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The collection includes the thesises of reports on modern trends in the development of technologies and means of production and mechatronic systems, top experience and implementation of them in fields of: industrial automation and production management systems; systems engineering; CAD/CAM/CAE systems; mechatronics (electrical and mechanical systems, electronic control tools, mechanical CAD systems); robotics and intellectual toolls; MEMS (modern materials and manufacturing technologies MEMS) and components and technologies for the automation of oil, gas and oil extraction, processing and transportation.

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Analysis of Production Data Monitoring and Visualization Systems for Cyber-Physical Production Systems

Shalko Yevhenii[1]
1. CITAM Department, Kharkiv National University of Radio Electronics, UKRAINE,
Kharkiv, Nauky Ave. 14., email: yevhenii.shalko@nure.ua

Annotation: In this material, a study of modern systems of monitoring and visualization of production data for cyber-physical production systems (CPPS) based on Industry 4.0 was conducted. In the course of the study, the production monitoring system, its main components, and structure will be considered, in addition, we will pay attention to the advantages and disadvantages of similar systems.

Keywords: Industry 4.0, Real-time, Internet of things, Production monitoring system (PMS).

I. INTRODUCTION

Every year, production becomes more and more complex, efficient and precise tools are needed to meet the needs. Because of this, the demand for the implementation of the concept of Industry 4.0, which is one thing, is increasing every year. of the main modern requirements in any production. This concept is one of the most important and popular because it requires the implementation of full automation of production processes, while their management will be carried out in real-time with minimal outside intervention.

Cyber-physical production systems are a logical continuation of the implementation of the Industry 4.0 concept, the essence of which is the creation of a virtual double of real production, which allows you to control various physical processes and make decentralized decisions on various tasks, that is, the creation of distributed systems [1]. The development of cyber-physical production systems requires the solution of many problems related to the processing of data obtained in production, such as storage, access, security, and others. One of the main problems that need to be solved during the implementation of cyber-physical production systems is the monitoring of production processes with the possibility of visualization of these processes. Monitoring the performance and condition of equipment has always been an integral part of information systems used in the industry to improve efficiency and minimize unplanned downtime. In general, monitoring system applications play an important role in predicting production improvements, reducing costs [2], and providing an early warning system [3,4]. Also, due to the increase in the volume of data collected in the production process, monitoring systems become even more important factors in making management decisions, as well as the effective operation of enterprises. Modern technologies, such as sensors based on the Industrial Internet of Things (IIoT), can be used as a solution to ensure effective monitoring of the production process[5]. Similar technologies can be used and integrated with monitoring systems. Research conducted in the manufacturing industry has shown significant benefits of using IoT-based sensors for monitoring, such as improving working conditions [6], preventing design errors [7], diagnosing faults [8], predicting quality [9], and assisting managers in making more effective decisions [10].

Real-time monitoring and control allow teams to respond appropriately to production-related issues. Machine operators can identify bottlenecks in real-time for continuous improvement. A proactive team can effectively and efficiently manage and resolve issues. From the above, we can conclude that a production monitoring system (PMS) is needed by companies in all manufacturing industries[11].

Some immediate benefits of PMS:

a. Process monitoring: visualization of the technological process at the production facility in real-time. More advanced systems can visualize processes in various modules of the production management system in the form of interactive diagrams that accurately reflect the topography of the enterprise.
b. Monitoring of integrated IIoT devices is usually valid for users of next-generation systems equipped with a reliable API.
c. Accurate tracking of supply chain data.
d. Monitoring of machine indicators, such as their physical condition, alerts, and warnings about possible violations and downtime;
e. Track overall equipment effectiveness (OEE), i.e. equipment availability, productivity, and product quality.
f. Production line metrics such as productivity, order lead time, cycle time, overhead, and waste.
g. Staff monitoring capabilities include tracking work hours, productivity, delays, and disruptions. This allows managers to better plan staffing needs, production, product shipments, and process lead times.

II. ANALYSIS OF THE PRODUCTION MONITORING SYSTEM

The data obtained during production monitoring are divided into two main groups: the state of resources and the state of tasks [12]. Task status represents data on each completed operation, estimated production time, sequences, and others. This group provides information about order flow to improve production sequences. It should also be noted that real-time monitoring of production processes supports a paperless approach to reporting. That is, it allows you to compare the planned and actual volumes of production, which makes it possible to more realistically plan the production plan, and also helps to meet the delivery deadlines.

The second group, the so-called state of resources, is used to control machinery and equipment, personnel, and the working environment (Fig. 1). This group shows machine workload, downtime, availability, and performance as a result of monitoring. Thanks to this, in case of equipment failure, operators know exactly why and can change planned operations in time, which saves time and money. Such data provides real-time and historical details of what is/has been happening in the equipment shop. In turn, personnel monitoring includes optimal movement tracking; planned and actual workforce data, etc. Various indoor positioning systems can be used to track the location of people and equipment [13], which is part of the Global Manufacturing Efficiency (GPE) concept[14].

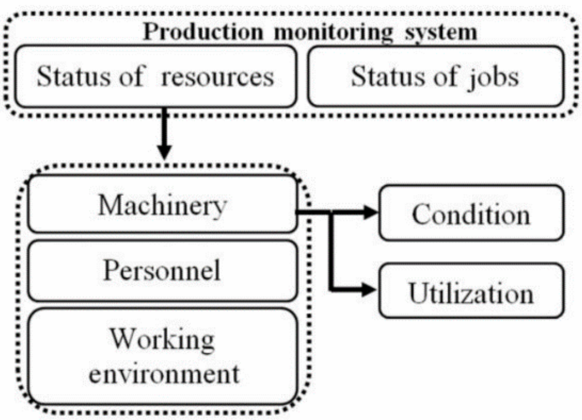

Fig. 1. Classification of production control systems

Such systems include HMI/SCADA software, which helps in the management of industrial enterprises in many industries. HMI/SCADA is a category of control system software architecture that uses network data to provide a graphical user interface through which an operator can monitor the performance of multiple pieces of equipment and issue process commands and settings. This result is achieved using a dedicated screen, a mobile device, or any PC connected to the control network via a web browser.

