"PRODUCTION OF METHYL ESTERS FROM MILK SCUM, PERFORMANCE AND EMISSION ANALYSIS ON CI ENGINE"

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Abstract—
The present scenario of world fuel consumption is massive and still increasing. The main source of fuel is fossil fuel. Today with the rise in prices of crude oil, petroleum products are becoming increasingly difficult for a average man to reach, also with alarming levels of pollution and the fear of depletion of petroleum products it's become inevitable to explore new possibilities in fuel production sector. Initiating from this view point various sources were looked at for production of alternative fuels .Most of the raw materials like seeds, grass, bio mass have been in the line of successful experimentation. Hence a unique raw material that is the milk dairy wash water scum has been selected. By trans- esterification methyl ester can be obtained from the scum which can be blended with diesel to get a new form of bio diesel and the further study of its properties and performance on IC engines can be obtained.
Keywords: Biodiesel, milkscum, transesterification

1. INTRODUCTION

Due to decrease in petroleum resources and increase in pollution problems there is a need in increasing the alternative fuels. As there is a Continuous reduction in the fossil fuel day by day it has become more attractive to trap renewable energy sources. Currently biodiesel is prepared from oil like palm, sunflower soybean, canola, etc. throughout the world, which results in the food crisis of using food crops for producing biodiesel. In India around 150 million tons of Scum oil is produced per year. Thousands of large dairies are engaged in handling this milk across the country. Generally, a large diary process 5 lakh litres of milk per day ,which produce approximately 200-350 kg of effluent scum per day.

2.METHODOLOGY

2.1 TRANS-ESTERIFICATION PROCESS

1. The 5 kg scum collected was first purified by hand picking of coarse and floating impurities.
2. It was later heated till it reaches 100 degree centigrade to lose all it moisture contents and was strained which in turn filtered it.
3. After the filtration process 3.7kgs of purified scum/clarified butter was obtained.
4. 1 kg (1000ml) of purified scum was used for experimentation.


(A) Raw milk scum (B)Heating


(C)Removing floating impurities (D) Heating


E) Separation of oil & solid waste (F)Filtering


F) Pure milk scum (G)Heated refined milkscum
Figure: Stages Of Scum Filtration

The Trans-esterification process was carried out for the purified scum by a 2 stage process which involves

1.Acid catalyzed esterification.

2.Base catalyzed esterification.

2.1.1 ACID CATALYZED ESTERIFICATION Steps involved:

1. 750 ml of scum is heated to 50 degree centigrade.

2. Add 263ml methanol ,9ml sulphuric acid and 2ml Iso propyl alcohol into a beaker.

3. Transfer the heated scum to the round bottom flask of the esterification set up.

4. Pour the methanol and acid mixture to the other beaker in the set up.

5. Slowly allow the methanol acid mixture by opening the valve into the flask containing scum.

6. The magnetic stirrer stirs the mixture of scum, methanol and acid , there by does not allow the mixture to solidify.

7. The stirring is carried on for 60 to 120 minutes.

8. In a test tube a sample of mixture is taken and kept aside for few minutes to check if the FFA's are forming a separate layer on top.

9. If the FFA's form a separate layer the process is complete.

10. Pour the mixture in the flask to the settling flask and allow to settle for 15 minutes for the FFA's to form a separate layer.

11. Separate the FFA's layer from the remaining


Figure: scum, Methanol & acid mixture and Separation of FFA layer

2.1.2 BASE CATALYZED ESTERIFICATION Steps involved:

1. The product of acid catalyzed esterification obtained from is heated for 55 degree centigrade.

2. In a beaker add 123ml of methanol and 1.5 grams of KOH pellets and allow it to dissolve.

3. Transfer the heated scum to the round bottom flask of the esterification set up.

4. Pour the methanol and KOH mixture to the other beaker in the set up.

5. Slowly allow the methanol KOH mixture by opening the valve into the flask containing scum.

6. The magnetic stirrer stirs the mixture of scum ,methanol and KOH, there by does not allow the mixture to solidify.

7. The stirring is carried on for 60 to 150 minutes.

8. In a test tube a sample of mixture is taken and kept aside for few minutes to check if the glycerol is forming a separate layer in the bottom.

