

## Air Bearing and its Stability

Prof. Mahajan.S.M<sup>1</sup>, Mahajan Pratiksha N<sup>2</sup>, Bankar Abhijit K<sup>3</sup> and Varade Mayur A<sup>4</sup>

<sup>1</sup>Professor, Department of Mechanical Engineering, Sandip Institute of Engineering and Management, Nashik, Maharashtra, INDIA

<sup>2</sup>Student, Department of Mechanical Engineering, Sandip Institute of Engineering and Management, Nashik, Maharashtra, INDIA

<sup>3</sup>Student, Department of Mechanical Engineering, Sandip Institute of Engineering and Management, Nashik, Maharashtra, INDIA

<sup>4</sup>Student, Department of Mechanical Engineering, Sandip Institute of Engineering and Management, Nashik, Maharashtra, INDIA

<sup>2</sup>Corresponding Author: pratikshamahajan121@gmail.com

### ABSTRACT

Bearing are machine element that allow components to move with respect to each other. A little consideration will shows that some part of power wasted in overcoming the frictional resistance and due to the contact of surfaces large amount of wear and tear takes place between the contacted surfaces. Hence to avoid wear and tear in sliding contact bearing and to reduce frictional resistance the thin layer of fluid is introduced which is called as lubricant. Air bearing are introduced to reduce such frictional resistance and wear of sliding contact bearings. Air bearings are bearings that use a thin film of pressurized air to provide low frictional load bearing interfaces between surfaces. There is a small gap between two surfaces i.e. two surfaces do not touch. As these bearings are contact free various problems in traditional bearing like friction, wear, particulates, and lubricant handling are avoided. There are advantages like precision positioning, such as lacking backlash and static friction as well as in high speed application. Other than this characteristics, stability is also important factor in air bearing.

**Keywords**— Air Bearing, Stability, Machine Tools

### I. INTRODUCTION

Air bearing have been special type of technology. Air bearing technologies are generally used coordinate measuring machines. Air bearing utilize a thin film of pressurized air to provide a Zero friction load bearing interface between surfaces that would be otherwise be in contact with each other non-contact, air bearings avoid the traditional bearing related problems of friction, wear, and lubricant handling and offer distinct advantages in precision positioning and high speed applications.

Fluid film of the bearing is achieved by supplying a flow of air through the bearing face and into the bearing gap. This is typically accomplished through an orifice or a porous media that restricts or meters the flow of air into the bearing gap. This is typically accomplished through an orifice or a porous media that restricts or meters the flow of

air into the gap. The restriction is designed such that, although the air is constantly escaping from the bearing gap, the flow of pressurized air through the restriction is sufficient to match the flow through the gap. It is the restriction through the gap that maintains the pressure under the bearing and supports the working load. If air pressure were introduced to the gap without restriction, the flying height would be higher, the air consumption higher and the stiffness would be lower than could be achieved with proper restriction. This restriction is referred to as air bearing compensation. It is used to optimize the bearing with respect to lift, load and stiffness for particular applications.

### II. HISTORY & BACKGROUND

In 1828 Rev. Wills published a work in the Cambridge philosophical society entitled “on the pressure produced on a flat surface when opposed to stream of air issuing from an orifice in a plane surface “. Most air bearings operate on the same basic principle.

A Kingsbury in 1897 experimented with a 6 diameter journal bearing supported on externally pressurized air. His problems, the practical problems of matching bore and shaft geometry and size so as to achieve a consistent .0005” gap all the way around were a manufacturing challenge at the turn-of-the century. Small gaps are required with air because its viscosity is so low. Kingsbury found that the higher viscosity of water or oil worked better with the relatively large gaps that could be manufactured in the day. Today the company he founded, Kingsbury Corporation, is still a major supplier of fluid film bearings for applications like ship propeller shafts and shafts for hydroelectric turbines.

