Abstract. In vibration diagnostics of rotating equipment, methods and means of monitoring and diagnostics are being developed. Diagnostic maintenance of ship equipment. Vibration allows to ensure the maximum volume of diagnostic forms.

Keywords. Equipment, bearing units, vibration indicators, vibration forces, diagnostics

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THE MODERN SINGLE SHAFT MARINE GAS TURBINE ROTOR STRESS-STRAIN STATE

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Abstract. The paper outlines a finite elements refined mathematical model of the stress-strain state of single shaft gas turbine engine that can be used in ground or floating power plants. The mathematical model is taken into consideration the contact thermoelasticity problem in the joint area of disk and blades. On the base of the developed mathematical model the fields of turbine rotor dynamic stresses and displacement have been found too. To make the clear decision about the developed mathematical model adequacy mostly loaded impeller dynamic stresses field has been found and verified by comparison with the calculated results without contact and experimental data. The turbine rotor displacements and dynamic stresses have been found for different forced vibration modes. The obtained results along with the previous studies of this rotor fluid flow and thermal state could be used in further studies of the turbine rotor creep and fatigue strength and blades crack researches.

Key words: Gas turbine rotor, contact thermoelasticity problem, dynamic stresses field, finite elements method, experimental verification.

The *research object* is the turbine rotor stress-strain state taking into the contact between the blades and disks. The whole rotor should be considered as an assembly of three impellers, connected together. Each impeller also is an assembly that consists of the disk and working blades of the same shape and geometric characteristics. The *research subject* is the influence of contact in the joint of rotor blades and disks on its fields of dynamic stresses.

Thus the aim of the research is to develop a refined mathematical model for calculating the gas turbine rotor stress-strain state taking into account the rotor contact thermoelasticity problem solution.

To achieve this aim, the following tasks must be solved:

Develop a refined mathematical model of the turbine rotor on the base of FEM, using the layer of contact finite elements between the blades and disks surfaces;

Determine the contact finite elements displacement and temperature fields;

Determine the field of rotor dynamic stresses, taking into account the results of contact thermoelasticity problem solution.

According to the generalized Hooke's law [1 − 3] the solid body stress-strain state can be described by the next matrix dependence:

$$\{\sigma\} = [D](\{\varepsilon\} - \{\varepsilon_T\}) \qquad (1)$$

where $\{\sigma\}$is stress matrix-vector;$\{\epsilon\}$ is elasticity deformation vector; $\{\epsilon_T\}$ is thermal elasticity vector; $[D]$ is elasticity matrix of the turbine rotor material.

As the turbine rotor is located in Cartesian coordinate system, its elasticity deformation vector has the following components:

$$\{\varepsilon\} = \begin{Bmatrix} \varepsilon_X \\ \varepsilon_Y \\ \varepsilon_Z \\ \gamma_{XY} \\ \gamma_{XZ} \\ \gamma_{YZ} \end{Bmatrix} = \begin{Bmatrix} \frac{\partial \delta_X}{\partial X} \\ \frac{\partial \delta_Y}{\partial Y} \\ \frac{\partial \delta_Z}{\partial Z} \\ \frac{\partial \delta_X}{\partial Y} + \frac{\partial \delta_Y}{\partial X} \\ \frac{\partial \delta_X}{\partial Z} + \frac{\partial \delta_Z}{\partial X} \\ \frac{\partial \delta_Y}{\partial Z} + \frac{\partial \delta_Z}{\partial Y} \end{Bmatrix} \qquad (2)$$

where δ_X, δ_Y, δ_Z are components of the generalized displacement vector.

Elasticity matrix of the rotor material is given in paper [1]:

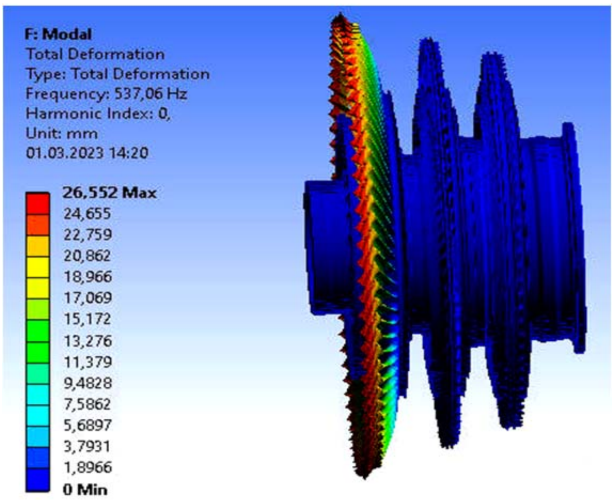
The vector of the rotor thermal deformation is represented by the equation (3) [1, 2]:

$$\{\varepsilon_T\} = \begin{Bmatrix} \varepsilon_{XT} \\ \varepsilon_{YT} \\ \varepsilon_{ZT} \\ 0 \\ 0 \\ 0 \end{Bmatrix} = \alpha \begin{Bmatrix} T_X \\ T_Y \\ T_Z \end{Bmatrix} \qquad (3)$$

