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INNOVATIVE TECHNOLOGIES AND SCIENTIFIC SOLUTIONS FOR INDUSTRIES

No. 1 (3), 2018

CONTENTS

Technical sciences

Economic sciences

Сучасний стан наукових досліджень та технологій в промисловості. 2018. № 1 (3)
ISSN 2522-9818 (print)
ISSN 2524-2296 (online)

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ANALYSIS AND MODELLING THE PREFERENCES OF SOCIAL NETWORKS USERS

The **subject matter** of the research is the models and technologies of analyzing the processes of developing the loyalty and preferences of social networks users. The **goal** of the research is to increase the efficiency of marketing analysis of clients' preferences and promoting products and services. The following **tasks** are solved in the article: the analysis of the methods and technologies of simulation modelling; the survey of available simulation packages; designing a datalogical context chart; developing the agent-based model of the impact of social networks on preferences; developing a database for data storage; a graphical analysis of preferences. The following research **methods** are used – simulation modelling methods, Laravel and YouTube Data and Analytics API methods. The following **results** were obtained: the model that explains how advertising affects the development of clients' preferences, as well as the impact of clients' communication on loyalty, the information system for the graphical analysis of Wow–How Studio of YouTube channel The model that reveals the impact of advertising and clients' communication was developed. The suggested model proves the fact that the communication of social networks users greatly increases a number of actual clients as well as the level of loyalty. Using such technologies as Laravel and YouTube Data API, the designed application enables clear and timely monitoring and analyzing Wow-How Studio channel, which is very important to be always aware of the preferences of potential clients and to know what can be interesting for them and how to meet their expectations. The **results** can be implemented in enterprises of various spheres that offer their products and services. Any company is interested in obtaining the maximum profit and integration into social networks is free advertising and as a result attracts additional profit.

Keywords: social CRM, CRM-marketing, simulation modelling methods, YouTube API, loyalty, clients' preferences.

Introduction

The worldwide network is widely known and popular all over the world and every day a large number of people access the Internet visiting social networks as well. Business cannot ignore such a popular structure and therefore it also participates in this communication. However, selecting the method appropriate for achieving this goal is rather problematic today. Therefore, the sphere of building the preferences of social networks users is one of the promising areas of business development, so it draws the great attention of both scientists and business. Such factor as the loyalty of client to the company is of great interest for analyzing preferences [1, 2, 3].

Many companies join social networks, but largely for advertising. However, the client relationship can be monitored and their loyalty can be developed through social networks [4]. This is a new type of management which is called Social CRM (social client relationship management) [5, 6]. Using Social CRM, companies can develop client loyalty, as a certain category of buyers spends a lot of time on social networks.

Modern marketing strategy is aimed at acquiring and retaining clients, at finding opportunities for increasing sales. That is why a modern business is interested in turning potential clients into actual ones. To predict the behaviour of potential and actual clients in social networks, the means of simulation modelling should be used, particularly, the agent-based modelling [7, 8].

The analysis of literary sources and problem statement

In the process of simulation modelling, the researcher deals with four basic elements:

1) a real system;

2) the logical and mathematical model of an object being modelled;

3) a simulation (machine) model;

4) a computer which is used for simulating – directed simulation experiment.

The simulative nature of the research involves logical or logical and mathematical models that describe the process under investigation.

Due to a composite nature, a complex system is represented as:

$$<A, S, T>,$$

where A is a set of elements (including the external environment);

S is a set of admissible links among the elements (the structure of the model);

T is a set of considered moments of time.

A key moment in the simulation modelling is dedicating and describing the system state. The system is characterized by a set of variable states, each combination of which describes a particular state. So, by changing the values of these variables, the transition of the system from one state to another can be simulated. These changes in states can occur either continuously or at discrete instants of time [8].

Therefore, while simulation modelling, the logical structure of a real system is reflected in a model and the dynamics of subsystem interactions in a modelled system is simulated.

The following packages are used as dominating basic concepts of formalizing and structuring in the modern systems of modelling: AnyLogic, Arena, AutoMod, eM-Plant, Extend Industry, ProModel, QUEST, Witness.

The characteristics of various systems of modelling are given in Table 1.

ISSN 2522-9818 (print)
ISSN 2524-2296 (online) Innovative technologies and scientific solutions for industries. 2018. No. 1 (3)

Table 1. *Modelling packages characteristics*

Package	Package typical modules	Areas of packages use	Support of the output data analysis
AnyLogic 7.3	Analysis of system dynamics, market analysis, optimization, scheduling, support for approval of the decision, agent-based approach	Strategic management, production, servicing, logistics, supply chain, medicine, transport, IT-management, telecommunications, science	Data collection and statistical processing (deviation from the average probability distribution, etc.), the representation (Gantt charts, histograms, etc.)
Arena	Manufacturing, supply chain, business processes, medicine, military production industry, warehousing, logistics	Manufacturing, supply chain/logistics, business process management, medicine, military production industry	Output Analyzer (deviation from the mean, Anova, bar graphs, charts)
AutoMod	Transport systems, packaging lines, manufacturing	Automobile and aerospace branches, simulating airports, manufacturing, warehousing and selling	AutoStat module provides increased statistical analysis over the whole period of experimenting with the object
eM-Plant	Manufacturing, transportation, loading-unloading operations, simulating business processes, logistics, selling, scheduling, process verification	Discrete manufacturing (automobile branch, electronics, shipbuilding, machine tool building, warehouse facilities), logistics, marketing, consulting, healthcare, banking	Standard tool for data analysis DataFit is included (CI, medium, etc.)
Extend Industry	Modelling of large-scale systems with heavy loads. It includes an internal relational database and modelling unit	Queue system, including sales logistics, call centres with a large load, package lines, etc.	Confidence intervals, etc.
ProModel	Variance analysis, six sigma, portfolio design and scheduling, assessing capacity, cost analysis, modelling of cyclic improvements, supply chain	Manufacturing, logistics, pharmaceutics	The complete analysis of the output data, the use of graphs, export to Excel and Access for further analysis
QUEST	Manufacturing, supply chain, business processes, verification	Manufacturing (automobile, aviation, aerospace, electronics, shipbuilding)	Performs a combined analysis, stochastic analysis of general probabilities of events
Witness	Manufacturing, optimization, planning, modelling of business processes	Six Sigma, call-centres, BIS, modelling of business processes, production	None

The advantages of the AnyLogic package lies in the fact that its standard modules correspond to the simulated domain that enables building a graphical model; using software and step-by-step debugging; simulating an experiment; viewing animations on a real-time basis; animation export is also available.

Therefore, to determine the preferences of social networks users, the agent-based simulation modelling will be used as well as a set of technologies such as Laravel framework and YouTube Data and Analytics API.

The goal and objectives of the research

The goal of the article is to develop the informational and analytical system that should contain the agent-based model of social networks impact on the preferences of users, should enable graphical analysis of data on users' preferences provided by Wow-How Studio of YouTube channel.

The following tasks are solved:

- the agent-based model of social networks impact on preferences is developed;
- the database (DB) for storing the received data is developed;
- the graphical analysis of preferences is carried out.

The materials and methods of the research

1. The agent-based model of the impact of social networks on the preferences of clients

An elementary model of social networks impact on a client's loyalty is the model that grounds the fact that a client's loyalty is influenced by only one parameter, i.e. "the degree of advertising impact".

The diffuse model of Frank Bass is the basis for building an elementary model. The probability that a new product will be purchased at the time T is a linear function of a number of previous clients:

$$P(T) = p + \frac{q}{m} Y(T), \quad (1)$$

where p is the probability of purchase at the time $T = 0$ (const); $Y(T)$ is a number of previous clients; q and m are constants.

Сучасний стан наукових досліджень та технологій в промисловості. 2018. № 1 (3)
ISSN 2522-9818 (print)
ISSN 2524-2296 (online)

One of the ways to build complex models in computer simulations is the step-by-step construction when the basic model is considered as a primary basis and then a new model is built as a result of step-by-step complication and this model is included in a set of hierarchical models with increasing complexity.

With the help of the AnyLogic package, an agent model for 1000 agents was built. The network of 1000 agents is a small network. It was chosen as a point of consideration for this study due to the fact that the smaller model, the greater the confidence in the agents and the more obvious the impact of any indicators.

The behaviour of an agent is generally described in the class of this agent (this is the Person class in the model) using a statechart. The statechart consists of two states – a potential client (a person who has not bought the company's product/ has not used its services yet) and a current client. There is a transition between these two states. This transition will model the purchase of a product. To build an elementary model, let us assume that once a person has used the services of the company, they will forever remain a client and, therefore, there is no transition from "Client" to "Potential Client". The parameter which determined whether a potential client will become an actual one is the degree of impact of social networks advertisement on the agents that are registered there. The time spent by a person to buy a product/use service exponentially depends on the degree of impact of a product/service advertisement:

$$t_{buy} = \exp(a), \qquad (2)$$

where t_{buy} is the time spent by a person to buy a product;

a is the degree of an advertisement impact or the information influence of social networks, i.e. it shows how effective an informational message is and how it influences a potential client.

An elementary model assumes that a person will always remain a regular client if they have bought a product/ have used the company's services at least once. That's why there is no transition from "Client" to "Potential Client" (fig. 1).

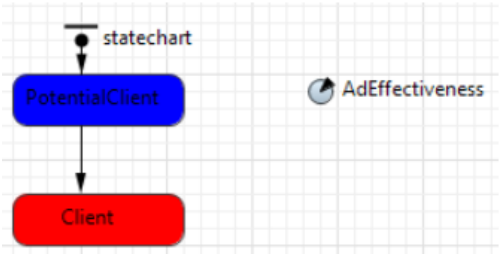

Fig. 1. The Statechart of the elementary model of the influence on clients' loyalty

The model is built for 7 units of simulation time that can be interpreted as a week.

The main task of the model of product distribution is to study how fast people are buying a new product. To do this, a number of clients and potential clients should be counted. In AnyLogic it can be done with the help of collecting statistics.

In order to count potential clients, the following function for collecting statistics was created:

item.statechart.isStateActive (item.PotentialClient)

This function will count a number of agents for whom the specified condition is true, that means those agents that are currently in the state of PotentialClients. An item here is an agent (the replication of the object "people").

One more function was created for collecting statistics about clients:

item.statechart.isStateActive (item.Client).

This function will count a number of agents who are in the state of "Client" (who has already purchased a product).

To visualize the results, the time graph was added; this graph reflects the dynamics of changes in a number of clients and potential clients of a product.

Fig. 2 shows the result of the dynamics of the process being modeled.

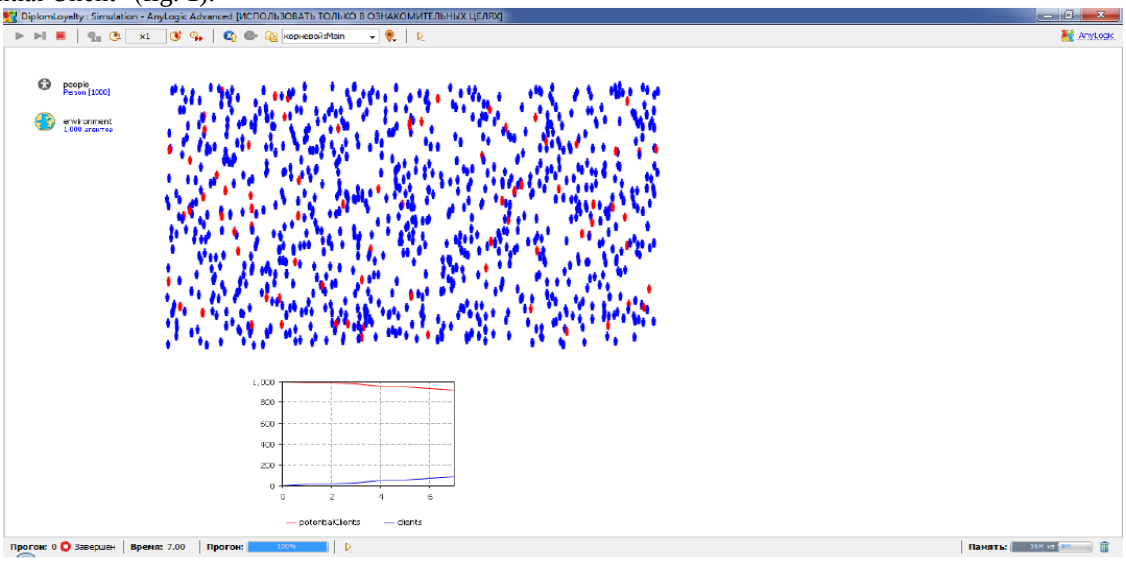

Fig. 2. The result of the dynamics of the impact of social networks on the loyalty of clients in the network of 1000 agents

ISSN 2522-9818 (print)
ISSN 2524-2296 (online) Innovative technologies and scientific solutions for industries. 2018. No. 1 (3)

Thus, this model can be built for any number of agents and the result will be identical – a number of potential clients decreases while the amount of actual ones grows and soon all the agents of the model will become actual clients. This is a drawback of the model, so it cannot be applied as it is in real life all the time since it takes into account only one factor whose duration is limited – "the degree of an advertisement impact". Also, this model does not take into account the fact that an actual client can again become a potential client. Therefore, this model will be further modified and parameters that take into account the degree of the trust of agents and the average annual number of new contacts will be added to it.

The advertising effect is of great importance only at the time when a product is launched on the market. In future, communication among people will play an increasingly important role – people who have already purchased this product share their opinion with their acquaintances and recommend that they also purchase a new product. This process is somewhat similar to the spread of the epidemic.

The following parameters were added to the existing model to enlarge it:

1) ContactRate parameter that is the annual average number of an agent's new contacts. Suppose that on average the agent has contacts with 100 agents per year;

2) ClientFraction parameter that is a person's strength of words; it shows how many people can be persuaded to buy the product. The default value is 0.015. The type is double.

The statechart should also be changed. The internal transition is added to the state "Client". The intensity of the transition is ContactRate. This transition will model the purchasing of the product by a buyer's acquaintance. The speed at which the client can convince his friend to purchase will depend on the strength of words of the buyer and on a number of friends the buyer meets a year. The transition is actuated when the agent's state diagram receives "Buy!" message from another agent

send ("Buy!", RANDOM).

This transition sends a message to a randomly selected person. The method "send ()" transmits the message to another agent. The first argument specifies a message to be sent, and the second one specifies the agent the message is addressed to. In this case, the message is sent to any randomly chosen agent as the argument value uses the special constant RANDOM.

This transition generates a signal for the statechart of any friend. Then the statechart is actuated and it models the purchasing of a product by this friend.

Also, another transition from the state of PotentialClient to the state of Client was added (fig. 3). It is actuated by a signal which is generated by the inner transition of the state "Client".

The properties of this transition were changed. The probability of making a decision about buying a product will depend on the strength of a person's words. In this model, this feature is set by ClientFraction parameter.

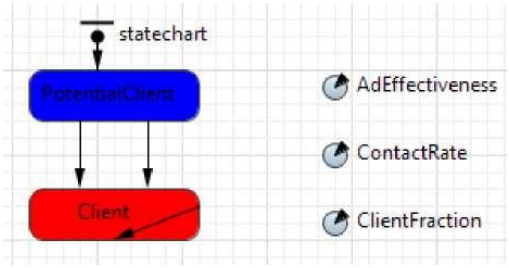

Fig. 3. The Statechart of the model that takes into account the impact of agents' communication

The field "Extra condition" was added by

randomTrue (ClientFraction)

As a result of the introduction of an extra condition, the product is purchased with the probability specified by the ClientFraction parameter.

The properties of an agent were changed. The field "Action after receiving a message" was added by

statechart.receiveMessage (msg).

The created model is shown in fig. 4.

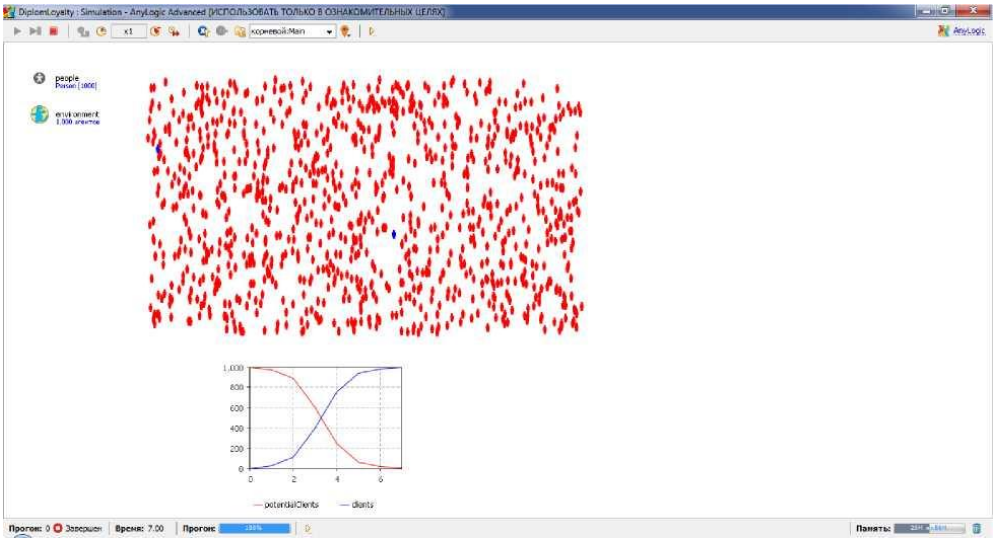

Fig. 4. The model that takes into consideration the impact of people's communication

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Thus, after studying the dynamics of changes in a number of clients and potential clients, the conclusion can be made that a number of actual and potential clients is gradually changing. The graphs of variables are S-shaped curves. A number of potential clients varies from the maximum to the minimum, while a number of potential clients changes from the minimum to the maximum. But this model does not take into account the fact that clients can transit from the state of actual clients to the state of potential ones.

2. Developing the DB for storing the received data

The data base was developed for the efficient work; this data base enables storing the data received from the requests to YouTube API. The data base is presented in fig. 5.

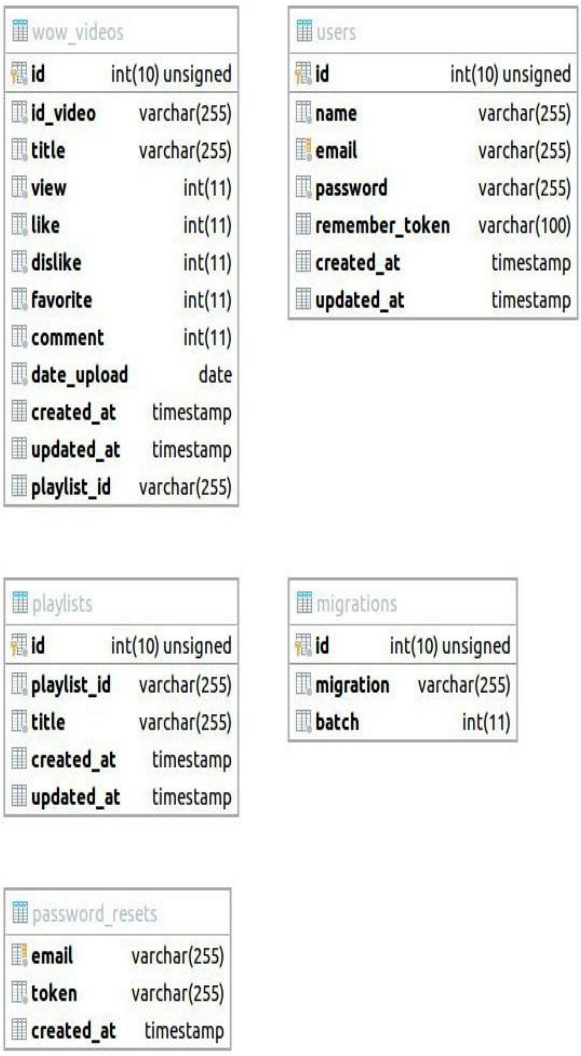

Fig. 5. The data base

The table “migrations” is the system table Laravel that contains migrations.

The table “users” is the system table for saving the users of the system.

The table “playlists” is necessary for saving the playlists that are on the YouTube channel.

The table “wow-videos” is designed for saving meta-information about videos on the channel.

The table “password_resets” is used to restore the passwords of the users registered in the system.

The table “wow-videos” and “playlists” are connected as one-to-many.

3. Integration with WOW-HOW Studio of YouTube channel

The API YouTube data enables connecting the functions of YouTube to the application. The API can also be used to receive the search results and to retrieve, insert, update, and delete such resources as videos or playlists.

Along with the API-interface YouTube Player and API YouTube Analytics, API allows the application to provide full access to YouTube, which includes searching and detecting, creating the content, video playback, account management and spectator statistics.

Table 2. *A list of API references to the site of request*

API end point	Description
youtube.videoCategories.list	Returns a list of categories that can be related to YouTube channels
youtube.videos.list	Returns a list of videos that correspond to the API request parameters
youtube.playlistItems.list	Returns a collection of playlist items that corresponds to the API request parameters. All the playlist items in a specified playlist can be retrieved or one or more playlist items can be retrieved according to their unique IDs
youtube.channels.list	Returns a collection from zero or more channel resources that meet the request criteria

Wow-How Studio of the YouTube channel was integrated using the YouTube API. Basing on the data obtained, the preferences of customers can be analyzed. Using the YouTube API, a number of opportunities for further analysis of the channel was obtained. First of all, videos were analyzed according to a number of views and the graph “Top-20” was constructed; this graph is presented in fig. 6.

The graph was constructed according to a number of video likes/dislikes in 2017+, as updated videos should be used to analyze preferences. The graph is presented in fig. 7.

The playlists were analyzed according to a number of videos to understand what type of video is the most widespread among the clients of Wow-How. The chart is presented in fig. 8.

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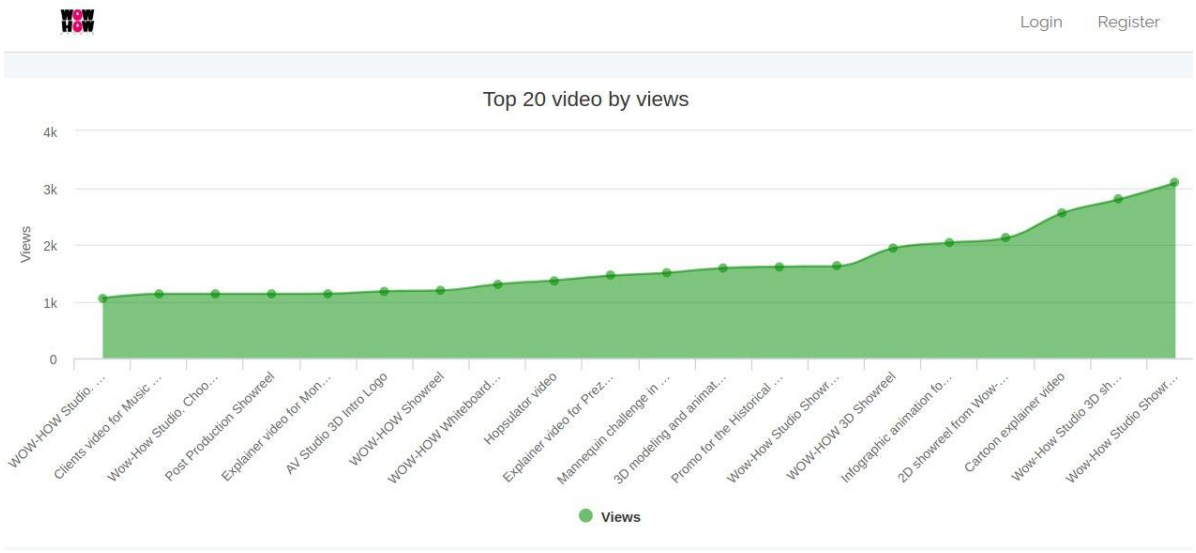

Fig. 6. Top-20 according to a number of views

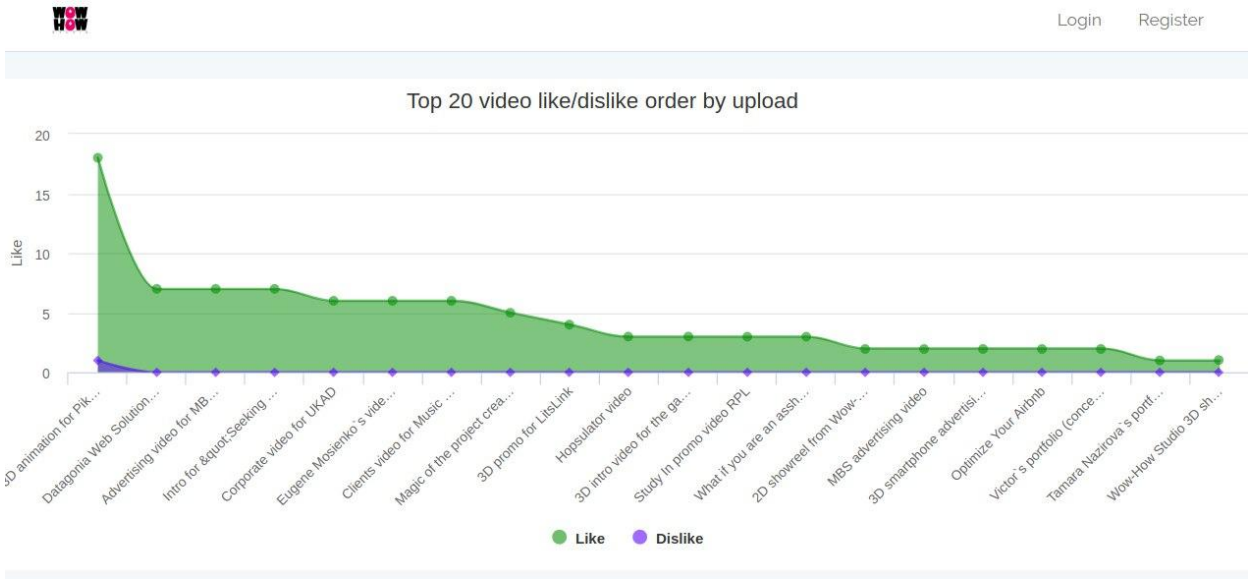

Fig. 7. Top-20 according to a number of likes/dislikes (2017+)

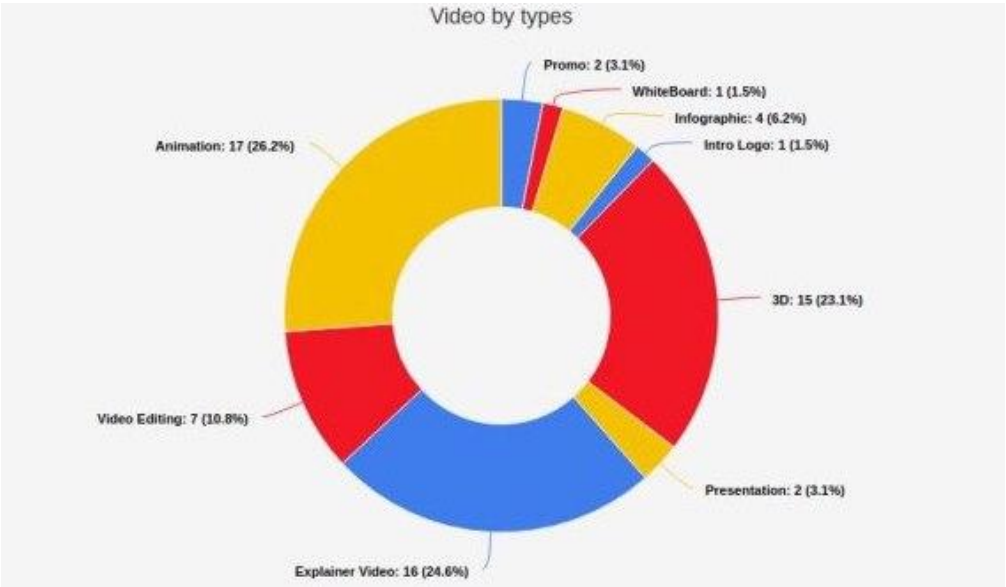

Fig. 8. A number of videos in playlists

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Basing on the received graphs, the conclusion can be made that various 2D videos (animation, advertising, explainer) and 3D products commercials have been and still are the most popular ones.

Conclusions

As a result of the analysis of literature sources, the loyalty of clients was determined as a certain positive attitude of clients to the activities of a company, its products and services, its personnel, image, trademarks, logo and so on. This loyalty, that is a favourable attitude of a client to a target company or to a product is the basis for a stable sales volume.

The created model enables detecting the fact that communication among clients greatly increases a number of actual clients as well as the level of loyalty.

The developed application with the help of such technologies as Laravel and YouTube Data API enables accurate and timely monitoring and analyzing the Wow-How Studio channel, which is very important to understand the preferences of potential clients, to know what they are interested in and what can satisfy them.

The results of the research can be implemented at enterprises of various fields that offer their goods and services. Any company is interested in maximizing profits; integrating into social networks is free advertising and, due to it, a way of attracting additional profits.

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АНАЛІЗ І МОДЕЛЮВАННЯ ПЕРЕВАГ КОРИСТУВАЧІВ СОЦІАЛЬНИХ МЕРЕЖ

Предметом дослідження в статті є моделі і технології аналізу процесів формування лояльності і переваг користувачів соціальних мереж. **Мета** роботи - підвищення ефективності маркетингового аналізу переваг споживачів і просування продуктів і послуг. У статті вирішуються наступні **завдання:** аналіз методів і технологій імітаційного моделювання; оглядовий аналіз існуючих систем моделювання; проектування даталогічної контекстної діаграми; розробка агентної моделі впливу соціальних мереж на переваги; розробка БД для зберігання отриманих даних; проведення графічного аналізу переваг. Використовуються такі **методи** дослідження - методи імітаційного моделювання, методи Laravel і YouTube Data and Analytics API. Отримані наступні **результати:** розроблена модель, яка дозволяє зрозуміти вплив реклами на формування споживчих переваг, а також вплив спілкування клієнтів на лояльність, інформаційна система для графічного аналізу YouTube каналу Wow-How Studio. Розроблена модель відображає вплив реклами і фактор спілкування користувачів соціальних мереж. Створена модель дозволяє відстежити той факт, що спілкування клієнтів між собою значно збільшує кількість реальних клієнтів, а також рівень лояльності. Додаток, розроблений за допомогою таких технологій як Laravel і YouTube Data API дає можливість чітко і своєчасно відстежувати, і проводити аналіз каналу Wow-How Studio, що дуже важливо для того, щоб завжди бути в курсі про переваги потенційних клієнтів, знати, що їм цікаво і що можливо їх може задовільнити. Результати дослідження можуть бути впроваджені на підприємствах різних сфер, що пропонують свої товари і послуги. Будь-яка компанія зацікавлена в отриманні максимального прибутку, а інтегрування в соціальні мережі є безкоштовною рекламою і, таким чином, інструментом залучення додаткового прибутку.

Ключові слова: соціальний CRM, CRM-маркетинг, методи імітаційного моделювання, API YouTube, лояльність, переваги клієнтів.

АНАЛИЗ И МОДЕЛИРОВАНИЕ ПРЕДПОЧТЕНИЙ ПОЛЬЗОВАТЕЛЕЙ СОЦИАЛЬНЫХ СЕТЕЙ

Предметом исследования в статье являются модели и технологии анализа процессов формирования лояльности и предпочтений пользователей социальных сетей. **Цель** работы – повышение эффективности маркетингового анализа предпочтений потребителей и продвижение продуктов и услуг. В статье решаются следующие **задачи**: анализ методов и технологий имитационного моделирования; обзорный анализ существующих систем моделирования; проектирование даталогической контекстной диаграммы; разработка агентной модели влияния социальных сетей на предпочтения; разработка БД для хранения полученных данных; проведение графического анализа предпочтений. Используются следующие **методы** исследования – методы имитационного моделирования, методы Laravel и YouTube Data and Analytics API. Получены следующие **результаты**: разработана модель, которая позволяет понять влияние рекламы на формирование потребительских предпочтений, а также влияние общения клиентов на лояльность, информационная система для графического анализа YouTube канала Wow-How Studio. Разработана модель отображающая влияние рекламы и фактор общение пользователей социальных сетей. Созданная модель позволяет отследить тот факт, что общение клиентов между собой сильно увеличивает число реальных клиентов, а также уровень лояльности. Разработанное приложение при помощи таких технологий как Laravel и YouTube Data API дает возможность четко и своевременно отслеживать, и проводить анализ канала Wow-How Studio, что очень важно для чтобы всегда быть в курсе о предпочтениях потенциальных клиентов, знать, что им интересно и что возможно их может удовлетворить. Результаты исследования могут быть внедрены на предприятиях различных сфер, предлагающих свои товары и услуги. Любая компания заинтересована в получении максимальной прибыли, а интегрирования в социальные сети является бесплатной рекламой и, таким образом, привлечением дополнительной прибыли.

Ключевые слова: социальный CRM, CRM-маркетинг, методы имитационного моделирования, API YouTube, лояльность, предпочтения клиентов.

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LEADERSHIP AS A FACTOR FOR BUILDING A PROJECT TEAM

The **subject** matter of the article is to determine the role of leadership for building a project team as the team quality and the professionalism of the team participants play a key role in ensuring the proper work performance that is specified by the tasks of the project. The **goal** of the article is to reveal the significance of the capability of a leader to build a project team and to develop in it a favorable psychological climate, common values and ideals and show the place of this capability in the general system of the leader's behavioural competences, that is to justify the importance of this skill and its application to increase the effectiveness of the impact of leadership on the project team. The **objectives** of the study involve - identifying a project team as a complex social organism where highly qualified people perform a specific set of functions; - emphasizing the fact that different individual features and qualities of participants greatly complicate the process of building a project team as well as coordinating the goals, aspirations and interests of team participants. Besides, the students who study Project Management should be familiarized with the methods of acquiring the knowledge and developing skills necessary for building a team. The **methods** of the study involve the analysis of the role of motivation in the process of team building since while building a team the leader has to solve many problems and the issues of motivation are among them. Second, the character of relations among the participants and the rational organization of their efficient teamwork should be analyzed. Third, the analysis of the leader's capability to foster the professional and personal development of the participants in the teamwork is of great importance. Fourth, the effective method of cultivating in leaders the skills of building a team is increasing the level of teaching behavioural competences using innovative pedagogical techniques. **Results.** The clear goal setting and system use of efficient methods of building a project team are critical for professional training specialists in the sphere of project management. The development of relevant skills should be combined with the intentional development of students' leadership potential. The adequate organization of teaching behavioural competences plays a special part and the clear practical orientation of conducting lectures and seminars using active teaching methods are of primary importance. **Conclusions**. First, the prevalence of command methods and forms of activity in project management significantly enhances the importance of the membership of the project team and the nature of the relations among the participants. Secondly, the effective formation of the team requires that the leader have the relevant knowledge and skills, strategic thinking, psychological culture and the ability to assess the professional competence of candidates and their significant professional and social personal qualities. Third, the leader should use a clear system of motivation and incentives to build a project team and organize the teamwork.

Keywords: project team, leader, leadership, team building, teamwork, relations, the system of professional training, behavioural competences, pedagogic techniques.

Introduction

The world practice of applying project management technology convincingly demonstrates the essential role of the project team in ensuring the possibility of a successful implementation of the project of any complexity. Therefore, building the team is one of the most important and responsible stages of the activities of the project manager. A.D. Orr states that "to perform a project, a strong project team capable to do necessary work is needed" [1, p. 87]. Only a strong leader, a real authority can build a strong team. To do this, he needs a clear psychological focus on unconditional achievement of the goals specified by the project tasks, self-confidence and confidence in the team as well as a highly developed sense of self-responsibility.

Therefore, leadership as a complex social and psychological phenomenon is an important behavioural competence of a project management specialist as S. D. Bushuev considers [2] but the essential attribute of the project management itself. Leadership plays a decisive role both in building the project team and in developing and maintaining the special team spirit, it becomes an extremely important factor that encourages the members of the team to do work and fulfil functions specified by the project tasks.

The processes of team building, the development of common goals and values, norms, relations and teamwork are challenging as they are aimed at coordinating and harmonizing different and sometimes directly opposite aspirations and interests of participants in joint activities within the project. Therefore, the study of their features is an important and urgent problem.

The target problem is connected with important theoretical and applied issues as the results of its comprehensive studies will enable making a significant contribution to the theoretical foundations of project management in general and considering leadership as one of the important behavioural competences of a specialist and the processes of building a project team. At the same time, a clear general practical focus of the technology of project management creates the prerequisites for the immediate direct application of the results obtained while solving applied tasks that are specified by the objectives of the project.

Leadership, team spirit, common values and the nature of the relations among the members of the project team has a decisive role in implementing the project objectives successfully and are a powerful stimulus for studying the processes of team building and purposeful actions of leaders in this direction since they urgently need a project team as a cohesive, efficient and competitive team of highly professional specialists with creative abilities and innovative thinking.

The analysis of studies of the stated problem indicates that this problem is important and topical and emphasizes its theoretical and practical significance, which is proved by numerous scientific works dealing with general issues of leadership as well as with specific

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aspects of leadership and particular spheres of its application. The first group of studies involves the detailed analysis of the phenomenon of leadership conducted by W. Bennis and B. Nanus [3]. The laws of leadership are considered in the works written by J. Maxwell, V.P. Sheinov studies the psychology of leadership.

The second group of works involves interesting studies of political leadership conducted by J. Blondel, V. I. Karasiov, I. G. Shablinsky and others. V. A. Rozanova considers the peculiarities of leadership in the context of anti-crisis management. The nature of relations and interactions between the organizational culture and leadership is studied by E. Shein. V. Sheklton analyzes the features of the psychology of leadership in business. J. P. Kotter studies important issues of leadership from the point of view of theory and practice considering the life and actions of a fabulously successful Japanese entrepreneur and business leader Konosuke Matsushita.

Most researchers do not just consider the nature and essence of leadership and its role in building a team but also analyze qualities a leader should have to improve the effectiveness of impact on people. Thus, D. Carnegie emphasized such important feature of a leader as the ability to persuade people. He states that "if you are making a speech having the aim to persuade listeners in something, you should be confident in it or you will fail to be convincing enough. Before persuading others, assure yourself" [4, p. 176]. Some results of studying the phenomenon of leadership are presented in the previous work [5, p. 81-87].

The attempts to analyze publications that deal with the role of leaders in building project teams seem rather difficult. Except for the work written by A.D. Orr mentioned above and the special chapter devoted to the issues of building a team for a project written by G.M. Tarasiuk [6]. Most authors consider the relations between a leader and their team without regard to project management, among them the book written by J. Maxwell is worth mentioning [7]. In their book [8], H. Mintzberg, B. Ahlstrand and J. Lampel pay a great attention to the issues of interrelations between a leader and a team. S. O. Zavetny, O. S. Ponomaryov and S. M. Pazynich also study these relations. They analyze the mutual influence on a leader and their subordinated and believe that "the nature of the managerial impact of a leader on subordinates plays an important role in ensuring proper operating and developing the organization and achieving certain goals". However, the scientists emphasize that "its real success is possible only if a manager has a well-organized cooperation with the staff if both the interests and aspirations of people and their practical suggestions on the technology and organization of production and its management are taken into account" [9, p. 152].

The works by R. Acoff, E. Babosov, V. Beloshapka, D. Bossidi, P. Vlasov, V. Knorring and many others [10] contain a lot of interesting and useful information concerning team building and interaction of a leader with the team. Even the title of the book "The Soul of an Organization" written by R. Gallagher draws great attention; this book considers the peculiarities of a leader's influence on the team; these peculiarities are conditioned by the leader's so-called emotional intelligence. O. M. Mitin quite reasonably reveals the meaning and role of the culture of personnel management, while E. Singer considers the essence and importance of the management ethics.

A. Orr analyzes the process of building a project team most fully and consistently. He determines the appropriate composition of a team, details the ways and means of motivating the participants of a project team, points the role of clarifying the opinions of team participants and shows how to win the respect of the participants of a project team. In particular, the author emphasizes that "winning the respect of the members of your team is a difficult task, this can only be achieved when you are consistent and fulfil your promises. It does not matter to what extent you are fed up with all this – you should always have a positive attitude and act from the position of the leader" [1, p. 99-100]. These qualities of a leader ensure the success of their actions both in building a project team and in organizing its fruitful activity.

The aspects of the problem that are not sufficiently studied

The project team acts as a complex social organism, in which people of a high level of professional competence usually have to perform a certain set of interrelated functions. Each of them has their own psychological characteristics, their own interests, goals and aspirations, their values and ideals. This difference significantly complicates both the formation of a project team and the coordination of the goals, aspirations and interests of its participants. And the ways, methods and means of its efficient coordination are not fully studied in the available literature on the problems of project management.

Psychological difficulties that arise in the process of building a project team, the ethical and value aspects of these processes and their impact on the dynamics of team building, on the mechanisms for coordinating the goals, aspirations and interests of team members are considered first and foremost. In other words, the works on the issues of the formation of teams and work collectives do not pay much attention to the specifics connected with the peculiarities of these processes in the system of project management techniques.

Such aspects of the problem as the methods of imparting the knowledge and skills concerning teambuilding to students who study Project Management are insufficiently solved. Although the curriculum for the discipline "Behavioural Competences in Project Management" involves studying the issues of participation and motivation, the resolution of conflicts and crises, values and ethics, the task of building a project team, developing certain norms, principles and standards of teamwork as well as the role of a leader in solving these tasks are not clearly defined.

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The role of a leader in building a team

It seems quite obvious that the success of a project depends on the quality of the project team and the nature of its management. Therefore, the processes of team building and its purposeful development acquire special importance and responsibility. These processes are complex, demanding from the leader considerable efforts, time and resources. They involve clear planning and selecting necessary professional personnel. But this is not enough. To create a real team, all its participants should have common goals and values, people's energy should not be directed only to the proper performance of individual tasks and functions but also to team results, project interests. To achieve this, the leader should develop a team spirit and make sure that each participant follows it; the leader should establish interpersonal relations on the principles of comradeship and mutual assistance. These purposeful efforts of the leader will necessarily contribute to developing the expected synergetic effect and its manifestation in the activities of the team.

However, the successful formation of a project team requires that the leader should not only have developed leadership features and qualities, should not only have a clear vision of the system of project objectives but the leader should be able to select the professionals needed for their successful achievement. It is extremely important for the leader to have all behavioural competencies.

Thus, G. M. Tarasiuk states that "the power of a leader is based on good knowledge of subordinates, the ability to put themselves in their place, to analyze the situation, to determine the immediate and long-term consequences of their actions, on the need in self-actualization, the ability to instill confidence in subordinates and the awareness of the need to perform certain actions. The real source of leadership lies in the leader's independence, readiness to vacant the place he occupies at any moment since following the interests of the collective does not mean obeying them" [6, p. 102]. This quality testifies to the dignity of the leader and self-confidence but it can also indicate capriciousness, so it should be used cautiously.

G. M. Tarasiuk believes that "building a team, the project manager brings together a group of people, trying to unite them with a common goal and common tasks. Novelty, uniqueness, risk and short duration are the integral features of a new project, they also determine the difficulties in building a team. Building a team for a new project is also complicated by the fact that these people have not worked together, they do not have common values and norms but they should work efficiently and synchronously" [6, p. 91]. In should be noted that this situation requires that behavioural competences should be added by psychological and pedagogical competences that will help the leader teach and train the members of a team properly.

The general orientation of the course

A significant part of the aspects of the leadership role in building a project team which are insufficiently studied should be considered as extremely important for professional training of project management specialists. Therefore, they are not only closely related to the goals and nature of the organization and implementation of the educational process but should be considered as one of the main components of the professional and social competence of future specialists. This connection is conditioned by the fact that a leader acts as the subject of team building, he selects performers who are able not only to solve production tasks specified by the project successfully but who can also learn, constantly increasing their professional competence and readiness for changes.

Moreover, the leader as a real manager cares for the psychological compatibility of the members of a project team, for the development of the system of ethical standards and unfailing respect for them, the creation of the favorable psychological climate in a team. The technology of project management is considerably enhancing, which upgrades both professional training of specialists and the social and psychological climate in the team and raise the standards of a leader as a person who creates this climate and ensures it as well as the purposeful use of its advantages for cooperation and mutual relations among participants.

According to the requirements of the IPMA standards (International Project Management Association), the basic components of the discipline "Behavioural competences in project management" related to the processes of building a project team are leadership, participation and motivation, openness, focus on results, values and ethics. A general characteristic of this course is its clear focus on ensuring the high professional competence of specialists and on their ability to work successfully as part of the team while fulfilling the tasks of the project. The effectiveness of teamwork depends on such conditions.

First, a manager should be a real leader in strategic vision and advanced creative abilities, which are evident both at the stage of team building and in the process of fulfilling the project tasks. Therefore, the content of the educational material on behavioural competences, the nature of the presentation and the general orientation should be aimed at the effective consistent development of the students' leadership potential and teamwork skills. This requires special attention to preparing and conducting lessons and using the active methods of teaching.

Second, while building a project team, a leader should pay attention not only to the level of professional but also the social competence of candidates and their psychological features and characteristics. At the same time, the leader should immediately create a favourable psychological atmosphere in the team and the principles of interpersonal relations. Therefore, in the process of teaching behavioural competencies, students should be taught the essence and significance of such components of this course as self-control, confidence and openness, common values and ethics of business relations. The

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leader should show their pedagogical abilities in cultivating in the team members the devotion to the team and to common goals.

Third, teaching the material of the course should be based on the triple nature of the phenomenon of managing in general and project management in particular. Management is a kind of science which has a certain conceptual and categorical apparatus, certain laws and theoretical principles as well as a range of problems that should be further investigated. At the same time, management is a kind of art since no management situation is repeated with absolute precision and the leader should creatively apply their theoretical knowledge and practical skills. In addition, management is a professional activity. And students should acquire this triad of meanings as an important premise of the ability to build a project ream effectively and ensure its fruitful activity.

Fourth, while teaching the behavioural competencies, future specialists should be taught how to understand the advantages of team methods of organizing joint activities and the need for constant professional and personal development. This will contribute to creating and developing the leadership qualities and selection skills in the process of team building. At the same time, common professional and psychological culture should be developed, which is necessary for providing the team spirit and the sense of pride in the team. After all, the favourable psychological climate in the team, an atmosphere of goodwill, sociability and willingness to lend a hand to those who need it are the basic prerequisites for the successful teamwork of the team.

These conditions determine not only the overall orientation of the teaching and training the behavioural competencies but also contribute to making students acquire the knowledge and skills necessary for building an effective project team, for mastering the methodology of teamwork. At the same time, these conditions help identify and develop the managerial competence of potential leaders. It is extremely important to cultivate in them a deep understanding that the team may have several leaders and managers should not jockey for influence over other participants but cooperate with them, delegating certain functions for managing the fulfilment of the project tasks.

Building a project team is one of the really important aspects of any project as the success of the project depends on its composition, on the nature of the relationship between the leader and the team and among the participants. Therefore, in the system of professional training of project management specialists, especially in the process of studying behavioural competencies, the issues of team building should take a significant place alongside the acquisition of professional competence and the development of leadership potential. A manager as a real leader should be able to determine the rational composition of the team as well as to have the means for motivating and encouraging team members, the ability to combine moral and material forms of personnel encouragement efficiently.

Thus, the general orientation of the course on behavioural competencies should sensitize future specialists, especially leaders, to developing effective teamwork skills. These skills should cover the range of processes from the preliminary selection of candidates and the final determination of the personal composition of the project team to the distribution among the executors of production tasks and the functions provided by the project and the organization of their proper execution. At the same time, students should understand that the successful implementation of the project also involves the motivation of project team members and quality control of their activities as well as meeting the project requirements.

An extremely important task of the leader in the process of teambuilding is also their personal purposeful development. First of all, their professional managerial competence and leadership potential should be developed to win the respect, business and personal prestige. The team recognize the leader due to their constant personal development and encouragement of the development of each team member. That is why the development of professional competence and leadership potential of a future project management specialist should be considered as another manifestation of the general orientation of teaching behavioural competencies.

The course is aimed at developing leadership potential and its proper use while carrying out project tasks. Therefore, it is taught along with the disciplines on technical competencies and the practical experience of students is taken into account. Thus, a manager should constantly remember that the process of team building is not over when the project team is staffed, the team should be built as an integral highly professional unit.

Thus, behavioural competencies are taught to project management specialists in the general context of proper social and psychological support, which involves developing certain skills of effective teamwork. It involves increasing the level of professional and social competence of future specialists significantly, cultivating in them the desire for self-actualization and self-realization and the capability to use the knowledge of humanities that create reliable preconditions for the efficient fulfilment of the project tasks.

The problems of identifying and developing the leadership potential of students as conditions for successful building a project team. In the process of training, a future specialist should clearly understand that project management is joint activities of people which is organized primarily in the form of teamwork and building and managing a team require that a manager or a leader should have both technical and human competences. Every member of the project team should not only fulfil its tasks but also participate actively in the implementation of tasks, which is possible only due to the collective interaction of team members. Understanding this as well as distributing individual tasks is a serious problem that requires awareness of not only the capabilities of each team member but also the nature of the relationship among the people in the team.

In general, the problems of identifying and developing the student's leadership potential are related both to the complexity and multidimensionality of

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leadership itself and to its contradictory individual and social nature. In addition, this potential and individual characteristics should be identified and revealed in the context of multiple teaching and training tasks and the predominance of group activities. However, a significant public need for leaders, for their capability to build effective teams and ensure efficient joint activities of participants require that the education system should solve this important, relevant and socially significant problem efficiently.

The lack of the student's psychological knowledge is another problem in cultivating in a student the skills of building a project team directly within the teaching and training process. An extremely negative trend in modern engineering education is a constant reduction of the academic time for studying the disciplines of the social and humanitarian cycle. At the same time, the complication of public life, the increase in the level of educational and professional training of people and their self-actualization only increase the need for this knowledge and skills to use them properly.

An essential problem in cultivating in a potential leader the skills necessary for building an effective project team successfully arises from the conventional nature of duties, tasks and functions, whose implementation requires that a leader should select specialists. The distribution of duties, tasks and functions among the performers and their groups should complete the process of teambuilding. However, when active teaching methods, particularly role-playing and business games, are used systematically in the teaching process of, the desired skills can be developed. These methods help a student develop their leadership qualities and direct them to the ability to build a team and work with it successfully, organize joint activities of people and manage the proper execution. It is understandable that the knowledge, skills and abilities acquired in this case will be helpful for professional activities on project management in future.

While developing these skills, there arises such a problem as the stratification of students according to their material and social status which results in weakening of collectivism and friendly relations among students, the increase in the tendencies of individualism and some uncertainty with employment after graduating from a higher educational institution. Under these conditions, a rather wide divergence of the life goals and values of students as representatives of various social strata of the population hinder successful teambuilding.

However, even under these conditions, student's leadership qualities usually manifest themselves in the strong influence of their personality on other students and in the authority that they have with the representatives of different groups. Depending on the strength of this impact, the ability to build a project team is determined as well as the ability to coordinate the goals, aspirations and interests of the team participants and to organize efficient fulfilment of tasks and functions specified by the goals of the project. Leadership qualities allow such a student to involve teamwork participants in the active search for better ways to organize its implementation and rational ways of using available resources. Such a student will be a real and effective leader in future professional activity and have an indisputable authority with the team.

The pedagogical technologies to be used are determined by the complexity and responsibility of the task of building a project team that cause the necessity of the search and systematic use of effective ways and techniques, methods and pedagogical technologies aimed at developing the skills and abilities of such activities while teaching. First of all, business and role games mentioned above should be kept in mind. Case studies are also rather efficient as well as the analysis of problem situations and so on. These technologies should form the basis of practical classes on behavioural competencies. At the same time, they should contain tasks on the selection of specialists for building a project team, the distribution of roles, tasks and functions and an assessment of their implementation.

Lectures should be carried out on the basis of the systemic application of the dialogue method. If possible, the previous conditional division of roles in the group as the simulation of the relationship and interaction in the project team can also be useful. The experience of attracting students with the developed leadership potential to the discussion of the system of team members' motivation and the stimulation of their activity is also positive. The synergetic effect that arises in this case helps develop skills not only for building a project team but also for systemic work with it. At the same time, the leadership potential of future specialists in the sphere of project management is further developed.

It is important that students - potential leaders obtain developed skills and abilities in developing a project team and its effective management; this requires that a teacher as a professional, leader and personality should have appropriate skills. Therefore, the teaching process should be successfully implemented and students should be also involved in active participation in the scientific research. This allows the teacher to build a team in which students master both new knowledge and methodology of the scientific work and the ethics of a researcher, the nature of the relationship and interaction in a scientific team.

In general, while using innovative pedagogical technologies, an interesting relationship arises between the development of the student's leadership potential and the acquisition of skills in the formation of the project team. This relationship is a completely natural result of the teacher's purposeful use of active teaching methods. But this application should be also of an active nature, it should encourage the initiative of students, offer them to suggest alternative ideas, options for the solutions of certain problem situations. This is what the modern paradigm of the binary educational process involves.

An important feature of the pedagogical technologies used for teaching the rules for building a project team to students should be a regular change in the roles that a student performs in game situations. This is due to the fact that for the skilful management, a person should be able to obey. In addition, playing the role of a subordinate and performing corresponding tasks and functions helps a future leader understand the psychology

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of his subordinates better and use the gained knowledge in the relationship with them. Finally, another feature of pedagogical technologies aimed at developing potential skills for building an effective project team is cultivating in potential leaders the sense of responsibility and the aspiration to analyze the shortcomings of their actions, record them and identify possible ways and means to overcome them successfully.

The ways and means to develop the abilities of a leader to build a project team. The analysis of pedagogical technologies used for this purpose mentioned above involves considering the reasonable ways and methods of developing the skills of building a project team. It should be emphasized that this skill is an important part of the general structure of the leadership potential of a future project management specialist. It should be noted that the corresponding ways and methods were detailed in [5]. But to develop these skills is rather difficult. Life practice shows that even experienced managers sometimes make mistakes while selecting the necessary staff and building a capable project team; to teach this to a student who does not have the proper knowledge and experience is even more difficult.

An important way to develop the leader's skills to build an efficient project team is to suggest the leader the ideology of the system analysis, which enables identifying the needs for personnel, the capabilities to meet these needs, the methods of motivating employees to expand the range of tasks and functions performed by them through their self-training and mastering new knowledge and skills. The purposeful organization of the system of advanced training of the project team members can also become appropriate.

In addition, the process of teaching the academic discipline of behavioural competencies almost is affected by various, often undesirable factors of the objective and subjective nature, either random or regular. At the same time, this circumstance can be used to teach potential leaders to analyze complex situations, to identify disadvantages and to find ways and means to overcome them effectively. At the same time, this circumstance contributes to the development of the leader's self- and trust in the team.

The involvement of each teacher engaged in the training of project management specialists in the general system of teaching activities can be considered as an effective method of developing leadership skills to build a project team. Due to this the possibility to diversify the ways and methods, abilities and forms of pedagogical impact on students. The integral result of these impacts will be the intensification of the processes of developing the students' leadership potential, including their ability to build a project team and work with it effectively. Student see and understand how different teachers use different methods to make the influence of different intensity and this is an additional educational impact; the result is developing students' professional and social competence and personal development. In other words, the team of teachers who want to achieve this goal works coherently and purposefully.

The proper organization of the educational process of their professional training is a method of mastering the skills of productive use of their leadership potential for building a project team. It should involve using the group interaction technologies actively, the game design is an acting one. For increasing the effectiveness of these technologies and their use to develop students' skills in building a project team and organizing efficient teamwork, students should change the roles, functions and responsibilities that they perform. This facilitates the identification of potential leaders and the development of their potential as well as of those who can perform the roles of doers or experts, managers or advisers.

The efficient method of developing the skills of using the students' leadership potential for building a skilful project team is the integral combination of their professional and social competence and responsibility. It helps unify the participants in teamwork rapidly and develop common goals and values among them. And the sincere concern of a leader about them, the desire to take into account their interests and promote their personal development become a reliable prerequisite for the successful achievement of the project goals.

The control of acquired skills. One of the important conditions for the development of the professional competence of project management specialists is the effective control over the acquired teaching material. This fully applies to the development of their leadership potential and its use in building the project team and organizing the efficient teamwork to fulfil the tasks and works specified by the project. The main place in the control system should be occupied by the analysis of the dynamics of leadership potential development and its manifestations in building the team and the nature of its relationships with team members. The importance, public importance and high level of responsibility of project activities require constant monitoring and diagnosis of students' educational and cognitive activities.

The technology of control involves taking into account the level of knowledge and skills of a student and their activity during practical and seminar classes, especially their performance of role functions and tasks of business games and the analysis of problem situations. The diagnosis is primarily aimed at identifying gaps in knowledge and skills as well as their causes and at selecting efficient ways and means to eliminate them. However, the student's mistakes that happen while building a project team should not be underestimated. After all, they are often inevitable in real practice. It is important to teach a student to identify these mistakes timely and to select efficient ways and means to correct them.

The control of the level of mastering skills in building a project team should be combined with the analysis of the assessment of the leader's actions conducted by the team members. This develops the activity of all participants in the educational process and makes them understand the importance of such activity for effective teamwork in the context of their professional activity.

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Conclusions

The results of theoretical researching and the practical pedagogical activity in the field of preparation of experts in project management enable making the following the conclusions.

First, the dominance of team methods and forms of activity in project management significantly enhances the importance of the composition of a project team and the nature of the relationship among its participants. Therefore, the ability of a leader to build a highly professional team efficiently and to establish norms and rules of relationships that actively contributed to the cohesion of the team, the development of common life goals and values and the professional and personal development of participants play an extremely important role in the system of behavioural competencies of leaders.

Second, the complexity and the responsible nature of building the project team requires that a manager as a true leader should have general strategic thinking, deep psychological culture and the ability to assess properly not only the level of highly professional competence of candidates but also their professional and socially relevant personal features and qualities. Particular attention should be paid to assessing the employees' proneness to conflict and identifying so-called conflict personalities among them as their impact on the psychological climate in the team and on the nature of the relationship among team members can undermine the employees' attitude to their functions and responsibilities and, therefore, on the general quality of the project.

Third, for building a project team successfully and organizing the subsequent efficient teamwork, a manager as a true leader should know and skilfully use a well-thought-out system of motivation and incentives for employees. It should be based on the combination of the general objectives of the project and the interests of all stakeholders, primarily the goals, aspirations and interests of the project team members. To achieve this, the system should involve developing a range of material and moral incentives. Among them, an important place belongs to the extensive use of the technology of the authority delegation, which raises the self-esteem of employees and encourages their efficient activity in implementing the tasks and functions specified by the project.

Fourth, the requirements for high professional skills and the development of professionally and socially significant personal features and qualities of a leader lead to the high mobility of the leader and the project team and their preparedness to carry out the tasks of various projects, portfolios and programs in various areas of social production. The condition for successful execution is a cohesive, highly professional, efficient team and the constant concern of a manager or a leader about the constant professional and personal development of team members.

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ЛІДЕРСТВО ЯК ЧИННИК ФОРМУВАННЯ ПРОЕКТНОЇ КОМАНДИ

Предмет статті полягає у визначенні ролі лідерства в процесі формування проектної команди, оскільки саме якісний склад цієї команди та професіоналізм її учасників відіграють визначальну роль у забезпеченні належного виконання робіт, передбачених завданнями проекту. **Мета** статті – розкрити значення і місце в загальній системі поведінкових компетенцій лідера його уміння формувати проектну команду й затверджувати в ній сприятливий психологічний клімат, спільні цінності та ідеали. Мається на увазі обґрунтувати важливе значення цього уміння та його використання для підвищення ефективності лідерського впливу на проектну команду**.** **Завдання** дослідження передбачають, по-перше, показати, що проектна команда є складним соціальним організмом, у якому певну сукупність функцій мають виконувати люди високої професійної компетентності. По-друге, передбачається показати, що відмінність їхніх індивідуальних рис і якостей істотно ускладнює як формування проектної команди, так і узгодження цілей, прагнень та інтересів її учасників. По-третє, вважається за необхідне показати методи прищеплення знань і умінь з формування команди студентам, які навчаються за спеціальністю «Управління проектами». **Методи** дослідження включають, по-перше, аналіз ролі мотивації в процесі командоутворення, оскільки серед проблем, які доводиться розв'язувати лідерові при формуванні команди, істотне місце посідають питання мотивації її учасників. По-друге, слід проаналізувати характер взаємовідносин між цими учасниками та раціональну організацію їхньої ефективної командної діяльності. По-третє, важливим методом виступає також аналіз здатності лідера сприяти професійному й особистісному розвитку учасників командної діяльності. По-четверте, ефективним методом прищеплення лідерам навичок формування команди постає підвищення рівня викладання курсу поведінкових компетенцій із застосуванням інноваційних педагогічних технологій. **Результати**. Чітка постановка цілей і системне застосування ефективних методів формування проектної команди є вкрай необхідними ще в процесі професійної підготовки фахівців з управління проектами. Як свідчить досвід такої підготовки, розвиток відповідних умінь і навичок має поєднуватися з цілеспрямованим розвитком лідерського потенціалу студентів. Особливу роль відіграє правильна постановка викладання навчального курсу з поведінкових компетенцій, в першу чергу чітка практична спрямованість проведення лекцій і семінарських занять із застосуванням активних методів навчання. **Висновки**. По-перше, переважання командних методів і форм діяльності в управлінні проектами істотно посилює значення складу проектної команди й характеру взаємовідносин між її учасниками. По-друге, ефективне формування команди вимагає від лідера відповідних знань та умінь, стратегічного мислення, психологічної культури й уміння оцінювати рівень професійної компетентності кандидатів та їхніх професійно і соціально значущих особистісних якостей. По-третє, для формування проектної команди та організації командної діяльності лідер має застосовувати чітку систему мотивації і стимулювання.

Ключові слова: проектна команда, лідер, лідерські якості, формування команди, командна діяльність, взаємовідносини, система підготовки фахівців, поведінкові компетенції, педагогічні технології.

