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Experimental Investigation On The Single Cylinder Diesel Engine With Multi-Blend Biodiesel

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ABSTRACT

The recent research on biodiesel focused on performance of single biodiesel and its blends with diesel. The present work aims to investigate the possibilities of the application of mixtures of two biodiesel and its blends with diesel as a fuel for diesel engines. The present investigations are planned after a thorough review of literature in this field. The combinations of jatropha biodiesel, pongamia biodiesel, along with diesel (JPD) are taken for the experimental analysis. Experiments are conducted using a single cylinder direct-injection diesel engine with different loads at rated 1500 rpm. The brake thermal efficiency of JPD-2 has maximum 28.5% compare to pure diesel 27.5% at 4 kW brake power Maximum specific fuel consumption is obtained in JPD-5 (0.77) compare to pure diesel at 1 kW brake power. The results which obtained are significantly comparable to pure diesel. The multi-blend biodiesels are suitable alternative fuel for diesel in stationary/agricultural diesel engines.

Key words: alternate fuel; diesel engine; performance; jatropha and pongamia multi-blend biodiesel.

Abbreviations-used:
BSFC: Specific fuel consumption*;* BP: Brake power; B10: 10% biodiesel + 90% petro diesel; B20: 20% biodiesel + 80% petro diesel; BTHE: Brake thermal efficiency*;* BMEP: Brake mean effective pressure.

1. Introduction

As the fossil fuels are depleting at a very faster rate, there is a need to find out an alternative fuel to fulfill the energy demand of the world. Biodiesel is one of the best available sources to fulfill the energy demand of the world. The petroleum fuels play a very significant role in the development of industrial growth, transportation, agricultural sector and to meet many other basic human requirements as shown in figure 1.1 general energy distributions. However, these fuels are limited and depleting day by day as the consumption is increasing very rapidly. Moreover, their use is alarming the environmental problems to society. Hence, Available abundantly in India which can be there is a need of research for alternative fuels. There is a long list of trees, shrubs, and herbs exploited for the production of biodiesel [1]. India ranks sixth in the world in total energy consumption and needs to accelerate the

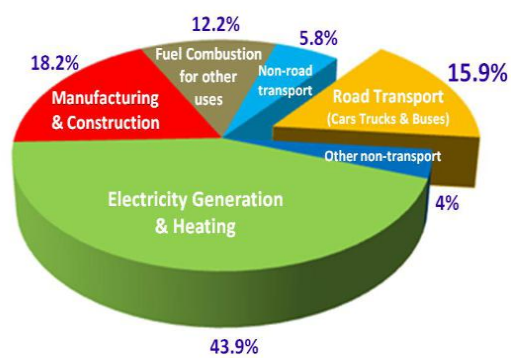

Figure 1.1 general energy distributions

Development of the sector to meet its growth aspirations. In the figure 1.2 shows energy demand projection in India. India had approximately 5.6 billion barrels of proven oil reserves as of January 2010, the second-largest amount in the Asia-pacific region after China.

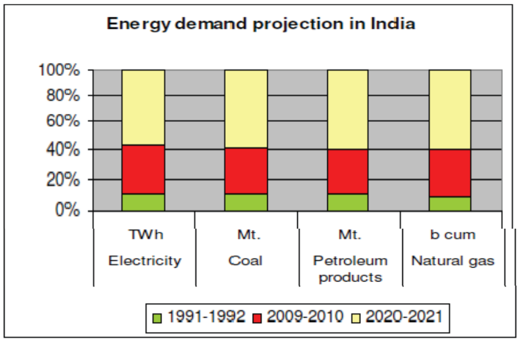

Figure 1.2 Energy demand projection in India.

In 2009, India consumed nearly 3 million bbl/d (figure 1.3), making it the fourth largest consumer of oil in the world. EIA (Energy Information Administration) expects approximately 100 thousand bbl/d annual consumption growth through 2011.

