EXPERIMENTAL INVESTIGATIONS OF DIESEL ENGINE USING FISH OIL BIODIESEL AND ITS BLENDS WITH ISOBUTANOL AS AN ADDITIVE

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Abstract

Biodiesel with fuel additives has been gaining increased attention from engine researchers in view of the energy crisis and increasing environmental problems. The present work is aimed at experimental investigation of Isobutanol as an additive to the diesel- biodiesel blends. Experiments were done on a 4-Stroke single cylinder diesel engine by varying percentage by volume of Isobutanol in diesel-biodiesel blends. The effect of Isobutanol on brake thermal efficiency, brake specific fuel consumption, cylinder pressure, heat release and exhaust emissions were studied. It was Ghose M K found that brake thermal efficiency is increased with increase in blend percentage both with 5% and 10% Isobutanol. Addition of Isobutanol shows negative impact on Brake specific fuel consumption (BSFC) which decreased with blend percentage while it increases with Isobutanol percentage. CO emissions and smoke capacity decreased significantly while NOx emissions decreased marginally with the increase in Isobutanol percentage.

Keywords: *Combustion characteristics, Diesel-Biodiesel blends, Isobutanol, Performance.*

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1. INTRODUCTION

Ethanol has been known for many decades. Indeed, when Henry Ford designed the model-T, it was his expectation that ethanol made from renewable biological material would be a major automobile fuel. Ethanol is one of the possible fuels for diesel replacement in CI engines as it reduces environmental pollution. As gasoline prices and emission regulations become more stringent, ethanol could be given more attention as renewable fuel or gasoline additive [1, 2].

Gasoline with additives like Ethanol and Ethanol- Isobutanol increased the brake power, volumetric and brake thermal efficiencies and fuel consumption. The CO and HC concentrations in the engine exhaust decreased while the NOx concentration increased. The addition of 5% Isobutanol and 10% Ethanol to gasoline gave the best results [3]. Bio-additives (matter extracted from palm oil) as gasoline additives at various percentages (0.2%, 0.4% and 0.6%) showed improvement in fuel economy and exhaust emissions of SI engine [4]. Methyl-ester of Jatropha oil diesel blends with Multi-DM-32 diesel additive showed comparable efficiencies, lower smoke, CO2 and CO [5]. The addition of Di Methyl Carbonate (DMC) to diesel fuel increases efficiency marginally with reductions in NOx emissions while PM and soot emissions were reduced considerably [6,7]. Biodiesel with Di Ethyl Ether in a naturally aspirated and turbocharged, high-pressure, common rail diesel engine reduced NOx emissions with slight improvement in brake thermal efficiency [8, 9]

Ethanol addition to diesel-biodiesel blends increased brake thermal efficiency with reduction in carbon monoxide and smoke emissions and at the same time hydrocarbons, oxides of nitrogen and carbon dioxide emissions increased [10]. Some researchers have used cetane improvers and some others have used additives in coated engines. Biodiesel blended fuel, and a cetane improving additive (2-EHN) reduced PM emissions [11]. Addition of di-1-butyl peroxide and the conventional cetane improver, 2-ethylhexyl nitrate additives to diesel fuel reduced all regulated and unregulated emissions including NOx emissions [12].

Present work attempts to investigate performance, combustion and emission characteristics of diesel engine with Isobutanol as an additive to the diesel-biodiesel blends. Isobutanol has higher energy density and lower Reid Vapor Pressure (RVP) which make it as a suitable additive for diesel-biodiesel blends. The properties of Isobutanol are shown in Table.1.

Table-1: Properties of Isobutanol

Property	Range
Flash Point, Tag open cup, °C	37.7
Specific gravity, 20/20°C	0.8030
Viscosity at 20°C (Centipoises)	3.95
Auto ignition temperature, 20°C	440
Surface tension at 20°C (dynes/cm)	22.94
Heat of combustion, KJ/kg	36162

2. MATERIALS AND METHODS

2.1 Biodiesel Production

Transesterification is the most widely applied in industrial biodiesel production. Three types of catalysts can be used in the transesterification process: a strong alkali, strong acid or enzyme. A strong alkali catalyst is frequently used in the transesterification reaction due to its dominant advantages of a shorter reaction time and smaller amount of catalyst required. Figure 1 shows the flow chart for biodiesel production.

