Journal of Faculty of Engineering & Technology
Journal homepage: www.pu.edu.pk/journals/index.php/jfet/index

EXPERIMENTAL ANAYLYSIS OF DIESEL ENGINE PEROFRMANCE CHARACTERISTICS USING BIODIESEL BLENDS PREPARED WITH ETHANOL

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ABSTRACT: The present day energy crisis and increasing prices of the fossil fuels in view of global pollution scenario challenged to look for economical and sustainable fuels keeping in mind the GHG technologies. A lot of research has been reported about the solution to the given problem which includes the use of sustainable alternative fuels as biofuels than the fossil fuels. Bio fuels, also known as renewable fuels are based on carbon neutral cycle. These have a different chemical and thermo-physical behavior as compared to fossil fuels so that can be used directly into the engines. Biodiesel, an alternative to diesel fuel, produced by the transesterification of vegetal oil is suitable to use in diesel based engines without their modifications.

In this research biodiesel has been produced with density similar to that of the gasoline because ethanol is used instead of methanol. A series of experiments were conducted using blends of the prepared biodiesel and the pure diesel oil. The performance characteristics of the Perkins Engine were analyzed at 1500 rpm where load was increased gradually from 50 to 100%. As a result specific fuel consumption of biodiesel has decreased by 7.0% as compared to the conventional diesel fuel. It was also investigated that the brake thermal efficiency of the engine is increased by 6.0% when ordinary diesel is replaced with the mixture of biodiesel and diesel.

Keywords: *Biodiesel, Canola Oil, Ethanol, Perkin Engine, Renewable Fuels, Transesterification*

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1. INTRODUCTION

Climate change, due to increased greenhouse gases in the atmosphere, is one of the most hazardous problems of the present-day world. Augmented focus on curbing carbon dioxide (CO_2) discharges and an inadequate and unstable supply of fossil fuel resources make divergence of energy resources significance for energy gurus. These fuels are in limited quantities and are sure to be depleted in the future. The soul of the energy problems is that the world is running out of ecological capacity to absorb emissions and of the time to attain a smooth changeover from available fossil fuels to the other novel energy sources. As a logical solution either adapt to the conforming changes caused by the fossil fuels or try to lessen their impact, on the globe, by meaningfully reducing their use. It is therefore necessary, to reduce their use and in the second, to substitute the fossil fuels with environment friendly energy sources [1, 2].

The conventional sources of energy are depleting day by day and this fact is leading to concentrate on the renewable energy resources [3]. Renewable energy sources including bio-fuels seem viable options to overcome this energy challenge at hand. Biodiesel is regarded as ecologically friendly fuel that can be used in internal combustion engines without their alteration. Biodiesel appears to be a realistic fuel for forthcoming and has become better-looking recently because of its ecofriendly benefits. [4, 5]. Today, nearly 300 million gallons per year of biodiesel is produced in industry which will soar to an amount of 600 million gallons per year in the near future.

Biodiesel fuel is a renewable substitute for petroleum diesel or petro diesel made from vegetal or animal fats instead of refined from the crude oil. It can be used in any combination with petro diesel fuel, as it has very analogous features, but it has lesser exhaust emissions. Biodiesel fuel has improved properties than those of the petrol diesel fuel as it is renewable, ecofriendly, non-poisonous, and essentially free of sulphur and aromatics [6]. When replaced with conventional diesel, it can lessen the percentage of hydrocarbons (HC), carbon monoxide (CO), carbon dioxide (CO_2) and sulphur dioxide (SO_2) and other particulates from exhaust that can cause detrimental effects on the human respiratory system when inhaled [7].

