EXPERIMENTAL INVESTIGATION ON PERFORMANCEAND EMISSION CHARACTERISTICS OF A DI DIESEL ENGINE FUELLED WITH RICE BRAN OIL METHYL ESTER AND METHANOL AS AN ADDITIVE

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Abstract:

The present work deals with the preparation of bio-diesel from Rice Bran oil and testing the performance and emission characteristics of a single cylinder, four stroke, Direct Injection (DI) diesel engine by using conventional diesel, 100% Rice Bran Methyl Ester (RBME), RBME with 1% Methanol additive, RBME with 3% Methanol and RBME with 5% Methanol at various loads (no load, 0.97 kW, 1.94 kW, 2.91 kW, 3.88 kW) and comparing the important properties such as Flash and Fire points, Kinematic Viscosity, Density, Calorific Value and performance parameters such as Brake Specific Fuel Consumption, Brake Power, Brake Thermal Efficiency, A/F ratio, Equivalence ratio of diesel and bio diesel and also their Emission characteristics. It is observed that, for RBME + 1% methanol, the Brake Thermal Efficiency at full load i.e 3.88 kW is increased by 5.83% compared to conventional diesel, Exhaust gas temperature is decreased by 9.6%, O_2 emissions are decreased by 29.42% and CO_2 emissions are increased by 55.17%.

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INTRODUCTION

1.Biodiesel-The concept of using bio fuels in diesel engines was originated from the demonstration of the first diesel engine by the inventor of diesel engine ''Rudolf Diesel" at the World Exhibition in Paris in 1900 by using peanut oil as a fuel. However, due to abundant supply of petro-diesel, R&D activities on vegetable oil were not seriously pursued. It received attention only recently when it was realized that petroleum fuels were dwindling fast, and environment-friendly renewable substitutes must be identified. The esters of vegetable oils are popularly known as biodiesel. It is the process of reacting triglyceride with an alcohol in presence of a catalyst to produce glycerol and fatty acid esters. In India, attempts are being made for using non-edible and under- exploited oils or production of esters. Blending conventional diesel fuel with esters (usually methyl esters) of vegetable oils is presently the most common form of biodiesel. There have been numerous reports indicating that significant emission reductions are achieved with these blends. In the recent years, serious efforts have been made by several researchers to use different sources of energy as fuel in existing diesel engines. The use of straight vegetable oils is restricted by some unfavorable physical properties, particularly their viscosity. Due to higher viscosity, the straight vegetable oil causes poor fuel atomization, incomplete combustion and carbon deposition on the injector and valve seats resulting in serious engine fouling.

2. Additive- Methanol is an alcohol-based fuel additive which has approximately 30% higher oxygen in basis compared to mineral diesel which helps diesel engines to achieve higher complete combustion. The additional oxygen in fuel means a more complete combustion can be achieved. Furthermore, the implementation of alcohol additives tends to reduce PM, HC and CO significantly in the exhaust emission.It is also commonly accepted that diesel engine emission can be reduced effectively using oxygen content alternative fuels, or potentially the addition of oxygen within the diesel fuel. Therefore, much research has focused on screening of oxygenated fuel additives, including alcohols, esters and ethers to reduce emissions. Normally additives are used to boost the combustion hence improves fuel economy at lower emission rates from the engine. NOx emissions include high-pressure injection, turbo charging and exhaust after treatments or the use of fuel additives, which is thought to be one of the most attractive solutions .Blends of diesel and biodiesel usually require additives to improve the lubricity, stability and combustion efficiency by increasing the cetane number. Blends of diesel and methanol usually require additives to improve miscibility and reduce knock. Ozer Can et al. investigated the effects of ethanol addition to Diesel on the performance and emissions of a four stroke cycle, four cylinder, turbocharged indirect injection diesel engine with different fuel injection pressures at full load. They showed that the ethanol Oxides of nitrogen (NOx) emissions. It was also found that increased injection pressure, reduced the CO and smoke emissions with some reduction in power

