EXPERIMENTAL EVALUATION OF METAL OXIDE NANO PARTICLES INFLUENCE ON A DIESEL ENGINE USING DIESEL-METHANOL BLENDS

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Abstract:

With the increases in demand for the fossil fuels that are, depleting day by day the need of alternative fuels also increased accordingly. Alcohol fuels are one of the best examples as an alternative to be used for instead of fossil fuels. Researchhas been carried out on the performance of alcohol blends in the diesel engine where it satisfies both performance and emission characteristics of C.I engine that makes feasible to use alcohol fuel as an alternative fuel. In this research the methanol fuel is used as an alternative fuel for the direct injection diesel engine. The performance characteristics of the engine using different blends for the diesel-methanol are analyzed.

The performance of the engine can also be improved with the addition of zinc oxide nanoparticles to the blended fuel. In this research this nanoparticle will improves the oxygen percentage in the combustion that will increase the burning ability of the fuel, which will increases the thermal efficiency. The performance and emission characteristics of the metal-oxide nanoparticles and methanol blends (B0, B5, B10) in the diesel engine at constant speed of 1500rpm by varying the loads. The performance was improved and emissions HC, CO, NOx are very less at B10 with nanoparticles when compared with other blends.

***Key*words- Methanol, Zinc-Oxide nanoparticles, diesel engine, Performance and Emission characteristics, Magnetic stirrer.**

I. INTRODUCTION:

Over for a long period of time diesel engine played a key role in transportation and many other areas due to their high performance, combustion characteristics. The diesel engine has significant part in man's life and it plays a major role in countries economy.Although diesel engine runs at a lean mixture the availability of oxygen is insufficient in the local region at the time of combustion this will leads to incomplete combustion. The fuel in local region will not completely oxides due this engine experiences loss of energy and formation of emission. There are many researches conducted to control the emissions and to enhance the combustion efficiency. This development are done some areas like characterization of the spray, increase air motion inside the cylinder, adding oxygenated additives to the fuel, Low heat rejection engine, varying mean diameter of spray nozzle, fuel ionization technique with the magnets, by using Nanoparticles. The techniques like characterization of spray, increase air motion inside the cylinder, Low heat rejection engine, varying mean diameter of spray nozzle are needed some changes inside the cylinder an difficult processes, costly and design should be changed according to the size and type of the cylinder. The technique like adding oxygenated additives to the fuel, adding different Bio fuel blends to the fuel should be carefully done because the blended fuel should match the standards other wise combustion of this fuel will damage the engine cylinder. But in the Nanoparticles technique the design of the engine cylinder need not to be changed. It is a process of adding Nanoparticles to the fuel. Which is very effective in working when compared to the other blending processes.

Sajin et.al 2019[1] conducted experiment on single-cylinder, 4 stroke direct-injection diesel engine at full load condition and studied the effect of ZnOnano particles in mango seed biodiesel blends. ZnO nanoparticles of size 20 nm and 40 nm were considered for the test samples and are phrased as M100, M100ZnO20,and M100ZnO40. It is reported that addition of ZnO particles improved performance characteristics and reduced Smoke, CO,HC and NOx emissions. Increased size of nanoparticles(40) reduced emissions. Megavath et.al 2018 [2] performed experiment on electronically controlled system of 3.5 kW single-cylinder vertical four-stroke diesel engine. Cerium oxide nanoparticles were considered as additives and are blended with B20 in various ratios .It is reported that brake thermal efficiency increased due to high heat release rate and high peak cylinder pressures . Due to overall combustion improvement, CO and HC emissions got reduced. It is also reported that as the quantity of nano particles increases , exhaust emissions decreases and excessive addition of the nanoparticles results in limit and unstable operation of engine. Mohamed Nour et.al 2018[3] considered Al2O3 Nanoparticles in diesterol blend (70% diesel+ 20% ethanol+ 10% Jojoba biodiesel) and performed experiment on single cylinder direct injection diesel engine. Nanoparticles were mixed in different volumetric proportions and tested for combustion and exhaust emission characteristics. It is reported that

