Study on improvement of combustion in marine diesel engine using electronically controlled fuel injection system

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Diesel engines are widely used for main engine of ships because of their reliability and efficiency. Recently ships are enforced strict regulations restricting harmful substances and CO_2 emission. For now, marine industries and researchers have to clear regulations of NOx and SOx emission being tightened up from 2011 to 2016. On the other hand, heavy fuel oil for marine diesel engines has a trend of degradation in their ignition and combustion characteristics, making the problem harder.

In this study, effect of increasing pressure of fuel injection and controlling injection rate on spray combustion in diesel engine is investigated by using electronically controlled fuel injection system, and some countermeasures for above issues are discussed.

First, to confirm the effect of EFI, high pressured fuel injection cases using conventional injection system and EFI system are compared using the visual test engine. As a result, combustion characteristics are drastically improved in EFI case, reducing soot formation and shortening after burning phase, leading less fuel consumption. However, the NOx emission is increased with such fine combustion. Next, for the purpose of breaking the trade-off relationship between the NOx formation and fuel consumption, the method of shaping injection rate named “boot injection” is tried. As a result, boot injection case has less sacrifice of fuel consumption for reducing NOx emission comparing to timing-retarded injection, which is also NOx reducing method.

Countermeasures for low grade fuel are also investigated. In this study, light cycle oil (LCO) is used as representative of low grade fuel. LCO is high-aromatic, low-sulfur by-product from oil refinery process. Characteristics of combustion of LCO are investigated using visual test engine and low-speed, large-sized 2 stroke engine. As a result of these test, using LCO as diesel fuel causes more soot emission and more NOx emission especially in low load operation. Next improvement of LCO combustion using EFI system is investigated with visual test. In this experiment, effect of injecting small amount of pilot fuel before the main injection is investigated. As a result, LCO fuel with pilot case gets similar characteristics of ignition and after burning with gas oil fuel case. This result demonstrates that EFI can be the countermeasure for the issue of degrading fuel.

Effect of extremely high injection pressure on diesel combustion is also investigated using CFD simulation. At first, a test to visualize burning sprays with injection pressure of 150 MPa is carried out. Combustion simulations inputting high injection pressure up to 350 MPa are tried, after a CFD code is validated using above-mentioned

visual data. Finally, effect of such high injection pressure on large-sized engine is also simulated. As a result, considering some trade-offs, there is less merit using too high injection pressure, and it is thought that optimum pressure exits around 200 MPa.