

EXPERIMENTAL INVESTIGATION OF PERFORMANCE CHARACTERISTICS OF CI ENGINE FUELLED WITH CALOPHYLLUM INNOPHYLLUM OIL BIODIESEL BLEND

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ABSTRACT

The Present work is carried out to investigate the performance characteristics of CI Engine when it is run on the biodiesel blend made from Calophyllum Innophyllum oil and High Speed Diesel. The experiment is carried out by using the biodiesel blend of 5%, 10%, 15% and the performance characteristic are compared with that of Diesel. During this experimental study engine is run on various engine loads ranging from zero to 18 Kg in the increment of 6 Kg, compression ratio 18 : 1 and 16 : 1. The Engine run at speed of 1500 rpm and the performance characteristics Exhaust Gas Temperature in °C, Brake Power in KW, Brake Thermal Efficiency in % and Specific Fuel Consumption in Kg/KW-h are studies to find out the optimum parameter to run CI engine fuelled with Calophyllum Innophyllum Oil Biodiesel. From this experimental study it is found that the Biodiesel blend with 5% is best situated and at CR 16 : 1 it gives better performance.

Keywords : Biodiesel Blends, Callophyllum Innophyllum, Compression Ratio, Engine Load, CI Engine, Performance Characteristics

I. INTRODUCTION

The automobile industry production is divided into mainly four categories, Two Wheelers – which included mopeds, motorcycles, scooters, electric two wheeler etc., Three Wheelers – this included passenger carriers like auto rickshaws and goods carriers like small logistic vehicles, Passenger Vehicles – it included cars, multi-purpose vehicles and other utility vehicles, Commercial Vehicles – this categories included all light duty,

medium duty and heavy duty vehicles like tempo, truck, container carriers, dumpers etc. The automobile industry in now a days play a key role in the growth of economic of the country.

As per the Confederation of the Indian Industry, the world standing for the Indian Automobile Sector as follows, The largest three wheeler market, the second largest two wheeler market, fourth largest tractor market, fifth largest commercial vehicle and bust and truck segment market and tenth largest passenger car market. But the factor mainly determine the growth of automobile industry are, fuel economy and the increased demand of the more fuel efficiency, this directly affect the consumer purchase decision thus now the companies focus on delivering performance oriented vehicles.

The future trend in the automobile industry are, almost self-governing cars will be on the road by 2020, more than the 50% of the cars on road will be powered by diesel by 2020, and the high performance hybrid cars and biodiesel operated cars likely to gain greater popularity among consumers.

The automobiles fuel researchers focus is now shifted to finding the more economical alternative which sustain in the future demand. The biodiesel from the various feedstock are the research topic at the peak but most of them are not economical as the harvesting and production of these are not so popular also the awareness toward bio-fuel is spreading very slowly.

The present work is divided into two part, first part to produced the biodiesel from the second highest productivity feedstock i.e. calophyllum innophyllum and second part is to analyzed the performance characteristic of CI engine to optimize engine on the basis of compression ratio, fuel blend and load conditions.

II. METHOD AND MATERIAL

The transesterification also called as methanolysis is used to produce biodiesel which is the most common method of biodiesel production. The process of methanolysis, is conversion of one ester into other ester. In the process the equilibrium reaction takes place by mixing the raw oil and methanol. The reaction can be enhanced by rising temperature upto 60 °C in the presence of catalyst Sodium Hydroxide or Potassium Hydroxide.

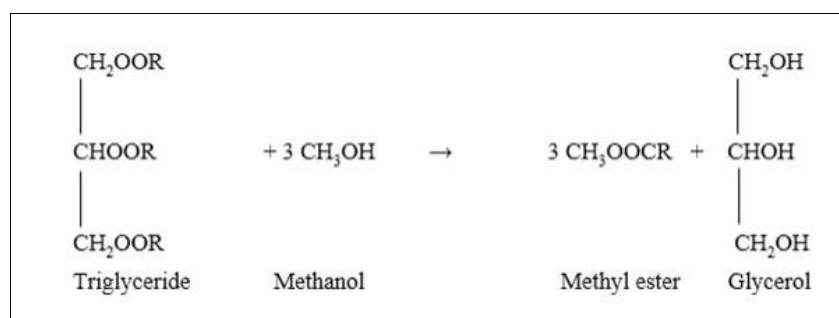


Fig. 2.1 Transesterification Reaction for Production of Methyl Ester (Biodiesel) [1]

