ISSN: 2277-9655
Impact Factor: 4.116
CODEN: IJESS7

IJESRT
INTERNATIONAL JOURNAL OF ENGINEERING SCIENCES & RESEARCH TECHNOLOGY

EXPERIMENTAL INVESTIGATIONS OF SINGLE CYLINDER CI ENGINE USING FISH OIL BIODIESEL

G.Veeresh Kumar*, B.Raja Narender, N.V.Siva Sai
* Department of Mechanical Engineering, Teegala Krishna Reddy Engineering College, Hyderabad, India
Department of Mechanical Engineering, Anurag Group of Institutions, CVSR College of Engineering, Venkatapur, R.R Dist,Telangana, India
Department of Mechanical Engineering, Anurag Group of Institutions, CVSR College of Engineering, Venkatapur, R.R Dist,Telangana, India

DOI: 10.5281/zenodo.233480

ABSTRACT
Alternate fuel research has been the topic of the highest priority in the context of depletion of fossil fuels at an alarming rate and increasing of pollution levels of the engines with conventional fuels. The high consumption of diesel fuel in not only in agriculture sector but also in transport sector compels for the substitution of diesel fuel with suitable, renewable energy resources. Alcohols and vegetable oils are the major alternate fuels for diesel fuel as they are renewable in nature. The disadvantages of alcohols (ethanol and methanol) with low cetane numbers and vegetable oils with low volatility and high viscosity call for the hot combustion chamber, provided by low heat rejection diesel engine. About 30% of the heat energy supplied to the engine is being rejected through the chamber walls to the coolant and hence all efforts of the researcher turned towards reducing the heat rejection to the coolant and keep the combustion chamber hot which is suitable for burning renewable fuels like alcohols and vegetable oils quite effectively. The recent biodiesel research in India receives its attention towards fish-oil based biodiesel. In the present work, biodiesel derived from the fishoil extracted from fish species was used as fuel in the diesel engine to investigate its performance. This project presents the results of an investigation carried out in studying the properties and behavior of methyl esters of fish oil and its blends with diesel fuel in a C I Engine. Engine tests have been carried out to determine the performance characteristics of the fish oil. The tests have been carried out in a 4-stroke, single cylinder, constant speed, direct injection diesel engine with different loads. The loads were varied from 0% to 90% of the maximum load in steps of 20%. The various blends of fish-oil biodiesel with diesel, B20, B40, B50, B60 were used in the experiments and the results show that brake specific fuel consumption and brake thermal efficiency were higher with B60fuel than that of diesel. The performance parameters like brake specific fuel consumption, brake thermal efficiency, volumetric efficiency, mechanical efficiency and air fuel ratio were found and compare with diesel.

KEYWORDS: alternate fuels, Biodiesel, fish oil.

INTRODUCTION
The drawbacks associated with the use of vegetable oils in compression ignition engines though they are a renewable source of energy are low volatility and high viscosity call for low heat rejection diesel engine. A large number of studies on performance, structure, and durability of the low heat rejection engine have been carried out since Kamo and Bryzik [1] presented a new concept of the low heat rejected engine with turbo compound system. Although promising results of the investigations have been somewhat mixed. Most have concluded that insulation reduces heat transfer, improves thermal efficiency and increases energy availability in the exhaust. However, contrary to the above expectations some experimental studies have indicated almost no improvement in thermal efficiency and claim that exhaust emissions deteriorated as compared to those of the conventional water- cooled engines. In the last one or two decades, the concept of the adiabatic engine has gained importance. Various concepts of low heat rejection engines are being developed employing the technique like ceramic in the components, the air gap in the piston and liner and other components, etc. Out of the total amount of heat rejected

to the various components piston and liner are found to be the major contributors through which heat rejection take place to the coolant. It is also found that the coatings provided on the moving piston of an engine create problems. The technique of providing air gap in the piston is less effective in achieving lower brake specific fuel consumption and reduction of pollutants. It also provides the lower degree of insulation causing combustion chamber of diesel engine less hot. Hence the technique of air gap insulated piston and air gap insulated liner with ceramic coatings on the piston, liner and cylinder head finding favor from the various researchers from the point of view of effectiveness ease of manufacture and operation. Hot combustion chamber permits efficient combustion of fuel and alternate and renewable fuels like vegetable oils can be more effectively burnt in such hot environment existing in the cylinder.

