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Experimental Investigation of Multi Cylinder Diesel Engine fuelled with Biodiesel and diesel fuel

Dr. Hiregoudar Yerrennagoudaru[1], Chandragowda M[2], Prasanna G P[3]
[1]*Principal and PG Co-ordinator (Thermal Power Engineering), Mechanical Engineering Department, RYMEC Bellary, Karnataka, VTU, India*
[2]*Assistant Professor (Thermal Power Engineering), Mechanical Engineering Department, RYMEC Bellary, Karnataka, VTU, India*
[3]*M.Tech (Thermal Power Engineering), Mechanical Engineering Department, RYMEC Bellary, Karnataka, VTU, India*

Abstract: *Rapid population growth and modernization in human lifestyles are resulting in increased energy consumption. The power generation and transportation sectors are the main consuming source of energy. The diesel engine plays a major part of both of these sectors throughout the world. Petroleum based fuels worldwide have not only resulted in the rapid depletion of conventional energy sources, but also have caused severe air pollution. Hence it has become necessity to go for an alternate fuel. The existing studies have revealed that use of biodiesels or non edible vegetable oil as an alternative fuel for diesel fuel. The objective of our project is experimental investigation and performance and emission characteristics of mango seed biodiesel & soybean biodiesel fuelled with multi cylinder diesel engine. In our experimental set up consist twin cylinder, constant speed, four stroke, and oil cooled diesel engine. The engine is started using diesel fuel and its performance and emission readings are recorded. Later engine is fuelled with biodiesel, which makes engine to run under dual fuel mode and compare the Performance and emission characteristics two biodiesel with diesel fuel.The results of the project indicate that the use of mango seed biodiesel & soybean biodiesel can substitute diesel fuel by 100% biodiesel, performance characteristics and smoke level are closer to diesel fuel where as emission characteristics is closer and at full load which is same as that of diesel fuel. This will lead to increase in investigation on use of biodiesel or vegetable oil instead of diesel; it helps in production of bio fuel in India which in turn helps in the increased employment.*
Keywords: *Diesel, Exhaust emissions, Mangoseed Biodiesel, Performance, soybean Biodiesel.*

I. Introduction

In country like India, majority of population lives in rural areas and they depend on agriculture. The large increase in number of automobiles in recent years has resulted in great demand for petroleum products [7]. India spending 30% of her total foreign exchange on oil imports which import 70% of the required fuel [8].In the event of regular electricity failure, diesel engines are used to operate water pump sets and other agricultural implements. If fuel for these diesel engines is prepared locally, it makes the farmers self-sufficient with regard to their energy needs. There are many vegetable oils available, which can be used as fuel for diesel engines. Use of edible oils like sunflower oil, peanut oil sand soya oil, etc. for diesel engine may cause conflict between food and fuel [1].As far as India is concerned because of its vast agro forestry base, fuels of bio origin can be considered to be ideal alternative renewable fuels to run the internal combustion engines. Vegetable oils from plants both edible and non-edible and methyl esters (Biodiesel) are used as an alternate source for diesel fuel. Biodiesel was found to be the best alternate fuel, technically, environmentally acceptable, economically competitive and easily available. There are more than 350 oil bearing crops that have been identified, among which only sunflower, soyabean, cottonseed, mango seed, rapeseed and peanut oils are considered as potential alternative fuels for diesel engines. Apart from the renewability, the advantages of biofuels are as follows: High oxygen content, higher flash point and higher lubricity that produce complete combustion in comparison with conventional diesel fuel. Traditional oilseed feedstock for biodiesel production predominantly includes soybean, rapeseed, palm, sunflower, cottonseed, peanut and coconut oil [3].More than 95% of biodiesel production feedstock's come from edible oils. In order to overcome these disadvantages, many researchers are interested in non-edible oils which are not suitable for human consumption because of the presence of some toxic components in the oils. Furthermore, non edible oil crops can be grown in waste lands that are not suitable for food crops and the cost of cultivation is much lower because these crops can still sustain reasonably high yield without intensive care [6].The biodiesel results in a recognizable increase (10%) in NOx emissions when compared to diesel. NOx causes human health and also affects the environment resulting ground level ozone forming potential[2,9].Furthermore, the regulations for particulate matter (PM) and NOx emissions from diesel engines have strengthened, and reductions in carbon dioxide (CO2), which is a greenhouse gas, emission, also raised important issues. These reasons have pushed the countries towards searching for the alternative energy sources with particular emphasis on those renewable in nature. For substituting the petroleum fuels used in internal combustion engines, fuels of bio-origin provide a feasible solution to the twin crises of 'fossil fuel depletion' and 'environmental degradation'. Vegetable oil esters are receiving increasing attention as a non–toxic, biodegradable, and renewable alternative diesel fuel. These esters have become known as "biodiesel." Many studies have shown that the properties of biodiesel are very close to those of diesel fuel. Therefore, biodiesel can be used in diesel engines with few or no modifications [4, 11] .Studies has revealed that the usage of non-edible oil in neat form is possible but not preferable. The high viscosity of nonedible oils and low volatility affects the atomization and spry patterns of fuel, leading to incomplete combustion and severe carbon deposits, injector choking and piston ring sticking. The methods used to reduce the viscosity are-Emulsification, Pyrolysis, Dilution and Transesterification [5]. The main aim of our study is to use 100% biodiesel in diesel engine without modification and compare the performance and emission characteristics with diesel fuel.

