Reduction of Piston Friction with Engine Oils Containing Ultra Fine Bubbles

Kai Horiba*, Syusuke Hoshino*, Masaya Fukuda*, Daisuke Shimooki*, Takumi Iwata*, Masakuni Oikawa**, Yuji Mihara **

*Tokyo city university, ** Tokyo City University Advanced Research Laboratories (HEET)

1. Introduction

Recent advancements have shown that ultra fine bubbles(hereinafter "UFBs"), particularly when dissolved in water, can act as friction modifiers, especially noted in chemical engineering applications[1]. In lubrication, we have reported that UFBs generated by an ultra-fine pore method reduce piston friction in engine oil[2]. Additionally, in sliding bearings, testing has demonstrated up to a 20% reduction in friction torque with UFBs-containing lubricants[3]. This study investigates how varying the length of the UFB generation device affects piston friction work, using a floating liner engine.

2. Experimental Methods

The ultra-fine pore UFB generator used in this experiment utilizes porous carbon ceramics. Compressed air fed into the device is released into the liquid through the porous interface, and the force of the liquid flow generates bubbles by shear exfoliation before the bubbles grow to a large size, which is less than several tens of micrometers. These bubbles then contract to the nanoscale due to their own surface tension. In this experiment, SAE viscosity grade 0W-20 was used.

3. Floating liner engine and experimental condition

In this test, a floating liner engine was used for friction force measurement. This engine is a single-cylinder, 4-stroke gasoline engine with a bore of 80.5 mm and a stroke of 88.3 mm. The cylinder liner of this engine has a dual structure with an outer liner and an inner liner. A total of 12 axial force sensors are installed to measure frictional force. The frictional force generated on the sliding surface of the inner liner was measured at each crank angle by these three axial force sensors.

4. Results (Effect of differences in operating conditions on friction characteristics)

Figure 1 shows the average effective pressure of piston system friction (FMEP) at IMEP 800 kPa for various engine speeds, along with the friction reduction rates for different nanobubble generation conditions. For UFB200 mm, it was confirmed that friction increased by approximately 10% at 1000 rpm. On the other hand, with UFB400 mm and UFB600 mm, where the amount of generation was increased, friction increased by 5%, but a tendency for reduced friction was observed compared to UFB200 mm. At 1500 rpm and 2000 rpm, a friction reduction effect of about 10% was achieved with UFB200 mm. The friction reduction effects for UFB400 mm and UFB600 mm were almost equivalent, but it was confirmed that the friction reduction effect was expanded compared to UFB200 mm.

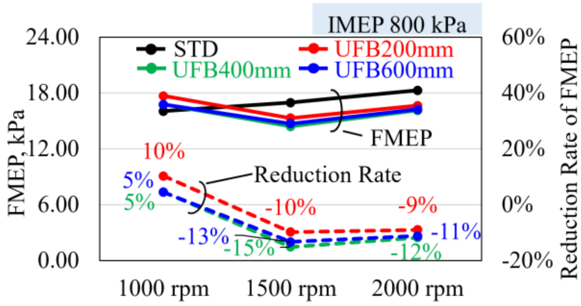

Fig. 1 FMEP comparison in each rpm at IMEP 800 kPa

5. Conclusions

It was confirmed that the friction increase was reduced at 1000 rpm and the friction reduction was increased at 1500 rpm and 2000 rpm by increasing the generating length from 200 mm to 400 mm. The friction reduction effect of changing the length of generation saturated at 400 mm. From this, it is expected that the UFB generation conditions are almost the same at 400 mm and 600 mm. In order to elucidate the reason why the friction reduction effect is limited to a specific crank angle, we will continue to investigate the relationship between the oil film thickness and the amount of UFBs generated.

Acknowledgement

This paper is obtained as a result of a grant project (JPNP21014) conducted by The Research association of Automotive Internal Combustion Engines (AICE) with support from the New Energy and Industrial Technology Development Organization (NEDO). We would also like to thank Mr. Anzai of Anzaikantetsu Co.,Ltd and Mr. Nambu of Fintech Tokyo Ltd. for their cooperation in carrying out the experiments.

References

1) Masami Nakagawa et al.: Nanobubbles as friction modifier, Tribology International 165 (2022) 107333
2) Kai Horiba et al.: Effect of Engine Oil Containing Nanobubbles by Ultrafine Pore Method on Reduction of Friction Loss in

Piston System, Tribology Conference 2024 Spring Tokyo(in Japanese)
3) Shusuke Hoshino et al.: Friction Reduction of Engine Bearings by Lubricating oil with Ultra-Fine Bubble, 2024 International Conference on Engineering Tribology and Applied Technology