Seizure Time of Journal Bearing with Varying Parameters for Different Materials

Mr. Davulury Sri Harsharam
Student, Department of Mechanical,
CBIT College, Hyderabad, India,
Harsharam.d@gmail.com

Dr. G. V. R. Seshagiri Rao
Professor, Department of of Mechanical,
Institute of Aeronautical Engineering College,
Hyderabad, India

ABSTRACT
The current trend of modern industry is to use hydrodynamic journal bearings machineries rotating at high speed and carrying heavy rotor loads. When a bearing operates at high speed, the heat generated due to large shearing rates in the lubricant film raises its temperature. The study is performed to find out optimum model based on three parameters namely Internal radius (Ri), Length of Journal(L) and Clearance(C) for different materials i.e., Cast Nylon, Gun metal, Steel and Brass. Equations are derived for the rate of heat generation and for the rate of heat dissipation in terms of factors of construction and operation. Three dimensional models are created in CATIA and transient thermomechanical analysis is performed for every model in ANSYS. Seizure times of the journal in the bearing are noted to find out optimum parameter to ensure the optimum material for Journal Bearing.

Keywords
Journal bearing, Hydrodynamic bearing, oil film, CATIA, ANSYS.

1. INTRODUCTION
The past decade has seen a considerable advance in the science of journal-bearing lubrication. A number of mathematical and analytical treatments have extended the knowledge of the mechanics of the load-carrying oil film, and experimental investigations have justified the concept of such a film as a basis fOT design and have also provided correction factors for use in applying theoretical relations. The problem of bearing design, however, is complicated by the fact that a journal bearing not only is required to support its load under all conditions of operation, but also in many applications must provide means for dissipating the heat generated in shearing the film of lubricant. With bearings operating at moderate loads and speeds, the heat generated in the bearing usually is small in comparison with the capacity of the bearing for heat dissipation, and the prime consideration in design is to insure that the bearing shall operate with a complete film of lubricant between the surfaces.

2. HEAT GENERATED IN JOURNAL BEARING
The rate of heat generation is expressed as
H=k1fΠDN------1
by using the fundamentals which may also be written as
H=k1ΠfPLD2N --------------2

Values for *f*, the coefficient of friction, for a given bearing at various operating conditions may be computed from theoretical hydro dynamical equations

f= k2 (ZN/P) (D/C), +Δf--------3 -------------- (3)

In this equation k2 is equal to 473E-10 when the units given in the list of symbols are employed. D= journal diameter,

L= bearing length, C= running clearance,

P= *W/LD* = pressure on projected area of bearing, W=total load acting on bearing,

Δf =correction factor, function of length-diameter ratio, (ZN/P)= Bearing Characteristic Number,

Z=Absolute viscosity of the lubricant kg/m-s,

N=speed of the Journal R.P.M,

P=Bearing Pressure N/mm^2

k1=mechanical equivalent of heat and k2=coefficient in equation.

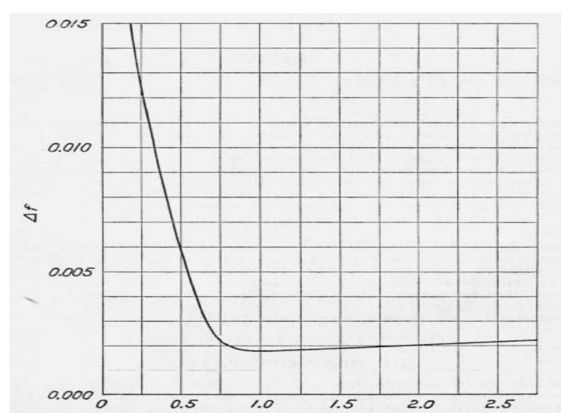

Figure 1: Values of f for Various LID Ratios

using above theoretical calculations , heat flow and heat flux values are calculated for five different parameter varying in inside radius of bearing ,length of bearing and clearance between bearing and shaft and parameter, values are noted in table below.

