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Experimental Investigations on Ci Engine Using Biodiesel With Fuel Additives

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Abstract - **Now a days petroleum products utilization are rapidly increased due to expanding of the road, water and air transportation sectors. The heavy utilization of petroleum products leads to exhaust these fuels in nature near future. In this association there is necessitate to investigate alternative fuel in place of petro diesel products. The alternative fuels are extracted from biomass, vegetable oils and municipal wastage. The vegetable oil parameters are nearly equal to diesel fuel. Hence in this work Neem and Jute methyl esters are selected as substitute fuels in place of diesel without engine alteration. The performance characteristics like Specific fuel consumption, Brake Thermal Efficiency, Mechanical Efficiency and Indicated Thermal Efficiency are analyzed. The emission characteristics like carbon monoxide, unburnt hydrocarbon, nitrogen oxide and carbon dioxide are determined. When correlated to diesel the oxides of nitrogen emissions levels in biodiesel are relatively high. The fuel fast burning rate, superior combustion start, heat transfer low radiation and fluctuating AFT(Adiabatic Flame Temperature) are main causes for oxides of nitrogen pollutant development. The addition of fuel additives plays a vital role to reimburse the above said parameters. Therefore in this effort appropriate additive is need in biofuel with diverse proportions such as 3gm/l & 5gm/l. The results obtained are optimum for fuel additive $CaCO_3$ 3gm/l.**

Keywords—Biodiesel, Jute methyl esters, Neem methyl esters, performance, emissions, fuel additive

I. INTRODUCTION

The vegetable oil properties were suitable to use in compression ignition engines in place of petro diesel. But the vegetable oils have high viscosity compared to diesel fuel. Due to high viscosity the problems like incomplete combustion, carbon deposit and further it causes more environmental pollution [1].

Population wise India occupy second place in the world. In this connection the usage of vehicles in the world is rapidly increasing economic growth[2]. Compared to preceding years in India the automobile utilization was increased. The expanded automobile leads to depletion of petroleum products. In this circumference majority of petroleum products were imported from various countries like Iran, Iraq and Saudi Arabia [3].

Diesel engines were acting as main cause of transportation sector around the country due to their lower specific fuel consumption & carbon monoxide emission. For so many years, the availability and cost of fossil fuels were major factors to affecting the power and transportation sectors. In this connection alternative fuels were determined in place of fossil fuel [4-5].

According to the biodiesel and diesel composition, the fuel additives will influence directly on the parameters like density, flash point, cetane number, viscosity, volatility and heating value[6]. The fuel additive aids in decreasing the density & viscosity also increasing the amount of oxygen in bio-diesel. The di-ethyl ether, ethanol and isobutanol minimize the brake specific fuel consumption[7-8]. Generally all exhaust pollutants of carbon dioxide, hydrocarbon, carbon monoxide and nitrogen oxide pollutants were reduced by the addition of fuel additives to biodiesel and diesel [9].

An analysis was conducted on 4 stroke water cooled single cylinder CI engine using nanofluids in place of petro diesel. The temperature was measured unsteady and steady conditions, by proper location of thermocouples at

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exhaust valve seat and valve spindle in cylinder head. The results indicates that at full load condition, there was a reduction of temperature upto 13.5% on the EV seat & upto 4.0% on the EV spindle [10-11].

Investigations have been conducted on diesel engine with three types of fuels like biodiesel, biodiesel with ethanol and biodiesel with nanoparticles & ethanol. The result shows that adding carbon coated aluminum nano-particles with reduces fuel consumption with an average of 10%. The carbon monoxides and oxides of nitrogen pollutants were decreased to 12% & 10% respectively[12].

The experiments are conducted on direct injection single cylinder water cooled diesel engine using Nano-additive pongamia biodiesel as substitute fuel. Rhodium oxides were used as nanoparticles and processed by ball milling process [13]. The rhodium nano-particles act as oxygen content which enhances performance parameters and decreases emission characteristics. The results concluded that the nitrogen oxides emissions were reduces upto 36% when correlated with diesel fuel. It also decreases the hydro carbon emissions upto 44%. Rhodium nano-particles were reduces fuel consumption and enhances thermal efficiency [14-15].

Minor alteration in diesel engine parameters such as piston geometry should subsidize to enhance the performance of the diesel engine fueled with biofuel. The results revealed that the rate of heat release and brake thermal efficiency improved by 16.24% and 5.4% respectively. The carbon monoxide, un burnt hydro carbon emissions and fuel consumption were reduced about 14.8%, 8.70% and 14.3% respectively [16].

