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Influence of Nanoparticles on the Performance and Emission Characteristics of Diesel Engine Fuelled with Chicken Biodiesel

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Abstract*: The present experimental study examines the impact of aluminium oxide nanoparticles (ALN) as additives in chicken waste oil biodiesel on a single cylinder diesel engine performance and emission characteristics. Different dosage of ALN was blended with chicken biodiesel (CB) using ultrasonic mixing in 200th by volume of biodiesel. The performance and exhaust emissions were evaluated using 100ppm, 150ppm and 200ppm aluminium oxide nanoparticles dosages blended chicken biodiesel for different brake power at a constant speed of 1500rpm and compared the results with diesel(B0) and 20% by volume of chicken biodiesel (CB20). Increased brake thermal efficiency and reduced brake specific fuel consumption were observed with the addition of aluminium oxide nanoparticles as compared to biodiesel blend and diesel at 3/4th of load. Also, reduced emissions hydrocarbon and carbon monoxide and increased NOX with ALN at full load. Overall, biodiesel with aluminium oxide nanoparticles improved the diesel engine performance and emissions characteristics with a slight increase in NOX.

Keywords: Chicken biodiesel, Diesel engine performance and emission, Nanoparticles, Ultrasonicator.

I. INTRODUCTION

The need of diesel fuel is increasing in the current situations from several industries and vehicles. simultaneously, because of its high compression ratio it increases the pollution to the environment. The demand for petroleum products and the cost is increasing day by day, so considering into current and future requirements for the usage of petroleum products there is a need of alternative fuels. The addition of biodiesel to diesel fuel improve the performance and emission characteristics of the diesel engine. The optimized biodiesel mix can reduce some important portion of fuel dependency and surroundings from pollution with none modification to the diesel engine [1]. The oxygen content presence in biodiesel reduces the carbon monoxide and hydrocarbons emissions and it increases the NOX formation at the exhaust [2]. It leads to incomplete combustion due to poor atomization and to reduce the viscosity, pouring point and increasing the calorific value of biodiesel many researches have been carried out by researchers on different types of additives. The additives, metal and platinum based blended biodiesel improve the diesel engine performance and emission characteristics, but increases the size of the particles and accumulate less. Aluminium oxide has high level of purity in water and release hydrogen which provides more surface area helps in the combustion process [3, 4]. The optimum fuel with alumina brake thermal efficiency (BTE) increased and specific fuel consumption minimized as related to neat diesel. The emissions carbon monoxide (CO) and hydrocarbons (HC) reduced respectively however increase in NOX were observed [5]. Improved hydrocarbon and carbon monoxide with addition of nanoparticles blended biodiesel compared to biodiesel. Reduced NOX with alumina nanoparticles due to sufficient fuel accumulation made early combustion and reduced ignition delay [6]. Increase in brake thermal efficiency for biodiesel-ethanol blend was observed due to better mixing abilities of nanoparticles in the presence of oxygen and significant reduction in unburnt hydrocarbons and carbon monoxide as compared to diesel at 1/4th and 1/2nd percentage load. [7]. Brake thermal efficiency increased as compared to biodiesel and exhaust emissions hydrocarbons, carbon monoxide and NOx were reduced with nanoparticles compared to biodiesel [8]. The higher dosage of alumina nanoparticles to diesel increased brake thermal efficiency compared to diesel and reduced carbon monoxide, hydrocarbons and NOx with alumina nanoparticles in comparison with diesel [9] [10]. The addition of Al_2O_3 nano additive blended grape seed methyl ester biodiesel(B20) in compression ignition engine were improved performance and reduced emissions hydrocarbon, carbon monoxide and NOx with nano additives in diesel engine as compared to biodiesel [11]. The nanoparticles by mass fraction 100ppm and 150ppm were added to diesel fuel and compared the results with diesel. Observed that average brake thermal efficiency increased with nanoparticle dosages compared to diesel fuel. Exhaust emissions with nanoparticles dosages hydrocarbon,

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carbon monoxide and NOx were decreased after 25% of the load then the diesel fuel [12].

Bio-diesel with aluminium metal oxide nanoparticles added on the diesel engine with various dosage of nanoparticles results same brake thermal efficiency and emissions carbon monoxide and NOx were decreased for biodiesel with 50ppm as compared to diesel [13]. The added alumina nanoparticles result in lower BTE, BSFC and exhaust emissions compared to diesel. However, increase in NOX was noted with nanoparticles [14].

