

The effect of piston skirt lubrication on piston performance by modified piston shape

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Improving the efficiency of internal combustion engines is one of the key approaches to achieving carbon neutrality. Therefore, pistons are required to perform multiple functions at a high level. The lubrication condition of the piston skirt, which reciprocates in contact with the cylinder bore, is a major factor affecting piston performance, including friction reduction and vibration transmission to the cylinder block.

In this study, the lubrication condition of the piston skirt was modified by changing the skirt stiffness and profile. Figure 1 shows the skirt stiffness of the two piston designs (pistonA and pistonB). The upper skirt stiffness of pistonA was higher than that of pistonB. The skirt profile was adjusted to achieve equivalent piston dynamics between the two pistons.

Engine tests were conducted using these two pistons. Figure 2 shows the piston skirt wear and the vibration acceleration measured on the outer wall surface of the cylinder block. The results show that pistonA had lower skirt wear and lower vibration acceleration than pistonB. Furthermore, an elastohydrodynamic lubrication (EHD) analysis was conducted for these two pistons, and the difference in friction was found to be small. To investigate the cause of these results, the oil film thickness formed on the piston skirt was analyzed using EHD analysis. As a result, pistonA was found to form a thicker oil film than pistonB during the latter half of the compression stroke. This is considered to be due to the larger space for storing oil in the upper part of the piston skirt of pistonA. Figure 3 illustrates the space for storing oil in the upper part of the piston skirt. To verify the proposed mechanism, a confirmation test was conducted.

Based on these results, design guidelines for achieving the required piston performance were investigated, and their effectiveness was verified.

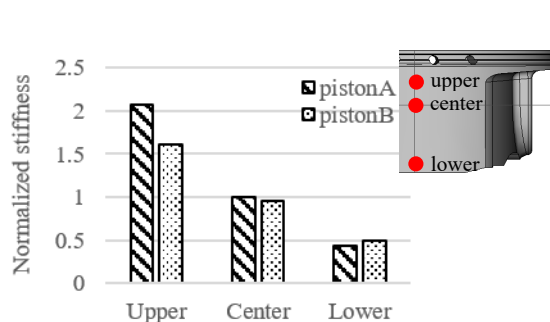


Fig.1 Piston skirt stiffness

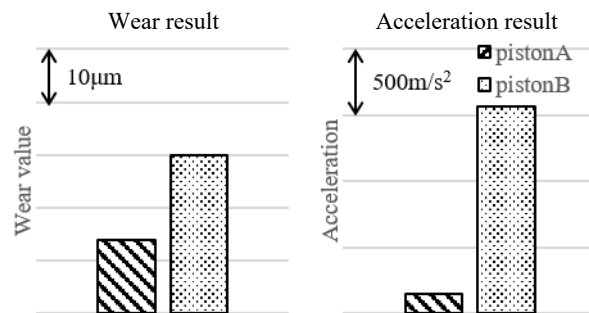


Fig.2 Result of wear and acceleration

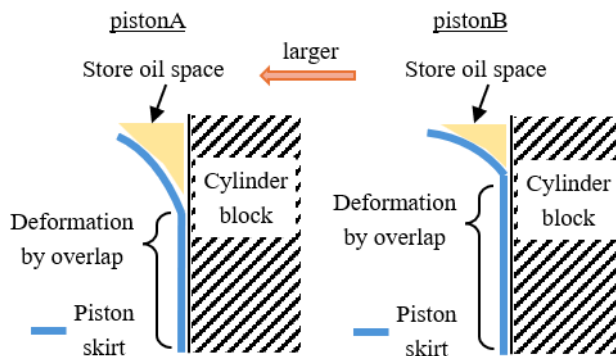


Fig.3 Image of store oil space on upper skirt