EXPERIMENTAL INVESTIGATION ON DIESEL ENGINE USING DMC AS A FUEL ADDITIVE IN TAMARIND SEED OIL METHYL ESTER

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Abstract: *The increasing industrialization and motorization there is a scarcity of petroleum products. So, there is need for suitable alternative fuels for diesel engines. In the present study, Tamarind seed oil methyl esters (TSOME) were prepared through Transesterification and the properties of oil were found within acceptable limits. A compression ignition engine was fuelled with three blends of TSOME (10,20 &30) with diesel on basis of volume and the performance and emission results are evaluated and compared with base line data of diesel. The performance results are shows that there is an increase in BTE and decrease in BSFC, The emission parameters are HC and smoke opacity are lower compared to the diesel. This may be accredited to improve the combustion for TSOME blends. The oxides of nitrogen emissions are almost all nearer for blends compared to the diesel fuel. Addition of DMC (Di-methyl carbonate) fuel additive as 5%, 10% and 15% volume ratios to the optimum blend as TSOME20 for evaluating the engine performance and emission parameters the main intention is to use fuel additives as improve the combustion process and reduce the emissions. Finally the results are concluded that the potentiality of the Tamarind seed methyl ester as alternative fuel for compression ignition engines without any modifications.*

Keywords: **Tamarind seed oil, Transesterification, Bio-diesel, Methanol, DMC**

1.Introduction

The Energy comes in a variety of renewable forms like wood energy, wind energy, solar energy, ocean energy, Geothermal energy, bio energy generated by bio fuels is viewed as a strong source of energy in the coming years. The energy is key input for technological, social and economic development of a nation. Five generations ago, wood supplied up to 90% of our energy needs. Due to the convenience and low prices of fossil fuels. Rapid depletion ,increasing prices, Un certainty in supply and ever increasing demand of petroleum products and most importantly stricter emission norms have triggered an intensive research for alternative fuels. Hence, fuels which are renewable, clean burning and can be produced in a decentralized manner are being investigated as alternative fuels. Over past few decades ,lot of researchers has gone into use of alternative fuels in internal combustion engines. The tests based on the engine performance, emissions and evaluations have established the feasibility of using different types of biofuel. Methyl esters of vegetable oils, known as biodiesel are become increasingly because of their low environmental benefits. Biodiesel can't be used as directly for combustion because of their high viscosity and low calorific value. Transesterification is a most useful method to reduce viscosity of vegetable oils. Biodiesel is non-toxic and biodegradable. The combustion of biodiesel contributes less CO_2 to the atmosphere [1-3].Analyzed the performance of a CI engine fuelled with biodiesel-diesel blends (BD) and biodiesel-diesel blends with methanol(10%v/v) as additive (MBD). They revealed that, for BD blends, BSFC were higher by 3.5% while it fluctuatedfrom2 to 13% for MBD blends in comparison with diesel. Also, the reduction of CO, HC and soot emissions were 8%, 32% and 22% for BD blend whereas for MBD blend, the reduction is about 13%, 18% and 45%, respectively[4]. The methyl esters of a Hodge oil, Jatropha oil, and sesame oil. Comparative measures of BTE, smoke opacity, HC, CO, NO_x, ignition delay, combustion duration , HRR have been discussed the results are higher BTE and lower emissions. Smoke emissions are higher compared with diesel and increased ignition delay and combustion duration[5].Performed a comparative study in a single cylinder diesel engine powered by biodiesel-ethanol-diesel (BED) and biodiesel-methanol-diesel (BMD) blend. The author concluded that, ethanol addition resulted in increased NO_x emissions, whereas methanol addition resulted in reduction of HC and CO emissions. Also, the author concluded that dependence of optimum alcohol blend ratio is essential in emission control as the blend ratio influences the oxygen content and cooling effects[6].Experimented with ethanol-biodiesel diesel blends in a high temperature combustion chamber. Initially when biodiesel added to diesel, soot formation and burning rate reduced significantly. The biodiesel used was castor oil which is found to be a promising alternative for soot reduction since castor oil contains an extra –OH functional group in its molecular structure. Moreover, there was micro-explosion phenomenon during the burning of biodiesel-diesel blends with ethanol, thus reducing the overall burning time and fuel consumption[7].Evaluated the performance, combustion and emission characteristics of diesel with DEE blends (5–15% bywt) on a single cylinder DE diesel engine. They interpreted that,10% DEE addition improved the BTE, lowered the smoke and CO emissions without affecting NO_x[8]. From, the review of literatures, abundant works in the utilization of Biodiesel and it blends in diesel engines have done. Raju et al. [9] conducted experiments on compression ignition engine with mahua seed oil as alternate feedstock and reported that the mahua seed bio-fuel blends shown enhanced BTE and lowered exhaust emissions when analyzed with conventional diesel. Biodiesels contain inherent oxygen content; better lubricity and higher Cetane are the main reason for the improvement in thermal efficiency with biodiesel However, most of the cases the work is on to use as single biodiesel and blends. From literature studies [10-14], biodiesel play a vital role in diesel engine. Finally, it is concluded that biodiesel is one of the potential alternative fuel for the diesel to minimize the tailpipe emissions towards the sustainable green environment. The characteristics of biodiesel are close to mineral diesel, and therefore tamarind seed oil become a potential fuel source to replace partially or completely the mineral diesel if need arises.

