Development of Piston Ring Friction Measurement System

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In this study, a piston ring friction measurement system has been developed to investigate single factor based on floating liner method. Unlike a conventional floating liner experiments, an immovable extra connecting rod is adopted above the conventional crank-piston system to minimize a friction from thrust force. Therefore, friction force from piston secondary motion can be excluded for the parametric study of friction force from only piston rings. The piston ring friction force with minimized thrust effect will be shown in this paper. Even though liner is on floating state, combustion stability is high to measure friction data.

Keywords : floating liner, piston thrust force, piston ring friction

1. Introduction

Engine friction loss has constantly been an issue to improve fuel efficiency. Due to the nature of engine that has moving parts, mechanical friction loss is inevitably linked with fuel consumption. Piston friction has been mainly studied because of its significant portion among mechanical friction losses. It is complicated to analyse piston friction, for it has a wide lubrication regime from boundary friction to hydraulic friction. In addition, there are various factors that affect this lubrication condition including piston design and environmental parameters such as engine oil temperature. To see the effect of each factor on piston friction individually, it is important to reduce the possible friction effect from other factors.

2. The Piston Ring Friction Measurement System

To minimize piston secondary motion from thrust force occurred by the angle created between connecting rod and crankshaft, another piston is adopted. One another piston is installed on the conventional piston, which is connected on crankshaft. An upper piston with an extended connecting rod is placed top of a lower piston. The extended connecting rod and the upper piston are connected with a piston pin. The upper piston can move solely, so the radial piston movement from the lower piston can be reduced on the upper piston. Furthermore, the liners are separated for the upper and lower pistons. The upper liner is in floating state. Load cells are placed underneath of the liner. Therefore, it captures friction force of the upper piston.

3. Experimental Results

Both motoring and firing conditions were tested at various engine speed, oil temperature, and coolant temperature. Engine speed and load were varied up to 2000 rpm and IMEP 5 bar each excluding natural frequency points of the engine. On Figure 1, motoring and one of the firing conditions are plotted. Both cases were implemented at 700 rpm. As in-cylinder pressure increases, lubrication regime is shifted according to Stribeck curve. Boundary lubrication near firing TDC shows the highest friction force than other locations. The friction force at IMEP 2.3 bar shows higher value around firing TDC than one at motoring condition, for the in-cylinder pressure at IMEP 2.3 bar condition is higher than one at motoring condition. And also, the friction force before and after firing TDC shows similar absolute values. This indicates that the friction force from the piston thrust force has been minimized.

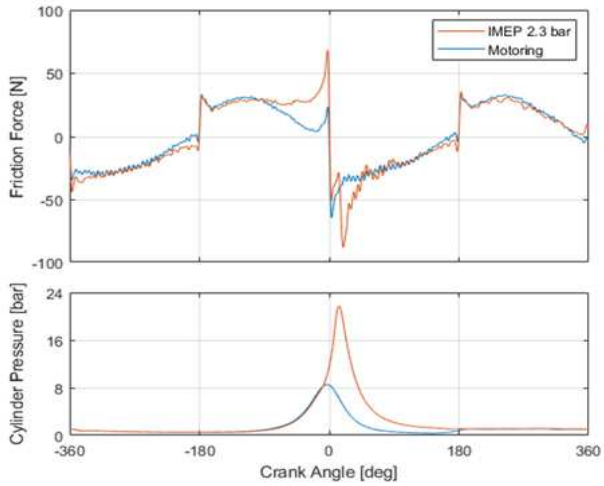

Figure 1: Friction force at motoring/firing conditions

4. Conclusion

Floating liner method is useful method to investigate piston friction. However, it is still challenging to exclude other force factors from measured data. In this study, piston secondary motion from the angle created between con-rod and piston center is highly reduced to measure the friction force from only piston rings. So the double piston structure is adopted, which is different from conventional engine structure for floating liner method. The experimental result shows the piston ring friction data, and it has a good agreement with base theory at various cylinder pressure and oil temperature.