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Performance and Emission Analysis of Diesel Engine Using Fish Oil And Biodiesel 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 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 NO_x emissions decreased marginally with the increase in isobutanol percentage.

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

I. INTRODUCTION

Researchers have used different additives to petrol and diesel fuels for efficiency and emission improvement. The addition of alcohol based fuels to petroleum fuels has been increasing due to advantages like better combustion and lower exhaust emissions. Oxygenates like ethanol, I-propanol, I-butanol and I-pentanol improved performance parameters and reduced exhaust emissions [1, 2]. Gasoline-ethanol blends with additives such as cyclooctanol, cycloheptanol increased brake thermal efficiency when compared to gasoline with reduction in CO,CO_2 and NOx while HC and O_2 increased moderately[3]. 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[4]. 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[5]. Methyl-ester of Jatropha oil diesel blends with Multi-DM-32 diesel additive showed comparable efficiencies, lower smoke, CO_2 and CO [6]. 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 [7,8]. 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 [9,10]. 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 [11]. 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 [12]. 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 [13].

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 Isobutanol properties

Property	Range
Flash Point, Tag Open Cup, °C	37.7
Specific Gravity, 20/20°C	0.8030
Viscosity at 20°C (Centipoise)	3.95
Auto ignition Temperature, °C	440
Surface Tension at 20°C(dynes/cm)	22.94
Heat of Combustion, Kj/kg	36162

II. EXPERIMENTAL SET UP AND PROCEDURE

2.1 EXPERIMENTAL SET UP

The engine shown in plate. 2.1 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. A governor is provided to maintain the constant speed.

Plate 2.1 Diesel Engine Test Rig

Table 2 Specifications of the Test Engine

Specifications of the Test Engine	
Particulars	**Specifications**
Make	Kirloskar
Rated Power	3.7 kw(5hp)
Bore	80 mm
Stroke Length	110 mm
Swept volume	562 cc
Compression ratio 16.5:1	Compression ratio 16.5:1

2.2 TEST FUELS

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.

2.3 EXPERIMENTAL PROCEDURE

Calculate full load (W) that can be applied on the engine from the engine specifications. Clean the fuel filter and remove the air lock. Check for fuel, lubricating 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 total dead weight, spring balance reading, time taken for 20cc of fuel consumption and the manometer readings. Repeat the above step for different loads up to full load. Connect the exhaust pipe to the smoke meter and exhaust gas analyzer and corresponding readings are tabulated. 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 Stop the engine pulling the governor lever towards the engine cranking side. Check that there is no load on engine while stopping.

III. RESULTS AND DISCUSSION

3.1 PERFORMANCE ANALYSIS USING OPTIMUM BLEND WITH IGNITION IMPROVER

The experiments are conducted on the four stroke single cylinder water cooled diesel engine at constant speed (1500 rpm) with varying loads. Various performance parameters such as, The variation of Brake Thermal efficiency with Brake Power is shown in Fig. 3.1From the plot it is observed 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. The variation of Mechanical efficiency with Brake Power is shown in Fig. 3.2. From the plot it is observed optimum blend and various blends like F300D69.5I5, B30D69I10 slightly increases at full load conditions. The variation of volumetric efficiency with Brake Power is shown in Fig. 3.3. From the plot it is observed optimum blend contains 75.95% at full load condition, but in case of after adding the ignition improver blends slightly variation at compared to optimum blends. The variation of Brake Specific Fuel Consumption with Brake Power is shown in Fig. 3.4. The plot it is observed that as the load increases the fuel consumption decreases, the minimum fuel consumption is 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. The variation of Indicated Specific Fuel Consumption with Brake Power is shown in Fig. 3.5. From the plot it is observed that F30D69.5I5 line varies similar with the optimum blend, The ISFC of after adding ignition improver of Bio-diesel is increases slightly as compared with optimal blend at full load condition. The variation of Air-Fuel Ratio with Brake Power is shown in Fig. 3.6. From the plot it is observed that decreases compare with optimum blend at full load condition of F30D69.5I5. 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.

