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CFD Analysis of Factors Affecting Conical Journal Bearing Performance

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Abstract

CFD analysis of conical journal bearings involves simulating fluid flow within the bearing to assess how factors like lubricant viscosity and flow rate impact performance. It includes evaluating pressure distribution and shear stresses to understand the effects of load and rotational speed. CFD Examination of Conical Journal Bearing (CJB) Relating Factors Performance involves using computational fluid dynamics to study and optimize the various parameters influencing the efficiency and behavior of conical journal bearings. CFD Analysis for conical journal-bearing performance is the high computational cost and time required for accurate simulations. To overcome the high computational cost of CFD analysis for conical journal bearings, use model simplification, mesh optimization, and parallel computing techniques. CFD analyzes the fluid flow and pressure distribution within conical journal bearings to evaluate how various factors impact their performance. It helps in understanding complex interactions and optimizing design parameters for improved efficiency and reliability. CFD provides detailed insights into fluid dynamics and pressure distribution, allowing for precise optimization of bearing performance. CFD analysis can reveal how factors like lubrication flow, bearing geometry, and operating conditions affect friction and wear, leading to more effective design improvements and enhanced bearing longevity.

Keywords

Conical Journal Bearings, CFD Simulation, Eccentricity Ratio, Reynolds Number, Lubrication Dynamics, Bearing Pressure Distribution

1. Introduction

Journal bearings (JB) are essential parts of many types of rotating equipment, providing support and facilitating smooth motion between moving parts [1]. Their performance directly impacts the efficiency, reliability, and lifespan of the machinery in which they are used [2]. To optimize the layout and functionality of JB, it is crucial to comprehend the influence of several design and operational frameworks on their behavior [3]. This study aims to ascertain the impact of eccentricity ratio, aspect ratio, semi-cone angle, and Reynolds number on the static force distribution and overall execution of JB using advanced Computational Fluid Dynamics (CFD) software [4]. The value known as the ratio of the eccentricity of the displacement of the journal center between the radial tolerance and the bearing core is a key parameter that affects the capability to bear a load and stability of JB [5]. An increased eccentricity ratio typically indicates a more loaded bearing, which can influence the division of force in the lubricating film and the overall performance of the bearing [6]. Parallel to this, the Reynolds number is a crucial factor in establishing the flow rate regime. This dimensionless quantity indicates the proportion of inertial motion to viscous pressure in the lubricating stream [7]. According to the RE, the flow can be laminar or turbulent, significantly impacting the static tension and the bearing's resistance properties [8]. The proportion of the bearing dimension to its circumference known as the ratio of aspect, affects the flow pattern and heat dissipation within the bearing [9]. A higher aspect ratio can enhance the load-carrying capacity but may also lead to increased friction and heat generation [10]. The semi-cone angle, relevant in tapered journal bearings, influences the alignment and pressure distribution [11]. A well-designed semi-cone angle can improve load distribution and reduce edge loading, thereby enhancing the bearing's performance and lifespan [12]. By using CFD software, this study provides a detailed analysis of how these parameters individually and collectively affect the performance of journal bearings [13]. Advanced CFD software allows for precise simulation of fluid flow and pressure distribution within journal bearings under varying conditions [14]. Through these simulations, we can visualize and quantify the effects of eccentricity ratio, aspect ratio, semi-cone angle, and Reynolds number on the static pressure and performance metrics of the bearings [15]. The insights gained from this analysis will offer valuable guidelines for optimizing journal-bearing design, improving their efficiency, and extending their operational life [16].

Ultimately, this study aims to aid in the creation of more dependable and efficient journal bearings, favoring numerous industrial uses where rotating machinery is employed [17]. The semi-cone angle and aspect ratio further contribute to the performance of the bearing by influencing the overall geometry and alignment of the bearing surfaces [18]. A higher aspect ratio can improve load distribution but may require careful management of thermal effects and friction [19]. The semi-cone angle, particularly relevant in tapered bearings, affects how the load is spread across the bearing surfaces, with implications for wear and longevity [20]. Through CFD analysis, we can optimize these geometric parameters to enhance bearing performance under various operational conditions [21]. The power of CFD software to explore the effects of eccentricity ratio, RE, semi-cone angle, and aspect ratio on the performance of JB [22]. By providing a detailed and controlled analysis of these parameters, we aim to offer valuable insights that can guide the design and optimization of journal bearings [23]. The ultimate goal is to improve the efficiency, reliability, and lifespan of these critical components, benefiting several industrial uses and advancing the field of bearing technology [24]. The use of CFD software in this context offers a sophisticated approach to modeling and analyzing the fluid dynamics within journal bearings [25]. CFD allows for the simulation of complex interactions between the lubricant and bearing surfaces, providing a detailed visualization of pressure distribution and flow patterns [26]. By manipulating the eccentricity ratio, Reynolds number, aspect ratio, and semi-cone angle within the simulations, we can observe how changes in these parameters change how the lubrication film behaves and, consequently, the bearing functionality [27]. This method provides a comprehensive view that is difficult to achieve through experimental means alone, offering precise control over each variable and the ability to isolate their effects [28]. The outline of this article is articulated as follows. In section 2 we have written a related study. In section 3 we have written the proposed methodology. In section 4 we have written the result and discussion section. In section 5 we have written the conclusion section.

