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THERMAL ANALYSIS OF JOURNAL BEARING USING CFD UNDER NON-ISOTHERMAL CONDITION

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ABSTRACT

This report on Journal Bearings gives us brief information on Temperature distribution; Pressure distribution; radial temperature distribution from journal to bearing; Minimum film thickness; and viscous forces. Journal bearings are machine elements commonly used in all mechanical systems with rotating shaft subjected to high rotational speed and applied load axially on the for the rotating shaft since the beginning of industrial revolution. The innovatory modifications in the field of journal bearing are at quite slow speed. In the field of tribology tools requires high stiffness to improve accuracy. Thus it is necessary for the designer to study the parametric influence of journal bearing quantitative as well as qualitative. Since there have been lot of developments in design, the parametric optimization has been performed by many researchers. Numbers of researchers have been working on different aspects of performance of the journal bearing, ranging from temperature rise, geometry of grooves, damping, eccentricity ratio and clearance etc. Based on the state of art in bearing identification, valuable discussions are made with future directions.

1. INTRODUCTION

1.1JOURNALBEARINGS:

Hydrodynamic bearings are machine parts that are usually used for various applications varying from small motors to vast turbines which are used to create controlled and free motion of the machine elements. A journal bearing is normal hydrodynamic bearing in which load carrying round shaft called Journal and it is made rotate in a settled sleeve called Bearing. There outline and development might be moderately of very simple to understand but the hypothesis and study operation of these rotational is might be very difficult. The investigation of journal bearing goes under Tribology. The science that deals with rubbing, lubrication, wear in all the moving parts which are in relative motion is called Tribology.The contact degree between the lubricant and the strong surface impact the lubricating property of bearing. The round shaft called journal and settled sleeve called bearing will have great warm properties, quality and load carrying limit. The contact coefficient between the journal and bearing come to be low keeping in mind the end goal to get high performance of the journal bearing. At rest when no rotation of the shaft is taking place the contact between journal and the bearing

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will be separated by a minimum film thickness. At this point friction coefficient will be high. As the journal start rotating, the fluid plays a major role, the contact degree between the journal and the bearing will be increases and fluid comes in between the journal and bearing as this decrease the friction coefficient and mixed lubrication takes place. As the shaft attains its maximum speed, hydrodynamic lubrication takes place and the friction coefficient will be constant after reaching some point. Fluid now will get maximum separation between journal and bearing and it is called maximum film thickness. The way fluid taking the place between the journal and bearing is due to the viscous forces and raise in temperature of the fluid takes place also due to this viscosity. This results in the increase of the temperature of lubricating fluid, and we know as the temperature increases viscosity decreases and this effect in the load carrying capacity and the performance of the journal bearing.As of late, after the advance in PC innovation, numerous scientists started to utilize business Computational Fluid Dynamics (CFD) programs in their examinations. The fundamental preferred standpoint of CFD code is that it utilizes the full Navier– Stokes conditions and gives an answer for the stream issue likewise relevant in exceptionally complex geometries.

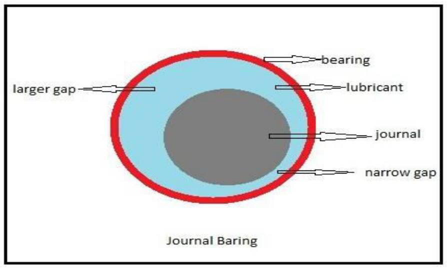

Fig.1 (Journal Bearing)

1.2MAIN PARTS:

The significant parts of the journal bearing are shaft which is additionally called journal and journal is that parts of the shaft which is under the bearing surface, removable bearing shell parts and oil. The primary work of removable bearing shell parts are to bolsters the heap which is hitting on the journal. On the off chance that we need to keep the metal to metal contact between the surfaces of the journal bearing then we provide lubricant between their surfaces which make smoothness and because of the rotate of the shaft they make film of oil and, for example, their surfaces are isolated from each other. That is shaft rotate under the bearing and it constrained increasingly liquid in to the bearing surface and because of this revolution they apply a power on liquid because of which weight is made on the fringe ofthe bearing.