ЛИДЕРСТВО КАК ФАКТОР ФОРМИРОВАНИЯ ПРОЕКТНОЙ КОМАНДЫ

Предмет статьи состоит в определении роли лидерства в процессе формирования проектной команды, поскольку именно качественный состав этой команды и профессионализм ее участников играют определяющую роль в обеспечении надлежащего выполнения работ, предусмотренных задачами проекта. **Цель** статьи – раскрыть значение и место в общей системе поведенческих компетенций лидера его умение формировать проектную команду и утверждать в ней благоприятный психологический климат, общие ценности и идеалы. Имеется в виду, обосновать важное значение этого умения и его применение для повышения эффективности лидерского влияния на проектную команду. **Задача** исследования предполагают, во-первых, показать, что проектная команда является сложным социальным организмом, в котором определенную совокупность функций должны выполнять люди высокой профессиональной компетентности. Во-вторых, предполагается показать, что отличие их индивидуальных черт и качеств существенно усложняет как формирование проектной команды, так и согласования целей, стремлений и интересов ее участников. В-третьих, представляется

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необходимым показать методы привития знаний и умений по формированию команды студентам, обучающимся по специальности «Управление проектами». **Методы** исследования содержат, во-первых, анализ роли мотивации в процессе командообразования, поскольку среди проблем, которые приходится решать лидеру при формировании команды, существенное место занимают вопросы мотивации ее участников. Во-вторых, следует проанализировать характер взаимоотношений между этими участниками и рациональную организацию их эффективной командной деятельности. В-третьих, важным методом выступает также анализ способности лидера способствовать профессиональному и личностному развитию участников командной деятельности. В-четвертых, эффективным методом привития лидерам навыков формирования команды становится повышение уровня преподавания курса поведенческих компетенций с применением инновационных педагогических технологий. **Результаты**. Четкая постановка целей и системное применение эффективных методов формирования проектной команды являются крайне необходимыми еще в процессе профессиональной подготовки специалистов по управлению проектами. Как показывает опыт такой подготовки, развитие соответствующих умений и навыков должно сочетаться с целенаправленным развитием лидерского потенциала студентов. Особую роль в этом играет правильная постановка преподавания учебного курса по поведенческим компетенциям, в первую очередь четкая практическая направленность проведения лекций и семинарских занятий с применением активных методов обучения. **Выводы**. Во-первых, преобладание командных методов и форм деятельности в управлении проектами существенно усиливает значение состава проектной команды и характера взаимоотношений между ее участниками. Во-вторых, эффективное формирование команды требует от лидера соответствующих знаний и умений, стратегического мышления, психологической культуры и умение оценивать уровень профессиональной компетентности кандидатов и их профессионально и социально значимых личностных качеств. В-третьих, для формирования проектной команды и организации командной деятельности лидер должен применять четкую систему мотивации и стимулирования.

Ключевые слова: проектная команда, лидер, лидерские качества, формирование команды, командная деятельность, взаимоотношения, система подготовки специалистов, поведенческие компетенции, педагогические технологии.

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ІНФОРМАЦІЙНЕ ТА ПРОГРАМНЕ ЗАБЕЗПЕЧЕННЯ МЕНЕДЖЕРА З ПЕРСОНАЛУ IT–КОМПАНІЇ

Предметом статті є процеси формування та тестування персоналу IT– компанії. **Мета** – забезпечення якісного складу персоналу шляхом автоматизації обробки даних і тестування кандидатів при наймі до IT-компанії. **Завдання**, що вирішуються в статті: проаналізувати діяльність IT-компаній і обов'язки менеджера персоналу; дослідити методи управління персоналом компанії; розробити базу даних кадрового забезпечення та процесів тестування персоналу компанії; розробити програмний додаток для тестування персоналу. Використовуються **методи**: системний, аналітичний, проектного управління, об'єктно-орієнтоване проектування. Отримано такі **результати**: Розглянуто завдання управління персоналом. Проаналізовано обов'язки менеджера по персоналу та його цілі. Сформовано схему взаємодії внутрішніх і зовнішніх підрозділів компанії при управлінні персоналом, що відображає подвійне підпорядкування менеджера з персоналу. Процес управління персоналом розглянуто як сукупність проектів компанії, кожен із яких реалізується за визначеними стандартами, має свої вимоги, потребує своїх ресурсів. Сформовано схему зв'язку фаз програмного процесу з галузями знань. Розглянуто сфери діяльності IT-компаній, основні види проектів, фази розробки та галузі знань, які є задіяними в IT-сфері, а також існуючи посади і спеціальності працівників. Сформовано схему структури посад IT-компанії в залежності від етапу розробки проекту. Визначено основні вхідні та вихідні параметри системи, які дозволяють глибше проаналізувати зв'язки між окремими елементами, за допомогою яких і формується штат робітників компанії. Розроблена база даних, яка реалізує інформаційне забезпечення менеджера з персоналу і власне сам додаток для роботи з цією базою даних і її підтримки. **Висновки:** процес управління персоналом IT-компанії має бути системним, він не є однорідним, тобто залежить від внутрішнього середовища в кожній компанії. Система актуальна для використання на підприємствах, які зацікавлені в автоматизації робочого місця менеджера по персоналу, що забезпечить якісний контроль і управління персоналом на всьому підприємстві.

Ключові слова: персонал IT-компанії, менеджер по персоналу, управління персоналом, кадрове забезпечення, база даних, тестування.

Вступ

Сьогодні ринок праці ставить сучасним IT-компаніям принципово нові умови: жорсткість конкуренції, швидко мінливі потреби споживачів, досить висока нестабільність зовнішнього середовища. Людські ресурси розглядаються як найбільш цінні ресурси, а розвиток їх потенціалу – як важливе стратегічне завдання розвитку компанії. Для реалізації проектів IT–компанії слід оцінити необхідну кількість трудових ресурсів за категоріями.

У сучасних умовах розвитку кожне підприємство прагне мати свою систему управління кадровим забезпеченням. Яка допомагала б менеджеру персоналу в контролюванні і фіксуванні надходження і звільнення працівників, їх переміщення в компанії, зберігала б всю інформацію про працівників, відділах, посадах і відкритих вакансіях, а також відповідала б за весь документообіг, який є необхідним для вищеперелічених цілей, а також мала б функції атестації робітників шляхом тестування і розподіл робіт між робітниками за декількома критеріями. Всі ці дії відносяться до обов'язків менеджера по персоналу і потребують відповідного інформаційного забезпечення.

Аналіз останніх досліджень та постановка завдання

У публікаціях з управління проектами існують різні підходи до класифікації персоналу в залежності від професії або посади працівника, рівня управління, категорії працівників. [1, 2].

Питанням, присвяченим підбору і оцінки персоналу проекту займаються Волкова Т.Р. [3], Банько Н.А. [4], Одегов Ю.Г. [5]. Роботи Новікова Д.А. [6], Пінто Дж.К. [7] присвячені проблемам формування ефективної команди проекту.

Наука і практика управління людськими ресурсами організації використовує ряд методів для аналізу і побудови системи управління персоналом організації [8 - 10]: системний аналіз; метод декомпозиції; метод порівнянь; метод структуризація цілей; експертно-аналітичний метод; нормативний метод; метод функціонально-вартісного аналізу; метод аналогій; метод творчих нарад; метод контрольних питань; морфологічний аналіз та ін. Сучасні методи вивчення персоналу припускають виявлення кількісних і якісних вимог до персоналу з урахуванням перспектив розвитку організації, появи нових напрямків роботи [11].

В роботі Баскіної Т. [12] представлені методики оцінки персоналу. Всі критерії при оцінці персоналу зазвичай поділяють на дві основні категорії - критерії результативності та критерії компетентності.

Виділяються чотири підходи до формування команд: цілеспрямований, міжособистісний, рольовий і підхід управлінської решітки [12]. Для формування персоналу IT-проекту основним є проблемно-орієнтований підхід, може бути використаний і рольовий. Однак для будь-якого з перерахованих методів потрібне спеціальне інформаційне забезпечення, яке відображає види, особливості IT-проектів і відповідні вимоги до категорії посад персоналу. Цьому завданню в зазначених публікаціях не приділяється належної уваги.

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Метою роботи є забезпечення якісного складу персоналу шляхом автоматизації обробки даних і тестування кандидатів при наймі до ІТ-компанії.

Для досягнення мети в статті вирішуються такі завдання:

- проаналізувати діяльність ІТ-компаній і обов'язки менеджера персоналу;
- дослідити методи управління персоналом компанії;
- розробити базу даних кадрового забезпечення та процесів тестування персоналу компанії;
- розробити програмний додаток для тестування персоналу.

Матеріали та методи досліджень

Розглянемо цілі управління персоналом компанії. Вони поділяються на зовнішні і внутрішні Зовнішні цілі – зв'язок фірми з навколишнім середовищем (ринок праці, охорона навколишнього середовища, взаємовідносини з державною та місцевою владою, профспілками і т. п.):

- виявлення і попередження можливих трудових конфліктів, підготовка пропозицій керівництву фірми про відповідну лінію поведінки з урахуванням укладених тарифних угод;
- вивчення стану на ринку праці, тенденцій розвитку нових технологій, вимог до випереджаючої підготовки кадрів;
- розробка перспективних вимог до вакантних посад та кадрового складу;
- складання посадових інструкцій за новими посадами і особистісних специфікацій.

Внутрішні цілі спрямовані на поліпшення відносин фірми зі своїми співробітниками.

Процес залучення і відбору персоналу заснований безпосередньо на підпроцесах планування і розвитку персоналу (рис. 1).

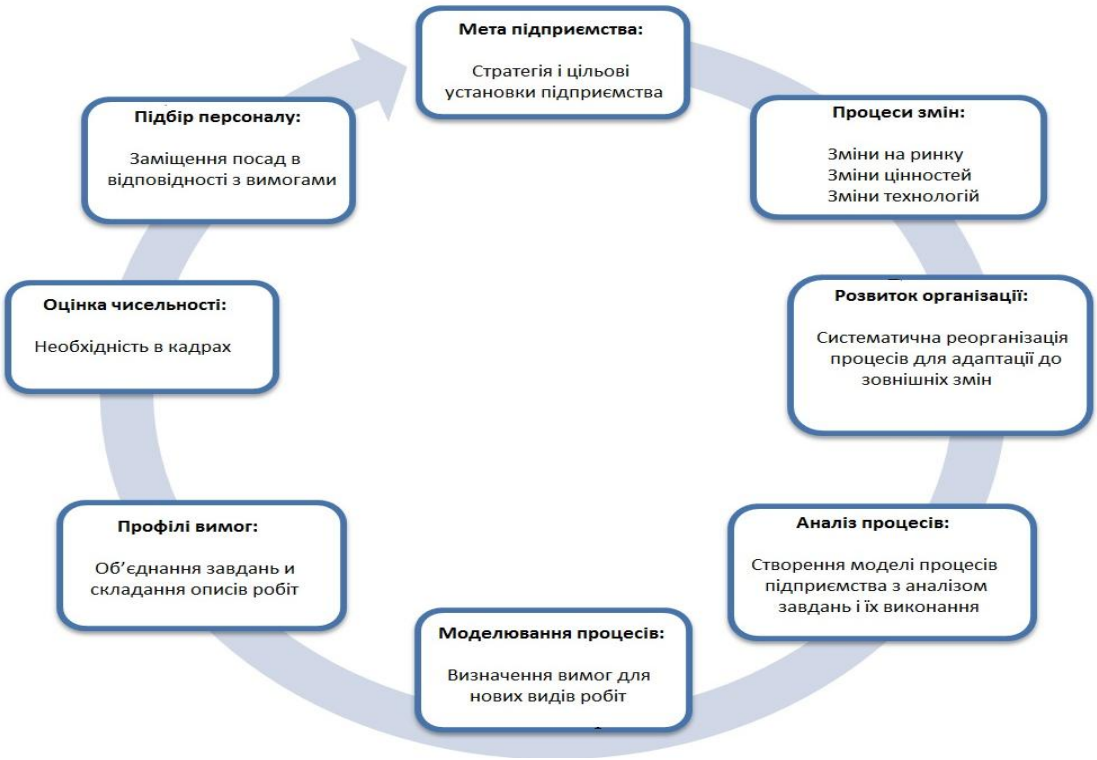

Рис. 1. Взмаємозв'язок мети кампанії з завданнями управління персоналом, та послідовність їх вирішення

Основне завдання менеджеру з персоналу – підготувати до потрібного часу потрібну кількість працівників, для чого необхідно строго дотримуватися послідовність кроків, що забезпечують визначення потреби в кадрах для всіх без винятку процесів, залучення й відбір найбільш підходящих кандидатур. Підбір персоналу являє собою процес відбору підходящих кандидатур, для включення в команду проекту по номенклатурі спеціальностей, посад і професій, передбаченими планами розвитку підприємства і прогнозом реалізації цих планів в часі [14].

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Результати досліджень

1. Інформаційне забезпечення менеджера з персоналу ІТ-проектів

На рисунку 2 приведено схему подвійного підпорядкування менеджера персоналу. Менеджер

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персоналу є сполучною ланкою в управлінні персоналом, яка поєднує з однієї сторони на зовнішньому рівні центральний офіс з територіальними відділеннями, а з іншого – взаємодіє з багатьма підрозділами і структурами організації на внутрішньому її рівні.

Рис. 2. Подвійне підпорядкування менеджера персоналу

Таким чином, служба управління персоналом виконує одну з головних завдань у розвитку підприємства – підвищення ефективності виконання проектів, завдяки своєчасному якісному підбору працівників за фахом і кваліфікації, їх розвитку, навчання і службового просування, а також мотивації персоналу.

Процес взаємодії менеджера персоналу з іншими службами, що займаються кадровими питаннями, представлено на рисунку 3. Крім основних своїх обов'язків менеджер з персоналу має зв'язок з багатьма іншими відділами і безпосередньо приймає участь в їх роботі, виконуючи свої завдання. До них можна віднести: облік персоналу, адаптація персоналу, оцінка і мотивація персоналу, навчальний центр, координування проектів, реклама.

Рис. 3. Схема взаємодії менеджера персоналу з іншими службами компанії

Розглянемо особливості IT-проектів, для того щоб сформувати інформаційне забезпечення для менеджера з персоналу.

Основною діяльністю IT-компаній зазвичай є розробка програмних продуктів і проектів, що виходять з цього. Але це далеко не все, чим займаються компанії (рис. 4).

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Рис. 4. Сфери діяльності IT-компанійВсі види IT-проектів можна поділити на три групи:

1) розробка програмного забезпечення та інформаційних систем. Включає в себе розробку програмного забезпечення, модулів, додатків та інформаційних систем для потреб споживачів;

2) продаж і супровід програмного забезпечення та інформаційних систем. Продаж готового програмного забезпечення (ПЗ) та інформаційних систем з подальшою їхньою підтримкою і супроводом;

3) IT–аудит та IT–консалтинг. IT–аудит (аудит інформаційних систем) передбачає незалежну перевірку ефективності використання і застосування інформаційних технологій в роботі.

В групі проектів розробки і розвитку приділяється увага таким напрямкам:

- розробка програмного забезпечення, що здійснюється в рамках методологій, методів і підходів програмної інженерії;

- програмна інженерія (Software Engineering) – це інженерна дисципліна, яка пов'язана з усіма аспектами розробки ПЗ від початкових стадій створення специфікації до підтримки системи після здачі в експлуатацію; реалізує структурний підхід до створення ПЗ, націлений на створення ефективного продукту найбільш прибутковим (cost-effective) шляхом.

- модель програмного процесу – це спрощений опис програмного процесу, представлений з деякої точки зору;

- метод програмної інженерії –

Підбір виконавців для цих проектів слід виконувати по групах, які відповідні до основних фаз програмного процесу:

- створення специфікації ПЗ;

- розробка ПЗ;

- тестування ПЗ (включає в себе validation і verification) ;

- розвиток або еволюція ПЗ (software evolution).

Спеціалістів з програмної інженерії слід підбирати згідно основних галузей знань:

- Software requirements – програмні вимоги;

- Software design – дизайн (архітектура);

- Software construction – конструювання ПЗ;

- Software testing – тестування;

- Software maintenance – експлуатація (підтримка) ПЗ;

- Software configuration management – конфігураційне управління;

- Software engineering management – управління проектами ПЗ;

- Software engineering process – процеси ПЗ;

- Software engineering tools and methods – інструменти і методи ПЗ;

- Software quality – якість ПЗ.

Зв’язок фаз програмного процесу з галузями знань показаний на рисунку 5.

IT-професії численні і різноманітні, а представники однієї і тієї ж професії можуть займати в IT-компанії різні посади (рис. 6).

Для підтримки діяльності менеджера IT-компанії була розроблена база даних кадрового складу, структура якої представлена на рисунку 7.

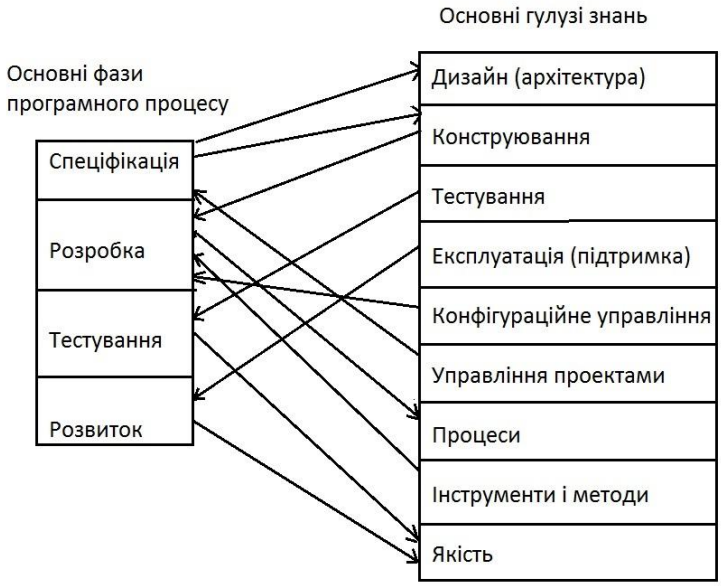

Рис. 5. Зв’язок фаз програмного процесу з галузями знань

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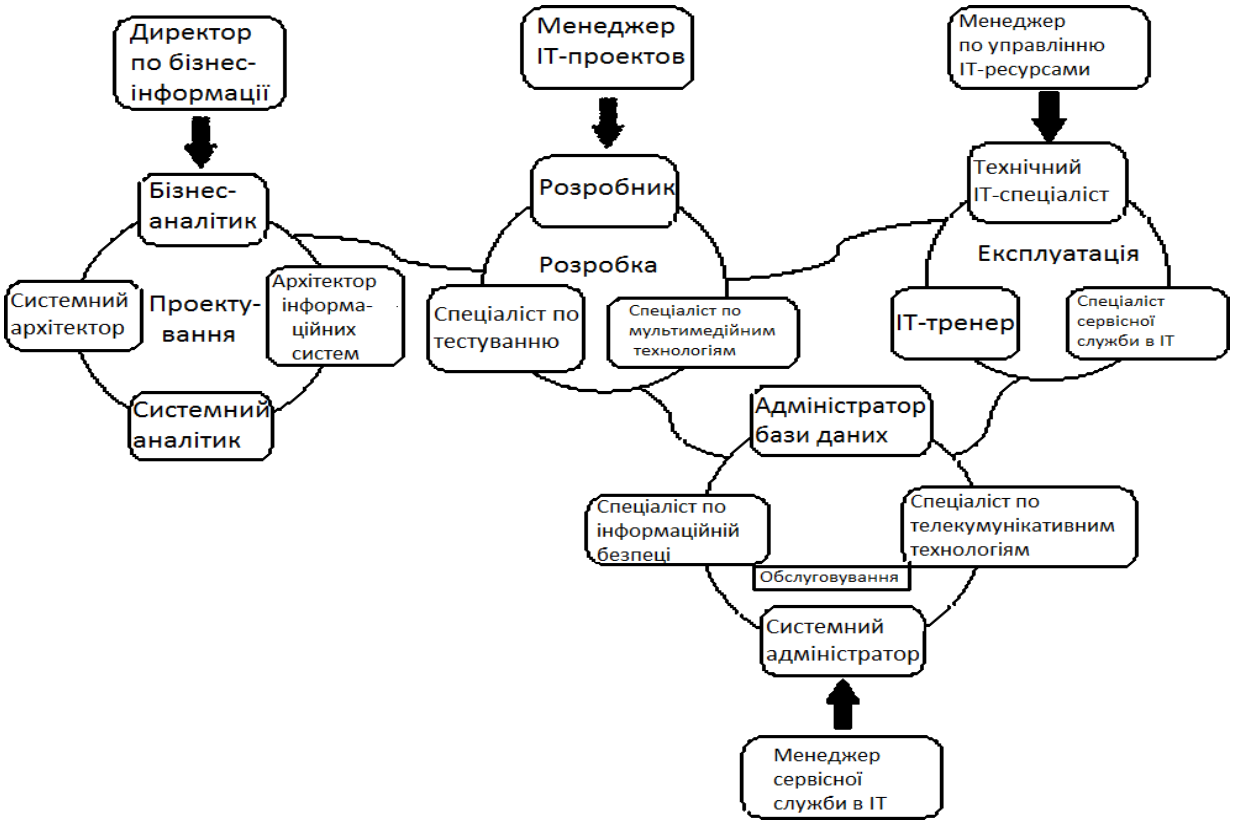

Рис. 6. Структура посад IT-компанії в залежності від етапу розробки проекту

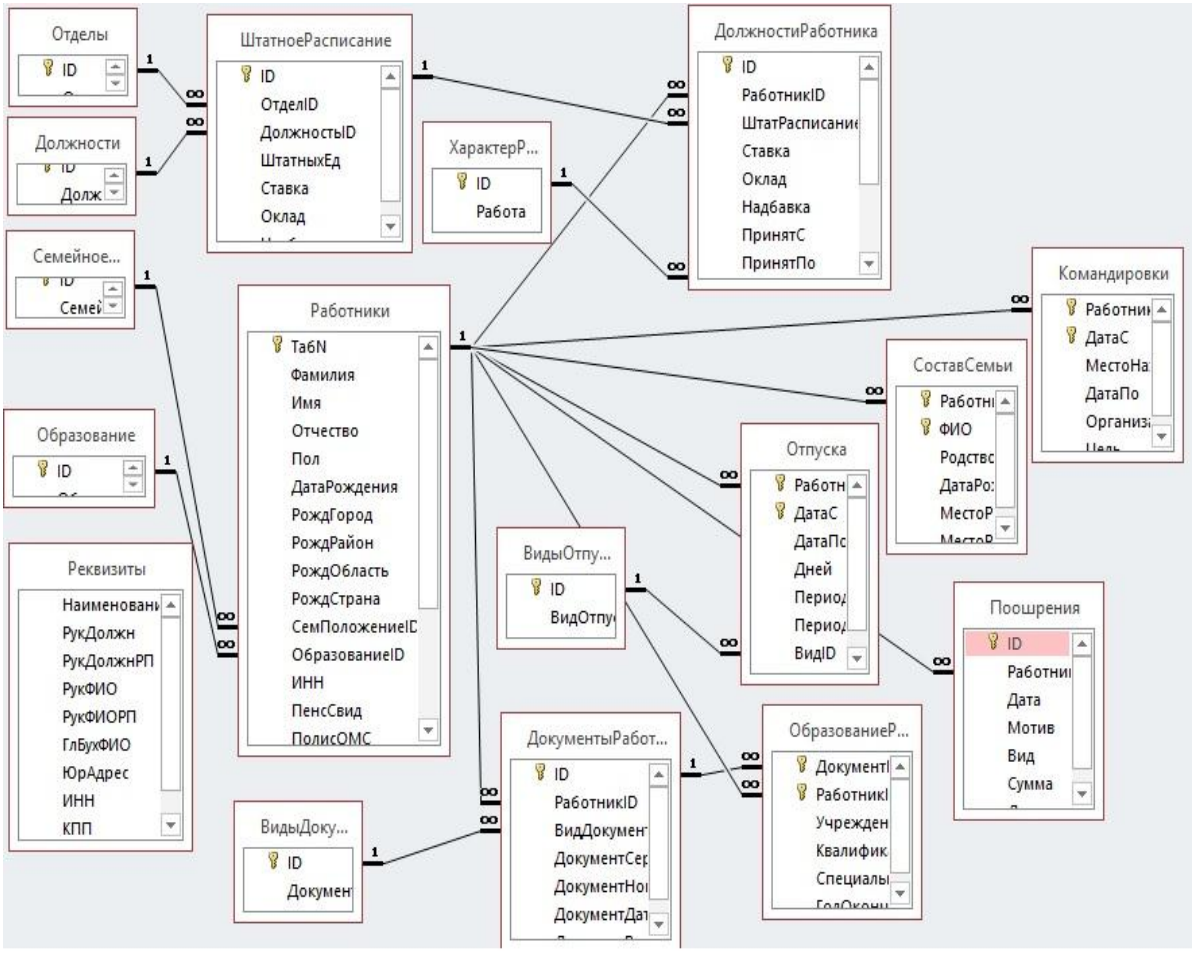

Рис. 7. Структура бази даних кадрового складу IT-компанії

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В даній структурі представлені сімнадцять таблиць. Таблиця «ВидыДокументов» зберігає в собі перелік документів, які надає працівник при надходдженні до роботи. В таблиці «ВидыОтпуска» знаходиться перелік відпусток, в які можуть іти працівники. Таблиця «ДокументыРаботника» зберігає в собі інформацію про його документи. В таблиці «Должности» зберігається перелік посад, які існують в рамках підприємства. Таблиця «ДолжностиРаботника» зберігає інформацію про те, на якій посаді працює/працював робітник, його ставку, оклад, надбавку, з якого дня прийнятий на роботу, номер і дату складання договору, характер роботи, а токож якщо працівник уже не працює в компанії – коли вибув і причину. В таблиці «Командировки» зберігається інформація про відрядження робітників (дати періодів відряджень, місто, організація і ціль). В таблиці «Образование» зберігається перелік можливих освіт працівників. В таблиці «ОбразованиеРаботника» зберігається інформація про освіту працівників. В таблиці «Отделы» зберігається перелік відділів. В таблиці «Отпуска» зберігається інформація про відпустки. В таблиці «Поощрения» зберігається інформація про заохочення. В таблиці «Работники» зберігається вся інформація про працівників. В таблиці «Реквизиты» зберігається інформація про реквізити компанії. В таблиці «СемейноеПоложение» зберігається перелік можливих сімейних станів. В таблиці «СоставСемьи» зберігається інформація про склад сім'ї. В таблиці «ХарактерРаботы» зберігається перелік можливих видів характеру роботи. В таблиці «ШтатноеРасписание» зберігається інформація про штатний розклад.

На рисунку 8 представлена структура бази даних додатку з проведення тестування працівників.

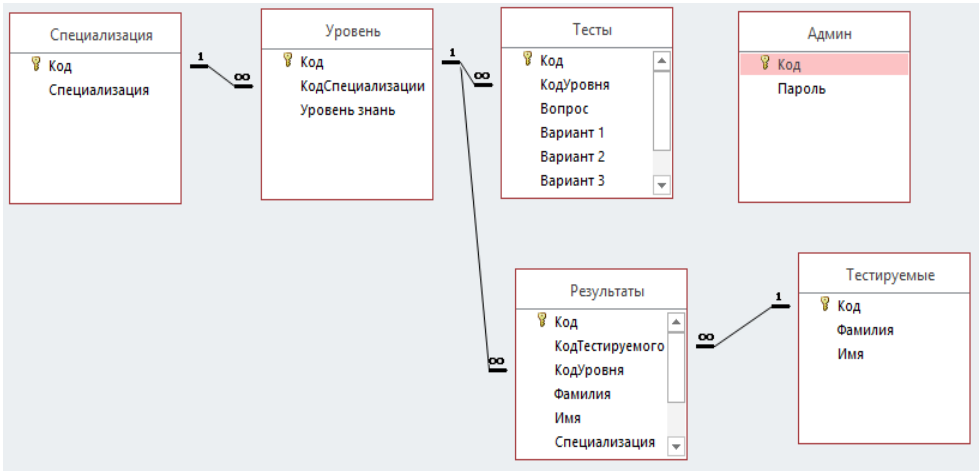

Рис. 8. Структура бази даних тестування працівників

В таблиці «Специализация» знаходиться перелік різних напрямків спеціалізацій робітників фірми. Таблиця «Уровень» зберігає в собі інформацію про рівень знань кожної спеціалізації, частіше всього це початковий, середній та високий рівні. В таблиці «Тесты» зберігається власне перелік запитань і варіантів відповідей (рис. 9).

	К	Вопрос	Вариант 1	Вариант 2	Вариант 3	Вариант 4	Ответ
5	1	Какой будет р	Three	Four	One	Two	2
6	1	Как будет выг.	Array([0] => 4[:	Array([0] => 0[:	Array([0] => 0[:	Array([0] => 1[:	2
7	1	Какой будет р	a = David	a = Mark	a = David	Ошибка	1
8	1	Какой будет р	61	7	6	Ошибка	1
9	1	Как будет выг.	Array ([0] => 1	Array ([0] => 4	Array ([0] => 1	Ошибка	1
10	1	Какая из след	array_count_v	array_combine	array_change_	array_chunk()	3
11	1	Какую функци	$string = func_	list($string) = f	$string = $argv	$string = get_f	2
12	1	Какой будет р	4	19	6	Ошибка	1
13	1	У нас есть мас	sort()	asort()	ksort()	natsort()	4

Рис. 9. Таблиця тестів

Таблиця «Тестируемые» зберігає інформацію про робітників, як тих, хто уже проходив тести, так і тих, хто ще цього не робив, але повинен. В таблиці «Результаты» зберігається інформація про результати проходження тестування (рис. 10).

Код	Кс	Кс	Фамилия	Имя	Специализаци	Уровень зна	Дата прохо	Оценка (%)
1	1	1	Руденко	Александр	PHP developer	Junior	16.05.2017	50
2	1	1	Игунов	Святослав	C++ developer	Junior	16.05.2017	55
3	1	1	Мухина	Юлия	Java developer	Junior	16.05.2017	65
4	1	1	Глушко	Констянтин	Javascript develo	Junior	16.05.2017	80
5	1	1	Борисов	Николай	.net developer	Junior	16.05.2017	75
6	1	1	Никитин	Артем	PHP developer	Junior	16.05.2017	70
7	1	1	Зинченко	Денис	C++ developer	Junior	16.05.2017	90

Рис. 10. Таблиця результатів тестування

ISSN 2522-9818 (print)
ISSN 2524-2296 (online) Innovative technologies and scientific solutions for industries. 2018. No. 1 (3)

2. Програмне забезпечення

Архітектура програми є клієнт-серверною архітектурою «товстий клієнт». На стороні клієнта здійснюється робота з тестами (спеціалізація, рівень знань, запитання) і з тестуємими, дані про яких та про їхнє проходження тесту находяться в базі даних. На стороні сервера виконується зберігання даних і робота з базою даних, а також перевірка тестів і збереження результатів.

На рисунку 11 представлено діаграму прецедентів, з якої видно, які дії може виконувати адміністратор системи, які виконує тестуємий, а що знаходиться на стороні сервера. Таким чином, сервер зберігає базу даних, забезпечує доступ до неї і роботу з нею, а також здійснює перевірку пройденого тесту і зберігає результат.

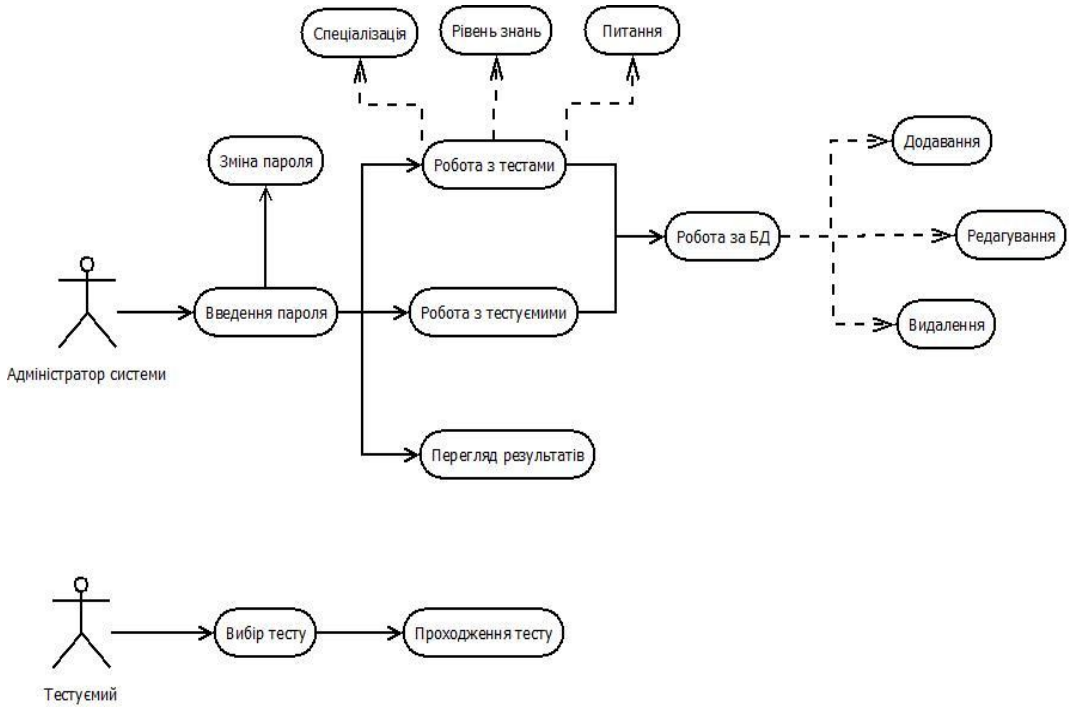

Рис. 11. Діаграма прецедентів

Додаток має два основних режими роботи: режим адміністратора і режим тестуємого.

Перше із двох робочих областей адміністратора - це область тестів, де знаходяться власне самі тести і є можливість виконувати з ними різні дії. У другій області результатів знаходиться інформація про тестуємих і результати тестів (рис. 12).

Передбачені можливості додавання та зміни: спеціалізації, рівня знань, запитань, нового тестуємого (рис. 13). Після вибору режиму проходження тесту програма переходе на вікно вибору тестуємого, а потім на вікно вибору тесту (рис. 14).

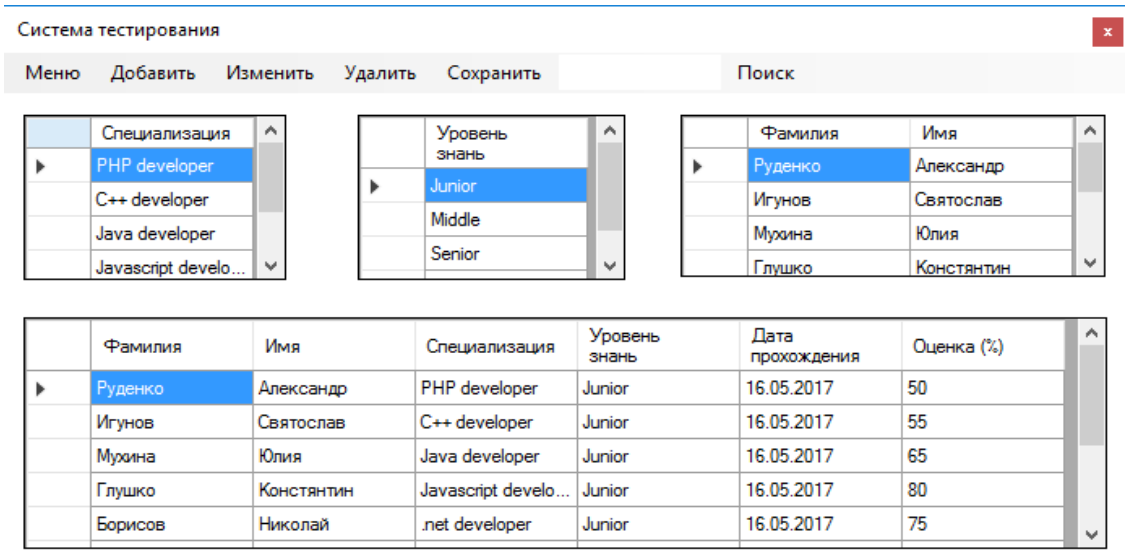

Рис. 12. Робоча область адміністратора «Результаты»

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ISSN 2522-9818 (print)
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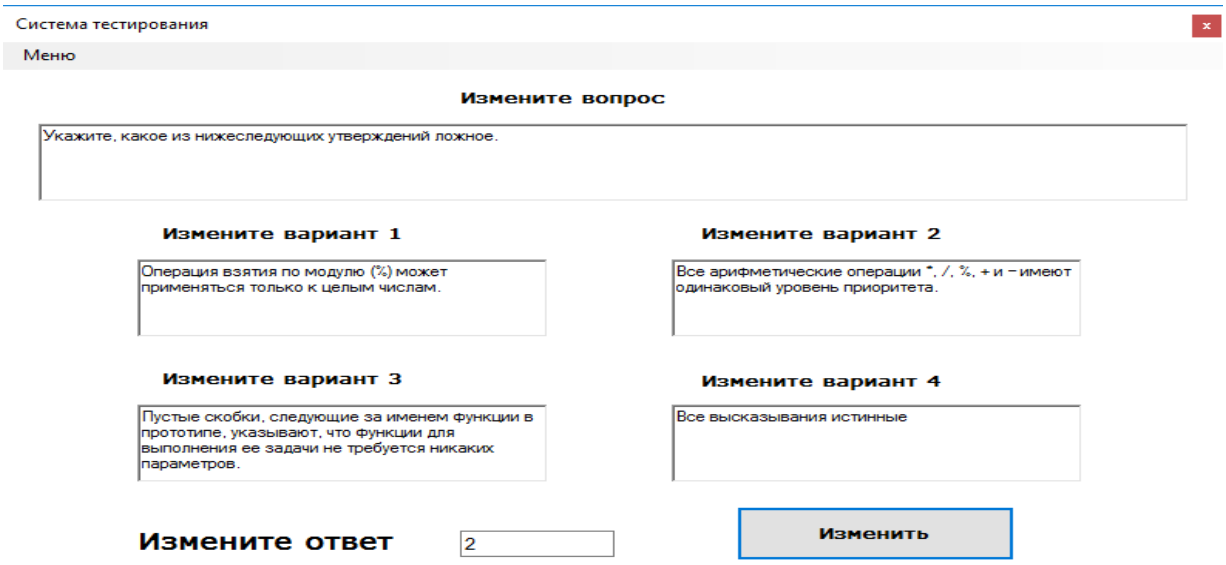

Рис. 13. Вікно зміни запитань

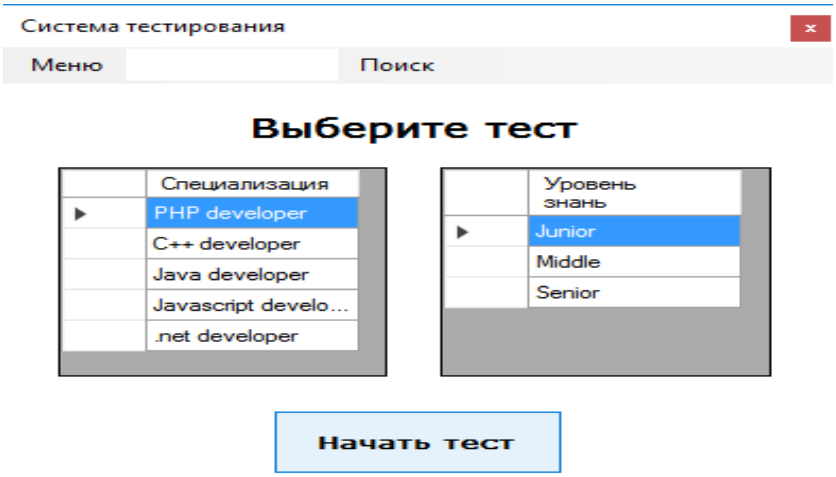

Рис. 14. Вікно вибору тесту

Обговорення результатів

В статті розглянуто завдання управління персоналом і методи, які для цього можуть використовуватися. Проаналізовано обов'язки менеджера по персоналу, і те які цілі він переслідує. Сформовано схему взаємодії внутрішніх так і з зовнішніх підрозділів компанії при управлінні персоналом, що відображає подвійне підпорядкування менеджера з персоналу. Процес управління персоналом розглянуто як сукупність проектів компанії, кожен із яких реалізується за визначеними стандартами, має свої вимоги, потребує своїх ресурсів. Сформовано схему зв'язку фаз програмного процесу з галузями знань. Розглянуто сфери діяльності IT-компаній, основні види проектів, фази розробки та галузі знань, які є задіяними в IT-сфері, а також існуючи посади і спеціальності працівників. Сформовано схему структури посад IT-компанії в залежності від етапу розробки проекту. Визначено основні вхідні та вихідні параметри системи, які дозволяють глибше проаналізувати зв'язки між окремими елементами, за допомогою яких і формується штат робітників компанії.

Після аналізу методів зберігання в якості СУБД була обрана MS Access, так як структура даних не є дуже складною і не має складних запитів. Була визначена структура бази даних, створені та описані таблиці і також реалізовано зв'язки між ними. Була розроблена архітектура додатку, в якій база даних знаходиться на стороні сервера, всі інші дії вибору та перегляду відбуваються з боку клієнта, а звернення до серверної частини в разі потреби роботи з БД і перевірки тестів. Для більш наочного уявлення вимог була сформована діаграма прецедентів.

Висновки

Процес управління персоналом IT-компанії має бути системним, він не є однорідним, тобто залежить від внутрішнього середовища в кожній компанії. Розроблена база даних реалізує інформаційне забезпечення менеджера з персоналу і власне сам додаток для роботи з цією базою даних і її підтримки.

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ISSN 2524-2296 (online) Innovative technologies and scientific solutions for industries. 2018. No. 1 (3)

Система актуальна для використання на підприємствах, які зацікавлені в автоматизації робочого місця менеджера по персоналу, що забезпечить якісний контроль і управління персоналом на всьому підприємстві.

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ИНФОРМАЦИОННОЕ И ПРОГРАММНОЕ ОБЕСПЕЧЕНИЕ МЕНЕДЖЕРА ПО ПЕРСОНАЛУ IT-КОМПАНИИ

Предметом статьи являются процессы формирования и тестирования персонала ИТ- компании. **Цель** - обеспечение качественного состава персонала путем автоматизации обработки данных и тестирования кандидатов при найме в ИТ-компании. **Задачи**, решаемых в статье: проанализировать деятельность ИТ-компаний и обязанности менеджера по персоналу; исследовать методы управления персоналом компании; разработать базу данных кадрового обеспечения и процессов тестирования персонала компании; разработать программное приложение для тестирования персонала. Используются **методы**: системный, аналитический, проектного управления, объектно-ориентированного проектирования. Получены следующие **результаты**: Рассмотрены задачи управления персоналом. Проанализированы обязанности менеджера по персоналу и его цели. Сформирована схема взаимодействия внутренних и внешних подразделений компании при управлении персоналом, которая отражает двойное подчинение менеджера по персоналу. Процесс управления персоналом рассмотрен как совокупность проектов компании, каждый из которых реализуется по определенным стандартам, имеет свои требования, требует своих ресурсов. Сформирована схема связи фаз программного процесса с отраслями знаний. Рассмотрены сферы деятельности ИТ-компаний, основные виды проектов, фазы разработки и области знаний, которые задействованы в ИТ-сфере, а также существующие должности и специальности работников. Сформирована схема структуры должностей ИТ-компании в зависимости от этапа разработки проекта. Определены основные входные и выходные параметры системы, которые позволяют глубже проанализировать связи между отдельными элементами, с помощью которых и формируется штат работников компании. Разработана база данных, которая реализует информационное обеспечение менеджера по персоналу и собственно само приложение для работы с этой базой данных и ее поддержки. **Выводы:** Процесс управления персоналом ИТ-компании должно быть системным, он не является однородным, то есть зависит от внутренней среды в каждой компании. Система актуальна для использования на предприятиях, заинтересованных в автоматизации рабочего места менеджера по персоналу, который обеспечит качественный контроль и управление персоналом всего предприятия.

Ключевые слова: персонал ИТ-компании, менеджер по персоналу, управление персоналом, кадровое обеспечение, база данных, тестирование.

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INFORMATION AND SOFTWARE SUPPORT OF THE HR MANAGER OF AN IT-COMPANY

The s**ubject** matter of the article is the processes of developing and testing the personnel of an IT company. The **goal** is to ensure the qualitative structure of personnel by automating data processing and testing candidates while hiring them for an IT company. The following **tasks** are solved in the article: the activities of IT companies and the responsibilities of the HR manager are analyzed; the methods of personnel management of the company are studied; the database for staffing and testing the personnel of a company is developed; the software application for staff testing is developed. The following **methods** are used: the systematic and analytical ones, the method of project management and object-oriented design. The following **results** are obtained: the problems of personnel management are considered; the duties of the personnel manager and their objectives are analyzed; the pattern of the interaction of internal and external divisions of the company while managing the personnel which reflects dual subordination of the personnel manager is designed. The process of personnel management is considered as a set of projects of the company, each of which is implemented according to certain standards, has its own requirements, requires its resources. The pattern of the connection of the program process phases with the branches of knowledge is developed. The areas the IT companies' activities, the main types of projects, the phases of development and the areas of knowledge that are involved in the IT sphere are considered as well as the existing positions and specialities of employees. The pattern of the structure of the IT company's positions is developed depending on the stage of the project development. The main input and output parameters of the system are determined, which enables analyzing the links among individual elements which help form the company staff. The database that provides information support for the HR manager is developed as well the application for working with this database and its support. **Conclusions.** The process of personnel management of an IT company must be systemic, it is not homogeneous, that is, it depends on the internal environment in each company. The system is relevant for the use in enterprises that are interested in the automation of the workplace of the personnel manager, which will ensure the quality control and management of personnel throughout the enterprise.

Keywords: IT company personnel, human resources manager, personnel management, personnel support, database, testing.

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INTELLIGENT MEANS IN THE SYSTEM OF MANAGING A MANUFACTURING AGENT

The subject of the study is intellectual means in the system of managing an intelligent manufacturing agent; **the goal** is to ensure the quality of managing a flexible integrated robotic system by developing the intellectual decision support system. The following **problems** are solved in the work: current tendencies of developing and implementing the intelligent systems for production management are considered; the demands for developing simulation models of decision support systems for solving flexible integrated production systems are formulated; the logical model of a decision support system for an intelligent manufacturing agent is developed, this model describes the decision-making process in the form of the functioning strategy formation on the basis of the knowledge of the current state of the integrated system, the system of knowledge describing probable actions of the robotic equipment, the objectives of the production system, and adapts the strategy if the working space of the integrated system or its individual goals change; the system of knowledge of a flexible integrated system is presented as a set of standard description of probable actions for robotic equipment; the distributed workspace of integrated systems is considered and described; separate objects are identified using the means of computer vision. The research is based on the following **theoretical and practical** foundations: the theory of sets is used to represent general simulation models of the decision support system; the theory of predicates is used to create a logical model of decision-making; knowledge-oriented methods and the tools of Prolog programming language use used to represent the knowledge system of a flexible integrated system, the MatLab system is used to analyse the workspace of a flexible integrated system. **The following results** are obtained – mathematical and informational software of the system for managing an intelligent production robotic agent is developed. The possibilities of the proposed model application in the system of managing an intelligent robot are shown and the ways for improving such systems are suggested.

The keywords: logical model, intellectual agent, mobile robot, the theory of predicates.

Introduction

The automation of modern production is based on a large-scale introduction of flexible integrated systems (FIS) of various types. Their features are the capability to adapt quickly to changes in the technology of manufacturing products at the levels of technical re-conditioning of individual units, equipment and tools, the possibility of reprogramming in accordance with new technological challenges. Also, the key feature of FIS is their close interaction and structural implementation in existing production systems, which provides the possibility of their gradual upgrading in a modular way, facilitates the operation of technological systems and their maintenance. This way of designing, developing and implementing technical systems is typical for modern car manufacturing, aircraft construction and shipbuilding, mechanical engineering, the production of electronic and other devices.

Flexible integrated manufacturing systems (FIMS) are considered as a way of organizing production, which provides complete management of the production process and involves the integration of machine tools and other process equipment into a single system using a local computer network to combine the threads of processing or assembling streams, applying cutting tools and other equipment and corresponding information flows [1].

The use of industrial robots (IR) in flexible integrated systems enables increasing the efficiency of production and reducing the cost of a unit of production. For instance, [2] shows the examples of cost reduction by 3 times. On the other hand, using robots does not always suggest high results. The experience of administrative implementation of robots in the USSR [3] indicated the unreliability of IR, their limited application, the significant amount of costs for buying and introducing, a small number of personnel that was discharged from employment due to the use of IR, a rather low level of quality and the lack of component parts, the lack of necessary microcontroller control systems. Probably, such experience, at the same time, showed the lack of preparedness of specialists for the widespread introduction of industrial robotics.

The analysis of the construction of flexible integrated production systems shows that the artificial intelligence (AI) of a robot is mainly implemented by using a computer system that controls the movements of robot manipulators or their transport system (chassis). The artificial intelligence of robots is based on a highly developed sensor system consisting of different kinds of vision systems, a number of touch-sensitive sensors, range finders, gyroscopes, compasses, light sensors, colour and sound sensors and other ones. In addition to recognizing scenes and tactile feelings, speech recognition and natural language processing play an important role in the intellectualization of FIMS [3, 4].

The analysis of the trends in the development of flexible integrated production systems indicates the growing complexity of the organization of modern production, both in a separate workplace and in the conditions of a work section, shop or factory. Under such conditions, the role of automated control systems using AI tools is growing and is capable of receiving information about the state of production systems in a timely and appropriate manner with the help of sensory systems, of analyzing it, and making decisions to ensure the operation of the enterprise. On the other hand, the role of making production decisions at each specific workplace increases, which becomes a function of the servicing equipment: industrial robots, robocars, other technological and support systems.

Thus, the topical problem is the development and implementation of intellectual tools of decision support at different levels of production management and individual

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units of flexible integrated production systems.

The analysis of literary sources and problem statement

The areas of using artificial intelligence systems are constantly expanding. Today we are talking not only about the use of classical automated technologies but also about flexible intelligent manufacturing systems (IMS) which include parts of machine intelligence. The expansion of IMS should replace human manual labour. The IMS includes systems that can support decision making, knowledge acquisition, training and adaptation to changes in the work environment and can interact with real equipment [5].

An intelligent manufacturing system is a system with the built-in property of adaptation to unpredictable changes, in particular, changes in the necessary assortment of goods, market requirements, technological changes, social requirements. However, the intelligence of such systems is often understood as software management but not as the implementation of modern technologies of machine-based artificial intelligence. Intellectual production systems contain subsystems like FMS: technological, transport, manipulative ones.

Subsystems should be equipped with the means that provide them with a certain level of intelligence. They should be considered as the highest phase of FMS.

The functional capabilities of IMS should include [5]:

- intellectual design;
- intellectual support of technological operations;
- intellectual management;
- intellectual planning;
- intellectual support of processes.

The objectives of implementing IMS are:

- reduction of production costs;
- Reduction of time spent on manufacturing;
- easy integration of new processes, subsystems and technologies, their updating, maintenance of operational interaction;
- reduction of manufacturing defects, environmental impact;
- rapid reconfiguration, adaptation to expected and unexpected events.

IMS operation requires that they should be created as an open architecture with a modular structure that enables using different methods of knowledge representation and their integration into manufacturing systems, decision-making processes and knowledge acquisition.

IMS should integrate the following methods and technologies for processing knowledge and decision-making processes:

- artificial neural networks that are an AI tool capable to simulate complex functions, to imitate learning processes that occur in the human brain;
- fuzzy logic – a set of technologies and methods for formalizing natural language, linguistic and quantitative data processing;
- genetic algorithms and methods of evolutionary modelling which include learning algorithms based on theoretical achievements of evolutionary theory enriched with artificial intelligence technologies.

When the tools, in which knowledge is represented symbolically, are combined with the expert system, sophisticated complex software solutions for decision-making tasks at each stage of production operation can be created.

The structural organization of *IMS* is grounded on the basic rule of object-oriented methods, in which the processes of information and processes modelling coincide. It is also assumed that the development process is based on the conceptual description of an object. The approach should take into account the methodology of the development and implementation of computer-integrated enterprises CISMOSA (Open System Architecture for CIM), developed in the context of the projects of the European Union.

An intelligent control system can be considered as a distributed system in the following way:

$$IMS = <M, R(M), F(M), F(IMS)>,$$

where $M=<Mi>$ is a set of formal or logical-linguistic models that represent certain intellectual functions;

$R(M)$ is the function of selecting the necessary models (a set of models) for a particular situation;

$F(M)=\{F(M)i\}$ is a set of model modification functions;

$F(IMS)$ is the function of modifying ICS and its basic elements are M, $R(M)$, $F(M)$. The conceptual structure of the ICS is presented in fig. 1.

Thus, the current trends in the development of manufacturing systems are the use of technical means with bio-like and human-like properties (intelligence, experience, knowledge) and can be used in ICS. ICS should be built as open structures that unite existing information systems with subsystems, use artificial intelligence methods to create the integrated environment for solving problems of intelligent manufacturing systems (IMS). At the same time, increasing the adaptive and intelligent means of technological and maintenance equipment should be focused on, in particular, industrial and transport robots, which generates a need to improve the mathematical, organizational, algorithmic and software solutions for robotic systems.

The goal and objectives of the research

It was mentioned above that the task of robotics in terms of the nature and result of the performed tasks is mostly a multi-stage one. For example, in the case of planning strategies for solving tasks of robotic assembly, the result is a sequence of individual technological transitions or operations, and the end result is the assembled product or its part.

When considering the process of designing a robotic technology, each separate strategy planning act is important at each stage of a technological operation. Solving the problems of planning the movements of mobile platforms is similar - the result of movement is a set of operations connected with movement in a certain direction, stops, changes in directions, individual

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movements of a manipulator (if it is installed on a platform). However, if during the movement there is a need for additional actions that are related, for example, with preventing a collision with an obstacle which suddenly appears, the planning task should not focus on the entire multi-stage structure but on the planning of each individual decision regarding work actions.

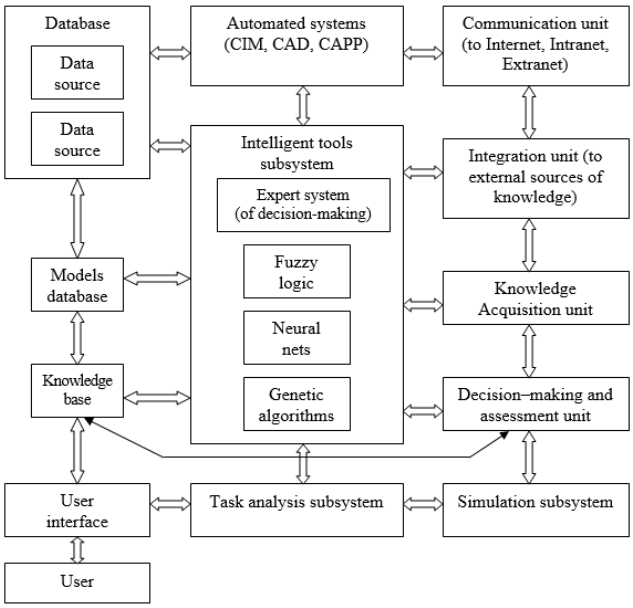

Fig. 1. The conceptual structure of the intelligent manufacturing system [5, 6]

Most of the individual strategic planning tasks are adaptive, that is, they should change when the environment changes either predictably or unpredictably. Although adaptive systems in technical planning systems are not studied thoroughly, works in the area of psychology and human decision making pay significant attention to the mentioned systems [7, 8].

The ability of a person (or another organism or technical system) to adapt to a slow, moderate or rapid change in the impact of external factors and at the same time stay capable to perform set tasks is called adaptation. Adaptation is certainly possible only under conditions when the organism (or technical system) can react to the outside world, that is, they have sensory organs (sensors) that enable monitoring any changes in the environment or in the state of objects according to which a certain task is performed (a decision is made). In addition, the mechanism of the organism response to external impacts is needed, including internal changes and an external reaction in the form of specific actions of a human or a robot, which consist in eliminating external impacts (for example, detouring around stones or removing them from the way of movement) or in adapting to them (choosing actions that correspond to the conditions of chassis operation).

Such reasoning, however, does not fully answer to how a robotic system (including a mobile one), which has certain means of perceiving the environment in the form of sensors, an intellectual component like a component of planning travels; executive mechanisms in the form of manipulators, will be able to react to changes in the external world and rebuild its actions correctly regarding the complexity of pre-set tasks and the need to support its functional ability.

The methods of adaptive are understudied in the theory of automatic control. Among classical sources, [9] should be noted, which understand the control system, which automatically determines the necessary control law by analyzing the behaviour of an object, as an adaptive one. At the same time, adaptive systems are divided into two classes: systems capable of self-organization, and systems capable of self-configuring.

During operating, a control algorithm is formed in systems capable of self-organization. This algorithm enables optimizing the system from the point of view of the control objective. Such tasks arise in conditions of changing the structure and parameters of a control object, depending on the mode of operation if a priori information is insufficient to determine the current mode. In this case, the free structure of a controller [9] and rather complex problems are referred to.

The tasks of synthesizing for continuous dynamic objects are described in [9]. Let the control object is influenced by measured disturbances (initial effects) $Y=Y(t)$, immeasured effects $N=N(t)$ and control effects $U=U(t)$. The output variables of the object $X=X(t)$ should be monitored. The object behaviour depends on a set of unknown parameters that create the sum total ξ. A set Ξ of probable values ξ is given; it determines the class of admissible objects and perturbations. The goal of control, that determines the behaviour of the control object, is set. The result should be the synthesized control algorithm that will use the values that are measured or calculated on the basis of measurements, which do not depend on $\xi \in \Xi$ and will ensure achieving a set goal of control for each $\xi \in \Xi$ [10-11].

In the terms of FIMS, adaptivity means capabilities to maintain the operability of the manufacturing system in the terms of changes in the conditions of its operation due to external factors (other FIMS, heat, power and ventilation systems, etc.) and internal factors (the operation of individual machining centres and numerically controlled machine tools, the actions of personnel, heat systems and so on).

In such circumstances, the FIMS should adapt to the available conditions and change the schedule (plan) for the entire system or its individual nodes, ensuring the adaptation of the strategies of its operation.

The task of adapting the strategies of functioning is formulated under certain conditions of real mechanical assembly, in particular, the housing assembly parts of fuel systems of aviation equipment of PO “FED”, radio electronic equipment of NDVO “Kommunar”.

The technological process of machining and assembly should be carried out in one or several shops that contain machining centres, CNC machines, industrial and transport robots, storage and transportation systems that connect the technological equipment with an automated warehouse.

The shortcomings of the manufacturing process organization in the mentioned machine-assembly departments particularly include:

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- the fixed nature of the transport system and its low level of automation with limited use of transport robots
- manual loading methods for CNC machines;
- lack of automated means to eliminate abnormal or non-standard manufacturing situations.

To overcome these shortcomings, it is suggested
- to introduce a mobile transport-assembly robot into the equipment of the flexible integrated system of shops (fig. 2.)
- to develop mathematical, and algorithmic software for the specified robot.

A mobile transport-assembly robot should meet the following requirements:
- the robot freely moves within the shop outside the working spaces of individual units of technological equipment;
- the robot ensures the delivery of blank parts and other materials to the working area of machining centres and CNC machines;
- the robot provides the delivery of the necessary equipment or tools for regular or urgent calls;
- the robot provides cleaning operations;
- the robot monitors technological equipment and other equipment of shops;
- the robot monitors the operation of the technological equipment.

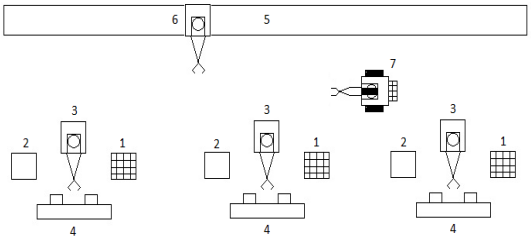

Fig. 2. The structure of the flexible automated area

(1, 2 – input and output storage devices, 3 – industrial robot, 4 – CNC machine, 5 – transport system, 6 – transport robot, 7 – intelligent transport and cleaning robot)

To ensure its functionality, a transport-cleaning robot should meet specific design requirements, in particular, it should be fitted out with:
- a mobile platform chassis;
- a manipulator (or several manipulators)
- a cargo compartment for transportation of blanks, parts, tools and equipment;
- a telecommunications system;
- a control system based on the onboard computer;
- the sensor system of the chassis and manipulator.

The transport-cleaning robot should be selected on the basis of available models of transport robots and manipulators.

A separate element of the system for controlling a mobile transport-assembly robot is the decision support system (DSS). Due to the dynamic nature of the working space, the DSS should ensure moving the transport-assembly robot to individual workplaces, should plan the necessary operations for loading and unloading the technological equipment, tools and accessories, plan individual assembly operations. The dynamic nature of the working space of transport and assembly robot, which is determined by manufacturing, requires adapting the operational strategies that should ensure the stability of flexible integrated manufacturing systems.

Basing on the conducted analysis, it can be concluded that the topical problem of modern flexible integrated manufacturing systems still is to ensure manufacturing functions at all levels of the enterprise organization: at the levels of centralized or local management, at the level of planning manufacturing functions, at the level of direct execution of production processes. A significant shortcoming of automated control systems of flexible integrated robotic manufacturing is the fact that changes in the working environment of technological equipment are not taken into consideration as well as the means for further adaptation of the subsystems of controlling industrial and transport robots at the level of decision support systems that should monitor the states of flexible integrated systems, ensure the development, operation and adaptation of the strategies of manufacturing functions [12].

An intelligent control system that takes into account changes in the working environment and the conditions of a flexible integrated manufacturing system should develop a plan for the operation of technological equipment and industrial and transport robots servicing it, monitor the conditions for its implementation in the process of decision making and, if necessary, adapt (modify) strategies of implementing manufacturing functions by robots and other technological equipment. The introduction of the systems of the adaptation of operational strategies should significantly improve the characteristics of the robotic control systems and, therefore, is a topical scientific direction.

The goal of the research is to solve a topical scientific and applied problem of developing theoretical foundations of intellectual support for decision-making in automated control systems for flexible robotic integrated systems for manufacturing radio electronic equipment, mathematical and information software for planning manufacturing tasks for FIMS operation, which takes into account changes in the states of the manufacturing system and workspace, quickly re-build plans for solving complex practical problems in the process of their implementation and will increase the efficiency of the process of control the flexible integrated system for manufacturing radio electronic equipment

The objectives of the study are:
- the panalysis of the current state of development of automated control systems for flexible integrated robotic systems in general and intelligent decision support systems for autonomous robots;
- the research and development of the concept of the operation of adaptive flexible integrated robotic systems;
- the development of models of intellectual support for decision-making in automated control systems based on the method of adaptation of strategies for the operation of flexible integrated systems;
- the development of knowledge representation models and the method of creating intelligent decision support systems in automated control systems for flexible integrated robotic manufacturing;

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- the development of information software for intelligent decision support in automated control systems of flexible integrated robotic systems for manufacturing radio electronic equipment.

