Impact of Thermal Variations on the Load and Stability Behavior of Hydrodynamic Journal Bearings

[1] Prem Pal Singh, [1] Sharad Kumar, [1] Ashutosh Singh, [1] Sushil Kumar Jha, [1] Rahul Bhatnagar, [2] Vikas Sharma

[1] School of Engineering & Technology, Shri Venkateshwara University, Gajraula, U.P. India

[2] Department of Computer Applications, SRM Institute of Science and Technology, Delhi NCR Campus, Ghaziabad, U.P. India

DOI : https://doi.org/10.51583/IJLTEMAS.2026.150100023

Received: 07 January 2026; Accepted: 12 January 2026; Published: 27 January 2026

ABSTRACT

Hydrodynamic journal bearings are critical components in high-speed rotating machinery, where their performance is strongly influenced by thermal effects generated due to viscous shearing of the lubricant. This paper investigates the impact of thermal variations on the load-carrying capacity and stability characteristics of hydrodynamic journal bearings. Temperature rise within the lubricant film alters viscosity distribution, pressure development, and film thickness, thereby affecting bearing stiffness, damping coefficients, and dynamic stability limits. A thermo-hydrodynamic framework is employed to analyze the coupled effects of heat generation, heat dissipation, and fluid–structure interaction on bearing behavior under varying operating conditions. The results demonstrate that increased thermal gradients lead to a reduction in load capacity and can significantly influence the onset of instability phenomena such as oil whirl and oil whip. The study highlights the necessity of incorporating thermal considerations in bearing design and performance prediction to ensure reliable and stable operation of rotating systems.

Keywords—Hydrodynamic journal bearing, thermal variations, load-carrying capacity, dynamic stability, thermo-hydrodynamic analysis, lubricant viscosity.

INTRODUCTION

Hydrodynamic journal bearings play a vital role in the reliable operation of rotating machinery such as turbines, compressors, electric generators, pumps, and automotive engines. These bearings support radial loads by generating a pressure field within a thin lubricant film formed between the rotating journal and the stationary bearing surface. The pressure developed in the lubricant film is sufficient to separate the contacting surfaces, thereby minimizing wear, reducing friction, and enhancing the overall efficiency and service life of mechanical systems. Owing to their simplicity, high load-carrying capability, and durability, hydrodynamic journal bearings remain one of the most widely used bearing types in industrial applications. Under practical operating conditions, journal bearings are subjected to high rotational speeds and heavy loads, which lead to significant viscous shear within the lubricant film. This shearing action generates heat, resulting in a temperature rise in the lubricant and bearing surfaces. Thermal effects are therefore inherently coupled with the hydrodynamic behavior of journal bearings and can no longer be neglected, especially in modern high-speed and high-power-density machinery. The temperature distribution within the lubricant film directly influences key physical properties of the lubricant, most notably viscosity, which is highly temperature dependent. Variations in viscosity modify the pressure distribution and film thickness, ultimately affecting the bearing's load-carrying capacity and frictional characteristics. In addition to steady-state performance, the dynamic behavior and stability of hydrodynamic journal bearings are critically affected by thermal variations. The bearing stiffness and damping coefficients, which govern the dynamic response of the rotor–bearing system, are sensitive to changes in temperature and viscosity. Elevated temperatures tend to reduce lubricant viscosity, leading to a decrease in hydrodynamic pressure generation and a corresponding reduction in stiffness. This can increase rotor vibrations and lower the threshold speed for instability phenomena such as oil whirl and oil whip. These self-excited vibrations pose a serious threat to the safe operation of rotating machinery and may result in excessive noise, reduced efficiency, or catastrophic failure if not properly controlled. Traditional bearing analysis often relies on isothermal assumptions, where the lubricant temperature is considered constant throughout the film. While such assumptions simplify the mathematical formulation and computational effort, they may lead to inaccurate predictions of bearing performance under realistic operating conditions. Experimental and numerical studies have shown that neglecting thermal effects can result in an overestimation of load capacity and stability margins. Consequently, thermo-hydrodynamic (THD) and thermo-elastic-hydrodynamic (TEHD) models have been developed to account for the coupled interactions between fluid flow, heat transfer, and structural deformation. These advanced models provide a more accurate representation of bearing behavior by considering temperature-dependent viscosity and heat generation due to viscous dissipation. Despite significant progress in thermo-hydrodynamic modeling, the complex relationship between thermal variations, load-carrying capacity, and stability characteristics of journal bearings continues to be an active area of research. Variations in operating parameters such as speed, load, lubricant properties, and cooling conditions can lead to non-uniform temperature fields and complex dynamic responses. Understanding how these thermal variations influence bearing performance is essential for improving design methodologies, selecting appropriate lubricants, and implementing effective thermal management strategies. The present study aims to examine the impact of thermal variations on the load and stability behavior of hydrodynamic journal bearings using a thermo-hydrodynamic approach. By analyzing the coupled effects of temperature rise, viscosity variation, and pressure development within the lubricant film, this work seeks to provide deeper insights into the mechanisms governing bearing performance under realistic operating conditions. The findings of this study are expected to contribute to more accurate performance prediction, enhanced stability assessment, and improved reliability of journal bearing-supported rotating machinery.

