МІНІСТЕРСТВО ОСВІТИ І НАУКИ УКРАЇНИ
ХАРКІВСЬКА ОБЛАСНА ВІЙСЬКОВА АДМІНІСТРАЦІЯ

Державний біотехнологічний університет
Національний технічний університет «ХПІ»
Національний університет «Львівська політехніка»
Національний університет біоресурсів і природокористування України
Інститут механіки та автоматики агропромислового виробництва НААН України
University Maryland (USA)
University of British Columbia (Canada)
Lublin University of Technology (Poland)
Israel Electric Corporation (Israel)

Матеріали Міжнародної науково-практичної конференції

ЕЛЕКТРОЕНЕРГЕТИКА, ЕЛЕКТРОМЕХАНІКА ТА ТЕХНОЛОГІЇ В АПК

5 листопада 2025 р.

м. Харків

Матеріали Міжнародної науково-практичної конференції
ЕЛЕКТРОЕНЕРГЕТИКА, ЕЛЕКТРОМЕХАНІКА ТА ТЕХНОЛОГІЇ В АПК
Харків, 2025

МІНІСТЕРСТВО ОСВІТИ І НАУКИ УКРАЇНИ
ХАРКІВСЬКА ОБЛАСНА ВІЙСЬКОВА АДМІНІСТРАЦІЯ
Державний біотехнологічний університет
Національний технічний університет «ХПІ»
Національний університет «Львівська політехніка»
Національний університет біоресурсів і природокористування України
Інститут механіки та автоматики агропромислового виробництва НААН України
University Maryland (USA)
University of British Columbia (Canada)
Lublin University of Technology (Poland)
Israel Electric Corporation (Israel)

ЕЛЕКТРОЕНЕРГЕТИКА, ЕЛЕКТРОМЕХАНІКА ТА ТЕХНОЛОГІЇ В АПК

Матеріали Міжнародної науково-практичної конференції

5 листопада 2025 р.

Харків
ДБТУ
2025

УДК 621.3.620.9]:631]](06)
Е50

Збірник матеріалів видано відповідно до наказу в.о. ректора ДБТУ про проведення Міжнародної науково-практичної конференції «Електроенергетика, електромеханіка та технології в АПК» (№ 01-01/403 від 31.10.2025 р.).

Е50 **Електроенергетика, електромеханіка та технології в АПК** [Електронний ресурс] : матеріали Міжнар. наук.-практ. конф., 5 листопада 2025 р. / Держ. біотехнологічний ун-т. – Харків, 2025. – 348 с. – Електронні текстові дані. – Режим доступу : http://btu.kharkov.ua/nauka/konferentsiyi/

У збірнику подано теоретичні та практичні результати досліджень і розробок учених спільно з молодими науковцями, аспірантами, співробітниками організацій та підприємств.

Призначено для викладачів, студентів, наукових співробітників, фахівців у галузі енергетики, електромеханіки, робототехніки, автоматики, інформаційних технологій, енергетичного машинобудування, біомедичної інженерії.

УДК 621.3.620.9]:631]](06)

UDC 616.7-77:539.3

BIOMECHANICAL JUSTIFICATION OF THE SHAPE OF A HUMAN LOWER LIMB PROSTHETIC FOOT

Panchenko S. P., Cand. of Tech. Sc., Ass. Prof., e-mail: panchenko.s.p@nmu.one
Dnipro University of Technology
Datsok O. M., Cand. of Tech. Sc., Ass. Prof., e-mail: oleh.datsok@nure.ua
Kharkiv National University of Radio Electronics

Relevance of the study. In the context of modern biomedical engineering development, limb prosthetics represents one of the key fields that is rapidly advancing under the influence of progress in materials science, mechatronics, digital modeling, and biomechanics [1]. The issue of prosthetics is of particular importance in Ukraine, where the number of patients with amputations has significantly increased due to military actions, occupational injuries, road accidents, and chronic vascular diseases. Moreover, the situation in Ukraine has another crucial aspect: a large portion of prosthetic devices are imported from abroad, making them expensive and inaccessible to a significant number of patients.

Modern approaches to lower limb prosthetics focus not only on restoring the basic functions of gait but also on achieving the most natural biomechanics of movement, reducing the user's energy expenditure, and improving overall comfort during use [2].

