Experimental Studies of Diesel Engine Performance, Combustion and Emission Characteristics with Diesel and Pumpkin Seed Oil Blends

M.Kannan,M. ArunKumar, K.Senthil Kumar, R.Prabhu

Abstract—In the current study, the primary components used are pumpkin seed oil biodiesel with diesel was tested in diesel engine and its performance, exhaust emissions, and its effects were observed. The pumpkin seed oil that is used to produce biodiesel undergoes transesterification process along with ethanol, sulphuricacid ,andNaOH catalysts . With blends like B0,B20,B40,B60,B80,and B100, the test on engine performance is obtained, and the reports exposed that, B40 is overlying blend among the other biodiesel blends. In addition, to enhance the performance characteristics of B20,B60,B80 by volume was combined with B40 blend. Due to lower heating characteristics of biodiesel, the observations of BTE for B40 is 4.6% lower than diesel. But the observations of BSFC for B40 is 7.3% higher than diesel. The heat emission rate ofB20,B40,andB60 are almost identical to diesel fuel ,apace with ,at higher loads B40 emitted37.5%less CO and NO_x emission was raised at the rate of 95% when correlated to diesel fuel. However, It is observed that there is no major difference not much difference in the emissions (HC, NO, andCO) and characteristics of the engine when using the diesel fuel and Pumpkin seed biodiesel fuel blends.

Keywords - diesel engine, pumpkin seed oil, NOx reduction, performance, biodiesel blends.

I. INTRODUCTION

The worldwide use of fossil fuels has caused very high demands for it. Since its nonrenewable,in recent times it started depleting. Thus the booming cost and environmental concerns have given way to the researchers to examine the new ways to find alternative energy resources. Likewise, the emission of carbondioxide from fossil fuel combustions is also rising year by year. The air pollution and global warming problems must also be controlled. The spontaneous growth in population and lifestyle changes are resulting in ever increased usage of energy[1]. In the world energy market, fossil fuels play a vital role, dominates the energy market and its present worth is about 105 trillion dollars. The recent studies revealed that the depletion time of oil, gas, and coal is 35,37,107 years respectively and which means that the coal will be the only fossil fuel left after 2042. The middle east enclosed with 61% of worlds petroleum reserves. It is estimated that the global fuel consumption in 2018 is 99.1 million barrels per day. When compared with the previous year, which means an increaseof 1.41%. To meet even half of the fuel demand the existing reserves of liquid fuel won't be adequate around 2023 [2]. In the area of fuels, Biodiesel proved its significant role as it has similarities with diesel fuel. Dominant diligence owing to its non-toxicity, biodegradability, renewability, with high flash point and a better minimization of greenhouse emissions are gained [3-5]. It is produced from animal fat,vegetable oil or pumpkin seed oil in the process of transesterification.The ready availability of pumpkin seed oil is one of its advantages most of the companies dump their waste oil into aquatic resources and it causes very harmful environmental problems. It is estimated that a liter of waste oil can pollute 5,00,000liters of water[6-9].

The waste cookinglosesits quality and it can be used as one of the main components in the production of Biodiesel. As a raw material, pumpkin seed oils cheapest when compared with fresh edible and non-edible oil[10]. The pumpkin seed oil has a higher viscosity than other fossil fuels and it cannot be used in the Internal Combustion engine directly. This one of the main limitation. The oil with higher viscosity has a higher chemical structure and molecular mass[11,12]. If the oil with higher viscosity is directly used in Internal combustion engines, the performance, spray characteristics and fuel atomization will be adverselyaffected. Larger droplets will be formed due to the higher viscosity, which shortens the spray angle and also results in poor vapourization. This also affects the fuel atomization and the entire system, which reduces the efficiency and leads to the emission of toxic gases[13]. So, several chemical pre-treatment methods are to be completed to reduce the viscosity and to produce Biodiesel. One of the commonly used reaction is transesterification reaction. It was recorded that at 16:1 molar ratio ethanol and oil, a higher yield is obtained [14,15].It is taking into the account that the combustion process becomes more efficient with an increase in injection pressure, next generation engines most seeming work with a pressure between 200 MPa and 300 MPa. There is no direct measurement and extrapolations for this pressure range. Obtained using lower pressure values are not suggested, because it is expected that the fuel components can freeze[16].