Biodiesel is mainly produced by the transesterification, a chemical reaction of vegetal oils and alcohols, and results in a mixture of methyl esters of naturally fatty acids (FAME) [8]. Owing to many possible feed stocks, FAME composition of biodiesel may, however, vary substantially in terms of carbon lengths, substitution and unsaturation level [9]. As various feed stocks can be used, the preparation of biodiesel has become a topic of active research [10]. It can be produced locally without any issues of 'security of supplies' and could contribute to develop sustainability in energy sector. The use of biofuels can decrease the external energy dependence and can promote local and regional engineering (as every region can produce biodiesel with different feedstock). It can also increase the level of services in the rural areas and can generate jobs, especially, in developing countries like Pakistan [11].

Mittlebach et al. [12] have reported the behavior of biodiesel in relation to the cetane number. In his research the biodiesel prepared from ethanol exhibited a higher cetane number. Jinlin Xue found that the power and torque reduces with the increase of biodiesel concentration [13].

In present research, biodiesel is produced by means of transesterification of canola oil and ethanol. Various blends of diesel and biodiesel are prepared and various performance characteristics for example break thermal efficiency, break power and specific fuel consumption of Perkins engine are investigated. The result shows that the blends of biofuels are low cost and efficient for the use of biodiesel.

2. MATERIALS AND METHODS

2.1 Preparation of biodiesel oil

Pure canola oil could produce at massive scale with better yields per acre but it could not be used in compression engines in its pure form because of inherent technical problems of higher density and viscosity, low volatility and poor filtration. Biodiesel used in this study is prepared by the transesterification process using canola oil and ethanol as shown in Fig 1. The process of transesterification removes those technical barriers by enhancing its properties required for the usage in diesel engines. The biodiesel prepared can be used in unadulterated form or in blends with diesel or water as emulsion. Various blends e.g., B5, B10, B15, B20, B25 and B30 of biodiesel and diesel are produced according to the volume of biodiesel in Table 1. B5 represents 5.0% biodiesel and 95.0% diesel.

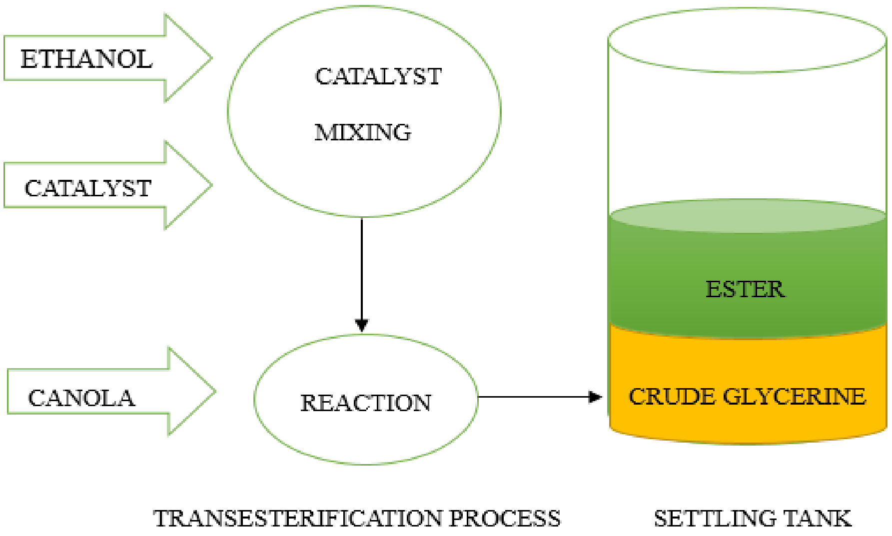

Fig.1: Schematic of bio-diesel production and canola oil from transesterification process of ethanol

Table 1: Fuel characteristics of canola oil, diesel oil, canola bio-diesel and blends of the bio-diesel [14]

Fuel property	Canola oil	Diesel	B5	B10	B15	B20	B25	B30	B100	Bio-diesel Standards	
										ASTM D 6751 - 02	DIN EN 14214
Density at 25°C (kg/m^3)	914-917	855	860	855	851	846	842	838	776	–	860 – 900
Viscosity at 40°C (mm^2/s)	37	3.06	3.26	3.46	3.65	3.86	4.05	4.25	7.038	1.9 – 6.0	3.5 – 5.0
Calorific value (MJ/kg)	35	43.4	43.2	43.05	42.87	42.7	42.5	42.35	39.9	–	–
Flash point (°C)	275-290	76	79.2	82.4	85.6	88.8	92	95.2	140	> 130	>120
Pour point (°C)	–18	–19	–18.4	–17.8	–17.2	–16.6	–16	–15.4	–7	–	–

