GAS TURBINE ENGINES IMPELLERS FORCED VIBRATION, CAUSED BY THE TURBULENT GAS FLOW STUDY

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The task of the gas turbine impeller forced vibration amplitudes and frequencies determining is given. It is also assumed that the considered system of solid bodies (impeller) has the properties of cyclic symmetry. So it can be interpreted as a set of q subsystems (sections) with the same geometric, inertial and stiffness properties [1]. In this case, q determines the system's order of symmetry. So a section of such impeller generally includes a disk sector and a blade set in it with parts of bandages.

The considered mechanical deformable system energy state could be described by Lagrange variation principle. Thus:

$$\delta \boldsymbol{L} = 0, \quad \boldsymbol{L} = \boldsymbol{\Pi} - \boldsymbol{T} \tag{1}$$

where L – Lagrange function; Π – potential energy of system's resistance to deformation; T – the kinetic energy of the system vibration.

After FEM approximation [2] the main equation of the mechanical system balance (1) is transformed to:

$$[\boldsymbol{M}]\left\{\frac{\boldsymbol{d}^2\delta}{\boldsymbol{dt}^2}\right\} + [\boldsymbol{C}]\left\{\frac{\boldsymbol{d}\delta}{\boldsymbol{dt}}\right\} + [\boldsymbol{K}]\{\delta\} = \{\boldsymbol{p}\} \tag{2}$$

where $[K]$ – global stiffness matrix of finite elements model; $[M]$ – global mass matrix of finite elements model; $[C]$ – global damper matrix of finite elements model $\{\delta\}$ – vector of finite elements nodes generalized displacement; $\{p\}$ – pressure caused by the gas flow.

The value of pressure field, caused by the influence of non-stationary gas-dynamic flow is known. Due to the periodicity of the gas flow intensity, the function of pressure can be decomposed into a Fourier row:

$$\boldsymbol{p} = \boldsymbol{p}_1 \boldsymbol{cos}(\boldsymbol{k}\omega \boldsymbol{t}) + \boldsymbol{p}_2 \boldsymbol{sin}(\boldsymbol{k}\omega \boldsymbol{t}) \tag{3}$$

where k − is the number of the gas flow pressure harmonic.

Therefore, for the solution of gas turbine engine impellers forced vibration problem we need to solve matrix equation (2) that is formed by the usage of dependencies (3).

References:

1. *Kairov A. S.* Turbine engines bladed disks with circular damping links forced vibration / A. S. Kairov, S. A. Morhun // Journal of Mechanical Engineering. 2013. Issue №68. P. 128-133. doi: 10.20535/2305-9001.2013.68.36149. (in Russian).

2. *Morhun S.* The influence of the blade feather constructional inhomogeneity on the turbine cooling blades stress-strain state // Eastern-European Journal of Enterprise Technologies. Series: Applied Mechanics. 2018. Issue 2/7 (92). P. 11-17. DOI: 10.15587/1729-4061.2018.125937.