Table 1: Heat flow and heat flux values

R_i	L	C	FINAL HEAT	Area	Flux
35	50	0.10	55.099	152.638	0.360
35	70	0.10	77.139	213.694	0.360
35	90	0.10	99.179	274.750	0.360
35	100	0.10	110.199	305.277	0.360
35	120	0.10	132.238	366.333	0.360
35	50	0.10	55.099	152.638	0.360
40	50	0.10	82.247	174.444	0.471
50	50	0.10	160.640	218.055	0.736
60	50	0.10	277.586	261.666	1.060
75	50	0.10	542.160	327.083	1.657
35	50	0.10	55.099	152.638	0.360
35	50	0.15	52.664	152.638	0.345
35	50	0.20	51.446	152.638	0.337
35	50	0.30	50.229	152.638	0.329
35	50	0.35	49.881	152.638	0.326

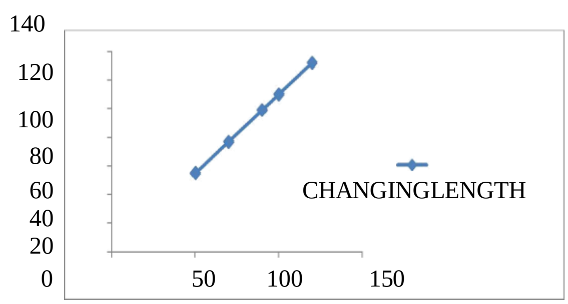

Figure 2: Heat flow at changing length (L)

The above graph is for relation between bearing length and heat flow. In that heat flow is increase with increasing the length of bearing and it was varying from 40 w to 140 w.

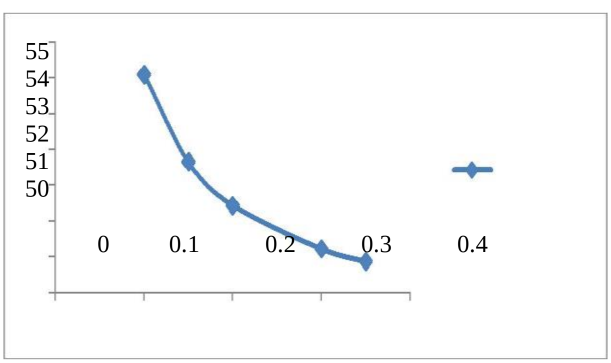

Figure 3: Heat flow at changing clearance (C)

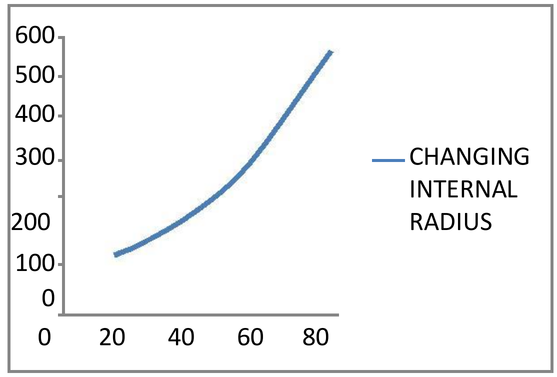

Figure 4: Heat flow at changing bearing radius (ri)

The above graph is for relation between internal radius and heat flow. In that heat flow is increases with increasing the internal radius of bearing. And it was varying from 40 w to 600 w.

2. HEAT DISSIPATED

In self-cooled bearings the heat is dissipated to the surroundings by a combination of radiation, convection, and conduction. Some heat also is carried away by the oil flowing through the bearing. The influence of these factors will vary with different types of bearings and different operating conditions. The available experimental data on the heat dissipation of bearings are not of such scope as to provide a rigorous evaluation of the factors involved. There is some indication; however, that with some types of bearings the rate of heat dissipation may be approximately represented as: The value for the over-all coefficient of beat dissipation k3 will depend upon many factors, including the convection currents present. Some data indicate that when the bearing is in a strong draft the value of ka may be 3 or 4 times as great as when the bearing is in still air.

3. THERMALLY INDUCED SEIZURE IN JOURNAL BEARINGS DURING START UP

Thermally induced seizure (TIS) in journal bearings is a mode of failure that can occur quite suddenly and end up with a catastrophic damage to the system. Although TIS can take place in lubricated bearings, it is predominant when a hydrodynamic bearing happens to operate in the boundary or mixed lubrication regimes. These conditions occur during start-up or in an event of lubricant supply blockage. A significant amount of work has been reported that analyzed the thermo mechanical interactions in stationary loaded bearings susceptible to TIS. Bishop and Ettles analyzed the thermo elastic interaction of a journal in a plastic bushing that is interference-fit with the shaft. The seizure criterion was based on a cut-off temperature. When the surface temperature of the shaft or the bushing reaches 320o C above the ambient temperature, the shaft is assumed to seize in the bearing. A critical PV/C number was proposed to be an influential Parameter for assessing the seizure time. Dufrane and Kannel analyzed the catastrophic seizure of bearings due to dry friction by a simple 1D equation relating the seizure time to the bearing operating parameters and material properties. A series of experiments were also conducted to determine the seizure time CATIA is software which is used for creation and modifications of the objects. In CATIA, design and modeling feature is available. Design means the process of creating a new object or modifying the existing one. Drafting means the representation or idea of the object. Modeling means create and converting 2D to 3D. By using CATIA software, model of the journal bearing assembles is created. Here all parts are created by using pad, pocket and constrain commends and shaft and bearing parts are assembled using contact and offset constrains. And final model is saved as I.G.E.S. format.

