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Investigation of Performance and Emission Characteristics of VCR Engine Fuelled with Mahua Biodiesel Blends Using Nanoparticles.

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ABSTRACT

An experimental investigation was done on a computerized single cylinder four stroke variable compression diesel engine fueled with diesel, diesel blended with Mahua oil in 30%, 50% and Aluminum oxide nanoparticles as additive to analyze the performance and emission characteristics. Experiments were conducted with varying loads from no load to full load at compression ratios 14, 16 and 18 using diesel and biodiesel blends. The effect of compression ratio on fuel consumption, efficiency and emissions of the engine were investigated. It is found that biodiesel blend B50A100 increases the performance and reduces the emissions effectively compared to the other blends and diesel at CR 18. It is also found that by the addition of aluminum oxide nanoparticles both CO and HC emissions are reduced at all compression ratios. Smoke is also decreased by using nanoparticles as additive.

Keywords: biodiesel, emissions, Mahua oil, nanoparticles, additive

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INTRODUCTION

There is a need to find an alternative fuel to fulfill the demand of the world for energy due to the depletion of fossil fuels and increased population. Biodiesel is one of the best alternatives from the available sources. Biofuel is derived from the fatty acid methyl or ethyl esters of animal fats and vegetable oils. Availability of biofuels is more, renewable and oxygenated [1]. More number of studies has been committed to develop vegetable oil based alternate fuels for internal combustion engines. Without any major engine modifications, biodiesel can be used [2-6].It is found that, different metal oxide additives to biodiesel improve the fuel properties, engine performance and reduce the emissions. Lower emission levels of HC and NO_x emissions were observed using biodiesel additives in the form of nanoparticles when compared to diesel operation [7-10]. These additives in biodiesel are popular for varying the chemical properties and combustion characteristics of fuels. Nanoparticle additives are more efficient due to increase in surface area-to-volume ratio. From various studies it is concluded that the engine performance parameters such as break thermal efficiency, fuel consumption and emissions of CO_2, CO, HC and NO_X are influenced by the engine design parameters such as injection pressure and compression ratio. Specific fuel consumption reduces, brake thermal efficiency increases whilst the emissions reduces with increase in compression ratio [11-13].

EXPERIMENTAL SET UP AND PROCEDURES

The experiments were done on a computerized 4 stroke single cylinder variable compression ratio compression ignition engine to evaluate the performance, combustion and emission characteristics using diesel and biodiesel (Madhuca indica oil) blends (B30,B50) with and without alumina nanoparticles as additives (100mg/l) and surfactant Tween80 2% by volume. Specifications of engine are mentioned in the Table 1. Engine was operated at different compression ratios 14, 16, and 18, at 200bar injection pressure, 1500 rpm constant speed at different loads. The performance of the engine was measured by using a data acquisition system, emissions are measured by using gas analyzer and smoke is measured using the AVL smoke opacity meter.

Table 1: Engine Specifications

Engine	4 stroke, 1 cylinder
Rated Power	3.7KW
Compression Ratio	12:1 to 20:1
Rated Speed	1500 rpm
Dynamometer	Eddy current dynamometer
Stroke Length	110 mm
Bore Diameter	80 mm
Swept Volume	562cc

Production of Mahua biodiesel

Mahua biodiesel was prepared by using two steps. Esterification followed by transesterification process. In esterification process, one liter quantity of Mahua oil was heated up to 100°C to 110°C to remove water from the oil. Add 10ml of H_2SO_4 to 200 ml of methanol in a flask and add the mixture to Mahua oil after cooling it to 30°C. The mixture is stirred continuously for 2 hours maintaining the temperature below 60°C. After that, the mixture was allowed to settle for 8 to 12 hrs. Two layers are appearing. The upper one is esterified oil used for further process and the lower layer is the residue to be removed. The oil obtained was taken further for water wash with distilled water for 1- 2 times for the removal of acids. In transeterification process the esterified oil was heated to remove the water content. Add 7.5 grams of potassium hydroxide pellets with 200 ml of methanol and the mixture was added to the oil. With magnetic stirrer, the mixture was

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continuously stirred for one hour to react. Maintain the temperature of the mixture at 55°C during the stirring process and then allowed the mixture to settle for 8hrs. Two layers were formed, the upper one is the biodiesel and the lower one is the glycerol. Now the biodiesel was separated and purified by water washing and heated it up to 100°C. Basic properties of testing fuels are shown in Table 2.