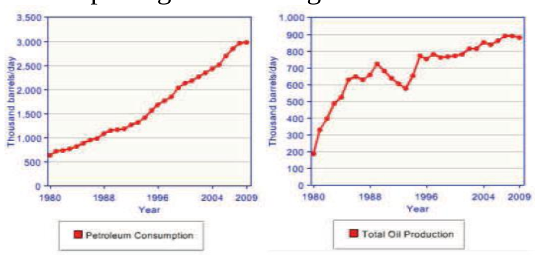

Figure1.3 Petroleum consumption and production in India.

And it is also necessary for better economic growth for our country [2]. Dr. Rudolf Diesel invented the diesel engine to run on a host of fuels including coal dust suspended in water, heavy mineral oil, and, vegetable oils. Dr. Diesel's first engine experiments were catastrophic failures, but by the time he showed his engine at the world exhibition in Paris in 1900, his engine was running on 100% peanut oil. Research is still in progress in diesel engine for finding better ways of making good performance and less emissions emitting and fuel efficient engines for the reduction in emission of toxic gases while brining fuels. The research on internal combustion engine is of more than 150 years maturity. Due to various challenges faced in the use of petroleum fuel, researchers are working for the development of other fuel sources.

All the studies are mainly focus on the performance characteristic for the diesel engine operating with biodiesel and comparison to conventional diesel engine. Sejal narendra patel [3] et.al conducted an experimental analysis of diesel engine using bio-fuel at varying compression ratio using jatropha oil. It is found that when compression ratio increases brake thermal efficiency (BTHE) increases and brake specific fuel consumption (BSFC) decreases. M.Prabhahar; [4] et.al he conducted on performance and emission studies of a diesel engine with pongamia methyl ester at different load conditions using pongamia methyl ester the brake thermal efficiency obtained for B20 is closer to diesel fuel. The BSFC are slightly increases for biodiesel due to lower calorific value of biodiesel. Siddalingappa R. Hotti; Omprakash Hebbal [5] et.al conducted on the experiment on karanja biodiesel the variation of brake specific fuel consumption with brake power is, as the power developed increases the specific fuel consumption decreases for all the tested fuels. K. Arun Balasubramanian [6] et.al conducted with diesel, and blends of Jatropha oil biodiesel and neem oil biodiesel at different loads and constant speed (1500 rpm).On the whole it is seen that operation of the engine is smooth dual biodiesel blends. From the experimental results obtained, compared to neat diesel operation, dual biodiesel of jatropha oil and neem oil results in comparable engine performance and slightly higher emissions.

The present work aims to investigate the possibilities of the application of mixtures of two biodiesel jatropha and pongamia and its blends with diesel as a fuel for diesel engines.

2. Materials and method

Based on the availability of biodiesel, the properties like calorific value, kinematic viscosity, flash point and fire point, Jatropha biodiesel and pongamia biodiesel is estimated in the table 2.1 selected for bio-fuel preparation and experimental analysis. Various blending combinations of multi-blend biodiesel i.e. JPD-1 (Jatropha biodiesel 5% and Pongamia biodiesel 5%, Diesel 90% by volume), JPD-2 (Jatropha biodiesel 10% and Pongamia biodiesel 10%, Diesel 80% by volume), JPD-3 (Jatropha biodiesel 20% and Pongamia biodiesel 20%, Diesel 60% by volume), JPD-4 (Jatropha biodiesel 30% and Pongamia biodiesel 30%, Diesel 40% by volume) , JPD-5 (Jatropha biodiesel 50% and Pongamia biodiesel 50%, Diesel 0% by volume), are prepared.

Table 2.1 Estimated the properties of multi-blend biodiesel

Properties / Fuel samples	Fuel density Kg/m^3	Kinematic viscosity @40^{0}C cSt	Flash point ^{0}C	Calorific value Kj/kg
Diesel	830	3.0	50	42680
JPD-1	835	3.3	54	42461
JPD-2	840	3.5	58	42243
JPD-3	850	3.8	64	41807
JPD-4	870	5.0	85	41370
JPD-5	880	6.5	153	40498
Apparatus used	Hydrometer	Water bath viscometer	Pensky-marten's	Bomb calorimeter

3. Experimental setup:

The various components of experimental set up are described below. Figure 3.1 shows line diagram of the experimental set up.