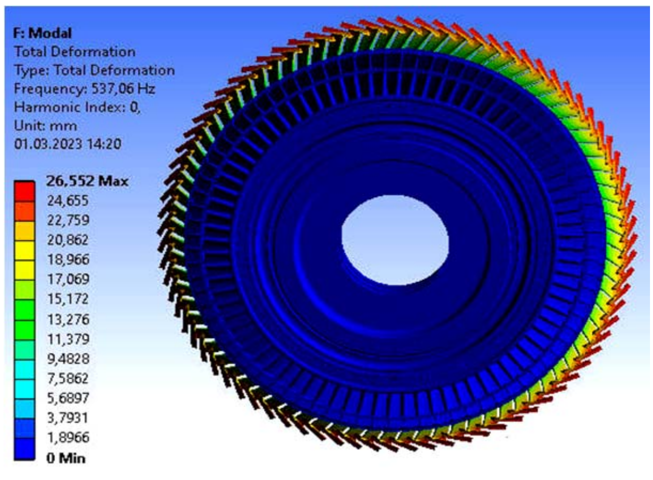
where α is thermal extension coefficient of the rotor material; T_X, T_Y, T_Z are the rotor temperature field projections on the X, Y, Z coordinate axis.

Thus on the base of equations (1 − 3) we see that solution to the turbine rotor stress-strain state problem depends on the correct finding of the rotor displacement and temperature fields, taking into account the contact between the blades and disks in impellers.

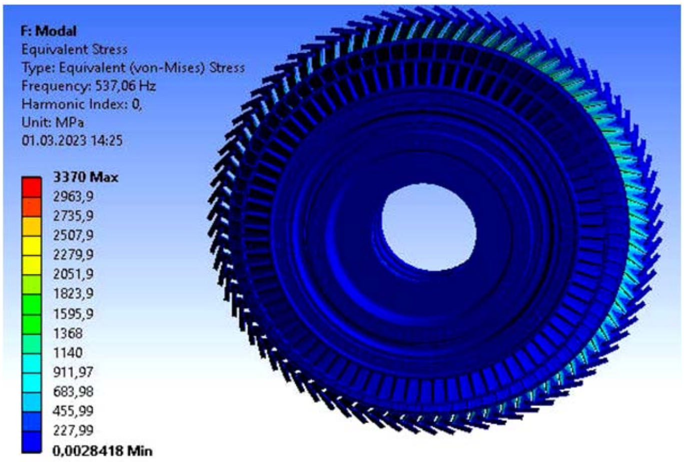
The power of the turbine under study P is 15 MW. The temperature of the working fluid at the flow path entrance T is 1410 K; the total pressure at the first stage entrance p is 1.4 MPa; the rotor angular velocity ω is 11330 rev/min.



a



b



c

Fig. 1 Turbine rotor displacement (*a*, *b*) and dynamic stresses (*c*) fields. Harmonic index *k* = 0, vibration frequency *f*= 537.06 Hz

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THE MODERN SINGLE SHAFT MARINE GAS TURBINE ROTOR THERMAL STATE

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Abstract. The paper outlines a finite elements refined mathematical model of the thermal state of modern single shaft gas turbine engine that can be used in ground or floating power plants. The mathematical model is based on special finite elements of hexagonal type. On the base of the developed mathematical model the turbine rotor temperature field was found and experimentally verified. Using the results of temperature field calculation the rotor thermal deformations and stresses have been found too. The obtained results could be used in further studies of the turbine rotor stress-strain state and fatigue strength.

Key words: Gas turbine rotor, thermal stresses, temperature field, refined mathematical model, finite elements method.

The *research object* is the heat exchange between the turbulent working flow and the solid bodies, forming the turbine rotor. The whole rotor should be considered as an assembly of three impellers, connecting together by means of a shaft. Each impeller also is an assembly that consists of