Influence of Tamarind Seed oil methyl esters and Diesel Blends as fuel in a Stationary Diesel Engine

K. Sri Rama Murthy, S. Sudhakar Babu, Venkata Ramesh Mamilla

Abstract*: From the aim of consideration of the universal protection and the interest for long-run provides of standard diesel fuels, it becomes essential to develop alternative fuels as good as with standard fuels. To exchange traditional diesel, biodiesel is a safe alternative fuel. The Transesterification process is adopted to prepare the tamarind seed oil methyl esters. In the current study the effects of performance, emissions and combustion characteristics has been investigated in a single cylinder four stroke vertical diesel engine for 20%, 40%, 60%, 80% and 100% by volume tamarind seed oil methyl esters mixed to diesel. From experimental results, it is determined that there is decline in brake thermal efficiency and raise in the brake specific fuel consumption by application of the blends of tamarind seed biodiesel in the diesel engine, owing to the smaller calorific value of the tamarind seed biodiesel and its blends. However, the tamarind seed biodiesel notably reduced the emissions such as carbon monoxide, hydrocarbons and smoke density, while the nitrogen oxide emissions are increased. The engines combustion analyses showed that adding tamarind seed biodiesel and its blends to the base diesel fuel reduced the peak cylinder pressure. These results showed that the tamarind seed biodiesel could be commissioned as an alternative fuel in the engine exclusive of any engine alterations.

Index Terms: Alternative fuel, Combustion, Diesel engine, Emissions, Performance, Tamarind seed oil methyl ester, Transesterification.

I. INTRODUCTION

The consumption and demand for the oil based goods are expanding each year because of increment in vehicle inhabitants, way of life and urbanization. This causes speedy consumption of oil based commodities, which prompts move towards the elective fuels for specialists. Among such massive numbers of elective fuels for diesel, non edible oils are the most broadly utilized[3]. J.S.Gitayet. al. [2] studies the diesel engine characteristics by means of jatropha oil methyl esters and ethanol with diesel by changing the loads. BTE, CO and HC emissions of all the fuel blends are discovered to be slightly poorer, Brake Specific Energy Consumption and BSFC to be slightly higher analyzed to the base fuel owing to lower calorific value of the biodiesel. Amruth. E et al. [3] have executed the experiments on diesel engine and operated with blended fuels at the speed of 1500 rpm and 200bar injection pressure. Engine performance parameters and exhaust emission char acteristics of different varieties are quantified with SOME blends and equated to diesel fuel behaviour. The engine test results showed that, better performance and lower emissions are produced at B30. N.Venkateswara Rao et al. [4] have analysed the engine characteristics of tobacco seed oil and blends. The tests are conducted on a diesel engine for pre-heated temperature at dissimilar nozzle pressures, injection timings and comparative studies were made and it was seen that the Smoke levels diminished and NOx levels expanded with biodiesel. The examination discoveries shows that the diesel can be replaced with the biodiesel. Thiyagarajan Subramanian [5] studies the features of a twin-cylinder tractor engine with neat Camphor oil and fuel additives such as Diglyme, Eugenol, Acetone and Cumene - bio-additives which runs at a constant speed of 1500 rpm and summarized that with the addition of DGE, EU, A the NOx emissions can be reduced without affecting the performance parameters. M. Vijay Kumar et al. [6] have done the experiments on a modified diesel engine with modified nozzle hole diameter at 20% blend of Mahua oil for different EGR rates. The results exposed that the characteristics of the altered engine were improved at Exhaust Gas Recirculation rate of 10% for sole fuel and B20 Mahua oil. G Lakshmi Narayana Rao et al. [7] analysed the characteristics of Used cooking oil methyl ester and its blends on a 4.4kW compression ignition engine. They briefed that the SFC, peak pressure, the NOX emissions increases and the brake thermal efficiency, CO, Unburnt Hydrocarbons emissions and smoke intensity decreases with extended with the percentage of UCME. Dharmendra Yadav et al. [8] investigates the performance of neem oil methyl ester on a diesel engine at different blends 20% , 50% , and 100% of neem oil biodiesel and concluded that the performance of the blends are deprived. A.P Sathiyagnanam et al. [9] have considered the potential of using Waste Pork Lard methyl esters blends of 25%, 50%, 75% and 100% in a 5.2kWpower diesel engine.