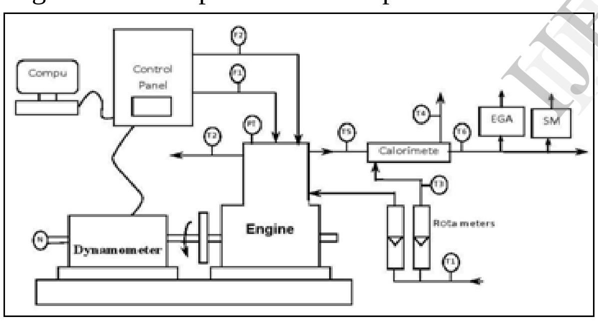

Figure 3.1 Schematic diagram of experimental setup.

T1-Inlet temperature of water into engine jacket and calorimeter; T2-Outlet temperature of water from the engine jacket; T3-Outlet temperature of water from the calorimeter; T4-Inlet temperature of exhaust gases into the calorimeter; T5-Outlet temperature of exhaust gases from the calorimeter; W-Load sensor (Eddy current dynamometer); N-Non contact type speed sensor(Engine shaft speed); F1-Fuel supply to engine cylinder; F2-Air flow to engine cylinder; F3-Water flow to the engine jacket; F4-Water flow to calorimeter

Table 3.2 Engine specifications

Manufacturer	Kirloskar oil engines Ltd, India
Model	TV-SR, naturally aspirated
Engine	Single cylinder, DI
Bore/stroke	87.5mm/110mm
C.R.	16.5:1
speed	1500r/min, constant
Rated power	5.2kW
Working cycle	four stroke
Injection pressure	200bar/23 deg TDC
Type of sensor	Piezo electric
Response time	4 micro seconds
Crank angle sensor	1-degree crank angle
Resolution of 1 deg	360 deg with a resolution of 1 deg

4. Result and discussions

The experimental results obtained from the tests carried out on engine performance and combustion characteristics are presented in this section. The results which obtained are significantly comparable to pure diesel.

4.1 Brake thermal efficiency

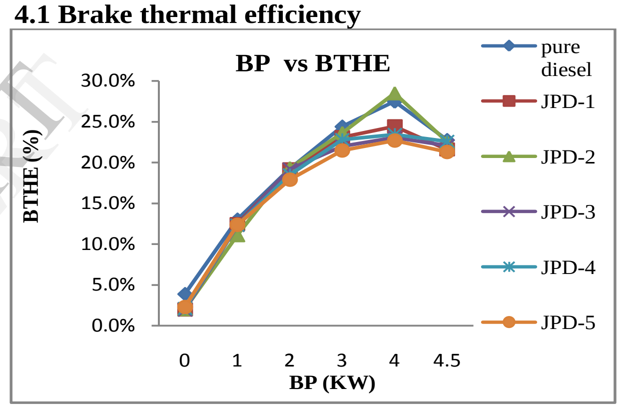

Figure 4.1 Variation of brake thermal efficiency with respect to brake power.

Figure 4.1 shows the Brake thermal efficiency is increasing with increasing brake power for all multi-blends of biodiesel and diesel. It may be due to reduction in heat loss and increase in power with increase in load. It may be because of the presence of oxygen in multi-blend biodiesel which enhance the combustion as compared to diesel and multi-blend biodiesel is more lubricant than diesel that provides additional lubrication. Multi-blends of biodiesel have higher viscosity, density and lower calorific value than diesel. Higher viscosity leads to decreased atomization, fuel vaporization and combustion. These may be the possible reasons of JPD-5 have lowest brake thermal efficiency for all loads.