One of the most important parts of the lower limb is the foot [3], which provides contact with the supporting surface, participates in the roll-over phase of gait, maintains balance, and absorbs impact loads. Therefore, the efficiency of the entire prosthesis and the patient's quality of life depend on the geometry of the foot module, the properties of its materials, and its kinematic characteristics.

An analysis of the literature [4, 5] shows that there is a wide variety of prosthetic foot designs – ranging from simple rigid models to high-tech bionic systems with microprocessor control. The choice of the optimal design type depends on several factors, including the level of amputation, the patient's physical activity, operating conditions, and economic constraints. However, despite significant advances in the field of biomedical engineering, improving the efficiency and durability of lower limb prosthetic feet remains an urgent task, which requires a thorough understanding of their elastic and strength characteristics.

Existing engineering solutions are mostly based on empirical approaches or limited testing of finished products, which does not allow for an accurate assessment of the influence of geometry and material parameters on the mechanical behavior of the prosthesis. As a result, this may lead to excessive weight and dimensions, reduced service life, and decreased user comfort.

In this regard, a relevant scientific and applied task is the study of the stress-strain state of lower limb prosthetic feet of various designs in order to determine their elastic and strength characteristics and establish the optimal structure. To achieve this goal, it is advisable to apply modern numerical analysis methods, particularly finite element modeling, which allows for a comprehensive evaluation of the stress-strain state of the prosthesis without the need for a large number of physical experiments.

The objective of the study is to develop and analyze finite element models of prosthetic feet with different configurations, to investigate their stress-strain states under operational loads, to compare the obtained results, and to formulate recommendations for optimizing the geometry of the prosthetic foot in order to improve its strength, reliability, and biomechanical efficiency.

The aim of the study is to investigate the influence of prosthetic foot geometry on their stress-strain state and biomechanical efficiency under operational loads.

Main materials. The study was conducted in a software environment based on the finite element method. To reduce the computational load on the computer, the models were limited in terms of the number of components, focusing only on the foot modules (Fig. 1). The development of the computational schemes was carried out using a specialized software package for creating three-dimensional models.

a b

Fig. 1 – Human foot: a) natural, b) prosthetic foot module

The models differed in the shape of the prosthetic foot profile: Model 1 – anatomical shape, Model 2 – downward convex profile, Model 3 – control model with a flat profile.

The overall dimensions of all models – length, width, and height – were identical. The models were based on the average dimensions of an adult human foot.

Each model was studied in three positions, with orientation depending on the gait phase: contact, support, and push-off.

The material chosen for the models in this study was carbon fiber composite, a material based on carbon fibers and a polymer matrix, as it provides a combination of key operational characteristics – lightweight, strength, elasticity, durability, and energy efficiency.

During the calculations, the prosthetic foot was loaded with a force equivalent to the body weight of an adult human.

Conclusion. Based on the results of this work, it is planned to analyze the stress-strain state of prosthetic feet under operational loads; to evaluate the effectiveness of the proposed prosthetic foot designs depending on their shape, gait phase, and walking mode in terms of strength and stiffness; and to provide recommendations for optimizing the shape of the prosthetic foot according to the conditions of use.

REFERENCES

1. Cong B., Zhang H. Innovative 3D printing technologies and advanced materials revolutionizing orthopedic surgery: current applications and future directions. Frontiers in Bioengineering and Biotechnology. 2025. Vol. 13. https://doi.org/10.3389/fbioe.2025.1542179

2. Sitenko O., Sitenko T. Biomechanical aspects of endo-exo-prosthetics of the lower limbs. orthopaedics traumatology and prosthetics. 2024. No. 2. P. 69–75. https://doi.org/10.15674/0030-59872024269-75

3. Kapandji A. I. The Physiology Of The Joints, 5Ed, Vol. 2: The Lower Limb. Elsevier, 2009.

4. Ahmed S. I., Kadhim F. M. Modeling and simulation of a multi-axis ankle foot prosthetic. International Review of Applied Sciences and Engineering. 2025. https://doi.org/10.1556/1848.2025.01036

5. Variable-stiffness prosthesis improves biomechanics of walking across speeds compared to a passive device / E. Rogers-Bradley et al. Scientific Reports. 2024. Vol. 14, no. 1. https://doi.org/10.1038/s41598-024-67230-3