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Mr. K. Sri Rama Murthy, Department of Mechanical Engineering, Koneru Lakshmaiah Eductional Foundation (Deemed to be University), Vaddeswaram, Guntur, Andhra Pradesh, INDIA.

Dr. S. Sudhakar Babu, Department of Mechanical Engineering, Koneru Lakshmaiah Eductional Foundation (Deemed to be University), Vaddeswaram, Guntur, Andhra Pradesh, INDIA.

Dr. Venkata Ramesh Mamilla, Department of Mechanical Engineering, Sri Vasavi Engineering College, Pedatadepalli, Tadepalligudem, Andhra Pradesh, INDIA.

Their results indicate a reduction in SFC, BTE, hydro carbon and smoke emission, nitrogen oxides were slightly higher for Waste Pork Lard methyl esters and its blends and with the use of Selective Catalytic Reduction, the NOx emissions are reduced however a minor increase in CO_2 and O_2 were identified. S. D. Sekar et al. [10] conducted tests on the diesel engine which runs with the Nerium seed biodiesel with a range of proportions B5, B10 and B15. This work states that, the performance of the Nerium seed oil methyl esters is slightly higher than base fuel. Mohd Hafizil M. Yasin et al. [11] evaluates the commercial four stroke, four cylinder, Indirect Direction Injrction diesel engine's performance and combustion using pure PME as fuel. The results revealed that higher BSFC is observed for Palm methyl ester as compared with the diesel. It is also observed that, for diesel and PME the peak cylinder pressures are 56.6 bar and 61.6 bar at 14°CA respectively. V. Narasiman et al. [12] performed the experiments on a diesel engine to study the outcome of sardine oil and its methyl ester on combustion. They observed that, at full load, for Sardine biodiesel there is increase in peak cylinder pressure, peak heat re-lease rate during the premixed combustion phase, ignition temperature and Ignition delay when compared with diesel. In the current work, to identify the best biodiesel and diesel blend, the performance, emission and combustion characteristics of B20TME, B40TME, B60TME, B80TME, neat TME and diesel fuels were studied in a single cylinder four stroke constant speed diesel engine at 1500 rpm with variable loads.

II. PRODUCTION OF TAMARIND SEED METHYL ESTERS AND CHARACTERIZATION

A. *Production Procedure of Tamarind seed methyl esters*

Rajalingam et al. [1] states that, Biodiesel can be used to overcome the demand of fuel. To prepare the biodiesel, four methods are used such as direct blending, transesterification process, pyrolysis and micro emulsion and out of every one of these approaches, the transesterification procedure can be the better. In 1853, E. Duffy and J. Patrick used this process for vegetable oil. The transesterification procedure is commonly used to decrease the viscosity of triglycerides and it is the response of oil with an alcohol, for example, methanol, ethanol, propanol and so on in the presence of catalyst (NaOH) to form esters.1000gms.of tamarind seed oil, 180gms. of methanol and 6gms. of NaOH pellets were taken and it was heated to 60oC and agitated for one hour with the help of magnetic stirrer. The mixture was next permitted to settle under gravity almost for one day. The two layers of methyl esters and glycerol are formed. The water washing was done to the methyl ester. It separates the residual fatty acids, soap bubbles, and the remained catalyst traces. Finally the moisture from methyl esters was removed.

B. *Properties of fuels used*

The fuels used in this research work are TME and its blends with diesel. The test blends B20TME, B40TME, B60TME and B80TME were prepared on volume basis. The properties Diesel, TME (B100), and blends B20TME, B40TME, B60TME and B80TME has been determined as per ASTM standards and are presented in the Table I.

