Development of a Split Bush Bearing System

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Abstract- **In the presented work a simple but effective bearing system is developed. It reduces the disadvantages of hydrodynamic and hydrostatic bearing systems. Like a taper roller bearing the developmental work includes the tapered and split collate fitted inside a matching tapered bush. The working clearances can be set to the desired closer limits. The split bush bearing system is developed, manufactured and run for sufficient period to see the performance. It is low cost, effective and easy to manufacture. The shaft rotates fairly concentric and therefore is a better suited bearing system**

Keywords: Adjustable bearing, No eccentricity, Tapered split bush.

I. INTRODUCTION

The word bearing, applied to a machine or structure, refers to contacting surfaces through which a load is transmitted. When relative motion occurs between the surfaces, it is usually desirable to minimize friction and wear. A grey cast iron bush in suitable housing with an alloy steel shaft having close running fit of H7/h6 along with other parameters is one initial bearing system. In general the sliding bearings require direct sliding of the load carrying member on its support, as distinguished from rolling element bearings, where balls or rollers are interposed between the sliding surfaces.

For shafts, the anti friction bearings give point contacts / line contacts and avoid surface contacts but rotating at higher revolutions the friction component increases. There are always radial and axial clearances. In taper roller bearings the axial and radial play may be set to closest possible micron clearances. But since taper rollers have two motions i.e. one on its own axis and the other around shaft axis therefore gyroscopic actions appear in such conic rolling. [1]. this gives a pulsating variable to

$$T= -I\omega^2 Sin\alpha\, Cos\alpha + J\ \psi\omega\, Cos\alpha \qquad (1)$$

I and J = The moment of inertia of taper roller about X and Y axis.

α = Semi vertical angle of cone (taper roller)

ψ = Angular velocity of the cone about the vertical axis Z

ω = Angular velocity of cone about a vertical axis through apex O

This affects the bearing performance for the precision shafts, and therefore other alternatives are required. Instead the hydrodynamic / hydrostatic bearings are used to give better performances at higher speeds and loads. It is well known that the hydrostatic bearings are more concentric and much costly but lot of skill is involved in setting the concentricity in the hydrostatic bearing [2].There is a complete surface separation by a highly pressurized fluid such as air, oil or water which is introduced into the load bearing area and therefore hydrostatic bearing is used only for specialized applications. Since the fluid is pressurized by external means, full surface separation can be obtained whether or not there is relative motion between the surfaces. The principal advantage is extremely low friction at all times, including during starting and low speed operation. Disadvantages are the cost, complication and bulk of the external source of fluid pressurization. The hydrostatic bearing has disadvantages like – auxiliary equipments, pump, filter, oil supply line etc. which are liable to failure. Further overall power loss of pumping and friction is not necessarily low.

On the other hand the hydrodynamic bush bearings are less costly but give eccentricity to the shaft. The surfaces are completely separated by the lubricant film. The load tending to bring the surface together is supported entirely by the fluid pressure generated by the relative motion of the surfaces. Surface wear does not occur, and friction losses originate only within the lubricant film. Typical film thicknesses at the thinnest point are 8 to 20 micron. Typical value of coefficient of friction is 0.002 to 0.010. The disadvantage is that when the load and / revolution change then there is corresponding variation in the eccentricity [3]. In hydrodynamic bearing the assumption is that the successive positions of a journal rotating in a stationary bearing are coincident circles which provide six contacts without force closure at no load or with five contacts plus force closure i.e. with load. This is a lower pair applicable to identical geometric form, so that one element encloses the other completely.

But due to the clearance between journal and bush there is deviation to ideal geometric form. And this does not give the contact profile between journals and bearing a true curve of solid of revolution [4].Therefore this gives a limitation to have a concentric rotation of shaft. The friction depends upon the clearance between bush and journal.

$$\mu = A\ (zn/p).\ (r/c) + B \qquad (2)$$

μ = Coefficient of friction

z = Viscosity of lubricant

n = speed of journal, rpm

p = bearing pressure

r = journal radius

c= clearance between bush and journal

A, *B* = constants

Therefore as the clearance reduces below a threshold value so that the friction increases. It is possible to get the advantages of both, hydrodynamic and hydrostatic bearings. It is possible to have a shaft rotating concentric as well as at low cost and with design simplicity [5].

II. DEVELOPMENT OF A SPLIT BUSH BEARING

Refer to the figure no.1. (Assembly drawing of the split bush bearing system)

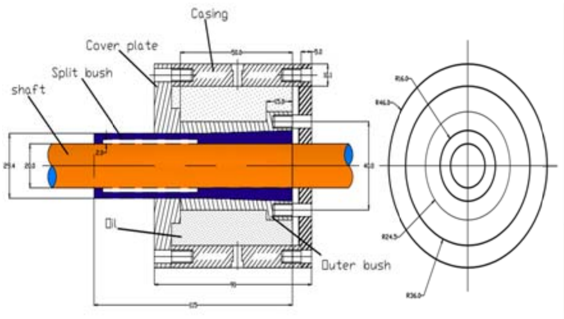

Fig.1. Assembly drawing of split bush bearing

The kinematic elements are so developed that each one of a pair shall always occupy the intended position relative to the other. The necessary and sufficient restraints prevent any motion of translation of the axis of journal relative to split bush bearing.