It is quite common nowadays to learn that every country is in the race to find suitable and affordable alternative fuel options for the diesel engine as the present-day diesel fuel reserve is depleting fast. In addition, the price of conventional diesel fuel is sky rocketing due to great demand, the exponential increase of vehicles number on road and political turmoil. Therefore, it is an urgent need for India as well to search for an option to run diesel engine using a fuel other than conventional and petroleum-based diesel. Biodiesel, as a diesel engine fuel alternative, receives more attention among many feasible options. Biodiesel has been considered as one of the most versatile alternative fuel options for petroleum diesel indirect injection diesel engine applications because it has a substantial prospect as a long-term replacement for diesel fuel [2].

Research work on biodiesel reveals that a large number of experimental studies of biodiesel, derived from various feed stocks, as fuel for engines used for transportation and or other applications have been carried out all over the world. Application of biodiesel, as a fuel in transportation vehicles, has nowadays become common in almost all types of oil importing from different countries, due to the high oil import bills and uncertainties associated with the imports due to political chaos. Depending upon the availability of domestic products of feedstock material these countries started using biodiesel from domestically available or producible vegetable oil. In this context, different type of oils have been used by different countries, depending upon the availability and economical affordability. It is reported that biodiesels derived from soybean [3], rapeseed [4], sunflower [5], palm [6], coconut oil [7], rubber seed, waste cooking oil, waste plastic oil etc. have been found suitable and feasible for use in diesel engines. Several types of researches carried out in India reveal that biodiesels derived from jatropha, Karanja,mahua, polanga, [8-12] etc, are a suitable fuel for use in diesel engine applications. The recent biodiesel research in India includes its attention towards alternate fuels like algae biodiesel, waste cooking oil biodiesel, fish oil biodiesel, etc. The use of fish-oil biodiesel as a fuel in diesel engines and the performance studies carried out on the single cylinder direct injection diesel engine is presented in this project.

Ramesh et al. [13] investigated the performance fish oil in direct injection diesel engine the B20 Fish oil Methyl Ester shows least BSFC and Maximum Brake Thermal efficiency at peak load.

Sevariraj et al. [14] used various blends of fish-oil biodiesel with diesel, B25, B50, B75, B100 were used in the experiments and the results show that brake specific fuel consumption and brake thermal efficiency were higher with B100 fuel than that of diesel.

Kirankumar et al. [15] conducted experimental investigations on 4-stroke direct Injection diesel engine using fish oil biodiesel as alternative fuel showed blend B30 has highest BTE and lowest SFC.

Pavanpujar et al. [16] conducted the performance on Direct Injection diesel engine using with mackerel fish biodiesel and diesel fuel blends, the performance parameters like brake specific fuel consumption, brake specific energy consumption, brake thermal efficiency and air fuel ratio analyzed. Results show that all blends followed the same trend as diesel fuel. There was no much difference between the performance of diesel fuel and fish oil biodiesel. At higher load, both specific energy and specific fuel consumption were low for FOB (100). FOB can be used in the DI diesel engine as an alternative fuel without much engine modifications.

Ramesh et al. [17] A computerized 4-stroke, single cylinder, constant speed, direct injection diesel engine was operated on fish oil biodiesel of different blends. Three different blends of 10, 20, and 30 % by volume were used for this study. Various engine performance, combustion and emission parameters such as Brake Thermal Efficiency, Brake Specific Fuel Consumption, Heat Release Rate, Peak Pressure, Exhaust Gas Temperature, etc. were recorded from the acquired data. The data was recorded with the help of engine analysis software. The recorded parameters were studied for varying loads and their corresponding graphs have been plotted for

comparison purposes. Petroleum Diesel has been used as the reference. From the properties and engine test results it has been established that fish oil biodiesel is a better replacement for diesel without any engine modification.
Ravi Kiran et al. [18] The methyl esters of vegetable oils, known as biodiesel are becoming increasingly popular because of their low environmental impact and potential as a green alternative fuel for diesel engine and they would not require significant modification of existing engine hardware. The Methyl ester of Fish oil (FME) is derived through transesterification process. Experimental investigations have been studied to examine properties, performance, and emissions of different blends (B00, B20, B40, B60, B80, and B100) of FME comparison with diesel.

