Performance and Emission Analysis of Tallow Biodiesel by Varying Fuel Injection Timing

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***Abstract*: -The emissions are increasing in large extent in our day-to-day life. Emissions are one of the most effective and dangerous to our ozone layer (i.e., which causes ozone depletion). And human gets suffered a lot because of this harmful emission. It may cause global warming, Acid rain and decrease in level of oxygen as emissions must be stopped or reduced. The aim of our project is to reduce emission and to find the better efficiency of biodiesel, which prepared by using tallow fat (mutton or beef fat).We have used B20 blend, methanol (methyl alcohol) and Potassium Hydroxide (KOH) and blending of Alcohol is done in fixed ratio (i.e., 6:1 ratio) and Potassium hydroxide at 4:1 ratio. The prepared biodiesel is tested in single cylinder, four stroke, water cooled CI engine with the fuel injection is fixed on 200bar and compression ratio is 17.5:1. By fixing these parameters constant, Injection timing is varied to know the better injection timing of the prepared biodiesel such as 19^0, 21^0, 23^0, 25^0 and 27^0. In this study, injection timing is better for specific fuel consumption at 27^0 BTDC, brake thermal efficiency is high in 27^0 BTDC.**

Key words: Diesel, Biodiesel blend, Testing Engine, Injection Timing, Performance and Emission

1. INTRODUCTION

❖ **About Biodiesel**

Biodiesel refers to animal fat based oil or vegetable oil which consists of long-chain alkyl esters. It is an esterified kind of vegetable or animal fat oil. Biodiesel is made up of lipids like vegetable oil, soyabean oil, animal fat (Chicken fat or Tallow) with alcohol which produces fatty acids. Biodiesel is a drop-in biofuel and it is meant to be used in standard diesel engines and it is distinct from tallow oil used to fuel converted diesel engines. It can be used alone or it can be blended with diesel (petro-diesel) in any proportions. This reaction is by the general equation as shown below.

- RCOOR' + R"OH ----- RCOOR" + R'OH

❖ **Blends**

Blending is a process of mixing of biodiesel into any kind of fuel in various proportions by volume. Mostly blend is referred as factor "B" of biodiesel in any fuel mixtures;

a. 100% of Biodiesel, 0% Diesel is labeled as B100,
b. 50% of Biodiesel, 50% Diesel is labeled as B50,
c. 20% of Biodiesel, 80% Diesel is labeled as B20,
d. 10% of Biodiesel, 90% Diesel is labeled as B10

❖ **TYPES OF BIODIESEL**

Some of the following types

i. Neem Oil
ii. Rapeseed and Canola
iii. Soybean Oil
iv. Sunflower Oil
v. Jatropha Oil
vi. Cotton Seed Oil
vii. Peanut Oil
viii. Waste Cooking Oil
ix. Plastic Oil
x. Karanja Oil
xi. Animal Fat
xii.

2. LITERATURE SURVEY

[1] Srinath Pai (2014): A Study on the effect of fuel injection timing on Diesel Engine performance and emission. The experiment was conducted on single cylinder, four stroke water cooled diesel engine. Injection pressures are 180bar, 190bar, 200bar, 210bar and 220bar and injection timings 15.5, 20.5, 23.5 and 25.5 degree BTDC at compression ratio of 17.5:1. He concluded that increase of injection pressure with relatable injection timing will significantly increase the engine performance and at 220bar and 25.5degree BTDC gives better combustion.

[2]. M. MANI (2009): Influence of Injection timing on Performance, emission and combustion characteristics of Diesel Engine running on waste plastic oil. The test is conducted in four strokes, single cylinder engine. He tested at four injection timings (23, 20, 17&14 BTDC). He concluded that at 14 degree BTDC, oxides of nitrogen, CO and unburned hydrocarbon is decreased while Brake thermal efficiency, carbondioxide and smoke is increased under test conditions.

[3]. C. ANUSHA – Y. DATTA BHARADWAZ (2016): Improvement of biodiesel methanol blends performance in a variable compression ratio engine using response surface methodology. The main objective of her work was to improve the performance of biodiesel- methanol blends in a variable compression ratio engine by using optimized engine parameters. She stated that for optimization of engine, the operational parameters like compression ratio, fuel blend and load are taken as the factors, where as performance parameters such as brake thermal efficiency, Brake specific fuel consumption, CO, HC, NOx and smoke are taken as responses. She concluded that for B5 blend and 18 compression ratio and at 9.03 kg load, it is found that 0.37 kg/kW-hr of SFC, CO of 5ppm, HC is 531.23ppm and NOx is 15.35.