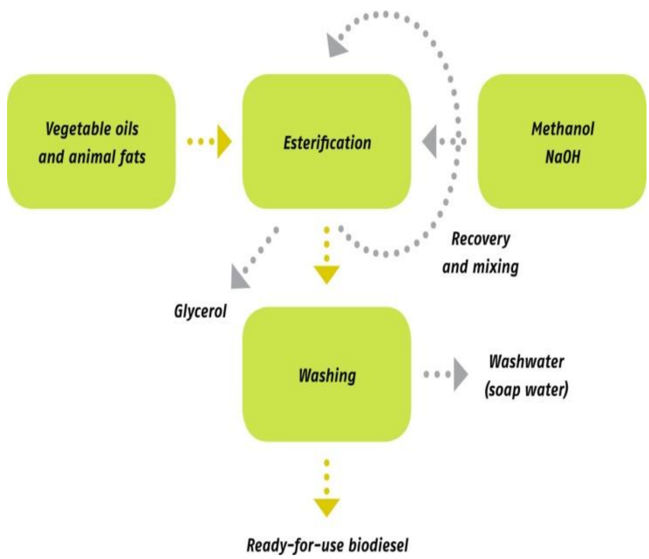

Fig-1: The main process of obtaining biodiesel

In the course of test, it is observed that fish oil having high acid number processed in the presence of sulphuric acid catalyzed transesterification, consumed higher amount of acid to decrease the acid number but with the increase in acid catalyst percentage, resulting in darkening of final product. Hence, it is processed through all the three stages. It has been optimized the first stage with oil to methanol volumetric ratio of 30:1 and 0.6% v/v of orthophosphoric acid as reagent with the reaction duration 1.5hr at a temperature of 55˚C , has resulted with the acid number of 10.48 mg KOH/g i.e. 5.24% of FFA. The FFA is more than 2%, the extra FFA is converted in to triglycerides in the second stage which has been optimized with the 0.6% v/v of sulphuric acid, oil to methanol volumetric ratio of 20:1, reaction duration of 1.5 hr. The experiments conducted for base catalyzed transesterification that the oil to methanol volumetric ratio of 12:1 and 0.6% w/v of KOH is found to give the maximum conversion of 97.2% at 60˚C with the reaction duration of 2hr et al [13].

2.2 Fuel Properties

Crude fish oil was brought from Mangalore, Karnataka, India, filtered to remove the impurities and then transesterified by the above said method. The fish oil methyl ester contained no suspended matter but had an undesirable smell peculiar to fish oil. The color was transparent, light yellow. The physical characteristics of fish oil methyl ester are closer to diesel oil. The fuel properties were tested in Bangalore Test House Bangalore, India. Optimized results for the production of biodiesel from the oils are shown in Table. 2.

Table-2: Properties of biodiesel

Property	Diesel	Fish oil biodiesel
Density (kg/m^3)	850	875
Specific gravity	0.850	0.875
Kinematic viscosity at 40°C (Cst)	3.05	4.0
Calorific value (KJ/kg)	42800	41325
Flash point (°C)	56	175
Fire point (°C)	63	188
Oxygen content (%)	Nil	10.8

2.3 Experimental Set Up

The engine shown Fig. 2 is a 4 stroke, vertical, single cylinder, water cooled and constant speed diesel engine which is coupled to rope brake drum arrangement to absorb the power produced. The engine crank started. Necessary dead weights and spring balance are included to apply load on brake drum. Suitable cooling water arrangement for the brake drum is provided. Separate cooling water lines fitted with temperature measuring thermocouples are provided for engine cooling. A measuring system for fuel consumption consisting of a fuel tank, burette, and a 3- way cock mounted on stand and stop watch are provided. Air intake is measured using an air tank fitted with an orifice meter and a water U- tube differential manometer. Also digital temperature indicator with selector switch for temperature measurement and a digital rpm indicator for speed measurement are provided on the panel board.

Fig- 2: Diesel Engine Test Rig

2.2 Experimental Procedure

For experimental investigations, biodiesel derived from fish oil was mixed with diesel in varying proportions 10%, 20% and 30% by volume and Isobutanol as an additive was added as 5% and 10% by volume respectively to all the blends. The engine was started with standard diesel fuel and warmed up. The warm up period ends when the cooling water temperature is stabilized. Then various performance parameters such as, BTE, Mechanical efficiency, BSFC, A/F ratio and different exhaust emissions like NOx, HC, CO, CO2 and smoke were measured. A similar procedure was repeated for biodiesel mixed with Isobutanol for various blends.

