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Synthesis and Characterization of Biodiesel from Animal Fat

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ABSTRACT
Biodiesel, an alternate and ecologically acceptable substitute for the conventional fuel, is usually produced from a wide range of edible vegetable oils, which are normally used for human consumption and whose prices are expected to increase in future. In this regard, reliable and low-cost raw materials have increasingly drawn interest for biodiesel production, such as by-products of the meat processing industries or waste animal fats. In present work biodiesel production from waste animal fats was carried out by Transesterification reaction. Animal fats in biodiesel production will cause biodiesel expenditures to be reduced. The present work also focusses on studying properties of bio diesel and performance characterization.

Keywords: *Bio diesel, Animal Fat, Esterification, Engine test, Transesterification reaction, biodiesel production*

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INTRODUCTION

The human society, with its expansion and high technological development, is very dependent on petroleum fuel for its activities. Nonetheless, non-renewable energy sources are non-sustainable assets, which take a huge number of years to shape with restricted stores and high costs. The generation and utilization of non-renewable energy source in motors with inward burning reason ecological issues, for example, rising carbon dioxide levels in the environment, expanding the normal encompassing temperature of the Earth. In outcome, a worldwide development toward the sustainable power sources is one approach to meet the expanded vitality needs of humankind.

In the gathering of interchange and naturally worthy substitutes for the customary energizes, biodiesel has pulled in an expanded consideration around the world. Next to numerous points of interest of biodiesel over diesel fuel, for example, inexhaustibility, prepared accessibility, movability, lower sulfur and fragrant substance, higher efficiency, higher cetane number, better outflow profile and more secure dealing with, the surprising expense of biodiesel creation is the principle explanation behind its constrained business application. The cost of crude material comprises of the 70% – 95% of the absolute biodiesel cost. Since biodiesel from nourishment grade oils isn't economically focused with oil based diesel fuel, it is important to utilize novel and lower-cost sleek feedstock for its generation. The utilization of shabby waste cooking oils, waste slick results from consumable oil greenery, non-consumable oils and waste animal fats can improve the generation economy of that supportable and biologically satisfactory item [8]. Before it very well may be acknowledged as biodiesel, item should meet stringent quality. Biodiesel comprises of a blend of fatty acid alkyl esters, got from sustainable lipid feedstock, for example, vegetable oils and animal fats, which are fundamentally triacylglycerols.

Palatable vegetable oils are usually utilized for biodiesel generation, yet waste animal fat are likewise reasonable lipid assets. Whenever methanol or ethanol are utilized in an overabundance as reactants in the Transesterification (alcoholysis) responses, a blend of fatty acid methyl esters.

Transesterification of Fat

Animal fats were trans-esterified with acid impetus and fundamental impetus with and without pre-esterification. Biodiesel of 89.0weight percentage ester content was obtained by acid-Transesterification. Weight percentage hydrochloric acid, 6:1 methanol: fats molar ratio, 60ºC, 48 hour. Pre-esterification conditions were studied for different fats and acid catalysts: 0.5 weight percentage hydrochloric acid or 1.0 weight percentage Tolueneslofnic acid, 6:1 methanol fats molar ratio, 65ºC and 4 hour made it possible to obtain fats with acid value less than 0.5% free fatty acid. Pre-treatment was effective for fats with different free fatty acid content. [1-3, 7]

Alkali Transesterification of esterified fats resulted in a product with 97.3 weight percentage ester content. Transesterification of the purified fat described above was conducted to convert the triglycerides to biodiesel. In this process, the recovered fatcontent was preheated to 100°C and cooled to room temperature to remove the traces of water present. A solution of methanol and potassium hydro oxide (as a catalyst) were added to the fat. The reaction mixture was refluxed at 60°C for 1 hour. Optimization of the Trans-esterification reaction was achieved by varying the amounts of methanol and potassium hydroxide [4–5].

After the Transesterification procedure, the response blend was permitted to cool to room temperature medium-term. The glycerol layer, which contains unreacted liquor and impetus, was isolated from the biodiesel. The top layer was then washed twice with warm water and with acidified water to expel the abundance methanol and the hints of impetus. The water washing step is proposed to evacuate any outstanding impetus, cleanser, salts, methanol, or free glycerol from the biodiesel Neutralization before washing lessens the measure of water required and limits the potential for emulsions to shape when the wash water is added to the biodiesel. After the wash procedure, any outstanding water is expelled from the biodiesel by a Vacuum streak process [7].

