Performance and Emission Characteristics of Di Diesel Engine Fuelled with Camphor Oil-Diesel Blends

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Abstract— In recent years, the usage of vehicles have been increased and this leads to the demand for fossil fuels. It has become an urgent need to carry out the research work on alternate source of energy to reduce the demand of fossil fuels and also to reduce the emission. Biofuel is one of the alternative sources of energy. The aim of the paper is to blend the camphor oil with diesel fuel at various proportions by volume. The camphor oil is directly blended with diesel fuel without any trans-esterification process, because of its low viscous property. The prepared blends were tested in a single cylinder DI Diesel engine at various load running at constant engine speed of 1500 RPM and coupled to eddy current dynamometer. Finally the observed performance and emission value of these blends were compared with pure diesel fuel operations. Among the results, the B15 blends gives better performance compared to B20 & diesel based on BTE. The B15 blends gives BTE (34%), B20 (BTE 32.95%) and diesel (BTE 31.5%) at full load conditions. The B20 blends emit 676 ppm of NO_X, while diesel emits 617 ppm of NO_X.

Key words: Diesel, Camphor Oil, Viscosity, No_x Emission

I. INTRODUCTION

Emission from conventional diesel engine directly affects the environment and it leads to global effects. Many researchers have searching some alternative solution to improve the conventional diesel engine working at better performance with minimum emissions. For that reasons, many researchers have concentrated on modifying the engine operating parameters such as ignition timing, fuel injection pressure and multipoint fuel injector [1].

One of the alternative source of energy is biodiesel. Biodiesel are made from various sources such as animal fats, edible oil, algae and non-edible oil. The biodiesel is prepared from various methods like Micro emulsions, Thermal cracking (pyrolysis) and Trans-esterification (Alcoholysis) [2].

Vegetables oil is biodegradable, non-toxic, low emission level and it is environmentally beneficial. The idea of using the vegetable oil as the fuel in conventional diesel engine is not a new technique. In 1900, Rudolf operating the diesel engines fuelled with peanut oil. Jatropa oil is used as a biofuel in conventional diesel engine by using different techniques such as blending with some other vegetables oil and blending with additives. The variation of brake thermal efficiency was clearly noted at different techniques. The jatropa oil is used as fuel in diesel engine which gives 28.5% BTE and jatropa oil is blended with methanol gives 30% BTE [3].

Vallinayagam reported that pine oil is directly blended with diesel fuel without any trans-esterifying process. The pine oil has low viscosity compared to that of diesel fuel. At full load condition, 100% pine oil increases the brake thermal efficiency of the conventional diesel engine by 5% [4]. This experimental work shows that pine oil is blended directly with diesel and 100% pine oil is successfully used as a fuel in diesel engine. Kasiraman reported that cashew nut shell oil was blended with camphor oil and it has low viscous property. Due to its low viscous property, it burns quickly and improves combustion efficiency. As a result, 30% camphor oil blended with cashew nut shell oil gives better performances compared to other blend ratio & diesel fuel with respect to BTE [5].Vegetables oil is used as a fuel in diesel engine but it is more expensive than diesel fuel. Many researchers have made several efforts to use some of the oil as a fuel namely sunflower, jatropa, pongamia, rubber seed and it is naturally edible. Some researchers have decided to use non edible vegetables oil as a biofuel in conventional diesel engines

II. CAMPHOR OIL

Camphor oil is generally extracted from cinnamomum camphora (also known as Laurus camphora) and is also named as true camphor and Formosa camphor. It has toxic effects. The camphor oil is used to clean the defected lungs and also dispel apathy. For psychosomatic ailments benefits the camphor oil is used with great important. The camphor tree will grow upto 35 meters tall. The camphor tree is more founded in china and japan. Camphor oil have good aromatic and durable properties.

