Performance Analysis of Diesel Engine Using Jaggery Based Bioethanol-Diesel Blend

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Abstract— Since the sources of fossil fuels are depleting, it has become essential to find a replacement for it. One such replacement found was biofuel which can be produced by naturally available substances like oil and fat. Like biofuel the alcohol is also a suitable replacement for the petroleum. Biofuel or ethanol can be mixed with the petroleum products to run an engine without modifying it. Bioethanol can be produced in different methods, one of the methods is from jaggery by fermentation process. Performance test conducted by using diesel and 10% ethanol blend have shown better performance characteristics. So, this paper concentrates mainly on production of bioethanol using jaggery and conducting performance test on the diesel engine using the bioethanol and diesel blends. This study targets comparing the performance parameters of the engine for pure diesel and for 5%, 10% and 15% bioethanol blends. The parameters considered for study are thermal efficiency, brake power and specific fuel consumption.

Keywords— Bioethanol, Blending, Comparison, Diesel engine, Fermentation, Jaggery, Performance test

1 INTRODUCTION

In the present era petroleum-based fuels are having wide range of applications in many fields like transportation, agriculture, power production, construction etc., Many equipment has been designed to work using petroleum-based fuels. Since the petroleum sources are depleting, it is necessary to find an alternative which can replace the petroleum-based fuels in that equipment without modifying them. Biofuels which are mainly produced by chemically combining any natural oil or fat with an alcohol such as methanol or ethanol can be used as a replacement for the petroleum. Ethanol alone can also be used as an alternate fuel. It is bio-based resource, renewable and oxygenated. In compression-ignition engines it will reduce the particulate emissions. Ethanol produced by using agricultural products is called as bioethanol. It is renewable and an attractive fuel as well. It is difficult to use bioethanol directly in diesel engines. But they can be blended with diesel in different proportions to use in engines. In colder countries such as Spain, diesel-biodiesel blends upto 10% have shown better performance [1]. Yahuza I et.al., [2] conducted performance test on compression ignition engine using ethanol-diesel blend of 5%, 10%, 15% and 20%. The ethanol was produced from saw dust of Masonia wood by means of simultaneous saccharification and fermentation process and found an increase in brake thermal efficiency for all the fuel blends. JinlinXue, et al.,[3] showed that by using diesel-biodeisel blend to conduct performance and emission tests, the heating value will reduce when compared to the pure diesel. But the power production will recover due to the consumption of biodiesel. De-gang Li, et al., [4] conducted experiment using pure diesel, 5%, 10%, 15% and 20% ethanol–diesel blended fuels, and found that at overall operating conditions the characteristcs like brake thermal efficiency and specific fuel consumption increased with increase in ethanol content. Daming Huang et. al., [5] also conducted the experiment on diesel engine using ethanol-diesel blend and found that there is an increase in brake thermal efficiency of the engine with increased proportion of ethanol in the fuel blends. Istvan Barabas, et al., [6] discussed that the main advantages of using biodiesel for CI engines are as follows biodiesel is non-toxic, biodiesel degrades four times faster than diesel, pure biodiesel degrades 85–88% in water, the higher flash point makes the storage safer, provides a domestic, renewable energy supply, biodiesel does not produce greenhouse effects, because the balance between the amount of CO_2 emissions and the amount of CO_2 absorbed by the plants producing vegetable oil is equal, biodiesel can be used directly in compression ignition engines with no substantial modifications of the engine. The use of biodiesel can be considered as an alternative for CI engines, but some of its properties, as density and viscosity, are higher than those of classic diesel fuel. These properties can be ameliorated by adding bioethanol which on one hand allows the biofuel's level-increase in the whole blend, and on the other hand brings the mentioned properties in standard diesel fuel prescribed limits. In the experiment it was also found that the engine performance decreases at low loads because of the lower heating value of the biodiesel. As the biofuel is made from vegetables, cellulose etc., it not only improves the performance of the engine but also reduces the environmental issues caused by the petroleum products [7]. Also producing biofuels from locally grown sources and using them as an alternative for various petroleum products is one of the best attractive method to overcome the energy crisis. Any investments in biofuels will lead to a considerable boost in economic development of the country as well [8]. In this section jaggery has been used as a sugar-based feedstock and to see how the bioethanol performs when it is blended with diesel.