LITERATURE REVIEW

Extensive research has been carried out on hydrodynamic journal bearings to understand their load-carrying capacity, thermal behavior, lubrication mechanisms, and stability characteristics under various operating conditions. Dhande and Pande [1] presented a detailed multiphase flow analysis of hydrodynamic journal bearings using CFD coupled with fluid–structure interaction, incorporating cavitation effects. Their study highlighted the importance of realistic fluid modeling in accurately predicting pressure distribution and bearing performance, particularly under high-speed conditions. Kumar et al. [2] performed a numerical investigation of journal bearings under transient dynamic conditions and demonstrated that time-dependent operating parameters significantly influence pressure development and journal motion, emphasizing the need for dynamic analysis beyond steady-state assumptions. The influence of lubricant additives, especially nanoparticles, on the static and dynamic characteristics of journal bearings has also been widely explored. Yathish et al. [3] investigated the static characteristics of two-axial groove journal bearings operating with TiO_2 nano-lubricants and reported enhanced load capacity and reduced friction compared to conventional lubricants. In a related study, Yathish et al. [4] further examined the role of TiO_2 nanoparticles as lubricant additives and showed improvements in pressure distribution and bearing performance, attributing these benefits to modified rheological properties of the lubricant. Baskar and Sriram [5] experimentally analyzed the tribological behavior of journal bearing materials under different lubricants and concluded that lubricant composition plays a critical role in reducing wear and friction. Several studies have focused on the tribological performance of nano-lubricants using different nanoparticle materials. Wan et al. [6] examined lubricants containing boron nitride nanoparticles and observed significant reductions in friction and wear. Similarly, Charoo and Wani [7] studied IF-MoS_2 nanoparticles as lubricant additives and reported improved tribological performance for cylinder liner–piston ring tribo-pairs. Ilie and Covaliu [8] and Laad and Jatti [9] investigated titanium dioxide nanoparticles as lubricant additives and highlighted their potential to enhance thermal stability, viscosity characteristics, and anti-wear behavior of lubricants, which are directly relevant to hydrodynamic bearing applications. Thermal aspects and heat transfer characteristics of lubricants have also been addressed in the literature. Azmi et al. [10] experimentally studied turbulent forced convection heat transfer using SiO_2 nanofluids and demonstrated improved heat transfer performance, suggesting the potential of nano-lubricants for better thermal management. Binu et al. [11] analysed the static characteristics of fluid film bearings using TiO_2-based nano-lubricants by incorporating modified viscosity and couple stress models, showing that nanoparticle additives can significantly alter pressure distribution and load capacity. Gunnuang et al. [12] extended this analysis to non-Newtonian Carreau fluids and observed notable changes in

