Mohamad Ali Ahmad, & Salmiah Kasolang. (2019). Test rig: Characterisation of journal bearing. Mytribos Symposium, 3, 40-43

Mytribos Symposium
Friction is not a devil

This paper was presented at the 3rd Mytribos Symposium,
Universiti Malaysia Perlis, Kampus Pauh Putra, Arau, Perlis on 29th April 2019

Test rig: Characterisation of journal bearing

Mohamad Ali Ahmad[1,*], Salmiah Kasolang[1]
[1] Faculty of Mechanical Engineering, Universiti Teknologi MARA, 40450 Shah Alam Selangor.

KEYWORDS
Temperature Profile
Pressure Profile
Friction Coefficient
Film Thickness
Viscosity Profile

ABSTRACT
The journal bearing can be represented by a plain cylindrical sleeve (bushing) wrapped around the journal (shaft), but the bearing can adopt variety of forms. It consists of two main components. The shaft in the middle is the journal and the part enveloping the shaft is the bearing, which is also known as the bush. The housing or the sleeve is to support the journal bearing structure. In current study, journal bearing test rig was developed to study oil behaviour characteristics. The benefits of test rig such as applicability to multiple or repetitive tests, wide range of operation, possibility of performing extreme value tests safely, possibility of using accurately adjusted bearing loads, possibility of studying different variables separately and possibility of performing demanding measurements is the key factors of test rig selection.

1. Introduction

The use of journal bearing is critical in most machines. Journal bearings were used to support shafts and to carry radial loads with minimum power loss and minimum wear. The journal bearing can be represented by a plain cylindrical sleeve (bushing) wrapped around the journal (shaft), but the bearing can adopt variety of forms. The lubricant is supplied at some convenient point in the bearing through a hole or a groove. If the bearing extends around the full 360º of the journal, it is described as a "full journal bearing." If the angle of wrap is less than 360º, the term "partial journal bearing" is used.

A schematic of the general features in a plain journal bearing is shown in Figure 1 as adapted from [1]. It consists of two main components. The shaft in the middle is the journal and the part enveloping the shaft is the bearing, which is also known as the bush. The housing or the sleeve is to support the journal bearing structure. The journal diameter *(D)*, the bearing internal diameter *(d)*, length *(L)*, and radial clearance *(C)* are important criteria. The values and relative proportions of these parameters play an important role in the capacity and performance of the journal bearing in actual applications.

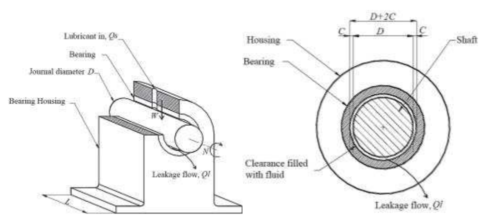

Figure 1: Journal bearing geometry and nomenclature (adapted from [1]).

An important parameter in journal bearing operation is its eccentricity, *e*. It is the distance between the centre of the journal (O_j) and the centre of the bearing (O_B) as shown in Figure 2. The line passing through both O_j and O_B is called the centre line. The positions of Oj relative to O_B for three initial stages in a journal bearing operation are illustrated in Figure 2. An idle position is shown in Figure 2(a) where the journal is in contact with the bearing with the line of contact opposing to the load and the distance between O_j and O_B is equal to the radial clearance, *C*. At start up in Figure 2(b), mixed lubrication prevails, and the journal is displaced and slide in the interior of the bearing in the opposite rotational direction. As the fluid wedge becomes established and lift speed is attained, the journal starts to assume the position in Figure 2(c).

