Production, Perfomance and Emisions of Bio Diesel from Mixture of Animal Waste Fats and Degradation of Bio Diesel over Time

Vegivada Venkata Ganga Pradeep, Bikkavolu Joga Rao

Abstract: ***As the population increases day by day that makes the use of automobiles globally and hence the use of fuel increases especially diesel. Diesel fuel plays vital role due to immense working efficiency and less fuel consumption which increases the demand of diesel. As the crude oil going to be exhausted in few decades, so many researches are striving to find an alternate and finally found Bio-sources to manufacture Biodiesel whose properties are near to the Diesel fuel. These fuels are prepared from Crude oils.***

This paper deals with the production, performance and emissions of Biodiesel which is obtained after a chemical reaction called 'Transesterfication'. It is a mixture of waste animal fats viz., fat from Pig called 'Pork Lard' and also fat from chicken called 'Chicken Tallow' are tested for different properties of the Biodiesel. The prepared bio diesel was tested in a Variable compression ratio diesel engine with different blend ratio of fuels (Bio diesel and normal diesel) and (bio diesel, diesel and ethanol) at different injection pressures. Also compared the performance of freshly blended biodiesel with degraded biodiesel for 2 years.

Keywords**:** ***Bio Diesel, Fat Oils, Ethanol, Transesterification and emissions.***

I. INTRODUCTION

The fossil fuel demand increases(9) due to increase in population day by day. Crude oil availability going to exhaust in the near future and also using products of crude oil such as petrol and diesel as the fuel causes environment pollution, global warming and also increase in price of crude oils make it uneconomical. All these factors created interest in researchers for manufacturing biodiesel which should be good in performance compared to normal diesel, economical and ecofriendly(11).

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Most of the animal fats having a vast amount of lipid content this makes them a promising source for Biodiesel production(7) and also most of the fat content is under the layers of skin which is usually discarded by the meat vendors makes them cheap and also even in some cases getting all these are free of cost. All these fats are very common and available globally. In india, from all available sources of meat discards pork is having maximum amount of fat followed by chicken and fish.

Usually the pork lard oil is highly viscous and having high density that is the reason it is difficult to use. Hence the pork lard is mixed with chicken tallow to reduce its density and viscosity(3). Transesterfication is the best process of converting all the fats from the sources into Biodiesel and glycerine. This is a chemical reaction between the animal fat oil and alcohol in the presence of catalyst at prescribed temperature, time and mixing speed which generates maximum amount of Biodiesel from the animal fat oil.

II. EXTRACTION, REFINING AND TESTING OF RAW OIL (4)

A. Raw Material

The waste animal fats used are fats from chicken tallow and pork lard. These chicken tallow and pork lard are obtained free of cost from the meet vendor, As the fat is obtained from waste which is not uneatable and nauseous. Dumping and degradation is also not an easy process for the meet vendor that is the main reason they offered the fat at free of cost.

B. Extraction

The fats are fried in a cooking bowl at a low flame. During cooking, the oil was separated from the solid mass into the cooking bowl. On repetition of the above process with remaining solid fat for two to three times extracted 70% and remaining 20% to 30% extracted from compressing the final solid mass. Thus finally, 90% of the oil was extracted from the chicken and pork fat.

C. Refining

The refining process consists of heating the oil above 100^0 C and then filtering for solid waste particles separation. The process of refining done many times till the final oil did not have any solid particles in the filter sieve.

D. Titration

Titration is a chemical reaction was done to find the Free Fatty Acid (FFA) and Acid Value of an oil (5).

i) For 100 % Pure pork lard oil (1).

FFA = 0.94 % by mass

Acid Value = 1.87

ii) For 100 % Pure chicken tallow oil

FFA = 0.47 % by mass

Acid Value = 0.95

iii) For Mixture of 80 % volume of Pork lard oil and 20 % of volume Chicken tallow oil

FFA = 0.75 % by mass

Acid Value = 1.50

From experimental data, it is abserved that the pre-esertification is not required as the acid value is within the limiting value for getting forward to Transesterification process.