1.3 Objective

The objectives of my research work is to carry out both CFD analysis and experimental work of lubricated journal bearing functioning at different operating condition by supplying lubricant whose properties are known or by considering for the easy calculation of the problem and studying the both the results.The present study mainly focuses on various types of factors which mainly affects the performance of journal bearing. The factors that affect the performance of the journal bearing are coefficient of friction, load carrying capacity, minimum oil film thickness.The main proportional work of this research is to carry out the working of journal bearing under different load factors and to know how the pressure is varies from point to point. The design of this work is carried out in software called CFD (Computational Fluid Dynamics).

Stribeck curve which deals with coefficient of friction and viscosity, velocity, pressure in the all lubrication methods that are static lubrication mixed lubrication and dynamic lubrication.

2. LITERATURE REVIEW

QIYIN LIN (2017):

The impact of surface on the execution of the journal bearing working under the transient condition is explored by a liquid structure association (FSI) approach. The key parameter of the present work is the uprooting of the journal and additionally the whimsy proportion which better speaks to the genuine operation of a journal bearing than the customary methodologies that depend on the relentless state presumption. The outcomes demonstrate that relying upon its position in the circumferential heading; a surface may either upgrade or hinder the execution of a journal bearing as far as the age of the heap carrying limit.

MARK DESJARDINS (2013):

This undertaking proposition portrays the reason, system and expected results of an investigation into a full journal bearing and the impact of wear on execution. Specifying the hypothetical investigation of a full journal bearing will be performed and contrasted with the outcomes got by a computational liquid dynamic (CFD) examination. Wear, it's potential causes, and aversion will be portrayed and supplemented by a CFD examination of the impact of wear seriousness and area on the bearing execution also, liquid attributes. The investigation will recommend conceivable framework changes to amend issues coming about from wear. Key assignments and points of reference are recorded and depicted to guarantee consistence with tight undertaking plan. Arrangements of fundamental assets, references and potential distribution areas are additionally given.

FANGRUI LV (2017):

This paper examines property of vertical misaligned journal bearing, pointing to give a way to deal with productively investigating identical supporting point area what's more, carryinglimit of misaligned journal bearing without using numerical reproduction. Identical supporting point area is depicted through the dimensionless rotate arrange of proportional supporting point and exhibited versus length-breadth proportion, capriciousness proportion, and dimensionless misalignment point. The proportion between misaligned bearing carrying limit and relating adjusted bearing carrying limit is eluded as to misalignment factor for carrying limit with respect to short. Elements of proportional supporting point area and misalignment factor for carrying limit reliant on length-width proportion, capriciousness proportion, and dimensionless misalignment point are acquired. By common cases, the correctness's of the capacities are checked to meet building prerequisites.

Christian Kim Christiansen(2017):

A hydrodynamic bearing has been researched using both theconventional two-dimensional (2D) Reynolds condition, and the full arrangement being the three-dimensional (3D) Navier-Stokes conditions. The two methodologies are to come about by playing out an examination of two bay

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depression plans: the rotate and the circumferential furrow, individually, on a holding on for length-to-measurement proportion of 0.5 presented to a sinusoidal stack design. Weight disseminations, journal circles and frictional misfortunes are looked at. The demonstrating of scores by weight limit conditions versus geometric conditions is inspected. It is examined if the nearness of a groove increments frictional misfortunes and the expansion identifies with groove measurements. Moreover, the in ounce of the notch outline on the lowend is contemplated using the 3D arrangement.

Faisal Rahmani (2016):

This paper endeavours to explore the dynamic qualities of a powder lubricant up journal bearing. The firmness and damping coefficients are acquired using limited irritation technique. The soundness furthest reaches of the rotor speed is gotten for a framework comprising of a solitary rotor circle amidst an adaptable shaft having indistinguishable plain round and hollow journal direction at the finishes. The limit speed of flimsiness for a rotor upheld on powder lubricant up journal bearing is contrasted and that of oil lubricant up journalbearing. The numerical outcomes demonstrate that a rotor upheld on powder lubricant up journal heading stays stable for a speed restrain substantially higher than that for oil lubricant up direction.