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4.2 Specific fuel consumption

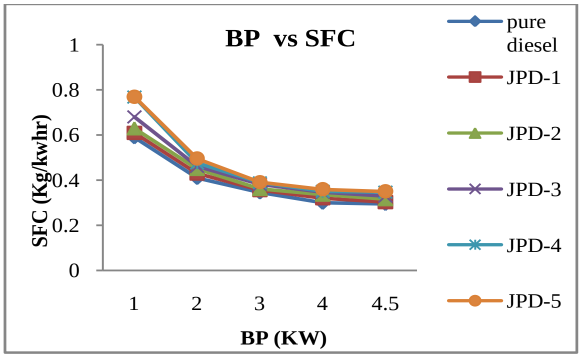

Figure 4.2 variation of specific fuel consumption with respect to brake power

Figure 4.2 Show the specific fuel consumption with respect brake power. When using multi-blend biodiesel fuel is expected to increase as compared to the consumption of diesel fuel. SFC decreased sharply with increase in load for all fuel samples. As the SFC is calculated on weight basis, so higher densities resulted in higher values of SFC.

4.3 Exhaust gas temperature

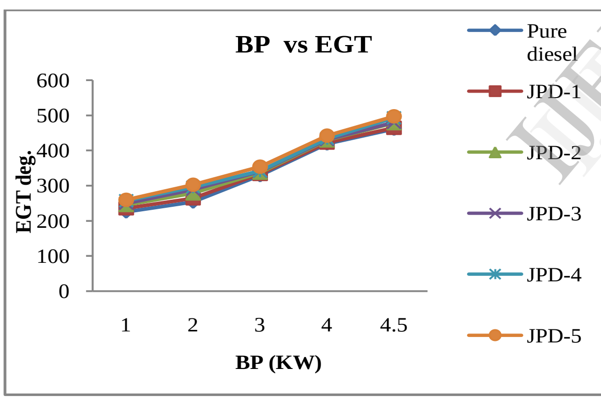

Figure 4.3 Variation of exhaust gas temperature with respect to brake power

The variation of exhaust gas temperature with brake power for different multi-blend biodiesels are shown figure 4.3. This graph shows that exhaust gas temperature of the fuel blends are higher than the diesel fuel and there is not much variation among multi-blends at all load conditions. The exhaust gas temperature variation depends upon the flash point temperature and the viscosity of the fuel. The multi-blend biodiesel have higher flash point and viscosity than the diesel fuel and also lower volatility. So the multi-blends have higher exhaust gas temperature.

4.4 Mechanical efficiency

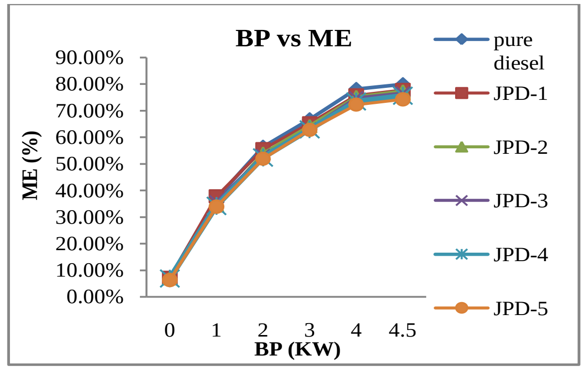

Figure 4.4 variation of specific fuel consumption with respect to brake power

The variation of mechanical efficiency with brake power for pure diesel and multi-blend biodiesel are shown in figure 4.4 the mechanical efficiency of pure diesel is slightly higher than the multi-blend biodiesels. In this case the pure diesel and JPD-1 are almost nearer to each other. From the graph it is evident that as the percentage of multi-blend biodiesel increases in diesel the mechanical efficiency goes on decreasing. This happens due to lower calorific value of multi-blend biodiesel compared to pure diesel.

