Influence of MWCNT Addition on the Performance and Emission Characteristics of A Diesel Engine Operated on Honege Oil Methyl Ester

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Abstract **-- Use of renewable and sustainable fuels for engine applications provides energy security and addresses environmental and socio-economic issues. Experimental investigations have been conducted on the diesel engine and investigated the performance and emission characteristics operated on multi walled carbon nanotubes (MWCNTs) blended Honge oil methyl ester (HOME) fuels. Results from diesel operation are considered as base line data. The MCNTs were appropriately mixed with HOME fuel in the mass fractions of 30 and 50 ppm. The blend is mixed properly using mechanical homogenizer and an ultrasonicator. Experimental investigations were conducted on single-cylinder diesel engine coupled with an eddy current dynamometer throughout experimental investigations engine speed was kept constant at 1500 rpm and the results showed improvement in the brake thermal efficiency with reduced harmful emission levels due to the presence of MWCNTs in the HOME.**

Keywords-- Performance, combustion, emissions, biodiesel, Hydrogen-producer gas fueled engine.

I. INTRODUCTION

Diesel engines are used for power generation applications due to its higher compression ratio, brake thermal efficiency, lower fuel consumption, and lesser hydrocarbon (HC) and carbon monoxide (CO) emissions and durable. In this context compression ignition (CI) engines can be used for transportation and power generation applications. In the present energy scenario, fossil fuels are diminishing, and demand for fuel for energy applications is increasing. In addition increased price of fuels, and strict environmental legislations, fuels derived from renewable and sustainable sources for diesel engine applications is required. However the main drawback of CI engine is that, its exhaust containing larger smoke and nitric oxide emissions. These emissions are reduced by the use of nano-particles in the blended form. Several research works have been conducted by many researchers to adopt a proper alternative fuel in place of fossil petroleum products. To avoid the dependence on fossil fuels, biodiesel from different origin are gaining prime importance. In this direction investigators studied biodiesel-nano-particles blended fuels. But use of nano-particles for transport and power generation can be used..

Investigators studied various fuel modification techniques in which some chemical reagents were added along with the conventional diesel and biodiesel fuel. Some of the changes done for the fuel modification is the water–diesel emulsion, which consists of diesel, water, and surfactant in appropriate proportions. Presence of water in the emulsion is suspended in the required fuel with a appropriate surfactant. This does not allow the water to mix or come into contact with the engine components [1]. Several investigators have reported on use of nano–particles for CI engine applications. In this context, several noval approaches and improvements in nano-technology are directed to utilize nano blended fuels for engine applications [2]. Nano particle blended fuels have different thermo physical properties compared to fossil fuels. At nano meters scale the surface – area -to-volume ratio of the particle enhances and this results into a greater surface area contact during oxidation process [3]. Biodiesels from different origin is not used as fuel directly in engines because of higher smoke, HC and CO emissions and durability problems. Hence biodiesel can be mixed with nano-particles and it can lead to better performance with lower emissions.

For instance, they can release energy more than twice the energy of even the best molecular explosives due to better thermodynamic properties [4]. Investigators have presented lesser melting point and lower heats of fusion for decreasing sizes of metal particles [5, 6, 7]. Nano-particles have high specific surface area and have greater potential to store energy [Yetter *et al*. 8]. This feature may results into high reactivity. Addistion of nano-particle in the fuels may lead to better combustion and lower the ignition delay, combustion duration and smoke emissions. In view of this effect of nano-particles (MWCNT) addition to biodiesel on the performance and emission characteristics have been studied using single cylinder, four stroke water cooled direct injection (DI) compression ignition (CI) engine operated on single and nano-particle-HOME blended fuels. This provides liberty in controlling nano-particle proportion in the HOME. Finally the results obtained were compared with diesel operation.