2. Related Study

The semi-cone angle CHJB performance investigation (γ = 5, 10, 20, 30) over a broad radial load range ($\overline{W}_r$ =0:1 - 0:9) on rotating journals has been suggested by Gangrade et al [29]. The modified RE has been solved by utilizing the FEM to examine the movement of lubricant in the gap that exists in the journal and the bearing. For a variety of CHJB arrangements, execution parameters such as LCC, FFT, coefficients of stiffness, coefficients of damping, and speed of threshold have been shown and analyzed. The findings indicate that, in comparison to the foundation semi-cone angles joint $\gamma = 5^{\circ}$, the speed of threshold ($\overline{\omega}_{th}$) of the CJB reduces dramatically with increasing semi-cone angle to $\gamma = 30^{\circ}$.

A hydrodynamic bearing lubricated with a fluid that is not Newtonian was studied using CFD is covered by Tyagi et al [30]. The lubricant's non-Newtonian behavior is modeled using a power-law. By utilizing the CFX 17.2 software component to change the power-law index (n) under steady-state circumstances from 0.8 to 1.2 in terms of its stiffness, bearing parameters like FFP and LCC are found. The laminar flow model was chosen based on RE calculation by the simulation's evolved geometry. Additionally, the connection between pressure and LCC is derived for varying L/D ratios, RPM, and relative clearance. An FFP profile was created by altering the input factors at different power-law indices to comprehend how HDB performed in dilatant, Newtonian, and pseudoplastic fluid regimes.

Through the introduction of a state of roughness in a particular stationary bearing surface's zone, Cahyo et al [31] sought to offer a revolutionary journal-bearing design. Furthermore, a more thorough investigation is conducted into the effects of intended roughness on Bingham plastic-lubricated bearing performance. The investigation was carried out using a 3D CFD model of a JB, taking into account the influence of cavitation. The study's findings demonstrate that designed roughness significantly alters how well a bearing performs tribologically under non-Newtonian lubrication. Additionally, it was demonstrated that the carefully selected roughened surface had a greater impact on improving support for loads and reduction of friction force. The findings of the simulation also show that using an engineered surface has no appreciable impact on the bearing's noise level.

Because of its unparalleled performance, hybrid conical journal bearings have drawn a lot of interest from researchers and design engineers, according to Pawar et al.'s [32] study. However, wear has an impact on these bearings' performance. The purpose of this research is to give an analytical investigation on the execution of HCJB with hole entrance wear. There is a noticeable change in performance as a result of wear, based on the results of numerical simulations of the efficiency characteristics of worn bearings. Therefore, at the wear value of nearly 50% of radial clearance levels, the value of C22 reduces by 24.6% with the bearing design that is presented and the semi-cone angle of g = 25.

Analytical research on how wear affects the Performance of the membrane-adjusted 2-lobe four-pocket HJB system was given by Phalle et al [33]. Using the Newton-Raphson technique and FEM, the altered RE controlling the lubricant flow in a JB system's clearance gap was resolved. The numerically calculated findings show clearly that wear has a major effect on the functionality of the bearing. Better bearing performance might be achieved by carefully choosing parameters like d, dw, and Cm.

Conical hydrodynamic journal bearings, which can withstand loads in both radial and axial directions, are advantageous for use in rotating machinery such as compressors and turbines, according to research by Gangrade et al [34]. Conical hydrodynamic journal bearing performance is influenced by a wide range of operating factors, including aspect ratio, semicone angle, clearance ratio, eccentricity ratio, and speed. Currently, CFD models are working in research to overcome the operational and financial challenges, in place of experimental approaches. Using Ansys Fluent software, the aspect ratio (λ = 0.5, 0.8, 1.0), semi-cone angles (γ = 00, 50, 100, 200, 300), clearance ratio (Ꞓ= 0.001, 0.002), and speed (N = 2000, 5000, 10000 rpm) of conical hydrodynamic journal bearings were examined in this work. It was discovered that the operating parameters of the bearing had an impact on the numerically simulated outcomes of the water-filled CJB.