3. RESULTS AND DISCUSSION

3.1 PERFORMANCE ANALYSIS

3.1.1 Brake Specific Fuel Consumption

Brake Specific Fuel Consumption (BSFC) is the fuel consumed by the engine per unit of power output or produced. The variation of BSFC is shown in Fig. 3. It is observed that as the load increases the fuel consumption decreases, the minimum fuel consumption are for F30D69I10 is 0.25 as to that of F30 is 0.258. The BSFC of after adding ignition improver of Bio-diesel is slightly increases as compared with optimum blend (F30) at full load condition.

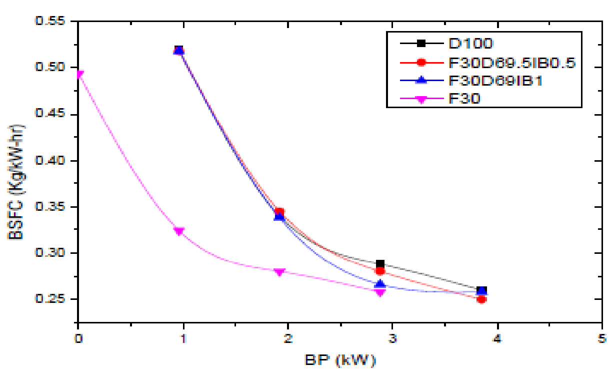

Fig-3: Variation of BSFC with Brake Power

3.1.2 Mechanical Efficiency

The variation of Mechanical efficiency with Brake Power is shown in Fig. 4. From the plot it is observed optimum blend and various blends like F300D69.5I5, B30D69I10 slightly increases at full load conditions.

3.1.3 Brake Thermal Efficiency (BTE)

Brake Thermal Efficiency is the ratio of the power output of the engine to the rate of heat liberated by the fuel during the combustion. As shown in Fig. 5, it is observed that as the BP increases there is considerable increase in the BTE. The BTE of diesel at full load is 32.82% while the blends of F30 is 34.01%, B30D69.5I5 is 35.14%, B30D69I10 is 34.01%, among the three the maximum BTE is 35.14% which is obtained for B30D69.5I5. The increment in brake thermal efficiency due to better combustion because of adding ignition improver it effects to decrease the viscosity.

3.1.4 Air Fuel Ratio (A/F)

The variation of Air-Fuel Ratio with Brake Power is shown in Fig. 6. From the figure it is observed that as load increases more power is to be developed by the engine to compensate the load. The only way to increase the more power development is to inject the more amount of fuel into the cylinder which tends to reduce the air fuel ratio.