Production of Biodiesel

Production of biodiesel is produced, as mentioned in above Figure 1, through a process called trans-esterification. It is illustrated in Figure 2 which shows the reaction between a triglyceride extracted from animal fat (beef tallow or chicken fat), and potassium hydroxide, potassium hydroxide, which acts as a catalyst. The reaction is typically carried out at 60°C under vigorous stirring [6, 12–13].

The R1, R2, and R3 groups are long hydrocarbon chains that are also called fatty acid chains. Once the reaction completed, two different layers are formed: a light crude biodiesel layer at the top and a heavier crude glycerin layer at the bottom. Glycerin, the co-product of the reaction, can be refined to be subsequently used in the manufacture of a variety of products such as soaps and pharmaceuticals among others it was necessary to evaluate the best catalyst used to be Transesterification reaction in order to produce biodiesel.

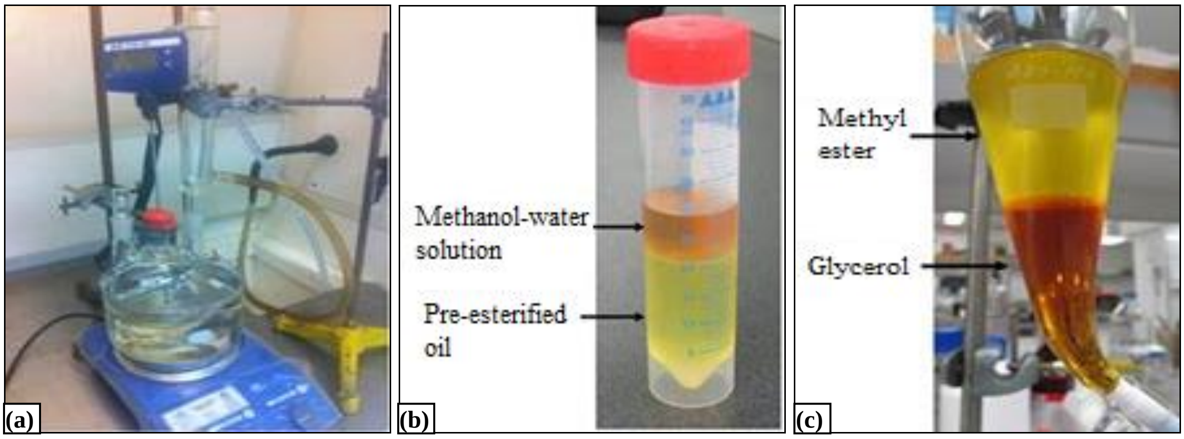


Fig. 1. *Production of biodiesel.*

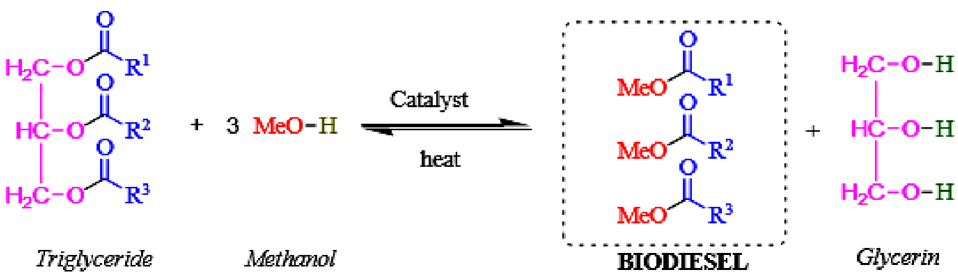


Fig. 2. *Chemical reaction.*

Experimental Setup

Exploratory setup Biodiesel is created from the triacylglycerol containing material by methods for a trans-esterification response. In this procedure, liquor (methanol/ethanol) and animal fats are blended in the molar proportion of 6:1, warmed at 60°C–65°C for 1hr and the Surrounding weight within the sight of impetus, for example, hydroxide and potassium hydroxide. Prior to that, Before that, animal fat gets warmed up to 105°C–110°C with the goal that it will be changed over into fat oil then in the different level base cup, liquor and sodium hydroxide and potassium hydroxide are blended exothermic response happen. This blender is at that point added to warmed fat and keeps it at 60°–65°C for 1hour after this, it is filled a bottle so that biodiesel and glycerol get isolated as appeared as follows. The technique is utilized for the planning esterification this biodiesel is utilized in diesel motor as dissolvable in ethanol-diesel blender for staying away from a stage detachment. The increasing percentage of biodiesel in ethanol-diesel blends results in the increase of emissions nitrogen oxides but it reduces the emissions of carbon monoxide, sulphur and particulate matter considerably.

Collection of fat