III. PRODUCTION OF BIO-DIESEL

The Biodiesel was prepared by using a mixture of 80 % volume of pork lard oil and 20% volume of chicken tallow oil. The reason behind using the mixture instead of using pure oil is that pork lard oil has higher calorific value compared to the chicken tallow oil and pork lard oil has high density and viscosity as compared to chicken tallow oil. In this project, an optimal volume ratio of 80 : 20 Pork lard oil and Chicken tallow oil were mixed and Biodiesel was prepared to get higher calorific value and to get oil properties close to diesel.

A. Trans-esterification

Transesterification is a process of converting the mixture of raw oil by a chemical reaction with methanol and NaOH as a catalyst into bio diesel with glycerin as a byproduct (2).

- Take 3kg of oil mixture in a steel vessel and heat up to 60^0 C.
- Take 850 ml of methanol into another beaker and add 44 ml of NaOH and mix well.
- Insert mechanical stirrer into the oil and stir the oil until the oil shows a standard temperature of 60^0 C uniformly.
- Now pour the alcohol and NaOH mixture into the oil vessel and mix by using stirrer at 1000 rpm and keep the temperature constant at 55-60^0 C for one hour.
- Now transfer the contents into a conical jar and kept aside for 24 hours.

B. Seperation

After 24 hours, the mixture in the conical jar separated as Biodiesel and glycerin. The glycerin having high density which was settled at the bottom of the jar and the biodiesel having low density was found on the top layers.

C. Washing and Drying

For purifying the biodiesel, it should be washed with water. Add hot water to the biodiesel and gently shake the vessel for 5 to 10 times.

Separate the hot water as it found in the bottom of the vessel due to more density.

After washing some of the water particles are mixed up with bio diesel. To separate those particles from water, heat the bio diesel to above 100^0 C on induction or oven thus the water particles get evaporated.

IV. TESTING THE PROPERTIES OF OIL

A. Blends

Different blends were prepared on volumetric basis: bio-diesel along with diesel and bio diesel, diesel and ethanol. Different properties are found for all those blends. The blends are as following

a) B5 + D95, b) B10 + D90

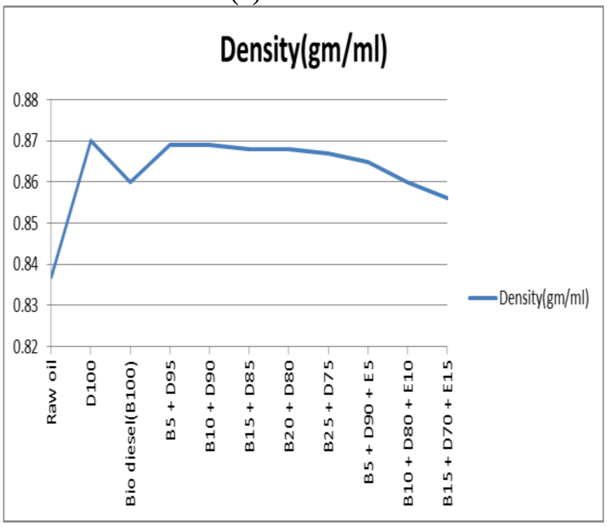
c) B15 + D85 d) B20 + D80

e) B25 + D75 f) B5 + D90 +E5

g) B10 + D80 + E10 g) B15 + D70 + E15

B. Density

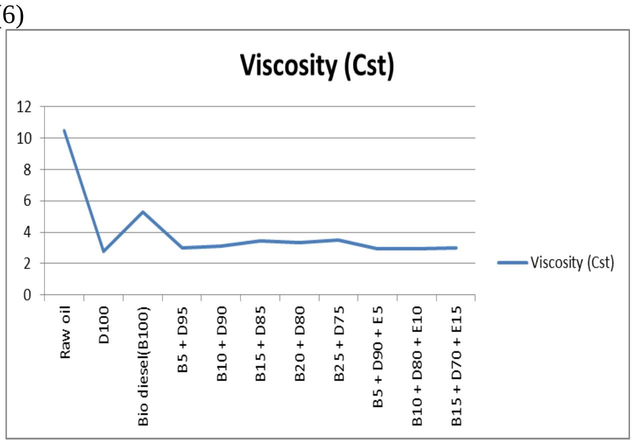
Density is a measure of amount of matter that anything consists in unit volume (6)



