DETERMINATION OF COEFFICIENT OF FRICTION OF HYDRODYNAMIC JOURNAL BEARING EXPERIMENTALLY

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Abstract— **Knowing friction coefficient is important for the determination of wear loss conditions at Journal bearings. Tribological events that influence wear & its variations effect experimental results. In this study, friction coefficient as example at radial bearings such as copper, brass hasbeen determined by a new approach .in experiment ,friction effect of bearing have been examined loads and velocities .The coefficient of friction ,often symbolized by greek letter , is a dimensionless scalar value which describes the ratio of the forces of friction between two bodies and the forces pressing them together . the coefficient of friction depends on the material used; for example ,ice on steel has a low coefficient of friction ,while rubber on pavement has a high coefficient of friction .coefficient of friction range near zero to greater than one.**

Vortex tube is considered as a mechanical device which operates as a refrigerating machine. This device separates a compressed gas stream into hot and cold streams. In this paper a series of experiments has been carried out to investigate the influence of uniform curvature of main tube on the performance of the vortex tube. The Ranque-Hilsch vortex tube has been used for many decades in various engineering applications.

Because of its compact design and little maintenance requirements, it is very popular in heating and cooling processes. Despite its simple geometry, the mechanism that produces the temperature separation inside the tube is fairly complicated.

A number of observations and theories have been explored by different investigators concerning this phenomenon. This report goes over some of the major conclusions found from experimental and numerical studies since the vortex tube's invention. One of these studies showed that acoustic streaming caused by vortex whistle plays a large part in the Ranque-Hilsch. In addition, thermal and kinetic energy considerations have been used to explain temperature separation.

I. INTRODUCTION

The force known as friction may be defined as the resistance encountered by one body in moving over another. This broad definition embraces two important classes of relative motion: sliding and rolling. The ratio between this frictional force and the normal load is known as the coefficient of friction and is usually denoted by the symbol l: l = Ff/Fn. The magnitude of the frictional force is conveniently described by the value of the coefficient of friction.

The Laws of Friction:

1. The friction force is proportional to the normal load.
2. The friction force is independent of the apparent area of contact.
3. The friction force is independent of the sliding velocity.

Friction coefficient is characteristic of tribological system but is not material characteristic. The quantity known as the friction coefficient has long been used in science and engineering. It is easy to define but not easy to understand on a fundamental level. Conceptually, defined as the ratio of two forces acting, respectively, perpendicular and parallel to an interface between two bodies under relative motion or impending relative motion. Despite the fact that both static and kinetic friction coefficients can be measured with little difficulty under laboratory conditions. The former is called the static friction coefficient, and the latter, the kinetic friction coefficient. In the case of solid-on-solid friction (with or without lubricants), these two types of friction coefficients are conventionally defined as follows:

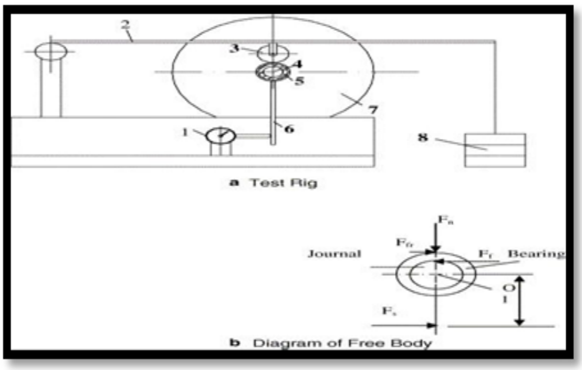
l ¼ F f=F n and l ¼ F k=F n;

