Performance and emission characteristics of diesel engine fuelled with methyl ester of cotton seed oil blended diesel fuel with additives of DEE

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ABSTRACT

Biodiesel has good impact on the alternate fuel for compression engine. Cotton seed oil has good viability to produce the biofuel for diesel engine. Cotton seed oil methyl ester was produced by the transetrification process using methanol as solvent and KOH as catalyst. The fuel was prepared by blending the methyl ester of cotton seed oil with diesel with 10%, 20% and 30% with the additives (DEE) of 5% and 10% on volume basics. The experiment was conducted on the single cylinder four stroke water cooled naturally aspirated diesel engine coupled with eddy current dynamometer at constant speed of 1500rpm by varying the load. The result shows that reduction in the Brake thermal efficiency for the blended fuel with and without additives of DEE. SFC was found higher for the blended fuel with and without DEE. Addition of the DEE increases the CO, HC emissions and reduces the Nox and Co_2 emissions.

KEY WORDS: CI Engine, Cotton seed oil methyl ester, Di Ethyl Ether

1. INTRODUCTION

For past two hundred years world energy scenario was struggling in meeting the demand and fails to meet the environment aspect. Economy of the country was depending mainly on fuel. Transport plays major role in a country economy which mostly reliable in diesel engines. So demand of petroleum diesel is increasing in current status. Diesel fuel is suffering in its availability and more emissions. Compression ignition engine is supporting for alternate fuel like oil derived from the vegetables, non edible plants, and animal feedstock and from the animal waste. Biodiesel is best alternate fuel for compression ignition engine by having good diesel engine fuel properties like cetane number, less viscosity when fuel is blended with diesel fuel, more oxygen content supporting for good combustion behaviour. One of the most viable methods for producing biodiesel transterification process. Many researches was conducted in edible oil and non-edible oil biodiesel which shows the favour of good combustion, performance and emission characteristics. Umer Rashid (2009) produced cotton seed oil methyl ester from cotton seed oil by transesterification process. He produced methyl ester by four different catalyst namely potassium methoxide, sodium methoxide, sodium hydroxide and potassium hydroxide. Experiment was carried out for the molar ratio (oil to methanol) of 1:3 to 1:15, Reaction temperature of 25 to 65°C, catalyst concentration of 0.25 to 1.5%, stirring speed of 180 to 600 rpm. He found that best thing as sodium methoxide of 0.75%, molar ratio of 1:6, reaction temperature of 65°C and stirring intensity as 600 rpm. Ali Keskin (2008) conducted the experiment on single cylinder diesel engine fuelled with cotton seed oil methyl ester blended diesel fuel. His result shows reduction in brake power and torque and increase in brake specific fuel consumption. At higher load conditions smoke intensity was found reduced. Basavaraj, Shrigiri (2016) produced methyl ester of cotton seed oil and neem oil by the transetrification process using methanol as solvent and alkaline as catalyst. His results showed that brake thermal efficiency was lower than diesel fuel and BSFC was found higher than diesel fuel. Emission parameter like NO_x, HC, CO was found higher than diesel fuel. Murat Karabektas (2008) found that preheating the biodiesel reduces the viscosity of the fuel. Brake thermal efficiency of biodiesel was found higher than diesel for biodiesel which was preheated to temperature of 90°C. Nox emission was found higher than diesel because of pre heating of biodiesel. Anbarasu Augustine (2009) preheated the methyl ester of cotton seed oil to reduce the viscosity upto 4.25 times. Cotton seed oil methyl ester heated to temperature of 80°C has better brake thermal efficiency and lower emission expect the oxides of Nitrogen. Md. Nurun Nabi (2012) found that high oxygen content of the cotton seed oil methyl ester blended diesel fuel has lower the particulate matter, smoke intensity and Co emissions and increase the oxides of nitrogen. K.R. Patil (2015) found that addition of Di ethyl ether to mixture of kerosene and diesel reduced the calorific value, density and improved the oxygen content and cetane number. Imtenan (2015) found that addition of DEE has significant effect on the lower blended fuel of jatropha methyl ester with diesel fuel. DEE addition to lower blended fuel reduces the Nox emission when compare to lower blended fuel but higher than diesel fuel. Obed Ali (2016) found that addition of DEE with palm oil biodiesel with diesel in reduce the calorific value, kinematic viscosity, density, acid value, pour point, cloud point

2. METHODS AND METHODOLOGY

Cotton seed oil methyl ester was produced by transesterification process by using methanol as solvent and KoH as calatayst. Cotton seed oil was cleaned with water having temperature 70°C and separated using separating funnel kept 3-5hrs. Cleaned oil was heated above 108°C to remove the water content in the oil. Initially oil was heated up to 60°C and mixed with methanol in the molar ratio 1:9 oil to methanol and 2% by weight KoH was added and stirrer for 2 hours. Then whole mixture was poured in the separating funnel for 3hours to separate the methyl ester and glycerol. The separated methyl ester of cotton seed oil was heated up to 108^0C in order to remove the water content.

