EFFECT OF NANO FUEL ADDITIVES IN EMISSION REDUCTION OF BLENDED BIODIESEL

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Abstract - B20 has proven to be a practical fuel that can be used in any diesel engine with few precautions or changes. Most of the industry believes that blends up to 20% (B20) will cause no harm to performance. However the use of blends over 20%, can leave harmful impacts on equipment and fuel systems changing its cold flow properties, material compatibility, maintenance intervals, fuel stability, biological growth, energy content, emissions and overall handling. A successful attempt was done by adding nanoparticles (25 ppm and 50 ppm) in higher blended biodiesel (B30 and B40) using ultrasonicator for proper dispersion and for improving the stability of the blends. The results showed significant enhancement in some thermo-physical and combustion properties of the resulting suspension, where lower dosing level of NPs further improved the performance of the engine. The performance and emission is carried out in a single cylinder four stroke diesel engine for an each combinations in order to get the maximum performance and minimum emission levels. As a result of this study, engine emission values NOx and CO were decreased and engine performance values slightly increased after the successful addition of nanoparticle additives.

Keywords - Blended Biodiesel; Combustion Properties; Nanoparticle

I. INTRODUCTION

Now a days renewable sources such as coal, natural gas andpetroleumproducts are going to be exhausted because of high demand and less availability. Due to this crises fuel prices are hiking up day by day.Hence it is necessity to discover a cost effective fuel to fulfill our needs. Biodiesel is a better option and has proved to be an efficient cost effective alternative[1,2]. Biodiesel is a clean burning fuel made from domestic, renewable sources which can be a good alternative for diesel. It can be used in a pure form (B100) or can be blended with diesel in the form of B30 and B40[3].It can be used in engines, causing less green-house gas emissions[4]. However in biodiesel due to lower calorific value, more fuel consumption is a major issue which can be important the application of nanotechnology. One of the recently popularity gaining methods to vary the physicochemical properties and combustion characteristics of a hydrocarbon fuel is the use of additives, which are found to be especially effective in nanoparticle form, due to the enhancement of the surface area to volume ratio[5]. Nanoparticles can be synthesized using various methods like physico-chemical and biological. Thenaturally synthesized nanoparticles are cost effective andenvironmental friendly compared to chemically synthesized nanoparticles. Recent studies have proved that the blendingof nanoparticles can improve the performance and the combustion of biodiesel while producing fewer emissionsdue to high surface to volume ratio of nanoparticles. Highsurface to volume ratio gives them more reactive surfacesallowing them to act as more efficient catalyst thusincreasing fuel combustion. analysis of exhaust gas properties and engine performance of diesel engineusing different nanoparticles[6,7].The aim of this study is to investigate effects of nanoparticleadditives at different dosing levels (25 and50 ppm) to the biodiesel fuel(B30 and B40) for improvement of the performanceand reduced exhaust emissions in a Compression IgnitionEngine.

II. MATERIALS AND METHODS

The fuel used for the current investigation is a biodiesel product (mahua methyl ester), derived from mahua oil. The fuel additive used in this investigation is oxygen containing nanoparticles given in the Table 1, in the form of commercially available nanoparticle size of 10 to 30 nm. The dosing level of the nanoparticle samples (by weight) in the base fuel was 25 and 50 ppm. The required quantity of the nanoparticle samplerequired for each dosing level was measured using a precisionelectronic balance and mixed with the fuel by means of an ultrasonicprocessor, applying a constant agitation time of one hourto produce a uniform suspension. The modified fuel was utilizedimmediately after preparation, in order to prevent any precipitateor for sedimentation to occur.Sonic Vibra-Cell VC 750 model ultrasonic processor was usedto stir nanoparticles with biodiesel fuel homogeneously in orderto obtain modified fuels. Fuel properties as density, viscosity,flash point, and pour point of the test fuels were determinedaccording to standard test methods. Engine performance tests were conducted on a commercialfour cylinder, four-stroke, naturally aspirated, water-cooled direct injection compressionignition engine[8]. Emission data were collected with the help of a computer program.

III. RESULTS AND DISCUSSION

Fuel Properties - Density, viscosity, flash point, pour point characteristic was testedaccording to

standards.Addition of different dosage of SiO2 nanoparticleshas no noticeable effect on density value of B30 and B40 fuel. Viscosity of fuel was increased with the additionof SiO2 nanoparticles at the dosage of 25 and50 ppm. Viscosity has an effect on fuel atomization, the fuel with lowerviscosity tends to form smaller droplets on injection, whichcan lead better combustion and decreased exhaust emissions[9].Viscosity results of modified fuels are in the acceptable rangeof European biodiesel standard EN 14214.