Graph 1: Density v/s different blend mixtures

C. Viscosity

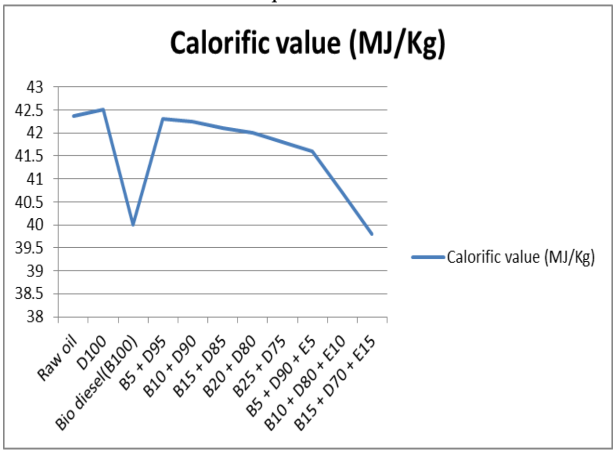
Viscosity may be defined as the resistance of a fluid to flow. (6)



Graph 2: Viscosity (Cst) v/s different blend mixtures

D. Calorific Value

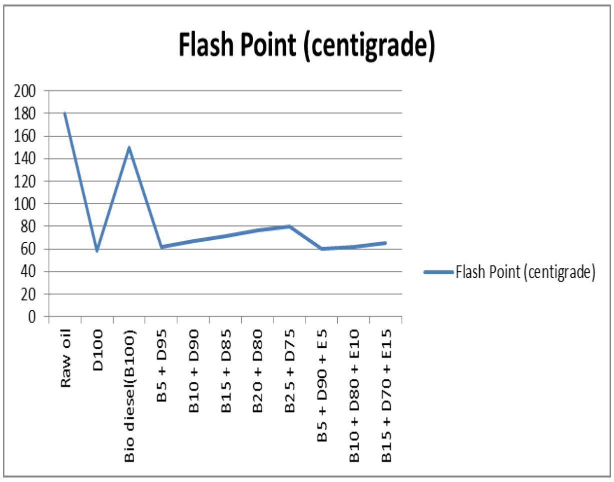
The calorific value is the amount of energy contained in a certain mass of a solid or liquid.



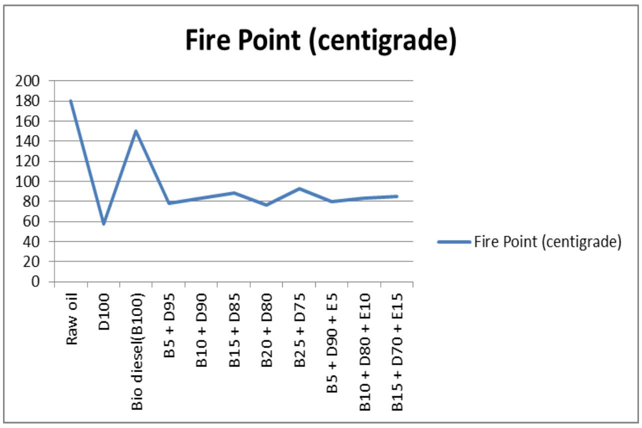
Graph 3: Calorific value (MJ/Kg) v/s different blend mixtures

E. Flash Point and Fire Point

The flash point is the lowest temperature at which the fuel ignites and the fire point is refers to the lowest temperature at which the fuel starts combustion and continues at least 5 seconds.