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2 METHODOLOGY

The analysis carried out are

1. Ethanol production using Jaggery as a feedstock by fermentation method.
2. Blending the bioethanol with diesel in 5%, 10% and

15% proportions.
3. Conducting the performance test on diesel engine using the diesel-bioethanol blends.
4. Comparing the results obtained from the performance analysis of diesel engine for various blends.

3 Production of Bioethanol

Bioethanol production involves two steps, fermentation and distillation. Jaggery is fermented in a closed container. It is done by adding water to jaggery and keeping the mixture for seven to ten days. After the fermentation process, fermented jaggery is put in a large vessel and heating process is carried out. A small vessel is placed inside the large vessel with help of a thin layered cloth and above the large vessel, another vessel containing cold water is placed. The area between the large vessel and the top vessel is covered with thick layered cloths tightly from the outside so that air from outside does not go inside and the vapor from inside doesn't come outside. The alcohol vapors from the large vessel passes through the cloth and gets condensed at the top and collects inside the small vessel. The alcohol that gets distilled is nothing but Ethanol (Ethyl Alcohol).

4 Experimental Setup

Performance Test was carried out on a Single Cylinder 4 Stoke Diesel Engine Test rig with Rope Brake Dynamometer. It is a vertical water-cooled compression ignition engine and the test was carried out for 5%, 10% and 15% Ethanol Diesel blends. The diesel engine test rig in Figure 1 used for the experiment has the following specifications.

4.1 Specifications

Make	: Kirloskar
Type	: AVI
Bore	: 80mm
Stroke	: 110mm
Cubic Capacity	: 553cc
RPM	: 1500
Compression ratio	: 16.5:1

Figure 1: Diesel Engine

4 Results and Discussions

Certain properties of the extracted Ethanol were obtained by conducting the appropriate tests. The flash and fire point tests were conducted by using Pensky Martins open cup apparatus. The flash point of ethanol obtained is 25^0C and fire point is 32^0C. Viscosity and density were calculated using Redwood Viscometer apparatus. Specific gravity, Density, Dynamic Viscosity and Kinematic Viscosity of Ethanol is calculated in the following ways. Weight of empty flask was found to be 40.7g and Weight of empty flask + oil was found to be 79.9g. So, Weight of 50cc oil turned to be about 39.2g. Specific gravity of oil was found to be 0.784. Therefore, the density of the bioethanol is 784 kg/m^3. Kinematic viscosity and dynamic viscosity found are 11.065×10^{-6} m^2/s and 8674.96×10^{-6} Pa-s or Ns/m^2 respectively.

From Figure 2 it is observed that as the Load on the engine increases Brake Power of the engine also increases. From the graph the 10% fuel blend and diesel fuel has almost equal Brake Power at the end of the graph. 15% fuel blend has a gradually increasing value throughout the load on the engine. So, compared to 10% and diesel fuel, 15% has less value of Brake Power. 5% fuel blend has a greater brake power when initially the load is applied on the engine but the rate of graph decreases. It can be concluded that both 10% and diesel fuel has better performance when Brake Power is compared with the corresponding Loads that is applied on the Diesel Engine.

