Abstract

Theoretical studies on hydrodynamically lubricated bearings is complicated by the nature of fluid film extent and the elemental non-linearities involved in the problem. A comprehensive study thus warrants linearization of the fluid film forces and calculation of fluid film extent based on the later. Thus any modification to the journal bearing assembly cannot be easily studied through mere theoretical analyses. The theory of regeneration proposed in this work attempts to enhance the grasp on the very basic mechanism of instability in systems with planar orbits in general. This theory maintains its strength in the physical arguments derivable from the analysis rather than going through complex mathematical abstractions that often obscure the inherent internal mechanism causing the instability. It is known that two-dimensional systems having skew-symmetric stiffness coefficients give rise to non-potential force fields that cannot be expressed as gradients of scalar-valued functions. When such a system executes a planar orbit, the net work extracted by the non-potential forces is a function of the orbital area. These guiding principles thus evolved are then used to propose new methods for stabilizing rotor-bearing systems specially in those ranges where a mixed occurrence of stable equilibrium point and large whirl orbit becomes plausible. The theory has been tested with applications to various linear and non-linear systems, including stability considerations for rotors mounted on journal bearings.

It has been observed that distortion of the critical orbit of a system with above characteristics can be exploited to achieve orbital stability or guided branch transition effects. As a result, certain modifications to the flexible bush type structures in a journal bearing assembly are proposed in this work. These include the proposals for incorporation of additional support snubbers or use of bucklable support springs. In this work, it has been established that bucklable support springs or its equivalent structures have tremendous capacity to suppress the growth of large amplitude whirl of rotors operating in meta-stable condition (i.e., where the equilibrium point is stable and large amplitude vibrations are unstable) and also to control the amplitude of whirl orbit of rotors operating at higher speed range, where the equilibrium point

itself is unstable.

The work is completely theoretical and the conclusions are derived mostly from numerical simulation of the corresponding bondgraph models. The bondgraph modelling language provides a platform that represents the physical assortments in the system and its dynamics in an integrated manner using the concept of energy exchange between various lumped parameter elements of the system. The equations of motion or of other dynamical variables are procedural outcome of the bondgraph model. Hence, throughout this thesis, presentation of such differential equations and the corresponding simulation codes are felt rather unnecessary.

Earlier in this work, the effect of various support parameters, viz. its weight, stiffness and damping coefficients etc., have been analyzed to obtain specific stability charts, that can be used as design guidelines. Occurrences of large amplitude whirl orbits in meta-stable operating zone have been investigated through numerical simulation of the rotor-bearing and support models. Later, the effect of bucklable supports on stability of rotor-bearing systems have been analyzed with reference to various operating conditions and threshold speeds, corresponding to the respective stability charts.