2.2 Experimental setup

Numbers of experiments were conducted by using naturally aspirated compression ignition engine with direct injection, water cooled and three cylinders vertically in-lined. A 3-phase electric generator supply was provided to the engine. Specifications of engine running at speed of 1500 rpm are shown in Table 2. The schematic diagram for the experimental system is shown Figure 2.

Table 2: Specification of Perkins Engine

Particulars	Details
Bore × stroke (mm)	91.4 x 127.0
Cycle	4
Maximum power (kW)	27
Compression ratio	16.5:1
Speed (rpm)	1000 – 2000
Displacement (liter)	2.5
Direction of rotation	Clockwise
Firing order	1, 2, 3

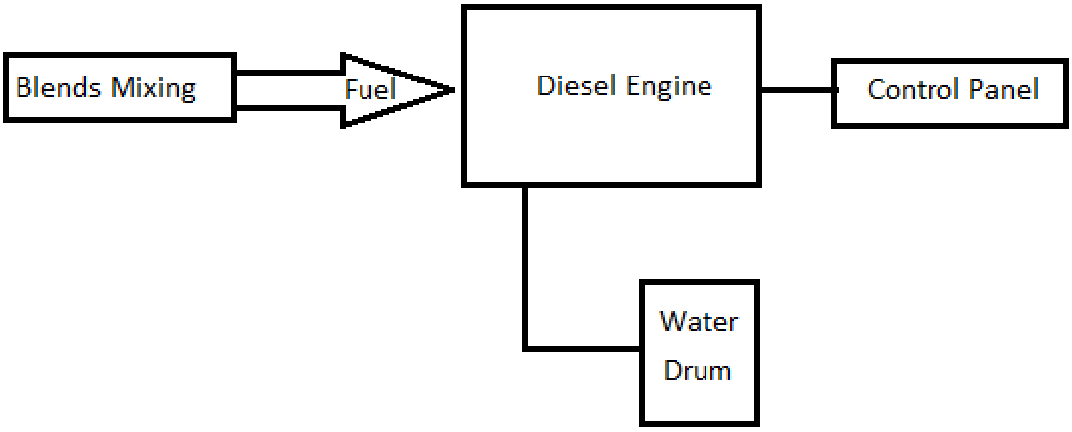

Fig.2: Experimental setup of the system

3. RESULTS AND DISCUSSION

The performance parameters such as the specific fuel consumption (SFC), brake power and brake thermal efficiency of the working engine were investigated under identical conditions in order to make a comparative assessment. These parameters were measured, after achieving steady working conditions, for different blends of biodiesel and pure diesel (Diesel, B5, B10, B15, B20, B25 and B30) under increasing load of 50, 67, 83 and 100%. The load was applied on the generator coupled with the engine and applied through the heaters palced in the water drum.

3.1 Specific fuel consumption (SFC)

It can be observed in Fig. 3 that at 50% load, the values of SFC are farther apart, the points of the diesel biodiesel blends come closer. This can be understood as initially the engine consumes fuel to overcome the internal frictional forces but at higher load, it consumes less fuel. The engine was running at speed of 1500rpm.