II. Literature Survey

Vijay Sisarwal et.al [1] conducted experiment on a single cylinder, four stroke, direct injection, and naturally aspirated compression ignition engine to evaluate effect of straight vegetable oil fuel on engine performance parameters and concluded that the brake thermal efficiency with vegetable oil blends is higher than straight vegetable oil due to better combustion characteristics and the brake specific energy consumption with blends is lower as compared to SVO on account of better atomize-blends resulted in lower BSEC. Hence SVO is good option for the substitute of fuel on the diesel engine.K. Velmurugan et.al [2] conducted experiment on single-cylinder, water-cooled, naturally aspirated direct injection diesel engine of 5.9 KW rated power coupled with an eddy current dynamometer to evaluate impact of antioxidants on NOx emissions from a mango seed biodiesel powered DI diesel engine and concluded that the antioxidants and biodiesel mixtures reduced the nitrogen oxides. Among the antioxidants tested, the phenolic derived additive Pyridoxine Hydro Chloride (PHC) delivered highest reducing activity of NO emissions compared to the DEA and TBHQ antioxidant additives. K. Vijayaraj et.al [3] conducted experiment on Kirloskar TAF 1 engine to evaluate the performance, emission and combustion characteristics of a direct injection, compression ignition engine fueled with methyl ester of mango seed oil and its blends and compared with diesel fuel. They concluded that almost all the important properties of biodiesel are in close agreement with the diesel fuel and suggested that the diesel engine can perform satisfactorily on methyl ester of mango seed oil and its blends with diesel fuel. Mohamed F. Al Dawody et.al [4] conducted experiment on a single cylinder, direct injection diesel engine operating on different blends of a soybean methyl ester (SME) with diesel fuel to evaluate Combustion, Performance and Emission Parameters of a Diesel Engine Fueled with Soybean Biodiesel. According to the results he conclude that the use of biodiesel produces lower smoke opacity up to 48.23% with 14.65% higher brake specific fuel consumption (BSFC) compared to diesel fuel. The measured CO emissions of B20% SME and B100% SME were found to be 11.36% and 41.7% lower than that of diesel fuel respectively. All blends of SME were found to emit significantly lower UHC concentration compared to that of diesel over the entire load. NOx emissions are observed to be higher for all blends of SME. V.Mahesh et.al [5] conducted experiment on single cylinder 4 stroke naturally aspirated water cooled diesel engine having 5 BHP as rated power at 1500 rev/min to evaluate performance and emission characteristics of non-edible oil (honge oil) as alternate fuel in ci engine and concluded that the specific fuel consumption increases with increase in percentage of HOME in the blend due to the lower calorific value of HOME and Methyl ester of Honge oil results in a slightly increased thermal efficiency as compared to the of diesel. As well as CO2 and CO emissions are low with methyl ester of Honge oil. M.Abdelfatah et.al [6] conducted research on Production of biodiesel from non-edible oil and effect of blending with diesel on fuel properties and concluded that biodiesel produced from Egyptian jojoba oil can be used as an alternative fuel in conventional diesel engines. The results showed that the production of biodiesel from Egyptian jojoba oil by transesterification with methanol in presence of an alkaline catalyst (KOH) is affected by reaction time, methanol: oil molar ratio, catalyst concentration and temperature. S. Jaichandar et.al [7] conducted study on the production of biodiesel as an alternative fuel for diesel engine and concluded that the production of biodiesel from vegetable oil is very simple. In the production of biodiesel it is observed that the base catalyst performs better than acid catalysts and enzymes. The biodiesel and their blends have similar fuel properties as that of diesel. It is also observed that biodiesel has similar combustion characteristics as diesel. Biodiesel engines offer acceptable engine performance compared to conventional diesel fueled engines. Kevin pethani et.al [8] conducted experiment on single cylinder, four stroke, water cooled, direct injection CI engine to determine the relationship between engine performance and emissions using diesel, volumetric blends of Mahua bio-diesel and diesel and pure Mahua bio-diesel as a fuel engine at various load conditions. He concluded that the brake specific fuel consumption decreases with increase in additive percentage. Exhaust gas temperature increases almost linearly with load for all test fuels and decreases with increase in additive percentage. It is also seen from the results that both CO and HC emissions tend to decrease with increase in additive percentage in biodiesel.