In 1904 air bearings were used in turbines. G. Westinghouse received a patent for an air thrust bearing used in a vertical steam turbine. Thrust bearings were easier to make as two flat surfaces are easier to match than ID and OD surfaces. The low

Viscosity of air with nearly zero friction was an important factor in the high efficiency of the Westinghouse steam turbine.

### III. TYPES OF AIR BEARING

Gas-lubricated bearings are classified in two groups, depending on the source of pressurization of the gas film providing the load-carrying capacity:

**Aerodynamic Bearing:** The principle of aerodynamic bearings depends on relative motion between surfaces in contact and usually spiral groove used to draw air between the bearing lands. Aerodynamic bearings require relative motion between the surfaces, so there is problem found when bearing surfaces comes in contact at low speed or when there is no relative motion. Another name of aerodynamic bearings is foil bearings or self-acting bearings. The read write head flying over a spinning disk, crankshaft journals, camshaft journals, and thrust bearings are examples of this type of bearing.

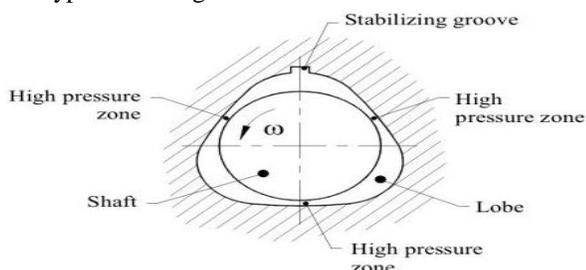


Fig1. Aerodynamic bearings

**Aerostatic Bearings:** In aerostatic bearings, pressurized air is supplied between the bearing surface and precision hole, groove. The pressure of this air is maintained by external source. Since air pressure is maintained by external source so at low relative motion between the bearing surfaces or when there is no relative motion between them the air pressure is controlled.

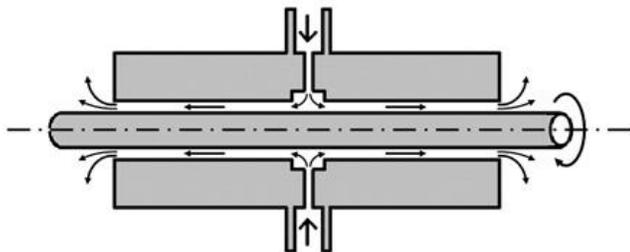


Fig2. Aerostatic Bearings

### IV. WORKING

There are a lot of technical advantages of air bearings such as negligible friction and wear, high speed and

high precision capabilities and no oil lubrication requirements. Till now these benefits are not properly utilized due to its manufacturing difficulties.

New Technologies were found in manufacturing of air bearings. The porous media technology makes air bearings robust, simple to use, inexpensive, and available off-the-shelf. Some advantages over traditional bearing are:

1. Greater Precision: Air bearings provide excellent precision in both directions i.e. the rotation may be in axial or radial. Since there is no physical contact, wear is minimal, ensuring accuracy remains constant over time.
2. High Speed: Low shear forces within the air bearing allow extremely high rotational speeds with minimal loss of power and very low heat generation. Speeds can exceed 300,000 rpm.
3. Tool Life: By using air bearing the life of the tool increased.
4. Long Bearing Life: With no mechanical contact and a clean air supply, free from oil and water, bearing life is dramatically increased.
5. Low Thermal Growth: Low friction, constant air flow and efficient power transmission result in minimal thermal growth.
6. Lack of Maintenance: Only the very minimum of maintenance is required. A regular check of air supply and coolant systems is all that is necessary to ensure complete reliability.
7. Large Load Capacity: Air bearings can support heavy loads, allowing them to be applied to many industrial machine tool applications.
8. Reduced Vibration: Only minimal levels of vibration and audible noise are produced when running an air bearing spindle.
9. Cleanliness: Air is the only lubrication used; therefore, air-bearing technology is ideal where there must be no contamination of the work piece or working environment