9. If the glycerol forms a separate layer the process is complete.

10. Pour the mixture in the flask to the settling flask and allow to settle for 15 minutes for the glycerol to form a separate layer.

11. Separate the glycerol layer from the remaining biodiesel.

Fig. Formation Of Glycerol Layer

2.1.3 WATER WASH

The biodiesel obtained is washed 4 times with water to remove the catalyst. If clear wash water is got back it indicates that the catalyst is not present in the biodiesel. This is later heated to 100 degree centigrade to get dry biodiesel which is free from moisture .Thus neat bio diesel is obtained.

Fig: Water washing of Bio Diesel and Heating Bio Diesel

2.2 PROPERTIES OF SCUM BIODIESEL

The blended fuel samples and biodiesel were tested for different chemical and physical properties. The first test conducted was the flame test for the produced biodiesel to make sure that it is in an hydrous form. This test was conducted with the help of a spirit lamp to check whether it burns without sparks and with a blue flame.

Second test was to find out calorific values of the blended fuel samples and also for regular diesel. This is done by testing 50 grams of fuel in a bomb calorimeter and directly obtaining the calorific value of the fuel.

The next test conducted was the viscosity test with the help of a Red Wood Viscometer for the blended fuel samples as well as regular diesel to check whether they hold good for ASTM fuel standards.

The fuel samples were also tested for the flash points. The results have been furnished below

FUEL BLENDS	FLASH POINT C	FIRE POINT C	Specific gravity	CALORIFIC VALUE (kJ/kg)	DENSITY (kg/m^3)	VISCOSITY (CP)
DIESEL	46	53	0.820	43125	844	3.5
B10	48	56	0.825	42591	833	3.3
B20	50	61	0.830	42057	834	3.35
B30	56	67	0.835	41523	836	3.38

2.3 EXPERIMENTAL SETUP FOR ENGINE PERFORMANCE TEST

The experimental setup of the present work with various components is shown in the figure. 5.19.

(1) Engine, (2) Dynamometer, (3)Shaft, (4) Flywheel, (5) Exhaust pipe, (6) Dynamometer control unit, (7) Gas analyzer, and (8) Fuel measurement system.

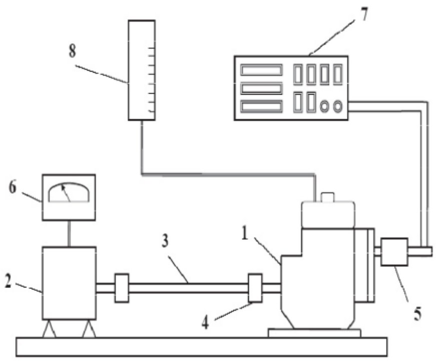

Fig.: The schematic diagram of the experimental set-up of Diesel fuel Engine test rig

Fig: Kirloskar Diesel Engine with sensing exhaust gas temperature

ENGINE AND DYNAMOMETER SPECIFICATION FOUR STROKE SINGLE CYLINDER DIESEL ENGINE TEST RIG

Make	Kirloskar
Capacity	3.7Kw
Compression Ratio	16.5:1
Cylinder Bore	80mm
Stroke	110mm
Cylinder capacity	553cc
Cooling	Water cooling
Electrical dynamometer	
Loading	Eddy current Dynamometer
Make	POWERMAG
Speed	1500rpm
Excitation Voltage	80v