where Ff is the force just sufficient to prevent the relative motion between two bodies, Fk is the forces needed to maintain relative motion between two bodies, and Fn is the force normal to the interface between the sliding bodies Friction coefficient as it is sometimes called, evolved from the work of many philosophers, scientist and engineers . These thinkers attempted to rationalize the sliding resistance between solid bodies with a universal law that explained observations of their day . Friction of metals varies at different conditions. If metal surfaces are cleaned in high vacuum and then placed in contact, strong adhesion is usually observed. The coefficient of friction under these conditions has a very high value. Solid lubricants and thin soft metallic films can provide valuable protection. For most common materials sliding in air, however, the value of l lies in the narrower range from about 0.1 to 1. This value is ten times less at vacuum condition. This situation comes from oxide films in air. Oxide films are also important in the friction of dissimilar metals and alloys in air. In general, the coefficient of friction for an alloy tends to be rather less than that for its pure components. When the temperature of sliding metals increased, several effects will occur: its mechanical properties will change, its rate of oxidation will increase, and phase transformations may take place. All these will influence its frictional behaviourIt has been determined by studies at sintered self-lubricating bronze bearings that additional oil at bearing considerably decreased friction coefficient especially at high velocities and pressures. In addition, it has been seen that friction coefficient decreased more by additional additive. In addition, effects of loads, spindle speed and oil types influence on friction coefficient. In this study, friction coefficient has been determined by a new approach with a radial journal bearing test rig. Copper based materials have been used as bearing material. Effects of friction coefficient have been examined at different conditions.

II. EXPERIMENTAL SETUP

4.1Experimental Test rig

In this study, the system is formed from a weight pressed by a rigid bar and a steel bar to the bearing tied from a distance and a comparator. Friction coefficient is determined from the friction force formed along the rotating direction of the bearing and from the movement of the steel bar tied to the bearing. Measuring principle of the friction coefficient has been illustrated.



Radical journal bearing wear test rig. (a) Test rig:
(1) comparator (2) rigid bar, (3) rolling bearing, (4) journal, (5) bearing, (6) sheet,
(7) motor (8) weight and (b) diagram of free body. If we take the moment to point O to determine the friction coefficient (Fig. (b))

XMo ¼ 0;
F fsd=2
F sl ¼ 0
F f ¼ 2F sl=d;
F s ¼ kx an
F f ¼ 2kxl=d;
(4)

equation 1 where Ffr is rolling friction force is neglected because it is too small; Ff, friction force; Fn, normal force; Fs, spring force; k, spring coefficient; d, diameter of bearing; I, spring force– distance of central bearing and x, movement of comparator Ff = 2kxl/d happens. k = 0.11 (N/mm), diameter of journal d = 10 mm, l = 100 mm, Ff = 2.2x and l = 50 mm, Ff = 1.1x happens. If movements obtained from comparator are written instead of x, friction force can be determined. If it is placed in equation Ff = lFn, friction coefficient can be calculated. For experiments of lubricated conditions, very little movement has taken place for high comparators spring coefficient and low friction. For this reason, a tensile spring of k = 0.004 N/mm has been tied opposite to the comparator. Movements formed by the effect of the friction force have been measured by this method. If l = 50 mm, then Ff = 0.04x.

4.2. Experimental studies

experiments of bronze bearing, inner diameter d = 10 mm, width B = 10 mm, outer diameter D = 15 mm have been used as basic friction element DIN 1705 CuSn10 and SAE 1050 steel journal of diameter d = 10 mm has been used as opposing friction element. Experiments have been carried out for 25min repeating every 5min. Experiments have been repeated at 4.905N, 9.81 N loads and 1200, 1400,1600,1800,2000 rpm at dry and lubricated conditions. Results of these experiments are v = 0.392 m/s velocity, 3532.5 m sliding distance at n = 750 rpm and v = 0.785 m/s velocity, 7065 m sliding distance at n = 1500 rpm. The roughness of CuSn10 bronze is approximately Ra = 1.5 lm and the roughness of SAE 1050 steel journal is Ra = 0.5 lm. The friction force and friction coefficient have been calculated for every 5 min.

4.3Working Principle:

Bearings materials in journal bearings are generally selected from materials which have lower wear strength than the shaft material, and this lowers the wearing of the shaft significantly. Therefore, journal bearing wear test apparatus is designed to examine the wearing of bearing materials. In this study, a special bearing wear test apparatus has been designed to examine the wearing behaviour of bearing material and the shaft together. Therefore, it is possible to investigate different bearing and shaft materials and the effects of heat treatments on these materials. Such a mechanism provides lower wear of bearings as compared to traditional methods. The system is formed by a weight applied by a rigid bar, a steel bar connected to the bearing by a comparator. Friction coefficient is determined from the friction force formed along the rotating direction of the bearing and from the movement of the steel bar connected to the bearing. For Copper bearings, very little movement was taken place for high comparator's spring coefficient and low friction in the experiments under dry conditions. Therefore, a tensile spring of k = 0.011 N/mm has been connected on the opposite side of to the comparator. The movements formed by the effect of the friction force have been measured by this method.

