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An Experimental Investigation of Hydrodynamic Journal Bearing with Different Oil Grades

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ABSTRACT

Journal bearings are known to be intrinsic components in different marine applications. They are regarded as the most instrumental means by which large loads could be transmitted at mean speed of rotation. Hydrodynamic journal bearing, based on hydrodynamic lubrication, has undoubtedly proved to be among the most effective types of journal bearings designs, commonly used in marine applications. In hydrodynamic lubrication, metal-to-metal contact could be prevented via a separation between the load carrying surfaces of the bearing, that could be attained by means of a relatively thick film of lubricant. Extending bearing life in marine propulsion systems, auxiliary equipment and diesel engines, reducing friction energy losses and wear, minimizing maintenance expenses and downtime of machinery due to frequent bearing failure are the most important objectives being born in mind on launching the bearing design procedures.

In the study at hand, an attempt has been made to perform a study of pressure distribution within hydrodynamic journal bearing on experimental bases. The experimental study has entailed the use of versatile lubrication oils, among of which comprised SEA 20W50, SEA 10W40 and SEA 5W30, for the sake of identifying their individual role in determining the condition of lubrication "hydrodynamic or hydrostatic". Besides, the study has been extended to cover the pressure behaviour of different lubricants within the hydrodynamic journal bearing, at different speeds ranging from 50 to 400 RPM at constant loads. For accurately testing the 105 mm internal diameter, 58 mm bearing length and "l/d = 0.5" made of white metal, a use has been made of the universal journal bearing test rig "UJBTR". Pressure distribution is further circumferentially investigated under constant loading, with operating at different journal rotational speeds.

Keywords: Hydrodynamic Journal Bearing, Viscosity, Pressure Distribution, SAE Graded Oils, Universal Journal Bearing Test Rig "UJBTR", Lubrication, Propulsion Shafting System, Plain Bearing.

1. INTRODUCTION

A journal bearing could be defined as a journal "such as a shaft", rotating within a supporting sleeve or plain bearing. In order that they could pressurize a lubricant, which is supplied between the stationary surface and the moving surface, that is, "Journal Bearing" to eliminate surface-to-surface contact and bear the external load, hydrodynamic journal bearings use the rotation of the journal. Sliding lubricated surfaces can be broken down into three lubrication regimes, corresponding to the Stribeck curve shown below in figure (1).

The curve illustrates the relation between the friction factor being represented by the vertical axis and the lubrication parameter **μN/P** featured on the horizontal axis, where μ is the dynamic viscosity, N is the shaft speed and P is the external load. On analyzing the curve, a number of outcomes could be drawn. On the right side of the curve, it is obvious that in the presence of high dynamic viscosity, high speed and low loads, the highest friction condition between the oil molecules or rather the squeeze condition tends to show signs with the subsequent result of increasing the friction factor. The region in the curve where this condition occurs is called the hydrodynamic lubrication or the fluid-film lubrication region. Hence, there is a positive relation between the friction factor and the lubrication parameter or ration. There is, however, a reverse relation, noted on the left side of the curve, between the friction factor and the lubrication parameter or ration "μN/P".

This condition could be attributed to lying in the boundary lubrication region. This region features significant or complete asperity contact between the surfaces. In other words, the likelihood of the metal-to-metal contact gets higher in the boundary lubrication region, where the oil film layer tends to be intermittent. Low viscosity, high load and low speed are among the main factors creating this situation. The stable lubrication could be identified through the comparison held between the boundary lubrication and the hydrodynamic lubrication. Finally, the mixed lubrication region represents starting up and partial load support from the lubricating fluid and partial load support from asperity contact.

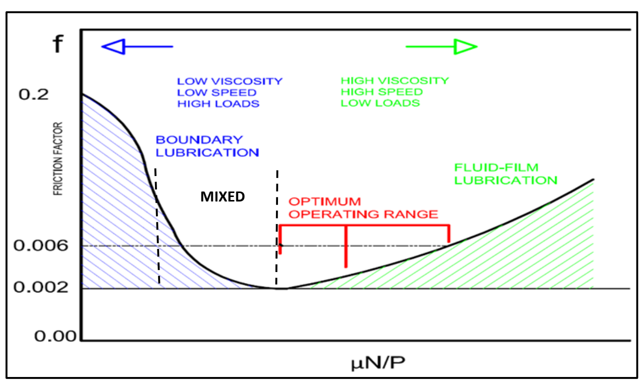

Figure 1: An illustration of the Stribeck curve.

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Problem statement; Among the different problems, that would constitute major obstacles in the way of the final aspired goal of promoting the thrust force relating to ships, wear is regarded as the most notably complicated problem. High friction conditions often arise as a result of the direct contact between the journal and the bearing. That, in turn, would ultimately lead the bearing liner to wear. In an attempt to overcome or minimize the undesirable effects of wear in marine propulsion system, the introduction of lubrication fluid, in journal bearing designs, is essential so that it would decrease the friction between the two surfaces "Journal Shaft and Journal Bearing". This solution is, however, not an ultimate one, as contact between the two surfaces would still exist even in the presence of lubrication. The endeavor towards attaining the final aspired goal of enhancing the thrust force, relating to ships, would necessitates effecting a reduction in relation to the speed of the propeller. Reducing speed in the journal bearing would, however, have unfavourable consequences and would eventually interfere with the final goal reaching the effective performance of the lubrication oil film. Investigating the other factors, affecting the pressure profile and which work side by side the speed factor, is thus an essential task to be carried out. Those other factors would comprise the viscosity, the density and temperature relating to the journal bearing lubricating oil. Besides, there ought to be a thorough investigation into that issue for the sake of reducing and overcoming the negative repercussions incurred as a consequence.