Various Factors Affecting Transesterification [1] :

1. **Oil Temperature** – the raw oil must be pre-heated before mixing with methanol as it affect the reaction rate. The preheating of oil conversion to biodiesel and recovery increases also preheating of oil to 60°C the process result in methanol losses due to low boiling temperature of methanol.
2. **Reaction Temperature** – rate of reaction at room temperature take enough time to completion, whereas at certain temperature it increases and reduced the completion time. Normally reaction is conducted at atmospheric pressure and the temperature is maintained between 60°C to 70°C. But on further increase in temperature a negative effect is seen. Also at low temperature conversion is unaffected but the biodiesel separation is affected.
3. **Catalyst Type and Concentrations** – in transesterification alkaline catalyst are more effective and increases the rate of reaction several times than that of acidic catalyst. Sodium alkoxides are most effectively used for the purpose also Potassium alkoxides can be used. The optimum alkaline catalyst percentage by weight is taken 0.5 to 1 % , as after increasing the its concentration it will not reduces the conversion due to generation of more glycerol during recovery.
4. **Alcohol to Oil Ratio** – as per the transesterification stoichiometry, the molar ratio of 3 : 1 of alcohol to triglycerides is required. More than 3 : 1 ratio increase in alcohol amount there is increase in hindrance in the separation of glycerol. The optimum molar ratio are depends on the quantity and the types of raw oil.
5. **Mixing Intensity** – it is seen that after adding alcohol and catalyst to the oil if the stirring is done for 5 to 10 min. then it results in high rate of conversions and recovery of ester.
6. **Purity of Reactants** – the free fatty acids in oils with impurities have difficulty in conversion to esters but can be overcome at high temperature and pressure. It is seen that 67 to 84% conversion are there in esters using crude oils whereas in refined oils it 94 to 97% .
7. **Stirring Effect** – an optimum rate of stirring is required to have a good yield of esters i.e if its less than certain limit then the reaction can be incomplete while by increasing it more can lead to no changes in yield.
8. **Moisture and Water Content Effect** – with the presence of water in the oil it put a great negative effect on the yield of esters. The effect of presence of water in oil has much worse effects than having Free Fatty Acid in it. The removal of moisture content from oil is done by heating it on 383K.

There are more than 350 tree born oils identified, among these only few are considered as potential alternative fuels. Out of these palm, peanut, soybean, sunflower etc., - edible oils and *Jatropha curcas*, *Karanja*, cotton seed, etc., - non-edible oils.

The sources for biodiesel production is usually chosen according to availability in each region or country. European countries have surplus amount of edible oil to export. Hence, rapeseed oil is used as biodiesel feed

stock. In the United States – soybean biodiesel becoming the important source of biodiesel. The coastal countries like Malaysia, Thailand and Indonesia – palm oil and coconut oil are used in biodiesel production. However, some Asian countries are not self sufficient in edible oils due to food Vs fuel problem, they are exploring non-edible oils like *Jatropha curcas* and *Karanja* as biodiesel raw materials. The other different oil sources reported in various scientific articles are: sunflower oil, peanut oil, cotton seed oil, neem oil etc.

The oil yield of various oil sources for biodiesel feedstock. Palm oil has potential of high productivity (litres per hectare) when compared to other vegetable oils. The highest oil productivity of palm oil is about 5950 litres per hectare which is about 13 times better than soybean oil.

The material used for the present study is a *Calophyllum Innophyllum* Oil, which is second highest oil productivity of 4930 litres per hectare.



Fig. 2.2 Transesterification Process Setup



Fig. 2.3 Raw Oil
(*Calophyllum Innophyllum*)



Fig. 2.4 Transesterified Oil
(Top layer Biodiesel and Bottom Layer Glycerol)



Fig. 2.5 Neat Diesel

Parameter	Units	Test Method	Neat Diesel	Raw Calophyllum Innophyllum Oil	Biodiesel
Density at 15°C	Kg/m ³	ASTM-D 7042 2016	835	941.9	893
Kinematic Viscosity at 40°C	Cst	ASTM-D 4052 2016	3.5	57.6	9.231
Calorific Value	MJ/Kg	ASTM-D 240 2017	44.00	39.7	34.43

