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IMPROVEMENT OF FLOW PARTS OF GAS TURBINE INSTALLATIONS WITH METHODS IN APPLIED GEOMETRY

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This work is devoted to the description of one of the ways of improving the flow parts of gas turbine installations, specifically modern methods of geometric modeling of the elements of the flow parts of turbomachines. The developed methods make it possible to generate geometric models of moving and stationary elements of the flow parts of turbomachines with improved diagrams of the distribution of differential characteristics of the contours and surfaces formed on their basis. An example of a spatial solid-body model of a centrifugal compressor impeller built on the basis of the proposed methods is given.
Key words: geometric modeling, flow part, impeller, optimization methods, solid body model.

The limits of the use of gas turbine engines have been expanding very intensively in recent years. They are widely used both on high-speed vessels of various purposes and in stationary installations. The factor of the spread of their use in wartime, when Ukraine pays great attention to the creation of modern highly effective technical means, becomes especially important.

The achievements of recent years in applied geometry and computer graphics in the field of modeling and visualization of curved lines and surfaces, providing the user with the possibility of local influence on the distribution of their differential characteristics, allow raising to a qualitatively new level the solution of problems of geometric modeling of turbomachinery blades and, in particular, centrifugal compressors.

Geometrical modeling of the flow part of centrifugal compressors is a solution to a complex of problems of profiling the contours of elements based on a single mathematical approach. The scientific direction regarding the geometric modeling of the flow parts of turbomachines of various structural design and purpose characterizes a comprehensive approach to the profiling of aerodynamic contours and surfaces that limit the flow of the working substance in turbomachines. It is based on modern achievements of applied, analytical, drawing, differential, computational geometry and computer graphics in the field of analytical representation of curves and surfaces of complex technical forms.

One of the factors that affects the improvement of the gas-dynamic characteristics of the flow of the working substance, contributes to the improvement of the efficiency of gas turbine engines, is the improvement of the geometry of the flow parts of turbomachines, in particular, centrifugal compressors and centrifugal turbines. One of the ways to increase the efficiency of turbomachines is to improve the aerodynamic performance of the elements of their flow parts, which is inextricably linked with the improvement of the geometric characteristics of the flat and spatial contours of the blade units that form the flow of the working substance.

Many enterprises of Ukraine use modern mathematical models and methods developed under the leadership of Dr. Tech. of Sciences Professor V.D. Borysenko [1,2]. This scientific direction solves the problems of geometric modeling of the elements of the flow parts of turbomachines of different design and purpose using different mathematical curves and surfaces [3]. Bezier curves, *B*-splines, rational cubic curves based on Bernstein polynomials, parametric cubic curves with two degrees of freedom, modified Nicomedes conchoids, logarithmic spirals and other mathematical curves that allow local influence on the shape of the curve are the basis of the developed methods and methods of geometric modeling of elements of flow parts of turbomachines.

Let's consider the mathematical foundations that are laid for geometric modeling using Bezier curves, which are distinguished by the relative simplicity of the mathematical description and the possibility of local changes in the shape of the curve. Concerning to the limits of the meridional section of the impeller, a flat curved line describing them can be represented by parametric correlation of the form

$$x(t) = \sum_{k=0}^{n} x_k \Phi_{k,n}(t); \qquad y(t) = \sum_{k=0}^{n} y_k \Phi_{k,n}(t),$$

where n is the degree of the approximating polynomial; x_k, y_k, - polynomial coefficients, which represents the coordinates of the vertices of the characteristic broken line; $\Phi_{k,n}(t)$ – the system of Bernstein basis functions, which is determined by the dependence

$$\Phi_{k,n}(t) = \frac{n!}{k!\cdot(n-k)!} t^k (1-t)^{n-k}, k \in [0, n].$$

By changing the coordinates of the vertices of the characteristic broken line, you can arbitrarily vary the shape of the contour curve being modeled.

The use of optimization methods in determining the parameters influencing the shape of the modeled curve made it possible to develop geometric models of movable and immovable elements of the flow parts of turbomachines with improved diagrams of the distribution of differential characteristics of outlines and surfaces formed on their basis. This has a positive effect on the distribution of flow parameters and, therefore, contributes to the improvement of the flow of energy processes occurring in the flow parts of turbomachines.

Thus, based on the results of the gas dynamic calculation, the designer has the opportunity to solve the optimization problems of the geometric modeling of the elements of the flow parts of turbomachines, which has a positive effect on the performance of installations with gas turbine engines.

As an example of computer implementation of the developed geometric models of elements of the flow parts of centrifugal compressors, Fig. 1 shows a spatial solid image of the impeller, rendered in the *AutoCAD* graphics system.

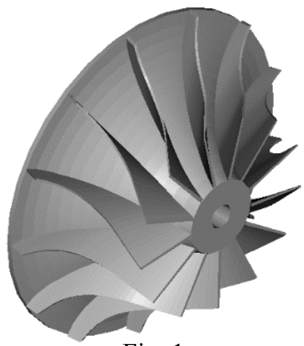

Fig. 1

Conclusions. 1. It has been proven that the geometric modeling of the flow parts of turbo machines is one of the ways to improve the gas-dynamic characteristics of the flow of the working substance and affects the efficiency of gas turbine engines. 2. Some mathematical curves are presented, which are the basis of the developed methods of geometric modeling. 3. An example of a solid model of a centrifugal compressor impeller is given.

LITERATURE

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