4. LITERATURE REVIEW

Jun Wang et al (1) The lubrication performance of journal bearings with different sorts of uniformly distributed micro-spherical textures are studied in this paper. Geometries and dynamic models of journal bearings with pure concave/convex textures are developed. The validity of the proposed models is verified against the oil film pressure distribution from the literature. The effects of geometry parameters (the texture depth and the area density) on the load capacity and the friction coefficient of the bearing are analyzed and discussed.

N.B. Naduvinamani et al [2] presents the theoretical study of the effect of surface roughness on the hydrodynamic lubrication of porous step-slider bearings. A more general form of surface roughness is mathematically modeled by a stochastic random variable with non-zero mean, variance and skewness. The numerical computations of the results show that the negatively skewed surface roughness pattern increases the load carrying capacity and decreases the coefficient of friction whereas the adverse effects were found for the positively skewed surface roughness pattern.

A steady-state thermo hydrodynamic analysis of an axial groove journal bearings in which oil is supplied at constant pressure is performed theoretically [3]. Thermo hydrodynamic analysis requires simultaneous solution of Reynolds equation, energy equation and heat conduction equations in the bush and the shaft. From parametric study it is found that the temperature of the fluid film raises due to frictional heat thereby viscosity, load capacity decreases. Increased shaft speed resulted in increased load carrying capacity, bush temperature, flow rate and friction variable. It is difficult to obtain the solution due to numerical instability when the bearing is operated at high eccentricity ratios.

Kim Thomsen et al [4] gives a numerical simulation presented for the thermo-hydrodynamic selflubrication aspect analysis of porous circular journal bearing of finite length with sealed ends. It consists in analyzing the thermal effects on the behavior of circular porous journal bearings. The effects of dimensionless permeability parameter and eccentricity ratio on performance parameters are presented and discussed.

M. Fillon et al [5] deal with the friction coefficient during running, given a constant rotational speed. In order to understand the mechanisms occurring during the transition between mixed lubrication and hydrodynamic lubrication, several studies have been conducted over the past three years. The aim of this paper is to provide an overview of the results of these studies and also to draw several general conclusions on the behavior of a plain journal bearing during start-up. The main focus of this work is then to provide useful experimental data for bearing users and designers.

Joon Young Jang and Michael M. Khonsari (6) load, deflection of the shaft, manufacturing and assembly errors, improper installation, and asymmetric loading. During operations, misalignment has a considerable effect on the static and dynamic performances. It could cause wear, vibration and even system failure. In this article, a literature review of misalignment of the journal bearings is presented.