Table I. Properties of Diesel and TME.

Property	Units	Diesel	TME
Flash point	^{0}C	54	85
Fire Point	^{0}C	58	97
Kinematic Viscosity	cSt	3.6663	4.72
Density	kg/m^3	840	910
Calorific Value	kJ/kg	42500	33530

III. EXPERIMENTAL METHODOLOGY

The diesel engine chosen for conducting the experimentation is coupled to eddy current dynamometer and necessary instruments. The technical specifications of the engine used for experimentation are given in the Table II.

Table II. Engine Specifications.

Parameter	Specification
Engine	Kirloskar
Model	TV1
Rated power	5.2kW
Rated speed	1500rpm
Bore	87.5mm
No. of strokes	4
No. of cylinders	1
Type of cooling	Water cooling
Stroke	110mm
Compression ratio	17.5:1
Dynamometer arm length	185mm

Diesel and biodiesel blends were filled separately in the fuel tanks. The diesel engine was firstly started with diesel fuel and remains for 15 minutes. Slowly Loads were applied on the engine and fuel consumption rate, emissions and smoke values were recorded after the engine attains the stability. Then the engine was run with all considered biodiesel and blends repeating the same procedure.

Fig.1 Experimental setup of test engine.

The performance and emission characteristics of the engine were determined for B20TME, B40TME, B60TME, B80TME, TME and diesel fuels. The fuels are injected at 230 before top dead centre and at the nozzle opening pressure of 200 bar. The emission testing were carried out on AVL DI 444N Five gas analyser and smoke opacity was measured by AVL 437C Smoke meter. The photograph for the experimental setup is specified in the Fig.1.

IV. RESULTS AND DISCUSSION

The engine was started without any difficulty, and it runs smoothly when tamarind methyl easter and its blends were used. The engine tests were conducted at different loads of 0%, 20%, 40%, 60%, 80 % and100% at the speed of 1500 rpm. The effect of performance characteristics, Emission characteristics and Combustion characteristics are presented in this part.

A. Performance Characteristics

There are several parameters which are used to determine the performance of an engine which are generally known as Engine Performance Characteristics. Some of the important parameters are studied in this session.

B. Brake Thermal Efficiency

Brake thermal efficiency variations for all blends of tamarind seed oil methyl ester and diesel has been represented in Fig. 2. As shown in the figure, the values of Brake thermal efficiency when fuelling with biodiesel blends are decreased as compared to diesel. The main factor to this decrease in brake thermal efficiencies is owing to poorer heating values of tamarind seed biodiesel blends. Higher viscosity of fuel results in poor atomization and inadequate mixing of fuel and the heated air. For diesel and all biodiesel blends, with enhancing in load the Brake thermal efficiency also increases smoothly. At most extreme load for B20TME, the greatest brake thermal efficiency was 30.78% which is closer to diesel (33.86%) when contrasted with the rest of the blends.

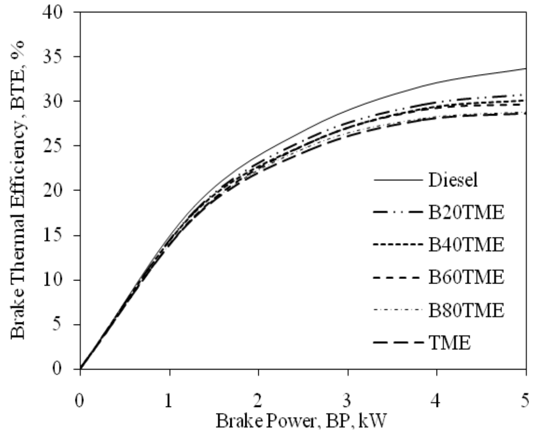

Fig. 2 Variation of BTE with Brake Power at different TME blends.