ISSN 2278-2540 | DOI: 10.51583/IJLTEMAS | Volume XV, Issue I, January 2026

bearing performance due to nanoparticle additives. The combined effects of thermal variations and nanoparticle additives on journal bearing behavior have been explored by Solghar [13], who investigated the thermo-hydrodynamic characteristics of journal bearings with nano-lubricants and reported improved load capacity and reduced temperature rise. Shenoy et al. [14] examined externally adjustable fluid film bearings and demonstrated that nanoparticle additives enhance performance under varying operating conditions. Nicoletti and Trabalhador [15] emphasized the importance of lubricant heat capacity in determining the static behavior of journal bearings, particularly when nanoparticles are present, highlighting the strong coupling between thermal and hydrodynamic effects. Studies have also considered non-Newtonian lubricants, bearing wear, and fuel–lubricant interactions. Kushare and Sharma [16] analysed worn two-lobe journal bearings operating with non-Newtonian lubricants and showed that wear and lubricant rheology significantly influence pressure and stability characteristics. Khuong et al. [17] investigated the effect of gasoline–bioethanol blends on engine oil properties and lubrication performance, revealing changes in viscosity and thermal behavior that can impact bearing operation. More recently, Lin et al. [18] studied the transient behavior of textured journal bearings using a fluid–structure interaction approach and demonstrated that surface texturing and transient effects play a crucial role in pressure development and dynamic response. From the reviewed literature, it is evident that while significant progress has been made in understanding hydrodynamic lubrication, nanoparticle-enhanced lubricants, and dynamic behavior of journal bearings, the explicit influence of thermal variations on load-carrying capacity and stability behavior under realistic operating conditions still requires further investigation. Most existing studies focus either on lubrication enhancement or dynamic effects, with limited emphasis on a comprehensive thermo-hydrodynamic stability analysis. The present work addresses this gap by systematically analyzing the coupled effects of temperature rise, viscosity variation, load capacity, and stability characteristics of hydrodynamic journal bearings.

PROPOSED METHODOLOGY

The proposed methodology aims to investigate the influence of thermal variations on the load-carrying capacity and stability characteristics of hydrodynamic journal bearings through a comprehensive thermo-hydrodynamic (THD) analysis. The approach integrates fluid flow modeling, heat transfer analysis, and dynamic performance evaluation to capture the coupled interactions between temperature, viscosity, pressure distribution, and bearing stability.

1. Bearing Geometry and Physical Modeling: The study begins with the development of a physical model for a finite-length hydrodynamic journal bearing. The bearing system consists of a rotating journal and a stationary bearing separated by a thin lubricant film. Key geometric parameters such as journal radius, bearing length, radial clearance, and eccentricity ratio are defined to represent realistic operating conditions. The journal and bearing surfaces are assumed to be rigid, and the lubricant is modelled as a Newtonian, incompressible fluid operating under laminar flow conditions. These assumptions provide a practical balance between modeling accuracy and computational efficiency while capturing the essential hydrodynamic and thermal characteristics of the bearing.

2. Thermo-Hydrodynamic Lubrication Modeling: To account for thermal effects, a thermo-hydrodynamic lubrication framework is adopted. The generalized Reynolds equation is employed to determine the pressure distribution within the lubricant film, with viscosity treated as a temperature-dependent parameter. An empirical viscosity–temperature relationship is used to model the variation of lubricant viscosity due to heat generation. Appropriate boundary conditions, including ambient pressure at the bearing edges and cavitation constraints in the divergent region, are applied. The Reynolds equation is discretized using a finite difference approach, and an iterative numerical solution is implemented to ensure convergence between the pressure and viscosity fields.

3. Thermal Analysis and Energy Equation: The thermal behavior of the journal bearing is analysed by coupling the hydrodynamic model with the energy equation governing heat transfer within the lubricant film. Heat generation due to viscous shearing of the lubricant is considered the dominant heat source, while heat dissipation occurs through conduction to the journal and bearing surfaces and convection to the surrounding environment. The energy equation is solved simultaneously with the Reynolds equation to obtain the temperature distribution across the lubricant film. This coupled solution allows accurate prediction of thermal gradients and their influence on lubricant properties and pressure development.

ISSN 2278-2540 | DOI: 10.51583/IJLTEMAS | Volume XV, Issue I, January 2026

4. Load-Carrying Capacity Evaluation: Once the steady-state pressure and temperature distributions are obtained, the load-carrying capacity of the journal bearing is computed by integrating the hydrodynamic pressure over the bearing surface. The influence of thermal variations on load capacity is examined by comparing thermo-hydrodynamic results with conventional isothermal predictions. This comparison highlights the reduction in load-carrying capability caused by temperature-induced viscosity loss and provides insight into the limitations of isothermal assumptions under high-speed and high-load operating conditions.