Properties	**Units**	**Diesel**	**Camphor Oil**
Density at 15^0C	kg/m^3	840	894.2
Kinematic viscosity at 40^0C	CSt	3.4	1.9
Flash point	**ºC**	50	50
Fire point	**ºC**	72	68
Cetane number	-	52	5
Calorific value	kJ/kg	42700	38200

Table 1: Properties of Diesel and camphor oil

Camphor oil is prepared from the steam distillations of chipped wood and branches under vacuum. Then the filter products is pressed, distilled and rectification under vacuum. Finally the filtered oil is collected at 3 fractions of oil. Normally white, yellow, and brown camphor oil. The brown and yellow camphor is toxic, also used in the treatment for muscular aches and pains. The molecular formula of camphor oil is $C_{10}H_{16}O$. Molecular weight is 152.23 g/mol. The viscosity of camphor oil is 1.9 Cst. The study on the physical and chemical properties of pine oil is comparatively similar to that of diesel and is tabulated in Table 1.

III. ENGINE SETUP AND INSTRUMENTATION

The Kirloskar is a single cylinder – four stroke, vertical, water cooled DI diesel fuelled engine. This engine setup is used to carry out the performance and emission characteristics of the diesel and camphor oil-diesel blends is shown in Figure1.

The engine is to produce rated power of 3.5kW at rated speed of 1500rpm. Diesel fuel and camphor oil blends were tested in same engine without any modification such as ignition timing, ignition pressure and operating speed etc.

There are different types of engine loading are used. In this experiments, eddy current dynamometer are chosen to apply various load such as 0%, 25%, 50%, 75%, 100%. Fuel is injected directly into the cylinder by means of fuel injector and the engine is cranked manually. The fuel consumption is measured by using a burette and time is noted for a sample of 10 cc volume consumptions.

Exhaust emission from diesel engines such as carbon dioxide, carbon monoxide, hydrocarbons and oxides of nitrogen is measured by AVL Di-gas analyzer. One end of the cable is fitted with inlet side of the gas analyzer and other end of the cables is fitted with the exhaust tail pipe of the engine Gases from the exhaust are subjected to a moisture separator and filter element in order to trap particulates and vapor. HC and NO_X are measured in terms of parts per million (ppm), whereas the oxides of carbon are measured in terms of percentage volume (%). These emission measurements are measured using selective absorption principle.

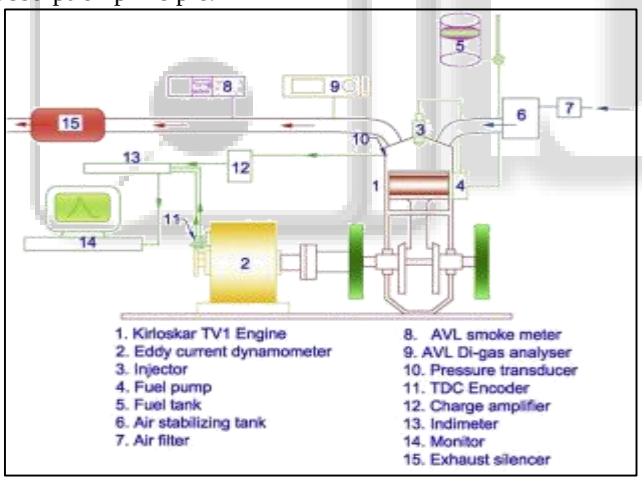

Fig. 1: Engine setup

A. *Experimental Procedure*

Initially the engine is running with diesel fuel for the duration of 10 to 15 minutes before using camphor oil blends in order to attain stable working environment. After that diesel fuel is completely drained out from the fuel tank and then the sample of (500 ml) camphor oil-diesel blends are poured into the fuel tank. It is important to note that whether the engine has attained its optimum (warm) temperature conditions. At constant speed of 1500 rpm, engine is loaded with 0%, 25%, 50%, 75%, 100% load by using an eddy current dynamometer. The B15 & B20 proportions of camphor oil blends are tested at all load conditions running at constant speed, where the experimental procedure is same for every proportion to be tested.

IV. RESULTS AND DISCUSSIONS

Different proportion of the blended fuels were tested in the DI diesel engine, in which performance parameter and exhaust gases emissions were noted and tabulation were formulated for finding the performance.