2. LITERATURE REVIEW

Evaluating the behaviour of conventional and new bearing designs together with synthetic lubricants in operating parameters has been the main concern of the researchers Simmons, et al, 2011. Synthetic lubricants were proved to be superior to their mineral based counterparts characterized by higher viscosity grade. High VI ISO VG32 synthetic ester lubricant has proved its effectiveness and success in replacing ISO VG32 mineral oil. While keeping an equivalent lubricant film thickness, it could as well effect a reduction in power loss. The results obtained have ascertained the efficiency of such lubricants in improving performance if compared with the mineral based lubricants at both high and low speeds. It could reduce power loss and offered an equivalent film thickness. Also, greater power loss was noted at high speeds as a result of the thicker film it provided. (Simmons, et al, 2011).

Examining the tribological characteristics concerning journal bearings, under boundary and mixed lubrication conditions during shaft startup, shutdown and low speeds has been the incentive that pushed forward the research presented by Pickering, 2011. On tackling the issue of wear, it was proved that performance and pressure loads would negatively be affected in the existence of wear. To overcome the undesirable consequences of wear on performance, some suggestions have been made. Such solutions have involved surface hardening, polymer liners in addition to using lubrication fluids with additives. The potential solutions could ultimately help promote the product reliability and could as well optimize journal bearing design. The author stressed the need of a thorough investigation and a comprehensive understanding of that wear so that bearing life could be improved and costs could be reduced. Using lubrication additives as well as enhanced materials were just but a few of the solutions recommended on the road to reaching the aspired optimal working conditions. (Pickering, 2011).

Allmaier et al. 2011 have launched a beneficial and a systematic research with the aim of predicting friction in journal bearings. That was carried out in a reliable and an accurate way based on validated comparisons held between simulation results and experimental measurements. Two different loads were studied, namely, 41 and 70 MPa. The outcomes obtained have proved the effectiveness of optimum viscosity lubricants as opposed to other index lubricants in relation to helping ensuring friction reduction. In other words, the results showed that reducing friction was, to a great extent, dependent on selecting a lubricant with reduced viscosity. (Allmaier, et al. 2011).

Studying the lubrication and the operation of the journal bearing together with its design have been the main focus of study in the research carried out by Simmons, 2013. Suggestions were made to improve the robustness of equipment and to overcome the obstacles resulting from the effects of wear and tear on machines. That improvement, if made, would ensure the usefulness of the equipment in the future applications. Results showed that changing from a traditional mineral oil to a high viscosity index oil of much lower base viscosity grade could reduce power loss while keeping the bearings minimum film thickness. The author proved that reduction of power loss and maintaining safe machine operation were all attainable goals that could be achieved through the selection of high viscosity index synthetic lubricants. Furthermore, the author supposed that new lubricants, materials and adjustments in operational methods could enhance the performance of the journal bearings. To increase viscosity index and reduce friction at start up, the author recommended the use of select additives as well as select polymer bearing materials. (Simmons, 2013).

In another study, Baskar and Sriram, 2014, worked on understanding and investigating the tribological behaviour of journal bearing material under different lubricants. Wear tests were carried out using three different lubricating oils. They were carried out at maximum load of 200N and sliding speeds of 2-10 m/s. The results illustrated that the sliding conditions and lubricating oils would cause a change to the friction and wear behaviour of the journal bearing. The journal bearing material tended to have a lower friction coefficient for the chemically modified rapeseed oil(CMRO) with Nano Cuo. It was found out that Nano Cuo lubricating oil could outweigh the other types tested upon and could as well be preferred for the lubrication purpose in journal bearing applications. (Baskar and Sriram, 2014).

Sander et al 2015, focused on the impact of high pressure and shear thinning on journal bearing friction. Those studies aimed at predicting the friction power losses for journal bearings under both mode rate (50 MPa peak load) and high dynamic loads (100 MPa peak load). Extensive measurements on a journal bearing test rig with a low viscosity multi-grade lubricant “OW20” were made. It was found out that a complete description of the rheological lubricant properties was crucial to achieve a very close agreement with the experimental data. The study stressed the need to consider viscosity in modern viscosity engine oil and considered it as the key parameter to describe lubricated contacts. (Sander et al. 2015).

Singh, 2015, conducted an experimental study of pressure distribution on hydrodynamic journal bearing with twin groove “5mm” using three different types of lubricating oils, namely, SAE 15 W40, 20 W40 and refined oil. The researcher filled the space between the shaft and the bearing with oil. Pressure distribution was studied by applying one unloading and three loading conditions, with operating at journal rotational speed of 1120 rpm. The results showed that pressure tended to increase with the increase in load and followed sinusoidal form at the periphery of bearing. (Singh, 2015).