Investigations were carried out on 6 cylinder engine with turbocharger using soybean biodiesel as alternative fuel. the results exposed that engine power and combustion efficiency were decreased with stable fuel supply. It was observed that the brake thermal efficiency decreased due to high viscosity and lower heating value of biofuel. It was found that with the amendment of combustion chamber design the biodiesel was acceptable in the position of diesel fuel [17].

II. EXPERIMENTAL SETUP

A four stroke stationary direct injection single cylinder compression ignition engine was adopted in this experimentation. The parameters of the base engine are indicated in table 2.1. The engine was connected with eddy current dynamometer by changing load on the engine from no load to full load condition. The test equipment was prepared to work nearly at constant speed of 1500 rpm. The values were recorded for all engine load conditions. Using stop watch and standard burette 10cc fuel-consumption time was recorded. Initially the engine was warm up almost 30 minutes by utilizing the standard diesel fuel. After different biodiesels like jute methyl and neem methyl esters are tested with different piston configurations (hemispherical, toriodal, shallow depth) for experimentation. The lay out of the test setup is displayed in figure 2.2. Mars 5 gas exhaust analyzer was utilized to determine different engine pollutant parameters such as HC, CO, CO_2 & NO_X emissions. The k- type thermo-couples were used to measure the exhaust gas temperature.

2.1 The test engine

Engine Power	:	5.2 kW
Max.Speed	:	1500 rpm
Stroke Length	:	110 mm
Compression Ratio	:	17.5
Connecting rod length	:	235 mm
Engine Bore	:	87.5 mm
Stroke Length	:	110 mm
Speed	:	constant
Stroke	:	four
Loading	:	Eddy current Dynamometer
Number of cylinders	:	one

Table: 2.1 Specifications of the engine

Properties	Diesel fuel	Neem methyl ester	Jute methyl ester	Method
Specific gravity	0.83	0.88	0.85	ASTM D 1298
Density (kg/m^3)	830	948	978	ASTM D 1298
Kinematic Viscosity@ 40°C(cSt)	3.01	13.05	3.8	ASTM D 445
Heating value MJ/kg)	42.5	34	38	ASTM D 5865
Flash point (°C)	50	175	166	ASTM D 92
Fire point (°C)	60	191	179	ASTM D 92
Cetane number	47	45-47	44-48	ASTM D 613

Table -2.2 Chemical and physical properties of Diesel, Neem Methyl Ester and Jute Methyl Ester

Fig. 2.1 Experimental setup

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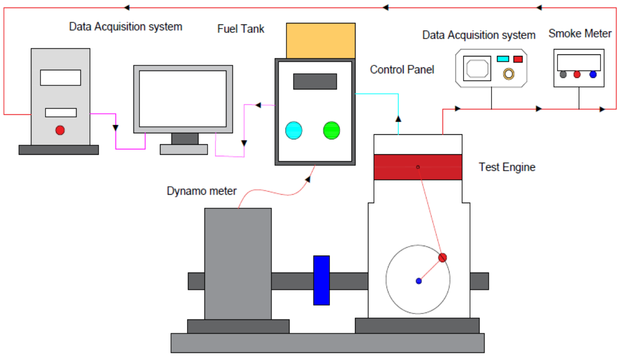

Fig-2.2 Schematic layout of the test engine

Fig.2.3 HCC

Fig.2.4 TCC

Fig.2.5. SDCC

III. RESULTS AND DISCUSSION

The output characteristics of Compression ignition engine with various piston configurations & Jute methyl ester (JME) with $CaCO_3$ as fuel Additive are analyzed. The performance characteristics are Mechanical efficiency, brake thermal efficiency, specific fuel consumption and Indicated thermal efficiency are evaluated.

Fig-3.1 shows deviations in Brake Power vs BTE with various proportions of $CaCO_3$ in bio fuel. It is recognized that from 0% to 100% load condition the BTE is high for all fuel additive proportions. The BTE for toroidal jute methyl ester 3gm is 28.4% at partial load operation. The Brake Thermal Efficiency(BTE) for standard engine is about 27.4% at full load condition. The BTE of JME with toroidal combustion chamber is high correlated to base fuel at partial load operation. The mixing of additives in biodiesel increases the output power and reduces the friction in the engine.

The variations in Brake power against ITE graph is drawn in fig 3.1.2. Small increment is observed in Indicated Thermal Efficiency from 0% load condition to 100% load condition. The ITE for T JME 3 gm is 40% at partial load condition. The ITE for base engine is 38% at 100% load condition. The ITE for TJME 3 gm is high correlated to base fuel and about 5.11% at partial load condition. The combustion properties of fuel are improved due to addition of additives in biodiesel.

