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Combustion Property Analyses with Variable Liquid Marine Fuels in Combustion Research Unit

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Abstract. The quality of ignition and combustion of four marine and power plant fuels were studied in a Combustion Research Unit, CRU. The fuels were low-sulphur Light Fuel Oil (LFO, baseline), Marine Gas Oil (MGO), kerosene and renewable wood based naphtha. To meet climate change requirements and sustainability goals, combustion systems needs to be able to operate with a variety of renewable and 'net-zero-carbon' fuels. Due to the variations in the chemical and physical properties of the fuels, they generally cannot simply be dropped into existing systems. The aim of this research project was to understand how changes in fuel composition affect engine operation. The focus was on how various attributes of the fuels impact on the combustion process – especially ignition delay and in-cylinder combustion. The goal of the research project was to allow broad fuel flexibility without any or only minor changes to engine hardware. The results showed that the ignition delay decreased expectedly with all fuels when the in-cylinder pressure and temperature increased. The differences in the maximum heat release rates between fuels decreased in high-pressure conditions. MGO had the shortest ignition delay under both pressure and temperature conditions. Based on the CRU results MGO and kerosene are suitable to use in compression-ignited engines like the reference fuel LFO. In contrast renewable naphtha had a long ignition delay. If naphtha is used in a CI engine, the engine must be started and stopped with, e.g. LFO or MGO.

Key words: Diesel engines, alternative fuels, ignition delay, heat release rate

INTRODUCTION

In compression ignition (CI) engines the combustion process starts when liquid fuel is injected as one or more jets into the cylinder fulfilled with hot high-pressured air near the top dead centre (TDC) position of the piston. The ignition delay (ID) is a period when injected fuel entrains to cylinder, atomizes and mixes with existing air. Chemical reactions start slowly and ignition occurs after the ID. Good atomization provides rapid air-fuel mixing decreasing the ID. The ignition of air-fuel mixture prepared during the ID causes a rapid pressure rise that is called as rapid uncontrolled or premixed combustion. Controlled combustion follows and is the part where preparation of fresh air-fuel mixture determines the rate of combustion. Combustion continues until all the fuel or air is utilized. This last phase is called as final combustion.

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