3. RESULTS AND DISCUSSION

Worldwide, biodiesel is largely produced by methyl transesterification of edible and nonedible oils. The concept of methyl transesterification is gaining attention as ethanol is derived from renewable biomass sources. The studies were, therefore, conducted on methyl esters transesterification process for dairy scum biodiesel B100 and blends of different percent volumes of Biodiesel B10, B20, B30 were carried out. The fuel consumption test and rating test of a constant speed CI engine was also conducted to evaluate the performance of the engine on diesel and methyl esters of dairy scum biodiesel B100 and blends of different percent volumes of Biodiesel B10, B20, B30 In this chapter the characterization of fuel analyzed by drawing different graphs, some of the important properties like kinematic viscosity the density and calorific value of different blends on the addition of biodiesel, blends were also studied with comparing with the fossil diesel and 100% biodiesels. Also the engine performance and emission characteristics were also discussed and different graphs of showing the performance and emission characteristics were drawn and those graphs were analyzed in detailed.

3.1characterization of diesel, biodiesel blends.

The fuel characterization includes the fuel properties like viscosity, density, calorific value, flash and fire point etc.

In this experiment some of the fuel properties were analyzed and were discussed below.

3.1.1. SPECIFIC GRAVITY

The specific gravities Diesel , Biodiesel and blends are shown in graph. This test was carried at a temperature of 250c (ASTM standard). From the graph we can conclude that the specific gravities of the blends increase with the percent volume of biodiesel. The specific gravity of biodiesel is 0.880 and it is more than fossil diesel (0.820).

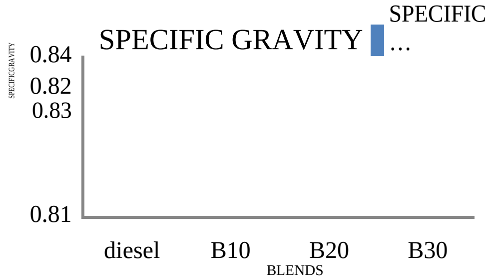

Figure: Specific Gravity Of Different Blends

3.1.2. Density

The density of Diesel, Biodiesel and blends are shown in graph. This test was carried at temperature of 150c (ASTM standard). From the graph we can conclude that the densities of the blends were less compared with fossil diesel as % of biodiesel increases the density increases slightly. The density of biodiesel is 0.880kg/m3 and it is more than fossil diesel (0.855kg/m3).

density
density
0.865

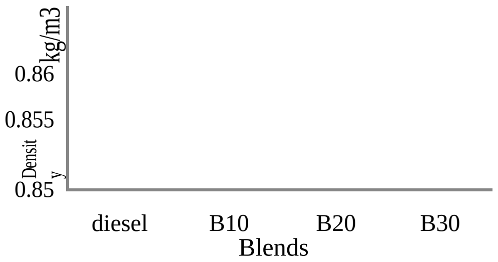

Figure: Density Of Different Blends

3.1.3. Calorific Value

The calorific Diesel ,Biodiesel and blends are shown in graph The CV of B100was found to be 37785.216 KJ/Kg and the CV of different blends were also determined according to ASTM standards. The CV of blends was found to be less than the fossil diesel (43125 KJ/KG).

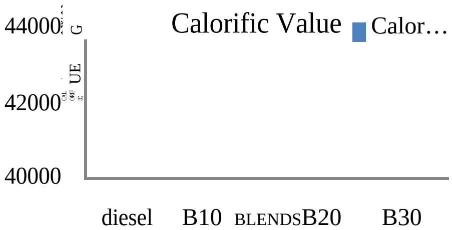

Figure: Calorific Value Of Different Blends

3.2. ENGINE PERFORMANCE AND EXHAUST EMISSION ANALYSIS

3.2.1. PERFORMANCE CHARACTERISTICS

3.2.1.1. BRAKE SPECIFIC FUEL CONSUMPTION

The results obtained pertaining to the performance of the engine are demonstrated with the help of graphs. The variation of Brake specific fuel consumption with load for diesel fuel, biodiesel and blends B10 ,B20, B30 and B40 is shown in the Fig

Figure: Variation Of Brake Specific Fuel

Consumption With Load

The variation of specific fuel consumption with respect to load is presented in Figure for different diesel–biodiesel blends. As the load increases, BSFC decreases for all fuel blends. At full load, B10 shows the lowest fuel consumption and is 0.279 kg/kWh .The BSFC of the blends B20,B30 and B100 at full load is 0.295 kg/kWh,0.282 kg/kWh and 0.324 kg/kWh, whereas for diesel it is 0.303 kg/kWh. At higher percentage of blends, the BSFC increases. This may be due to fuel density, viscosity and heating value of the fuels. B10 has higher energy content than B20, B30 and B60, but lower than Diesel. Lesser values of BSFC are apparently desirable.

