Journal of Mechanical Engineering Advancements, *Volume 1 (Issue 3: September-December, 2024): Pages 38-43*
Published on: January 10, 2025.

ISSN: 3048-5673 (Online)

Journal of Mechanical Engineering Advancements

Contents available at: https://www.swamivivekanandauniversity.ac.in/jmea/

Tribological Behavior of EN8 Steel in Dry Sliding and Lubricating Conditions

Palash Biswas[1], Thia Paul[2] and Bikash Panja[3]*

[1]*Department of Mechanical Engineering, JIS College of Engineering, Kalyani-741235, India; palashbesus@gmail.com*

[2]*Department of Mechanical Engineering, JIS College of Engineering, Kalyani-741235, India; thia.paul@jiscollege.ac.in*

[3]*Department of Mechanical Engineering, Swami Vivekananda University, Barrackpore, North 24 Pargana, Kolkata-700121, India; bikashpanjame@gmail.com*

Abstract

Wear is a significant concern in the automotive industry, where shafts made of various alloys and high-hardness dies are extensively utilized. This study investigates the friction and wear characteristics of EN8 steel, commonly employed in such applications. A pin-on-disc tribometer was used to evaluate the frictional behavior of the specimens under dry and lubricated conditions. The experiments were conducted at a fixed rotating speed and track diameter, with varying loading conditions. The results indicate that lubricating conditions yield better tribological performance. The specimens exhibited improved wear resistance under lubricated conditions at a 30N load. The surface texture of the steel specimens after heat treatment was examined using a scanning electron microscope.

Keywords: *EN8 Steel, Dry-sliding, Lubrication, Hydro-68, Coefficient of friction, Wear Behaviour .*

1. Introduction

EN8 steel, also known as unalloyed medium carbon steel, is a widely used engineering material in various industries, including automotive, aerospace, manufacturing, and construction [1]. Its popularity stems from its excellent mechanical properties, such as high strength, toughness, and ductility, which make it an ideal choice for applications involving high stress, impact, and wear. The tribological behavior of EN8 steel, including its friction and wear characteristics, plays a critical role in determining its performance and lifespan in these applications [2, 3]. In dry sliding conditions, EN8 steel exhibits high friction and wear rates, which can lead to increased energy consumption, reduced component life, and decreased system efficiency. In contrast, lubricating conditions can significantly improve the tribological behavior of EN8 steel, reducing friction and wear rates, and enhancing its overall performance [4, 5]. However, the effectiveness of lubrication depends on various factors, including the type of lubricant used, surface roughness, and operating conditions. This literature review aims to provide a comprehensive overview of the tribological behavior of EN8 steel in both dry sliding and lubricating conditions.

*Author for correspondence

2. Experimental Details

2.1 Tribological test

Tribological tests are conducted in accordance with ASTM standard G99-05 using a pin-on-disk tribo-meter (TR-208-M2, DUCOM, India). The tests are performed at a temperature of 32°C and a relative humidity of 62%. Both dry sliding and lubricated environments are evaluated. A hardened steel disk (58-62 HRC) served as the counter face material. Pin samples (30 mm × Φ6 mm) are attached vertically to the stationary holder and the tests are conducted for 10 minutes [6]. The tribological tests are conducted by applying incremental loads of 25 N, 35 N, and 45 N, while keeping the constant track diameter at 60 mm and the fixed rotating speed at 200 rpm [7,8]. The frictional force and wear rate were recorded during the tests. The pictorial view of a pin-on-disc tribometer is shown in Figure 1.