[4]. METIN GUMUS…MUSTAFA CANAKCI (2017): The impact of fuel injection pressure on the exhaust emission of a direct injection diesel engine fuel with biodiesel- diesel fuel blends. The test was conducted through Direct Injection (DI) diesel engine have been

discussed when running the engine at 4 different fuel injection pressure (18, 20, 22 and 24 Mpa) and four different loads in engine, and the mean effective pressures are (12.5, 25, 37.5 and 50kPa). The result found that the BSFC, CO2, NOx and O2 emission increased smoke capacity, unburnt HC and CO emission decreased due to the fuel properties and the combustion characteristics of biodiesel. The increased or decreased injection pressure caused to increase in BSFC values compared to original injection pressure for diesel fuel and low percentage biodiesel- diesel blends (B5).

[5]. METIN GURU – ALI KESKIN (2016): Evaluation of biodiesel production, engine performance and emission. The work is based on evaluation of biodiesel and the author states that the biodiesel one of the best alternative fuel and it consists of less emission. The biodiesel is renewable, non toxic, biodegradable and enviro- friendly. It can be produced from vegetable oil, animal fat and used cooking oils. In production of biodiesel the process undergoes transesterification reaction through the use of alcohols such as methanol, ethanol, propanol and butanol etc., He concluded that the effects of biodiesel and its blends on diesel engine performance and exhaust emission are described and reviewed.

[6]. PRADEEP KALE (2017): Beef Tallow

Biodiesel as an Alternative Transportation fuel. The author stated that recycling of waste products are one of the most important issues in developing countries. He said that the fats are incinerated or disposed in a sanitary landfills. The beef fats can be used to made biodiesel production. The biodiesel is made by using methanol and potassium hydroxide as catalyst. Therefore the slaughter houses can be considered as one of the available source to produce biodiesel. He concluded that beef tallow biodiesel is suitable to mix with petro-diesel, the process can become economical by recovering methanol and glycerin.

[7]. AYHAN DEMIRBAS (2013): Biodiesel fuels from vegetable oils via catalytic and non – catalytic super critical alcohol transesterification and othermethods. He narrates that vegetable oil fuels have not been acceptable because they were more expensive than petroleum fuels. And he says about various methods of preparation of biodiesel. Dilution of oils with solvents and microemulsion of vegetable oils lowers the viscosity but some engine performance problems still exists. Pyrolysis is one the methods of production of biodiesel, it is also known as soap pyrolysis. The main factors affecting transesterification are the molar ratio of glycerides to alcohol.

[8]. JIAN – CHIING – CHANG – CHEN (2012): Transesterification of soyabean oil to biodiesel using cement as a solid base catalyst. This study is based on the recycling of soyabean oil with cement as the catalyst in the production of biodiesel by transesterification with methanol. This literature survey showed that cement has never been studied as a solid catalyst in the transesterification of triglycerides. Concrete is a composite construction material composed of cement, aggregate water and chemical administration of these composite Portland cement was supposed to be an an efficacious catalyst for biodiesel production. Therefore the effects of calcinations temperature, oil / alcohol ratio (mol/mol) & catalyst amount (wt % of oil) of hydrated cement were discussed. He finally concludes that the waste concrete catalyst was successfully used in the transesterification reaction of soyabean oil according to catalytic property of the cement catalyst.

[9]. PRATAP VORA (2018): Performance and emission to study direct injection timing. The quality of producing biodiesel will evacuate by following measuring different properties. The viscosity of the natural beef tallow can be extracted in high and actually it was in solid form. However after transeterification the viscosity will produce less final product in liquid. He concludes that the efficiency of catalyst can further maintain to use of bio-residue in chinesis (jojoba), Tobacco, Neem.

[10]. MUKESH PANDA (2017): Biodiesel using different mixture of diesel and the fuel.

The expensive of Jojoba methyl ester has superior ignition characteristics compared to pure diesel fuel, methanol and their formation of NOx can obtain by thermal mechanism in which increase in the detoration tolerance. This method is effective in reducing NOx emission. The engine test variable include at the percentage of methyl ester in the blend, engine, speed, load and injection timing.