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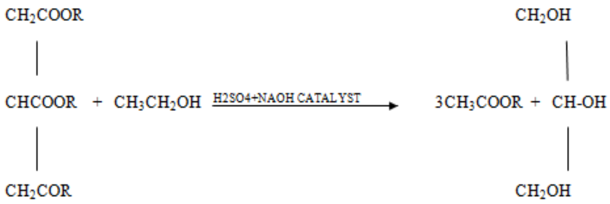
The thermophysicalparameters were observed in fossil fuels, and their volume measurements to implement the process control in engines cannot be directly assigned to the biofuels. Mainlytheviscosity,density and other factors like temperature and pressure differences in conventional hydrocarbon-basedfuel[17].

There are limitations in blending ethanol with Pumpkin oil because itsexcess, it produces a knocking effect and increases in concentration ethanol may decrease the Cetane number of the blend. Therefore the addition of ethanol and Pumpkin oil with diesel fuel may parallel result in the above-stated problems anyhow, thesatisfying engine performance and pollutants of blended fuels needs to be proved, whichis the main primary of the work.

II. MATERIALS AND METHODS

2.1 Trans-esterification process



Transesterification is the process which is used to produce the biodiesel from the raw seed oil. Alcohol is added to the seed oil at the time of transesterification process with glycerol is act as a catalyst.

2.2 Properties of Biodiesel

Table 1: Properties of pumpkin oil biodiesel

Properties	Diesel	Pumpkin Biodiesel	Testing Procedure
Flash point °C	66	128	ASTM D92
Fire point °C	74	130	ASTM D92
Kinematic viscosity at 40°C in (mm^2/sec)	3.7	5.67	ASTM D2217
Calorific value (MJ/kg)	43.2	36.2	ASTM D4809
Density (kg/m^3)	828	842	ASTM EN 14213

In table -1 the diesel was tested and acquired as per the ASTM the thermal and physical properties of pumpkin biodiesel. It exhibits the calorific value and density of the diesel is more than that of pumpkin biodieselby 18.3% and 1.6% respectively, it means producing of using pumpkin biodieselis less while comparing to diesel, so the pumpkin biodieselneeds more quantity to be injected to the ignition chamber. The kinematic viscosity of diesel fuel is less than of pumpkin biodiesel. Fuels which are considered for handling and storage must be in a safemanner, ithas more than 65℃ of flashpoints,although biodiesel has 130℃ of flash point and it is drastically safe. While comparing biodiesel to diesel fuel it is safer to use.

2.3 Biodiesel production

The oil was heated at 100℃ to remove the suspended food particle. By the process of heating, the moisture content in the oil should be removed . On the yield of the methyl esters , It will lead to negative effects. With 3% Orthophosphoric acid , the oil is again heated at 95℃, it is heated for an hour and clean oil was taken in a conical flask after removing the waste. The transesterification process successfully wasdone with 100ml conical flask along with a thermometer and stirrer. Where $H_2SO_4$and NaOH was used as a catalyst for 5% of H_2SO_4 were separated in a bottle with methoxide (methoxide and NaOH) solution ,and then the prepared combination was spilled into the unwanted cooking oil , which was already filtered in the conical flask ,and for the oil is triglycerides to diglycerides for active conversion ,while maintaining the molar ratio 16:1 methanol was added and heated for an hour by 60℃ at 700rpm, on the reaction period the substance was mixed with the help of a magnetic stirrer and also maintaining the parallel temperature. The glycerine was separated with the help of separating funnel,for4 hours. After removing the glycerine from the container the biodiesel is washed with the help of tap water 90% of biodiesel output was obtained after filtration which was shown in fig 1,2,&3.

Fig1: Transesterification reaction

Fig 2: Biodiesel in separating funnel

Fig 3: Water washing

2.4 Engine setup

Table 2. Specification of test engine

Make	Kirloskar
Model	TAF 1
Type	Direct injection, air cooled
Bore x Stroke (mm)	86.5 x 110 mm
Compression ratio	17:1
Swept volume	659 cm^3
Rated power	4.5 kW
Rated speed	1500 rpm
Start of injection	24° bTDC
Connecting rod length	210 mm
Injector operating pressure	20 Mpa

A single cylinder DI four-strokediesel engine is used to analysis the performance and emission parameters of pumpkin biodiesel .The test engine details are given in the table 2. In fig 4 the test engine is given as a schematic diagram. With an eddy current dynamometer, the engine was completed to calculate the load from 0 to 100% with 25% of incrementation. The engine is warmed up for 30 minutes for a continuous run using pure diesel fuel at a constant speed of 1000rpm a conducting test is required for each load and the readings were recorded. A fuel consumption time was noted with the help of a stopwatch for 10cc fuel which is filled in the burette. Emission of pumpkin biodieseland its several blends and some emission gases were found by AVL smoke meter.