Fig. 2.6 Physico- Chemical Properties

III. EXPERIMENTAL SET-UP AND EXPERIMENTATION

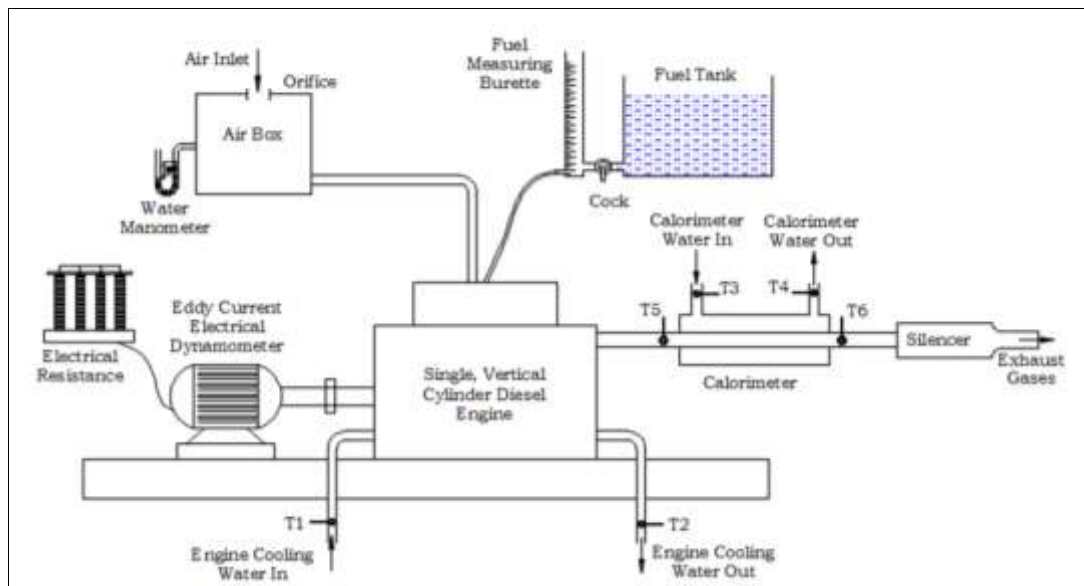


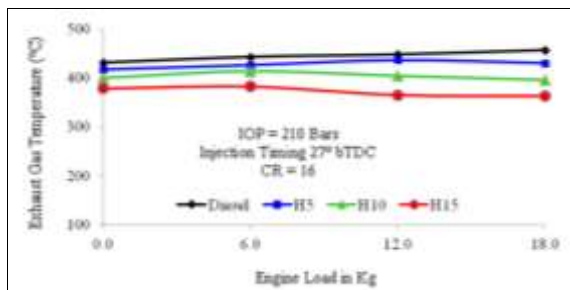
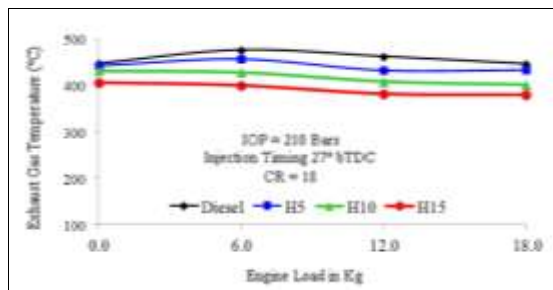
Fig. 3.1 Experimental Setup

TABLE 3.1 Experimentation

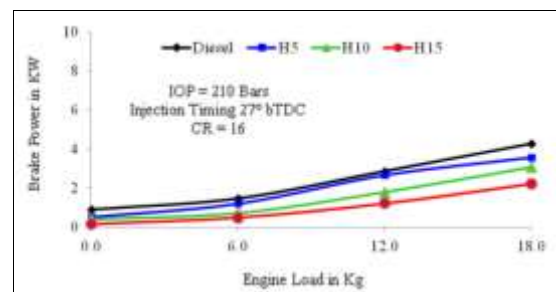
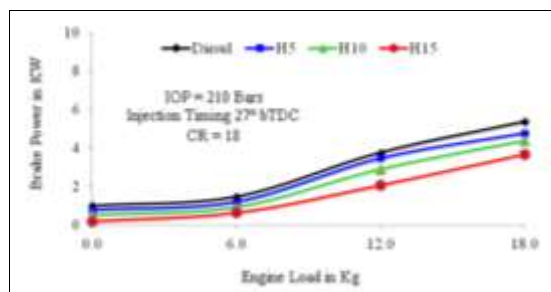
Blend Type	Description	IOP in bars	Injection Timing in °bTDC	Load in Kg	CR
H0	100% Diesel	210	27	00	18 : 1
H5	5% CIME + 95% Diesel			6	
H10	10% CIME + 90% Diesel			12	16 : 1
H15	15% CIME + 85% Diesel			18	