Raghu Yogaraju (2016):

In this paper, points of interest identified with preparatory research made towards building up a novel semi-dynamic journal bearing have been introduced. The examination which is transcendently trial in nature utilizes a test fix outlined and manufactured with the end goal of mimicking a multi-lobed journal bearing and furthermore to examine the likelihood of using brilliant materials for transformation of a roundabout bearing profile to a multi lobed bearing profile amid operation. Preparatory test examines have shown that while shape memory analysis (SMA) can be used as a medium to apply important powers at recognized areas to get the coveted profile shapes for a multi-flap bearing setup encouraging the advancement of semi dynamic journal direction, ovality proportions of the bearing profile under scrutiny extending from 1.5 to 2 have been acknowledged by appropriate use of direct powers in restricting bearings. The execution upgrade characterized as far as solidness and damping of the recently designed bearing comparable to two lobed bearing over the traditional bearing has been examined. The test fix is adaptable in nature, with an office to explore assortments of semi dynamic journal orientation. The investigation shows an expansion in powerful firmness and damping with increment in the modality proportion of the semi-dynamic journal orientation.

Amit Chauhan (2014):

Hydrodynamic journal direction is used as a part of apparatuses which are rotating at high speeds and conveys overwhelming burdens. These outcomes in high temperature ascend in the oil film which fundamentally influences the execution of bearing. Thermo-hydrodynamic examination comes to be completed keeping in mind the end goal to acquire the practical execution parameters of journal bearing. Thermo-hydrodynamic investigation of roundabout

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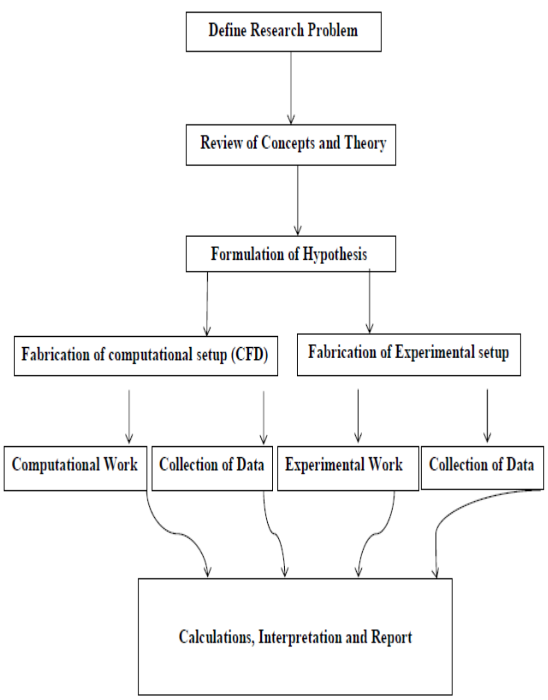
journal bearing has been mimicked by usingComputational Fluid Dynamics approach. This approach illuminates the three dimensional Navier-feeds condition to foresee the bearing execution parameters, for example, the weight and temperature of the lubricant along the profile of the bearing. The CFD method has been connected through ANSYS Familiar programming. The oil stream is to come to be laminar and the unfaltering state condition has been accepted in the present work. The impact of variety of weight and temperature on the oil film has been considered amid contemplate.

3. RESEARCH METHODOLOGY



Problem Background:

There are diverse sorts of issues which happen in the Hydrodynamic journal bearing. Because of improper for supply of oil in the bearing the age of warmth happens in huge sum because of which metal temperature increments and bearing gets harmed. Load is likewise fundamental factor which may harm bearing. On the off chance that expansive load is connected on the journal then its introduction ends up plainly inappropriate because of which journal and bearing surface begin to strike each other and they get harmed.

3.1 Experimental work

3.1.1 Aim of the work:

The aim of this experimental work is to study the pressure variation of lubricating oil at different working loads in the journal bearing setup.

3.2 Requirements:

- Lubricating oil SAE-40 (4 litres.)
- Power supply: 220 v AC single phase.
- Journal bearing setup with journal having circumferential tubes (1 to 12) and axial tubes (a, b, 12, c, d)
- Oil tank
- Measuring unit.

3.3 Theory of the work:

The part of the bearing which revolves inside it is called journal and it is subjected to load a right angles to the axis of the shaft (journal). As he speed of the shaft increases the viscous force which results in the drag the oil between he surfaces of the journal and bearing also increases them. More and more of the load will be taken by the oil film in the convergent portion of both journal and bearing. This slowly lifts the line of action round the direction of motion of the shaft. Ultimately the oil film will may break into, so that the two surfaces are completely separated and the load will be moved from the journal to the bearing by the oil. And how the hydrodynamic journal bearing works is shown in the fig.2