Fig 4. Test Engine Setup

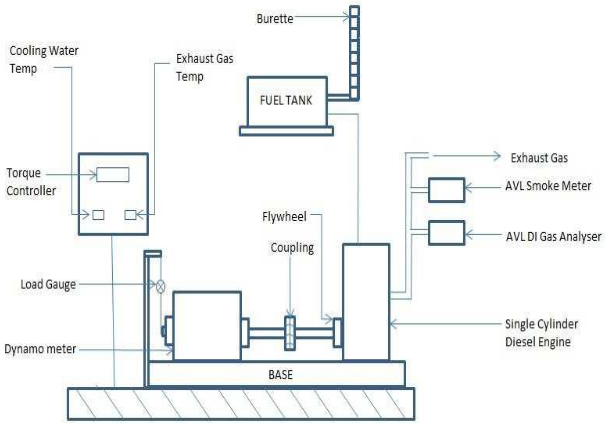


Fig 5. Block diagram of engine setup

Checking the average value and repeatability value were taken for the discussion before three times of the engine test. The angle of the engine crank was measured with the help of some devices such as AVL GH12D miniature pressure.

III. RESULTS AND DISCUSSION

The efficiency ignition and exhaust features pumpkin biodieseland diesel blend (B0,B20,B40, B60 and B100) with different loading conditions at a speed of 1500rpm a 4 stroke ,single cylinder vertical diesel engine is tested ,exhaust and release rate of thermal efficiency, cylinder gas pressure, brake specific fuel consumption, NOX, smoke, HC,and CO resulted and it is compared to diesel fuel.

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3.1 Brake thermal efficiency

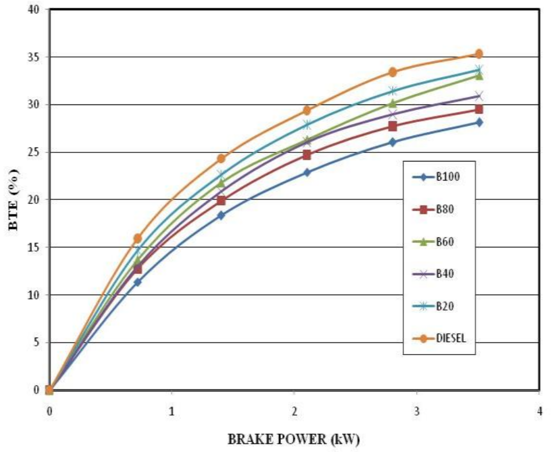

Fig 6. Brake thermal efficiency Vs Brake power

The brake thermal efficiency of pumpkin biodiesel and its blends was shown in fig 6, respect to the load. BTE tells about Conversion of mechanical energy from heat by efficiently. BTE increases with respect to the load due to irrespective of blends, along with the 7.5% reduction in BSFC and then increased. By diesel, the minimum brake thermal efficiency is obtained. When the engine loaded 75% of maximum load, the blend B100 results in lowest BTE. Due to high viscosity and low calorific value and an air-fuel mixture of the blend at lower loads than diesel, B20 results in minimum brake thermal efficiency. When n-butanol is added with B40, the efficiency is decreased due to its low calorific value. In the blend,B40 blend shows better BTE than B40 higher power output may be attributed and B20 is compared to lower BSFC.

3.2 Brake specific fuel consumption

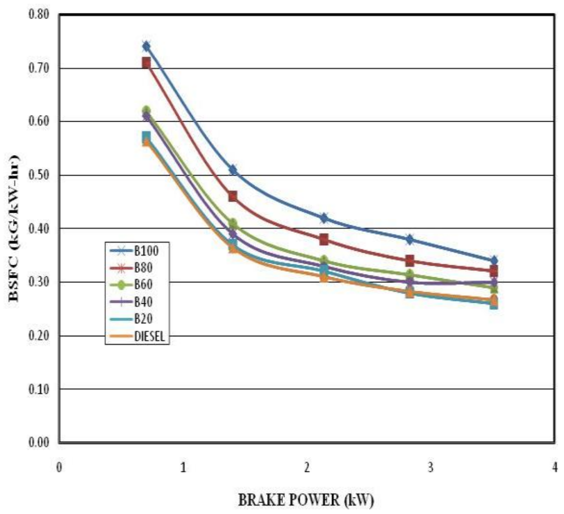

Fig 7. BSFC Vs Brake power

In various blends of diesel and pumpkin biodiesel of a varying condition of loads. Fig 7 explains the diversity in BSFC, BSFC slightly increases during 100% loading conditions and decrease with increase in load irrespective of the blends. The calorific value and the amount of fuel injected is proportional to BSFC. Diesel has high calorific value, lower mass and low BSFC. Also the engine executes the same or less amount of fuel. Due to low calorific value, B100 results in maximum BSFC. In the low calorific value of B40 shows high BSFC and B40 blend has low viscosity while comparing to other blends. In previous studies of B40 has high calorific value and diesel the lowest value of BSFC is 0.2607kg/kWh in the diesel fuel.