EXPERIMENTAL SETUP AND PROCEDURE

The engine shown in plate.1 is a 4 stroke, vertical, single cylinder, water cooled constant speed diesel engine which is coupled to rope brake drum arrangement to absorb the power produced. The engine crank started. Necessary dead weight and spring balance are included to apply load on the brake drum. Provided Suitable cooling water arrangement for the brake drum. Separate cooling water lines are provided for engine cooling and fitted with temperature measuring thermocouples . A measuring system for fuel consumption consisting of a fuel tank, 3-way cock and burette mounted on stand and stopwatch is provided. The Air intake is measured using by an air tank fitted with an orifice meter and a water U-tube differential manometer, also digital temperature indicator with the selector switch for temperature measurement and a digital rpm indicator for speed measurement are provided on the panel board. A governor is provided to maintain the constant speed.

TABLE Specification of the Test Engine

Specification of the Test Engine	
Particulars	**Specifications**
Make	Kirloskar
Rated Power	8hp(5.9kw)
Bore	80 mm
Stroke Length	110 mm
Compression Ratio	16.5:1

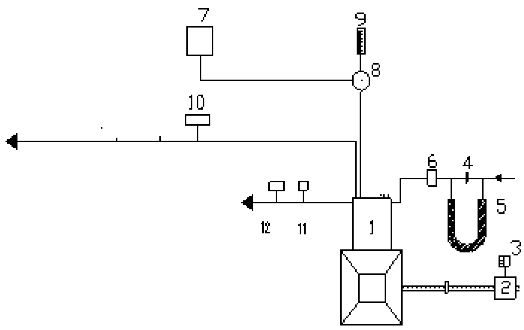

Figure.1 Schematic Diagram for Experimental Setup

Engine, 2.Electical Dynamometer, 3.Load Box, 4.Orifice flow meter, 5.U-tube water manometer, 6.Airbox, 7.Fuel tank, 8, Pre-heater, 9.Burette, 10. Exhaust gas temperature indicator, 11.Outlet jacket water temperature indicator, 12. Outlet-jacket water flow meter,

Test Fuels:
In this experimental investigations, pure diesel and biodiesel derived from fish oil were mixed with diesel in varying proportions 20%, 40%, 50% 60% by volume respectively to all the blend. The properties of test fuels are presented in the table.

TRANSESTERIFICATION OF FISH OIL

The term transesterification is used as synonymous for alcoholises of carboxylic esters, in agreement with most publications in this field. The transesterification is an equilibrium reaction and the transformation occurs essentially by mixing the reactants. However, the presence of a catalyst (typically a strong acid or base) accelerates considerably the adjustment of the equilibrium. In order to achieve a high yield of the ester, the alcohol has to be

ISSN: 2277-9655
Impact Factor: 4.116
CODEN: IJESS7

used in excess.

Mild Acid Catalyzed Transesterification

The first stage removes organic matter and other impurities present in the oil in the presence of orthophosphoric acid, used as a reagent. Fish oil extracted from the MARINE FISH consists of the impurities of high quality, which were causing the Transesterification difficulty. Hence, this necessitated the use of the first stage. This is a type of reaction that takes place in the presence of methanol (30%) and orthophosphoric acid (0.6%) at 60˚c with constant stirring, helps in the separation of impurities which were dissolved in the methanol as an upper layer and oil in the lower layer. The oil is separated and taken to the 2nd stage.

Strong Acid Catalyzed Transesterification

The Anhydrous sulphuric acid used as a catalyst in this stage which helps in reducing FFA content in the oil obtained from the first stage. The first stage product is reacted with the sulphuric acid (0.6%) and methanol (20%) for 2 hours at 60˚c with constant stirring. The reaction product is allowed to settle. The FFA and the other impurities were removed in this stage as an upper layer and oil in the lower layer. Oil is separated and taken for 3rd stage.

