BIODIESEL AS AN ADDITIVE FOR DIESEL-ETHANOL BLENDS TO STUDY THE PERFORMANCE AND EMISSION CHARACTERISTICS ON SINGLE CYLINDER DIESEL ENGINE

Amarkumar Vatambe[1] Dr.Sanjeev Doijode[2]

[1]Assistant Professor [2]HOD
[1,2]Department of Mechanical Engineering
[1,2]BKIT College of Engineering, Bhalki-585328

ABSTRACT:

Energy is the basic need to any nation's growth. Due to energy crisis whole universe is struggling with many issues like fossil fuels are losing ground drastically, demand for energy is ever increasing, concerns to the climate changes & high energy prices are putting us on our toes in the search of alternative and cleaner fuel sources which is the biggest challenge to the energy industry & various nations. As a substitute of conventional diesel fuel, biodiesel fuel is made from renewable resources and it also has non-toxic and biodegradable nature. Our country i.e. INDIA has many potential for the production of biodiesel from the seeds of edible and non -edible oils. Out of many variants of oil seeds, only some variants are tested till the time. Many researchers studied on the properties part of biodiesel fuel that has shown that it is completely miscible with conventional diesel fuel. A unique property of biodiesel over conventional diesel fuel is that biodiesel releases particulate matter and gases. Amongst the potential sources of non-edible oils of India, Mahua has shown very bright prospects. This paper shows the past and current progress along with other types of biodiesels, the characteristics, processing and economics available to Biodiesel industry and also it's their respective application part to automotive industry. The current paper fairly shows the studied comparison of conventional diesel fuel and Mahua biodiesel usage in view of its performance and exhaust characteristics parameters.

Keywords*: Biodiesel, Transesterification, Mahua oil, Performance, Emission, Energy, Policy.*

1. INTRODUCTION:

A century before, Rudolf diesel first came with the concept of diesel engine, used peanut oil (vegetable oil) for experimental evaluation, that time only it indicated that vegetable oils are appropriate to cater the needs of future. In today's century, it is assumed as per the usage data of conventional petroleum fuels that it will become very scarce & expensive to locate and manufacture, although researchers have found number of ways to increase the fuel economy but population of nations has increased many folds and also energy is the backbone of any nation's economy. Extreme exploration of crude oil deposits has been used in much type of usages, just because of sudden bursting of population around the globe. Lubricants that are in regular usage, made from mineral oils and additives which are very poisonous to water & soil due to its respective denser chemical composition and lesser biodegradability. There is always an alarming situation as far as environment is concern which pulls our attention towards natural counter parts just because of rising crude prices, inappropriate disposal methods and absence of lubricant usage across the globe.

Figure 1.1: Mahua seed

Fuels are very important to all of us in many ways due to its useful energy which we received during its combustion and satisfy many parameters of day to day life like transportation of public and supplies. Fossil fuel provides us major boon of energy which are petroleum oil, coal and natural gas. Today fuels from fossils carries 80% of the total energy requirement, also many of the industries using diesel engines are totally dependent for its manufacturing reason. Transport sector consists of busses, trucks, cars, ships etc consuming major amount of diesel and gasoline. This way we are totally dependent on this type of source of energy to the great extent where as growing demands of population possibly will not be fulfilled by household production of raw oil. Fossil fuels are derivatives of plant and animal fossils that are million years' old which lies in non- renewable energy sources category. The demand for energy and fuel price will never be in the declining graph. Developing countries are totally dependent on fossil fuel for their growth and development but regrettably these will be consumed in next 65 years. Emission from the combustion of fossil fuel leads to pollution in atmosphere and global warming. Many nations are facing such pressure from outside of national territory to work on issues of global warming. Due to these every nation is looking for clean, green and renewable alternate fuel to address the today's and tomorrow's need.

2. CHARACTERISTICS OF MAHUA OIL:

As per standard methods, the physical and chemical properties of Mahua oil are determined in Department of Chemical Engineering, B.I.T., Mesra – Ranchi. Table 1 shows the comparison between Pure Mahua oil properties with Diesel. The properties like Kinematic viscosity, flash point, fire point and density of Mahua oil is higher than diesel. The calorific value of the oil is observed to be lower than diesel. Viscosity is determined in Redwood Viscometer and other properties like flash and fire point is determined by using Cleveland Open cup apparatus in the above-mentioned laboratory. Determination of calorific value is carried out in a Bomb calorimeter in Aerospace Engineering Department, B.I.T., Mesra. The density of Mahua oil is found to be 0.87g/cc at 20°C which is higher than diesel. The Flash and Fire point are found to be 360°C and 368°C respectively which are very higher than Diesel. The % FFA (Free Fatty Acid) content of oil is determined by the method of titration.