A. *Performance Characteristics*

The variations of brake thermal efficiency with respect to applied load were discussed for diesel, Camphor oil-diesel blends in the following sections. Figure 2 shows the variation of brake thermal efficiency with applied load for camphor oil and its blends in comparison with diesel. The brake thermal efficiency indicates that how the heat energy is effectively converted into work energy and also indicate combustion of fuel. As a result, the brake thermal efficiency increases with increase in applied load. The calorific value of Camphor oil is comparable to diesel. It can be seen from Figure 2 that the proportionate addition of camphor oil with diesel increases the efficiency of the engine. The variations of Brake Thermal Efficiency for the blend fuels were nearly comparable to that of diesel fuel.

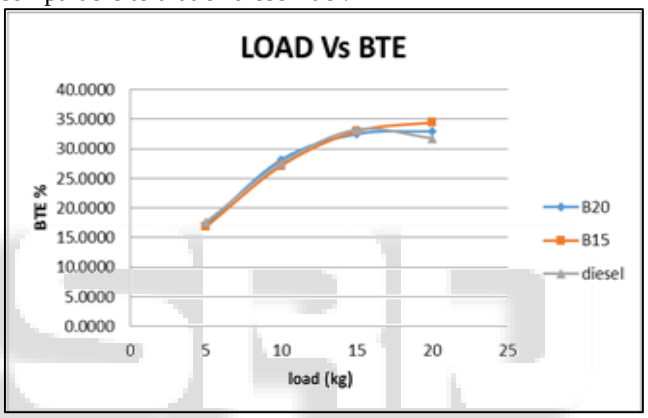

Fig. 2: Load vs BTE

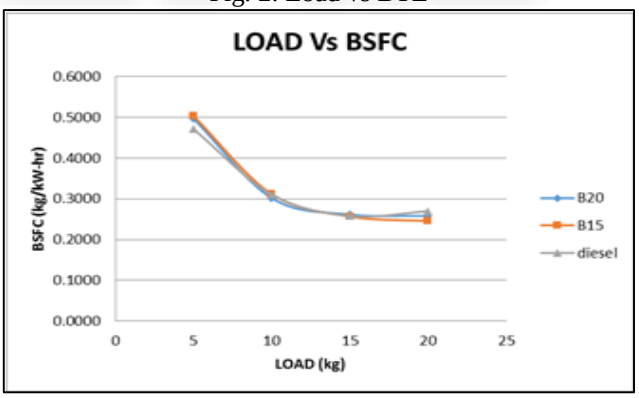

Fig. 3: Load vs BSFC

The Figure 3 shows the SFC values for various applied load were plotted for Camphor oil diesel blend. At maximum load conditions, diesel shows higher specific fuel consumption, which means poor fuel efficiency and mileage than camphor oil blends. This may be due to the superior evaporation and mixing of camphor oil over diesel. The lower viscosity of the camphor oil provokes better atomization, which helps accomplish a faster and more complete combustion. It is well known that specific fuel consumption is inversely proportional to the brake thermal efficiency.

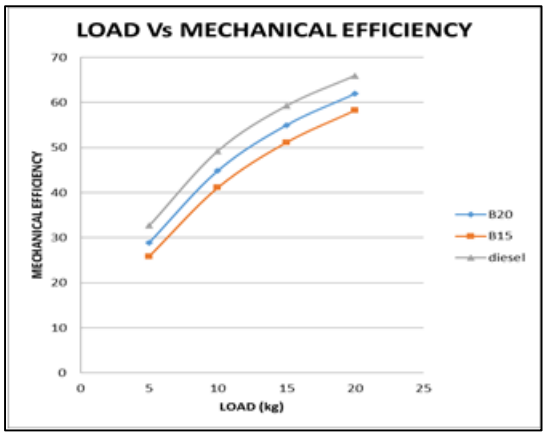

Fig. 4: Load vs Mechanical Efficiency

The Figure 4 shows the mechanical efficiency with load of camphor oil blend with diesel fuel. It was learn that mechanical efficiency with camphor oil diesel blend was comparable to that of diesel fuel. The mechanical efficiency of diesel fuel is higher than that of biodiesel diesel blends. This is due to excess amount of fuel supplied to the engine compared to diesel in order to maintain the equal energy output to the engine. The fuel pump of the engine delivers in volumetric basis, such that the density of blended fuel is marginally higher than that of diesel. This does not create a great impact on the discharge quantity of blended fuel compared to that of diesel. The camphor oil diesel blends having similar spray characteristics and comparable viscosity when compared to diesel. As a result the B20 give more mechanical efficiency than that of B15 blends and also closer to that of diesel value.

