Impact of DTBP Additive on Performance of Mahua Biodiesel

Satyam Seela[1], Challa Dhilleswararao[2], Korrai. Sreenu[2], Panda Sai Krishna[2], Mukala Lakshmana Rao[2]

Corresponding Author: seelasatyam45@gmail.com

[1] Assistant Professor, Department of Mechanical Engineering, Avanthi's St. Theressa Institute of Engineering & Technology, Garividi, Vizianagaram, Andhra Pradesh.

[2] U.G Student, Department of Mechanical Engineering, Avanthi's St. Theressa Institute of Engineering & Technology, Garividi, Vizianagaram, Andhra Pradesh.

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ABSTRACT

As the usage of conventional fuelsare increasing day by daydue to the increasing trend of vehicles running on roads, there is a problem of extinction of conventional fuels in nearby future. Alternative fuels are the best source to solve this problem. Biodiesels obtained from non edible oils is one of the best alternative fuels. Our research is blending bio diesel with dtbp additive to enhance the performance. A computer aided variable compression ratio engine made to run with blended biodiesels. By changing the percentage of mahua biodiesel blend with 15% variation i.e. M15, M30 and M45 with and without DTBP additive with concentration of 1%, the experimentation is done. The blend which is showing better performance among allother blends is the optimumone.

1. INTRODUCTION

The ever rising cost of fossil fuel internationally has forced major world economies, which are also major importers of fossil fuel had made them to examine about renewable and cheaper alternatives to fossil fuelto meet their energy demands. Biodiesels have emerged as the most suitable renewable alternatives to fossil fuel as their quality constituents match Diesel. In addition they are less polluting than their fossil fuel counterparts. Environmental concerns and the desire to be less dependent on imported fossil fuel have intensified worldwide efforts for production of biodiesel from various sources. The use of additives to enhance the performance of fuels and protect against the consequences of combustion has a long history. Fuels continue to evolve, with increasingly tight controls on the qualityofthe mineral base fuel being coupled to the incentivized introduction of new, renewable fuel streams, Biofuels in particular have introduced a range of opportunities for the additive producers to respond to with their different properties compared to mineraloil based fuels, ranging from solubilizing performance to the types of contaminants present. As engines increase their specific power and duty cycles change in response to regulatory drivers, the stresses on fuel are changing. Engines in hybrid vehicles operate for relatively short periods, but at higher load conditions than conventional powertrains. This will lead to more extreme thermal conditions that the fuel and additives will be exposed to, and to changing requirements of additives to support these engines. Concurrently, in the drive to further differentiate their products and give themselves a marketing advantage, fuel suppliers are becoming more demanding. Having products that address identified consumer needs is critical to the long term sustainability of the fuel additives business.

2. LITERATURE REVIEW

The increasing demand for sustainable and renewable energy sources has led to the exploration of biodiesel derived from non-edible oils such as mahua (*Madhuca indica*). Mahua biodiesel is biodegradable, oxygen-rich, and suitable for use in compression ignition (CI) engines. However, its limitations—such as high viscosity, low calorific value, and poor volatility—affect engine performance and combustion efficiency. To overcome these drawbacks, various fuel additives, particularly ignition enhancers like Di-tert-butyl peroxide (DTBP), have been widely investigated.

