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Investigation of Performance and Emission Characters of Compression Ignition Engine Fuelled with Diesel Blends of Linseed and Cottonseed Oil

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ABSTRACT

Modern civilization is much dependent on fossil energy. Energy obtained from fossil resources is much higher than any other resources. The petroleum based fuels are highly contributing to environment pollution. With greater environmental concerns and long term sustainability point of view, it becomes necessary to develop alternative fuels with properties comparable to petroleum based fuels. Biodiesel is the suitable option for transportation vehicles. Vegetable oils are considered as good alternatives to diesel as their properties are close to diesel and able to reduce the net CO_2, HC and NO_X emission. This paper is aimed at the study of the performance and emission characteristics of direct injection diesel engine fueled with blends of diesel, linseed oil and cottonseed oil as fuel. The experiment was conducted with various blend proportions of biodiesel at different engine loads. It was found that BMEP, Indicated thermal Efficiency, Brake thermal efficiency and Specific fuel consumption is slightly maintained at base fuel performance. The main factor is emission of CO_2, unburnt hydrocarbons, NO_x and EGT were less compared with base fuel however, and smoke density and CO were slightly increased.

Keywords: Biodiesel; Transesterification; Linseed oil; Cottonseed oil; Performance; Emission.

1. INTRODUCTION

It is important to long term plan for alternative energy sources in a balanced manner by making optimal use of available land and manpower resources. The identification of suitable alternate for diesel has been posed as a challenge for the researchers nowadays. Hence, it has become the need to study the feasibility of substitution of diesel with an alternative fuel, which can be produced locally on a substantial scale for commercial utilization. Vegetable oils are considered as good alternatives to diesel as their properties are close to diesel. But direct utilization of vegetable oils in internal combustion engine causes some problems due to the high viscosity compared with conventional diesel fuel. Various techniques and methods are used to solve the problems resulting from high viscosity. Transesterification of vegetable oils is the most commonly adopted technique, which helps converting vegetable oils into biodiesel fuel. Our work mainly focuses on testing the performance of the diesel engine when running with a biodiesel. Linseed (Linumusitatissimum) is a naturally growing crop requiring less water for its life cycle. It is available in most of the regions of the world. It is also known by various names like Chih-ma, Lint Bells, Winterlien, etc., there are many unsaturated fats as well as mucilage in the linseed. The linseed oil is abundantly available oil and renewable in nature. Cottonseed is produced from cotton plant, its botanical name is Gossypium arboretum and its family is Malvaceae, the marshmallow.

2. LITERATURE REVIEW

Sigar (2009) studied the effects of Biodiesel, derived from the transesterification of vegetable oils or animal fats as alternative fuel for compression ignition engine for their effects on engine performance and emissions. It was concluded that the use of biodiesel favours to reduce carbon deposit and wear of the key engine parts, compared with diesel. It is attributed to the lower soot formation, which is consistent to the reduced PM emissions of biodiesel, and the inherent lubricity of biodiesel. Vallinayagam (2014) tried to improve the performance and emission characteristics of diesel engine fueled with biodiesel, by altering the fuel properties of it through the addition of additive 1,4-Dioxane. It is a multipurpose additive, has been zeroed in as one of the indispensable additive to be added with the optimum blend of KME (kapok methyl ester). The performance parameters such as BSFC and BTE, for B25-10 ml were observed to be improved by 5.7%. The emissions such as CO, HC, NOX and smoke were reduced by22.5%, 25.3%, 15.2%, and 24.6%, respectively, for B25-10 ml than B25. It was presented a review focused specifically on the production of biodiesel fuels by supercritical (SC) TG ethanolysis within a global analysis “feed stocks conversion engine”. Non-catalytic supercritical ethanolysis of TG, combined with “glycerol valorization” and “materials (feed stockresidues/ glycerol/ biodiesel) heat power cogeneration” admitting all these feedstocks is thus a viable conversion process for reaching the objective of a sustainable biodiesel alternative.

Arcoumanis (2008) presented a review on the production and characterization of vegetable oil as well as the experimental work carried out in various countries. The two-step esterification process converts the crude high FFA rubber seed oil to a more suitable form of fuel for diesel engines. The flash point of biodiesel produced was higher than that of diesel and possesed about 80% heating value of diesel. Tripathi Neha (2013) identified FAME(Fatty Acid Methyl Ester) as a viable alternatives to the fossil fuel. He attempted to compare two production process viz. base catalyzed and two stage acid-base catalyzed for two possible feedstock viz. sunflower oil and cottonseed oil. During the production, glycerol was produced as a by-product. Alexandra Gruia (2012) evaluated the characteristics of Linseed oil to determine whether it could be exploited as an edible oil. Petroleum ether extraction of linseeds produced yields of30% (w/w) oil. The chemical composition, including moisture, total oil content and ash, was determined. Linseed oil was found to contain high levels of linolenic (53.21%) followed by oleic (18.51%), and linoleic (17.25%),while the dominant saturated acids were palmitic (6.58 %) and stearic (4.43%).Regarding fatty acid composition , the saturates composed an average of 11.01 % of the total fatty acids and of 88.97% unsaturated acid.