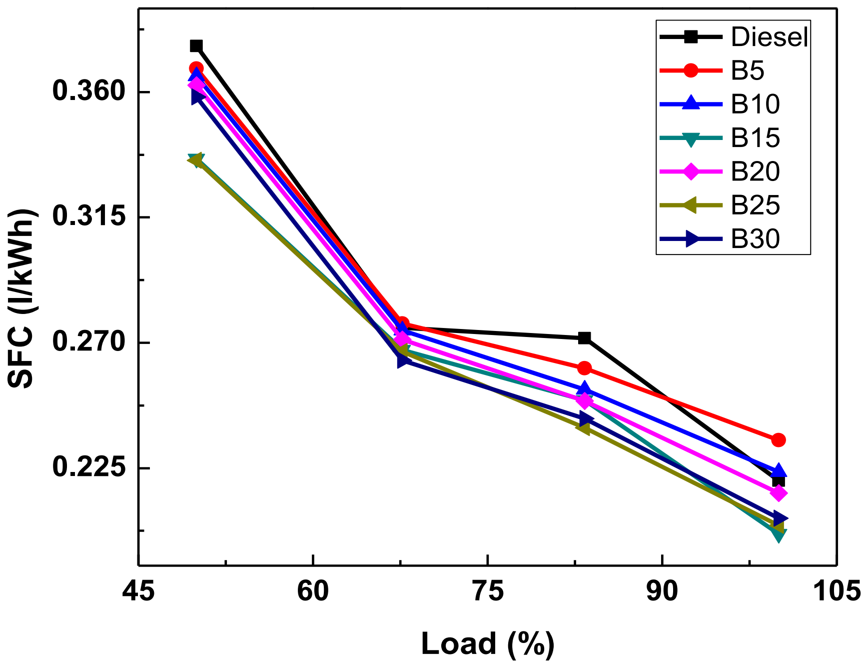

Fig. 3: Variation of the Specific Fuel Consumption (SFC) and Load of diesel and bio-diesel blends

3.1.1 Effect of blends

The mean Specific Fuel Consumption (SFC) values of diesel, and bio-diesel blends i.e. B5, B10, B15, B20, B25 and B30 were found to be 0.377, 0.368, 0.365, 0.336, 0.362, 0.335 and 0.358 liter/ (kWh) at a 50% load. By measuring SFC values of fuels at partial load, it is observed that every blend has a lower SFC value which show excellent combustion properties as compared to the pure diesel fuel. When engine operated at 100% load, it was detected that the SFC of B15, B20, B25 and B30 reduced respectively to 8.72%, 7.3% and 6.0%, respectively. However, the specific fuel consumption (SFC) of B5 and B10 were increased by 6.9% and 1.4%, respectively.

It could be as a result of the presence of the oxygen into molecular structure of the bio-diesel which leads to whole combustion of the fuel while the increase in SFC may be due to insufficient oxygen presence to lead complete combustion.

3.1.2 Effect of density

Normally the biodiesel prepared using transesterification process has higher density than the diesel fuel. This leads to the higher Specific Fuel Consumption (SFC) values than that of the diesel fuel. The bio-diesel used in these experiments was prepared by the reaction between canola oil and ethanol instead of methanol. It has been reported by many researchers [7–10]. The chain of hydroxyl family compound, the size of the biodiesel molecule after transesterification process increases. The increase in the size means the density of the molecule decreases and this could be the reason to get lower SFC compare to diesel.

3.1.3 Effect of load

The effect of Specific Fuel Consumption (SFC) related to the load is observed that it decreases as the load on the test engine rises. This is because that percentage increases in fuel needed to run test engine is lower than that the percentage increases in brake power. So this shows that the heat loss to surrounding is lower at higher loads.