Nayak and Pattanaik [1] conducted experimental studies on mahua biodiesel blended with dimethyl carbonate additive and reported significant reductions in CO, HC, NOx, and smoke emissions compared to neat biodiesel and diesel. Their work highlighted the importance of oxygenated additives in improving combustion. Roy et al. [2] investigated biodiesel blends with Wintro XC 30 additive and observed improved fuel properties, higher BTE, and reduced emissions compared to diesel fuel. Yang et al. [3] studied combustion characteristics of biodiesel with additives and found improved ignition quality and reduced emission levels. Musthafa [4] examined the effect of DTBP as a cetane-enhancing additive in palm oil biodiesel and found that the addition of 1% DTBP significantly reduced CO, HC, and NOx emissions while improving combustion characteristics. Channappagoudra et al. [5] demonstrated that additives improve combustion efficiency and reduce harmful emissions such as CO and HC. Devarajan et al. [6] performed a detailed study on ignition enhancers, including DTBP, and reported improvements in ignition delay, heat release rate, and overall combustion efficiency. Their results showed enhanced BTE and reduced BSFC in biodiesel–diesel blends. Kumar et al. [7] analyzed oxygenated additives and concluded that DTBP improves fuel atomization and combustion kinetics, resulting in better engine performance and reduced emissions. Lawan et al. [8] reported that additive-blended biodiesel fuels significantly enhance engine performance and reduce exhaust emissions, emphasizing the effectiveness of additives in CI engines. Yadav et al. [9] optimized engine parameters using the Taguchi method for mahua biodiesel blends and observed that proper optimization improves brake thermal efficiency (BTE) and reduces brake specific fuel consumption (BSFC) and emissions. Janaki et al. [10] investigated nanoparticle-enhanced mahua biodiesel and reported improved combustion efficiency, increased BTE, and reduced emissions, indicating that additives play a key role in enhancing biodiesel performance.

3. METHODOLOGY

Table 1: Mahua Biodiesel properties

PROPERTY	VALUE
Density	900 Kg/m^3
CalorificValue	38000KJ/Kg
FirePoint	181°C
FlashPoint	170°C
CetaneNumber	57

3.1 ENGINE SETUP

The setup consists of single cylinder, four stroke, Diesel engine connected to eddy current type dynamometer for loading. It is provided with necessary instruments for combustion pressure and crank-angle measurements. These signals are interfaced to computer through engine indicator for Pθ−PV diagrams. Provision isalso made for interfacing airflow, fuel flow, temperatures and load measurement. The set up has stand-alone panel box consisting of air box, fuel tank, manometer, fuel measuringunit, transmitters for air and fuel flow measurements, process indicator and engine indicator. Rotameters are provided for cooling water and calorimeter water flow measurement. The setup enables study of engine performance for brake power, indicated power, frictional power, BMEP, IMEP, brake thermal efficiency, indicatedthermal efficiency, Mechanical efficiency, volumetric efficiency, specific fuel consumption, A/F ratio and heat balance. Lab view based Engine Performance Analysis software package ―Engine soft‖ is provided for on line performance evaluation. A computerized Diesel injection pressure measurement is optionally provided.

3.2 VCR ENGINE

The Engine chosen to carryout experimentation on a single cylinder, four strokes, vertical, water cooled, direct injection computerized Kirloskar made CI Engine. This engine can withstand higher pressures encountered and is used extensively in agriculture and industrial sectors. Therefore, this engine is selected for carrying experiments.

Fig 1 : VCR Engine.

Table 2 : Engine Specifications

S. No	Description	Specification
111	No.of cylinders	1
2	No.of strokes	4
3	CylinderBore	87.5mm
4	Stroke length	110mm
5	Connectingrod	234mm
6	Swept volume	661.45cc
8	Power	5.2KW
9	Speed	1500rpm

10	Dynamometer	EddyCurrent
11	CompressionRatio	17.5:1
12	Orificediameter	20mm

The performance parameters such as Brake Thermal Efficiency (BthE), Specific fuel consumption are measured. These performance parameters of mahua biodiesel and mahua biodiesel along with DTBP additive blends are compared to those of pure diesel.

4. RESULTS AND DISCUSSIONS

Brake thermal efficiency

The Brake thermal efficiency of Diesel, M15, M30, M45, M15+A, M30+A, M45+A blends at 0kg, 4.5kg, 9kg,13.5kg, and 18 kg are tabulated in the graph 1

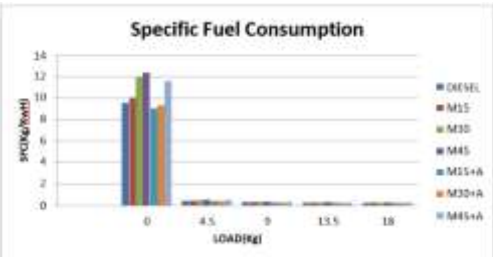
Experimental Outcome:

From the results obtained, we can observe that Brake thermal efficiency of mahua biodiesel is less than diesel, but after adding DTBP additive, there is an increase in Brake thermal efficiency. Especially when we are adding DTBP to M30

i.e. M30+A, Brake thermal efficiency is highest among all other blends. At this blend percentage, it is showing good improvement in brake thermal