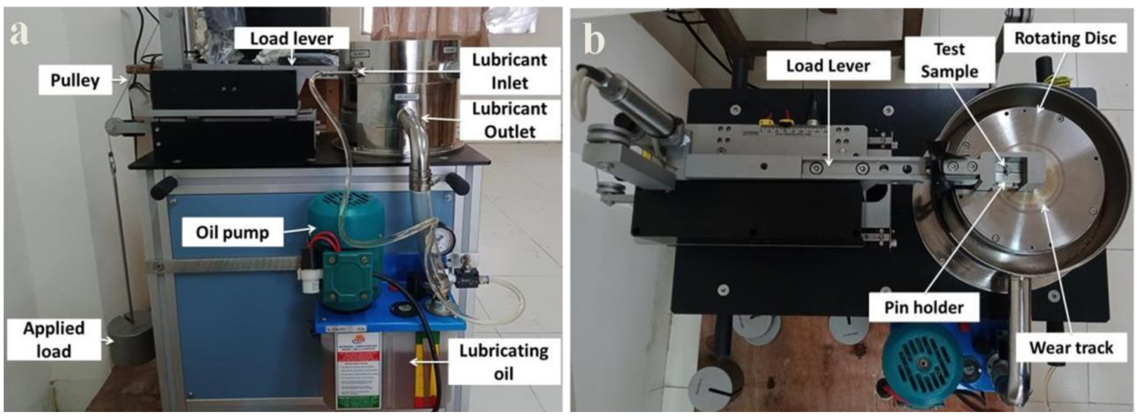

Fig. 1 Pictorial view of a Pin-on-Disc Tribometer.

3. Result and discussion

3.1 Friction behavior

The coefficient of friction of EN8 steel varies depending on the surface roughness, lubrication conditions, sliding velocity and the presence of micro-asperities. The coefficient of friction for EN8 steel in dry sliding conditions ranges from 0.322 to 0.495 as shown in Figure 2. The COF is reduced with increase in applied load. Because of the load increases, the surface asperities (small bumps and valleys) are flattened, reducing the surface roughness [3]. This can lead to a decrease in the COF. As the load increases, the material may undergo plastic deformation, which can lead to a change in the surface topography and a decrease in the COF. Higher loads can result in a larger contact area between the surfaces, which can reduce the pressure and, consequently, the COF.

The COF is drastically falls after lubricant use. Lubricants create a thin film between the contacting surfaces. This film physically separates the surfaces, preventing direct contact between the microscopic irregularities (roughness) that would otherwise cause friction [4]. By separating the surfaces, lubricants significantly reduce the actual contact area between them. Less contact area means less friction. Lubricants, especially fluids, allow for easier shearing (sliding) motion between the surfaces. This reduces the force required to overcome friction. The combined effect of surface separation, reduced contact area, and easier shearing due to lubrication leads to a significant decrease in the coefficient of friction. At applied loads of 25N, 35N, and 45N, the coefficient of friction (COF) values decreased by approximately 95%, 83%, and 77%, respectively, due to the use of lubrication (refer to Figure 2).

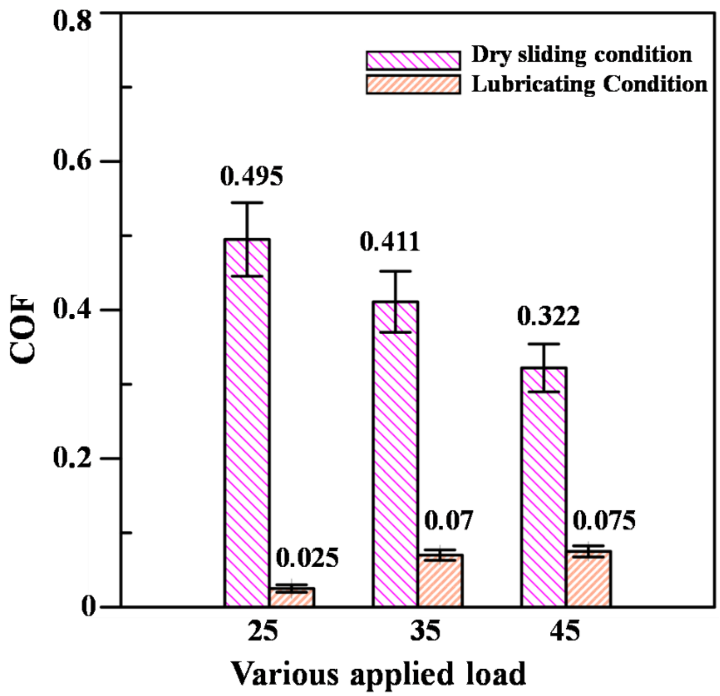

Fig.2 Coefficient of friction for various applied load in dry sliding and lubricating condition

