

Influence of Variable Speed on Performance and Emission Characteristics of Diesel Engine using Fish Oil Biodiesel Blends



M. Vijay Kumar, U. Gopala Rao

Abstract: *Alternative fuel sources are needed to be developed to meet the escalating demand for fossil fuels. Also from an environmental point of view, these most modern resources of fuels must be environment-friendly. The rapidly increasing consumption of fossil fuel and petroleum products has been a matter of concern for many countries which imports more crude oil. So, there is necessary for the development of new energy sources. The biomass, edible oil, inedible oils from plants and fish fat oil are imperatives and seen to be a potential substitute for diesel fuel. Acid and Base catalyzed transesterification is the most acceptable process for biodiesel production.*

In this project, an attempt towards finding the effect of alternate fuels as a substitute over diesel and reduce its consumption to lessen the environmental effects. Biodiesel has been extensively used in diesel engines as a partial substitute in the past few decades. The present investigation is carried out with blending up fish oil biodiesel with diesel in varying proportions to test out the emission and performance characteristics of direct injection single cylinder, four strokes, and air-cooled diesel engine. The fish oil biodiesel was produced by the transesterification process and obtained fish oil biodiesel blended with diesel fuel with various propagations of B20, B50, B75 & B100. These blended fuels were further investigated in a diesel engine with variable speeds such as 1000rpm, 1250rpm, 1500rpm, 1720rpm, 2000rpm 2250rpm & 2500rpm. In this comparative study, the effects of fish oil biodiesel fuel blends are compared and evaluated with pure diesel.

Keywords: *Fish oil biodiesel, Direct injection single cylinder four-stroke air cooled diesel engine, Performance and Emissions.*

I. INTRODUCTION

Fossil fuels are the major source of energy, since the economic revolt in the 18th century. Coal is still one of the easily accessible sources, and there was almost unlimited availability when it was discovered. During the 19th century, technology allowed for the processing of crude

and it rapidly regained as a substitution fossil energy supply [1-2].

The fuel that was used for heating, was the crudest product spent however, because of the process knowledge advanced, a lot of crudest products entered the market. These crude products, with their high energy content and portability. Electricity can be provided to houses. The demand for Energy is closely joined to economics. With a lot of evolving countries from developing to an industrial country, the worldwide demand for energy has quickly risen. With the development of the economy, comes a standard higher in living and demand. Henceforth the need for economical fuels with fewer environmental effects has risen, resulting in various investigations to provide fuels with cost-effectiveness and comparatively less pollution [3-5].

A. Biofuels

The history of biofuels has its origins from kerosene lamps as a supply of light associated with a historic oil lamp in 1950 created in a place that is believed to be populated. The primary form of a created vehicle, the Ford motorcar, has engines running with Otto cycle designed to operate on plant-based fuels and Dr. Rudolph Diesel in 1894 stated that the compression-ignition engine has to be designed in a way it might be hopped-up by edible fat [6]. His dream was one day farmers may build their fuel to use in agricultural areas, wherever fossil fuel product was inaccessible. Fuel and its high-energy content have become a fuel of desire and also the style of the CI engine was modified to match these properties of the newly created fuel. Because of this provision and also due to the price of diesel (edible fat wasn't given any consideration except at some crossroads throughout the 1930s) the lack of oil pushed the costs up. Miserably, the newly created engine style won't operate on edible fat anymore because of high viscosity [7].

B. Transesterification

Transesterification could be a natural action to manufacture biodiesel from fatty oils. This method consists of reacting to the fixed oil with the alcohol and a catalyst. The foremost ordinary alcohols utilized for this method is fermentation alcohol and wood alcohol. As a catalyst, a protein, an acid or a base is considered in this process but the analysis recommends employing a base catalyst like sodium hydroxide (NaOH) or potassium hydroxide (KOH) [8].

