SYNOPSIS

This thesis presents theoretical and experimental analysis of the 'Dynamic characteristics of externally pressurised multirecess oil journal bearings'.

Externally pressurised bearings are used extensively in the recent days viz. in machine tools and aerospace industries due to their high stiffness and low friction. Multirecess externally pressurised journal bearings are used as main spindle bearings in machine tools. Rigidity being the major design criterion for machine tools, these bearings are usually designed for maximum stiffness. Often these bearings are subjected to vibrations and dynamic loading, which may be detrimental to their proper functioning if adequate precautions are not taken at the design stage. Exhaustive literature is available on the analysis and design of static multirecess externally pressurised bearings but their dynamic behaviour has not been given much attention.

Dynamic behaviour of multirecess hydrostatic journal bearings has so far been investigated by using simplified assumptions of short axial and circumferential lands and for lower operating eccentricities. Effects of shaft rotation and the compressibility of lubricant between the recess and supply line have been investigated. Squeeze film effects have been studied using simplified theory and quasi-static assumption.

In majority of the cases squeeze film effect over the sill areas and the hydrodynamic effect caused by the shaft rotation have been neglected in the analysis of the dynamic characteristics of multirecess pressurised journal bearings. The aim of the present thesis is to investigate the dynamic behaviour of the multirecess oil journal bearings taking into account the squeeze film effect over the sill areas and the hydrodynamic effect caused by the rotation of the shaft.

The Reynolds equation for a finite bearing with the time dependent terms is linearised using perturbation theory for small vibrations. Dynamic recess pressures are evaluated from the perturbed flow continuity equations for the recesses. Equations are written in finite difference form and solved by iteration satisfying appropriate boundary conditions using an over relaxation factor with the help of a high speed digital computer. Some experimental results are also incorporated. The above information is presented in the following chapters.

First chapter presents a brief review of the available literature.

In the second chapter generalised Reynolds equation for fluid film lubrication has been derived from the Navier-Stokes equations for fluid flow. The complete Reynolds equation for an incompressible finite journal bearing with the time dependent terms is also derived.

Third chapter deals with the theoretical analysis of the dynamic characteristics under plane vibration in the absence of shaft rotation. Results of static and dynamic characteristics of the bearing are presented.

In the fourth chapter theoretical analysis of the hydrodynamic effect and the dynamic behaviour of a hybrid bearing with film cavitation is presented. The effect of journal rotation on load capacity, oil flow and friction is reported. The dynamic characteristics of the above bearing configuration are also included. Stiffness and damping coefficients obtained from the above have been used to investigate the stability of a rigid rotor.

Fifth chapter presents experimental method, design and fabrication of the set-up, the experimental procedure and observations.

Sixth chapter presents the discussion of the results reported in earlier chapters.

In the seventh chapter some conclusions have been drawn based on the results and discussion reported in previous chapters.

Some important conclusions are as follows :

There exists optimum values of the capillary and orifice design parameters at which the load capacity and stiffness of the bearing are maximum.

Load capacity and stiffness of orifice compensated bearings are higher than capillary compensated bearings, whereas the damping of capillary compensated bearings are somewhat higher than orifice compensated bearings at higher eccentricity ratios. At lower eccentricity ratios orifice compensated bearings exhibit higher damping.

Stiffness usually decreases with increase in eccentricity ratio.

Damping increases with increase in eccentricity ratio.

With increase in capillary and orifice design parameters damping decreases.

Damping increases with decrease in recess to bearing area ratio whereas the stiffness of the bearing decreases.

With increase in number of recesses stiffness increases, the damping also increases but less significantly.

Load capacity of the bearing increase with increase in shaft speed while the bearing flow is not affected significantly. The bearing becomes susceptible to whirl instability at higher speeds.