INTRODUCTION

Machine components having relative surface motion must be supported on bearings to minimise friction and prevent wear. They may be supported either on antifriction bearings or bearings operated on the principle of fluid-film lubrication. It has been found that fluid-film bearings can be used successfully in many devices rather than antifriction bearings. There are basically three main ways of creating fluid film lubrication. These are: (i) hydrodynamic or self-acting, (ii) hydrostatic or externally pressurized and (iii) squeeze-film. In all cases a substance called 'lubricant' is fed in the clearance space between the two mating surfaces. In the first method the pressure is created by the relative tangential motion between these surfaces due to wedge action. The pressure thus generated takes up load avoiding metal-to-metal contact. If the relative motion is extremely low and the load to be supported is very high, the hydrodynamic lubrication fails. In such a case the load supporting ability is derived from the pressure being fed in the clearance space from an external source. The bearings operating under this principle are called hydrostatic or externally pressurized. When the pressure is developed by the relative normal motion of the surfaces, it is known squeeze-film lubrication. A bearing is called journal or thrust if the applied load is radial or thrust.

A bearing operating on hydrostatically or externally pressurized principle of lubricatio n is relatively expensive, because an elaborate arrangement for supplying lubricant under pressure is to be provided. Although the power loss due to 'fluid friction' alone in this type of lubrication is very low, the total power consumption for the system as a whole is of considerable amount. In some applications the pressure cannot be generated with self-acting bearings, therefore one has to depend on hydrostatic bearings. But hydrostatic bearings have some attractive features, such as (i) high load capacity, (ii) low friction and (iii) high stiffness when suitably compensated.

If gas (or air) instead of oil is used as a lubricant, a bearing can also operate on one of the above principles, such as (i) hydrodynamic, (ii) hydrostatic and (iii) squeeze-film. Most gas lubricating films are laminar and negligible film inertia. As gas has very low coefficient of viscosity compared to mineral oil, gas bearing can be used for a wide range of temperature.

Gas bearings are useful both in high temperature missile and low temperature cryogenic applications because the viscosity does not vary significantly with temperature. The abundant supply of air as low friction, comparatively clean lubricant is an inducement to use gas film for high speed bearings. As gases are normally free from adverse effects due to radioactivity, gas bearings are used in auxiliary equipment for nuclear power plants. Gas bearings are particularly valuable when used in precision instruments due to their inherently low frictional characteristics. Dynamometers of high accuracy and great sensitivity can be made. Machine tool builders have also found these bearings quite useful to support large plane surfaces which must move easily and rapidly with no stick-slip motion. When air is used as gas no fluid recovery system is needed. An externally pressurized air (or aerostatic) bearing when designed for stiffness (or rigidity) must have a compensating element (or restrictor) between the supply manifold and the bearing. Without the restrictor the bearing would not be practicable. It would support a load, but there would be no change in the load supported with film thickness. To have a practical bearing, it is necessary that the load vary inversely with film thickness. A restrictor performs this in both with oil and gas bearings. When the load on the bearing is not consta nt it contributes two important characteristics of the film, i.e. stiffness and damping. The commonly used restrictors are (i) capillary, (ii) orifice and (iii) flow control valve. Sometimes a simple circular hole communicating pleunum chamber with bearing clearance can act as a restrictor. This type of bearing is called inherently compensated. In gas bearings orifice restrictors are widely used because they have better characteristics than capillary ones. However, inherently compensated bearings are better than orifice-compensated bearings from the stand point of stability.

Because of some of the aforementioned attractive features, aerostatic bearings are now-a-days finding wide acceptance in many industrial applications. However, aerostatic bearings exhibit two types of instability, one of pneumatic, self-excited in nature called 'pneumatic hammer' or 'pneumatic instability', which is independent of system resonance, and the other induced by the surface motion of the moving member which is known as 'hybrid instability'. Pneumatic instability sets in even if there is no surface motion. This adverse effect of aerostatic bearings puts a serious limitation on their design and application. Moreover, very small film thicknesses are required to hold fluid flow to reasonable values, thus requiring very precise machining of the components.

It has been mentioned earlier that a bearing when used to support an axial or thrust load is known as thrust bearing. An aerostatic bearing has mainly two parts, the bearing pad and the runner. The important parts of the pad are the recess, the inlet supply hole and the sill. The runner is separated by film of pressurized air. The pad may be flat, cylindrical, conical or spherical but in all cases the runner must conform to the pad shape. The flat and cylindrical shapes are common.

For a given load, the size and geometry of pad and recess is normally left to the designer's discretion. The load capacity, flow rate and power required to compress air through the bearing clearance depend on pad configuration.

Again, when the load is fluctuating, the performance of the bearing, i.e., film thickness, stiffness, damping, flow etc., are drastically affected by the choice of the dimension and the type of compensating element.

A flat pad bearing (thrust bearing) may have several possible configurations: (a) circular and (b) rectangular. These may have either a central supply hole or a recess around the supply hole. The bearing pads may be of two kinds: (i) pad with single port and (ii) multiple ports. The single recess (or supply hole) bearing is mainly of theoretical interest and finds little application in practical design, as unable to carry offset load. Multiple-port pads or multipad bearings can carry such off-centre loads. When the load on the bearing reverses, opposed pad bearings are used. Because of axisymmetry theoretical analysis of circular thrust bearing is relatively easy. However, when the multiple-port pad bearings with offset load are considered, the problem becomes a little complicated. Although, the bearing configuration having a recess around a supply hole may have higher load supporting ability, the large recess volume at the downstream of restrictor is discouraged for pneumatic instability.

About the Thesis:

The thesis presents theoretical and experimental investigation of dynamic behaviour, e.g., dynamic stiffness and damping of rectangular aerostatic thrust bearings with