For assessment of output power and ME plot is drawn in Fig 3.13. from the plot it is concluded that mechanical efficiency(ME) is progressively improve from 0% load condition to 100% load condition. The ME for T JME 3 gm is nearly about 85.6% at 100% load condition. The Mechanical efficiency of base engine is 76.6% at 100% load operation. The mechanical efficiency for TJME 3 gm is high correlated to base fuel and about 10.65% at partial load condition. The addition of fuel additives to fuel improves the cetange number.

Fig-3.4 shows the difference between brake output power and fuel consumption for unit brake power. The specific fuel consumption is decreased from 0% to 35% rated load. The SFC for T JME 3 gm is 0.27 kg/kWh at partial load condition. The brake specific fuel consumption of base engine is 0.302 kg/kWh at 100% load operation. The brake specific fuel consumption(BSFC)for TJME 3 gm is high correlated to base engine and is 6.8% at partial load operation. The main cause is mixing of fuel additives in biodiesel improves the bonding strength of mixture, this leads better mixing of fuel air ratio.

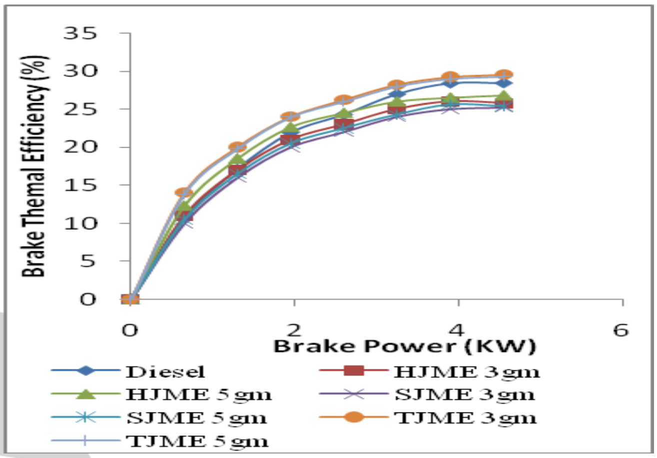

Fig.3.1. BP vs BTE

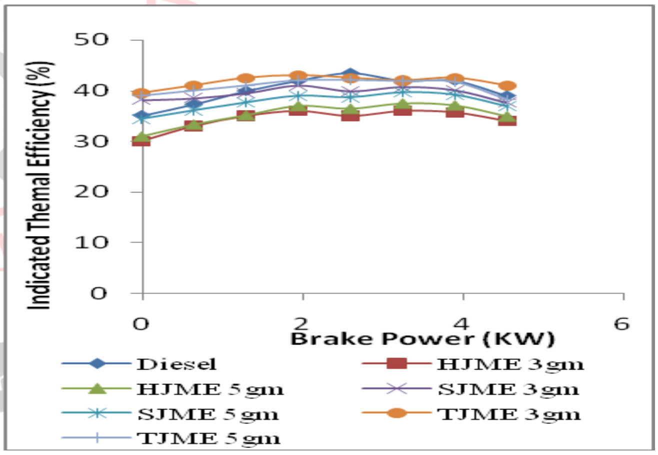

Fig.3.2. BP vs ITE

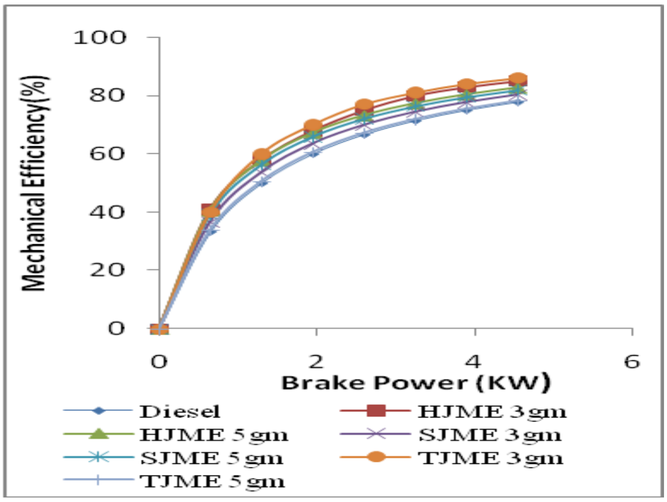

Fig.3.3. BP vs ME

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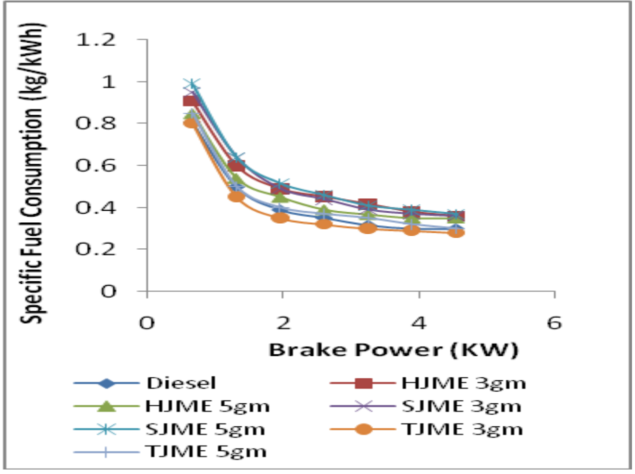

Fig.3.4. BP vs SFC

The pollutant parameters are evaluated by using compression ignition base engine with various piston configurations & $CaCO_3$ fuel additive particles. The pollutant characteristics like hydro carbons, NO_x, carbon dioxide & Carbon monoxide are analyzed.

Fig-3.5 shows the variation of brake power vs CO emissions with various proportions of $CaCO_3$ in biofuel. In the graph it is observed that the Carbon monoxide pollutant parameters are low for 0% to 85% rated load condition. Further the pollutant parameters are drastically increased after 85% of full load condition. At maximum load condition the carbon monoxide pollutants are about 0.14% for Toroidal JME 3gm. Further the CO pollutants are about 29.5% less for Toroidal JME 3gm correlated to standard engine at maximum load condition. This is mainly due to increased burning rate of biofuel.