3.2 Wear behavior

Figure 3 presents the results of a dry sliding wear test, where the wear rate is plotted against various applied loads. The wear rate decreases with increasing applied load, likely due to the flattening or removal of surface asperities, resulting in reduced wear. The wear debris is welded to the surface and smoothed out on the rubbing surface, leading to a reduction in wear with increasing applied load [4]. The minimum wear rate is observed at higher applied load with fixed track diameter and sliding speed in dry sliding wear test. Comparing applied loads of 25N and 45N, the wear rate decreased by approximately 50% at the higher load. In lubricating conditions, the wear rate is drastically reduced compared to dry sliding wear tests. Hydro-68 oil forms a thin film between contacting surfaces, preventing direct metal-to-metal contact. This separation minimizes friction and wear. In many cases, the oil film is carried into the contact by the relative motion of the surfaces, creating a hydrodynamic wedge that supports the load and completely separates the surfaces. Hydro-68 also helps dissipate heat generated during friction and can carry away wear debris, minimizing further damage [4, 5]. The use of lubrication resulted in a substantial reduction in wear rates, achieving approximately 50% and 98% decreases at 25N and 35N, respectively. At 45N, the wear rate reduction was approximately 50% (refer to Figure 3).

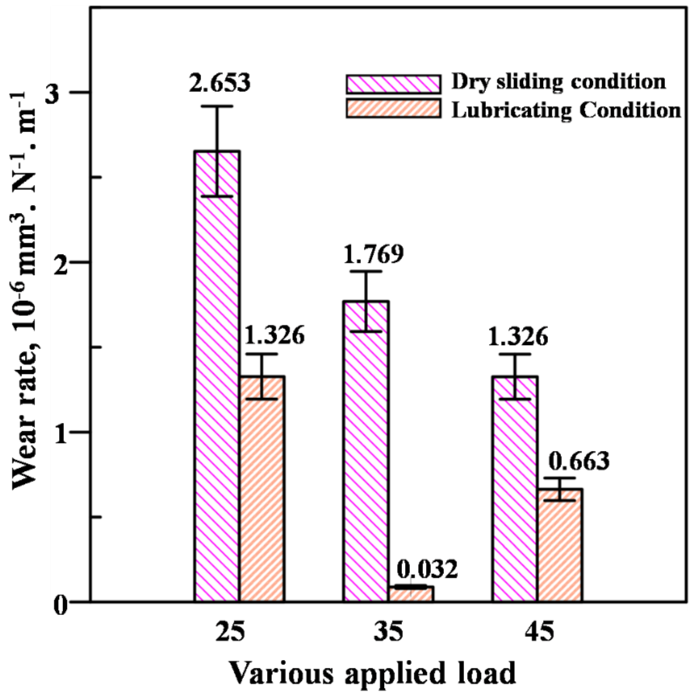

Fig. 3 wear rate for various applied load in dry sliding and lubricating condition

3.3 Wear mechanisms

The wear mechanism of EN8 is displayed in Figure 4 for 35N applied load condition. The samples observed the clear wear tracks and ploughing with deep groove. Also, a few cracks and micro cracks are observed on the surface. In the abrasion surface the wear debris is observed [6, 8]. In the worn of samples, the delamination effect is observed. Also, observed more plastic deformation and micro cracks. In hydro-68 oil lubricant, wear mechanisms typically involve a combination of adhesive and abrasive wear. Adhesive wear arises from the attraction and subsequent tearing apart of contacting surface asperities. Abrasive wear occurs when hard particles, such as contaminants, scratch or gouge the surfaces [9].