In 2015, Sriniv, et al worked on performing an evaluation of hydrodynamic journal bearing by using two different types of oil. An attempt has been made to present two different commercial lubricant oils with the aim of studying and detecting their role in determining the condition of lubrication, the type of pressure distribution and the stresses developed in the bearing under varying loads and speeds. It was noted that variation of pressure distribution with respect to angle of rotation for both SAE 20 W50 and SAE 90 oils revealed a pressure increase from 0 to 800 of rotation and then decreased for the remaining rotation of bearing. That clearly indicated the presence of a hydrodynamic lubrication which meant the need of high speed journal bearing. (Sriniv, et al, 2015).

Researching into the field concerned with studying the effect of surface texturing on the steady state performance characteristics of highly loaded journal bearing lubricated with a contaminated lubricant has been the target of a study carried out Dadouche and conlon, 2016. Bronze journal bearings were found out to have the ability to endure a considerable quantity of hard particle contaminants. Providing the size of the particles was lower than the minimum film thickness and the bearing ran with minimal misalignment. The study made it clear that lightly surface texturing together with tighter manufacturing tolerances could results in better contaminant allowance in bearing lubrication system. (Dadouche and conlon, 2016).

In 2016, a study was carried out by sander, et al, with the aim of studying the friction behaviour of journal bearings. Operating from hydrodynamic to mixed lubrication regime where severe metal-to-metal contact occurred. It was found out that the surface texture of journal bearings had a major influence on friction in mixed lubrication regime. (Sander, et al, 2016).

In 2018, Fricke, et al, had an interest in tracing the influence of surface from deviations on friction in mixed lubrication. The overall from deviation of the test bearing was measured. Simulation results have shown a noticeable effect of the surface form deviations on the pressure distribution of the lubricant, and hence on the size of the asperity contact area. Results demonstrated that there was a considerable influence of surface form deviations of the bearing surface on the friction force of journal bearings. The study explained that reducing the influence of the surface form deviations depended on increasing the journal bearing clearance. (Fricke, et al, 2018).

3. ELABORATIONS ON JBTR EXPERIMENTAL DESIGN AND SETUP

Figure (2) sheds light on the journal bearing test rig “JBTR”, designed and manufactured by the author, comprising its different components working together to fulfil the aspired goals and tasks for which the experiments are being held, and for any other potential tests, that could be conducted in the future in case any advanced marine applications are introduced and the need a rises for more reliable tests, proofs and outcomes. Table 1, provides the main dimensions of the “JBTR” at hand. There is an oil inlet port mounted on the upper part of the test rig. It functions as a supplier of lubricating oil flowing through the oil inlet port into the bearing clearance. On the vertical center line of the bearing there is an inlet port through which the lubricant is supplied to the bearing. The inside pressure, induced as a result of the rotation of the journal, is measured by means of the ten pressure transmitters, distributed around the circumference of the plain bearing, and is hence displayed on Programmable Logic Controller “PLC”. In order that the validity of the journal bearing test rig “JBTR” experimental results could be ensured, several comparisons were to be held, to prove their consistency and accordance with their previously derived theoretical counterparts. Hence, the journal bearing test rig could safely be deemed as valid for the potential experiments that are most likely to be conducted on it in the future, as pointed out in reference, (Marey. Nour, et al, 2018).

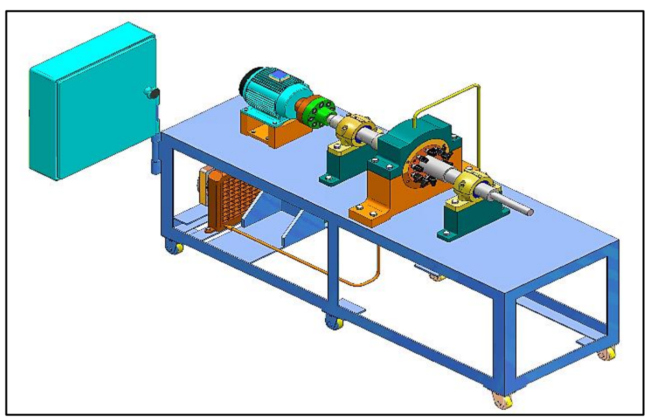


Figure 2: An outline of the whole structure of JBTR. [6]

Figure 3: The Journal Bearing Test Rig "JBTR". [6]

Table [1]: The dimensional data concerning the journal bearing test rig.