The temperature at which crystal formation is extensiveenough to prevent free pouring of fluid is determined by measurementof its pour point (PP). If pour point of a fuel is not lowenough, some concerns with storing, transferring can occur. Pourpoint of the RME fuel was slightly increased with the addition of 50 ppmSiO2 nanoparticles. This indicates that the addition of SiO2nanoparticles has a little effect on the cold temperatureproperties of the fuel[10].

Exhaust Emissions

Carbon monoxide (CO) emission of the diesel fuel, which isa colorless lethal gas formed due to incomplete combustionof fuel air-mixture in the combustion chamber was found todecrease with the inclusion of the nanoparticle additives. Table 2 demonstrates the carbon monoxide (CO) emissions versus enginespeed with the variation of additive dosage. SiO2 nanoparticles with addition dosage of 25 and 50 ppm decreasedthe CO emissions of the fuel[11]. The average CO emissionreduction is 38.3% and 33.3% for the modified fuels at thenanoparticle addition dosage of 25 and 50 ppm SiO2 nanoparticles in B30 whereas 0.12 % and 0.06%at thenanoparticle addition dosage of 25 and 50 ppm SiO2 nanoparticles in B40. The variations of measured nitrogen oxides (NOx) emissionsvalues of biodiesel and modified biodiesel with different dosinglevels of the additive with engine speed are reported in theTable 2. SiO2 nanoparticles addition dosage of 25 and 50 ppm decreased the NOx emissions of fuel. The maximum nitrogen oxides emission reduction to diesel result is 63% for the modified B30 fuels atthe nanoparticle addition dosage of 25 ppm SiO2[12]. The hydro carbon load variation with diesel and biodieselalong with their blends confirms that the additionof silica nanoparticles to the biodiesel blend reduces thehydro carbon emission than compared with diesel. Heresilver nanoparticles act as oxidation catalyst which help inthe complete and clear combustion. The HC emission for25ppm and 50 ppmdose of nanoparticle in the biodiesel blend B30 was17 ppm and 28 ppmrespectively.Reduction in HC emissions may be due to redox nature of nanoparticles which cause oxidation of hydrocarbons. The oxide nanoparticle also lowers the soot oxidation temperature and thus enhances hydrocarbon oxidation, promoting complete combustion[13].

CONCLUSIONS

Overall it is clear from the results that silvernanoparticles (AgNPs) can be efficiently used for improvingthe properties of biodiesel. It also enhances the performanceof the engine and reduces emissions to certain extent, furtherinvestigations are required in trying to reduce CO emissionby using modified injection strategies with multiple injectionevents [14].As a result of the study, SiO2nanoparticles at the addition dosage of 25 ppm can be used asadditives with a low extra cost for the biodiesel to decrease theexhaust emissions of diesel engines.

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Table 1- Specification of SiO2 nanoparticle used

Appearance	Fluffy white powder
BET-Surface Area (m^2/g)	190 + 20
Average primary particle size (nm)	12
Tapped density (g/l)	40
SiO_2 (wt%)	≥ 99.8
Al_2O_3 (wt%)	≤ 0.05
Fe_2O_3 (wt%)	≤ 0.01
TiO_2 (wt%)	≤ 0.03
HCl (wt%)	≤ 0.025
Wettability	Partially hydrophilic

Table 2: Blending of mahua methyl ester and diesel and their physical and chemical properties

Properties	Mahua oil	Mahua biodiesel	B30%	B30%-25 ppm SiO2	B30%-50 ppm Sio2	B40%	B40%-25 ppm SiO2	B40%-50 ppm SiO2	Diesel
Density(g/cm^3) 20^{0}C	2.32	1.2	0.76	0.795	0.796	0.8	0.895	0.896	0.82
40^{0}C	2.12	0.98	0.64	0.676	0.68	0.71	0.743	0.765	0.80
80^{0}C	2.07	0.88	0.62	0.632	0.65	0.65	0.705	0.71	0.79
Viscosity (mm^2/s) 20^{0}C	18.25	4.6	3.4	3.5	3.5	3.6	3.7	3.8	2.8
40^{0}C	15.14	3.9	3.1	3.3	3.4	3.2	3.2	3.3	2.4
80^{0}C	9.47	3.4	2.9	3.1	3.1	3.0	3.1	3.1	2
Acid value (mg/KOHg)	10	2.1	0.98	0.73	0.63	1.0	0.85	0.71	0.35
Iodine value (g/100g)	55	90	89.3	95.4	90.6	86.3	91.6	89.8	125
Cloud point (^{0}C)	16	10	9	2	4	10	3	3	-10
Pour point (^{0}C)	11	5	4	-1	2	5	-2	1	-15
Refractive Index	1.329	1.328	1.375	1.378	1.38	1.374	1.383	1.384	1.32
CO (%vol)	0.050	0.045	0.047	0.037	0.040	0.051	0.053	0.056	0.060
NO (ppm)	278	172	191	103	145	201	172	178	280
HC (ppm)	40	31	33	17	28	37	36	38	45

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