II Literature Review

LITERATURE REVIEW FOR BIO DIESEL: Diesel fuels have an important role in the industrial economy of any country. Because of the depletion of petroleum reserves, increasing fuel prices and uncertainties concerning petroleum availability, stringent emission standards and global warming caused by carbon dioxide (CO_2) emissions, development of alternative energy sources and fuels has become increasingly important day by day. Vegetable oils have comparable energy density (10 percent lower) and a cetane number almost similar to diesel. The idea of using vegetable oils as fuel for diesel engine is not new. When Rudolf Diesel first invented the diesel engine, he demonstrated it at the 1900 world exhibition in Paris, employing peanut oil and said; 'The use of vegetable oils for engine fuels may seem insignificant today, but such oils may become in course of time as important as petroleum and the coal tar products of the present time' [1]. The climate changes occurring due to increased Carbon Dioxide (CO_2) emissions and global warming, increasing air pollution and depletion of fossil fuels are the major problems in the present century. The present researchers have been focused on the bio fuels as environment friendly energy source to reduce dependence on fossil fuels and to reduce air pollution. The bio fuels can play an important role towards the transition to a lower carbon economy and also combine the benefits of low green house emissions with the reduction of oil import. The role bio fuels can play within these economies becomes clearer when their relatively developed agricultural sector is taken into account [2]. Biodiesel as replaced for diesel fuel because emits smaller amount of CO_2 when burned. More over bio diesel have greater amount of oxygen in the molecule [3]. HC Emissions, carbon monoxide emissions can be reduced by using biodiesel blends [4]. It is also commonly accepted that diesel engine emission can be reduced effectively using oxygen content alternative fuels, or potentially the addition of oxygen within the diesel fuel. Therefore, much research has focused on screening of oxygenated fuel additives, including alcohols, esters and ethers to reduce emissions [5-6]. The effect of increasing percentage of biodiesel in the mixture on brake power, brake specific fuel consumption, brake thermal efficiency, and exhaust emission from the engine [7]. It was observed from literature review that reductions in HC and CO emissions substantially and NOX emissions moderately, where as there was a minor rise in CO2 emissions. Moreover, a slight decrease in engine power and an increase in specific fuel consumption occurred, which are acceptable due to the reduction of exhaust emissions [8]. It can be see that biodiesel is a viable alternative and sustainable fuel to diesel fuel, reduce emission significantly without any modifications to the diesel engine configurations [9]. It was observed from the literature [10-11] that the use of biodiesel in diesel engine results in a slight reduction in brake power and a slight increase in fuel consumption. However, the lubricant properties of the biodiesel are better than diesel, which can help to increase the engine life. Also the exhaust emission of the biodiesel is lower than the neat diesel operation due to the presence of oxygen in the molecular structure of the biodiesel. The drawbacks of biodiesel are higher nitric oxide emissions and poor oxidation stability than petroleum-based diesel fuel. This oxidation can cause the fuel to become acidic and to form insoluble gums and sediments that can plug fuel filters [12]. It was observed that the combustion of fuels used in this study does not require any modifications in engines. In addition, the combustion of fuel was smooth and there was no physical and visible damage in the engine components when fueled with biodiesel and the pentol blends [13]. Bio fuels include energy security reasons, environmental concerns, foreign exchange savings, and socioeconomic issues related to the rural sector [14]. The problem of oxidation stability has to be resolved in order to store the biodiesel fuels for long time storage. The formation of mono nitrogen oxides can lead either to an increase or decrease due to blending [15,16]. These papers show that in general pre 1997 diesel engines have an increase in NOx emissions with increased biodiesel percentage due to problems with the injection timings, which is after all designed in accordance with the fuels viscosity [17].

LITERATURE REVIEW FOR ADDITIVES: A few authors investigated the effect of additives on the power performance of biodiesel. Although Keskin et al. [18] found no significant effect of Mo and Mg as the additives into B60 biodiesel blend on engine torque and power tested on a single cylinder, 4-stroke, AC, DI diesel engine, Gürü et al. [19] obtained the positive effect of a blend of 10% chicken fat biodiesel and diesel fuel with an additive 12 mol Mg, which improved the performance of biodiesel in flash point, viscosity and pour point. Kalam and Masjuki [20] found that B20X with 1% 4-nonyl phenoxy acetic acid (NPAA) additive produced higher brake power over the entire speed range in comparison to B20 and B0 (diesel), and the maximum brake power obtained at 2500 rpm is 12.28 kW from B20X followed by 11.93 kW (B0) and 11.8 kW (B20). They contributed to the increase of fuel conversion efficiency by improving fuel ignition and combustion quality due to the effect of fuel additive in B20 blend.