No	Discerption [6]	Specification
1	L, bearing length	58 mm
2	d, inner diameter for plain bearing	105.05 mm
3	Φs shaft diameter	104.97 mm
4	W, Weight of journal shaft	727.65 N
5	C0, total clearance	0.08 mm
6	C, radial clearance	0.04 mm
7	L/D ratio	0.5
8	Bearing material	White metal
9	Operating speed	50:400 rpm

4. EXPERIMENTAL SETUP AND PROCEDURES

The process concerning the design and set up of the test rig was primarily motivated by the urgent need, arising from the desire therein of procuring a structure, characterized by as much validity and accuracy as possible. A discipline marked by the essential efficiency required for conducting special tests, relating to the oil pressure distribution within the journal bearing, of the type single groove plain bearing. Tests that were intended to be performed at the time or that were more likely to be conceived and conducted in the future utilizing the bearing at hand. The measurement task has required experimenting on three different types of commercial oils, SAE 20W50, SAE 10W40 and SAE 5W30 each of whose properties are to be more elaborately pointed out in the tables 2, 3 & 4 that are to be shown later below. The tests were to be carried out under different rotating speeds, ranging from "50 to 400 RPM". It was put into much consideration that the procedures were to be implemented under constant loads. The readings, relating to the pressure distribution of each lubricating oil, were also to be taken and registered one by one, in a separate way and individually. In this way it was possible to identify the optimal lubricating oil inside the bearing, in the light of the acquired pressure distribution data. It was found out that certain criteria such as the correct selection of lubricant as well as suitable running conditions were among the most crucial grounds relating to the tribological characteristics of the journal bearings. The most effective and beneficial lubricating oil was, as a consequence, determined on the basis of its effectiveness in as far as hydrodynamic lubrication was concerned. Oil pressure distribution and relations between the different lubricating oils could be elaborated, exposed and explained in detail through the following polar graphs.

5. DESCRIPTION OF THE LUBRICATION OILS EXPERIMENTALLY TESTED

Table (2): Properties of SAE 20W50 grade oil.

SAE 20W50 Parameters	Specification	Test Method
Density @ 15 °C	0.895 g/ml	ASTM D-1298
Kinematic Viscosity at 40 °C	153 mm^2/s	ASTM D- 445
Kinematic Viscosity at 100 °C	17.0 mm^2/s	ASTM D- 445
Viscosity index	120	ASTM D-2270
Flash point	230 °C	ASTM D-92
Pour point	-21 °C	ASTM D-97

Table (3): Properties of SAE 10W40 grade oil.

SAE 20W50 Parameters	Specification	Test Method
Density @ 15 °C	0.862 g/ml	ASTM D-7042
Kinematic Viscosity at 40 °C	93.0 mm2/s	ASTM D-7042
Kinematic Viscosity at 100 °C	14.2 mm2/s	ASTM D-7042
Viscosity index	156	ASTM D-7042
Flash point	236 °C	ASTM D-92
Pour point	-27 °C	ASTM D-97

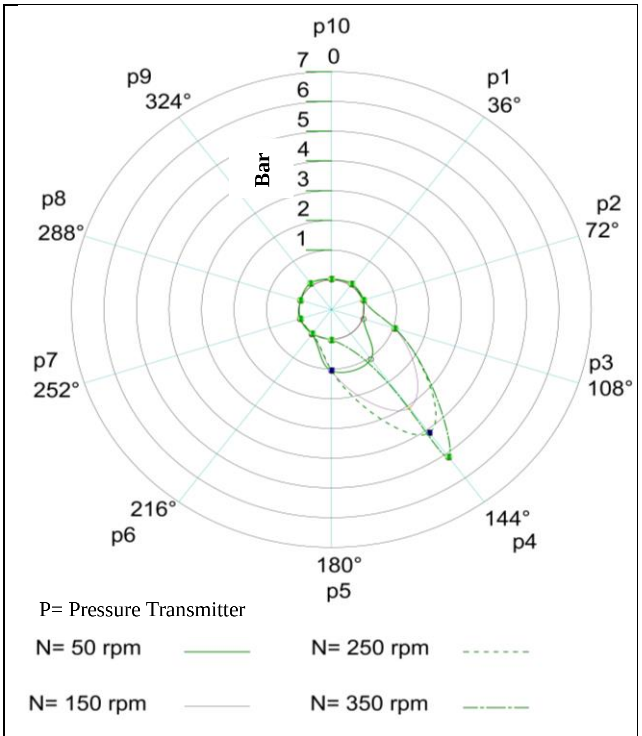
Table (4): Properties of SAE 5W30 grade oil.

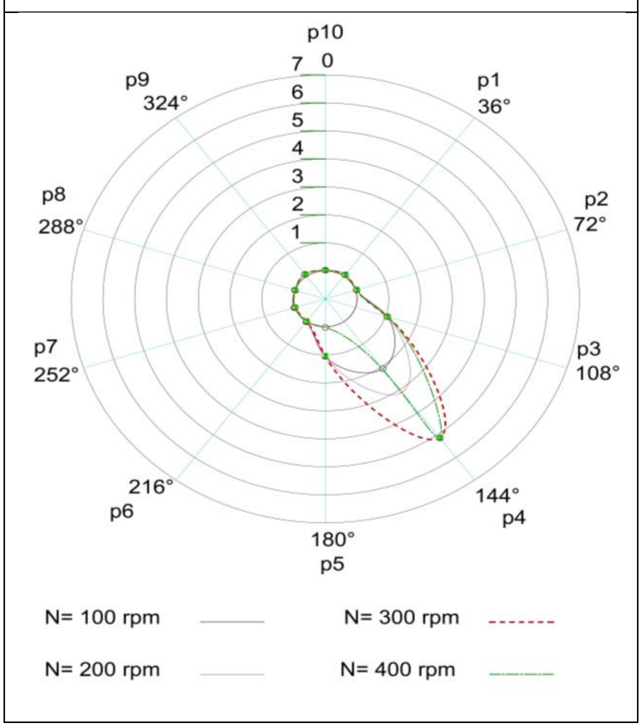
SAE 20W50 Parameters	Specification	Test Method
Density @ 15 °C	0.855 g/ml	ASTM D-7042
Kinematic Viscosity at 40 °C	61.7 mm2/s	ASTM D-7042
Kinematic Viscosity at 100 °C	11.0 mm2/s	ASTM D-7042
Viscosity index	172	ASTM D-7042
Flash point	230 °C	ASTM D-92
Pour point	-42 °C	ASTM D-97

