# Evaluation of Performance and Emission parameters of a CI engine fuelled with Palm Styrene, Sun Flower and Rice Bran Methyl Esters Blends Blended with Diesel

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**Abstract:** This Paper deals with the study of the potential substitution of Palm Styrene methyl ester, Sun flower methyl ester and Rice bran methyl ester blends for diesel as fuel for automobiles and other industrial purposes. Biodiesel was prepared from the edible Palm Styrene oil , Sun flower oil and Rice bran oil by transesterification of the crude oil with methanol in the presence of NaOH or KOH as catalyst.

The objective of this study is the analysis of the performance and emission characteristics of the Biodiesel that is mixing of equal proportion of three methyl esters are Palm Styrene methyl ester, Sun flower methyl ester and Rice bran methyl ester (PSME+SFME+RBME) Mixture of methyl ester (MME) in equal proportion and comparing with petroleum diesel. The tests were carried out on a 4.4 KW, single cylinder, direct injection, air-cooled diesel engine. Engine tests have been carried out with the aim of obtaining comparative measures of Brake power, specific fuel consumption and emissions such as $CO_2$, CO, HC, and NOx to evaluate and compute the behavior of the diesel engine.

***Keywords:*** Performance, Emission, C.I Engine,Palm Styrene Methyl Ester,Sun Flower Methyl Ester, Rice Bran Methyl Ester, Alternative Fuel, Diesel.

## I. INTRODUCTION

Biodiesel is composed of long chain fatty acids with an alcohol attached, often derived from vegetable oils. It is produced through the reaction of a vegetable oil with methyl alcohol or ethyl alcohol in the presence of a catalyst. Animal fats are another potential source. Commonly used catalyst is potassium hydroxide (KOH) or sodium hydroxide (NaOH).The chemical process is called transesterification which produces biodiesel and glycerine.

Chemically biodiesel is called a methyl ester if the alcohol used is methanol. If ethanol is used, it is called an ethyl ester. They are similar and currently, methyl ester is cheaper due to the lower cost for methanol. Biodiesel can be used in the pure form, or blended in any amount with diesel fuel for use in compression ignition engines.

Bio-diesel is a domestic, renewable fuel for diesel engines and it is refer to a family of CI engines fuels that are produced from natural sources such as oils of sunflower, sesame, palm, neem, cotton seed, and jatropha. It is believed that Biodiesels which may be the oils themselves or their esters are the most likely successors to petroleum derived diesel. It is also more practical that these alternate fuels are introduced gradually as blends with diesel so that the production facilities are able to grow and markets are able to Biodiesel.

## II. PRODUCTION OF BIODIESEL

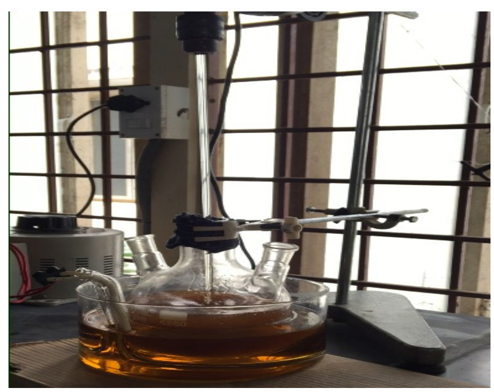

**Figure 1: Transesterification**

A lot of research work has been carried out to use vegetable oil both in its neat form and modified form. Studies have shown that the usage of vegetable oils in neat form is possible but not preferable. The high viscosity of vegetable oils and the low volatility affects the atomization and spray pattern of fuel, leading to incomplete combustion and severe carbon deposits, injector choking and piston ring sticking. The methods used to reduce the viscosity are

- Blending with diesel
- Emulsification
- Pyrolysis
- Transesterification

Among these, the transesterification is the commonly used commercial process to produce clean and environmental friendly fuel. The non-edible and edible oils such as jatropha oil, karanja oil, cotton oil, sunflower oil, rice bran oil, mustard oils are attractive due to their large availiability and good properties.

**Brief Introduction on Transesterification**

In organic chemistry, Transesterification is the process of exchanging the alkoxy group of esters by another alcohol. These reactions are often catalyzed by the addition of an acid or base

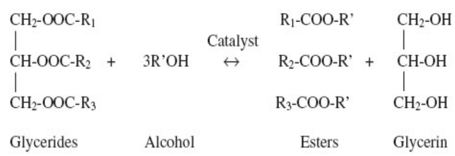


**Figure .2: Trans-Esterificaion Equation**

R1, R2 and R3 are fatty acid alkyl groups and depend on the type of oil. The fatty acids involved determine the final properties of the biodiesel.

The overall process is normally a sequence of three consecutive steps, which are reversible reactions. In the first step, from triglycerides diglyceride is obtained, from diglyceridemonoglyceride is produced and in the last step, from monoglyceridesglycerine is obtained. In all these reactions esters are produced. The stiochiometric relation between alcohol and the oil is 3:1. However, an excess of alcohol is usually more appropriate to improve the reaction towards the desired product.

