ISSN 2229-5518

Preparation, Performance and Emissions of Cotton Seed Biodiesel Fuel

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Abstract - During this COVID-19, when the world population is suffering, earth is healing and one of the biggest reasons behind this is exponential reduction in greenhouse gas emissions. We can watch how good it is for our environment if we reduce COx, NOx, SOx ,etc harmful gas emissions in the atmosphere. Hence, we must come together and find alternatives for these harmful gas emissions during this crisis period.
We have worked upon a bio-fuel called as “cotton seed oil”. We would like to present the preparation techniques, the performance and emission statistics of this fuel when tested with a diesel engine in this paper.

Index Terms – Transesterification, Bio fuel, Cotton Seed, Bio Diesel, Performance, Emission, Diesel Engine

1 INTRODUCTION

Biofuels are fuels made from freshly grown plant or animal matter. The environmental impact due to use of fossil fuels is enormous, adding to the depletion of the limited amount of resources. Many toxic chemicals contained in fossil fuels are released into the atmosphere upon burning of oil and coal. Biofuels are less toxic than fossil fuels. Biofuels have been identified as a potential solution (at least partially) to the issue of greenhouse gases resulting from fossil fuels. The biofuels still release carbon dioxide into the atmosphere, but since the fuel is derived from recently grown plants, the carbon dioxide has been extracted from the atmosphere through photosynthesis, and will be reused by future crops. By limiting the amount of carbon moving from the underground to the atmosphere, the idea is to reduce the intensity of global warming.

2 SECTION 1: PREPARATION

Biodiesel is obtained by reacting triglycerides (natural oils) with an alcohol (usually methanol) in the presence of a catalyst. There are different methods for carrying out the reaction, but one of the simplest and most common is a base-catalyzed batch reaction of oil with methanol. This reaction is called transesterification. Any type of triglyceride, which includes plant or animal based oils, can be used as the feedstock. The base catalyst, typically lye (sodium hydroxide or potassium hydroxide), is mixed with the alcohol before the reaction is started. The alcohol/catalyst mixture is then added to the oil and the whole mixture is stirred vigorously. After the reaction occurs, there will be two products, which separate into phases (like oil and water). The lower density phase (on top) is the biodiesel, and the higher density phase is glycerin.

2.1 Procedure – Transesterification

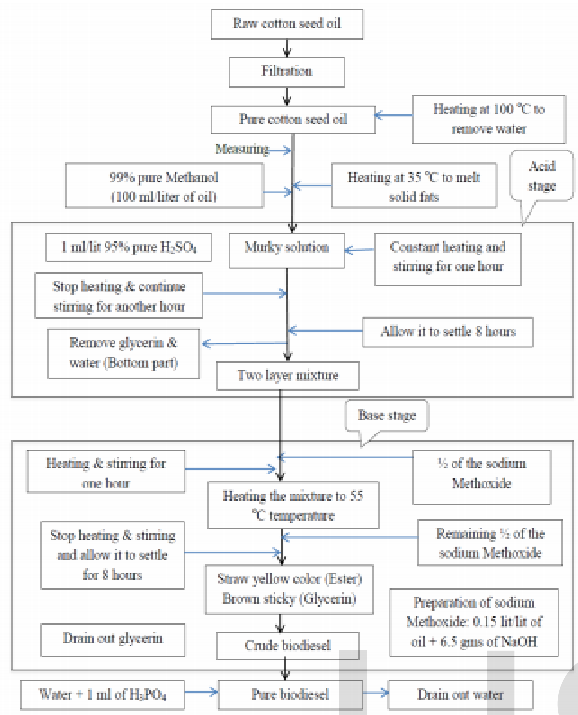
- Put the stir bar in the 250mL flask and place the flask on the heated stir plate and turn the heat onto high.
- Pour the oil sample into the reaction vessel (250 ml flask)
- The oil is warmed before adding the methoxide. The stirring is made to speed up the heating process.
- The thermometer is used to observe oil temperature.
- When the temperature reaches 55 degrees C, the oil is ready for usage.
- Slowly add the 50mL of methoxide to the reaction vessel.
- The two layers were formed and the bottom layer is glycerol was discarded and the top layer was washed with lukewarm water and heated to remove moisture.