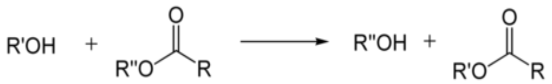
Fat for extracting the oil we can collect from meat shop. It is a waste product which will be throwing out. That will be in the form of thick flush. So we need to transform it into oil by heating [8].

Oil Extraction Process

The setup consists of heating mantle (induction) and ceramic pan. Approximately 1 Kg of animal fat was taken in a ceramic pan and started heating. Heater was set to 60˚C. As it get heated up the fat got melted and transformed into oil. When the maximum transformation took place we stopped heating and let it to be cooled. We need to filter the oil to remove all impurities and then we, moved oil into a bottle and stored. Then oil is measured, approximately 700 ml to 800 ml of oil was obtained.

Transesterification Process

Transesterification is the process of exchanging the organic group R″ of an ester with the organic group R′ of an alcohol. These reactions are often catalyzed by the addition of an acid or base catalyst.



(Alcohol + ester → different alcohol + different ester)

Free fatty acid test was conducted for fat oil and the value was found to be ranging from 8.5-15%. Based on this value, two step esterification process was selected and whole process is shown in in Figure 3.

Fatty Acid Test

The test was conducted by performing titration process. The burette was filled with 0.1 Normal NaOH up to 30ml level. A small 50 ml beaker was kept under the burette containing 10 gm of fat oil with alcohol and 5-6 drop of phenolphthalein indicator.

NaOH from the burette was allowed to flow into the beaker in a drop wise manner. This was continued till the colourless liquid in the beaker changes till a pale pink colour was permanently obtained. This is an indication that the titration process has to be stopped and NaOH consumed by the burette was measured and was decreased by 0.8ml. Free fatty acid value was then measured using the following formula.

Settling and Separation

Once the reaction is complete, it is allowed to settle for 10–12 hours in separating funnel. At this stage two major products are obtained; glycerin and biodiesel. The glycerin phase is much denser than biodiesel phase and settles down while biodiesel floats up as shown in Figure 4. The two were gravity separated with glycerin simply drawn off the bottom of the separating funnel.