3.2.1.2 Brake Specific Energy Consumption

The variation of Brake specific energy consumption with load for diesel fuel, biodiesel and blends B10, B20, B30 and B40 is shown in the Fig.

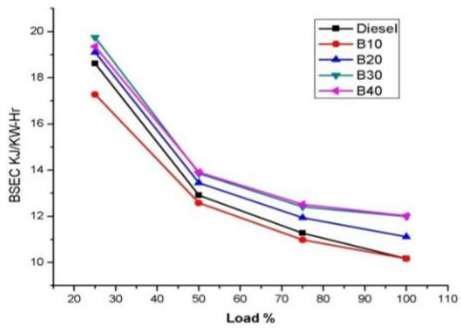

Figure: Variation Of Brake Specific Energy

Consumption With Load

Brake Specific Energy Consumption (BSEC) is an ideal variable because it is independent of the fuel. Hence, it is easy to compare energy consumption rather than fuel consumption. The variation in BSEC with load for all fuels is presented in Fig.. In all cases, it decreased sharply with increase in percentage of load for all fuels. The main reason for this could be that the percent increase in fuel required to operate the engine is less than the percent increase in brake power, because relatively less portion of the heat is lost at higher loads. The BSEC for B20,B30 and B40 blends was higher than that of diesel. This trend was observed due to lower calorific value, with increase in biodiesel percentage in blends. Here maximum BSEC was found in B40. The brake specific energy consumption for B10 was low for the lower blends as compared with the diesel. As the blend increses the BSEC will also get increses with decrese in the load.

6.2.1.3 BRAKE THERMAL EFFICIENCY

The variation of brake thermal efficiency with load for diesel fuel, biodiesel and blends

B10,B20, B30 and B40 is shown in the Fig

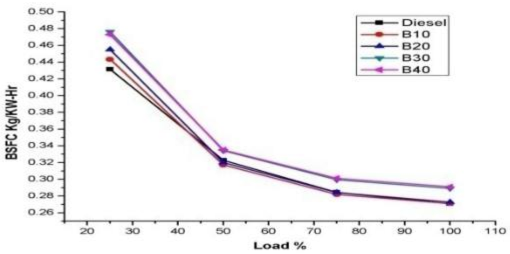

Figure: Variation of brake thermal efficiency with Load

Brake thermal efficiency is defined as the ratio between the brake power output and the energy of the oil/fuel combustion. The variation of brake thermal efficiency with load for different fuels is presented in Fig.. In all cases, it increased with increase in load. This was due to reduction in heat loss and increase in power with increase in load. It is observed that the maximum efficiency for B10 blend was higher BSEC as compared to diesel. It shows an comparable Performance with biodiesel addition of 10%. The brake thermal efficiency obtained for B20, B30, and B40 were less than that of diesel. The decrease in brake thermal efficiency for higher blends may be due to the combined effect of its lower heating value and increase in fuel consumption. This drop in thermal efficiency with increase in proportion of mixed biodiesel can be attributed to the poor combustion characteristics of the blends due to their relatively high viscosity and poor volatility that overcomes the excess oxygen present in the biodiesel and due to coarse spray formation and poor atomization and mixture formation of biodiesel during blending. This lower brake thermal efficiency obtained could be due to reduction in calorific value and increase in fuel consumption as compared to B10. Hence, this blend was selected as the optimum blend for further investigations and long-term operation.