* Corresponding author:
nurrinarosli@ump.edu.my

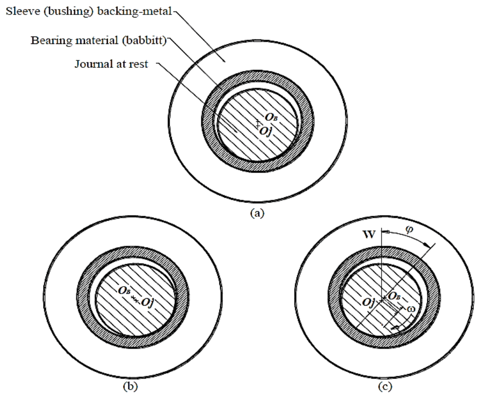

Figure 2: Schematic diagram of bearing positions at (a) start-up, (b) no load and (c) steady running conditions.

The film thickness around the journal bearing is given by,

$$h = C + e\ cos\theta \quad (1)$$

where, C is the radial clearance
e is the eccentricity
θ is the angular position

The eccentricity ratio, e, is often determined from the operating conditions of a journal bearing.

In current study, journal bearing test rig was developed to study oil behavior characteristics. The benefits of test rig such as applicability to multiple or repetitive tests, wide range of operation, possibility of performing extreme value tests safely, possibility of using accurately adjusted bearing loads, possibility of studying different variables separately and possibility of performing demanding measurements is the key factors of test rig selection. Therefore, in many cases of bearing research studies, the optimum and best way to obtain knowledge is to carry out an experimental work.

An experimental work using the test rig is also typically performed as preliminary studies and tests before bearing are tested in the machinery or in the field, as well as for verifying bearing calculations. Typically, the benefits of experiments by test rig depend on the benefits of the bearing test apparatus. Versatility, wide operating range, applicability to true scale experiments with realistic bearing loads, and advanced control and measuring systems are some critical requirements of bearing test apparatus.

2. Methodology

Normally, a test rig consists of a frame unit, a bearing unit and loading, drive unit, lubrication system, system controller and measuring systems. Most of the main components of the test rig were installed within the frame unit. Generally, the frame unit is relatively rigid to avoid disturbing by deformations and vibrations. The bearing unit consists of the bearing, housing, shaft and bearing supporting system. The housing, which the bearing is placed for testing normally, has a simplified cubic or cylindrical design, but housings of real types have also been used. For example, [2] has used a real type of bearing housing for simulation of a connecting rod big end. A large high precision roller bearing with both radial and axial load carrying capacity is a common supporting bearing type used in low and medium speed applications. These have been used, for example, by [3]. In high speed or extreme load applications, sliding bearings have been used as an alternative, for example by [4, 5]. The shaft is typically supported on both sides of the bearing, but single side support solutions have also been used, for example by [6]. Tanaka (2000).

The journal bearing test rig, used in this study is shown in Figure 3.

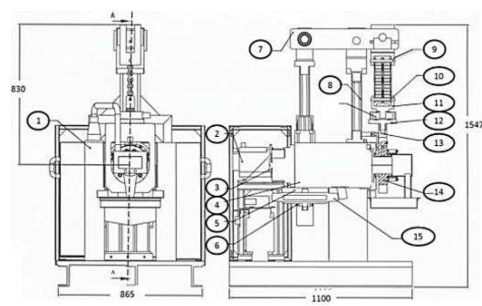

Figure 3: An assembly diagram of journal bearing test rig. 1) Frame, 2) Motor, 3) Motor bracket, 4) Spindle assy. 5) Bellow top plate, 6) Bellow guide plate, 7) Loading Lever, 8) Pivot assembly, 9) Chain, 10) Chain holder, 11) Load Cell holder, 12) Load Cell, 13) Loading plate, 14) Bearing unit and 15) Pneumatic bellows.

The test rig was fabricated and assembled by Ducom Inc based in Bangalore India. The frame of the bearing test rig consists of a base plate and two firm angular beams with housings for the journal assembly. The width, length and height of the frame are about 0.9, 1.1 and 1.5 m, respectively. The journal is mounted horizontally on self-aligned bearings as shown in Figure 4. It is rotated by the servo motor with timer belt of 2 over 1 pulley ratio.

The journal or shaft is tightened to spindle by a draw bolt. The spindle is mounted to the inside housing rotating on taper roller bearings.

