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Investigation of the Effect of Different Engine Oils on the Amount of Cylinder Liner Wear

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Abstract – In internal combustion engines, cylinder liner wear is a significant factor that adversely affects engine performance. The rough surfaces and geometric changes resulting from wear impede gas flow, reduce compression, and decrease combustion efficiency. This leads to a decrease in engine power, an increase in fuel consumption, and a loss of performance. Therefore, the control of cylinder liner wear and the use of appropriate lubricating oils are of great importance in enhancing motor performance. This study experimentally investigates the effects of different lubricants on cylinder liner wear in the context of internal combustion engines. The study is conducted under various loads and speeds. The commonly used 5W30 and 10W40 lubricating oils are employed as lubricants. Based on the results of the wear tests, it is observed that as the applied load on the cylinder liner increases, the wear amount also increases. Additionally, motor speed is identified as another influential parameter on wear amount. As the motor speed increases or decreases, the wear amount decreases or increases, respectively. The study reveals that the minimum wear amount is obtained with the 10W40 lubricating oil. Furthermore, SEM images are examined to assess the resulting damages on the cylinder liners after the wear tests.

Keywords – Cylinder Liner, Wear, 5W30 Engine Oil, 10W40 Engine Oil, SEM

I. INTRODUCTION

Internal combustion engines are widely used in automotive, marine, aviation, and industrial sectors [1]. These engines require proper lubrication systems to achieve high efficiency, power, and durability [2]. Motor oils are a critical component that directly affects the performance, efficiency, and lifespan of internal combustion engines. Therefore, the correct selection of lubricants used in engines and the evaluation of their performance are of great importance [3].

Diesel engines are the most widely used type of engines in marine and land transportation compared to gasoline engines. Approximately 17% of the energy obtained from fuel in diesel engines is lost due to mechanical losses. The majority of these mechanical losses are attributed to piston ring-cylinder liner wear [4,5]. The aim of conducted studies and research is to reduce friction and wear between the piston ring and cylinder liner [6]. However, in order to effectively reduce friction and wear between the piston ring and cylinder liner, factors such as friction, strength, noise and vibrations, fuel and oil consumption need to be thoroughly investigated in their interactions [7]. Therefore, the selection of appropriate lubricating oil, load, and engine speed is important for reducing cylinder liner wear [8].

Many studies have been conducted to reduce cylinder liner wear between the piston ring and cylinder liner. Grabon et al. investigated the wear of different materials in a wear test rig under dry and lubricated conditions. The wear characteristics of the piston ring and cylinder liner in dry and lubricated states were compared. The experimental studies were conducted at speeds of 0.44 m/s, 0.66 m/s, and 0.88 m/s, and under loads ranging from 50 N to 300 N, in both dry and lubricated conditions.

The results showed that a good lubricating oil reduced wear and friction by two-fold [9]. Ma Yajun et al. examined the effect of different oil additives as lubricants between nitrided piston rings and cast iron cylinder liners. The study revealed that GF-3 lubricants had lower friction coefficients. Additionally, SEM-EDX analysis showed fewer wear marks on the piston rings and cylinder liners when GF-3 was used [10]. Truhan et al. investigated the effect of lubricating oil conditions on the wear and friction of piston rings and cylinder liners in a test rig they developed for heavy-duty diesel engine applications. Fully formulated machine oils used in ASTM standard machine tests were used as lubricants. The presence of soot and solid particles in the oil was taken as an oxidation parameter. The results showed that viscosity had minimal effect on the piston ring-cylinder liner friction in the boundary lubrication regime, while the presence of soot and solid particles in the oil had a significant impact on wear [11].

In In this study, the amount of liner wear was experimentally investigated in the case of using 10W40 and 5W30 lubricating oils as lubricants at low speeds and under different loads, where maximum friction and wear occur in engines.

II. Materials and Method

To determine the amount of wear, a pin-on-disc wear testing device was used (Figure 1). The device is equipped with a DC motor that provides the necessary motion. By controlling the DC motor through a driver, the experimental setup could be operated at different speeds. To maintain a consistent temperature throughout the experiments, cartridge heaters were placed beneath the cylinder liner sample. A thermostat was used for circuit control to ensure temperature regulation.

Fig. 1 Wear device

The "Weight Difference Method" was employed to determine the amount of wear on the cylinder liner. A precision balance with a sensitivity of ±0.0001 g, branded AND, was used for weight measurements.

Prior to the experiments, the samples were cleaned with ethanol and dried. The experiments were conducted at low speeds where wear was expected to be higher. The experimental conditions included operating speeds of 50, 75, and 100 rpm, and for normal loads, 40, 60, and 80 N were selected.

The lubricants used in the experiments were 5W30 and 10W40 lubricants, respectively. The lubricants were supplied using a drip method at a flow rate of 0.5 ml per hour.

