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A Study for High Efficiency of Gas Engine by Hydrogen Addition

- Effect of Different Hydrogen Supply System on Combustion Characteristics -

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In recent years, as solution of an environmental problem, hydrogen of carbon-free fuel attracts attention. There are various manufacturing methods in hydrogen. In particular, green hydrogen attracts interest. Green hydrogen is produced by electrolysis of water using surplus power from renewable energy sources. Therefore, it is the clean fuel which does not have CO_2 emission in a Well-to-Wheel. By using green hydrogen, the potential of fluctuating renewable energy can be maximized. Hydrogen has the highest diffusion velocity than other gases due to its small molecular weight. Therefore, it has excellent combustion characteristics such as wide limits of inflammability, fast burning velocity, and high auto-ignition temperature and have been studied in various institutions. In a previous study, the effects of hydrogen addition during lean burn on combustion and exhaust characteristics were investigated using an SI engine fueled by city gas (13A) and hydrogen. The results showed that hydrogen addition during lean burn can achieve both high thermal efficiency and low NO_x emissions. However, due to the short quenching distance of hydrogen, a large cooling loss was found to occur. Therefore, the purpose of this study is to reduce cooling loss of SI engine by hydrogen, and to further improve thermal efficiency. As a test engine, it used the Mixer system (Mixer) SI engine which mixes hydrogen and air before the intake pipe, and the port injection system (PI) SI engine which injects hydrogen into the intake pipe. The PI decreases hydrogen near the wall surface by making the heterogeneous hydrogen mixture, and suppresses the wall-heat-transfer by combustion, and it is expected that a cooling loss will decrease.

The apparent ROHR of the PI and the Mixer are shown in Figure 1. It can be seen that the rise of ROHR is faster for PI, regardless of the excess air ratio. This is thought to be due to the PI forming a heterogeneous mixture and making the area around the spark plug rich, resulting in a shorter ignition delay. Fraction of cooling loss of the PI and the Mixer are shown in Figure 2. This Figure shows that the fraction of cooling loss decreases with the PI. It can also be shown that the fraction of cooling loss decreases with the increase of the excess air ratio. This is because the PI forms a lean mixture near the wall surface, resulting in a smaller temperature gradient between the flame and the combustion chamber wall.

The main conclusions from this study are as follows:

(1) By changing the hydrogen supply system from a mixer to a PI system, a hydrogen-rich mixture is formed around the spark plug. This results in steep heat generation, which shortens the ignition delay and combustion period.

(2) The PI has a higher brake thermal efficiency than the Mixer. This is thought to be because the PI decreases the fraction of cooling loss by suppressing the wall heat transfer to the combustion chamber wall due to heterogeneous mixture.

(3) The PI promotes combustion and increases the maximum cylinder temperature, resulting in an increase in thermal NO_x emission and a decrease in THC and H_2 emissions.

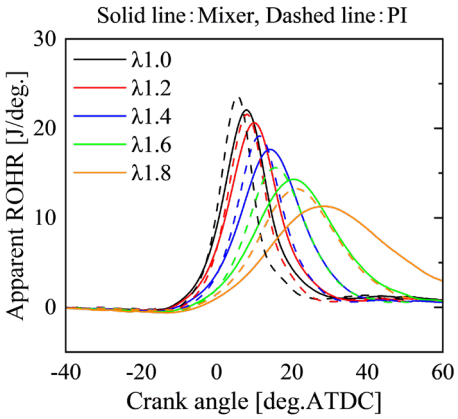

Fig.1 Apparent ratio of heat release for different hydrogen supply systems

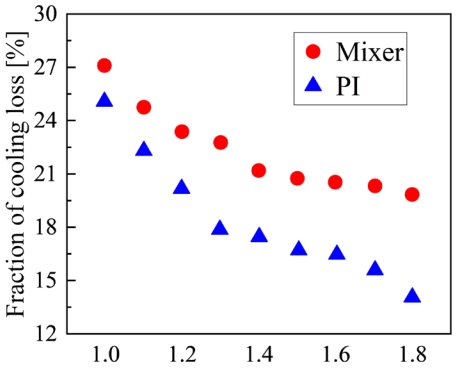

Fig.2 Fraction of cooling loss