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TRIBOLOGICAL ANALYSIS OF NEW GENERATION PISTON RING

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ABSTRACT

Mechanical losses of friction in internal combustion engines are mainly caused through the contact between the piston ring and cylinder liner. Therefore, it is crucial to have proper methods and equipment set up for investigating into these frictional losses and wear effect on the components. Several design of test rig created for testing the piston ring and cylinder liner behaviours in term of friction and wear described in this paper. Each design using different method and variable to obtain the results. Repeated testing using some variables are conducted and an unexpected behaviour of the piston ring is found.

KEYWORD

Piston ring, friction, wear, automotive engine.

LOSSES IN AUTOMOTIVE ENGINE

Nowadays, the use of a vehicle, especially an engine vehicle, can be said to be a necessity for every group of society. The main important consideration in contemporary engine manufacturing field is considering to the fuel energy consumption. Following to the analyses obtained on research conducted to a reciprocating internal combustion engine, there is about 38% of fuel energy is utilized to mechanical power which the major is coming from counter friction while the remaining 62% going to the cooling, exhaust and among other major systems (Holmberg et al., 2012). The friction losses divided 11.5%, 11.5%, 5%, and 5% to engine, rolling resistance, transmission and braking system respectively. 45% from the total engine friction losses are caused by the part of piston assembly which produced by the contact piston ring with cylinder liner (Wei, 2018). Figure 1 and 2 illustrated in graph is the fuel energy distribution on an internal combustion engine.

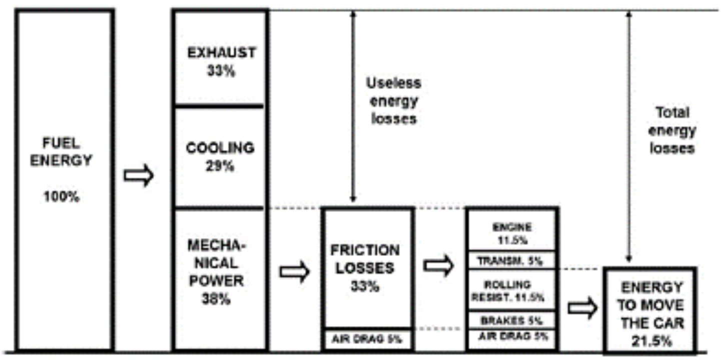

Figure 1: Fuel energy loss in an internal combustion engine (Holmberg et al., 2012).

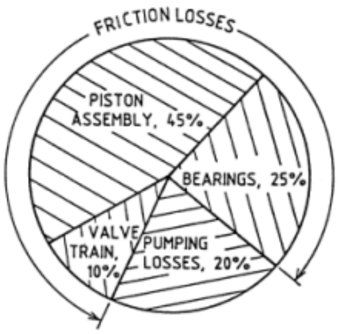

Figure 2: Mechanical losses in an internal combustion engine (Taylor et al., 1998).

In view of that, it is essential to have equipment available for analysing friction and wear effect at the area where the piston ring and cylinder liner contact. This paper describes several setups of equipment and method to find the valuable parameter in this field. Even the experiments and testing conducted in the different setup such as in real scale of engine, small scale of engine, and laboratory setup condition, but all of them still have the same objective which is to measure the friction and wear on the piston ring and cylinder liner. This paper also will show that the results for each research are presented in same trend and shape for the parameters.

EXPERIMENTAL WORK TO EVALUATE FRICTIONAL BEHAVIOR IN ENGINE

The friction properties of the piston ring and cylinder liner able to obtain by using laboratory apparatus and device such as pin on disk tribometer (ASTM G99-05 standard). The material of the pin is using the specimen of piston ring while the disk is using the same material as cylinder liner which is SCM 440 carbon steel. The simple setup as shown in Figure 3 (Adiyanto et al., 2021).

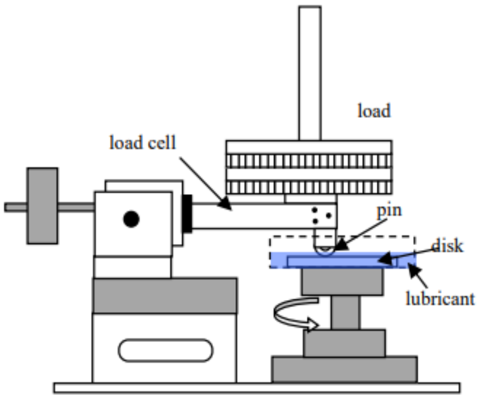

Figure 3: Schematic of the experimental apparatus (Adiyanto et al., 2021).

Several method and test rig designed that make the friction properties directly obtained from the setup without using laboratory apparatus such as tribometer because on the setup had attached with the sensors and other device that will present the result directly from the monitor. The Figure 4 and 5 show the different schematic of test rig for the engine where each engine driven by using electrical motor. The engine used in the test rig such as single cylinder 780cc motorcycle engine, single cylinder 125cc motorcycle engine and heavy-duty diesel engine (HDDE).