Several researchers have investigated the performance, combustion and emission characteristics of diesel and biodiesel blends in CI engines. Presence of nano-particles in the fuel increases surface-area-to-volume ratio and settling time [2]. Addition of MWCNT nano-particles in HOME increases the thermal efficiency and lowers the smoke compared to diesel operation [9]. Further the study reported that the MWCNT lower the evaporation time of high viscous fuels and decreases the delay period. Nano-particle can act as a catalyst and energy carrier. Also fuel properties can significantly improved when nano-particles are added in the liquid fuel. Researchers also used ceria nano-particle in the Jatropha biodiesel and used as a fuel in a CI engine. Researchers were reported that the presence of ceria nano-particles in the Jatropha considerably improve the thermal efficiency, lowers the hydrocarbon (HC) and nitric oxide (NOx) emission levels [10]. Significant improvement in the thermal efficency for the CNT blended biodiesel fuels compared to the biodiesel and diesel fuel has been reported [10, 11]. Similar experiments were conducted by Kao *et al*. [8] using aluminium nano-particles in the diesel. They observed significant enhancement in the thermal efficiency with reduction in the emission levels [Madhan et al (10)].

II. FUEL PROPERTIES

In this present work, Honge oil methyl ester (HOME) is used as injected fuel and roperties of fuels used are measured at laboratory and are shown in Table 1. In the first step of blends preparation, CNT weight is measured to a mass fraction of 30 ppm and mixed in a HOME using ultrasonicator at a frequency of 40 kHz, 120W for 30-50 min.

Table1 Properties of fuels used

Sl No	Properties	Diesel	Honge oil	HsOME	HOME30 MWCNT	HOME50 MWCNT
1	Kinematic Viscosity @ 40 ^{0}C, cSt	3.6	40.8	4.6	5.4	5.6
2	Flash point, ^{0}C	56	34	163	168	165
3	Calorific Value, kJ / kg	44500	36580	39550	35225	36560
4	Specific gravity	0.840	0.915	0.860	0.885	0.890
5	Density, kg / m^3	840	915	860	885	890

III. EXPERIMENTAL SET UP:

The experimental investigations have been conducted on a single cylinder four stroke diesel engine. Figure 1 shows the schematic experimental set up used for trial tests. The specification of the compression ignition (CI) engine was given in Table 1. Eddy current dynamometer was used for loading the engine. The fuel flow rate was measured on volumetric basis using a burette and stopwatch. The exhaust emissions were measured by using HARTRIDGE smoke meter and five gas analyzer and all the data are recorded when the engine was attained steady state operation. The trial runs on the CI engine were carried out using HOME – nano particle blends and compared with diesel operation. Injection timing was kept as 23^0 bTDC for diesel and 19^0 bTDC for HOME-MWCNT blends and 230 bar for diesel and 19 ° BTDC. Injection pressure used is 205 bar for diesel and 230 bar for HOME- MWCNT blend.

IV PERFORMANCE CHARACTERISTICS

Influence of MWCNT on the brake thermal efficiency for HOME and HOME-MWCNTs blended fuels is presented in Figure 2. Diesel operation provides greater thermal efficiency than HOME and blended fuels. This could be due to its higher viscosity, lower volatility and inferior energy content of biodiesel fuels. It is observed that brake thermal efficiency of the HOME-MWCNT blended fuels showed enhanced thermal efficiency compared to HOME biodiesel operation. This may be due to presence of nano-particles in the HOME, which in turn leads to improved combustion characteristics. MWCNT has nanosize particles and have greater surface area and reactive surfaces which enhances the chemical reactivity. Moreover, in case of HOME-MWCNT with 50 ppm, the catalytic activity was increased due to more addition of MWCNT compared to that of HOME-MWCNT with 25 ppm. More addition of MWCNT (50 ppm) may lead to increased brake thermal efficiency compared to that of HOME-MWCNT-25ppm.

