IOP Conf. Series: Materials Science and Engineering **330** (2018) 012104 doi:10.1088/1757-899X/330/1/012104

Experimental studies on natural aspirated diesel engine fuelled with corn seed oil methyl ester as a bio-diesel.

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Abstract: This paper evaluates the possibilities of using corn seed oil methyl ester as a fuel for compression ignition engines. The biodiesels are contained high oxygen content, and high Cetane number, due to this properties efficiency of biodiesel is higher than diesel fuel. The experiments were conducted with different biodiesel blends of (B10, B15, B20 and B25) corn seed oil on single cylinder four stroke natural aspirated diesel engines. Performance parameters and exhaust emissions are investigated in this experimental with the blends of the corn seed oil methyl ester and diesel fuel. The test results showed that the bio-diesel blends gives improved results for brake thermal efficiency and specific fuel consumption when compared with the diesel fuel. The emissions of corn seed methyl esters follow the same trend of diesel but the smoke opacity was reduces for all blends. From the investigation, corn seed methyl ester is also having the properties similar to diesel fuel; it is biodegradable and renewable fuel, so it will be used as an alternative for diesel fuel.

Abbreviations:

CSOME: Corn Seed oil methyl ester; SFC: specific fuel consumption; BTE: Brake thermal efficiency; B10: Blend of 10% CSOME & 90% diesel; B15: Blend of 15% CSOME & 85% diesel; B20: Blend of 20% CSOME & 80% diesel; B25: Blend of 25% CSOME & 75% diesel; CO: carbon monoxide; NO_x: nitrogen oxides

1. Introduction:

The considerable amount of Biodiesel generation is the highly necessary step for our mechanical world, mainly due to tremendous decrement in fossil fuel resources and environmental impacts. It can be replaced the diesel fuel in compression-ignition engines with little or no modifications in the engine setup. Raju et al. [1] conducted experiments using mahua seed oil at various concentrations with diesel and the results revealed that blend of mahua seed oil produces high BTE and lower exhaust emissions when analysed with conventional diesel, due to inherent oxygen availability of biodiesel and the more Cetane value. B.Ashok et al. [2] conducted a novel research on the production of biodiesel from lemon fruit rinds and concluded lemon peel biodiesel and its blends show better performance and lower emissions when compared to conventional diesel because of its lesser density and low boiling point. Pankaj S. Shelke et al. [3] experimented on the use of cottonseed as biodiesel and investigated of combustion characteristics of diesel engine. Based on the experimental results of the diesel engine with cottonseed biodiesel blends as compared to base diesel, cottonseed biodiesel can be used in blended form as an alternative fuel in any diesel engine without any modification. Biodiesel was easier to use, reproducible, and essentially free of toxic particulates. The advantages of biodiesel are that it displaces petroleum thereby reducing global warming gas emissions, particulate matter, hydrocarbons, carbon monoxide, and other poisonous pollutants [4, 5]. Biodiesel improves lubricity and reduces premature wearing of fuel pumps. Transesterification process solves the high molecular weight and high viscosity problems of biodiesel and increases its Cetane number. F. Aydin et al.[6] and Mark W. Majewski et al.[7] reported the detailed description of the Transesterification process can be found in the literature. The density and viscosity of fatty acid methyl ester of corn oil-diesel fuel blend increase with the increase of biodiesel concentration [8-10]. If CSOME is used as a feedstock to produce biodiesel, it will contribute to both economic advantages and also reduction of environmental problems caused by fossil fuels. This experimental investigation, carried out with the aim to decrease the viscosity of corn oil by dilution with diesel and to identify key characteristics of CSOME blends that affect the performance of engines running on these fuels. The fuel obtained by blending CSOME oil with diesel in a pre-defined percentage by volume was characteristics were compared with diesel. Researchers [11-13] investigate on the emission quality, performance and combustion quality of the naturally aspirated compression ignition engine fuelled with CSOME-diesel blends. Dalyelli S. Serqueira et al. [14] and M.B. Dantas et al. [15] they were concluded that both oxygen content and exposition time play an important role in the formation of undesired compounds, which can corrode the engines.[16-18] investigated biodiesel of various origins and concluded that CO emissions were reduced with the use of biodiesel of various origins with respect to diesel. Harveer S. Pali et al. [19] conducted experiments on sal methyl ester biodiesel blends and shown lower exhaust emissions such as CO, HC and smoke for all biodiesel blends when compared with base fuel. However, the NOx emissions were higher for the sal methyl ester blends. Ayatallah Gharehghani et al. [20] performed experiments on waste fish oil as biodiesel on diesel engine and the experimental results indicates that waste fish oil generates increased thermal efficiency and reduced SFC at full load condition when compared to diesel. S.Saravanan et al. [21] investigated on rice bran oil as bio diesel is stationary diesel engine and noticed that higher reductions in hydrocarbons and intensity of smoke when differentiated with diesel and finally concluded that due to lesser emissions, this biodiesel is promising source for sustainable nature. Mishra et al. [22] used the Calophyllum vegetable oil blends with diesel at various concentrations and reported that bio diesel blend of 10% concentration produces significant emission reductions of 12% carbon monoxide and 25% oxides of nitrogen. However, there was some decrement in engine performance.