Investigations from researchers were carried out on aluminium oxide nanoparticles to see the effect of addition of alumina to biodiesel and diesel fuel on performance and emission characteristics of the diesel engine. In the literature review most of the researchers established the addition of varying dosages of aluminium nanoparticles in biodiesel blends and diesel increases the calorific value of the fuel and found improvement in brake specific fuel consumption and brake thermal efficiency. Results also showed that reduced carbon monoxide and hydrocarbons but increased in NOx with the addition of aluminium oxide nanoparticles to diesel and biodiesel. Also, with lower dosage levels of alumina nanoparticle as additive in B20 and B40, the BTE, BSFC and emissions characteristics were comparable results with the diesel [14].

The objectives of the present paper are to see the influence of higher aluminium oxide dosage levels nanoparticles blended with chicken biodiesel on the DI engine performance and emissions characteristics. The outcome of this study is improvement in the engine performance and exhaust emissions with higher dosage levels of 100ppm, 150ppm and 200ppm ALN blended with biodiesel were investigated

II. MATERIALS & METHODS

Two hundredth by volume of chicken biodiesel (CB20), diesel(B0) and aluminium oxide nanoparticles (100ppm, 150ppm and 200ppm) fuels are used in the present experimental investigation. Biodiesel extraction was done through transesterification chemical process to remove free fatty acid from chicken waste products [15]. The fuels prepared for study were CB20ALN100 (80% diesel+20% CB+100ppm ALN), CB20ALN150 (80% diesel+20% CB+150ppm ALN) and CB20ALN200 (80% diesel+20% CB+200ppm ALN), CB20 and B0.

Table-I: Properties of diesel and chicken biodiesel

Fuel Properties	Diesel	Chicken Biodiesel
Density, Kg/m^3	850	875
Specific gravity	0.85	0.875
Viscosity at 40^0 cSt	2.6	4.3
Calorific value, KJ/kg	42800	40673

The properties of diesel, chicken biodiesel and aluminium oxide nanoparticles are shown in "Table-I". The experimental set up of a single cylinder four stroke compression ignition engine is shown in "Table-II". The study was carried out by varying loads at a constant speed of 1500 rpm for different fuels.

Table-II: Engine specifications

Parameters	Specification
Type	TV 1 (Kirloskar)
Number of cylinders	Single cylinder
Number of strokes	Four strokes
Nozzle opening	180 to 225bar
Compression ratio	16.5:1
Cylinder bore diameter	80mm
Stroke length	110mm
Cooling	Water cooled

The performance constraints such as brake specific fuel consumption, brake thermal efficiency, exhaust gas temperature and emissions characteristics carbon monoxide, hydrocarbons, NOx were evaluated and compared the results of aluminium oxide nanoparticles blended biodiesel with CB20 and diesel.

The performance constraints such as brake specific fuel consumption, brake thermal efficiency, exhaust gas temperature and emissions characteristics carbon monoxide, hydrocarbons, NOx were evaluated and compared the results of aluminium oxide nanoparticles blended biodiesel with CB20 and diesel. "Fig.1", illustrates the flow chart of engine test set up for different fuels.

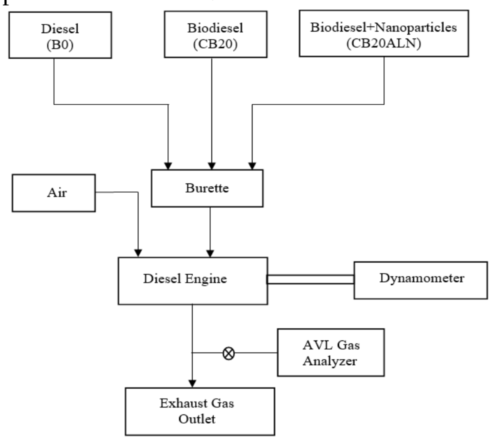

Fig. 1. Experimental set up in diesel engine

III. RESULTS & DISCUSSIONS

Analysis of diesel engine fueled with diesel(B0), CB20, CB20ALN100, CB20ALN150 and CB20ALN200 were evaluated. The Performance and emission characteristics of the engine were discussed and results of fuel samples at various loading conditions with constant engine speed are compared.

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III. A. Engine performance fueled with B0, CB20 and ALN blended CB20

"Fig.2", shows fuel samples diesel, CB20 and the result of aluminium oxide nanoparticles added to CB20 on brake specific fuel consumptions (BSFC) of the diesel engine at different brake power (BP).

It is observed that lower BSFC at 3/4th of load for CB20, CB20ALN100, CB20ALN150 and CB20ALN200 fuel samples as compared to diesel.