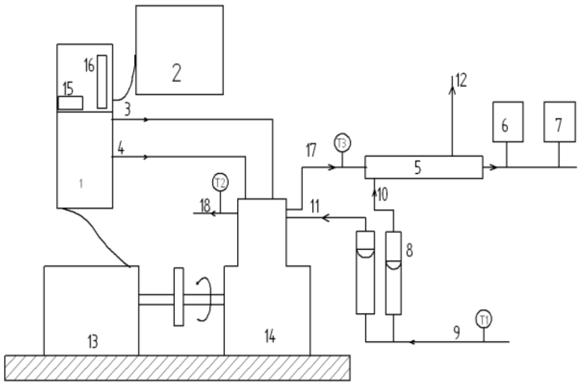

Figure 1.0 C I Schematic experimental set up.

1 - Control Panel, 2 - Computer system, 3 - Diesel flow line, 4 - Air flow line, 5 - Calorimeter, 6 - Exhaust gas analyzer, 7 - Smoke meter, 8 - Rota meter, 9, 11 - Inlet water temperature, 10 - Calorimeter inlet water temperature, 2 - Calorimeter outlet water temperature, 13 - Dynamometer, 14 - CI Engine, 15 - Speed measurement, 16 - Burette for fuel measurement, 17 - Exhaust gas outlet, 18 - Outlet water temperature, T1- Inlet water temperature, T2 - Outlet water temperature, T3 - Exhaust gas temperature

Table 3 Specifications of the engine and downdraft gasifier

Sl No	Compression ignition engine	
1	Engine Type	Single cylinder 4- stroke DI diesel engine
2	Nozzle opening pressure	205 bar
3	Rated power	3.7 KW at1500 RPM
4	Cylinder Bore and Stroke length	87.5 mm, 110 mm
5	Compression ratio	17.5 : 1

Variation of smoke opacity at 80% load for diesel, HOME and HOME-MWCNT blends id shown in the Figure 3. Diesel operation always resulted in lower smoke levels compared to HOME and HOME-MWCNT blends. This could be due to its presence of heavier fatty acids and molecular structure of biodiesel and this feature decreases the volatility of HOME. But addition MWCNT in HOME lowers the smoke emissions due to improved volatility of HOME and shorter ignition delay blended fuels. The smoke opacity for HOME-MWCNT-50 operation resulted in lesser smoke levels compared to the operation with 25 ppm MWCNT operation.