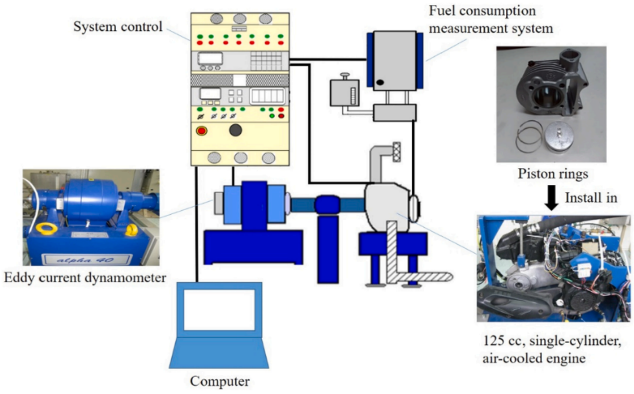

Figure 4: Schematic diagram of test rig for single cylinder 125cc motorcycle engine (Huang et al., 2022).

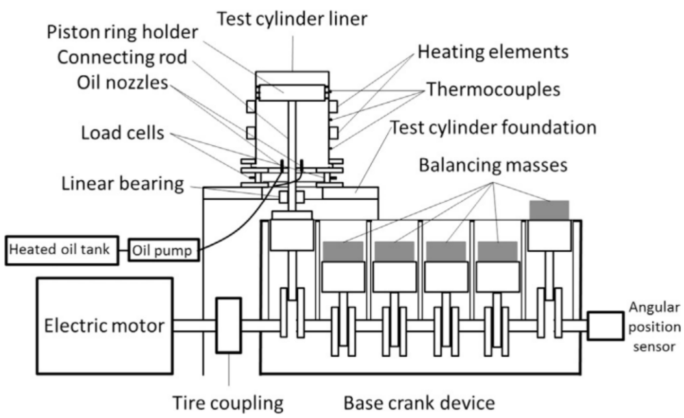

Figure 5: Schematic diagram of test rig for heavy duty diesel engine (Söderfjäll et al., 2016).

After the engine running, the wear scar effected on the piston ring and cylinder liner surface able to be detect using Scanning Electron Microscope (SEM).

After the piston ring and cylinder liner testing complete with the repeated experiment using various variable such as engine speed, coated piston ring, load and so on, the result of friction and wear properties will show in the graphical illustration. Figure 6 present the result of friction force generated on piston ring and cylinder liner for 0 to 360 degrees of crank angle in different engine speed (Söderfjäll et al., 2016). The result on wear effect detected on the surface of cylinder liner by using Scanning Electron Microscope (SEM) as shown in Figure 7 (Rao et al., 2021).

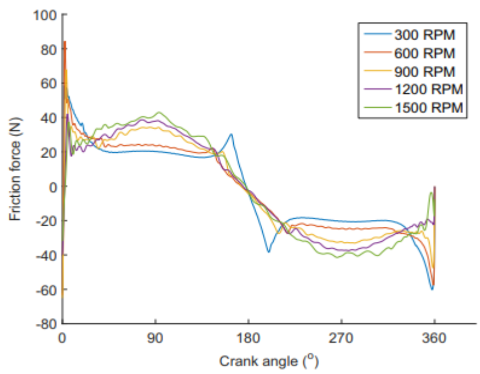

Figure 6: Graph friction force against crank angle for various speed (Söderfjäll et al., 2016).

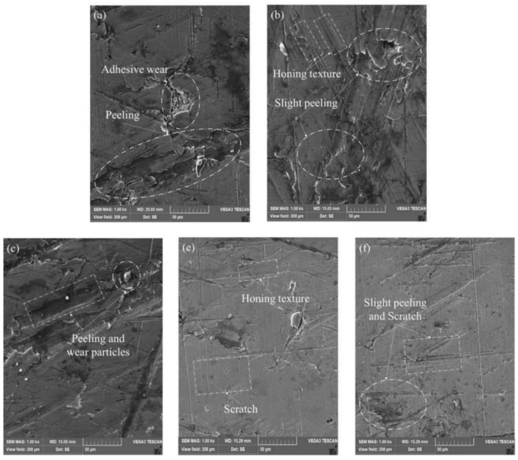

Figure 7: Wear effect of worn cylinder liner specimens using SEM (Rao et al., 2021).

SUMMARY

By using the test rig of engine, the result such as friction and wear properties obtained are more accurate that direct experiment from laboratory because the piston ring is contacting with the cylinder liner as realistic condition in term of speed, load, lubrication regimes and contact area. frictional losses between of three-piece of piston ring with the cylinder liner able to be measure as been shown by the previous researchers. The modification applied on the piston ring such as coating with other material and texturing on the surface of piston ring also able to successfully make the friction losses of engine reduced. So, when the friction losses on the engine can be reduce, the fuel energy consumption also can be reduced and at the same time will make the engine be more efficient and powerful.

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