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Analysis Of Hydrodynamic Journal Bearing With Various Types Of Lubricants For Pressure Distribution

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ABSTRACT

A Journal bearings are widely applied in different rotating machineries. These bearings allow for transmission of large loads at mean speed of rotation. There are several types of journal bearing designs commonly used in machineries such as Hydrodynamic Journal bearing, which is based on hydrodynamic lubrication. Hydrodynamic lubrication means that the load-carrying surfaces of the bearing are separated by a relatively thick film of lubricant, so as to prevent metal-to-metal contact. The most important objectives of bearing design are to extend bearing life in machines, reduce friction energy losses and wear, and minimize maintenance expenses and downtime of machinery due to frequent bearing failure. From the Literature review and previous investigation, it is found that the cavitation area in hydrodynamic journal bearing is very essential area of investigation because it reduces the load capacity and leads to a risk of material damages. When a bearing operates at maximum speed, the heat generated due to large shear rates in the lubricant film increase its temperature, which decrease the viscosity of the lubricant and it affects the performance of journal bearing. Different combination of nano particle concentration is studied and it had been found that by addition of nanopartical, results in high viscosity, high pressure distribution and ultimately high load carrying capacity of journal bearing. The determination of the cavitation boundaries are important to get a realistic model of a hydrodynamic journal bearing with various nanofluid lubricants such as CO_2, TiO_2, ZnO, SiC and Al_2O_3. Studied the performance of the hydrodynamic journal bearing for the cavitation and pressure distribution. For Theoretical Analysis mostly summerfeld equation is used for finding the pressure distributation and Reynolds equation is used to get the cavitation location. From the previous research paper it is studied that various Experimental Analysis is done For finding the pressure distributation, cavitation location and cavitation shape. A Comparatively studied is done for the Theoretical Analysis and Experimental Analysis for various types of lubrication such as SAE30,SAE40 ,engine oil ,TiO_2,SiC and AL_2O_3.

KEYWORDS-Journal bearing tester, SAE20W50,AL_2O_3, Ducom software, Brass bearing, etc.

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I. INTRODUCTION

Moving parts in machinery involve relative sliding or rolling motion. Examples of relative motion are linear sliding motion, such as in machine tools, and rotation motion, such as in motor vehicle wheels. Most bearings are used to support rotating shafts in machines. Bearings can be classified according to their geometry related to the relative motion of elements in machinery. Examples are journal, plane-slider, and spherical bearings. A journal bearing, also referred to as a sleeve bearing, is widely used in machinery for rotating shafts. The term hydrodynamic bearing refers to a sleeve bearing or an inclined plane-slider where the sliding plane floats on a thin film of lubrication. The fluid film is maintained at a high pressure that supports the bearing load and completely separates the sliding surfaces. The lubricant can be fed into the bearing at atmospheric or higher pressure. The pressure wave in the lubrication film is generated by hydrodynamic action due to the rapid rotation of the journal. The fluid film acts like a viscous wedge and generates high pressure and load-carrying capacity. The load bearing capacity of hydrodynamic journal bearing get enhanced by addition of nanoparticle because of enhancement of viscosity of lubricant and in turn affect various performance characteristics of hydrodynamic solid journal bearings. Various metals and metal oxide nanoparticles have been studied as lubricant additives in thin film lubrication. These studies have reported reduced friction and wear in tribo-surfaces with the use of nanoparticle lubricant additives. Nano particles have received considerable attention because of their special physical and chemical properties. In recent years, with the development of nano materials, many scientific researchers added nano particles into lubricating oils to improve extreme pressure, anti-wear and friction reducing properties, and the efficiency and service life of machinery were improved and prolonged. The application of advanced nanomaterials has played an active role in improving and reforming traditional lubrication technology.

II. LUBRICANTS

SAE20W50

Description : HP 20W 50 grade is the premium quality motor cycle engine oil made to cater to the highly demanding lubrication requirements of modern Stroke geared bikes. HP 20W 50 is manufactured from the finest Group II base stocks and state of art additive technology to meet the most stringent requirements of API SL as well as JASO MA 2. HP 20W 50 provides superior protection for engine, clutch and gears of a motor cycle which helps you to derive the best performance from your bike all the time, while ensuring high engine durability.