Chauhan (2012) assessed about the different tree borne oilseeds, extraction of oil, biodiesel processing and effect of different parameters on production of biodiesel to be used in the compression ignition engine. Vegetable oil prices being relatively high posed a potential challenge to biodiesel proedction. It was concluded that the biodiesel can be used most effectively as a supplement to other energy forms and not as a primary source. Pradhan (2012) studied the production process, fuel properties, oil content, engine testing and performance analysis of biodiesel from karanja oil which is known as Karanja oil methyl ester(KOME). The oil extraction was found 35% by n-hexane method. Lower calorific value indicated more oil consumption. The specific gravity, Kinematic viscosity of B20 and B40 blends were much closer to diesel. At higher load maximum brake power was observed for B20 blend. BSFC reduces with increase in load and BTE shows better result than diesel. Incomplete combustion of KOME is much lower than diesel which was indicated in smoke opacity curve. Abulkalam (2013) investigated the use of ferric chloride ($FeCl_3$) as a fuel borne catalyst (FBC) for waste cooking palm oil based biodiesel to be used in a CI engine. The metal based additive was added to biodiesel at a dosage of 20 lmol/L. The results revealed that the FBC added biodiesel resulted in a decreased brake specific fuel consumption (BSFC) of 8.6% while the brake thermal efficiency increased by 6.3%. FBC added biodiesel showed lower nitric oxide (NO_x) emission and slightly higher carbon dioxide (CO_2) emission as compared to diesel.

3. EXPERIMENTAL SET UP AND PROCEDURE

3.1 Title and Author Information

The transesterification process is used to prepare biodiesel from linseed and cottonseed oil as shown in Fig1. The process uses an alcohol in the presence of catalyst, such a sodium hydroxide or potassium hydroxide, to break the molecule of raw renewable oil chemically into methyl or ethyl esters of the renewable oil, with glycerol as the byproduct. First oil is produced by using the press machine squeezing the linseed and cottonseed. The raw oil is heated up to 135 ºC along with a mixture of methanol (100ml) and potassium hydroxide (3.5gm) and stirred for 20minutes. The product was allowed to settle for 24hrs to produce two distinct liquid phases: crude ester phase at the top and glycerol phase at the bottom. Glycerol was separated using separating funnel. Srinivasan (2017) studied and analysed about the missile with grid fins and the effect on flow drag using ANSYS. Godwin (2017) and Lakshmanan (2017) investigated about the optimum parameters for obtaining the best performance using alternate fuels of IC engines working under the current cooling system using Nanofluids.

3.2 Production of Biodiesel

Crude methyl ester contains excess alcohol, soap and glycerol. It was washed with water two times the amount of crude biodiesel, so that the molecules will move freely and separate easily and quickly. It was purified by washing with distilled water to remove all the residual by-products. The crude biodiesel and water mixture was shaken thoroughly for 1 min and placed on a table to allow separation of biodiesel and water layers. The washing process was repeated for several times until the washed water became clear. The washed biodiesel was heated at 110ºC for 3-4 mins, so that remaining water will be evaporated. Then pure biodiesel is prepared. Then different blends of biodiesel are prepared with varying volume proportions as listed in table 1. The table 2 depicts about all property values of the fuel samples and virgin oils along with diesel.