Table 2: Properties of the fuels tested.

Fuel↓ Property→	**Density (Kg/m^3)**	**Calorific value (kJ/kg)**
Diesel	840	43,400
B30 (70% Diesel + 30% Biodiesel)	846	40820
B30A100 (70% Diesel + 30% Biodiesel + 100 ppm Almuina + 2% Tween80)	860	42,675
B50 (50% Diesel + 50% Biodiesel)	871	36349
B50A100 (50% Diesel + 50% Biodiesel + 100 ppm Alumina + 2% Tween80)	878.8	39167
B100 (Mahua biodiesel)	900	34210

Preparation of Mahua biodiesel blend with alumina nano particles

Alumina nanoparticles were blended with biofuel uniformly with the help of ultrasonicator. Properties of alumina naoparticles are shown in Table 3. First, 100mg alumina nano particles were weighed using the digital weighing machine. Prepare B30A100 and B50A100 by adding 100mg alumina nanoparticles with one liter of B30 and B50 blends. Mahuabiodiesel was kept in an ultrasonicator at 20 KHz for 30 minutes while adding nanoparticles, to disperse the nano particles into oil. Surfactant Tween80 was mixed with Mahua biodiesel blends in the proportion of 2% by volume while preparing B30A100 and B50A100.

Table 3: Properties of alumina nanoparticles

Chemical Name	Alumina/ Aluminum oxide (Al2O3)
Particle size	<50nm
Specific surface area	130-140 m2/g
Density	3.95 g/cm3
Color	White

RESULTS AND DISCUSSIONS

Using diesel, B30, B50 B30A100 and B50A100 biodiesel blends, Tests were conducted on VCR engine at different compression ratios and the results were plotted against torque.

Performance characteristics

Brake thermal efficiency

Variation of brake thermal efficiency with increasing torque at different compression ratios for all blends is shown in figure1. Brake thermal efficiency was increased for all blends with increasing loads at all compression ratios due to increase in the fuel injection for higher loads and increase in the cylinder pressure. At full load condition, break thermal efficiency values for the blend B50A100 are 24.13%, 28.2%, 28.38% at CR 14, 16 and 18 respectively. These values are higher than the other blends at full load condition at all compression ratios tested. Increase in brake thermal efficiency is due to reduction in heat lost.