III. RESULTS AND DISCUSSIONS

Experimentation is conducted on Direct Injection Diesel engine in the Department of Mechanical Engineering, NSRIT. The maximum power of the engine is 5 hp at a constant speed of 1500 rpm. The engine is operated at 1500 rpm at full load approximately 3.88 kW at a spring balance load of 16 kg (equivalent to 3.88 kW) which can be taken up at strategic loads of 4- 8-12-16 kg each. Totally, the 16 kg load has been divided into five loads progressively increasing 4-8-12-16 kg each. All the fuel samples have been tested for performance and emissions of the Engine. In an attempt to improve the performance of the engine with neat biodiesel application, methanol is used an additive to control the combustion temperatures. Blends of Rice bran oil methyl ester and methanol have been used to verify the engine performance. The chosen blends are 1%, 3%, and 5% of methanol with Rice bran oil methyl ester. It is observed homogenous blends with all these percentages of alcohol.

EFFECT OF EQUIVALENCE RATIO ON BSFC:

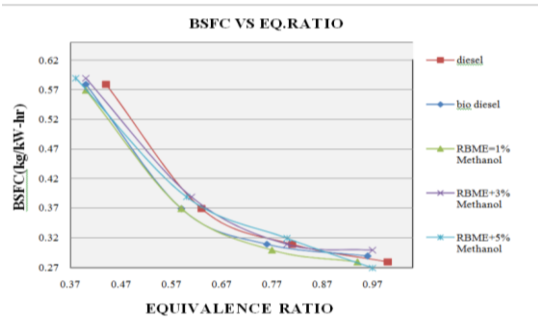

FIG 1 EQUIVALENCE RATIO vs BSFC

The variation of Brake Specific Fuel Consumption with Equivalence Ratio is shown in FIG 1.The equivalence ratio is observed to be within limits for the part load operation of the engine at 1500 rpm. A smoother trend of the curve is observed for the additive blend of 1% (Green line).The equivalence ratio for the 1% of additive blend is observed on higher side i.e. 0.94 nevertheless the performance can be better when compared to other samples.

EFFECT OF BRAKE POWER ON BSFC

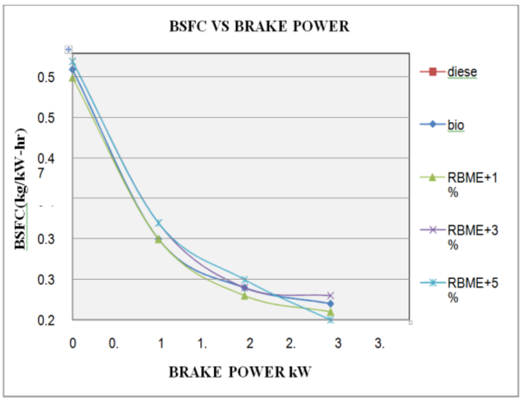

FIG 2 BSFC VS BRAKE POWER

The variation of BSFC with Brake Power (kW) is shown in FIG 2. The brake power is observed for the part load operation of the engine i.e; 2.91 kW. A smooth curve is observed for RBME + 1% Methanol. It means that at 2.91 kW load, the fuel consumption is low compared to other fuel samples.

EFFECT OF EQUIVALENCE RATIO ON BRAKE THERMAL EFFICIENCY

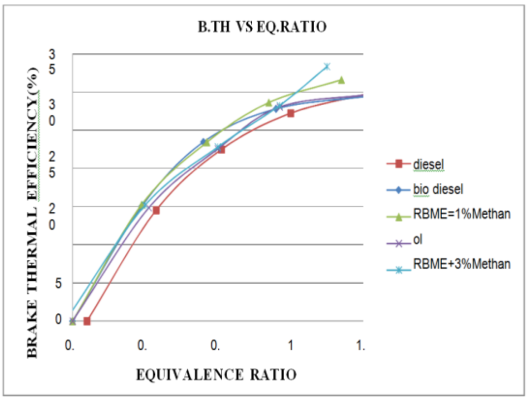

FIG 3 B.TH VS EQ.RATIO

The variation of Brake Thermal Efficiency with Equivalence Ratio is shown in FIG 5.3.A smooth trend of the curve is observed for RBME + 1% Methanol. This means maximum Brake Thermal Efficiency i.e 31.6% is obtained with RBME + 1% Methanol at equivalence ratio 1.14 when compared to other fuel samples.