Base-Catalyzed Transesterification

The settled lower layer of the earlier stages having low FFA is used as a raw material for this stage. The product of earlier stages i.e, pure triglycerides is made to react with methanol

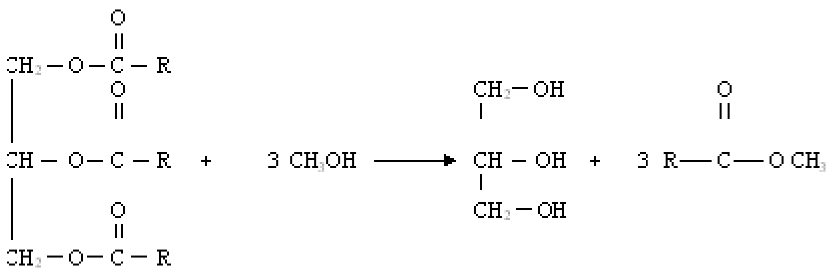

Figure.2 Transesterification Process

TABLE 1: Properties of DF and FOBD

Property	Diesel Fuel (DF)	Fish Oil Bio Diesel (FOB)
Cetane No.	45-55	59
Density (kg/m^3	820-880	860
Kinematic Viscosity at 30ºC (Cst)	3	5
Calorific Value KJ/Kg	42000	39000
Flash Point ºC	56	162

Experimental Procedure:

Calculate full load (W) that can be applied to the engine from the engine specifications. Clean the fuel filter and remove the air lock. Check for fuel, lubrication oil, and cooling water supply. Start the engine using decompression lever ensuring that no load on the engine and supply the cooling water allow the engine for 10 minutes on no load to get stabilization. Note down the spring balance reading, time is taken for 10 cc of fuel consumption and the manometer readings. Repeat the experiment at 10% to 100% load at the steps of 10% increase. Allow the engine to stabilize on every load change and then take the readings. Before stopping the engine remove the loads and make the engine stabilized and run the engine with pure diesel for 5 minutes so that the engine will not be jammed due to clogging of valves by previous blends. Check there is no load on the engine while stopping.

ISSN: 2277-9655
Impact Factor: 4.116
CODEN: IJESS7

RESULTS AND DISCUSSIONS

PERFORMANCE ANALYSIS:

The experiments are conducted on the four stroke single cylinder water cooled diesel engine at a constant speed (1500 RPM) with varying loads. Various performance parameters such as the variation of brake thermal efficiency with the load for different fuels are presented in Fig.3. In all cases, it increased with increase in load. This was due to the reduction in heat loss and an increase in power with the increase in load. It is found that the maximum thermal efficiency for B60 was higher (43.57%) at 80% load than that of the diesel engine (36.34%).

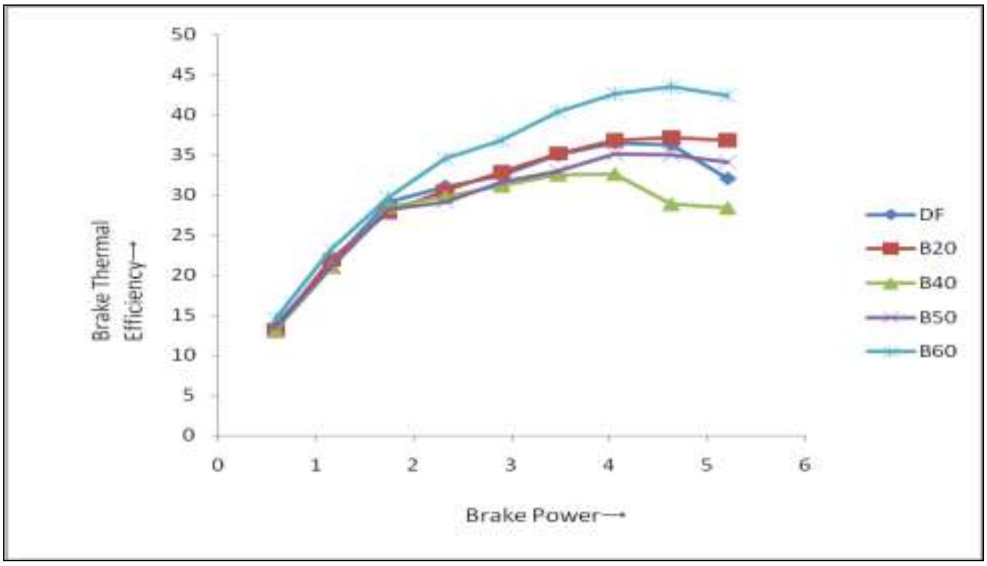

Figure.3 Variation of Brake Thermal Efficiency with Brake Power using Fish oil Methyl Ester (FOME) blends

This blend of 60% also gave minimum brake specific energy consumption (0.1966 kg/kW-hr). Hence this blend was selected as an optimum blend for further investigations and long-term operation.