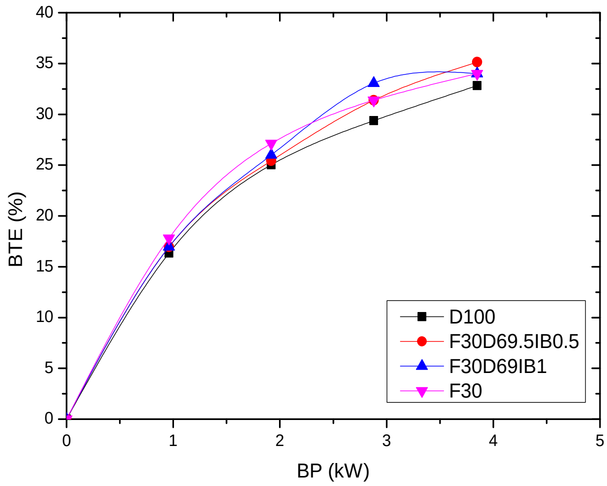

Fig. 3.1 Variation of Brake Thermal Efficiency with Brake Power Using Ignition Improver

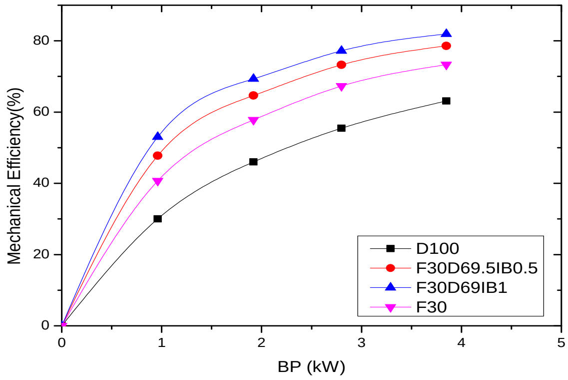

Fig. 3.2 Variation of Mechanical Efficiency with Brake Power Using Ignition Improver

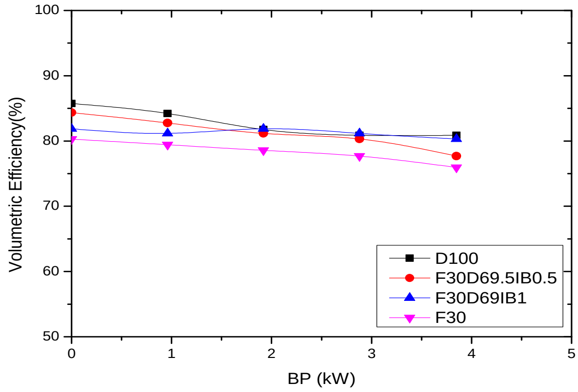

Fig. 3.3 Variation of Volumetric Efficiency with Brake Power Using Ignition Improver

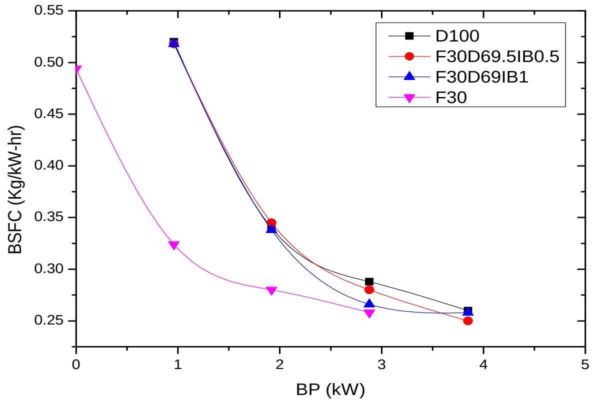

Fig. 3.4 Variation of Brake Specific Fuel Consumption with Brake Power Using Ignition Improver

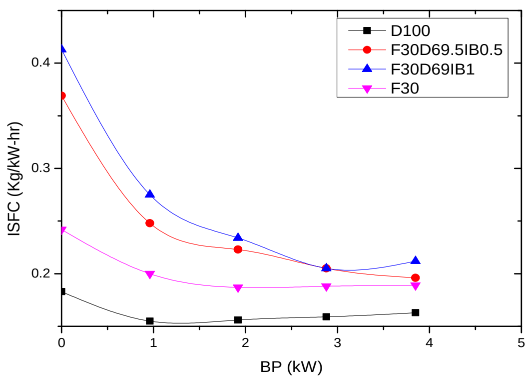

Fig. 3.5 Variation of Indicated Specific Fuel Consumption with Brake Power Using Ignition Improver