3.3 NOX Emission

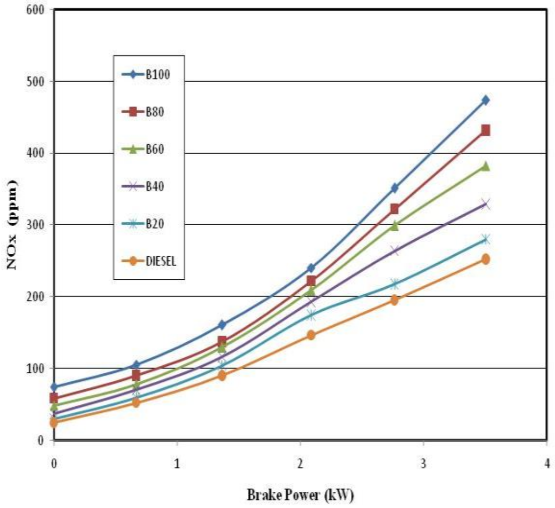

Fig 8.NOx Emission Vs Brake power

The characteristics of NOx with brake power were obtained in fig 8. The peak radiant of different blend ratios of B0, B20, B40, B60, B80, B100. In the ignitionprocess, NO_X increases with the increase and the heat release rate is at the peak at full load. NO_X value is 17% higher than the diesel when B100 is at 100% load. The NO_X value of B40 is 9% higher than diesel due to the high oxygen content the NO_X emission is reduced. It is obtained due to temperature reducing the effect. NO_X emission is increased by catalyst B40 blend observation. Flame temperature, ignitiondelay, availability of O_2,N_2 and fuel bound oxygen are the efficient parameters which affect the NO_X emission.

3.4 CO emission

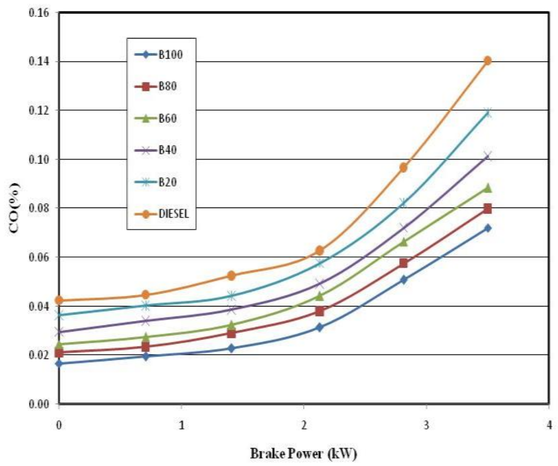

Fig 9. CO emission Vs Brake Power

The characteristics of co-emission for various loading conditions at 1500rpms and brake power was shown in the fig 9. Due to the lack of air and low flame temperature, CO, CO_2 are formed. In combustion chamber, there is an increment in co-radiant along with the load.

2.5 Hydrocarbon(HC) emission

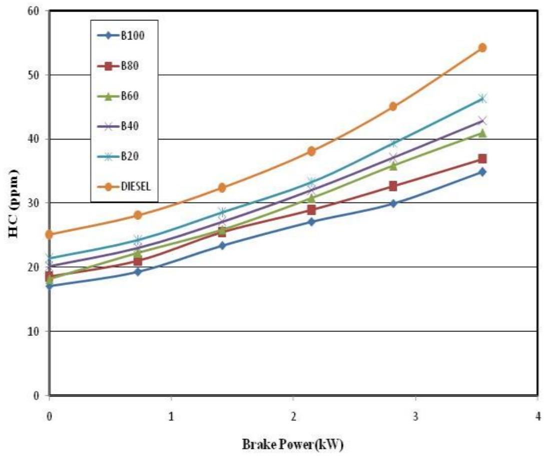

Fig 10. HC Emissions Vs Brake power

Fig10 shows the diversity of HC emission for various blends of pumpkin biodiesel for different loads. Incomplete ignition is the primary factor to generate HC. The emission of various blends B0, B20, B40, B60, B80, B100at 100% load are 41,32,25,24,16,26 and 18. When compared to diesel fuel in the HC emission, B40 is lesser. On the fuel characteristics condition in the cylinder and air-fuel mixing, the amount of unburned HC is depended. In emission, no particular tendency was observed and also the ratio of biodiesel increased in the blends emission was increased by adding of catalyst to B40 . When compared to diesel, The blends like B60 have higher emission .When the cylinder temperature increases as the HC decreases at high loads.