A centrifugally casted flawless bearing made from brass materials was freely slides over journal with clearance of 104-micronmeter. Hydrodynamic lubrication mechanism is formed as it rotates. The load is introduced by pulling up the bearing upwards. This radial force is applied by a loading lever having 1 to 2 ratios of mechanical advantages. This loading lever was pulled down by pneumatic bellow which fixed at the below of spindle housing.

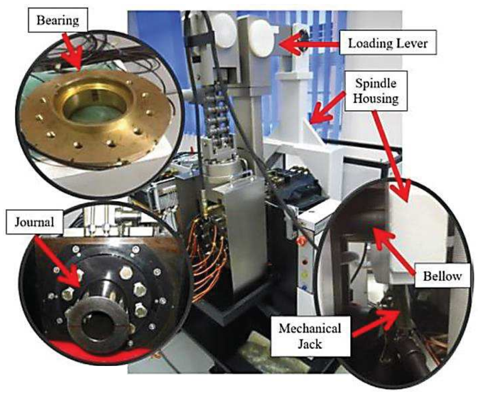

Figure 4: An assembly of journal bearing test rig.

3. Results

The behaviour of hydrodynamic lubrication in journal bearing has been investigated for varying speeds, loads, oil inlet pressure and groove locations.

The measurement of temperature profiles, pressure profiles and friction coefficient at specific speed for different loads and at a specific load for different speeds was reported in [7-15].

Temperature profile in journal bearing can be presented as shown in Figure 5.

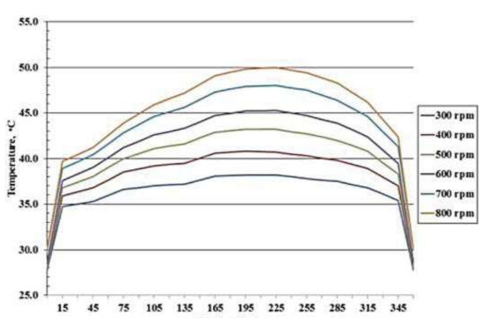

Figure 5: Oil temperature profiles in journal bearing at 10kN load for speeds of 300, 400, 500, 600, 700 and 800 rpm.

Pressure profiles for different loads for hydrodynamic lubrication journal bearing are shown in Figure 6. Theoretically, increasing the loads at the same speed tends to increase the maximum pressure profile. As shown in Figure 6, the pressure in the journal bearing increases as the bearing angle increases up until the maximum pressure position. Beyond, the pressure starts to decrease and becomes negative after the pressure termination position.

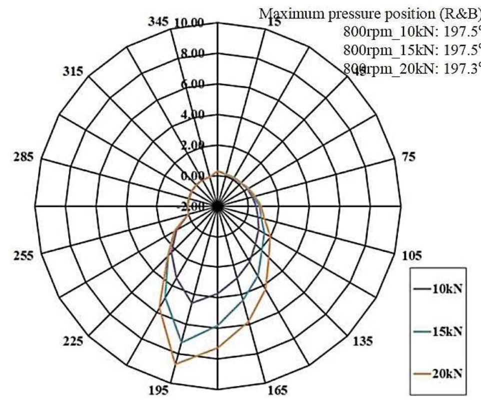

Figure 6: Oil pressure profiles of journal bearing at 800 rpm for speed of 10kN, 15kN and 20kN.

4. Conclusion

An experimental work using the test rig is also typically performed as preliminary studies and tests before bearing are tested in the machinery or in the field, as well as for verifying bearing calculations. Typically, the benefits of experiments by test rig depend on the benefits of the bearing test apparatus. Versatility, wide operating range, applicability to true scale experiments with realistic bearing loads, and advanced control and measuring systems are some critical requirements of bearing test apparatus. The benefits of test rig such as applicability to multiple or repetitive tests, wide range of operation, possibility of performing extreme value tests safely, possibility of using accurately adjusted bearing loads, possibility of studying different variables separately and possibility of performing demanding measurements is the key factors of test rig selection.

