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Research Article

Exploring the performance of a Single Cylinder Diesel Engine with alternative fuels such as CME and CME-Diesel Blends

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Abstract

The current economic scenario in India demands and impresses upon the need for exploring alternatives to petroleum derived fuels, due to their depletion as well as due to the concern for environmental issues. The biodiesel is a non-toxic, biodegradable and renewable alternative fuel that can be used as a substitute for diesel in diesel engines. This paper discusses the performance characteristics of a single cylinder diesel engine, using Coconut Methyl Ester (CME) and its diesel blends. Experiments were conducted with pure diesel and the blends of CME-diesel by volume for different load range. The exhaust conditions were measured using exhaust gas analyzer. The effect of use of CME as well as CME-diesel blends on the performance of the engine for brake thermal efficiency, brake specific fuel consumption, exhaust temperature and air-fuel ratio as well as the engine emissions from CME and CME-diesel blends are analyzed and compared with that of the conventional diesel fuel.

Keywords: *Biodiesel, coconut methyl ester, diesel blends, performance. emissions*.

1. Introduction

The vegetable oil is found to be a good alternative for diesel, due to its properties, such as low evaporation, high flash point, low toxicity and lower emissions. Vegetable oil is also considered as a good substitution for diesel in the larger context of environment. The use of vegetable oils as a fuel in diesel engine is possible, but not preferable due to their extremely higher viscosity, strong tendency to polymerize and bad cold start properties. The vegetable oils can be used as a fuel or its blends with diesel fuel (Senthil Kumar, M. Ramesh, Nagalingam B., 2001). Higher viscosity of oil also leads to improper atomization of fuel during injection, resulting in incomplete combustion and higher smoke levels in the exhaust (Ramadhas A S., Muraleedharan C., 2005). The problem of high viscosity of vegetable oils is reduced by preheating the oils, blending with other fuels and transesterificaton process (Masjuki H., M Z. Abduimuin, 1995.

The deposits on the pistons, valves, combustion chambers and injectors can cause severe loss of output power, engine lubricant deterioration or even failure of the engines. The lower iodine value of coconut oil leads to lower carbon deposits. With a 30 % coconut oil-diesel blend producing higher brake power and reduction in HC, NOx and CO, at increased percentage of coconut oil, the power decreases due to its lower calorific values (M. A Kalam, M. Hunsawan, H. H. Masjuki. 2003).

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The coconut oil could be used as an alternative fuel for the existing conventional diesel engines without major modifications. Preheated (50%) coconut oil-diesel blends are also found to be better in terms of both emission and performance. Without preheating, 20% coconut oil-diesel blends gave optimum results, but specific fuel consumption and emissions were higher than those of preheated blends (Raffiq H. M. and Ahmed K. M. B. 2005). Hence, pure coconut oil and coconut oil–diesel fuel blends can be successfully used in a diesel engine.

2. Preparation of Biodiesel (CME)

The coconut oil methyl ester (CME) is prepared by transesterification process. Oil containing less than 4% free fatty acids are filtered and preprocessed to remove water and contaminants and then fed directly to the transesterification process along with the products of the acid esterification process. The catalyst, Sodium hydroxide is dissolved in methanol and then mixed with the pretreated oil. If an acid esterification process is used, then extra base catalyst must be added to neutralize the acid added in that step. Once the reaction is complete, the major co-products, biodiesel and glycerin are separated into two layers. After esterification process is complete, the solution contains methyl ester of respective oil with glycerol and alcohol. The solution is then poured in the separating funnel and kept in it for few hours. After a few hours, two respective layers of methyl ester and glycerol can be seen in the funnel. The upper layer being the methyl ester of respective oil and the bottom layer is the glycerol. Glycerol can be drained from the tap and remaining is the biodiesel. Once separated from the glycerin, the biodiesel goes through a purification process to remove excess alcohol, residual catalyst and soaps. This is then further taken for testing purpose.

Table 1 Properties of Diesel and CME

Property	Diesel	CME
Viscosity (Cst)	4.0	4.5
Density (Kg/m^3)	830	870
Flash Point (K)	369	391
Ignition Point (K)	543	528
Lower heating value(KJ/Kg)	42580	37821
Oxygen content weight (%)	0	11

Table 2 Engine Details

Make	Kirloskar Ltd.
Engine	Single Cylinder 4-Stroke Diesel Engine
Rated power	7.4 KW@ 1500rpm
Cylinder diameter	102 mm
Stroke length	116 mm
Compression ratio	17.5:1
Length of arm	180 mm
Dynamometer	Eddy Current Dynamometer, water cooled, with loading unit
Calorimeter	Type Pipe in pipe
Piezo sensor	Range 5000 PSL,with low noise cable
Crank angle sensor	Resolution 1 Deg,Speed 5500 RPM with TDC pulse
Temperature sensor	Type RTD, PT100
Load sensor	Load cell, Type strain gauge

3. Experimentation

Table 1 gives the properties of Diesel and CME. Four stroke single cylinder diesel engine details are as shown in Table 2 and the experimental setup is shown in Fig.1 is used for the experimental work with CME-diesel blends. Experiments were conducted with pure diesel, pure CME and with the blends of CME - diesel. The blends are prepared in volume at different proportions. Emissions were measured using exhaust gas analyzer respectively. The performance and emission graphs of the engine are shown in Figures 2 to 7.