FIG 4.2:Test rig

III. EXPERIMENTAL OBSERVATION

Table No.1 For Brass Bearing

Sr. no	Weight (N)	Speed (rpm)	Displacement (mm)				
			5 min	10 min	15 min	20min	25min
0	0	1200	0.01	0.01	0.01	0.01	0.01
1	4.905	1200	0.11	0.1	0.08	0.07	0.07
2	4.905	1400	0.12	0.11	0.11	0.11	0.11
3	4.905	1600	0.1	0.09	0.8	0.8	0.8
4	4.905	1800	0.09	0.09	0.08	0.07	0.07
5	4.905	2000	0.08	0.08	0.07	0.06	0.06
1	9.81	1200	0.11	0.10	0.09	0.08	0.08
2	9.81	1400	0.09	0.08	0.08	0.07	0.07
3	9.81	1600	0.08	0.08	0.07	0.07	0.07
4	9.81	1800	0.08	0.07	0.07	0.06	0.06
5	9.81	2000	0.07	0.06	0.06	0.05	0.05

CALCULATIONS

Friction force:

XMo ¼ 0;
F fsd=2
F sl ¼ 0
F f ¼ 2F sl=d;
F s ¼ kx and

F f ¼ 2kxl=d;
Ff= 2kxl=d;

Normal force :

Ff=W.

Coefficient of friction :

$$\mu = \frac{Ff}{Fn}$$

IV. RESULT AND DISCUSSION

Journal bearing samples were worn under 4.905, 9.81 N loads and at 1200, 1400,1600,1800,2000 rpm for every 5 min, totally 25min, at dry conditions.When journal began to rotate, and friction force caused a movement at comparator. Friction force was calculated from the equations using this movement (x). Friction coefficient was determined as a function friction force and applied load. This friction coefficients have been illustrated in quite higher friction coefficients l = (0.004-0.012) were obtained at dry condition experiments. As a result, excessive wears were observed at samples.

Table No 2 For Brass Bearing Condition

Sr. no	Weight (N)	Speed (rpm)	Coefficient of friction				
			5min	10min	15min	20min	25min
0	0	1200	0.0	0.0	0.0	0.0	0.0
1	4.905	1200	0.024	0.022	0.0175	0.0154	0.0154
2	4.905	1400	0.026	0.024	0.022	0.024	0.024
3	4.905	1600	0.022	0.0196	0.0175	0.0175	0.0175
4	4.905	1800	0.0196	0.0196	0.175	0.0159	0.0159
5	4.905	2000	0.0175	0.0175	0.0154	0.0131	0.0131
1	9.81	1200	0.012	0.011	0.0098	0.0088	0.0088
2	9.81	1400	0.0098	0.0088	0.0088	0.0077	0.0077
3	9.81	1600	0.0088	0.0088	0.0077	0.0077	0.0077
4	9.81	1800	0.0088	0.0077	0.0077	0.0066	0.0066
5	9.81	2000	0.0077	0.0066	0.0066	0.0055	0.0055

CONCLUSION

In this study, a new test rig and method have been developed for measuring coefficient of friction at journal bearings. By this method, friction coefficients have been calculated at different loads and velocities at journal bearings. Repeatability of the results shows the suitability of the test rig and the method. As mentioned in the literature, high friction coefficients and high wears have been observed at dry test conditions. Low friction coefficients and low wears have been observed at lubricated test conditions. In addition, friction coefficient has been determined as a function normal force and friction force. Friction force increases by increasing load and velocity. At the beginning of the motion because of the dry friction, the friction coefficient increases and later decreases. As the load increases, friction coefficient decreases at dry condition. But at lubricated condition, friction coefficient increases by increasing load because of decreasing oil film thickness. Finally, bearing temperature increases by increasing load and velocity. Friction force is approximately stable by increasing time.

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