3. EXPERIMENTAL SETUP AND TEST PROCEDURE

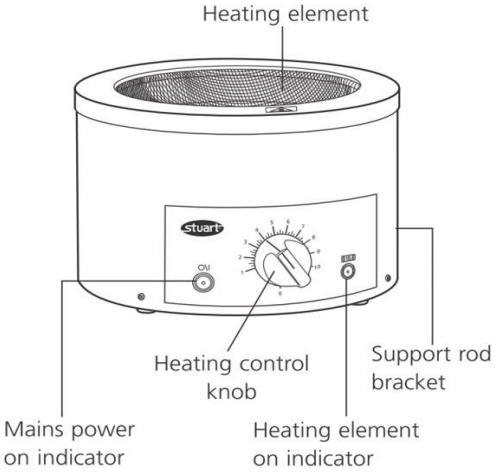

Fig.1 Heating Mantle

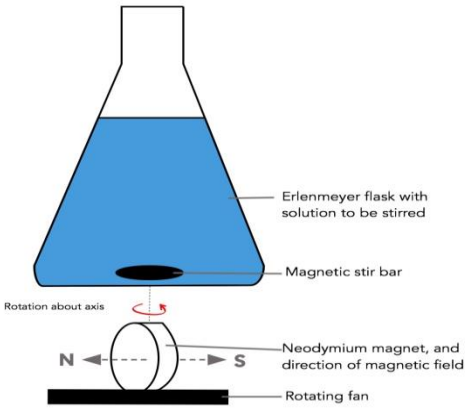

Fig.2 Magnetic Stirrer Setup

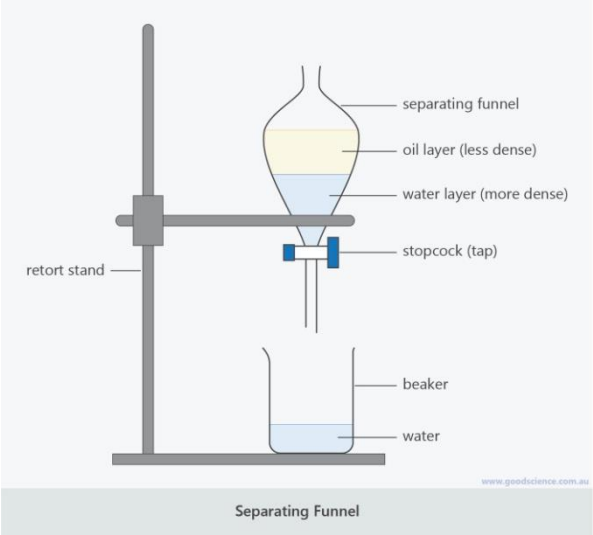

Fig.3 Separating Funnel

Table: 1 Engine Specification

General Details	Four Stroke, Compression, ignition, constant Speed, vertical, Air cooled Diesel injection
No. of Cylinder	1
Bore	87.5mm
Stroke	110mm
Swept Volume	661cc
Clearance volume	36.87cc
Compression ratio	17.5:1
Rated Output	5.2kW at 1500Rpm
Rated Speed	1500Rpm
Type of injection Pump	Mechanical

4. RESULT AND DISCUSSIONS

❖ **Performance Analysis**

Brake power Vs Indicated Power

The Fig.4 shows that indicated power increases with increase in Brake power. It is found that indicated power is always greater that brake power.

The graph clearly shows that indicated power is greater in advanced injection angle i.e., 270 BTDC.

This due to advanced fuel spray system and this induced due to fuel spray behavior in the engine which develops more power. And it is found that retarded injection system does not have that much of impact, the curve is lower in the graph, this due to fuel spray characteristics.

Table: 2 Fuel Specifications

Fuel Details	**Properties**
Blend Type Fuel	B2O
Density	848 kg/m3
Flash Point	56°c
Fire Point	58°c
Calorific Value	41600kJ/kg
Cetane index	50.5

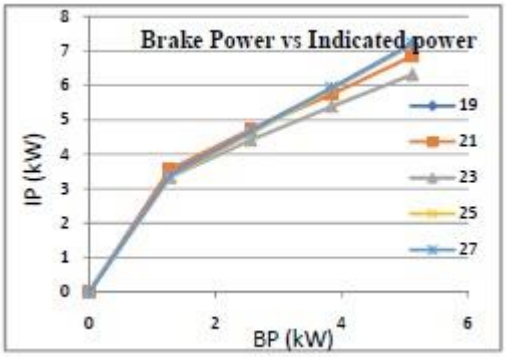

Fig.4 BP Vs IP

Brake Power Vs Specific Fuel Consumption

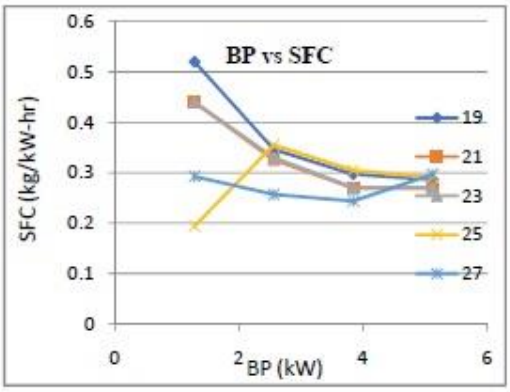

Fig.5 BP Vs SFC

The Fig.5 demonstrate the variation between Brake power and specific fuel consumption, It is very clear that specific fuel consumption decreases with increase in Brake power. Initially at CA 250 specific fuel consumption is very low at 25% of load but from the graph advanced spray angle is found to be very much economical, this is may be due the internal temperature of the engine is very high, and it requires very less amount of fuel to develop the power.