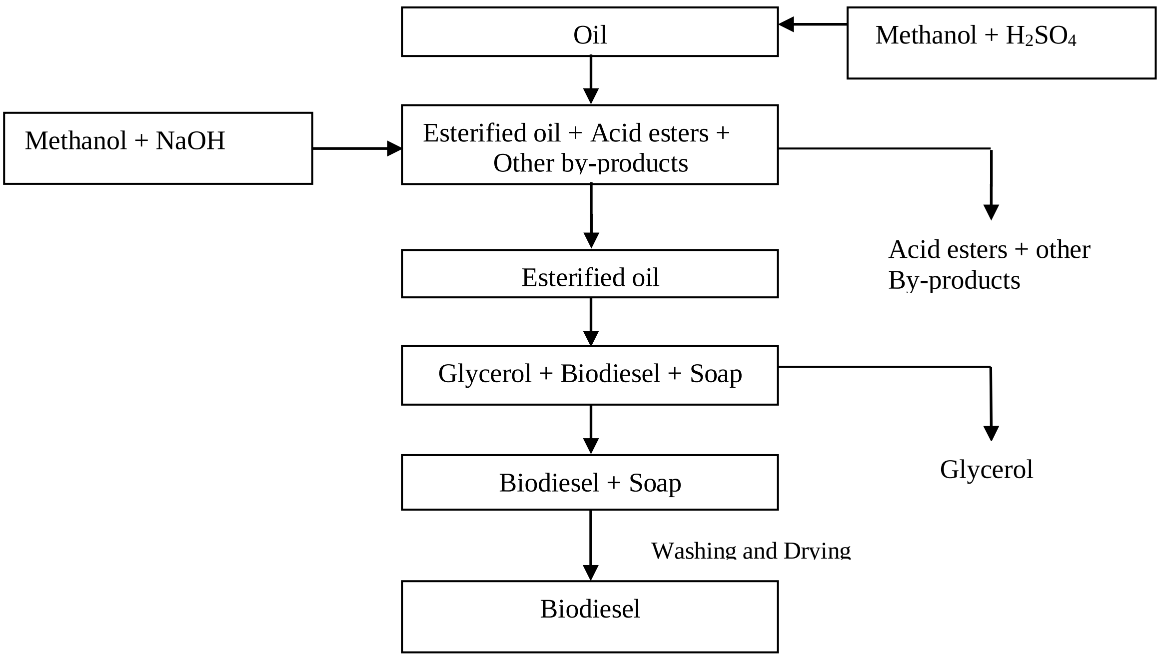


***Fig. 3.** Esterification process flow chart.*

***Fig.** 4. Settling of trans-esterified oil.*

Alcohol Removal

Once the glycerin and biodiesel phases were been separated, the excess alcohol in each phase was removed by distillation. In either case, the alcohol is recovered using distillation equipment and is re-used. Care must be taken to ensure no water accumulates in the recovered alcohol stream.

Methyl Ester Wash

Glycerin and alcohol were removed; the crude biodiesel was purified by washing gently with warm water around 20 times to remove residual catalyst or soaps. The biodiesel was washed by air bubbling method up to the clear water was drained out. This shows the impurities present in the biodiesel were completely removed Figure 5.

Drying of Biodiesel

This is the final production process to remove water content in the biodiesel to obtain a clear amber-yellow liquid with viscosity similar to petro diesel (Figure 6-7)

Engine Performance

Torque (N-m)

An engine's torque is the measure of its rotational force exerted to transmit power from the engine to the vehicle through the drive train. The torque and power produced by the engine can he measured using a dynamometer which is mounted to the engine as separate component. Torque can be improved by addition of engine cylinders or increasing capacity of the engine, although an increase in fuel consumption would be significant. Torque of an engine is the product of the force acting on the arm and the length of the arm. The product of the torque and the angular speed gives a power developed by the engine. The torque is given by

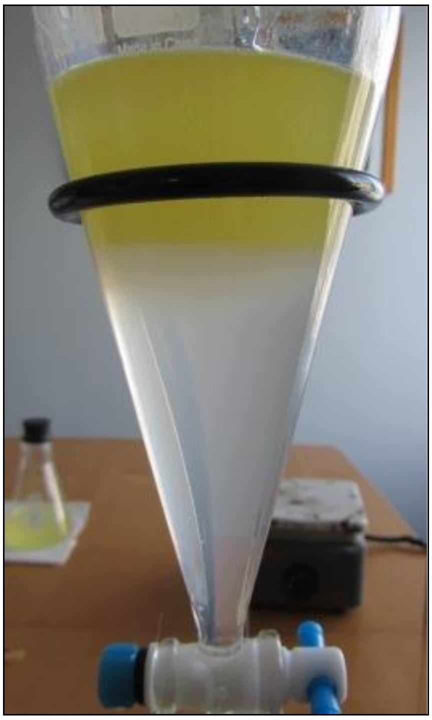


***Fig. 5.** Washing of biodiesel.*

***Fig. 6.** Drying of biodiesel.*

Fig. 7. *End product.*

$$\text{Torque } T = m \times g \times l \text{ N-m}$$

Where,
T = Torque in N-m
m = Mass in kg
g = Acceleration due to gravity which is 9.81 m/s^2
l = Length of the crank arm in m

Brake Power (kW)
The brake power is the power output delivered by the engine shaft. It is less than the indicator power since heat is lost to overcome the total friction generated in the engine which is summed as friction power. Friction power consists of pumping friction during intake and exhaust, mechanical friction in bearings, valves and components such as oil and water pumps. Brake power refers to the rate at which work is done and shows the maximum value when the engine speed is increased close to maximum before decreasing since friction becomes very significant at high engine speeds.