The concept of adapting the operation strategies

To solve the task of creating intelligent systems of decision support of flexible integrated robotic systems (FIRS), the following concept of adapting the strategies of operation is suggested [14]:

a) there is a subject (subjects) of planning strategies in the form of a mobile or manipulative robot (robots) equipped with an automated control system (ACS);

b) there are FIRS objects about which a decision is made and is implemented;

c) there is a working space, including subjects and objects of planning strategies, as well as foreign objects that can influence the process of planning strategies, the nature of the FIRS space is defined and can be either deterministic or stochastic;

d) a subject of strategy planning (robot ACS) has the following properties:

- technical characteristics (capability to implement the decision);
- the development of operational strategies in accordance with the current state of the workplace;
- the implementation of the strategy for moving in space or manipulating objects in accordance with the developed strategy;
- the adaptation of the strategy in case of a change in the manufacturing task or in the working environment;
- the adaptation of implementation of decisions in accordance with the strategy

e) the intelligent decision support system of the control system of an actuator, respectively, consists of the following parts:

- the unit accumulating information about the environment (in the simplest case, it is a database, in a more complex one - it is connected with the sensor system of the actuator);
- a unit of operator schemes that contains standardized descriptions of the solution of individual subtasks (in other words, the knowledge database of the robot ACS);
- a unit of strategy searching which puts forward a hypothesis (in general) on the operational strategy basing on the information about the goal of an individual step of planning the strategy or on the basis of a global goal ;
- a unit of planning the policy that, along with the sensor system, should actually observe (monitor) changes in the system workspace and thus change (modify or adapt) the plan of decision implementation [15];
- a unit for formulating the aim of the system;
- a unit for verifying the results of the robot ACS;
- a unit for creating and executing movements (manipulations).

The mentioned components of ACS are shown in fig. 3.

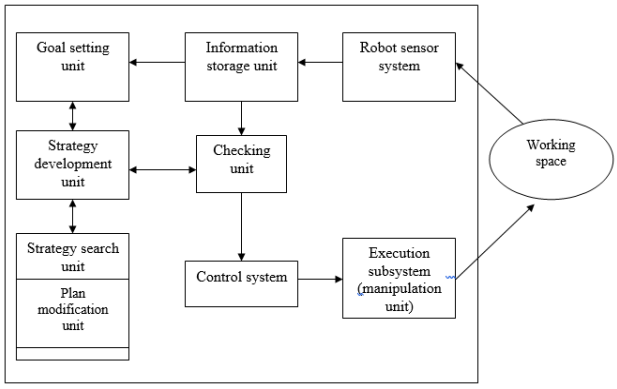

Fig. 3. Structural diagram of the automated control system of FIRS

The developed structure perceives information about the state of the working environment and modifies the process of planning strategies in accordance with changes in the environment, that is, it has features of an adaptive system.

The following description of the data of the automated control system (ACS) of a robot can be specified. ACS in terms of planning strategies is characterized by the following sets:

The robotic system (RS) that is a part of FIS whose state is characterized by a set of elements $x_i \in X, i = 0...n-1$ as a vector of states $X = \{X^0, X^1, \ldots, X^{n-1}\}$ that at the moments of time $t_0, \ldots, t_{n-1}$ take values $X_0 = \{x_0^0, x_0^1, \ldots, x_0^{n-1}\}$, $X_1 = \{x_1^0, x_1^1, \ldots, x_1^{n-1}\}, \ldots, X_{n-1} = \{x_{n-1}^0, x_{n-1}^1, \ldots, x_{n-1}^{n-1}\}$.

A RS operates in a working space (WS) $s_i \in S, i = 0...m-1$.

The WS is two- or three-dimensional and depends on time. A set of the WS characteristics is determined as a vector of states $S = \{S^0, S^1, \ldots, S^{n-1}\}$ and at the moments of rime $t_0, \ldots, t_{n-1}$ takes values $S_0 = \{s_0^0, s_0^1, \ldots, s_0^{n-1}\}$, $S_0 = \{s_0^0, s_0^1, \ldots, s_0^{n-1}\}, \ldots, S_{n-1} = \{s_{n-1}^0, s_{n-1}^1, \ldots, s_{n-1}^{n-1}\}$;

The RS can plan decisions $d_k \in D, k = 0...l-1$ on the transformation of their states and states of WS. A number of decisions made by the strategy planning system (SPS) of the automated control system (ACS) form a vector $\vec{D} = \{d_0, d_1, \ldots, d_{m-1}\}$, where m is a number of decisions made within the time period $t_0, \ldots, t_{n-1}$;

Decisions are implemented by RS actions: $a_i \in A, i = 0...l-1$.

A number of actions $A = \{a^0, a^1, \ldots, a^{n-1}\}$ is implemented by a robotic system as the implementation of made decisions $\vec{D}_i$ within movements or manipulations $a_{mv} \subset A$, $a_{mp} \subset A$.

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The goal of RS operation is the state $y \in X$ which is achieved by the sequential transformation of states: $x_0 \to x_1 \to ... \to x_{n-1} = y$.

Thus, while achieving the goal, the following transformation takes place:

$$x_1 = f_1(x_0, y, s_0, d_0, a_0) + \varepsilon_0, \ \|x_1 - x_0\| \le \varepsilon_0,$$

$$x_k = f_k(x_{k-1}, y, s_{k-1}, d_{k-1}, a_{k-1}) + \varepsilon_k, \ \|x_k - x_{k-1}\| \le \varepsilon_k,$$

$$y = f_n(x_{n-1}, y, s_{n-1}, d_{n-1}, a_{n-1}) + \varepsilon_n, \ \|y - x_{n-1}\| \le \varepsilon_n,$$

f is a transition function, ε is a transition faluire.

Transitions are characterized by the cost $c_i \in A, i = 1...n$ and duration $t_i \in T, \ i = 1...n$. The goal is to find such sequence of transitions $f_1, \ldots, f_n$ which will ensure the transition of the system from the initial state x_0 to the target one *y*.

The conditions of searching are: $\sum_{i=1}^{n} t_i \to \min$, $\sum_{i=1}^{n} c_i \to \min$, $\sum_{i=1}^{n} \varepsilon_i \to \min$.

The mentioned sets represent particular elements of ACS.

In particular, the robotic system (X set), from the point of view of solving ACS tasks, can be described in the following elements:

- a manipulator (the description of the movements of individual manipulator joints);
- a control system (a set of signals sent or received by the manipulator);
- a sensor system (sensors providing the transmission of signals about the state of the working space (WS) to the robot control system (CS));
- a vision system (provides observing (monitoring) of WS and signalling in the robot CS);
- a communication system (transmitting and receiving signals from the robot CS, other robots);
- a robot chassis (receiving information from CS, transmitting data to CS, implementing movements).

A set of decisions *D* can be described within:

- the decision to move a manipulator (manipulators) at the level of individual operations (take an object, move, put, change objects in places, etc.), including reaching a target point;
- the decision on the direction of movement of the chassis of a mobile robot (right, left, forward, back, etc.), changes in speed and acceleration;
- the requests of sensors and the systems of technical vision;
- the expected result (the decision made)
- prerequisites for making decisions.

A set of objects of the external environment *S* can be described as:

- the objects of space (coordinates of objects, the direction and speed of movement, the class of the object ownership, technical condition, the possibility of using it while implementing the decision);
- the state of the environment (the terrain feature, tracks and their condition, obstacles and their changes, meteorological conditions, light, etc.).

A set of goals *Y* of the robot ACS can be described as:

- the location of the robot at the point of space (or near the necessary object);
- operations (manipulations) at the point of space (or near the necessary object);
- data on the state of space obtained using a sensory system or a computer vision system.

A robot can be tasked:

to be _at_ point (x, y, z);
to conduct an operation (take_object(class(nut))).

An example of the arrangement of the FIRS working space is shown in fig. 4-a.

Another example of the working space is a task of a manipulation robot that operates within an assembly FIRS.

A flexible integrated assembly system (FIAS) is presented as a part of assembly machines (soldering tools), transport-assembly robots, storage devices that form a set $eq_i \in Eq, i = 0...n-1$. The goal of the FIAS is to ensure assembling the devices (units) of radio electronic equipment, in particular on printed circuit boards *M* [13].

And $M = < B, Ch, T, R, C, L, ... >$, where *B* is a printed circuit board, *Ch* is microprocessor devices, *T* is semiconductor devices, *R* is resistors, *C* – capacitors, *L* – inductors.

The configuration of the device is determined by its design project M^G which determines the target arrangement of the elements on the printed circuit board. In fact, the unit (board) is a rectangular matrix, which is filled with the elements of the set *M* (is shown in fig. 4-b).

Initially, M_0 is a null matrix. THE FIAS generates decisions $d_k \in D, k = 0,...,l-1$ that are implemented by the action (technological transitions): $a_k \in A, k = 0,...,l-1$. The decision $\vec{D}$ on the order of implementing assembly operation is the sequence of operations which involves establishing the individual elements of sets *Ch, T, R, C, L* ... in *B*, for example

$$\vec{D} = \{Ch_0, Ch_1, T_0, T_1, R_0, Ch_3, C_0, L_0, ...\}.$$

While achieving the target state M^G, there are transformations $M_i = f_i(Eq, D_i, M_{i-1})$:

$$M_0 \to M_1 \to M_2 \to ... \to M^G.$$

Filling in *M* is determined by the order of assembly operations. This order is defined by the project M^G, technological rules Tr, technological equipment capabilities E. Thus, there is $\vec{D} = g(M^G, Tr, E)$. The goal is to find such sequence of transitions $f_1, \ldots, f_n$ which

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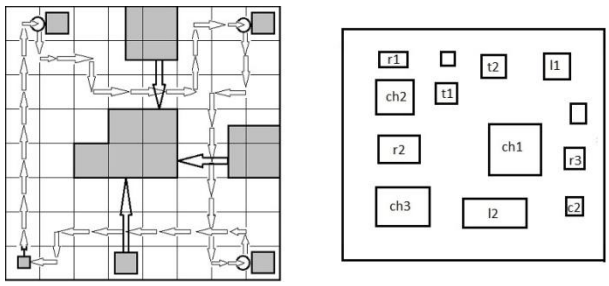
will ensure the transition of the system from the initial state M_0 in the target one M^G.



a) b)

Fig. 4. The examples of organization of the FIS working space
(a) – the tasks of a transportation robot,
(b) – the tasks of a manipulation robot

The process of planning strategies is a process of constantly comparing the goals of the system with its current position, current capabilities and so on. The process of planning a strategy in accordance with the discreteness of operations should be discrete and correspond to the achievement of the goal and implement certain technological operations.

Generally, the process of planning strategies is the reflection of:

$$F: D \times X \to Y, \qquad (2.1)$$

that is the process of planning strategies means the application of a set of the operations of a decision $D = \{D_0, D_1, \ldots, D_n\}$ to the sets $X_0, \ldots, X_{n-1}$ at every step, which is formally regarded as the Cartesian product of set $X \times D \to Y$, where Y is a set, characterizing the state of ACS at the time of achieving the decision.

The process of the transition of a robotic system from its initial state in a target one is the sequence of the system state transformations and looks like:

$$\begin{bmatrix} x_0^0 \\ x_0^1 \\ \cdots \\ x_0^{n0} \end{bmatrix} \Rightarrow \begin{bmatrix} x_1^0 \\ x_1^1 \\ \cdots \\ x_1^{n1} \end{bmatrix} \Rightarrow \begin{bmatrix} x_2^0 \\ x_2^1 \\ \cdots \\ x_2^{n2} \end{bmatrix} \Rightarrow \ldots \Rightarrow \begin{bmatrix} x_n^0 \\ x_n^1 \\ \cdots \\ x_n^{nn} \end{bmatrix} \equiv \begin{bmatrix} y^0 \\ y^1 \\ \cdots \\ y^n \end{bmatrix}. \qquad (2.2)$$

This corresponds to the real situation when in the process of generating and executing solutions, the evolution of the states of the robotic system

However, this sequence of changes can characterize not only the decision-making process but also the dynamics of changes in the states of the system over time. When planning strategies, the state of the system changes in an active mode, that is, at each step of strategy planning, the characteristics of the system should change. Considering the sequence of actions for planning strategies, the function (vector) of decision-making should be determined as $\vec{D} = \{D_0, D_1, ..., D_{n-1}\}$.

Therefore, the application of the decision D_i at each step of ACS operation results in the transformation of $X_i^j \to X_{i+1}^j$ column of robotic system states.

$$\begin{bmatrix} x_0^0 \\ x_0^1 \\ \cdots \\ x_0^{n0} \end{bmatrix} * D_0 \Rightarrow \begin{bmatrix} x_1^0 \\ x_1^1 \\ \cdots \\ x_1^{n1} \end{bmatrix} * D_1 \Rightarrow \begin{bmatrix} x_2^0 \\ x_2^1 \\ \cdots \\ x_2^{n2} \end{bmatrix} * D_2 \Rightarrow \ldots \begin{bmatrix} x_{n-1}^0 \\ x_{n-1}^1 \\ \cdots \\ x_{n-1}^{n-1} \end{bmatrix} * D_{n-1} \Rightarrow \begin{bmatrix} x_n^0 \\ x_n^1 \\ \cdots \\ x_n^{nn} \end{bmatrix} \equiv \begin{bmatrix} y^0 \\ y^1 \\ \cdots \\ y^n \end{bmatrix}. (2.3)$$

It should be also noted, that in the case of adaptive planning strategies, the third party should be taken into in consideration, for example, as an object of as objects of the external world or a competitor party that affects (negatively or positively) on the process of planning a strategy. On the one hand, the system should feel the effect of the external environment and then, in order to take into account its existence and effect on the process of planning a strategy, an additional factor S should be introduced. This factor characterizes the state of the external environment (which includes a certain set of objects $S_i = \{s_i^0, s_i^1, \ldots, s_i^m\}$, where the index i means that the external environment is discrete):

$$\begin{bmatrix} x_0^0 \\ x_0^1 \\ \cdots \\ x_0^{n0} \end{bmatrix} * \begin{bmatrix} s_0^0 \\ s_0^1 \\ \cdots \\ s_0^{m0} \end{bmatrix} * D_0 \Rightarrow \begin{bmatrix} x_1^0 \\ x_1^1 \\ \cdots \\ x_1^{n1} \end{bmatrix} * \begin{bmatrix} s_1^0 \\ s_1^1 \\ \cdots \\ s_1^{m1} \end{bmatrix} * D_1 \Rightarrow \ldots \begin{bmatrix} x_{n-1}^0 \\ x_{n-1}^1 \\ \cdots \\ x_{n-1}^{n-1} \end{bmatrix} * \begin{bmatrix} s_{n-1}^0 \\ s_{n-1}^1 \\ \cdots \\ s_{n-1}^{m-1} \end{bmatrix} * D_{n-1} \Rightarrow \begin{bmatrix} x_n^0 \\ x_n^1 \\ \cdots \\ x_n^{nn} \end{bmatrix} \equiv \begin{bmatrix} y^0 \\ y^1 \\ \cdots \\ y^n \end{bmatrix} \qquad (2.4)$$

Another approach is introducing the functional dependence of individual acts of planning strategies on the state of the environment:

$$F: D(S) \times X \to Y, \qquad (2.5)$$

and consequently:

$$\begin{bmatrix} x_0^0 \\ x_0^1 \\ \cdots \\ x_0^{n0} \end{bmatrix} * D_0 \left(\begin{bmatrix} s_0^0 \\ s_0^1 \\ \cdots \\ s_0^{m0} \end{bmatrix} \right) \Rightarrow \begin{bmatrix} x_1^0 \\ x_1^1 \\ \cdots \\ x_1^{n1} \end{bmatrix} * D_1 \left(\begin{bmatrix} s_1^0 \\ s_1^1 \\ \cdots \\ s_1^{m1} \end{bmatrix} \right) \Rightarrow \ldots \begin{bmatrix} x_{n-1}^0 \\ x_{n-1}^1 \\ \cdots \\ x_{n-1}^{n-1} \end{bmatrix} * D_{n-1} \left(\begin{bmatrix} s_{n-1}^0 \\ s_{n-1}^1 \\ \cdots \\ s_{n-1}^{m-1} \end{bmatrix} \right) \Rightarrow \begin{bmatrix} x_n^0 \\ x_n^1 \\ \cdots \\ x_n^{nn} \end{bmatrix} \equiv \begin{bmatrix} y^0 \\ y^1 \\ \cdots \\ y^n \end{bmatrix} \qquad (2.6)$$

Therefore, D_i as an act of planning strategies depends on the state of the objects of the external environment.

Externally, the two approaches are slightly different, but their interpretation may seem different. In the first case, the strategy planning system interacts directly with the environment and this interaction leads to changes in the states of the robotic system, so the act of planning a strategy concerns the state of the system that has been affected by the environment. In the second case, the act of planning depends on the state of the environment and should take into account its influence while determining the procedures (strategies) of decisions and a decision maker changes the state of the robotic system as it depends on the environment.

Thus, the goal of the ACS in the phase of planning strategies for implementing the task is to determine the ordered set (vector) $\vec{D} \subset D$ as , a set of acts of decision making that will ensure the implementation of the ACS transition by the robot from the initial X_0 to the target Y according to the reflection $F: D \times X \to Y$.

The need for planning the adaptive strategy arises under significant changes in the conditions of the implementation of decisions. In the static environment of the robot, the task Y, as a state of the robotic system,is

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achieved by using a set of possible actions $\vec{D}=\{D_0, D_1, ..., D_{n-1}\}$, which transfers the system from the initial state X_0 to the target $X_{n-1}=Y$. A set of selected actions $\vec{D}$ is regarded as a decision plan.

Under the conditions of static working space, the initial decision plan $\vec{D}_0=\{D_0^0, D_1^0, D_2^0 ..., D_{n-1}^0\}$ should be developed and separate acts of a decision (strategy) are directly interrelated, and the use of the local act of decision making D_i in the current state X_i will transfer the system in the state X_{i+1}, which, in fact, is the target for the act of decision D_i. In its turn, the state X_{i+1} is initial for a new state D_{i+1}, which will transfer the system from the state X_{i+1} in X_{i+2} and so on.

Under the conditions of the dynamic state, DSS, by its acts of decision D_i can transfer the system in the state X_{i+1}, which might be insufficient for implementing the act D_{i+1} and might need additional acts of decision D'_{i+1}, D'_{i+1}, etc. Therefore, the changes in the environment will lead to the uncertainty of available means for their solving.

The variants differ by the sequence of their implementation. If the interaction of the robotic system and the environment occurs before the act of decision-making, the expression (2.1) is true, if the interaction occurs during the act, the dependence of the decision-making function on the impact of external factors should be taken into account, and, consequently, (2.2) should be considered. Although, both variants undoubtedly have should be the same result.

When developing automated control systems for mobile and manipulation robots, an important stage is selecting models for planning strategies, taking into account the specific conditions of the working space, the capabilities of the robot model, the characteristics of its sensor system and other indicators. The character of the selected models determines the essence of the methods of planning strategies.

Planning a strategy takes place in real-time mode and beyond it. As a rule, the initial decision is made under the conditions of setting the task and taking into account the initial state of all the objects involved in the process. At the same time, operator procedures of ACS, which satisfy the initial and current decision-making conditions to the greatest extent, are searched for. The developed will correspond to the model of decision-making that was selected at the initial stage.

The suggested plan is carried out at the implementation stage. It is carried out in real time and can be limited by the duration of actions of other objects and by internal factors (for example, a limited charge of mobile robot batteries). The deviation of the operating conditions of the robot from the planned ones, external factors that significantly affect the implementation of decisions will require adapting the approved plan at the level of restructuring the individual parts of the plan (with respect to solving individual subtasks) or restructuring the entire plan for solving the task. Thus, the method of adaptive strategy planning should take into account changes in the working space and adapt planning strategies in accordance with them.

The logical model of making decisions on the strategy of the operation of robots under the conditions of FIRS

Selecting a logical model as the basis for building a model for planning strategies is not random. The planned actions of a robot should look consistent, verified and, therefore, logical in the ordinary sense. Another feature of the decision is its trueness in accordance with the current condition of the working space, that is, the decision made in the space S is true at time t and may be untrue at time $t + 1$ but the solution will always have a true value.

While considering the logical model, a number of symbols that are similar to the set-theoretic model of the previous subdivision will be used.

Let sets X, D, S of RS states, its decisions, WS states are given.

Then, $x_i \in X, d_i \in D, s_i \in S$ are the atomic expressions of the model of RS and WS actions.

Among the separate elements of sets X, D, S, operations $\neg, \wedge, \vee, \rightarrow, \leftrightarrow$ are introduced.

Therefore, the formulas that are correctly constructed are:

$$\neg x, x \wedge y, x \vee y, x \rightarrow y, x \leftrightarrow y .$$

To describe the theory of sets, X, D, S functions and predicates are introduced.

The transformation function of RS conditions is as follows: $x_i = f(x_0, ..., x_{i-1})$,

The transformation function of WS conditions is as follows: $s_i = f(s_0, ..., s_{i-1})$.

Predicates that connect the elements of sets X, D, S are also introduced

$$pt(x_i),\ pt(s_i),\ pt(d_i),\ pt(x_i, s_i),\ pt(x_i, d_i),$$

$$pt(d_i, s_i),\ pt(x_i, d_i, s_i)$$

and ensure describing the properties of RS and WS, their mutual influence and dependence.

The following predicates are determined:

$pr(x_i, s_i) \subset pt$ is a set of descriptions of RS in WS,

$ps(x_i, s_i) \subset pt$ is a set of descriptions of WS in view of with RS,

$pa(x_i, s_i) \subset pt$ is a set of actions of RS in WS,

$pg(pr, ps) \subset pt$ is a set of goals of RS in WS.

The goal of RS is set as a new or (or available) state of RS or WS:

$$pg(pr, ps) \leftarrow (pr(x_i, s_i) \vee ps(x_i, s_i)) .$$

The database of RS is determined as a set of descriptions $pr()$, $pt()$:

$$pr(x_i),\ pr(x_i, s_i),\ ps(s_i),\ ps(x_i, s_i) .$$

The database of RS is determined as a set of descriptions $pa(x_i, s_i)$ of possible actions of RS in WS.

The description $pa(x_i, s_i)$ is a strategy of goal solving

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$pg(pr(x_i,s_i),ps(x_i,s_i))$, is there is such conjunction of sets for RS actions $pa(x_i,s_i)$, which ensures $pg(pr(x_i,s_i),ps(x_i,s_i))$:

$$pg(pr(x_i,s_i),ps(x_i,s_i)) \leftarrow pa^0(x_i,s_i) \wedge pa^1(x_i,s_i) \wedge ... \wedge pa^{n-1}(x_i,s_i),$$

or

$$pg(pr(x_i,s_i),ps(x_i,s_i)) \leftarrow \wedge_{i=0}^{n-1} pa^i(x_i,s_i),$$

and:

$$\exists f, f \in F: x_i = f_i(x_{i-1},s_{i-1}),\ \exists \psi, \psi \in \Psi: x_i = \psi_i(x_{i-1},s_{i-1}).$$

Therefore, $pa(x_i,s_i) = T\left\| f_i + \psi_i \right\|$.

The process of decision-making is a successive set of *m* alternatives to the solution of the objectives of the system:

$$pg^0(pr,ps) \leftarrow pg_0^0(pr_0,ps_0,pa_0) \wedge pg_1^0(pr_1,ps_1,pa_1) \wedge ...$$
$$\wedge pg_{n-1}^0(pr_{n-1},ps_{n-1},pa_{n-1}) = \wedge_{i=0}^{n-1} pg_i^0(pr_i,ps_i,pa_i)$$

……

$$pg^m(pr,ps) \leftarrow pg_0^m(pr_0,ps_0,pa_0) \wedge pg_1^m(pr_1,ps_1,pa_1) \wedge ...$$
$$\wedge pg_{n-1}^m(pr_{n-1},ps_{n-1},pa_{n-1}) = \wedge_{i=0}^{n-1} pg_i^m(pr_i,ps_i,pa_i).$$

Thus, the general goal is described as:

$$pg^{total}(pr,ps) \leftarrow \vee_{j=0}^{m-1} \wedge_{i=0}^{n-1} pg_i^m(pr_i,ps_i,pa_i).$$

Under the conditions of RS goal setting, the initial plan is worked out; this plan involves the following transformations of the system states:

$$pr(x_1,s_1) \leftarrow pa_0^0(pr(x_0,s_0) \vee ps(x_0,s_0)),$$
$$pr(x_2,s_2) \leftarrow pa_1^0(pr(x_1,s_1) \vee ps(x_1,s_1)),$$

……..

$$pr(x_n = Y,s_n) \leftarrow pa_{n-1}^0(pr(x_{n-1},s_{n-1}) \vee ps(x_{n-1},s_{n-1})).$$

Under the conditions of the dynamic state of RS, separate $pg(pr(x_i,s_i),ps(x_i,s_i))$ cannot be achieved:

$$pr(x_i,s_i) \neq pa_i^0(pr(x_{i-1},s_{i-1}) \vee ps(x_{i-1},s_{i-1})).$$

Under such conditions, the system should be modified:

$$pr(x_i,s_i) \leftarrow pa_i^*(pr(x_{i-1},s_{i-1}) \vee ps(x_{i-1},s_{i-1})),$$

$$pr(x_{i+1},s_{i+1}) \leftarrow pa_{i+1}^*(pr(x_i,s_i) \vee ps(x_i,s_i)),$$

which results in modifying the decision strategy:

$$pg^{m*}(pr,ps) \leftarrow pg_0^{m*}(pr_0,ps_0,pa_0) \wedge$$
$$pg_1^{m*}(pr_1,ps_1,pa_1) \wedge ...$$
$$\wedge pg_{n-1}^{m*}(pr_{n-1},ps_{n-1},pa_{n-1})$$
$$= \wedge_{i=0}^{n-1} pg_i^{m*}(pr_i,ps_i,pa_i).$$

In particular, $X = \left\{X^0, X^1, \ldots, X^{n-1}\right\}$ is determined as a set of states of a robotic system.

Let automated control system, while implementing the approved decision, ensure transforming the initial state $state(x_0^0, x_1^0, x_2^0, \ldots, x_{n-1}^0)$ into a particular target state $state(x_0^m, x_1^m, x_2^m, \ldots, x_{n-1}^m)$.

If the system (a robot and the environment around it) at the initial moment of time makes up a set of arguments $x_0^0, ..., x_n^0$ and is characterized by the state $state(x_0^0, x_1^0, x_2^0, \ldots, x_{n-1}^0)$, while considering the discrete process of planning strategies that comprises separate actions $action_0, ..., action_k$, it can be mentioned that the transition from one discrete state to another is a certain relationship among objects:

$$state(x_0^1, x_1^1, ..., x_n^1) \leftarrow action_0(state(x_0^0, x_1^0, ..., x_n^0)), \quad (2.34)$$

where *state* is the relation (predicate) which characterizes the state of the system in general, *action(state)* means the action of changing one state to another.

All the actions for transforming the system from one state to another (by implementing a list of decisions) are a set of predicates

$$state(X^1) \leftarrow action_0(state(X^0)),$$

$$state(X^2) \leftarrow action_1(state(X^1)), \quad (2.35)$$

……..

$$state(X^{n-1} = Y) \leftarrow action_{n-2}(state(X^{n-2})).$$

Thus, the goal of planning strategies is to find a corresponding number of $action_i$, which would meet the conditions $state_i$ of the system.

Selecting $action_i$ for transforming $state(X^i)$ in $state(X^{i+1})$ is carried out by the compatibility of arguments *action* and the corresponding state X^{i+1}, which in practice will mean the possibility of realizing the state (local goal) of X^{i+1} by performing ACS actions *action*:

$$X^{P+1} \leftarrow action(X^P), \quad (2.36)$$

where X^{P+1} is a possible result of *action* under the conditions of X^P state and the following conditions should be met:

a) $X^i \sim X^P$ is the compatibility of initial data of *action* with the current initial data;

b) $X^{i+1} \sim X^{P+1}$ is the compatibility of *action* with the local goal X^{i+1}.

Thus, the definition can be introduced:

Definition 2.9. The predicate scheme is adaptive if the constituent parts of the antecedent (the right side of the predicate expression) and the result of the scheme (the consequent) change depending on the changes in the state of the ACS and the workspace (WS):

$$state(Y) \leftarrow action(S_0), action(S_1), \ldots, action(S_{n-1}), \quad (2.37)$$

where *Y* is the goal of the system;

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S_0, S_1, ... S_{n-1} are successive states of ACS.

However, under the conditions of the dynamic state of WS (a robot environment) and the state of the robot might change (changes are not obligatory but probable) and the situation can occur when, at the particular state $state(X^{i-1})$ the action $action_{i-1}(state(X^{i-1}))$ does not result in transforming the system in the state $state(X^i)$, тобто:

$$state(X^i) \neq action_{i-1}(state(X^{i-1})). \quad (2.38)$$

At first glance, in these conditions, a predicate *action* that would meet the condition of the expression should be found. However, in fact, a number of possible real actions is limited (in contrast to a number of states), so the conclusion will consist in finding such the discrete sequence $\overrightarrow{action}$ (a vector of predicates) that will meet the objectives of the system.

Therefore, if there is a set of objects *X* and the initial state is X^0, to achieve the target state *Y*, the sequence of actions that is reflected by the predicates *action* should be planned, while the state of the system – by the predicate *state*:

$$\begin{gathered} state(X^0), \\ state(X^1) \leftarrow action_0(state(X^0)), \\ state(X^2) \leftarrow action_1(state(X^1)), \\ \ldots\ldots\ldots\ldots \\ state(Y) \leftarrow action_{n-1}(state(X^{n-1})). \end{gathered} \quad (2.39)$$

If at a certain level *i*, the state X^i cannot be achieved, that is $state(X^i) \neq action_{i-1}(state(X^{i-1}))$, the adaptive system of planning strategies should generate a new sequence of the predicates of actions $\overrightarrow{action}$, which will meet the changes in the WS:

$$\begin{gathered} state(X^{i1}) \leftarrow action^1_{n-1}(state(X^{i-1})), \\ state(X^{i2}) \leftarrow action^2_{n-1}(state(X^{i-1})), \\ \ldots\ldots\ldots\ldots\ldots\ldots \\ state(Y) \leftarrow action^{m-1}_{n-1}(state(X^{n-1})). \end{gathered} \quad (2.40)$$

The similar situation occurs when SPS has information about changes in the system goal. This means that the target state *state(Y)* changes for a certain $state(Y^i)$. In this case, two situations are possible:

а) information about the goal change comes at the moment when the system is in the state *i* – $state(x^i)$ and the plan $\overrightarrow{action}$ can be generated for the transition from the state x^i in the state y^i;

б) information about the goal change comes at the moment when the system is in the state $state(x^i)$ but the plan $\overrightarrow{action}$ can be generated only from the state $state(x^{i-k})$, where $k \leq i$, that is for generating the system should return to the previous states up to the state $state(x^0)$.

This will also cause the necessity to generate a new sequence of predicates-actions.

According to the definition 2.7, the decision plan will include sets $\{action_0, action_1, \ldots, action_n\}$ and the complete plan will include all the plans that were developed while making a decision. The adaptive plan of the decision will be expressed as:

$$\begin{gathered} plan^{adaptive}(Y) \leftarrow action_0(state(X^0), \\ action_1(state(X^1), \ldots, action_{n-1}(state(X^{n-1})))) \end{gathered}.$$

Such a plan is the final decision of the ASPS.

It should be noted that the developed plan will be changed until the final subgoal of the planned sequence has been completed. That is, the capability of the plan to be adapted is its essential characteristic.

Let us also consider the time of assessing the actions are planned by the SPS in the sequence of predicates.

The predicate is known to have the true value, in the classical sense – the mapping of n arguments to the true value. Although taking into consideration the fuzzy logic, the concept of a fuzzy predicate can be introduced [15]. The classical predicate has only *true* and *false* values. From this point of view, the transition of the DSS from one *state* (X_{i-1}) to the *state* (X_i) state will also have a true or false value, that is, the system either turns into a new state or not. Probably, even in the terms of the idealized approach, the state of the whole system is difficult to predict, and especially unambiguously assess the state of the system in binary values "true" and "false". Individual characteristics of the system can rather be considered as true and false. According to the predicate theory, the robot world can be described as a set of relations among the objects within such a world, for example, *is_a* means that an object belongs to the type of objects, *is_at* means that one object is located near another one, *stands* means that the object is in a certain state, and so on.

Developing information on the robot working space with computer vision technique

The implementation of intelligent robots requires that the control process should be carried out with the help of an autonomous control system or, under certain conditions, by a human operator.

There are several types of organization of information input into the robot control system, which can be classified as follows:

- the input of information from the onboard decision-making system;
- the introduction of control commands from the human operator;
- the input of information using voice commands
- the input of information using a visual control system.

The onboard decision-making system controls the robot with the help of decision-search algorithms, which are built in the device itself. The basis for the operation of the decision-making system is information obtained from the sensory system. Sensor devices of the robot and computer control make up a map of the terrain.

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Controlling the robot includes its positioning on this map. The operation of the sensory system has limited capabilities, in particular, when changing the environment, it is not always possible to re-arrange immediately the working space of the map where the orientation and control are carried out.

Another example of the organization of information input is command-based control the operator provides using the control device. The control algorithm is limited by a list of commands and an increase in the time to enter.

In the third case, the remote control of robots is carried out with the help of voice commands and analyzers. Each of these commands is set by an individual user. Such a system also requires a lot of time to input and a human operator, besides, the drawback is the lack of clarity and individuality while giving commands.

The main task of the multi-zone system is to monitor the object in different working areas with the help of several cameras, object recognition, the determination of the motion trajectory. The OpenCV computer vision library was used to solve the problem [9]. A number of cameras can vary but when connecting a large number of cameras, there is a problem associated with a heavy load when transferring a significant amount of video information. This problem is solved by reducing the size (quality) of the image or reducing the frame rate. The observation zones of the chambers are shown in fig. 5, a.

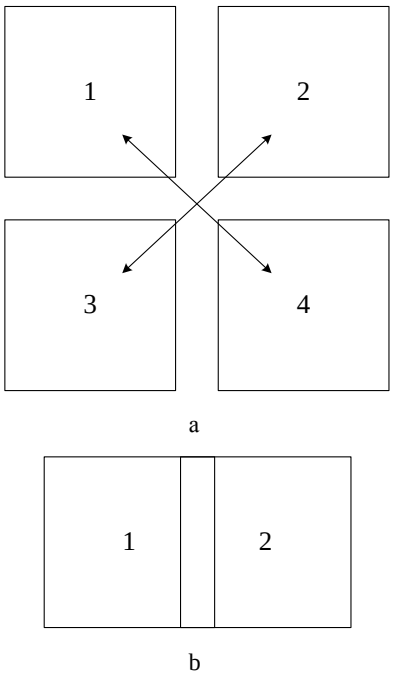

Fig. 5. The areas of cameras: a – an example of working space; b – the intersection of working areas

All the camera observation areas will intersect one another, as shown in fig. 5, etc. This simplifies determining the trajectory of the object motion. If the object is off the visual field of the cameras, then it is necessary to wait until the object appears. To do this, the cameras one by one prompt for movement. This is done with some delay in order to reduce the load on the system. If the object is in the camera visual field, the active camera is selected in the direction of the object's movement. But in this case, the common coordinate system for several cameras is necessary. If the object is on a flat surface and the cameras are perpendicular to this surface, the image dimensions can be used to determine the coordinates. In this case, the initial coordinate system is the coordinate system of the first camera where the motion was detected. If the object is detected by two cameras simultaneously, the coordinates of the object on the second camera are the coordinates of the object on the first camera. Then, the displacement of the coordinate system is calculated.

Movements can be identified in various ways. The most correct is selecting the moving contour and recording the trajectory of motion. The trajectory of motion is necessary for determining the direction of the object movement. Using the camera, in the visual field of which the object will appear, the direction of motion can be determined but only if the position of the cameras are known.

Let the mechanisms of connection of distributed areas of the working space be considered. Let the workspace of an intelligent robotic object be equipped with a set of video cameras (computer vision systems), where the working spaces of all cameras intersect in some areas (fig. 6).

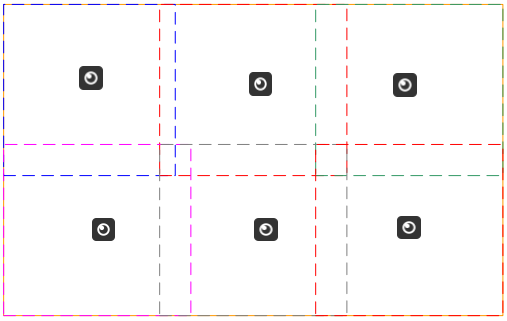

Fig. 6. Working space with cameras placed inside.

where  is a web-camera which acts as a computer vision system; different colours indicate the visual angles of each camera.

All schematic symbols presented on the fig. should be commented on in the way to clarify the sense it contains.

Fig. 6 shows the working space where a mobile robot operates; this robot is a part of the flexible integrated system, in particular, a global system of computer vision. If there are several cameras in the working space, the image of each of them may differ in several parameters, such as:

- the matrix resolution;
- the matrix type;
- brightness and contrast;
- sensitivity;
- viewing angle;
- frame rate, etc.

It follows that the image or streaming video received from the cameras can have different parameters, which makes it difficult to stitch it into one image for further work.

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As the stitching algorithm, the SIFT (Scale Invariant Feature Transform) algorithm is suggested. The algorithm consists in finding the singular points on the image and their descriptors. As points of singularity, those points that are most likely to be found on another image are considered. Descriptors are unique parameters of singular points.

To find such points, it is necessary to calculate the Gaussians (the application of Gaussian blur to the image) and their differences.

The descriptor for the SIFT method is a vector that is calculated on Gaussian nearest in scale to the key point, which is on the gradient in a window with selected key points. Before calculating the descriptor, this window is rotated to the angle of the direction of the key point, which ensures the invariance as for the rotation.

On the basis of the obtained singular points, there is an opportunity for stitching the images, that is, for obtaining a panoramic image.

The algorithm for obtaining a panoramic image consists of the following steps:

- loading images;
- registering the pairs of images;
- initializing the panorama;
- creating a panorama.

To create a panorama, successive pairs of images should be registered using the following 3 steps:

- identifying and comparing the characteristics of the last and penultimate image
- assessing geometric transformations;
- calculating the transformations necessary to create a panoramic image.

Fig. 7 shows original images and fig. 8 shows the result of their stitching (panoramic imaging) made by SIFT method.

Fig. 7. Original images

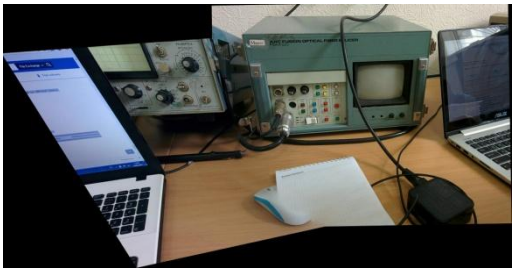

Fig. 8. Panoraming the images

Initializing a panorama means to create an empty panorama where images will be stitched together.

When the transformation with the input images is completed, the mixing function is performed in order to overlap the images. As a result of these actions, a panoramic image is obtained.

The selection of features and their comparison can be used to find necessary objects. To do this, the SURF (Speed Up Robust Features) method can be used.

The main advantage of this method is the speed of the key point detector. This is achieved using the integrated images and calculating the weighted determinant of the Hess matrix. Two-dimensional Haar wavelets are used to construct the descriptor. The main advantage of SURF is the speed of the key point detector. In addition, SURF is invariant to the scale and rotation of the image, small changes in lighting.

Let the algorithm of the software for searching for objects (in this case, the robot-hexapod) implemented in the MatLab environment be considered.

First, those images with which are going to be worked with are loaded (fig. 9 – 10).

After that, the resulting images turn into gradations of grey colour.

Fig. 9. The target object

Fig. 10. The object working space

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Then, all the key points on the image should be found and displayed. To do this, the algorithm SURF is used. The MatLab environment of the Image Processing package provides the function detectSURFFeatures for finding singular points and selectStrongest for displaying the strongest of them (fig. 11).

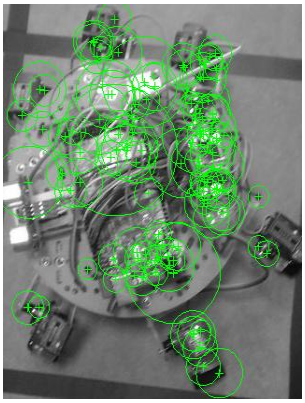

Fig. 11. The image of the strongest points

The main characteristics in the singular points on the two images are determined and extracted (the function extractFeatures).

Similarities are found according to their features on the images (matchFeatures).

After this, settled matching points are shown.

Peaks - the values of the experimental values that differ enormously - can appear on the images. They are eliminated by estimateGeometricTransform function.

Also, a polygon should be created, this polygon will limit the object that should be highlighted and shown. To do this, the transformPointsForward function is used.

The result of programme operation is shown in fig. 12.

Thus, the developed software implements SURF algorithm for determining the positions of individual objects of the working space of FIMS. And the working space includes one or several working areas that are united with the help of the software based on SIFT method.

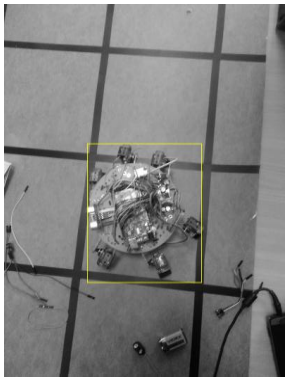

Fig. 12. The result of object selection by SURF method for finding the key points

Conclusions

According to the results of the studies carried out in the proposed article, the following is achieved:

Intellectual production systems, in particular, the control systems of itelligent type, were analyzed.

The features of operation of flexible integrated robotic systems are considered, to support them, mobile robotic transport-assembly platforms using decision support systems should be used.

The concept of adapting the functioning strategies as a basis for building an intelligent management system is suggested.

The logical model of decision support system is suggested, it is capable of solving transport and manipulation problems.

The software is developed that uses computer vision tools to unite the distributed parts of a workspace and to monitor its objects by recognizing and identifying mobile robots, process facilities and the most significant participants in the technological processes under the conditions of modern FIMS.

Experimental studies were carried out to recognize and identify mobile robots in a complex workspace with the help of the developed software.

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ІНТЕЛЕКТУАЛЬНІ ЗАСОБИ В СИСТЕМІ КЕРУВАННЯ ВИРОБНИЧИМ АГЕНТОМ

Предметом дослідження є інтелектуальні засоби в системі керування інтелектуального виробничого агента, **метою** – забезпечення якості управління гнучкою інтегрованою роботизованою системою шляхом створення інтелектуальної системи підтримки прийняття рішень. В роботі розв'язано наступні **завдання**: розглянуто сучасні тенденції розвитку та реалізації інтелектуальних систем керування виробничого призначення, сформульовано вимоги до формування імітаційних моделей систем підтримки прийняття рішень для розв'язання завдань гнучкого інтегрованого виробництва; розроблено логічну модель системи підтримки прийняття рішень інтелектуального виробничого агента, яка на основі подання даних про поточний стан інтегрованої системи, системи знань із описом можливих дій роботизованого обладнання, цілей виробничої системи описує процесс прийняття рішень у вигляді формування стратегії функціонування, здійснює адаптацію стратегій у разі змін робочого простору інтегрованої системи або окремих її цілей; сформовано подання системи знань гнучкої інтегрованої системи у вигляді стандартизованного опису можливих дій роботизованого обладнання; розглянуто формування опису розподіленого робочого простору інтегрованих систем та ідентифікації окремих об'єктів за допомогою засобів комп'ютерного зору. В основу дослідження покладено наступні **теоретичні та практичні засади**: теорія множин – для формування спільного подання імітаційних моделей системи підтримки прийняття рішень; теорія предикатів – для формування логічної моделі прийняття рішень; знання-орієнтовані методи та засоби мови програмування Prolog – для подання системи знань гнучкої інтегрованої системи, система MatLab – для аналізу робочого простору гнучкої інтегрованої системи. В **результаті** розроблено математичне, інформаційне та програмне забезпечення системи керування

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інтелектуального виробничого роботизованого агента. Показано можливості застосування запропонованої моделі в системі керування інтелектуальним роботом та вказано на можливості удосконалення подібних систем.

Ключові слова: логічна модель, інтелектуальний агент, мобільний робот, теорія предикатів, комп'ютерний зір

ИНТЕЛЛЕКТУЛЬНЫЕ СРЕДСТВА В СИСТЕМЕ УПРАВЛЕНИЯ ПРОИЗВОДСТВЕННЫМ АГЕНТОМ

Предметом исследования являются интеллектуальные средства в системе управления интеллектуального производственного агента, **целью** – обеспечение качества управления гибкой интегрированной роботизированной системой путем создания интеллектуальной системы поддержки принятия решений. В работе решены следующие задачи: рассмотрены современные тенденции развития и реализации интеллектуальных систем управления производственного назначения, сформулированы требования к формированию имитационных моделей систем поддержки принятия решений для решения задач гибкого интегрированного производства; разработана логическая модель системы поддержки принятия решений интеллектуального производственного агента, которая на основе представления знаний о текущем состоянии интегрированной системы, системы знаний с описанием возможных действий роботизированного оборудования, целей производственной системы описывает процесс принятия решений в виде формирования стратегии функционирования, осуществляет адаптацию стратегии в случае изменений рабочего пространства интегрированной системы или отдельных ее целей; сформировано представление системы знаний гибкой интегрированной системы в виде стандартизированного описания возможных действий роботизованного оборудования; рассмотрено формирование описания распределенного рабочего пространства интегрированных систем и идентификации отдельных обьектов при помощи средств компьютерного зрения. В основу исследования положены следующие **теоретические и практические основы**: теория множеств – для формирования общего представления имитационных моделей системы поддержки принятия решений; теория предикатов – для формирования логической модели принятия решений; знание-ориентированные методы и средства языка программирования Prolog – для представления системы знаний гибкой интегрированной системы, система MatLab – для анализа рабочего пространства гибкой интегрированной системы. В **результате** разработанным является математическое, информационное и программное обеспечение системы управления интеллектуального производственного роботизированного агента. Показаны возможности применения предложенной модели в системе управления интеллектуальным роботом и указано на возможности усовершенствования подобных систем.

Ключевые слова: логическая модель, интеллектуальный агент, мобильный робот, теория предикатов.

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THEORETICAL AND METHODICAL TOOLKIT FOR MANAGING THE STAKEHOLDERS OF A PROJECT

The **subject** matter is the processes of managing the stakeholders of a project. The **goal** of the work is to develop a theoretical and methodological toolkit that will help rationalize the work with the stakeholders of a project. The objectives of the project are to improve the processes of managing the stakeholders of a project by analyzing the stakeholders of the project, creating a list of stakeholders, grouping stakeholders, identifying key stakeholders and building the reserve of project stakeholders. The **methods** used are the methods of strategic management in the project activity. The **result** of the study is modelling the process of managing the stakeholders of a project with the help of the Allfusion Process Modeller software, which will enable systematizing the information on the stakeholders of a project, forming the reserve of stakeholders and thereby reducing the risk of the project incompleteness. The first step of the model is the analysis of project documentation and the creation of a list of the stakeholders of a project. Further, with the help of the Mitchell model, the stakeholders of a project are grouped. Four key stakeholders are identified for the project, namely – a customer, a project team, project performers, the future consumers of the project product. Contributions to the project are determined for each group of key stakeholders as well as incentives (benefits) that stakeholders receive from the project using the ASC model. Contributions and incentives are prioritized (by importance). Then the indicators for each contribution and incentive are determined and this information is recorded. The next step is to create a database of the stakeholders of a project, which enables systematizing information on the importance and the role of all stakeholders in the project. After dividing all the participants into three main categories, namely, the owner of the process or the manager, a key participant or a performer, an observer or important participant, they should be put in the project database. The given work presents the example of such a database organized in a table. The final step of the model for managing the stakeholders is building the reserve of the project stakeholders and updating project documentation. **Conclusions.** Improving the processes of managing the stakeholders of a project is of great importance in the current context as the impact of stakeholders on the project is growing every year and ignoring it will be a big mistake of the project manager.

Keywords: project, project management, management of project stakeholders, theoretical and methodological toolkit, contributions, incentives, role in the project, database.

Introduction

Managing the stakeholders of a project is a very important component of the project management, which is actively developing, as the role of stakeholders and their impact on the project are growing.

A project stakeholder is a person, a group or an organization that may influence the project, or which may be affected by the results of a project or by certain project objectives. [1]

Stakeholders include all participants of the project team as well as all interested subjects, both internal and external, in relation to the organization.

Internal subjects include company authorities, line services, a project team, workers, trade unions, groups of consultants and others.

External ones comprise managers of various specialized organizations in the fields of construction, export-import, insurance, safety engineering, job placement, environment, financial sources such as banks, shareholders of public funds; mass media; politics; trade unions; church; competitors; suppliers; personnel families.

Projects will be more successful if managers properly match their internal resources and opportunities with the needs of stakeholders. At the same time, the influence of stakeholders on the success of a project is significantly higher than in the corporate management.

The analysis of literary sources and problem statement

The theory of stakeholder management was first worked out by E. Ariman in 1984 [2]. Common approaches to managing the stakeholders of a project were developed by H. Sylvasti, R. Youker, S. Bushuev and others. Mathematical models for these purposes were considered in the works by such authors as C. Bell, N. Rackham, A. Frenkel and others [3,4].

However, many theoretical, methodological and especially applied aspects of the project management by the project stakeholders are not sufficiently developed, which determines the importance of this issue.

The goal and objectives of the study are the development of the theoretical and methodological toolkit that will help rationalize the work with the stakeholders of a project.

Materials and methods of the study

Introducing the theory of the stakeholders of a project into practice is based on the use of various tools designed to analyze the stakeholders of a project and their interaction.

The given work suggests that the Mitchell model should be used; this model was described by R. Mitchell, B. Agle and D. Wood in 1997 and is based on the assertion that managers will be concerned about the interests of the stakeholders only if it leads to better results of the firm. The Accountability Scorecard (ASC) system which was described for the first time by the well-known consultant F. Nichols in 2000 is also suggested for using. The database of the stakeholders of a project should also be built to develop the reserve.

The given work suggests modelling the process of managing the stakeholders of a project using AllFusion Process Modeller, namely, building the model “Managing

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the stakeholders of a project" on the basis of the methodology of the project management.

The results of the study

The development of a practical toolkit for improving the management of the project stakeholders will reduce the risks of the project, thereby increasing the probability of its successful implementation as the correct assessment of a potential partner is one of the key tasks of a project manager.

The description of results

One of the first tasks of the project manager is to compile a list of project stakeholders. To complete the list of project stakeholders, the project documentation should be analyzed. A project manager thoroughly examines all project documents such as a project plan, a project charter, the retrospective information on similar projects, evaluates the project product and creates the list of project stakeholders on the basis of a detailed study.

The Mitchell model is suggested for managing projects. This model is used for identifying the significance of stakeholders. Stakeholders are classified according to three attributes – power, law, urgency [5].

The attribute "Power" means the capability of a stakeholder to obtain the desired result using force, power, finances and emotional resources. The attribute "Law" means the compliance with legal norms and norms of public morality. The attribute "Urgency" means promptness.

Depending on the amount of each of them, seven groups are distinguished:

- inactive;
- dominating;
- controlling;
- depending;
- demanding;
- dangerous;
- determining.

A certain attribute is not permanent: the parties can acquire or lose it after a while. Project stakeholders are grouped according to the Mitchell model, which is presented in Table 1.

Table 1. *The examples of grouping the project stakeholders according to the Mitchell model*

A stakeholder group	A stakeholder name
Determining group	Customer
Dominating group	Project team
Dependent group	Project performers (a repair and construction company, a designing agency, a recruiting agency)
Dangerous group	Future consumers of the project product
Inactive group	Local authorities
Controlling group	State institutions
Demanding group	Personnel

The model is graphically presented in fig. 1.

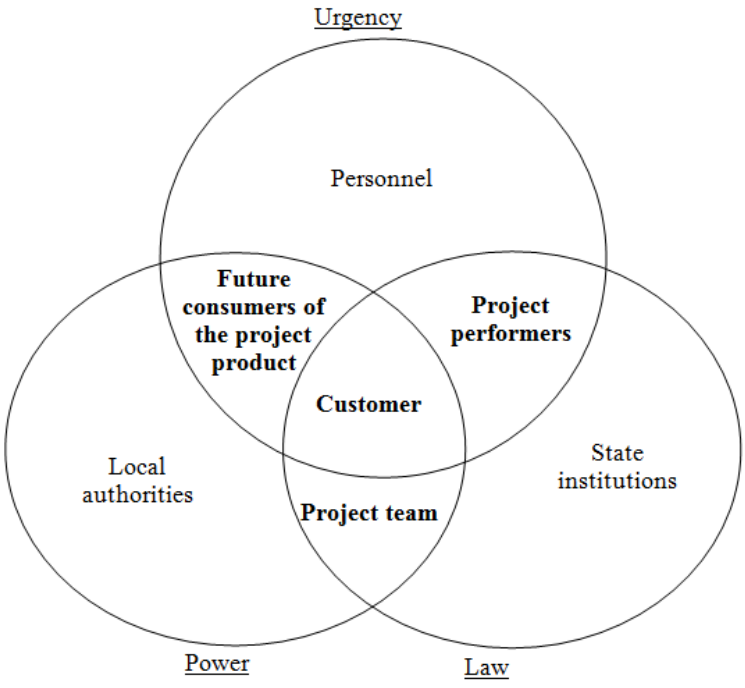

Fig. 1. Graphical presentation of the Mitchell model for the project

Four key stakeholders were distinguished on the basis of the Mitchell model, namely,

- customer;
- project team;
- project performers;
- future consumers of the project product.

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The system of accountability indicators (ASC – Accountability Scorecard) is suggested for using in project activities. ASC is developed; this system comprises an enterprise and stakeholders are linked by contributions and incentives. ASC is designed for finding the "balance of interests" between a project and various stakeholders, for studying the interrelations among various stakeholders.

Two types of interaction of a project and stakeholders are distinguished – the contributions of stakeholders, benefits and incentives which maintain the project. In general, stakeholders remain interested only as long as the project provides incentives whose value exceeds contributions or at least compensates them.

Contributions are considered in this article as a material, monetary, physical and other participation of stakeholders in the project.

Incentives are benefits and compensation in any form that provide the project to interested parties.

Thus, the project receives contributions which are determined for each group of key stakeholders of a project and the stakeholders receive incentives (benefits) from the project. Contributions and incentives are prioritized (by significance). Then, the indicators for each contribution and incentive are determined; this information is recorded.

The example of contributions, incentives and corresponding indicators for the basic groups of project stakeholders is given in table 2.

Table 2. *Determining contributions, incentives and corresponding indicators for the basic groups of project stakeholders according to the ASC model*

Project stakeholders	Contributions	Indicators of contributions	Incentives	Indicators of incentives
Customer	Project capital	The amount of investment	Return on investment	Net profit
Project performers	Filling of an order	Average term of work performance	Full and timely payment for work	Average term of payment for work
Project team	Full implementation of the project	Average term of work performance	Working schedule, full and timely payment for work	Favourable working conditions
Future consumers of the project product	Interest in the product of the project	The share of regular customers, the amount of sales revenue	Availability and cost of the project product	The price of the product of the project compared to competitors

It is also suggested to create the database of project stakeholders, which enables systematizing information on the significance and role of all project stakeholders. The creation of the database of project stakeholders should start at the beginning of the project when the goal of the project, the main project participants are known and the charter and the project plan are created. Since the most important task of the project manager is managing the project environment, the database of participants should be constantly updated.

Having a list of project stakeholders, the next step of the project manager is to group them according to the impact they can make on the project. There are three types of participants – the owner of the process or the manager, a key participant or a performer, an observer or an important participant. After dividing all participants into three main categories, they should be put into the project database. One of the easiest tools for creating the database of participants is the Microsoft Excel spreadsheet.

The database of project stakeholders is given in table 3.

Table 3. *The example of the database of the project stakeholders*

The type of the project participants			The scale of the participants' accountability for the project					
PO	KP	IP	F	A	C	P	Pr	I
Customer			+	+				
	Project manager			+		+	+	
	Project team					+	+	
	Project performers				+	+		
	Supplying firms				+			
	State institutions				+			
		Government						+
		Local authorities						+
		Consumers of the project product						+
		Competitors						+
		Social groups of population						+

The type of the project participants and the level of their impact include:

- *PO* – the process owner (can stop or continue a project);

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- *KP* – a key participant (can delay the performance of a project);
- *IP* – an important participant (people who are interested in the project and its results and do not actively participate in it).

Accountability for the project and making a decision includes:

- *F* – a person who finances the project;
- *A* – a person who approves or vetoes;
- *C* – consultant (necessary information should be received from him);
- *P* – preparation (accountability for work initiation);
- *Pr* – a performer (accountability for performing the work);
- *I* – a person who obtains information (only necessary information).

In the database, the positions of the manager, key and important participants are recorded in the left part of the table, while the specific characteristics of participants are given in the right side of the table.

The general model "Managing the project stakeholders" is suggested to be built using AllFusion Process Modeller.

The diagram of the process decomposition "Managing the project stakeholders" is given in fig. 2. According to the model, the cycle of the process "Managing the project stakeholders" is as follows – the analysis of project documentation, the creation of the list of stakeholders, the use of the Mitchell model, the use of the ASC system, building the database of project stakeholders, updating project documentation.

Conclusions

Thus, the processes of managing project stakeholders are modelled using the software All Fusion Process Modeller, which enables systematizing information on stakeholders, forming the reserve of stakeholders and reducing the risk of the project incompleteness.

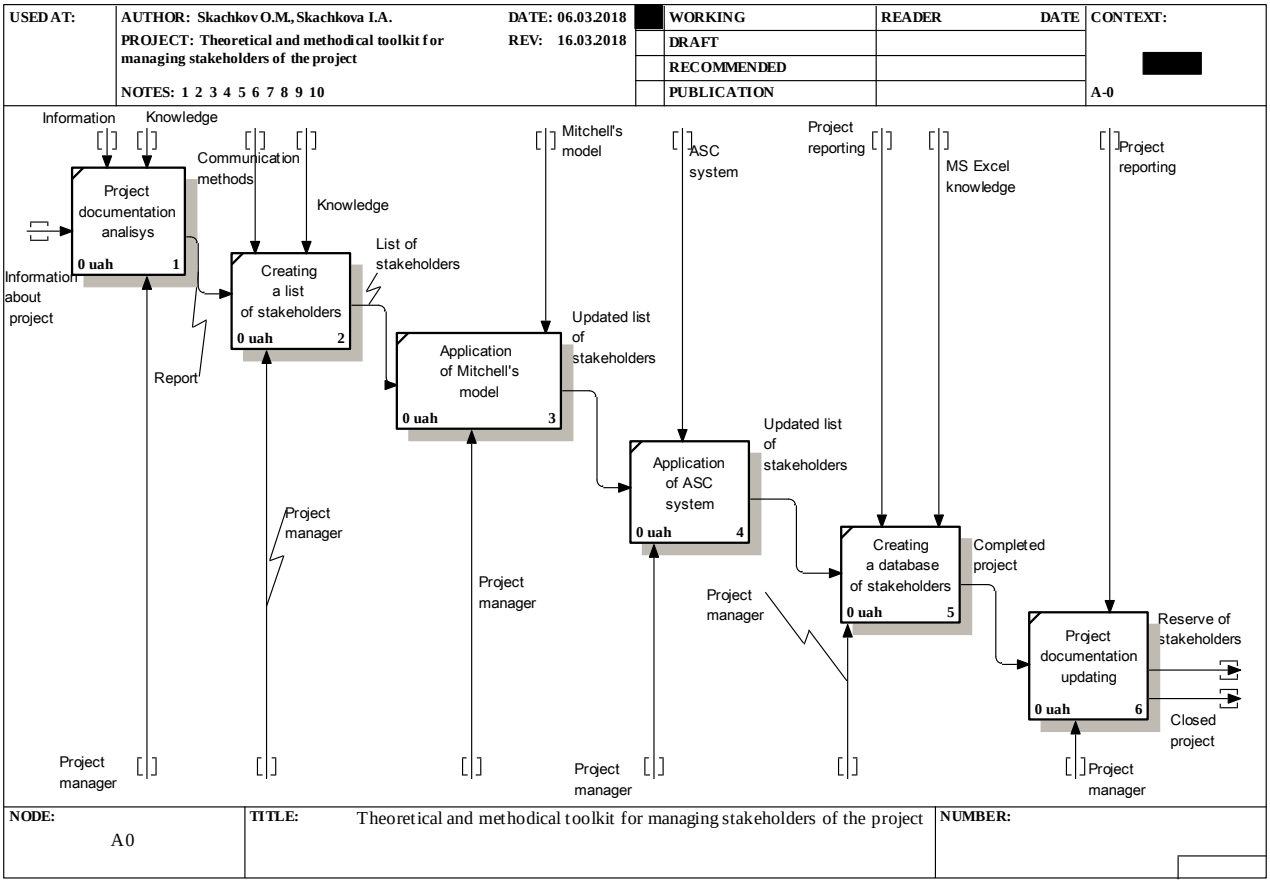

Fig. 2. The diagram of the process decomposition "Managing the project stakeholders"

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ТЕОРЕТИКО-МЕТОДИЧНИЙ ІНСТРУМЕНТАРІЙ УПРАВЛІННЯ ЗАЦІКАВЛЕНИМИ СТОРОНАМИ ПРОЕКТУ

Предметом є процеси управління зацікавленими сторонами проекту. **Метою** роботи є розробка теоретико-методичного інструментарію, який допоможе раціоналізувати роботу із зацікавленими сторонами проекту. **Завданням** проекту є удосконалення процесів управління зацікавленими сторонами проекту шляхом аналізу зацікавлених сторін проекту, створення переліку зацікавлених сторін, групування зацікавлених сторін, виділення ключових зацікалених сторін та формування резерву зацікавлених сторін проекту. В якості **методів** дослідження пропонується застосувати методи стратегічного управління в проектній діяльності. **Результатом** дослідження є моделювання процесів управління зацікавленими сторонами проекту за допомогою програмного продукту AllFusion Process Modeller, що дозволить систематизувати інформацію щодо зацікавлених сторін проекту, сформувати резерв зацікавлених сторін і тим самим зменшити ризик незавершення проекту. Першим кроком моделі є аналіз проектної документації та створення переліку зацікавлених сторін проекту. Далі за допомогою моделі Мітчелла проведено групування зацікавлених сторін проекту . Було визначено чотири ключові зацікавлені сторони для проекту, а саме: замовник, команда проекту, виконавці проекту, майбутні споживачі продукту проекту. Для кожної групи ключових зацікавлених сторін визначаю ться внески, які проект отримує від них, і стимули (вигоди), які отримують від проекту зацікавлені сторони за допомогою використання моделі ASC. Проводиться ранжування внесків і стимулів за пріоритетом (важливістю). Далі визначення показників для кожного внеску і стимулу і ця інформація фіксується. Наступним кроком пропонується створити базу даних зацікавлених сторін проекту, що дасть можливість систематизувати інформацію щодо важливості і ролі в проекті всіх його зацікавлених сторін. Після поділу всіх учасників на три основні категорії, а саме: власник процесу чи розпорядник, ключовий учасник чи виконавець, спостерігач чи важливий учасник, їх необхідно занести в базу даних проекту. В представленій роботі надано приклад таблиці такої бази даних. Останній кроком моделі управління зацікавленими сторонами проекту є формування резерву зацікавлених сторін проекту та оновлення проектної документації. **Висновки:** таким чином, удосконалення процесів управління зацікавленими сторонами проекту є досить актуальним в сучасних умовах, так як вплив стейкхолдерів на проект з кожним роком росте, і не враховувати це буде великою помилкою менеджера проекту.