Applications : HP 20W 50 grade is recommended for new generation geared 4-stroke bikes manufactured by most of the reputed manufacturers like Hero Motors, Bajaj, Yamaha, Honda, Suzuki, TVS, Royal Enfield etc.

Features & Benefits:

- High engine durability
- High fuel efficiency
- Low oil consumption
- Lower maintenance cost
- Longer oil and engine life

Physical and Chemical properties :

Kinematic viscosity @100 deg cent,cSt	: 18.0-20.0
Viscosity index	: 110
Flash point (COC) deg.cent,min	: 200
Pour point,deg.cent,max	: -18
TBN,mgKOH/g,min	: 4.19

III. ADDITIVES

Nanoparticles are being used more and more often in research and in industry, due to their enhanced properties compared to bulk materials. The benefits of nanoparticles can include increased electrical conductivity, toughness and ductility, and increased hardness and strength of metals and alloys.This article discusses the properties and applications of aluminum oxide nanoparticles. Aluminum is a Block P, Period 3 element, while oxygen is a Block P, Period 2 element.The morphology of aluminum oxide nanoparticles is spherical, and they appear as a white powder. Aluminum oxide nanoparticles (both liquid and solid forms) are graded as highly flammable and an irritant that can cause serious eye and respiratory irritation.Nano-scale Al_2O_3 spherical particles, prepared via a hydrothermal method and modified by silane coupling agent, can be well-dispersed in lubricating oil. The tribology properties of Al_2O_3 nanoparticles as lubricating oil additives have been studied by four-ball and thrust-ring friction test, which illustrate that the modified Al_2O_3 nanoparticles can effectively improve the lubricating behaviors compared to the base oil. When the added concentration is 0.1 wt%, the friction coefficient and the wear scar diameter are both smallest. The lubrication mechanism is that a self-laminating protective film is formed on the friction surface and the wear behavior changes from sliding friction to rolling friction.

How Are They Produced? What Do They Contain?

A lubricant consists of 70-100% base lubricants and up to 30% chemical compounds known as additives, which are fully mixed.

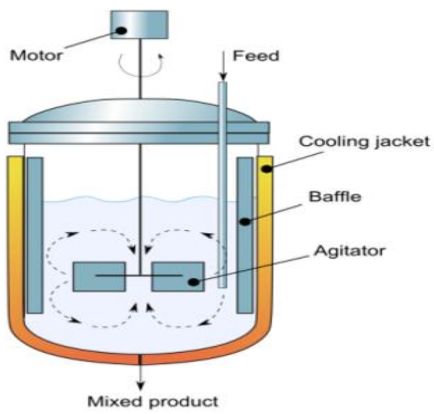

Fig.3.1 Mixing Of Lubricant SAE20W50 And Additive AL2O3

IV. LITERATURE REVIEW

(1) Surojit Poddar, et.al. studied the Detection of journal bearing vapour cavitation using vibration and acoustic emission technique with the aid of oil film photography. A journal bearing rig with transparent sleeve, a bronze bearing insert and an LED illuminator has been designed for rapid development of vapour cavitation and to carryout oil film photography.In addition to this, simultaneous photography of oil film has been carried out to evaluate changes in vapour bubbles under different stages of experiment. The captured photographs have been image-processed for better visualization of bubbles. The vapour cavitation of journal bearing has been experimentally studied using vibration,acoustic emission and oil film photography. Vibration has been measured in terms of RMS Velocity and

Acoustic Emission involves measurement of parameters: RMS, energy and peak frequency. The captured photographs have been image-processed using Mathematica software package for clear visualization of vapour bubbles. The evolution of vapour bubbles and its collapse during cavitation increases with increase in speed of journal; and there is relative decrease in size of bubbles with elevation of speed. Vapour cavitation involves generation of acoustic emission due to evolution of vapour bubbles and their subsequent collapse. This is a high frequency activity and is registered in AE measurement as scattered events.