Fuel was blended with diesel in the ratio B10, B20, B30, B10 with 5% and 10% of DEE (B10(5%DEE) and B10(10%DEE)),B20 with 5% and 10% of DEE(B20(5%DEE) and B20(10%DEE)) and B30 with 5% and 10% of DEE(B30(5%DEE) and B30(10%DEE) whose properties are shown in the Table 1.

The performance test was conducted on four stroke single cylinder water cooled naturally aspirated compression ignition engine coupled with eddy current dynamometer at constant speed 1500rpm by varying the load from 0% to 100%. Engine set up diagram shown in the figure no 1.The engine specification was given in the Table no 2. Engine set up consist of orifice meter with U-tube manometer for measuring the volume flow rate of air. Burette was attached in between the fuel tank and engine to measure mass flow rate of fuel. Speed of the engine was measured by the speed indicator (photoelectric sensor type) having the range of 6000rpm. Load on the eddy current dynamometers was measured by load indicator (load censors – load cell range of 0-50kg). Exhaust gas emission was recorded by AVL gas di gas analyser whose specifications are shown in the table 2.

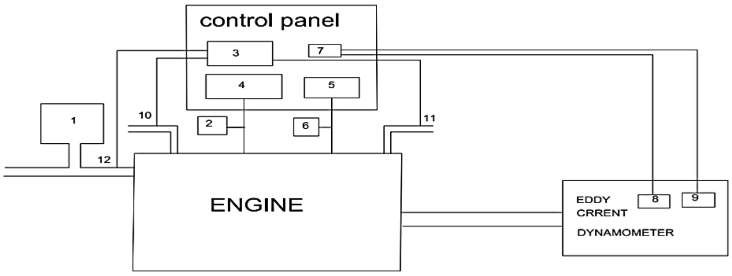

Figure.1. Engine setup

1) AVL gas analyzer, 2)Burette, 3) Temperature indicator, 4) Fuel tank, 5) Air tank, 6) u-tube manometer, 7) Load indicator and speed indicator, 8) Speed sensor, 9) Loading sensor, 10) Cooling water inlet temperature, 11) Cooling water outlet temperature, 12) EGT thermocouple

Table.1. Specifications of engine

Description	Specification
Make	Kirloskar
Type	TV1
No of cylinder	Single cylinder
No of stroke	Four stroke
Rated power	5.2 kW (7 BHP) at 1500 rpm
Type of Dynamometer	Type Eddy current
Type of cooling	Water cooling
bore	87.5 mm
stroke	110 mm
capacity	661 CC

Table.2. Specifications of Measuring instruments

Instrumentation	component	Measuring range	Accuracy	Resolution
AVL gas Digas 444 Analyser	HC (PPM)	0-20000	± 10PPM	1ppm
	Co (% by vol)	0-10%by vol	±0.5%	0.01%vol
	Co_2(%by vol)	0-20%by vol	±0.5%	0.1%by Vol
	O_2 (%by vol)	0-22% by vol	±0.1%	0.01% by vol
	Nox (ppm)	0-5000ppm	±50 ppm	1PPM

Table.3. fatty acid composition

Fatty acid	(%)
Palmitic acid $C_{16:0}$	28
Stearic acid $C_{18:0}$	1
Oleic acid $C_{18:1}$	13
Linoleic acid $C_{18:2}$	58

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Table.4. Properties of Fuels

Properties	Dies el	MECSO	B10	B10 5%	B10 10%	B20	B20 5%	B20 10%	B30	B30 5%	B30 10%
Density (kg/m^3)	840	875	843	836	830	847	840	833	850	850	836
Viscosity at 40^{o}C cST	2.6	4.6	2.8	2.60	2.5	3	2.8	2.7	3.2	3.2	2.90
Cetane Number	45	54	45.9	49.8	53.8	46.8	50.70	54.60	47.70	47.70	55.40
net calorific value MJ/kg	44	41	43	43	42	43	43	42	43	43	42

3. RESULT AND DISCUSSION

Brake thermal efficiency:

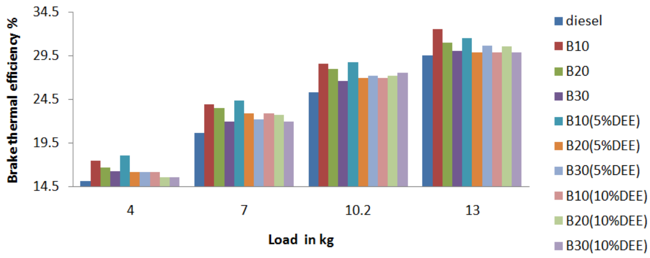

Figure.2.Variation of brake thermal efficiency with load

Brake thermal efficiency for all fuel was increasing with increasing with load. Maximum efficiency was found for B10 at full load condition. BTE was found decreasing with increasing with blending ratio of MECSO without DEE additives to the fuel this is due to high viscosity (Ali, 2016). Blended fuel without additives of DEE has high BTE than diesel fuel because of reduction in heating value and higher oxygen content of the blended fuel. Without DEE additives BTE for B10 was found higher because of its higher oxygen content and less compensation with lower heating value compared to diesel. Addition of 5% of DEE by volume in B10 decrease the BTE because of combined effect reduction viscosity and lower calorific value of the DEE. Further increasing in the blending ratio of MECSO with DEE decrease the BTE due its higher viscosity of CSOME.

Brake Specific fuel consumption

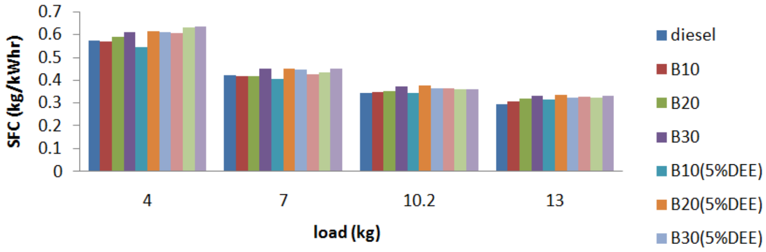

Figure.3.Variation of Specific fuel consumption with load

SFC for blended fuel was higher than the diesel because of its lower heating value of the fuel. SFC for all fuel was gradually decreasing with increasing in load applied to the engine because SFC was inversely proportional to brake power. SFC was found lesser for diesel than blended fuel at higher loading conditions of the engine because of higher calorific value. Without additives of DEE, B10 have less SFC and somewhat close to diesel at all range of loading conditions. Further addition of MECSO, SFC was increasing because of its lower calorific value of the fuels. Addition of DEE to Blended fuel was found increased because of lower heating value of DEE. B10 (5%DEE) has significant effect on SFC fuel because of higher cetane number and less reduction in heating value and less viscosity. Further increase in amount of DEE leads to higher SFC because of lower calorific value of CSOME and DEE.

Carbon di oxide

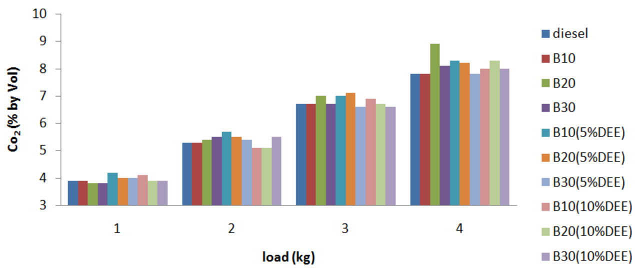

Figure.4.Variation of CO2 with load

Co_2 emission was found increase with increase in load of the engine. All the blended fuel has very close emission value this is because of higher oxygen content. B10 is very close to diesel than B20 and B30 due to is higher calorific vale with good oxygen content. Addition of 5% to DEE leads to higher emission because of high volatile nature of DEE and reduce the viscosity of the fuel. B10 has higher co_2 emission because of the combined effect of higher calorific value, higher oxygen content, higher cetane number and lower viscosity of the fuel. Further addition of DEE leads to reduction of Co_2 because of lower calorific value of the fuel.

Carbon monoxide

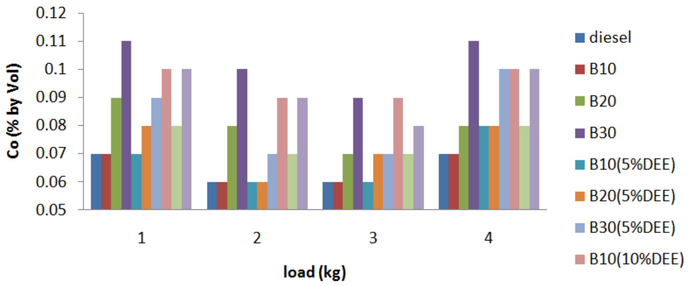

Figure.5.Variation of CO with load

CO emission was gradually decreasing with increasing in load applied on the engine up to middle load condition and increase further with increase with load. All blended fuel has higher co emission than diesel fuel because of its higher viscosity. B10 and B10(5%DEE) has very close co emission behaviour with diesel. Increasing the blending ratio of MECSO without additives of DEE found increased in co emission because of poor atomization of fuel due its higher viscosity. B30 has higher emission of Co because of poor atomization of fuel lead to higher ignition delay period. At higher blending ratio and higher content to additive level lead to increase in co behaviour because of higher latent of evaporation of DEE. B10(5%DEE) has lower co emission because of higher cetane number and its lead to reduction in period of the ignition delay of fuel.