TRANS-ESTERIFICATION is the process that brings the properties of pure vegetable oil close to those of the diesel fuel. It refers to the conversion of an organic ester into another ester of the same acid by reacting with alcohol to produce alkyl ester.Vegetable oils themselves are triglycerides, which are esters derived from long chain fatty acids and polyalcohol glycerol. With 0 to 3 double bonds that are responsible for the Physic-chemical properties of the oil.

The reaction takes place at proper mixture ratios of reactants with a suitable catalyst at designated temperature ranging from 32°C to 83°C in reaction vessel with vigorous stirring. This is a batch process for small-scale productions and is time consuming. In commercial practice, large-scale production is only feasible in continuous process.

## III. EXPERIMENTAL SET UP

**Figure 3: Experimental Setup**

**CI Engine Specifications**

| | | |
|---|---|---|
| MAX. BP | : | 4.4kW (5 H.P) |
| SPEED | : | 1500 RPM |
| BORE | : | 87.5mm |
| STROKE | : | 110mm |
| ORIFICE DIA | : | 13.6mm |
| COMPRESSION RATIO | : | 17.5:1 |

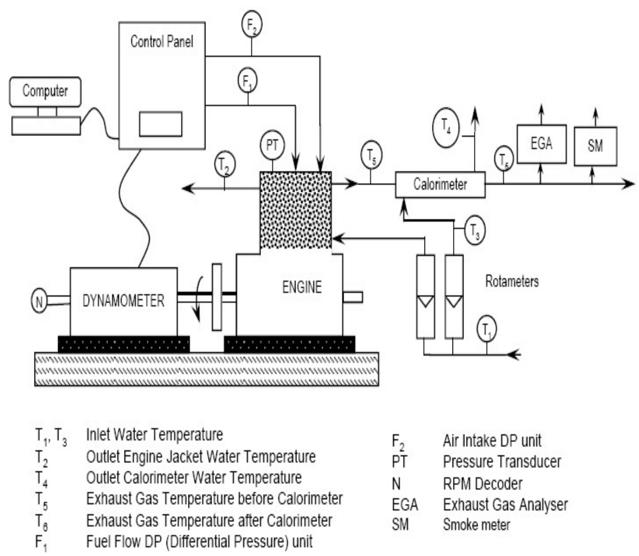


**Figure 4: Experimental setup of Diesel engine**

## IV. PERFORMANCE ANALYSIS OF MME (PSME+SFME+RBME)

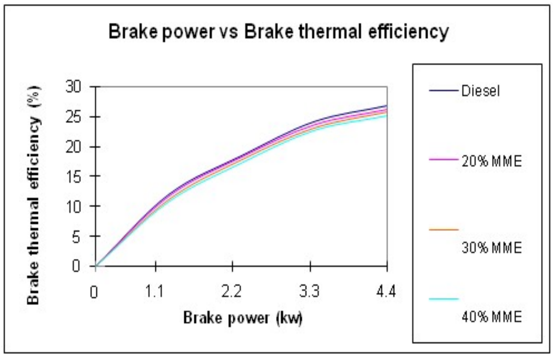


**Figure 5: Comparison of Brake Power Vs Brake Thermal Efficiency For MME/Diesel Blends**

The variation of BTE with different load conditions is shown in Figure.5 for diesel, blends B20, B30 and B40. The study found that increase in BTE with increase in load for all the cases. This is due to the reduction in heat loss and increase in power developed with increase in load. At lower load conditions the variation of BTE between three cases is observed as low compared to higher load conditions. BTE variation at higher loads is due to improvement of diffusive combustion phase on account of oxygen enrichment in the MME which leads to better combustion and higher BTE as compared to diesel.

## V. EMISSIONS ANALYSIS OF MME

### Carbon monoxide (CO) Emissions

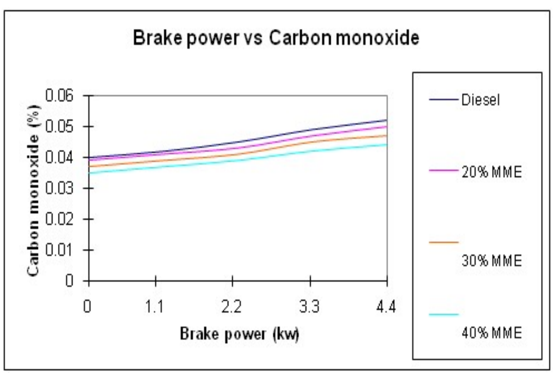


**Figure 6: Comparison of Brake Power Vs CO Emissions For MME/Diesel Blends**

Carbon monoxide is a by product of incomplete combustion, the CO present in the exhaust gas indicates that the combustion is incomplete. Higher CO emission is the presence of local rich mixtures at the core of the injection spray, which is deficient in air during the combustion process. Figure.6 shows that the variation of CO emissions with different load conditions for diesel and MME blends. Lower CO values were observed for B20, B30 and B40 blends as compared to diesel for all load conditions. This could be due to enrichment of oxygen in MME which oxidizes CO in to CO2 during combustion process and produce lower CO and higher $CO_2$ emissions.