Al2o3 nanoparticles helped in reduced the ignition delay period and improved start of combustion Lower heat release rate and brake specific fuel consumption came down by 20%. It is noticed that exhaust emissions NOx, CO,UHC reduced by 50%, 30%, 60%. Respectively.Selvaganapathy et al. 2013 [4] considered Zn_o nanoparticles mixing them with diesel fuel in the fraction of 250ppm–500ppm. Experiment is performed on single cylinder 4-stroke diesel engine at 1500 rpm. It is observed that there is an increase in thermal efficiency around 36.8% and 37.35% as compared to 35.825% brake thermal efficiency of diesel fuel at full load condition.Total heat release rate for the fuel blend is greater and ignition delay is short compared to neat diesel.Sajith et al., 2010[5] the added cerium oxide nano-particles to biodiesel fuels and reported an appreciable increase in the flash point and fire point, thermal efficiency and decrease in hydrocarbon and nitrous oxide emissions.Fangsuwannrak and Triratanasirichai1 [6] considered Titanium oxide nanoparticles in palm biodiesel and performed experiment on indirect injection diesel engine. It was reported that for all volume fraction of biodiesel blended with 0.1% of TiO2 nanoparticles higher brake power was recorded .Kannan et al.[7] considered FeClnano-particles and performed experiment adding them to biodiesel obtained from waste cooking oil. He reported that addition of nanoparticles increases that rate of reaction thereby promoting better heat/mass transport properties , improves combustion efficiency which leads to better brake thermal efficiency.

II. EXPERIMENTAL SETUP AND PROCEDURE

The setup consists of single cylinder, four stroke, Diesel engine connected to eddy current type dynamometer for loading, an alternator, top load system, fuel tank along with immersion heater and manometer.. It is provided with necessary instruments for combustion pressure and crank-angle measurements. These signals are interfaced to computer through engine indicator for Pθ−PV diagrams. Provision is also made for interfacing airflow, fuel flow, temperatures and load measurement. The setup has stand-alone panel box consisting of air box, fuel tank, manometer, fuel measuring unit, transmitters for air and fuel flow measurements, process indicator and engine indicator. Rota meters are provided for cooling water and calorimeter water flow measurement. The setup enables study of engine performance for brake power, indicated power, frictional power, BMEP, IMEP, brake thermal efficiency, indicated thermal efficiency, Mechanical efficiency, volumetric efficiency, specific fuel consumption, A/F ratio and heat balance. Lab view based Engine Performance Analysis software package “Engine soft” is provided for on line performance evaluation. A computerized Diesel injection pressure measurement is optionally provided. Engine Soft is Lab view based software package developed by Apex Innovations Pvt. Ltd. for engine performance monitoring system. Engine Soft can serve most of the engine testing application needs including monitoring, reporting, data entry, data logging. The software evaluates power, efficiencies, fuel consumption and heat release. It is configurable as per engine set up. Various graphs are obtained at different operating condition.

Fig.1 4-Stroke Diesel Engine with eddy dynamo meter

Product	Engine test setup 1 cylinder, 4 stroke, Diesel (Computerized)
Product code	224
Engine	Make Kirloskar, Model TV1, Type 1 cylinder, 4 stroke Diesel, water cooled, power 5.2 kW at 1500 rpm, stroke 110 mm, bore 87.5 mm. 661 cc, CR 17.5

III. BLEND PREPARATION

- During the course of present study, two blends of methanol and diesel were prepared which include 5% methanol blended with 95% diesel (v/v %), called as B5 and 10% methanol blended with 90% diesel (v/v %) which was termed as B10 .The nomenclature of neat diesel was D100.
- A magnetic stirrer is to be used to prepare a single phase methanol diesel blend for engine application. The magnetic stirrer will sitter the blend at 400-500 rpm for 1 hour for the both blends.
- The 10ppm Zinc-oxide nanoparticles were added after the methanol blend preparation

Fig.2 Magnetic Stirrer

IV. RESULTS AND DISCUSSIONS

The performance of engine is evaluated based on the brake thermal efficiency and brake specific fuel consumption. The emission characteristics of the engine are studied in terms of concentration of HC, CO, CO2 and NOx. The results obtained for the three blends of methanol and methanol Nanoparticles are compared with the baseline of the diesel.