3 SECTION 2: EXPERIMENTAL SETUP

The experimental tests were conducted on a single-cylinder, four-stroke, and water cooled diesel engine with eddy current dynamometer having a rated output of 3.5 kW at a constant speed 1500 rpm. It was fuelled with CSOME and PD fuel separately and was operated at different engine load conditions.

The Eddy current dynamometer was coupled to the engine for different loading (0-12 kg) conditions. The engine and dynamometer were interfaced to a control panel which is connected to a computer. The exhaust gas emissions from the engine was measured using AVL multi exhaust gas analyzer (NOx, HC, CO, CO2, O2) and the smoke opacity was measured using AVL smoke meter.

3 FIGURES AND TABLES FOR PREPARATION



Flowchart for Biodiesel Production

Properties	Element	Value
Carbon chain C_n	-	C_{14}-C_{22}
MW (g/mol)	-	859.64
Fatty acids (%)	Saturated	27
	Unsaturated	73
	Mono-unsat	20
	Poly-unsat	53
	Unsat-sat	2.7
Iodine value (g I_2/100g)	-	98-115
Cetane number	-	41.8
kV @40°C (mm^2/s)	-	34
Density @15°C (kg/ m^3)	-	915
Composition (%)	C	70.96
	H	11.43
	N	1.31
	O	9.46
	S	0.29
	C/H	6.2

Properties of Cotton Seed Oil

Model	Kirloskar TV1 engine
Engine type	Four stroke diesel engine
Number of cylinders	One
Cooling system	Water
Rated power	3.5 kW
Bore × Stroke	87.50× 110.0 (mm×mm)
Connecting Rod length	234 mm
Compression ratio (variable)	17.5:1
Fuel injection system	In-line, direct injection
Fuel injection timing	23° BTDC
IVO	4.5° BTDC
IVC	35.5° ABDC
EVO	35.5° BBDC
EVC	4.5° ATDC
Nozzle opening pressure	215 kgf/cm^2
Rated speed (constant speed)	1500 rpm
Swept volume	661.45 (cc)
Loading device	Eddy current dynamometer (water cooled)
Dynamometer Arm Length	185 mm

Technical Specifications of Engine Test Rig

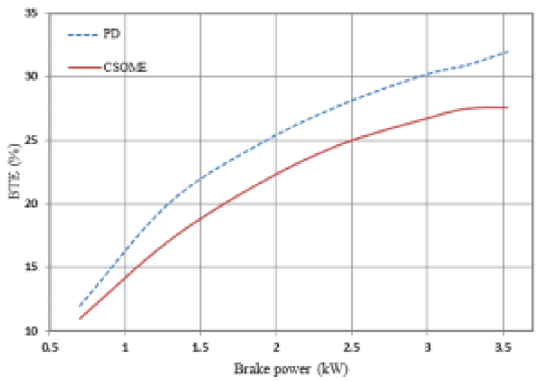
Visual Schematic of Engine Test Rig

ISSN 2229-5518

4 SECTION 3: PERFORMANCE ANALYSIS AT DIFFERENT BRAKE POWERS(FIGURES AND TABLES)

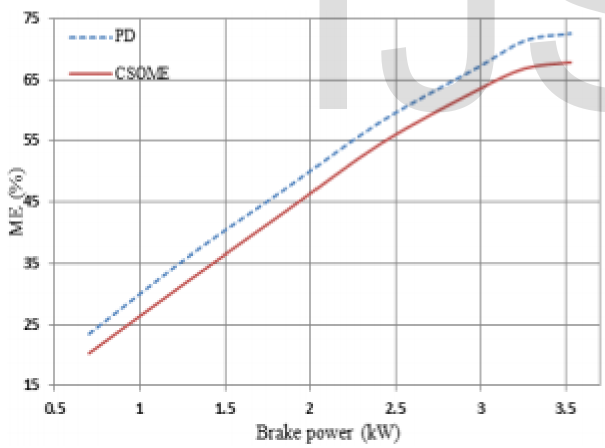
- PD- Pure Diesel
- CSOME – Cotton Seed Oil Methyl Ester