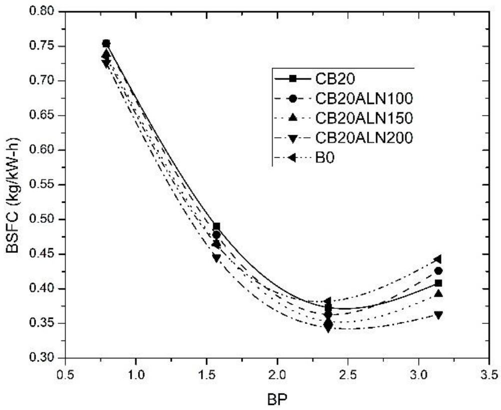

Fig. 2. Brake specific fuel consumption (BSFC) with brake power (BP) for five fuel samples

Decrease in BSFC by 2.86%, 5.71% and 8.57% for fuels CB20ALN100, CB20ALN150 and CB20ALN200 compared to the CB20 and 5.26%, 8.19, 11.11% to that of diesel. With the addition of ALN dosage quantity to biodiesel increases the density of the fuel and BSFC decreases as it is directly proportional to the weight of the fuel. This could be due to enhancement in combustion with the addition of aluminium oxide nanoparticles which increases the surface area to volume ratio in the combustion chamber [7, 8, 12].

"Fig.3", shows the brake thermal efficiency for fuel samples diesel, CB20, CB20ALN100, CB20ALN150 and CB20ALN200 at different load. Increase in BTE is observed with addition of aluminium oxide dosage levels to CB20 at 3/4th load. Brake thermal efficiency increases by 2.78%, 5.41%, 7.89% for fuel samples CB20ALN100, CB20ALN150, CB20ALN200 and 5.97%, 8.51%, 10.92% compared to CB20 and diesel. The reason for increase in BTE could be with the addition of aluminium oxide nanoparticles to biodiesel increases the calorific value of the fuel which makes better combustion by increasing the surface area for proper mixing in the chamber and decreases the ignition delay at higher loads where the temperature increases [7, 10, 11, 12]. For 50ppm of ALN in biodiesel the BTE is below the diesel fuel as studied by N. K. Gurusala [14].

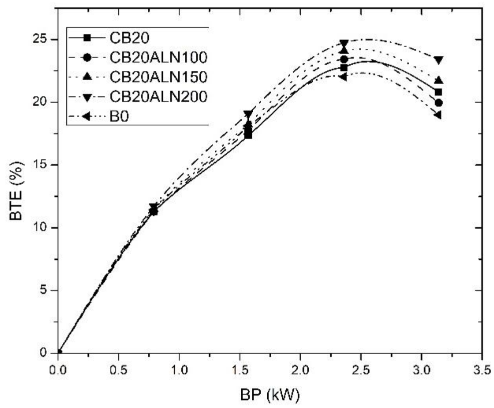

Fig. 3. Brake thermal efficiency (BTE) with brake power (BP) for five fuel samples

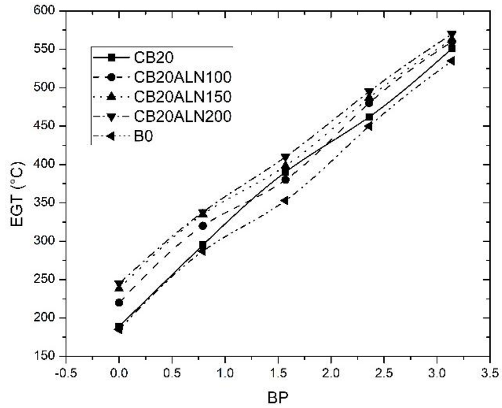

Fig. 4. Exhaust gas temperature (EGT) with brake power (BP) for five fuel samples

"Fig.4", shows the exhaust gas temperature (EGT) with the different load for diesel, CB20, CB20ALN100, CB20ALN150 and CB20ALN200. It is seen that with the addition of higher dosage aluminium oxide nanoparticles to CB20, the EGT was higher at 3/4th of engine load. Increase in EGT by 3.75%, 5.13%, 6.67%, and 6.67%, 8.22%, 10% for fuel samples CB20ALN100, CB20ALN150, CB20ALN200 compared to CB20 and diesel respectively. The same trend is also observed by S.H. Hosseini and A Praveen [5, 8].

III. B. Engine emissions fueled with B0, CB20 and ALN blended CB20

The exhaust emissions carbon monoxide (CO), hydrocarbons (HC) and oxides of nitrogen (NOx) from the diesel engine using fuel samples diesel, CB20, CB20ALN100, CB20ALN150 and CB20ALN200 were examined experimentally.

"Figs. 5-6", shows Lower HC and CO with different engine loads. It was examined that both HC and CO reduced with the addition of aluminium oxide to CB20. Decrease in HC by 9.24%, 25%, 36.84% and 13.44%, 29.8%, 42.11% for fuels CB20ALN100, CB20ALN150, CB20ALN200 compared to CB20 and diesel fuel samples respectively.