Unburnt Hydrocarbon

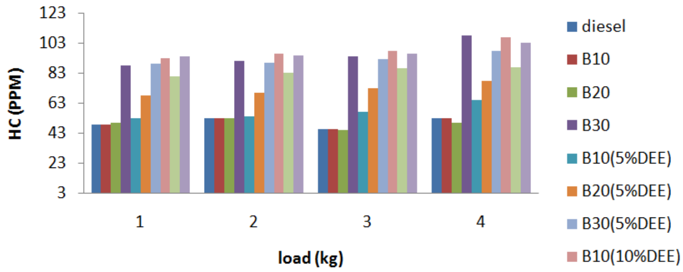

Figure.6.Variation of HC with load

Incomplete combustion of fuel leads to unburnt hydrocarbon emission. Unburnt Hydrocarbon emission increase with increase in load because of increased amount of fuel to obtain the power. Increasing the MECSO blending ratio increase the Hydrocarbon emission. Increasing the amount of DEE in blended fuel also increase the Hydrocarbon emission because of the higher fumigation rate (Devaraj, 2015). B10 has very close HC emission with diesel. Higher blended fuel of CSOME and DEE has higher emission of HC because of lower calorific value and higher viscosity of fuel. Higher viscosity leads to poor atomization of fuel increase the ignition delay.

Oxides of Nitrogen

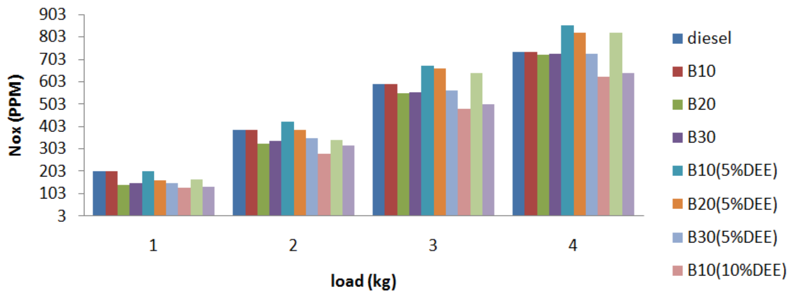

Figure.7.Variation of NOX with load

Nox emission was increasing with increase in load. B10(5%DEE) was found higher Nox emission than all other fuels. This is because of higher cetane number and higher calorific value and more oxygen content in the fuel. Increasing the blending ratio of CSOME increase the Nox emission because of higher oxygen content of fuel. Addition of DEE leads less Nox emission because of high cetane number of DEE (Devaraj, 2015) and Volatile reduce the ignition delay leads to good combustion. Increasing the CSOME and DEE leads in reduction in calorific value and DEE has the effect to lower the temperature is reason for the reduction of Nox (Dimitrios, 2012).
and found lesser Nox emission.

4. CONCLUSION

From the graphical analysis, the following points were concluded

- By adding the MECSO to Diesel fuel leads to reduction in the brake thermal efficiency because of the higher viscosity of the fuel. Addition of DEE leads to lower the brake thermal efficiency.B10 and B10 (5%DEE) has closer value of the BTE to diesel fuel.
- SFC was found lesser for diesel fuel when compare to blended fuel because of the higher calorific value of the fuel. Addition of the DEE leads to higher SFC because of the lower heating value of the DEE.
- Co_2 emission was found higher for B10 and B10 (5%DEE) because of higher oxygen content and higher calorific value of the blended fuel.
- Co emission was found higher for B30 because of the higher Viscosity. Addition of DEE leads to reduction in Co emissions.
- Unburnt Hydrocarbon was found higher for the 10% addition of the DEE when compare to the diesel duel.B10, B20 and B30 has closer emission of HC with diesel fuel.
- Addition of 10% of DEE to blended fuel reduces the Nox emission because of lower calorific value of the fuel. Addition of 5% of DEE to the blended fuel has higher Nox emission because of the combined effect of the higher cetane number and lower viscosity of DEE.

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