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## **COMPUTATIONAL MODELING OF THE DEFORMATION OF THE “BONE–IMPLANT–PROSTHESIS” SYSTEM**

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*Abstract.* The study investigates the deformation behavior of a “bone–implant–prosthesis” system using finite element analysis. It shows that increased friction at the bone–implant interface, due to osseointegration, improves system strength under static loading.

*Keywords:* finite element method, bone–implant–prosthesis system, osseointegration, friction coefficient, biomechanical modeling, stress analysis, prosthetic design.

*Introduction.* Currently, the issue of prosthetics for lost limbs is becoming increasingly acute in Ukraine. Improving the quality of prostheses is essential for enabling individuals with amputations to return to a full life as quickly and comfortably as possible. Since every individual is unique in terms of biometric parameters, achieving optimal ergonomic performance requires that each prosthesis be customized. This uniqueness must be supported by appropriate computational studies, including the deformation process. Based on such computational analysis, it becomes possible to determine rational values for key geometric and operational parameters of prosthesis.

One of the modern directions in prosthetics development is the use of so-called implants-components that directly integrate with the bone. In this approach, the prosthesis is attached directly to the implant. This technique offers several advantages over conventional external prostheses: for example, it reduces or eliminates friction between the prosthesis and soft tissues of the stump, and simplifies and improves control of the prosthesis during movement.

When prostheses with implants are used, computational studies of the deformation behavior of the “bone-implant-prosthesis” system become essential. These studies possess unique characteristics. Similar analyses have been conducted in contexts such as damaged bone modeling, for instance when using various fixation elements needed for bone fusion [1,2].

In light of the above, the relevance of this research is evident both scientifically and practically. The modeled system included the upper section of the femur, an implant, and a prosthesis model. The prosthesis consisted of two steel tubes connected by a hinge and a thin, curved steel plate simulating a foot. This model differs from most common ones used in analyzing the strength of bones with artificial inclusions, where the bone is typically rigidly fixed at one end, as in [1]. A static load corresponding to a person weighing 90 kg was applied to the femoral head.

The aim of the research is to examine the effect of the friction coefficient between the bone and implant on the system’s strength. Over time, the conditions at the bone–implant interface change — the degree of osseointegration increases, and consequently, the friction coefficient also increases.

The complexity of the geometry and the specific interaction conditions require the use of numerical methods for simulation. The finite element method (FEM) is the most widely used approach due to its versatility.

A geometric model of the “bone–implant–prosthesis” system was created, along with a corresponding finite element model that incorporated contact interaction conditions. A series of simulations was conducted to determine the tensor-vector components of the deformation process. The friction coefficient between the implant and bone was varied from 0.2 (initial insertion of the implant) to 6 (nearly complete integration). Equivalent stress values were used to evaluate strength. For the bone, equivalent stress was assessed based on the Mohr criterion (due to the material's different strength limits in tension and compression), while for the implant, stress intensity was used.

Analysis of the results shows that, under the given loading conditions, neither the bone nor the implant fails, as the maximum equivalent stresses remain significantly below permissible limits. For example, the maximum equivalent stress in the bone did not exceed 10 MPa, while the average allowable tensile stress is approximately 80 MPa [2]. It was also noted that increasing the friction coefficient reduces equivalent stresses, indicating that as osseointegration progresses, the system becomes structurally stronger.

*Conclusions.* The study presents a finite element simulation of the “bone–implant–prosthesis” system. It demonstrates that under the considered loading and geometric conditions, the system components maintain their structural integrity. Future research may focus on accounting for dynamic loads during walking or jumping.

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## WAYS OF OBTAINING NITRIC ACID WITH A HIGHER CONCENTRATION

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*Abstract.* The paper addresses the problem of obtaining nitric acid with a higher concentration, which is crucial for increasing raw material utilization, reducing energy consumption, improving environmental safety, and producing a more competitive product. The negative impact of nitrogen(II) oxide on the absorption process is analyzed, and the potential of catalytic oxidation of nitrogen(II) oxide for increasing nitric acid concentration is explored.

*Keywords:* Nitric acid, concentration, nitrogen oxides, absorption, catalytic oxidation, nitrate industry, environmental safety.

*Introduction:* Currently, one of the main branches of the chemical industry playing a very important role for the agricultural complex is the nitrate industry. This industry enterprises produce nitrate fertilizers and products containing bound nitrogen, in particular nitric acid. Nitric acid is one of the most important inorganic acids and, as a key component of fertilizers, is one of the most frequently produced chemical raw materials in the world. As of the time before the full-scale invasion of the Russian Federation, from 75 to 80% of the nitric acid produced was used to produce nitrates and complex mineral fertilizers, and from 10 to 15% was used to produce