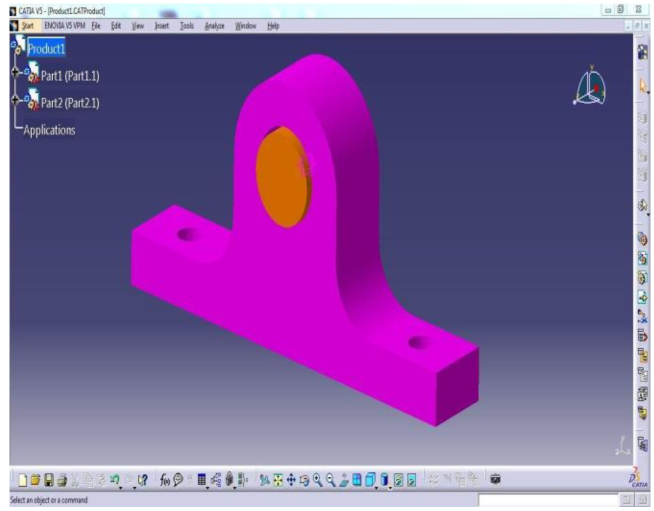

Figure 5: Journal bearing model created in CATIA V5 R20

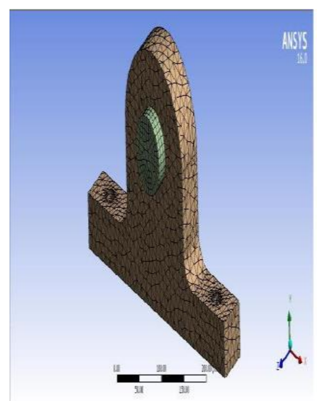

Figure 6: Finite element model

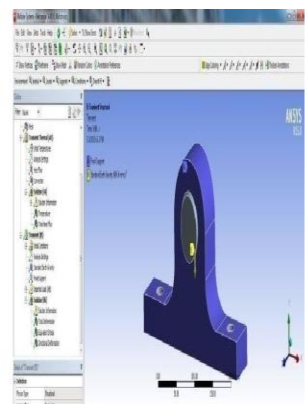

Figure 7: Boundary condition

Results for steel material, 40 mm shaft radius

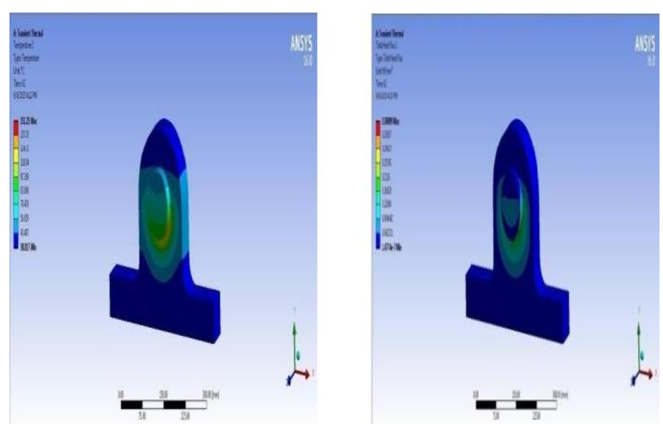

Figure 8: Figure for temp (seizure time 60sec)

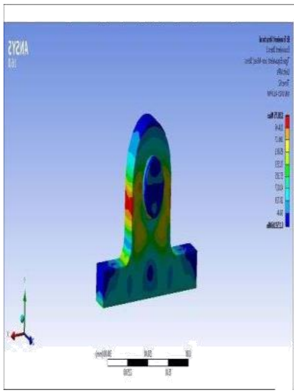

Figure 9: Deformation (seizure time)

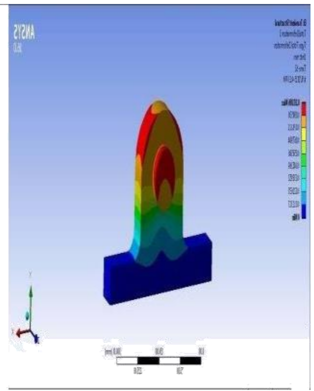

Figure 10: Stresses (seizure time60sec)

5. REVIEW THE RESULTS

Once the solution has been calculated, we can use the ANSYS postprocessor to review the results. Two postprocessors are available: POST1 and POST 26. We use POST 1, the general postprocessor to review the results at one sub step over the entire model or selected portion of the model. We can obtain contour displays, deform shapes and tabular listings to review and interpret the results of the analysis. POST 1 offers many other capabilities, including error estimation, load case combination, calculation among results data and path operations. We use POST 26, the time history post processor, to review results at specific points in the model over all time steps. We can obtain graph plots of results, data vs. time and tabular listings. Other POST 26 capabilities include arithmetic calculations and complex algebra. In the solution of the analysis the computer takes over and solves the simultaneous set of equations that the finite element method generates, the results of the solution are Nodal degree of freedom values, which form the primary solution Derived values which form the element solution.

6. STRUCTURAL STATIC ANALYSIS

A static analysis calculates the effects of study loading conditions on a structure, while ignoring inertia and damping effects, such as those caused by time varying loads. A static analysis can however include steady inertia loads and time varying loads that can be approximated as static equivalent loads. Static analysis is used to determine the displacements, stresses, strains and forces in structures or components caused by loads that do not induce significant inertia and damping effects. Steady loading and response conditions are assumed, i.e. the loads and the structure's responses are assumed to vary slowly with respect to time. The kinds of loading that can be applied in static analysis included.