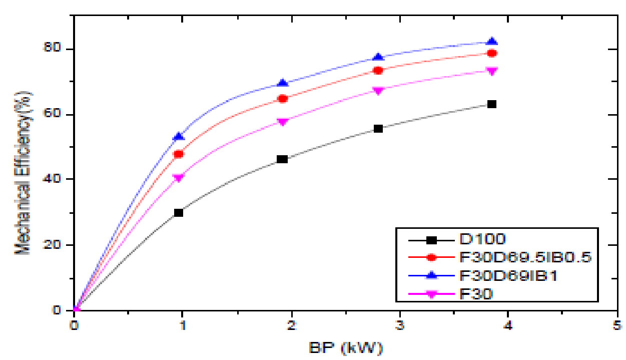

Fig-4: Variation of Mechanical Efficiency with Brake Power

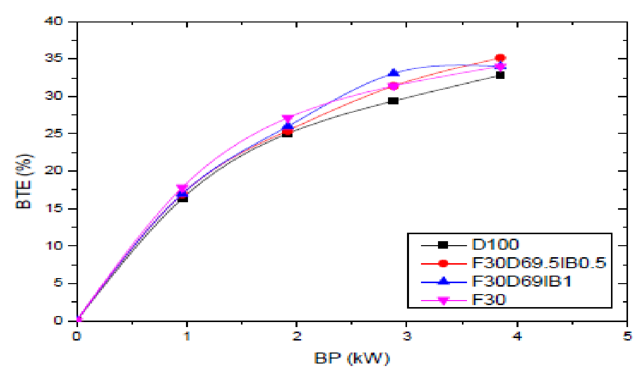

Fig-5: Variation of BTE with Brake Power

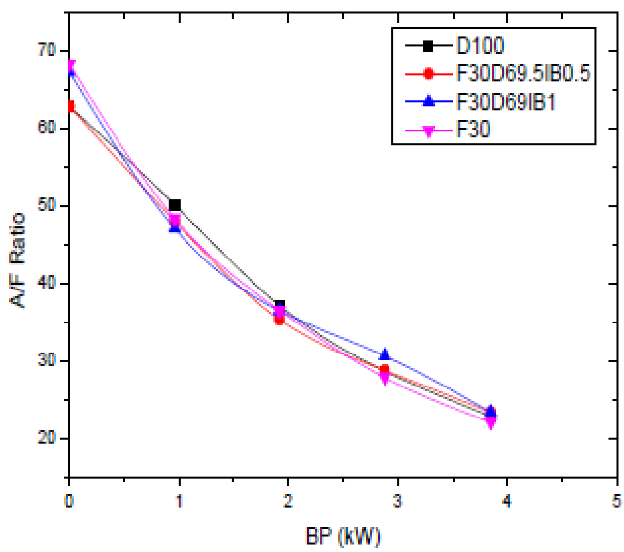

Fig-6: Variation of A/F Ratio with Brake Power

3.2 EMISSION ANALYSIS

3.2.1 Carbon Monoxide (CO)

The variation of CO emission with Brake Power is shown in Fig. 7. It is observed that the engine emits more CO for diesel as compared to biodiesel blends under all loading conditions. The CO concentration decreases for the blends of F30D69.5I5 and F30D69I10 for all loading conditions. At lower biodiesel concentration, the oxygen present in the biodiesel aids for complete combustion. However as the biodiesel concentration increases, the negative effect due to high viscosity and small increase in specific gravity suppresses the complete combustion process, which produces small amount of CO.

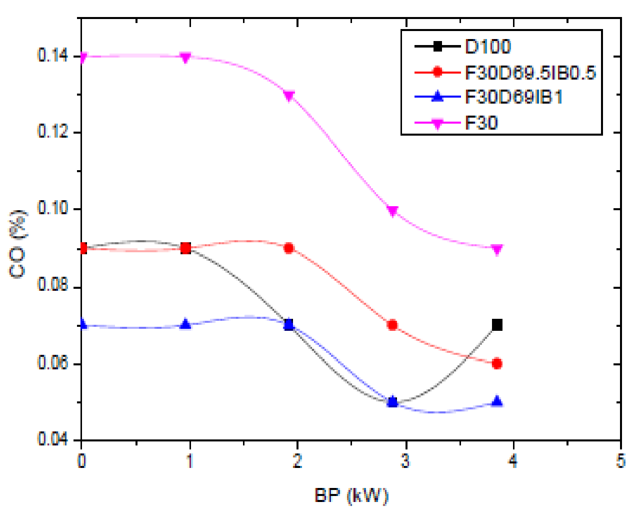

Fig-7: Variation of CO with Brake Power

3.2.2 Carbon dioxide (CO_2)

The variation of CO_2 emission with Brake Power is shown in Fig. 8. From the figure it is observed that CO_2 emission increased with increase in load for all blends. The lower percentage of biodiesel blends emits less amount of CO_2 in comparison with diesel. Blends F30D69.5I5 and F30D69I10 emit very low emissions. Using higher content biodiesel blends, an increase in CO_2 emission was noted, which is due to the high amount of oxygen in the specified fuel blends which converting CO emission into CO_2 emission contents.

3.2.3 Hydrocarbons (HC)

Fig. 9 shows the variation of HC emission with respect to brake power for various blends of diesel, bio-diesel and ethanol. HC emission for diesel fuel is slightly higher at low load than other three blends.