Table 1 Literature summary

SI. No.	Author name	Objective	Advantages	Disadvantages
1	Gangrade et al [29]	To analyze the functionality of CHJB with varying semi-cone angles and radial loads,	The threshold speed of the conical journal bearing significantly decreases with increasing semi-cone angles, enhancing performance under varying loads.	Increasing the semi-cone angle reduces the load-carrying capacity, which may affect the bearing's effectiveness in high-load applications.
2	Tyagi et al [30]	Carrying out CFD study on non-Newtonian fluid-lubricated hydrodynamic bearings	study provides detailed insights into the execution of hydrodynamic bearings in various lubrication regimes	The analysis may be limited by the assumptions of steady-state conditions and laminar flow, potentially overlooking transient or turbulent effects.
3	Cahyo et al [31]	To suggest a new JB design in a certain zone with designed surface roughness	Engineered roughness significantly enhances load support and reduces friction force in non-Newtonian lubricated bearings.	The introduction of engineered roughness has minimal effect on reducing bearing noise.
4	Pawar et al [32]	To present an analytical study on the performance impact of wear on hole entry worn HCJB.	The study highlights the significant performance changes in hybrid conical journal bearings due to wear, aiding in better design and maintenance.	Performance degradation, such as a 24.6% reduction in C22 for a semi-cone angle of 25°, is considerable at 50% of the radial clearance is the wear value.
5	Phalle et al [33]	To provide analytical research on how wear affects a membrane-compensated two-lobe, four-pocket HJB system's performance.	The study provides insights into optimizing parameters (d, dw, and Cm) to mitigate the adverse effects of wear and enhance bearing performance.	The bearing's ability is significantly compromised using wear, requiring careful parameter choice to maintain efficiency.
6	Gangrade et al [34]	To investigate the execution of CHJB with varying operational parameters using CFD models	The study uses CFD models to effectively analyze the impact of multiple operational parameters on bearing performance, reducing the need for costly experimental methods.	Various factors impact the performance of CJB lubricated with water, which may complicate the interpretation of results and optimization.

3. Materials and Methods

The methodology includes a thorough validation process to guarantee the CFD model's correctness. Experimental data from journal-bearing tests are used to validate the simulation results. Sensitivity analyses are conducted to determine the influence of mesh density and solver settings on the accuracy of the predictions. Parametric studies are carried out by systematically varying the eccentricity ratio, Reynolds number, aspect ratio, and semi-cone angle to observe their individual and combined effects on static pressure distribution and bearing performance. Visualization techniques, such as contour plots and vector fields, are employed to illustrate the flow characteristics within the bearing. The insights gained from these simulations help in identifying optimal design configurations and operational conditions that maximize the LCC and reduce wear and friction. Ultimately, the proposed CFD-based methodology provides a powerful tool for the detailed analysis and optimization of journal-bearing performance, leading to enhanced durability and efficiency in practical applications.

Table 2 Geometric and operating characteristics for CHJB

Sr. No.	Geometric characteristics	Notation	Values
1	Aspect ratio	λ	0.5, 0.75, 1.0
2	Semi-cone angle	γ	05deg, 10deg,150deg
3	Eccentricity ratio	ε	0.1 - 0.9
4	Reynolds number	R_e	800-10000
5	Radial clearance (Micron)	C	50
6	Supply pressure (MPa)	P_s	0.5
7	Operating Temperature (deg C)	T_s	40

Table 2 outlines various geometric and operational parameters relevant to a certain engineering or fluid dynamics context, with their corresponding notations and values. Here is a detailed description of each parameter:

Aspect Ratio (λ): This is the ratio of different dimensions of the geometry, which can affect the flow characteristics. The values provided are 0.5, 0.75, and 1.0.

Semi-cone Angle (γ): This parameter represents the angle of a cone's half-apex, influencing flow dynamics. The given angles are 5 degrees, 10 degrees, and 150 degrees.

Eccentricity Ratio (ε): This ratio measures the deviation of a shape from being circular, affecting how the fluid flows through or around it. The values range from 0.1 to 0.9.

Reynolds Number (R_e): This dimensionless number is crucial in fluid dynamics to predict flow patterns in different fluid flow situations. The provided range is from 800 to 10,000, indicating the range of flow conditions considered.

Radial Clearance (C): Represented in microns, this is the small gap between two components, such as in bearing systems, affecting the lubricant flow and pressure distribution. The specified value is 50 microns.

Supply Pressure (P_s): This is the pressure at which the fluid is supplied into the system, measured in megapascals (MPa). The given supply pressure is 0.5 MPa.

Operating Temperature (T_s): The temperature at which the system operates, given in degrees Celsius. The specified operating temperature is 40°C. These parameters are essential for analyzing and designing fluid flow systems, influencing factors like efficiency, stability, and performance.

Calculations for aspect ratio = 1.0

Here the aspect ratio is calculated for 1.0. In the CFD analysis of conical journal bearing performance, an aspect ratio of 1.0 is considered to ensure that the bearing's length equals its average diameter.

$$\lambda = \frac{L}{d} = 1.0$$

$$\varepsilon = \frac{e}{c} = 0.1 \text{ to } 0.9$$

Mean Diameter =d=100 mm
Radial clearance = c = 50 micron =0.05 mm
Semi-cone angle = 05deg, 20deg, 30deg
Cone angle γ =10deg, 20deg, 30deg

$$\lambda = \frac{L}{d} = 1$$

$$\therefore \frac{L}{100} = 1$$

$$\therefore L = 1 \times 100$$

$$\therefore L = 100 \text{mm}$$

$$\frac{d_1 + d_2}{2} = 100$$

$$\therefore d_1 + d_2 = 200$$

$$\therefore 2d_1 + 2x_1 = 200$$

$$\therefore d_1 + x_1 = 100$$

For semi-cone angle = 05deg

In the CFD analysis of conical journal bearing performance, setting a semi-cone angle of 5 degrees affects the geometric configuration and fluid dynamics within the bearing. With a semi-cone angle of 5 degrees, the bearing exhibits a gradual tapering from the small end to the large end, influencing the pressure distribution and lubrication characteristics.

