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An Experimental Examination on Diesel Engine

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ABSTRACT

Experimental work was done to examine the impact of diesel fuel with alumina nanoparticles on combustion characteristics, emissions and performance of diesel engine. Alumina nanoparticles were mixed with crude diesel in various weight fractions of 20, 30, and 40 mg/L. The engine tests showed that nano alumina addition of 40 ppm to pure diesel led to thermal efficiency enhancement up to 5.5% related to the pure diesel fuel. The average specific fuel consumption decrease about neat diesel fuel was found to be 3.5%, 4.5%, and 5.5% at dosing levels of 20, 30, and 40 ppm, respectively at full load. Emissions of smoke, HC, CO, and NOX were found to get diminished by about 17%, 25%, 30%, and 33%, respectively with 40 ppm nanoadditive about diesel operation. The smaller size of nanoparticles produce fuel stability enhancement and prevents the fuel atomization problems and the clogging in fuel injectors. The increase of alumina nanoparticle percentage in diesel fuel produced the increases in cylinder pressure, cylinder temperature, heat release rate but the decreases in ignition delay and combustion duration were shown. The concentration of 40 ppm alumina nanoparticle is recommended for achieving the optimum improvements in the engine's combustion, performance and emission characteristics.

Keywords : Alumina nanoparticles, diesel engine, performance, combustion characteristics, emissions

I.INTRODUCTION

The continuous growth of world energy demand, harmful engine emissions and fossil fuel depletion have prompted the search for alternative fuels and fuel-additives. Among the various alternatives which are believed to be useful for bringing down the energy and the environmental crisis are the nano-fuel additives.1 Al_2O_3, TiO_2, CeO_2, Co_3O_4, and Fe_2O_3 nano-oxide additives are used to obtain the reduction in fuel consumption and exhaust emissions. Nano-metal oxide additives promote the combustion activation and thus improve the overall combustion process. Nowadays, the research in heat transfer improvement in thermal systems is increased. This is affected by the surface tension and liquid droplet shape. Addition of nanoparticles such as alumina, TiO_2, and carbon nanotubes improves the heat transfer properties in cooling water and lubrication oil in vehicles. Inclusion of nanoparticles in base fuel improves the chemical properties of fuel. Addition of nano additives enhances the heat transfer, chemical reactivity and this leads to the improvement in engine performance and emissions reduction. Cerium oxide nanoparticles added to diesel oil shortens the ignition delay, improves the oxidation rate and reduces the exhaust emissions. The oxygen atoms in cobalt oxide particles (Co_3O_4) improve the combustion reaction. CO, NOx, and HC emissions were reduced. The metal reacting with water creates hydroxyl radicals and lowers the oxidation temperature. Nano-particles have some special characteristics like higher activity, higher surface area, and improved combustion. Aluminum particles produce the enhanced thermal behavior with the stored internal energy. Aluminum particles improve the combustion characteristics because of its higher heat of reaction as stated by Galfetti et al.Aluminum nano-particles boost the burning rate of fuel-air mixture. Furthermore, it demonstrates the greater surface area to volume ratio between the oxidizer and fuel.3–5 Nano-alumina particles of size 40 nm mixed with diesel fuel at the rate of 1 g/L and 1.5 g/L produced the brake thermal efficiency improvement, HC and NOX emissions reductions about diesel fuel. Biodiesel blend B40 with 50 ppm alumina nanoparticles achieved the reduction in smoke emission of 52.8% at full load. The nanoparticles of alumina are dispersed with diesel fuel in weight fractions of 25 ppm to 75 ppm. Many researchers have reported that, blending of nanoparticle shortens the ignition delay and increases the atomization that in turn, will reduce NOx emission and increase the thermal efficiency.6 Gurusala and Selvan7 conducted the tests by adding alumina nanoparticles to biodiesel blends. The decrease in harmful emissions and brake thermal efficiency increase were shown compared to neat biodiesel. A hot plate ignition probability test was used to examine the ignition properties of aluminum oxide nanoparticles added to diesel fuel.8 The addition of nanoparticles achieved the improvement in heat transfer properties and droplet ignition about pure diesel. Nanoparticles added to fuel showed the rapid oxidation, shortened ignition delay and complete combustion.9 Performance and emissions were studied to show the effect of adding aluminum, iron and boron nanoparticles in base diesel fuel by Mehta et al.10 There were improved combustion rate and reduced ignition delay. Brake thermal efficiency increases by 4%, 9%, and 2% for iron, aluminum and boron about diesel fuel, respectively. Specific fuel consumption was reduced by 7% when the engine fueled with aluminum related to diesel fuel. While for iron and boron, it is almost the same as gas oil at higher loads. CO and HC pollutants reductions were 25% and 8% when the engine fueled with nano-aluminum, respectively about diesel fuel. The rise in NOX emission compared to pure diesel oil was because of the increment in cylinder combustion temperature, as explained by Tyagi et al.11 Nano-fuel additives reduced the ignition delay. Moreover, the cylinder pressure was reduced at higher engine loads and the specific fuel consumption was decreased with aluminum nanoparticles addition about neat diesel fuel. HC and CO emissions were reduced for alumina-doped nano-fuel at higher engine loads. Aluminum and alumina nanoparticles added to diesel fuel lead to the improvement in ignition delay.12 Heat transfer properties of pure diesel can be increased by the dispersion of nanoparticles in pure diesel and therefore the ignition delay can be improved. Usage of nano-additives is aimed to augment the combustion characteristics of the diesel fuel.