Ключові слова: проект, управління проектами, управління зацікавленими сторонами проекту, теоретико-методичний інструментарій, внески, стимули, роль в проекті, база даних.

ТЕОРЕТИКО-МЕТОДИЧЕСКИЙ ИНСТРУМЕНТАРИЙ УПРАВЛЕНИЯ ЗАИНТЕРЕСОВАННЫМИ СТОРОНАМИ ПРОЕКТА

Предметом являются процессы управления заинтересованными сторонами проекта. **Целью** работы является разработка теоретико-методического инструментария, который поможет рационализировать работу с заинтересованными сторонами проекта. **Задачами** проекта является усовершенствование процессов управления заинтересованными сторонами проекта

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путем анализа заинтересованных сторон проекта, создания перечня заинтересованных сторон, группирования заинтересованных сторон, выделения ключевых заинтересованных сторон и формирования резерва заинтересованных сторон проекта. В качестве **методов** исследования предлагается применить методы стратегического управления в проектной деятельности. **Результатом** исследования является моделирование процессов управления заинтересованными сторонами проекта с помощью программного продукта Allfusion Process Modeller, что позволит систематизировать информацию относительно заинтересованных сторон проекта, сформировать резерв заинтересованных сторон и тем самым уменьшить риск незавершения проекта. Первым шагом модели является анализ проектной документации и создания перечня заинтересованных сторон проекта. Дальше с помощью модели Митчелла проведено группирование заинтересованных сторон проекта. Было определено четыре ключевые заинтересованные стороны для проекта, а именно: заказчик, команда проекта, исполнители проекта, будущие потребители продукта проекта. Для каждой группы ключевых заинтересованных сторон определяются взносы, которые проект получает от них, и стимулы (выгоды), которые получают от проекта заинтересованные стороны с помощью использования модели ASC. Проводится ранжирование взносов и стимулов за приоритетом (важностью). Далее определяются показатели для каждого взноса и стимула и эта информация фиксируется. Следующим шагом предлагается создать базу данных заинтересованных сторон проекта, что даст возможность систематизировать информацию относительно важности и роли в проекте всех его заинтересованных сторон. После деления всех участников на три основных категории, а именно: владелец процесса или распорядитель, ключевой участник или исполнитель, наблюдатель или важный участник, их необходимо занести в базу данных проекта. В представленной работе предоставлен пример таблицы такой базы данных. Последней шагом модели управления заинтересованными сторонами проекта являются формирования резерва заинтересованных сторон проекта и обновление проектной документации. **Выводы:** таким образом, усовершенствование процессов управления заинтересованными сторонами проекта есть довольно актуальным в современных условиях, так как влияние стейкхолдеров на проект с каждым годом растет, и не учитывать это будет большой ошибкой менеджера проекта.

Ключевые слова: проект, управление проектами, управление заинтересованными сторонами проекта, теоретико-методический инструментарий, взносы, стимулы, роль в проекте, база данных.

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ON THE APPROACH TO SEARCHING FOR FUNCTIONAL DEPENDENCES OF DATA IN RELATIONAL SYSTEMS

The **subject** matter of the study is information systems built on the basis of relational databases. The **goal** of the article is to develop a method for re-engineering relational databases that takes into account implicit interrelated functionally dependent data that affect the structure of the logical model. The following **results** are obtained: the approach to identify previously unknown functional dependencies based on the analysis of a set of relational database data is suggested; the classes of tasks of reengineering relational databases are specified; the stage of developing the target logic diagram which is common for the problems of adaptation and refactoring was studied; the sub-task of checking if the logic diagram of the relational database corresponds to the third normal form within this stage is considered using the synthesis method; it is shown that the solution of this task involves a number of difficulties, in particular, it is necessary to find a set of functional dependencies that are performed on the current instance of the data of a relational database; the approach for finding a set of functional dependencies from an instance of the data of a relational structure is suggested. The direction of further research can be the support of empty values at the stage of identifying functional dependencies as well as the issues of data transfer without any loss from the initial structure of the database to the target data obtained as a result of applying the methods of re-engineering. **Conclusions.** The approach is suggested to identify previously unknown functional dependencies which are based on the analysis of a set of relational database data. The first step is to get a set of functional dependencies for each relationship. The similar operation for the universal relation of the target database is performed at the second step. At this step, functional dependencies among the attributes of different relationships, that is the interrelationships among the data that were established during the information system operation, can be identified. The method for determining their information novelty is suggested; this method consists in verifying the membership of the functional dependencies of the universal relation while discovering the union of sets of dependencies of individual relations. A promising direction for further research is the development of methods to implement the technology for verifying if the obtained dependencies correspond to the logical model of the domain.

Keywords: reengineering, relational database, functional dependence, discovering dependences, universal relation, closing functional dependencies.

Introduction

The rapid development of information technology has led to major changes in all stages of the life cycle of information systems (IS), in particular, at the stage of support and maintenance. Constantly changing requirements in the condition of shortened terms of development adversely affect both the quality of the product and the further opportunities for its development and maintenance. Situations often happen when further support for individual components or the whole system becomes extremely difficult because of the significant complexity of the internal structure while the design of a new system that can meet current requirements is inappropriate for a number of reasons (economic or time factors and so on). One way to solve such problems is to carry out re-engineering, whose goal is to improve the characteristics of the initial IS based on a preliminary analysis of the IS current state and its individual components [1].

The basic problems of information system design

The development and implementation of many modern large information projects are usually long, their cost exceeds the planned one and the final product can be unreliable and difficult to maintain. All this leads to the situation that is known as the “software crisis”. Although the crisis was first mentioned in the late 1980s, even after 30 years it still cannot be bridged over.

Some of the reasons for the general problem of designing complex information systems are as follows:

- the development of about 40% of systems fails to be successful or stops before the work is completed;
- business interests are rationally integrated and the developed information technology is used only in 25% of systems;
- only 20-30% of information systems meet all the criteria for achieving success.

The major failures in developing software have been caused by the lack of the complete specification of all requirements within the design phase, the shortage of acceptable development methodology or by the fact that a general global project is not sufficiently divided into separate components that can be effectively controlled and managed.

In the case of the partial implementation of the requirements of users of the information system or a change in the business process to such an extent that the system ceases does not meet the requirements of users any more, several options of the development are possible:

- developing a new system;
- modifying (developing) the existing system (legacy system);
- reengineering the existing system (legacy system).

The first option is the simplest and preferable for the developer but does not satisfy the requirements of users because additional time and financial resources are required; besides, there are development risks and the risks of loss of the accumulated information within the life cycle of the used IS. The re-engineering of legacy information systems requires that experts in the field of information systems and technologies should be engaged, which makes the work overcomplicated. There is an opinion that in most cases it is easier to develop a new system than to re-engineer it. This is connected with the qualification of specialists who need to be involved in work. Their skills should be sufficiently high level to

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solve a set of design problems and create a modified information system [1].

Re-engineering of information systems in general and databases, in particular, has become an object of close attention and active studies. To expand the functionality and improve the performance of available systems, the process of re-engineering requires determining and understanding all the components of such systems. The database, which is a part of the system, is the most important component of the information system. Nowadays, relational databases (RDBs) are dominant and the vast majority of available software applications and services use them. This is the reason for selecting the RDB as the object of the research.

Current studies in the field of this topic were analyzed. The main areas of development are re-engineering of the logic diagram with the help of an intermediate representation such as an ER-model or own metamodels and applying of a set of pre-set rules for translating model objects in RDB designs, re-engineering of obsolete databases; extracting the structure of both obsolete and relational databases and presenting it as a conceptual data model, in particular, an ER-model [2, 3].

This article examines the task of identifying information about the relationships among data that could be established during the operation of the database. Relationships are represented as dependencies of various types, which can then be used as input data for the methods of re-designing the RDB. To achieve this, methods for restoring the data structure conditioned by their interrelations are being developed for later analyzing and transferring data to a modern platform, usually relational one. The data are of the greatest value, therefore a range of measures described above is aimed at minimizing the loss of meaningful information during the transfer process. Another area of interest is the support and maintenance of modern RDBs.

Methods to identify the relationships among the data preferentially use functional dependencies (FD) as a means of representing such relationships [4]. This happens due to the fact that functional dependencies enable representing in the simplest possible manner the relationships among the objects of the target subject domain. Other types of dependencies that are taken into account are inclusion dependencies and multi-valued dependencies but their use and methods of detection are not considered in this paper. It should be noted that the mentioned methods are directed primarily at using in data-mining systems and focus on identifying approximate functional dependencies that enable presenting probable links that have a certain error [5]. In this paper, the use of such methods also makes it possible to obtain a set of strict FDs, that is, valid for the entire set of input data at the time of processing.

Problem statement

This article deals with the methods for solving the task to identify previously unknown functional dependencies from a set of data of the target RDB, which will be definitely correct at the time of processing. The task of discovering hidden dependencies is an integral part of the task of re-engineering and refers to the stage of preliminary collection of information about the target RDB. The described method is a variant for making an automated decision directly oriented to the detection of new dependences in the data generated by the target area [6].

Discovering hidden dependences

Initial data for solving the set task are – the logic diagram of a relational database $\Sigma = \{\sigma_i\}, i = \overline{1,n}$, where σ_i is a diagram of one relation that is a *DB* part, n is a number of relations; the diagram of relations $\sigma_i =< R_i, F_i >$, where R_i is the medium of relations (many attributes), F_i is a set of functional dependences (*FD*) that meet this relation. $\mathrm{P} = \{\rho_i, i = \overline{1,n}\}$ is a set of relations of the target *DB*.

The functional dependence of $A \to B$ type indicates that for any two tuples u, v of a certain relation ρ_k there is the conclusion $u(A) = v(A) \Rightarrow u(B) = v(B)$. As an associated example, the logic diagram $\Sigma = \{\sigma_1, \sigma_2\}$ is considered, this diagram comprises two diagrams of relations: $\sigma_1 =< R_1 = \{A, B, C\}, F_1 >, \sigma_2 =< R_2 = \{C, D\}, F_2 >$. Let us assume that there is no information about F_1, F_2 or it has been lost. A set of FD that meet these relations can be obtained using the method of FD detection from instances of target relations, in particular, Tane method whose principles and methods of implementation are detailed in [7, 8]. When this method is used, a set of minimal FDs that meet a set of data in the relation at the moment of processing can be obtained. A minimal FD is the FD of the $X \to Y, X = \{A_1, \dots, A_n\}, Y = \{B_1, \dots, B_m\}$ type that does not contain a set of $Z \subset X$ where $Z \to Y$ is true. Trivial FDs of the $A_1 \to A_1$ type are neglected by the used method as they are not significant. Let us consider the example; the relations ρ_1, ρ_2 are presented below:

ρ_1

A	B	C
1	1	1
2	2	1
1	2	2
1	3	3
3	1	1
4	2	2
2	2	4

ρ_2

C	D
1	1
2	1
3	1
4	1

Using Tane method, the following sets of FD for the given relations $F_1 = \{AC \to B\}, F_2 = \{C \to D\}$ are obtained.

Taking into considerations sets of FD for F_1 and F_2, a set of FD diagram Σ is as follows: $F_\Sigma = \bigcup_{i=1}^{2} F_i = \{AC \to B, C \to D\}$; the medium of universal

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relation $R=\{R_1 \cup ... \cup R_n\}$ for the target example is as follows: $R=R_1 \cup R_2 = \{A,B,C\} \cup \{C,D\} = \{A,B,C,D\}$;

The universal relation can be obtained through the natural combination of all relations that are included in the diagram. The result of this combination for the example is presented below.

Table 1. *Universal relation*

A	B	C	D
1	1	1	1
2	2	1	1
1	2	2	1
1	3	3	1
3	1	1	1
4	2	2	1
2	2	4	1

Using Tane method for the obtained universal relation, the following FDs are discovered: $\overline{F_\Sigma} = \{AC \to B, C \to D, A \to D, B \to D\}$. This set contains all minimal FDs that are included in F_Σ as well as additional earlier unknown FDs $F_\Sigma^{'} = \{A \to D, B \to D\}$. Consequently, a set of *FD* of the universal relation for the logic diagram Σ can be expressed as follows: $\overline{F_\Sigma} = F_\Sigma \cup F_\Sigma^{'}$, where F_Σ is a set of FDs that meet the initial relations Σ, and $F_\Sigma^{'}$ is a set of additional FDs.

It is necessary to determine whether FDs from a set of $F_\Sigma^{'}$ can be derived from F_Σ or they are new information. To do this, it is suggested that the method of checking if FD corresponds to the closure $(F_\Sigma)^+$ should be used; this method was offered by D. Meyer in [9] – solving the problem of membership. The principle is as follows: as F^+ building is connected with sorting out all the subsets of attributes that belong to F and has an exponential complexity, it is suggested that F should be built – the closure on a set of attributes. F - closure of a set of X is such a set of attributes X^+ where $X \to X^+ \in F^+$ and there are no attributes in R that would depend on X but would not belong to X^+ [10]. The implementation of the method of building F - closure has a linear complexity. Thus, the method of checking if FD $X \to Y$ belongs to the closure F^+ consists of building F - closure of X^+ and determining if the expression $Y \subseteq X^+$ is true. If the expression is true, $X \to Y \in F^+$.

Let us consider the example: to check if $A \to D$ belong to F_Σ^+, A^+ should be built. According to [8], $A^+ = \{A\}$, as F_Σ does not contain FDs where A is the only attribute on the left side of FD. $D \notin A^+$, therefore, $A \to D \notin F_\Sigma^+$. It is shown that $B \to D \notin F_\Sigma^+$ in a similar way. Thus, a set of discovered dependences $F_\Sigma^{'}$ is non-derivable and therefore if new information [11,12].

It should be noted that this approach does not ensure that new dependences fully correspond to the target area. As it is based on a set of data which are included in RDB at the moment of processing and does not take into consideration their semantics, there is a major risk that random FDs can be obtained. A random FD is a FD which is not correct for a particular subject area (for example, the date of a person's birth determines the date of the person's child) and can be removed at any moment by changing or adding the tuples of dates that contradict the discovered dependence in the process of RDB operation [13].

Thus, there is another task – to check if new dependences are correct for the subject area which is modelled by the considered RDB. This work does not consider the solution of this task, this is the area of further studies. An expert assessment can be used as a way for solving this task. Or a numerical criterion for each single FD can be used, which enables establishing a threshold value, and dependences that are below this value are considered as random ones.

Conclusions

This paper suggests the approach to identify previously unknown functional dependencies, which is based on the analysis of a set of relational database data. The first step is to obtain a set of FD for each relationship. The similar operation is performed for the universal relation of the target RDB at the second step. At this step, the FD among the attributes of different relationships – the relationship among the data established in the process of the RDB operation can be discovered. The method for determining their information novelty is suggested; this method consists in checking if the FZ of the universal relation participates in closing the union of FD sets of individual relations.

The area for further studies is the development of methods and means for checking if the obtained dependencies are correct for the subject area, which is modelled by the considered RDB.

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ПРО ОДИН ПІДХІД ДО ПОШУКУ ФУНКЦІОНАЛЬНИХ ЗАЛЕЖНОСТЕЙ ДАНИХ У РЕЛЯЦІЙНИХ СИСТЕМАХ

Предметом дослідження є інформаційні системи, побудовані на основі реляційних баз даних. **Метою** статті є розробити метод для реінжинірингу реляційних баз даних, що враховує неявні взаємопов'язані функціонально залежні данні, які впливають на структуру логічної моделі. Отримані такі **результати**: в статті запропоновано підхід до виявлення раніше невідомих функціональних залежностей, який ґрунтується на аналізі безлічі даних реляційної бази даних. Виділено класи завдань реінжинірингу реляційних баз даних; досліджений етап формування цільової логічної схеми, яка є спільною для задач адаптації та рефакторінга. Розглянуто підзавдання перевірки відповідності логічної схеми реляційної бази даних третій нормальній формі в межах даного етапу за допомогою методу синтезу; показано, що її рішення пов'язане з низкою труднощів, зокрема, необхідністю знаходження безлічі функціональних залежностей, що виконуються на поточному екземплярі даних деякої реляційної бази даних. Запропоновано підхід для знаходження безлічі функціональних залежностей з примірника даних реляційної структури. Напрямком для подальших досліджень може стати реалізація підтримки порожніх значень на етапі виявлення функціональних залежностей, а також питання перенесення даних без втрат з вихідної структури бази даних в цільову, отриману в результаті застосування методів реінжинірингу. **Висновки.** В роботі запропоновано підхід до виявлення раніше невідомих функціональних залежностей, який ґрунтується на аналізі безлічі даних реляційної бази даних. Першим кроком є отримання безлічі функціональних залежностей для кожного відношення. На другому кроці проводиться аналогічна операція для універсального відношення даної бази даних. На цьому кроці стає можливим виявлення функціональні залежності між атрибутами різних відносин – взаємозв'язку між даними, які встановилися в процесі функціонування інформаційної системи. Запропоновано спосіб визначення їх інформаційної новизни, який полягає у перевірці членства функціональних залежностей універсального відношення в замиканні об'єднання множин залежностей окремих відносин. Для подальших досліджень перспективним напрямком є розробка методів для реалізації технології перевірки отриманих залежностей на предмет відповідності логічної моделі предметної області.

Ключові слова: реінжиніринг, реляційна база даних, функціональна залежність, виявлення залежностей, універсальне відношення, замикання функціональних залежностей.

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ОБ ОДНОМ ПОДХОДЕ К ПОИСКУ ФУНКЦИОНАЛЬНЫХ ЗАВИСИМОСТЕЙ ДАННЫХ В РЕЛЯЦИОННЫХ СИСТЕМАХ

Предметом исследования являются информационные системы, построенные на основе реляционных баз данных. **Целью** статьи является разработать метод для реинжиниринга реляционных баз данных, учитывающий наличие неявных взаимосвязанных функционально зависимых данных, которые влияют на структуру логической модели. Получены следующие **результаты:** в статье предложен подход к выявлению ранее неизвестных функциональных зависимостей, который основывается на анализе множества данных реляционной базы данных. Выделены классы задач реинжиниринга реляционных баз данных; исследован этап формирования целевой логической схемы, которая является общей для задач адаптации и рефакторинга. Рассмотрена подзадача проверки соответствия логической схемы реляционной базы данных третьей нормальной форме в рамках данного этапа с помощью метода синтеза; показано, что ее решение сопряжено с рядом трудностей, в частности, необходимостью нахождения множества функциональных зависимостей, выполняющихся на текущем экземпляре данных некоторой реляционной базы данных. Предложен подход для нахождения множества функциональных зависимостей из экземпляра данных реляционной структуры. В качестве направления для дальнейших исследований можно выделить реализацию поддержки пустых значений на этапе выявления функциональных зависимостей, а также вопросы переноса данных без потерь из исходной структуры базы данных в целевую, полученную в результате применения методов реинжиниринга. **Выводы.** В работе предложен подход к выявлению ранее неизвестных функциональных зависимостей, который основывается на анализе множества данных реляционной базы данных. Первым шагом является получение множества функциональных зависимостей для каждого отношения. На втором шаге проводится аналогичная операция для универсального отношения рассматриваемой базы данных. На этом шаге становится возможным выявить функциональные зависимости между атрибутами различных отношений – взаимосвязи между данными, которые установились в процессе функционирования информационной системы. Предложен способ определения их информационной новизны, который состоит в проверке членства функциональных зависимостей универсального отношения в замыкании объединения множеств зависимостей отдельных отношений. Для дальнейших исследований перспективным направлением является разработка методов для реализации технологии проверки полученных зависимостей на предмет соответствия логической модели предметной области.

Ключевые слова: реинжиниринг, реляционная база данных, функциональная зависимость, выявление зависимостей, универсальное отношение, замыкание функциональных зависимостей.

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OPTIMIZING THE TECHNOLOGY OF RECONDITIONING LARGE HIGH PRECISION GEAR RIMS

The **subject** matter of the research is issues related to the optimization of the technology for reconditioning large-size high precision gear rims of the drives of mining complexes, mine lifting equipment, heavy vehicles; these issues are a perspective trend for reducing the cost of reconditioning and operation of expensive unique equipment. The **goal** is to ensure intensifying production processes, increasing workloads and speeds, reducing the deterioration of high precision gear rims. The **objective** is to develop a new technology to optimize reconditioning large high precision gear rims. To achieve this, the following **method** is suggested – to machine gear rims after they have been surfaced by pre-milling with special hob cutters with a prominence and by final machining the teeth with special cutters equipped with hardmetal inserts that process teeth along the line of engagement, which does not require making full-length cutting teeth and increases the quality of machining, the durability of hardmetal milling cutters. The process of reconditioning of large high precision gear rims is a resource-saving technology, as compared with manufacturing new parts, this technology considerably reduces the cost of materials for manufacturing, decreases a number of process steps, reduces the cost of machining equipment, tools, cutting and measuring instruments. The smooth operation of a gear train can be ensured only at a constant gear ratio but due to manufacturing and operational errors, the gear ratio is not constant at every time, which intensify the deterioration of large high precision gear rims. The following **results** are obtained. The possibility and practicability of using hob cutters with a prominence (m = 20-28 mm) while rough cutting the worn and reconditioned large gear rims was proved. To obtain the necessary durability of rough milling cutters, it is recommended that the prominence angle be set within 8-10°. The use of hardmetal hob cutters for finishing makes it possible to increase the performance rate by 2 to 3 times as compared to high-speed cutters of other designs and to obtain the necessary quality and precision of manufacturing worn and reconditioned large gear rims. **Conclusions.** The technology for the optimization of reconditioning large high precision gear rims with the use of special and universal hardmetal single- and double-flute cutters that have both re-sharpened cutting elements and disposable rotary tools was developed and introduced.

Keywords: new optimization technology, reconditioning large gear rims, high precision, hob cutters with a protuberance, special cutters, machining tooth along the line of engagement, improving the quality of machining.

Introduction

The performance of mining complexes, mine lifting equipment, heavy vehicles is gradually getting worse due to the deterioration of their equipment in the process of operation. Among them, there are large high precision gear rims. Such large gears can have failures and malfunctions that are fixed in the course of various types of reconditioning and repairing activities. To ensure high-quality recovery, a new technology for the optimization of reconditioning large high precision gear rims is suggested.

The service life of fast-wearing large gear trains determines the prove-in performance of expensive machines. Stopping equipment to replace worn large gear trains with new ones leads to a significant decrease in labour productivity, disrupts the rhythm of the production process, causes non-productive metal costs to manufacture new parts and results in the need for special maintenance teams.

Analysis of literary sources and problem statement

Modern trends in intensifying of production processes, increasing workloads, speeds, temperatures lead to faster deterioration of parts, and along with the need for production automation, give points to the problem of increasing the service life of quickly deteriorated machine parts [1, 4, 7, 9], so most of the parts that are connected with other parts wear out fast. This process results in material damage when the material scales off the solid surface and its friction strain accumulates. These phenomena lead to a gradual change in the size and shape of a part. The techniques for reconditioning the parts and joint connections are resource-saving, as compared to the manufacture of new parts, the costs for materials in manufacturing are significantly reduced, a number of technological operations is decreased, the costs for machine tools, devices, cutting and measuring equipment as well as for labour remuneration of workers are reduced [2, 3, 5, 10]. A part that has toothed surfaces is known to be under cyclic and dynamic loads while operating, which leads to the damage of working surfaces. The smooth operation of the gear train can be ensured only at a constant gear ratio but due to manufacturing and operation errors, for example, the deformation of teeth, the gear ratio does not remain constant at every time [6, 8, 11]. Moreover, dynamic loads or interference generate an additional negative impact. The deformation of gear wheels, as well as manufacturing errors lead to uneven distribution of the load across the width of the gear rim.

When the worn-out teeth are repaired by surfacing, the worn side of each tooth is surfaced when the gear wheels are of a large diameter (up to 15 m) and a module is of more than 10 mm. High wear resistance and durability of the faced surfaces of teeth can be ensured by using the alloys of sormite and stalinite types. A thin coat of sormite is spread on the surface firstly faced with a filler material and roughed up (fig. 1). After surfacing with sormite, the teeth are firstly milled with special hob cutters with a prominence and finally machined with special cutters with hardmetal inserts [1, 2, 3].

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a) b)

Fig. 1. Worn large gear wheels: a) a worn cylindrical gear wheel; b) a worn cylindrical gear wheel surfacing

When operating large cylindrical gear trains, the following types of tooth fracture occur: fatigue spalling of the teeth working surfaces, chipping of the teeth, deterioration, binding of teeth, crushing of the teeth working surfaces. Fatigue spalling of the teeth working surfaces which usually occurs near the operating pitch circle on a tooth root fillet is the main type of destruction of enclosed gears. The cause is variable contact pressures on the surface of the teeth σH; these stresses cause primary cracks, extending cracks, chipping, shelling, slivering of metal from the tooth surface (fig. 2) [7]. A crack at the tooth root often causes chips which results in the increase in the contact pressure and the disruption in the tooth gearing [4, 5, 6, 7, 12]. Surface layers in open gears abrade before fatigue cracks appear in them, so spalling happens very rarely.

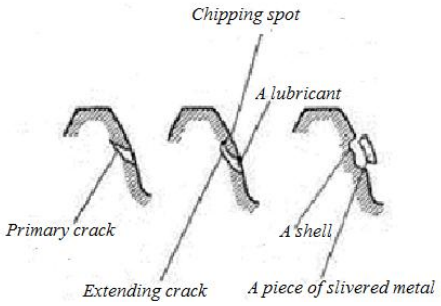
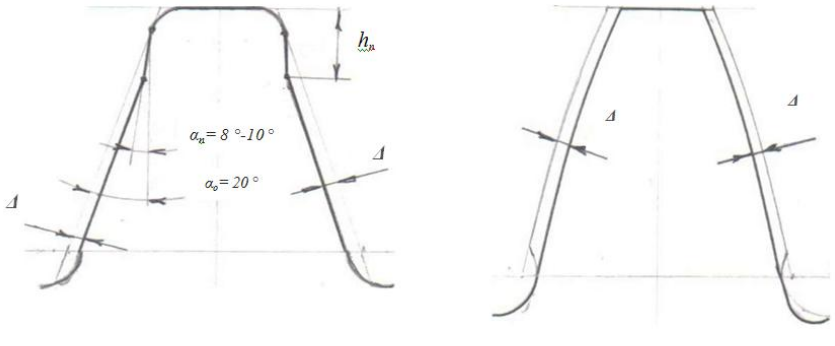


Fig. 2. Fracturing on the involute flank of the teeth of large gear rims

The goal and objectives of the research

The goal and objectives of the research are to ensure intensifying production processes, increasing workloads, speeds, reducing the deterioration of high precision gear rims and developing a new technology to optimize the recovery of large high precision gear rims. To achieve this, a method for machining teeth after surfacing by pre-milling with special hob cutters with a protuberance and by final machining the teeth with special cutters equipped with hardmetal inserts that machine teeth along the line of engagement, which does not require that cutting teeth of milling cutters be manufactured along the full length and which significantly improves the quality of machining, increases the durability of hardmetal milling cutters. A new technology for reconditioning large high precision cylindrical gears is suggested, where primary rough milling cutters with a modified face of a tooth with a prominence are used at the stage of pre-machining of the wheel teeth for strengthening and final speedy edge cutting machining of the tooth [7, 8].

For this purpose, the tip of a milling cutter (fig. 3, a) has a tooth angle that differs from the standard one which is αo= 20° near the tooth tip and the tooth thickness is reduced by the allowance amount Δ which is necessary for further final machining (fig.1, b).



(a) (b)

Fig. 3. Wheel teeth precutting: *a* – a tooth of hob cutter with a prominence; *b* – a wheel tooth machined with Δ allowance: h_n – the prominence height, a_0 – the angle of original profile, a_n – the angle of prominence profile

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The required allowance Δ is left on the wheel teeth flanks after machining by this milling cutter (fig. 3, b), while teeth inverts are machined adequately. The fact that the tips of a finishing tool, for example, tips of a grinding wheel, do not participate in cutting the inverts improves the process of cutting. Radial forces of cutting are reduced, vibration and springing of a tool decrease and, subsequently, its durability increases as well as the quality of the machined teeth.

The drawback of milling cutters with a prominence is the lowered angle (α3= 1,5°-2°) on the tooth flank due to relieving work.

The developed technique of pre-machining on the teeth of a large module (m =20- 25 mm) was successfully tested for the first time while gear cutting the worn bur reconditioned large gear rim with the following dimensions – Da=8058,4mm, m =28 mm; zk= 284; β0= 6°25'; bz=1000mm, produced of 35ХМЛ steel; 220-260 НВ; the precision rate is 8-В GOST1643-81, which is used in the ore-pulverizing mill (fig. 4) of МБ 90х30 model.

Gear hobbing was dome by a special heavy vertical gear hobbing machine of КУ-306 model (fig. 5) with the diameter of the operating face plate equal to 8000mm. The fast-cutting hob cutter "Progress" was used for rough teeth cutting [7, 8, 9]. This cutter has an elongated starting taper (lk=350 mm) and an expanded tool bore – ϕ100H7. According to the diagram given in fig. 1(a), a prominence is made on the teeth of a milling cutter (fig. 4); the teeth have complete profile heightwise. There are chip control flutes on the teeth of the starting taper, which enables separating box chips, i.e. escaping the space-limited cutting. This improves the tool durability.

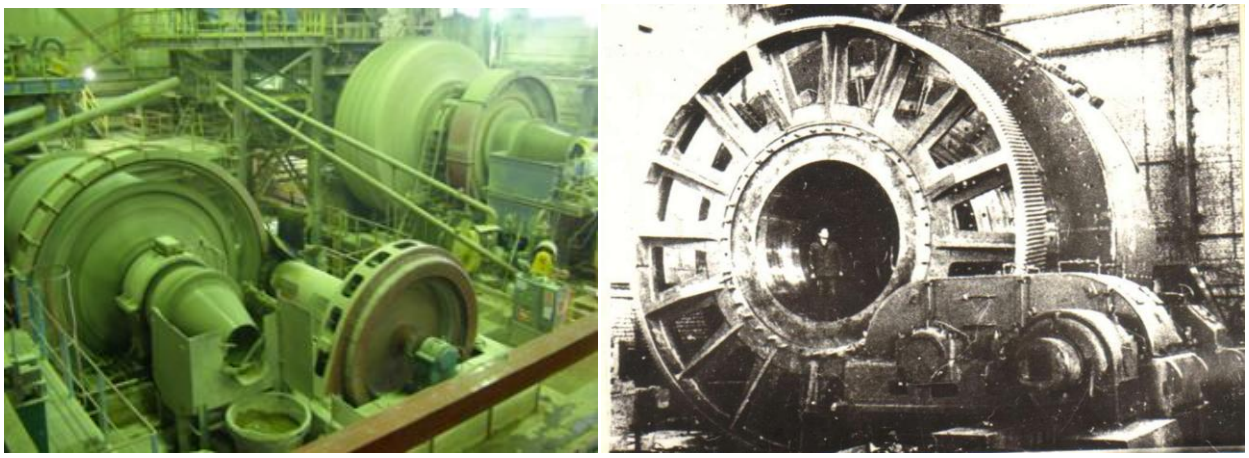

Fig. 4. The general view of the ore-pulverizing mill of МБ 90х30 model with the reconditioned gear rim with the following dimensions m = 28 mm; z_k = 284, D_a = 8058,4 mm

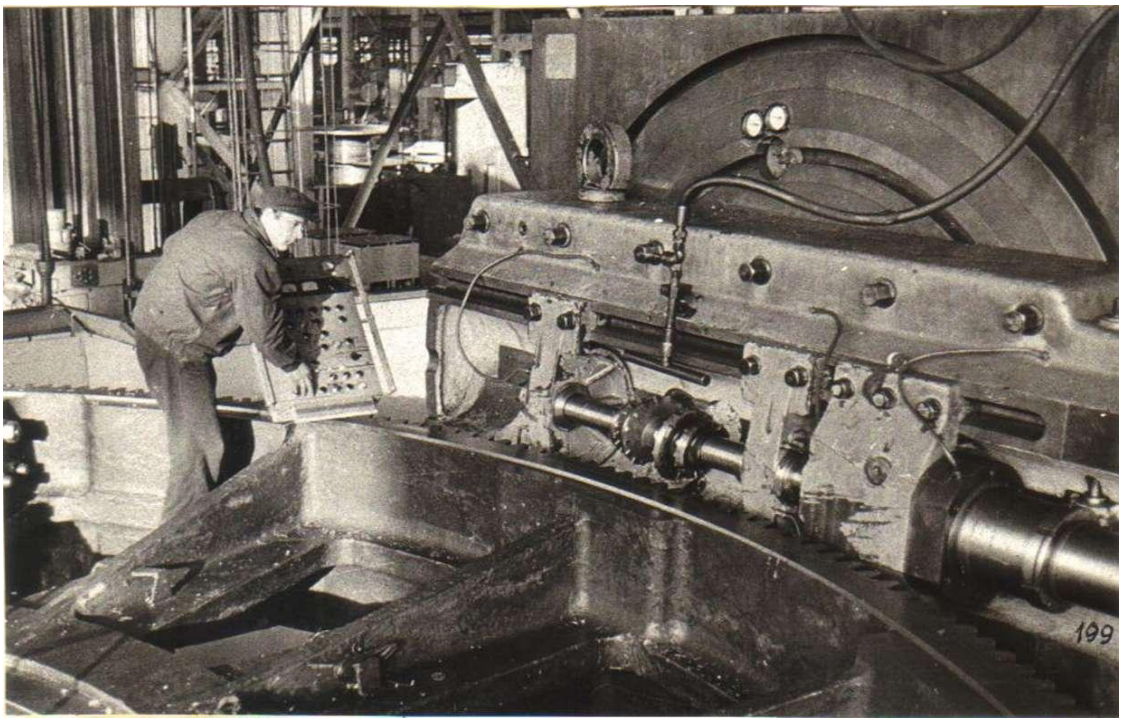

Fig. 5. Finish cutting the worn and reconditioned large gear rim (m= 28; z_k =284) with the use of the gear hobbing machine of КУ-306 model

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The rough cutting modes were as follows: cutter feed Sf=2,5 mm/r; rotary velocity nf= 0,2 sec-1; the cutting direction is counter, metal cutting oil is "Industrial-20". The machining time of rim cutting in one operation was 110 hours.

For reference: the time for machining this rim by other cutters, for example, by the "Frezer" plant is 350 hours.

The special hob cutter m= 28 (fig. 6) was used for teeth finish machining in one operation, this cutter has hardmetal inserts made of BK 10-XOM alloy [7, 9, 10].

The cutting direction was counter, the cutting modes – t = 0,6 mm, S_f = 3,86 mm/r; n_f = 0,33 sec-1.

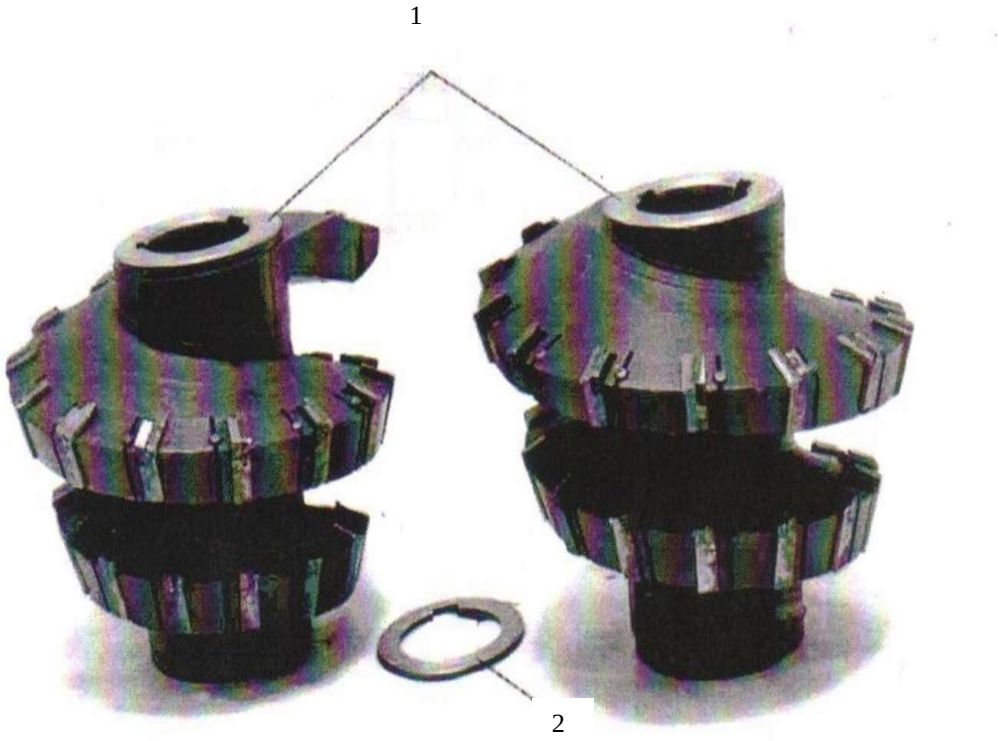

Fig. 6. Special double hob cutter for two-way cutting (m= 28 mm); αf=19°20'
1- cutter housing; 2 - distance ring

The machining time for finishing the rim was 65 hours. The maximum wear of the individual teeth of the milling cutter after this continuous working time did not exceed 0.3 mm, which is 4-5 times less than in the case of similar machining with high-speed cutters. The fact that the difference in the thickness of the teeth of the machined rim at the upper and lower ends (l3 = 1000 mm) did not exceed 0.06 mm indicates the high durability of the cutter. The measurement of the precision parameters of the cut teeth with attachable devices showed that the gear corresponds to the 8th degree of precision in accordance with GOST 1643-81 in the context of the deviation of the circumferential pitch of the teeth and the pitch of the engagement.

Materials and methods of the research

The technique of rough and finishing teeth machining after the teeth (fig. 5) of large rims were reconditioned by rough cutters "Progress" with a prominence and a hardmetal finishing cutters (fig. 6) of a special design was introduced at PrAT "NKMZ".

The vertical gear hobbing machine of HHA-750A model manufactured by the firm "Shibaura" (Japan) (fig. 7) was used for machining by counter milling with the use of metal cutting oil is "Industrial-20". The rim with the following parameters m = 20 mm; Zk = 268; βz= 5°15'; b= 700 mm; 35L steel; 140-160 HB was finished in one operation under the following modes of cutting – t=0,9 mm; Sf= 4,72 mm/r; nf= 0,5 sec-1; Vr.=32m/min.

The machining time for finishing one rim is 24 hours, which is by 1.8 times less than while machining by a high-speed cutter (fig. 8) (STP 4-15-70).

Fig. 9 shows chips cut during finishing of teeth with a high-speed cutter without rough cutting by a cutter with a prominence. Most of the teeth of a finishing milling cutter cut the box chips; there is the space-limited cutting. In this case, the perimeter of the chips is approximately equal to half the perimeter of the wheel tooth which is 45-48 mm when the tooth module m = 20 mm. The tips of the individual teeth of the milling cutter cut thickened chips from the bottom of the tooth groove (fig. 9, the upright row), which raises the radial cutting forces and leads to vibrations and springing of the tool, increases the wear of the teeth (fig. 10).

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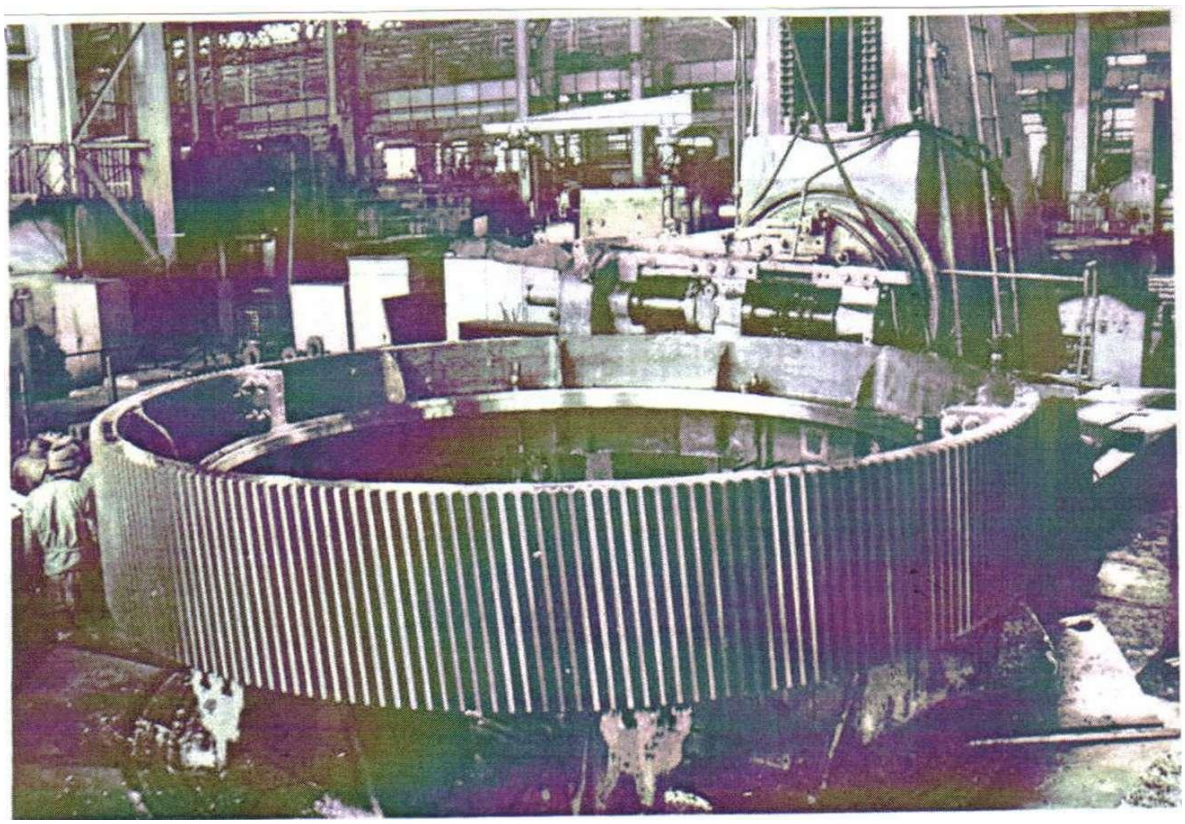

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Fig. 7. Finish cutting the rim teeth (т=20 mm; Zк=268; βz= 5°15'; b=700mm; 140... 160 HB) using the machine of HHA-750 model (Japan)

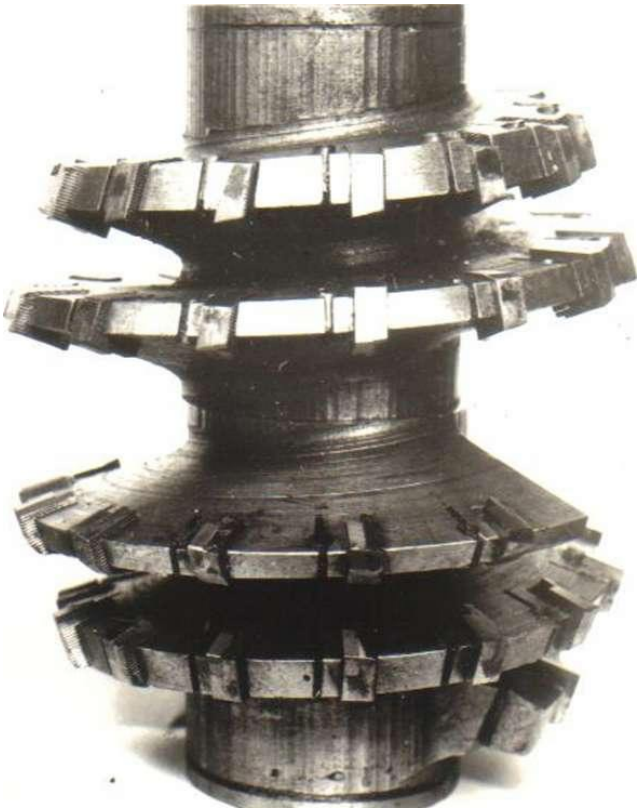

Fig. 8. Finishing hardmetal hob cutter (т=20 mm)

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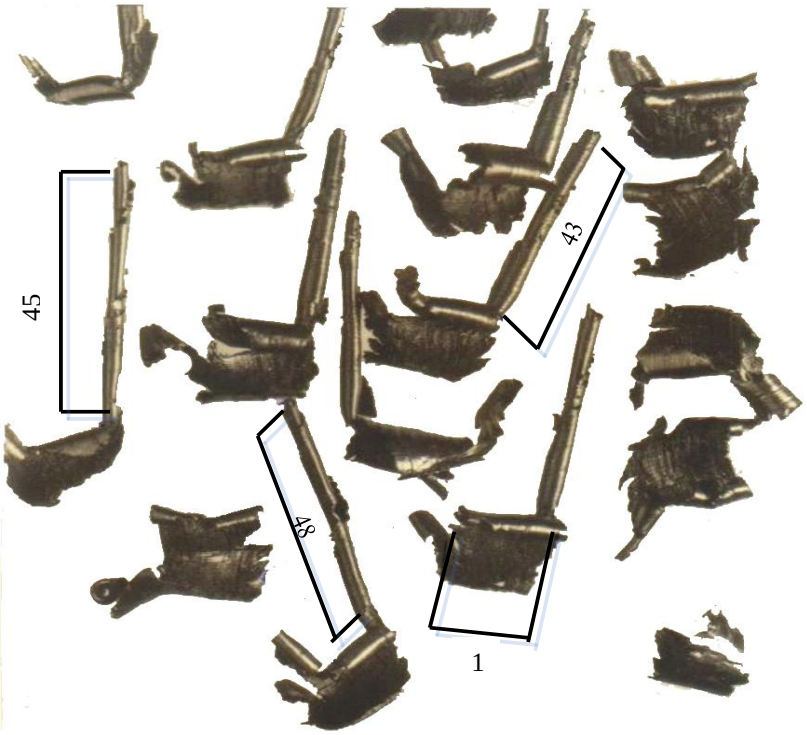

Fig. 9. Chips cut by the finishing cutter (т=20 mm) without teeth cutting by a cutter with a prominence

Fig. 10. Increased wear of the teeth of a finishing high-speed cutter of a pre-fabricated welded design

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Fig. 11. Chips cut by a hardmetal finishing cutter (т=20 mm)

Fig. 11 shows chips cut by a hardmetal finishing cutter (fig. 8). There are no box chips and the length of the chips does not exceed 10-16 mm while the length of the tooth cutting edge of the milling cutter is 20 mm. The length of the teeth cutting edge of the teeth in the developed designs of milling cutters does not exceed 20 mm and is the same for the modules with m = 12-65 mm. In this case, a number of teeth of the cutter is by1.5-2 times greater than the milling cutters of other designs have.

Chips (fig. 11) are compactly twisted, and their backside is shiny, which indicates a free cutting process, minor efforts and deformations in the SPEED system.

Hardmetal hob cutters with m = 12 - 65 mm (fig. 12) that have disposable rotary tools made of BK 10-XOM alloy were designed to improve the milling cutter.

Fig. 12. The right housing of a special hardmetal milling cutter with m=20 mm that has hardmetal disposal rotary tools made of the BK 10-XOM alloy

Under the factory conditions at the PrAT "NKMZ", hardmetal hob cutters with disposable rotary tools were designed and calculated by modelling and a solid model was obtained on SOLID WORKS programme. The control programme was further developed for machining grooves for inserts that are tangentially placed using a numerically controlled machine tool manufactured by the firm "Ferrari" (Italy). The machining time for cutting the grooves of a cutter housing isTmach= 16-20 hours.

Finishing the teeth of the worn and conditioned large gear rims can be further intensified by increasing the lobe configuration of hob cutters.

While gear machining, long-pitch multi-thread hob cutters (m> 12) of the standard design were not spread due to manufacturing complexity, a comparatively small number of cutting teeth and so on (fig. 13).

The designs of double-flute hardmetal hob cutters suggested in this work allow them to be used for machining the worn and conditioned large gear rims with the tooth module with m = 12-40 mm.

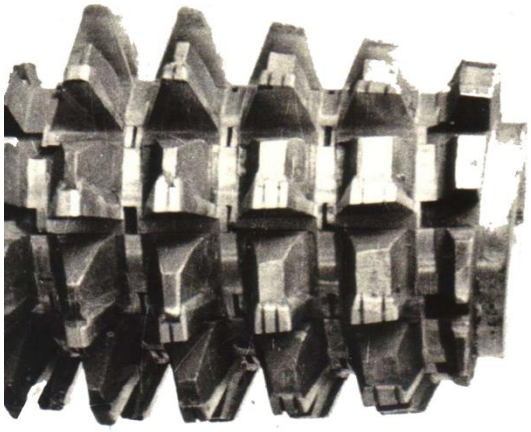

Fig. 13. A rough hob cutter with m=28 mm "Progress" with a prominence and a chip control flute on the teeth of the starting taper

Two milling cutters are designed – special double and universal single ones [7, 11, 12]. A distinctive feature of a special double-cased cutter is the displacement of first A flutes (fig. 14) from the starts of the second B flutes by the angle Q = 180°. The angle of teeth profile of this milling cutter depends on a number of teeth of the machined wheel (α_n =5°19°30') and the ranges of its usability are determined like special single flute cutters [3].

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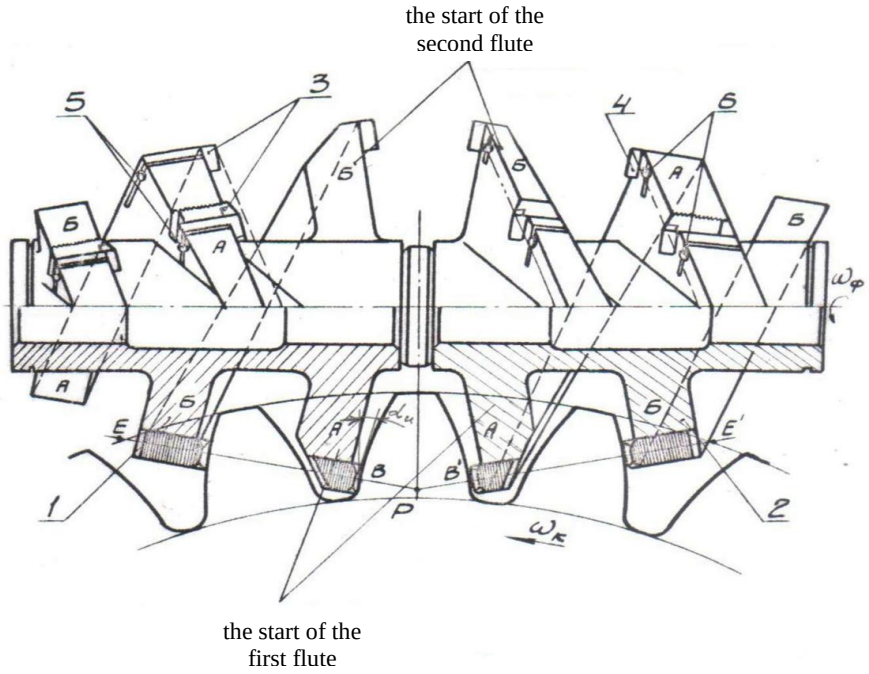

Fig. 14. The basic design of a double-cased special double-flute cutter (α_u =5° – 19°30')

The first flute of the cutter (1) (fig. 14) machines the right flank of the wheel teeth along the active patch BE of the machine line of engagement BE, while the second flute (2) machines the left flank of the teeth along the patch *B'E'*. The taper angle of the flutes screw thread equals to the machine angle of engagement of the "tool-workpiece" pair, in the instant case – $\alpha_n = 20^\circ$. Fig. 14 shows that the bottom boundary points *B* and *B1* of the teeth involute flanks are machined at the moment when a tooth of a wheel placed on the interaxial perpendicular shift to the right or to the left by β_k angle. Consequently, basing on the kinematics of the coupling of a tool and a workpiece, the start points of cutter flutes (fig. 14) should be shifted by θ_z angle.

Let us determine the angles β_k and θ_z:

$$\beta_k = \sigma_b - (\gamma_2 - \mu_y) = \sigma_b - \left(\frac{360^0}{z_k} - \mu_y\right), \quad (1)$$

where μ_y is the angle that corresponds to the setup distance ly (fig. 14).

$$\mu_y = \arcsin\frac{ly}{r_b}, \quad (2)$$

where r_b is the radius of the basic circumference of the wheel teeth.

Basing on the kinematics of the machine engagement of the double-flute cutter, the angle θ_z is determined according to the dependence:

$$\theta_z = \beta_k z_k = (\sigma_b - \frac{360^0}{z_k} + \mu_k) z_k. \quad (3)$$

Like angles σ_b, γ_2, μ_k, the angle θ_k depends only on a number of teeth z_k of the machined wheel. Angle ranges within a number of teeth z_k = 30–200 are presented in table 1.

Table 1. *Changes of the angle of shift of* θ_z *flutes*

Zk	30	60	100	150	200
Θz	104039'	103039'	103025'	103019'	103014'

Table 1 shows that when a number of the wheel teeth z_k increases, the angle θ_z decreases. The angle θ_z within z_k = 30–200 changes insufficiently and equals to $1^0$25' only. Therefore, it is sufficient to make a cutter with the angle of flutes shift θ_k =104039' and this cutter can machine the wheels of the whole range of teeth.

The cutter provides the most qualitative machining if a number of teeth of the cut wheel is not divisible by a number of the cutter flutes, i.e. by two. Only in this case, each cutter flute cuts all slots of the wheel teeth and both involute flanks of the teeth can be machined completely and identically.

The results of the research

When a wheel is machined by a milling cutter with a number of teeth that is divisible by two, only a half of the wheel teeth can be fully machined in one operation. Therefore, after the first operation of the tool, the wheel should be rotated by one angular pitch of the teeth and one more operation should be performed.

The design parameters of hob cutters, especially multi-flute ones, significantly affect the quality and precision of machining gears. In this regard, such

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parameters as faceting and waviness of the working involute flanks of the teeth are considered. Both the studied above designs of double-flute cutters and single-flute standard cutters of known designs ensure the same faceting and waviness on the wheel teeth flanks. 0.6–0.8 rotation of each flute is engaged in profiling the involute flank of the wheel teeth by double-flute milling cutters, while in the context of single-flute cutters 1.2 – 1.8 rotation are needed; however, the suggested double-flute cutters have a number of teeth placed along the rotation circuit that is twice as much.

The amount of calculated or geometrical waviness on the processed surface of the wheel teeth is calculated by a set of design parameters of the cutter and a workpiece that is machined, that is by the profile angle of the cutter, its dimensions, the helix angle of the wheel teeth and so on. To determine the magnitude of the geometric waviness, the equation of the path of the tooth cutting edge point of a hob double-flute cutter in relative motion can be used. The waviness parameter h_c on the machined surface of the wheel teeth can be determined by the coordinate of the point of intersection of the two projections of the cutter tooth path that are shifted relative to one another by the amount of the tool feed S. The initial dependence for determining the wave height h_b is:

$$h_b = 2r_k \cos(\beta - \frac{\gamma_b}{2}) \sin\frac{\gamma_b}{z_k} - r_f \sin\gamma_b \sin\beta_y, \qquad (4)$$

where r_k is the radius of the rotation of a wheel tooth point adjacent to the corresponding point of the cutter tooth; r_f is the radius of the rotation of the target point on the cutter tooth; β is the central angle corresponding to the distance from the machine axis to the target points of the pair "tool – workpiece"; γ is the target angle of the wave formation; βy is the angle of bringing a cutter in the machine support into operation position.

The equation (4) is used for calculating the amount of waviness in case of machining the wheel by a single-flute hob cutter under the standard pattern of cutting and by a double-flute sinlge-casing cutter, the basic design parameters are given in Table 2.

Table 2. *Hob cutters specifications*

Parameter name	Parameter meanings	
	Single-flute standard (STP 48-15-70)	Double-flute sinlge-casing
outer diameter *D*, mm	295	295
a number of teeth at the length of one thread turn z_f	10	18
the angle of the teeth profile α_u	200	200
the angle of the turn gradient τ	4046'	9028'40"
the radius of the cutter tooth rotation that produces waviness at the tip of the wheel tooth r_f, mm	104,24	103,19

The calculations were carried out under the same tool feed rate S = 4 mm/rev and while machining spur gears with the module m = 20 mm and a number of teeth z_k = 40 and z_k = 200. The calculated amounts of waviness are obtained at the tips of the wheel teeth, i.e. in the places where the waviness is of the largest amount. The results of calculations are presented in Table. 3.

Table 3. *Calculating the amounts of waviness height* h_b

Cutter design	H_b, mcm	
	$Z_k = 40$	Z_k =200
Single-flute standard	35	27
Double-flute one-cased	70	58

The data from table 3 show that a double-flute cutter produces waviness on a machined surface that is twice as large as the waviness formed by a standard single-flute cutter. This happens due to the greater curvature of the trajectory of the motion of its teeth while machining. The waviness does not exceed the allowance for the wheel teeth profile within 8-9 degrees of precision according to GOST 1643-81, which is quite acceptable for pre-processing before subsequent gear grinding or other types of finishing.

The waviness in case of finishing milling limits the tool feed rate and, consequently, the performance rate. The suggested designs of double-flute milling cutters should be efficiently used for preliminary edge cutting machining the hardened wheels for subsequent gear grinding. While pre-machining, the tool feed rate is not limited by waviness of the machined surface but by the physical and mechanical properties of the material of the cutting part of the milling cutter and of the material of the wheel being machined which have a decisive impact on the durability of the tool.

The discussion of the results

The previously described universal designs of hardmetal cutters can be profiled according to the considered technique on the basis of the involute hob. The need for such profiling arises both while the final edge cutting machining of hardened wheels in order to reduce noise and increase the smoothness of the transmission operation and with preliminary edge cutting machining of the teeth for subsequent tooth grinding. The abrasive tool coupled with a workpiece in a machine reproduces a theoretically exact involute on the gear grinding machine. The approximation of the profile of the wheel teeth to the theoretical involute already at the stage of preliminary edge cutting machining enables significant reducing the time for low-performance gear grinding of a worn and reconditioned large gear rim.

The universal double-flute cutter (fig. 15) has the standard angle of teeth profile α_n =20°. Its screw addendums of the case are conical and placed opposite to one another and the start points of the addendums have an angular shift within the teeth being machined Z_k =30-300 equal to Zoffset.= 104°0' [7, 9].

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Both suggested designs of double-flute milling cutters ensure the most qualitative machining in case if a number of teeth of the cut wheel is not divisible by a number of cutter flutes, i.e. by two. Only in this case, each flute of the milling cutter participates in shaping all the slots of the wheel teeth and complete and identical machining of both lateral involute tooth flanks will be achieved.

While milling a wheel with a number of teeth divisible by two, only a half of the wheel teeth can be completely machined in one operation. Therefore, the wheel should be rotated by one angular teeth pitch after the first operation of the tool and one more operation should be performed.

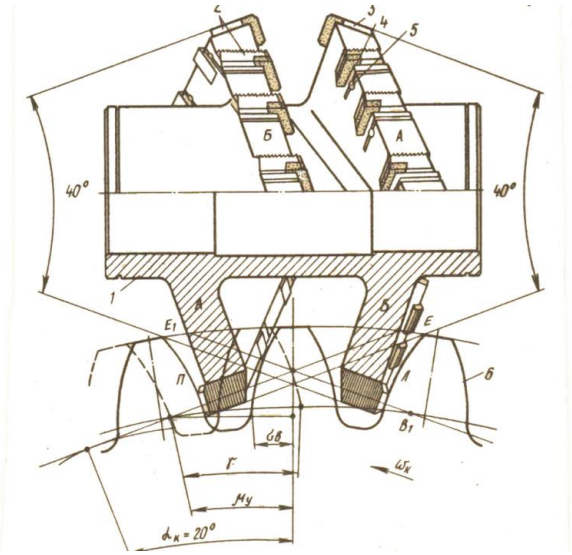

Fig. 15. The basic design of a sinlge-casing double-flute cutter

The design parameters of hob cutters, especially multi-flute ones, significantly affect the quality and precision of machining worn and reconditioned large gear rims. At the same time, such parameters as faceting and waviness of the working involute surface of the teeth are considered [1, 9, 12].

For the efficient use of the technology for reconditioning large high precision gear rims, heavy hobbing machines with a mechatronic control system should be re-engineered to ensure cutting speeds of up to 3-5 m / s.