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By fermentation of alcohol, one winds up with carboxylic acid ethyl group organic compound and by fermentation of wood alcohol the product is a carboxylic acid, methyl radical organic compound. Each of those product square measures characterized as biodiesel though their properties are slightly different. Wood alcohol is the commonest alcohol used. The trans-esterification process is caused by the chemical process. Bio-diesel fuel has better properties than that of Petro-diesel fuel as the varying values can be observed in table 1. given below.

Table 1. Properties Of Fuels

	Density (kg/m ³) at 15°C	Viscosity (mm ² /sn) at 40°C	Calorific Value (KJ/kg)	Cetane Number	Flash Point (°C)	Pour Point (°C)
Diesel Fuel	845	3.54	44350	51	60	-15
B100	875	4.35	42500	52.5	155	-14
B75	868	4.14	42962	-	130	-14.2
B50	860	3.94	43425	-	106	-14.4
B25	853	3.74	43887	-	82	-14.7

II. METHODOLOGY

A. Experimental Procedure

Before beginning the study on the utilization of any different fuels during the process of CI engine, it is very essential in the choice of engine and arrangement of the setup. The information and also the methodology to be approved in every technique and calculations for deciding completely various parameters also are needed. Required investigation needed for Preparatory work. The following procedure steps were followed before beginning the investigation:

- The required specified fish oil for the study was collected and later transesterification processes were followed to obtained biodiesel.
- Most of the important properties were found and were within the limits.
- A single cylinder, four stroke, air-cooled, DI engine and gas analyzer was selected for investigation.
- Further investigation was carried out with variable speed with different propagation of fuel blends, pure fish oil and pure diesel.
- The speed, fuel consumption, gas temperature and emissions reading were noted for variable speeds.

B. Measurement of Exhaust Gas

An AVI DeGas444 exhaust gas instrument was used to record or measure the pollutants; NO_x, CO and HC emissions. The HC, CO, were measured with the assistance of sensors functioning on non-dispersive infrared (NDIR) principle and NO_x was measured with a chemical science detector.

The gas instruments were initially observed in standard/ideal conditions to confirm the accuracy value of the analyzer. This activity procedure is concerned with the injection of gases of higher concentration and the responses are validated. The composition ranges of CO and HC gases were; 3.6% volume of CO, 2000 ppm gas volume of HC, where as for the NO_x gas it is 2300 to 3000 ppm volume.

C. Blends of Fish oil with Diesel fuel

Blending is a simple technique of employing a mostly highly viscous fuel as an alternative fuel in an exceedingly CI engine by combining it within a fuel produces a low viscous fuel. For the study, the fish oil was blending with diesel in numerous proportions on a volume from 25 percent to in steady steps until 100 percent. The mix was represented because of the fish oil, trailed by the numerical worth that represents the share of the fish oil within the mix. For instance, the numerical worth within the mix B-25 indicates 25 percent of fish oil biodiesel. Likewise, alternative blends were denoted as B25, B50, B75, B100 of fish oil biodiesel. The mixture was stirred well with the assistance of a magnetic stirrer, to urge a mixture is stable which is homogeneous.

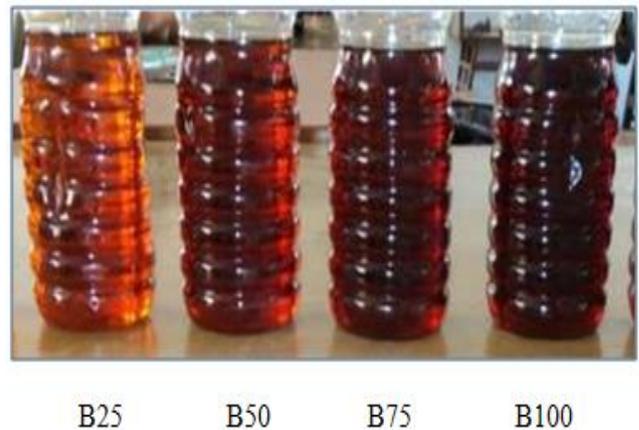


Fig 1. Various samples of the fish oil biodiesel-fuels

D. Experimental Setup



Fig 2. Engine setup

The investigation was done on a Kirloskar TAF-1 single-cylinder, air-cooled, four-stroke, and, direct-injection internal combustion engine with the variable speed device employed in it and experimentation runs on this engine.