3.3EMISSION CHARACTERISTICS

3.3.1 CARBON MONOXIDE EMISSIONS

The variation of Carbon monoxide Emissions with load for diesel fuel, biodiesel and blends B10,B20, B30 and B40 is shown in the Fig

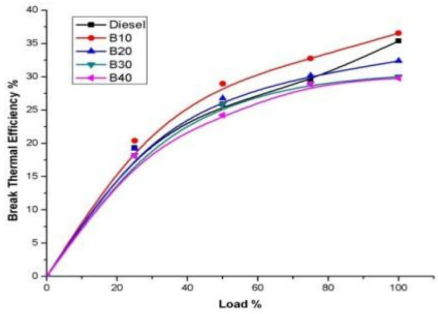

Figure: Variation of CO with Load Variation of CO emissions with engine

loading for different fuel is compared in Fig. The minimum CO produced was found by increasing blends of milk scum Biodiesel and it was observed that a reduction order as compared to diesel. Also It is observed that the CO emissions for biodiesel and its blends are lower than for diesel fuel. These lower CO emissions of biodiesel blends may be due to their more complete oxidation as compared to diesel. Some of the CO produced during combustion of biodiesel might have converted into CO2 by taking up the extra oxygen molecules present in the biodiesel chain and thus reduced CO formation. It can be observed from Fig. that the CO initially decreased with load and later increased sharply up to full load. This trend was observed in all the fuel blend tests.

3.3.2 HYDROCARBON EMISSIONS

The variation of Hydrocarbon Emissions with load for diesel fuel, biodiesel and blends B10,B20, B30 and B40 is shown in the Fig.

Figure: Variation of Hydro-carbon with Load The hydrocarbons (HC) emission trends

for blends of methyl esters oil and diesel are shown in Fig. B40 has least HC emission in all cases and in blends, B10 shows the lower HC emission compared to neat diesel at full load. The reduction in HC was linear with the addition of biodiesel for the blends tested. A reason for the reduction of HC emissions with biodiesel is the oxygen content in the biodiesel molecule, These reductions indicate a more complete and cleaner combustion. The presence of oxygen in the fuel was thought to promote complete combustion. There is a reduction from 70 ppm to 45 ppm was obtained resulting in B40 ,as compared to diesel at the maximum load.

3.3.3 CO_2 EMISSIONS

The variation of Carbon dioxide Emissions with load for diesel fuel, biodiesel and blends B10,B20, B30 and B40 is shown in the Fig.

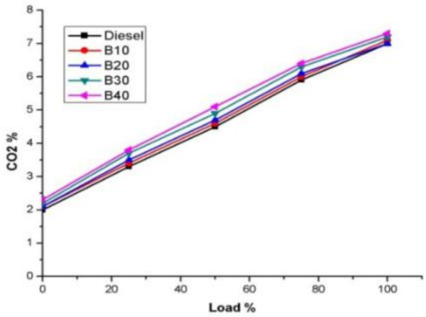

Figure: Variation of CO_2 v/s load

The carbon dioxide emission from the diesel engine with different blends is shown in Fig. CO_2 emission increases linearly as the load increases, which was higher than in case of diesel. the maximum CO_2 emission was found in B20 at full load because of complete combustion of fuel as compared to fossil diesel. The CO_2 emissions of all other blends were also higher than the conventional fossil diesel this is due to beacause of unburnt gases.

3.3.4 O_2 EMISSIONS

The variation of O_2 Emissions with load for diesel fuel, biodiesel and blends B10,B20, B30 and B40 is shown in the Fig.