Brake Power Vs Brake Thermal Efficiency

The Fig.6 demonstrates the variation between brake power and the brake thermal efficiency. The graphical curves clearly shows that lower angled spraying system (19^0) exhibits lower efficiency compared to other degrees of injection units. Advanced such as 21^o, 23^o, 25^o and 27^o CA i.e., 27^0 BTDC have better efficiency compared to other injecting angle. This may due to advanced injection will have better atomization of fuel. There is a sudden reduction on full load due to cut down delay period reduces the peak pressure and decrease the thermal efficiency at full brake power.

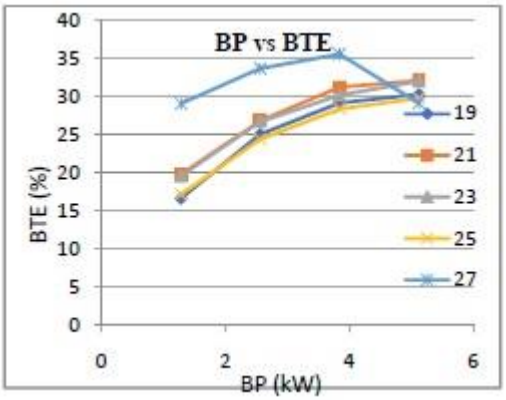

Fig.6 BP Vs BTE

Brake Power Vs Carbon Monoxide

The Fig.7 demonstrates the variation between brake power and percentage of carbon monoxide. The graphical curve shows that retarded injection angle at minimum load gives better result towards reduction of CO.

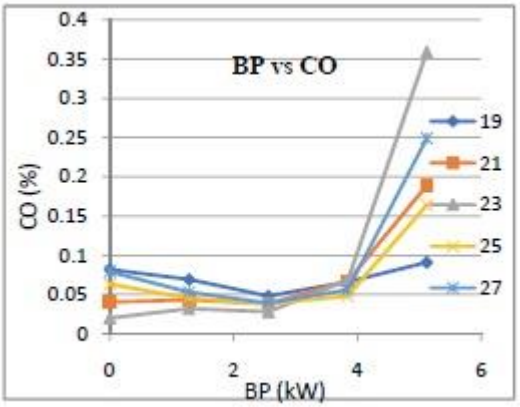

Fig.7 BP Vs CO

This may be due to complete combustion of fuel and better fuel spray characteristics. And in full load, the emission of CO is maximum at retarded injection angle (23º), it is due to incomplete combustion of fuel. Here in emission point of view injection angle 19^0 gives better results.

Brake Power Vs Oxides of Nitrogen

The Fig.8 demonstrates the variation between brake power and NOx. The curve clearly shows that NOx emission is slightly equal at minimum load to all injection angles. But in full load condition the emission is very less in retarded injection angle; this is due proper supply of air with less moisture content. In advanced injection angle NOx emissions are slightly higher due to enhanced pre combustion process and excess oxygen content in air fuel mixture and when engine reaches high temperature NOx emissions are slightly higher.

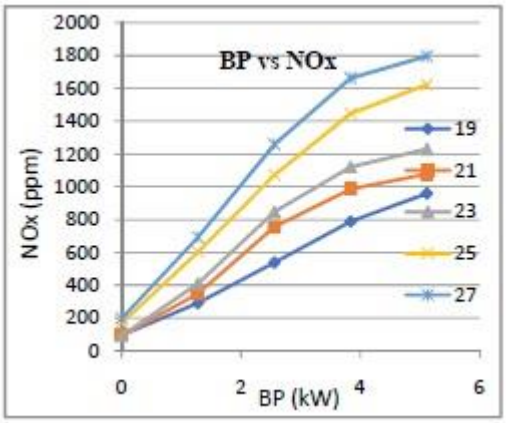

Fig.8 BP Vs NOx

Brake Power Vs Hydrocarbons

Initially at zero brake power advanced injection curve lie in satisfactory point. But in full load condition the curve reaches maximum. This is due to ignition delay causes incomplete combustion of fuel and due ignition lag, much quantity of fuel escape from crevice gap. In retarded injection angle emission remains very less.