A control panel was close-fitting in the generator to produce the assigned load to the engine. The engine output will be varied by dominant the sphere current. The measuring device was marked statically by the produced current. The post load will be measured by the measuring device with the assistance of a strain gauge system of load cell straddling between the stator coil base and also the frame. A measuring device and a fuel indicator enclosed within the circuit of fuel to live record or measure the consumption of fuel and it provides the power consumption as engine input.

The burette was close-fitting with a 2-method valve. The fuel released from 1 in the fuel tank was directed to the engine and in place "2" the contained with fuel within the measuring device was also directed to engine. For the activity of fuel rate of flow of the engine, the valve was set at the place "2". The fuel rate of flow was measured on a degree basis. The fuel detector detected the time for a certain flow in the system.

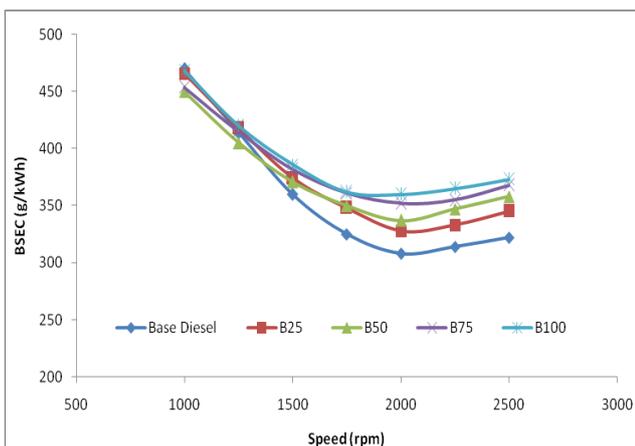
III. RESULTS AND DISCUSSION

This article gives about the information about the results obtained from the performance of the engine and its emissions from the single-cylinder, four strokes, air-cooled, DI diesel with variable speed rpm is considered for producing power by burning the blended fuels. Fuel modification techniques are used for mixing the fish oil biodiesel at percentages with diesel fuel.

A. Performance Parameters

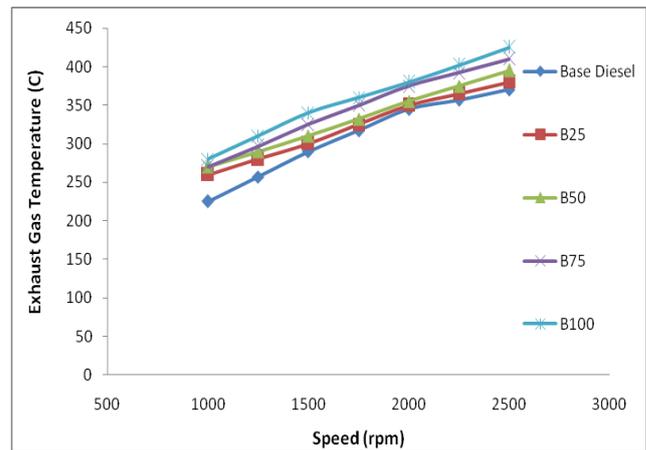
▪ Brake Specific Energy Consumption(BSEC)

The Break specific fuel consumption (BSEC) values obtained for the fuels namely Diesel, B25, B50, B75, B100 at the above-mentioned speeds have increased by about 2.65%, 3.23%, 5.65% and 8.32%. These values indicate that at B100 i.e. pure fish oil biodiesel the value of BSEC is higher when compared to any other fuel in the experiment and this is obtained due to the density of the B100 fuel due to which when sprayed in the combustion chamber the volume turns out to be more. But the values for BSEC of fish oil biodiesel have decreased in the low engine speeds are lower when compared to that of base diesel. But the slightly overall fuel consumption has lowered in the use of fish oil biodiesel blends due to presence of oxygen in the biodiesel, and also due to the efficient combustion timing that is available by the fish oil biodiesel.