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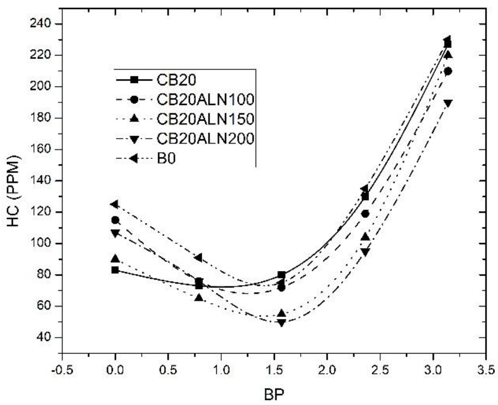

Fig. 5. Hydrocarbon (HC) emission with brake power (BP) for five fuel samples

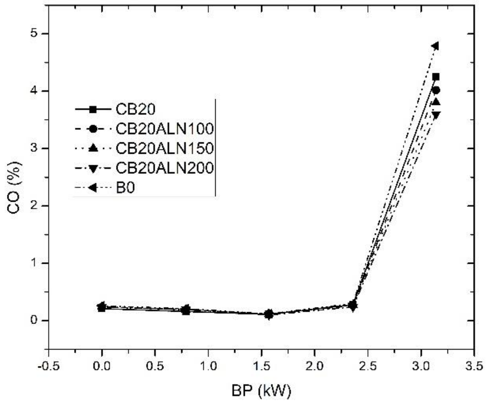

Fig. 6. Carbon Monoxide (CO) emission with brake power (BP) for five fuel samples

From "Fig. 6", CO decreased by 7.69%, 3.7%, 16.67% and 15.38%, 11.11%, 25% with CB20ALN100, CB20ALN150, CB20ALN200 fuel samples compared to CB20 and diesel respectively at 75% load conditions. The presence of oxygen in biodiesel reduces the HC and CO emissions which in turn decreases the ignition delay. Reduction of HC and CO improved with the addition of aluminium oxide nanoparticles because of higher oxygen presence in ALN makes proper mixing of air-fuel ratio in combustion chamber results in complete combustion [5, 8, 10].

NOx emission for fuel samples diesel, CB20, CB20ALN100, CB20ALN150 and CB20ALN200 with various load at constant speed is shown in "Fig.7". It is seen that highest NOx in case of added aluminium oxide nanoparticles to biodiesel. Increase in NOx by 1.59%, 9.52% and 15.7% 20.51% for fuels CB20ALN150, CB20ALN200 compared to CB20 and diesel. The ALN acts as catalyst by providing more oxygen in chemical reaction resulted in an increase in temperature with more heat release rate at higher loads [5, 7, 10]. Opposite trend was noticed by J. Sadhik Basha and S. Karthikeyan [6, 11].

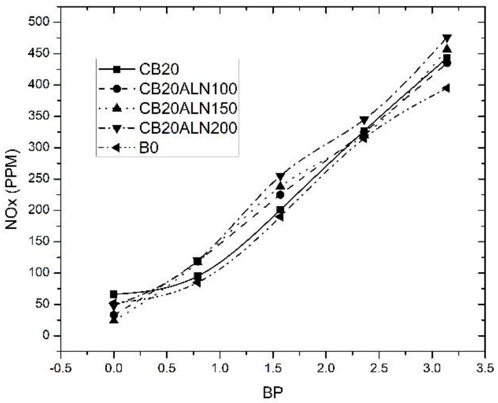

Fig. 7. Oxides of nitrogen (NOx) emission with brake power (BP) for five fuel samples

IV. CONCLUSION

The performance and emission characteristics of a diesel engine from the experimental study using fuel samples diesel, CB20, CB20ALN100, CB20ALN150 and CB20ALN200 with various loads at constant speed are studied and following are the conclusions made from present study.

The BSFC is lowered with the addition of ALN dosage level to CB20. Observed that 8.57% and 11.11% reduced BSFC with CB20ALN200 fuel as compared to CB20 and diesel at 3/4th engine load. Increased BTE with the addition of aluminium oxide nanoparticles to CB20 about 7.89% and 10.92% for fuel sample CB20ALN200 than CB20 and diesel at 75% of the load. The higher dosage level of ALN blended CB20 decreases the HC and CO of a diesel engine by 36.84%, 42.11% and 16.67%, 25% than those with CB20 and diesel fuel samples respectively. Increase in NOx is found with the addition of aluminium oxide nanoparticles by 9.52% and 20.51% compared to CB20 and diesel fuels. The contribution of oxygen by ALN releases more heat during combustion compared to CB20 and diesel fuels.

With this study, it is concluded that higher dosage levels of ALN blended to diesel-biodiesel improve the performance and exhaust emissions of a diesel engine without any engine modifications.

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