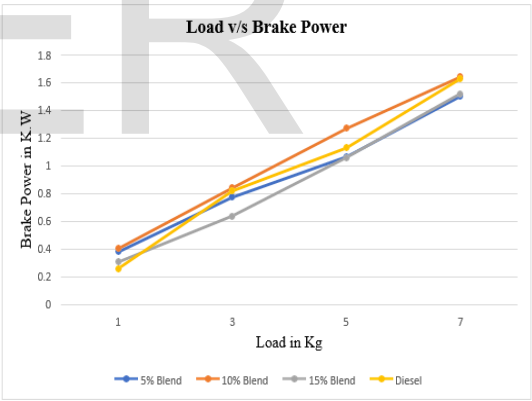

Figure 2: Load vs Brake Power

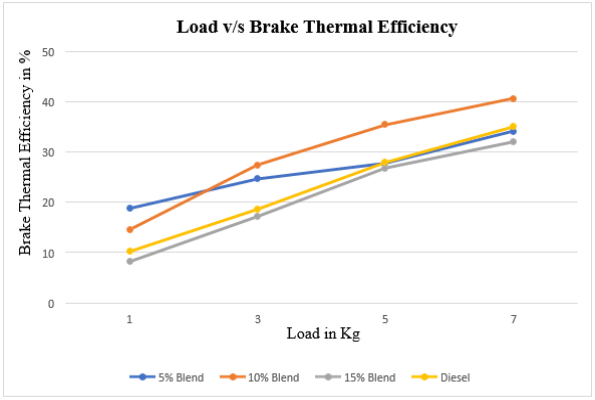

Figure 3: Load vs Brake Thermal efficiency

From Figure 3 it is observed that as the Load on the Engine

increased the brake Thermal Efficiency of the engine also increases. The Highest increase in the Brake Thermal Efficiency is found to be in 10% fuel blend as when compared to other fuel blends. 5% fuel blend has high brake thermal efficiency initially but as the load increases it gradually increases and almost becomes equal to the diesel fuel for 7kg load. 15% Fuel blend has the lowest brake thermal efficiency when the load is applied and the value increases as the load increases but becomes the lowest among diesel and all the other fuel blends. Figure 4 shows that as the Load on the engine increases Specific Fuel Consumption decreases. Firstly, the 15% fuel blend has the highest Specific fuel Consumption when compared with diesel and other fuel blends. Diesel also initially has a high value of Specific Fuel Consumption and decreases along with the load applied on the diesel engine. 10% Fuel Blend has specific fuel consumption less than that of diesel and 15% fuel blend but slightly greater than that of 5% fuel blend but the rate of fuel consumption decreases as the load increases. So, 10% fuel blend is efficient and economical because of the fuel consumption is least when compared to all the fuels. 5% Fuel Blend has least fuel consumption initially but the rate of fuel consumption increases through the graph.

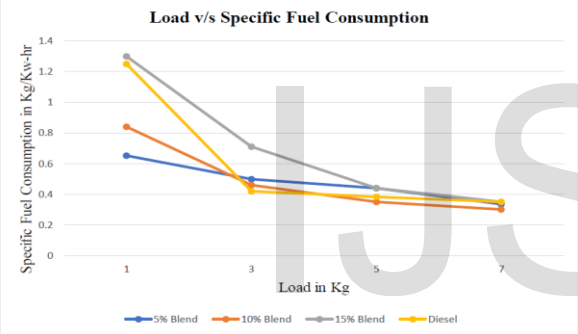

Figure 4: Load vs Specific Fuel Consumption

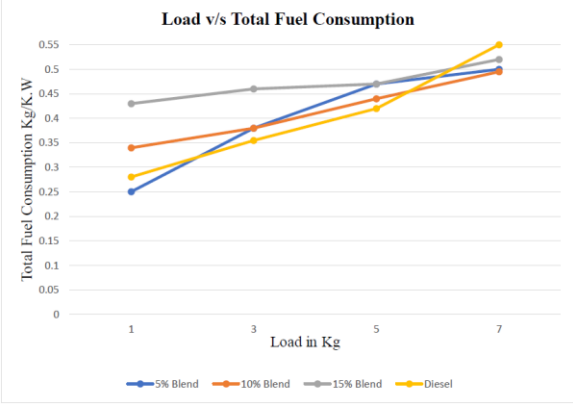

Figure 5: Load vs Total Fuel Consumption

From figure 5 it is observed that as the load on the engine increases, the total fuel consumption also increases. 5% fuel blend has the least fuel consumption compared to other blends at the beginning, but as load on the engine increases, fuel consumption for 5% fuel blend along with diesesl increases. But from the graph it can be observed from the graph that at a load of 7kgm 10% fuel blend is having the least fuel consumption. So at higher loads, 10% blend is more economical and efficient compared to pure diesel and other blends.

4 Conclusions

The experiment was conducted on a 4-stroke diesel engine. In this analysis bioethanol which was produced from jaggery by fermentation process is blended with diesel in 5%, 10% and 15% proportions were tested. It is observed that for 10% ethanol-diesel blend, the brake power, specific fuel conption, total fuel consumption and brake thermal efficiency has significantly increased when compared to other blends and pure diesel. From this it can be concluded that the 10% fuel blend gives sufficient increase in the engine performance and since the specific fuel consumption and total fuel consumption were less than other blends, 10% bioethanol blend is more efficient and economical. By using 10% fuel blend, brake thermal efficiency also increases compared to diesel engine.

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