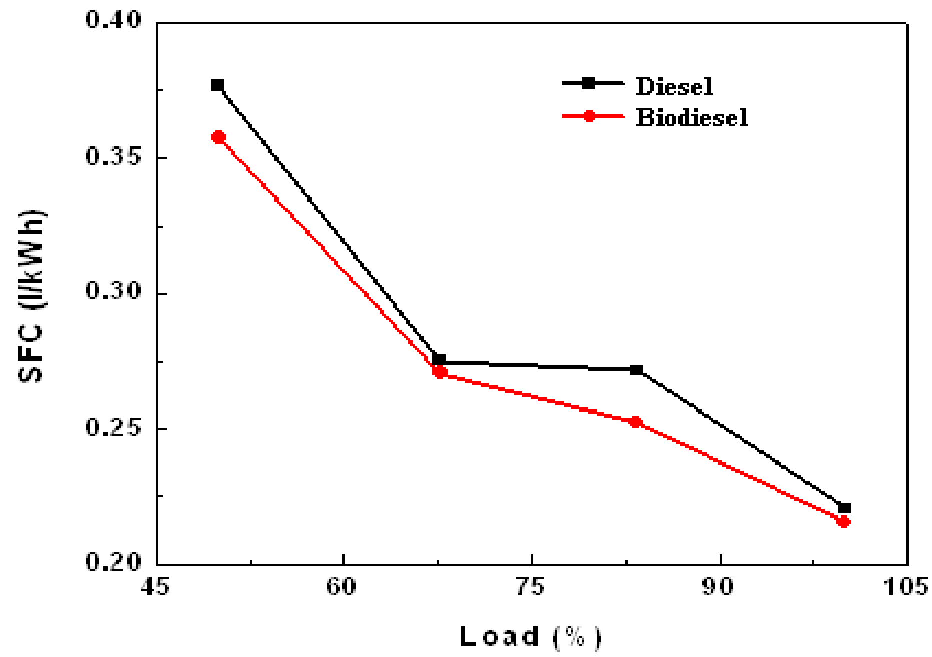

Fig. 4: Specific fuel consumption (SFC) and load for diesel and average bio-diesel blends

The average values of biodiesel were 0.354, 0.270, 0.249 and 0.215 Liter/ (kW.h) at 50, 67, 83 and 100% load, whereas the values of diesel fuel were 0.376, 0.275, 0.271 and 0.2205 Liter/ (kW.h) respectively and the relationship is shown in the Fig. 4.

It can be observed from graph that the difference between diesel and average biodiesel SFC is lower at full load compare to partial load. This is because the test engine requires more biodiesel to accommodate heat losses as compare to diesel fuel at full load.

3.2 Effect of brake thermal efficiency

The relation between load and BTE of all blends used in the experiments are shown in Fig 4. Due to lower calorific value and even lower density, the BTE of the bio-diesel is higher than that the diesel fuel. At partial load 50%, 25.49%, 26.29%, 26.72%, 29.35%, 27.46%, 29.94% and 28.30% of diesel, B5, B10, B15, B20, B25 and B30 is recorded respectively. The main reason behind this relation is due to complete combustion at partial loading. But when operating at full load, 43.51%, 41.19%, 43.68%, 48.96%, 46.07%, 49.15% and 48.97% of diesel, B5, B10, B15, B20, B25 and B30 are recorded respectively. This shows that the performance of maximum blends at full load is increased except B5 for which efficiency is not increased accordingly.

3.2.1 Effect of viscosity

The biodiesel prepared using ethanol has higher viscosity. Also the fuel viscosity does not have any effect on the engine performance but it will increase the maintenance cost of the test engine.