1.1Tamarind seed oil

Tamarindus indica is probably indigenous to tropical Africa, but has been cultivated for so long on the Indian subcontinent that it is sometimes also reported to indigeneous there. Tamarind Tree belongs to the family of Fabaceae .Its scientific name is ‘Tamarindus Indica’.The name of this tree was derived from the Persian word Tamar-e-Hind, which means Indian date. The consumption of Tamarind is wide spread due to its central role in the cuisines of the Indian subcontinent, South East Asia and America, particularly in Mexico.

Fig:1 Tamarind tree crop and Seeds

1.2Tamarind seed oil Methyl Esters

As the availability of Tamarind seed oil is to be found, a certain percentage of biodiesel can be replaced by some other second generation biofuels such as methanol which is commonly used in transesterification. In this process catalysts such as KOH or NAOH are used to increase the reaction to quickly break the triglycerides into glycerol and methyl esters. So, the major focus on biodiesel research has been mainly of transesterification process. Two distinct layers are formed, the lower layer is glycerin and the upper layer is ester. The upper layer (ester) is separated and moisture is removed from the esterby using calcium chloride. It is observed that 90% ester can be obtained from vegetable oils. The products of the reactions are the biodiesel itself and glycerol. The chemical reactions of biodiesel are shown in below. The physical and chemical properties of tamarind seed oil is shown in Table 1.

Table1. Properties of Tamarind seed oil

properties	Value
Calorific value(kJ/kg)	38,880
Specific gravity	0.883
Kinematic viscosity (cst)	6.86
Flash point(^{0}c)	159
Fire point(^{0}c)	173
Cetane number	52.4

2.Experimental set up and procedure

Fig: 2 Experimental set up

The experimental set up is shown in figure.2 consists of a Single cylinder, Four stroke, Constant speed, Water cooled, Diesel engine coupled with eddy current dynamometer. The test rig engine consists of fuel supply system and various sensors attached and integrated with the computerized data acquisition system for the measurement of load, cylinder pressure, injection timing and crank angle etc, The specifications of the test engine are showed in Table 2.For the analysis AVL Di-gas analyzer and AVL 437C Smoke meter is used.

Table 2.Test engine specifications

Engine type	Kirloskar TAF1
power	4.4kw
Cylinder bore	87.5mm
Stroke	110mm
Compression ratio	17.5
No of cylinders	01
Injection timing	23^0BTDC
Method ofcooling	water

2.1Experimental Test Procedure:

The engine is allowed to reach its steady state by running it's for ten minutes. The engine was warmed up and stabilized before taking all readings. After the engine reached working condition, the load is applied, fuel consumption ,brake power and other parameters were measured. The engine performance and exhaust emissions are noted at different loads. The brake specific fuel consumption and brake thermal efficiency are calculated. The emissions such as CO,HC&NO_x were measured with exhaust gas analyzer and Smoke capacity with AVL437C smoke meter. The performance, combustion and emission characteristics for different fuels compared with diesel fuel.