It is evident that most of the work has been focussed on edible oils to replace diesel in diesel engines. It is also noted that among edible oils jatropha, mahua, lemon peel oil and some other biodiesels have been explored. The current experimental work deals with use of corn oil have biodiesel feedstock, its physico-chemical properties and experimental investigation of performance and emission characteristics.

2. Material & Method

This study used corn oil methyl ester, procured from a local supplier. In this present work commercially available diesel fuel was blended with the CSOME. The transesterification method was preferred for converting crude oil into biodiesel. Corn seed is available annually in India. From the dry seeds of corn oil was obtained by means of solvent extraction technique. The corn seed oil process was done with sodium hydroxide as the catalyst in the transesterification. It is the reaction of fat or oil with alcohol to form methyl ester and glycerine. Sodium hydroxide and potassium hydra oxide are commonly used in esterification process to enhance the chemical reactions. Transesterification process is the best process to produce the cleaner and environmentally safe form of vegetable oils and physio-chemical properties of the biodiesel sample were evaluated experimentally and compared with that of base diesel as per the standards of the ASME. Fatty acid methyl esters derived from Corn seed oil was evaluated as an alternative feedstock for biodiesel production.

2.1 Fuel properties:

The corn seed crude oil is having the higher viscosity than diesel. To improve the volatile nature of biodiesel and reducing the viscosity of the corn oil, transesterification is one of the feasible approaches for obtaining the desirable properties of the biodiesel. Thermal, physical and chemical properties of biodiesel and its blends were experimentally determined at srivenkateswasara engineering services, Kanchipuram, Chennai. The different properties of biodiesel and its various blends showing that these are very close to the diesel fuel. The complete properties of tested fuels are represented in table 1.

Table 1: Properties of Diesel, Corn oil and its blends

Properties	Standard test methods	Diesel	CSOME10	CSOME15	CSOME20	CSOME25	CSOME
Calorific Value(kJ/kg)	ASTM D4809	42,500	42,098	41,897	41,749	41,495	39,920
Specific Gravity	ASTM D 2217	0.830	0.839	0.842	0.846	0.849	0.904
Kinematic Viscosity (mm^2/s)	ASTM D445	3.05	3.198	3.265	3.346	3.412	4.5094
Flash Point(^OC)	ASTM D 93	56	68	70	73	75	168
Cetane number	ASTM D 613	43	43.95	44.42	44.9	45.37	52.5

3. Experimental setup:

A series of experiments has been conducted on Kirloskar Model TV1 Single Cylinder, stationary, 4-stroke, constant speed, water cooled diesel engine using the corn seed methyl ester and its various concentration of bio-blends along with the base fuel. All tests were conducted at varying load conditions. .Necessary instruments were provided after inspection and calibration to estimate the various parameters of the engine and the exhaust emissions. The Engine was run with base fuel to provide the baseline data, and then it was fuelled with different blends of CSOME (B10, B15, B20 and B25) and the detailed engine specifications are represented in table 2.

Fig.1: Experimental setup

Table 2 Engine Specifications

Engine type	Kirloskar model TV1
Rated power/speed	5.2kw/1500rpm
Cylinder diameter	87.5mm
Stroke length	110mm
Displacement volume	661.5cc
Compression ratio	17.5:1
No. Of cylinders	01
No. Of strokes	04
Orifice diameter	20mm
Dynamometer arm length	185mm
Type of cooling	Water cooled

Table 3 List of Instruments used and its Range, Accuracy & uncertainties

Instruments	Measurement	Range	Accuracy	Uncertainty
AVL DI GAS 444N Five gas analyzer	CO[vol]	0-15%	± 0.03%	±0.2%
	CO_2[vol]	0-20%	± 0.5%	±0.15%
	HC[ppm]	0-20000	± 10[ppm]	±0.2%
	O_2[vol]	0-25%	± 0.1[%]	±0.5%
	NO_X[ppm]	0-6000	± 50 [ppm]	±1%
AVL 437C Smoke meter	Opacity[%]	0-99.9	± 1%	±1%

4. Results and Discussions:
4.1 performance characteristics*:*

4.1.1 Brake thermal efficiency:
The variation of brake thermal efficiency with load is shown in Figure 2. It was observed that all the tested biodiesel blends were followed the same trend, that is thermal efficiency is increases with increasing in engine load and also noticed that corn seed methyl ester of 20% biodiesel blend generated better performance characteristics. The maximum BTE for CSOME 20 blend was 34.58% and it was 2.519% higher than the diesel fuel operation and it is mainly due to the inherent oxygen availability and the higher Cetane value contributes the improved thermal efficiency over diesel fuel.