(2) D.C.Sun, et.al. worked on the Simultaneous Pressure Measurement and High-Speed Photography Study of Cavitation in a Dynamically Loaded Journal Bearing Cavitation of the oil film in a dynamically loaded journal bearing was studied using high-speed photography and pressure measurement simultaneously. Comparison of the visual and pressure data provided considerable insight into the occurrence and non-occurrence of cavitation. It was found that cavitation typically occurred in the form of one bubble with the pressure in the cavitation bubble close to the absolute zero; and for cavitation-producing operating conditions, cavitation did not always occur; with the oil film then supporting a tensile stress. The appearance or absence of cavitation might be crucially dependent on the availability of cavitation nuclei in the oil. Where nuclei were not present, the oil could sustain tension without cavitation up to its tensile strength. Where nuclei were present, the tensile strength of the oil was annihilated and cavitation occured. The cavitation nuclei in the experiment were most likely the small air bubbles not thoroughly vented out of the test chamber.

(3) S. Natsumeda, et.al. studied Negative pressures in statically and dynamically loaded journal bearings The circumferential pressure distribution in a journal bearing is measured under static and dynamic loading. Compared with conventional pressure transducers a pressure pickup mounted in the journal has given more accurate results and yielded negative pressure o r tension as much as -1.2MPa (absolute) in the oil film. Two patterns are found in the pressure distribution: the one similar to the pressure curves calculated under separation boundary condition, and the other similar to the Sommerfeld's one. In order to expound the negative pressure o r tension, a hydrodynamic theory is developed regarding the lubricant as two-phase liquid of oil and small bubbles. Equation of motion for small spherical bubbles is solved taking into account surface-dilational viscosity.

(4) M. Riedel, et.al. done the Numerical investigation of cavitation flow in journal bearing geometry .The appearance of cavitation is still a problem in technical and industrial applications. Especially in automotive internal combustion engines, hydrodynamic journal bearings are used due to their favourable wearing quality and operating characteristics. Cavitation flows inside the bearings reduces the load capacity and leads to a risk of material damages. Therefore an understanding of the complex flow phenomena inside the bearing is necessary for the design development of hydrodynamic journal bearings. Experimental investigations in the fluid domain of the journal bearing are difficult to realize founded by the small dimensions of the bearing. In the recent years more and more the advantages of the computational fluid dynamics (CFD) are used to investigate the detail of the cavitation flows. The analysis in the paper is carried out in a two-step approach. At first an experimental investigation of journal bearing including cavitation is selected from the literature. The complex numerical model validated with the experimental measured data. In a secondstep, typically design parameters, such as a groove and feed hole, which are necessary to distribute the oil supply across the gap were added into the model. The paper reflects on the influence of the used design parameters and the variation of the additional supply flow rate through the feed hole regarding to cavitation effects in the bearing.

(5) Feng Cheng, et.al. studied A Velocity-Slip Model for Analysis of the Fluid Film in the Cavitation Region of a Journal Bearing. The Reynolds equation is derived by using the continuity equation, Navier-Stokes equation and slip length equation within cavitation region. A finite difference method are used to obtain the static and dynamic parameters of journal bearing. A comparison with the available experimental results reveals that the load capacity is well predicted by the present model. The results also show that slip effects in the cavitation region have an influence on the oil film pressure, the load capacity, the dynamic characteristics coefficients and the stability of journal bearing. The good behavior of the proposed algorithm is further illustrated in one example of a dynamically loaded journal bearing, and evolution with time of the journal center is well obtained. A velocity-slip model for analysis of the fluid film in a journal bearing, including slip length within the cavitation region and slip boundary conditions at the gas-liquid interfaces, has been developed, and well predicts the load capacity by the available experiment results.

