Influence of Combustion Mode on Heat Loss Distribution in Gasoline Engines

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As a technology to reduce the heat loss of engines, the application of heat insulation coating to the surface of combustion chamber is studied. In this study, transient behavior of wall heat flux was analyzed using 3D-CFD in order to investigate the location of heat insulating points where higher heat loss reduction can be achieved. The combustion chamber geometry for this analysis was shown in Fig.1. In order to obtain a wide range of knowledge, three combustion modes, Spark Ignition (SI) combustion, Homogenous Charge Compression Ignition (HCCI) combustion, and Spark Controlled Compression Ignition (SPCCI) combustion, were applied. The piston has large amount of heat loss due to large portion of the combustion chamber surface area. The piston surface was divided into five areas in the radial direction from center in order to analyze the heat loss in detail (Fig.2). The results show that area1 and 2 account for more than half of the heat loss for any combustion modes (Fig.3). These results were discussed and the findings were as follows:

(1) The heat loss distribution was affected by timing when high temperature gases generated by combustion reached the wall surface and the distribution of turbulent kinetic energy during combustion. The turbulent kinetic energy distribution was induced by the effect of intake air flow and the flow resulting from combustion.

(2) The mechanism of flow resulting from combustion depended on the combustion mode. In SI combustion (Fig.4(a)), flow from unburned areas to burned areas occured in the late combustion period. In HCCI combustion (Fig.4(b)), flow toward the early combustion area was induced by combustion from middle to late period. In SPCCI combustion (Fig.4(c)), the flow toward the early combustion area was induced by the rapid pressure increase due to rapid combustion.

(3) In case of combustion chamber geometry as shown in Fig.1(ignition point location: center of cylinder head, piston: with cavity), heat loss could be effectively reduced by insulating from the inside to the outer edge of the piston cavity.

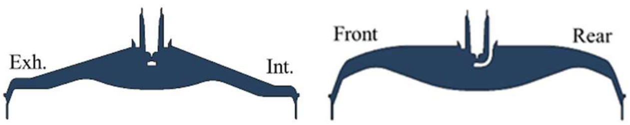

Fig.1 Schematic diagrams of combustion chamber

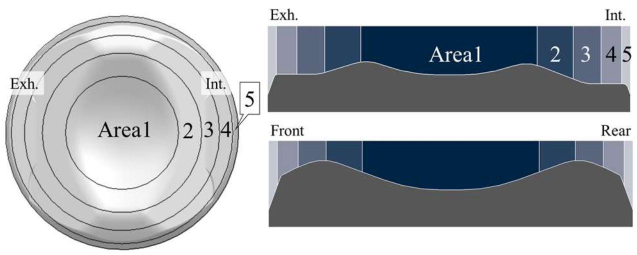

Fig.2 Areas division of piston

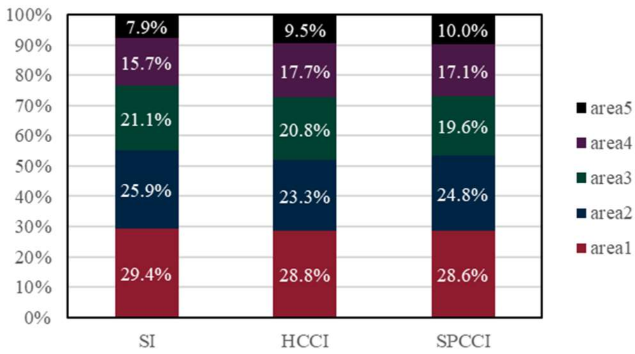

Fig.3 Percentage of heat loss per "area" of piston

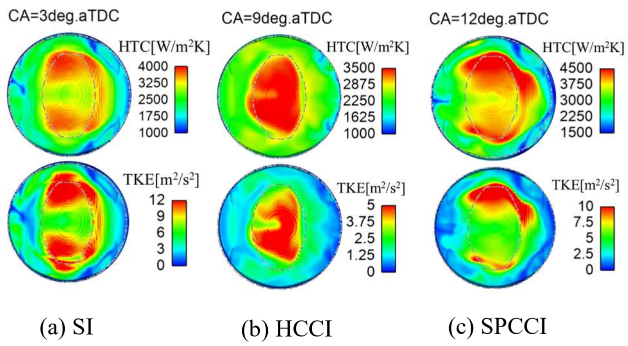

Fig.4 Distribution of heat transfer coefficient and turbulent kinetic energy