Property	Unit	Pure Mahua Oil	Diesel
Density at 20°C	g/cc	0.87	0.80
Kinematic Viscosity at 40°C	Cst	51.85	3.80
Calorific Value	KJ/Kg	41220	42850
Flash Point	°C	360	68
Fire Point	°C	368	73
Pour Point	°C	13	-18
Cloud Point	°C	12	-15
Acid Value	mg KOH/mg	38	0.35
Free Fatty Acid	%	19	0.17

Table1: **Comparison of Pure Mahua oil and Diesel characteristics**.

2.1 Required Properties of Mahua Oil as Fuel:

The diesel and Mahua oil performance on the Diesel Engine is quite similar as per the experiments conducted by the researchers. The properties of good vegetable oil as a substitute for diesel are;

- Viscosity: High viscosity of oil can lead to problems like increased system pressure, injection problem, cold starting problem whereas the lower viscosity oil causes internal leakages.
- Calorific Value: The calorific value of various vegetable oils lies in the range of 30-40 MJ/Kg. For vegetable oils, the calorific value nearer to diesel oil is desirable.
- Flash Point and Fire Point: The higher values of flash point and fire point are desirable because of safety point of view. For smooth working the temperature should be high.
- Pour Point and Cloud Point: For cold weather operations, the satisfactory working is possible only when the pour and cloud point values are below the freezing point of the oil used.
- Blending with Diesel: The proper mixing of vegetable oil and diesel in different proportion is desirable. As the temperature increases the percentage blend of diesel decreases. As a result, of which we can run the engine on pure vegetable oil.

2.2 Demerits of Mahua Oil as Fuel:

a. The high viscosity of vegetable oils causes atomization and pumping problems in the injection system, as it creates filter plugging and cold starting.
b. Vegetable oil mixes with the lubricant oil and forms sludge's on all parts of the engine.
c. After combustion, a large amount of carbon deposition on the injection nozzle tips and in the combustion chamber.
d. The poor volatility causes vegetable oil difficult to ignite and vaporize.

2.3 Way to Overcome the Demerits:

a. Starting problems can be overcome by starting aids like glow plugs and fuel heaters.
b. Modification of fuel such as Pyrolysis, micro-emulsification, dilution and transesterification.
c. Filter plugging is minimized if crude oils are made gum free by passing through a filter (four micro meter).

3. LITERATURE REVIEW:

1. **Hemanth D,et al(2017)** experimental work was to study the effect of using various blends of bio-fuel and pure diesel on performance of normal single cylinder diesel engine. The blends tested where 10%, 25%, 50%, 75%and 100%. BioDiesel in pure diesel is a successful use as an alternative fuel.
2. **Gaurav Atravalkar, et al.(2017)**, analysed the Vegetable oils offer an advantage of comparable fuel properties with diesel. It was found that Mahua could be easily substituted up to 20% in diesel without any significant difference in power output, brake specific fuel consumption and brake thermal efficiency. The performance of engine with Mahua oil blends improved with the increase in compression ratio from 16:1 to 20:1.
3. **Arun Magadum,et al.(2017),** The experiments were conducted on a direct injection compression ignition engine for various loads and blends of biodiesel & pure diesel. Analysis of combustion characteristics and performance parameters like peak pressure, specific fuel consumption (SFC) and Brake thermal efficiency are evaluated.
4. **Himangshu Sekhar Brahma, et al. (2013),** had investigated the study of diesel engine emission characteristics using Mahua biodiesel (mahua oil methyl ester) with the help of a Three Way Catalytic converter

(TWC) with DEF (Diesel Exhaust Fluid) by running the engine in steady state conditions. Almost 90% NOX emissions got reduced and the emission values recorded were much less when compared to Bharat stage- IV Norms for selected engine at all operated loads with retrofit arranged.