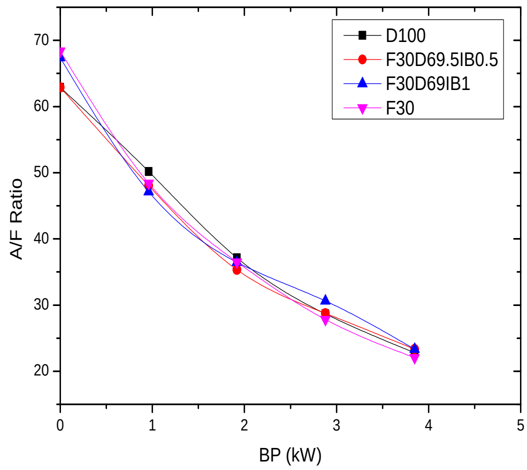

Fig. 3.6 Variation of Air Fuel Ratio with Brake Power Using Ignition Improver

3.2 EMISSION ANALYSIS USING OPTIMUM BLEND WITH IGNITION IMPROVER

The experiments are conducted on the four stroke single cylinder water cooled diesel engine at constant speed (1500 rpm) with varying loads. Various emission parameters in the sense of, the variation of Smoke density with Brake Power is shown in Fig. 3.7. The plot it is observed that the Smoke is nothing but solid soot particles suspended in exhaust gas. Figure 12 shows the variation of smoke level with brake power at various loads for different blends like F20, F30D69.5I5, and F30D69I10 tested fuels. It is observed that smoke is higher for optimum blend at full load conditions compared to ignition improver blends. Better and optimum fuel air mixture obtained for F30D69.5I5.The variation of *CO* emission with Brake Power is shown in Fig. 3.8. The plot it is observed that is interesting to note that the engine emits more CO for diesel as compared to biodiesel blends under all loading conditions. The CO concentration is 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. The variation of CO_2 emission with Brake Power is shown in Fig. 3.9. The plot it is observed that the 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. The variation of *HC* emission with Brake Power is shown in Fig. 3.10. The plot it is observed that the HC emission variation for different blends is indicated. That the HC emission decreases with increase in load for F30 and it is almost slightly decreases for adding ignition improver blends where some traces are seen at no load and full load. The variation of NO_x emission with Brake Power is shown in Fig. 3.11.

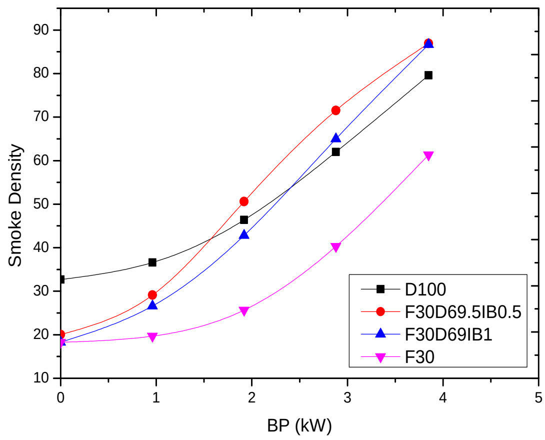

Fig. 3.7 Variation of Smoke Density with Brake Power Using Ignition Improver.

The plot it is observed that for different blends is indicated. The NO_x 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. A reduction in the emission for all getting after adding the ignition improver blends as compared to optimum blend was noted. 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.The variation of unused oxygen emission with brake power is shown in Fig.3.12. From the plot reveals that the as load increases the unused oxygen decreases. 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. The decrement of unused oxygen is due to better combustion and CO emission converted into CO_2 emission.