Fuel additive improves engine performance and lowers pollutant emission of Mahua bio-diesel blends. Maria I. Martins et.al [10] conducted experiment of Transesterification of Soybean Oil for Biodiesel Production Using Hydrotalcite as Basic Catalyst and concluded that the hydrotalcite synthesize showed satisfactory catalytic activity for biodiesel production by the reaction of soybean oil with methanol under mild conditions of temperature and pressure. These results reinforce the possibility of obtaining biodiesel from transesterification of soybean oil using hydrotalcite as catalyst. The obtained results showed that greater conversions are obtained carrying out the reaction at greater times (10h) or at greater methanol oil molar ratios.

III. Objective

- It is proposed to use 100% vegetable oil or Biodiesel in the diesel engine
- To study the performance and emissions characteristics of a diesel engine with Mango seed biodiesel and Soybean biodiesel as fuel and it is compared with diesel fuel.
- To measure the level of CO, HC and smoke in the exhaust emissions in the above said engine.
- To analyze the exhaust emission.
- To substitute diesel fuel by 100% biodiesel and vegetable fuels.
- To decrease the dependency of fossil fuel.

IV. Properties of Diesel, Mango Seed Biodiesel and Soyabean Biodiesel

Table-1 Properties

Sl. No	Properties	Diesel	Mango seed oil	Soybean oil
1	Density(kg/m^3)	832	894	916.5
2	Calorific value (kJ/kg)	43200	39097	38857
3	Kinematic viscosity @ 40^{0}C (mm^2/s)	2.78	5.6	5.9
4	Flash point ºC	50	168	92
5	Specific gravity	0.86	0.895	0.876

V. Experimental Setup and Engine Specification

The experimental test set as shown in fig.1 consists of four strokes, constant speed, oil cooled and twin cylinder diesel engine. The injection timing given by the manufacturer is 27º BTDC, the opening pressure of the nozzle was set at 1800 bar and the engine speed is 1500rpm.There are a number of transducers used in the engine such as piezoelectric pressure transducer flush with the cylinder head surface to measure cylinder pressure. Specifications of engine are shown in Table 2.

Fig.1: Schematic arrangement of Experimental Set-up

Table-2 Test Engine specification

Engine type	Four stroke Twin cylinder diesel engine
No. of cylinders	02
Stroke	100 mm
Bore Diameter	87 mm
Engine power	15 KV
Compression ratio	17.5:1
RPM	1500
Type of starting	Crank starting
Load type	Water loading

Fig. 2: Water Loading

Table-3 water load bank specification

Max. Output	15 KV
Generator type	1 Phase
Amps	63
RPM	1500
PF	0.8
Volts	240

VI. Experimental Procedure

- ✓ Experiments were initially carried out on the engine using diesel as fuel in order to provide base line data.
- ✓ Initially the engine was started using diesel fuel and allowed to run for few minutes until to reach steady state; the base line data were taken. Load was varied from zero loads to full load condition using the water loading and Emissions, smoke and fuel consumption reading were recorded.
- ✓ The engine was started on duel fuel mode, when engine became sufficiently heated; the supply of diesel was slowly substituted by 100 % Mango seed biodiesel for which a two way valve was used. Once the engine reaches steady state, the emission, fuel consumption and smoke reading were taken. The same procedure is carried from zero to full load condition.
- ✓ The engine was started on duel fuel mode, when engine became sufficiently heated; the supply of diesel was slowly substituted by 100 % soyabean biodiesel for which a two way valve was used. Once the engine reaches steady state, the emission, fuel consumption and smoke reading were taken. The same procedure is carried from zero to full load condition.
- ✓ At the end to stop an engine is fuelled by diesel fuel and run minimum half an hour.

VII. Results and Discussion

Carbon Monoxide:

Fig. 3 shows, that variation CO level with respect to load for mango seed oil, soybean oil and diesel at different loads. From the graph it is clear that the CO level initially high at zero loads for both diesel fuel and biodiesel but as the load increases emission level decreases up to full load for biodiesel and for diesel fuel emission level decreases up to 50% load and then increases to full load. CO emission level for soyabean biodiesel is lower than mango biodiesel.