Brake thermal efficiency: Brake thermal efficiency is the percentage ratio of the output and the input. In this testing, the output is set to a certain load and the input can be calculated based on the amount of fuel used and time taken.

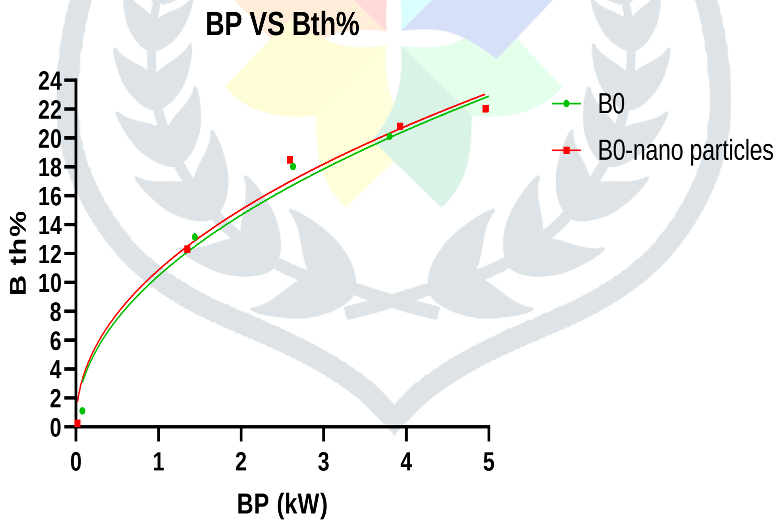

Fig.3 BP vs Bth% for Diesel and Diesel Nanoparticles

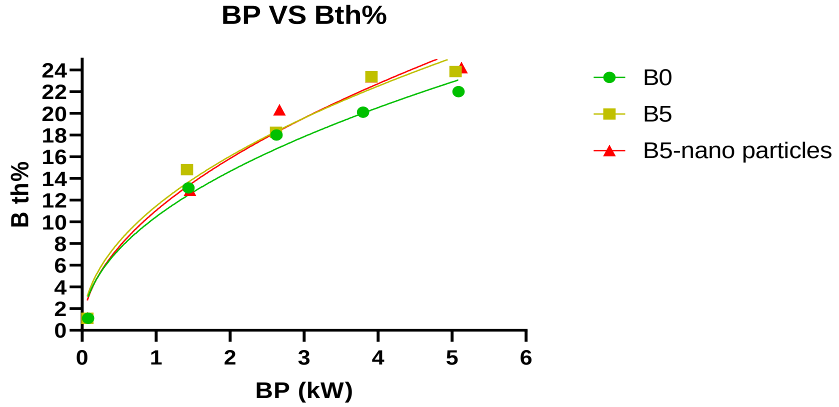

Fig 4 BP vs Bth% for Diesel, B5 and B5 Nanoparticles

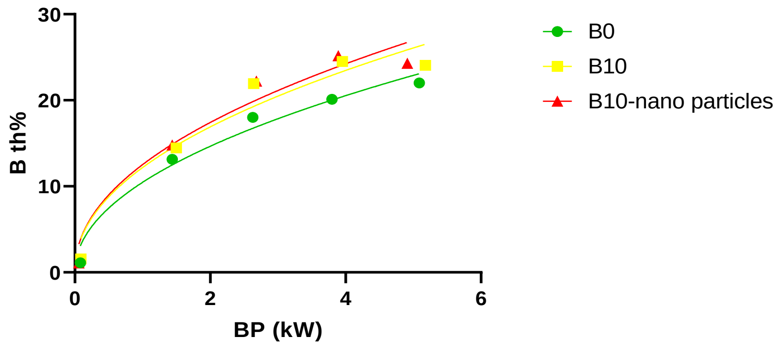

Fig.5 BP vs Bth% for Diesel, B10 and B10 Nanoparticles

The above figures 1, .2 and .3 represents compression between brake power and brake thermal efficiency of Diesel, B5, B10 respectively along with 10ppm Nanoparticles separately. From the above figures it was absorbed that the highest break thermal efficiency was obtained in B10 with 10 ppm Nanoparticles which increases by 2.29% when compared to Diesel. These Nanoparticles works effectively at hot load conditions with respective Diesel, B5 and B10 blends.

It is observed that the brake thermal efficiency was increasing with increasing methanol blend percentage (up to 10%). As methanol contains more oxygen by mass (50%) than pure diesel it results in better combustion and increases the efficiency. The oxygen content of methanol blended fuels enhances the combustion efficiency and decreases the heat losses in the cylinder due to lower flame temperature. In addition to that, the vaporization of the fuel continues in the compression stroke as the latent heat of vaporization is more with methanol blended fuel. As the fuel absorbs heat from the cylinder during the vaporization, the work required for compressing the air–fuel mixture decreases and this situation increases the thermal efficiency.

BRAKE POWER VS SPECIFIC FUEL CONSUMPTION

Brake specific fuel consumption (BSFC) is defined as the fuel consumption rate to produce unit brake power.