3.Results and Discussion

The experiments are conducted on the four stroke single cylinder water cooled diesel engine at constant speed (1500 rpm) with varying loads of diesel and TSOME (10, 20 & 30) Blends. FuelAdditive such as DMC (Di-methyl carbonate) is added to the optimum blend in different proportions (5%, 10% and 15%) for improving the performance parameters and reducing the emissions as discussed below.

3.1 Brake thermal efficiency

The variation of brake thermal efficiency with load for different fuels as shown in Fig.3.In all cases it increases with increasing in load. This is due to reduction in heat loss and increasing in power with increasing load. The maximum brake thermal efficiency for TSOME20 is 34.40% was nearer to the base fuel diesel as 34.00%.

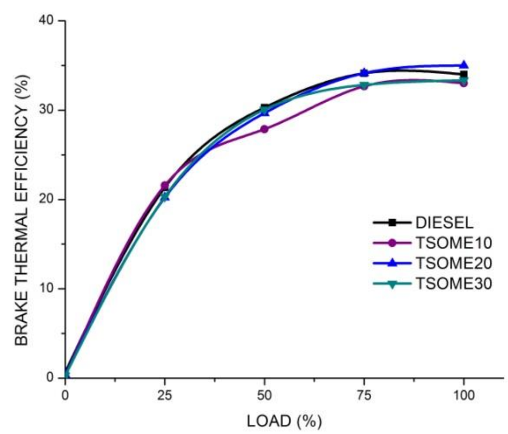

Fig:3 Variation of Brake thermalefficiency withLoad Using TSOME Blends

3.2 Brake specific fuel consumption

The variations of brake specific fuel consumption with load for different fuels are as shown in Fig.4. BSFC is the ratio between mass of fuel consumption and brake effective power. And it is inversely proportional to the thermal efficiency. It can be observed that the BSFC as

0.245kg/KWh as obtained as diesel fuel and 0.25kg/KWh for TSOME20 at full load. It was observed that BSFC decreased with the concentration of increasing in Tamarind oil in diesel.

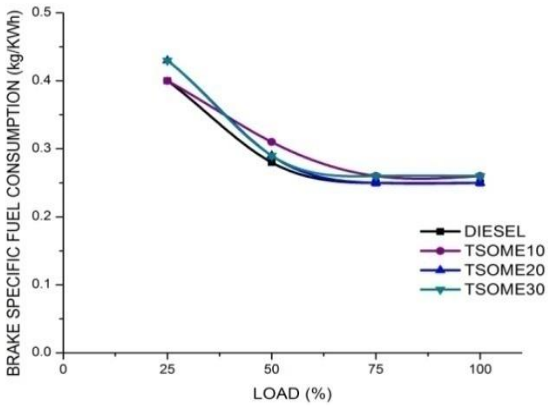

Fig:4 Variation of BSFC with Load Using TSOME Blends

3.3 Carbon Monoxide

The comparison of carbon monoxide for various biodiesel blends with respect to load as shown in Fig.5. Carbon monoxide (CO) occurs only in engine exhaust it is a product of incomplete combustion due to insufficient amount of air (or) time in combustion process. The CO emission level is nearer to the diesel in order to gives extra oxygen.