Brake power = Indicated power – Friction power kW

In a diesel engine, the brake power can be varied by changing the fuelling rate or A/F ratio to produce the desired BP. It can be obtained by

$$BP = \frac{2\pi NT}{60000}$$

N = Engine speed in rpm

Brake Thermal Efficiency (%)
Generally, an IC engine loses almost 42% of its energy to the exhaust system and further 28% to the cooling system. The engine thermal efficiency refers to the ratio of work produce per cycle to the amount of fuel input to the engine per cycle [8–11].

$$\eta_b = (BP \times 3600) / (m_f \times CV)$$

Where,
η_b = Brake thermal efficiency
m_f = Mass flow rate of fuel in kg/s
CV = Calorific value of fuel

Brake Specific Fuel Consumption (kg/kWh)
BSFC is the measure of fuel flow rate per unit power output and relates to the fuel efficiency of the engine. It is inversely proportional to the efficiency of the engine as lower values of specific fuel consumption are favorable for higher performance. BSFC is defined as, [10]

$$BSFC = m_f / BP$$

Volumetric Efficiency (%)
Volumetric efficiency is defined as the ratio of volume of air taken into the cylinder to the cylinder swept volume.

$$\eta_v = V_{air} / V_c$$

RESULTS AND DISCUSSION
Brake Specific Fuel Consumption (kg/kWh)
Brake specific fuel consumption (BSFC) is a measure of the fuel efficiency of any prime mover that burns fuel and produces rotational or shaft power. It is typically used for comparing the efficiency of internal combustion engines with a shaft output. It is the rate of fuel consumption

divided by the power produced. Its unit is kg/kWh and properties of biodiesel is shown in Table 1.

Table 1. *Properties of biodiesel.*

Property	Bio Diesel	B15	B20	B25
Density (kg/m^3)	850	850	850	850
Viscosity (cSt)	5.88	5.88	5.88	5.88
Calorific value (kJ/kg K)	43000	43000	43000	43000
Flash Point (C)	134	60	60	70
Fire Point (C)	139	65	65	75

The operations were carried out under full load and speed of 1500 rpm on a 4-stroke engine. It is observed that BSFC for all IPs decreases with increasing load as shown in Figure 8. This is due to higher percentage increase in BP with load as compared to increase in fuel consumption. This would be due to presence of oxygen in biodiesel and its blend that enable complete combustion and negative effect of increased viscosity.

Result show that fuel consumed for B10 blend at 200 bar pressure is lower than all other combination.

B10 at 240 bar is 0.28 kg/kWh as that of diesel is 0.27 kg/kWh.

Brake Thermal Efficiency

Brake thermal efficiency is defined as brake power of a heat engine as a function of the thermal input from the fuel. It is used to indicate how an engine converts the heat from a fuel to mechanical energy. The operations were carried out under full load and speed of 1500 rpm on a 4-stroke engine [10].

At 200 bar pressure B10 blend shows comparatively less BTE than diesel at same pressure. This is because of lower CV of fuel.

Biodiesel is more efficient then diesel because of oxygenated molecules and excess oxygen molecules as well as quantity of fuel injected at high IP.