4.1 Brake Thermal Efficiency :



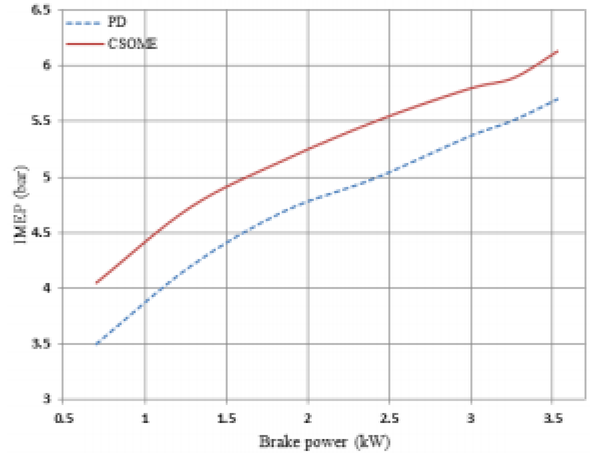
Variation in brake thermal efficiency with change in brake power

4.2 Mechanical Efficiency :



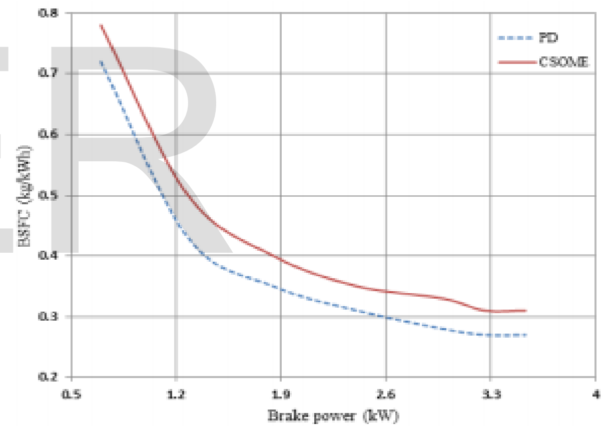
Variation in mechanical efficiency with change in brake power

4.3 Indicated Mean Effective Pressure :



Variation in indicated mean effective pressure with change in brake power

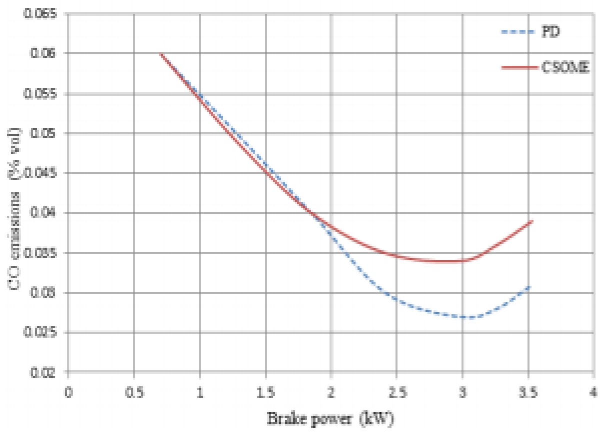
4.4 Brake Specific Fuel Consumption(BSFC)



Variation in brake specific fuel consumption with change in brake power

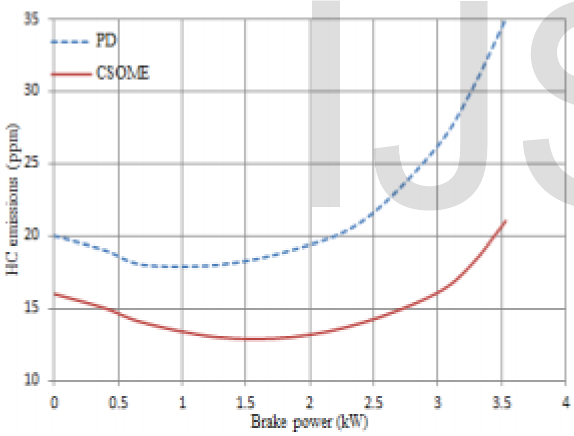
5 SECTION 4: EMISSION ANALYSIS AT DIFFERENT BRAKE POWERS(FIGURES AND TABLES)

5.1 Carbon Monoxide :



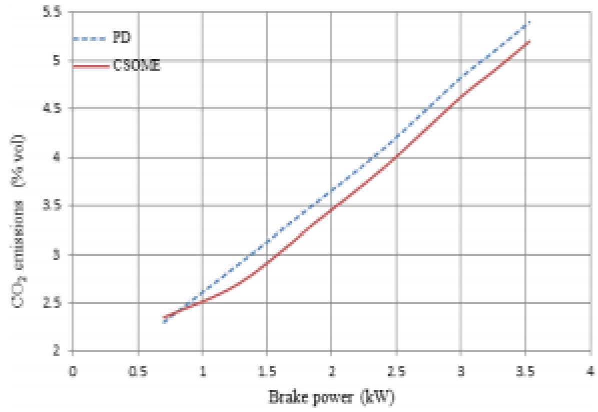
Variation in CO emission with change in brake power