The Brake specific fuel consumption (BSFC) in fig.4 full load in brake power due to the relatively less portion of the heat losses at higher load .conditions for the diesel are 0.267 and among all the blends B60 has taken minimum fuel giving the value of 0.1966. The main reason for this could be that percent increase in fuel required to operate the engine is less than the percent increase in brake power due to relatively less portion of heat losses at higher loads. The BSFC for B60 was observed lower than diesel.

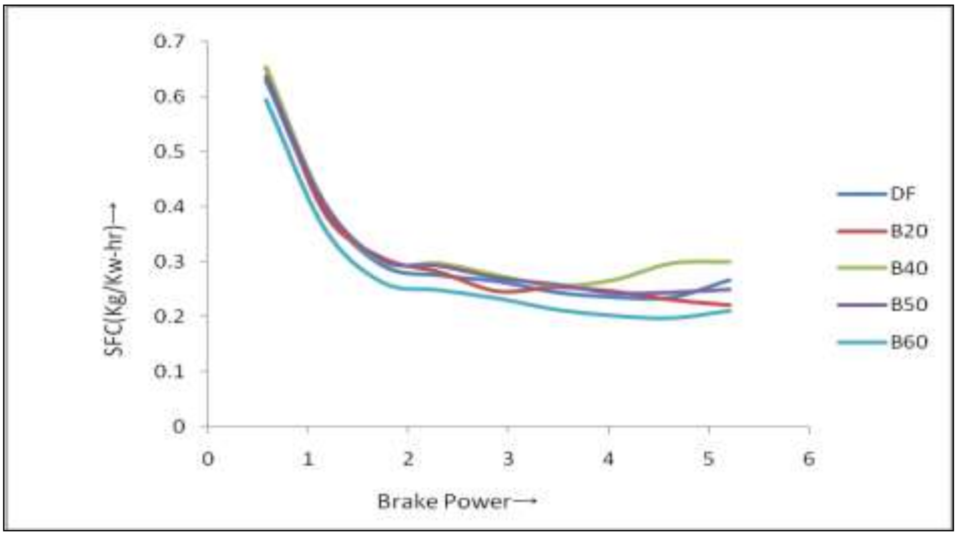

Figure.4 Variation of Brake Specific Fuel consumption (BSFC) with brake power using FOME blends

ISSN: 2277-9655
Impact Factor: 4.116
CODEN: IJESS7

Generally, Brake Specific Fuel consumption is not used to compare two different fuels, because their calorific values, density, chemical and physical parameters are different [19]. Performance parameter Brake Specific Energy Consumption (BSEC) is used to compare two different fuels by normalizing BSEC in terms of energy released with the given amount of fuel. The variation of BSEC against Brake Power is shown in the fig.5

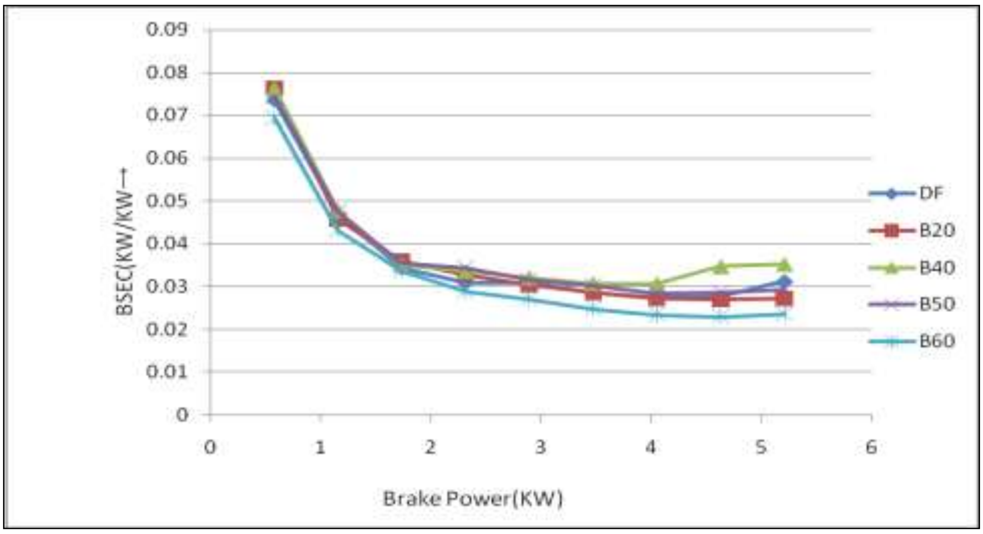

Figure.5 Variation of Brake Specific Energy consumption (BSEC) with brake power using FOME blends

Brake specific energy consumption of biodiesel is almost the same as that of neat diesel fuel as shown in Figure.6. Even though viscosity of biodiesel is slightly higher than that of neat diesel, inherent oxygen of the fuel molecules improves the combustion characteristics.