EFFECT OF BRAKE POWER ON BRAKE THERMAL EFFICIENCY

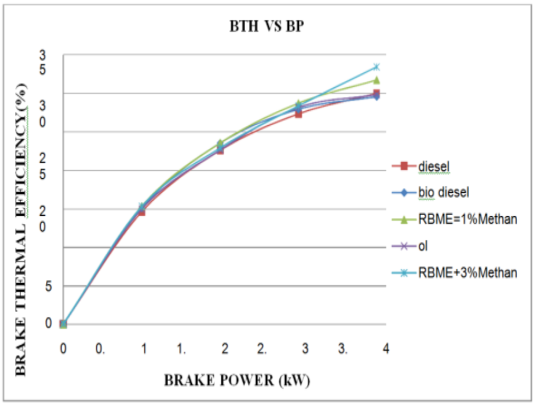

FIG 4 BTH VS BP

The variation of Brake Thermal Efficiency with Brake Power is shown in FIG 4.A smooth trend of the curve is observed for RBME + 1% Methanol. This means maximum Brake Thermal Efficiency i.e; 31.6% is obtained with RBME + 1% Methanol at full load condition i.e; 3.88 kW when compared to other fuel samples.

EFFECT OF ENGINE LOAD ON EXHAUST GAS TEMPERATURE

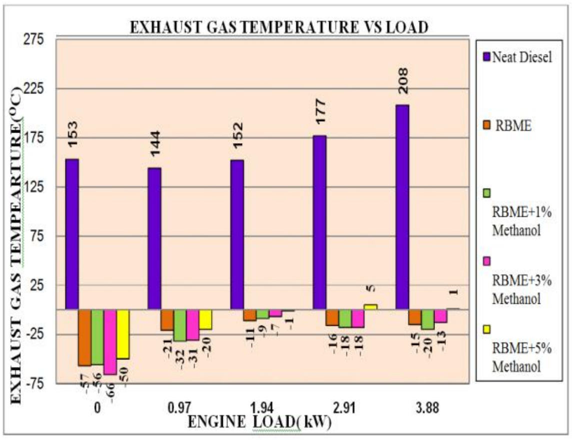

FIG 5 EXHAUST GAS TEMPERATURE VS LOAD

The variation of Exhaust gas temperature with Engine load is shown in FIG 5. At full load of the engine, Exhaust gas temperature is decreased by 9.6% in the case of RBME + 1% Methanol and this decrement is with respect to the diesel fuel. This observation of lower exhaust gas temperature is the representation of lower combustion temperatures.

EFFECT OF ENGINE LOAD ON SMOKE

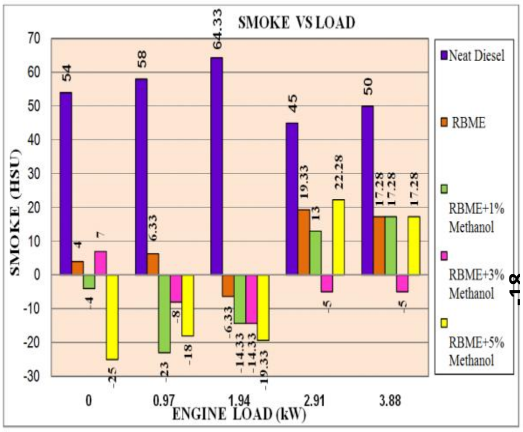

FIG 6 SMOKE VS LOAD

The variation of smoke in Hatridge units with Engine load in kW is shown in FIG 6. At full load of the engine, smoke levels are decreased by 18%, in the case of RBME +3% Methanol and this decrement is with respect to the diesel fuel. At half load of the engine, smoke levels are decreased by 22.3%, in the case of RBME + 1% Methanol. The decrease in smoke level in exhaust with respect to the neat diesel fuel operation is appreciable. This is an indication of better combustion.