Externally applied forces and pressures. Steady state inertial forces, Imposed displacement Temperatures Fluences (for nuclear swelling) ANSYS as software is made to be user friendly and simplified as much as possible with lots of interface options to keep the user as much as possible from the hectic side of programming and debugging process. Here model is imported by using I.G.E.S. File and different material properties are entered. Meshing is applied to Journal bearing assemble using tetrahedron and brick Mesh 200 elements, the model having 21539 nodes and 9818 elements. Fixed Boundary conditions are applied at bottom of bearing and heat flux is applied at shaft bottom face, convection boundary condition is applied are all the faces. Transient thermo mechanical analysis is performed and thermal readings are imported into structural analysis. Here deformation and stresses and temperature and heat flux reading are noted at seizure time.

Table 2: Results with Changing Length (Steel)

LENGTH	TIME	TEMP	FLUX	STRESS
50	82	134	0.310	203
70	83	138	0.269	134
90	75	136	0.273	153
100	70	133	0.262	139
160	60	128	0.277	174

Table 3: Results with Changing Length (Gun Metal)

LENGTH	TIME	TEMP	FLUX	STRESS
50	43.5	100	0.30	97.0
70	45	103	0.27	90.5
90	37	98	0.28	90.6
100	35	96.74	0.24	92.5
160	31	92.8	0.25	96.5

The above table shows results for gun materials with changing the length parameter from 50 mm to 160 mm. here if length increases seizure time is decreases. And temp is increasing with increasing length. Thermal stresses are decreases and all are in allowable limit. Maximum seizure time is 45 sec at 70 mm length. And minimum seizure time 31 sec at 160 mm shaft length

7. RESULTS AND DISCUSSION

Three dimensional models are created in CATIA and transient thermo mechanical analysis is performed for every model with considering heat flux and convection parameter in ANSYS. And Seizure times of the journal in the bearing are noted to find out optimum parameter to ensure the optimum material for Journal Bearing.

8. Results with changing lengths of shaft for (STEEL, GUN METAL, CAST NYLON and BRASS materials 60sec)

The above table shows results for steel materials with changing the length parameter from 50 mm to 160 mm. here if length increases seizure time is decreases. And temp is increasing with increasing length. Thermal stresses are decreases and all are in allowable limit. Maximum seizure time is 82 sec at 50 mm length. And minimum seizure time 60 sec at 160 mm shaft length.

9. CONCLUSION

When rotating machinery that is supported on fully lubricated bearings is started up from rest, the lubrication flow may not have been established and there would be metal-to-metal contact. The effect of the dry sliding during start-up was analyzed by studying the effect of start-up friction on the bearing operating parameters such as clearance loss and frictional torque by a thermo elastic finite element model. A series of simulations were performed by varying the geometrical parameters. A statistical analysis was performed using the simulated results to determine the relationship of these geometrical parameters on the seizure time. Temperature reduces with increasing the length of bearings and radius of shaft. Steel and nylon cast material having more seizure time as compared to remaining materials. Seizure time increases with increasing clearance and reducing the shaft

REFERENCES

[1] Jun Wang, Junhong Zhang, Jiewei Lin and Liang Ma ‘ Study on Lubrication Performance of Journal Bearing with Multiple TextureDistributions” Applied Sciences (ISSN 2076-3417; CODEN: ASPCC7) is an international peer-reviewed open access journal on all aspects of applied natural sciences published semi-monthly online by MDPI. Published: 6 February 2018

[2] N.B. Naduvinamani, A. Siddangouda; Effect of surface roughness on the hydrodynamic lubrication of porous step-slider bearings with couple stress fluids; Tribology International, Volume 40, Issue 5, Pages 780-793, May 2007

[3] U.Singh, L. Roy, M. Sahu; Steady-state thermo-hydrodynamic analysis of cylindrical fluid film journal bearing with an axial groove; Tribology International, Volume 41, Issue 12, December 2008, Pages 1135-1144

[4] S. Boubendir, S. Larbi, R. Bennacer; Numerical study of the thermo-hydrodynamic lubrication phenomena in porous journal bearings; Tribology International, Volume 44, Issue 1, Pages 1-8, January 2011

[5] J.Bouyer, M.Fillon; Experimental measurement of the friction torque on hydrodynamic plain journal bearings during startup;Tribology International, Volume44,Issues 7-8,pages 772-781,July 2011.

[6] Joon Young Jang and Michael M. Khonsari “On the Characteristics of Misaligned Journal Bearings” Lubricants (ISSN 2075-4442; CODEN: LUBRCF) is an international peer-reviewed open access journal of tribology.

