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Investigation of the Combined Application of Water-in-Fuel Emulsion and Exhaust Gas Recirculation in a Medium Speed Diesel Engine

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ABSTRACT

Medium speed diesel engines are utilized as prime movers or auxiliary generators in the maritime transportation sector as well as for stationary power generation. To regulate the environmental footprint, strict emission legislations are effective and further regulations are under evaluation. Therefore, continuous overall improvement of engine performance and R&D on low emission technologies, with respect to NO_x as well as PM emission reduction, are of high importance.

A well-established method for NO_x reduction in diesel engines is the use of cooled exhaust gas recirculation (EGR), which reduces flame temperature resulting in lower NO_x formation. The adoption of EGR leads to increased soot emissions due to the lower flame temperature and reduced oxygen availability, both of which hamper soot oxidation. The application of water-in-fuel emulsions (WFE) has been shown to improve the NO_x vs. soot tradeoff.

A medium speed marine diesel engine equipped with 2-stage turbocharging, Miller valve timing as well as common rail injection is utilized for the experiments where EGR and WFE have been applied simultaneously. The emulsion is produced by a custom-designed on-line emulsifier upstream the high-pressure pump.

The investigations presented include the influence of EGR rate, rail pressure and injection timing on the engine operation with and without WFE. The study shows the analysis of combustion characteristics, emission measurements, performance indicators as well as engine energy flows for the simultaneous application of the emission reduction technologies EGR and WFE.

The findings extend the understanding and knowledge regarding engine operation and performance of the combined application of EGR and WFE with focus on large engines in order to achieve a significant NO_x emission reduction with minimal penalties in soot emissions and fuel consumption.

INTRODUCTION

In recent years, strict emission legislations for diesel engines were brought into force and further regulations are under evaluation. NO_x is a major pollutant occurring in diesel combustion and its emissions are limited [1]. Hence, additional NO_x reduction technologies need to be developed and adopted.

The use of cooled Exhaust Gas Recirculation (EGR) which reduces the flame temperature, resulting in lower NO_x formation, is a well-established method to reduce NO_x in diesel engines [2,3]. Due to the known tradeoff relationship between the emission of NO_x and soot [5,6], the reduction of NO_x by utilizing EGR yields to increased soot emissions, as the lower flame temperature and reduced oxygen availability both of which hamper soot oxidation [2,4-6].

In order to overcome the disadvantage of increased soot emissions when lowering NO_x via EGR, water-in-fuel emulsion (WFE) application has shown to be a promising technology to simultaneously reduce soot