II. EXPERIMENTAL SETUP AND METHODOLOGY

Engine setup In the current experiments, a single cylinder DEUTZ diesel engine of output power 5.775 kW rated at a rated speed of 1500 rpm was used. This engine was modified for research purpose. Detailed specifications of the engine setup are mentioned in Table 1. The fuel injection has a reciprocating fuel pump with a single injector. The length of injector nozzle is 57 mm with inner diameter of 3.5 mm. The fuel injector opening pressure is 210 bar with ignition advance angle of 24 BTDC. The experimental set up schematic diagram was shown. in Figure 1. AC generator was connected to the engine for determining the output power. A sharp-edged orifice mounted on an air box was connected to the inlet of the engine for measuring the air flow rate. The U-tube manometer was employed to measure the drop of pressure across the orifice. K-type thermocouples were used to measure the temperatures of intake air and exhaust gas. A tachometer was used to evaluate the engine speed. Fuel systems of diesel oil and the introduction of nanoparticles were mounted on the engine setup. Consumption time measurement of fixed fuel volume of 20 mL was used for the fuel consumption recording. A piezoelectric pressure transducer with water cooling (Type: Kistler, Model 601A) measures the cylinder pressure values up to 250 bar. It has an accuracy of 1.118% and sensitivity of 16.5 pc/bar. The pressure transducer is connected with a charge amplifier (Type: Nexus, Model (2692-A-0S4)). The transducer flush installed in the cylinder head minimized the lag in pressure signal and resonance. A LM12-3004NA proximity switch was fixed on the engine shaft to determine the piston top dead center position (TDC).

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Table 1 : Shows Engine Specifications

No.	Engine parameters	Specification
1	Engine model	DEUTZ F1L511
2	Number of cylinders	1
3	Number of Cycles	Four-stroke
4	Cooling type	Air-cooled
5	Bore (mm)	100
6	Stroke (mm)	105
7	Compression ratio	17.5:1
8	Fuel injection advance angle	24° BTDC
9	Rated brake power (kW)	5.775 at 1500 rpm
10	Number of nozzle holes	1
11	Injector opening pressure (bar)	210

The in-cylinder pressure data were averaged over 120 consecutive engine cycles. Data acquisition card (NI-USB6210) adapted with LABVIEW□ software was used for the high-speed data acquiring and analysis. MRU DELTA 1600-V gas analyzer and OPA 100 smoke meter were operated for exhaust gas and smoke emissions measurements, respectively. The accuracy and reproducibility of the instrument was 6 1% of fullscale reading. NOx and O2 were measured by electrochemical sensors but CO and HC emissions were measured by infrared sensors. The engine load was varied from 0 to 100% at 1500 rpm rated speed. During each experiment, the performance, emission and combustion characteristics measurements were triplicated. Diesel engine was warmed up for ten minutes. After reaching the steady state operation, all the tests were carried out for three times to obtain the mean value of the measured parameters.