Specific fuel consumption

The Specific fuel consumption of Diesel, M15, M30, M45, M15+A, M30+A, M45+A blends at 0kg, 4.5kg, 9kg,13.5kg, and 18 kg are tabulated in the results graph 2



From the obtained results, we can observe that Specific fuel consumption is less for diesel at 0 kg load and reduces drastically for other loads such as 4.5 kg, 9 kg, 13.5 kg, and 18 kg. Compared to Diesel, mahua biodiesels blends are having high specific fuel consumption. After adding DTBP additive of 1% it even reduces up to 30% of mahua and then slightly decreases. This is due to the variation in ratio of fuel consumption rate and the brake power. Specific fuel consumption is lowest for at M15 along with 1% DTBP additive and M30 along with 1% DTBP

upon considering the emissions, so we can conclude M30 with 1% additive i.e. M30+A as the optimum blend among all other blends as it

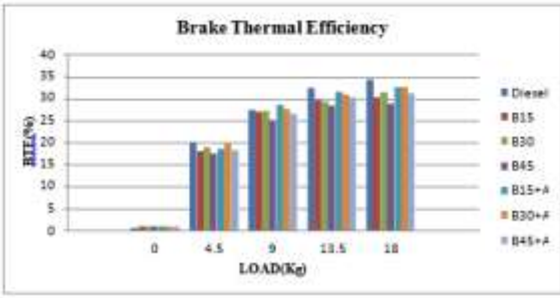
efficiency which is approximately equal to diesel values. After M30+A blend percentage, the Brake thermal efficiency is reducing at M45+A, because of the increase in total fuel consumption. The increase in total fuel consumption is due to poor atomisation. Poor atomisation is because of higher viscosity. Generally, Viscosity increases when there is more percentage of biodiesel and less percentage of diesel. So adding DTBP at higher percentages may also increase viscosity and hence the brake thermal efficiency is optimum at M30+A

blend and reducing further. We can also observe that as the load increases, brake thermal efficiency increases and it is also optimum at M30 along with additive blend i.e. M30+A .the variation in brake thermal efficiencies are also due to variation in brake power, calorific value and also total fuel consumption and the brake power is highest at M30+A and total fuel consumption is lowest at this blend this leads to optimum brake thermal efficiency at M30+A.

Graph 1: Bar graph showing Load vs Brake Thermal Efficiency

Graph 2: Bar graph showing Load vs Specific Fuel Consumption

Experimental Outcome:



additive is closely following it. After M30, Specific fuel consumption started decreasing due to the variations in ratios of total fuel consumption and brake power. Especially in this case, total fuel consumption reduces.it may be due to the increase in viscosity of blend. This shows that DTBP at 1% concentration is working well up to blending ratio of 30% and later its viscosity increases. As M15 and M30 are closely following and

showing optimum specific fuel consumption.

conclusion

In this chapter, engine performance characteristics of diesel and best of all mahua biodiesel blends are presented to select the optimum condition.

The usage of the bio diesels reduces the emissions but the performance is comparatively low. Biodiesels are generally mixed with diesel upto specific percentage to increase the performance and decrease the emissions. According to the literature survey, mahua biodiesel is selected as its availability is abundant and its blending ratio is holding well up to 15% and even more. Its performance increases if an additive added is noticed. An additive like DTBP is selected with the help of literature survey as it contains the properties which will be useful for reducing the problems of mahua biodiesel. The experimental analysis on VCR engine concluded that, generally bythe usage ofthe mahua biodieselwithout additive, the brake power, brake thermal efficiency are less than diesel and other properties are slightly morethan diesel but the emissions are less than diesel. DTBP additive increases the performance properties better than the mahua biodiesel without additive and the blends are also having better emissions than diesel. Among the 6 blends considered, M15 is having good performance properties but less than diesel. After adding DTBP, mahua biodiesel is holding good up to M30 i.e. it had shown an increase of nearly 10% in Brake power, indicated power, BTE and ITE and also 12% significant reduction of SFC on comparing blends with and without DTBP.

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