5. Dynamic Coefficients and Stability Analysis: To evaluate the stability behavior of the bearing, a linearized perturbation approach is applied around the equilibrium position of the journal. Small dynamic perturbations in journal motion are introduced, and the resulting pressure fluctuations are used to compute the bearing stiffness and damping coefficients under thermo-hydrodynamic conditions. These dynamic coefficients are then incorporated into the rotor–bearing system equations to analyze stability characteristics. Particular attention is given to identifying threshold speeds for the onset of oil whirl and oil whip instabilities, which are strongly influenced by thermal effects.

6. Parametric Study and Performance Assessment: A comprehensive parametric study is conducted to investigate the impact of operating conditions such as rotational speed, applied load, inlet lubricant temperature, and cooling effectiveness on bearing performance. The resulting variations in temperature distribution, load-carrying capacity, and stability margins are systematically analysed. This parametric assessment provides valuable insights into the sensitivity of hydrodynamic journal bearings to thermal variations and supports the development of improved design guidelines and thermal management strategies for enhanced bearing reliability and stability.

RESULT & ANALYSIS

This section presents the numerical results obtained from the thermo-hydrodynamic analysis of the hydrodynamic journal bearing and discusses the influence of thermal variations on load-carrying capacity and stability characteristics. To clearly demonstrate the impact of temperature effects, results are compared with conventional isothermal predictions under identical operating conditions. The computed temperature distribution reveals a significant rise in lubricant temperature along the direction of rotation, with peak temperatures occurring near the region of maximum pressure. As rotational speed increases, viscous shear intensifies, leading to higher heat generation and non-uniform temperature fields across the bearing clearance. This temperature rise causes a noticeable reduction in lubricant viscosity, particularly in high-pressure zones, thereby altering the hydrodynamic pressure profile. The results confirm that thermal gradients become more pronounced at higher speeds and loads, emphasizing the necessity of thermo-hydrodynamic modeling for realistic performance prediction.

1. Effect of Thermal Variations on Load-Carrying Capacity: The load-carrying capacity of the journal bearing was evaluated for different operating speeds under both isothermal and thermo-hydrodynamic conditions. TABLE I. presents the comparison of load capacity values, highlighting the reduction caused by temperature-induced viscosity loss. The hydrodynamic pressure distribution in the lubricant film is governed by the generalized Reynolds equation (1) with temperature-dependent viscosity:

$$\frac{\partial}{\partial x}\left(\frac{h^3}{12\mu(T)}\frac{\partial p}{\partial x}\right)+\frac{\partial}{\partial z}\left(\frac{h^3}{12\mu(T)}\frac{\partial p}{\partial z}\right)=\frac{U}{2}\frac{\partial h}{\partial x} --- (1)$$

The lubricant temperature distribution is obtained by solving the energy equation (2) :

$$\rho c_p U\frac{\partial T}{\partial x}=k\left(\frac{\partial^2 T}{\partial y^2}\right)+\mu(T)\left(\frac{\partial u}{\partial y}\right)^2 ----(2)$$

ISSN 2278-2540 | DOI: 10.51583/IJLTEMAS | Volume XV, Issue I, January 2026

TABLE I. COMPARISON OF LOAD-CARRYING CAPACITY UNDER ISOTHERMAL AND THD CONDITIONS

Rotational Speed (rpm)	Maximum Film Temperature (°C)	Load Capacity – Isothermal (N)	Load Capacity – THD (N)	Reduction (%)
1000	52	5120	4865	4.98
2000	68	6240	5710	8.49
3000	87	7350	6425	12.58
4000	109	8420	7060	16.15

The results clearly show that load-carrying capacity decreases with increasing temperature. While isothermal analysis overestimates bearing performance, the thermo-hydrodynamic model captures the realistic reduction in pressure generation due to viscosity degradation. This effect becomes increasingly significant at higher rotational speeds, where thermal effects dominate bearing behavior. The pressure distribution obtained under thermo-hydrodynamic conditions exhibits a lower peak pressure compared to the isothermal case. The reduction in viscosity in high-temperature regions leads to a flattened pressure profile, resulting in a decreased net supporting force. This shift in pressure distribution also influences the equilibrium position of the journal, increasing eccentricity and making the system more susceptible to dynamic instability.