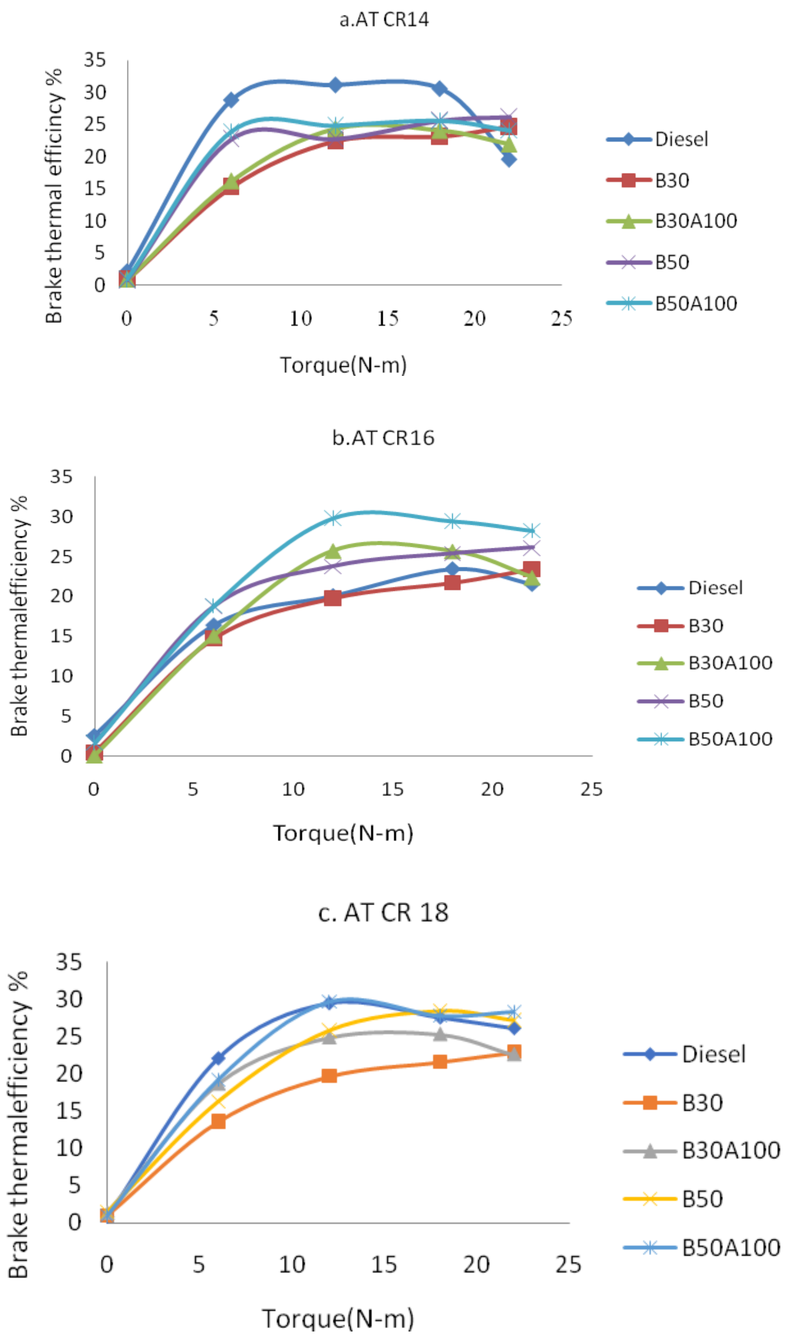


Figure 1: Variation of break thermal efficiency with Torque at different compression ratios

Brake Specific Fuel Consumption (BSFC)

Variation of bsfc with troque at different compression ratios is shown in Figure 2. Rate of fuel consumed to produce a kW brake power is known as brake specific fuel consumption. BSFC was increased with the blends B30 and B50 compared to the diesel due to less calorific value. The bsfc was reduced with B30A100 and B50A100 compared to B30 and B50 due to increase in calorific value. The presence of nanoparticles improves the combustion. In case of CR16, 18, 16.6%, 14.7% increase in bsfc was observed with B50A100 compared to the diesel at full load condition.