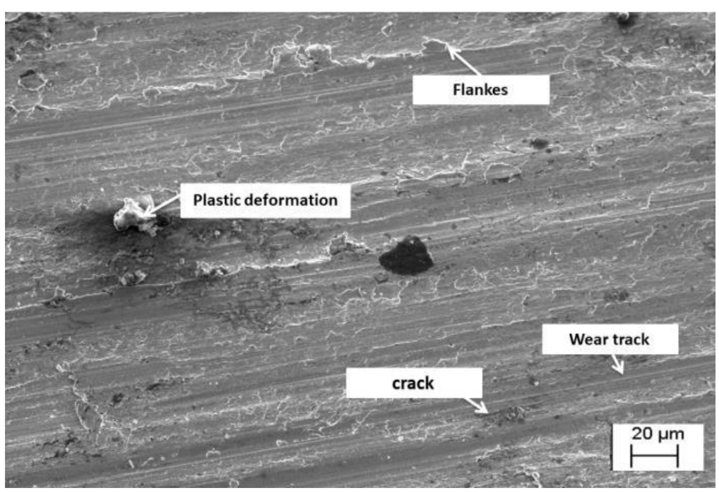

Fig. 4 SEM image of the sample after dry-sliding wear test at 35N applied load

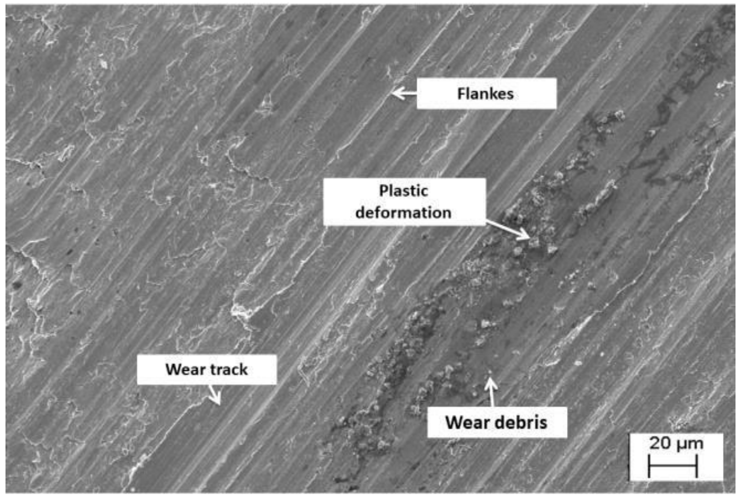

Fig. 5 SEM image of the sample after lubricating wear test at 35 N applied load

4. Conclusions

The present study investigated the tribological properties of EN8 steel, with a focus on wear mechanisms and the effects of lubrication. The results showed that EN8 steel exhibited improved wear resistance under lubricated conditions compared to dry sliding wear tests. Specifically, the wear volume loss was significantly reduced when lubrication was used. The Pin-on-disc tribometer tests revealed that EN8 steel with a load of 45 N demonstrated better friction and wear resistance in both lubricated and dry sliding condition. Scanning Electron Microscopy (SEM) images provided valuable insights into the wear mechanisms, allowing for a comprehensive understanding of the material's behavior under different conditions. Overall, this study highlights the importance of lubrication in reducing wear and improving the tribological properties of EN8 steel, with implications for its potential applications in various industrial sectors.

5. References

1. Kumar, P., Philip, J. T., Wani, M. F., Rai, H., Vashishtha, H., Kuriachen, B., & Kumar, D. (2023). Study of Tribological Properties of EN8 Steel against Inconel X-750 Alloy under Dry and Lubricated Conditions. Transactions of the Indian Institute of Metals, 76(9), 2353-2361.
2. Menezes, P. L., & Kailas, S. V. (2006). Influence of surface texture on coefficient of friction and transfer layer formation during sliding of pure magnesium pin on 080 M40 (EN8) steel plate. Wear, 261(5-6), 578-591.
3. Debnath, A., Pal, S., Mitra, M., Sarkar, M., Chakraborty, P., Ghosh, S., & Biswas, P. (2023, December). Dry sliding tribological behavior of EN8 steel. In AIP Conference Proceedings (Vol. 2901, No. 1). AIP Publishing.
4. Bakshi, S., Saha, M., Mandal, S., Biswas, P., & Ghosh, S. (2022). Influence of Heat Treatment on Mechanical and Tribological Behaviors of Brass. International Journal of Surface Engineering and Interdisciplinary Materials Science (IJSEIMS), 10(1), 1-14.
5. Charoo, M. S., Wani, M. F., Hanief, M., Chetani, A., & Rather, M. A. (2017). Tribological characteristics of EN8 and EN24 steel against aluminium alloy 6061 under lubricated condition. Advanced Materials Proceedings, 2(7), 445-449.
6. Biswas, P., Das, S. K., & Sahoo, P. (2024). Tribological and corrosion performance of duplex electrodeposited Ni-P/Ni-WP coatings. Physica Scripta, 99(11), 115018.

7. Saha, M., Bakshi, S., Mandal, S., Biswas, P., & Ghosh, S. (2022). Tribological behavior of EN8 and EN24 steel in lubricating condition. Materials Today: Proceedings, 66, 3890-3896.
8. Biswas, P., Das, S. K., & Sahoo, P. (2024). Mechanical, Tribological and Corrosion Performances of Autocatalytic Duplex Ni–P/Ni–Mo–P Coating. Arabian Journal for Science and Engineering, 49(2), 2443-2462.
9. Banerjee, S., Sahoo, P., & Davim, J. P. (2022). Tribological performance optimization of Mg-WC nanocomposites in dry sliding: A statistical approach. Frontiers in Materials, 9, 791447.