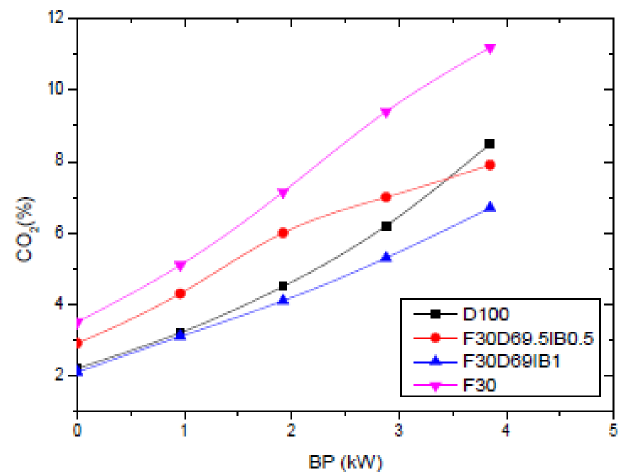

Fig-8: Variation of CO_2 with Brake Power

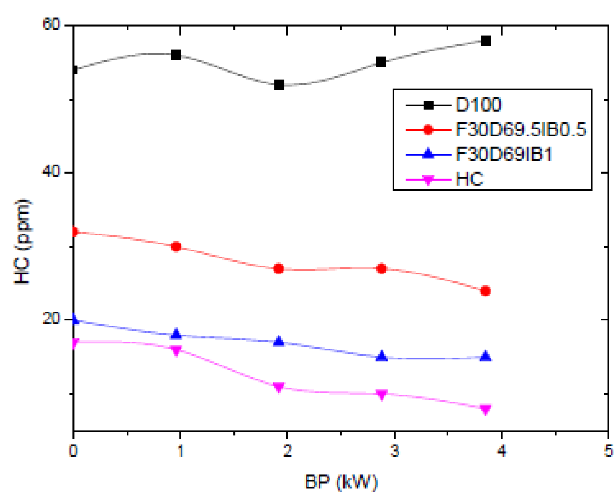

Fig-9: Variation of HC with Brake Power

3.24 Oxides of Nitrogen (NO_X)

The NOx emission for all the fuels tested followed an increasing trend with respect to load. The reason could be the higher average gas temperature, residence time at higher load conditions. As shown in Fig. 9, with increase in the fish oil content of the fuel, corresponding reduction in emission was noted and the reduction was remarkable for F30D69.5I5 and F30D69I10. At full load condition the unused oxygen obtained are 18.62%, 19.50%, 15.97% and 14.91% for the fuels of diesel, F30, F30D69.5I5 and F30D69I10 respectively.

Similar results were observed by the researchers at [14, 15].

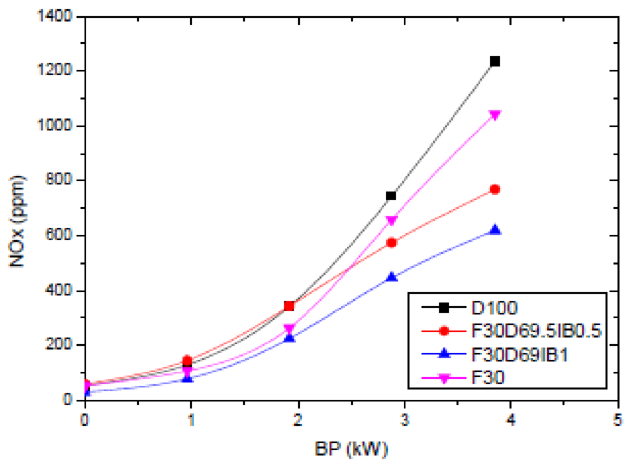

Fig-9: Variation of NO_X with Brake Power

4. CONCLUSIONS

Following are the conclusions drawn from the experimental results obtained while operating on single cylinder diesel engine fuelled with biodiesel, Isobutanol & its diesel blends.

- It is observed that as the BP increases there is considerable increase in the BTE. The BTE of diesel at full load is 31.82% while the blends of F30 is 34.35%, F30D69.5I5 is 35.14%, F30D69I10 is 34.01%, among the three the maximum BTE is 35.14% which is obtained for F30D69.5I5. The BTE of fish oil is increases up to 0.398% and 0.856% as compared with to fuels of optimum blend and diesel at full load condition.
- Brake specific fuel consumption is observed that as the load increases the fuel consumption decreases, the minimum fuel consumption is for F30D69.5I5 is 0.29 kg/kW-hr as to that of F30 is 0.310 kg/kW-hr at full load condition.
- It is interesting to note that the engine emits more CO for diesel as compared to fish oil blends under all loading conditions. The CO concentration increases for the blends of F30D69.I5 and same as the diesel for F30D69I10. At full load condition the CO emission obtained are 0.05%, 0.09%, 0.06% and 0.05% for the fuels of diesel, F30, F30D69.5I5 and F30D69I10 respectively.
- As biodiesel has higher cetane number & more oxygen compared to diesel & ethanol both, which acts as combustion promoter inside cylinder, resulting in to better combustion of fuel so, HC emission for F30 fuel blend are observed lower than the all fuel/fuel blends & higher in case of F30D69.5I5 fuel blend.
- The NOx emission for all the fuels tested followed a decreasing trend with respect to load. At full load condition the NOx emissions obtained are 1236ppm, 1044ppm, 769ppm and 619ppm for the fuels of diesel, F30, F30D69.I5 and F30D69I10 respectively.

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