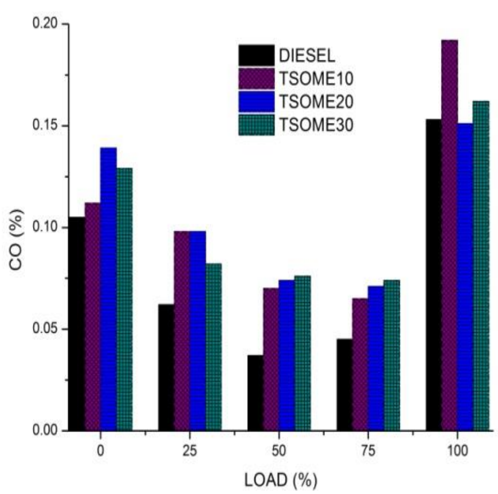

Fig: 5 Variation of Carbon Monoxide with Load Using TSOME Blends

3.4 Oxides of Nitrogen

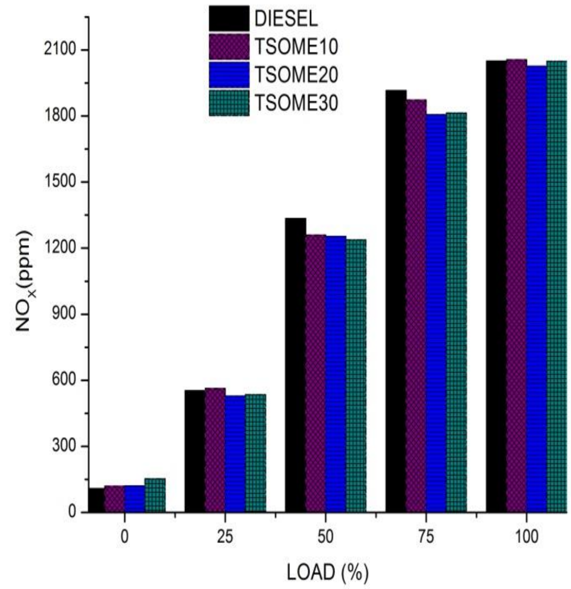

Fig:6 Variation ofNO_x with Load Using TSOME Blends

The variation of NO_x emission with load is shown in Fig.6.At full load condition the NO_x emission obtained are 2049ppm, 2056ppm, 2026ppm, and 2048ppm for the fuels of diesel, TSOME10, TSOME20, and TSOME30 respectively. The NO_x emission for all the tested fuels followed an increasing trend with respect to the load. The reason could be the higher average gas temperature, residence time at higher load conditions. A reduction in the NO_x emission for all the blends as compared to diesel was noted.

3.5 Hydro carbons

The variation of HC emission with load is shown in Fig.7. The HC emission decreases with increase in load for diesel and it is almost slightlyincreased for all biodiesel blends. At full load condition the UHC are obtained 45ppm, 81ppm, 89ppm and 92ppm for the fuels of diesel, TSOME10, TSOME20 and TSOME30 respectively. HC emission increases gradually up to full load and exhibits a shorter delay period and results in better combustion leading to low HC emission. The oxygen contained in the biodiesel was responsible for the reduction in HC emissions.

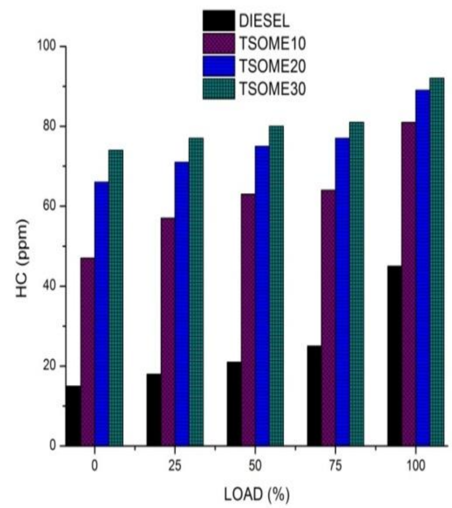

Fig:7 Variation of HC emissions with Load Using TSOME Blends

3.6 Smoke opacity

The variation of smoke opacity with load is shown in Fig.8.At full load condition the smoke opacity obtained are 76.6%, 59.3%, 61.4% and 62.3% for the fuels of diesel, TSOME10, TSOME20 and TSOME30. It is observed that smoke is gradually decreases at full load conditions as compared to diesel. The reason for the reduced smoke is the availability of premixed and homogeneous charge inside the engine as well before the commencement of combustion.

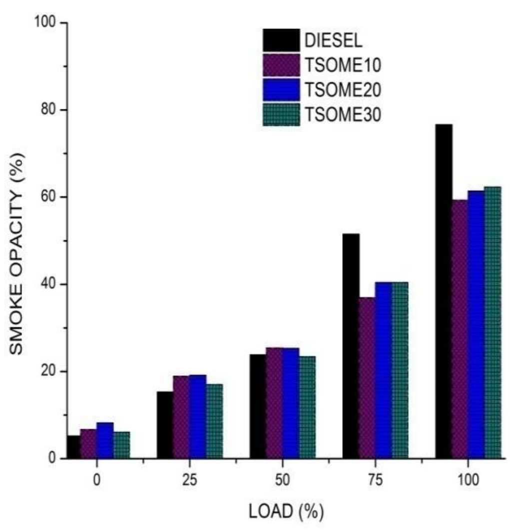

Fig:8 Variation of Smoke opacity withLoad Using TSOME Blends

4.Performance and Emission Analysis for TSOME20 with fuel additive (DMC):

For the obtained optimum blend TSME20, DMC is added as a fuel additive. The main purpose of adding fuel additive is to improve the performance and combustion rate at the same time reduce the emissions. The additive blends are added with the basis of 5%, 10% and 15% on volume ratios. The results are shown in given below.