### Carbon dioxide ($CO_2$) Emissions

The $CO_2$ emission release from the hydrocarbon fuel combustion depends on carbon content per mole of the fuel and availability of oxygen during combustion process. Variation in $CO_2$ against the load is shown in Figure.7 for both diesel and blends. It is observed that higher $CO_2$ emission is observed for B20, B30 and B40 blends compared to diesel. This could be due to high oxygen content in the blends. The lower $CO_2$ emission in B30 as compared B20 may be due to incomplete combustion in B30 blend.

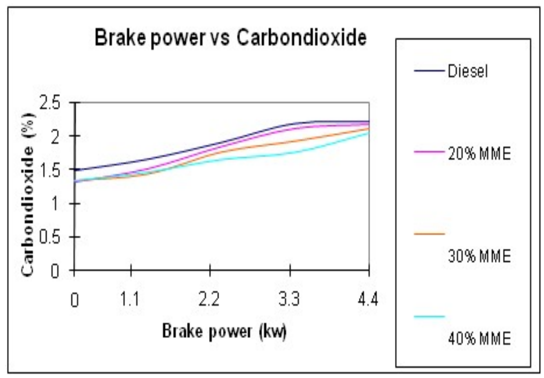


**Figure 7: Comparison of Brake Power Vs $CO_2$ Emissions For MME/Diesel Blends**

### Hydrocarbons (HC) Emissions

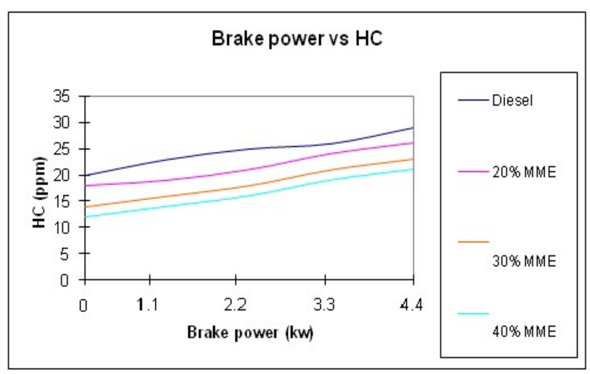


**Figure.8: Comparison of Brake Power Vs HC Emisions For MME/Diesel Blends**

The variation of Hydrocarbon emission is shown in Figure.8. It is observed that the variation of HC emissions with different load conditions for blends are having same trends with diesel and the values are lower than the diesel. The presence of oxygen in the MME leads better combustion and lower hydrocarbon emission as compared to diesel. Also, higher cetane number of MME blends reduces the combustion delay, which causes to decrease in HC emissions

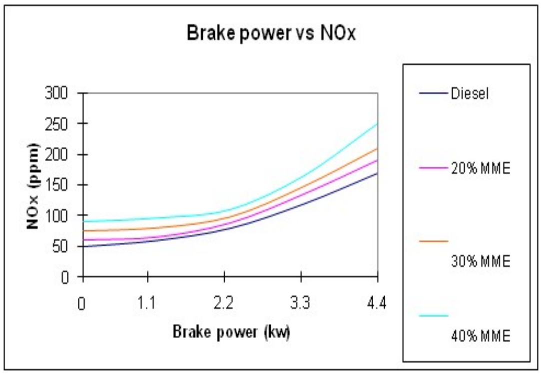


**Figure.9: Comparison of Brake Power Vs $NO_X$ Emissions For MME/Diesel Blends**

The nitrogen oxides emission is directly related to the engine combustion chamber temperatures, which in turn indicated by the prevailing exhaust gas temperature. Figure.9 shows that the variation of NOx emission for diesel and MME blends with different load conditions. The presence of oxygen molecule in biodiesel causes an increase gas temperature resulting in a marginal increase in NOx emissions. Higher value of NOx emission is observed for MME blends compared to diesel with B20,B30 and B40 blends at full load condition.

Analysis of CI engine was carried out for pure diesel and blends of Mixture of Methyl Esters (MME) and it was observed that there was an improvement in mechanical and brake thermal efficiency. Emissions of blends of MME were reduced

## CONCLUSION

Performance of CI engine was carried out by pure diesel and mixture of methyl esters (MME) and was observed that blends of MME of 20%,30% and 40% showed a reduced emissions and improved performance parameters in comparison with pure diesel.

Here for the blends of 30% and 40% MME, It is observed that there was an improvement in the brake thermal efficiency and mechanical efficiency. Specific fuel consumption (SFC) for this blends is lower in comparison with pure diesel. Emissions of these blends are stable at particular value for each load. It was observed with the help of Crypton gas analyzer that at exhaust gases, carbon monoxide and unburned hydrocarbons are less in comparison with pure diesel and oxygen content at exhaust gases for B30 and B40 blends was high.

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