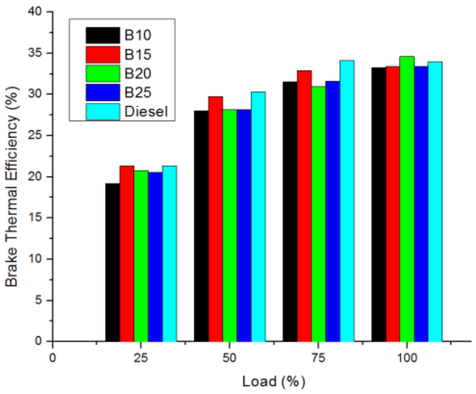

Fig.2: Brake thermal efficiency vs. Load

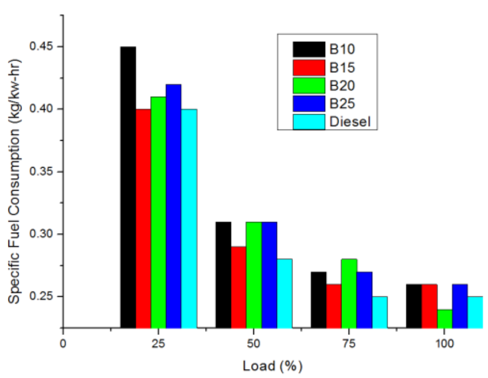

Fig 3: Specific fuel consumption vs. Load

4.1.2 Specific fuel consumption

The main distinction of specific fuel consumption with respect to the engine load is shown in fig: 3. It was found from the figure 3 that specific fuel consumption was decreases with increasing the engine load for all the tested fuels. At peak load condition, the BSFC obtained as 0.25 kg/kW-hr, 0.26 kg/kW-hr, 0.26 kg/kW-hr, 0.24 kg/kW-hr, and 0.26 kg/kW-hr for fuels of diesel, B10, B15, B20 and B25 respectively. It can be observed from the figure 3 that the SFC for CSOME biodiesel blends were lower values than diesel fuel at full load. The availability of the oxygen in the CSOME blends may be the reason for the lower SFC. The CSOME 20 blend showed lower SFC of 0.24 kg/kW-hr than all other tested fuels at maximum load condition.

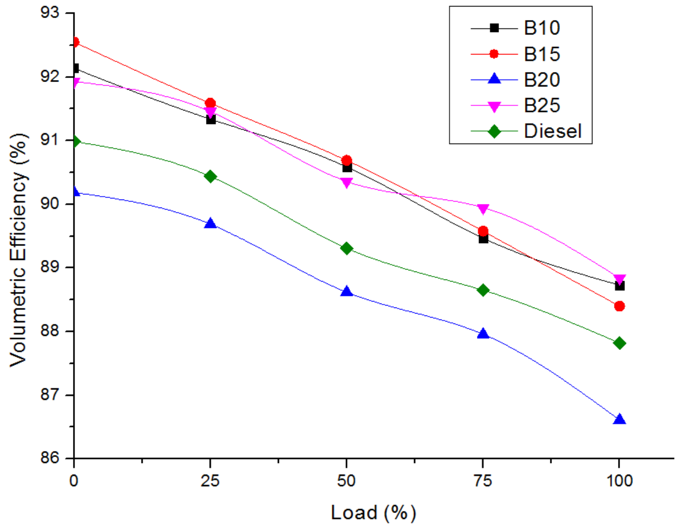

Fig. 4: volumetric efficiency vs. load

4.1.3 Volumetric efficiency

The variation of volumetric efficiency with brake power is shown in fig: 4from the plot it is observed as load increases volumetric efficiency also decreases for diesel as well as blends of CSOME. At full load condition the volumetric efficiencies obtained are 87.82%, 88.73%, 88.4%, 86.61%, and 88.84% for the diesel, B10, B15, B20, and B25 respectively. The decrement in volumetric efficiency is due to take the less amount of intake air due to high exhaust temperature and residual gasses inside the cylinder.

4.2 Emissions characteristics:

4.2.1 Nitrogen of oxides (NO_x)

The formation of NO_x mainly depends on temperature and availability of oxygen during combustion. Fig: 5. indicates the variation of nitrogen oxides (NO_x) emissions of tested fuels with respect to engine load. The availability of oxygen and higher exhaust gas temperature in biodiesel blends produces the higher NO_x formation. It is also seen that the NO_x level increases with increasing load for all the test fuels. The NOx emission for CSOME 20 blend was 2062 ppm when compared to diesel of 2049 ppm, which is 1% higher at full load condition.