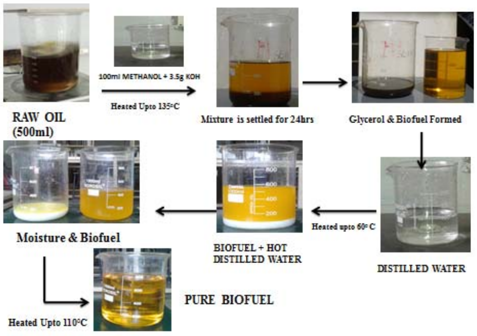

Fig.1. Transesterification of vegetble oil to biodiesel

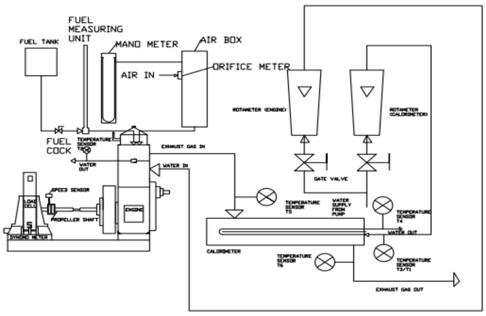

Fig. 2. Schematic layout of Experimental setup

Table 1 Various sample composition details

Sample	Composition
Sample 1	100 % diesel
Sample 2	95% diesel + 2.5 % of both linseed oil & cottonseed oil
Sample 3	90% diesel + 5 % of both linseed oil & cottonseed oil
Sample 4	85% diesel + 7.5 % of both linseed oil & cottonseed oil

3.3 Enigne Setup

A naturally aspirated single cylinder direct injection diesel engine test rig was used for experimental study as shown in Fig2. Initially the engine was run at no load condition and at rated speed (1500 ± 10rpm). Then tests were performed at varying loads, i.e., 20, 40, 60, 80 & 100%; with different blends of linseed and cottonseed biodiesel with diesel. The engine was tested at different loads and the readings were taken after study temperatures were reached. The performance parameters like brake power (BP), brake thermal efficiency (BTE), specific fuel consumption (SFC), mechanical efficiency (η_{mech}), and emissions like carbon monoxide (CO), carbon dioxide (CO_2), un-burnt hydrocarbon (HC), oxides of nitrogen (NO_X), smoke density and exhaust gas temperature(EGT) were noted.

4. RESULTS AND DISCUSSION

The engine operating at full load was tested for different diesel blends of linseed and cotton seed oil. The performance characteristics and the corresponding emission characters were noted during the experiments and are explained using the following figures.

4.1 Specific Fuel Consumption

The Fig 3 shows the Specific fuel consumption of all the samples with variation in load. It can be seen that the SFC value of blended samples are little higher than that of the base fuel diesel. This is because of the lower calorific value of the vegetable oils yet there is only slight increase in SFC at higher loads. The sample 1 has lower SFC compared to other samples. The sample 4 holds highest SFC at 20% load condition because of the increased concentration of vegetable oils. The sample 1 & 2 exhibits almost an equivalent SFC at medium and high loads. The increment of around 12% is observed by using blended fuels.

Table 2 Property values of samples used in the experiment

Properties	Sample 1	Sample 2	Sample 3	Sample 4
Density (kg/m^3)	823	825	830	835
Specific Gravity	0.823	0.825	0.830	0.835
Flash Point (^{0} C)	40	40	45	47
Fire Point (^{0} C)	45	53	56	60
Calorific Value (kJ/kg)	44800	42700	41200	40300
Free Fatty Acid (%)	0.110	0.070	0.084	0.107
Viscosity (cst)	2.97	1.87	2.19	2.38

4.2 Brake Thermal Efficiency

The variation of Brake thermal efficiency with load for all the samples is shown in Fig 4. The sample 1 again shows a higher BTE value at all operating loads when compared to the others. The lower BTE is obtained by using the sample 4 with increased vegetable oil content. As SFC, the reduction in BTE is caused by the lower calorific value of the vegetable oils. The sample 2 shows almost an equivalent value of BTE to that of sample 1 (Sole diesel). The decrement is only around 14%.