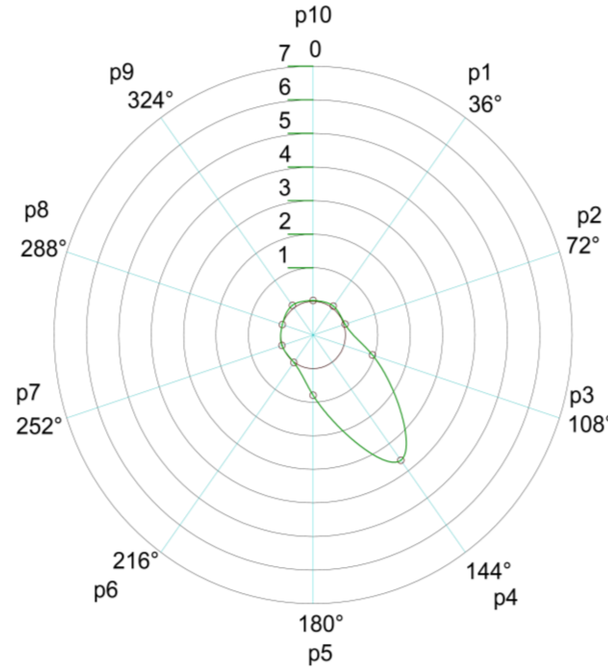
6. RESULTS AND DISCUSSION

The following is an illustration of outcomes, fed by the pertaining discussions, made in view of the experimentally conducted operations on the journal bearing test rig **"JBTR"** with SAE 20W50, SAE 10W40 and SAE 5W30 at constant load and varying speeds. Pressure distribution profile relating to each type of lubricating oil is individually shown below.

6.1 Polar pressure distribution curve for SEA 20W50







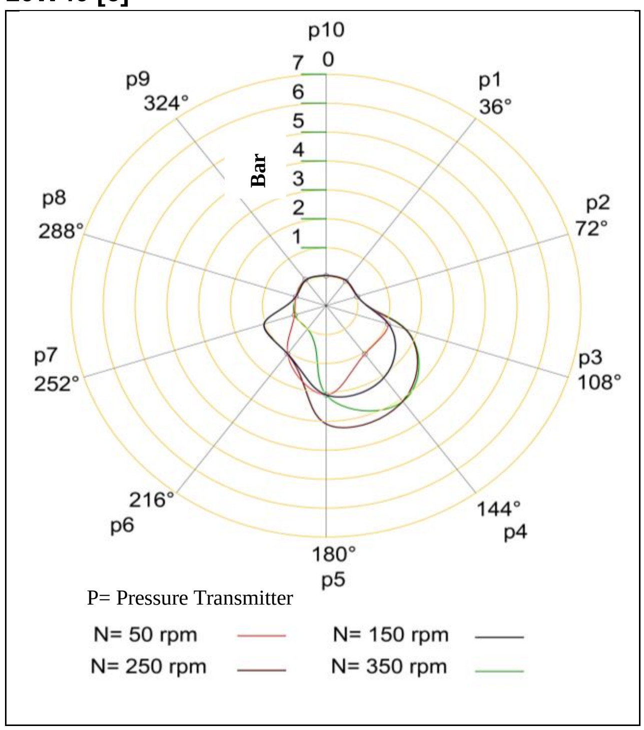
Distribution of mean pressure with the angle of rotating shaft at mean number of revolutions N = 225 rpm Oil SEA 20W50