4.1Brake thermal efficiency

The variation of brake thermal efficiency with load is shown in Fig.9. From the plot it is observed as the load increases there is a considerable increase in the BTE. The BTE of diesel at full load is 34.0% while the blends of TSOME20 is 34.40%, TSOME20D75DMC5% is 33.25%, TSOME20D70DMC10% is 35% and TSOME20D65DMC15% is 32.97% , among the four the maximum BTE is 35% which is obtained for TSOME20D70DMC10%. The BTE of TSOME is increases up to as compared with optimum blend at full load condition. The increment in BTE due to better combustion because of adding fuel additive or ignition improver it effects to decrease the viscosity of TSOME

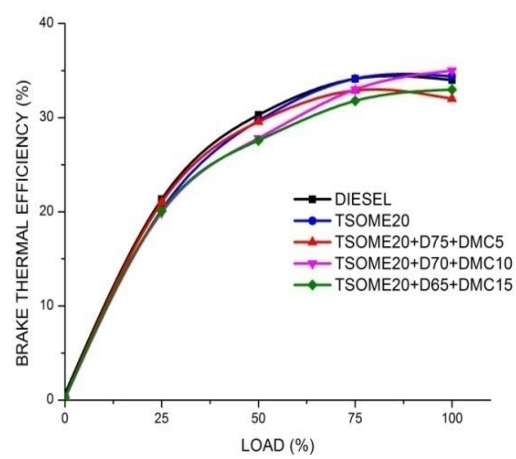

Fig:9 Variation of Brake thermal efficiency withLoad Using fueladditive

4.2 Brake specific fuel consumption

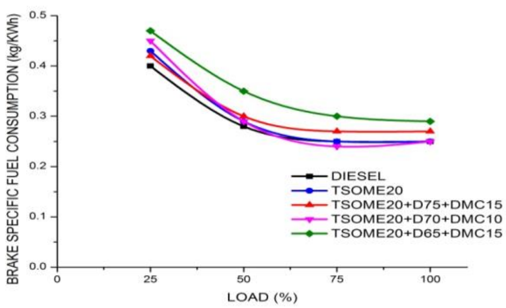

Fig:10 Variation of BSFC with Load Using fuel additive

The variation of brake specific fuel consumption with load is shown in Fig.10. The plot it is observed that as the load increases the fuel consumption decreases, the minimum fuel consumption for TSOME20D70DMC10% is 0.245 as to that of TSOME20 is 0.25. The BSFC of after adding Fuel additive of TSOME is decrease up to 2% as compared with optimum blend at full load condition the BSFC obtained are 0.25, 0.25 for diesel and TSOME20, DMC concentrations are 5,10 &15% are 0.27, 0.245, and 0.29 kg/KWh respectively.

4.3 Oxides of Nitrogen Emissions

The variation of NO_x emission with load is shown in Fig.11. The plot it is observed that the oxides of nitrogen emissions for all the fuel tested followed an increasing trend with respect to load. The results are obtained ad 2049ppm, 2026ppm and 2073ppm, 2049ppm and 2081ppm for the fuels of diesel, TSOME20 and DMC Blends respectively. After adding the fuel additives like 5, 10% and 15% concentrations as DMC there is a increase the oxides of nitrogen emissions and there having a better combustion characteristics occurred in the engine cylinder.

