GAS TURBINE ENGINE ROTOR THERMAL STATE DETERMINATION

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The paper outlines a finite elements refined mathematical model of the thermal state of 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 displacements and stresses have been found too.

The considered mechanical deformable system thermal state could be described by next variation equation [1]:

$$\delta J_T = 0 \tag{1}$$

where J_T – thermal functional.

For the functional J_T minimization (1) we need to use the general heat equation [2]:

$$\frac{\partial(\rho c T)}{\partial t} = \frac{\partial}{\partial x}(\lambda_x \frac{\partial T}{\partial x}) + \frac{\partial}{\partial y}(\lambda_y \frac{\partial T}{\partial y}) + \frac{\partial}{\partial z}(\lambda_z \frac{\partial T}{\partial z}) \tag{2}$$

where λ_x, λ_y, λ_z – thermal conductivity coefficients on the *x, y, z* coordinate axis, Wt*m/K; ρ – material's density; *c* – specific heat capacity.

As the heat exchange between the gas flow and the rotor surfaces is convective, we need to use the Newton-Richman boundary conditions [2]:

$$\frac{\partial T}{\partial n}\Big|S = \alpha(T - T_0) \tag{3}$$

where T_0 – gas flow temperature, K; *S* – heat exchanging surface ($x,y,z \in S$), *n* – normal to the surface *S;* α – thermal extension coefficient of the rotor material

After FEM approximation of (2) and (3) the main equation of the turbine rotor thermal state is transformed to:

$$[K_T]\{T\} = \{F_T\} \tag{4}$$

where $[K_T]$ – global matrix of the turbine rotor thermal conductivity; $\{T\}$ – vector of the turbine rotor temperature; $\{F_T\}$ – vector of the heat exchange between the turbine rotor and gas flow.

References:

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2. -*Morhun S.* Numerical analysis of working processes in the blade channels of the highly loaded turbine of a marine gas turbine engine, using a refined finite element model / S. A. Morhun // Проблеми машинобудування. 2019. Т. 22, №3. С. 14-20. https://doi.org/10.15407/pmach2019.03.014.