Conclusions

Industrial confirmation of the possibility and expediency of using hob cutter with a prominence (m = 20–28 mm) while rough cutting of worn and reconditioned large gear rims were proved industrially. To obtain the required durability of roughing milling cutters, it is recommended that the angle of the prominence profile be set at 8 ° – 10 °.

The use of hardmetal hob cutters for finishing enables increasing the performance rate by 2 to 3 times in comparison with high-speed cutters of other designs and makes it possible obtain the required quality and precision of manufacturing worn and reconditioned large gear rims.

The technology of optimization of reconditioning large high-precision gear rims with the use of the design of special and universal hardmetal single- and double-flute cutters with both re-sharpened cutting elements and with disposable rotary tools turn plates was developed and introduced.

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ОПТИМІЗАЦІЯ ТЕХНОЛОГІЇ ВІДНОВЛЕННЯ КРУПНОГАБАРИТНИХ ЗУБЧАТИХ ВЕНЦІВ ПІДВИШЕНОЇ ТОЧНОСТІ

Предметом дослідження є питання, пов'язані з оптимізацією технології відновлення великогабаритних зубчастих вінців підвищеної точності приводів гірничодобувних комплексів, шахтного підйомного обладнання, важких транспортних засобів і є актуальним напрямком по зниженню витрат на відновлення і експлуатацію дорогого унікального обладнання. **Мета** - забезпечити інтенсифікацію виробничих процесів, збільшення робочих навантажень, швидкостей, зниження зношування зубчастих вінців підвищеної точності. **Завдання.** Розробка нової технології оптимізації відновлення великогабаритних зубчастих вінців підвищеної точності, для чого запропоновано метод обробки зубів після наплавки попередніми фрезеруванням спеціальними черв'ячними фрезами з «протуберанцем» і остаточної обробки зубів спеціальними фрезами, оснащеними твердосплавними пластинками, які виробляють обробку зубів по лінії зачеплення, на чого не потрібно виготовляти ріжучі зуби фрез по всій довжині, що значно підвищує якість обробки, підвищення стійкості фрез, оснащених твердим сплавом. Процес відновлення великогабаритних зубчастих вінців підвищеної точності відносяться до ресурсозберігаючих технологій, тому що в порівнянні з виготовленням нових деталей значно скорочуються витрати на матеріали при виготовленні, зменшується кількість технологічних операцій, знижуються витрати на верстатне обладнання, пристосування, ріжучий і вимірювальний інструмент. Плавна робота зубчастої передачі може бути забезпечена тільки при постійному передатному відношенні, але через похибки виготовлення і похибок, пов'язаних з експлуатацією, величина передавального числа в кожен момент часу не є постійною, що призводить до інтенсифікації зносу великогабаритних зубчастих вінців підвищеної точності. **Результати.** Отримано промислове підтвердження можливості і доцільності застосування черв'ячних фрез з «протуберанцем» (m = 20–28 мм) при чорновому зубонарізуванні зношених і відновлених великогабаритних зубчастих вінців. Для отримання необхідної стійкості чорнових фрез кут профілю «протуберанця» рекомендується призначити в межах 8–10 °. Застосування при чистовому зубофрезерованню черв'ячними твердосплавними фрезами дозволяє підвищити продуктивність обробки в 2 – 3 рази в порівнянні з швидкорізальними фрезами інших конструкцій і отримати необхідні якість і точність виготовлення зношених і відновлених великогабаритних зубчастих вінців. **Висновки.** Розроблено та впроваджено технологію оптимізації відновлення великогабаритних зубчастих вінців підвищеної точності із застосуванням конструкції спеціальних і універсальних одно - і двухзаходних твердосплавних фрез, як з переточуваними ріжучими елементами, так і з непереточуваними поворотними пластинками.

Ключові слова: нова технологія оптимізації, відновлення великогабаритних зубчастих вінців, підвищена точність, червячні фрези з «протуберанцем», спеціальні фрези, обробка зубів по лінії зачеплення, підвищення якості обробки.

ОПТИМИЗАЦИЯ ТЕХНОЛОГИИ ВОССТАНОВЛЕНИЯ КРУПНОГАБАРИТНЫХ ЗУБЧАТЫХ ВЕНЦОВ ПОВЫШЕННОЙ ТОЧНОСТИ

Предметом исследования являются вопросы, связанные с оптимизацией технологии восстановления крупногабаритных зубчатых венцов повышенной точности приводов горнодобывающих комплексов, шахтного подъемного оборудования, тяжелых транспортных средств и являются актуальным направлением по снижению затрат на восстановление и эксплуатацию дорогостоящего уникального оборудования. **Цель** – обеспечить интенсификацию производственных процессов, увеличение рабочих нагрузок, скоростей, снижение изнашивания зубчатых венцов повышенной точности. **Задание.** Разработка новой технологии оптимизации восстановления крупногабаритных зубчатых венцов повышенной точности, для чего предложен метод обработки зубьев после наплавки предварительным фрезерованием специальными червячными фрезами с «протуберанцем» и окончательной обработки зубьев специальными фрезами, оснащенными твердосплавными пластинками, которые производят обработку зубьев по линии зацепления, для чего не нужно изготавливать режущие зубья фрез по всей длине, что значительно повышает качество обработки, повышение стойкости фрез, оснащенных твердым сплавом. Процесс восстановления крупногабаритных зубчатых венцов повышенной точности относятся к ресурсосберегающим технологиям, так как по сравнению с изготовлением новых деталей значительно сокращаются затраты на материалы при изготовлении, уменьшается число технологических операций, снижаются затраты на станочное оборудование, приспособления, режущий и измерительный инструмент. Плавная работа зубчатой передачи может быть обеспечена только при постоянном передаточном отношении, но из-за погрешностей изготовления и погрешностей, связанных с эксплуатацией, величина передаточного числа в каждый момент времени не является постоянной, что приводит к интенсификации износа крупногабаритных зубчатых венцов повышенной точности. **Результаты.** Получено промышленное подтверждение возможности и целесообразности применения червячных фрез с «протуберанцем» (m=20-28 мм) при черновом зубонарезании изношенных и восстановленных крупногабаритных зубчатых венцов. Для получения необходимой стойкости черновых фрез угол профиля «протуберанца» рекомендуется назначить в пределах 8-10°. Применение при чистовом зубофрезеровании червячных твердосплавных фрез позволяет повысить производительность обработки в 2 - 3 раза по сравнению с быстрорежущими фрезами других конструкций и получить необходимые качество и точность изготовления изношенных и восстановленных крупногабаритных зубчатых венцов. **Выводы.** Разработана и внедрена технология оптимизации восстановления крупногабаритных зубчатых венцов повышенной точности с применением конструкции специальных и универсальных одно - и двухзаходных твердосплавных фрез, как с перетачиваемыми режущими элементами, так и с неперетачиваемыми поворотными пластинками.

Ключевые слова: новая технология оптимизации, восстановление крупногабаритных зубчатых венцов, повышенная точность, червячные фрезы с «протуберанцем», специальные фрезы, обработка зубьев по линии зацепления, повышение качества обработки.

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USING THE ECONOMIC AND MATHEMATICAL MODELS FOR DETERMINING THE MARKET CAPACITY

The subject matter of the article is economic and mathematical forecasting models of the market capacity based on the system of influential factors. The **goal** is to systematize and substantiate theoretical and methodological approaches to forecasting the market capacity in the conditions of the current unstable state of the economy. The following **tasks** are solved**:** the factors that influence on the development and amount of the market capacity are completely systematized; peculiarities, advantages and disadvantages of applying available economic and mathematical forecasting models of the market capacity are considered; the necessity for taking into account the structural changes in a number of consumers by age groups is emphasized; the features of the influence of the consumption of luxury goods and goods of prime necessity were is revealed taking into account the return on the change in the market capacity. The **methods** used are – the system analysis, the factor analysis, the regression and correlation analysis, the methods of cumulative curves. The following **results** are obtained –the principles of building economic and mathematical forecasting models of the market capacity are considered; the factors that influence on the market capacity at micro and macro level and have a random or systematic nature of the impact were systematized; advantages, disadvantages and peculiarities of multi-factor and single-factor models of the market capacity, in particular, cumulative curves are revealed; compulsory registration of demographic factors (changing the structure of age groups in time) in multi-factor models is suggested; the alternative use of cumulative curves of demand on the groups of luxury goods and goods of prime necessity depending on income is shown. **Conclusions.** Taking into consideration structural changes in a number of consumers in time, the features of consumption of luxury goods and goods of prime necessity using the factors of the elasticity of demand on income and other significant factors enable mathematical describing the consumption of the basic groups of goods and services, forecasting the amount of their market capacity, determining the critical values of the factors that can completely stop consuming products of a certain group or reduce the consumption to the minimum level.

Keywords: market capacity, economic and mathematical model, the elasticity of demand, income, consumption, price, demand.

Introduction

Dynamic changes that have taken place in the economy over the recent decades are so intensive and fast that the theoretical understanding of new market realities lies far behind their implementation. The active activity of enterprises or their survival under a turbulent economy requires using adequate and efficient mechanisms of the economic regulation of development. So, one of the most important and responsible issues of the activity of enterprises is the awareness of the market capacity, the amount of demand for the goods of an enterprise. All this becomes especially topical in the context of the crisis, the growth of costs, the reduction in purchasing power, the saturation of markets, increased supply of certain types of goods, the intensification of competition.

The awareness and forecast of market indicators and its capacity are very important, they are of great interest to the market participants as they allow companies to understand clearly, strengthen and expand their positions on the market.

It should be noted that today the need for information on the capacity, size and shares of the market has already been formed; there are many companies that carry out similar marketing research. At the same time, some enterprises estimate the capacity of the market on their own.

The analysis of literary sources and problem statement

The issues of the technique of the methodology of calculating the market capacity were studied in the works written by G. Azoyev and V. Khrutsky, P. Zavyalov, S. Lavrov, E. Golubkov, I. Lipsitz, S. Pivovarov, E.I. Lunin, J.-J. Lamben, V. Praude, F. Kotler, D. Evans, G. Chandezon, K. Schmittchoff, G. Harding and other authors. Such scientists as G. Pospelov, V. Leontiev, L. Abalkin, I. Bestuzhev-Lady, N. Malchotry, G. Tayla, H. Schumann, D. Hicks, C.Arrow contributed to developing the forecasting methodology.

However, the methodological issues of forecasting the market capacity are insufficiently worked out in the mentioned works, factors that determine the market capacity are insufficiently indicated, the influence of micro and macro factors on the development of market potential is not fully reflected, the specificity of the structural and regional features of the markets is not taken into account, the demographic factor of structural changes in a number of consumers by age groups is not fully elaborated, the impact of consumers' incomes in terms of different conditions and development of the economy. Theoretical and practical problems of forecasting the market capacity need to be understood on the principles of market relations. It should be noted that today there are many economic and mathematical methods for calculating the market capacity, while there are no universal ones. The mentioned above determined the subject of this article.

The goal and objectives of the research

The goal of the article is to systematize and substantiate theoretical and methodological approaches to forecasting the market capacity in the conditions of the current unstable state of the economies of individual countries.

The objectives are:

- to systematize factors that affect the development and amount of the market capacity;
- to consider the peculiarities, advantages and

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disadvantages of using available economic and mathematical models of forecasting the market capacity;

- to consider the necessity for taking into account structural changes in a number of consumers by age groups in the forecasting models;

- to identify the peculiarities of influence on changing the market capacity of the consumption of luxury goods and goods of primary necessity using the indicators of the elasticity of demand taking into account the stratifications of the society in different countries.

The results of the research

The choice of the method for determining the capacity of a product or company market depends on the specifics of the business, the urgency and importance of the task, the accessibility of information, labour and financial resources, patterns for the promotion of goods to a consumer; each group of goods needs an individual approach.

The analysis of the current practice of forecasting market processes enables highlighting a number of features of building the economic and mathematical models of the market capacity whose choice and use is conditioned not only by the objectives of the research but also by the quality of available empirical data [1, 2].

Various methods are used to forecast the market capacity [3-5]. It should be noted that the application of any particular method does not improve the accuracy of the forecast, does not provide an integrated approach and reduce the risk of making managerial decisions on the direction of the development of an enterprise.

Building economic and mathematical models for determining (forecasting) the capacity of the market and demand should be based on the following principles [6, 7]:

1) analyzing and modelling the structure of consumption per the totality of groups of goods and services presented in the market and necessary to meet various human needs; the structure of consumption should be considered in two aspects:

- as the amount of consumption of a certain group of products in physical terms;

- as the level of expenses for purchasing a certain group of products;

2) substantiating the lower and upper regulatory boundaries of consuming goods intended to meet the needs of people who are in the lower stages of the needs hierarchy. Due to these boundaries, the main object of the analysis of the market capacity is the consumption of a certain group of products in physical terms whose values exist and vary within a certain interval. At the same time, at a certain point of an interval between the lower and upper consumption standards the moment of market saturation takes place, it depends on the specific features of a particular group of goods or services. After saturation, the subsequent change in the independent factor causes a decrease in the rates of consumption growth of a certain group of goods;

3) taking into account the factors that determine the change in the market capacity and the amount of the demand for a particular group of goods;

4) ranking different groups of goods and services by the degree of their value for consumers, which enables determining the order of their purchasing when changing other considered factors of product consumption;

5) determining the weight coefficients of the value of goods (commodity groups) for consumers;

6) taking into account the size of the market – the data of state statistics should be used to assess the size of the market in large areas (country, region). On small territories (district, city) field researching can be carried out as market statistics are not usually conducted;

7) substantiating the influence of different levels of average income per capita and average prices on the amount of the market capacity and demand.

Let summarize and categorize the well-known factors that need to be taken into account while determining the market capacity (some factors are often taken into account; others are not considered at all) [8]:

- *the geographic boundaries of the market* – a district of the city (Kharkiv, Kyivsky district, Saltivka area), a city (the city of Kharkiv), several cities Kharkiv, Kyiv, Odesa), one region or several regions of the country (Slobozhanschina, Zakarpattia), Ukraine, foreign markets (Poland market, European market), etc.;

- *the time interval of marketability* – a season, a quarter, a year, etc. A year is widely viewed as the interval as the majority of goods and services are seasonal within a period that is usually equal to a year;

- *the homogeneity of the market* – if the market is heterogeneous and is divided into segments (buying behaviour among the segments varies considerably), the market capacity needs to be determined for each segment separately. The resulting indicators should be later aggregated;

- *the units of measurement* – natural or value; when calculating the cost index of the market it is necessary to determine what prices (consumers or producers) and which currency to take into account. It is recommended that producer prices be used in the b2b segment, consumer prices be used in the b2c segment, the national currency – hryvnia – should be used on the domestic market and euros or dollars should be used on the international market;

- *demographic characteristics of consumers* – the quantity, density, social composition of the population and its composition by gender and age; general market conditions; a kind and type of goods, commodity groups, their aggregation; the amount and structure of the product offering; enterprises-representatives; the quality of products and changes in the quality of goods; the amount of imports of a particular product or group; the demand for goods and the elasticity of demand;

- *the level of prices and changes in the average market price for the whole population or individual product groups*; the ratio of prices for goods that are presented on the market and are necessary to meet different types of human needs;

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- *the achieved standard of living and needs of the population*; changing the population lifestyle;

- *the incomes of the population, the purchasing power of the population*; a share of the income that a consumer is ready to spend on purchasing a particular product;

- *the degree of value of a certain type of goods and services for consumers*, which is conditioned by the need for a specific group of products to meet the needs of people who are at different hierarchical stages;

- *the stage of the product life cycle* and the corresponding type of a consumer (innovators, early majority, later majority, those who lag behind); the degree of development and saturation of a particular market, the probability of similar goods or other goods with similar properties (characteristics) on the market;

- *changes in macroeconomic indicators* – business activity; prices for energy; the leading indicator, that is, the change of the target market or another one that responds to the future change in the market capacity with a predetermined time lag;

- *the advent, expansion and accessibility of new technologies*;

- *the intensity of marketing efforts of producers and sellers*; the efficiency of promotion on the market; the cost-effectiveness of advertising; the state of the marketing, sales and service network;

- *specific factors* that determine the development of markets for individual products while each market may have characteristics that are specific only to it. A specific factor in the degree of impact may be crucial for generating and developing the demand and offer of a particular product. Specific factors include natural and climatic conditions, changes in fashion; national and everyday traditions (for the markets of fabrics, clothes and footwear); the achieved level of prosperity; the terms of physical and moral wear; the size and composition of a consumer's wardrobe; the increased housebuilding and so on.

These factors have a different impact because when the income changes by a certain value and prices change by the same value but with the opposite sign, the change in the volume of product consumption is not the same. In this case, consumers' incomes and the level of prices on the amount of the market capacity of a particular group of goods or services can have the overall impact while combining them into one indicator that is determined as the ratio of factors, which characterizes the purchasing power of population to buy goods from the target group of products.

Thus, a great number and variety of factors should be taken into account in economics and mathematical models and the effects of individual factors cannot be distinguished.

Random and systematic factors should be distinguished [6]. Random factors display the individual tastes of consumers and their environment, customs, the peculiarity of the circumstances which surround them, in other words, all things that are related to the personality and behaviour of a consumer. Systematic factors characterize the size of the family, gender and age of family members, profession and social group membership; the effect of these factors can be eliminated by classifying families and grouping them but anticipating all the factors in advance is impossible.

Factors can be distinguished experimentally, then consumer budgets can be clearly classified. Distinguishing families according to the different age, size, the level of income, etc. enables determining the impact of factors related to a small intra-group dispersion.

After eliminating all the distinguished systematic factors by grouping and selecting other factors, all the factors that have not been taken into account should be considered as random. This allow the manufacturing companies to quantify the impact of factor changes on the amount of the market capacity of the manufactured products, to anticipate the change in the scale and duration of the life cycle of the market and, consequently, to respond to changing market conditions in the most effective way taking into account the final results of the organization activities.

The dependencies of the market capacity on macroeconomic parameters can be modelled by building factor forecasting models that characterize the dependence of consumption on the level and composition of monetary incomes, the price level and the ratio of price indices as well as on the social and the demographic composition and size of households. The essence of this approach lies in the fact that the market capacity is presented as a function of one or several factors. To build this class of models, the income differentiation and the elasticity of consumption of goods by all the population should be studied, certain groups of people with different paying capacity should be analyzed.

Multi-factor models of determining the market capacity.

Over long time intervals, market phenomena and processes are determined by a combination of factors, their overall impact on the amount of the market capacity is taken into account by multi-factor models of forecasting

$$S = \varphi(X) = \varphi(x_1, x_2, ..., x_n), \quad (1)$$

where $x_1, x_2, ..., x_n$ are the factors that influence the market capacity.

If a model is built for a short period of time, individual factors can be considered as constants.

For forecasting of the market capacity, works [8, 9] suggest using such multi-factor models that take into account the available statistical data:

1) *depending on the income obtained within the current and previous periods*

$$S_t = a_0 + a_1 I_t + a_2 I_{t-1}, \quad (2)$$

where S_t is the market capacity in the planned period; I_t is the level of customers' income in the planned period; I_{t-1} is the level of income in the period that preceding the planned period; a_0, a_1, a_2 are the coefficients of regression;

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2) *depending on the income of consumers obtained within the current period and the demand within the period preceding the planned period*

$$S_t = a_0 + a_1 I_t + a_2 S_{t-1}, \quad (3)$$

where S_{t-1} is the market capacity within the period preceding the planned one;

3) *depending on the level of consumers' income within the period preceding the planned one and on the maximum values of consumers' demand within a certain previous time period*

$$S_t = a_0 + a_1 I_{t-1} + a_2 E_{max}, \quad (4)$$

where E_{max} is the maximum value of the market demand within a certain time period that precedes the planned period of time;

4) *depending on the level of current income of consumers and on the average level of prices for all the consumer goods within the target period*

$$S_t = a_0 + a_1 I_t + a_2 P_t, \quad (5)$$

where P_t is the average level of prices for all the consumer goods within the target period.

Dynamic models for calculating the demand (the market capacity).

The selection of factors that determine the dynamics of the market capacity in the context of building macroeconomic models has certain features. Analytically, there is a system of factors that are causally related to the market capacity indicator. However, mathematically, not all of them can be adequately taken into account in the model since macro-factors have a complex hierarchical structure and can be measured using various indicators. For example, the purchasing power of people's income depends on incomes and on inflation rate at the same time.

Despite the fact that the market capacity is changing dynamically and in different periods, the market situation can be different but the general trends that reflect the specifics of the type of consumption remain unchanged. At the same time, the change in the nature of processes that determine the behaviour of consumers in the dynamics affects their statistical certainty. Consequently, an index that did not have a significant decisive influence in the past is considered as a weak signal. In case, when it cannot be used in future, the available indices should be retrospectively reviewed as those that characterize differences in the typology of consumers' behaviour.

1. *Basing on the dynamic model of consumption with due regard for stocks (H. S. Houthakker and L. J. Taylor)*:

$$C_t = a_0 + a_1 Z + a_2 I + \varepsilon, \quad (6)$$

where C_t is the consumption; Z is the stock of goods or the habit of their consumption habit; I is the income; ε is a random component.

2. *Depending on the price and time*. The simplest models of the demand depending on the time and price include the following one

$$C_t = a_0 + a_1 P_t + a_2 t, \quad (7)$$

where P_t is the price; t is the factor of time.

3. *Taking into account the ratio of price indices*

$$\ln C_j = \ln a_0 + a_1 \ln P_j + a_2 \ln \frac{J_{P_j}}{J_P} t, \quad (8)$$

where C_j is the demand for a certain item of goods; P_j is the price for a certain item of goods; $\frac{J_{P_j}}{J_P}$ is the comparative index of prices that characterizes the ratio of changes in prices for a certain item of goods and the general index of prices.

The dependence of the amount of consumption on the income is represented by the function of consumption on the macro level, and this fact should be taken into consideration. In his works, *J. M. Keynes* illustrates the ratio of the generalized indices of income, consumption, capital investments, savings – when the income increases, the consumption also increases but slower. At a certain level of consumption, people start to save.

Actual data on the market capacity show how consumers are supplied with different types of goods and services in each specific period of time. The structure of consumers' demand in any period of time and its change under the influence of various factors is the reflection of objectively existing limits of the consumer behaviour in the area of distributing their income for purchasing one or another group of products. Within these boundaries of consumption, different types of human needs are met with the help of a certain group of products. The following should be taken into consideration:

- the lower boundary characterizes the amount of consumption of products necessary to meet minimum demand;
- the upper boundary is the natural boundary of product saturation is conditioned by the law of diminishing marginal utility; that means that consumers' needs for certain groups of goods or services are entirely met or their needs cannot be met better by increasing the amounts of purchasing.

Depending on the amount of available statistical information, the patterns of the market capacity change *S* as the function of changing any factor from the mentioned ones and forecasting the market capacity can be analyzed using the coefficients of the demand elasticity:

$$S = f\left(E_P, E_{AB}, E_I, E_K\right), \quad (9)$$

where E_P is the coefficient of price elasticity; E_{AB} is the coefficient of cross-price elasticity; E_I is the coefficient of the consumers' income elasticity; E_K is the coefficient of the goods quality elasticity.

The goods are distinguished as those of

1) low elasticity (0 < E < 1); this group includes the goods of primary necessity (bread, salt, matches); as income I grows, the increase in demand for essential goods Q gets slower and has the saturation boundary;

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2) moderate elasticity (E = 1 or E ≈ 1); this group includes the goods of secondary necessity; the function has the saturation boundary but of a higher order; the demand for such goods arises after the income reaches a certain desired value;

3) elasticity (E > 1); this group includes luxury goods; the function has no boundaries, the demand for luxury goods arises after the income exceeds a certain level of income and the increase in demand outruns the increase in income.

A drawback of multi-factor models is the fact that the limited volume of statistical information about the amount of the market capacity and its determinants leads to significant errors in the calculations of the current value and forecasts. This is due to the fact that the value of the target variables for a basic period of time can turn out to be indistinctive, false for a particular market when empirical data is accumulated.

The above models also have significant *limitations*. Forecasting the demand at the following moment of time, using statistics of historical data, can lead to completely opposite results; this can happen when the demand is seasonal (taking into account the seasonal wave requires other approaches), when the goods moved from one phase of the life cycle to another, when the consumption of goods is very sensitive to inflationary processes and so on.

It should also be noted that the above models do not take into account the state of the demographic situation on the target market. The demographic structure of consumers is very variable in age, gender, the density of residence due to active migration and emigration processes, structural shifts in the age pyramid (fig. 1).

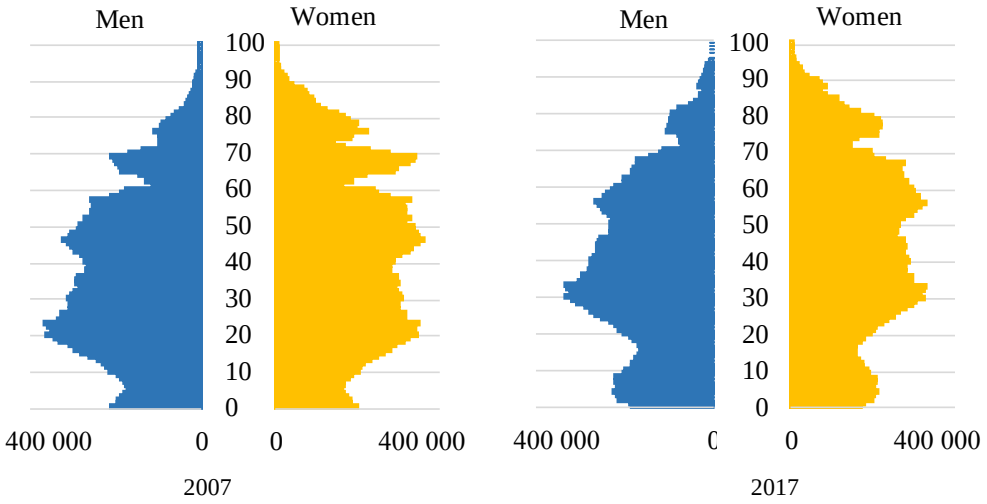

Fig. 1. The structure of Ukrainian population according to the gender and age (according to the State Statistics Committee of Ukraine [10])

The information on the gender and age distribution of the residents of a country, region, or any administrative-territorial entity is demanded practically in all spheres of public life that are related to human life and activities. In marketing, following F. Kotler, scientists consider the age of consumers to be very significant and refer it to a group of personal factors. So, A.S. Posipanova noted in her monograph [11] that social and demographic factors (gender, age, social status) have a significant influence on consumer behaviour (demand) and the influence of price, income and quantity of goods is insignificant since they are included in traditional economic models. The author also emphasizes that income affects the choice of goods but not on preferences. D. Borzekovski [12], V. Stefan [13] found a significant difference not only in the preferences of children and adults but also in the attributes of preferences, their range (children have significantly narrower one) and the rate of development (children develop preferences more quickly).

The influence of age on consumption patterns is manifested in the choice and frequency of consumption of goods and services. So, according to marketing research, in 2007 young people of 17-23 years often made use of beauty salon services of (26.7%), entertainment centres (17.8%), cafes and bars (11.5%). This is a very large proportion of the population. In 2017 these consumers moved to another group (a group of 30-year-old people), and now their views and desires are aimed at the services of banks (45.8%), entertainment centres (28.7%). At the same time, in 2017 the category of 20-year-old consumers of services mentioned above decreased almost twice (fig. 1): in 2007 – 791 thousand people, in 2017 – 446 thousand people.)

It should be noted that information on the number of children already born enables forecasting the consumption of a group of children's products (baby carriages, baby beds, linens, diapers, baby food, etc.) in the short term and makes it possible to forecast the consumption of certain goods and services in the future.

Single-factor models of calculating the market capacity taking income into account.

Despite the fact that multi-factor models of the market capacity forecasting can take into account factors that can have a profound effect, single-factor models remain the most popular for determining the market capacity and consumption level. While using these models, the most significant factor one should be discriminated which takes into account the change in the market capacity. Thus, the implementation of correlation

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regression analysis according to the series of the values of the market capacity and an independent macroeconomic parameter, that mean that the formation of the functional dependencies of the general form $S = f(x_i)$, x_i is the *i*-th factor that affects the market capacity) enables identifying a statistically grounded relationship between the target variables.

Single-factor models of the predictive estimates of the market capacity should be applied in short-term time intervals during which only one target factors substantially changes and all other factors remain or are considered to remain unchanged or their change causes a slight change in the market capacity within the permissible statistical errors.

Single-factor models have their advantages while being applied:

- the differentiation of goods into main groups, selection and justification of the specific form of the functional dependence of the market capacity for each group of goods on the level of per capita income enables reflecting the peculiarities of consumers' preferences of various types of goods and services and providing the most accurate modelling of consumer behavior in solving the tasks of the market capacity forecasting;

- for specific forecasts, such models enable determining which goods belong to the category associated with stocks and which ones are related to the category associated with habits.

But single-factor models also have a drawback – while they are being formed and justified, the vector of the impact on the dynamics of the market capacity of only one macroeconomic parameter can be taken into account on the basis of the predictive estimates of the market capacity. At the same time, other significant factors of market conditions are excluded from the analysis and neglecting these factors reduces the degree of the accuracy of the forecast estimates.

Single-factor models of the dependence of the demand (the market capacity) on prices or on income are widely used. Studies show that it should be kept in mind that the consumption of goods and services by a family over a certain period of time depends not only on its incomes within the target period but also on the previous incomes and on the incomes expected in the future. The amount of expenses also differs depending on the wish to save a part of the income or, conversely, to spend savings and take loans. That is, within a limited time interval, the statement "expenses are determined by the income level" is not correct; it is necessary to consider the long-term cash balance of a family taking into account planned purchases and current savings.

To study the change in demand depending on the income of various consumer groups, mainly two types of models are used – Engel functions and Törnqvist functions.

In the XIX century the German scientist Ernst Engel substantiated the economic law according to which the behaviour of consumers is related to the amount of their income and, as the incomes of the population's consumption of goods increase, it grows disproportionally. Costs for food is growing more slowly than costs on durable goods, travel or savings and the structure of food consumption is changing toward better products. The growth of incomes leads to an increase in the share of savings and consumption of high-quality goods and services with a decrease in low-quality goods. The law is very outdated but Engel proved that empirical dependence is confirmed by a long experience of economic development.

Engel functions are known to be static models $S = aI^{E_I}$. Engel curves characterize the dependence of consumption (the market capacity) of various types of goods on income:

- for the items of primary necessity the index E < 1, that means that when the income increases, the extra costs for the goods of this category is a past that constantly decreasing (fig. 2, curve 1);

- for the durable goods the index of elasticity E ≈ 1, that means that a share of costs for these goods in the extra income remains approximately unchanged (fig. 2, curve 2);

- for luxury goods the index of elasticity E > 1; that means that when the income increases greatly, its bigger share is spent for the goods of this group (Fig. 2, curve 3).

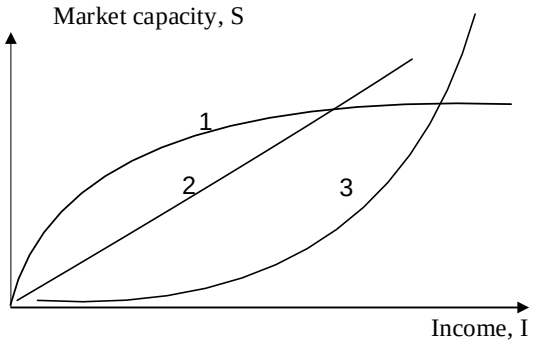

Fig. 2. Engel curves

According to Engel's law, the elasticity of purchasing basic necessities from casual income is less than from the constant share of income. In particular, food costs are insensitive to income fluctuations. For luxury goods, the consumption of which is closely related to unforeseen incomes, the elasticity of purchasing from casual income is higher than from the constant income share.

But studies have shown that the tendencies of the Engel curve in developing countries differ from the trend of the curve of developed countries. When the level of total income is low, the overall elasticity of spending on food is elastic but if the total amount of costs increases, the total elasticity of food costs becomes inelastic. That is, the category of essential necessity is replaced by the category of luxury goods for certain market segments.

The Ukrainian society is a rather complex socially differentiated structure that was developed by N.M. Rymashevska, a specialist in the field of social demography and economic sociology and consists of ten social strata and at least three major social classes – "upper", "middle" and "lower" ones [14]. Many sociological surveys testify that about half of Ukrainians

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are considered to be middle class but experts believe that only10% of the population can be classified as middle class in Ukraine according to two basic indicators – the standard of living and education [15. 16], while 75–80% of the population can be referred to the lower class. In developed countries, the middle class includes the population that receives average incomes typical of a target society and this is the majority of the society (60–80%), so they can influence the overall direction of the development of a country and on the level and structure of consumption of goods and services.

The pattern of the dependence of demand on income was mathematically described in the studies of L. Törnqvist [17], these are special *Törnqvist* curves that are constructed according to Engel's law. According to this approach, the whole set of goods and services can be submitted by three main groups; in each group, the relationship between the market capacity and consumer income is expressed by a certain form of dependence.

1. *The goods of primary necessity*, for which the curve that reflects the change of the market capacity (the change of demand for the necessities *S* when the income I increases) asymptotically approaches the upper boundary, which characterizes the level of saturation $S_{\max_1}$ with these goods (fig. 3, curve 1).

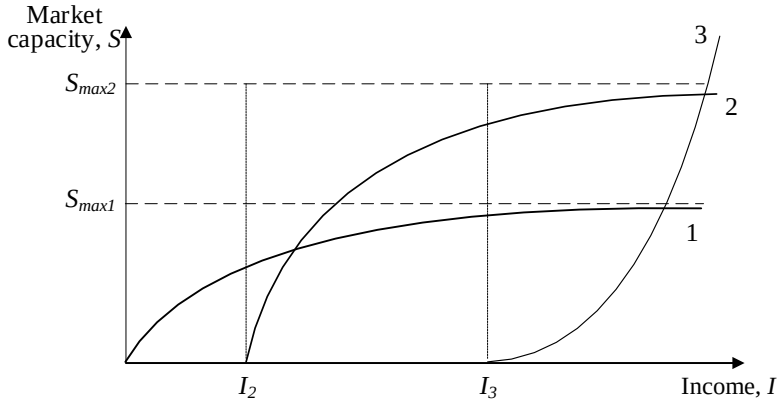

Fig. 3. Engel and Törnqvist curves for various groups of goods:
1 – the goods of prime necessity; 2 – the goods of secondary necessity;
3 – luxury goods

The coefficient of elasticity of consumption of necessities varies from zero to one. The dependence of the market capacity on the income level of this group of goods is as follows

$$S_1 = \frac{S_{max_1} I}{I + a_1}, \qquad (10)$$

where S_1 is the market capacity of the target group of goods or services of primary necessity; S_{max_1} is the upper boundary of the consumption of necessities (maximum market capacity, the market potential of a target good of primary necessity): $\lim\limits_{I\to\infty} S_1 = S_{max_1}$; a_1 is a model parameter.

2. *Goods of the secondary necessity*, for which the curve of the market capacity is convex (fig. 3, curve 2) and, when incomes increase, it approaches the upper boundary of consuming a certain group of goods S_{max_2} that has greater value for these goods than for the goods of primary necessity; the demand for this group of goods occurs after the income reaches a certain amount $I \geq I_2$ and then the goods of this group can be purchased. The elasticity of demand for such goods approaches 1. The dependence of the market capacity S_2 on per capita income for the goods of the secondary necessity is as follows

$$S_2 = \frac{S_{max_2}(I - I_2)}{I + a_2}, \qquad (11)$$

where S_{max_2} is the upper boundary of consuming the goods of the secondary necessity: $\lim\limits_{I\to\infty} S_2 = S_{max_2}$; I_2 is the boundary value of income (if $I < I_2$, the market capacity of the goods of the secondary necessity $S_2 = 0$); a_2 is the parameter of a model.

3. *Luxury goods*, the consumption of which does not have the upper boundary and increases more rapidly when the income increases, it occurs only after the income exceeds the lower boundary value $I \geq I_3$, goods are not purchased (there is no demand) until this value is achieved. The curve of the market capacity of luxury goods S_3 is concave (fig. 3, curve 3) and is described by the following functional

$$S_3 = \frac{S_{max_3} I(I - I_3)}{I + a_3}, \qquad (11)$$

where I_3 is the boundary value of income (is $I < I_3$, the market capacity of luxury goods $S_3 = 0$); a_3 is the parameter of a model.

When the values of income *I* are great enough

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$$S_3 \approx S_{max_3} I \ . \qquad (12)$$

That means almost all income growth can be spent on luxury goods in this situation.

Another curve $S_4 = a_4 I - b_4 I_4$ for goods or groups of goods that are not used when a certain level of income is reached can be added to the Törnqvist functions. So, the demand for such products increases at first, reaches the maximum for $I = a_4/2b_4$ and then starts decreasing up to 0, that means that there is no demand for such products when incomes are greater than this boundary.

In their works, *A. Maki* and *M.A.Kamwe* [18] on the basis of theoretical and empirical data considered and proved the hypothesis alternative to the Törnqvist-*Wold* hypothesis on the definition of luxury goods and necessities using the elasticity of the demand for general costs, direct and cross-price elasticity in the context of recent empiric observations taking into account the stratification of society in different countries.

Let us consider the available approaches to using the Törnqvist functions. Thus, in their works, *H. Wold* and *L. Juréen*) [19] classify goods as necessities when the coefficient of direct price elasticity is negative, necessities and luxury goods are classified using the combination of prices and general income elasticity according to Törnqvist approaches, as "Törnqvist groups the commodities into "necessities" and "luxuries", with price elasticity below and above unity, respectively. This leads to the conclusion that, as a rule, income elasticities of necessities are smaller than their price elasticities, whereas income elasticities of luxuries are greater than their price elasticities" [19, p.115].

This phenomenon can be explained by the fact that in the elasticity of demand there are two important characteristics of the complete demand system (and the demand functions of homogeneous products are determined by zero degree):

1) the sum of total cost elasticity, direct price elasticity and cross-price elasticity (cross-elasticity) for the *i*-th element is equal to zero

$$\frac{E_{Q_i}}{E_X} + \frac{E_{Q_i}}{E_{P_1}} + ... + \frac{E_{Q_i}}{E_{P_i}} + ... + \frac{E_{Q_i}}{E_{P_n}} = 0 \,, \qquad (13)$$

where $\frac{E_{Q_i}}{E_{P_j}} = \frac{\partial \log Q_i}{\partial \log P_j}$, $j = 1,...,n$ i $\frac{E_{Q_i}}{E_X} = \frac{\partial \log Q_i}{\partial \log X}$.

2) if the weight factor is taken into account, the mean value of the demand elasticity with account for the price of a fixed item of goods is equal to a negative proportion between the costs for the *i*-th item of goods and general costs.

$$\frac{\sum_j \left(P_j Q_j\right)\left(\frac{E_{Q_j}}{E_{P_i}}\right)}{\sum_j \left(P_j Q_j\right)} = -\frac{P_j Q_j}{X} \,. \qquad (14)$$

For two items of goods, for example, food and non-food items, according to the formula (13), the following system of equations is true

$$\begin{cases} \frac{E_{Q_1}}{E_X} + \frac{E_{Q_1}}{E_{P_1}} + \frac{E_{Q_1}}{E_{P_2}} = 0 \\ \frac{E_{Q_2}}{E_X} + \frac{E_{Q_2}}{E_{P_1}} + \frac{E_{Q_2}}{E_{P_2}} = 0 \end{cases} . \qquad (15)$$

According to the direct price elasticity of the first item of goods (food), the demand is inelastic; thus this product can be classified as a necessity according to the Törnqvist-Wold hypothesis. If the characteristics of the first product are focused on, according to (15), the Törnqvist-Wold hypothesis is obtained as the following system of equations

$$\begin{cases} \left(P_1 Q_1\right)\left(\frac{E_{Q_1}}{E_{P_1}}\right) + \left(P_2 Q_2\right)\left(\frac{E_{Q_2}}{E_{P_1}}\right) = -P_1 Q_1 \\ \left(P_1 Q_1\right)\left(\frac{E_{Q_1}}{E_{P_2}}\right) + \left(P_2 Q_2\right)\left(\frac{E_{Q_2}}{E_{P_2}}\right) = -P_2 Q_2 \end{cases} . \qquad (16)$$

According to the second equation of the system (16), the following is true

$$\frac{E_{Q_1}}{E_{P_2}} = -\frac{P_2 Q_2}{P_1 Q_1}\left(\frac{E_{Q_2}}{E_{P_2}} + 1\right). \qquad (17)$$

Let us consider these two cases.

1) if the demand for the second item of goods (non-food group) is elastic by own price and cross-price, $\frac{E_{Q_1}}{E_{P_2}} > 0$ and, hence, $\frac{E_{Q_1}}{E_X} + \frac{E_{Q_1}}{E_{P_1}} < 0$, if $\frac{E_{Q_1}}{E_{P_2}}$ is changed in the first equation of the formula (15). That leads to the Törnqvist –Wold hypothesis – as a rule, *the income elasticity of demand for necessities is less than their elasticity of prices*.

2) if the demand for the second item of goods is inelastic in its own price but elastic in cross-price, $\frac{E_{Q_1}}{E_{P_2}} < 0$ and $\frac{E_{Q_1}}{E_X} > -\frac{E_{Q_1}}{E_{P_1}}$. That leads to the following conclusion of the Törnqvist –Wold hypothesis – *the income elasticity of demand for necessities is greater than their own (direct) price elasticity*.

In case of the *n*-dimension product case

$$\frac{E_{Q_i}}{E_X} + \frac{E_{Q_i}}{E_{P_i}} = -\left(\frac{E_{Q_i}}{E_{P_1}} + \frac{E_{Q_i}}{E_{P_2}} + ... + \frac{E_{Q_i}}{E_{P_n}}\right). \qquad (18)$$

When the sum of general elasticity and costs and own price elasticity is negative $\frac{E_{Q_i}}{E_X} < -\frac{E_{Q_i}}{E_{P_i}}$, the following inequality occurs

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$$\sum_{i \neq j} \frac{E_{Q_i}}{E_{P_i}} > 0 . \quad (19)$$

This indicates that the sum of the cross-price elasticity for the ith product is positive and the ith product can be classified as a "necessity" according to the results obtained in the case of two goods. On the other hand, when the total elasticity of costs is greater than the absolute value of direct price elasticity $\frac{E_{Q_i}}{E_X} > -\frac{E_{Q_i}}{E_{P_i}}$, the following inequality occurs

$$\sum_{i \neq j} \frac{E_{Q_i}}{E_{P_i}} < 0 . \quad (20)$$

This indicates that the sum of cross-price elasticities is negative and the *i*-th product is classified as a luxury one. But to obtain the mathematically exact relationship between the cross-price elasticity $\frac{E_{Q_i}}{E_{P_j}}$, $(i \neq j,\ j = 1, 2, ..., n)$ and direct (own) price elasticity $\frac{E_{Q_j}}{E_{P_j}}$, $(j = 1, 2, ..., n)$ for all the goods available at the market is rather difficult. There are also difficulties in estimating the elasticity of the cross-price for the complete product assortment. For these reasons, the Thörnqvist-Wold hypothesis can be studied and substantiated only empirically using actual observations and accumulated statistics.

It should be also noted that other empirical laws of consumption were found on the basis of Engel's law [20]:

Schwabe's law – the poorer the family, the more the share of income is spent on housing;

Wright's law – the higher the income, the higher the level of savings and the share of savings in costs;

Ginny's law – if food costs grow or decrease in the arithmetic progression, the other types of costs change in the opposite direction but in the geometric progression.

Conclusions

While forecasting the market capacity, the following things should be taken into account – current purchases of durable goods depend not only on the income and prices but also on the stock of goods from consumers and substantially on a number of consumers and structural shifts in time; when consuming short-term goods, the product habit is of decisive importance; it is important to know which goods belong to the first category (related to stocks) and which ones belong to the second (related to habits), what goods of a certain segment are of primary necessity while they are considered as luxury ones in another group.

When developing and applying models, the following limitations should be taken into account – in some cases, the actual values of the market capacity at the previous moments of time that are used to build the trend model cannot be approximated by any one of the traditional functional dependencies (linear, static, logarithmic, exponential,) due to the following factors – there are significant fluctuations in the change in the rate of growth in the development of the market; a spontaneous decrease in the market capacity over time; crisis phenomena; the group of products develops under the strong influence of various factors at different times, which leads to the stochastic consumption of goods.

Taking into account the mentioned above while developing of models for forecasting the market capacity enables describing the behaviour of consumers when purchasing the main groups of goods and services mathematically and estimating the consequences of the change in various factors, taking into account their influence on the market capacity of specific groups of goods and services in the most accurate way; determining the critical values of factors due to which the consumption of a certain group of products can be absolutely stopped or reduced to a minimum level.

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ВИКОРИСТАННЯ ЕКОНОМІКО-МАТЕМАТИЧНИХ МОДЕЛЕЙ ДЛЯ ВИЗНАЧЕННЯ МІСТКОСТІ РИНКУ

Предмет: економіко-математичні моделі прогнозування місткості ринку з урахуванням системи впливаючих факторів. **Мета:** систематизація та обгрунтування теоретичних і методологічних підходів до прогнозування місткості ринку в умовах сучасного нестабільного стану економік. **Завдання**: дати найбільш повний систематизований перелік факторів, що впливають на розвиток і величину місткості ринку; розглянути особливості, переваги та недоліки застосування існуючих економіко-математичних моделей прогнозування місткості ринку; розглянути необхідність урахування в прогнозних моделях структурних зрушень в чисельності споживачів за віковими когортами; виявити особливості впливу споживання товарів розкоші и товарів першої необхідності з урахуванням доходу на змінення місткості ринку. **Методи:** системний аналіз, факторний аналіз, регресійно-кореляційний аналіз, методи кумулятивних кривих. **Результати:** розглянуто принципи побудови економіко-математичних моделей прогнозування місткості ринку. Систематизовано фактори, які впливають на

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місткість ринку на мікро- та макрорівнях та мають випадковий або систематичний характер впливу. Виявлено переваги, недоліки та особливості застосування багатофакторних та однофакторних моделей місткості ринку, зокрема кумулятивних кривих. Запропоновано обов'язкове урахування у багатофакторних моделях демографічних чинників (змінення структури вікових когорт у часі). Показано альтернативне використання кумулятивних кривих попиту щодо груп товарів розкоші та першої потреби в залежності від доходу. **Висновки.** Урахування структурних зрушень кількості споживачів у часі, особливостей споживання товарів розкоші та товарів першої необхідності із застосуванням коефіцієнтів еластичності попиту за доходом та інших значущих факторів, дасть змогу математично описати споживання основних груп товарів і послуг, спрогнозувати величину місткості їх ринку; визначити критичні значення факторів, за яких можливим є повне припинення споживання певної групи продукції або зменшення споживання до мінімального рівня.

Ключові слова ємність ринку, економіко-математична модель, еластичність попиту, дохід, споживання, ціна, попит.

ИСПОЛЬЗОВАНИЕ ЭКОНОМИКО-МАТЕМАТИЧЕСКИХ МОДЕЛЕЙ ДЛЯ ОПРЕДЕЛЕНИЯ ЁМКОСТИ РЫНКА

Предмет: экономико-математические модели прогнозирования ёмкости рынка на основе системы влияющих факторов. **Цель:** систематизация и обоснование теоретических и методологических подходов к прогнозированию ёмкости рынка в условиях современного нестабильного состояния экономик. **Задачи:** дать наиболее полный систематизированный перечень факторов, влияющих на развитие и величину ёмкости рынка; рассмотреть особенности, преимущества и недостатки применения существующих экономико-математических моделей прогнозирования ёмкости рынка; рассмотреть необходимость учёта в прогнозных моделях структурных сдвигов в численности потребителей по возрастным когортами; выявить особенности влияния потребления товаров роскоши и товаров первой необходимости с учётом дохода на изменение ёмкости рынка. **Методы:** системный анализ, факторный анализ, регрессионно-корреляционный анализ, методы кумулятивных кривых. **Результаты.** Рассмотрены принципы построения экономико-математических моделей прогнозирования ёмкости рынка. Систематизированы факторы, влияющие на ёмкость рынка на микро- и макроуровне и имеющие случайный или систематический характер воздействия. Выявлены преимущества, недостатки и особенности применения многофакторных и однофакторной модели ёмкости рынка, в частности кумулятивних кривых. Предложен обязательный учёт в многофакторных моделях демографических факторов (изменение структуры возрастных когорт во времени). Показано альтернативное использование кумулятивных кривых спроса по группам товаров роскоши и первой необходимости в зависимости от дохода. **Выводы.** Учёт структурных сдвигов количества потребителей во времени, особенностей потребления товаров роскоши и товаров первой необходимости с применением коэффициентов эластичности спроса по доходу и других значимых факторов, позволит математически описать потребления основных групп товаров и услуг, спрогнозировать величину ёмкости их рынка; определить критические значения факторов, при которых возможно полное прекращение потребления определённой группы продукции или уменьшение потребления до минимального уровня.

Ключевые слова: ёмкость рынка, экономико-математическая модель, эластичность спроса, доход, потребление, цена, спрос.

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E. DIDENKO

MODELLING THE FLEXIBLE SCHEDULES OF WORK OF INDUSTRIAL ENTERPRISES MANAGERS

The **subject** matter of the article is analyzing ways of using the potential capabilities of managers of industrial enterprises to implement high-performance activities as a factor of direct influence on the state and nature of the relationship between an employer and an employee. The **goal** is to build a model for flexible scheduling the work of enterprise managers that take into account the priority of solving production tasks in the subsystem of the personnel management of the decision support system for organizing the activities of an industrial enterprise. The **objectives** are to develop an economic and mathematical model that enables taking into account the rhythm of the fluctuations of the opportunities for achieving high results in the managerial activity and the activation of hidden potentials of managers by introducing flexible forms of managers' work into the scheduled plans of the production activities of industrial enterprises. The general scientific **methods** such as system analysis, structural analysis and specific network methods are used. The following **results** are obtained. The conceptual model of activating the efficiency of managers' production activities is suggested; the manager's activities are activated by minimizing the involvement of managers in performing production tasks when the values of the indicators of managers' potential capabilities are low, which objectively reduces the productivity of managerial work. At the same time, it is suggested to use the manager's capabilities at a time that coincides with the opportunities for high-performance work by adapting flexible schedules of managers' work to the requirements of the scheduled plans of an industrial enterprise. The integral indicator for assessing the impact of the rhythms of managers' activities on the state of their labour productivity is suggested for using in the models of organizing the activity of industrial enterprises. Recommendations are given to minimize the risks of disregarding the terms of employment contracts that are caused by the potential inability to obtain high indicators of managers' labour activities and to explain the advantages of using flexible schedules of managers' work to the representatives of an employer's personnel services. **Conclusions.** Modelling of flexible schedules of the work of managers of industrial enterprises enables correcting the work of managers at an enterprise taking into account the wave character of managers' readiness for highly productive work according to the positive feedback principle. The recommendations for calculating the integral indicator of assessing the impact of the rhythms of managers' activities on the state of productivity of their work are given. The obtained results can be used to determine more specifically the obligations of employers and managers as the parties of labour relations to agree on the duration, regularity, and the rhythm of managers' performance of their work-related obligations.

Keywords: enterprise, flexible work schedule, employee, model.

Introduction

Managing an industrial enterprise in the market conditions of business environment generates a number of relations among the different subjects of management. The alignment of the interests of owners, employees, labour collective requires improving the mechanism of interaction as a way to achieve the goal and objectives of an enterprise. Business planning of the enterprise activities enables solving these problems but the plans are usually detailed and scheduled in order to overcome the complex nature of available contradictions among the subjects of management. At this stage, the opportunities of the enterprise related to the motives and incentives of the work activity are not fully taken into account; flexible forms of the work organization are often considered as a means of the intangible motivation of the personnel of the enterprise and less as a means of tangible minimization of the enterprise costs. Under the increase of the percentage of salary costs compared with tangible costs, this factor becomes sufficient to be considered in the scheduled plans of an industrial enterprise. First of all, the solution to these tasks depends on the organization of the activities of managers of different levels of management, whose activities should be a model of a high-performance work for all personnel of the enterprise.

Analysis of literary sources and problem statement

Labour distribution in the process of organizing the interaction of members of the labour collective is the driving force for improving the performance of the enterprise. The specialization of the members of the labour collective according the tasks of management has always required the application of the systematic approach to the study of the content of managerial work and has been widely studied by foreign and Ukrainian scholars, in particular by V.G. Aliyev, L.V. Balabanova, O.M. Vinogradskaya, O.E. Kuzmin, L.E. Dovgan, A.A. Mazaraki, B.Z. Milner, S.V. Mocherny, P. Drucker, L. Seiwert [1, 2, 4, 5, 11, 12, 13, 14, 15, 16] and many others.

According to V.G. Aliyev's the scientific views [1, c. 249–261] the management work as an element of the organization of the production process requires the application of the systemic approach which is based on scientific principles. P. Drucker [2, p.289] considers that an effective manager should combine "useful time" to consolidate the time in order to spend it efficiently. R.A. Fathutdinov [3, c.458] thinks that the basic approach to the formation of a company manpower is standardizing the complexity of work for each group of staff and establishing the manpower norms that correspond to the rational organization of work. According to L. Seiwert [4, c.79, p.140], the system of planning the working time is an integral part of any manager's activity which should take into account the impact of the rhythms of human activity on the ability to work. A.A. Mazaraki [5, c.414-426] has come to the conclusion that selecting personnel for accomplishing target tasks is an integral part of the human resources management process which should be

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carried out on the basis of the scientific organization of work.

It is clear that all the above views have differences but they have similar features: firstly, understanding the managerial labour as a component of the labour process which is connected with the transformation of information and requires the involvement of highly skilled specialists is a considerably complex process which uses much energy, memory and mental tension of the subject of management; secondly, promoting the implementation of economic and mathematical methods of management in general and economic and mathematical modelling the schedules of the personnel work of enterprises in particular; and thirdly, finding ways to optimize management costs.

This theoretical foundation enables identifying the problem of developing the models of highly effective organization of managers' work due to the introduction of the systematic approach to the process of selecting managers and making them perform the tasks scheduled by the plans for the development of enterprise activities.

Goals and objectives of the study

The analysis of available approaches to minimizing management costs requires the study of the impact of a manger's personal state on the results of their work: the models for developing scheduled plans should take into account the managers' capability for high-performance work within the time determined by the plans of company activities. It is correctly reasoned that the groups of managers and individual managers are not equally prepared for completing production tasks, which poses a problem that should be solved.

Therefore, the company authorities should develop a concept for achieving the goal of the company activity, work out mechanisms necessary for its implementation, and bring the main talking points to the owners and members of the company labour collective. Thus, the goal of this study is to improve the mechanisms of the enterprise activities, to find opportunities for integrating flexible schedules of managers' work into the scheduled plans of enterprise activities, providing personnel units with tools for selecting staff and grouping managers within the units that ensure high performance of the enterprise. Therefore, the objectives of this study are to find ways to ensure the competitive advantages of an industrial enterprise, to maximize the profitability of its activities, to minimize management costs, to facilitate establishing a high-performance rhythm of managers' work.

Materials and methods of the study

An important prerequisite for the profitability of an enterprise is the efficiency of management. Management as an activity bear the costs. First of all, this is the cost of management of an enterprise caused by executing managerial functions including administration costs (managing the activities of the enterprise authorities), financial management, risk management and so on. Specific features of the types of managers' work are linked to the distribution of their work among various functions and processes of management (planning, organization, control, motivation, regulation) and the corresponding dominance of one function over another one in the daily work of a manager. Under rapid changes in food and financial markets, the markets of information and other services, low-productive labour costs of managers are the losses of an enterprise that reduces its profitability, as they are a part of products (services) that are produced for their own needs, a part of products that have not been or sold. And if excess costs for low-productive work of managers are direct for sold production, they are indirect for domestic and unsold products.

The issues that arise when production costs exceed the available norms in the main production process are usually clearly regulated by existing standards, regulations, orders, and so on, while insufficient attention is still paid to the problem of setting standards for costs of managers' work. In particular, this is due to the lack of the unified approach to determining the indicators of labour productivity of a manager. Thus, the indicators that depend on conscious changes of values of labour productivity indicators are studied more than the ones that depend on unconscious changes.

A manager as a human being cannot objectively maintain the consistently high level of productivity, so in order to avoid excessive costs, an enterprise should take into account the wave character of the fluctuations in the manager's capacity for productive labour including situations when the manager deliberately reduces the labour productivity and when it unintentionally decreases because of the manager's personal state. This problem is rather complicated, as the mechanism of regulating the activities of a manager linked with the conscious reduction of labour productivity by using relevant motivators is well known and more or less worked out but the mechanism that takes into account the effects of the rhythm of a manager's personal status still remains less studied as some specialists who work with personnel step back from the issue, since they consider that an enterprise can violate human rights that are declared in the European Convention for the Protection of Human Rights and Fundamental Freedoms [6], they also think that there are contradictions of manager's personal interests, labour collective interests and the interests of an enterprise. These arguments are vicious since the employment contract (agreement) is signed with the knowledge and acceptance of the use of intellectual, mental, physical, and other resources; and when its terms are being fulfilled, managers are obliged to maintain these terms in accordance with their obligations. A company as a party of the employment contract in its turn is obliged to use the work of a manager at a time when their potential capabilities are at the highest level. And if at a specific time moment, these capabilities lie below the required level, another manager whose potential capabilities lie within the specified limits should work. Managers can arrange different variants of work – each manager can work during a week, or they can work day by day or in

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shifts, and so on, but the enterprise arranges only such a schedule of managers' work (managers' rotation) where, if all other conditions are equal, at every moment of working time the value of the integral indicator of the potential capabilities of a manager engaged in work lies within the norm, which makes the low-productive work impossible.

Such a schedule of managers' work will almost never coincide with the typical schedule of other employees' work but will allow the company to avoid excessive low-productive costs of their labour. The progressive experience of using flexible working schedules and the results obtained by enterprises due to the application of the latest methods of personnel work enable concluding that there is a dependence of the profitability of an enterprise on the quality of the managerial time use.

The algorithm of solving the tasks of developing flexible schedules of managers' work is based on the ideas of the scheduling theory with the use of network approach.

Let us take the following notations:

j is the manager index, $j=\overline{1,J_\gamma}$; i the index of activity direction, $i=\overline{1,I}$;

n is the task index, $n=\overline{1,N(i)}$; γ is the index of managers group, $\gamma=\overline{1,n}$; k is the index of available or created for implementing the *i*-th direction of an enterprise activity, $k=\overline{1,K(i)}$; λ is the index of the j-th manager's resource that is needed to complete a set of tasks of the j-th activity direction, $\lambda=\overline{1,\lambda_j}$; ϕ is the index of the type of activity rhythm of the j-th manager, $\phi=\overline{1,\omega}$; f_ϕ are the values of the variable of the ϕ-th rhythm of the manager activity; $\mathfrak{z}^\gamma=\{(i,n)\}$ is a set of all tasks that can be solved by the γ-th group of managers; $\mathfrak{z}_i$ is a set of all tasks of the i-th direction of activity; $\tilde{\mathfrak{z}}^\gamma$ is a set of tasks assigned to the γ-th group of managers; $\mathfrak{z}^{\gamma j}$ is a set of tasks that can be solved by the j-th manager; $\overline{R}^{\gamma\lambda}$ is the maximum level of the λ-th resource of the γ-th group of managers; $R^{\gamma\lambda}$ is the actual level of the λ-th resource of the γ-th group of managers; $\tilde{R}^{\gamma\lambda}$ is the actual level of the λ-th resource of the γ-th group of managers; X_{in}^{γ} is the Boolean variable that is equal to 1, if the tasks (i,n) can be solved by the γ-th group of managers, and is equal to 0 if the tasks cannot be solved; $X_{in}^{\gamma j}$ is the Boolean variable that is equal to 1, if the tasks (i,n) can be solved by the j-th manager of the γ-th group, and is equal to 0, if the tasks cannot be solved; $\overline{t}_i$ is the time necessary for implementing the $\mathfrak{z}_i^j$ set of tasks of the i-th activity direction; t_i is the moment of time when the $\mathfrak{z}_i$ – set of tasks of the i-th activity direction are completed; t^γ is the moment of time when the last task of the $\tilde{\mathfrak{z}}^\gamma$ set of tasks is completed; $\overline{t}^\gamma$ is the time necessary for implementing the $\tilde{\mathfrak{z}}^\gamma$ set of tasks by the γ-th group; t_{in}^{γ} is the moment of time when the (i,n) task from the $\tilde{\mathfrak{z}}^\gamma$ set of tasks is completed by the γ-th group; $\overline{t}_{in}^{\gamma}$ is the time necessary for implementing the (i,n) task from the $\tilde{\mathfrak{z}}^\gamma$ set of tasks by the γ-th group; $t_{in}^{\gamma j}$ is the moment of time when the n-th task is completed by the j-th manager of the γ-th group; $\overline{t}_{in}^{\gamma j}$ is the time necessary for implementing the n-th task by the – j-th of the γ-th group; t_i^γ is the moment of time when the last task of the $\mathfrak{z}_i^\gamma$ set of tasks is completed by the γ-th group of managers of the i-th activity direction; $\overline{t}_i^{\gamma}$ is the time necessary for implementing – the $\mathfrak{z}_i^\gamma$ set of tasks by the γ-th group of the i-th activity direction; $T^{\gamma j}$ is the working time fund of the j-th manager of the γ-th group; T^γ is the working time fund of the γ-th group of managers; α is the moment of time when the tasks are implemented, $\alpha=\overline{1,T}$; T is the maximum possible time necessary for implementing the whole set of managerial tasks that are determined according to the plans for developing the activity of an enterprise; $\tilde{\mathfrak{z}}^{\gamma\lambda}$ is a set of tasks of the $\tilde{\mathfrak{z}}^\gamma$ set that corresponds to the λ-th resource necessary to solve the tasks of the $\mathfrak{z}^\gamma$ set.

The scenario contains the following assumptions.

1. The network schedule of the complex of directions of an enterprise activity is set, where the vertices correspond to the events that determine the completion of the tasks of all directions of activity, i.e. the arcs which are included in each given vertex. The set of tasks of the direction of the enterprise activity is characterized by the time necessary for their implementation, which depends on the productivity of managers who solve the specified tasks.

2. Each activity direction includes the sets of task (groups of operations). The process diagram is given for implementing the tasks (procedures) for each direction.