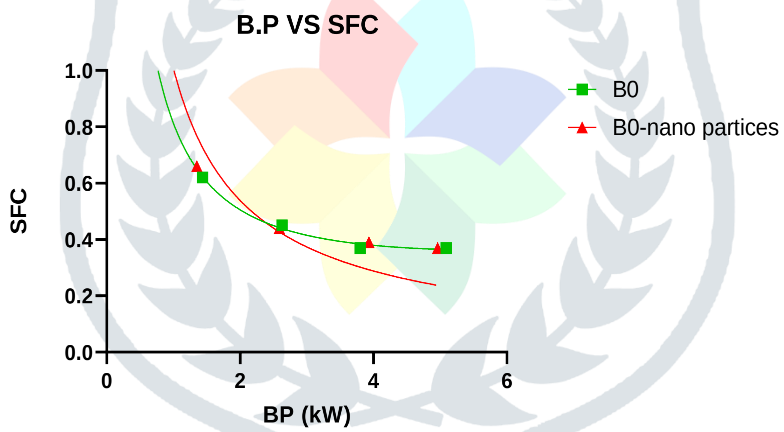

Fig.6 BP vs SFC for Diesel and Diesel Nanoparticles

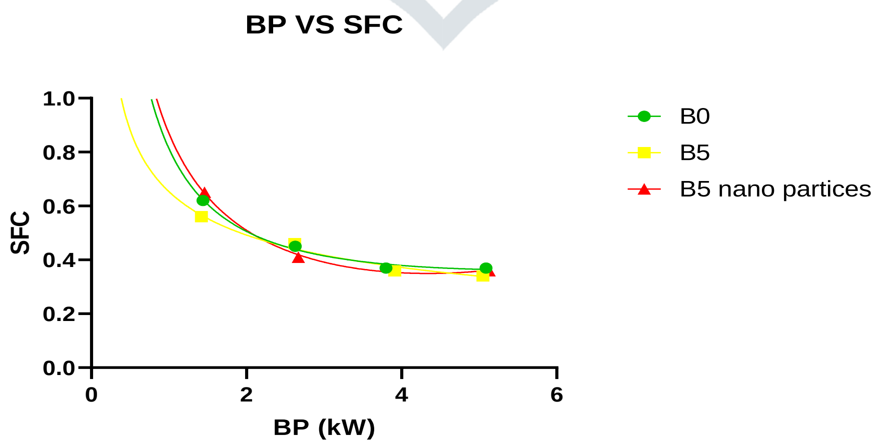

Fig.7 BP vs SFC for Diesel, B5 and B5 Nanoparticles

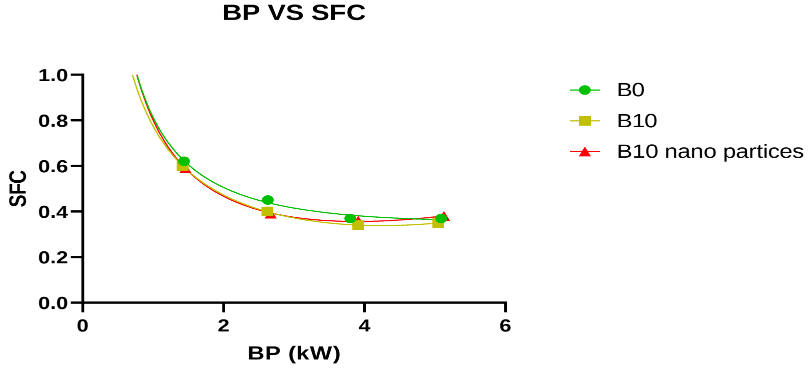

Fig.8 BP vs SFC for Diesel, B10 and B10 Nanoparticles

Specific fuel consumption reduces when nanoparticles are mixed with neat diesel as they contribute oxygen atoms and makes the fuel oxygenated. When neat diesel was blended with methanol SFC decreased (lower blends) and then gradually increased. In B5 blend Methanol acts a combustion improvers because of the oxygen content. For B5 blend with Nanoparticles the SFC gradually increased., Nanoparticles requires high temperature for vaporization and for donating oxygen atoms. In B10 blend the SFC increased because as it