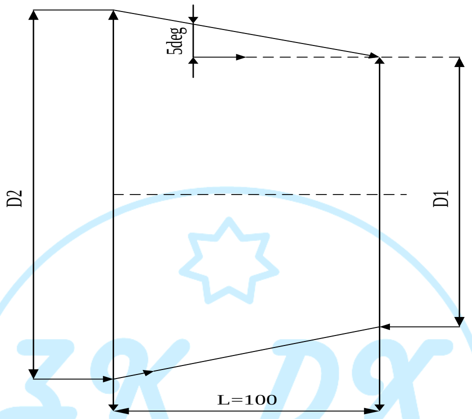

Fig. 1 aspect ratio = 1.0 and semi-cone angle = 05deg

$$\therefore \tan\text{ (05deg)}= \frac{x_1}{100}$$

$$\therefore \; x_1 = 8.7488$$

$$\therefore \; d_1 + x_1 = 100$$

$$\therefore \; d_1 \text{+8.7488=100}$$

$$\therefore \; d_1 = 91.2512 \text{ mm …..Journal minimum diameter}$$

$$\because \; \frac{d_1 + d_2}{2} = 100$$

$$\because \; d_2 = 108.7488 \text{ mm….Journal maximum diameter}$$

$$\because D_1 = d_1 + 2c$$

$$D_1 = 91.2512 + 2(0.05)$$

$$\because D_1 = 91.3512mm \text{ ….Bearing minimum diameter}$$

$$\because D_2 = d_2 + 2c$$

$$\therefore D_2 = 108.7488 + 2(0.05)$$

$$\therefore D_2 = 108.8488mm \text{ ….Bearing maximum diameter}$$

Calculations for aspect ratio = 0.75

For a CFD analysis where the aspect ratio is set to 0.75, the length of the conical journal bearing must be 75% of its average diameter. This adjustment ensures that the bearing's dimensions are proportionally optimized for the simulation, affecting both the fluid flow and performance characteristics accurately.

$$\lambda = \frac{L}{d} = 0.75$$

$$\varepsilon = \frac{e}{c} = 0.1to0.9$$

Mean diameter = d =100 mm
Radial clearance = c = 50 micron = 0.05 mm
Semi-cone angle = 050, 100,150
 Cone angle γ = 10deg, 20deg, 30deg

$$\lambda = \frac{L}{d} = 0.75$$

$$\therefore \frac{L}{100} = 0.75$$

$$\therefore L = 0.75 \times 100$$

$$\therefore L = 75mm$$

$$\frac{d_1 + d_2}{2} = 100$$

$$\therefore d_1 + d_2 = 200$$

$$2d_1 + 2x_1 = 200$$

$$\therefore d_1 + x_1 = 100$$

For semi-cone angle γ = 05

In the CFD analysis of conical journal bearing performance with a semi-cone angle γ of 5 degrees, the bearing's geometry is defined by a relatively gentle taper. This semi-cone angle affects the distribution of pressure and the flow of lubricant within the bearing.

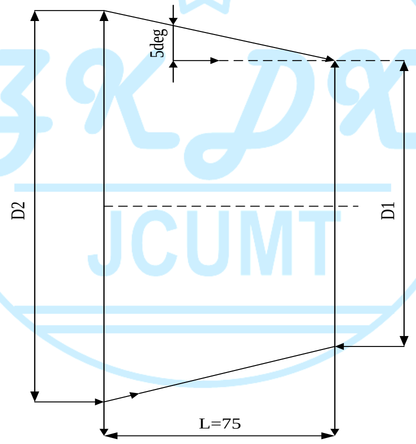

Fig. 2 for aspect ratio = 0.75 and semi-cone angle = 05deg

$$\therefore \tan(05^\circ) = \frac{x_1}{75}$$

$$\therefore x_1 = 6.5616mm$$

$$\therefore d_1 + x_1 = 100$$

$$\therefore d_1 = 93.4384mm$$ …..journal minimum diameter

$$\frac{d_1 + d_2}{2} = 100$$

$$d_2 = 106.5616mm$$ …...Journal maximum diameter

$$\because D_1 = d_1 + 2c$$

$$\therefore D_1 = 93.4384 + 2(0.05)$$

$$\therefore D_1 = 93.5384mm$$ …..Bearing minimum diameter

$$\because D_2 = d_2 + 2c$$

$$\therefore D_2 = 106.5616 + 2(0.05)$$

$$\therefore D_2 = 106.6616mm$$ …..Bearing maximum diameter

Table 3 The properties of fluids used for CFD analysis

Sr. No.	Properties	Water
1	Mass Density (kg/m³)	998.2
2	Fluid Viscosity (Pa-s) (Kg/m. s)	0.001003
3	Specific Heat (J/Kg ° C)	4182
4	Thermal Conductivity (W/m ° C)	0.6