IV. RESULTS

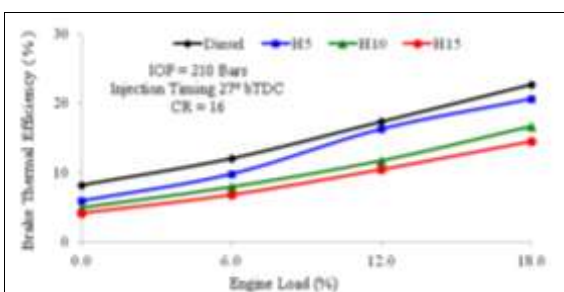
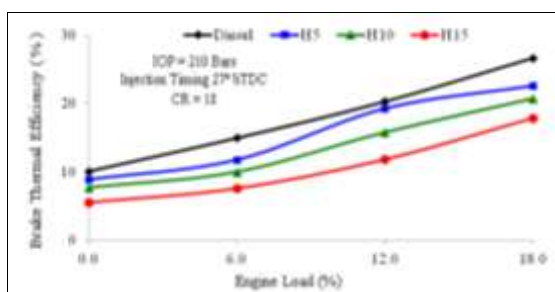
4.1 Exhaust Gas Temperature – Vs – Engine Load



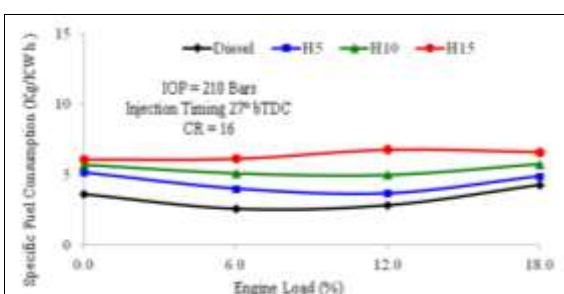
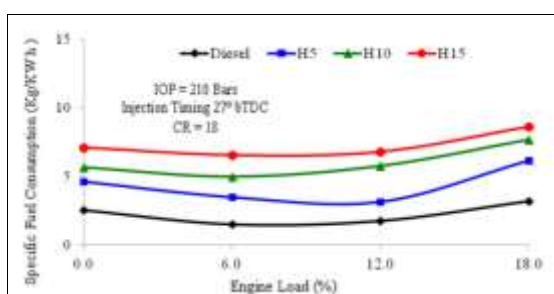
4.2 Brake Power – Vs – Engine Load



4.3 Brake Thermal Efficiency – Vs – Engine Load



4.4 Specific Fuel Consumption – Vs – Engine Load



V. CONCLUSIONS

From the present experimental study it is concluded from the results,

1. Biodiesel production by transesterification process is possible for Calophyllum Innophyllum oil and the properties are nearly matching to those of diesel.
2. The calorific value of the biodiesel produced is lower than diesel hence the overall heat generated in combustion and the thus power output will be lesser than the diesel fuel.
3. From the result graph, the exhaust gas temperature goes on increasing with the engine load and compression ratio, the most closed readings are shown by the 5 % blend and at compression ratio 18 : 1 it works better than that of 16 : 1 and maximum temperature achieve at 12 Kg load condition.
4. From the result graph, the brake power increases with the engine run on full load condition, and the output brake power is also directly proportion to the compression ratio. The blend with 5 % shows the more closed curve to that of diesel and better at compression ratio 18 : 1 and 12 Kg load condition.
5. From the result graph, the brake thermal efficiency goes on increasing with engine load as expected, and the 5 % blend given better performance among all other blends, more specifically at 16 : 1 compression ratio
6. From the result graph, the specific fuel consumption is higher at zero load and decreases to moderate load and again shows higher values at full load conditions, among all blends 5% blend gives less fuel consumption after neat diesel.
7. Thus the final conclusion is that, the biodiesel from calophyllum innophyllum oil can be used as alternative fuel with 5 % blend at compression ratio 18 : 1 and most efficiently at engine load of 12 Kg.

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