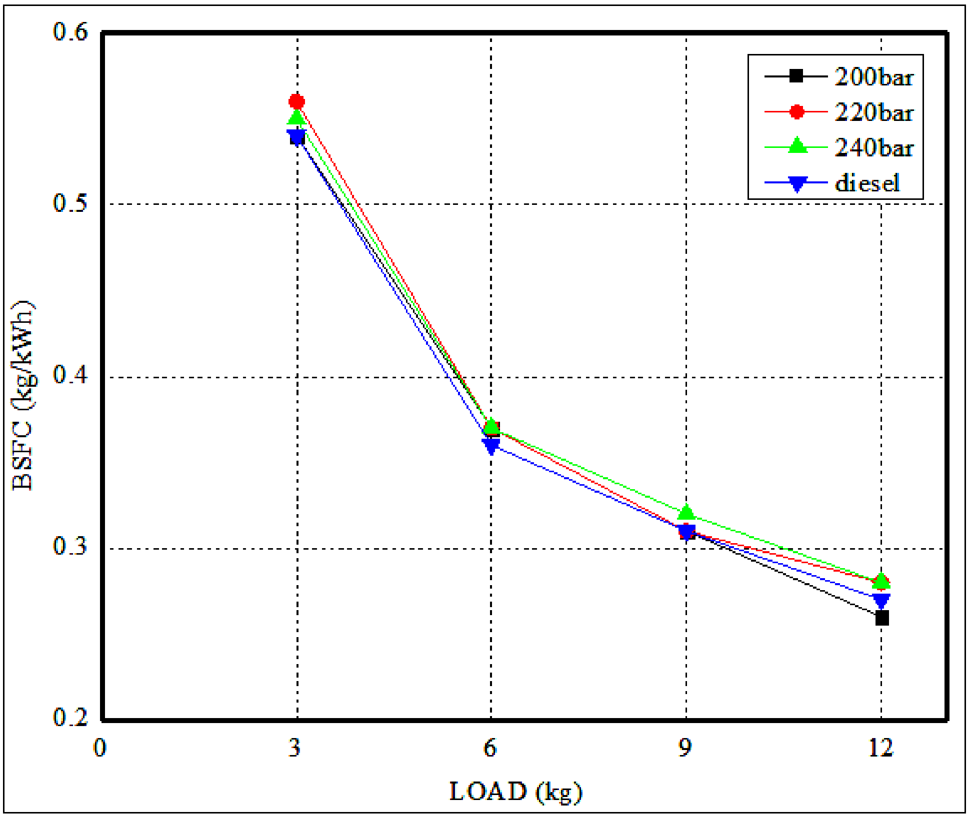


Fig. 8. *Bsfc V/S Load.*

At maximum load and 240 bar IP, B10 blend was found to be 31.79% compared to diesel which is 29.97% at standard conditions as shown in Figure 9.