### V. APPLICATIONS

#### A. High Speed Equipment

Machines are being designed today that have moving elements that may cycle as many times as one billion cycles per year. It is simply not reasonable to try to do accelerated life testing on such machines. Another alternative is to switch the mode of wear by changing the bearing technology from roller bearings to air bearings. In air bearings the speed or distance the bearing travels does not affect wear. The mode of wear in air bearings is erosion, so the amount of particulates in the incoming air is the determining factor in how long a bearing will last. Even assuming relatively dirty air is used, the calculated life of an air bearing is measured in centuries regardless of whether it is moving at one billion cycles a year or remaining stationary.

The dynamic coefficient of friction increases with speed and will only contribute heat problems at over 20 meters per second and then only in confined rotating applications

### **B. Coordinate Measuring Machines**

Most coordinate measuring machines (CMMs) are built with air bearings because they allow for infinite resolution. Because air bearings actually float on a pressurized film of air there is no physical contact. This means only the shear of the molecules contributes to friction. The static and dynamic coefficients of friction at startup are identical and there is no stick-slip effect. This minimizes lost motion and reversal errors around the triggering of the probe. And because air bearings are more repeatable and smoother than rolling element bearings error correction is more effective. Mechanically, this allows for infinite motion resolution (putting the controls engineer back on the hot seat.

### **C. Ultra Accurate Machine Tools**

Many of the most accurate machine tools in the world employ air bearing technology. The zero static coefficient of friction allows for unmatched performance during stage reversal in contouring applications. Very accurate velocity control and elimination of perturbations in the stage movement allow for the turning of optical quality surface finishes that are measured on the angstrom level.

## **VI. STABILITY OF AIR BEARING**

Stability is a very common but difficult to solve problem in an air bearing system. An air bearing is said to be unstable if it is subject to an oscillation that can be observed as a vibration or hum. This instability is known as “pneumatic hammer” and occurs when the air escaping across the face is restricted by a gap slightly smaller than one allowing equilibrium.

The most cases that instability occurred were due to the lower damping in air bearings. In this situation, air pressure then increases displacing the bearing upward and resulting in a larger gap. The air pressure then escapes more easily, lowering the pressure, allowing the bearing to drop until the pressure increases again and the cycle is repeated resonating at the natural frequency of the structure. It has been experimentally and theoretically verified that the stability of an air bearing will be increased by applying an increased external pressurized air into bearings instability appeared at lower speed with higher external supply pressure, and the speed at which instability appeared was increased with a decrease of external supply pressure. orifices are used to control the flow of air into the gap. Frequently jeweled orifices (watch makers bearings) sized exactly to let just enough air through to carry a certain load at a certain gap with a certain air pressure are used to limit

the upper half of the pneumatic hammer cycle and thus making the bearing stable. This is a sensitive balancing act because the flow through a gap increases as a cubed function of the gap, meaning that a small change in gap makes for a large change in flow. What this means practically is that a small change in gap, from say some extra load, results in significantly less flow defeating the restriction of the orifice and allowing the bearing to become unstable.

The technical issues regarding the design of orifice bearings are documented several reference documents. Calculations are used to determine the optimal size and location for the orifice, often shallow air grooves (.002 deep by .010 wide) are used to improve the pressure profile under the bearing. A different type of bearing, groove compensated bearings are distinguished from orifice bearings because they do not depend on the orifice for restriction of air flow. Instead precise grooves control the flow of air into the bearing gap. The depth of these grooves are often 5 microns or less and may not be visible on the surface at first glance. Groove compensated bearings are considered to have relatively high stiffness compared to orifice type bearings.

## **VII. CONCLUSIONS**

A lot of studies and research have been done on air bearing. there are lot of advantages of air bearing over sliding contact bearing with large applications air bearing concepts are ready to solve the problem of sliding contact bearing. with the comparison with other types bearings the air bearings has been explained. also how can we achieve stability it is important topic to study.

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