III. Results

In this study, variations in the amount of wear on the cylinder liner between the piston ring-cylinder pair were investigated for different loads and motor speeds. Figure 2 presents the graph depicting the change in wear amount of the cylinder liner under a 40 N load for different motor speeds. In the figure, lubricating oils vary with motor speed. As the motor speed increases, the wear amount decreases. The maximum wear amount is obtained at 50 rpm, while the minimum wear amount is obtained at 100 rpm. This decrease in wear amount is attributed to the decrease in tangential force acting on the piston ring due to the increased piston velocity associated with higher motor speeds. Additionally, the 10W40 lubricating oil causes less wear on the cylinder liner compared to the 5W30 lubricating oil. The lower wear aomunt in the 10W40 lubricating oil is related to lubrication regimes. It is believed that under all conditions, the hydrodynamic lubrication regime is effective in the 10W40 lubricating oil. This is because the higher viscosity value of the 10W40 lubricating oil allows it to remain in the hydrodynamic lubrication regime, preventing the oil film from breaking.

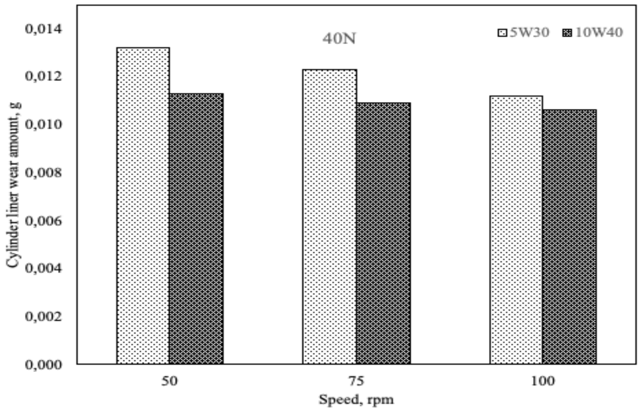


Fig. 2 Change of liner wear amount of different engine oil under 40N load

Figure 3 illustrates the variation in amount of wear of the cylinder liner under a 60 N load. Upon examining the figure, it can be observed that when using the 10W40 lubricating oil, lower wear amonut values are obtained at all speeds compared to using the 5W30 lubricating oil. Analyzing the changes in wear amount of the cylinder liner, it is found that the maximum wear amount occurs at 50 rpm when using the 5W30 lubricating oil. On the other hand, the minimum wear amount is observed under the conditions of using the 10W40 lubricating oil at 100 rpm.

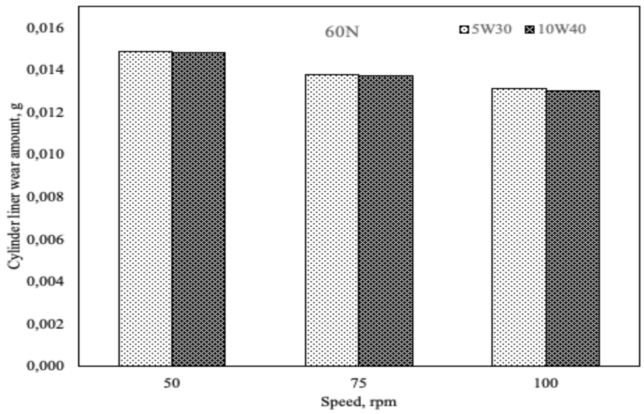


Fig. 3 Change of liner wear amount of different engine oil under 60N load

Figure 4 shows the variation in wear amount of the cylinder liner under an 80 N load. Upon examining the figure, it can be observed that when using the 10W40 lubricating oil, lower wear amount values are obtained at all speeds compared to using the 5W30 lubricating oil. Analyzing the wear amount of the cylinder liner, it is found that the maximum wear amount occurs at 50 rpm when using the 5W30 lubricating oil. On the other hand, the minimum wear amount is observed under the conditions of using the 10W40 lubricating oil at 100 rpm.

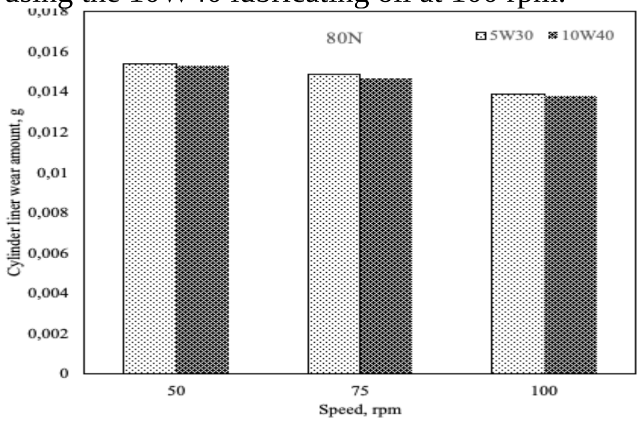
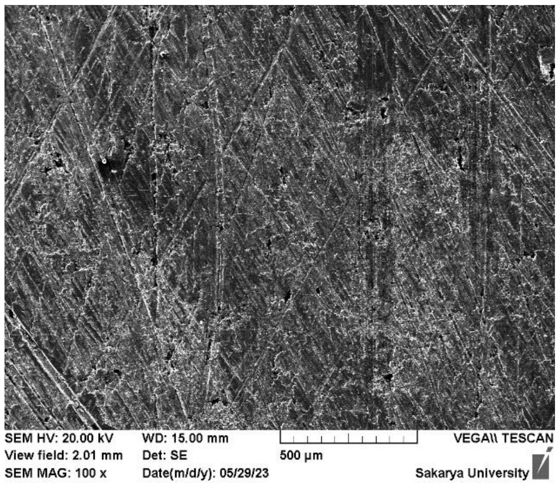