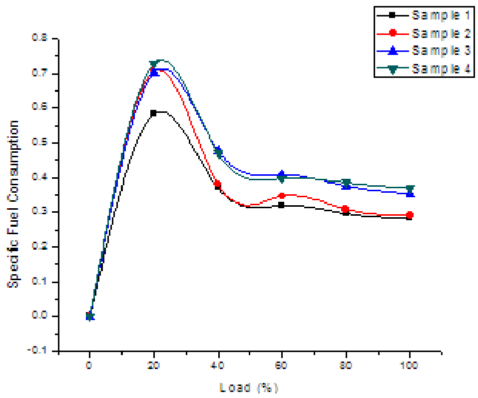

Fig. 3. Specific fuel consumption vs Load

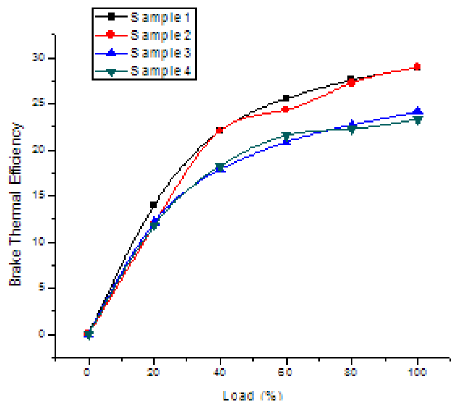

Fig. 4. Brake thermal efficiency vs Load

4.3 Exhaust Gas Temperature

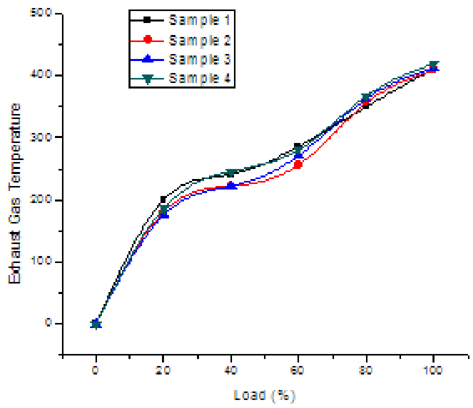

Fig. 5. Exhaust gas temperature vs Load

The exhaust gas temperature is a character that explains about the degree of combustion took place inside the chamber. Fig 5 shows the variation of exhaust gas temperature (EGT) with load. Higher amount heat produced will be utilized for power production and when carried by the exhaust, it is wasted. Hence lower exhaust gas temperature is preferred. The sample 2 shows lower EGT compared to rest of the samples. The sample 1 holds higher EGT at low loads and almost equivalent EGT is shown by all the samples at full load condition.

4.4 Smoke Intensity

The smoke particulates present in the emission shows the amount of impurity present in the fuel being used. The variation of smoke value with variation in load is plotted in Fig 6. The sample 4 holds highest smoke particle in the exhaust than other samples. The sample 1 & 2 shows lower smoke emission at all operating loads. There is only a slight increase in smoke particle content for the sample 3. The increment of 18% in smoke emission is produced by the increased content of biodiesel in the fuel.

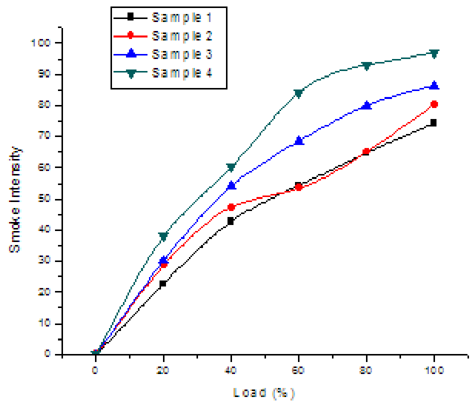

Fig. 6. Smoke intensity vs Load

4.5 Hydrocarbon Emission

The Fig 7 shows the unburnt hydrocarbon emitted during various operating condition of the engine. The sample 1 shows higher HC emission than other samples. All the blended samples show lesser HC emission than sample 1. The least value of HC emission is achieved by using sample 3. There has been a fluctuation in the HC emission for using sample 2 with a tendency of initially decreasing and then increasing nature. A drastic decrement of 30% is achieved by using the blended fuels.

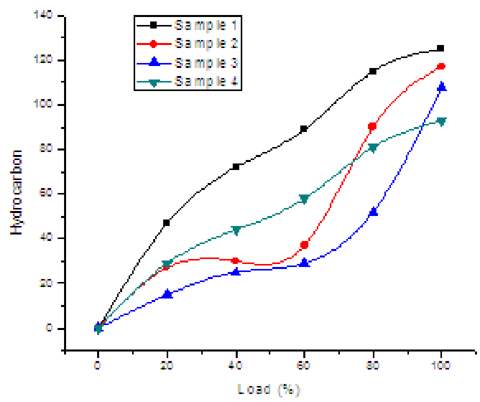

Fig. 7. Hydrocarbon vs Load

4.6 Carbon Dioxide Emission

The variation of carbon dioxide with load for all samples is shown in Fig 8. The sample 1 shows higher CO_2 emission than other blends. The sample 3 shows lower emission content at load range of 0 – 35 % and high loads. At 40% and 60% loads, all the samples exhibit an equivalent value of emission. The sample 2 emits lesser emission at the load of 40%. The decrement in emission is around the range of 10%.

4.7 Oxides of Nitrogen

Fig 9 shows the amount of nitrogen oxides emitted by various samples at all load conditions. It can be seen clearly that the emission of NOx inversely proportional to the concentration of vegetable oils in the fuel. The higher emission of NOx is shown by the sample 1 and the least value of NOx is emitted by using sample 4. There is a tendency of gradual decrease in NOx emission with increase in load and concentration of vegetable oil. There is a decrease of 35% in NOx emission by using blended fuels.