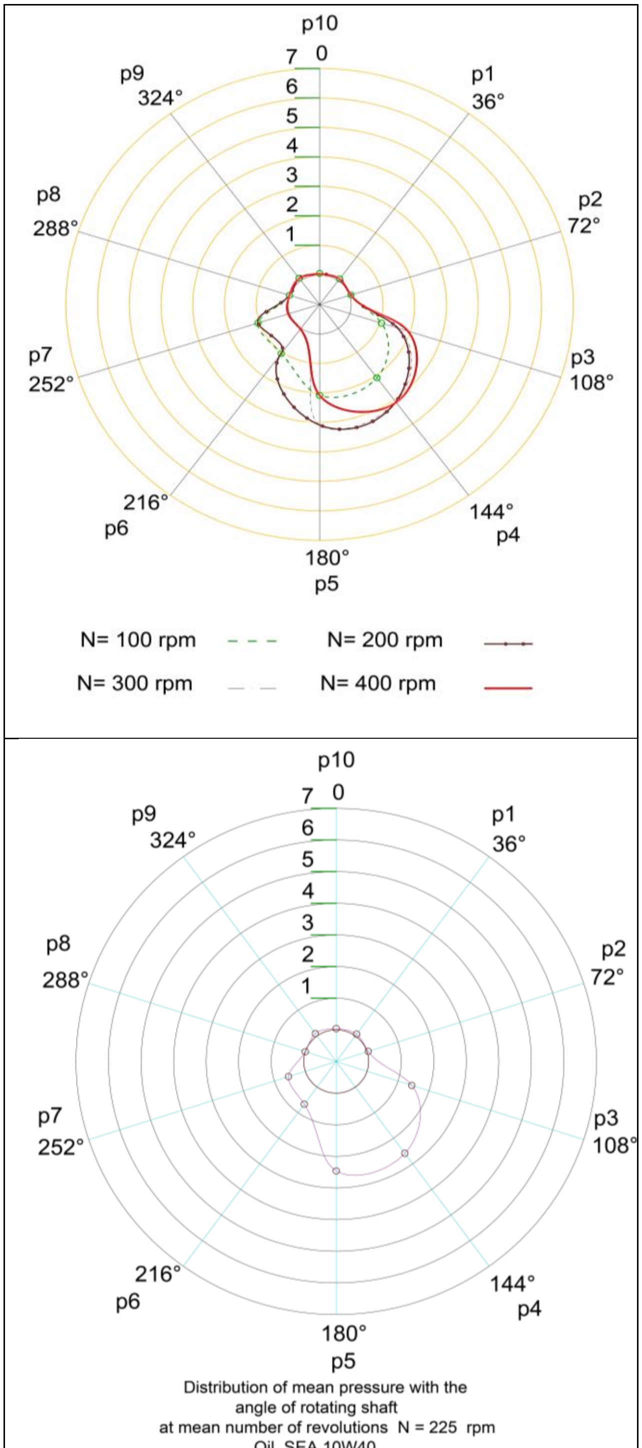
Mean pressure in bar at mean N=225 rpm											
Sensors	P10	P1	P2	P3	P4	P5	P6	P7	P8	P9	P10
Angle	0°	36°	72°	108°	144°	180°	216°	252°	288°	324°	360°
Pm	0.0275	0.063	0.0388	0.9273	3.6098	0.7951	0.0118	0.0131	0.0009	0.0886	0.0275

min = 0.0009, max = 3.6098, mean = 0.5576, median = 0.0510, mode = 0.0009, std = 1.1268, range = 3.6089 in bar

Figures 4: Representation of polar curve for SEA 20W50.