The BSEC for the blends is slightly varied entire load range due to pure atomization and decrease in the percentage of oleic acid [20] present in the biodiesel due to blends. FOB for medium loads to higher show lower BSEC than DF this may be due to combustion of volatile fats [21] present in the FOB. Whereas for B60 shows lower BSEC than DF at all loads. This may be due inherent oxygen of the fuel molecules improves the combustion characteristics.

The variation of Mechanical Efficiency with Brake Power is shown in the Fig.6

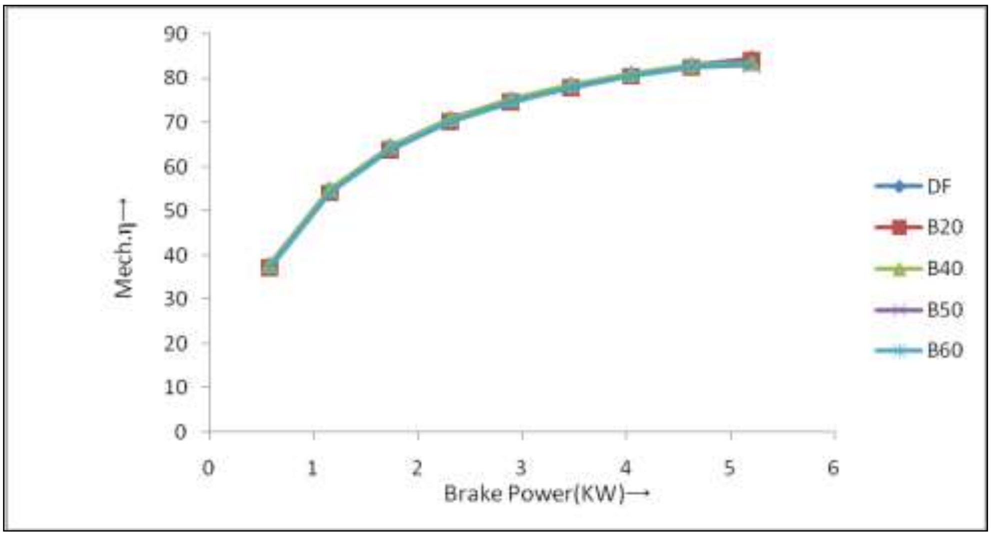

Figure.6 Variation of Mechanical Efficiency with brake power using FOME blends

From the plot, it is observed that there is the slight variation of mechanical efficiency for all the blends of fish oil compared to the diesel fuel.