Fig. 4 Change of liner wear amount of different engine oil under 80N load

Figure 5 shows the SEM images of the amount of wear occurring in the liner sample. SEM images show pre-wear test and post-wear test images. SEM images are images taken for 50rpm and 80N for 5W30 oil. When the figure is examined, it is seen that the honing lines have disappeared from place to place.



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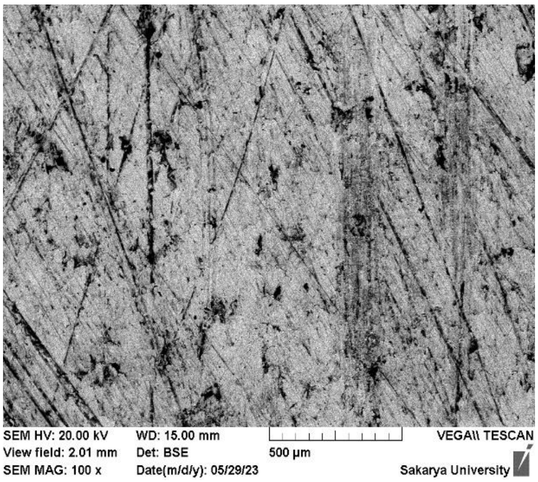
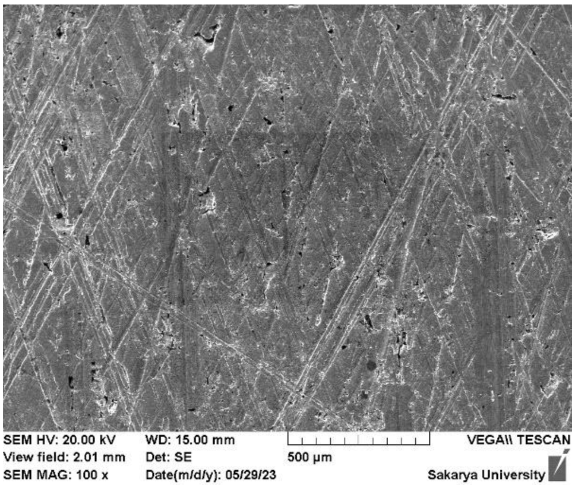


b)

Fig. 5 a) 5W30 cylinder liner before wear b) 5W30 post wear cylinder liner

Figure 6 illustrates the wear marks observed using 10W40 lubricating oil at 80N and 50 rpm. Upon examining the figure, it can be seen that the honing marks are still visible. We can interpret that it undergoes less wear compared to the 5W30 lubricant.



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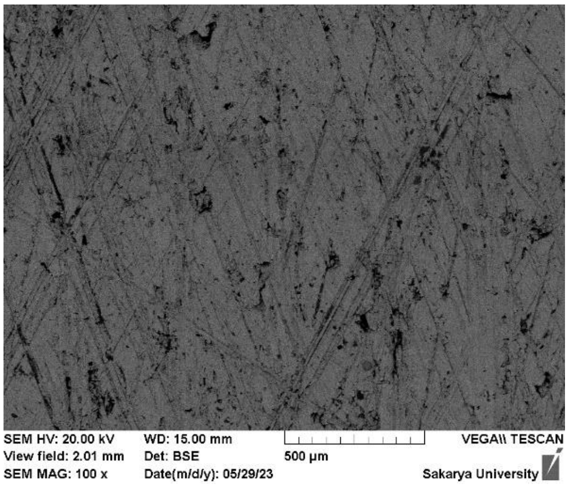

b)

Fig. 6 a) 10W40 cylinder liner before wear b) 10W40 post wear cylinder liner

IV. CONCLUSION

In this study, the effects of different motor lubricants on the wear amount of the cylinder liner were experimentally investigated. The findings obtained from the experiments conducted using a wear test device are as follows:

-The 10W40 lubricating oil resulted in a lower wear amount compared to the 5W30 lubricating oil.

-One influential parameter in wear amount is the motor speed. The minimum wear amount was observed at 100 rpm, while the maximum wear amount was obtained at 50 rpm.

- Lubrication regimes have an impact on the wear amount of the cylinder liner. The minimum wear amount was determined under the conditions of hydrodynamic lubrication.

The results of this study demonstrate the significant role of selecting appropriate lubricating oil in reducing cylinder liner wear. The use of motor oils with suitable viscosity is shown to improve motor performance and prolong the lifespan of motor components.

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