3.1 Experimental Test-Rig

The setup consists of a single cylinder, four stroke diesel engine, that is connected to an eddy current type dynamometer for loading. It is provided with necessary instrument for combustion pressure and crank-angle measurements. These signals are interfaced with a computer through engine indicator for P-θ and P-V diagrams. Provision is made for interfacing airflow, fuel flow, speed, temperatures and load measurement. The set up has a stand-alone panel box consisting of air box, fuel tank, manometer, fuel measuring unit, transmitters for air and fuel flow measurements. The set-up of single cylinder four-stroke diesel engine test rig is as shown in the Fig. 1

Fig.1 Single Cylinder 4-Stroke Diesel Engine Test Rig

4. Result and Discussion

At the rated speed of the engine variation of brake thermal efficiency, brake specific fuel consumption, exhaust temperature, air-fuel ratio, NOx and CO_2 emissions are drawn with respect to brake power for diesel, CME and diesel - CME blends.

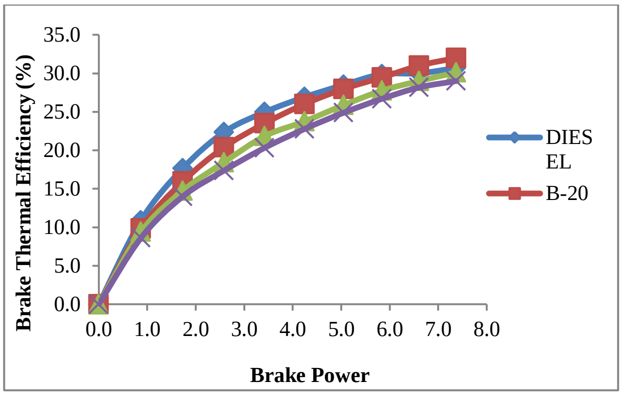

Fig.2 Brake Thermal Efficiency Vs Brake Power

Fig.2 shows the variation of brake thermal efficiency with brake power. It is observed that brake thermal efficiency gradually increases and is higher for diesel, where as thereafter it decreases and is minimum for B100 at full load. As the blends increase, the brake thermal efficiency decreases. The efficiencies are comparable with diesel, this is because of the small and medium carbon chain of CME and oxygen content in CME, which contribute to better atomization.

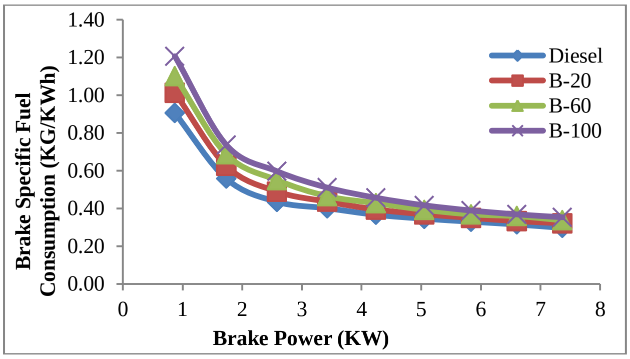

Fig.3 Brake specific Fuel consumption Vs Brake Power

Fig. 3 shows the variation of brake specific fuel consumption with brake power. Specific fuel consumption increases with increasing CME in blends. It is observed that BSFC for B100 is higher than B60, B20 and diesel. This is mainly due to its higher specific gravity and lower calorific value in comparison to the conventional diesel.

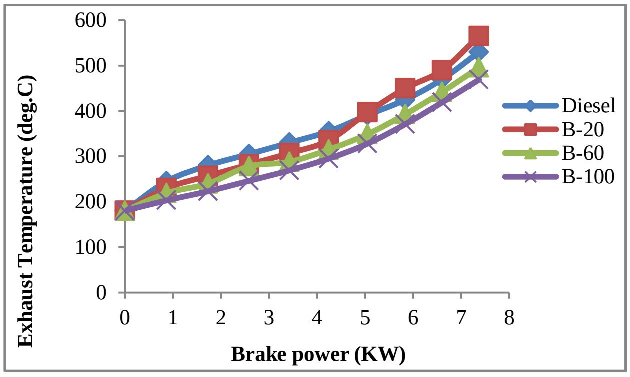

Fig.4 Exhaust Temperature Vs Brake Power

Fig. 4 shows the variation of exhaust temperature with brake Power. Exhaust temperature depends on the load on the engine. The increase in percentage of CME in the fuel blend leads to reduce exhaust gas temperature at all loads. The exhaust temperature for the diesel is higher than for CME blends. Calorific value of diesel is higher than the CME blends, hence more energy is produced and higher temperature is generated.