2.6 Exhaust gas temperature

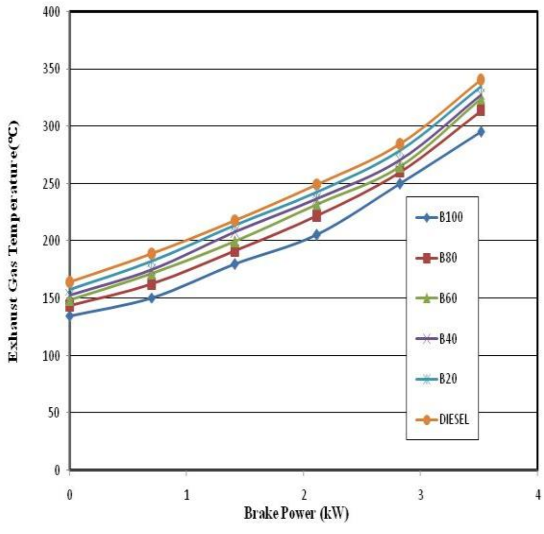

Fig 11.exhaust gas temperature Vs Brake power

In different blends, the exhaust gas temperature is varied for various blends of pumpkin biodiesel and diesel which was shown in fig11. Biodiesel blend causes poor atomization of fuel due to a high viscosity which leads to the presence of unburnt fuel with small traces in the premixed ignition phase. The EGT values for various blend ratios at 100% load are 428,464,447,470,418,438 and 442. Due to a longer ignition delay, the EGT value of B40 is 4.4%, and it is decreased by 2% by adding catalyst with B40 when compared to B20. When compared to B20, it is decreased along with the decrement of 1.1% in blend B40.

2.7 Smoke Opacity

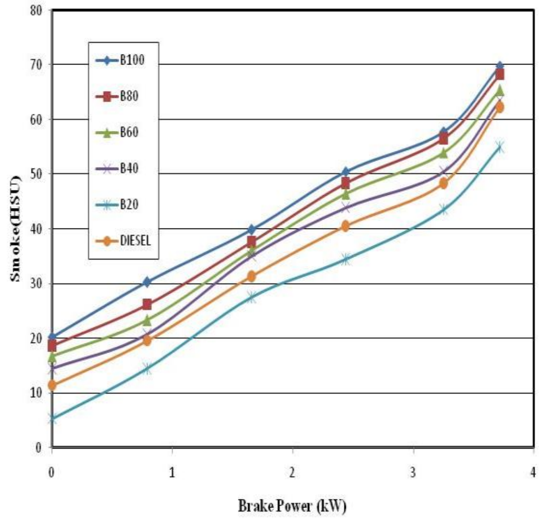

Fig 12.smoke opacity Vs Brake power

The characteristics if smoke opacity and brake power was shows in fig12. The highest value for various blend ratios are B0, B20, B40, B60, B80, B100 are 59,75,60,50,39.62 and 52.5. Diesel fuel is 51% less when compared to the smoke emission of B100 emission is reduced by 6.4% due to the addition of catalyst to B40 which is agreeing with previous studies. The radiant of B40 is than the diesel by 12.3% due to its higher oxygen content and efficient burning.

IV. CONCLUSION

By using a single cylinder 4 stroke direct injection diesel engine the biodiesel blends [B0, B20, B40, B60, B80, B100] were analyzed.The observation of BSFC for B40 is 7.3% higher than diesel where as the observation of BTE is 4.6%. The cylinder pressure valve for various blends nearly co-exists with diesel fuel. While comparing with diesel fuel, the CO emission in B40 is less by 37.05% and in NO_X,it is 9% more and EGT is 2.3% higher. Globally diesel is the best conventional fuel and it blendsgradually reduce performance such as BTE and BSFC as an increment in the fraction of bio-diesel. Simultaneously the mixture of B40 blend gives a satisfactory performance with the fuel stability. The blends of biodiesel are very Eco-friendly due to its good emissioncharacteristics than diesel. Therefore Biodiesel will be the best alternating fuel in the future.

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