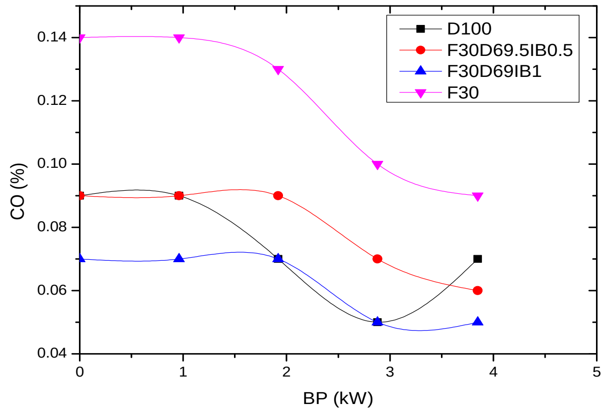

Fig. 3.8 Variation of Carbon Monoxide with Brake Power Using Ignition Improver

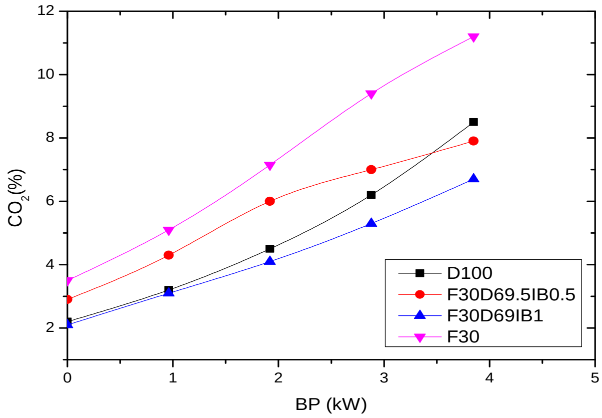

Fig. 3.9 Variation of Carbon Dioxide with Brake Power Using Ignition Improver

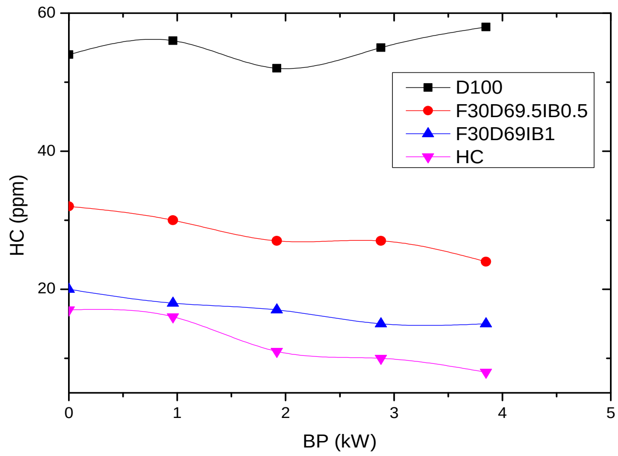

Fig. 3.10 Variation of Unburned Hydrocarbons with Brake Power Using Ignition Improver

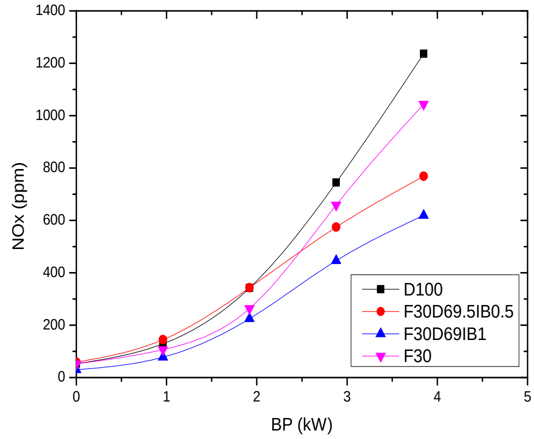

Fig. 3.11 Variation of NOx Emissions with Brake Power Using Ignition Improver

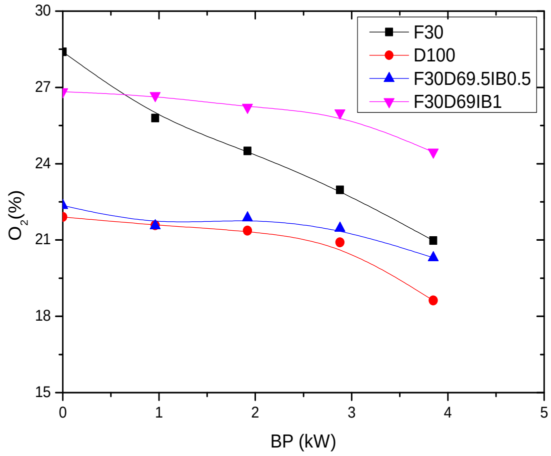

Fig. 3.12 Variation of Unused Oxygen with Brake Power Using Ignition Improver

IV. CONCLUSIONS

The test is conducted on the engine by taking the blend F30 along with the addition of ignition improver isobutanol in the quantity of 5ml (F30D69.5I5) and 10ml (F30D69I10) at the same operating conditions. Among these two compositions the one F30D69.5I5 has given the better performance in the following parameters.

- Brake thermal efficiency is observed 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 34.08%, 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 0.364% and 0.823% 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 F30D69.5I5is 0.25 kg/kW-hr as to that of F30 is 0.258 kg/kW-hr at full load condition.
- Smoke density is observed that smoke is higher for optimum blend at full load conditions compared to ignition improver blends. At full load condition the smoke density obtained are 79.6 HSU, 61.34 HSU, 86.92 HSU and 86.69HSU HSU for the fuels of diesel, F30, F30D69.5I5 and F30D69I10. It is observed that smoke is increases for fish oil blends at full load conditions as compared to optimum blend.
- Carbon monoxide is observed that 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 is 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.
- Unburned hydrocarbons are observed that the HC emission variation for different blends is indicated. At full load condition the unburned hydrocarbons are obtained 58ppm, 8ppm, 15ppm and 24ppm for the fuels of diesel, F30, F30D69.I5 and F30D69I10 respectively. The unburned hydrocarbons of after adding ignition improver of Fish oil decreases up to 24.44% as compared to diesel at full load condition.

- The NO_x 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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