EFFECT OF ENGINE LOAD ON OXYGEN EMISSIONS

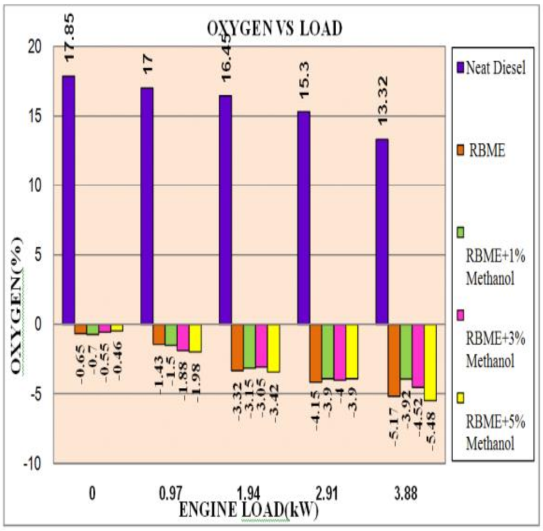

FIG 7 OXYGEN VS LOAD

The variation of oxygen emissions with Engine load in kW is shown in FIG 7.It can be observed that oxygen emissions are decreased by 29.42% in the case of RBME + 1% Methanol and this decrement is with respect to diesel fuel.

EFFECT OF ENGINE LOAD ON CARBON DIOXIDE EMISSIONS

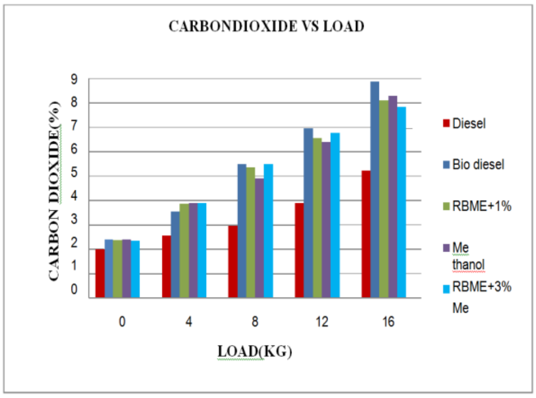

FIG 8 CARBONDIOXIDE VS LOAD

The variation of Carbon dioxide emissions with engine load in kg is shown in FIG 8.It can be observed that Carbon dioxide emissions are increased by 55.17% in the case of RBME + 1% Methanol and this increment is with respect to diesel fuel. Increase of carbon dioxide emissions indicates combustion improvement.

IV.CONCLUSION

In this study, Diesel, Rice Bran Methyl ester (RBME) and RBME with methanol additive are used as fuels in DI Diesel engine. The performance and emissions are measured to evaluate the suitable methanol percentage which gives maximum benefits. The conclusions are as follows:

1. Flash and fire points of biodiesel are quite high compared to diesel making it safer to store and transport.
2. The Brake Specific Fuel Consumption is increased by 3.57% when using RBME due to higher viscosity. However with the addition of methanol additive, BSFC is slightly reduced at full load conditions (i.e; 3.88 KW).
3. The Brake Thermal Efficiency of RBME and its blends with methanol additive is higher than that of conventional diesel at all load conditions. Brake Thermal Efficiency is increased by 5.83% for RBME + 1% Methanol and by 11.6% for RBME + 5% Methanol at full load conditions.
4. There is a significant decrease in exhaust gas temperatures of RBME and its blends with methanol additive compared to conventional diesel at all load conditions. Exhaust gas temperature is decreased by 9.6% for RBME + 1% Methanol at full load conditions.
5. Carbon dioxide (CO2) emissions are increased by 55.17% for RBME + 1% Methanol at all the load conditions because of which improvement

in combustion is observed.

6. Oxygen (O2) emissions are decreased by 29.42% for RBME + 1% Methanol at full load conditions.
7. At full load conditions, RBME+3% methanol has the lower smoke density than all the other fuels.

From the above analysis, RBME + 1% Methanol shows optimum performance when compared to RBME, RBME + 3% Methanol and RBME + 5% Methanol. It is observed that 1% additive with biodiesel can be used as substitute to di*esel fuel.*

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