The brake power vs hydrocarbon pollutants graph is shown in Fig-3.6. From the graph it is identified that the HC pollutants are increased gradually from zero load to maximum load condition. At maximum load condition the HC pollutants are about 55 ppm for Toroidal JME 5gm where as for standard engine it is about 64 ppm. The HC pollutants observed for TJME 5gm is about 13.8% which is less correlated to standard engine HC pollutants. The more oxygen content in the biofuel leads to proper combustion of the fuel in the combustion chamber. This reduces the hydrocarbon pollutants of the engine.

Fig-3.7 indicates the brake power vs carbon dioxide pollutants. The carbon dioxide pollutants are increased from zero load to maximum load condition for all additive proportion of the biodiesel. At maximum load condition the CO_2 pollutants are about 10.2 % for Toroidal JME 5 gm. The CO_2 pollutants at maximum load condition is about 11.4% for standard engine. At maximum load condition carbon dioxide pollutants are about 8.3% less for TJME correlated to base engine. The reduction in carbon dioxide pollutants are due to improved combustion of air fuel mixture.

Fig-3.8 shows the relation between brake power and oxides of nitrogen pollutants. From zero load to 80% full load condition the NO_x pollutants are increased linearly. After that the oxides of nitrogen pollutants are almost constant for all additive proportions. At maximum load condition the NO_x pollutants are about 1920 ppm for Toroidal 3gm where as for standard engine the oxides of nitrogen pollutants are about 2155 ppm. At full load condition the oxides of nitrogen pollutants are about 10% less for Toroidal JME 3gm compared to base engine. The reduced rate of heat release in combustion process is the main reason for reduction in nitrogen oxide pollutants.