A comparison of the physical and thermal characteristics is shown in Table 3 of water and oil. Four properties are compared: mass density, fluid viscosity, thermal conductivity, and specific heat. Water has a higher mass density (998.2 kg/m³) compared to oil (860 kg/m³). The fluid viscosity of water is significantly lower (0.001003 Pa·s) than that of oil (0.0277 Pa·s), indicating that oil is more viscous. Water also has a much higher specific heat capacity (4182 J/kg°C) than oil (2000 J/kg°C), meaning water can store more heat per unit mass. Finally, compared to oil, water has a greater thermal conductivity (0.6 W/m°C) than oil (0.13 W/m°C), indicating water is more effective at conducting heat. Figure 1 shows the aspect ratio = 1.0 and semi-cone angle = 05deg. The aspect ratio which is shown in figure 2= 0.75 and the semi-cone angle = 05deg. The aspect ratio which is shown in figure 3=1.0 and the semi-cone angle =10deg. Figure 4 shows the aspect ratio=0.75 and semi-cone angle=10deg. Figure 5 shows the aspect ratio =1.0 and semi-cone angle =15deg. Figure 6 shows the aspect ratio =0.75 and semi cone angle=15deg.

4. Result and Discussion

The CFD analysis of conical journal-bearing performance reveals several key findings. The simulations indicate that variations in semi-cone angle significantly impact pressure distribution and lubrication efficiency. Specifically, a semi-cone angle of 5 degrees results in a smoother transition between diameters, enhancing fluid flow and reducing localized pressure peaks. Additionally, the aspect ratio influences the bearing's overall performance, with an aspect ratio of 0.75 optimizing the balance between bearing length and diameter for effective lubrication.

Table 4 Maximum bearing pressure concerning RE and Eccentricity ratio

Sr. No.	Water			
	RE ⟶	780	1300	2200
	Eccentricity Ratio	Maximum Bearing Pressure (MPa)		
1	0.1	0.64	0.70	0.88
2	0.2	0.74	0.87	1.25
3	0.3	0.85	1.09	1.72
4	0.4	1.02	1.42	2.31
5	0.5	1.26	1.87	3.12
6	0.6	1.62	2.58	4.50
7	0.7	2.28	3.83	6.97
8	0.8	3.74	6.58	12.40

Table 4 presents the relationship between the eccentricity ratio and maximum bearing pressure (in MPa) for different load conditions (denoted as RE 780, 1300, and 2200). The eccentricity ratio, which measures the offset of the load from the center of a foundation, varies from 0.1 to 0.8. As the eccentricity ratio increases, the maximum bearing pressure also increases across all load conditions.

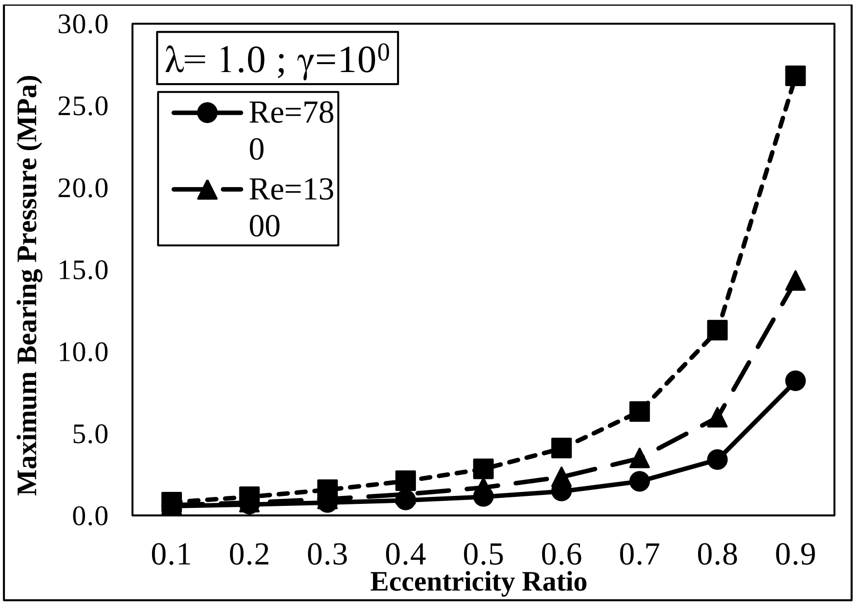

Fig. 1 Bearing pressure vs eccentricity ratio for Re=780, 1300, and 2200

Figure 1 shows the Bearing pressure vs eccentricity ratio for Re=780, 1300, and 2200 This indicates that as the load becomes more eccentric (i.e., further from the center), the bearing pressure on the foundation rises significantly, with more pronounced effects under higher loads. For example, at an eccentricity ratio of 0.1, the bearing pressure ranges from 0.64 MPa to 0.88 MPa, whereas at a ratio of 0.8, it escalates dramatically to between 3.74 MPa and 12.40 MPa, showing a strong correlation between load eccentricity and bearing pressure.