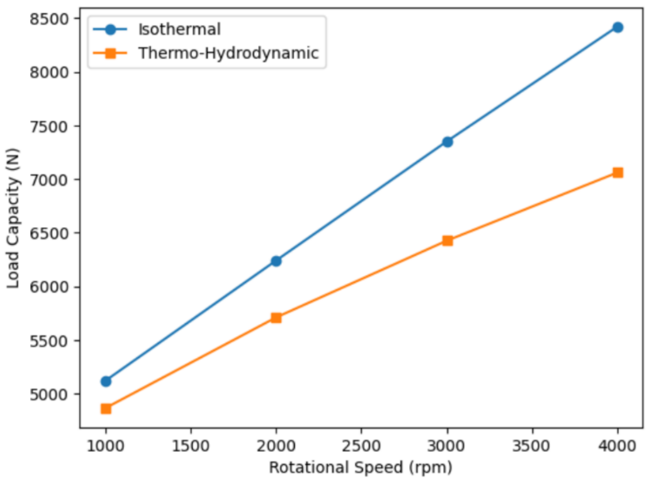

Fig. 1. Influence of Rotational Speed on Journal Bearing Load Support under Thermal Effects

Fig. 1. showing the variation of load-carrying capacity with rotational speed for a hydrodynamic journal bearing. Two curves compare isothermal and thermo-hydrodynamic conditions, indicating that load capacity increases with speed in both cases, while thermo-hydrodynamic predictions remain consistently lower due to temperature-induced viscosity reduction.

2. Dynamic Coefficients and Stability Characteristics: The dynamic stiffness and damping coefficients were computed using linearized perturbation analysis. TABLE II. summarizes the variation of direct stiffness and damping coefficients with rotational speed under thermo-hydrodynamic conditions. Dynamic behavior is analysed by introducing small perturbations around the equilibrium journal position. The linearized pressure response is expressed as equation (3):

$$p = p_0 + p_x \Delta x + p_y \Delta y + p_{\dot{x}} \Delta \dot{x} + p_{\dot{y}} \Delta \dot{y} - -(3)$$

The bearing stiffness and damping coefficients are defined as equation (4) & (5):

ISSN 2278-2540 | DOI: 10.51583/IJLTEMAS | Volume XV, Issue I, January 2026

$$K_{ij} = -\frac{\partial F_i}{\partial j}, C_{ij} = -\frac{\partial F_i}{\partial j} (i, j = x, y) - - - (4)$$

where F_i are hydrodynamic force components:

$$F_x = \int p\cos\theta\, dA, F_y = p\sin \int \Delta\,\theta\, dA - - - -(5)$$

TABLE II. COMPARISON OF LOAD-CARRYING CAPACITY UNDER ISOTHERMAL AND THD CONDITIONS

Speed (rpm)	Direct Stiffness (K_{xx}) (MN/m)	Direct Damping (C_{xx}) (kN·s/m)
1000	5.42	1.98
2000	4.85	1.62
3000	4.10	1.21
4000	3.36	0.87

A clear decline in both stiffness and damping coefficients is observed with increasing speed and temperature. Reduced damping adversely affects the system's ability to dissipate vibrational energy, thereby lowering stability margins. These findings indicate that thermal effects significantly weaken the dynamic support provided by the lubricant film.

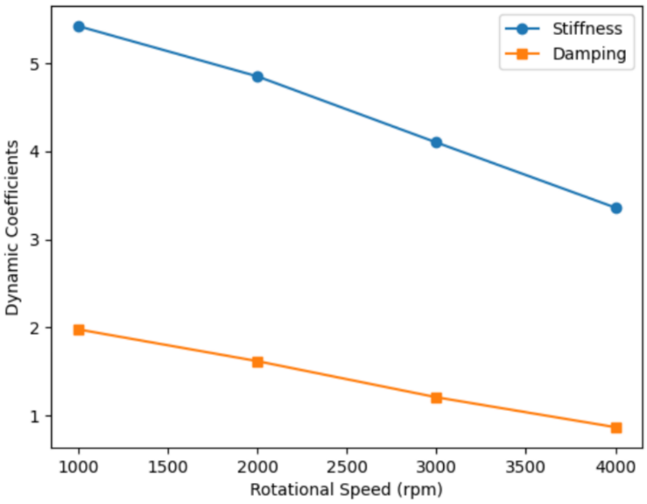

Fig. 2. Variation of Bearing Stiffness and Damping with Increasing Operating Speed

Fig. 2. illustrating the effect of rotational speed on dynamic stiffness and damping coefficients of a hydrodynamic journal bearing. Both stiffness and damping decrease as speed increases, demonstrating the adverse influence of thermal effects on dynamic support and vibration attenuation capability.

