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Evaluation of The Effects of Pilot Fuel Injection Ratio on Combustion Products in a Diesel Engine Using Ethanol/Diesel Mixtures

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ABSTRACT
Aim of this study, investigation of effects of pilot injection strategies with use of ethanol-butan2ol-diesel fuel on combustion and exhaust emission characteristics in a single cylinder diesel engine. In addition, in diesel-ethanol fuel blends, to prevent phase separation butan2ol was added as a solvent. Engine tests were conducted in a single cylinder, common rail diesel engine at constant 50% engine load, 1200 rpm constant engine speed conditions. The tests were completed by changing the injection application and fuel type. It was seen that the maximum cylinder gas pressure increased with 10% pilot injection application for each test fuel. Moreover, it was determined that the maximum pressure rise rate significantly decreased for all fuels as a result of 10% pilot injection application. While, a slight decline was seen in CO_2 emission with use of blends, a significant increase was observed in NO emission with use of FBDF, E10B2 and E15B3 fuel at 10% pilot injection applications. On the other hand, at all injection application, use of FBDF caused more NH_3 emission than blend fuels.

Keywords: Combustion, Diesel Engine, Fuel Blends, Pilot Injection, Exhaust Emissions.

INTRODUCTION
Global warming and limited oil reserves are the two main factors for the viability of diesel engines. Today, petroleum-based fuels are still the main fuel source for diesel engines. In addition, petroleum-based diesel fuels are considered as a non-renewable resource and it is predicted that due to their limited resources, it may lead to an energy crisis in the future. Therefore, the use of alternative fuels in the future is inevitable. In recent years, although cleaner diesel engines have been obtained with the developments in technologies such as high-pressure fuel injection, fuel injection control strategies, exhaust gas recirculation, exhaust gas aftertreatment, diesel particulate filters, etc. these technical developments have not reached a sufficient level for diesel engines to be used more widely. Today, there is a need for fuel injection technologies that increase the efficiency of diesel engines and developments in new exhaust aftertreatment technological and alternative fuel types that reduce CO_2 emissions [1-3].
Many countries want to use ethanol intensively as an alternative fuel in internal combustion engines in the future [4]. However, more stable combustion information on ethanol and diesel mixtures is still needed. Efforts to make ethanol suitable for diesel engines by overcoming the disadvantages of low carbon content alcohols such as high latent heat of vaporization, low cetane number, moisture retention and phase separation are still ongoing [5,6]. In the literature, it is recommended to add biodiesel, propanol and butanol to ethanol-diesel fuel mixtures to prevent phase separation in blend fuels [7,8]. In this study, 2-butanol was added to the blend fuels to prevent phase separation in ethanol-diesel fuel blends.
Some of the recent studies in the literature are as follows; In their study, Ge et al. [9] investigated the effects of pilot injection using ethanol-diesel fuel mixtures in a diesel engine. They stated that the maximum pressure rise rate for all fuels is 3 bar /^{o}CA. They found an increase in cylinder gas pressure with early injection timing. They reported that ethanol-diesel fuel mixtures caused an increase in HC emissions. Yao et al. [10] in their study, investigated the effects of using diesel-nbutanol fuel mixtures and different pilot injection amounts in a diesel engine. They noted that while the pilot injection application caused a decrease in soot emissions, it caused an increase in CO emissions. Sandalci et al. [11] investigated the effects of using ethanol-diesel fuel mixtures in a diesel engine. They found that the use of blended fuels caused a significant reduction in CO_2 and NO_x emissions.
In this study, the effects of pilot injection applications and the use of ethanol-butan2ol-diesel fuel mixtures on cylinder gas pressure, maximum pressure increase rate, CO_2, NO and NH_3 emissions were investigated with a common rail diesel engine at 1200 rpm constant engine speed and 50% constant engine load.