(6) Roberto Ausas, et.al. done Study the Impact of the Cavitation Model in the Analysis of Micro textured Lubricated Journal Bearings. In this paper, they analyze the impact of the cavitation model on the numerical assessment of lubricated journal bearings. We compare results using the classical Reynolds model and the so-called p- model proposed by Elrod and Adams to fix the lack of mass conservation of Reynolds‟ model. Both models are known to give quite similar predictions of load-carrying capacity and friction torque in nonstarved conditions, making Reynolds‟ model the preferred model for its better numerical behavior. Here, we report on numerical comparisons of both models in the presence of microtextured bearing surfaces. We show that in the micro textured situation, Reynolds‟ model largely underestimates the cavitated area, leading to inaccuracies in the estimation of several variables, such as the friction torque. This dictates that only mass-conserving models should be used when dealing with microtextured bearings.

(7) Gustavo G.Vignolo, et.al**.** done Approximate analytical solution to Reynolds equation for finite length journal bearings. The understanding of the behavior of hydrodynamic bearings requires the analysis of the fluid film between two solid surfaces in relative motion. The differential equation that governs them ovement of this fluid,called the Reynolds equation,arises from the integration over the film thickness of the continuity equation,previously combined with the Navier–Stokes equation. An order of magnitude analysis,which is based on

the relative value of the dimensions of the bearing, produces two dimensionless numbers that govern the behavior of the system:the square of the aspect ratio, length over diameter $(L/D)^2$, and the eccentricity ratio(Z). An analytical solution of the Reynolds equation can only be obtained for particular situations as, for example, the isothermal flow of Newtonian fluids and values of L/D-0 or L/D-N. For other conditions, the equation must be solved numerically. The present work proposes an analytical approximate solution of the Reynolds equation for isothermal finite length journal bearings by means of the regular perturbation method. $(L/D)^2$ is used as the perturbation parameter.

(8) D.Y. Dhande, et.al. studied Multiphase flow analysis of hydrodynamic journal bearing using CFD coupled Fluid Structure Interaction considering cavitation. In this study, a fully three-dimensional CFD analysis and multi-phase flow phenomena, has been successfully implemented for simulation of hydrodynamic journal bearing considering the realistic deformations of the bearing with Fluid–Structure Interactions (FSI) along with cavitation.Mixture model is used into model cavitation in the bearing and parametric modelling for modifying the flow domain due to deformation. Both systems are coupled and design optimization based on multi objective genetic algorithm (MOGA), is used to obtain optimized solution of the attitude angle and eccentricity for the combination of operating speed and load. In the study of bearings with and without effects of cavitation,it is observed that maximum pressure values drop when cavitation is considered in the bearing. Al there is decrease in maximum pressure when elastic deformation in the bearing is considered.The oil vapour distribution goes on increasing with the increase in shaft speed, thus lowering the magnitude of the pressure build up in the bearing. Multiphase study of bearings with cavitation hence becomes extremely important in case of bearings operating with higher speeds. The experimental data obtained showed very good agreements with numerical results and considerable reduction in computation time is observed.

(9) WANG Li-li, et.al. studied the effect of viscosity on the cavitation characteristics of a high speed sleeve bearing is investigated theoretically and experimentally. The cavitation characteristics, the cavitation shape and the cavitation location of a spiral oil wedge hydrodynamic bearing are investigated experimentally by using the transparent bearing and the high-speed camera. The generalized Reynolds equation is established with considerations of the cavitation mechanism based on the modified Elrod method in theory, and the cavitations of different viscosity sleeve bearings are analyzed and compared. It is shown that the cavitations are strip-shaped for both the high viscosity lubricant and the low viscosity lubricant, and in the rupture region of the oil film at a high speed, the oil vapour or bubbles are produced. With the decrease of the supply pressure and the increase of the rotating speed, the rupture area of the oil film increases distinctly. The cavitation area decreases distinctly and the quality of lubrication is better for the low viscosity lubricant than for the high viscosity lubricant. The experiment results in general are consistent with the theoretical results.