3. Stability Threshold and Onset of Instabilities: The stability analysis shows that the threshold speed for oil whirl decreases when thermal effects are included. Table 3 compares the predicted threshold speeds obtained from isothermal and thermo-hydrodynamic models. The stability of the rotor–bearing system is assessed using linearized equations of motion (6) & (7):

$$m\ddot{x} + C_{xx}\dot{x} + K_{xx}x = 0 \quad - - - - - - -(6)$$
$$m\ddot{y} + C_{yy}\dot{y} + K_{yy}y = 0 \quad - - - - - - -(7)$$

ISSN 2278-2540 | DOI: 10.51583/IJLTEMAS | Volume XV, Issue I, January 2026

In addition to direct stiffness and damping coefficients, cross-coupled stiffness and damping coefficients play a critical role in the dynamic stability of hydrodynamic journal bearings. The cross-coupled stiffness terms generate destabilizing forces that promote forward whirl motion of the rotor. As temperature increases, viscosity reduction weakens the stabilizing direct damping while the relative influence of cross-coupled coefficients increases. This imbalance accelerates the onset of oil whirl, a sub synchronous vibration phenomenon typically occurring at approximately half the rotational speed. With further increase in speed, oil whirl may transition into oil whip when the excitation frequency coincides with the natural frequency of the rotor–bearing system. The present thermo-hydrodynamic results indicate that elevated temperatures amplify this coupling effect, resulting in a lower threshold speed for both oil whirl and oil whip. These findings highlight the importance of including thermal effects and coupling coefficients in stability analysis for high-speed rotating machinery. Stability is determined by the characteristic equation (8):

$$\lambda^2 + \frac{C}{m}\lambda + \frac{K}{m} = 0 \quad ------ (8)$$

The threshold speed for instability (oil whirl onset) is reached when the real part of eigenvalue λ becomes zero. The critical or threshold speed Ω_{cr} is approximated as equation (9):

$$\Omega_{cr} = \sqrt{\frac{K_{\text{eff}}}{m}} \quad -------(9)$$

where K_{eff} is the effective bearing stiffness obtained from the thermo-hydrodynamic model.

TABLE III. COMPARISON OF LOAD-CARRYING CAPACITY UNDER ISOTHERMAL AND THD CONDITIONS

Analysis Type	**Threshold Speed (rpm)**
Isothermal Model	3650
Thermo-Hydrodynamic	3120

The thermo-hydrodynamic model predicts instability at a substantially lower speed, demonstrating that neglecting thermal effects can lead to unsafe design margins. The reduction in threshold speed is attributed to lower stiffness and damping caused by temperature-induced viscosity loss.

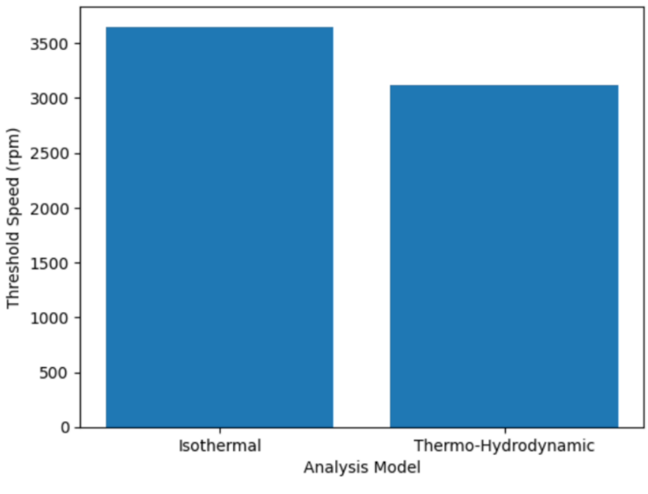

Fig. 3. Effect of Thermal Modeling on the Stability Limit of Journal Bearings

Fig. 3. comparing the threshold speed for instability predicted by isothermal and thermo-hydrodynamic models. The thermo-hydrodynamic model shows a lower threshold speed, highlighting the significant role of thermal effects in reducing bearing stability margins.