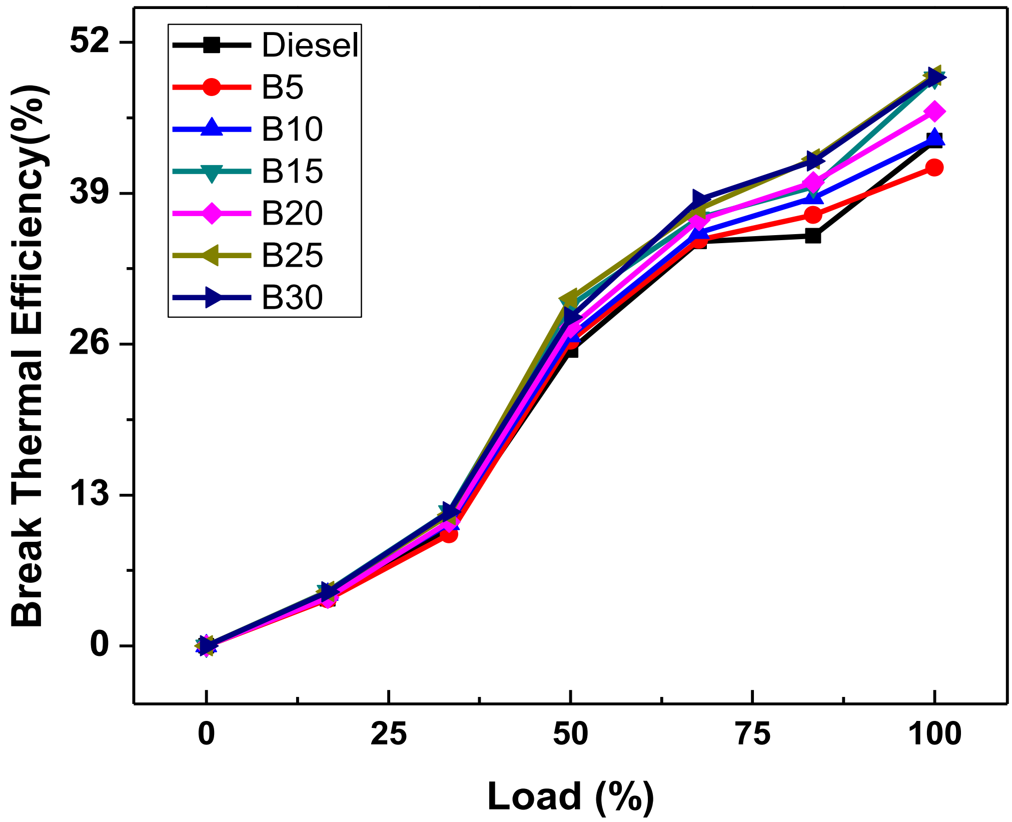

Fig. 4: Variation of the brake thermal efficiency (BTE) and load for diesel and bio-diesel blends

3.3 Effect of indicated power

Figure 5 shows that the indicated power of the engine fluctuated with the engine load. It is minimum at least speed of engine. It rises with the rise in load on engine and has a maximum value of 6.0 kW at peak load of 100%.

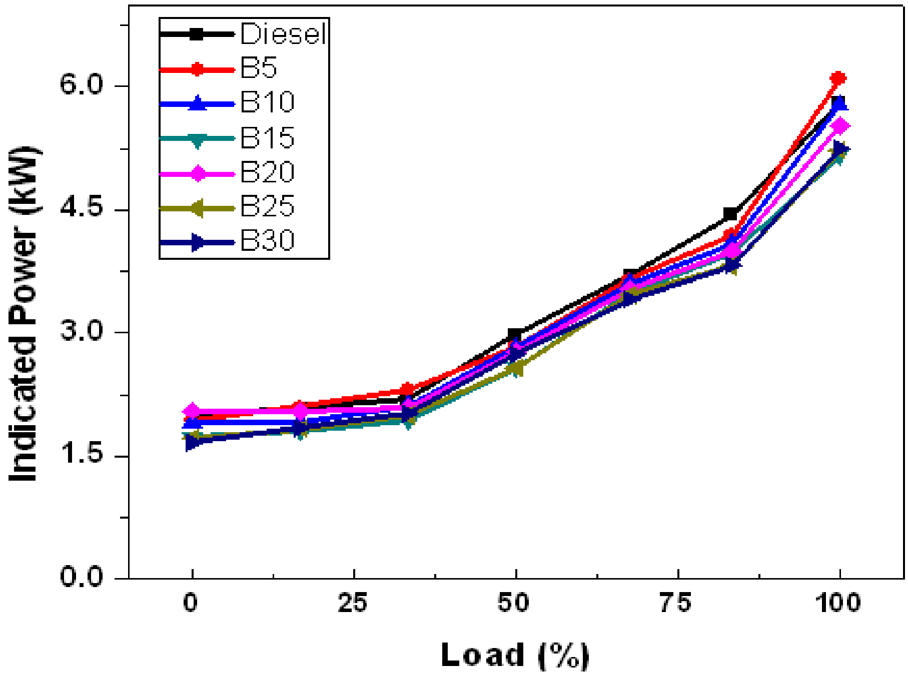

Fig. 5: Variation of the Indicated power and load for diesel and bio-diesel blends

3.4 Effect of mass and volume flow rate

Figure 6 shows the variation in mass and volume flow rate with variation in applied load.