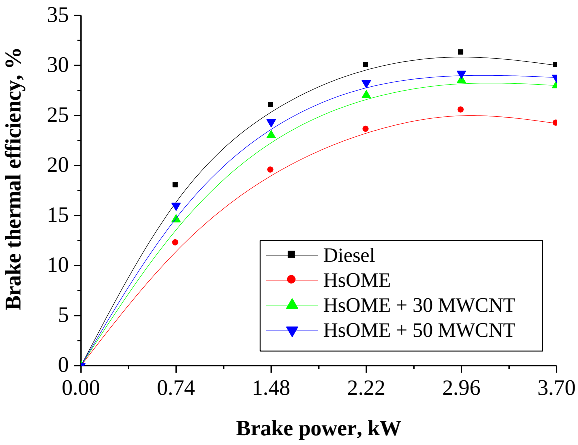

Fig. 2 Effect of HOME-nano-particle blend on the BTE

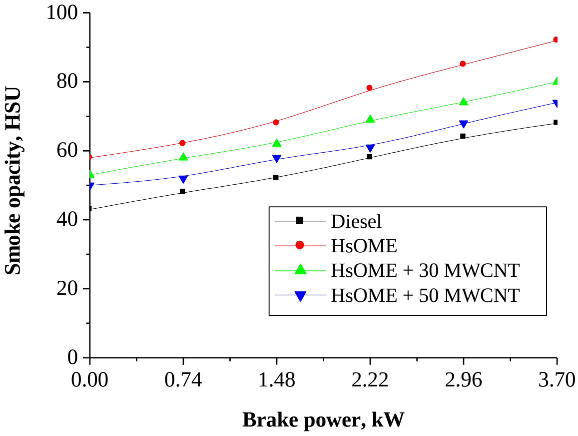

Fig. 3 Effect of HOME-nano-particle blend on the smoke Opacity

Effect of nano-particles on the unburnt HC and CO emissions for various fuel combinations are shown in Figure 4 and 5. HC and CO emission levels for HOME operation is found to be greater compared to diesel operation due to incomplete combustion of HOME. However HC and CO emissions for HOME-MWCNTs are marginally lower compared to HOME. This may be due to better catalytic activity and improved burning characteristics of nano-particles. Also, CO emission levels are found to be lesser for the HOME-MWCNTs blended fuels compared to HOME. Improved combustion characteristics caused by the catalytic reactivity of MWCNT, and it leads to enhanced combustion.

Effect of nano-particles on the NOx emission levels at 80% load is shown in Figure 6. HOME-MWCNT operation provides slightly greater NOx levels compared to HOME operation. It is due to increased initial combustion stages which lead to enhanced heat release during premixed combustion phase. This is the reason why BTE was greater for HOME-MWCNT operation. But HOME and its blends operation always resulted in reduced NOx levels compared diesel operation. That could be caused by the fact that presence of free fatty acids in the HOME biodiesel and lower calorific value of HOME.

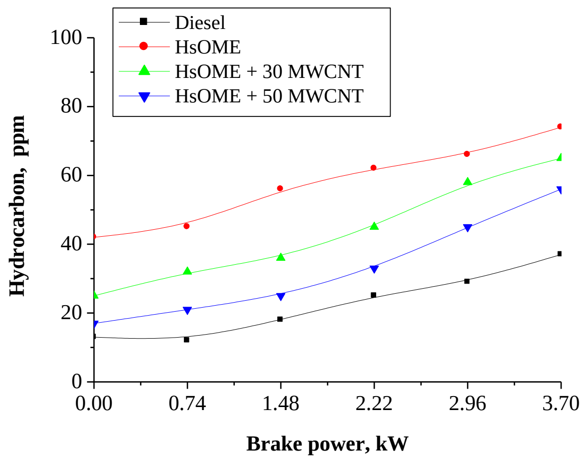

Fig. 4 Effect of HOME-nano-particle blend on the HC emission

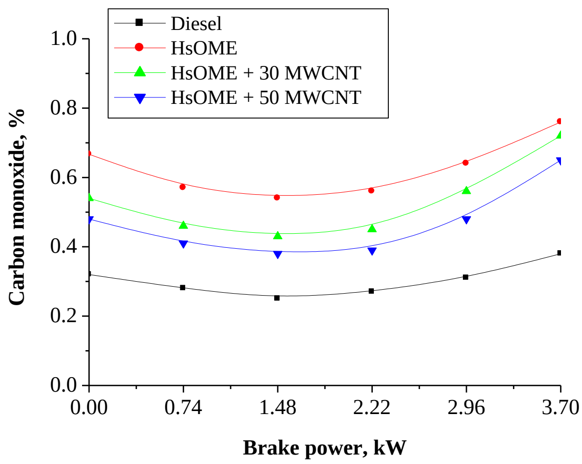

Fig. 5 Effect of HOME-nano-particle blend on the CO emission

V CONCLUSIONS

The HOME operation shows better combustion with MWCNT addition. This addition is successful in achieving the goals of the conversion process and a reduction of emissions. The following specific conclusions are drawn:

- From the experimental investigations, for HOME-MWCNT operation, it is observed that HOME-MWCNT operation with 30 and 50 ppm resulted in improved performance compared to the neat HOME operation. MWCNT addition to HOME resulted in 18.5% increased BTE compared to the operation without MWCNT addition. The increase in MWCNT addition beyond the limit leads to increased wearing of engine components due to increase in friction between piston and cylinder.