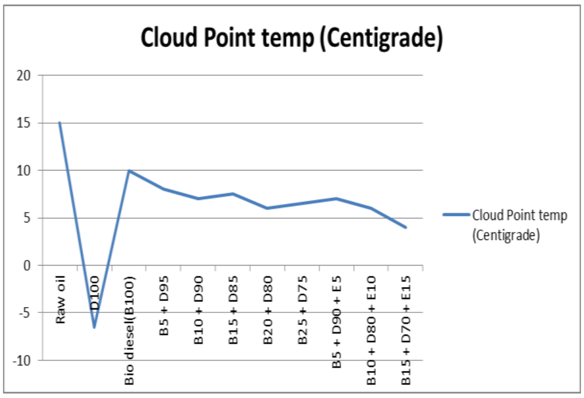
Graph 4: Flash point temperature v/s different blend mixtures



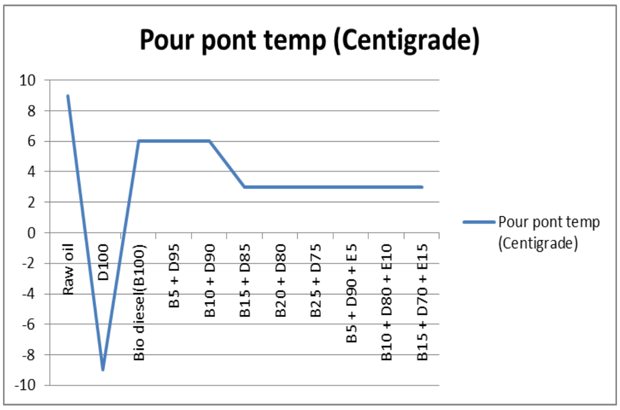
Graph 5: Fire point temperature v/s different blend mixtures

F. Pour Point and Cloud Point

The pour point temperature is the lowest temperature in multiples of 3^0C at which the test sample is observed to flow. On the other hand the cloud point temperature is the lowest temperature at which the solubility of dissolved solids is no longer completely soluble.



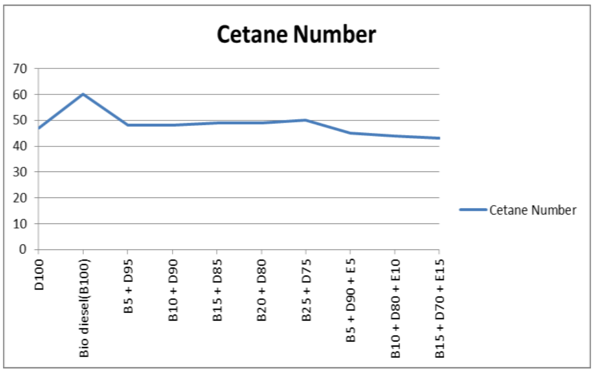
Graph 6: cloud point temperature v/s different blend mixtures



Graph 7: pour point temperature v/s different blend mixtures

G. Cetane Number

Cetane number of a diesel is having a direct impact on the performance of the diesel in an engine. Cetane number effects the emission and the noise generated by the combustion in an engine.



Graph 8: Cetane Number v/s different blend mixtures

V. PERFORMANCE TEST ON DIESEL ENGINE

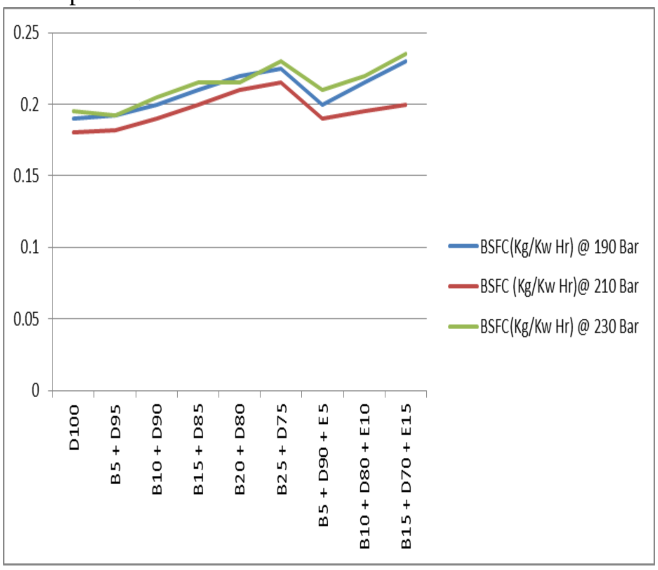
Performance test of different blends carried out on a 4 stroke stationary variable compression ratio (VCR) diesel engine which was kirloskar made. The engine is mounted on a mild steel frame and a brake drum is coupled to it. A belt with two springs is wound around the brake drum. The load on the engine may be varied by rotating the wheel provided by which the belt tightened and the load on the break drum is increased by the belt. The injection pressure of fuel into cylinder can be varied by adjusting a spring at fuel injector.