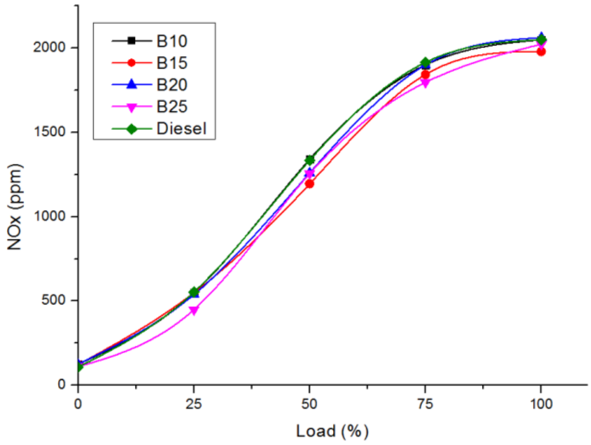

Fig.5: NOx emission with respect to load

4.2.2 Smoke opacity

Fig. 6 show the variation of smoke opacity of tested fuels at varying load conditions. At full load, the smoke opacity is reduced nearly 11% compared to diesel fuel for all tested biodiesel fuel blends (B10, B15, B20, and B25). The trend regarding the variation of smoke opacity with respect to load is almost similar to all type of fuels. Smoke opacity is decreased due to the presence of more oxygen content in the biodiesels, it helps for better combustion in the engines.

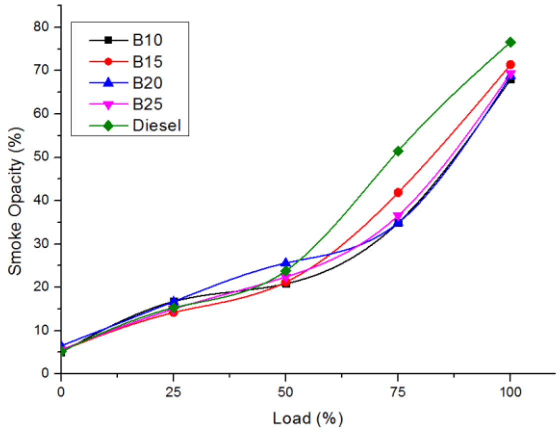

Fig.6: Variation of smoke with load

4.2.3 Carbon monoxide

The variation of carbon monoxide with the load for different biodiesels and diesel as shown in Fig: 7. it was mainly formed due to the incomplete combustion and also the CO formation depends on factors such as air-fuel ratio, injection pressure, and fuel injection timing and the type of fuel. It was noticed that CO emissions of biodiesel blends and diesel followed the same trend with respect to increasing in load but the CO emissions were increases rapidly for biodiesel blends and diesel at maximum load due to incomplete combustion.

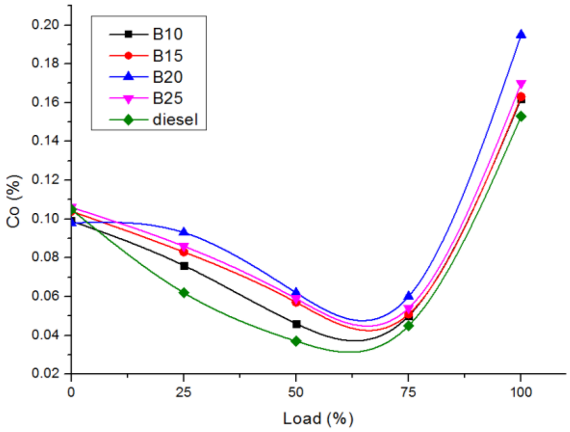

Fig.7: Variation of CO emissions with load

5. Conclusion

The experiments were conducted on four stroke single cylinder natural aspirated diesel engine at the constant speed (1500 rpm) and varying load (0 to 100%) fuelled with diesel and different blends of corn seed oil methyl ester. From the experimental results, the following conclusions were drawn.

- The diesel engine was successfully operated for all the tested corn seed oil blends without any modifications and produces competent results with diesel fuel.
- CSOME 20 biodiesel blend generated better performance and lower emissions when compared to the other blends and also with diesel.
- The maximum BTE obtained for CSOME 20 blend was 34.58% which is 1.7% higher than the diesel fuel (34%). The specific fuel consumption of all CSOME blends is decreases with increase in load and it was observed that BSFC is minimum for CSOME 20 blend, which is 0.24kg/kWh at full load condition.
- The exhaust emissions of tested biodiesel blends were marginally higher at all load conditions when compared with diesel. However the smoke opacity is very low for the biodiesel blends with respect to base fuel.
- As a whole, it was concluded that CSOME blends have shown better performance characteristics compared to diesel fuel. So that it can be used as a potential alternate fuel for diesel engine without any engine alteration. This biodiesel is promising providence for diesel engine and can be used in transportation and agriculture sector in future.

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