5. **A. Haiter Lenin, et al.(2013),** analysed the mahua methyl esters and its blends with diesel were used as fuel. Various proportions of mahua methyl ester fuel blends (25% and 50%) were used for conducting the performance tests at varying load conditions. The test results indicate that the fuel of B25 can be used in diesel engines without any engine modifications.
6. **M. C. Navindgi, et al. (2012),** had investigated the performance of biodiesel obtained from mahua oil and its blends with diesel from 20%, 40% and 60% by volume for running a diesel engine. The reductions in exhaust emissions and brake specific fuel consumption together with increase brake power, brake thermal efficiency made the blend of biodiesel (B20) a suitable alternative fuel for diesel and thus could help in controlling air pollution.
7. **N. Saravanan, G. Nagarajan, et al.(2010),** Investigated Biodiesel is a fatty acid alkyl ester, which is renewable, biodegradable and non-toxic fuel which can be derived from any vegetable oil by transesterification. Engine performance tests showed that power loss was around 13% combined with 20% increase in fuel consumption with Mahua oil methyl ester at full load. Emissions such as CO, HC were lesser for Mahua ester compared to diesel by 26% and 20% respectively. Oxides of N_2 were lesser by 4% for the ester compared to diesel.
8. **Sharanappa Godiganur, et al. (2009),** analyzed the use of biodiesel fuel as substitute for conventional petroleum fuel and he noticed that the volumetric blending ratios of biodiesel with conventional diesel fuel were set at 0, 20, 40, 60, and 100. The results indicate that with the increase of biodiesel in the blends CO, HC reduces significantly, fuel consumption and NOx emission of biodiesel increases slightly compared with diesel.
9. **H. Raheman, S.V. Ghadge et al.(2006),** Analysed the performance of biodiesel obtained from mahua oil and its blend with high speed diesel in a Ricardo E6 engine and he noticed that reductions in exhaust emissions and brake specific fuel consumption together with increase brake power, brake thermal efficiency made the blend of biodiesel (B20) a suitable alternative fuel for diesel and thus could help in controlling air pollution.
10. **Sukumar Puhan, G. Sankaranarayanan, et al.(2005),** in this investigation, Mahua Oil Ethyl Ester was prepared by transesterification using sulfuric acid (H2SO4) as catalyst and tested in and Bosch smoke number were reduced around 58, 63, 12 and 70%, respectively, in case of MOEE compared to diesel. Based on this study, MOEE can be used a substitute for diesel in diesel engine.

4. METHODOLOGY:

This chapter explains the methodology followed for the present work which starts from the baseline operation of a CI engine using direct injection of diesel. The methodology also involved development of experimental setup using a single cylinder, water-cooled, naturally aspirated, four-stroke diesel engine with all necessary instrumentation to measure the performance and emission characteristics. In this method the VCR engine is used to implement the evaluation of performance and emissions of MOME biodiesel. The performance of the engine with mahua oil blends improved with the increase in compression ratio from 16 to 20:1. Hence the ratios 17:1, 17.5:1 and 18:1 are selected in this project to optimize. And also three blends of B10, B20 and B30 are selected to optimize the mahua biodiesel. Hence by using the above methodology which compression ratio is best and which blend is best to optimize.

4.1 Transesterification Process:

1. Heating and Cooling:

One litre of mahua oil was poured into the glass beaker and placed on heater for heating. Oil was heated above 100^0c (approximately 115^0c) with beaker mouth open to atmosphere and maintained this temperature about 15 minutes, this is done to remove the water particles present in the oil which effect the reactions that are performed on the oil further. Heating was performed with continuous stirring and this is performed by magnetic stirrer which is placed inside the glass beaker in the oil. This is done to avoid formation of large water vapour bubbles inside the beaker which on a sudden evaporation may cause explosion. After this part cool the oil to 45^0C-50^0C. Filter the cooled oil with a neat cloth for removing any dust or dirt particles present in it.

2. Acid Treatment:

Add 120-150ml of CH_3OH methanol per litre of oil and close the conical flask with rubber stopper, this is done to avoid evaporation of methanol (since the boiling point temperature of methanol is 55^0 C to 60^0C). After half an hour add 3-7 ml of H_2SO_4 and maintain the temperature between 50^0C-55^0C (should not be more than 60^0C). After 1 hour (reaction time) take this liquid into separating flask for 2 or 3 hours later the liquid separates into two immiscible liquids.

3. Base Treatment:

Heat the oil to (40-45) ^{0}C in the conical flask. Take 200ml of methanol in round bottom flask and add 6.5gm of sodium hydroxide pellets and shake well so that there is no solved particle of sodium particles. This forms the sodium methoxide solution. Mix the sodium methoxide with the acid treated oil n maintains the temperature of (50-58) ^{0}C in conical flask. The reaction time is (1hr-1 1/2 hr).The temperature should not exceed above 60^0C as the methanol evaporates above 60^0C and stirring is done throughout the reaction. The colour of the oil changes from pale yellow to dark brown. Pour the oil in the separating funnel.

4. Settling:

The oil has been settled for 12hr. we observe the biodiesel at the top of funnel glycerol at the bottom.