(10) Tushar P. Gundarneeya, et.al. done the Theoretical Analysis of Journal Bearing With Nanolubricants. Fluid bearings are frequently used in high load, high speed or high precision applications where ordinary ball bearings have short life or high noise and vibration. The investigation of nanotribology shows that the nanoparticles have unique property in lubrication and tribology, such as anti-wear, reducing friction, and high load capacity. There were some investigations on the tribological properties of lubricants with different nanoparticles added, and it was reported that the addition of nanoparticles to lubricant oil is effective anti-wear and reducing-friction performances. The one dimensional solution method is extended to get the two dimensional solution for the pressure distribution in the Journal Bearing. Peak pressure obtained in two dimensional case is less than the one dimensional case, which is true because we neglect the side leakages in one dimensional analysis. Reynolds Boundary condition will give correct information about pressure distribution. With increase in nanopartical percentage concentration relative viscosity is increases and compared to other model modified Krieger-Dougherty is giving very high value and which can be verified by comparing it with experimental value. With increase in nanoparticle concentration percentage pressure distribution shows high value with it. Similarly it also increases load carrying capacity of journal bearing. Non dimensional friction force is also increased with increase in nanoparticle concentration which lead to high value of viscosity and high load carrying capacity.

V. METHODOLOGY

Methodology adopted:

a) Selected hydrodynamic journal bearing material (Brass material).

b) Selected various types of lubricants for testing (SAE20W40,SAE20W50).

c)Analyzes bearing with different lubricants and additives with respect to pressure distribution.

VI. ANALYSIS RESULTS

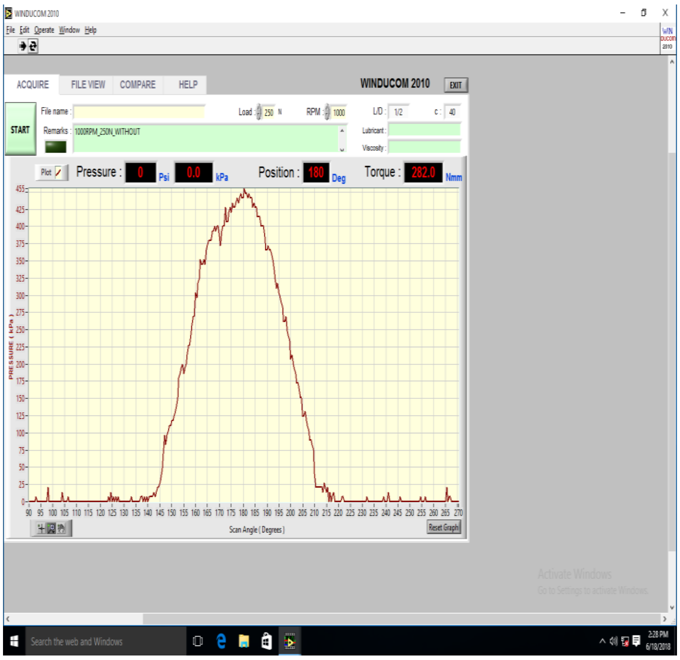

Fig 6.1: Pressure (Kpa) Vs Angle (Degree) SAE20W50 (At 250 N)

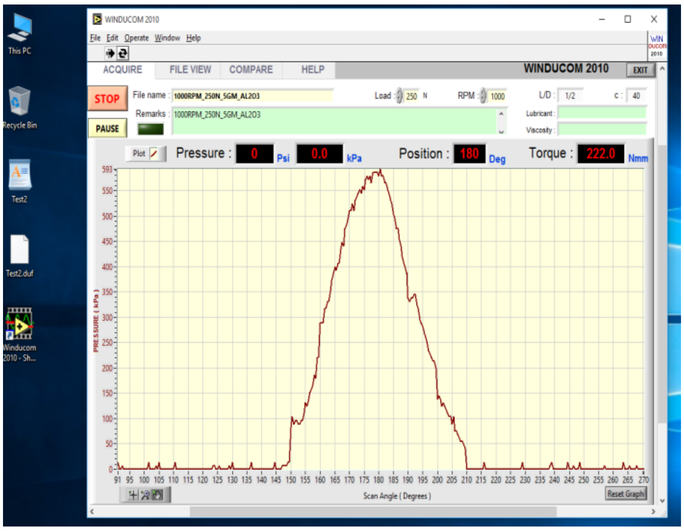

Fig.6.2: Pressure (Kpa) Vs Angle (Degree) SAE20W50 & 5gm AL2O3 (At 250N)