C. Brake Specific Fuel Consumption

This is an significant parameter to compare the performance of assorted fuels used in the engine. The performance depends on the properties of the tested fuels used in the engine. The BSFC of all the tested biodiesel fuels enhances with advance in the concentration of the biodiesel as shown in fig.3. Among all the blended fuels, the BSFC value for B20TME is nearer to that of diesel. It is observed that, there is decline in Brake specific fuel consumption values for all the fuels as the load elevates because for the same volume, more biodiesel blended fuel was injected into the engine cylinder compared with the amount of diesel due to the greater density and smaller calorific value of the biodiesel.

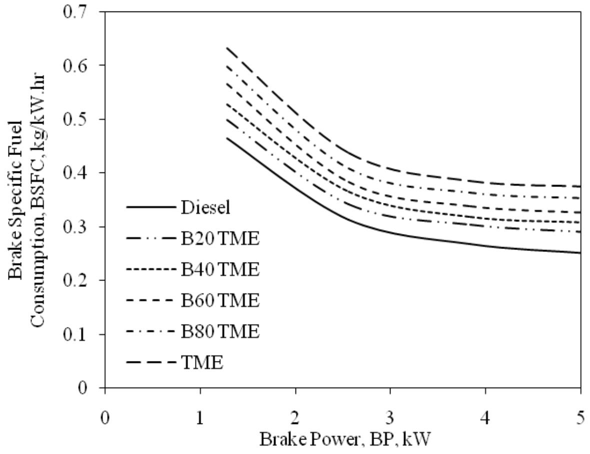

Fig. 3 Variation of BSFC with Brake Power at different TME blends.

D. Emission characteristics

The emissions generated in the combustion of IC engines, contaminate the environment and/or health problems. The different emissions generated are described in this session. The foremost causes of the below mentioned emissions are owed to poor combustion of fuel, dissociation of nitrogen and impurities in the fuel and air.

E. Carbon monoxide emissions

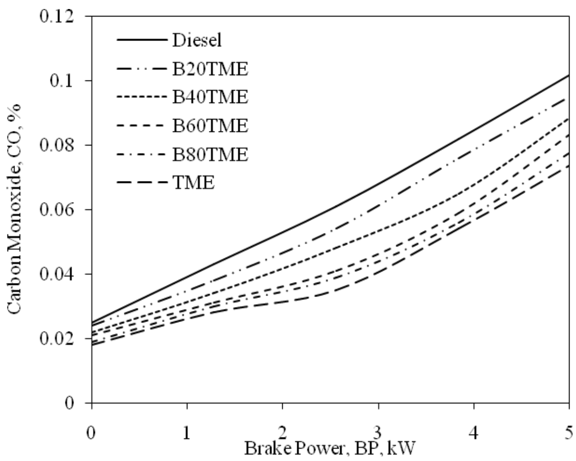

Fig. 4 Variation of Carbon monoxide with Brake Power at different TME blends.

The CO emissions were lower for the TME biodiesel and biodiesel blended fuels in comparison with the base diesel fuel as revealed in fig.4. It is discovered that, with the elevate in tamarind seed methyl ester percentage, the CO emissions decreases. CO is created as a result of partial combustion of the fuel and is an intermediate combustion product. Carbon monoxide can be reduced by promoting the entire combustion. Puhan et al. [14] also observed that, by using Mahua oil biodiesel in the engine the CO emissions decreases. The availability of enough oxygen content causes most of the CO to be converted to CO_2.

F. Hydrocarbon emissions

The variation of hydrocarbons with brake power for various used fuels is exposed in Fig 5.It was seen from the fig. that, hydrocarbons nearly increments with increment in brake power for every one of the fuels. Tamarind seed biodiesel and its different blends indicated inferior hydrocarbons apart from diesel fuel at all load conditions. Hydrocarbons formed due to incomplete combustion or incomplete burning of hydrogen reacts with carbon content. Because the TME is an oxygenated fuel, which promotes well-combustion in turn the hydrocarbon emissions are reduced. In the operating range, hydrocarbon emissions are less for TME compared to that of all other blends and diesel. A reduction of 32.14% in hydrocarbon emissions was observed at maximum load for TME. This may be due to an elevate in residual gas temperature within the cylinder and decrease in flame quenching thickness at higher loads in the engine [15].

