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Experimental Investigation of Performance and Emission Behavior of Biofuel Produced From Milk Scum: A Waste Product from Milk Processing Industry

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Abstract - *All over the world has experience the negative effect from the fossil fuel and global warming. Due to these factors there is a search for an alternative fuel. There are several preparation methods of producing alternative fuel. Among these techniques the Biodiesel preparation is one of the efficient methods in the preparation of alternative fuel. The principle used in the biodiesel preparation is the transterification process in which the Triglyceride is converted into glycerol and biodiesel in the presence of alcohol (OH group). In the present investigation milk scum is used to prepare the biodiesel. Milk scum is the bi- Product from the dairy waste. The experiment is carried out in single cylinder diesel engine fuelled with scum biodiesel at various blends like 10%, 20%,30% and 100% at different loading conditions the performance of the engine indicates break thermal efficiency, specific fuel consumption.*

Key Words: milk scum, transterification, biodiesel, diesel engine, specific fuel consumption

1. INTRODUCTION

Biodiesel is a best option for an alternative fuel for conventional petroleum based diesel because it can produced by the use of simplest transesterification reaction of the organic feedstock such as vegetable oils or animal fats. The benefits of biodiesel over to petroleum diesel is its low production cost, include reduction of most exhaust gas emission, high flash point, high cetene number and superior lubricity. It is nontoxic and essentially free of sulphur, aromatic compounds, metals & crude oil residues. Biodiesel can be used in its pure form or can be blended with diesel to form different blends. It can be used in diesel engines with very little or no engine modifications. This is because it has properties similar to mineral diesel.

Due to the problems of fuel crisis and environmental pollution, the survival of these engines has been threatened. Therefore to protect the global environment, it's become necessary to search an alternative energy source. Alternative fuel derived from vegetable oil and animal fat have increasingly important due to decreasing petroleum resources and increase in pollution problems. Bio-diesel is a cleaner fuel than petroleum diesel and an exact substitute for existing compression engines. Biodiesel has received much attention in the past decade due to its ability to replace fossil fuels, which are likely to run out within a century. Especially, the environmental issues concerned with the exhaust gases emission by the usage of fossil fuels also encourage the usage of biodiesel, which has proved to be eco-friendly far more than fossil fuels. Biodiesel is a biodegradable and nontoxic diesel fuel consisting of long polymeric chains of alkyl esters. Biodiesel is an alternative fuel that can be used in late-model (after 1992) diesel engines without any need to modify the engines beforehand. Biodiesel can be produced from straight vegetable oil, animal oil/fats, tallow and waste cooking oil, milk dairy wash water scum.

Biodiesel can be used in its pure form or can be blended with diesel to form different blends. It can be used in diesel engines with very little or no engine modifications. This is because it has properties similar to mineral diesel. Biodiesel is known as a carbon neutral fuel because the carbon present [1, 2] in the exhaust was originally fixed from the atmosphere. Biodiesel can be used in its pure form or can be blended with diesel to form different blends. It can be used in diesel engines with very little or no engine modifications. This is because it has properties similar to mineral diesel. Biodiesel is a nonpetroleum-based fuel defined as fatty acid methyl or ethyl esters derived from vegetable oils or animal fats and it is used in diesel engines and heating systems.
In the present study preparation of biodiesel from milk scum and its properties has been studied. The waste Milk scum is collected from the dairy industry and for the experimental purpose

2. MATERIAL & METHODS:

2.1 Raw Material

The milk scum is heated and filtered to remove waste particle like sand, packing materials, insects and other impurities present in the scum. After filtering we will be getting orange colour thick oil. From 3kg of scum about 1 litre scum oil was extracted. The free fatty acid of the oil was found to be high.

Fig -1: Waste milk scum & Scum oil

2.2 Methodology:

The basic principle used in the production of Biodiesel is trans esterification process. Before the trans esterification process the FFA (Free fatty acid) test has been carried out for the each oil. To find acid number of the given scum oil, the titration have been carried [3, 4] out by using KOH and phenolphalithe indicator. The FFA value is found to be 2.495. In order to decrease the fat present in the scum oil, two step trans esterification process has been carried out.

3. TRANSESTERIFICATION PROCESS:

3.1 Scum oil:

Since the FFA value is higher, it should follow the two step process (acid esterification) of trans esterification process. In acid esterification, 1liter blended oil is heated to about 50°C, and 150 ml methanol and 2% H2SO4 added and stirred at a constant rate with 65 °C for about one and half hour. After the reaction is over, the solution is allowed to settle for 24 hours in a separating funnel. The formation of layers takes place. The top layer formed is excess alcohol along with sulphuric acid and impurities which is removed. The lower layer is taken for the second step [5-7] (alkaline esterification). In alkaline catalyzed esterification, the lower layer product of first step is again heated to about 65 to70°C. To this mixture, 6.5g NaOH dissolved in 150 ml methanol is added and stirred for one and half hour. After the completion of reaction, the solution is again allowed to settle for 24 hours. The glycerin settles at the bottom and esterified blended oil rises to the top. This esterified blended oil is separated and washed with warm water. After purification the final product is heated up to 120°C for 30 minutes and then cooled to the room temperature. Thus the scum oil biodiesel is obtained.