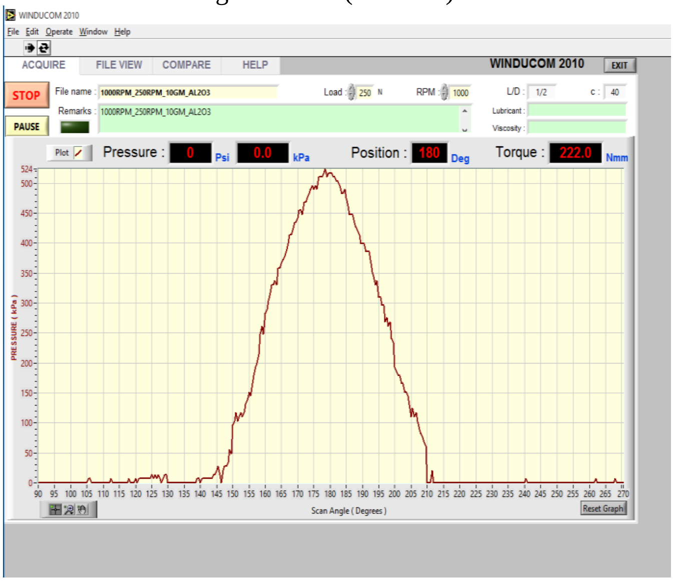

Fig.6.3: Pressure (Kpa) Vs Angle (Degree) SAE20W50 & 10gm AL2O3 (At 250N)

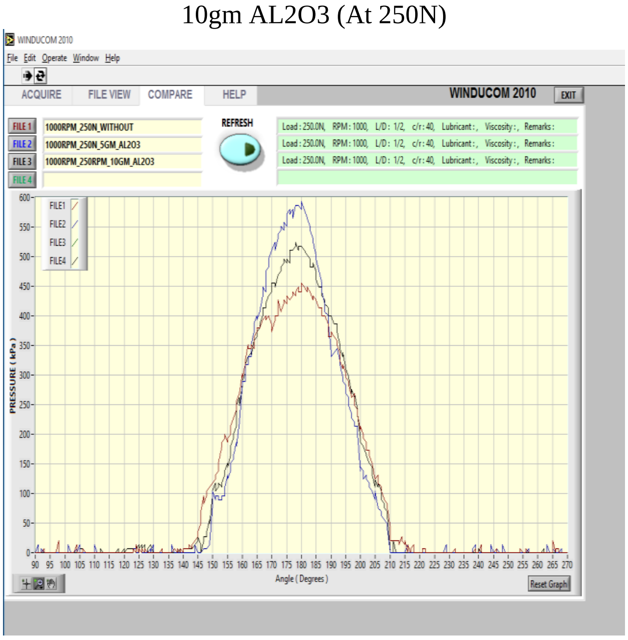

Fig No.6.4: Pressure (Kpa) Vs Angle (Degree) At 250N For SAE 20W50,With 5gm AL2O3 And 10gm AL2O3

VII. ACKNOWLEDGEMENT

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VIII. CONCLUSION

The main result of this study was the measurement of realistic oil film pressure in real type hydrodynamic journal bearing . The measured oil film pressure wave was clearly wider than the simulated one and the measured peak oil film pressures were clearly lower than those simulated.

We concluded that when we added 5Gm &10Gm Al2O3 Additive in SAE 20W50 Pressure Distribution Capacity of bearing is increased Compared to Base oil.In that case,Pressure distribution capacity is more at 5Gm Al2O3 compared to 10Gm Al2O3.

When using oil additives, more is not always better. As more additive is blended into the oil, sometimes there isn't any more benefit gained, and at times the performance actually deteriorates.

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