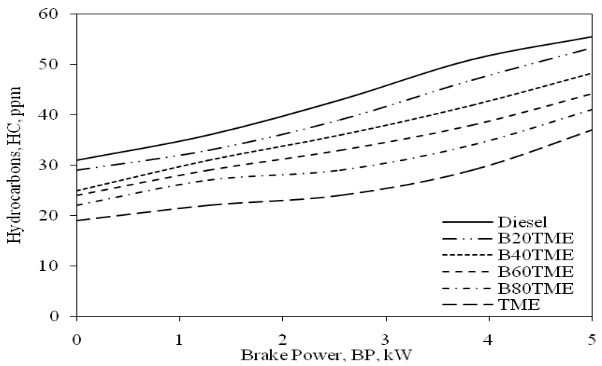

Fig. 5 Variation of Hydrocarbons with Brake Power at different TME blends.

G. Nitrogen oxide emissions

The discrepancy of Nitrogen oxides with brake power for tried TME biodiesel and mixed fuels are appeared in Fig.6. From the fig, it was observed that, these emissions are more for all the tested fuels as compared to the neat diesel fuel. These emissions are improved with raise in brake power for all the biodiesel fuels. It is also detected that, the emissions for B20TME is nearer to diesel. At full load, these emissions are increased by 13.62%, 18.65%, 34.38%, 40.35% and 47.79% for B20TME, B40TME, B60TME, B80TME and TME as compared to the diesel. The boost in nitrogen oxide emissions could have been influenced by the distinctions in the fuel properties [16]. When using biodiesel concerning the NOx emissions, the same was observed by many other researchers. The same trend was observed for the UCME and its Blends used as fuel in engine. Nitrogen oxides increase may be associated with the oxygen content of the biodiesel [7].

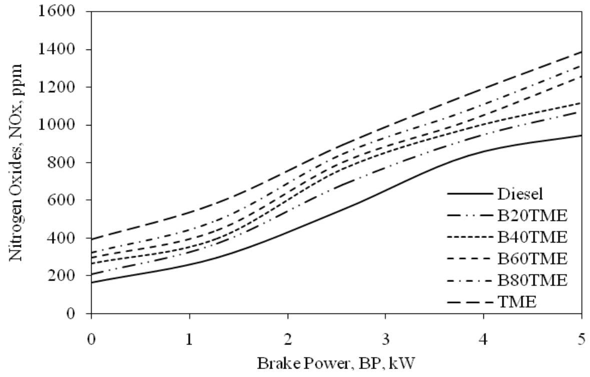

Fig.6 Variation of Nitrogen oxides with Brake Power at different TME blends.

H. Smoke Density

For every one of the fuels utilized, the variety of smoke density as for brake power is appeared in fig.7. The smoke density of B20TME, B40TME, B60TME, B80TME, TME and diesel are 91.36, 86.54, 79.62, 73.06, 69.51 and 93.4 at maximum load. From the fig, it is seen that, smoke density is expanded at higher loads for every one of the fuels. Smoke density is decreased in the biodiesels because of absolute combustion process. The pattern in regards to the variety of smoke opacity as for load is practically comparable in all kind of fills.

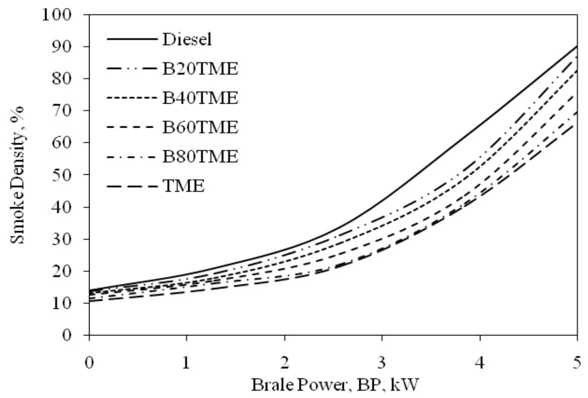

Fig.7 Variation of Smoke density with Brake Power at different TME blends.