Graph 1. BSEC vs Speed

▪ Exhaust Gas Temperature

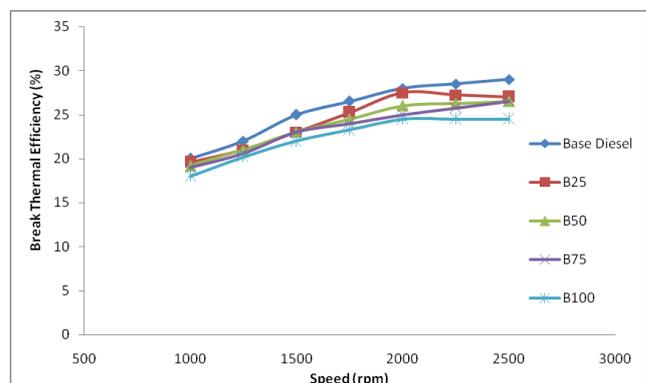


Graph 2. Exhaust Gas Temperature vs Speed

The values of the temperature of the gas at the exhaust can provide insights about the heat of the fuels in the combustion chamber during combustion can be of help in analyzing the values of the emission. The aforementioned graph provides the values of the exhaust gas temperatures with the lower values being from base diesel fuel and highest values coming from the B100 fish oil biodiesel at corresponding engine speed. The more the temperature the more is efficiency and the values of the B100 are higher due to the presence of the oxygen in the fish oil biodiesel blend from the origin which now helps in the higher combustion or full combustion producing the higher efficiency and also the values of the EGT decrease with decrease of the percentage of the blend in the diesel.

▪ Brake Thermal Efficiency

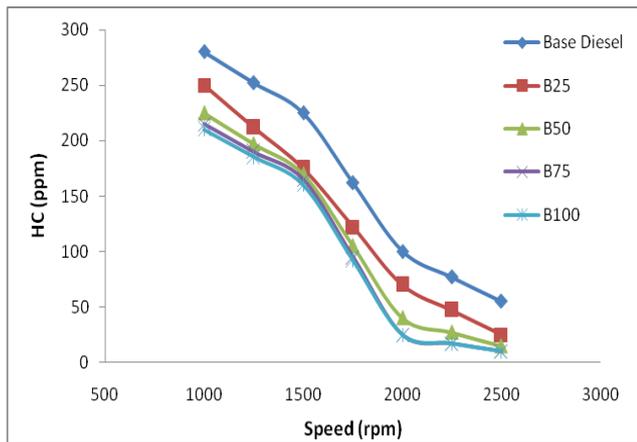
Thermal efficiency is one of the factors to be considered while evaluating the efficiency of the engine on various fuels. As we look into the values obtained, the thermal efficiency of B100 has decreased by 7.3% than that of its counterpart base diesel fuel. This is majorly due to the high density of the biodiesel and lowers effective power, higher consumption of fuel, lower values of heat regarding the Biodiesel. The B25 was shown good results as compared to B50, B75, and B100.



Graph 3. Brake Thermal Efficiency vs Speed

B. Emissions Parameters

▪ **Hydrocarbons Emission**

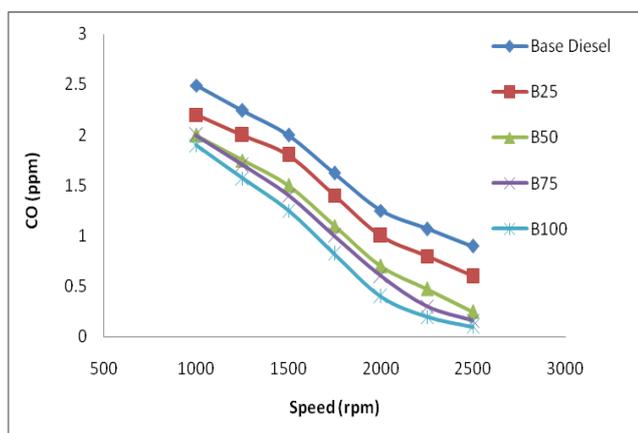


Graph 4. Hydrocarbons Emission vs Speed

HC presence in the emission is due to the incapability to utilize the chemical energy in the combustion chamber. And also due to the incapability of the fuel to burn due to lack of temperature which in turn is a result of insufficient combustion time and unavailability of oxygen but this problem is solved in the usage of Fish oil biodiesel as the presence of oxygen help in complete burning of the fuels thus reducing the emission of HC into the atmosphere. The graph proves the same with the values provide showing that diesel is the highest contributor of HC and the B100 is said to the fuel-producing lowest HC.