The results clearly establish that thermal variations have a pronounced influence on both load-carrying capacity and stability behavior of hydrodynamic journal bearings. Isothermal analysis consistently overpredicts performance and stability limits, particularly under high-speed operating conditions. The thermo-hydrodynamic approach provides a more realistic assessment by capturing the coupled effects of heat generation, viscosity variation, and pressure redistribution. These findings underscore the necessity of incorporating thermal considerations in bearing design, analysis, and condition monitoring to ensure reliable and stable operation of modern rotating machinery.

4. Model Validation and Comparison with Existing Studies: To validate the proposed thermo-hydrodynamic model, the obtained numerical results are compared with trends reported in previously published experimental and numerical studies. Earlier investigations by Solghar [13] and Nicoletti and Trabalhador [15] reported a noticeable reduction in load-carrying capacity and stiffness coefficients with increasing lubricant temperature due to viscosity degradation. Similar trends are observed in the present study, where thermo-hydrodynamic predictions show a consistent decrease in load capacity, stiffness, and damping with increasing rotational speed and temperature. Furthermore, the reduction in threshold speed for oil whirl predicted in this work agrees well with the findings reported by Kushare & Sharma [16], who demonstrated that thermal and viscosity effects significantly lower the stability margins of journal bearings. The close agreement in qualitative behavior confirms the reliability of the developed model. Minor quantitative differences can be attributed to variations in bearing geometry, lubricant properties, and operating conditions. Overall, the comparison validates the accuracy and applicability of the proposed thermo-hydrodynamic framework for realistic journal bearing analysis.

From an industrial perspective, the results of this study have direct implications for the design and operation of high-speed rotating machinery such as gas turbines, steam turbines, centrifugal compressors, turbochargers, and electric generators. In such systems, excessive temperature rise within journal bearings can significantly reduce load capacity and stability margins, leading to increased vibration levels, noise, and potential failure. The thermo-hydrodynamic analysis presented in this work enables more accurate prediction of bearing performance under realistic operating conditions, supporting improved lubricant selection, optimized clearance design, and enhanced cooling strategies. Incorporating thermal effects during the design stage can help prevent oil whirl and oil whip instabilities, thereby improving machine reliability, reducing maintenance costs, and extending service life in critical industrial applications.

CONCLUSION

This study has comprehensively analyzed the impact of thermal variations on the load-carrying capacity and stability behavior of hydrodynamic journal bearings using a thermo-hydrodynamic framework. The results demonstrate that temperature rise within the lubricant film significantly reduces viscosity, leading to a noticeable decrease in hydrodynamic pressure, load capacity, stiffness, and damping coefficients when compared to isothermal predictions. It is observed that thermal effects become increasingly dominant at higher rotational speeds, causing a substantial reduction in stability margins and lowering the threshold speed for the onset of oil whirl and oil whip instabilities. These findings confirm that conventional isothermal models tend to overestimate bearing performance and may result in unsafe design margins for high-speed rotating machinery. The study emphasizes the necessity of incorporating thermal effects into bearing analysis and design to achieve accurate performance prediction and enhanced operational reliability. As a future scope, the present work can be extended by incorporating thermo-elastic-hydrodynamic effects to account for bearing and journal deformation, considering non-Newtonian and temperature-dependent lubricant properties, and validating the numerical results with experimental investigations. Further research may also explore advanced cooling strategies, real-time thermal monitoring, and the integration of machine learning techniques for predictive stability assessment and intelligent bearing health management in next-generation rotating systems.

REFERENCES

1. D. Y. Dhande and D. W. Pande, “Multiphase flow analysis of hydrodynamic journal bearing using CFD coupled fluid–structure interaction considering cavitation,” Journal of King Saud University – Engineering Sciences, 2016, doi: 10.1016/j.jksues.2016.09.001.