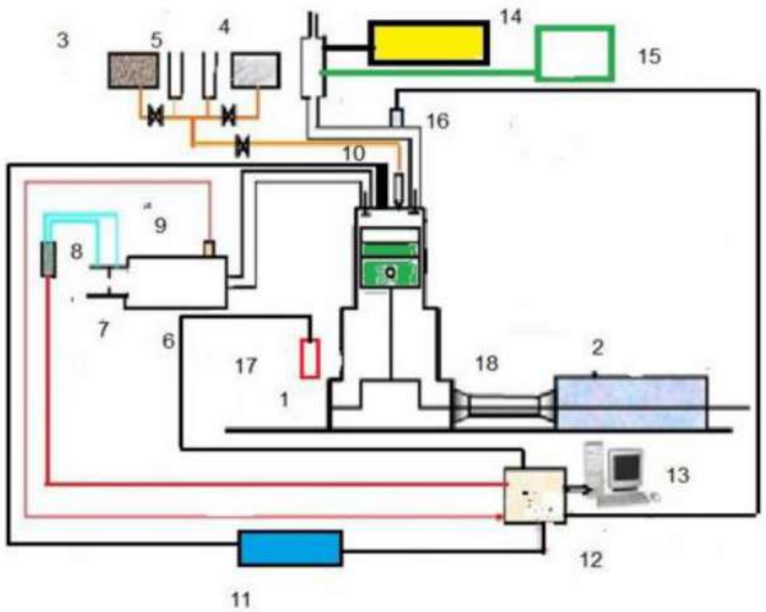

Figure 1 : Shows Schematic diagram of the experimental setup. (1) Diesel engine, (2) AC generator, (3) Diesel tank, (4) Biodiesel tank, (5) Burette, (6) Air surge tank, (7) Orifice, (8) Pressure differential meter, (9) Intake air temperature thermocouple, (10) Piezo pressure transducer, (11) Charge amplifier, (12) Data acquisition card, (13) Personal computer, (14) Exhaust gas analyzer, (15) Smoke meter, (16) Exhaust gas temperature, (17) Proximity switch, and (18) Cardan shaft.

Electrochemical sensors but CO and HC emissions were measured by infrared sensors. The engine load was varied from 0 to 100% at 1500 rpm rated speed. During each experiment, the performance, emission and combustion characteristics measurements were triplicated. Diesel engine was warmed up for ten minutes. After reaching the steady state operation, all the tests were carried out for three times to obtain the mean value of the measured parameters.

III. RESULTS AND DISCUSSIONS

Brake thermal efficiency BTE Figure 6 illustrates the effect on BTE by the nanoparticles blended with neat diesel at load variation. There are improvements in thermal efficiencies by adding nano-particles about the neat diesel operation at full load. Al_2O_3 additive minimizes the physical ignition delay, the fuel evaporation time, the enhancement in fuel properties and combustion about pure diesel. Presence of nano-particles caused the enhanced burning characteristics and fuel air mixing improvement. Very fine secondary fuel droplets were produced. These droplets were evaporated quickly. The secondary droplets formation in the combustion chamber improves the fuel-air mixing under the effect of nano additives addition. Nano-particles have the higher surface reactivity area that contributes for the better chemical reactivity. Basha and Anand14 and Aalam et al.21 noticed that nano-additives produced the higher brake thermal efficiency about diesel fuel and increased with the dosing level increase of Al_2O_3 nano-particles. Addition of nano-alumina led to the evaporation rate increase, ignition delay reduction and sufficient combustion in addition to the enhancement in the fuel calorific value. The increase of surface area to volume ratio was shown under the effect of nanoparticles. The maximum improvement in brake thermal efficiency was obtained as 5.5% at 40 ppm dosing level at full load. The percentage increase is between 3.5% and 4.5% at dosing levels of 20 and 30 ppm/L of fuel, respectively in comparison to the diesel fuel. Extra costs of nano-particles plus nano-fuel preparations per liter of fuel were 1, 1.5, and 2 dollars for Diesel + 20 NAO, Diesel + 30 NAO, and Diesel + 40 NAO, respectively. However, the enhancement of the thermal efficiency of diesel engines by 3.5%, 4.5%, and 5.5% for Diesel + 20 NAO, Diesel + 30 NAO, and Diesel + 40 NAO, respectively will pay back the additional fuel cost involved. These results are quite agreeable with that quoted by many other authors.

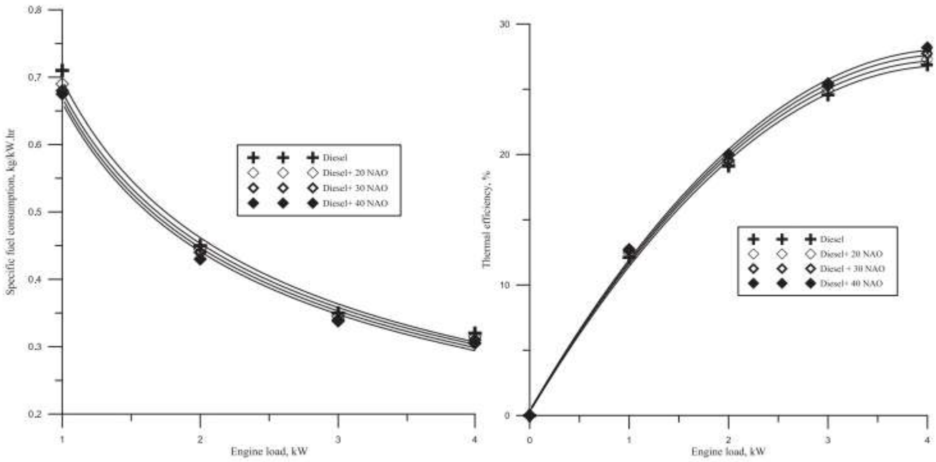

Figure 6: Shows Brake thermal efficiency and specific fuel consumption with engine brake power

