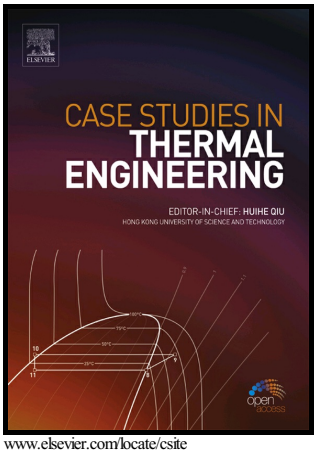

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Novel Technique for Enhancement of Diesel Fuel: Impact of Aqueous Alumina Nano-Fluid on Engine's Performance and Emissions

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ABSTRACT

Nanofluids are suspensions of nanoparticles mixed in liquids and show significant enhancement in some thermophysical and combustion properties of the resulting suspension. In this study, the changes in the performance and emissions characteristics of a conventional diesel engine are verified experimentally using the combustion of a mixture of nanofluid (water and Al_2O_3) and conventional Iraqi diesel fuel. The nano-Al_2O_3 (51 nm diameter) was used in this study; multiple weight ratios of this nanoparticle were mixed with water to form a nanoparticle suspension. The weight fractions used were 1, 3, 5, 7, and 10%. After that, a fixed volume ratio of the resulting suspension (10%) was added to the diesel and completely mixed. The results indicate that the addition of the nano-alumina-water suspension has increased the brake thermal efficiency up to 5.5%, and reduced the relative fuel consumption up to 3.94%, compared to diesel fuel. In the analysis of emitted exhaust emissions, CO, HC, NOx, PM and noise emissions, they were found to be lower than diesel fuel, while CO_2 emissions increased.

Keywords: diesel engine, engine emissions, aqueous alumina nano-fluid, Additive, nitrogen oxides, particulate matters.

INTRODUCTION

Compression ignition engines are widely used in automobiles, trains, construction equipment, and marines because of their efficient and reliable economy [1]. As with any oil derivative, the future of this material has become dubious because oil reserves are falling faster than expected due to high population growth and the need for greater energy use [2]. Many threats, such as global warming, ozone hole, and climate change, have prompted many governments to issue strict regulations on pollutants emitted from these engines, creating an urgent need for renewable fuel [3].

The concept of using diesel-water emulsion has become the focus of researchers in recent years. The use of such emulsions in compression ignition engines drives to improve engine performance, reduce emissions, and reduce fuel consumption [4]. Several improvements have been reported in the use of fuel emulsions, such as reduced fuel consumption, improved combustion to be more complete and significantly reduced exhaust emissions [5 & 6]. The use of a water-diesel emulsion is also an effective way to reduce nitrogen oxides, and particulate matters (PM) emissions as explained in References [7 and 8]. Nanoparticles (at least one of their main dimensions smaller than 100 nanometers) are mixed with liquids to form a nanofluid. Nanofluids have been shown to have enhanced thermophysical properties as thermal conductivity, thermal diffusion, viscosity, and convective heat transfer coefficient compared with base fluids such as oil or water [9 and 10]. References [11 & 12] clarified that the thermal conductivity of a nanofluid is increasing with the increase of volumetric fraction of nanoparticles in the suspension.

Metals such as aluminum (Al) and oxides such as alumina (Al_2O_3) are characterized by high combustion cards and have always been used as additives in warm fuel and explosives [13]. The production, monitoring and characterization of nanomaterials of multiple sizes have been made possible by recent advances in nano-science and technology. Nanomaterials have shown enormous advantages over micron sizes materials. The high surface area of metallic nanoparticles causes short bursts of ignition, which reduces the combustion time and results in a more complete combustion than the use of micro-particles [14 and 15]. Adding nanomaterials to fuel to enhance its combustion is an interesting concept. The high energy density of metals, especially aluminum, enhances the production of energy in engines and thus reduces the consumption of liquid fuels, and reduces emissions such as carbon dioxide and nitrogen oxides. Adding nanomaterials to fuel shortens ignition delay period and improves fuel oxidation by catalytic effect. However, studies on ignition behavior and combustion of liquid fuels with nanoparticles are still rare to date [16 and 17].

Tyagi et al. [18] studied the ignition properties of diesel fuel using a hot plate; also, they studied the implications of adding small amounts of aluminum and aluminum oxide particles. The results manifested that the ignition potential of fuel mixtures containing nanoparticles was much higher than that of pure diesel. The study showed that the adding n-Al to