4.5 Crank angle versus cylinder pressure

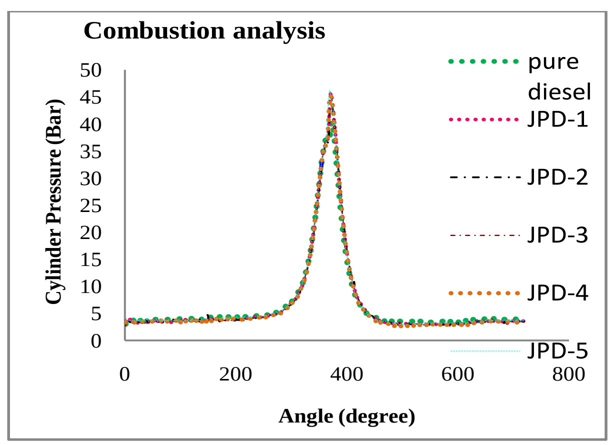

Figure 4.5 Variation of crank angle versus cylinder pressure

Figure 4.5 shows the variation of crank angle versus cylinder pressure. The cylinder peak pressure is highest with JPD-5 multi-blend biodiesel followed by pure diesel at crank angle 369^{0}C with cylinder pressure 46.22 bar. It is observed that the occurrence of peak pressure moves away with JPD-5 compared to pure diesel. This indicates that the ignition delay is longer with JPD-5 compared to pure diesel. Longer ignition delay means more fuel is injected. Due to high viscosity, poor volatility, poor spray characteristics and lower heating value of JPD-5 leads to less fuel being prepared for rapid combustion result in lower peak pressure compared to pure diesel.

4.6 Heat release rate

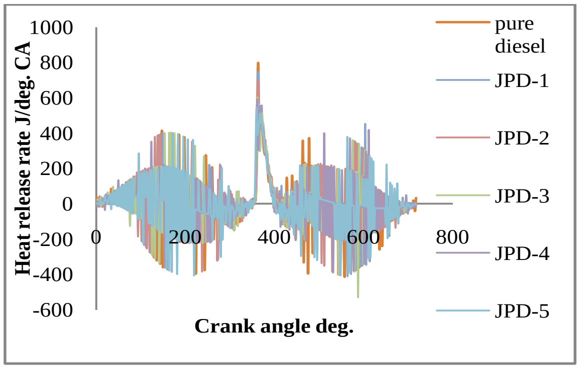

Figure 4.6 Variation of crank angle versus heat release rate.

From the figure 4.6 shows the maximum heat release rate of multi-blend biodiesel and their blends is lower than that of pure diesel, specifically at crank angle 363^0C with heat rate 793 J/degree CA for pure diesel. It was found that, premixed combustion in the case of multi-blends biodiesel fuel starts earlier than the diesel fuel and it may be due to excess oxygen available along with higher operating temperature in the fuel and the consequent reduction in delay period than that of pure diesel fuel. It may be expected that high surrounding temperature and oxygen availability of fuel itself (multi-blend biodiesel) reduce the delay period.

5. Conclusions

Use of a multi-blend biodiesel namely jatropha and pongamia biodiesel is considered as a new possible source of alternative fuel for diesel engine. No difficulty was faced at the time of starting the engine and the engine ran smoothly at constant engine speed of 1500 rpm.

- The brake thermal efficiency of JPD-2 has maximum 28.5% compare to pure diesel 27.5% at 4 kW brake power due to the presence of oxygen in the molecular structure of multi-blend biodiesel intensifies the complete combustion phenomenon.
- Maximum specific fuel consumption is obtained in JPD-5 (0.77) compare to pure diesel at 1 kW brake power.
- All multi-blends biodiesel have high exhaust gas temperature compare to pure diesel.
- The mechanical efficiency of pure diesel is slightly higher than the multi-blend biodiesels at 4.5 kW brake power.
- Maximum cylinder peak pressure of JPD-5 is obtained 46.22 bar at 369^0C CA. compare to pure diesel.
- The maximum heat release of engine with pure diesel is higher about 5.87% than engine fueled with JPD-1 (multi-blend biodiesel).

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