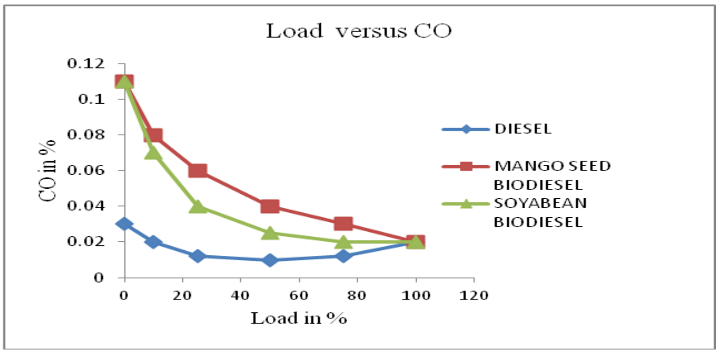

Fig. 3: Comparison of Carbon monoxide vs Load

Brake Thermal Efficiency:

Fig. 4 shows, the variation of brake thermal efficiency with respect to load for mango seed oil, soybean oil and diesel at different loads. From the graph it is observed that as load increases brake thermal efficiency is also increases for diesel and mango seed biodiesel up to 75% load and then decreases up to full load. Whereas soyabean biodiesel, BTE is increases from zero loads to full load. BTE for mango seed biodiesel is higher than both diesel fuel and soyabean biodiesel.

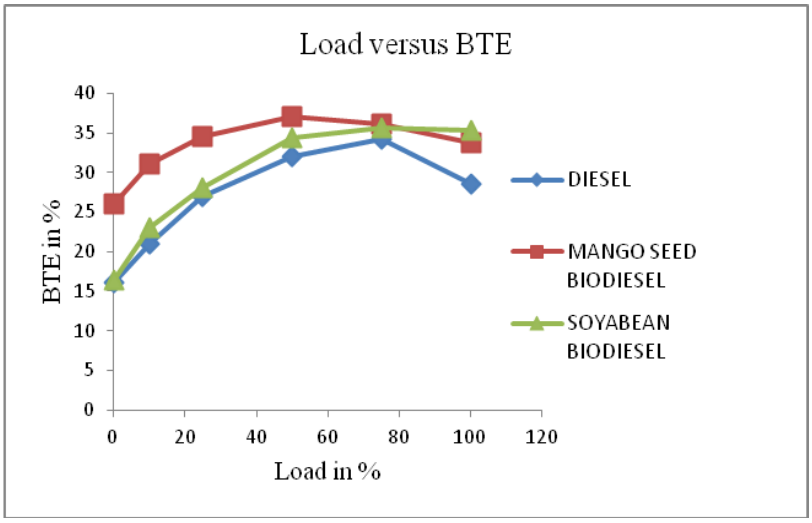

Fig. 4: Comparison of Brake thermal efficiency vs Load

Brake Specific Energy Conversion:

Fig. 5 shows the variation of brake specific energy conversion with respect load for mango seed oil, soybean oil and diesel at different loads. From the graph it is clear that BSEC is high at zero loads and then decreases up to 75% load, and then BSEC increases from 75% load to full load condition. BSEC for mango seed oil is lower than both diesel and soyabean biodiesel.

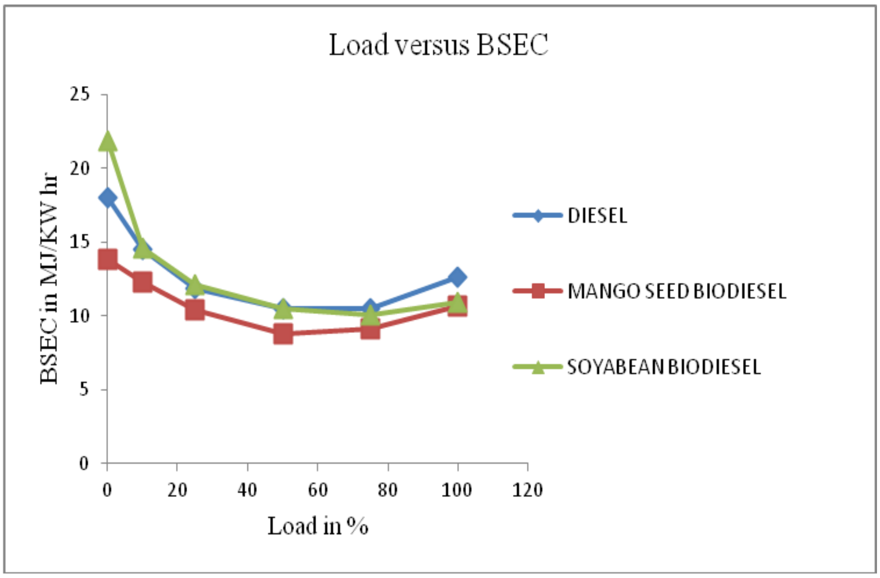

Fig. 5: Comparison of Brake Specific Energy Conversion vs Load

Hydrocarbon:

Fig. 6 shows, the variation of Hydrocarbon with respect to load for mango seed oil, soybean oil and diesel at different loads. It can be seen from the graph that biodiesel HC emission level decreases from zero loads to full load, whereas diesel fuel HC emission level is constant from zero loads to 50% load and then increases to full load condition. HC emission level for soyabean biodiesel is lower than mango seed biodiesel and at full load HC emission level for diesel and soyabean biodiesel is same.

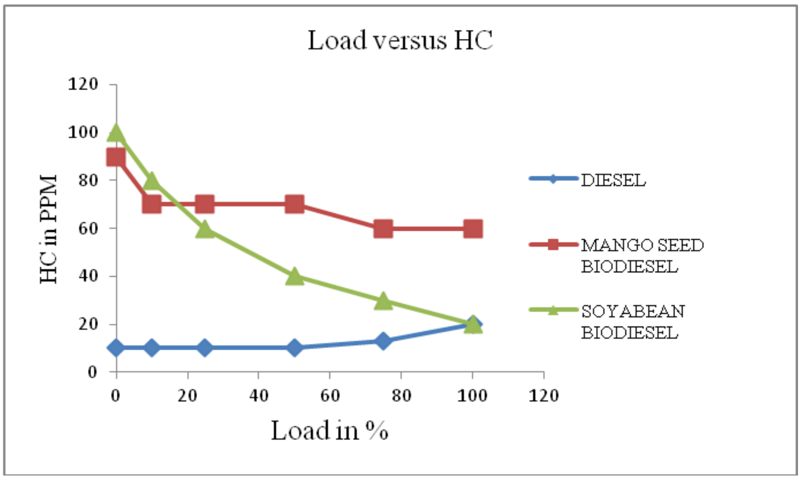

Fig. 6: Comparison of HC vs Load

Smoke:

Fig. 6 shows the variation of smoke with respect load for mango seed oil, soybean oil and diesel at different load. It can be seen from graph that there is a decrease in smoke level for mango seed oil as compared to diesel fuel, whereas increase in smoke level in soyabean biodiesel as compared to diesel fuel. Smoke level for mango seed biodiesel is lower than diesel and soyabean biodiesel.

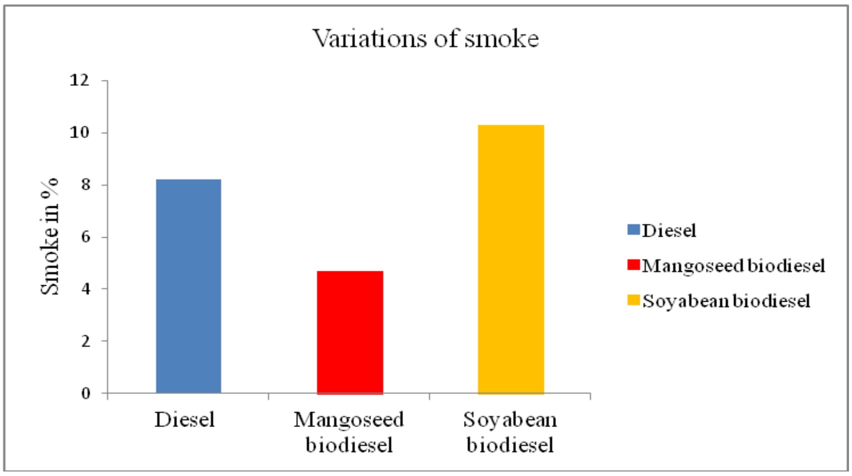

Fig. 7: Variations of Smoke for biodiesel and diesel fuel at full load.

VIII. Conclusion and Future Scope

Based on the performance and emission characteristics of mango seed biodiesel and soybean biodiesel, it is concluded that the mango seed oil and soybean oil shows a good alternative fuels with closer performance and emission characteristics to that of a diesel. Hence the 100% mango seed biodiesel and soybean biodiesel can be used as an alternative fuel for diesel engine that is without modification .The future research directions for scientists or researcher can be done with different piston geometrical modifications and coatings of different materials so that engine can reduces emission level from the biodiesel or vegetable oil.

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