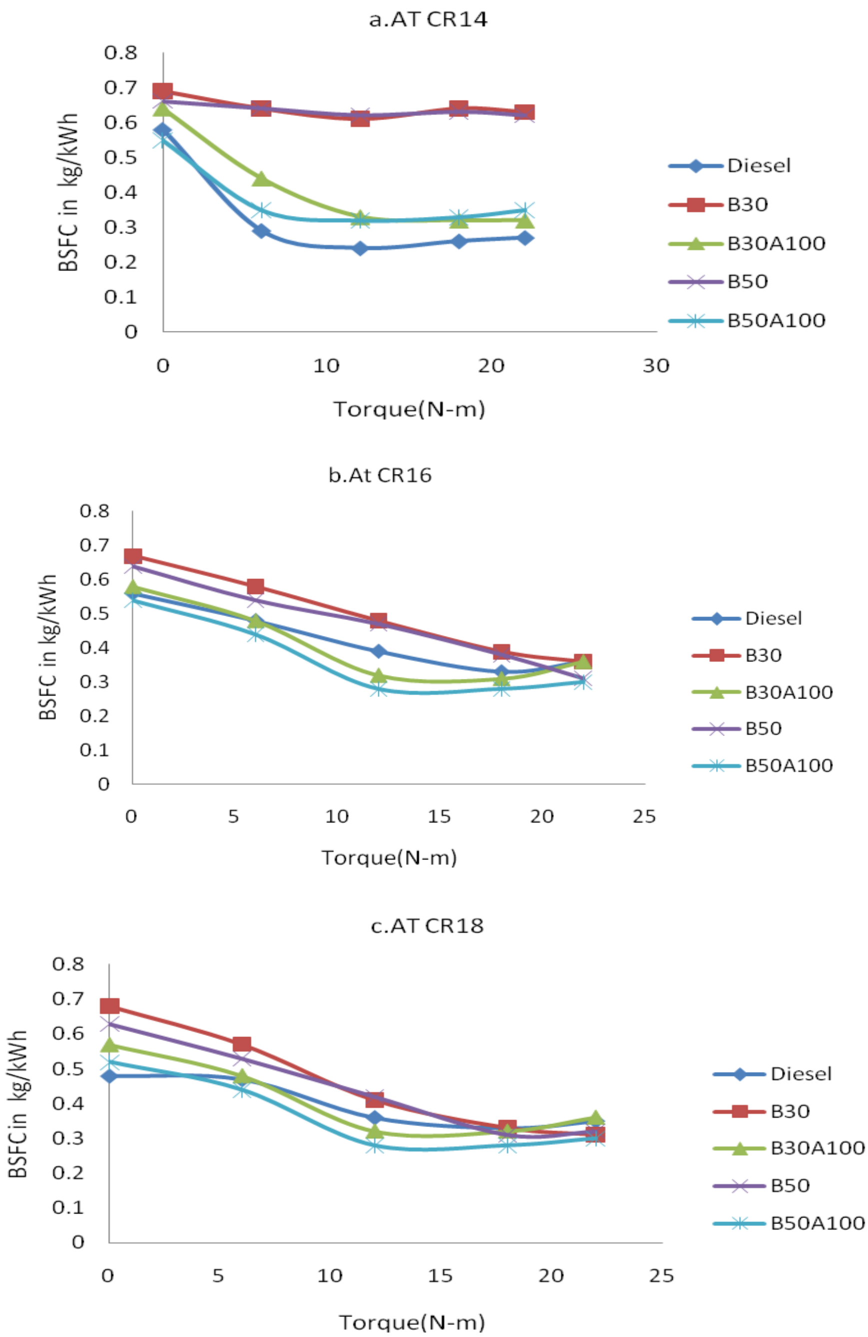
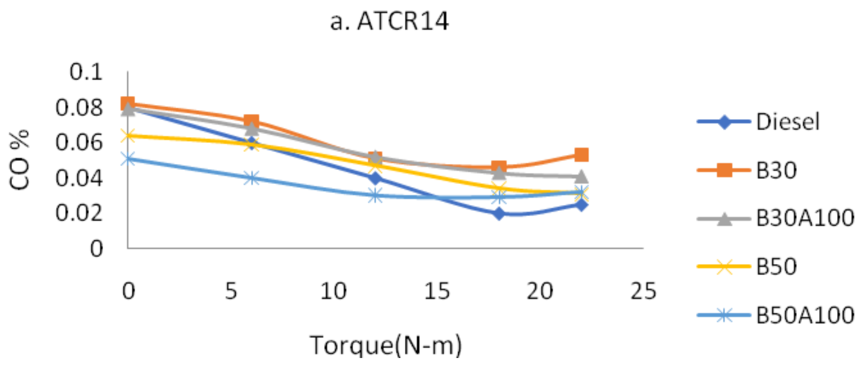


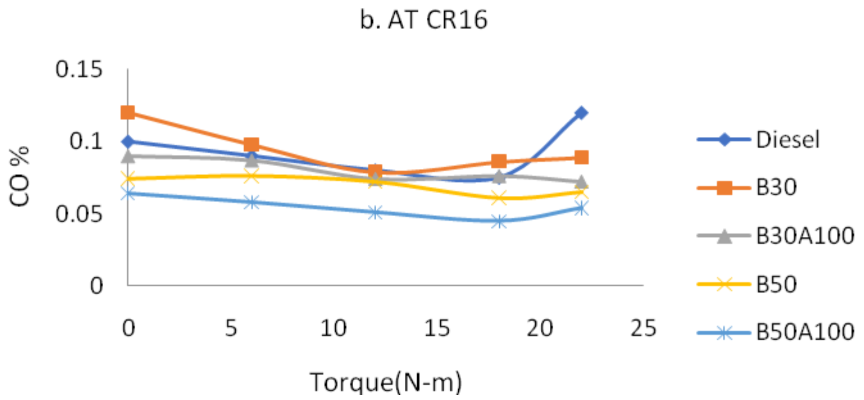
Figure 2: Variation of Brake specific fuel consumption with torque at different compression ratios

Emission Characteristics

Carbon Monoxide

Carbon monoxide emissions are caused due to lack of oxygen for combustion. Due to the oxygen enrichment of fuel, combustion was promoted and carbon monoxide emissions were reduced for all the biodiesel blends at all compression ratios. At different compression ratios, variation in carbon monoxide emissions is shown in Figure 3. At CR 16 and CR 18, 17% and 23.3% CO emissions were reduced with biodiesel blend B50A100 compared to diesel.