cohesion force reduction between diesel fuel molecules. The decline in BSFC was ascribed to the favorable effect of nanoparticles on the fuel physical properties and the reduction of ignition delay. Venkatesan6 and Aalam et al.23 noted the enhancement in the combustion efficiency and thus less amount of fuel is necessary for the specific power output. Alumina nanoparticles oxidize the carbon deposits leading to the fuel consumption reduction owing to the catalytic effect, surface area to volume ratio enhancement, and the combustion characteristics improvement. Specific fuel consumption at full load decreases when compared to diesel fuel were found to be 3.5%, 4.5%, and 5.5% at dosing levels of 20, 30, and 40 ppm, respectively. This aspect has been studied well and reported by many researchers.

IV CONCLUSION

The influence of multi nano additives upon the performance and emissions of CI engine burning Jatropha biodiesel was shown in a comparative study.40 The experiments were done to show the impact of alumina nanoparticles as additives to diesel fuel. Alumina nanoparticle concentrations of 20, 30, and 40 ppm were experimented under standard laboratory conditions. The effect of nanoparticle presence in the pure diesel on the combustion characteristics, performance and emissions of a diesel engine were studied in detail. The following conclusions were reached from the present experimental analysis:

1) However, the enhancement of the thermal efficiency of diesel engines by 3.5%, 4.5%, and 5.5% for Diesel + 20 NAO, Diesel + 30 NAO, and Diesel + 40 NAO, respectively. Specific fuel consumption at full load decreases when compared to diesel fuel were found to be 3.5%, 4.5%, and 5.5% at dosing levels of 20, 30, and 40 ppm, respectively.

2) Increase in air-fuel ratios in comparison to diesel fuel was indicated for all doses of alumina nanoparticle additives in the diesel fuel. Catalytic effect of nanoparticle additives led to lower levels of exhaust gas temperature in comparison to neat diesel fuel.

3) Also, it is observed that nanoparticle addition in diesel helps in reducing harmful exhaust pollutants and improving of the engine performance and combustion characteristics. .Altogether it can be concluded that, fuel borne nano-metal catalyst usage will enhance the combustion characteristics and engine performance while harmful exhaust emissions get reduced. The small size of nanoparticles (size ;10 6 2 nm) shall lead to the improvement in the stability of fuel suspensions, prevent the fuel atomization and clogging problems in fuel injectors.

REFERENCES:

[1] Bhagavatula A, Huffman G, Shah N, et al. Source apportionment of carbon during gasification of coalbiomass blends using stable carbon isotope analysis. Fuel Process Technol J 2014; 128: 83–93.

[2] Galfetti L, Severini F, Colombo G, et al. Pre and post burning analysis of nano aluminized solid rocket propellants. Aerosp Sci Technol 2007; 11: 26–32.

[3] Ivanov GV and Tepper F. Activated aluminum as a stored energy source for propellents. Int J Energ Mater Chem Propuls 1997;

[4] Pivika A, Ulyanova P, Frolov Y, et al. Nanomaterials for heterogeneous combustion. Properllants Explos Pyrotech 2004; 29: 39–48.

[5] De Luca L, Severini F, Meda L, et al. Burning of nanoaluminized composite rocket propellants. Comb Plos Shock Waves 2005; 41: 680–692.

[6] Kotia A, Borkakoti S and Ghosh SK. Wear and performance analysis of a 4-stroke diesel engine employing nanolubricants. Particuol J 2018; 37: 54–63.

[7] Ali MK, Xianjun H, Mai L, et al. Improving the tribological characteristics of piston ring assembly in automotive engines using Al2O3 and TiO2 nanomaterials as nanolubricant additives. Tribol Int J 2016; 103: 540–554.

[8] Aalam CS, Saravanan CG and Kannan M. Experimental investigations on a CRDI system assisted diesel engine fuelled with aluminium oxide nanoparticles blended biodiesel. Alexandria Eng J 2015; 54: 351–358