B. Emission Characteristics

Emissions such as CO, CO_2, NO_x and HC do rely mainly on fuel – air ratio and in – cylinder temperature. The variation of emission characteristics are discussed as follows.

1) Carbon Monoxide

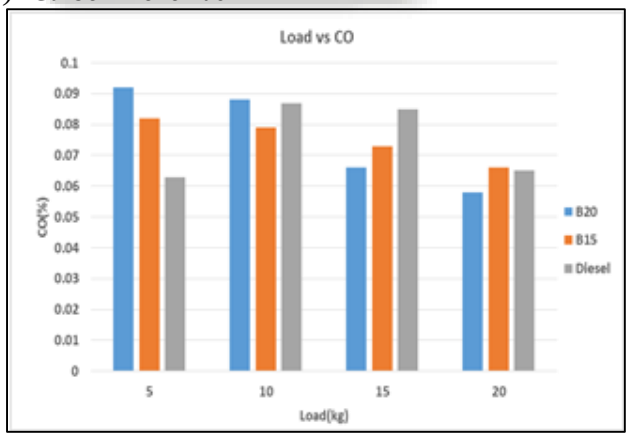

Fig. 5: Load vs CO emission

The Figure 5 shows the CO emissions of the camphor oil diesel blends. CO is an intermediate combustion product which is formed by incomplete combustion of fuel. At full load, a reduction in CO emission level was observed for Camphor oil B15 blends. Furthermore, CO emission decreases with the increase of Camphor oil percentage. This is due to the oxygen content present in the camphor oil increases the combustion rate. However, when the engine is operating at low load conditions, diesel produces less CO than camphor oil and its blends, the reason behind is when the engine is operating at 25 % load conditions, the fuel air ratio is very low and the induction of oxygen from camphor oil further reduces and leads to affect the combustion process, there by resulting in a relatively higher CO emissions for camphor oil and its blends.

2) Carbon Dioxide

The variations of carbon dioxide emissions with respect to load are depicted in Figures 7 for diesel, camphor oil-diesel blends. Figure 6 shows the variations of carbon dioxide emissions with load of camphor oil blends with diesel.

The experimental results proved that B20 blend shows better reduction of carbon dioxide emissions compared to diesel. At higher load conditions diesel fails to control CO_2 emissions over camphor oil blends.

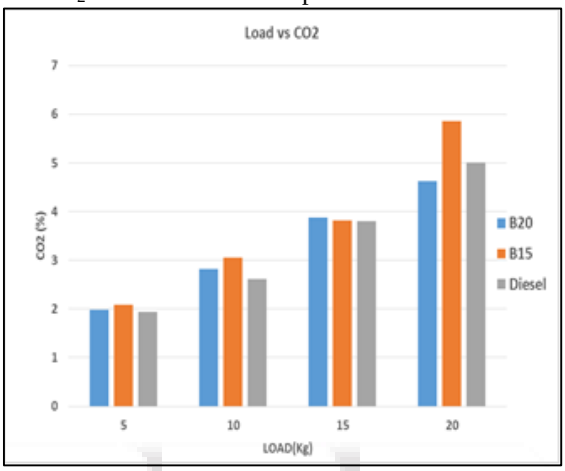

Fig. 6: Load Vs CO_2 emission

3) Oxides of Nitrogen

The exhaust emissions such as CO, CO_2, HC and NO_x are measured and analyzed. From the above mentioned emissions, NO_x is the most important emissions for diesel engine due to increase in temperature and combustion diffusion in the combustion chamber. The variations are shown in the Figure 7.