Table 5 Maximum Static Pressure concerning RE and eccentricity ratio

Sr. No.	**Water**			
	ε	**0.2**	**0.4**	**0.6**
	RE Reynolds Number	**Maximum Bearing Pressure (MPa)**		
1	800	0.78	1.08	1.73
2	900	0.80	1.15	1.91
3	1000	0.83	1.23	2.09
4	2000	1.21	2.14	4.18
5	3000	1.70	3.46	6.95
6	4000	2.31	4.94	10.49
7	5000	3.03	6.74	14.47
8	6000	3.95	9.04	19.14
9	7000	4.94	11.68	24.32
10	8000	6.13	14.48	29.92
11	9000	7.33	17.53	35.84
12	10000	8.58	21.12	42.50

Table 5 illustrates the relationship between the Reynolds Number (RE) and the maximum bearing pressure (in MPa) at three different water content levels (0.2, 0.4, and 0.6). As the Reynolds Number, which represents the flow condition in a fluid, increases from 800 to 10,000, the maximum bearing pressure also increases significantly across all water content levels. For lower Reynolds Numbers (e.g., 800 to 1,000), the bearing pressure rises gradually, ranging from 0.78 MPa to 2.09 MPa.

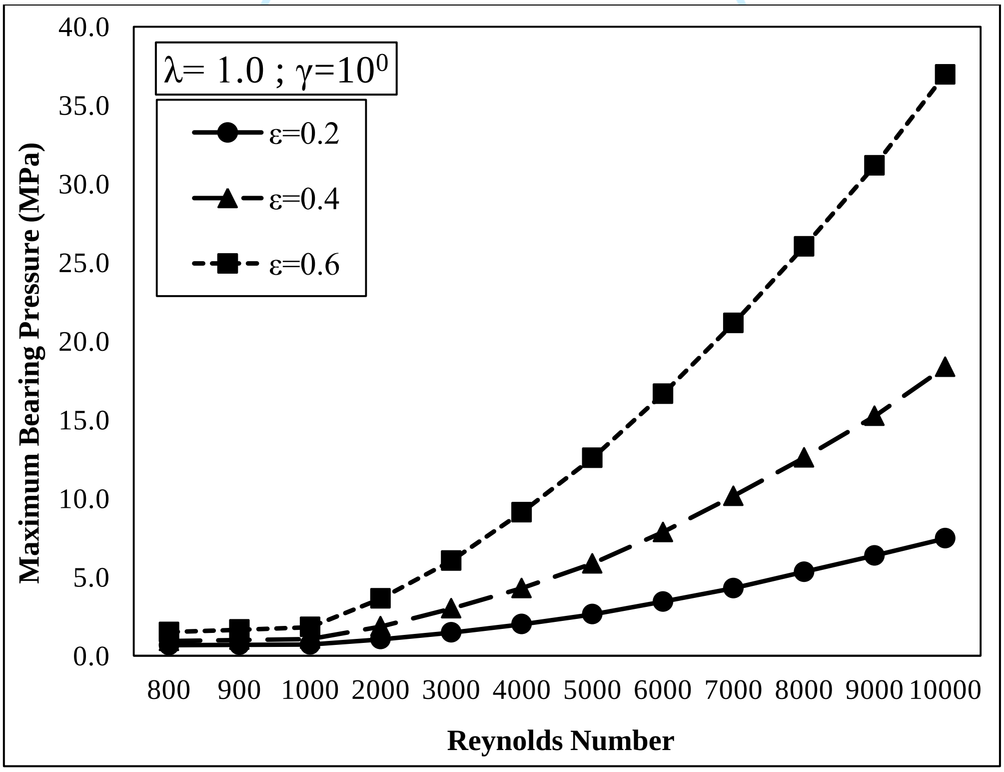

Fig. 2 bearing pressure vs Reynolds number for $\lambda = 1.0, \gamma = 10$ deg

Figure 2 shows the bearing pressure vs Reynolds number for $\lambda = 1.0, \gamma = 10$ deg. However, as the Reynolds Number exceeds 2,000, the bearing pressure begins to escalate more rapidly, particularly at higher water content levels. At a Reynolds Number of 10,000, the bearing pressure reaches up to 42.50 MPa for the highest water content of 0.6. This data indicates a strong positive correlation between the Reynolds Number and bearing pressure, with more substantial increases observed at higher water content levels, reflecting the impact of fluid dynamics on the bearing capacity of materials.