A. Procedure

a) Fill the diesel tank with the blend diesel.
b) Connect the power supply to the test rig.
c) Connect the coolant supply to the brake drum and engine jacket.
d) Open the valve at fuel burette and ensure that no air is trapped inside the burette.
e) Run the engine for some time till the rpm is stabilized to 1500 with a desired load.
f) Set the pressure of injection at required value by altering the spring at injection valve.
g) Record all the readings such as speed, load, rate of fuel consumption, Quantity of air flow and exhaust gases.
h) Now increase the injection pressure and repeat the above process.
The results from the performance test on VCR diesel is as given below.

B. Brake Specific Fuel Consumption (BSFC):

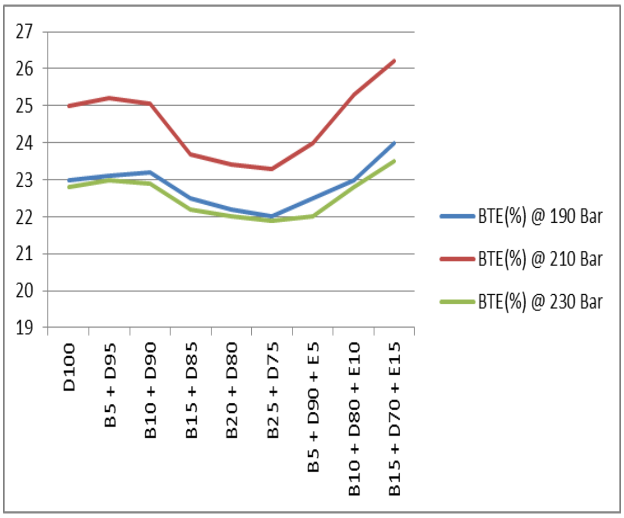
It is defined as the fuel consumed by the engine for producing brake power.



Graph 9: BSFC at different pressures v/s different blend mixtures

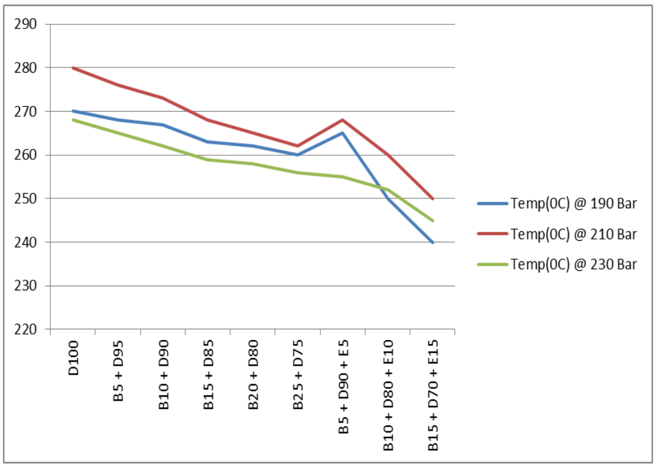
Brake specific fuel consumption variation with respect to different injection pressures are as shown is above graph. The BSFC values are less for less viscous fuels i.e, B5+D90 and B5+D90+E5 at injection pressure of 210bar. The initial decrease trend for 210bar is due to the increase in atomization which leads to become homogeneous mixture, thus results in complete combustion by which BSFC decreases. But after 210bar the atomization increases which leads to escape of fuel particles due to which the fuel particles escape without burning due to which BSFC increases.
As the composition of diesel decreases the BSFC increases since the calorific valve of blends decreases with decrease in diesel composition

C. Brake Thermal Efficiency (%)



Brake thermal efficiency consumption variation with respect to different injection pressures are as shown is above graph. It is observed that initially that the efficiency increases first upto 210 bar then after the efficiency decreases. The increase in efficiency for 210 bar. It is due to complete combustion and less loss of heat. For other blends at different pressures the efficiency decreases due to fine fuel particles with more momentum hits the cylinder walls which transfers the heat at fast rate due to which thermal efficiency decreased.