3. The time necessary for solving the whole set of tasks of the complex of business activities is considered as an interval between the beginning of his first task and the end of the last one:

$$t_i \overset{\Delta}{=} \max_{n=\overline{1,N(i)}} t_{in}^{\gamma} - \max_{n=\overline{1,N(i)}} (t_{in}^{\gamma} - \overline{t}_{in}^{\gamma}).$$

The time necessary for solving the γ-th group of tasks is considered as the value

$$\overline{t}^{\gamma} \overset{\Delta}{=} \max_{(i,n)\in\tilde{\mathfrak{z}}^\gamma} \overline{t}_{in}^{\gamma} - \max_{(i,n)\in\tilde{\mathfrak{z}}^\gamma} (t_{in}^{\gamma} - \overline{t}_{in}^{\gamma}).$$

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The time necessary for solving the task is determined by the labour productivity of the γ-th group that is solving this task:

$$\bar{t}_{in}^{\gamma} = \sum_{j=1}^{J_\gamma} \bar{t}_{in}^{\gamma j} X_{in}^{\gamma j}.$$

The Boolean variable $X_{in}^{\gamma j}$ is equal to 1, if the manager of the j-th manager of the γ-th group has the positive λ-th resource $R_{in}^{j^\lambda} = X_{in}^{j^\lambda} P^j F^j$ for implementing the (i,n) task, and is equal to 0, if the manager has no such a resource. Here, P^j is the predicted labour productivity of the j-th manager; $F^j = \sum_{\phi=1}^{\omega} f_\phi$ is the integral indicator of the manager's potential capabilities (for $\forall f_\phi \le 0 \Rightarrow F^j = 0$). According to the law of the weakest link, the availability of the group resource depends on the availability of the positive λ-th resource of an individual manager of the γ-th group: variable $X_{in}^{j^\lambda} = 1$, if the j-th manager of the γ-th group can solve the (i,n) task and $X_{in}^{j^\lambda} = 0$, if they cannot solve it.

The task is characterized by the maximum and minimum time for its implementation:

$$\min_{j=1,J_\gamma} \bar{t}_{in}^{\gamma j} \le t_{in}^{\gamma j} \le \max_{j=1,J_\gamma} \bar{t}_{in}^{\gamma j}.$$

4. The manager can perform only one task and has a set of task types that they can solve.

5. Managers are grouped. A group is characterized by a set of task types $з^\gamma$ it can solve, які вона може вирішувати, $з^\gamma = \bigcup_{j=1}^{J_\gamma} з^{\gamma j}$, and also by the general working time fund $T^\gamma = \sum_{j=1}^{J_\gamma} T^{\gamma j}$.

Besides, a vector of resources is determined for each group of managers, that is the vector $\bar{R}^\gamma$ with the length of $\lambda_\gamma = card\, з^\gamma$, where λ is the component that is equal to the $\bar{R}^{\gamma^\lambda}$ number of managers who can solve the λ-th task from the set $з^\gamma$. According to item 4 $\lambda_\gamma \ge J_\gamma$; at particular moments of time several or all $\bar{R}^{j^\lambda}$ components change. There is the connection among the maximum, actual and determined number of resources at the moment of time:

$$\tilde{R}^{\gamma^\lambda} \le R^{\gamma^\lambda} \le \bar{R}^{\gamma^\lambda}.$$

At the initial moment of time $R^{\gamma^\lambda} = \bar{R}^{\gamma^\lambda}$, $\tilde{R}^{\gamma^\lambda} = 0$.

Managers are grouped in such a way that $з^{\gamma_1} \cap з^{\gamma_2} = 0$, $\gamma_1 \ne \gamma_2$, that is every group has a clearly determined range of tasks. This condition assigns the known set of tasks in each *i*-th direction of the enterprise activity to each group of managers. Let us call each set a generalized task and assume that the implementation of generalized tasks is continuous. A generalized task comprises the groups of tasks that are related by the known sequence of execution (the technology of task solving).

6. $\bar{R}^\gamma$ resources of any group of managers are sufficient at least for assigning any group of tasks, that is $з^\gamma \ge \tilde{з}^\gamma \ge з_i^\gamma$.

Practically, it is reasonable to leave the resource of the group in the case when the *j*-th manager cannot perform the task due to unpredictable reasons. When this trouble happens, the group can take responsibility for relieving the consequences. The technique of its determining is the subject of a separate research.

7. The condition for solving the whole complex of tasks

$$\bigcup_{i=1}^{I} з_i \le \bigcup_{j=1}^{\gamma} з^J.$$

The mathematical model of the task of developing the flexible schedule of managers' work is as follows:

$$\bar{t}_{in}^{\gamma j} \ge t_{in}^{\gamma j} + \max_{\alpha \in U_{in}} t_{i\alpha}^{\gamma j},\ i = \overline{1,I},\ n = \overline{1,N(i)},\ j = \overline{1,J_\gamma};$$

$$\max_{\alpha,\gamma,j} t_{i\alpha}^{\gamma j} \le T_i,\ i = \overline{1,I};$$

$$\min_{j=1,J_\gamma} \bar{t}_{in}^{\gamma j} \le \max_{j=1,J_\gamma} \bar{t}_{in}^{\gamma j},\ i = \overline{1,I},\ n = \overline{1,N(i)};$$

$$\sum_{i=1}^{I} \sum_{n=1}^{N(i)} \bar{t}_{in}^{\gamma j} X_{in}^{\gamma j} \le T^{\gamma j},\ j = \overline{1,J_\gamma};$$

$$\tilde{R}^{\gamma^\lambda} \le \bar{R}^{\gamma^\lambda},\ \lambda = \overline{1,\lambda_j};$$

$$\bar{t}_{in}^{\gamma j} = \sum_{j=1}^{J_\gamma} \bar{t}_{in}^{\gamma j} X_{in}^{\gamma j},\ i = \overline{1,I},\ j = \overline{1,J_\gamma},\ n = \overline{1,N(i)};$$

$$\bar{t}^{\gamma} = \max_{\tilde{з}^\gamma} t_{in}^{\gamma j} - \min_{\tilde{з}^\gamma} (t_{in}^{\gamma j} - \bar{t}_{in}^{\gamma j});$$

$$\bar{t}^{\gamma} \to \min.$$

The value T_i can be given; otherwise, it is considered that $T_i = T$. The values $t_{in}^{\gamma}, t_{in}^{\gamma j}, X_{in}^{\gamma j}$ are unknown. The values $\bar{T}^{\gamma j}, \bar{R}^{\gamma^\lambda}, \bar{t}_{in}^{\gamma j}$ are given. Besides, a set of tasks that are preliminary according to the network schedule is considered known at all times.

The tasks of developing the flexible schedule are solved in two steps: firstly, a set of tasks is assigned to the groups of managers, then the tasks are fixed by the group managers. The algorithm of developing the flexible schedule of the γ-th group of managers is suggested.

1. Minimum and maximum time if given for implementing each task from $з_i^\gamma$ with no regard for the managers' load.

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2. The earliest moments of the implementation of all tasks are determined. At the initial moment of time the step value θ of the simulated time during which the assignment of tasks does not change $\theta^0 = 0$.

3. The counter of the simulated time α that is equal to the least time of task implementation is the following: $\alpha = 0$.

4. The extended front of tasks $\Im_{\theta^\alpha}$ is developed. Initially, it comprises all tasks that start at the moment of time $\alpha = 0$.

5. If $\Im_{\theta^\alpha} = 0$, see item 11.

6. Generalized reserves of time for each task $\tau(\Im_{\theta^\alpha}, \theta^\alpha)$ are determined.

7. The classes of tasks Q_β are developed according to the increase of the generalized reserves of time

$$\Im_{\theta^\alpha} = \bigcup_\beta Q_\beta .$$

8. Let us take in order the classes of tasks Q_β and assign the tasks for implementing whenever possible: if two conditions are met simultaneously

$$R_{in}^{j^\lambda} > 0 \text{ та } T^{\gamma j} \geq \bar{t}_{in}^{\gamma j}$$

the task is assigned to the manager who can execute it for the shortest time.

If $R_{in}^{j^\lambda} = 0$, the task is marked and put in the front of tasks for the following moment of time $\Im_{\theta^{\alpha+1}}$. If there is no manager who has the necessary time fund, the algorithm breaks and a message is sent that the fund of the working time lacks for the (i,n)-th task and the responsible person uses the heuristic procedure of appointing an executor from outsourcing managers or involves a new manager according to the criterion of economic feasibility of the decision made. When all tasks of the Q_β th class are considered, the $\beta = \beta + 1$ group of tasks is considered as long as all the front of the task is not considered. A manager is appointed for implementing each task.

9. For each task

$$\alpha_{in}^{\gamma j'} = \min \frac{\bar{t}_{in}^{\gamma j'}}{\bar{t}_{in}^{\gamma j}}$$

is calculated.

For each Q_β th class of tasks

$$\bar{\alpha}_\beta = \min_{Q_\beta} \alpha_{in}^{\gamma j}; \bar{\alpha}_\beta = \max_{Q_\beta} \alpha_{in}^{\gamma j};$$

is calculated.

Each Q_β class is considered as a set of Q_β^1 assigned tasks з $\alpha_{in}^{\gamma j} = 1$; a set of Q_β^2 tasks from $0 < \alpha_{in}^{\gamma j} < 1$; a set of Q_β^3 tasks from $\alpha_{in}^{\gamma j} = 0$, that have not been assigned:

$$Q_\beta = Q_\beta^1 \cup Q_\beta^2 \cup Q_\beta^3 .$$

10. Let us consider the time reserves for implementing the tasks of $\Im_{\theta^\alpha}$ front within such short period of time that $\Im_{\theta^\alpha} = \Im_{\tilde{\theta}}$. Let us calculate $\theta_{in}^{j^\lambda}$, that is the earliest moment of time of completion of the front of the $\Im_{\theta^\alpha}$ tasks as well as the earliest moment of time of probable restoration of the maximum level of resources $R_{in}^{j^\lambda}$. Let us restore the maximum level of resources and calculate the values $T^{\gamma j} = T^{\gamma j} - \theta^\alpha$ for all managers who completed the tasks within the time from θ^α to $\theta^{\alpha+1}$. Let us move to item 4.

11. All the tasks are completed for the time θ^α. If $\theta^\alpha > T$, the message which says that there is no solution is created. Let us develop the file where the time of beginning, execution duration and a responsible manager are determined for each task, that is the file where the codes of tasks and the corresponding moment of work beginning and end match up the code of the manager.

The results of the research

The analysis of the concepts of modelling managers' schedules which take into account the state of potential managers' capability to perform scheduled tasks makes it possible to state that accounting the rhythm of changes in managerial capabilities objectively contributes to reducing management costs. The integral index of such impact should be calculated according to the formula:

$$F^j = \sum_{\phi=1}^{\omega} f_\phi ; \; f_\phi = \sin \frac{2\pi(365y + v + o)}{p_\phi} 100\% ,$$

where ω is the number of rhythms of a manager's activity the calculation bases on, $\omega = 1,2,3$ (while making a decision, another number of the types of a manager's activity can be used as well as the correction of rhythms duration depending on personal capabilities of a manager); ϕ is the type of the rhythms of a manager's activity (for intellectual $\phi = 1$, the values $p_1 = 33$ days; for emotional $\phi = 2$, the values $p_2 = 28$ days; for physical $\phi = 3$, the values $p_3 = 23$ days; o is a number of days that passed from the day of birth till the date of calculation (less than a year, as a rule); v is the number of leap years on the day of calculation that have passed since the day of birth; y is a number of fully spent years on the date of calculation; π is a number that is approximately equal to 3,14159265359.

For example, for a 46-year-old person born on April 30, 1967 $f_1 = 45,82\%$; $f_2 = 62,35\%$; $f_3 = -52,96\%$ on 05.09.2013.

It should be mentioned that the integral index of potential capabilities of a group of managers calculated by the formula $F^\gamma = \sum_{j=1}^{J_\gamma} F^j$ does not take into account the

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synergistic effect of the mutual influence of group managers who work in direct contact and the factor of collective influence needs further investigation.

The probabilities of non-standard managerial work, remote work, personification and individualization of work modes at a modern enterprise prove that the organization of a manager's work according to the typical schedule of an enterprise should be regarded as an event that does not contribute to minimizing management costs, and vice versa, the organization of a manager's schedule greatly depends on the costs necessary for managerial work but not on the variable work schedule of the main production personnel and enables minimizes management costs and contributes to the growth of the profitability of the enterprise activity.

The obtained results are proved by scientific conclusions made by other scientists. Thus, the scientific research conducted by O. V. Zhadan enabled making the conclusion that "in a globalized world, the diversification of employment relations becomes an important competitive advantage" [7]. N. V. Kozhukhova, A. S. Molodova noted [8] that "experience shows that the optimization of the salary budget and the losses of working time due to introducing flexible work schedules allow the enterprise to save; the effect obtained as a result of the optimization can be compared with the result of reducing personnel by 15-20%". Considering the equal share of the mode of working time use, Z. Malyshevskaya [9] noted that "in order to introduce one of the working time modes within the labour legal relations that arise among the subjects of the labour law on the basis of an employment contract concerning the use of a wage worker, it is necessary to consider and discuss the feasibility of its introduction taking into account the specifics of the industry in which the company operates". I.A. Vetukhova [10] detailed the use of flexible schedules for various categories of workers and concluded that "the purpose of the introduction of such a mode lies in the fact that it should promote the appropriate organization of production, increase its efficiency, provide labour discipline and the best combination of economic, social and personal interests of workers and an enterprise". Consequently, solving the problems of the implementation of various modes of operation of the enterprise personnel lies in the capability of the management to take into account the request for developing the adaptive system of personnel support for the activities of a modern industrial enterprise.

In order to achieve the equivalence of the state of contract relations between the manager and the company, systematic studies of the compliance of the impact of the estimated and actual rhythms on the results of the labour activity should be conducted.

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The analysis of the concepts of modelling managers' schedules which take into account the state of potential managers' capability to perform scheduled tasks makes it possible to state that accounting the rhythm of changes in managerial capabilities objectively contributes to reducing management costs. The integral index of such impact should be calculated according to the formula:

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In order to achieve the equivalence of the state of contract relations between the manager and the company, systematic studies of the compliance of the impact of the estimated and actual rhythms on the results of the labour activity should be conducted.

Results discussion

The suggested approach to the integration of flexible plans of managers' activities restricts the activities of an enterprise by the requirements of the clear quantitative justification of their reasonability and limits of adapting the scheduled plans of activities in accordance with the results of economic and mathematical calculations. The need to take into account the requirements of the results of applying scientifically-based approaches requires efforts within the enterprise that could enable using opportunities for increasing the profitability of enterprises to the full extent.

It should be noted that not only the regulatory requirements of the current legislation that regard, for example, the duration of the working day at a six-day working week which should not exceed 7 hours a day (part 2 of article 52 of the Labor Code), 40 working hours per week (article 50 of the Labor Code), and other regulators of the company's capabilities act as an external limiting factor for introducing flexible, adaptive systems of personnel support of the activities of enterprises but also the unpreparedness of the internal environment to innovative types of labour relations, attempts to frame them within the standard employment which do not help minimize the cost of managerial labour.

The assessment of fluctuations in the group productivity of managers in different departments of the organizational structure of an enterprise remains unsolved as well as their impact on the final result of the activities of the whole labour collective of an industrial enterprise.

The problem of determining the basis and assessing the excessive costs of managerial work which determine the necessity of particular personnel changes and the improvement of the system of work organization in general also remains unresolved.

Conclusions

This article considers the issues of correcting the schedules of managers' work at the enterprise taking into account the wave character of the state of managers' preparedness for high-performance work.

The use of the integral indicator of the impact of managers' rhythms on their performance is suggested.

Industrial enterprises are invited to use the model of organization of flexible schedules of managers of industrial enterprises.

Managers are invited to study the adequacy of the impact of estimated and actual rhythms on the results of work.

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МОДЕЛЮВАННЯ ГНУЧКИХ ГРАФІКІВ РОБОТИ МЕНЕДЖЕРІВ ПРОМИСЛОВИХ ПІДПРИЄМСТВ

Предметом дослідження в статті є аналіз шляхів використання потенційних можливостей менеджерів промислових підприємств до здійснення високопродуктивної діяльності як фактору безпосереднього впливу на стан та характер відносин між роботодавцем та найманим працівником. **Мета** – побудова моделі формування гнучких графіків роботи менеджерів підприємств, які враховують пріоритетність вирішення виробничих завдань, в підсистемі кадрового управління системи прийняття рішень з організації діяльності промислового підприємства. **Завдання:** розробити економіко-математичну модель, яка дозволяє враховувати ритмічність коливань можливостей досягнення високих результатів менеджерської діяльності та активізації скритих потенціалів менеджерів шляхом широкого впровадження гнучких форм роботи менеджерів в план-графіки виробничої діяльності промислових підприємств. Використовуються загальнонаукові **методи** системного, структурного аналізу і специфічні мережеві методи. Отримано такі **результати.** У статті надана концептуальна модель активізації результативності виробничої діяльності менеджерів за рахунок мінімізації задіяння менеджера до виконання виробничих завдань під час низьких значень показників потенційних можливостей менеджера, які об'єктивно знижують продуктивність менеджерської праці. Водночас, запропоновано використання можливостей менеджера в такий час, який співпадає з потенційними можливостями до високопродуктивної праці шляхом адаптації гнучких графіків роботи менеджерів до вимог план-графіків діяльності промислового підприємства. Рекомендовано застосування в моделях організації діяльності промислових підприємств інтегрального показника оцінки впливу ритмів діяльності менеджерів на стан продуктивності їх праці. Надані рекомендації з мінімізації ризиків невиконання умов трудових договорів з причин потенційної неможливості отримання високих показників трудової діяльності з боку менеджерів та роз'яснення переваг застосування гнучких графіків роботи менеджерів для представників кадрових служб роботодавця. **Висновки.** Моделювання гнучких графіків роботи менеджерів промислових підприємств дозволяє коригувати роботу менеджерів на підприємстві з урахуванням хвильових особливостей станів готовності менеджерів до високопродуктивної праці за принципом позитивного зворотного зв'язку. Надано рекомендації з обчислення інтегрального показника оцінки впливу ритмів діяльності менеджерів на стан продуктивності їх праці. Отримані результати можуть бути використані для більш конкретного визначення зобов'язань роботодавців та менеджерів як сторін трудових відносин в частині узгодження питань тривалості, періодичності, ритмічності виконання менеджерами власних трудових зобов'язань.

Ключові слова: підприємство, гнучкий графік роботи, працівник, модель.

МОДЕЛИРОВАНИЕ ГИБКИХ ГРАФИКОВ РАБОТЫ МЕНЕДЖЕРОВ ПРОМЫШЛЕННЫХ ПРЕДПРИЯТИЙ

Предметом исследования в статье является анализ путей использования потенциальных возможностей менеджеров промышленных предприятий к осуществлению высокопроизводительной деятельности как фактора непосредственного влияния на состояние и характер отношений между работодателем и наемным работником. **Цель** – построение модели формирования гибких графиков работы менеджеров предприятий, учитывающих приоритетность решения производственных задач, в подсистеме кадрового управления системы принятия решений по организации деятельности промышленного предприятия. **Задача:** разработать экономико-математическую модель, которая позволяет учитывать ритмичность колебаний возможностей достижения высоких результатов менеджерской деятельности и активизации скрытых потенциалов менеджеров путем широкого внедрения гибких форм работы менеджеров в план-графики производственной деятельности промышленных предприятий. Используются общенаучные **методы** системного, структурного анализа и

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специфические сетевые методы. Получены следующие **результаты**. В статье предоставлена концептуальная модель активизации результативности производственной деятельности менеджеров за счет минимизации задействования менеджера для выполнения производственных задач при низких значениях показателей потенциальных возможностей менеджера, которые объективно снижают производительность менеджерского труда. В то же время, предложено использование возможностей менеджера в такое время, которое совпадает с возможностями к высокопроизводительному труду путем адаптации гибких графиков работы менеджеров с требованиями план-графиков деятельности промышленного предприятия. Рекомендовано применение в моделях организации деятельности промышленных предприятий использование интегрального показателя оценки влияния ритмов деятельности менеджеров на состояние производительности их труда. Даны рекомендации по минимизации рисков невыполнения условий трудовых договоров из причин потенциальной невозможности получения высоких показателей трудовой деятельности со стороны менеджеров и разъяснения преимуществ применения гибких графиков работы менеджеров для представителей кадровых служб работодателя. **Выводы.** Моделирование гибких графиков работы менеджеров промышленных предприятий позволяет корректировать работу менеджеров на предприятии с учетом волновых особенностей состояний готовности менеджеров к высокопроизводительному труду по принципу положительной обратной связи. Даны рекомендации по исчислению интегрального показателя оценки влияния ритмов деятельности менеджеров на состояние производительности их труда. Полученные результаты могут быть использованы для более конкретного определения обязательств работодателей и менеджеров как сторон трудовых отношений в части согласования вопросов продолжительности, периодичности, ритмичности выполнения менеджерами своих трудовых обязательств.

Ключевые слова: предприятие, гибкий график работы, работник, модель.

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SOCIAL REPORTING AS AN INDICATOR OF THE ENTERPRISE DEVELOPMENT

Over the recent years, social activities have been a very significant index of the activity of domestic enterprises. These events do not indicate only the development of an enterprise but also suggests the opportunity to provide certain benefits to the society. But in Ukraine today there are no approved domestic standards which contain the structure of such reports and a list of issues that should be covered in them. This requires a thorough study of the theoretical and practical aspects of social reporting, the characteristics of foreign standards. The **goal** of the article is to study social responsibility, the aspects of social reporting, users, structure and indicators that can be included in it. The study deals with scientific works of foreign and domestic economists on the issues of social responsibility and accountability. The study is based on the combination of **methods** and approaches such as the dialectical method, the method of synthesis as well as the comparative and systemic ones. The following **results** were obtained: the issues of social responsibility of business and social reporting, the users of social reporting and their needs were investigated, international accounting practices were considered, namely the international standards of social reporting, such as Sunshine; AA1000; ISO 26000, SA8000 as well as the most famous and most commonly used GRI. The domestic practice of social reporting, problems and aspects domestic enterprises face were analyzed. On the basis of the analysis of international standards and the structure of social reporting of companies, the MLESQ indicator system is suggested, which can be applied for social reporting, taking into account the characteristics of the social activity of an enterprise. **Conclusions.** It is proved that solving the tasks of social reporting requires professional dialogue between social responsibility specialists, financial directors, accountants and auditors within the business structure itself.

Keywords: financial reporting, social reporting, social responsibility of business.

Introduction

The realities of social development require reflecting a wide range of information on the activities of an enterprise including information on the social responsibility of business. In today's world, business reliability is measured not only by the criteria of economic efficiency and the quality of products and services but also by the willingness to solve social problems. It should be emphasized that in recent years a very significant indicator of the activities of domestic enterprises is their social activities. Such events do not indicate the development of an enterprise but also suggest the opportunity to provide certain benefits to the society. Such activities should be presented in non-financial social reporting whose goal is to provide information on social activities to stakeholders. But in Ukraine today there are no approved domestic standards that contain the structure of such reports and a list of issues that should be covered in them. This requires that the theoretical and practical aspects of compiling social reporting and the characteristics of foreign standards should be studied thoroughly.

The analysis of recent literary sources

The issues of social reporting and social responsibility were studied by such scientists as K. Bezverkhyy [2], C Bezruchuk [3], A. Berganir [4], Zh. Bogdanova [5], M. Bukovinskaya [6], T. Gilorme [8], T. Davydyuk [9], V. Evdokimov, D. Gritsyshen [11], T. Solovey [12] and others.

But in Ukraine today the structure and methodological bases of social reporting have not been defined, the concepts that explain the corresponding ideas and the peculiarities of their usage have not been specified and unified. “Non-financial reporting”, “Reporting on social responsibility”, “Social reporting”, “Reporting in the sphere of sustainable development” are just some of the terms used domestic researchers use in social reporting.

The **goal** of the article is to study the essence of social responsibility, the theoretical and methodological aspects of social reporting and the demands of users, its structure and indicators.

Materials and methods

The study deals with scientific works of foreign and domestic economists on the issues of social responsibility and reporting. A number of methods and approaches such as the dialectic method, the method of synthesis as well as the comparative and systematic methods were applied in the study.

The results of the study

First, the conception of “social responsibility” should be defined. A. Andryushchenko believes that “social responsibility is broadly interpreted as a set of its various types – the economic, political, legal, moral ones and so on” [1, p.134]. M. Bukovinskaya considers that “the corporate social responsibility is the philosophy of the company development and business achievements by the ways that are based on ethical standards and respect for people, communities, environment” [6, p.9].

Social responsibility should be considered as indicators that fully reveals the activity of an enterprise in this sphere. According to V. Vorobey, social (non-financial) reporting is a set of written company data that reflect the company environment, principles and methods of cooperation with the groups of influence, the results of company activities in the economic, social and ecological spheres” [7, p.6].

Social non-financial reposting as any other management tool has undisputed advantages – it increases

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the transparency of business, accumulates the trust of stakeholders, strengthens business relations, facilitates expanding sales markets, formalizes the processes of ratification and implementation of social technologies. All this makes it necessary to study the issues of social reporting.

Today, the rate of developing and expanding non-financial reporting in Ukraine lags behind the developed countries of the world. Social reports are published only by some companies including "Kernel", "ArcelorMittal Kryvyi Rih", "Galnaftogaz", "Metinvest", "Obolon", "DTEK", "Dneprospetsstal", "Nibulon", "Foxtrot", "UniCreditBank", "Nestle Ukraine", "Kyivstar", "Carlsberg Ukraine", "ViDi Group", "Mondelis Ukraine", "Alfa Bank Ukraine", "SCM". Some of these reports were prepared according to the new standard GRI 4.0 ("Kernel", "Metinvest", "Obolon") or with elements of GRI 4.0 ("Galnaftogaz") [2, c.111]. The analysis shows that in most of the mentioned companies social reports are the brief descriptions of achievements in the social sphere.

At the international level, the issue of integrated reporting that takes into account financial and non-financial aspects is actively discussed. Demonstrating the importance of social and environmental priorities for managing, attention and efforts for solving social problems give confidence that business is reliable, sustainable and attractive to potential investors, corporate clients, and, finally, for suppliers who are also interested in permanent and reliable customers.

In the modern world, the "reliability" of business is measured not only by the criteria of economic efficiency and the quality of products and services but also by the willingness to solve social problems. The addresses of social reports are stakeholders. i.e. employees and business partners, financial agents (creditors, investors, donors), shareholders (owners fnd co-owners), consumers as well as the state government and local authorities, non-governmental organizations (fig. 1).

Fig. 1. The users of non-financial reports

Indeed, for the staff, social reporting is a significant stimulus and the evidence of the job status that confirms the social significance of their work. Social reporting also contributes to creating the image of a responsible employer, particularly among young professionals. Non-governmental organizations, business partners, authorities and consumers also form an attitude towards business, taking into account the availability and content of social reporting.

Simultaneous financial and social reporting provides an opportunity to fully inform stakeholders about social and environmental aspects of activities along with economic results, which allows them to assess business risks (in particular, long-term ones) effectively. So, social reporting enhances business transparency.

According to the definition of the European Commission, social non-financial reporting, as a tool of social responsibility, is a concept according to which business voluntarily integrates social and environmental initiatives as well as interaction with stakeholders in commercial activities.

The most common international reporting standards are Sunshine standards; GRI; AA1000; ISO 26000, SA8000. The most known list of quantitative indicators in the world practice of non-financial reporting is the system of GRI indicators, the application of which is recommended for social reporting of an arbitrary format as well as for Progress Reports.

Let us analyze these standards and determine the differences in the definition and the list of non-financial indicators.

As a rule, in the social reporting domestic business give general information about irregular initiatives but do not specify the quantitative indicators that measure the efficiency of the implementation of projects. T. Davydyuk believes that "in the domestic business community there is no common understanding of how to deliver the information about their social activities to the society" [9, c.64].

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Table 1. *The analysis of foreign standards of social reporting*

Standard	Adopted by	The issues the standard covers
GRI	Global Sustainability Standards Board, since 2000	The reporting on sustainable development simultaneously covers the economic, environmental and social aspects of activities.
AA 1000	Institute of Social and Ethical Accountability, 1999	Social reporting takes into account: - social, environmental and economic impact and relevant indicators of their activities as well as the views of stakeholders; inquiries and needs of stakeholders and corresponding respond to them in the policies and practices of the organization.
ISO 26000	International Organization for Standardization, 2010	Contains information on how businesses can work in a socially responsible manner. This means a transparent and ethical behaviour that promotes the health and well-being of society.
SA 8000	developed by experts of Social Accountability International (SAI) in 1997	The social reporting covers such areas as: - the protection of employees' health, safety precautions; - the issue of discrimination; - the use of children's labour activity; - forced labour; - work time; - disciplinary action; - control systems; - the compensation of labour.
Sunshine standards	The Stakeholder Alliance (USA) is an association that unites environmental and religious organizations as well as consumer protection organizations, 1996	According to the standard, the following information is provided: - information provided to customers (about products and services); - Information for employees (employment, safety and health, equal employment opportunities); - information for the local community (ownership structure, financial indicators, impact on the external environment, the amounts of tax payments; -the number of jobs created, investments and charitable activities); - information for the general public (trade with hostile countries, state orders, fines, etc.)

The presented indicators are selective and non-systemic and relate to point initiatives rather than to social responsibility of business. However, the benefits of non-financial reporting cannot be fully obtained without the formalization of targets in specific figures (for example, the level of remuneration, the reduction of emissions, investments in modernization) and the quantitative reporting on the progress towards achieving these goals.

While preparing for social reporting, domestic business structures, as a rule, face the inconsistency of internal accounting data with the requirements of international practice, in particular, the GRI indicator system. T. Gilorme considers that "a business entity that follows the GRI requirements in corporate reporting should disclose five components: the strategy and analysis; the description of the organization; the parameters of reporting, management, the stakeholders' obligations; performance indicators (economic results, environmental performance, labour organization and product responsibility)" [8, c.674-675].

Solving these problems requires a professional dialogue among social responsibility specialists, financial directors, accountants and auditors within the business structure itself. So, S. King thinks that "to ensure the transparency of non-financial reports in free form, the following activities can be recommended:

- conduct surveys of stakeholders who work with this reporting to study their comments;
- design a plan of social events taking into account specific needs of stakeholders;
- inform stakeholders about the implementation of their requests and identified violations" [10, c. 111].

The adequate system of indicators that would characterize social projects is the most important for assessing the potential and increasing the level of confidence in Ukrainian enterprises. On the basis of the study of the international standards of social reporting and the structure of social reporting, the MLESQ indicator system is suggested that takes into account the following areas of social solutions (table 2).

The advantages of the suggested MLESQ system lie in the fact that it includes the most important issues that are interesting for stakeholders and can give the complex character of the social activities of an enterprise.

Conclusions

Summarizing the mentioned above, social reporting can be determined as a complex information system that reflects the activities of the business entity in terms of labour relations, work safety, the health of personnel, charity, corporate management, the protection of employees and social programmes. The quality of the provided social reporting affects the opinion of external organizations on the state of development of the enterprise with all the consequences that come with it. On the basis of the analysis of standards, the MLESQ indicator system

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is suggested. But every enterprise that has a public interest and plans to enter the international level should develop the system of indicators that most fully cover all aspects of the social responsibility of business and emphasize the most important areas of social work. In connection with this need, studies in this sphere should be devoted to updating the suggested to specify and detail the indicators that reflect the social activities of enterprises.

Table 2. *The essence of the system of MLESQ indicators*

Area	Essence	Indicators
Management	Efficient corporate management is based on the principles and practices of accountability, transparency, ethical conduct, respect for the interests of stakeholders and the recognition of the rules of law both in the process pf decision-making and in the process of their implementation	Indicators of the efficiency and risks of corporate management
Labour	Creating jobs, payment of wages and other payments provided by law, providing safe working conditions, developing personnel and so on. Particularly labour relations include such aspects as hiring and promoting personnel; the termination of employment; labour remuneration; disciplinary procedures; moving and appointing employees; training and developing skills; the protection of health, safety and industrial hygiene; any policies and practices that may affect working conditions, in particular, working hours and rest periods. Indirectly, labour relations include relations related to the rights of employees to organize and conduct collective bargaining, participation in labour disputes and social dialogue.	The costs an enterprise spends are connected with: - maintaining the personnel of the enterprise; creating new vacancies; - measures aimed at protecting the health and education of employees; - sports and other events. Indicators that are related to the movement of the labour movement.
Ecology	Preventing pollution, that is, not only meeting but also constant excessing environmental standards, including the reduction of emissions into the atmosphere, water, the amounts of solid or liquid waste; polluting land and soils, using and placing toxic and harmful chemicals and so on.	Activities and costs of the company to improve the environmental situation in the region, the state of the territories.
Social investment	Social investments include philanthropy and charity, it should expand the economic and social opportunities of the inhabitants of the territory, for example, increase the amounts of purchases of goods, works and services to support the activities of local producers and suppliers, attract local specialists to outsource business processes, implement programs aimed at improving social aspects of the life of the territorial community and related to education, training, culture, health, infrastructure development, improving the access to information or any other activity that contributes to the economic and social development of the local community or its individual groups	Activities and expenses for: -charity; - educational institutions; -culture, - sports, - initiatives of territorial communities in any form
Quality	Informing consumers about goods/works/services using honest and transparent marketing information, encouraging responsible consumption, declaring and constant confirming in practice the obligations for the production and sale of safe and quality goods/works/services.	Activities and expenses for: - improving the quality of goods (works, services), - quality control and so on

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СОЦІАЛЬНА ЗВІТНІСТЬ ЯК ІНДИКАТОР РОЗВИТКУ ПІДПРИЄМСТВА

Останні роки дуже вагомим показником діяльності вітчизняних підприємств є його соціальні заходи. Проведення таких заходів є свідченням не тільки розвитку підприємства, але й можливості надавати певні блага суспільству. Але ж в Україні на сьогодні не існує затверджених вітчизняних стандартів, які б містили склад такої звітності та перелік питань, які повинні бути висвітлені в ній. Це все потребує ретельного дослідження теоретичних та практичних аспектів складання соціальної звітності, особливостей закордонних стандартів. **Метою** статті є дослідження соціальної відповідальності, аспектів складання соціальної звітності, її користувачів, складу, а також показників, що можуть бути включені до неї. В дослідженні використані наукові праці зарубіжних та вітчизняних економістів з питань соціальної відповідальності та звітності. У статті використано сукупність **методів та підходів**, таких як діалектичний, синтезу та порівняльний, системний. **Результати**: досліджені питання соціальної відповідальності бізнесу та соціальної звітності, користувачі соціальної звітності та їх потреби, розглянута міжнародна практика складання звітності, а саме міжнародні стандарти соціальної звітності, такі як Саншайн; AA1000; ISO 26000, SA8000, а також найбільш відомий та найчастіше застосований- GRI. Проаналізована вітчизняна практика складання соціальної звітності, проблеми і аспекти, з якими зіштовкуються вітчизняні підприємства. На підставі аналізу міжнародних стандартів та складу соціальної звітності компаній запропонована система показників MLESQ, яка може бути застосована підчас складання соціальної звітності, враховуючи особливості соціальної активності підприємства. **Висновки.** Встановлено, що вирішення проблем соціальної звітності вимагає подальшого професійного діалогу між фахівцями із соціальної відповідальності, фінансовими директорами, бухгалтерами і аудиторами в межах бізнес-структур.

Ключові слова: фінансова звітність, соціальна звітність, соціальна відповідальність бізнесу.

СОЦИАЛЬНАЯ ОТЧЕТНОСТЬ КАК ИНДИКАТОР РАЗВИТИЯ ПРЕДПРИЯТИЯ

Последние годы очень весомым показателем деятельности отечественных предприятий является его социальные мероприятия. Проведение таких мероприятий является свидетельством не только развития предприятия, но и возможности предоставлять определенные блага обществу. Но в Украине на сегодня не существует утвержденных отечественных стандартов, содержащих состав такой отчетности и перечень вопросов, которые должны быть освещены в ней. Это все требует тщательного исследования теоретических и практических аспектов составления социальной отчетности, особенностей зарубежных стандартов. **Целью** статьи является исследование социальной ответственности, аспектов составления социальной отчетности, пользователей, состава, а также показателей, которые могут быть включены в нее. В исследовании использованы научные труды зарубежных и отечественных экономистов по вопросам социальной ответственности и отчетности. В статье использованы совокупность **методов** и подходов, таких как диалектический, синтеза и сравнительный, системный. **Результаты:** иисследованы вопросы социальной ответственности бизнеса и социальной отчетности, пользователи социальной отчетности и их потребности, рассмотрена международная практика составления отчетности, а именно международные стандарты социальной отчетности, такие как Саншайн; AA1000; ISO 26000, SA8000, а также наиболее известный и чаще всего применяемый- GRI. Проанализирована отечественная практика составления социальной отчетности, проблемы и аспекты, с которыми сталкиваются отечественные предприятия. На основании анализа международных стандартов и состав социальной отчетности компаний предложена система показателей MLESQ, которая может быть применена во время составления социальной отчетности, учитывая особенности социальной активности предприятия. **Выводы.** Установлено, что решение проблем социальной отчетности требует профессионального диалога между специалистами по социальной ответственности, финансовыми директорами, бухгалтерами и аудиторами в пределах самой бизнес-структуры.

Ключевые слова: финансовая отчетность, социальная отчётность, социальная ответственность бизнеса.

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THE TECHNOLOGY OF BUDGETING ENTERPRISES WITH THE DIVISIONAL STRUCTURE

The **subject** matter of the study are the components of budgeting enterprises with the divisional structure. The **goal is** to determine the composition of budgeting technology and develop its main components for enterprises with the divisional structure. The following **tasks** are solved in the article: the composition of budgeting technology is justified; the income generation model for an enterprise with a divisional structure is improved; the system of obligatory indicators of an enterprise with the divisional structure is suggested as well as the information model of budgeting the income of the cost centre of the second type. The **methods** used are – logical and theoretical generalization, formalization, modelling. The following **results** are obtained. The composition of budgeting technology as a set of formalized knowledge about the implementation of the process of planning for structural divisions is grounded. The efficiency of presenting the budgeting technology as graphic and information models is proved. It is determined that the obligatory indicators of an enterprise that evaluate its goals should be structured to solve the task of composing standard target indicators for responsibility centres of various types. The obligatory income indicator is structured on the basis of the economic model of its generation. The model of income formation for an enterprise with a divisional organizational structure was improved by introducing the indicators of coverage amounts of the first and second level and by excluding the revenues obtained from domestic sales. The obligatory income indicator is structured on the basis of the improved model. The system of obligatory indicators of an enterprise with a divisional structure for each responsibility centre is suggested, particularly, for the strategic economic centre, a income centre, cost centres of the second and third type. The obligatory indicator of the transfer price was introduced to solve the problem of regulating the relations among the divisions of an enterprise with the divisional structure. The information model of budgeting the income obtained from the main activity of an enterprise with a divisional structure was improved by calculating the coverage amounts of the first and second levels, by calculating the income obtained from domestic sales according to transfer prices, and by distinguishing variable and constant parts from the planned expenses. The information model of budgeting the income obtained from the centre of expenses of the second type using the transfer prices is suggested. **Conclusions.** Graphic and information models should be introduced into the budgeting technology; the model of income generation for an enterprise with the divisional organizational structure should be improved by introducing the coverage amounts of the first and second levels and excluding the income obtained from domestic sales. The obligatory indicator of transfer prices should be used to solve the problem of regulating the relations among business units of an enterprise with the divisional structure; the information model of budgeting the income of the centre of expenses of the second type should be presented with the use of the transfer prices.

Keywords: budgeting, planning technology, obligatory indicators, transfer prices.

Introduction

Planning is an integral part of the management process. It provides an opportunity to determine the goals of the enterprise and identify the ways to achieve it. Therefore, this stage of the management process is essential for any economic relations. The high dynamic character of the environment causes the need for improved methods and planning techniques; the budgeting technology is one of the most important.

The analysis of literary sources and the problem statement

The works of numerous foreign scholars consider the theoretical aspects of budgeting, among them are the works by D. Brimson and D. Antos, J. Hope and R. Fraser, D. Shim та D. Siegel [1; 2; 3]. The definition “budgeting” is of a foreign origin.

Budgeting was introduced into the practice of domestic enterprises and their subdivisions due to Western management and was developed because of the increasing role of planning under the conditions of market transformations. The authors determine the principles of budgeting in their works [4, 5], investigate the stages of budgeting [6], determine the principles of building the centres of responsibility [7] and the aspects of budgeting organization [8] as well as the approaches to establishing planned indicators [9]. Despite the significant contribution of scientists to this area, it should be noted that particular issues of budgeting in terms of structural aspects require further research. This is linked to the proliferation of complex structures with a divisional structure. Managing such multi-level structures is complicated. Under these conditions, there is a problem of taking into account the complicated interconnections among the numerous structural subdivisions and ensuring their unidirectional development. The mentioned problem is solved by budgeting.

The **goal** and objectives of the study are to determine the composition of the budgeting technology for enterprises with the divisional structure.

The basic material

Vertically-integrated enterprises that appeared in the grain market resulted in the growth of grain companies with the divisional structure. The materials presented in the article were developed and tested for bakery enterprises.

The previous studies proved the idea that the main task of budgeting is to bring the indicators of the enterprise current plan to individual structural divisions or centres of responsibility [10]. The system of their planned documents is formed in this way. It is the result of applying budgeting technology.

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The budgeting technology is a set of formalized knowledge of the process of planning for structural divisions. This requirement can be met if it comprises:

- a list of obligatory indicators for the centres of responsibility;
- the clear sequence of executing the operations aimed at bringing the policy indicators of the enterprise to its divisions;
- a list of input and output information for each of them;
- a set of methods for receiving and converting input information;
- a list of workers and resources assigned to them.

Since the technology is a formalized knowledge, it can be presented as graphic and information models of the stages of the process (informograms) [11].

The first component reflects the logical sequence of the process stages and their interrelation, the second is the nature of the information transformation (the content and composition of the methods of execution) for each stage or operation.

However, using only graphical models and informograms is not enough. Being implemented within the framework of budgeting, this technology has its own specifics as it operates a special resource – information that requires developing information models of planned calculations and technological maps of the stages of the planning process.

Thus, following planned documents should be developed basing on the typical technology constituents and taking into account the peculiarities of planning for the formalization of the budgeting technology:

- graphic models of planning stages;
- information models of planned calculations;
- informograms of planning stages;
- technological maps of the planning stages.

To develop the composition of the planned indicators for the centres of responsibility of various types, the obligatory indicators of the enterprise that estimate its goals should be structured.

Due to the fact that the economic goal lies on the highest level of the hierarchy, the income indicator should be structured first of all.

Economic relations between the centres of responsibility of an enterprise with the division structure are based on transfer prices. If the responsibility centres of such structures are SEC (strategic economic centre), other market prices are used in the settlements of accounts between them and the income is generated according to the result of their activities. In a case when the centres of responsibility are the units that have the status of PC (income centre) and RC (responsibility centre), the prices that are less than the market domestic prices are used for domestic sales. The economic model should be used for structuring obligatory indicators of an enterprise and for developing the typical composition of planned indicators of responsibility centres.

The economic model of income generated due to the main activity at responsibility centres in the structures of the divisional type which is suggested for using to structure the income obligatory indicator is as follows [7]:

$$I_{EN} = \sum_i I_i^{SEC} + \sum_i I_i^{PC} - (\sum_i IRS_i^{2T} + C^{3T}) \qquad (1)$$

where I_{EN} is the income of an enterprise;

I_i^{SEC} is the income of the i-th SEC;

I_i^{PC} is the income of the i-th PC;

IRC_i^{2m} is the income of the i-th RC of the second type;

C^{3m} is the costs of RC of the third type.

The use of the economic model as it stands is not efficient due to some reasons. First, PC is a supplier (a service provider) to domestic and foreign customers. That is why their interim incomes obtained from domestic sales should be excluded from the enterprise income to avoid double calculation. Second, RCs of the second type sale products (services) to other divisions using transfer prices. They actually participate in distributing the enterprise income, i.e. they "draw back" a part of income earned by PC but they formally take part in generating the enterprise income. That is why their income should be taken into consideration while determining the results of the enterprise activities.

Grounding on the stated above, the economic model of the income generated by the main activities of an enterprise with the divisional structure should be improved by excluding the interim incomes of PC and RC. According to this, the economic model is as follows:

$$I_{EN} = \sum_i I^{SEC}_i + \sum_i I_i{}^{PC} + \sum_i I_i{}^{2m} - \sum_i I_i^{BH} - C^{3m}. \qquad (2)$$

where I_i^{2m} is the income of the i-th RC of the second type;

I_i^{BH} is the interim income of the i-th PC or RC of the second type obtained from selling products to other PCs.

The income of SEC I_i^{SEC} is calculated according to the formula:

$$I_i^{SEC} = AR_i \times P_i + AR_i^{BH} \times P_i - C_i \qquad (3)$$

where AR_i, AR_i^{BH} are the amounts of products sold to foreign consumers and other SECs in actual measurement (if the i-th SEC manufactures just one product);

P_i is the price of selling the products manufactured by the i-th unit on a foreign market;

C_i is the costs for manufacturing the products of the i-th unit (prime costs).

The income of PC $I_i{}^{PC}$ is calculated according to the formula:

$$I_i{}^{PC} = AR_i \times P_i + AR_i^{BH} \times P_i^{BH} - C_i \qquad (4)$$

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where AR_i is the amount of products sold to foreign consumers and other PCs in actual measurement (if the *i*-th PC manufactures just one product);

P_i^{BH} is the transfer price of selling the products manufactured by the *i*-th unit to other PCs.

To improve recording the economic model in expanded form, it is suggested to:

- plan costs by distinguishing their variable and constant parts;
- distinguish own expenses and cost of services of RC of the second type. In view the complexity of the divisional structure, the expediency of this suggestion is based on the possibility of taking into account the place of costs and their correlation with the income;
- incorporate coverage amounts into the model to ensure the flexibility of plans.

According to the stated above, the income of PC should be calculated as follows:

$$I_i^{PC} = \sum_i AR_i \times P_i + \sum_i AR_i^{BH} \times P_i^{BH} - \\ -(\sum_i C_{i\,\text{var}}^{OWN} + \sum_i IRC_{i\,\text{var}}^{2T}) - (\sum_i C_{i\,const}^{OWN} + \sum_i IRC_{i\,const}^{2T}) \quad (5)$$

where $C_i^{OWN}{}_{\text{var}}$, $C_i^{OWN}{}_{const}$ are own variable and constant costs of the ith PC for manufacturing and selling products;

$IRC_i^{2m}{}_{\text{var}}$, $IRC_i^{2m}{}_{const}$ are the cost of services (income) obtained from RC of the second type – variable and constant parts.

The income of SEC is transformed in the same way. Taking into account these transformations and due to the fact that the indicator of coverage amount of the second type (CA2) influences the amounts of sales, the expanded economic model of an enterprise with the divisional structure is as follows:

$$I_{EN} = I_i^{SEC} + \sum CA2_i + \\ \left[\sum_i ACR_i \times PH_i - (CRC_i^{2m}{}_{\text{var}od} \times ACR_i + CRC_i^{2m}{}_{const})\right] - \\ -\sum_i I_i^{BH} - C^{3m}. \quad (6)$$

The obtained expanded economic model is the basis for structuring the obligatory indicator of the income, which enables developing the system of indicators of responsibility centres of enterprises with the divisional structure (fig. 1).

In accordance with the principles of planning, namely: integrity and completeness, as well as the goal-oriented integration of the sections of the plan, the planned documents should cover not only all areas of the enterprise but also structural units of different levels of the hierarchy. That is, establishing the relationship between the functional plans of one level of the hierarchy as well as between the plans of different hierarchical levels is important.

The obligatory indicator of an enterprise

Net income

SEC obligatory indicators:	**PC obligatory indicators:**	**Obligatory indicators of RC of the second type:**	**Obligatory indicators of RC of the third type:**
Net income; *Standard charges on income;* *The amount of sales to foreign consumers;* *Capital turnover ratio*	*Standard charges on income;* *The coverage amount of the second level;* *Transfer price;* *The amount of sales to other income centres;* *The amount of sales to foreign consumers;* *Average time for collecting receivables*	*Standard charges on income;* *Transfer price;* *Cost limit;* *The amount of sales of НФ/ PC services;* *The amount of buying The amount of buying raw materials (only for the department of MT3)*	*Standard charges on income;* *Cost limit*

Fig. 1. Structuring the obligatory indicator of income for enterprises with the divisional structure

While developing planned documents and patterns of their interrelation, the peculiarities of activities of bakery enterprises were taken into consideration, namely:

- seasonal fluctuation of raw materials input, which requires establishing a planned period, i.e. a farming year;
- development of the organizational structure according to product or territory, depending on the degree of integration;
- centralized purchasing raw materials for all departments.

The income plan is the main document that reflects the generation and distribution of incomes. The content of the mentioned planned document is determined by the logic of calculating the obligatory indicator, i.e. the net income, and the starting point of its development is the structure of the income and costs of an enterprise.

The income in divisional structures is generated on the levels of responsibility: SEC and PC (fig. 1). That is why the income should be planned for an enterprise as a whole and for structural divisions.

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The sequence of obtaining planned indicators, the methods of their calculation and information sources should be established by developing relevant information models of planned calculations. D. Hahn [12] introduced this model for the first time as the basis for calculating the income plan, but this model was of a general nature and did not take into consideration the specificity of the enterprise organizational structure.

To make the income plan more advanced, in accordance with the economic model for generating the income obtained from the main activities of an enterprise with the divisional structure and taking into account the specifics of the activities of bakery enterprises, the information models of the planned calculations should be improved by:

- calculating coverage amounts (of the first and second level), which enables distinguishing direct constant costs of structural units from the constant costs of an enterprise and avoiding their allocation to make divisions contribute to the cross-organizational result. This also enables using the "CA2" indicator to determine a part of the income which is transferred to the disposal of responsibility centres;
- calculating the income obtained from domestic sales at transfer prices and the income obtained from selling products to foreign consumers at market prices;
- distinguishing variable and constant parts from planned costs, which enables planning prime costs and financial results more precisely;
- developing a plan for a marketing year because such planned period takes into account the peculiarities of the activity of bakery enterprises, namely, seasonal fluctuations of grain supply in the best way.

The budgeting technology is suggested to be formalized by the information models of planned calculations on the basis of the economic model of the income generated by the main activities of an enterprise with the divisional structure (table1).

Table 1. *The information model of budgeting the income of an enterprise with the divisional structure*

Indicators	The order of calculation	Sources of information
Net income obtained from selling products to foreign consumers	Income obtained from sales – charges on income	Previous calculations
Income obtained from domestic sales *	$\sum$ Transfer prices × The volume of products sold to other centres	Marketing programme, calculating transfer prices
Variable costs	$\sum$ PC variable costs + $\sum$ Variable costs of RC of the second type	Prime cost plan
Coverage amount I	Net profit – variable costs	Previous calculations
Constant direct costs	$\sum$ PC constant costs + $\sum$ Constant costs of RC of the second type	Prime cost plan
Coverage amount II	Coverage amount I – Constant direct costs	Previous calculations
Coverage amount II adjusted by the profit amount obtained from domestic sales	Coverage amount II – Income obtained from domestic sales	Previous calculations
Constant indirect costs	Costs of RC of the third type	Prime cost plan: administrative cost estimate
Income (losses) obtained from the main activities	Coverage amount II (adjusted) – Constant indirect costs	Previous calculations
Income (losses) obtained from the operation activities	Income obtained from other operational activities – Costs resulted from other operational activities	Marketing programme, consumer agreements
The financial result from the operation activities	Income (losses) from the main activities + Income (losses) from other operational activities	Previous calculations
Income obtained from investment and financial activities	$\sum$ Equity income + $\sum$ Income on the enterprise security yield + …	Analysis of the previous period data, information on security yield, equity income
Costs resulted from investment and financial activities	$\sum$ Equity income costs + $\sum$ Loan interest + …	Analysis of the previous period data, bank contracts for receiving a loan
Financial result obtained from ordinary activities to taxation	Financial result obtained from operational activities + Income obtained from investment and financial activities – Costs resulted from investment and financial activities	Previous calculations
Income tax	Financial results obtained from ordinary activities before taxation × Taxation rate	Previous calculations, legislative standards
Net income	Financial results obtained from ordinary activities before taxation – Taxation rate	Previous calculations
Distribution of the enterprise income	Net income × (Standard charges on income of SEC of the lower level +PC+RC of the second type + RC of the third type)	Owners' decisions on the income distribution

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The suggested information model represents the sequence of obtaining planned indicators and methods of their calculation as well as the source of information taking into account the characteristics of bakery enterprises.

The income obtained from domestic sales should be taken into consideration in subsequent calculations to prevent a double counting for representing the results of the enterprise activities.

According to the structure, the first eight indicators of a PC planned document should be similar to the ones of the SEC plan. However, in order to detail the cost according to the place of their origin, they should be divided into the cost of services of RC of the second type and the costs that PC had.

The constant indirect costs of an enterprise and the costs of investment and financial activities cannot be directly attributed to PC and their distribution is not feasible. Therefore, the target level of the target unit should be determined as the indicator "coverage amount of the second level (II)". It can also be used it as the basis for distributing the income that comes at the disposal of an enterprise. This enables determining the remuneration of PC depending on the results of its activities and on the contribution to generating the income of an enterprise.

Basing on the fact that the income plan of RC of the second type represents the result of the activities of the centres and is the ground for determining the amount of their remuneration, the information model of planned calculations should be suggested as the basis of this document (Table 2).

Table 2. *The information model for budgeting the income of RC of the second type*

Indicators	The order of calculation	Sources of information
The income obtained from selling PC products (services)	$\sum$ Transfer prices × The volume of services sold to the ith PC	Work schedule, transfer costs calculations
General cost limit, including	$\sum$ Variable costs of RC + $\sum$ Constant costs of RC	Estimate of costs
variable	Variable cost rate × $\sum$ The volume of PC services sold	Estimate of costs
constant	$\sum$ Constant costs according to the cost estimate	Estimate of costs
The income obtained from selling PC services	The income obtained from selling PC products (services) – General cost limit	Previous calculations

In this case, the RC income does not increase the enterprise income but redistribute it among the units with the help of transfer prices.

Conclusions

All the stated above make it possible to make the following conclusions:

1) the main task of budgeting is to bring the indicators of the enterprise current plan to the centres of responsibility. Graphical and informational models should be introduced into the structure of the budgeting technology as a set of formalized knowledge about the process of planning for structural subdivisions;

2) typical planned indicators for the centres of responsibility of various types should be accomplished by structuring the enterprise obligatory indicators which estimate its goals. Structuring the income obligatory indicator should be based on the economic model of its generation. The appropriate model for generating income for an enterprise with the divisional organizational structure should be improved by introducing the indicators of coverage amounts of the first and second level and excluding the obtained from domestic sales;

3) for solving the problem of regulating the relations between divisions of an enterprise with the divisional structure, the obligatory indicator of the transfer price should be used;

4) the informational model for budgeting the income obtained from the main activities of an enterprise with the divisional structure should be improved by calculating the indicators of coverage amounts of the first and second levels, by calculating the income obtained from domestic sales at transfer prices, by distinguishing variable and constant parts from the planned costs;

5) the informational model of budgeting the income of the centre of costs of the second type should be presented with the use of transfer prices.

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ТЕХНОЛОГІЯ БЮДЖЕТУВАННЯ ДІЯЛЬНОСТІ ПІДРИЄМСТВ З ДИВІЗІОНАЛЬНОЮ СТРУКТУРОЮ

Предметом дослідження є складові бюджетування діяльності підприємств з дивізіональною структурою. **Ціль** роботи - визначити склад технології бюджетування та розробити її основні компоненти для підприємств з дивізіональною структурою. В статті вирішено **завдання:** обґрунтовано склад технології бюджетування; вдосконалено модель формування прибутку для підприємства з дивізіональною структурою; запропоновано систему директивних показників підприємства із дивізіональною структурою; запропоновано інформаційну модель бюджетування прибутку центру витрат другого типу. Використано **методи:** логіко-теоретичного узагальнення, формалізації, моделювання. Отримано такі **результати.** Обґрунтовано склад технології бюджетування як сукупності формалізованих знань про виконання процесу планування за структурними підрозділами. Доведено доречність представлення технології бюджетування через графічні та інформаційні моделі. Визначено, що для реалізації завдання формування типового складу планових показників для центрів відповідальності різних типів доцільно структурувати директивні показники підприємства, які вимірюють його цілі. В основу структуризації директивного показника прибутку покладено економічну модель його формування. Відповідну модель формування прибутку для підприємства з дивізіональною організаційною структурою вдосконалено авторами шляхом введення показників сум покриття першого і другого рівня, та виключення прибутків від внутрішньої реалізації. На підставі удосконаленої моделі структуровано директивний показник прибутку. Запропоновано систему директивних показників підприємства із дивізіональною структурою за кожним центром відповідальності, а саме: для стратегічного господарського центру, центру прибутку, центрів витрат другого та третього типу. Для вирішення проблеми регламентації відносин між підрозділами підприємства з дивізіональною структурою введено директивний показник трансфертної ціни. Вдосконалено інформаційну модель бюджетування прибутку від основної діяльності підприємства з дивізіональною структурою шляхом введення розрахунків показників сум покриття першого та другого рівнів, введення окремого розрахунку доходу від внутрішньої реалізації за трансфертними цінами, виокремлення у складі планових витрат змінної та постійної частини. Запропоновано інформаційну модель бюджетування прибутку центру витрат другого типу з використанням трансфертних цін. **Висновки:** до складу технології бюджетування доречно ввести графічні та інформаційні моделі; модель формування прибутку для підприємства з дивізіональною організаційною структурою доречно вдосконалити шляхом введення показників сум покриття першого і другого рівня, та виключення прибутків від внутрішньої реалізації; для вирішення

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проблеми регламентації відносин між підрозділами підприємства з дивізіональною структурою доречно використовувати директивний показник трансфертної ціни; інформаційну модель бюджетування прибутку центру витрат другого типу доцільно представити з використанням трансфертних цін.

Ключові слова: бюджетування, технологія планування, директивні показники, трансфертні ціни.

ТЕХНОЛОГИЯ БЮДЖЕТИРОВАНИЯ ДЕЯТЕЛЬНОСТИ ПРЕДПРИЯТИЙ С ДИВИЗИОНАЛЬНОЙ СТРУКТУРОЙ

Предметом исследования является составляющие бюджетирования деятельности предприятий с дивизиональной структурой. **Цель** работы - определить состав технологии бюджетирования и разработать ее основные компоненты для предприятий с дивизиональной структурой. В статье решены **задачи:** обоснованно состав технологии бюджетирования; усовершенствована модель формирования прибыли для предприятия с дивизиональной структурой; предложена система директивных показателей предприятия с дивизиональной структурой; предложена информационная модель бюджетирования прибыли центра затрат второго типа. Использованы **методы:** логико-теоретического обобщения, формализации, моделирования. Получены следующие **результаты.** Обоснован состав технологии бюджетирования как совокупности формализованных знаний о выполнении процесса планирования по структурным подразделениям. Доказана целесообразность представления технологии бюджетирования в виде графических и информационных моделей. Определено, что для реализации задачи формирования типового состава плановых показателей для центров ответственности различных типов целесообразно структурировать директивные показатели предприятия, измеряющие его цели. В основу структурирования директивного показателя прибыли положено экономическую модель его формирования. Модель формирования прибыли для предприятия с дивизиональной организационной структурой усовершенствована авторами путем введения показателей сумм покрытия первого и второго уровня, и исключения доходов от внутренней реализации. На основании усовершенствованной модели структурирован директивный показатель прибыли. Предложена система директивных показателей предприятия с дивизиональной структурой для каждого центра ответственности, а именно: для стратегического хозяйственного центра, центра прибыли, центров затрат второго и третьего типа. Для решения проблемы регламентации отношений между подразделениями предприятия с дивизиональной структурой введено директивный показатель трансфертной цены. Усовершенствована информационная модель бюджетирования прибыли от основной деятельности предприятия с дивизиональной структурой путем введения расчетов показателей сумм покрытия первого и второго уровней, введения отдельного расчета дохода от внутренней реализации по трансфертным ценам, выделение в составе плановых расходов переменной и постоянной части. Предложена информационная модель бюджетирования прибыли центра затрат второго типа с использованием трансфертных цен. **Выводы:** в состав технологии бюджетирования уместно ввести графические и информационные модели; модель формирования прибыли для предприятия с дивизиональной организационной структурой целесообразно усовершенствовать путем введения показателей сумм покрытия первого и второго уровня, и исключения доходов от внутренней реализации; для решения проблемы регламентации отношений между подразделениями предприятия с дивизиональной структурой следует использовать директивный показатель трансфертной цены; информационную модель бюджетирования прибыли центра затрат второго типа целесообразно представить с использованием трансфертных цен.

Ключевые слова: бюджетирование, технология планирования, директивные показатели, трансфертные цены.

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THE ECONOMIC SUBSTANCE OF ACCOUNTING FOR FINANCIAL INVESTMENT AND THE PROSPECT OF USING "BLOCKCHAIN" TO CONTROL INVESTMENT ACTIVITY IN UKRAINE

The **subject** matter of the research is the financial investment and the application of innovative technologies to improve accounting in the context of investment management as one of the most important components of economic development. The **goal** is to study the methodology of reflecting financial investments of domestic enterprises. The **objectives** are to improve accounting of financial investments in the enterprise, to research the development prospects of accounting by introducing innovative technologies through the disclosure of theoretical aspects of research and the estimation of practical aspects of the study, the possibility of using the technology of blockchain in Ukraine to improve the financial reporting taking into account the experience of international partners (foreign countries). The **methods** used are system analysis and structural analysis. The following **results** are obtained. The state of investment accounting was analyzed and the prospects of using blockchain technology for improving auditing efficiency, increasing the transparency of financial investments and for counteracting corruption were found. **Conclusions**. During the analysis of the cause and effect relations of using innovative technologies in accounting, the immaturity of the existing accounting methodology was shown; this immaturity specifies incompleteness, the decline in the adequacy of accounting data in accordance with the realities of investment processes and the development of the industry as a whole. The use of blockchain technology enables restructuring the processes of accounting and their automation and increases the level of transparency of information disclosure by enterprises. Using blockchain for auditing becomes a unique solution as auditing affects all industries and is the foundation that helps global financial markets gain investor confidence. Taking into account the economic problems of Ukraine, the use of blockchain technology will help solve the problems of corruption and capital legalization. Relevant actions will improve the investment climate of Ukraine in the long run.