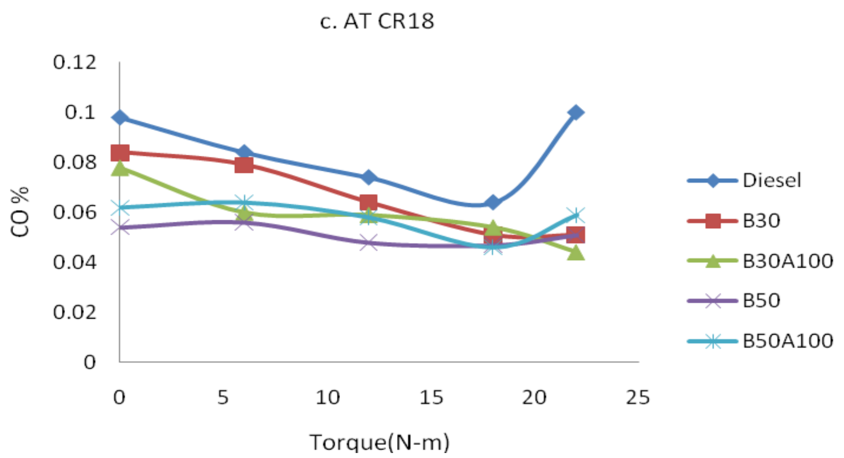


Figure 3: Variation of carbon monoxide with torque at different compression ratios

Hydro Carbon emissions

The variation of HC emissions with increasing torque at different compression ratios is shown in fig 4. Incomplete combustion of fuel causes hydrocarbon emissions. By increasing the compression ratio, the oxygen and fuel molecules come close and the reaction time decreases. The presence of nano particles in biodiesel blends causes complete combustion. HC emissions were reduced compared with diesel for all blends at CR 16 and CR 18. HC emissions are reduced more with biodiesel B50A100 at CR 18 for full load condition.