6.2 Polar pressure distribution curve for SEA 10W40 [6]



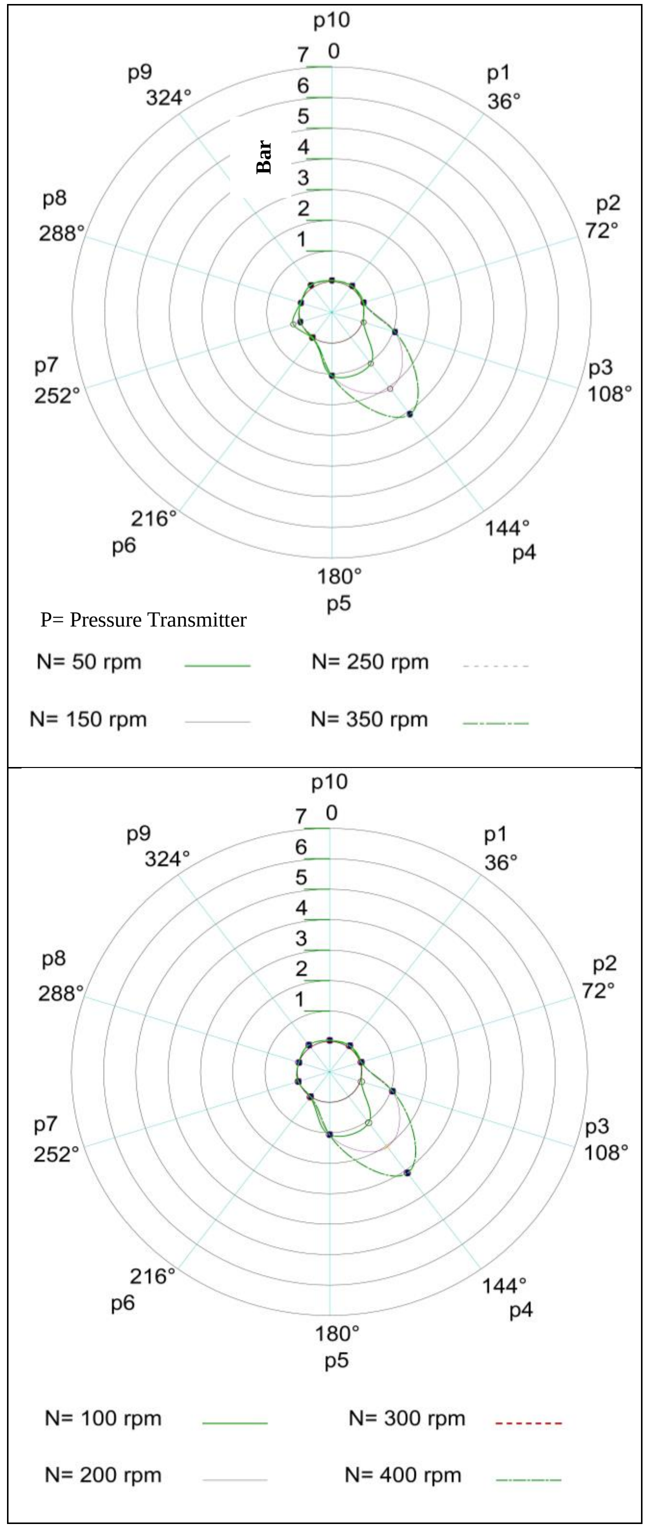


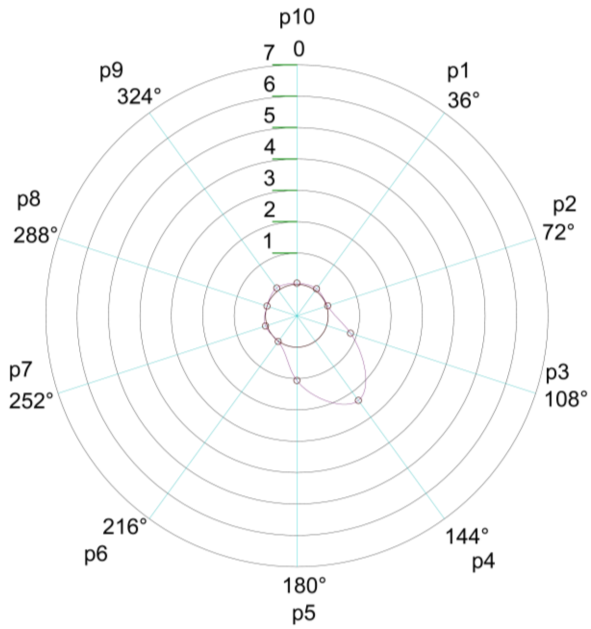
Mean pressure in bar at mean N=225 rpm											
Sensors	P10	P1	P2	P3	P4	P5	P6	P7	P8	P9	P10
Angle	0°	36°	72°	108°	144°	180°	216°	252°	288°	324°	360°
Pm	0.039	0.0655	0.035	1.4421	2.5873	2.4585	0.6691	0.5429	0.001	0.0915	0.039

min = 0.001 max = 2.5873 mean = 0.7932 median = 0.3171
mode = 0.001 std = 1.0157 range = 2.5863 in bar

Figures 5: An outline of polar curve for SEA 10W40.

6.3 Polar pressure distribution curve for SEA 5W30





Distribution of mean pressure with the angle of rotating shaft at mean number of revolutions N = 225 rpm Oil SEA 5W30

Mean pressure in bar at mean N=225 rpm											
Sensors	P10	P1	P2	P3	P4	P5	P6	P7	P8	P9	P10
Angle	0°	36°	72°	108°	144°	180°	216°	252°	288°	324°	360°
Pm	0.0641	0.0329	0.7969	2.334	1.0602	0.0131	0.0498	0.0131	0.0011	0.0931	0.0406

min = 0.0011 max = 2.334 mean = 0.4484 median = 0.057
mode = 0.0011 std = 0.761 range = 2.3329
in bar

Figures 6: Polar curve for SEA 5W30

Based on the polar diagrams provided, a number of conclusions could be drawn in light of the values obtained and registered. The SAE 5W30 lubricating oil “Fig.6” tended to score the least values, in as far as lubrication characteristics profile was regarded. Further, it appeared to effect the best performance on operating the journal bearing test rig at lower speeds ranging to 150 RPM. The performance is, however, inclined to feature a gradual decline when operating at non-stop varying lower speed revolutions starting from 150 RPM until 400 RPM. In comparison, the lubricating oil of the type SAE 20W50 “Fig.4” was noted to secure promoted operation performance values on being tested at speeds ranging from 150 RPM until 400 RPM. The performance was otherwise on the decline trend on experimenting at all speeds lower than 150 RPM. Furthermore, the SAE 10W40 lubricating oil “Fig 5” has assumed, what could be described as, the optimal values regarding the operating conditions when experimenting at speed limits ranging from 150 RPM to 250 RPM subsequently. Furthermore, it was observed that on effecting a gradual increase in the speed revolution from 50 RPM to 400 RPM, the lubricating oil pressure tended to feature a comparatively significant rise. Hence, it is discerned that increasing revolution speed according to the lubrication parameters would result in better squeeze between the oil molecules. The evidence that indicated the existence of hydrodynamic lubrication.