I. Combustion characteristics

J. Cylinder pressure

The cylinder pressure variations for engine run by different tested fuels are presented in fig. 8. It is found that diesel presents the high cylinder pressure related to that of all biodiesel fuels. The high value of cylinder pressure observed for diesel is 70.42 bar, whereas it is 68.82, 67.56, 66.92, 66.83 and 66.58 bar for the B20TME, B40TME, B60TME, B80TME and TME fuels correspondingly at utmost load of the engine.

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The increase in cylinder pressure values are not observed in biodiesel and its blends than pure diesel due to the properties of biodiesel [13].The pressure rise depends on mixing capability of air fuel mixture and on the combustion phenomena. It is seen from the below fig. that for B20TME, it is very close to the diesel.

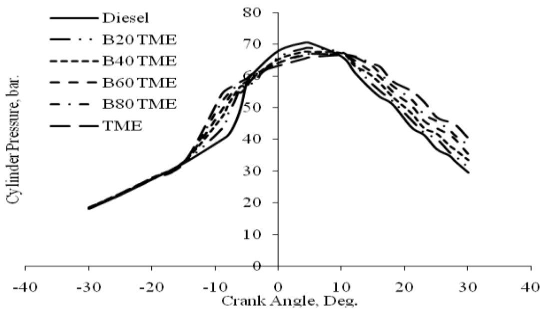
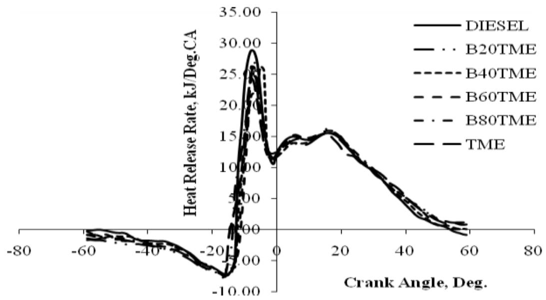


Fig.8 Variation of cylinder pressure with crank angle at different TME blends.

K. Heat release rate

The differentiation of heat release rate with crank angle for all blends of biodiesel at maximum load is exposed in fig.9. It's determined from the fig. that, the utmost heat release rate of biodiesel blends are under that of diesel oil within the engine. This could be attributed to low-grade calorific value, shorter ignition delay, poor spray atomization characteristics and better viscousness of biodiesel blends [13]. The maximum heat release rate observed for base fuel, B20TME, B40TME, B60TME, B80TME and TME fuels are 28.79, 27.04, 26.27, 26.15, 25.3 and 24.34 kJ/Deg.CA correspondingly at maximum engine load.



V.CONCLUSION

Biodiesel is produced by means of transesterification method. The investigational consequences compared with diesel shows the following:

1. The brake specific fuel consumption with raise in fraction of TME blends lifts owed to the low level calorific value of biodiesel.
2. The brake thermal efficiency losses with raise in fraction of blends of TME in the fuel.
3. The NOx emissions are improved for all tested fuels as compared to diesel at every one of loads owing to more oxygen content in TME and its blends.
4. Biodiesel provides decline in CO, HC and smoke density with improve in percentage of biodiesel.
5. The combustion analysis showed that the by adding biodiesel to the conventional fuel, the peak pressure inside the cylinder decreases.

It was observed from above discussions that, B20TME is an optimal blend when compared to all other remaining blends because for the blend B20TME the Brake Thermal Efficiency (30.78%) is nearer to the conventional diesel (33.86%) at full load. Hence, it can be recommended that the B20TME can be used as biodiesel in the diesel engine exclusive of any engine alterations.

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