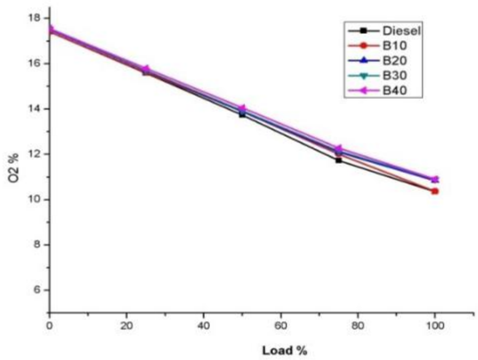

Figure: Variation of O_2 v/s load

For methyl ester and its blends, the graph indicated that the O_2 level is Comparatively higher in all blends compared to diesel. At all load condition, B40 shows increasing trend with diesel fuel. Level O_2 of for blends of was slightly in increasing order as blend ratio increased. This may be due to the fact that fuels are oxygenated. The fuel have more oxygen content inherent in itself may be the cause of higher O_2 level, compared to diesel. The higher O_2 level in fuel blends is always preferred.

3.3.5 NOX EMISSIONS

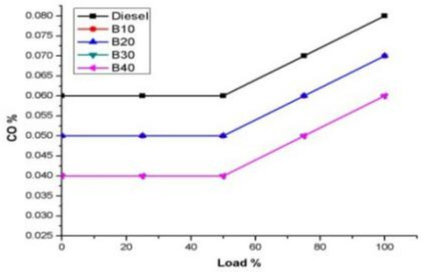

Figure: Variation of oxide of nitrogen with Load Above Figure indicates the NOx emission based on temperature trends for mixed biodiesel blends and diesel at different engine loads. The increase in the local temperature and the oxygen concentration within the fuel spray envelope at increasing power level favours the increase in NOx emissions. The NOx emissions of the blend were slightly higher than those of the diesel fuel at both full and partial loads. The higher temperatures of combustion and the presence of fuel oxygen with the blend caused higher NOx emissions.

The nitrogen oxides emissions formed in an engine are highly dependent on combustion temperature, along with the concentration of oxygen present in combustion products. By comparing all the Blends B10 was emit less oxide of nitrogen.

CONCLUSIONS

The overall studies based on the production, fuel characterization, engine performance and exhaust emission of Scum biodiesel and its blends B10, B20, B30 and B40 were successfully carried out. The following conclusions can be drawn:

1. The production of Scum biodiesel methyl esters is a two stage transesterification process.

2. Approximately 150 ml of methanol can be recovered

3. The time required to produce 860ml of biodiesel is 7 hrs and the blending stability time is 24 hours

4. Cost of one litre scum biodiesel = 44 rupees

5. The density of biodiesel is 0.880kg/m3 and it is more than fossil diesel (0.855kg/m3).

6. The CV of B100was found to be 37785.2166 KJ/Kg (9027caloyr/gram) and the CV of different blends were also determined according to ASTM standards. The CV of blends was found to be less than the fossil diesel (43125 KJ/KG).

7. The specific gravity of biodiesel B100 is 0.880 and it is more than fossil diesel (0.820).

8. The maximum BSFC was found in B40 and it is 23% higher than the diesel. The heat content of pure B40 was lower than diesel . Due to these reasons, the BSFC for blends ,namely B10, B20 and B30 were also higher than that of diesel.

9. The BSEC for all blends was higher than that of diesel. This trend was observed due to lower calorific value, with increase in biodiesel percentage in blends. The maximum BSEC was found in B40. Minimum BSEC was B10.

10. The maximum thermal efficiency is for B10 (2.7%) was higher than that of diesel.

11. The brake thermal efficiency obtained for B20, B30, and B40 were less than that of diesel.

12. The blend of 10% also gave minimum brake specific energy consumption. Hence, this blend was selected as the optimum blend for further investigations and long-term operation.

13. The minimum CO emission produced was found in B40 and it was observed that are reduction of 50%, as compared to diesel.

14. The HC emission shows a reduction from 70 ppm to 45 ppm was obtained resulting inB40and it is 35%, as compared to diesel at the maximum load.

15. CO2 emission increases linearly as the load increases, the maximum CO2 emission was found in B40 because of complete combustion of fuel as compared to fossil diesel

16. The biofuel have more oxygen content inherent in itself may be the cause of higher O2level, compared to diesel. The higher O2 level in fuel blends is always preferred.

17. The amount of NOx produced for B40 was found to be little higher when compared to diesel.

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