requires a high temperature for its latent heat of vaporization and auto ignition temperature. For B10 with Nanoparticle the SFC further increased to maintain temperatures inside the cylinder.

UNBURNT HYDROCARBON EMISSIONS (HC)

HC emissions are mainly formed due to insufficient temperature inside the cylinder and incomplete oxidization of the fuel.

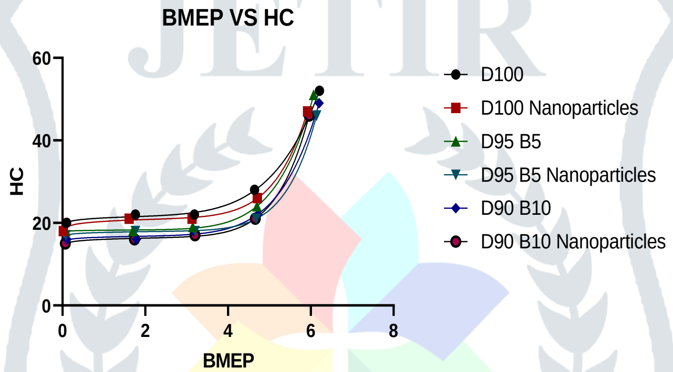

Fig.9 BMEP vs HC Emissions for B0, B5, B10 and Nanoparticles

Form the above figure it shown that as alcohol content increases HC emissions were gradually decreases due to high oxygen contain within the fuel .B10 curve shows a promising result when compared to B5 and Diesel. By adding Nanoparticles to the fuel the further reduced due to more availability of oxygen in local regions for more oxidization of fuel.