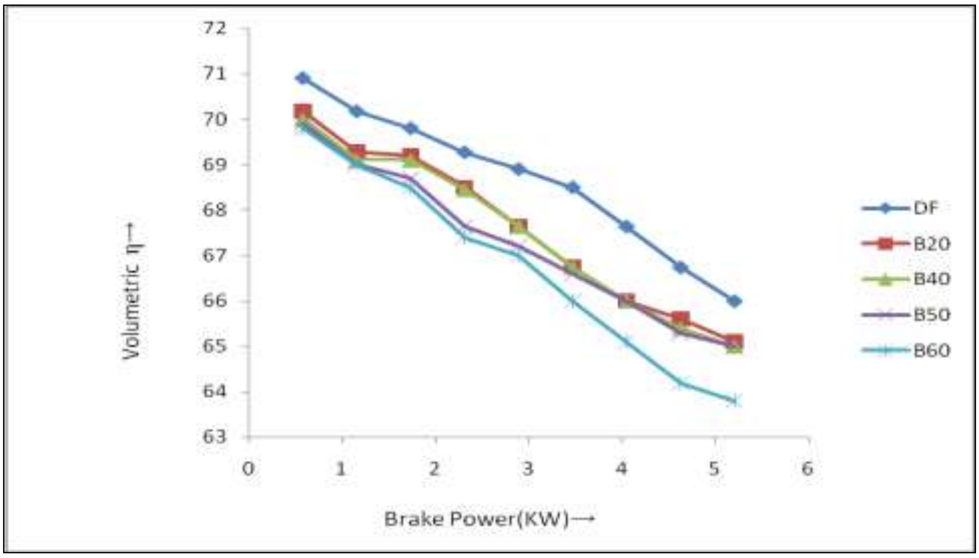

Figure.7 Variation of Volumetric Efficiency with brake power using FOME blends

From the plot, it is observed that diesel contains 66% at full load, but in the case of fish oil blends, it showed a slight decrement. The decrement in the volumetric efficiency is due to the decrease in the amount of intake air due to high temperature in the cylinder.

In diesel engines for given speed irrespective of load, an approximately constant fuel enters the cylinder. Fig. 8 shows variations of air fuel ration of different blends as a function of load on the engine

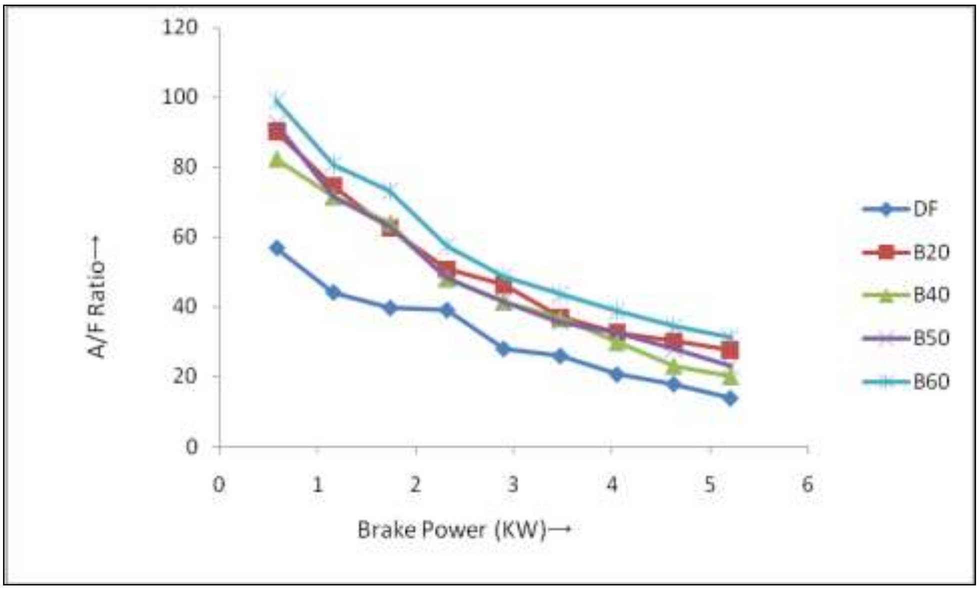

Figure.8 Variation of air fuel ratio with brake power using FOME blends

All blend follow the same trend as diesel fuel. The air-fuel ratio decreases with increase in load because of compensation of load can only be done by increasing the quantity of fuel injection to develop the power required to bare the load.

CONCLUSIONS

The conclusions deriving from present experimental investigation to evaluate the experimental tests are conducted on 4-stroke, single cylinder, water cooled and direct injection diesel engine by using fish oil blends of B20, B40, B50 and B60, pure diesel at a constant speed of 1500 rpm. From the first set of results, it can be concluded that the blend B60 has given the better performance in the sense of brake thermal efficiency, specific fuel consumption. No engine seizing, injector blocking was found during the entire operation while the engine running with different blends of fish oil and diesel is summarized as follows;

[1] The minimum fuel consumption is 0.1966 kg/kW-hr as that of diesel 0.267 kg/kW-hr. The BSFC of fish oil blend B60 is decreased up to 26.36% as compared with diesel fuel at full load operation.
[2] The maximum Brake Thermal Efficiency is 43.57% which is obtained for B60 blend at 80% load. The BTE of fish oil is increased up to 32% as compared with diesel at full load operation.
[3] The Volumetric efficiency decreased by3.3% at full load operation compare with B60 Blend.
[4] The Mechanical Efficiency decreased by 1.6% at full load operation compare with B60 Blend.
[5] BSEC was decreased by 24% at full load operation.