Table 6 Maximum Bearing Pressure (MPa) concerning RE and λ

Sr. No.	Water			
	λ	0.5	0.75	1.0
	RE	Maximum Bearing Pressure (MPa)		
1	800	0.78	0.96	1.08
2	900	0.81	1.02	1.15
3	1000	0.84	1.08	1.23
4	2000	1.17	1.71	2.14
5	3000	1.61	2.58	3.46
6	4000	2.14	3.62	4.94
7	5000	2.79	4.93	6.74
8	6000	3.55	6.48	9.04
9	7000	4.48	8.24	11.68
10	8000	5.42	10.29	14.48
11	9000	6.52	12.38	17.53
12	10000	7.76	14.62	21.12

Table 6 shows the relationship between the Reynolds Number (RE) and the maximum bearing pressure (in MPa) at three different water content levels: 0.5, 0.75, and 1.0. As the Reynolds Number increases from 800 to 10,000, the maximum bearing pressure also increases across all water content levels.

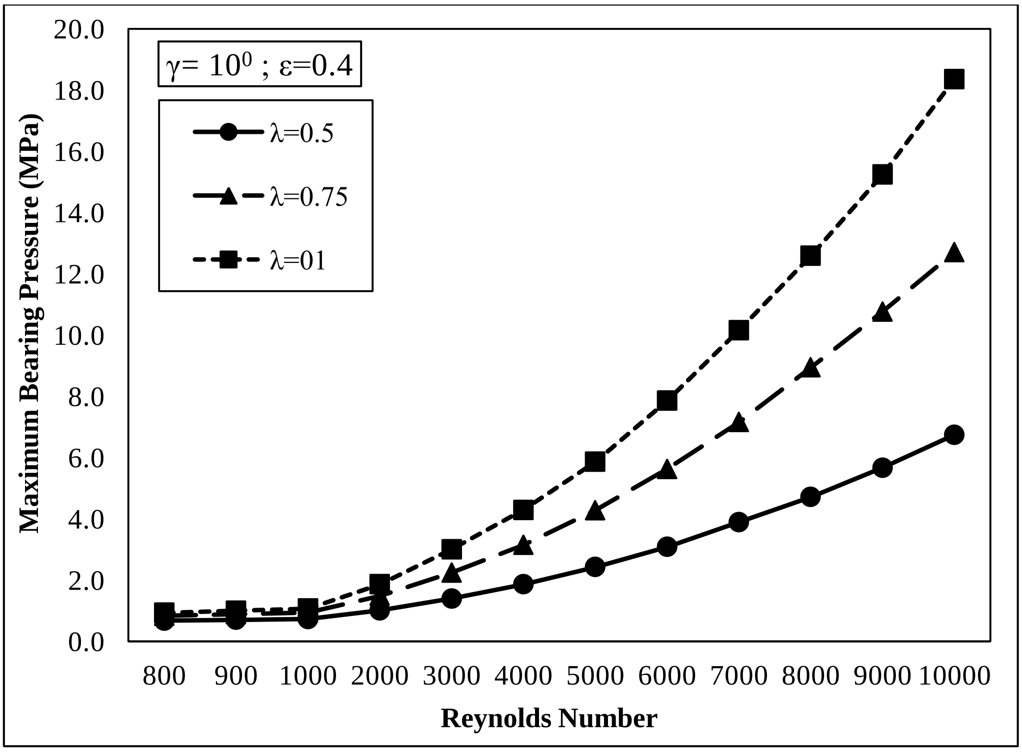

Fig. 3 bearing pressure vs Reynolds number for varying λ

Figure 3 shows the bearing pressure vs Reynolds number for varying λ. At lower Reynolds Numbers (800 to 1,000), the bearing pressure rises gradually, with values ranging from 0.78 MPa to 1.23 MPa. However, as the Reynolds Number climbs to 2,000 and beyond, the bearing pressure increases more significantly, particularly at higher water content levels. For instance, at a Reynolds Number of 10,000, the bearing pressure reaches up to 21.12 MPa for the highest water content of 1.0. This trend demonstrates that both the Reynolds Number and water content strongly influence the bearing pressure, with higher values of each leading to greater pressures.

Table 7 Maximum Bearing Pressure (MPa) concerning RE and Semi cone angle α

Sr. No.	Water			
	Semi cone angle α	05deg	10deg	15deg
	RE	Maximum Bearing Pressure (MPa)		
1	800	1.08	1.11	1.15
2	900	1.16	1.18	1.24
3	1000	1.24	1.27	1.33
4	2000	2.18	2.20	2.32
5	3000	3.47	3.55	3.72
6	4000	4.97	5.07	5.40

7	5000	6.88	6.92	7.40
8	6000	9.08	9.27	9.79
9	7000	11.56	11.99	12.51
10	8000	14.35	14.86	15.54
11	9000	17.40	17.99	18.80
12	10000	20.67	21.67	22.34

Table 7 presents the relationship between the Reynolds Number (RE) and the maximum bearing pressure (in MPa) for different semi-cone angles (α) of 5°, 10°, and 15°. As the Reynolds Number increases from 800 to 10,000, the maximum bearing pressure also rises for each of the semi-cone angles. At lower Reynolds Numbers (800 to 1,000), the increase in bearing pressure is modest, ranging from 1.08 MPa to 1.33 MPa.