D. Exhaust Gas Temperature



Graph 11: Exhaust Gas Temperature (0C) at different pressures v/s different blend mixtures

Exhaust Gas Temperature (^{0}C)(10) consumption variation with respect to different injection pressures are as shown is above graph. It is observed that the exhaust gas temperature is decreased for all blends at all injection pressures due to fine fuel particles with more momentum hits the cylinder walls which transfers the heat at fast rate due to which Exhaust Gas Temperature (^{0}C) decreased.

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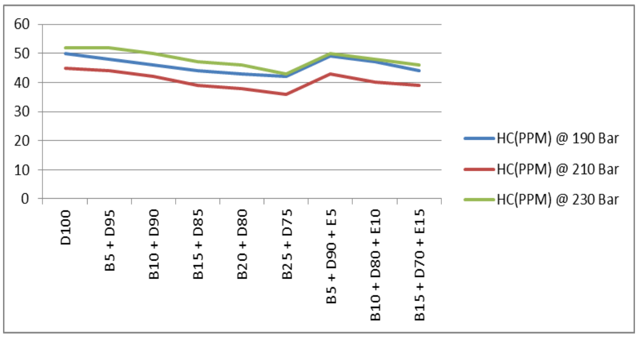
E. NO_X Emission

Graph 12: NO_X emission (PPM) at different pressures v/s different blend mixtures

Generally Bio diesels contains more amount of oxygen content as compared to conventional diesel. Due to the more content of oxygen in the fuel, the nitrogen in the fuel reacts with more amount of oxygen and generates more NO_x for all blends but especially for the injection pressure of 210bar the NO_x values are higher as the combustion rate is high.

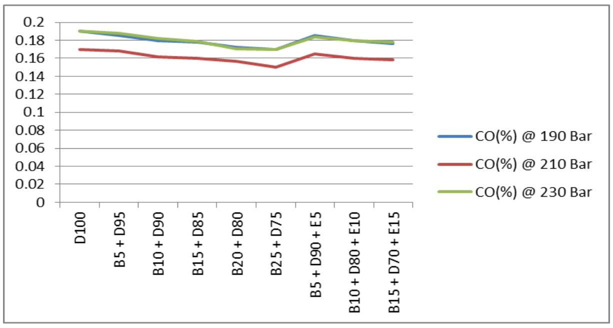
F. HC Emission



Graph 13: HC emission (PPM) at different pressures v/s different blend mixtures

HC emission(10) variation with respect to different injection pressures are as shown is above graph. Form the graph it is observed that HC emission decreases from high viscous fuels to low viscous fuels. HC values are observed less at 210 bar injection pressure because of complete combustion occurring there. Also the HC emission of blends are less as compared to the conventional diesel, This is due to more oxygenated bio diesel leads to complete combustion which is not happening in case of conventional diesel.

G. CO Emission

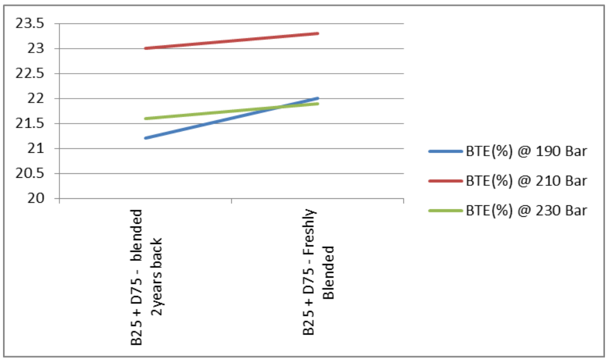


Graph 14: CO emission (%) at different pressures v/s different blend mixtures

CO emission (%) (10) variation with respect to different injection pressures are as shown is above graph. Form the graph it is observed that CO emission decreases for all blends at all injection pressures. The least point observed at 210bar injection pressure because of complete combustion at this instant. The emission of CO is mainly based upon the combustion process. If complete combustion occurs then the emission of CO is less, same phenomenon occurred for 210 bar but other injection pressures, CO emission increases due to incomplete combustion. Also CO emission of blends are less as compared to the CO emission of conventional diesel this is due to the presence of more amount of oxygen in the blends which leads to complete combustion and produces less CO emission.