4. EXPERIMENTAL SETUP

The specifications of the engine used for the experimentation is given in the Table 1& the specifications of the alternator coupled with the engine is given in the Table 2

Table -1: Engine Specification

Engine Specification	
Make	Kirloskar
Speed	1500 RPM
No. of cylinder	One
Bore	80mm
Stroke	110mm
Rated output	3 kW

Table -2: Alternator specification

Alternator Specification	
Make	Himalaya
Type of power	A.C
Power	4 kVA
Volts	230 volts
Phase	single phase
Speed	1800rpm
Frequency	50 Hz

A single cylinder four stroke diesel engine is coupled with the alternator having the provision of electrical loading. The specifications of the engine and the alternator are given in the Table I and II respectively. Continuous water supply is given to the engine for the cooling. The air box with an orifice meter and water manometer is used to measure the flow rate of air supplied to the engine. The volumetric flow of fuel is measured using burette and a stop watch. [10, 11]

Fig -2: Photograph of Experimental engine and alternator

5. RESULTS AND DISCUSSION

In this section the performance characteristics of a high speed diesel engine at various loads with Scum biodiesel and compared with standard diesel. The various fuel properties has been analyzed [8,9] for the prepared biodiesel as per the ASTM standards and its given below

Table -3: Biodiesel Table Properties

S.No	Properties	Scum oil
1	Viscosity at 40°C	3.7
2	Specific gravity	0.87
3	Calorific value (kj/K)	39,940
4	Flash point(°C)	132
5	Fire point	150
6	Cloud point(°C)	4
7	Pour Point	5

5.1 BRAKE SPECIFIC FUEL CONSUMPTION (BSFC)

Figure 3 shows the variation of specific fuel consumption with load. It is found that as load increases the brake specific fuel consumption decreases for both diesel & Scum biodiesel. BFSC decreases for all biodiesel blends.B10 shows the lowest fuel consumption at full load condition is 0.277kg/kWh, where the BSFC of the blends B20,B30 and B100 are 0.296kg/kWh, 0.283 kg/kWh and 0.323kg/kWh at full load condition respectively. Due the viscosity, fuel density and the heating value of the higher blended fuels the BSFC increases the biodiesel blend of B10 has higher energy content B20, B30 and B60 but the lower than diesel.

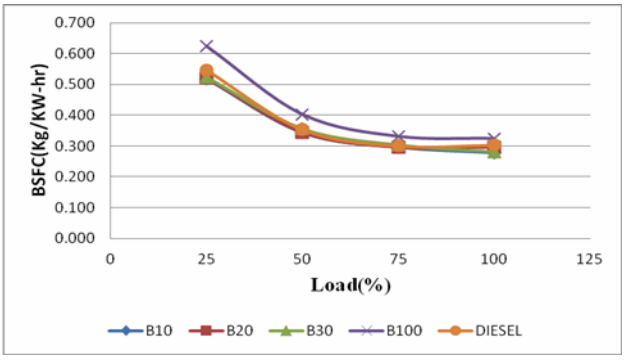

Fig -3: Variation of brake specific fuel consumption with load

5.2 BRAKE THERMAL EFFICIENCY (BTE)

Figure 4 shows the variation of brake thermal efficiency with load. It is found that with increase in load the brake thermal efficiency is also increasing for both diesel & scum biodiesel. This is due to the reason that at higher loads complete combustion tends to take place, thus lesser amount of fuel is required to deliver unit power. The break thermal efficiency at full load is 31.5 for B30, which is higher than the diesel brake thermal efficiency. The break thermal efficiency for diesel, B10,B20 and B100 are 30.02%, 28.49% and 27.43% if the load increases the break thermal efficiency also increases for the all the blends. For the higher blends BTE has been increased due to the combined effect of its lower heating value of the higher blend.