ISSN 2278-2540 | DOI: 10.51583/IJLTEMAS | Volume XV, Issue I, January 2026

2. M. S. Kumar, P. R. Thyla, and E. Anbarasu, "Numerical analysis of hydrodynamic journal bearing under transient dynamic conditions," Mechanika, vol. 2, no. 2, pp. 37–42, 2010.
3. K. Yathish, K. G. Binu, R. S. D. Silva, B. S. Shenoy, and R. Pai, "Static characteristics of two-axial groove journal bearing operating on TiO_2 nano lubricant," Journal of Mechanical Engineering and Automation, vol. 5, pp. 94–99, 2015.
4. K. Yathish, K. G. Binu, B. S. Shenoy, D. S. Rao, and R. Pai, "Study of TiO_2 nanoparticles as lubricant additive in two-axial groove journal bearing," International Journal of Mechanical, Aerospace, Industrial, Mechatronic and Manufacturing Engineering, vol. 8, no. 11, pp. 1803–1809, 2014.
5. S. Baskar and G. Sriram, "Tribological behavior of journal bearing material under different lubricants," Tribology in Industry, vol. 36, no. 2, pp. 127–133, 2014.
6. Q. Wan, Y. Jin, P. Sun, and Y. Ding, "Tribological behaviour of a lubricant oil containing boron nitride nanoparticles," Procedia Engineering, vol. 102, pp. 1038–1045, 2015.
7. M. S. Charoo and M. F. Wani, "Tribological properties of IF-MoS_2 nanoparticles as lubricant additive on cylinder liner and piston ring tribo-pair," Tribology in Industry, vol. 38, no. 2, pp. 156–162, 2016.
8. F. Ilie and C. Covaliu, "Tribological properties of the lubricant containing titanium dioxide nanoparticles as an additive," Lubricants, vol. 4, no. 12, pp. 1–13, 2016.
9. M. Laad and V. K. S. Jatti, "Titanium oxide nanoparticles as additives in engine oil," Journal of King Saud University – Engineering Sciences, 2016, doi: 10.1016/j.jksues.2016.01.008.
10. W. H. Azmi, K. V. Sharma, P. K. Sarma, R. Mamat, S. Anuar, and V. D. Rao, "Experimental determination of turbulent forced convection heat transfer and friction factor with SiO_2 nanofluid," Experimental Thermal and Fluid Science, vol. 51, pp. 103–111, 2013.
11. K. G. Binu, B. S. Shenoy, D. S. Rao, and R. Pai, "Static characteristics of a fluid film bearing with TiO_2-based nano lubricant using the modified Krieger–Dougherty viscosity model and couple stress model," Tribology International, vol. 75, pp. 69–79, 2014.
12. W. Gunnuang, C. Aiumpornsin, and M. Mongkolwongrojn, "Effect of nanoparticle additives on journal bearing lubricated with non-Newtonian Carreau fluid," Applied Mechanics and Materials, vol. 751, pp. 137–142, 2015.
13. A. A. Solghar, "Investigation of nanoparticle additive impacts on thermo-hydrodynamic characteristics of journal bearings," Proceedings of the Institution of Mechanical Engineers, Part J: Journal of Engineering Tribology, vol. 229, no. 10, pp. 1176–1186, 2015.
14. B. S. Shenoy, K. G. Binu, R. Pai, D. S. Rao, and R. S. Pai, "Effect of nanoparticle additives on the performance of an externally adjustable fluid film bearing," Tribology International, vol. 45, no. 1, pp. 38–42, 2012.
15. R. Nicoletti and S. Trabalhador, "The importance of the heat capacity of lubricants with nanoparticles in the static behavior of journal bearings," Journal of Tribology, vol. 136, no. 4, pp. 1–5, 2014.
16. P. B. Kushare and S. C. Sharma, "A study of two-lobe non-recessed worn journal bearing operating with non-Newtonian lubricant," Proceedings of the Institution of Mechanical Engineers, Part J: Journal of Engineering Tribology, vol. 227, no. 12, pp. 1418–1437, 2016.
17. L. S. Khuong, H. H. Masjuki, N. W. M. Zulki, E. N. Mohamad, and M. A. Kalam, "Effect of gasoline–bioethanol blends on the properties and lubrication characteristics of commercial engine oil," RSC Advances, vol. 7, pp. 15005–15019, 2017.
18. Q. Lin, Q. Bao, K. Li, M. M. Khonsari, and H. Zhao, "An investigation into the transient behavior of journal bearing with surface texture based on fluid–structure interaction approach," Tribology International, vol. 118, pp. 246–255, 2018.