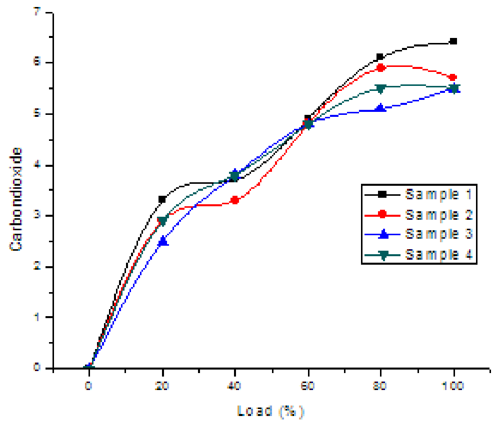

Fig. 8. Carbon dioxide vs Load

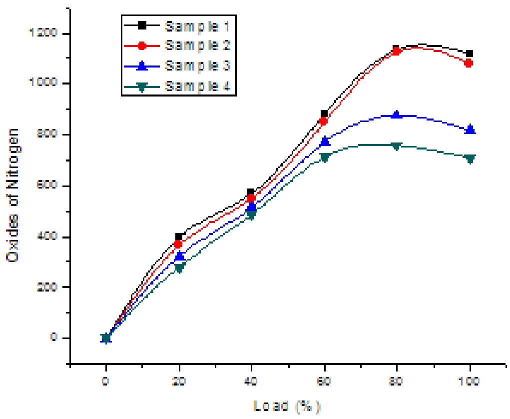

Fig. 9. Oxides of Nitrogen vs Load

5. CONCLUSION

It can be stated that the addition of biodiesel with the petroleum fuel must be in a way such that the calorific value of the blend should be increased. This would yield a higher performance with reduced emission. Based on the performance and emission characters of all samples, the following conclusions are made.

- The SFC & smoke particle concentration is lower for pure diesel fuel than blends.
- The BTE & Exhaust gas temperature is also higher for sole fuel than other samples.
- The emission of HC and CO_2 are lower for the sample 3 than rest.
- Lowest NOx emission is obtained by using sample 4 at all loads.

The sample 1 posses good performance characters whereas, the emission characters are better for blended fuels namely sample 3 & 4.

REFERENCES

AbulKalam (2013) An overview of biofuel as a renewable energy source: development and challenges, *Procedia Engineering* 56, 39 – 53.

Agarwal, S. G., (2003) *Characterization and utilization of biodiesel as an alternative fuels for diesel engines*, Consultative workshop in scientific strategies for production of non-edible oils for use as bio-fuels, 6 31-38

Alexandra, G. (2012) *Fatty acids composition and oil characteristics of linseed (LinumUsitatissimumL.) from Romania, Journal of Agroalimentary Processes and Technologies* 18 (2), 136-140.

Arcoumanis, C., C. Bae, R. Crookes, E. Kinoshita E. (2008) The potential of di-methyl ether (DME) as an alternative fuel for compression-ignition engines: a review, *Fuel* 87, 1014–1030.

Chauhan, Y. R. (2012) Biodiesel production from non edible-oils, *Journal of Chemical and Pharmaceutical Research* 4(9), 4219-4230.

Godwin Antony, A., S. Dinesh, K. Rajaguru, V. Vijayan (2017) Analysis and Optimization of Performance Parameters in Computerized I.C. Engine Using Diesel Blended with Linseed Oil and Leishmaan's Solution, *Mechanics and Mechanical Engineering* 21(2), 193–205.

Lakshmanan, P., P. Kaliyappan, M. Ranjithkumar, K. Aravinth, D. Vakkachan, C. Moorthy and S. Kumar, (2017) An Experimental Investigation to Study the Performance and Emission Characteristics of Chicken Fat Oil Fuelled DI Diesel Engine, *Journal of Applied Fluid Mechanics* 10, 85-91.

Pradhan, A. K. (2012) Non-Edible Karanja Biodiesel- A Sustainable Fuel for C.I. Engine, *Fuel* 2(6), 853-860.

Sigar, C. P., Soni, S. L., Mathur, J., Sharma, D., (2009) Performance and emission characteristics of vegetable oil as diesel fuel extender, *Energy Source Part SA* 31, 139–48.

Srinivasan, R., V. Vijayan and K. Sridhar, (2017) Computational Fluid Dynamic Analysis of

Missile with Grid Fins, *Journal of Applied Fluid Mechanics* 10, 33-39.

Tripathi, N. (2013), *Use of Sunflower and Cottonseed Oil to prepare Biodiesel by catalyst assisted Transesterification* 3(3), 42-47.

Vallinayagam, R. (2014) Effect of adding 1,4-Dioxane with kapok biodiesel on the characteristics of a diesel engine, *Applied Energy* 136, 1166–1173.