3.4 Experiment Procedure:

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a) Fill the oil tank with lubrication oil (SAE-40)

b) Drain out the air from all the tubes on manometer and check whether the level balance with supply level.

c) Check for some leakage of oil is there, and this leakage is necessary for cooling purpose.

d) Check the direction of rotation of the shaft and increase the speed slowly.

e) Now set the speed for particular rpm and let journal run for about 15 minutes to achieve the study level of the oil.

f) Now add the weights and keep the balancing rod in horizontal position by moving the weights on the rod and observe the study levels in the tubes.

g) And now after when manometer levels settled down after running 15 minutes , take the pressure readings on 1-12 manometer tubes where circumferential pressure distribution takes place and a, b, 12, c, d where axial pressure distribution takes place.

h) Repeating the experiment for different speeds and loads.

i) Note down the readings of settled level in manometer tubes.

j) After the completion of the experiment set the dimmer to zero and switch off of main supply.

3.5 Learning outcomes from experimental work:

- In this experiment I learned about how viscous forces are responsible for the drag and lift of the moving shaft (journal).
- How pressure distribution takes place at different loads and weights.
- How lubricating oil is distributed between the journal and the bearing.
- Also how the action of hydrodynamic bearing takes place.
- Hydrostatic oil film lubrication.
- Mixed oil film lubrication.
- Also how boundary layer lubrication comes between both the journal and bearing when the higher loads act on the shaft.

4. RESULTS AND DISCUSSION

4.1 Bearing input data:

NAME	SYMBOL	VALUE
Bearing length	L	90mm
Bearing diameter	db	75.05mm
Journal diameter	Dj	25.05mm
Radial clearance	C	50mm
Eccentricity	E	37.5mm
Eccentricity ratio	K	7mm
Load on bearing	W	9.81N
Speed of the shaft	N	30rpm
Film thickness	H	30.5mm
Bearing material	—	Babbitt

Table.1.Bearing input data

4.2 Lubricant input data:

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NAME	SYMBOL	VALUE
Lubricating oil	—	Sae-40
Density	P	889 kg/m3
Specific heat	Cp	1800j/kg-k
Viscosity	M	0.0911kg/m-s
Thermal conductivity	K	0.7w/m-k

Table.2.Lubricant input data

4.3 Experimental Observations:

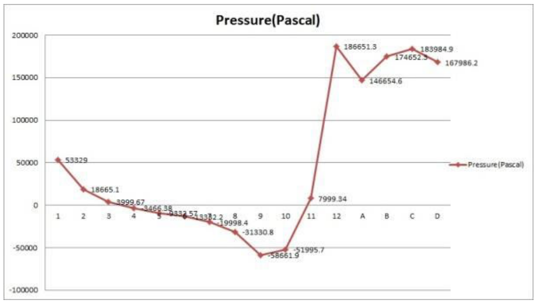
Supply head of oil, ps= 1000mm

Weight= 1 kg (9.81N) Speed=30rpm

TUBE NO.	Pressure head, p (mm)	Displacement of fluid (mm)	Pressure (Pascal)
1	880	400	53329
2	880	140	18665.1
3	880	30	3999.67
4	880	-26	-3466.38
5	880	-70	-9332.57
6	880	-100	-13332.2
7	880	-150	-19998.4
8	880	-235	-31330.8
9	880	-440	-58661.9
10	880	-390	-51995.7
11	880	60	7999.34
12	880	1400	186651.3
A	880	1100	146654.6
B	880	1310	174652.3
C	880	1380	183984.9
D	880	1260	167986.2

Table.3Observation table

Here 1 to 12 tubes are circumferential tubes along the diameter of journal and A, B, C, D, 12 are axial tubes along the axis of the journal.



Graph.1 Pressure vs. tube no.

4.4 CFD SIMULATION:

Table.5 parameters for CFD simulation

Geometry type	3D geometry(imported from solid works)
Surfaces	Surfaces from sketch

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Surface area	2054mm2
No. of edges	4
Meshing method	Fine meshing
Growth rate	1.20
Named sections	4
No. of iterations	10000
Initialisation methods	Hybrid initialisation
Angular velocity	10m/s
Rotational velocity	1rad/sec

Table.6 parameters for mesh

No. of elements	2067
No. of nodes	2772
Aspect ratio	1.5
Skewness	0.15
Orthogonal quality	0.99
Volume	2.2125e+005 mm³

