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Influence of adding aluminum oxide nanoparticles to diesterol blends on the combustion and exhaust emission characteristics of a diesel engine

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ABSTRACT

In the current article, the effects of adding aluminum oxide (Al_2O_3) nanoparticles into Diesterol blended fuel (70% diesel + 20% ethanol + 10% Jojoba biodiesel) on the performance, combustion and emission characteristics of a diesel engine were experimentally investigated. The diesel fuel and ethanol are immiscible; therefore, jojoba methyl ester was used as a mediator solvent to alleviate the phase deposition. The Al_2O_3 nanoparticles were added at different dose levels of 25, 50, 75, and 100 mg/l of Diesterol using an ultrasonic technique. These blends were examined under various engine loads and a constant engine speed of 1500 rpm. The Diesterol blended fuel showed an acceptable homogeneity to be tested on the diesel engine. The consequences exhibited that adding Al_2O_3 nanoparticles in Diesterol enhanced the engine performance, combustion, and emission characteristics compared to those of pure Diesterol. The maximum enhancement was achieved at a dose level of 75 mg/l, where the reduction in the brake specific fuel consumption (bsfc) was approximately 20%, while the increase in the peak cylinder pressure was approximately 1.5%. Additionally, the maximum reduction in UHC and NO_x emission was obtained at a dose level of 25 mg/l, while the concentration of 100 mg/l gave the lowest CO emission. The outcomes revealed that the dose level of 75 mg/l had the optimum improvement in the overall characteristics of engine performance and emissions.

1. Introduction

The compression ignition engines play a vital role in energy economy as it is used widely in transportation, electrical power generators, and agricultural machines. However, soot and NO_x emissions from both automotive and stationary diesel engines are a major contributor to air pollution. Operating diesel engines on alternative fuels decrease the dependency on the fossil fuel and reduce the engine exhaust emissions. Alternative fuels for diesel engines should be liquid fuels synthesized from biological material and their chemical and physical properties conform to those of diesel fuel. Biodiesel and ethanol are considered as promising alternative fuels which have been examined as a replacement for diesel fuel in diesel engines for the recent decades. The oxygen content in biodiesel fuels reduce the emissions of soot, CO, and UHC while increasing NO_x emissions [1]. Likewise, the oxygen content in ethanol reduces the emissions of soot, NO_x, CO, and UHC [2], while other researchers reported an increase in UHC emission [3]. Biodiesel and ethanol can be used without any technical modifications in diesel engines. However, biodiesel and ethanol still suffer from many limitations. Ethanol has a low heating value and cetane number compared to diesel fuel which reduces the auto ignition capability [4]. Additionally, the ethanol latent heat of vaporization is high compared to diesel which leads to charge cooling and combustion quenching [5]. Similarly, biodiesel fuels have high density, high pour point, and high viscosity, as well as lower energy content and volatility than that of diesel fuel. This worsens the atomization process and increases deposits in fuel injector but enhances the fuel lubricity [6].

Ethanol is not soluble in diesel fuel and ethanol-diesel blends are unstable mixtures which easily to separate in the presence of small amounts of water [7]. Therefore, several techniques were investigated for using ethanol in compression ignition engines, such as emulsion [8], fumigation [9,10], injection into exhaust manifold [11], and ethanol

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