HMI/SCADA enables operators to improve situational awareness, anytime, anywhere visualization mobility, and control of critical equipment providing a centralized view of operations[15].

HMI/SCADA collects data from remote terminals, programmable logic controllers and other control devices. This data is provided to the operator using a Human Machine Interface (HMI). HMI allows the operator to see what is happening in the plant in real-time, including configurable mnemonics, alarms, trends, etc., to make decisions on adjusting any controls or machine settings.

HMI/SCADA is used in conjunction with other technologies to improve productivity, such as a data logger, to provide trending and other analysis over a long period of time.

State-of-the-art HMI/SCADA, including data archive and centralized visualization technologies, enable a high-performance development and visualization environment that optimizes plant operations, supported by faster development, democratization of tools and capabilities throughout the plant, increased productivity, reduced costs, and employee mindset change . and the culture of continuous work[16].

Data from the groups discussed above allow you to support the functions of production process planning systems, and logistics for the supply of materials and resources, and also allow you to provide feedback at all stages of production. Such a system makes it possible to implement an effective system of informing all departments about what is happening in the shop and helps to respond in a timely manner to unplanned situations.

In most cases, data from different groups are treated as a single data set to identify, for example, the causes of quality problems, unplanned downtime, poor performance, etc. productivity, quality level, and overall equipment effectiveness (OEE). Different strategies can be used to diagnose equipment malfunctions:

• Preventive maintenance is the periodic shutdown of services for manual inspection. The main disadvantage of such a strategy is the need to temporarily turn off the equipment during the inspection to identify equipment problems.
• Condition-based monitoring – fault diagnosis through appropriate observations based on an acoustic signal, temperature, electrical current, vibration monitoring, etc.

PMS systems should be considered as a subset of the manufacturing management system (MES), which includes the same functions as data acquisition and collection, maintenance management, resource status, product tracking, and production performance analysis [17, 18.]

There are many special software products for managing production processes. They may be presented as MES, but functionality depends on customer expectations or tools (e.g. spreadsheets, complex management applications). The main functions of MES solutions developed by leading suppliers of industrial software and automation systems are inventory management and production status data collection with limited equipment status data with supporting functions such as performance analysis and maintenance management. The main focus of these solutions is on medium and large-sized companies, mainly in the processing (chemical, oil, gas, food) and automotive industries.

The main disadvantage of these solutions is investment costs. In some cases, such systems may have weak reconfigurability or require expert knowledge of the system, which may affect the flexibility of the company, when each change in the configuration must be prepared by the software provider and imported into the system [19,20,21]. Many companies offer solutions with limited functionality and work in a specific industry (e.g. Evocon Line Efficiency, Wintriss ShopFloorConnect). Such solutions are usually designed to capture the most important inputs from the production line (machine): unit count and flow rate, job list, downtime, quality reports, etc.

III. CONCLUSION

The functionality of the main PMS elements is described. One of the main advantages is that the proposed production monitoring system is based on open-source software and hardware, which makes it more accessible to users and supports collaborative knowledge creation.

But despite all the advantages, such systems have many shortcomings, which have a rather large impact, both at the stage of implementation of such solutions and operation. Among them, you can single out the following:

a. Determining the areas to be monitored in a monitoring system is an extremely complex matter that depends on a huge variety of needs, technological constraints, contractual obligations, and business considerations.
b. Building a team and set of technologies that are truly needed and will deliver the right set of tools is a daunting task that requires a wide range of technical expertise and time to properly configure and maintain.
c. In such systems, it is quite difficult to integrate a new tool or update an existing one, as it depends on the developers of the given system. Due to this quite simple problems can arise during the update stage. This makes changes to the system inflexible.
d. Many tools rely on logical checks and thresholds: these are static configurations that are extremely inflexible. Systems scale and evolve, so this mode of operation must be replaced by pattern recognition technologies.
e. Many tools have missing or poor integrations (APIs) and cannot be easily extended. These tools have been designed with a lot of assumptions about the system they will monitor, resulting in one of two solutions:
   1) Or improvement and adjustment of the existing system, to the criteria of new tools that must be implemented;
   2) Choosing tools that are not ideal for your needs but work well with your current system.
f. Many tools are not fast enough with reporting and analysis. Latency issues are incredibly expensive and painful for any organization.
g. Many tools do a very poor job of collecting metrics, and throwing away data after providing warnings. This problem exists due to legacy configurations that do not take into account the rapid growth of cloud storage and big data analysis that has occurred in recent years.
h. In case of errors in the system, it is extremely difficult to determine the location of the failure.
i. Many tools provide - due to poor system design or problematic configurations - information that is ultimately invalid. This creates a psychological burden on users and costs them valuable time.
j. Many tools are expensive in themselves and in addition have a slow payback due to huge configuration needs, multiple teams involved, tools to integrate, workflows to change, etc.
k. Many tools promise to deliver certain things but end up requiring additional costs for support, professional services, and important additional features.

Based on the analysis, it is planned to develop a sensor management system based on IoT technology, a part of which will be a production monitoring system using data received through the API. The planned system should solve the problems of system expansion due to the ease of adding new devices, detection of breakdowns in the system, cost-effective installation and exploitation of the product, and relevance and accuracy of data.

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