The journal portion of the shaft is press fitted with the gun metal bush. The longitudinal knurling is done on the gunmetal bush to reduce the contact area and the ample space for foreign material to leave. A tapered collate envelopes the journal and is located inside a tapered bush. The tapered collate is split longitudinally along the length of the journal. The collate can be drawn inside to envelope the journal to give desired fit on the journal. Since the collate is made up of spring steel material and suitably heat treated, Therefore for any number of times the setting may be done. The split and tapered collate thus acts like a bush and the complete assembly are inside a barrel housing filled with oil. Refer figure no.2a & 2b (Split bush).

Fig. 2a

Fig. 2b.

Fig..2 Two views of a Split bush.

Refer figure no.3 and 4 (Different components of split bush bearing system)

Fig.3 Different components

Fig..4. The shaft with a press fitted gun metal sleeve having longitudinal grooves.

III. EXPERIMENT AND TRIAL

Refer figure no 5a & 5b. (Equipment trial)

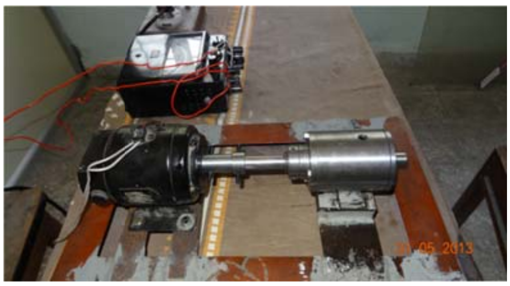

Fig. 5a.

Fig.5b.

Fig. 5. Two views of Equipment trial

The figure no.5 (a and b) shows the trial of split bush bearing, the shaft rotates within 30 microns. For further accuracy the components should be made on more precision machines and honing/ lapping like super finishing operations may be performed. For different revolutions and conditions like dry and oil filled housing the power consumption of the A.C. Parallel motor are shown in the table no.1 and table no.2 (power consumption v/s revolutions)

A. Dry Condition

TABLE I. EXPERIMENTAL READINGS POWER CONSUMPTION PER REVELATIONS IN TERMS OF WATTS AND RPM.

Sr. No	RPM	WATTS
1	1000	44
2	1500	45
3	2000	50
4	2500	55
5	3000	62
6	3500	68
7	4000	70
8	4500	90
9	5000	100

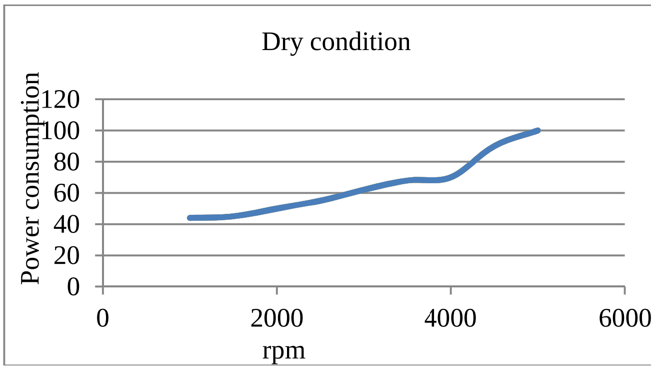

Fig. 6. Power consumption v/s revolution in dry condition

B. Lubrication Condition

TABLE II. EXPERIMENTAL READINGS POWER CONSUMPTION PER REVELATIONS IN TERMS OF WATTS AND RPM.

Sr. No	RPM	WATTS
1	1000	45
2	1500	50
3	2000	54
4	2500	60
5	3000	65
6	3500	70
7	4000	70
8	4500	70
9	5000	74

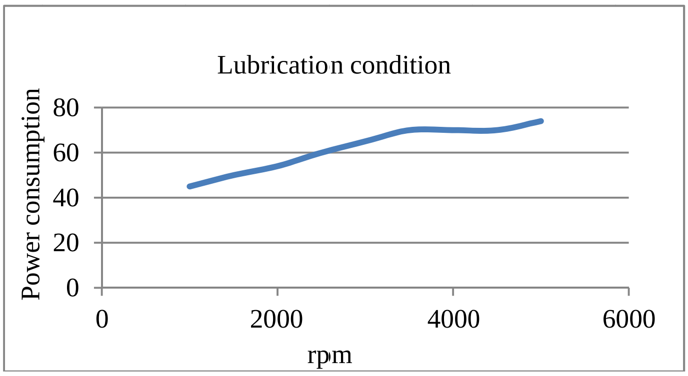

Fig. 7. Power consumption v/s revolution in lubricated condition

IV. CONCLUSION

The shaft was rotated for more than 12 hours continuously and it was almost noiseless operation. The filling of the casing with the oil is a normal full filling. The shaft was concentric with in 20 microns during the complete trial. Further trial is needed under different load conditions. This trial was performed in cantilever mode. The bearing system is altogether a new concept. The product is of industrial application and very easy to make. The load rating, product lifecycle and other calculations in different loading need to be done once sufficient long term field trials are taken.

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