For computation analysis for geometry, meshing all the dimensions are taken from the table.2

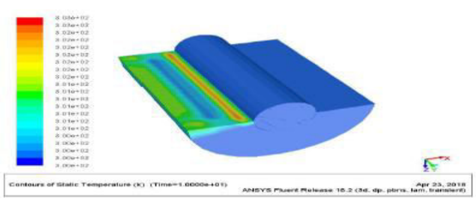


Fig.14 Temperature contours

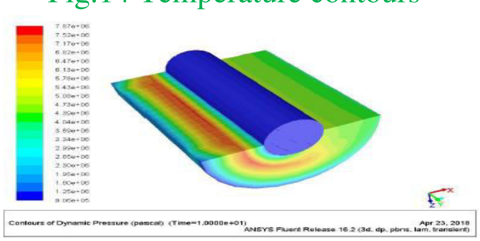


Fig.15 Pressure contours

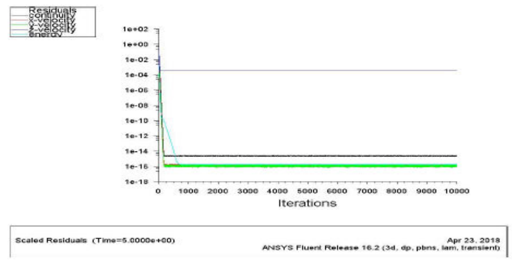


Fig.16 Iterations diagram

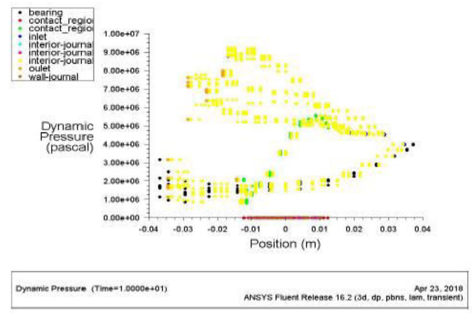


Fig.17 Pressure profile

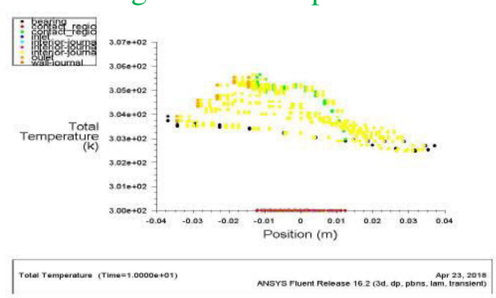
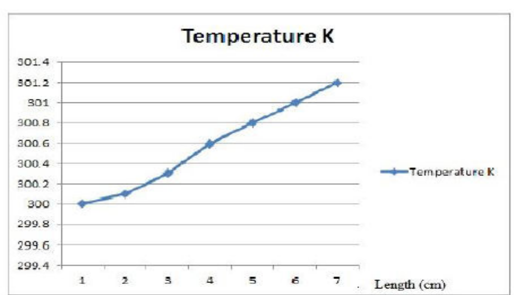


Fig.18 Temperature profile



Graph.2 Radial length vs. temperature

CONCLUSION AND FUTURE SCOPE

- Viscous forces are responsible for the drag and lift of the moving shaft (journal).
- Pressure distribution takes place at different loads and weights and also depends upon direction of rotation and speed also how lubricating oil is

distributed between the journal and the bearing.

- How the action of hydrodynamic bearing takes place, hydrostatic oil film lubrication, mixed oil film lubrication. Also how boundary layer lubrication takes between both the journal and bearing when the higher loads act on the shaft.
- The film thickness varies both in tangential as well as radial direction. At a given radius film thickness is maximum at minimum pressure and minimum at maximum pressure. At a given angle film thickness increases from inner radius to outer radius.
- Pressure developed along the direction of rotation due to hydrodynamic action is maximum corresponding to the mean radial position.Pressure developed along the direction of flow due to the hydrodynamic action is maximum corresponding to the angular (3.14 rad.) position.
- Film thickness developed along the direction of flow due to the hydrodynamic action is maximum along the minimum pressure.Film thickness developed along the direction of due to the hydrodynamic action is minimum corresponding to mean angular (3.14) position.
- After this we will show how the radial velocity changes from journal to bearing.
- Also fluid properties changes as the temperature increases, considering this we will assume the non-isothermal condition for the lubricating oil.