Acknowledgment

The authors would like to express gratitude to Institute of Research Management & Innovation (IRMI) of Universiti Teknologi MARA for the Research University Grant, LESTARI (087/2017), Faculty of Mechanical Engineering UiTM, and Ministry of Education Malaysia for their support.

References

[1] Booser, E. R. (2008). Applied tribology: bearing design and lubrication. John Wiley & Sons.

[2] Dowell, J. P. (2004). Thermal cracks in diesel engine crankshafts (Doctoral dissertation, Case Western Reserve University).

[3] Savaşkan, T., Pürçek, G., & Murphy, S. (2002). Sliding wear of cast zinc-based alloy bearings under static and dynamic loading conditions. Wear, 252(9-10), 693-703.

[4] Okamoto, Y., Kitahara, K., Ushijima, K., Aoyama, S., Xu, H., & Jones, G. J. (2000). A study for wear and fatigue on engine bearings by using EHL analysis. JSAE review, 21(2), 189-196.

[5] Zhou, H., Zhao, S., Xu, H., & Zhu, J. (2004). An experimental study on oil-film dynamic coefficients. Tribology International, 37(3), 245-253.

[6] Tanaka, M. (2000). Journal bearing performance under starved lubrication. Tribology International, 33(3-4), 259-264.

[7] Ahmad, M. A., Kasolang, S., & Dwyer-Joyce, R. S. (2014). Experimental study on the effects of oil groove location on temperature and pressure profiles in journal bearing lubrication. Tribology International, 74, 79-86.

[8] Kasolang, S., Ahmad, M. A., Joyce, R. D., & Tai, C. F. M. (2012). Preliminary study of pressure profile in hydrodynamic lubrication journal bearing. Procedia Engineering, 41, 1743-1749.

[9] Ahmad, M. A., Kasolang, S., & Dwyer-Joyce, R. (2013). The effects of oil supply pressure at different groove position on frictional force and torque in journal bearing lubrication. Procedia Engineering, 68, 70-76.

[10] Ahmad, M. A., Kasolang, S., & Dwyer-Joyce, R. (2013). Experimental Study of Oil Supply Pressure Effects on Bearing Friction in Hydrodynamic Lubrication. In Applied Mechanics and Materials (Vol. 315, pp. 977-981). Trans Tech Publications.

[11] Ahmad, M. A., Kasolang, S., Dwyer-Joyce, R. S., & Jumahat, A. (2013). The Effects of Oil Supply Pressure at different Groove Position on Temperature and Pressure Profile in Journal Bearing. Jurnal Teknologi, 66(3).

[12] Ahmad, M. A., Kasolang, S., & Ghani, J. A. (2015, November). Effects of oil groove location on viscosity profile in hydrodynamic lubrication journal bearing. In Proceedings of Malaysian International Tribology Conference 2015 (Vol. 2015, pp. 318-319). Malaysian Tribology Society.

[13] Kasolang, S., Ahmad, M. A., Dwyer-Joyce, R., Jaffar, A., Bakar, M. A. A., Saad, N. H., & Jumahat, A. (2012). Experimental Study of Temperature profile in a Journal Bearing. pdf. In 1st Joint Symposium on System-Integrated Intelligence: New Challenges for Product and Production Engineering (pp. 43-45).

[14] Ahmad, M. A., Kasolang, S., Dwyer-Joyce, R., & Bakar, M. A. A. (2013). The Effects of Oil Groove Position on Torque and Frictional Force in Hydrodynamic Journal Bearing. In Applied Mechanics and Materials (Vol. 393, pp. 907-912). Trans Tech Publications.

[15] Zulhanafi, P., Syahrullail, S., & Ahmad, M. A. (2018, September). The performances of palm mid olein as lubricant in journal bearing application. In Proceedings of Asia International Conference on Tribology 2018 (Vol. 2018, pp. 382-383). Malaysian Tribology Society.