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THE APPROACH TO COMPUTATIONAL ANALYSIS OF VIBRATION OF VERTICAL ROTORS SUPPORTED BY FLUID FILM BEARINGS AND HAVING A DISC SUBMERGED IN INWETTABLE LIQUID

Jaroslav Zapomel

VSB-Technical University of Ostrava
Department of Mechanics, 17. listopadu 15, Ostrava-Poruba, 708 33, Czech Republic
jaroslav.zapomel@vsb.cz

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ABSTRACT

Lateral vibration of rotors is significantly influenced by their supports and by their interaction with the medium in the ambient space. For their investigation a computer modelling method may be applied. In the proposed mathematical model the shaft is represented by a beam-like body and the disc is considered as absolutely rigid. The hydrodynamic bearings are modelled by means of nonlinear force couplings. The pressure distribution in the oil film is obtained by solving the Reynolds' equation and components of the hydraulic force are calculated by its integration around the circumference and along the length of the bearing. The disc is circular and is placed in a cylindrical vessel filled with liquid. Axes of the rotor with the disc and of the vessel are parallel. They do not need to be identical but they can be shifted one to another by a certain distance. It is assumed that the liquid is incompressible, inviscid, and inwettable. Therefore it does not lean to the disc and acts on it only by the pressure in the direction perpendicular to the disc surface.

Vibration of the liquid in the vessel is treated as 2D. Because only small displacements and velocities are assumed, the pressure distribution in the liquid can be described by a Laplace equation that is obtained by simplification of the Navier-Stokes equations and the equation of continuity. At each point of the cylindrical area of the disc the normal component of the pressure gradient is proportional to the normal component of the disc acceleration and of the liquid density. Components of the resulting force acting on the disc are obtained by integration of the pressure distribution around the circumference and along the width of the disc. These forces can be expressed as a linear combination of the components of the disc acceleration. Then the coefficients of proportionality can be considered as masses added to the disc and can be arranged into a matrix form (matrix of additional mass). Their magnitudes depend on geometry of the disc and on its position relative to the inner wall of the vessel. In general they represent a coupling between vibration of the rotor in two mutually perpendicular directions. If axes of the shaft and of the rotor are identical, all directions of the disc acceleration are equivalent. Then the additional mass matrix is diagonal and its elements can be precalculated. If the vessel vibrates, the hydraulic forces acting on the disc must be continuously calculated.

Analysis of the lateral vibration of such rotor systems requires to precalculate the coefficients of additional masses and to solve simultaneously the equation of motion, the Reynolds' equations for each bearing, and to determine the hydraulic forces by which the liquid acts on the disc of the rotor. The pressure distribution in the liquid is obtained by a direct solution of the Laplace equation and the hydraulic forces are calculated by intragration of the pressure around the circumference and along the height of the disc. To solve the Laplace equation a finite element method has been adopted and the formulations for the finite elements have been derived.

This approach was applied to investigation of vibration of a vertical rotor (Fig.1) excited by the disc imbalance. The steady state component of the disc centre trajectory (Fig.2) is a rather complicated curve but the resulting motion is periodic.

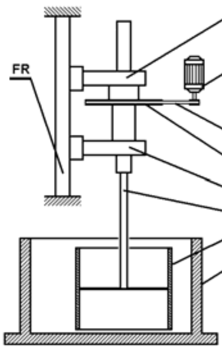

Fig.1

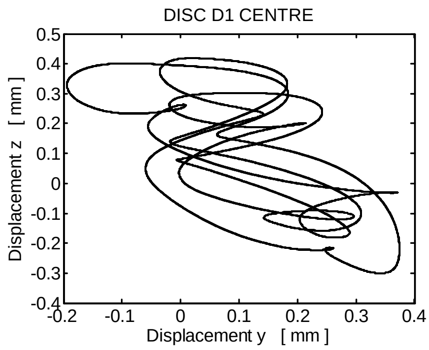

Fig.2

The proposed paper brings a new algorithm which enables to analyze a mutual intraction of the rotor, of the hydrodynamic bearings, and of the liquid in which the disc mounted on the shaft of the rotor is submerged. The additional goal of this research work was to analyze numerical stability of the proposed procedure, to get experience with its application, and to judge if more complicated mathematical models (covering more propertis of the liquid such as its viscosity) can be set up and used.

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