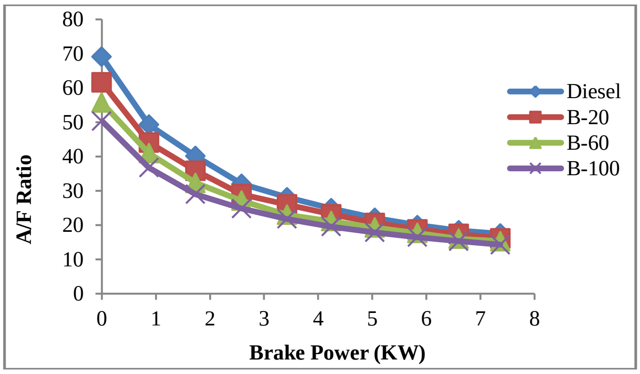

Fig.5 A/F Ratio Vs Brake Power

Fig. 5 shows the variation of A/F ratio with brake power. As the load increases, the A/F ratio decreases. The A/F ratio for diesel is higher than CME blends, this is because of higher calorific value of diesel than the CME blends.

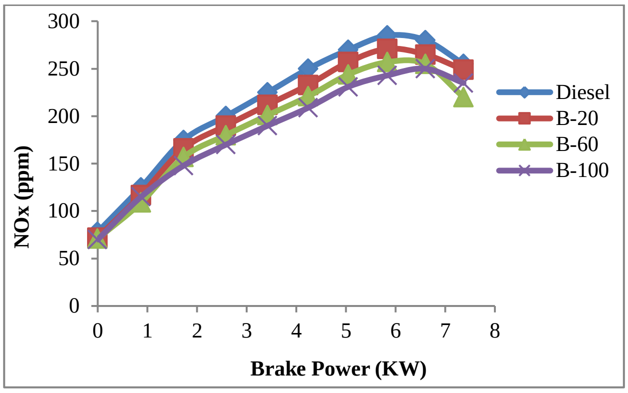

Fig.6 NOx emissions Vs Brake Power

Fig. 6 shows the variation of NOx emissions with brake power. The NOx emissions are increased with engine load due a higher combustion temperature. It is observed that NOx emissions at all loads for CME and its blends are lower than that of diesel fuel. The lower combustion temperature of CME blend is the main reason to reduce NOx and it is due to their chemical bond and its properties and also the lower calorific value of CME.

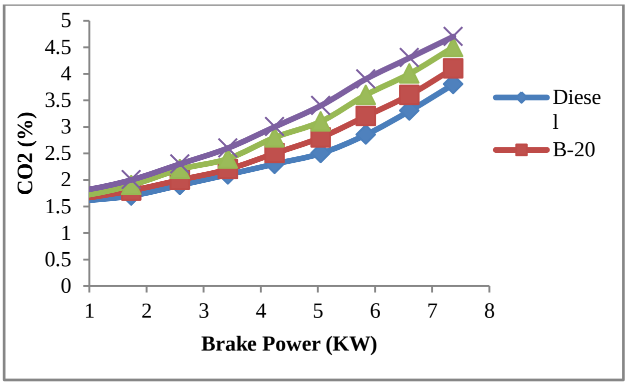

Fig.7 CO_2 emission Vs Brake Power

Fig. 7 shows variation of CO_2 emissions with Brake Power. At full load CO_2 emissions are higher. It is observed that CME blends produce higher CO_2 emission than the diesel fuel. It is mainly observed due to O_2 content in CME blends. Also the level of CO_2 increases with increasing CME in the blends.

5. Conclusion

This study shows that CME and CME- diesel blends can be used as alternative to diesel engine fuels. It can be used successfully to operate a direct injection diesel engine, without major modifications to the engine.

1) The Properties of CME blends are comparable with those of conventional diesel fuel.
2) CME blended fuels produce similar brake thermal efficiency as conventional diesel.
3) Brake specific fuel consumption (BSFC) increases with increasing CME in CME-diesel blends. This is attributed to the lower heating value of the CME.
4) CME and CME-diesel blends oil engine operation

results in better emissions, lower smoke and lower NOx emissions as compared with standard diesel fuel. Exhaust emission also reduces with increasing CME blends, except in case of CO_2.

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