REFERENCES

[1] R. Kamo and W.Bryzik, “Adiabatic Turbo compound Engine Performance Prediction”, SAE Paper No.780068, 1978.
[2] M. Marmach, D.Server, R.H.J.Hannink, M.J.Murray, and M.V.Swain, “Toughened PSZ Ceramics-Their Role as Advanced Engine Components”, SAE Paper No.830316, 1983.
[3] Moorhouse, Peter and Johnson, P. Michael “Development of Tribological Surfaces and Insulating Coatings for Diesel Engines”. SAE Paper No.870161, SP-700, 1987
[4] Y.Miyairi, T.Matsuhisa, T.Ozawa, H.Oikawa, and N.Nakashima, "selective Heat Insulation of Combustion Chamber Walls for a DI Diesel Engine with Monolithic Ceramics”, SAE Paper No.90141.
[5] K.L.Hoag, M.C.Brands and W.Bryzik, “Cummins/TACOM Adiabatic Engine Program”, SAE. paperNo.850356. 1985
[6] T.Morel, R.Keribar, P.N.Blumberg, and E.F.Fort, "Methods for Heat Transfer and Thermal Analysis of Insulated Diesels", proceedings of the 23rd Automotive Technology Development Contractors’ Coordination Meeting SAE, pp. 61-7, 1986.
[7] P.H.Havastad, I.J.Gervin, and W.R.Wade., “A Ceramic Insert Uncooled Diesel Engine”, SAE Paper No.860447, 1986.
[8] W.R.Wade, P.H.Havastad, E.J.Ounsted, F.H.Trinkler and I.J.Garwin, "Fuel Economy Opportunities with an Uncooled DI Diesel Engine". C432, pp.11-24, IMechE/SAE 1984.
[9] R.H.Thring, “Low Heat Rejection Engines”, SAE Paper No. 860314, 1986.
[10] G.Woschini, W.Spindler, and K.Kolesa, “Heat Insulation of Combustion Chamber Walls –A Measure to decrease the Fuel Consumption of I.C.Engines?” SAE Paper No. 870339, 1987.
[11] D.W.Dickey, “The Effect of Insulation Combustion Chamber Surface On Diesel Engine Performance, Emissions and Combustion”, SAE Paper No. 890292, 1989.
[12] W.K.Cheng, and V.W.Wong, “Does Heat Transfer increase in low Heat Rejection Engines-A Discussion on the recent results from Woschni et al.” Proceedings of the 25th Automotive Technology Development Contractors’ Coordination Meeting SAE, pp.57-60, 1987.
[13] D. K. Ramesha, Prithvish M Gowda, Manjunath N, Rajiv Simhasan, Rajiv K. T, “Performance, Combustion and Emission Evaluation of Fish and Corn Oil as a substitute fuel in Direct Injection C. I. Engine”, AMAE Int. J. on Production and Industrial Engineering, Vol. 4, No. 1, June 2013.
[14] S. Savariraj, T. Ganapathy, C. G. Saravanan, "performance and emissions and combustion characteristics of fish oil biodiesel engine", European Journal of Applied Engineering and scientific research, vol 2(3), pp. 26-32, 2013.
[15] S.Kirankumar, K.Appa Rao and R.Nagendra Babu, "Experimental Investigations on Performance, Combustion Characteristics of diesel engine by using Fish Oil”, International Journal of Engineering Research and Applications (IJERA) Vol. 2, Issue-6, pp.1258-1263, 2012.
[16] Pavan Pujar, B.K.Venkanna, M.Basavaraju and Pavan Kulkarni, "Performance Characteristics of direct injection diesel engine running on Mackerel Fish Oil biodiesel/diesel fuel blend", International Journal of Scientific & Engineering Research, Volume 6, Issue 1, January-2015
[17] D.K.Ramesha, P.M.Gowda, N.Manjunath, Rajiv Simhasan and K.T.Rajiv, “Performance, Combustion and Emission Evaluation of Fish and Corn Oil as substitute fuel in Direct Injection Diesel Engine”, AMAE Int. J. on Production and Industrial Engineering, Vol. 4, No. 1, June 2013.

ISSN: 2277-9655
Impact Factor: 4.116
CODEN: IJESS7

[18] Ravi Kiran and Ravi Prakash, "Experimental Investigations on diesel engine using fish oil methyl ester as an alternative fuel", International Journal of Engineering Research and General Science Volume 3,Issue 2, March-April, 2015.