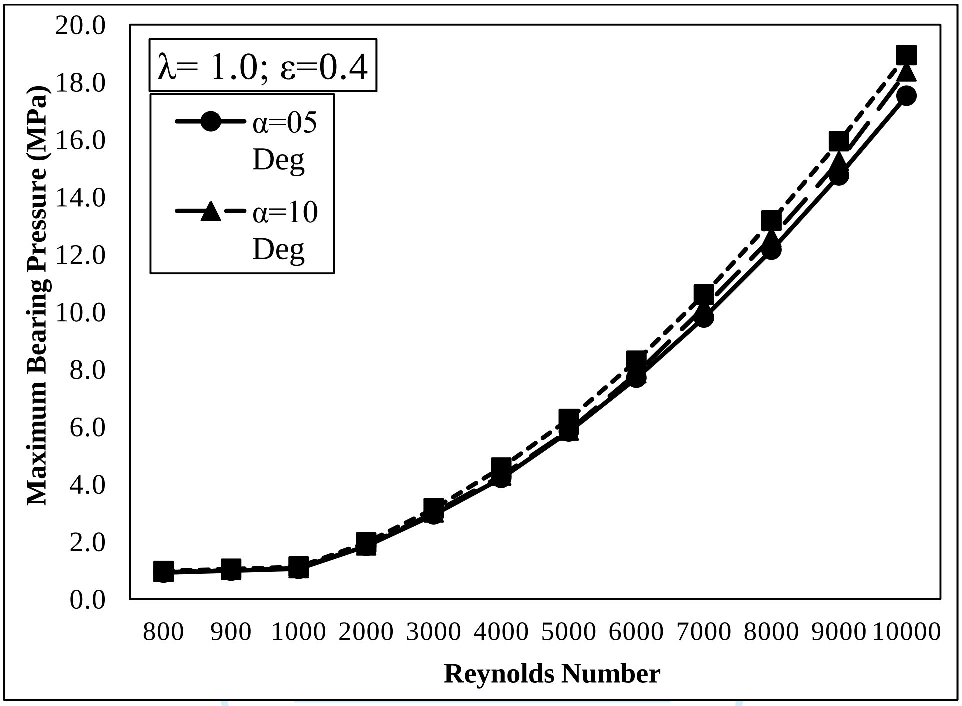

Fig. 4 bearing pressure vs Reynolds number for varying γ

Figure 4 shows the bearing pressure vs Reynolds number for varying γ However, as the Reynolds Number exceeds 2,000, the bearing pressure increases more sharply, particularly at higher Reynolds Numbers. For instance, at a Reynolds Number of 10,000, the maximum bearing pressure reaches 20.67 MPa for a 5° cone angle, 21.67 MPa for a 10° cone angle, and 22.34 MPa for a 15° cone angle. This data indicates that both the Reynolds Number and the semi-cone angle influence the bearing pressure, with larger cone angles leading to slightly higher pressures as the Reynolds Number increases.

5. Discussion

The Computational Fluid Dynamics (CFD) analysis of factors affecting conical journal bearing performance focuses on understanding the influence of various parameters like lubricant viscosity, bearing geometry, operating speed, and load conditions. By simulating the fluid flow and pressure distribution within the bearing, CFD allows for the detailed observation of hydrodynamic lubrication behavior, which is critical for reducing friction and wear. The analysis reveals how variations in these factors can lead to changes in film thickness, pressure profiles, and temperature distributions, ultimately impacting the bearing's load-carrying capacity, stability, and overall performance. The insights gained from CFD can be used to optimize bearing design and enhance its reliability in practical applications.

6. Conclusion

CFD analysis of factors affecting conical journal bearing performance involves using computational fluid dynamics to simulate and evaluate the impact of variables like lubricant viscosity, bearing geometry, and operating conditions on the bearing's load capacity, friction, and stability. This analysis helps optimize bearing design and performance for various engineering applications. To overcome disadvantages in CFD analysis of conical journal bearing performance, improve model accuracy with high-fidelity simulations, and validate results with experimental data. CFD analysis reveals that factors like lubricant viscosity, bearing geometry, and operating speed significantly influence the load capacity, friction, and stability of conical journal bearings. The CFD analysis shows that optimized bearing geometry and lubricant properties can enhance load capacity, reduce friction, and improve stability in conical journal bearings. Future scope includes refining CFD models with advanced turbulence and thermal effects, and integrating machine learning for predictive maintenance of conical journal bearings. For aspect ratio =1.0 and semi-cone angle =05 degrees, the d1 will be

91.2512 mm journal minimum diameter, d2 will be108.7488 mm journal maximum diameter, D1 will be 91.3512 mm bearing minimum diameter and D2 will be 108.8488 mm bearing maximum diameter.

Compliance with Ethical Standards

Conflict of Interest
Authors declare that they have no conflict of interest.

Ethical Approval
This article does not contain any studies with human participants or animals performed by any of the authors.

Consent to participate
All the authors involved have agreed to participate in this submitted article.

Consent to Publish
All the authors involved in this manuscript give full consent for publication of this submitted article.

Authors Contributions
All authors have equal contributions in this work.

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Data sharing does not apply to this article.

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