Keywords: accounting, financial investment, investing, accounts, blockchain, transaction.

Introduction

Investments are an essential factor in the economic development of each enterprise and the source of fixed assets. Financial investment helps distribute and apply investment resources that are the world largest ones. Due to the acceleration of the globalization, the investment sphere has been significantly revived over past decades, which conditioned the transformation of economic mechanisms, the development of business processes of enterprises and caused the urgent need for a qualitative change in the old economic means and the necessity for new innovative ones. In addition, based on the fact that the investment activity belongs to the riskiest types of business, the main problem of development of the innovation sphere in Ukraine is the lack of financing current and prospective activities of enterprises. The most significant factors that stream the activities of enterprises is incomplete and non-objective disclosure of information on investment processes in accounting and financial reporting, the lack of the innovative technologies such as 'blockchain".

To control innovation activity, the theoretical and methodological foundations of accounting for the investment processes of enterprises should be improved.

The analysis of basic literary sources and studies

Some issues of accounting the financial investments of private enterprises are analyzed in the works written by V. Gradiasov [1], A. Peresada [2], Yu. Veryga [3], V. Goncharov [4], A. Makhota [5], E. Mnykha, V. Sopko and others. However, they all considered these issues in general and did not pay enough attention to the rapid development of financing and the complication of accounting methodology. This work practically studies the relation and prospects of using the "blockchain" technology to improve accounting and auditing in Ukraine.

The presentation of main material

Investing is an integral part of the development of any economic system. According to the Law of Ukraine "On Investment Activity", investments are all types of property and intellectual property that are invested in objects of entrepreneurial activity and other activities that lead to generating (income) and/or achieving social and environmental effect [6].

The main methodological principles for the formation of financial information on joint actions in accounting and its disclosure in financial reports are determined in accordance with Accounting Principle (Standard) 12 "Financial investments" [7].

The organization of accounting should be rational, that is to stick to the systematic approach, take into account the interaction of different types of accounting and obey the general plans of operational and strategic management of the enterprise; comply with the requirements of the current legislation, particularly the Laws of Ukraine "On Investment Activity" "On the Treatment of Foreign Investments", "On Accounting and Financial Reporting in Ukraine", the Concept "Regulation of Investment Activity in the Conditions Of Market Transformation of the Economy"; Accounting Principles (Standards) 7, 12, 19 [8].

Table 1 shows the definitions of the term "financial investments" given by different sources of economic literature.

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Table 1. *Scientific views on the notion "financial investments"*

Authors	Interpretation of the concept
V. Gradiasov, S. Kravchenko, O. Isaeva [2, p. 102]	Means of providing The mechanism for funding the growth and development of the country economy; it is an instrument in which money can be invested to save or multiply it.
A. Peresada [1, p. 112]	Investing in various financial instruments (paper holdings, bank deposits, currency, precious metals and stones).
Yu. Veryga [3, p. 79]	These are assets held by an enterprise to increase profits, cost of capital or other benefits to an investor.

When accounting for financial investments, their division into current and long-term ones should be taken into account.

Current investments are securities in the form of bonds, shares, treasury obligations, deposit certificates, the maturity of which does not exceed 12 months or investments for profit for no longer than 1 year.

Long-term financial investments are investments that cannot be realized at any time or with the maturity of more than 12 months (shares, deposit certificates, charter capital of other enterprises, etc.) [8].

When accounting for financial investments, the purpose of acquiring investments (selling, making a profit as a result of participating in the capital of another enterprise, etc.) should be taken into account as this affects their further use and reflection in the financial records.

Financial investments as at the balance date are estimated according to the following types of value: fair, amortized, the method of capital participation.

In practice, the following financial instruments that are the objects of financial investment are identified [4]:

1. Basic (shares, domestic and foreign government bonds, local loan bonds, enterprise bonds, government treasury bonds, investment certificates, commercial papers);

2. Derivatives (contracts using derivatives, options, depositary receipts, etc.).

At the enterprises of Ukraine, the organization of accounting for financial investments includes various types of accounting: primary, synthetic and analytical.

Primary accounting helps enterprises to obtain the necessary information for making financial records of any business entity. It includes processing a number of documents (depending on the type of financial investment): a cash receipt, bank certificate, a statement of accounts.

Analytical accounting provides detailed information on the movement of various economic means; it is built for each synthetic account separately. It is maintained in the relevant accounts. Analytical accounting is maintained in Statement 4.2., where is the verification of data on investments in associated and subsidiary enterprises and enterprises with common activities. Data on long-term and current financial investments is compiled separately.

Financial investments while accounting are reflected on the following statements

1) 14 "Long-term financial investments" (sub-accounts – 141 "Investments in related entities on the equity method of accounting", 142 "Other investments in related entities", 143 "Investments in unrelated entities"). The cost of long-term investments – on debit account 14, disposal/decrease in value – on loan. Besides, credit involves obtaining dividends if the equity participation method for accounting financial investments [9];

2) 35 "Current financial investments" (sub-accounts – 351 "Cash equivalents", 352 "Other current financial ted investments"). Sub-accounts 351 are reflected on debit and 352 are reflected on their prime cost and revaluation surplus when the market cost increases. The balance cost of realized investments and revaluation surplus are written off on the credit of account 35. The fair value of financial investments at the balance date is reflected in the balance of the debit [9].

Financial investments in relation to other types of assets of the enterprise have a certain dynamics of value that causes the necessity of revaluation to restore the corresponding balance value that is adequate to the modern investment environment.

Financial income and expenses are the result of financial investments; investors receive income providing financial investments, emitters lose money for using the investment.

Income from financial investments have the following forms of implementation (according to Accounting Principle (Standard)15) [10]:

1) income from participation in the capital of associated, affiliated and subsidiary enterprises (72 "Income from equity participation" with corresponding sub-accounts);

2) dividends (373 "Calculations for accrued income");

3) interest (732 "Interest received");

4) discount (733 "Other incomes from financial operations");

5) royalties (733 "Other incomes from financial operations");

6) income from the growth of value (741 "Income from selling financial investments").

Losses from financial investments are reflected in the following accounts:

1) 15 "Capital investments" (sub-account 151 "Capital construction");

2) 96 "Equity participation loses" (sub-accounts – 961 "Losses from investments in associated enterprise", 962 "Losses from common activities", 963 "Losses from investments in subsidiary enterprises";

3) 97 "Other losses" (sub-accounts – 970 "Expenses from changes in the value of financial instruments", 971 "Cost of financial investments sold", 972 "Losses from

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decreasing the usefulness of assets" 973 "The discount of permanent assets and financial investments", 977 "Other activities".

Besides the mentioned above, it should be noted that financial investments are estimated at the following stages [5]:

1) recognition (compliance with the criteria for the possibility of reliable evaluation and the future economic benefits of using a financial investment)

2) initial estimation of a financial investment (according to the primary cost which includes the purchase price, commission fees, customs duties, taxes, fees, mandatory payments and other expenses);

3) classification (grouping into current and long-term financial investments);

4) reflection in the accounts (Table 2)

5) revaluation at the balance sheet date (equity method, amortized prime cost method, prime cost method including impairment of value, fair value method);

6) recognition, estimation and reflection of income on financial investment;

7) disclosure of information (balance sheet, notes to financial statements);

8) derecognition and write-down (at the moment of loss of control of the investor over these assets due to disposal (sale) of a financial investment, expiration of the circulation period of securities that were the objects of financial investment, etc.).

Table 2. *Financial investments reflected in the balance and accounts*

Types of financial investments	Balance-sheet items (Financial Status Statement)	Balance-sheet items (Profit and Loss Account)	Accounts whose balance is reflected in the relevant articles of the statement
Long-term financial investments	1030 "Long-term financial investments that are accounted according to the method of participation in other enterprises"; 1035 "Long-term financial investments: other financial investments"	040 "Long-term financial investments that are accounted according to the method of participation in other enterprises"; 045 "Other long-term financial investments"	141 "Investments in related entities according to the method of equity participation" 142 "Other investments in related entities" 143 "Investments in unrelated entities"
Current financial investments	1160 "Current financial investments"	220 "Current financial investments"	352 "Other Current financial investments"
Cash equivalents	1165 "Cash and equivalents"	230 "Cash and equivalents in native currency"	351 "Cash equivalents"
Cash equivalents		240 "Cash and equivalents in foreign currency"	

Source: compiled by the author on the basis of [4,7]

Financial investments are unreliably reflected in financial statements which causes the problem of accounting by some domestic enterprises that aim at minimizing taxes in tax reporting based on accounting data, which also affects the minimization of the displayed profit. The position of enterprises (companies) that are interested in demonstrating profitability in order to attract investment funds is fundamentally different. The problem of inaccuracy of information and improvement of the investment environment on the territory of Ukraine can be solved by reforming the Accounting Principles (Standards) according to the International Financial Reporting Standards (IFRS).

According to the hierarchy of IFRS, accounting financial investments is considered in the following provisions (IFRS, IAS, IFRIP) [11]:

1) IFRS 7 "Financial Instruments: Disclosures";

2) IFRS 9 "Financial Instruments";

3) IFRS 12 "Disclosure of Interests in Other Entities";

4) IAS 28 "Investments in Associates and Joint Ventures";

5) IAS 32 "Financial Instruments: Presentation";

6) IAS 39 "Financial Instruments: Recognition and Measurement";

7) IAS 40 "Investment Property");

8) IFRIC 2 "Members 'Shares in Co-operative Entities and Similar Instruments";

9) IFRIC 16 "Hedges of a Net Investment in a Foreign Operation".

The standards of IFRS, IAS are obligatory. IFRIC are interpretations that disclose one or another issue of the application of the relevant standards.

Investment accounting should be reflected in the reporting of an investor company in the balance sheet and should be accounted using the equity method of accounting on the prime cost as a financial asset (according to IAS 39 "Financial Instruments: Recognition and Measurement" [12] – at fair cost).

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Investment accounting is reflected in reporting according to IAS 28 “Investments in Associates and Joint Ventures” [13], where it is stated that investments in an associate enterprise should be recorded in the consolidated financial statements using the equity method of accounting, except for the cases when the investment is acquired and held for the purpose of selling in the near future (then they should be accounted for on the primary cost).

Thus, investment distribution, which is considered in the financial statements of private business entities (without taking into account banking institutions), requires that the consumers of accounting information understand the accounting reflection of financial decisions. All this makes it difficult to understand the accounting methodology of financial investments. This problem can be solved by using the technology of blockchain.

The blockchain is a means of structuring data whole unit is a block filled with certain information. These blocks are not numbered exactly but time mark is the structuring function. A new block is always added after the last block (according to the time dynamics). This technology is the widely used in cryptology. The blockchain is one of the best data structures as it makes it possible to track changes in information in blocks, to save the record of necessary data.

The effect of this technology can be studied by considering financial transactions using Bitcoin. It should be noted that Bitcoin blocks contain necessary information about the financial transactions that were carried out. It makes it possible to point out that the use of the blockchain significantly reduces the difficulty of verifying financial statements. The main advantage is that the transaction passes only after it is included in the block and is added to the chain, this causes the update of the blockchain state [12].

To check the state of the blockchain, peer-to-peer networks are used. To record a transaction by the blockchain technology in accounting, the passage of the transaction to the user should be checked. The security of the system operation is maintained by saving the updated blockchain on all computers of the network node. However, the main problem of “trust” of users is solved by means of the consensus mechanism (a set of rules that are coordinated by the nodes in the network launching the system software).

This technology has considerable development prospects in the financial sphere due to new products, the optimization of financial transactions [13], the significant acceleration and reduction of the costs for banking services (Chain Inc) (specialized cryptocurrency exchanges and various exchange instruments).

In addition, the most relevant (for Ukraine as well) are development prospects in the field of accounting – reporting, the transformation of accounting and auditing. The blockchain can be used to create a fully transparent and available recording system for regulators for coding transactions in the area of regulatory reporting (Primechain Technologies, Digital Trade Chain) [14].

Unlike most databases that are a kind of stored data at a certain point of time, block databases generate and update themselves on the basis of their own transaction history. They are an autonomous recording system that enables tracking the movement of financial assets (investments) over a certain period of time among specific participants [15]. Blockchain enables automating the search for business partners which result in more efficient, transparent and reliable models of P2P financing, accounting for dividends and coupon payments. Thus, having the ability to compare accounting entries between two trading partners, maintaining the confidentiality of blockchain data could significantly reduce the dependence on auditors to verify financial transactions. Developing blockchain in the sphere of accounting is a promising item under development.

Conclusions

A high risk of investment requires effective and constantly updated accounting and analytical support to improve economic activities of private enterprises. The imperfection of the available accounting methodology causes incompleteness, the inadequacy of accounting data in accordance with the realities of investment processes and the development of the industry as a whole. To improve the reflection of investment processes in financial statements, the structural reorganization of accounting processes should be carried out and automated and the level of transparency of information disclosure by enterprises should be increased.

The use of blockchain for auditing becomes a unique solution since auditing affects all sectors and is the fundamental basis that helps global financial markets gain investor confidence. Taking into account the economic problems of Ukraine, the use of blockchain technology will help solve the problems of corruption and attempts to legalize capital, improve the investment climate.

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ЕКОНОМІЧНА СУТНІСТЬ ОБЛІКУ ФІНАНСОВИХ ІНВЕСТИЦІЙ ТА ПЕРСПЕКТИВИ ВИКОРИСТАННЯ "BLOCKCHAIN" ДЛЯ КОНТРОЛЮ ІНВЕСТИЦІЙНОЇ ДІЯЛЬНОСТІ В УКРАЇНІ

Предметом дослідження статті є фінансові інвестиції та застосування інноваційних технологій для покращення обліку з позицій інвестиційного менеджменту як однієї з найважливіших складових економічного розвитку. **Мета** – дослідження методології відображення фінансових інвестицій вітчизняних підприємств. **Завдання:** вдосконалення обліку фінансових інвестицій на підприємстві, дослідження перспектив розвитку бухгалтерського обліку через впровадження інноваційних технологій за допомогою розкриття теоретичних та оцінки функціонування практичних аспектів дослідження та можливість використання технології blockchain на території Україні для покращення ведення фінансової звітності, враховуючи досвід міжнародник партнерів (зарубіжних країн). Використовуються загальнонаукові **методи:** системний аналіз, структурний аналіз. Отримано такі **результати.** У представленій роботі проведений аналіз стану інвестиційного обліку та знайдені перспективи використання технології blockchain для покращення ефективності аудиту, підвищення прозорості фінансових інвестицій, протидії корупції. **Висновки.** Під час проведення аналізу причинно-наслідкових зв'язків використання інноваційних технологій у бухгалтерському обліку була виявлена недосконаліть існуючої методології бухгалтерського обліку, що обумовлює неповність, падіння адекватності облікових даних відповідно до реалій інвестиційних процесів та розвитку галузі в цілому. Використання технології blockchain дозволить провести структурну перебудову процесів обліку, їх автоматизацію та підвищити рівень прозорості розкриття інформації підприємствами. Використання блокчейна з метою аудиту стає унікальним рішенням, тому що аудит впливає на всі галузі та є фундаментальною основою, за допомогою якої глобальні фінансові ринки отримують довіру інвесторів. Враховуючи економічні проблеми України, використання технології блокчейн допоможе розв'язати проблеми корупції та спроб легалізації капіталу. Відповідні дії дозволять покращити інвестиційний клімат України в довгостроковій перспективі.

Ключові слова: бухгалтерський облік, фінансова інвестиція, інвестування, рахунки бухгалтерського обліку, блокчейн, транзакція.

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ЭКОНОМИЧЕСКАЯ СУЩНОСТЬ УЧЕТА ФИНАНСОВЫХ ИНВЕСТИЦИЙ И ПЕРСПЕКТИВЫ ИСПОЛЬЗОВАНИЯ "BLOCKCHAIN" ДЛЯ КОНТРОЛЯ ИНВЕСТИЦИОННОЙ ДЕЯТЕЛЬНОСТИ В УКРАИНЕ

Предметом исследования статьи являются финансовые инвестиции и применение инновационных технологий для улучшения учета с позиций инвестиционного менеджмента как одной из важнейших составляющих экономического развития. **Цель** – исследование методологии отражения финансовых инвестиций отечественных предприятий. **Задача:** совершенствование учета финансовых инвестиций на предприятии, исследования перспектив развития бухгалтерского учета путем внедрения инновационных технологий с помощью раскрытия теоретических и оценки функционирования практических аспектов исследования, возможность использования технологии blockchain на территории Украины для улучшения ведения финансовой отчетности, учитывая опыт международник партнеров (зарубежных стран) . Используются общенаучные **методы:** системный анализ, структурный анализ. Получены следующие **результаты.** В представленной работе проведен анализ инвестиционного учета и найдены перспективы использования технологии blockchain для повышения эффективности аудита, прозрачности финансовых инвестиций, противодействия коррупции. **Выводы.** При проведении анализа причинно-следственных связей использования инновационных технологий в бухгалтерском учете было обнаружено несовершенство существующей методологии бухгалтерского учета, что обусловливает неполноту, падение адекватности учетных данных в соответствии с реалиями инвестиционных процессов и развитии отрасли в целом. Использование технологии blockchain позволит провести структурную перестройку процессов учета, их автоматизацию и повысит уровень прозрачности раскрытия информации предприятиями. Использование блокчейна с целью аудита становится уникальным решением, так как аудит влияет на все отрасли и является фундаментальной основой, с помощью которой глобальные финансовые рынки получают доверие инвесторов. Учитывая экономические проблемы Украины, использование технологии блокчейн поможет решить проблемы коррупции и попыток легализации капитала. Соответствующие действия позволят улучшить инвестиционный климат Украины в долгосрочной перспективе.

Ключевые слова: бухгалтерский учет, финансовая инвестиция, инвестирование, счета бухгалтерского учета, блокчейн, транзакция.

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MAHTAB JAFARI

THE RELATIONSHIP BETWEEN PERFORMANCE OF THE ADMINISTRATIVE SYSTEM AND NATIONAL AUTHORITY OF GOVERNMENTS: AN ISLAMIC POINT OF VIEW

Each government consists of two dimensions: 1) a structural dimension that involves policy- and decision-making bodies and, 2) a functional dimension that is a set of government institutions and administrations. Also, the national authority in a country is an outcome of three components, including legitimacy, acceptance, and efficiency of its government. The authority of governments is not merely limited to their structural legitimacy and acceptance; but, their functional dimension and the performance of their administrations also play a crucial role in building and strengthening their legitimacy. Therefore, the **aim** of the present study is to investigate how the administrative system of a government affects its national authority, with an emphasis on the Islamic point of view. To do this, this research has been carried out within the framework of theoretical research with a practical purpose. The research **method** of the current study was the descriptive and analytical. In this study, the relationship between two variables – namely, "administrative system" and "national authority" – has been investigated within the framework of the causal research. Due to the theoretical nature of this study, the resources used mostly include documents and library sources. The **results** of this study indicate that there is a direct and causal relationship between the national authority of governments (effect) and the performance of their administrative system (cause). Also, this relationship reveals how the administrative system affects national authority.

Keywords: structure and function of government, national authority, legitimacy, acceptance, efficiency of government.

Introduction

A political system is an integrated entity that is formed specifically from both structural and functional dimensions. A set of factors and institutions that constitute the structural dimension of the government include a set of institutions, such as parliament and other organizations. It is the responsibility of these institutions to formulate policies, policies and macroeconomic strategies as well as determining the principles of its political ideology. In contrast, a group of institutions and systems that undertake the implementation of the government plans and policies in the practical dimension, constitute the functional dimension of the political system. It must be noted that from the Islamic point of view, the legitimacy of a political system is provided by two sources. Firstly, it arises from Divine Satisfaction and from the conformity of its ideological framework with religious standards. Secondly, the legitimacy of a political system is provided by the will of the people and the members of society. Hence, from the Islamic point of view, the legitimacy of the government systems has a dual foundation. However, from the non-religious perspectives, it is based solely on the popular and social acceptance of the governments.

Generally, according to the basics and principles of Islam, the efficiency of governments is not confined to their structural legitimacy and acceptance. But additionally, the functional dimension and the performance of the administrations play a crucial role in building and strengthening the legitimacy of a government. The functional dimension and the performance of the administrations also assure the permanency of the legitimacy and authority of the government over time. This is a truth, not only in the Islamic systems but also in all political systems and in all eras of history. If we accept the fact that people, as the main aspect of each political system, are the key to authority and survival of governments at any given time, and their assessment of the nature of the system is mainly focused on the performance and administration of the system, and that the performance and administration of the system is the criterion of judgment about the system, the efficiency of the political system will be more salient than the legitimacy and acceptance. There is no doubt that in case of negligence towards the functional dimension of a political system (which is reflected in the performance of its institutions and administrative bodies, and is the criterion of public satisfaction and acceptance), the structural legitimacy of the government will be negated naturally and the general authority of that political system will be abolished. Therefore, the purpose of the current study is to resolve this problem, because regardless of the ideological framework of governments, satisfaction of the people fulfilling their needs is the main component of authority and legitimacy of political systems. Therefore, according to the explained above, in the present study, we examine how the administrative system of governments affects their national authority, with an emphasis on the Islamic point of view.

Methodology

This research is a theoretical study due to its nature; however, it can be also an applied research in terms of its purpose. This research has been carried out using a descriptive-analytical method, in order to investigate the relationship between two variables (the administrative system and the national authority) within a causal-inferential framework. Due to the theoretical nature of this study, the resources used in it mostly include documents and library resources.

Findings

Based on the basics and principles of Islam, the desirability of governments is not limited to their structural legitimacy, but is also affected by an axiom that "As one of the most important and influential factors of the desirability of governments, the importance of the functional dimension and performance of the

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administrative bodies has a crucial role in building, reinforcing and sustaining the authority of governments over time. This axiom is true within all political systems, including both Islamic and non-Islamic political systems. In order to explain this axiom, we first need to explain some of the administrative and executive managers' characteristics from the perspective of Islam. Afterwards, we will describe the concepts, principles, and components of the administrative system in Islam, based on the standpoint of Imam 'Ail (AS) as reflected in Nahj al-Balagha; we will describe two categories of factors, including structural and behavioral factors:

The Characteristics of Administrative Managers from the standpoint of Islam.

1. Knowledge and Faith

Science and knowledge are the keys to progress and survival of governments and to the security of communities (Movahedi Nejad, 2004: 100). But, obviously, science cannot be the sole protector against deviance. But, expertise must be accompanied by commitment. According to Qur'an, the management and leadership of the earth and its inhabitants should be in the hands of competent and faithful individuals (Al-Bahi,1981: 28). Virtue, meaning self-management, makes managers avoid violating the divine boundaries in favor of their personal desires.

2. Conformity of Words and Actions

Regarding the contradictions between words and actions, the Qur'an says O you who have believed, why do you say what you do not do? (Qur'an (61:2)). This verse revealed on the day of the battle of Uhud, and is about Jihad and Muslims escaping the war; it refers to one of the worst disasters that may occur in an Islamic society.

3. Consultation

In the Qur'an (Surah: Al Imran, Verse: 159), God addresses Prophet Muhammad (AS) and says: consult with your men about the quality of war and act in accordance with the majority vote. Also, Imam Ali (AS) emphasizes on the principle of consultation and says: Guidance leads to increased insight. Therefore, it is necessary for managers to pay special attention to the principle of consultation, so that they can make conscious and fair decisions.

4. Precedence of Mercy over Wrath

Among the attributes of God is his mercy. Although Allah has determined punishment for illegitimate actions, he considers "another chance" on the basis of his mercy and forgiveness (Hamed Moqadam, 1986: 124-125). Regarding the verses of the Qur'an and the Islamic principles, it can be understood that reward and punishment plays an effective role in the development of human personality. On-time application of these two factors can help managers to achieve constructive and productive management.

5. Openness to the principle of negotiation

One of the management skills is the awareness of the texts of debates and negotiations. Exploiting these factors helps managers to be effective and productive (Fisher, 2003: 13). Generally, the use of negotiation techniques is one of the most effective approaches for discovering facts and achieving better outcomes.

6. Politics

In Islamic management, policy is equal to the practical methods which a manager uses to deal with his opponents. It must be mentioned that the Imam Ali's goal in politics was beyond the achievement of political power, and the basis of the Imam Ali's diplomacy was a deep commitment to ethical principles and values for performing the Islamic and divine commands (Derakhshe, 1992: 206)

7. Equality

One of the most important requirements that each manager has to fulfil, is to recognize the facilities of organization and government institution as the properties of the people and to avoid personal usage (Nabawi, 2011: 229). Based on the ethics of all religions, violating the equality is always regarded as a great oppression, and those who are oppressive, will be defeated by God's will.

Concepts, principles and components of the administrative system in Islam, based on the standpoint of Imam Ali (AS) in his book, Nahj al-Balagha

A) Structural Factors

Political Factors.

Since autocratic political systems are not selected through the people's vote, they have no accountability to the people, and this is the most important factor for the development of corruption in administrative systems. Hence, in traditional approaches to the administration of government issues, the theory of separation of the administrative system from the political system, in order to prevent the administrative system from being corrupted. According to this theory, managers and employees are not accountable to the people and society. But in the Islamic system, the political system is the basis of the administrative system; so that the correctness and corruption of the administrative system are the results of correctness and corruption in the political system. It should be said that as the public will and supervision affect the formation and sustainability of the divine political system, it also influences the decision-making process and the implementation of plans in the divine administrative system. Monitoring the performance of the administrative system is necessary for preserving the correctness and sustainability of the system (Sheikhi, 2011: 117).

Advisory decision-making.

The logic of the Qur'an is that, even if the leader of the society has the highest position among humans (namely, the Prophet Muhammad (AS)), the Islamic community should not rely solely on him. In other words, this dependence should not be to an extent that could lead to the destruction of the foundation of the society in case of Prophet Muhammad (AS) not being present (Agha Piroz et al., 2015: 116). Therefore, it is obvious that individual decisions often lead to autocracy and eventually make the whole organization inefficient. Hence, Islam has emphasized advice and consultation with others, in order to undertake the administrative actions correctly. As stated

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by Imam Ali (AS), anyone who consults with the wise men will be guided in the right way (Nahj al-Balagha, Saying 173). This indicates that regarding the standpoint of Islam in general and the standpoint of Imam Ali (AS) in particular, people should use opinions of experts and wise men, but the final decision must be made by a single person.

Rule of Law.

The most important principle in the administration is the adherence of all individuals and especially managers to the law. Because the factor that sustains the correctness of governments and guarantees their public support is adherence to the law. In this regard, during his deprivation of the government, Imam Ali (AS) reminded managers that: "There are three things that if you honor them and act based on them, you don't need anything else; and if you neglect them, nothing else will benefit you. The three things are implementing the law equally for yourself and the strangers, following God's principles in happiness and anger, and fair and equal distribution of wealth among black and white (Al-Asqalani, 1946: 227).

Transparency.

The concealment of issues and subjects from the sight of the people underlies illegal and criminal actions. generally, if all issues are clear, many problems such as bribery, injustice and potential corruption in the Government, hidden and self-seeking relationships, hidden transactions that cannot be audited, etc. will be vanished and generally, a situation like this increases the efficiency of the governance and management. In this regard, Imam Ali (AS) regarded the transparency of issues as the basis of government. At the beginning of his governance, Imam Ali (AS) stated that: I swear to Allah that I have never concealed any truth, and I have never lied (Nahj al-Balagha, Sermon 16). He also stated that: It is your right and I promise that I will never hide a secret from you, unless during a war (Nahj al-Balagha, Letter 50).

Accountability.

Responsibility is a prerequisite of management. This means that anyone is accountable and responsible in accordance with their role. Imam Ali has said, "I recommend you to be afraid of God about what you do at your own responsibility, because you are pledged to it". Every man has a commitment to his own achievement, says God. He says, "God warns you to beware of his punishment. Indeed, to him, all will return". Then he says, "Thus, Swear to your God, I will ask all of them about what they were doing". O Servants of God, you know that God will ask you about your actions (Majlesi, 1670: 543).

Organizational Supervision.

In order to prevent the employees from violating the laws and offending the rights of the people, as well as to preserve the integrity of the administrative system, monitoring the administrations and the employees of the departments is essential. Imam Ali (AS) wrote a letter to one of his managers and told him: "I heard that you have destroyed useful lands and usurped as much as possible. Send me the details of your account immediately (Nahj al-Balagha, Letter 40).

Improving the livelihood of the employees.

The financial problems and poverty underlie many corruptions in the administrative systems. Therefore, one way to prevent administrative corruption from occurring is to improve the livelihood of employees and government managers. In the management methods provided by Imam Ali (AS), this important issue has been considered. Imam Ali (AS) told his commander (Malek Ashtar): Pay them (employees) enough, because it supports them for correcting and improving themselves. This way, they don't need to steal any amount of the public funds, and if they defy your orders or betray you, they will have no justification (Nahj al-Balagha, Letter 53).

B) Behavioral Factors

Impact of people on the correctness of the administrative system.

From the standpoint of Islam, without the participation of the people, the administrative system is not properly managed and its correctness cannot be guaranteed (Delshad Tehrani, 2000 b: 111). Islamic government is flourished only by the stability of the people and their full participation in the society. Imam Ali (AS) has tried to keep people away from dominative and submissive positions and to make them have a real presence in all areas (Delshad Tehrani, 2000 a: 111). He said: "don't speak with me the way people speak to arrogant kings. Don't walk away from me, as you walk away from angry people, and don't behave with duplicity and falsification. Don't think that if you express a truth, I'm going to get upset and don't think I'm trying to seem great. Someone who cannot tolerate hearing the truth or a complaint against injustice would have much more difficulty in acting based on truth and justice. Therefore, don't avoid saying the truth or counselling for justice; because I don't think that I am protected from making mistakes unless God protects me (Nahj al-Balagha, sermon 216).

Institutionalizing the Culture of Criticism and Openness to Criticism.

In order to nurturing the culture of criticism among the people, Imam Ali (AS) recommended his employees to get closer to the individuals who have more explicitness in saying the truth and give constructive criticism, rather than glorifying the current actions and plans (Mohammadi Rey Shahri, 2008: 42-43). Promoting the culture of criticism against managers and organizations will lead to disclosure (and correction) of possible shortcomings and corruptions.

Adherence to Justice.

According to the procedural justice, when current procedures of decision-making for the allocation of resources are considered fair by individuals, they will have more motivation for improving their performance (Rezaian, 2014:49). Procedural justice can be also an important factor for getting the people to cooperate and have a profound impact on one's work attitudes in the workplace (Ibid:49).

The principle of justice was one of the most important principles of administration in the management methods offered by Imam Ali (AS). The principle of justice is the criterion of everything; and without acting in

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accordance with justice, the goals of the Islamic government cannot be achieved. It is the most important principle in social management (Delshad Tehrani, 2000 b: 246). From the standpoint of Imam Ali (AS), justice is important in managing the affairs of administration and he considered justice as the criterion of policy (Tamimi Amedi, 1999: 116). "Justice is the criterion of administration" means that all employees are provided with equal facilities to make progress. Also, in the formulation and implementation of the law, justice and equality must be considered and the differences and advantages must be evaluated on the basis of qualifications and competencies (Delshad Tehrani, 2000 b: 253).

Education.

In each society, education has a direct impact on beliefs, ethics, and generally, on behaviors (Mesbah, 2012: 337). In general, education plays a crucial role in informing the people of the corruption of values, the malignancy of the powerful individuals and their misuse of power, as well as informing them of the desirable circumstances, values and goals (Ibid:64). In other words, training the employees of the administrations has a central role in the positive development of the administrative system. Imam Ali (AS) said that the origin of any material and spiritual goodness is knowledge, and he considers ignorance as one of the key causes of corruption in any social environment. "Knowledge is the basis of any goodness (Hakimi, 2001: 96), and ignorance is the root of all evils (Ibid:64).

Meritocracy.

To achieve efficiency in administrations, employees have to acquire some features such as skills, knowledge, and beliefs. In other words, if incompetent people undertake the management of the administrative system, the efficiency of the administrations will be reduced. From the standpoint of Islam, managers are trustees for the people. Assigning responsibility and administrative authority to competent individuals, is one of the important examples of this trusteeship. As God says in Qur'an, "Indeed, Allah commands you to render trusts to whom they are due and when you judge between people to judge with justice" (Qur'an, 4:58). Furthermore, one of the most important principles of the administrative management from the standpoint of Imam Ali (AS) was to consider competence in the process of assigning a responsibility to an individual. Imam Ali (AS) stated that the assigning the responsibilities to incompetent individuals leads to failure and disaster. Imam Ali (AS) addresses the judge appointed by himself and says: the government is a trust, and anyone who betrays in this trusteeship, will be damned by God until the doomsday, and Muhammad (AS) hates anyone who employs a traitor, in this world and in the world hereafter (Mahmoodi, 1997: 36).

Punishment and Reward.

The evaluation of employee performance, rewarding the competent employees and punishing the offenders, collectively cause the growth and advancement of committed individuals and correction of the offenders. In a recommendation, Imam Ali (AS) told one of his commanders that: Recognize their efforts through an accurate assessment and never reward someone because of someone else's efforts. Don't underrate the value of their services. The honor and dignity of individuals should not lead to overrating their works, and anonymity of some individuals should not cause you to misprize their great work (Nahj al-Balagha, letter 53).

Generally, other behavioral factors that promote the correctness and improve the performance of the administrative system are as follows:

1. Respecting the clients: Showing respectful and pleasant behavior toward clients;

2. Face-to-face communication with the people: Administrative managers in an Islamic system are obligated to investigate the people's problems directly and closely. In this regard, Imam Ali (AS) says that: The authorities hiding from the people are the origins of lack of awareness among the authorities (Nahj al-Balagha, letter 53);

3. Public Monitoring: From the standpoint of Islam and Nahj al-Balagha, the most effective form of monitoring the performance of administrations is the robust supervision carried out by social masses who believe in Islam and the Islamic government. Hence, social differences, social classes, the type of ideological attitudes, and other factors should not prevent people from monitoring the performance of the administrations and authorities;

4. Judicial factors: fair judgment, prevent employees from carrying out violations. In this relation, the religion of Islam has emphasized the provision of operators' rights in the judiciary system and monitoring their performance, in order to preserve the correctness of the judiciary and the administrative systems.

From the standpoint of Nahj al-Balagha, the government is a sociopolitical system which is assigned to the ruler or the Governing Council by God and the people, so that social order and improvement will be realized towards the material and spiritual well-being of the individual and the society (Navaei and SeyedMoosavi, 2011: 76). Imam Ali (AS) has told the rulers that: don't say that I am a king and you must obey me, as this leads to a retrogression and destruction of the government. Based on the principle that proper and correct management leads to the evolution of individuals, society and government in addition to establishing a political system, Islam has defined the characteristics of the administrative managers and the components governing the administrative system. In accordance with what was presented in this section of the study, these characteristics and components are as follows:

Characteristics of the Administrative Managers: A principled and ethical diplomacy; commitment and expertise; advisory decision-making; appropriate encouragement and punishment, in accordance with the principles of Islam, and with respect to human dignity and dignity as well as the propagation and promotion of justice.

Components governing the administrative system: Rule of law, the correctness and corruption in the government affecting the correctness and corruption of the administrative system, transparency, accountability,

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organizational supervision, improving the income of employees, the role of people in the correctness of administrative system, institutionalization of criticism and openness to criticism, meritocracy.

Therefore, considering the Islamic principles required for the realization of an efficient political system that causes the development and improvement of the individual and society, we can understand the role of functional dimension and the performance of the administrative system in realizing, strengthening and sustaining the desirability of governments over time. Also, we believe that there is a direct and causal relationship between the administrative system (as the Cause and the Independent Variable) and the national authority of governments (as the Effect and the Dependent Variable); so that increasing the quality of performance of the administrative system leads to increased national authority of governments and, decreasing quality of the performance of the administrative system leads to decreased national authority of governments. We described this relationship in the following conceptual model:

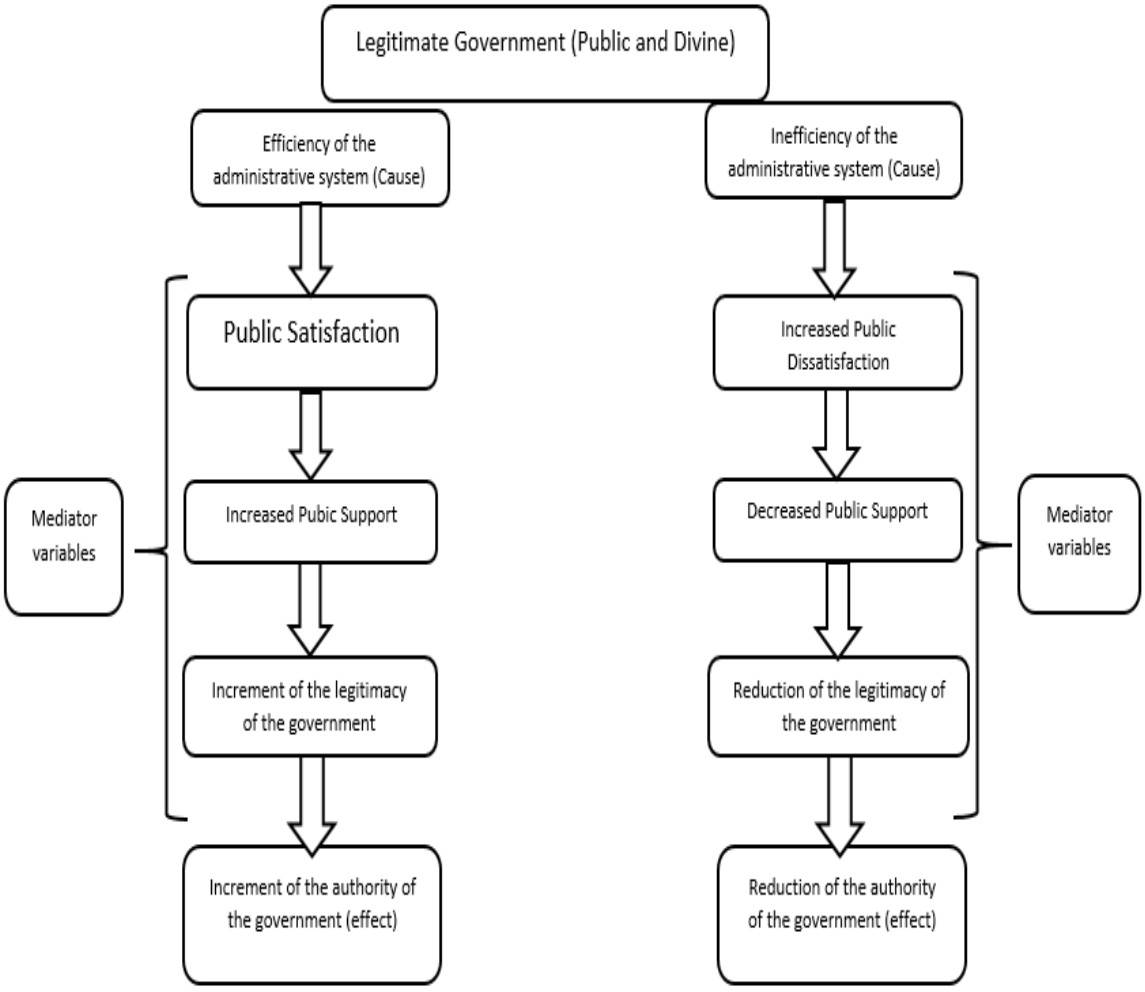

Fig. 1. Conceptual model of the relationship between the performance of the administrative systems in governments and national authority of the governments

Conclusion

Based on the results of the current study, we found that one of the factors for building legitimacy is the positive performance and efficiency of governments. But it must be explained that according to Islamic teachings and principles, legitimacy and desirability of governments are not confined to the structural legitimacy of the governments. Therefore, since the governments implement their programs and actions through their functional dimension and administrative bodies, it can be stated that the legitimacy of a government depends on both structural and functional dimensions of the government. We discovered a direct causal relationship between the two variables, including the performance of the administrative system (cause) and the national authority of governments (effect). We used a diagram to describe how the administrative system influences the national authority of governments (fig. 1).

It must be mentioned that in a significant number of Islamic countries, despite the existence of Islamic principles provided for monitoring the performance of administrative systems, there are deficiencies such as the lack of transparency, accountability, reward and punishment systems, and meritocracy as well as the weakness of the regulatory structures, and the unfair distribution of wealth, etc. In regard to the understanding the cause of these problems in the administrative system

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of all countries, including both Islamic and non-Islamic countries, we can mention the basis of the legitimacy of governments. Jean-Jacques Rousseau believes that "if a government and authority are delegated to an individual by the public will, it is legitimate; however, other routes for transmitting the political power are not legitimate". But from the standpoint of Nahj al-Balagha, people cannot be the sole origin of legitimacy. Because a society may suffer from intellectual, ethical and practical deviations and the people's ideas may not be rational, logical, and divine, and corruption may be embodied in the intellectual bases of the community. Indeed, such an issue is quite evident in many of the past and current societies. Obviously, these problems will lead to a reduction in the efficiency, acceptance, legitimacy, and finally the national authority of governments.

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ВЗАЄМОЗВ'ЯЗОК МІЖ ЕФЕКТИВНІСТЮ АДМІНІСТРАТИВНОЇ СИСТЕМИ УПРАВЛІННЯ І ОРГАНАМИ ДЕРЖАВНОЇ ВЛАДИ УРЯДІВ: ІСЛАМСЬКА ТОЧКА ЗОРУ

Кожен уряд існує в двох вимірах: 1) як структурний елемент, що містить органи, які визначають політику й прийняття рішень, і 2) як функціональний, що є сукупністю державних установ і адміністративних органів управління. Крім того, державна влада в країні будується на трьох компонентах, а саме – легітимності, прийнятності та ефективності уряду. Повноваження урядів не обмежуються тільки структурною легітимністю і прийнятністю, їх функціональність та ефективність органів державного управління також відіграють вирішальну роль в побудові та зміцненні їх легітимності. Тому **метою** даного дослідження є вивчення з точки зору ісламу як адміністративна система управління впливає на державну владу. Дослідження проводилося в межах теоретичних досліджень, що мають практичну спрямованність. Для дослідження застосовувався описово-аналітичний **метод**. У даному дослідженні відносини між двома змінними, а саме "адміністративною системою управління" і "державною владою" вивчалися в контексті причинно-наслідкових зв'язків. Виходячи з теоретичного характеру даного дослідження, використовувані джерела інформації містять в основному документи та бібліотечні ресурси. **Результати** даного дослідження показують, що існує прямий причинно-наслідковий зв'язок між державними органами влади (наслідок) та ефективністю їхньої адміністративної системи управління (причина). Крім того, цей взаємозв'язок показує, як адміністративна система управління впливає на державну владу.

Ключові слова: структура та функція уряду, державна влада, легітимність, прийнятність, ефективність уряду.

ВЗАИМОСВЯЗЬ МЕЖДУ ЭФФЕКТИВНОСТЬЮ АДМИНИСТРАТИВНОЙ СИСТЕМЫ УПРАВЛЕНИЯ И ОРГАНАМИ ГОСУДАРСТВЕННОЙ ВЛАСТИ ПРАВИТЕЛЬСТВ: ИСЛАМСКАЯ ТОЧКА ЗРЕНИЯ

Каждое правительство существует в двух измерениях: 1) как структурный элемент, который включает органы, определяющие политику и принятие решений, и 2) как функциональный, который представляет собой совокупность государственных учреждений и административных органов управления. Кроме того, государственная власть в стране строится на трех компонентах, а именно – легитимности, приемлемости и эффективности правительства. Полномочия правительств не ограничиваются только структурной легитимностью и приемлемостью, их функциональность и эффективность органов государственного управления также играют решающую роль в построении и укреплении их легитимности. Поэтому **целью** настоящего исследования является изучение с точки зрения ислама как административная система управления влияет на государственную власть. Исследование проводилось в рамках теоретических изысканий, имеющих практическую направленность. Для исследования использовался описательно-аналитический **метод.** В данном исследовании отношения между двумя переменными, а именно "административной системой управления" и "государственной властью" изучались в контексте причинно-следственных связей. Исходя из теоретического характера данного исследования, используемые источники информации включают в основном документы и библиотечные ресурсы. **Результаты** данного исследования показывают, что существует прямая причинно-следственная связь между государственными органами власти (следствие) и эффективностью их административной системы управления (причина). Кроме того, эта взаимосвязь показывает, как административная система управления влияет на государственную власть.

Ключевые слова: структура и функция правительства, государственная власть, легитимность, приемлемость, эффективность правительства.

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PRIORITY TRENDS IN ENSURING THE ENERGY SECURITY OF UKRAINE IN THE TERMS OF EUROINTEGRATION

The **subject** matter of the study is to find the priority tasks and to select ways to ensure the energy security of Ukraine as well as to identify its energy potential for accelerating the economic growth. The **goal** of the article is to study the trends and strategic prospects for creating, developing and ensuring the energy security of Ukraine under the conditions of European integration reforms. The following **methods** and ways of scientific research were used in the article: the dialectical and the system approach was used to generalize the scientific study; the method of logical generalization was used to study the existing situation and to justify the directions for ensuring the energy security, to substantiate the relevance of the topic, the goal and objectives of the study, to identify the essential features and threats of the excessive use of imported energy supplies; the method of grouping to systematize tasks and ways to diversify the energy consumption in Ukraine. Ukraine has a significant potential for accelerating the economic development and enhancing the energy security. The energy security is an important component of the national security of the state and one of the global problems of every country in the world. To realize the existing potential, Ukrainian laws and regulations should be reformed and the requirements of international agreements should be met, the relations with the countries of the European Union should be developed. The following **tasks** were solved: the current state of fuel and natural resources security of Ukraine was analyzed and the ways for improving the energy security were systematized, the trends in the development and the priorities of the strategic prospects of Ukraine in the context of integration processes were studied. The following **results** were obtained: the main steps to ensure the energy security of Ukraine, to enhance the cooperation with the EU countries, to strengthen the relations in the context of the energy security were highlighted, the available energy potential for accelerating the economic growth was substantiated. **Conclusions.** The need to neutralize threats to energy efficiency as a diversification of energy consumption in Ukraine is proved. This approach will ensure the international competitiveness of the Ukrainian economy, the prerequisites for membership in international organizations; it will also stimulate the renewal of the domestic energy industry. The prospects for further research in this area are the study of the development of the competitive energy market and transition to the energy-efficient use of energy resources in order to ensure the energy security of Ukraine.

Keywords: energy security, energy intensity, energy materials, European integration processes, fuel and energy resources.

Introduction

Ukraine is a country that is partly resourced with its own traditional fuel and energy so it needs for significant volumes of fuel and energy imports. The share of imports in the total supply of primary energy in Ukraine has been about 38% over the past few years, which determines its energy dependence as a Central European one. This dependence is caused not only by the lack of sufficient volumes of own energy materials but also by their inefficient use.

The energy intensity of Ukraine GDP is much higher not only in comparison with the leading economies of the world but also with neighbouring countries of Central and Eastern Europe. Thus, the energy efficiency index of the Ukrainian economy adjusted on the structure of the economy is calculated on the basis of the indicators recommended by the International Energy Agency and in 2013 it was 57.8% of the EU level [4].

Ukraine faces a number of problems that are linked with the overuse of expensive imported fuel, inefficient markets and infrastructure.

Despite this, Ukraine has a great potential for accelerating the economic growth and enhancing the energy security. The energy security, in its turn, is an important component of the national security of the state and one of the global problems of every world country. The realization of the available potential requires that the laws and regulations should be reformed and the demands of international agreements should be fully met. The efficient competitiveness along with the gradual switch to marker prices will also help Ukraine invite investments for developing the energy sector and for increasing the energy security [8].

The analysis of literary sources and recent research

A great number of scientific works of foreign and Ukrainian scientists deals with researching the strategic perspectives of developing the energy sector of the economy, international partnership and the energy security in general; among them are the works by L. Abalkin, O. Alimov, V. Barannik, O. Bilous, M. Voropay, V. Geitz, M. Zemlyanoy, I. Mazur, V. Mikitenko, I. Nedin, E. Oleynikov, B. Piriashvili, S. Panchenko, A. Sukhodolya, A. Shevtsov, A. Shidlovsky and so on.

The parts of the general problem that have not been solved

However, a significant number of issues related to ensuring the energy security, the coherence of the state policy and consistency of strategic prospects for developing relations at the level of the EU countries have not been sufficiently developed.

In this regard, it is necessary to analyze if the European integration processes have adequate and efficient mechanisms to ensure legislatively and institutionally the implementation and priority directions for improving public policy in the context of improving the energy security of the state.

The **goal** of the article is to determine the strategic prospects of developing the energy security of Ukraine taking into account the international trends of the world energy markets and the state policy in the sphere of energy security support.

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The basic material

The current stage of the domestic economic development is characterized by significant changes in the organization of production processes at the national and international levels, which is the basis for developing a new type of interaction of social and economic systems as well as developing new mechanisms for realizing the results of their interaction [1]. M.P. Voinarenko considers that globalization leads to the creation of a single economic space and the intensification of competition in the world market. Under such conditions, the decisive competitive advantages of the national economy of any country are the availability of raw materials, the level of science and technology development, innovative production potential, favourable geographic location. That is why the issue of the participation of our state as a country with an underdeveloped economy in the complicated process of economic globalization is one of the urgent problems.

Over the last few decades, Ukraine has been dependent on external energy sources, primarily from the Russian Federation. According to the world practice, the dependence on a supplier that exceeds 1/3 is a critical threat to the national security. In 2011-2013, more than 90% of the value sales of the natural gas, almost 85% of crude oil, 95-98% of nuclear fuel were imported from Russia.

Such dependence has become a clear signal for Ukraine that the energy security and energy independence of the state should be strengthened. Since then the speed and quality of implementation of EU laws in Ukraine have grown and the cooperation between Ukraine and the EU has reached a new, more effective level.

According to the data of National joint stock company "Naftogaz of Ukraine", gas was imported in Ukraine only from the European gas market in 2017. As compared with 2016, gas import increased by 27% – from 11.1 billion m3 to 14,1 billion m3 (fig. 1).

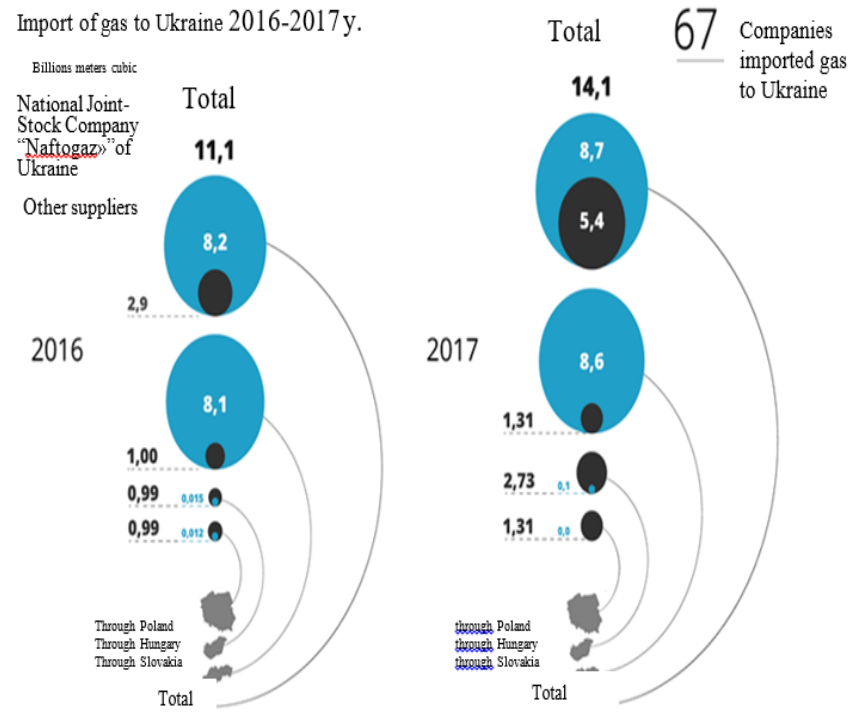

Fig. 1. Gas imported to Ukraine in 2016-2017 [5; 6; 8]

In 2017 the volume and share of import were increased by private traders and gas consumers. In 2017 these companies imported by 1.8 more gas than in 2016 – 5.4 billion m3 versus 2,9 billion m3.

In 2016 Naftogaz imported from the European market 8,7 billion m3 of gas, which is by 0.5 billion m3 (6%) more than in 2015 (Table 1). 13 European companies sold natural gas to Ukraine in 2017 (in 2016 there were 15 companies). None of these companies supplies more than 30% of imported gas.

Thus, changes in the Ukrainian gas market became possible as a result of the adoption of the "Law on the Natural Gas Market" (is effective from October 1, 2015) and other steps aimed at creating the open and transparent natural gas market in Ukraine.

Table 1. *The volumes of natural gas import to Ukraine in 2016-2017 (billion m3)*

The source of import	2016	2017	The rate of growth ,%
	11.1	14.1	127
for Naftogaz, totally	8.2	8.7	106
from Gazprom	0.0	0.0	-
from other suppliers (European direction)	8.2	8.7	106
for other companies, totally	2.9	5.4	186
from Gazprom	0.0	0.0	-
from other suppliers (European direction)	2.9	5.4	186

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In particular, in December 2017, the Stockholm Arbitration canceled all the claims of Gazprom regarding the gas that had not been received by Naftogaz and made the Russian monopoly sell 5 billion m^3 of gas to Naftogaz annually at the price of a liquid European hub (the point of intersection of a significant number of gas transport routes). This price is lower than currently available at the western border. Naftogaz is obliged to buy 4 billion m^3 from this volume per year, which is less than a half of gas import demand expected by Naftogaz. The company can purchase the rest of gas from suppliers that offer the most competitive conditions.

In 2017 the consumption of gas in Ukraine decreased by 1,.3 billion m^3 (from 33.2 to 31.9 billion m^3, that is 4%) as compared with 2016.

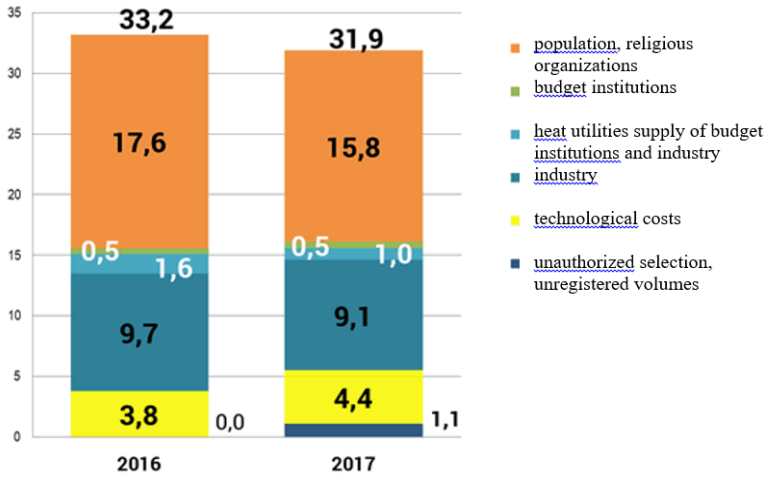

Fig. 2. The consumption of natural gas in Ukraine in 2016-2017 (billion m3) [8]

The analysis of the dynamics of natural gas consumption during 2017 shows a downward trend. Household consumers used 11.2 billion m3 of gas, which is 7 billion m3 less than in 2016 (-6%).

Enterprises of thermal power stations (TPS) that produce heat energy for the population used 4.6 billion m3 of gas, which is 1.1 billion m3 less than in 2016 (-19%).

The volume of gas used by TPS for producing heat for budgetary institutions and industry reached 1.0 billion m3 of gas.

Last year religious institutions used 19 million m3 as compared with 17 million m3 in 2016. The use of gas by this category of consumers in the total gas use is 0.06%.

The volume of gas used by industrial consumers decreased by 0.6 billion m3 (from 9,7 to 9,1 billion m3, -6%).

Production and technological expenditures of gas for the manufacture, transportation and distribution of natural gas and for the manufacture of liquid gas increased by 16%, from 3,8 billion m3 to 4,4 billion m3.

The increase in the gas used by this category of consumers is mainly connected with the growth in the volumes of the transit of Russian gas. In 2017, as compared with 2016, the volume of the transportation of Russian gas through Ukraine increased by 11.3 billion m3 (+14%), from 82.2 billion m3 to 93.5 billion m3. As a result, production and technological expenditures of PAT "Ukrtransgaz" increased by 29%, to 2.2 billion m3.

Such a rapid reduction in natural gas consumption is undoubtedly connected with a total decline in industrial production, which poses a threat to the national economy of Ukraine, with the reduction of consumption standards for population and also, to some extent, with the procedures of energy efficiency and gas replacement. According to the data presented by the Ministry of Finance of Ukraine, industrial production index in Ukraine in February 2018 was 96,5 % (table 2).

Table 2. *The indices of industrial production in 2016-2018*

	January	February	March	April	May	June	July	August	September	October	November	December	Over a year
2016	81,4	108,2	106,8	96,6	96,3	97,9	107,0	99,2	104,4	105,7	100,8	101,9	103,1
2017	82,5	97,8	108,9	93,1	103,4	100,1	100,3	103,0	102,5	106,9	100,3	101,0	97,1
2018	86,1	96,5											

Besides, new threats emerged in addition to these previously identified threats. They are related to the destruction of energy facilities in Ukraine, the reduction of its domestic resource base, the blockage of energy supplies from the eastern direction. These factors created new additional threats to national security.

The main way to neutralize these threats is diversification. In [2], diversification is defined as one of the main directions of the reduction of the energy dependence of a country in current conditions. At the same time, diversification should concern not only the

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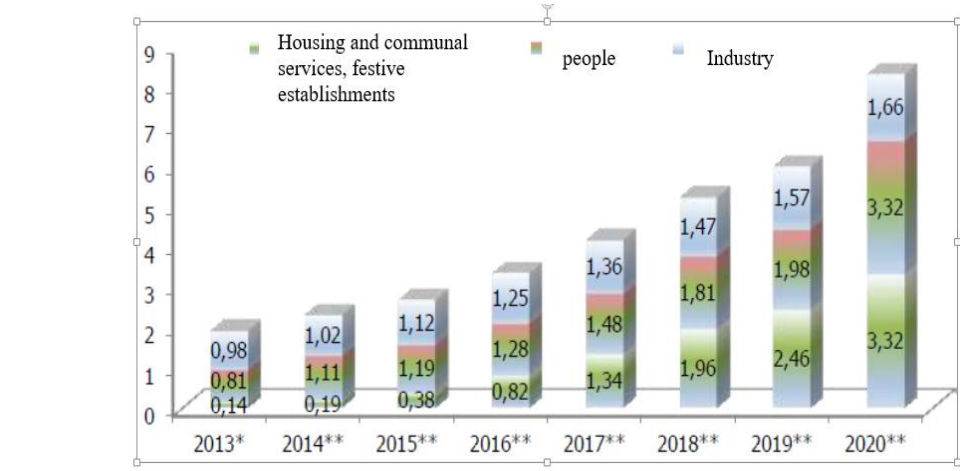
sources and routes of the transportation of energy resources but also energy technologies.

Diversification does not only reduce political risks connected with the monopoly supplier but is also a powerful factor in reducing the cost of purchasing fuel and energy resources due to business competition.

The countries of the European Union widely use several directions of energy materials diversification. The first direction is the large-scale use of liquid gas, in 2011 the share of liquid gas was about 20% of the of total natural gas imports [12]. The second direction of diversification involves the changes in the structure of consumed energy resources, which allows the country to raise the level of its energy security by reducing imports of energy resources [11].

In this respect, Ukraine has a high bioenergy potential; the future of bioenergy is defined by the National Action Plan on Renewable Energy Sources up to 2020. According to this plan, by 2020 bioenergy should reach the level of natural gas replacement by 7.2 billion m3 a year [9] (fig. 3).



* Assessment according to the data of the energy balance of Ukraine
** forecast according to the National Renewable Energy Plan

Fig. 3. The dynamics of the reduction of natural gas consumption at the expense of bioenergy in Ukraine

The generalizing macroeconomic indicator that describes the level of the expenditure of fuel and energy resources per unit of gross domestic product is the energy intensity of gross domestic product (EI of GDP).

EI of GDP is one of the fundamental characteristics of the energy efficiency of the economy of each country. The dynamics of EI of GDP of Ukraine and of the countries of the world in 2017 is presented in fig. 4.