When the engine is operating at high load conditions, a higher NOx emission level is observed for camphor oil blends. This is due to increased temperature caused by increased premixed burning. Because of the prolonged ignition delay, there is accumulation of air-fuel mixture in the combustion chamber while burning Camphor oil and its blends.

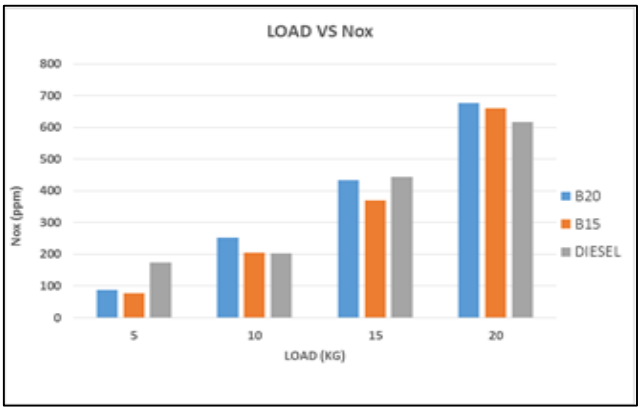

Fig. 7: Load vs Oxides of Nitrogen

As a result, the emission level of NOx is more for 20% camphor oil blends compared to diesel, since NOx is proportional to the operating temperature. However, at low load conditions, more NOx is produced for the diesel due to

the fact that it has relatively higher fuel to air ratio, which dominates the combustion process at extreme low load conditions.

4) Hydrocarbon Emission

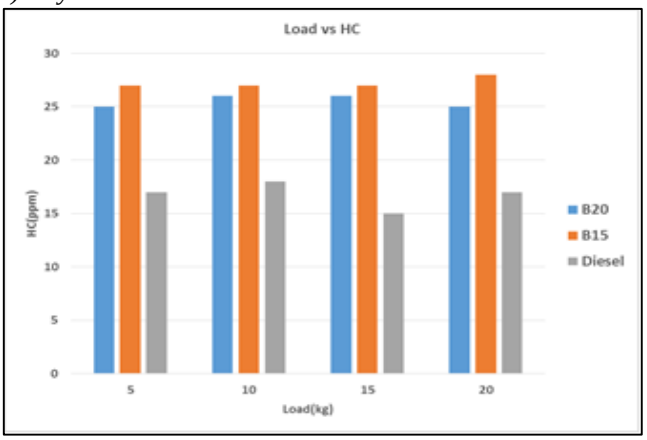

Fig. 8: Load Vs HC emission

The Figure 8 shows the impact of camphor oil blend over the emission of HC. The increased evaporation rate of fuel with air inside the cylinder makes the fuel burns completely. At 25% load conditions, diesel emits less HC compared to B15 & B20 blends due to the increased evaporation and mixing rate of fuel. It is also observed that the addition of load, the emission of HC increases as the mass of the fuel inducted into the cylinder is more and the fuel to air ratio is increased for camphor oil biofuel. It is seen that B15 & B20 blends give the higher amount of HC emission compared to that of diesel at all load conditions. This is due to the availability of relatively low oxygen content inside the cylinder for the combustion.

V. CONCLUSION

A single cylinder DI Diesel engine was operated successfully using diesel and blends of diesel with 15% and 20% of camphor oil respectively. Fuel consumption, brake power, brake power output, and emissions such as CO, HC, and NOx were measured at various loads. The performance and emission characteristics of diesel engine using these blend were compared with diesel fuel operation at 0, 25%, 50%, 75% and 100% load conditions. At 25% load conditions, the B15 & B20 blends emits lower level of NOX compared to that of diesel. The NOx emission from B15 & B20 blend at full load conditions are higher than that of diesel fuel. The B15 blend gives higher brake thermal efficiency compared to diesel & B20 blend at full load conditions.

B15 & B20 blends show better reduction of emissions than that of diesel at full load operating conditions. The Emission of HC is increased with the addition of camphor oil at all load conditions compared to that of diesel. At full load conditions, B15 blends consumed lower fuel consumption and higher brake thermal efficiency compared to diesel. As a result, the B15 blends significantly improves the performance & ecofriendly for DI diesel engine.

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