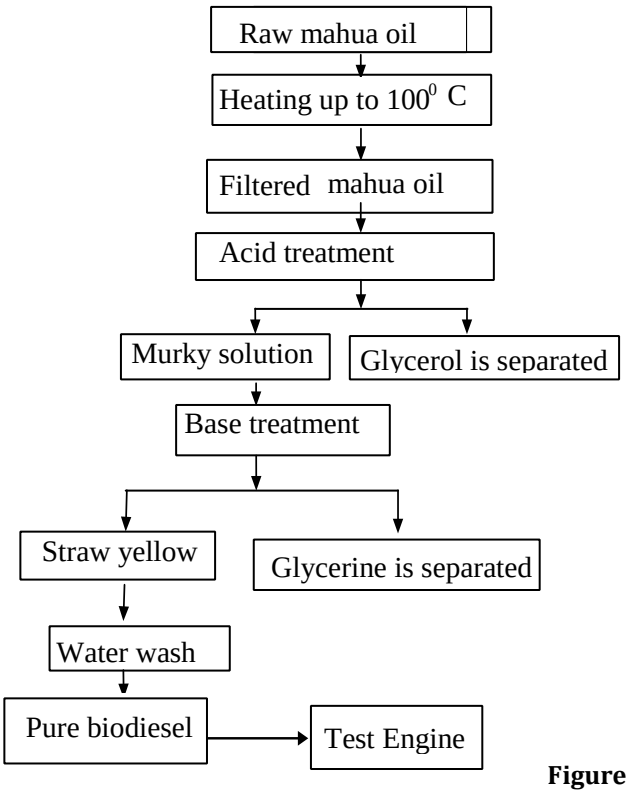
Remove the glycerol from the bottom of the separating funnel.

5.Water Wash: Take the oil into the separating funnel, mix distilled water with oil about half the volume of oil in separating funnel. Add 2 or 3 drops of Ortho-phosphoric acid. Keep bubbling for half an hour and this is repeated a number of times until clear water and oil are visible.

6.Heating:

Heat the Biodiesel above 110 ^{0}C (say 115^{0}C) with beaker mouth opened to atmosphere and maintains this temperature for about 15min. This is done to remove the water particles from biodiesel. Heating should be done with continuous stirring and this is performed my magnetic stirrer which is placed inside the glass beaker in the

4.1 Flow Chart Representation:



Figure

4.2 EXPERIMENTAL SETUP:

The engine performance and emission test were conducted on single cylinder diesel engine, which developing power output 3.75 Kw at 1500 rpm speed. The engine specifications are given in table 3.1. First the engine was run with diesel and reading were recorded, then the biodiesel blends with diesel in different proportion like B10, B20,B30 was used and reading were recorded. biodiesel. This is done to avoid formation of large water vapor bubbles inside the beaker which on sudden evaporation may cause explosion.

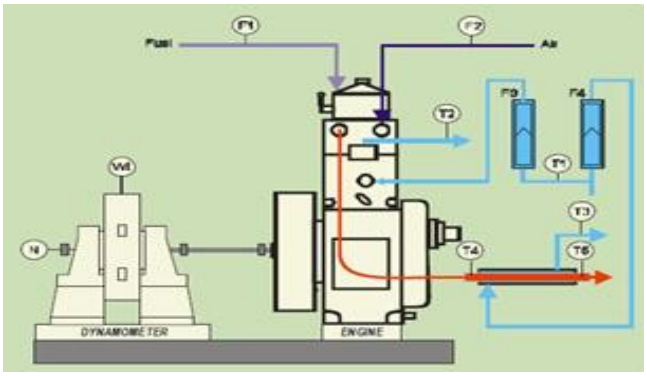


Figure 4.2 Schematic of the experimental setup.

Type	Vertical, Water cooled
Power	3.75kw (5HP)
Speed	1500 R.P.M
No. Of Cylinder	One
Compression Ratio	16:1
Bore Diameter	80 mm
Stroke Length	110 mm
Alternator	240Volt, 15Amps, Single Phase Efficiency-85%

4.3: Single cylinder 4-stroke diesel engine with specification.

8. CONCLUSIONS

The main aim of this experimental work was to study the effect of using various blends of bio-fuel and pure diesel on performance of normal single cylinder diesel engine. The blends tested where 10%, 25%, 50%, 75%and 100%. BioDiesel in pure diesel is a successful use as an alternative fuel.

- Mahua oil can be successfully transformed into biodiesel by the transesterification method.
- Transesterification process reduces viscosity of the Mahua oil and it improves the properties such as viscosity, flash point, fire point of the Mahua methyl ester.

- Smooth running of engine is observed with esterified Mahua oil compared with that of diesel.
- Brake thermal efficiency of B25 is closer to diesel.
- Specific fuel consumption of B10, B25 is close with the diesel.
- Minimum emission of CO compare with diesel.
- Highest HC emissions for diesel, B10 at no load, B100 has minimum HC emission at all loads.
- From this study it is conclude that the B10, B25 gives optimum performance where B100 gives the lower emission of HC and CO.
- Present experimental work shows the Mahua methyl ester give the good engine performance and less emission.
- Finally concluding B25 can be used as workable alternative fuel to operate single cylinder diesel engine with injection pressure of 180 bars.

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