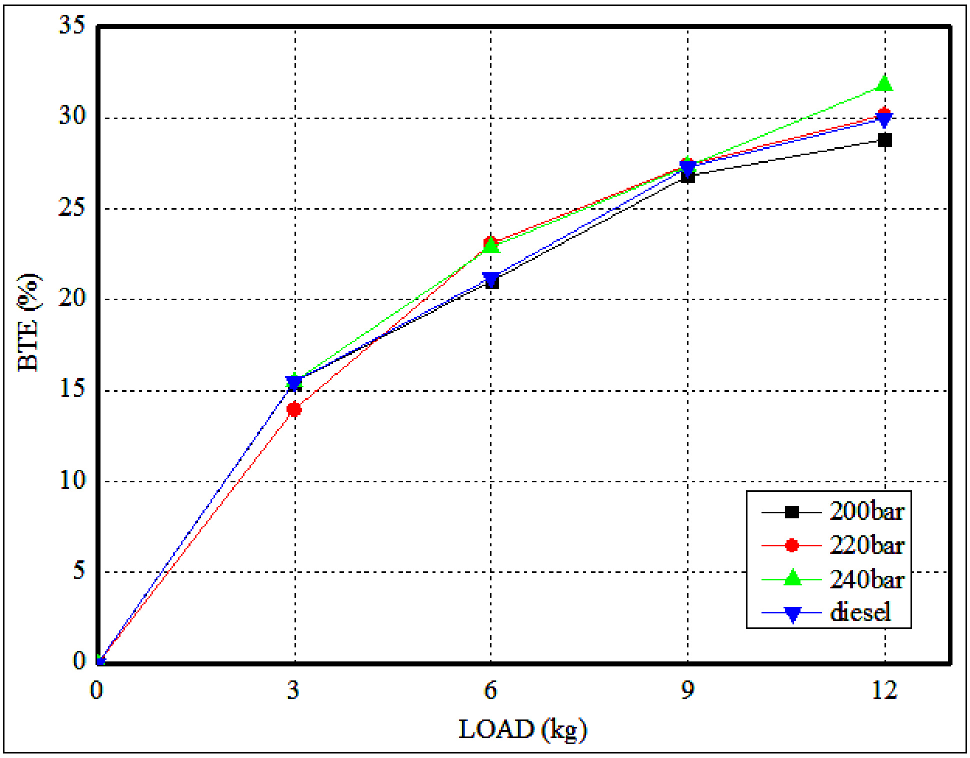


Fig. 9. *BTE V/S Load.*

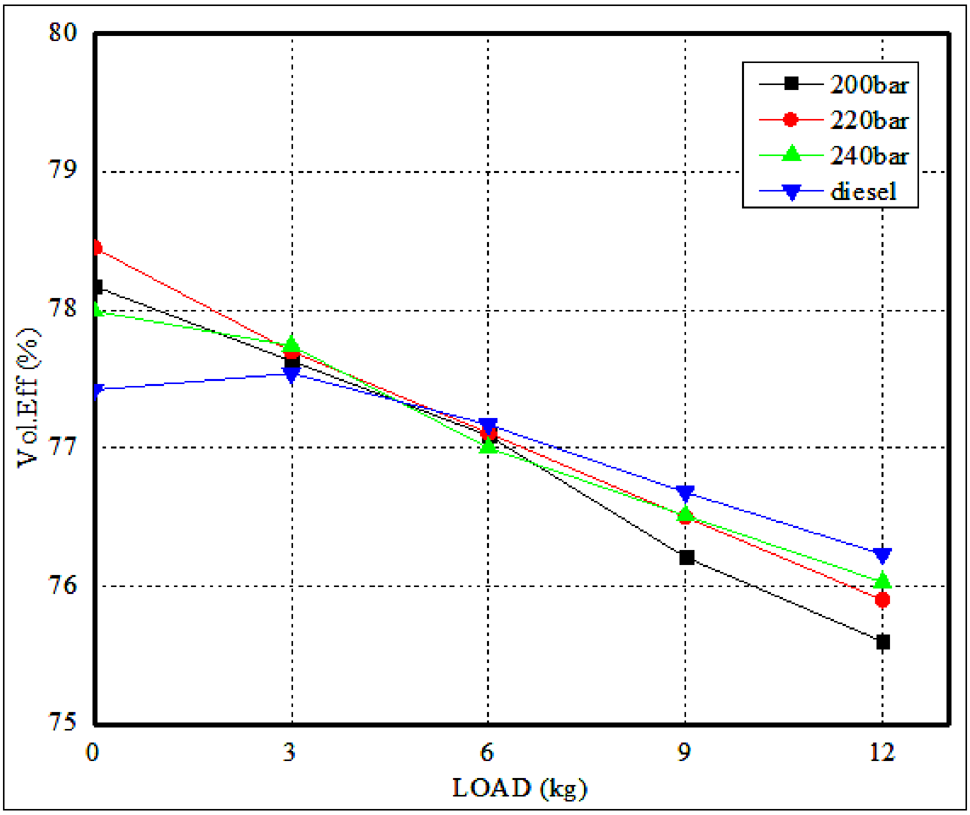


Fig. 10. *Volumetric efficiency v/s Load.*

Volumetric Efficiency

Volumetric efficiency is defined as the ratio of volume of air taken into the cylinder to the cylinder swept volume. The operations were carried out under full load and speed of 1500 rpm on a 4-stroke engine.

The volumetric efficiency increases with increase in engine load. This is due to less flow restrictions in air filter and intake manifold. This leads to increase in amount of air entering into the cylinder. The volumetric efficiency decreases with increase in biodiesel percentage in the blend because biodiesel fuel contains oxygen which decreases amount of air needed for complete combustion.

At maximum load condition, volumetric efficiency was found to be 76.23% for diesel and 76.03% for B10 at 240 bar IP as show in Figure 10.

CONCLUSION

- The production of biodiesel is one stage esterification process.
- The time required to produce the bio diesel is less.
- The density of bio diesel is 850kg/m^3 which is more than diesel that is 840 kg/m^3.
- The calorific value of bio diesel is 43000 kj/kg.
- Production cost of bio diesel is less.
- Properties of bio diesel from goat fat and its blends satisfy the ASTM Standards hence we can use bio diesel from goat and its blends as fuel in IC engine effectively.
- The thermal efficiencies of CI engine for all blends are found to be increased comparable to diesel and found to exist in narrow range.
- Can reduce the dependency on the fossil fuels like diesel, petrol etc.
- It gives solution for waste management as well as fossil fuel extension problems.

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