5.2 Unburnt Hydrocarbons :



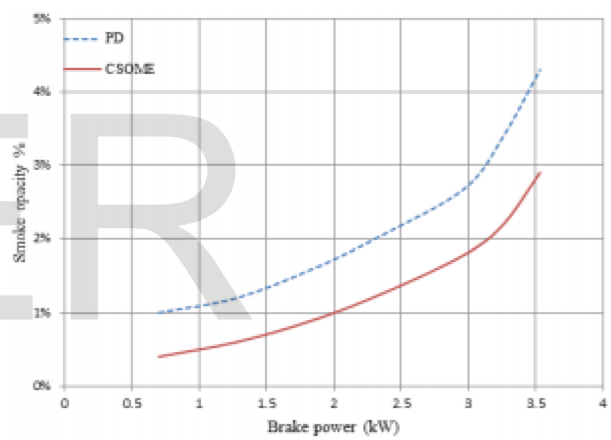
Variation in HC emission with change in brake power

5.3 Carbon Dioxide :



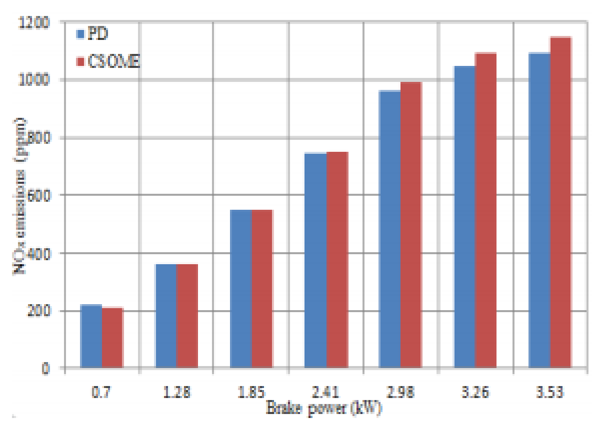
Variation in CO_2 emission with change in brake power

5.4 Smoke Capacity :



Variation in smoke opacity with change in brake power

5.5 NOx Emissions :



Variation in NO_x emission with change in brake power

ISSN 2229-5518

6 CONCLUSION

Based on the experimental study, the following conclusions are summarized as follows:

- Due to the higher density of biodiesel, an early injection occurs resulting in higher cylinder pressure.
- There is a decrease in brake thermal efficiency of CSOME comparing to PD (11.58%) since it has lower calorific value due to the presence of excess oxygen.
- Mechanical efficiency is slightly lower for CSOME (8.12%) due to its higher viscosity and lower volatility.
- Indicated mean effective pressure of CSOME is 10.12% greater than that of PD.
- Brake specific fuel consumption of CSOME is 14.18% greater than that of PD due to its lower energy content.
- A drastic reduction in unburned hydrocarbon (37.9%) and smoke opacity (32.56%) were recorded for CSOME as compared to PD because of its higher oxygen content which results in better and complete combustion but this leads also to an increase in oxides of nitrogen.
- Regarding carbon monoxide, there is an increase for CSOME compared to PD at maximum output power due to higher peak pressures (and also higher rate of pressure rise which is more than 6) leading to higher knock levels and less smooth combustion.
- In case of carbon dioxide, there is a 3.7% decrease for CSOME compared to PD because of its higher viscosity levels which leads to decreasing the cone angle and results in the reduction of air entrainment in the spray.
- In case of oxides of nitrogen, there is an observed 5.023% increase for CSOME compared to PD due to higher oxygen content of biodiesel which will form oxides of nitrogen at greater combustion temperatures.

Hence, the methyl esters of cottonseed oil can be used as an alternate fuel for (CIDI) diesel engines without any engine modification. It gives lesser un-burnt hydrocarbon, carbon dioxide and smoke emissions when comparing to PD fuel, however at the expense of nitrogen oxides and carbon monoxide emissions.

7 REFERENCES

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