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SIMULATION DYNAMICS PROCESSES OF ROTATING SYSTEM

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ABSTRACT

The rotating system consists of an asynchronous motor, rotors supported by oil-film bearings, gear box and couplings. Increased vibration of electric motor is of electromagnetic and mechanical nature. The electromagnetic nature vibration is excited by a magnetostriction phenomenon, the asymmetry of an air gap between a rotor and a stator, the asymmetry of a stator winding. Mechanical vibration is excited by the rotor unbalance, misalignment, bearing defects, varying and insufficient dynamic stiffness of supports, the shaft bend due to loading forces, oil induced instability in oil-film bearings.

The dynamic of rotor is investigated by finite element method. The complex finite element of rotor of electric motor has eighteen degree of freedom. The first out of eight degrees of freedom belong to asynchronous motor and ten degrees of freedom belong to deformable rotor.

The general assumptions made are: the material of the rotors and coupling is elastic; shear forces are evaluated; the deflection of the rotor is produced by the displacement of points of the center line; the axial motion of the rotors is neglected; the semi couplings are treated as rigid.

The system of equations of motion of a rotor of electric motor finite element

$$\begin{gathered}[M_e(q)]\{\ddot{q}\}+[C_e(q,\dot{q})]\{\dot{q}\}+[K_e(q)]\{q\}=\{B_e(q,\dot{q},\Psi,t)\} \\ \frac{d\{\Psi\}}{dt}=[A_1]\{\Psi\}+\omega(\dot{q})[A_2]\{\Psi\}+\{B_0(t)\},\end{gathered} \tag{1}$$

here $[M_e(q)]$, $[C_e(q,\dot{q})]$, $[K_e(q)]$ are mass, damping (with gyroscopic matrix) and stiffness matrices;, respectively; $\{B_e(q.\dot{q},t)\}$ is load vector; $\{q\},\{\dot{q}\},\{\ddot{q}\}$ − the nodal element displacement, velocity and acceleration vectors, respectively; $[A_1]$, $[A_2]$, $\{B_0(t)\}$ −

matrices and vector of model of an asynchronous motor; $\omega(\dot{q})$ is angular velocity of a rotor.

Gear box dynamics is characterized by a periodically changing stiffness and a backlash which can lead to a loss of the contact between the teeth.

In order to calculate the hydrodynamic forces in the oil-film bearings the Reynolds equation is solved by finite element method.

The dynamic turbulent Reynolds equation in the theory of hydrodynamic lubrication is used and may be written as [1]:

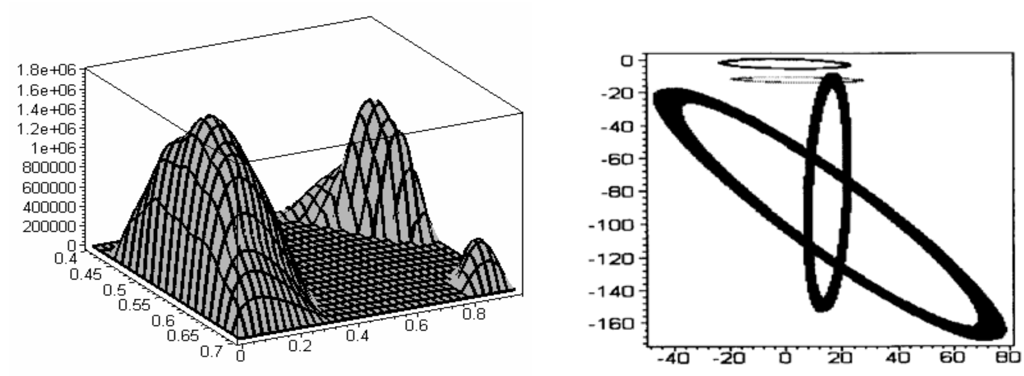
$$\frac{\partial}{\partial x}\left(\frac{h^3}{\mu}k_x\frac{\partial p}{\partial x}\right)+\frac{\partial}{\partial y}\left(\frac{h^3}{\mu}k_y\frac{\partial p}{\partial y}\right)=\frac{\partial}{\partial x}\left(hU_x+\frac{h^3}{12\mu}F_x\right)+\frac{\partial}{\partial y}\left(hU_y+\frac{h^3}{12\mu}F_y\right)+\frac{\partial h}{\partial t}, \qquad (2)$$

where $p(x,y,t)$ is the pressure; $h(x,y,t)$ is the film thickness; μ is dynamic viscosity; F_x, F_y are components of body forces; U_x, U_y are components of vector of surface velocity, $k_x = k_x(\mathrm{Re})$, $k_y = k_y(\mathrm{Re})$ are turbulence coefficients.

In an implicit time integration scheme, equilibrium of the system of equations of motion of a rotor is considered at time $t+\Delta t$ to obtain the solution at time $t+\Delta t$. In the nonlinear analysis, this requires that an iteration be performed.

On the each time step and iteration the systems of equations of motion of a rotor and Reynolds equation are solved together.

The pressure distribution in oil-film bearing and kinetic orbit of rotor are shown in the Figure 1.



a) b)

Figure 1 Results of simulation dynamic processes of rotating system: a - pressure distribution in oil-film bearing b - kinetic orbits

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