

Effect of PM Reduction due to Hydrogen Oxygen Gas addition to intake air in Diesel Engines.

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The electrification of vehicles is rapidly advancing as a countermeasure against global warming. However, internal combustion engines will continue to play a crucial role in heavy-duty vehicles and marine vessels, where complete electrification is difficult due to constraints regarding battery weight and energy density. Therefore, reducing CO₂ and particulate matter (PM) emissions from diesel engines remains an urgent issue to meet strict environmental regulations. Since utilizing hydrogen as a main fuel faces numerous practical challenges in terms of onboard tanks and infrastructure, this study proposes a method of generating the required amount of hydrogen-oxygen gas onboard to be used as a combustion improver.

When hydrogen-oxygen gas is added to the engine intake, the oxygen gas and highly reactive oxygen radicals promote the oxidation of soot accumulated in the intake and exhaust pipes. As this oxidation process discharges the soot as carbon dioxide, blockages within the pipes are cleared, resulting in smoother exhaust flow and consequently reducing pumping loss. Furthermore, the addition of hydrogen, which has an extremely fast flame propagation speed, is expected to shorten the combustion period. These combined effects significantly reduce the engine's rotational resistance, leading to an overall reduction in the amount of fuel required to maintain the same engine speed.

In this study, practical experiments using a real engine were conducted to investigate the specific effects of hydrogen-oxygen gas intake addition on the combustion characteristics and CO₂ emissions of a diesel engine. For the combustion tests, a direct-injection 6-cylinder diesel engine with a displacement of 13,700 cc, installed on an actual vessel, was utilized. Using a hydrogen-oxygen gas generating apparatus based on the principle of water electrolysis, hydrogen and oxygen were generated at a volume ratio of approximately 2:1, and 3,000 cc/min of the mixed gas was supplied directly into the engine's intake pipe. The generator was powered using the vessel's onboard 100V power supply.

Combustion experiments were conducted under no-load idling conditions with the engine speed kept constant at 520 rpm and 1,210 rpm. Fuel consumption at each engine speed was evaluated based on the CO₂ concentration in the exhaust gas. To accurately determine the impact on combustion, measurements were systematically recorded across three phases: (1) no gas supply, (2) during gas supply, and (3) no gas supply again.

The following findings were obtained from the experiments:

1. In the phase no gas supply again (3), the CO₂ concentration in the exhaust gas was reduced by approximately 10% compared to the initial level (1), confirming the soot oxidation process.
2. During the gas supply phase (2), the electrical load required for water electrolysis partially offset the fuel reduction effect, resulting in a CO₂ concentration that fell between the initial (1) and final (3) levels.
3. As the engine speed increased, the fixed volume of supplied gas became relatively insufficient for the increased intake air volume, leading to a tendency for the CO₂ reduction effect to diminish.

These results confirmed that the continuous intake addition of hydrogen-oxygen gas promotes the soot oxidation process and clears the soot, thereby reducing CO₂ emissions. It is also inferred that this oxidation mechanism effectively reduces PM emissions. In future studies, we plan to conduct detailed experiments under applied load conditions and perform quantitative measurements of PM to evaluate the soot oxidation effect.

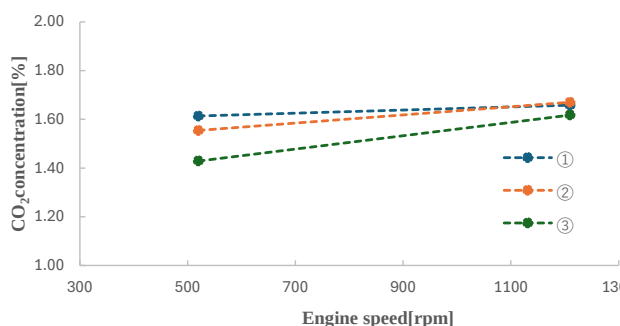


Fig. 1 CO₂ density on Engine