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DEVELOPMENT OF A NEW MEASUREMENT SYSTEM FOR PISTON RING FRICTION BASED ON THE FLOATING LINER METHOD

Hyunjung Oh[1)], Kyoung-Pyo Ha[2)] and Kyoungdoug Min[1)*]

[1)]School of Mechanical Engineering, Seoul National University, Seoul 08826, Korea
[2)]Hyundai America Technical Center Inc., 6800 Geddes Rd. Superior Township, MI 48198, USA

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ABSTRACT–A new friction measurement system was developed to investigate piston ring friction in detail based on the floating liner method. Unlike the conventional floating liner experiments, an extended piston was adopted for the conventional crank-piston system to minimize friction from a piston lateral motion. The interaction between piston skirt and liner caused by piston thrust force can be excluded with the new measurement system. Therefore, a parametric study for the only piston ring friction can be possible. In this study, the experiments were conducted under both motoring and firing conditions. The oil temperature was changed to observe the effect of the oil viscosity on the piston ring friction. The friction data showed good agreement with the Stribeck curve for the engine speed, in-cylinder pressure, and oil temperature changes.

KEY WORDS : Piston ring friction, Floating liner, Double pistons, Piston thrust force

1. INTRODUCTION

Now, global warming became a threat to the humanity. Unless the global greenhouse gas (GHG) emissions can be achieved a net-zero by 2050, additional warming will increase climate changes and may trigger tipping points. For decades, the main cause of GHG emissions has been the excessive use of fossil fuels. Internal combustion engines (ICEs), one of the most commonly used fuel-driven power systems, have faced the problem of maintenance or abolition. Many nations have attempted to convert ICEs into zero-emission vehicle systems. However, majority of the vehicles on actual roads still have ICEs. COP26 in Glasgow agreed on converting existing cars to zero-emission cars by 2035 (COP26 declaration on accelerating the transition to 100 % zero-emission cars and vans, 2021). Similar to the situation after the Paris Agreement in 2015, experts have determined that the total phase-out period of combustion cars is being prolonged by the capability gaps in the energy infrastructures between nations. Therefore, a contribution to the reduction in CO_2 emissions is still required for existing combustion cars.

Engine friction loss has constantly been an issue in improving fuel efficiency. Mechanical friction loss is inevitably linked to fuel consumption owing to the nature of engines with moving parts. Mechanical friction accounts for approximately 4 ~ 15 % of the total fuel energy for a typical estimate of friction for ICEs (Wong and Tung, 2016). The friction of the piston and piston ring system accounts for approximately 50 ~ 60 % of the total engine friction loss (Nakada, 1994). Majority of the piston assembly friction comes from either the (i) piston-skirt/ liner interaction, or (ii) ring-pack/liner interaction (Wong and Tung, 2016). Piston ring friction losses account for approximately 20 % of the total mechanical losses in modern ICEs (Smedley, 2004). Piston ring friction accounts for a significant amount of the total mechanical friction. Because piston rings are consumables, the piston friction loss can be improved by simply replacing the piston rings. Therefore, it is important to study piston ring friction.

Piston friction has been mainly studied because of its significant contribution to mechanical friction losses. It is complicated to analyze piston friction because it has a wide lubrication regime, from boundary friction to hydraulic friction. In addition, various factors affect this lubrication condition, including piston and ring designs, and environmental parameters such as engine oil temperature, engine speed, and in-cylinder pressure. To individually observe the effect of each factor on the piston friction, it is important to separate the piston friction from the other possible friction conditions for each component.

Several methodologies have been developed to capture only the piston friction. The most widely used method is engine strip-down. The strip-down method involves the literal removal of engine components one by one, and the comparison of the engine torque values before and after the disassembly of each part. Consequently, the friction torque of each engine component can be calculated. In addition,

*Corresponding author. e-mail: kdmin@snu.ac.kr