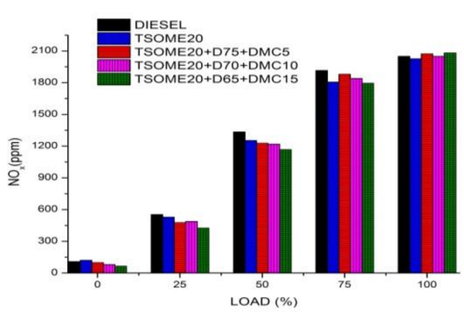

Fig: 11 Variation of Oxides of Nitrogen with Load Using fuel additive

4.4 Carbon Monoxide Emissions

The variation of CO emission with Load is shown in Fig.12. The plot it is observed that the CO concentrations are decreases for the blends of DMC as 5%, 10% and 15% respectively. At full load conditions the CO emission obtained are 0.153, 0.161 for diesel and TSOME blend.0.131, 0.117 and 0.112% are for DMC Blends respectively.

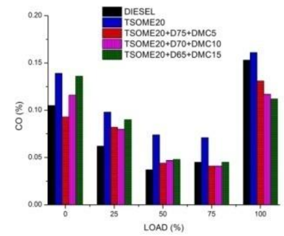

Fig: 12 Variation of CO emissions with Load Using fuel additive

4.5 Hydrocarbon Emissions

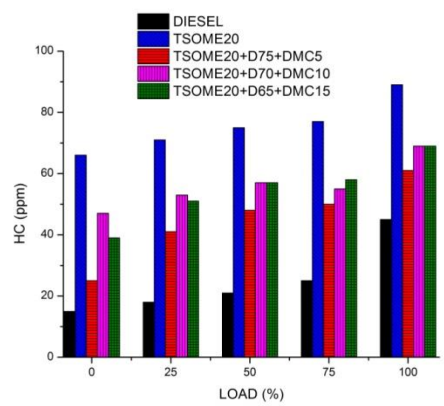

Fig: 13 Variation of HC emissions with Load Using fuel additive

The variation of HC emission with load is shown in below fig.13. The plot it is observed that the HC emissions are obtained as 45ppm, 89ppm for diesel and TSOME Blend. And DMC results are obtained as 61ppm, 69 and 69ppm respectively that the HC emissions increases with increase in load for adding fuel additive blends.

4.6 Smoke opacity

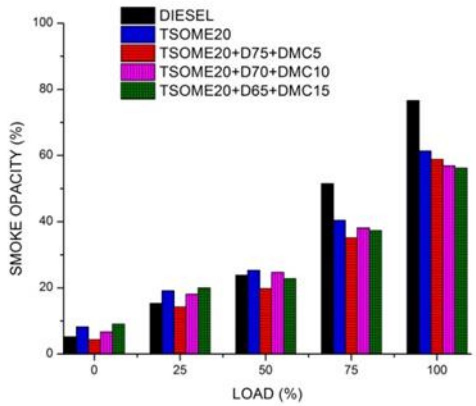

Fig: 14 Variation of Smoke opacity with Load Using fuel additive

The variation of smoke opacity with load is shown in Fig.14. The plot it is observed that the smoke is nothing but a solid soot particles suspended in exhaust gas. Various loads for different blends like TSOME20, TSOME20DMC5%, TSOME20DMC10% and TSOME20DMC15% tested fuels. The results obtained as 76.6%, 61.4% and for DMC blends as 58.8%, 56.9% and 56.2% respectively. It is observed that Smoke is lower for DMC Blends compared to the diesel and TSOME20 blend.

5. Conclusion

The performance and emission characteristics of conventional diesel, biodiesel blends and optimum blend with DMC as fuel additive were investigated on a single cylinder diesel Engine. The conclusions of this investigation are as follows.

- The Brake thermal efficiency increases with increase in biodiesel percentage.TSOME20 shows best performance. The maximum BTE obtained as 34.40%.
- Brake specific fuel consumption is decreased for the blended fuels. CO emissions reduced by 10%, with a marginal reduction in NO_X emissions when compared to the diesel fuel. Also, slight reductions in HC emissions when compared to the diesel.
- DMC fuel additive of 10% blend shows the best performance because the Brake thermal efficiency is higher 34.9% and BSFC was decreased.
- DMC fuel additive reduce the Emissions like CO, CO_2, and Smoke opacity. The oxides of Nitrogen emissions are nearer. HC emissions are higher with compared to the diesel fuel.
- Finally, by adding fuel additive as DMC (Di-methyl carbonate) the results are concluded that increase the performance and reduce the emissions.

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