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Effect of Blending of Fatty Acid Methyl Ester on Combustion and Exhaust Characteristics of Hydrotreated Vegetable Oil

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In order to prevent extreme climate events, there is an urgent need to reduce greenhouse gas emissions. In particular, it is important to reduce energy-derived CO_2 emissions. Since the Green Growth Strategy was formulated in response to Japan's declaration in Oct. 2020 that it aimed at the realization of carbon neutral and decarbonization society in 2050, the movement toward carbon neutral (CN) has been accelerating. In the transportation sector, not only electrification but also CN fuel is an important technology from the viewpoints of economy, cruising range, convenience, and LCA. Especially, in diesel engines, plant-derived biodiesel fuel (FAME: Fatty Acid Methyl Ester) is used as an alternative fuel to gas oil. The chemical composition of FAME is different from gas oil, and it contains about 10% oxygen, and has a higher density and viscosity. Nevertheless, FAME does not contain any aromatic hydrocarbons and can reduce emissions such as PM, HC, CO, etc., and can reduce the global warming. On the other hand, in these days, Hydrotreated Vegetable Oil (HVO) has been produced as a new biodiesel fuel which has the similar fuel properties to gas oil. HVO is composed of paraffinic hydrocarbons and has high cetane number, high evaporability, amelioration in lower temperature characteristics and stable oxidation property. In addition, emission regulations are becoming stricter every year, requiring not only hardware improvements but also approaches from the fuel side.

The objective of this study was improving the combustion and exhaust characteristics by using a blending of HVO and FAME that have CN fuels.

In this report, HVO and H80 (Fuel with 20% FAME blended with HVO) were used as the test fuels, and gas oil (GO) was used as the reference fuel. Combustion and exhaust characteristics were investigated by single-cylinder diesel engine.

Figure 1 shows the cylinder temperature and heat release rate for each test fuels. Figure 1 shows that HVO and H80 with high cetane index have shorter ignition delays, lower peak heat release rates, and lower cylinder temperatures than gas oil. Figure 2 shows the relationship between emissions and ratio of O_2. From Figure 2, compared to HVO, H80 of oxygenated fuel improved emission performance.

The main conclusions from this study are as follows:

(1) Ignition delay is shortened by a high cetane index, high evaporation, and an increase in cylinder temperature. Especially, in single injection, the effect of ignition delay affects combustion characteristics. H80 has a slightly longer ignition delay than HVO, but the heat release rate and cylinder temperature are not significantly affected.

(2) Regardless of engine load, the exhaust performance of H80 improves, reducing CO by 8-9%, NOx by 3-7%, THC by 10-17%, and Smoke by 5-27% compared to HVO. On the other hund, smoke decreases with prolonged ignition delay, but exhaust loss worsens.

(3) Although the binding energy of H80 is increased by mixing with FAME, the effect of low aromatic hydrocarbon and oxygen content is significant and improves exhaust performance without worsening environmental impact.

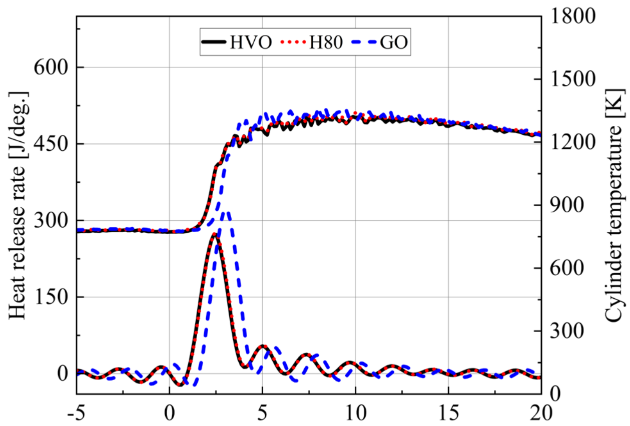

Fig.1 Images of Schlieren Photography

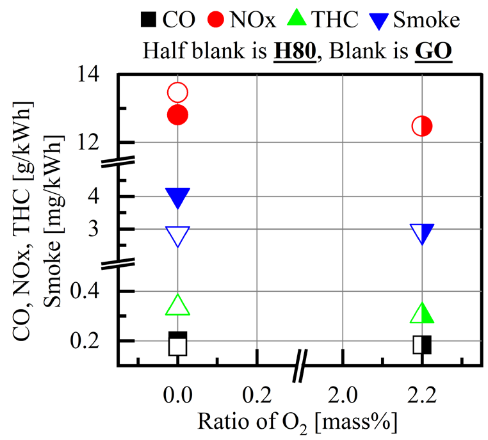

Fig.2 Relationship between emissions and ratio of O2