H. Degradation of Fuel

It is observed that clog matter and sediments are formed in fuel that was made and blended before 2 years back. An experiment is made and compared the performance characteristics of fuel (B25+D75) which was blended and the same fuel composition which was blended 2 years back and stored at room temperature and pressure and compared both which is as shown in graph below.



Graph 15: BTE of Degraded blend Vs Freshly made blend

Due to presence of excess amount of oxygen and presence of water molecules made the bio-diesels to degrade in a faster manner due to which its performance characters may be affected as shown above. Due to the degradation the performance of degraded fuel decreases at all the pressures.

VI. RESULTS

It has been observed that from the performance test on a VCR diesel engine at different pressure, Test results at 210 bar gives good performance and also the emission characteristics of the blends at 210 bar are less as compared to other pressures. Hence 210 bar is an optimal pressure at which all the blends generates good results. Thus is preferably better to run engine at an injection pressure of 210 bar.

S.No	Parameter	Diesel (D100)	Blend
1	BTE (%) @ 210 bar	25	25.2 –B5+D95
			25.05 – B10+D90
			23.7 – B15+D85
			24 – B5+D90+E5
			25.3 – B10+D90+E10
2	BSFC(Kg/KW Hr) @ 210 bar	0.18	0.182 –B5+D95
			0.19 – B10+D90
			0.2 – B15+D85
			0.19 – B5+D90+E5
			0.195 – B10+D90+E10

From the above table it is observed that the performance characteristics of the blends B5+D95, B10+D90, B15+D85, B5+D90+E5, B10+D90+E10 are very near to the conventional diesel. Also from the above comparison it is observed that with increase in ethanol content the performance of the blend in engine increases.

S.No	Parameter	B25 + D75 Freshly Blended	B25 + D75 Blended 2years back
1	BTE (%) @ 210 bar	23.3	23

From the above table it is observed that the blends which was freshly blended gives good performance characteristics as compared to the blends which was blended 2 years back.
Also the bio diesel blends generates less pollution causing parameters as compared to the conventional diesel.

VII. CONCLUSION

Bio diesel is made from a mixture of chicken tallow fat and pork lard fat by Transesterification process. Different blends were made by mixing biodiesel with conventional diesel and ethanol and also biodiesel and conventional diesel. Different properties of the blends were found. All the blends were tested for performance and exhaust gas analysis in a variable compression ratio diesel engine at different pressures. Finally, The following conclusions are made:-

a) An optimal ratio of 80 : 20 Volume ratio of Pork lard oil and Chicken tallow oil were mixed to get higher Calorific value and to get oil properties near to diesel.
b) The density and calorific value of Conventional diesel is more as compared to the biodiesel. This is due to less amount of presence of water particles and oxygen in conventional diesel.
c) Viscosity, Flash, Fire, Pour & Cloud point temperatures are less for conventional diesel as compared to biodiesel. This makes the conventional diesel easy to use at low temperatures but by adding different additives like ethanol, nano fluids etc makes the biodiesel to use at even low temperature(8).
d) It is observe from the BTE graph that the brake thermal efficiency is high for less viscous and low density blends at 210bar as compared to 190bar and 230bar. This is due to complete combustion of fuel inside the cylinder. Also bio-diesel blend with ethanol gives good performance because the atomization and evaporation properties of ethanol.
e) NOx emission of biodiesels are more than the emission of conventional diesels and HC emission of biodiesels are less than conventional diesels due to the presence of more amount of oxygen as compared to the conventional diesel. More amount of oxygen leads to complete combustion of biodiesel. Due to complete combustion CO emission of biodiesels are less.
f) It is observed that freshly prepared blends gave good properties which compared to the blends which was blended 2 years back and stored at room temperature and pressure.
g) Finally, Bio-diesel blended with diesel and ethanol (B5+D90+E5 and B10+D80+E10) is a perfect substitute for Conventional diesel and biodiesel blended diesel (B5+D95, B10+D90 and B15+ D85) also good for better performance and low emissions. The biodiesel is more efficient and also emits less pollution as compared to the conventional diesel.

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