Besides, it has been noted that the maximum pressure P_{max} in all of the operating conditions in the course of experimenting on each of the tested utilized oil tended to be at the pressure transmitter P_4, at an angle of 144^0, whereas the position of the terminating film pressure P_0 was at the pressure transmitter P_3 at an angle of 108^0, and it remained permanently fixed in position throughout the experimenting procedures.

In addition, the values relating to the maximum film pressure ratio P_0/P_{max} for the lubrication oils being tested, that is, SEA 20W50, SEA 10W40 and SEA 5W30 at maximum speed of 400 RPM were 0.2, 0.6 and 0.3 respectively.

7. Conclusion

Having carried out versatile tests and calculations, relating to the pressure distribution of the lubricating oils within the journal bearing under study, a number of conclusions could safely be drawn, on the basis of the credibility and validity to which those conducted tests bear witness. In addition to the previously mentioned observations, and by focusing on the right side of the lower half of the journal bearing of the type single groove bearing, where higher values regarding the oil film pressure distribution are observed, it is obvious that the pressure of the lubrication oil tends to increase at the pressure transmitters P_3, P_4 and $P_{5,}$ whose positions were at the angles of 108^0, 144^0 and 180^0 respectively, which means that there is a positive increase relation corresponding to the increase in each of the following

1. The oil viscosity from SEA 5W30 to SEA 10W40 and up till SEA 20W50.
2. The journal shaft revolution speed ranging from 50 RPM up to 200 RPM. The oil pressure recorded tended to be constant, after the speed 200 RPM, due to the increase occurring in the oil lubrication escape rate through the clearance therein between the journal shaft and the journal bearing.

Thus, the study illustrates the extent of the positive increase interrelation of the oil film pressure distribution with each of the rotation speed and the oil viscosity. In other words, effecting an increase in the pressure, relating to one of them or both together, would not induce a comparative increase resulting from the pressure incurred from the lubricating oil squeeze, which might potentially be crucial on adding extra loads on the journal shaft in the studies to come. It is as well a hard and a practically costly task to conduct tests, using different grade oil viscosity of values much less than those found in the markets. That is why, it has become a must to conduct the required future experiments, by means of the computational fluid dynamic techniques CFD, ahead of setting off in mixing available lubricating oils, in the appropriate required ratios, for the sake of attaining the optimum degree of stability, in as far as the oil film pressure distribution at varying speeds is concerned.

Nomenclature

C	Radial Clearance (mm)
C_0	Total Clearance (mm)
CFD	Computational Fluid Dynamics
d	Inner Diameter For Plain Bearing
JBTR	Journal Bearing Test Rig
L	Bearing Length (mm)
N	Speed (rpm)
P	Load
P_0	Terminating Film Pressure (Pa)
P_{max}	Maximum Film Pressure (Pa)
P_0/P_{max}	Maximum Film Pressure Ratio
UJBTR	Universal Journal Bearing Test Rig
W,	Weight of Journal Shaft (N)
Φs	Shaft Diameter (mm)
μ	Dynamic viscosity

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دراسة لأعمدة المحامل بموجب زيوت تزييت مختلفة النوع علي أسس عملية

تعد أعمدة المحامل كمكونات أساسية في مختلف التطبيقات البحرية. ذلك لما تلعبه من دور محوري في نقل الحمولات الكبيرة عند متوسط سرعة الدوران. إن فكرة إنشاء اعمدة المحامل مبنية علي أساس التزييت الهيدروديناميكي حيث ثبت أفضليتها علي الأنواع الأخري من التصميميات المستخدمة في التطبيقات البحرية. وقد يمكن الحد من إحتكاك معدن مع معدن أخر وذلك بواسطة الفصل بين أسطح أعمدة المحامل وذلك بخلق طبقة سميكة من زيت التزييت مع الأخذ في الأعتبار مراعاة مد عمر منظومة الدفع وتقليل فقدان الطاقة الناتجة عن الأحتكاك والتأكل وكذا تقليل تكاليف الصيانة وقصر عمر الألات وكل ذلك يجب إعتبارة عند التصميم والأنشاء.

وفي الدارسة المقدمة تم محاولة إجراء دراسة عملية لتوزيع الضغط داخل أعمدة المحامل بأستخدام أنواع مختلفة من زيوت التزييت وذلك بأستخدام ثلاثة أنواع من الزيوت التجارية وهم SEA 20W50, SEA 10W40 &SEA 5W30 وذلك بغرض التعرف علي دور كل منها في تحديد حالة التزييت الهيدروديناميكي. هذا وقد إمتدت الدراسة لتشمل توزيع الضغط داخل أعمدة المحامل لهذه الزيوت المختلفة عند سرعات مختلفة تتراوح من 50 وحتي 400 لفة في الدقيقة. كانت مواصفات المحمل هي القطر الداخلي والبالغ 105 مم وطوله يصل إلي 58 مم والمصنوع من المعدن الأبيض. حيث كان نسبة طول المحمل إلي قطره هي 0.5 . وبالأضافة لذلك فإنه قد تم بحث ودراسة توزيع ضغط زيت التزييت محيطيا وذلك بموجب حمولات ثابتة عند سرعات دوران متباينة.