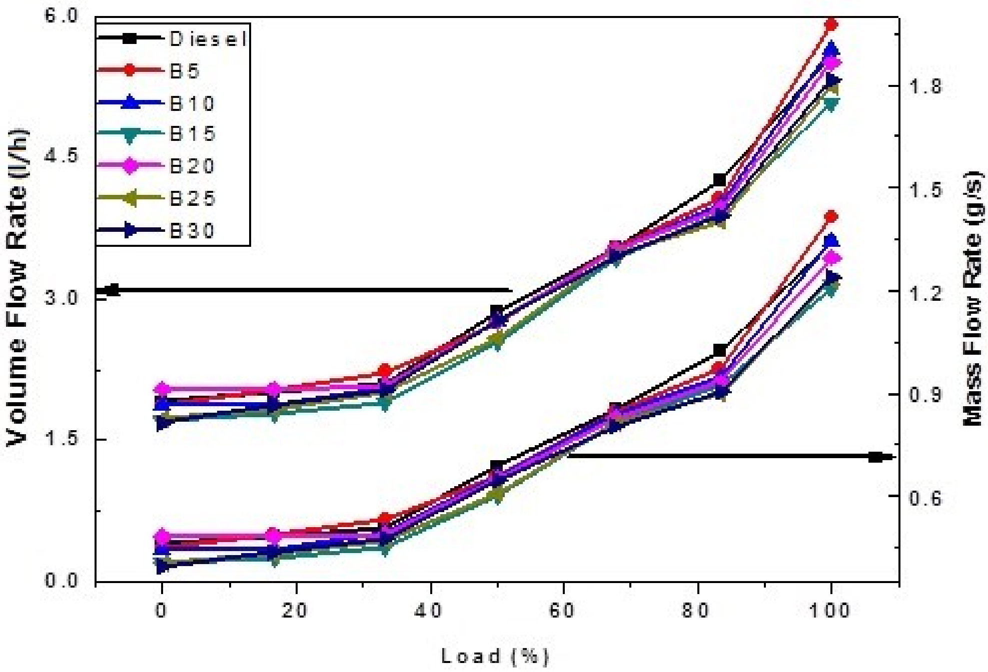

Fig. 6: Variation of load with mass and volume flow rate

It can be observed from Fig. 6 that there is continuous decrease in volume flow rate and mass flow rate at a specific load condition for diesel and bio-diesel blends. It is also concluded that the addition of increased percentage of bio-diesel in diesel fuel has decreased the mass and volume flow rate. The volume and mass flow rate are very close to each other at load of 67.67% and are scattered too much from each other at 100% load. This shows that at maximum load the addition of bio-diesel in diesel fuel results decrease in overall mass and volume flow rate with the rise in applied load and hence resulting as overall efficiency improvement.

4. CONCLUSIONS

On the basis of the results of the present research work, it is concluded that the Perkins Engine performance is enhanced by increasing the bio-diesel concentration in the form of blends. This study shows that there is a huge potential for biodiesel to use in engines in the form of blends. Biodiesel also reduces specific fuel consumption up to 6% which simply indicates less engine losses. The only problem which engine can face is the maintenance cost due to higher viscosity of the pure biodiesel and the effect will be prominent in the higher bio-diesel concentration in the form of blends. The experimental results show that the bio-diesel blend B15 seems to be most economical fuel. This is because it has maximum peaks in the specific fuel consumption (SFC) and brake thermal efficiency (BTE). It is also due to molecular structure of B15 and sufficient amount of available oxygen which required for complete combustion.

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