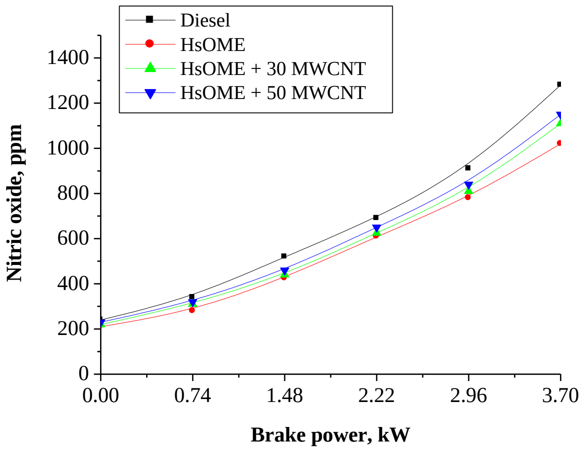

Fig. 6 Effect of HOME-nano-particle blend on the NOx emission

REFERENCES

[1]. Ghojel, J., Honnery, D., and Al-Khaleefi, K. Performance, emissions and heat release characteristics of direct injection diesel engine operating on diesel oil emulsion. Application. Thermal Engineering, 2006, 26, 2132– 2141.

[2]. Marquis, E. D. S. and Chibante, L.P.F. Improving the heat transfer of nanafluids and lubricants with carbon nanotubes. J.Miner, Metals Mater, Society, 2005 57, 32,43.

[3]. Wen. D, Nano fuel as potential secondary energy carrier, Energy environment Science, 2010, 3: pp 591 – 600.

[4]. Rossi C, Zhang K, Estève D, Alphonse P, Tailhades P, Vahlas C: Nanoenergetic materials for MEMS: a review. J Micromech System 2007, 16:919-931.

[5]. Sun J, Simon SL: The melting behavior of aluminum nanoparticles. Thermochimica Acta 2007, 463:32-40.

[6]. Lai SL, Guo JY, Petrova V, Ramanath G, Allen LH: Size-dependent melting properties of small tin particles: nanocalorimetric measurements. Phys Rev Lett 1996, 77:99-102.

[7]. Lai SL, Carlsson JRA, Allen LH: Melting point depression of Al clusters generated during the early stages of film growth: nanocalorimetry measurements. Application Phys Lett 1998, 72:1098].

[8]. Kao, M.-J., Ting, C.-C., Lin, B.-F., and Tsung, T.-T. Aqueous aluminium nano-fluid combustion in diesel fuel. J. Test. Evaluations, 2008, 36, PA 19428-2959.

[9]. Sadhik Basha, J. and Anand, R. B. Performance and emission characteristics of a DI compression ignition engine using carbon nanotubes blended diesel. In proceedings of the International Conference on advances in mechanical engineering, Surat, India, 3-5 August 2009, pp. 312-316.

[10]. Yetter R. A., Risha G. A., Son S. F., Metal particle combustion and nanotechnology, Proc Comb inst., 2009, 32: pp 1819 – 1838.

[11]. N. Madhan Raj , M. Gajendiran , K. Pitchandi, N. Nallusamy. Investigation on aluminium oxide nano particles blended diesel fuel combustion, performance and emission characteristics of a diesel engine Journal of Chemical and Pharmaceutical Research, 2016, 8(3):246-257.

[12]. M. Ghafoori, Barat Ghobadian, Gholamhassan Najafi Mohammad Layeghi , Alimorad Rashidi Najafi , Rizalman Mamat. Effect of nano-particles on the performance and emission of a diesel engine using biodiesel-diesel blend. International Journal of Automotive and Mechanical Engineering 12(1), 2015, PP 3097-3108, DOI: 10.15282/ijame.12.2015.23.0258

[13]. Sunilkumar T., G Manavendra, N. R. Banapurmath, Guruchethan A.M., Performance and Emission Characteristics of Graphene Nano ParticleBiodiesel Blends Fuelled Diesel Engine International Research Journal of Engineering and Technology (IRJET). e-ISSN: 2395-0056 Volume: 04, Issue: 10, 2017. PP 552-558