CARBONMONOXIDE (CO)

These emissions are formed due to unavailability of oxygen inside the cylinder at the time of combustion

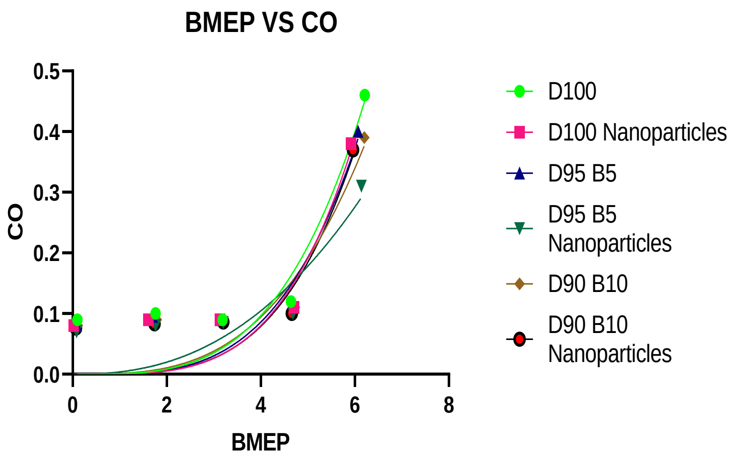

Fig.10 BMEP vs CO Emissions for B0, B5, B10 and Nanoparticles

Variation of CO emission with respect to engine BMEP for various test fuels is shown in Fig.8. It was found from the experiment that CO emission reduced with increase in methanol percentage in the test fuel. Full load CO emission exhibited by B5 was found to be 5% less and that of B10 was 12% less than full load neat diesel operation. This may be due to the fact that methanol is itself an oxygenated fuel and needs less amount of air to burn completely. By addition of Nanoparticles to the methanol blends the CO emissions were further decreased. For diesel Nanoparticles it was found to be 3% less, for B5 Nanoparticles it was found to be 7% and B10 Nanoparticles was found to be 15% less than that of Diesel at full load conditions.

NOx EMISSIONS

These emissions are mainly formed due to high temperatures. At high temperatures the diatomic nitrogen molecule decomposes into two mono atomic nitrogen molecules. These nitrogen molecules combine with oxygen to form NOx emissions.

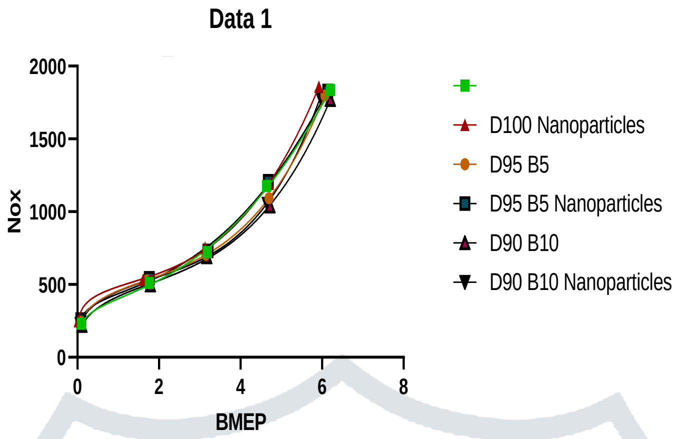

Fig.11BMEP vs NOx Emissions for B0, B5, B10 and Nanoparticles

From above figure the blending of diesel with methanol will definitely increases the NOx emissions due to higher oxygen availability at local regions. Due to the higher oxygen present in the local region the temperature will drastically increase at this temperature, the NOx emissions should be higher than that of obtained but inside the cylinder. ZnO Nanoparticles acts as a catalyst and reduced NOx emissions. The adding of methanol blends to the fuel with Nanoparticles further decreased the NOx emissions due to its higher latent heat of vaporization temperature.

V. CONCLUSIONS

Blending neat diesel with methanol resulted in better fuel properties due to it high oxygen content. The addition of nano particles acts as an catalytic converter and increases the performance characteristics like brake thermal efficiency, specific fuel consumption in all the blends compared to neat diesel and other fuel blends. Exhaust emissions like CO, HC and NOx were also reduced.

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