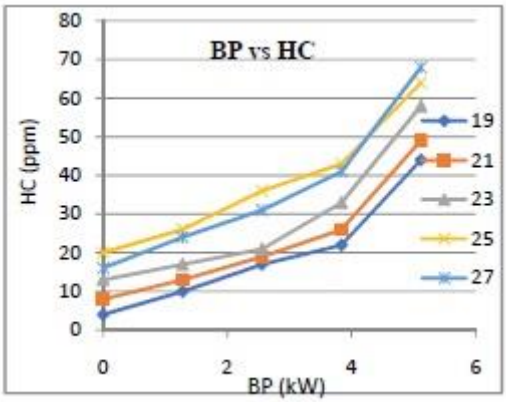

Fig.9 BP Vs HC

Brake Power Vs Smoke

The Fig.10 demonstrates the variation between brake power and smoke. From the graph it very clear that advanced injection have better emission content during all minimum loads and during advanced injection system at full load stage, the reaches maximum point. This is maybe due to incorrect air and fuel mixture at full load and poor quality of lubricating oil.

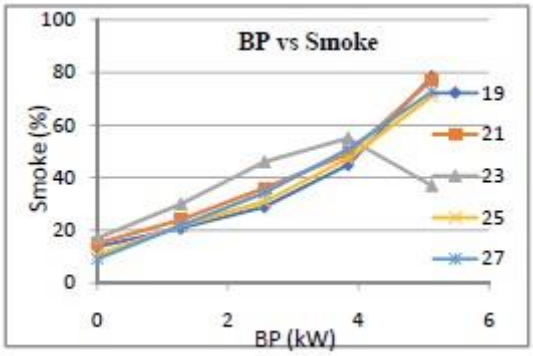

Fig.10 BP Vs Smoke

5. CONCLUSION

In this investigation, blend B20 was taken. B20 blend fuel was tested in the single cylinder four stroke diesel engines by varying the injection timing to find better performance and emission. The Properties of biodiesel were found and plotted the graph for performance and emissions. The result shows that, performance parameters like SFC and BTE are better in injection angle of 27^0 BTDC. And Emissions were found better in 19^0 BTDC. This study concludes that, the injection angle 27^0 BTDC was found better in performance point of view and in emission point of view 19^0 BTDC were found better. This blend can use directly at 200bar pressure and injection angle of 27^0 BTDC without any modification in engine.

- By using the biodiesel blend in diesel engine we can observe that emission can be controlled.
- Among the various injection timing 19^0, 21^0, 23^0, 25^0 & 27^0 BTDC, 27^0 BTDC were found suitable.

6. REFERENCES

[1] SRINATH PAI (2014): A Study on the effect of fuel injection timing on Diesel Engine performance and emission. (IJRST) 2014 Vol. No.4, Pages 70-84

[2] M. MANI (2009): Influence of Injection timing on Performance, emission and combustion characteristics of Diesel Engine running on waste plastic oil. (Energy) 2009 Vol. No. 34, Pages 1617-1623

[3] ANUSHA – Y. DATTA BHARADWAZ (2016): Improvement of biodiesel methanol blends performance in a variable compression ratio engine using response surface methodology. (Alexandria) 2016 Vol. No.55, Pages 1201-1209

[4] METIN GUMUS MUSTAFA CANAKCI (2017): The impact of fuel injection pressure on the exhaust emission of a direct injection diesel engine fuel with biodiesel- diesel fuel blends. (Fuel) 2017 Vol. No.95, Pages 486-494

[5] METIN GURU – ALI KESKIN (2016): Evaluation of biodiesel production, engine performance and emission. (Electronic Materials) 2016 Vol. No.45 Pages 3882-3888

[6] PRADEEP KALE (2017): Beef Tallow Biodiesel as an Alternative Transportation fuel. (ISSN) 2017 Vol. No.4 Pages 679-681

[7] AYHAN DEMIRBAS (2013): Biodiesel fuels from vegetable oils via catalytic and non – catalytic super critical alcohol transesterification and other methods. (Energy Conversion and Management) Vol. No. 44 Pages 2093-2109

[8] JIAN – CHIING – CHANG – CHEN (2012): Transesterification of soyabean oil to biodiesel using cement as a solid base catalyst. (Chemical Engineers) Vol. No.43 Pages 215-219

[9] PRATAP VORA (2018): Performance and emission to study direct injection timing. (Energy Conversion) Vol. No.45 Pages 699-711

[10] MUKESH PANDA (2017): Biodiesel using different mixture of diesel and the fuel. (Petroleum) Vol. No.28 Pages 183-188