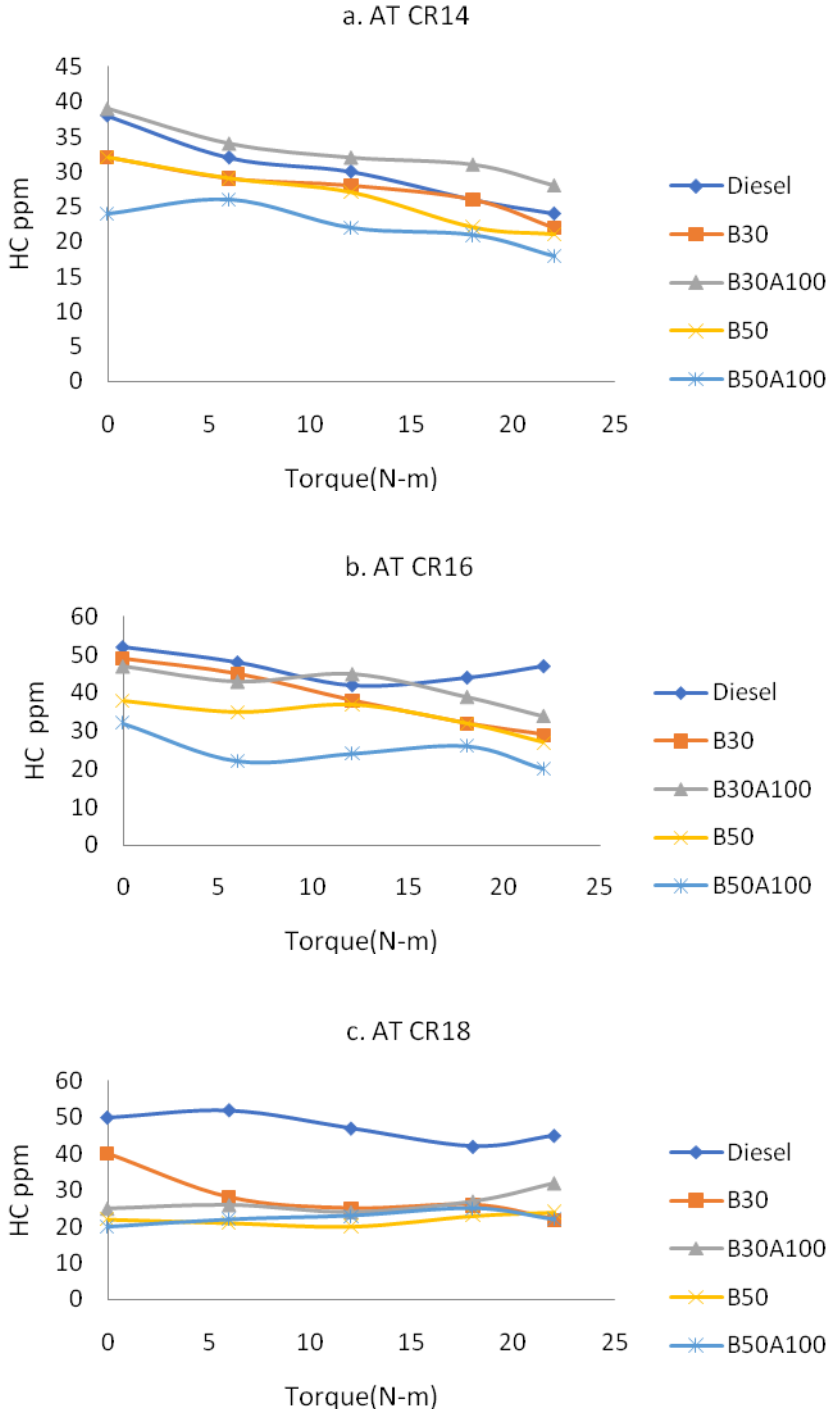


Figure 4: Variation of Hydrocarbon emissions with torque at different Compression ratios

NOx Emissions

NO_x emissions are dependent on the temperature of combustion. For all tested compression ratios, Variation of NO_x emissions with torque is shown in Figure 5. Due to the presence of more oxygen content and nanoparticles, the combustion temperature is high and the NOx emissions were increased for B50A100 compared to the other tested fuels at CR 14, 16 and 18. AT CR 18, NO_x emissions are more for the blend B50A100 with the increase in air compression temperature and minimum ignition delay results improved combustion characteristics.