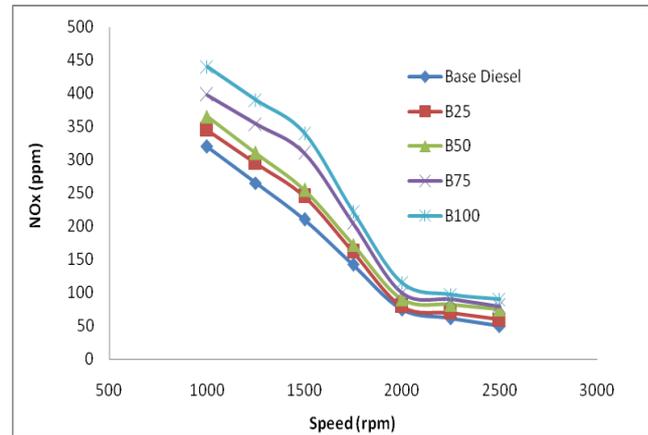
▪ **Carbonmonoxides Emission**

CO emission is one of the important parameters in the consideration of a better fuel. The more the amount of CO, the more is the loss of chemical energy which not only affects the environment but also reduces the efficiency of the engine. When looked into the numbers provided by the graph, diesel is the biggest contributor of CO and with an increase in the percentage of the biodiesel in the pure diesel, the emission values have come down. This is due to the increase of the air-fuel reaction when biodiesel/ fuel is present.



Graph 5. Carbonmonoxides Emission vs Speed

▪ **Oxides of Nitrogens Emission**



Graph 6. Oxides of Nitrogens Emission vs Speed

The main pollutants formed from the diesel engines are NOx, CO and HC. In this section, the graph provides the values of the NOx pollutants formed. The values seem to prove the existing arguments about the percentage of NOx produced in the performance of the blends and the base diesel fuel. The NOx value for the B100 is highest when compared to any other fuel in the experiment and that of diesel is lowest. The reason for such performance is peak temperature which ought to be the sole reason this is supported by the values of the exhaust gas temperature, which is due to the presence of oxygen in biodiesel.

IV. CONCLUSIONS

The engine performance and emission characteristics of single-cylinder, four strokes, cooled by air, a direct injection diesel engine have a different influence on output at various speeds. The conclusions of every method are given below.

- The usability of waste fish oil was converted into fish oil biodiesel by the transesterification process and later it was performed in a conventional diesel engine to find its performance and emissions.
- Performance parameters of the fish oil biodiesel blends have differed slightly when compared with the base diesel fuel outputs.
- The performance parameters of the B25 blend were very near to the base diesel fuel trends and seem to be favorable blends as compared to all other blends.
- BSFC values have higher in the case of B100, due to the higher density of the fuel blend. While the lowest is recorded for diesel.
- Exhaust gas temperature has also been recorded high in the case of B100 which indicates the high combustion due to the presence of oxygen in fish oil biodiesel.
- Emissions have a great effect on the fish oil biodiesel & diesel blends than base diesel fuel.
- These emission results prove the existing argument about the higher values of NOx for B100 and subsequently lowered with the decrease in blend percentage. NOx values of base diesel fuel are lower than B100.
- The values of Hydrocarbons have decreased in the use of B100 when compared to base diesel fuel.
- The use of blends has proven worth by releasing lower content of Carbon monoxide, Hydrocarbons into the atmosphere in comparison with the pure diesel fuel.

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