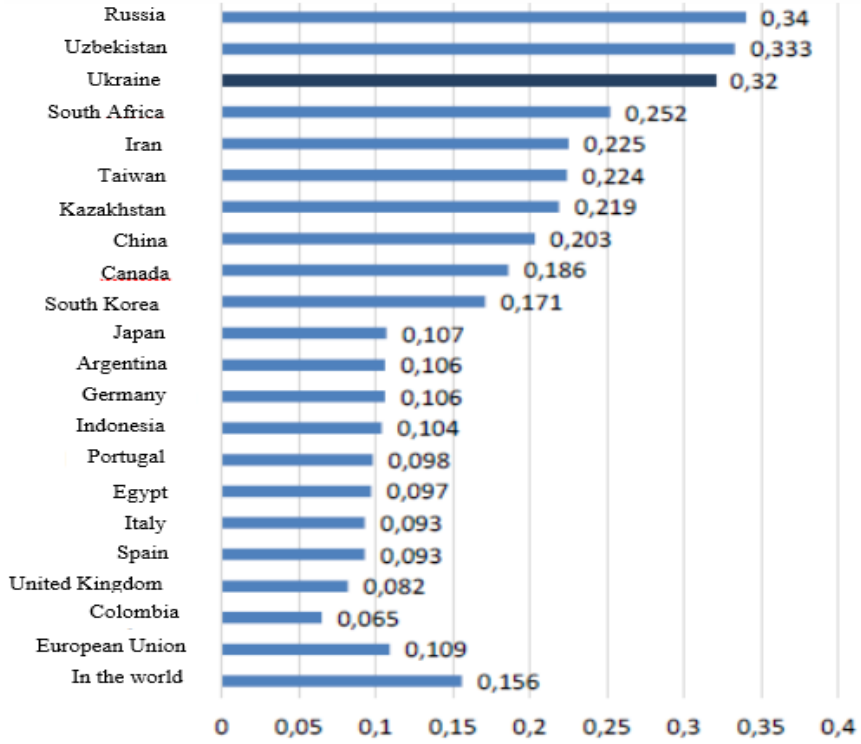


Fig. 4. The energy intensity of GDP of Ukraine and the countries of the world in 2017, kg.per u/$. [10]

ISSN 2522-9818 (print)
ISSN 2524-2296 (online) Innovative technologies and scientific solutions for industries. 2018. No. 1 (3)

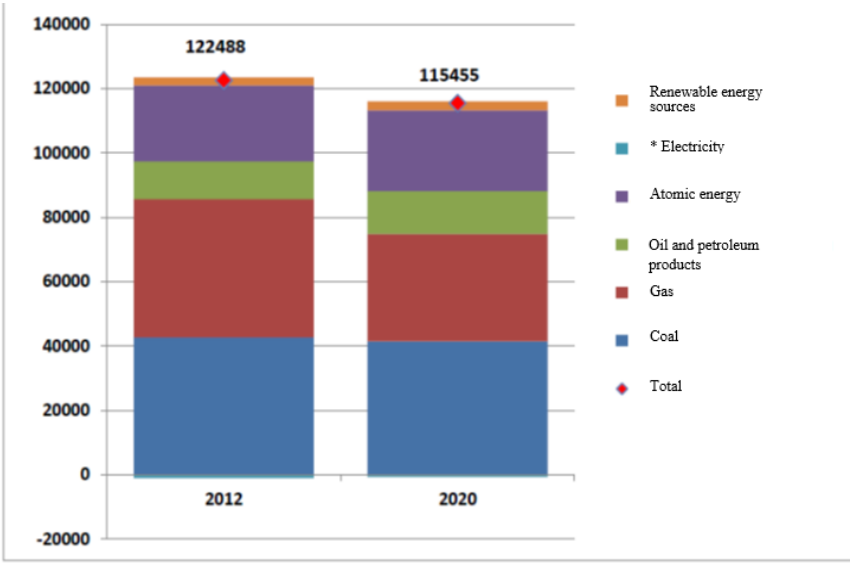
The current indicator of the energy intensity of Ukrainian GDP shows a deep systemic crisis in the economy of Ukraine. The energy intensity of Ukrainian GDP is much higher not only in comparison with the leading economies of the world but also with neighbouring countries of Central and Eastern Europe.

It should be noted that the high level of the energy intensity of GDP is objectively conditioned by the high share of resource-intensive and energy-intensive industries in the structure of the Ukrainian economy, such as metallurgy, the chemical industry and minerals mining. At the same time, the low energy efficiency in the sectors of energy transformation and supply, high specific energy expenditures for heating and hot water supply for households make the situation even more difficult.

Thus, the average efficiency of using coal in the thermal power industry of Ukraine is almost 1.5 times lower than in commercially available technologies, the power losses in the networks are twice as high as in Germany and the USA, and the average specific annual energy consumption of housing facilities is about 270 kWh /m2, which is almost twice as high as in the countries of Europe with similar climatic conditions [3]. A negative trend is not only the high energy intensity of Ukrainian GDP but also the fact that there is no dynamics to its decline over the recent years [7].

The main factors that determine the high energy intensity of production in Ukraine are [5; 6; 8]: inefficient and wasteful consumption of Fuel and Energy Resources (FER), particularly because the existing requirements for technology and equipment are not met, fixed assets and communications are out-of-date and the rate of their renewal is unsatisfactory, significant losses of energy resources, especially of natural gas, heat and electricity during their transportation, storage and distribution; the low level of introducing energy-efficient technologies and equipment (introducing new technological processes, in particular, low-waste, resource-saving and wasteless ones, realize no more than 3% of the total number of industrial enterprises); significant technological gap of the Ukrainian industry with the level of developed countries; a high level of depreciation of fixed assets in the economy (74.9%) and a corresponding increase in the specific consumption of FER for manufacturing a number of important types of products in the most energy-intensive industries; insufficient use of industrial waste processing, including solid domestic wastes.

According to the results of the study, achieving the goals of the National Energy Strategy (NES) to reduce GDP energy intensity by 20% is possible due to a gradual reduction of total primary energy supplies (TPES) by more than 10% by 2020 starting from 2017and thanks to the growth of GDP by reducing the consumption of all types of energy resources, except for electricity, the technological use of which is more efficient (fig. 5) [7].



* In this case, the indicator has a negative value, since the export of electricity exceeds the import

Fig. 5. Total primary energy supplies to Ukraine in 2012p. and 2020p., thous.t.

Under such conditions, gas consumption can be reduced by more than 22% and its share in the structure of TPES will decrease from 34.8% to 30.1%. The share of coal in the structure of TPES in 2020 will fall to the level of 29.2%, while the shares of nuclear energy, oil and oil products will grow by 4.8% and 2.1%, respectively. The energy production from renewable energy sources (RES) will grow due to the development of alternative energy in Ukraine (more than 60% due to biofuel). It is assumed that their share in the TPES structure will grow at a high rate – from 2% to 5.2% or by 2.6 times (this is more than 7.5%) but in the conditions of economic transformation the country has financial problems.

Taking into account the prospects for the development of the energy security of Ukraine in the context of processes of European integration, Ukraine signed a memorandum of understanding on the strategic energy partnership with the European Union together with the European Atomic Energy Community (Euratom). The Memorandum provides: enhancing the cooperation on the strengthening of the energy security on the basis of the principle of solidarity and trust; ensuring full integration

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of the energy markets of Ukraine and the EU and implementing the EU Third Energy Package; increasing energy efficiency in all sectors of energy consumption; reducing the emission of greenhouse gases; promoting the use and development of renewable energy sources [13].

The orientation of Ukraine towards European integration provides mainstreaming the adaptation of the domestic legislation in the field of the energy efficiency and the use of renewable energy sources to the laws of the European Union. Such an approach will ensure the international competitiveness of the Ukrainian economy, the prerequisites for membership in international organizations as well as the impetus for renewing the domestic energy industry.

In May 2014 the European Union has declared the energy security strategy, whose main goal is to provide the stable and sufficient energy reserve for both citizens and the economy as a whole. The distribution of the main activities of the strategy of the EU energy security regarding short-term measures involves introducing a market-based approach in providing energy, enhancing coordination in the implementation of safe materials, limiting restrictions on cross-border energy trade and improving the energy efficiency. In terms of long-term measures that are mainly focused on preserving the climate, increasing energy production in the EU, diversifying energy supplying countries, creating an infrastructure for rapid response to the problems of fuel and energy supply and strengthening the coordination among EU countries.

For example, in the countries of the European Union the leading program is called "20-20-20", which got its name due to the objectives that have been specifically defined: a 20 percent increase in the energy efficiency of the economy; a 20 percent increase in the production of green energy; a 20 percent reduction in the emission of carbon dioxide. In the European Union, every country is engaged in a large-scale work aimed at changing the environment. Sweden is the first European country that plans to stop using oil as an energy material by the end of 2020. Significant funds are required to implement these plans. In the USA, according to the law “On economic recovery” and reinvestment obtained in 2009 direct environmental investments reached 80 billion dollars, indirect – 400 billion dollars; over the 1990s-2010s the EU invested 260 billion euros and still increases investments. China, which does not belong to countries with post-industrial economies, invested 454 billion dollars for solving environmental problems for 5 years since 2009 and outstripped the United States and Japan according to this indicator [12].

According to A. Pavlenko [6] who covers the issues of the cooperation between the European Union and Ukraine in the context of strengthening the energy security of the latter, the legal basis for mutual relations between the two parties is the Association Agreement which was declared at the second meeting in Brussels on February 11, 2016. The agreement provides exchanging the experience between Ukraine and the EU, establishing the mechanism for accidents early warning at energy facilities, solving problems caused by the Chernobyl disaster, exchanging statistical information between the parties, cooperating in the use of infrastructure and so on.

In addition to the Association Agreement, the cooperation of Ukraine and the EU in energy is fixed in the Treaty on the Establishment of the Energy Community 3, which Ukraine joined in 2011. According to this treaty, the government have implemented about 15 EU directives in the spheres of gas, electricity, oil, competition, energy efficiency, environment [13].

It should be noted that the European side acts both as a donor for reforms in Ukraine, in particular, by providing grants, loans and macro-financial assistance, which was documented by the relevant Memorandum between Ukraine and the EU in May 2015 and as a consultant in developing the new legislative environment that would follow all European rules. European support and consulting assistance help raise awareness of the EU energy sector standards among officials, experts and journalists in Ukraine, shifts discussions about reforms to a new qualitative level, facilitates better monitoring the efficiency of changes in the country [6].

As for the Energy Strategy of Ukraine, this document was developed till 2035 and formalizes the policy of our state in providing the energy security, ensuring the sustainable development of the energy sector, stable energy supply of the national economy and public needs both in peacetime and during special periods [5]. Unlike the Energy Strategy of Ukraine till 2030, this document forms the target trajectory of the development of the energy sector ensuring the coherence of its priorities with the broader goals of the society as a component of the sustainable social and economic development of Ukraine and involves [8]:

- the target state of the energy sector of Ukraine relying on the priorities for ensuring the energy security and the implementation of the aspirations of Ukraine for European integration;
- the introduction of modern methodological approaches adopted in the EU countries to the development of documents on strategic planning and practical activities in implementing the state policy in the energy sector;
- the creation of the integrated system of the public management of the energy sector; the development of the coherent system of the mechanisms of public administration aimed at achieving the goals and establishing the system for monitoring the implementation of the Strategy, considering the statements of the Strategy by all the sides engaged in its activities.

It should be noted that the team of authors of the analytical report who commented on the updated Energy Strategy of Ukraine until 2035 [6] consider this document as progressive; its implementation would significantly improve the energy efficiency, eliminate aid grants in the fuel and energy sector, introduce the elements of demand response, integrate the EU Directives into the national legislation of Ukraine and meet the requirements that Ukraine has taken in the context of joining the Energy Community and signing the Association Agreement. However, despite this conclusion, the team of authors made a number of comments on the need to update this

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document, which is reasonable taking into account the importance and prospects for the development of the energy sector of Ukraine.

Conclusions

Taking into account all mentioned above, implementing strategic reforms in the sphere of energy supply, strengthening the energy security due to the implementation of the energy strategy, achieving mutual understanding on a strategic energy partner with the countries of the European Union countries, expanding cooperation, ensuring full integration of the energy markets of our state and the EU will provide an opportunity to ensure the protection of Ukraine, to create the competitive market of energy resources and sustainable social and economic development.

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ТЕНДЕНЦІЇ ПРІОРИТЕТНОСТІ ЗАБЕЗПЕЧЕННЯ ЕНЕРГЕТИЧНОЇ БЕЗПЕКИ УКРАЇНИ В УМОВАХ ЄВРОІНТЕГРАЦІЇ

Предметом дослідження в статті є процеси пошуку пріоритетних завдань та вибору шляхів забезпечення енергетичної безпеки України, а також виявлення її енергетичного потенціалу для прискорення економічного зростання. **Мета** статті полягає у дослідженні тенденцій та стратегічних перспектив формування, розвитку та забезпечення енергетичної безпеки України в умовах євроінтеграційних перетворень. У статті було використано такі **методи** і прийоми наукового пізнання: діалектичний метод пізнання та системний підхід – для узагальнення наукового дослідження; метод логічного узагальнення – при дослідженні наявного стану й обґрунтування напрямків забезпечення енергетичної безпеки; метод угрупувань – при систематизації завдань та шляхів диверсифікації енергоспоживання України; логічного узагальнення – для обґрунтування актуальності теми, мети і завдань дослідження, для визначення сутнісних ознак та загроз надмірного використання імпортованих енергоносіїв. Україна має значний потенціал для прискорення економічного розвитку та підвищення енергетичної безпеки. Енергетична безпека є важливою складовою національної безпеки держави та однією із глобальних проблем кожної країни світу. Реалізація наявного потенціалу вимагає глибокого реформування нормативно-правової бази та

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виконання вимог міжнародних договорів. розвитку взаємостосунків на рівні країн Європейського Союзу. **Завдання:** аналіз сучасного стану забезпечення України паливно-енергетичними ресурсами та систематизація завдань щодо вирішення проблем підвищення енергетичної безпеки, дослідження тенденцій розвитку та пріоритетів стратегічних перспектив України в умовах євроінтеграційних процесів. Отримано такі **результати:** виділено основні кроки на шляху до забезпечення енергетичної безпеки України, розширенні співробітництва з країнами Євросоюзу щодо зміцнення взаємовідносин з позиції енергетичної безпеки, а також обґрунтовано наявний енергетичний потенціал для прискорення економічного зростання. **Висновки.** Доведено необхідність нейтралізації загроз енергетичної ефективності в якості диверсифікації енергоспоживання України. Такий підхід забезпечить міжнародну конкурентоспроможність української економіки, передумови членства в міжнародних організаціях, а також є стимулом відродження вітчизняної енергетичної галузі. Перспективами подальших досліджень у даному напрямі є дослідження формування конкурентоспроможного ринку енергоресурсів та перехід до енергоефективного та енергозберігаючого використання енергоресурсів з метою забезпечення енергетичної безпеки України.

Ключові слова: енергетична безпека, енергоємність, енергоносії, євроінтеграційні процеси, паливно-енергетичні ресурси.

ТЕНДЕНЦИИ ПРИОРИТЕТНОСТИ ОБЕСПЕЧЕНИЯ ЭНЕРГЕТИЧЕСКОЙ БЕЗОПАСНОСТИ УКРАИНЫ В УСЛОВИЯХ ЕВРОИНТЕГРАЦИИ

Предметом исследования в статье являются процессы поиска приоритетных задач и выбора путей обеспечения энергетической безопасности Украины, а также выявление ее энергетического потенциала для ускорения экономического роста. **Цель** статьи заключается в исследовании тенденций и стратегических перспектив формирования, развития и обеспечения энергетической безопасности Украины в условиях евро интеграционных преобразований. В статье были использованы следующие **методы** и приемы научного познания: диалектический метод познания и системный подход - для обобщения научного исследования; метод логического обобщения - при исследовании существующего положения и обоснование направлений обеспечения энергетической безопасности; метод группировок - при систематизации задач и путей диверсификации энергопотребления Украины; логического обобщения -для обоснование актуальности темы, цели и задач исследования, для определения сущностных признаков и угроз чрезмерного использования импортируемых энергоносителей. Украина имеет значительный потенциал для ускорения экономического развития и повышения энергетической безопасности. Энергетическая безопасность является важной составляющей национальной безопасности государства и одной из глобальных проблем каждой страны мира. Реализация имеющегося потенциала требует глубокого реформирования нормативно-правовой базы и выполнения требований международных договоров. развития взаимоотношений на уровне стран Европейского Союза. **Задачи:** анализ современного состояния обеспечения Украины топливно-энергетическими ресурсами и систематизация задач по решению проблем повышения энергетической безопасности, исследование тенденций развития и приоритетов стратегических перспектив Украины в условиях интеграционных процессов. Получены следующие **результаты:** выделены основные шаги на пути к обеспечению энергетической безопасности Украины, расширении сотрудничества со странами Евросоюза по укреплению взаимоотношений с позиции энергетической безопасности, а также обоснованно имеющийся энергетический потенциал для ускорения экономического роста. **Выводы.** Доказана необходимость нейтрализации угроз энергетической эффективности в качестве диверсификации энергопотребления Украины. Такой подход обеспечит международную конкурентоспособность украинской экономики, предпосылки членства в международных организациях, а также является стимулом возрождения отечественной энергетической отрасли. Перспективами дальнейших исследований в данном направлении является исследование формирования конкурентоспособного рынка энергоресурсов и переход к энергоэффективному и энергосберегающему использованию энергоресурсов с целью обеспечения энергетической безопасности Украины.

Ключевые слова: энергетическая безопасность, энергоемкость, энергоносители, евроинтеграционные процессы, топливно-энергетические ресурсы.

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МЕТОДИЧНЕ ЗАБЕЗПЕЧЕННЯ ОЦІНЮВАННЯ ІННОВАЦІЙНОЇ КРЕАТИВНОСТІ ПРОМИСЛОВИХ ПІДПРИЄМСТВ ЗА КРЕАТИВНИМ ТА ДИНАМІЧНИМ НАПРЯМАМИ

Предметом дослідження є теоретичні та методичні положення, складові, методи та засоби оцінювання та підвищення інноваційної креативності. **Метою** статті є удосконалення методичних положень з оцінювання інноваційної креативності промислових підприємства з урахуванням їх креативного потенціалу та динамічних здібностей, а також обґрунтування рекомендацій щодо стратегічних напрямів підвищення інноваційної креативності. Для досягнення мети наукового дослідження було поставлено та вирішено такі **завдання:** визначити роль креативного потенціалу та динамічних здібностей підприємства у забезпеченні конкурентних переваг; узагальнити показники оцінювання креативного потенціалу та динамічних здібностей промислових підприємств; удосконалити методичні положення з оцінювання інноваційної креативності промислового підприємства; удосконалити рекомендації для підвищення рівня інноваційної креативності підприємств, виходячи з існуючого її рівня на підприємстві. Дослідження піднятої теми виконувалось за допомогою таких **методів:** аналіз, синтез, факторний аналіз, індукція та дедукція, систематизація та моделювання; графічний. Отримано такі **результати.** Проведений факторний аналіз дозволив виділити показники зі значним впливом на показник інноваційної креативності підприємства. Обрані показники запропоновано використовувати для визначення інтегральних показників креативного потенціалу та динамічних здібностей. Удосконалено методичне забезпечення та запропоновано алгоритм для оцінювання рівня інноваційної креативності промислових підприємств, що складається з трьох основних етапів. **Висновки.** Розроблені стратегії розвитку інноваційної креативності підприємства, які слід використовувати залежно від результатів оцінки інтегральних показників креативного потенціалу та динамічних здібностей. Удосконалено методичне забезпечення оцінювання інноваційної креативності промислових підприємств, що включає систему часткових показників з урахуванням їх вагомості та загального інтегрального, відмінність якого полягає у врахуванні креативної та динамічної складової діяльності підприємства. Проведено аналіз інноваційної креативності машинобудівних підприємств Харківщини за удосконаленою методикою та запропоновані стратегії підвищення інноваційної креативності. Згідно проведеному аналізу у 2017 році більшість підприємства мають досить високий рівень креативного потенціалу та низький рівень розвитку динамічних здібностей.

Ключові слова: інноваційна креативність, промислові підприємства, показники креативного потенціалу, динамічні здбності, стратегії підвищення інноваційної креативності.

Вступ

Інноваційна креативність підприємства є однією з найважливіших категорій ринкової економіки і характеризує можливість та ефективність адаптації підприємства до умов конкурентного середовища. У зв'язку з цим обґрунтування підходів до її дослідження з метою наступної розробки системи заходів для зміцнення позиції та досягнення конкурентних переваг підприємства є актуальним. Ключове положення в економіці України займають промислові підприємства. Це обумовлено тим значенням, яке має промисловість у структурі національної економіки. Тому проблеми підвищення інноваційної креативності промислових підприємств на внутрішньому і на міжнародних ринках є важливими як у сучасних умовах, так і в майбутньому.

Проблематиці теми інноваційної креативності підприємства притаманний комплексний, комбінований характер, оскільки вивчення теоретичних аспектів проблеми розробки та реалізації програм підвищення інноваційної креативності, а також питань, пов'язаних з управлінням цими процесами, слід здійснювати, виходячи із загально методичних підходів до управління програмами та проектами. Засвоєння прикладних аспектів має здійснюватися шляхом опрацювання спеціалізованої літератури (періодичні видання відповідного характеру, монографії, матеріали науково-практичних конференцій тощо), в якій викладено досвід розв'язання цих проблем.

З моменту свого створення і протягом всього життя будь-яка промислова фірма, будь-який товаровиробник поставлені перед необхідністю вирішення життєво важливої для них проблеми інноваційної креативності. Економіка більшості країн світу глибоко втягнута в світові господарчі зв'язки, а національний ринок, його вимоги в зростаючій мірі формуються під активною дією світового ринку і міжнародної конкуренції.

Конкурентні переваги – це перш за все наслідок якісного стратегічного управління підприємства, концентрованого прояву лідерства серед конкурентів. Такими показниками може пишатися лише та організація, яка знаходиться у постійному пошуку ресурсів для виробництва, форм і видів діяльності, засобів нової реалізації свого потенціалу. Результатом такої діяльності стає інноваційний розвиток на основі креативного забезпечення, а також стійка конкурентна перевага підприємства. Звісно, надзвичайно важливим моментом є визначення рівня інноваційної креативності підприємства. Проте тут не існує і не може існуВати єдина універсальна методика оцінювання інноваційної креативності, оскільки сама категорія інноваційної креативності розглядається з абсолютно різних аспектів.

Аналіз останніх досліджень і публікацій.

Чи мало вітчизняних та зарубіжних вчених

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займалися питанням інноваційної креативності та методами її оцінювання: Г. Л. Азоєва, І. Ансоффа, О. В. Ареф'євої, Є. М. Азарян, А. В. Грибов, В. С. Грузинов, Б. А. Доломанов, А. Ф. Єжова, С. М. Катькало, С. М. Клименко, О. М. Ястремська, Х. Виссема, Д. Тысс, Портер М., Питер Вейал, Р. Гранта, И. Дирекса, Д. Коллиза, К. Кулла, С. Монтгомери, М. Петераф, Р. Рамелта та ін. Однак, як теоретичні основи дослідження інноваційної креативності підприємств, так і методи її оцінки та діагностики, а також науково-практичні рекомендації щодо її організаційного забезпечення вимагають більш комплексного аналізу та обґрунтування з врахуванням особливостей національної економіки.

Нажаль, на сьогодні Україна не демонструє конкурентні переваги на світових ринках, що негативно відображається на економіці країни. Тому нагальною проблемою сьогодення є загальне підвищення інноваційної креативності підприємств. Важливим фактором вирішення поставленої задачі є створення ефективної системи управління на підприємствах, яка б і забезпечувала їм стійкі переваги на ринку. Проте для досягнення підприємством бажаного результату – створення стійких конкурентних переваг, слід знати рівень інноваційної креативності, а також виявляти та ліквідувати основні причини, що заважають досягненню високого рівня інноваційної креативності.

Виділення невирішених раніше частин загальної проблеми

Метою статті є удосконалення методичних положень з оцінювання інноваційної креативності промислових підприємства з урахуванням їх креативного потенціалу та динамічних здібностей, а також обґрунтування рекомендацій щодо стратегічних напрямів підвищення інноваційної креативності.

Для досягнення мети наукового дослідження було поставлено та вирішено такі завдання:

- визначити роль креативного потенціалу та динамічних здібностей підприємства у забезпеченні конкурентних переваг;
- узагальнити показники оцінювання креативного потенціалу та динамічних здібностей промислових підприємств;
- удосконалити методичні положення з оцінювання інноваційної креативності промислового підприємства;
- удосконалити рекомендації для підвищення рівня інноваційної креативності підприємств, виходячи з існуючого її рівня на підприємстві.

Матеріали та методи

Дослідження піднятої теми виконувалось за допомогою таких методів: аналіз, синтез, узагальнення та порівняння – для обґрунтування актуальності, визначення теоретичного підґрунтя дослідження, вивчення об'єкта та предмета дослідження, визначення теоретичних основ оцінювання інноваційної креативності підприємства; факторного аналізу – для виявлення впливу латентних факторів на рівень інноваційної креативності промислових підприємств та визначення вагомості часткових показників при оцінюванні інноваційної креативності; індукція та дедукція – для формування методичного забезпечення оцінювання інноваційної креативності промислових підприємств на основі аналізу підприємств машинобудівної галузі; системний підхід, систематизація та моделювання – для розробки узагальнених стратегій розвитку підприємств, спираючись на рівень креативного потенціалу та динамічних здібностей; графічний – для схематичного подання теоретичних та практичних положень роботи.

Результати досліджень та їх обговорення

Вітчизняна економіка сьогодні характеризується спадом виробництва та гострими диспропорціями розвитку. Складна ситуація в господарстві країни посилюється нестабільним станом однієї з найважливіших його галузей – машинобудування. Від результатів функціонування машинобудівних підприємств безпосередньо залежить стан та якісний рівень виробничого апарату країни. Саме тому набуває актуальності необхідність постійного контролю за станом і розвитком машинобудування.

Під час аналізу літературних джерел була виділена та теоретично обґрунтована достатньо велика кількість показників, що дозволяють оцінити креативний потенціал та динамічні здібності підприємства. Отже на даному етапі аналізу інноваційної креативності підприємства доцільно розглянути важливість кожного показника з практичної точки зору. Наступним кроком дослідження стане факторний аналіз обраних у попередньому розділі показників. Вирішення поставленого завдання здійснюється методом факторного аналізу за допомогою пакета STATISTICA 8.0. на основі статистичної інформації діяльності десяти машинобудівних підприємств Харкова за період з 2013 по 2017 рік. Отримані результати факторного аналізу на досліджуваних підприємствах представлені у табл. 1.

Згідно алгоритму виконання факторного аналізу в подальшому дослідженні беруть участь фактори, що забезпечують не менше 70 % загальної дисперсії. В такому випадку кожен фактор має достатньо власне значення та містить у своєму складі значущі показники. Факторний аналіз дозволяти виділити показники, що мають суттєвий вплив на об'єкт дослідження. Тому в подальшому аналізі будуть приймати участь показники, факторне навантаження яких більше 0,7 [6].

Тому для аналізу інноваційної креативності машинобудівних підприємств використовувались 7 факторів, що описують креативний потенціал, та 4 фактора, що описують динамічні здібності підприємства.

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Розрахунок факторних навантажень за креативними та динамічними складовими відбувався за методом Varimax raw. Результати представлені у таблицях 1 і 2.

У попередніх розділах зазначалося, що аналіз креативного потенціалу слід проводити за напрямами виробництво, персонал, фінанси, маркетинг, інформація. Отже, розглянемо результати факторного аналізу креативного потенціал з метою виявити які саме напрями та показники суттєво впливають на розвиток креативного потенціалу машинобудівного підприємства.

Таблиця 1. *Характеристика факторів креативного потенціалу*

Фактор	Значення фактора	Дисперсія	Накопичена дисперсія
1	3,940642	3,94064	20,74022
2	2,270303	6,21095	32,68919
3	1,858321	8,06927	42,46982
4	1,690321	9,75959	51,36625
5	1,432450	11,19204	58,90546
6	1,157666	12,34970	64,99843
7	1,121509	13,47121	70,90112

Таблиця 2. *Факторні навантаження для показників креативного потенціалу*

Показник		Фактор 1	Фактор 2	Фактор 3	Фактор 4	Фактор 5	Фактор 6	Фактор 7
Коефіцієнт фактичного використання виробничої потужності	X1	0,1613	0,1432	-0,0562	0,2995	0,4081	-0,5609	0,0987
Темп росту обсягів виробництва	X2	0,0423	0,0247	0,0577	0,0096	-0,8322	0,0572	0,1000
Коефіцієнт гнучкості устаткування	X3	0,0439	-0,8775	0,1939	-0,0834	0,1282	-0,0056	0,0555
Коефіцієнт прогресивності обладнання	X4	0,3137	0,0882	0,5364	0,4844	-0,1844	0,2210	0,1154
Рентабельність устаткування	X5	0,0009	0,0749	0,7302	-0,1517	-0,2032	-0,2339	-0,1792
Коефіцієнт стабільності кадрів	X6	0,3551	0,2686	-0,0701	0,3091	-0,3021	0,4648	0,0941
Коефіцієнт організації праці на робочому місці	X7	-0,1730	-0,0414	0,1287	0,1193	0,1989	0,0551	-0,7626
Рентабельність працівників	X8	0,0756	-0,2232	0,7649	-0,0427	0,2305	0,0474	-0,1478
Коефіцієнт виконання забов'язань перед кредитно-фінансовими установами	X9	0,2393	-0,1595	-0,0247	0,6878	0,0073	-0,1452	-0,2351
Коефіцієнт своєчасності виплати заробітної плати співробітникам підприємства	X10	0,1472	0,2603	-0,0098	-0,0798	-0,1757	0,0846	-0,6661
Коефіцієнт фінансування потреби підприємства в основних фондах і оборотних коштах	X11	0,0403	0,3430	-0,0501	0,1919	-0,5593	-0,3737	-0,1083
Питома вага витрат на участь у виставках та інших іміджевих заходах у загальних витратах на реалізацію продукції	X12	0,0411	-0,7240	-0,4116	0,1772	-0,0574	-0,1941	0,0570
Частка витрат на маркетинг в загальному обсязі витрат на інновації	X13	0,9213	-0,0515	0,1459	-0,0140	0,0024	0,0631	0,0476
Темпи росту обсягів реалізації	X14	0,2482	0,3788	0,5828	0,2525	0,2325	0,1690	0,0391
Темпи росту частки ринку	X15	0,2990	0,2220	0,0743	0,0685	0,1687	0,7064	-0,1401
Коефіцієнт забезпеченості відділів технічними засобами	X16	0,3630	0,0341	0,0557	-0,6830	0,0457	-0,1315	-0,0251
Частка нематеріальних активів у загальному обсязі активів підприємства	X17	0,0535	-0,4875	-0,2416	-0,6279	-0,0126	0,0747	-0,0554
Частка витрат на розвиток інформаційного забезпечення в загальному обсязі витрат.	X18	0,4268	0,0443	0,7082	0,2002	-0,1974	0,1247	0,1258
Питома вага інвестицій в нематеріальні активи у загальній вартості активів	X19	0,9211	-0,0139	0,1106	0,0006	-0,0237	0,0569	-0,0152

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Для аналізованих підприємств найбільшу значущість має перший фактор, який пояснює 20,74 % загальної дисперсії. У даному факторі найбільшу вагу мають такі показники: X13 (Частка витрат на маркетинг в загальному обсязі витрат на інновації) та X19 (Питома вага інвестицій в нематеріальні активи у загальній вартості активів). Тому можна вважати, що перший фактор відображає частку витрат на підвищення нематеріальної цінності підприємства.

Другий за значущістю фактор пояснює 11,94 % накопиченої дисперсії. В його складі найбільшою вагомістю відзначаються такі показники: X3 (Коефіцієнт гнучкості устаткування), X12 (Питома вага витрат на участь у виставках та інших іміджевих заходах у загальних витратах на реалізацію продукції). Отже, другий фактор характеризує ефективність використання власних джерел для формування продуктового пакету згідно ринкових вимог.

Третій фактор пояснює 9.78 % накопиченої дисперсії. Він поєднує показники: X5 (Рентабельність устаткування), X8 (Рентабельність працівників) та X18 (Частка витрат на розвиток інформаційного забезпечення в загальному обсязі витрат), тому його слід розглядати як прибутковість наявних фондів.

У четвертому факторі, що пояснює 8,89 % накопиченої дисперсії. Проте факторне навантаження показників не перевищує 0,7, але наближається до цього рівня: X9 – 0,68 (Коефіцієнт виконання зобов'язань перед кредитно-фінансовими установами) та X16 – 0,68 (Коефіцієнт забезпеченості відділів технічними засобами). Цей фактор зосереджує увагу на фінансовій автономності підприємства та рівні автоматизації зв'язку відділів.

П'ятий за значущістю фактор (7,5 % накопиченої дисперсії) має лише один вагомий показник – X2 (Темп росту обсягів виробництва), тобто підтверджує важливість динамічних процесів у обсягах виробництва.

У шостому факторі, який описує 6,09 % загальної дисперсії, найбільшу вагу отримав такі показник X15 (Темпи росту частки ринку). Показник X1 (Коефіцієнт фактичного використання виробничої потужності) має недостатньо високе факорне навантаження (0,58), але для більш повного аналізу його можна включити до складу впливових показників. Шостий фактор описує важливість розвитку частки ринку для формування креативного потенціалу машинобудівного підприємства.

Сьомий фактор пояснює 5,9 % загальної дисперсії. Аналізуючи його склад, можна дійти висновку, що найвагомішим показником у його складі є X7 (Коефіцієнт організації праці на робочому місці) та X10 (Коефіцієнт своєчасності виплати заробітної плати співробітникам підприємства), незважаючи на те що його факорне навантаження становить всього 0.66. Отже, даний фактор характерізує рівень організації робочого процесу та мотивації персоналу підприємства.

Отже, факторний аналіз показників оцінки креативного потенціалу машинобудівних підприємств доводить, для досягнення підвищення інноваційної креативності за допомогою поліпшення креативного забезпечення необхідно впроваджувати заходи за кожним розглянутим напрямом – виробництво, персонал, фінанси, маркетинг, інформація.

Аналогічно розглянемо результати факторного аналізу динамічних здібностей машинобудівних підприємств, котрі охоплюють інноваційний потенціал, інноваційну активність та організаційну структуру як основні напрями розвитку, таблиця 3.

Таблиця 3. *Характеристика факторів динамічних здібностей*

Фактор	Значення фактора	Дисперсія	Накопичена дисперсія
1	2,708342	2,708342	24,62129
2	2,337771	5,046112	45,87375
3	1,692748	6,738860	61,26237
4	1,140878	7,879739	71,63399

Перший фактор пояснює 24,62% загальної дисперсії та має у своєму складі показники — X5 (темпи приросту питомої ваги довгострокових інвестицій на технологічні інновації), X6 (темпи приросту питомої ваги інноваційної продукції в загальному обсязі виробництва) та X7 (темпи приросту нематеріальних активів підприємства). Поданий фактор характеризує інноваційну активність як засіб підвищення динамічних здібностей підприємства.

Другий за значущістю фактор пояснює 21,25 % накопиченої дисперсій. Виходячи зі складу показників, а саме – X9 (коефіцієнта гнучкості організаційної структури) та X11 (коефіцієнта регламентації структурних підрозділів), можна сказати, що він характеризує організаційну структуру підприємства.

У третьому факторі пояснюється 15,39 % загальної дисперсії. Найбільшу вагу отримали показники X1 (питома вага робітників, що закінчили ВНЗ) та X8 (темпи приросту кількості впроваджених інноваційних процесів та проектів), значить цей фактор описує відповідність якісного складу персоналу та впровадженню результатів інноваційного дослідження.

Четвертий фактор, на який припадає 10,37 % накопиченої дисперсії, містить лише один значущий показник X10 – коефіцієнта орієнтації організаційної структури на ринок. В зв'язку з цим його можна інтерпретувати як ефективність організації структури підприємства з урахуванням важливості вимог ринку.

Таким чином, за результатами факторного аналізу показників, що оцінюють динамічні здібності підприємства, можна зробити висновок про наступне: організаційна структура та інноваційна активність більшою мірою впливають на підвищення інноваційної креативності підприємств через розвиток динамічних здібностей ніж інноваційний потенціал. Ці підтверджується тим, що показники, які описують приведені напрями,частіше зустрічаються в сформованих факторах.

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У третьому факторі пояснюється 15,39 % загальної дисперсії. Найбільшу вагу отримали показники X1 (питома вага робітників, що закінчили ВНЗ) та X8 (темпи приросту кількості впроваджених інноваційних процесів та проектів), значить цей фактор описує відповідність якісного складу персоналу та впровадженню результатів інноваційного дослідження.

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Таким чином, за результатами факторного аналізу показників, що оцінюють динамічні здібності підприємства, можна зробити висновок про наступне: організаційна структура та інноваційна активність більшою мірою впливають на підвищення інноваційної креативності підприємств через розвиток динамічних здібностей ніж інноваційний потенціал. Ці підтверджується тим, що показники, які описують приведені напрями, частіше зустрічаються в сформованих факторах.

Таблиця 4. *Факторні навантаження для показників динамічних здібностей*

Показник		Фактор 1	Фактор 2	Фактор 3	Фактор 4
Питома вага робітників, що закінчили ВНЗ	X1	0,0073	0,2471	0,8836	-0,2035
Питома вага робітників, що виконують науково-технічну діяльність	X2	-0,0233	0,2017	-0,2763	0,5226
Питома вага витрат на дослідження та розробки в загальному обсязі витрат на інновації	X3	0,0994	0,3243	0,2557	0,3331
Питома вага на довгострокові інвестиції на технологічну підготовку виробництва в загальному обсязі витрат на інновації	X4	-0,0568	0,1236	-0,5047	0,1091
Темпи приросту питомої ваги довгострокових інвестицій на технологічні інновації	X5	-0,9662	0,0566	-0,0076	-0,0595
Темпи приросту питомої ваги інноваційної продукції в загальному обсязі виробництва	X6	-0,9584	0,0980	-0,0255	-0,1010
Темпи приросту нематеріальних активів підприємства	X7	-0,8529	-0,1176	-0,0280	0,0266
Темпи приросту кількості впроваджених інноваційних процесів та проектів	X8	0,0395	-0,3508	0,8347	0,0520
Коефіцієнта гнучкості організаційної структури	X9	0,0936	-0,9522	0,0342	0,0840
Коефіцієнта орієнтації організаційної структури на ринок	X10	-0,1199	0,0821	0,1191	-0,8913
Коефіцієнта регламентації структурних підрозділів	X11	0,0668	0,6865	0,0004	0,5952

Отже, факторний аналіз дозволив виявити показники які доцільно використовувати для оцінки інноваційної креативності машинобудівних підприємств за допомогою аналізу креативного потенціалу та динамічних здібностей, оскільки вони мають суттєвий вплив на загальні інтегральні показники креативного потенціалу та динамічних здібностей відповідно, що будуть розглядатися нижче.

Наступним кроком буде виявлення рівня впливу кожного показника на загальний інтегральний показник (табл. 5).

Таблиця 5. *Вплив обраних показників на інтегральний показник*

№ п/п	Показник	Питома вага показника за впливом на інтегральний показник
1	2	3
Креативний потенціал		
1	Частка витрат на маркетинг в загальному обсязі витрат на інновації	0,036
2	Питома вага інвестицій в нематеріальні активи у загальній вартості активів	0,051
3	Коефіцієнт гнучкості устаткування	0,080
4	Питома вага витрат на участь у виставках та інших іміджевих заходах у загальних витратах на реалізацію продукції	0,048
5	Рентабельність устаткування	0,024
6	Рентабельність працівників	0,031
7	Частка витрат на розвиток інформаційного забезпечення в загальному обсязі витрат	0,050
8	Коефіцієнт виконання забов'язань перед кредитно-фінансовими установами	0,085
9	Коефіцієнт забезпеченості відділів технічними засобами	0,150

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Продовження **таблиці 5**

1	2	3
10	Темп росту обсягів виробництва	0,054
11	Темпи росту частки ринку	0,039
12	Коефіцієнт фактичного використання виробничої потужності	0,091
13	Коефіцієнт організації праці на робочому місці	0,115
14	Коефіцієнт своєчасності виплати заробітної плати співробітникам підприємства	0,146
Динамічні здібності		
15	темпи приросту питомої ваги довгострокових інвестицій на технологічні інновації	0,028
16	темпи приросту питомої ваги інноваційної продукції в загальному обсязі виробництва	0,431
17	темпи приросту нематеріальних активів підприємства	0,094
18	коефіцієнта гнучкості організаційної структури	0,094
19	коефіцієнта регламентації структурних підрозділів	0,113
20	питома вага робітників, що закінчили ВНЗ	0,067
21	темпи приросту кількості впроваджених інноваційних процесів та проектів	0,0610
22	коефіцієнт орієнтації організаційної структури на ринок	0,112

Розрахунок інтегральних показників креативного потенціалу та динамічних здібностей підприємства здійснюється за формулою:

$$In = \sum_{i=1}^{n} b_i \frac{x_{\phi}}{x_{ет}}, \quad (1)$$

де $x_{iет}$ – еталонне значення показника креативного потенціалу або динамічних здібностей;

x_i – i-те значення показника креативного потенціалу або динамічних здібностей;

b – питома вага показника за впливом на інтегральний показник.

Для подальшого аналізу показників доцільно скористатись шкалою Харрінгтона та визначити рівень інноваційної креативності підприємства за його креативним потенціалом та динамічними здібностями (табл. 6) [7].

Таблиця 6. *Шкала Харрінгтона*

Рівень показника	Значення коефіцієнту
Низький	0 – 0,27
Середній	0,27 – 0,51
Високий	0,51 – 1

Отримавши значення рівня розвитку інноваційної креативності за креативним та динамічним напрямами, можливо розробити та спланувати стратегію підвищення інноваційної креативності підприємства, спираючись на обґрунтовані показники.

Таким чином, визначення рівня інноваційної креативності з точки зору креативного потенціалу та динамічних здібностей можливо проводити за наступним алгоритмом:

1. Визначення значення часткових показників для аналізу інноваційної креативності підприємства з позиції креативного потенціалу та динамічних здібностей.
2. Розрахунок інтегральних показників креативного потенціалу та динамічних здібностей підприємства
3. Вибір стратегій розвитку інноваційної креативності підприємства за рівнем інтегральних показників креативного потенціалу та динамічних здібностей підприємства згідно матриці стратегій.

У таблиці 7 наведені рекомендації, щодо узагальнених стратегій розвитку промислових підприємств, які спираються на наявний рівень розвитку креативного потенціалу та динамічних здібностей підприємств.

Проаналізуємо рівень розвитку креативного потенціалу та динамічних здібностей машинобудівних підприємства харківського регіону (табл. 8, 9).

Згідно проведеному аналізу у 2017 році всі підприємства мають досить високий рівень креативного потенціалу, що відповідає вище середнього. Лідерами серед проаналізованих підприємств є ПАТ «Харківський верстатобудівний завод», ПАТ Мереф'янський механічний завод, ПАТ «Харківський тракторний завод ім. С.Орджонікідзе», ПАТ «Харківський електроапаратний завод», інтегральний показник яких перевищує 1. Середню ланку займають ПАТ «Харківський електроапаратний завод», ПАТ Турбоатом, ПАТ Харківський електротехнічний завод «Трансзв`язок», ПАТ «Електромашина» – їх значення інтегрального показника змінюється від 0,8 до 1. Найнижчій рівень розвитку креативного потенціалу мають ПАТ «ФЕД» і ПАТ «Харківський підшипниковий завод» – 0,71 та 0,73 відповідно.

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Інтегральний показник рівня креативного потенціалу заводу «ФЕД» дорівнює 0,71. Це досить високий показник, проте завод «ФЕД» значно поступається аналогам. Якщо більш детально розглянути складові показники креативного потенціалу, які було аналізовано, то можливо виявити наступне. Підприємство має найнижчі порівняно з іншими рентабельність працівників та коефіцієнт гнучкості устаткування і дуже низькі питому вагу витрат на участь у виставках та інших іміджевих заходах у загальних витратах на реалізацію продукції, частку витрат на розвиток інформаційного забезпечення в загальному та темпи росту частки ринку. Тобто слабкими сторонами заводу «ФЕД» є обсяги виробництва та збуту, на що й слід звернути увагу управлінському складу.

Розглянемо рівень розвитку динамічних здібностей машинобудівних підприємства Харківщини (табл. 9.).

Абсолютна більшість машинобудівних підприємств Харкова у 2017 році має низький рівень розвитку динамічних здібностей, що негативно впливає на рівень інноваційної креативності підприємств як на внутрішньому, так і на зовнішньому ринках.

Таблиця 7. *Матриця стратегій розвитку інноваційної креативності підприємства [4;8;16]*

		Креативний потенціал		
		Низький	Середній	Високий
Динамічні здібності	Низький	Підприємство має низький рівень інноваційної креативності. Потрібно поступово проводити заходи щодо розвитку кожної складової креативного потенціалу та динамічної компоненти, а розпочати слід з удосконалення кадрового складу та інноваційного потенціалу	Підприємство має низький рівень інноваційної креативності. Для підвищення показника слід приділити увагу динамічним здібностям, особливо інноваційному потенціалу	Підприємство має задовільний рівень конкурентоспроможності в коро-ткостроковому періоді. Воно має достатньо можливостей для реалізації ідей, проте абсолютно відсутня інноваційна діяльність. Отже, слід залучити більшу кількість персоналу відповідної кваліфікації до інноваційного дослідження та впровадження інноваційних проектів у діяльність, а також збільшити фінансування цих заходів.
	Середній	Підприємство має низький рівень інноваційної креативності. Потенційно воно готове до розробки інноваційних проектів, але не вистачає ресурсів. Отже, потрібно розвивати кадровий склад та виробничий потенціал.	Підприємство має середній рівень інноваційної креативності. Тому слід гармонійно розвиВати кожну складову креативного потенціалу та динамічних здібностей	Підприємство має рівень інноваційної креативності вище середнього. На фоні креативного потенціалу динамічні здібності розвинуті не достатньо. Рекомендується здійснювати конкретні заходи щодо активізації впровадження інноваційних роз-робок у діяльність підприємства
	Високий	Підприємство має задовільний рівень інноваційної креативно-сті. Воно має достатньо розвинені динамічні здібностей, проте не вистачає ресурсів для впровадження ідей. Необхідно підвищувати креативний потен-ціал, розпочати слід з внутріш-ньої складової, а саме забезпече-ння основними та оборотними засобами виробництва.	Підприємство має рівень конкурентоспроможності вище середнього. Слабким місцем виступає ресурсний потенціал. Варто приділити увагу удосконаленню зовнішньої складової креативного потенціалу, спрямованої на активацію взаємодії з агентами зовнішнього середовища	Підприємство має високий рівень інноваційної креативності. Тому слід рівномірно розвивати кожну складову креативного потенціалу та динамічних здібностей аби досягти стійкої конкурентної переваги в стратегічному аспекті.

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Таблиця 8. *Оцінка рівня розвитку креативного потенціалу машинобудівних підприємств Харькова у 2017 році*

Назва підприємства	Показники														Інтегральний показник
	Частка витрат на маркетинг в загальному обсязі витрат на інновації	Питома вага інвестицій в нематеріальні активи у загальній вартості активів	Коефіцієнт гнучкості устаткування	Питома вага витрат на участь у виставках та інших імиджевих заходах у загальних витратах на реалізацію продукції	Рентабельність устаткування	Рентабельність працівників	Частка витрат на розвиток інформаційного забезпечення в загальному обсязі витрат	Коефіцієнт виконання забов'язань перед кредитно-фінансовими установами	Коефіцієнт забезпеченості відділів технічними засобами	Темп росту обсягів виробництва	Темпи росту частки ринку	Коефіцієнт фактичного використання виробничої потужності	Коефіцієнт організації праці на робочому місці	Коефіцієнт своєчасності виплати заробітної плати співробітникам підприємства	
ПАТ "Електромашина	0,00106	0,00017	0,585	0,1957	0,419	0,1356	0,0016	0,5656	0,8106	0,1031	0,00183	0,69	0,88479	1	0,96
ПАТ «Харківський верстатобудівний завод»	0,00404	0,00113	0,987	0,3703	0,002	0,0977	0,0009	0,97452	0	0,1619	0,00178	0,6547	0,86823	0,9687	0,98
ПАТ Куп'янський машинобудівний завод	0,02889	0,01197	0,7465	0,2303	0,001	0,01	0,0013	0,65479	0,9392	0,1157	0,00288	0,69785	0,5949	1	0,95
ПАТ Харківський електротехнічний завод «Трансзв`язок»	0,00075	0,00035	0,3974	0,058	0,004	0,01	0,0039	0,6489	0,828	0,3887	0,00186	0,5647	0,8735	1	0,82
ПАТ «Харківський тракторний завод ім. С.Орджонікідзе»	0,03631	0,02348	0,6541	0,2448	0,002	0,01	0,0026	0,56452	0,9619	0,103	0,01088	0,6475	0,82012	1	0,96
ПАТ Турбоатом	0,00077	0,00039	0,7223	0,1504	0,277	0,1077	0	0,14687	0,8122	0,1031	0,00183	0,4875	0,86084	1	0,96
ПАТ «Харківський електроапаратний завод»	0	0	0,4220	0,0684	0,001	0,01	0,001	0,87453	1	0,1619	0,00178	0,5486	0,79165	1	0,84
ПАТ «Харківський підшипниковий завод»	0,01688	0,01236	0,3258	0,0233	0,001	0,01	0,0029	0,64586	0,7174	0,0536	0,0012	0,5214	0,84722	1	0,73
ПАТ «ФЕД»	0,01828	0,01229	0,2314	0,0652	0,189	0,01	0,0013	0,45865	0,7848	0,1157	0,00288	0,65217	0,86699	1	0,71
ПАТ Мереф'янський механічний завод	0,06954	0,03457	0,6742	0,0214	0,332	0,1948	0,2181	0,45688	0,8688	0,3887	0,00186	0,6989	0	1	0,96
Еталонне значення показника	0,06954	0,03457	0,987	0,3703	0,414	0,1948	0,2181	0,97452	1	0,3887	0,01088	0,6989	0,88479	1	

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Таблиця 9. *Оцінка рівня розвитку динамічних здібностей машинобудівних підприємств Харькова у 2017 році*

Назва підприємства	Показники								Інтегральний показник
	Темпи приросту питомої ваги довгострокових інвестицій на технологічні інновації	Темпи приросту питомої ваги інноваційної продукції в загальному обсязі виробництва	Темпи приросту нематеріальних активів підприємства	Коефіцієнта гнучкості організаційної структури	Коефіцієнта регламента-ції структурних підрозділів	Питома вага робітників, що закінчили ВНЗ	Темпи приросту кількості впроваджених інноваційних процесів та проектів	Коефіцієнт орієнтації організаційної структури на ринок.	
ПАТ«Електромашина»	0,0000	9,0000	0,0000	0,0000	0,3450	0,2594	0,0000	0,1410	0,62
ПАТ «Харківський верстатобудівний завод»	0,0000	0,0000	0,5000	0,0000	0,0308	0,3080	0,0000	0,0140	0,10
ПАТ Куп'янський машинобудівний завод	0,0000	0,0000	0,5000	0,0000	0,3310	0,2941	0,0000	0,1560	0,24
ПАТ Харківський електротехнічний завод «Трансзв`язок»	0,0000	0,0000	0,5000	0,0000	0,3330	0,2293	0,0000	0,1580	0,23
ПАТ «Харківський тракторний завод ім. С.Орджонікідзе»	0,0000	9,0000	0,0000	0,0000	0,0306	0,3208	0,0000	0,0143	0,48
ПАТ Турбоатом	0,0634	0,0240	0,0000	0,0000	0,1530	0,1772	0,0000	0,3310	0,20
ПАТ «Харківський електроапаратний завод»	0,0000	0,0000	1,0000	0,0000	0,1460	0,1760	0,0000	0,3330	0,27
ПАТ «Харківський підшипниковий завод»	0,0000	0,0000	0,0000	0,0000	0,3330	0,3269	0,0000	0,1580	0,20
ПАТ «ФЕД»	0,0744	0,0000	0,0000	1,0000	0,3260	0,5980	1,0000	0,3310	0,46
ПАТ Мереф'янський механічний завод	0,0000	0,0000	0,0000	0,0000	0,1530	0,2021	0,0000	0,3450	0,18
Эталонне значення показника	0,0744	9	1	1	0,345	0,598	1	0,345	

Лише ПАТ «Електромашина» має достатньо розвинену динамічну складову (інтегральний показник 0,62), ПАТ «Харківський тракторний завод ім. С.Орджонікідзе» та ПАТ «ФЕД» дещо поступаються ПАТ «Електромашина» (інтегральний показник 0,48 та 0,46 відповідно), решта має показники нижче 0,3.

ПАТ "Електромашина" та ПАТ "Харківський тракторний завод ім. С.Орджонікідзе досягли високого рівня інтегрального показника завдяки темпам приросту питомої ваги інноваційної продукції в загальному обсязі виробництва, які у 2017 році становили 900%.

Слабкими місцями заводу «ФЕД» є темпи приросту питомої ваги інноваційної продукції в загальному обсязі виробництва та темпи приросту нематеріальних активів підприємства, тобто підприємство не підвищує інноваційну активність, зберігаючи рівень інвестицій у інноваційну діяльність та певному рівні. З одного боку стабільні інвестиції забезпечують поступовий розвиток інноваційної діяльності, проте у сучасних умовах завод «ФЕД» може втратити конкурентну перевагу, оскільки сучасний ринок потребує більш агресивної поведінки.

Показники коефіцієнта гнучкості організаційної структури та темпи приросту кількості впроваджених інноваційних процесів та проектів забезпечують відносно високий інтегральний показник динамічних здібностей, оскільки мають найвищі значення [9].

Узагальнимо отримані результати у таблиці 10 використовуючи шкалу Харрінгтона, що була описана вище.

Таким чином, отримавши інтегральні показники рівня інноваційної креативності за креативним та динамічним підходами, перейдемо до розробки стратегій подальшого розвитку інноваційної креативності промислових підприємств.

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Таблиця 10. *Результати аналізу рівня креативного потенціалу та динамічних здібностей*

Назва підприємства	Креативний потенціал		Динамічні здібності	
	Інтегральний показник	Рівень	Інтегральний показник	Рівень
ПАТ «Електромашина»	0,96	високий	0,62	високий
ПАТ «Харківський верстатобудівний завод»	0,98	високий	0,10	низький
ПАТ Куп'янський машинобудівний завод	0,95	високий	0,24	низький
ПАТ Харківський електротехнічний завод «Трансзв`язок»	0,82	високий	0,23	низький
ПАТ «Харківський тракторний завод ім. С.Орджонікідзе»	0,96	високий	0,48	середній
ПАТ Турбоатом	0,96	високий	0,20	низький
ПАТ «Харківський електроапаратний завод»	0,84	високий	0,27	низький
ПАТ «Харківський підшипниковий завод»	0,73	високий	0,20	низький
ПАТТ «ФЕД»	0,71	високий	0,46	середній
ПАТ Мереф'янський механічний завод	0,96	високий	0,18	низький

Підприємства ПАТ «Електромашина» має найкращі показники – високий рівень креативного потенціалу та динамічних здібностей, отже їй відповідає стратегія рівномірного розвитку кожної складову креативного потенціалу та динамічних здібностей аби досягти стійкої конкурентної переваги в стратегічному аспекті, та максимізації ефективності використання наявних потужностей.

За проведеним дослідженням ПАТ «Харківський тракторний завод ім. С.Орджонікідзе» та завод «ФЕД» мають високий креативний потенціал та середній рівень розвитку динамічної складової. Загалом вони мають рівень інноваційної креативності вище середнього. Поданим підприємствам слід приділити увагу динамічним здібностям, оскільки вони на фоні креативного потенціалу розвинуті не достатньо, а значить наявне ресурсне забезпечення не може використовуватись повною мірою. Рекомендується здійснювати конкретні заходи щодо активізації впровадження інноваційних розробок у діяльність підприємства.

Заводу «ФЕД» доцільно спрямувати сили на підвищення інноваційної активності шляхом придбання більшої кількості інноваційних технологій та устаткування, удосконаленням асортименту продукції за рахунок введення інноваційноємких позицій.

Решта підприємств, що досліджуються: ПАТ «Харківський верстатобудівний завод», ПАТ Куп'янський машинобудівний завод, ПАТ Харківський електротехнічний завод «Трансзв`язок», ПАТ Турбоатом, ПАТ «Харківський електроапаратний завод», ПАТ «Харківський підшипниковий завод» та ПАТ Мереф'янський механічний завод мають задовільний рівень інноваційної креативності в короткостроковому періоді. Їх можливостей достатньо для реалізації ідей та заходів, проте абсолютно відсутня інноваційна діяльність. Отже, слід залучити більшу кількість персоналу відповідної кваліфікації до інноваційного дослідження та впровадження інноваційних проектів у діяльність, а також збільшити фінансування цих заходів.

Висновки та перспективи подальшого розвитку

Розробка теми роботи вирішує досить важливі науково-практичні питання – удосконалення методичних положень з оцінювання інноваційної креативності промислових підприємств та рекомендації щодо подальшого розвитку підприємства згідно рівня його інноваційної креативності. На підставі проведених досліджень можна зробити такі висновки:

Під час розглядання теми було виявлено, що креативний потенціал та динамічні здібності відіграють чималу роль у забезпеченні конкурентних переваг підприємства, оскільки сучасний стан навколишнього середовища відрізняється нестабільним характером і тому потребує від суб’єктів господарювання високої динамічності креативного забезпечення. Вміння суб’єкта господарювання швидко реагувати на зміни у зовнішньому середовищі забезпечить стабільний рівень інноваційної креативності підприємства, а здатність передбачати зміни та заздалегідь здійснювати певні заходи, що попереджатимуть зниження ділової активності через зміни у оточенні, допоможе підвищити конкурентоспроможність підприємства та вийти на якісно новий рівень діяльності, водночас базою динамічності підприємства стають його ресурси. Таким чином поєднання креативної та динамічної концепцій забезпечують гармонійний розвиток підприємства.

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Узагальнити показники оцінювання креативного потенціалу та динамічних здібностей промислових підприємств за допомогою факторного аналізу, а також визначено рівень впливу кожного на інтегральний коефіцієнт креативного потенціалу та динамічних здібностей відповідно. Для досягнення підвищення інноваційної креативності за допомогою поліпшення креативного забезпечення необхідно впроваджувати заходи за напрямами - виробництво, персонал, фінанси, маркетинг, інформація. Організаційна структура та інноваційна активність більшою мірою впливають на підвищення інноваційної креативності підприємств через розвиток динамічних здібностей ніж інноваційний потенціал.

Робота з удосконалення методичних положення з оцінювання інноваційної креативності промислового підприємства дозволила запропонудати методику оцінювання інноваційної креативності підприємства на основі його креативного потенціалу та динамічних здібностей. Запропонований алгоритм визначення рівня інноваційної креативності включає етапи: визначення значення часткових показників для аналізу інноваційної креативності підприємства з позиції креативного потенціалу та динамічних здібностей; розрахунок інтегрального показника креативного потенціалу та динамічних здібностей; визначення рівня інноваційної креативності підприємства на основі отриманих даних.

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МЕТОДИЧЕСКОЕ ОБЕСПЕЧЕНИЕ ОЦЕНКИ ИННОВАЦИОННОЙ КРЕАТИВНОСТИ ПРОМЫШЛЕННЫХ ПРЕДПРИЯТИЙ ПО КРЕАТИВНЫМ И ДИНАМИЧЕСКИМ НАПРАВЛЕНИЯМ

Предметом исследования являются теоретические и методические положения, составляющие, методы и средства оценки и повышения инновационной креативности. **Целью** статьи является совершенствование методических положений по оценке инновационной креативности промышленных предприятия с учетом их креативного потенциала и динамических способностей, а также обоснование рекомендаций по стратегическим направлениям повышения инновационной креативности. Для достижения цели научного исследования были поставлены и решены следующие **задачи:** определить роль креативного потенциала и динамических способностей предприятия в обеспечении конкурентных преимуществ; обобщить показатели оценки креативного потенциала и динамических способностей промышленных предприятий; усовершенствовать методические положения по оценке инновационной креативности промышленного предприятия; усовершенствовать рекомендации для повышения уровня инновационной креативности предприятий, исходя из существующего ее уровня на предприятии. Исследование поднятой темы выполнялось с помощью следующих **методов:** анализ, синтез, факторный анализ, индукция и дедукция, систематизация и моделирования; графический. Получены следующие **результаты.** Проведенный факторный анализ позволил выделить показатели со значительным влиянием на показатель инновационной креативности предприятия. Избранные показатели предложено использовать для определения интегральных показателей креативного потенциала и динамических способностей. Усовершенствована методическое

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обеспечение и предложен алгоритм для оценки уровня инновационной креативности промышленных предприятий, состоит из трех основных этапов. **Выводы.** Разработанные стратегии развития инновационной креативности предприятия, которые следует использовать в зависимости от результатов оценки интегральных показателей креативного потенциала и динамических способностей. Усовершенствована методическое обеспечение оценки инновационной креативности промышленных предприятий, включая систему частных показателей с учетом их значимости и общего интегрального, отличие которого состоит в учете креативной и динамичной деятельности предприятия. Проведен анализ инновационной креативности машиностроительных предприятий Харьковщины по усовершенствованной методике и предложены стратегии повышения инновационной креативности. Согласно проведенному анализу в 2017 году большинство компаний имеют достаточно высокий уровень креативного потенциала и низкий уровень развития динамических способностей.

Ключевые слова: инновационная креативность, промышленные предприятия, показатели креативного потенциала, динамические здбности, стратегии повышения инновационной креативности.

METHODOLOGICAL SUPPORT FOR ASSESSING THE INNOVATIVE CREATIVITY OF INDUSTRIAL ENTERPRISES BY CREATIVE AND DYNAMIC DIRECTIONS

The **subject** matter of the study is the theoretical and methodological provisions, components, methods and tools for assessing and enhancing innovative creativity. The **goal** of the article is to improve the methodological provisions for assessing the innovative creativity of industrial enterprises, taking into account their creative potential and dynamic abilities and to substantiate recommendations on strategic directions for enhancing innovative creativity. To achieve the goal of the scientific study, the following **tasks** were set and solved: to determine the role of the creative potential and dynamic abilities of an enterprise in providing competitive advantages; to summarize indicators of the assessment of the creative potential and dynamic abilities of industrial enterprises; to improve the methodological provisions for assessing the innovative creativity of an industrial enterprise; to improve the recommendations for increasing the level of the innovative creativity of enterprises basing on its available level at the enterprise. The target topic was studied with the help of the following **methods:** analysis, synthesis, factor analysis, induction and deduction, systematizing and modelling; graphical method. The following **results** are obtained. The factor analysis made it possible to identify indicators with significant impact on the index of the innovative creativity of an enterprise. The selected indicators are suggested for determining the integral indicators of creative potential and dynamic abilities. The methodological support is improved and the algorithm for assessing the level of the innovative creativity of industrial enterprises which consists of three main stages is suggested. **Conclusions.** The strategies for developing the innovative creativity of an enterprise are worked out; they should be used depending on the results of the assessment of the integral indicators of creative potential and dynamic abilities. The methodological support for assessing the innovative creativity of industrial enterprises was improved as well as the system of particular indicators taking into account their importance and the overall integral which takes into account the creative and dynamic activity of an enterprise. The innovative creativity of machine-building enterprises of the Kharkiv region according to the improved methodology is analyzed and the strategies for increasing the innovative creativity are suggested. According to the analysis conducted in 2017, most companies have a sufficiently high level of the creative potential and a low level of dynamic abilities development.

Keywords: innovative creativity, industrial enterprises, indicators of creative potential, dynamic properties, strategies for increasing the innovative creativity.

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ALPHABETICAL INDEX

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СУЧАСНИЙ СТАН НАУКОВИХ ДОСЛІДЖЕНЬ ТА ТЕХНОЛОГІЙ В ПРОМИСЛОВОСТІ

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