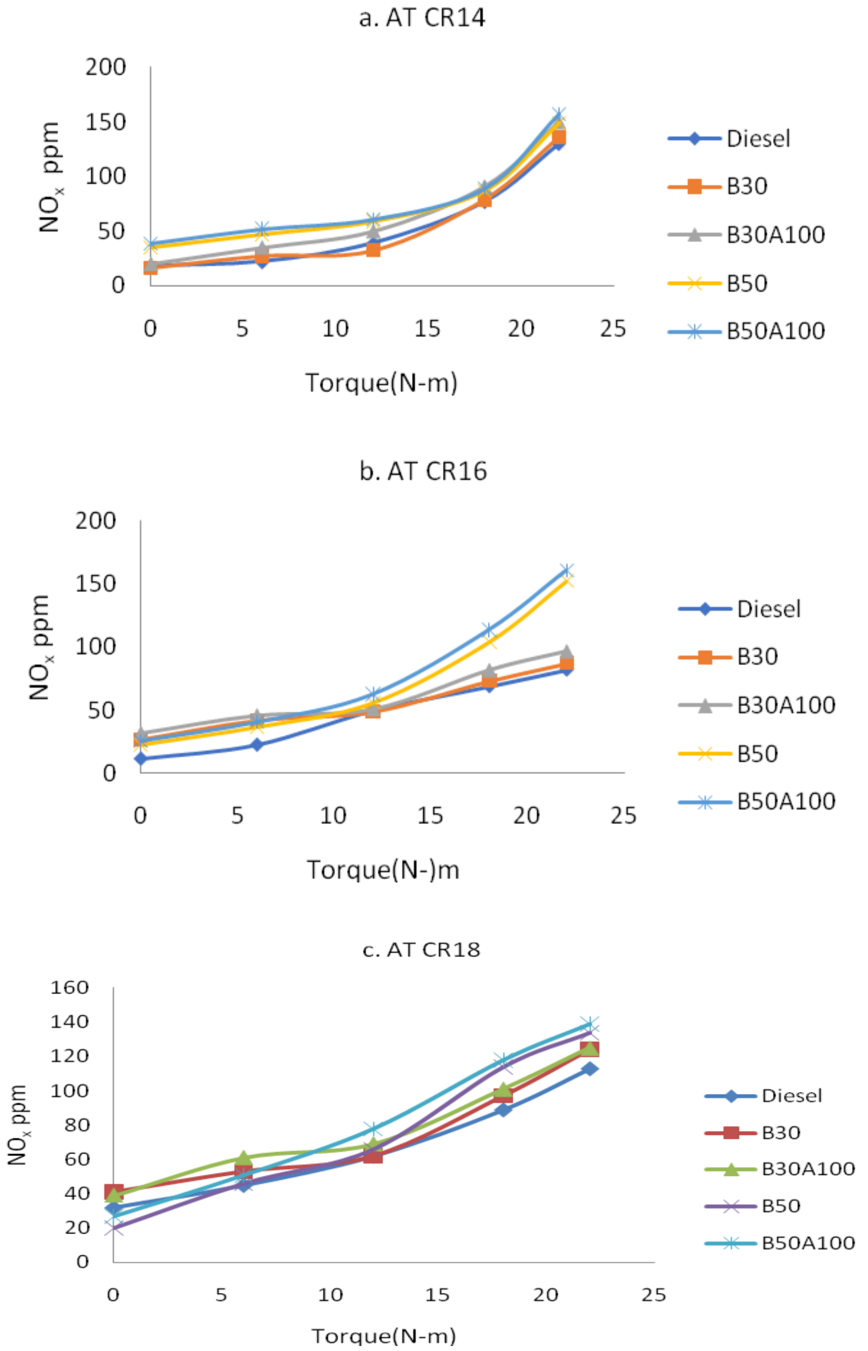


Figure 5: Variation of Nitrogen oxides emission with torque at different Compression ratios

Smoke Emission

Smoke emission is due to poor atomization and incomplete combustion of the fuel. Variation of smoke emissions with torque is shown in figure 6. Due to the addition of nanoparticles and higher oxygen content in biodiesel blends smoke emission were reduced at all loads than the diesel. Using B50A100 fuel blend, smoke emission was decreased by 19.3% at CR 18 compared to the other tested fuels

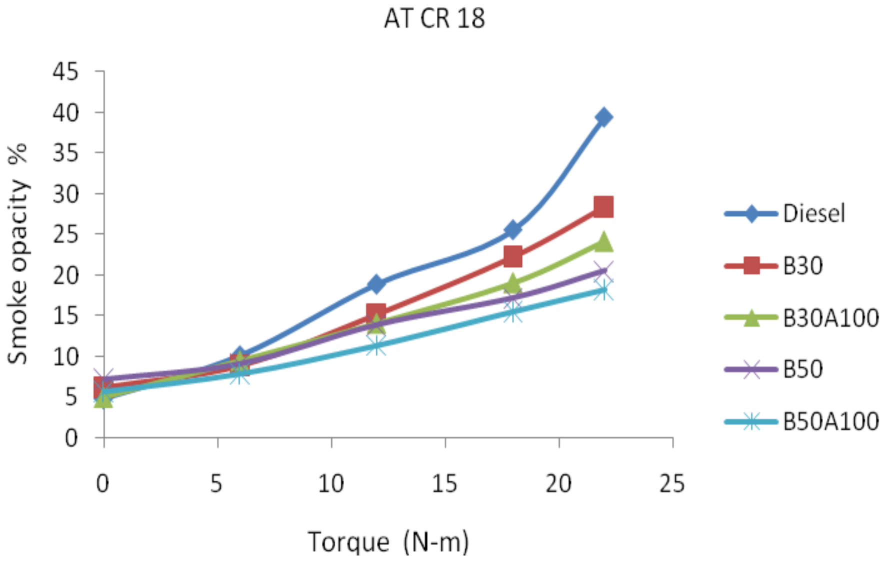


Figure 6: Variation of Smoke Opacity with torque

CONCLUSIONS

Experiments were conducted to understand the effect of alumina nanoparticles as additives on performance and emissions of a VCR engine using diesel and Mahuabiodiesel blends. Based on the experimental results the following conclusions are given

1. At full load, for CR 18, 28.38% increase in brake thermal efficiency was obtained with B50A100 blend compared to diesel.
2. At full load condition, brake specific fuel consumption was reduced by 14.7% at compression ratio 18 with B50A100 compared to diesel.
3. At all compression ratios, using the biodiesel blend and alumina nanoparticles as additive HC, CO and smoke emissions were reduced.
4. NOx emissions were increased slightly by using biodiesel blends with nanoparticles compared to diesel.
5. Smoke opacity was also reduced with biodiesel blended with nanoparticles.

The addition of Alumina nanoparticles as additives to the biodiesel blends engine performance increases and reduces the emissions and it can be used as an alternative for diesel fuel.

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