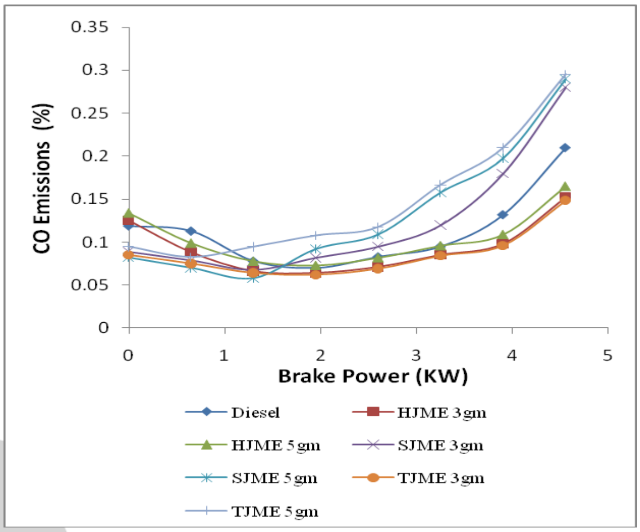

Fig.3.2.1 BP vs CO

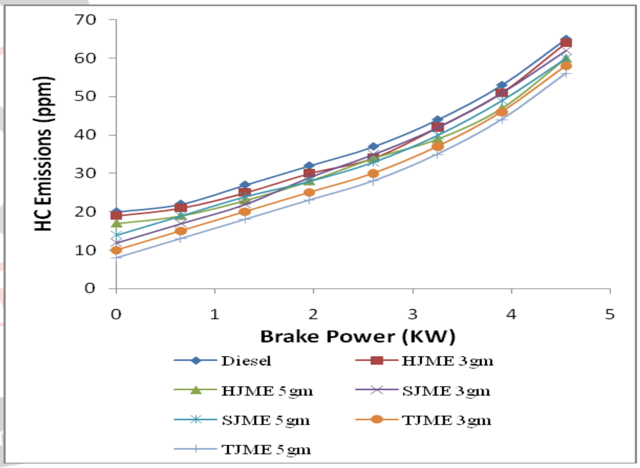

Fig.3.2.2 BP vs HC

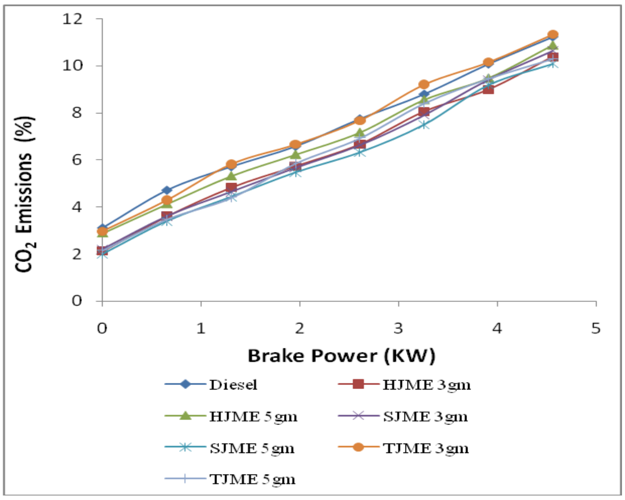

Fig.3.2.3 BP vs CO_2

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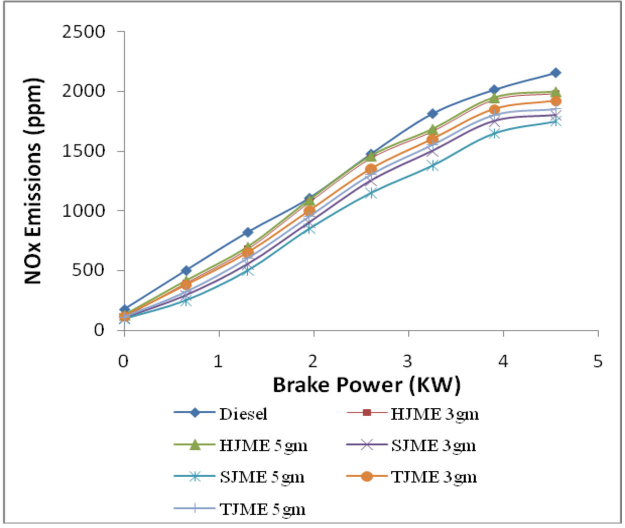

Fig.3.2.4 BP vs NO$_x$

IV. CONCLUSIONS

The experiments are conducted on 4- Stroke, direct injection, single cylinder, water cooled CI engine with Neem and Jute methyl esters used as fuels by addition of fuel additives. The conclusions are mentioned below:

- The Brake Thermal Efficiency(BTE) recorded with Toroidal JME 3 gm is 3.4% more correlated to remaining fuel additives percentages. The friction in the engine is reduced by the addition of fuel additives and the engine power is increased.
- By using Toroidal JME 3 gm the Mechanical efficiency is improved about 10.4% correlated with standard engine. This is due to quality of cetane number.
- The Specific Fuel Consumption(SFC) is decreased by addition of fuel additives and is about 6.9% correlated to standard diesel. The mixture bond strength is increased by addition of fuel additives which leads better mixing of fuel air ratio.
- The carbon monoxide pollutants of TJME 5 gm is minimized about 13.7% correlated to base diesel. The main cause is complete-combustion of fuel by the addition of additives.
- The hydrocarbon pollutants of TJME 5 gm is minimized about 13.79% correlated to base diesel. Complete combustion is the main reason for decrease in HC pollutants.
- The oxides of nitrogen pollutants are about 18.7% less for SJME 5 gm compared to base diesel. This is because of low heat release rate in combustion chamber.

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