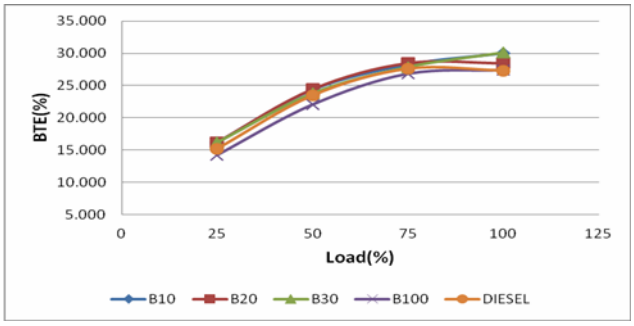

Fig -4: Variation of brake thermal efficiency with load

5.3 Exhaust gas temperature (EGT)

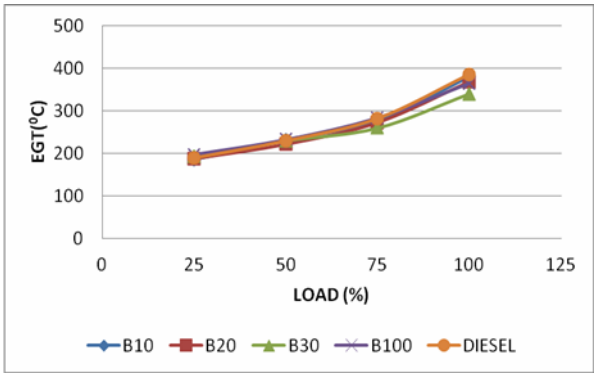

Fig -5: Load v/s Exhaust gas temperature

The figure 5 shows the EGT for the various biodiesel blend which indicate that the EGT has decreased for different blend than that of diesel. The highest temperature is 3586°C

for the diesel at full load condition, while the temperature is 380˚C, 342˚C and 368˚C for the biodiesel blends B10,B20 and B30 respectively. This happens due to the lower calorific value of the biodiesel blend compare to diesel.

5.4 Hydrocarbon (HC)

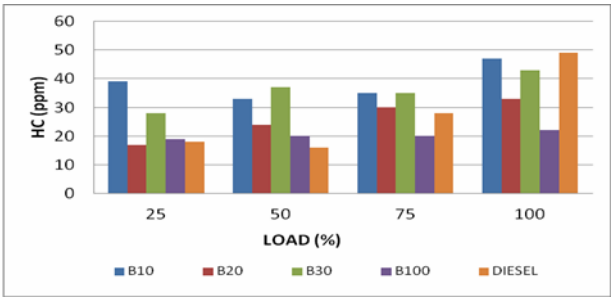

Fig -6: Load v/s Hydrocarbon

The unburned hydrocarbon emissions results in the incomplete combustion the fig. 6 indicates the variations of hydrocarbon for the different biodiesel blend. Among all the biodiesel blends B100 has lower HC emission compare to diesel at full condition this due to the oxygen content in the biodiesel molecule which kindle the clean combustion process.

5.5 Oxides of Nitrogen (NOx):

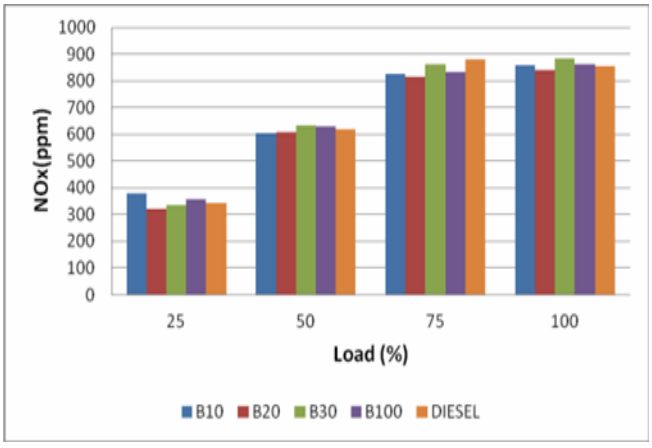

Fig -7: Load v/s Oxides of Nitrogen

From the figure 7 indicates that 50% of load NOx emission which lower for the B20 Biodiesel blends than that of diesel. At full load condition NOx emission B10, B30 is higher than that of diesel, where NOx emissions for other biodiesel blend is closer to the diesel. The NOx emission of the diesel and blend B10, B20 is 605ppm, 608ppm and 620ppm respectively.

5.6 Carbon Monoxide (CO)

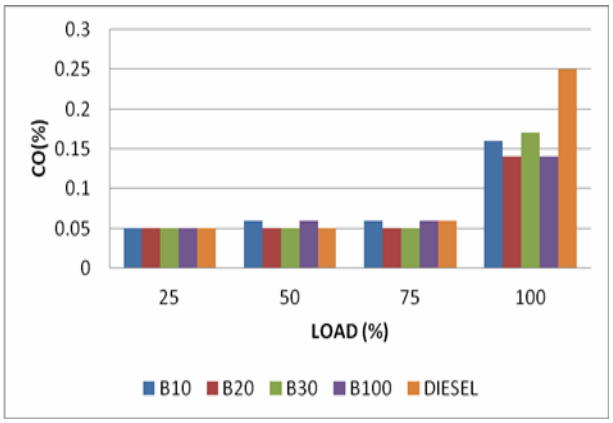

Fig -8: Brake Power v/s Carbon monoxide

The figure 8 shows the CO emissions for the diesel and other biodiesel blends. The CO increases due to the rise in the combustion chamber temperature, chemical properties of the fuel, air fuel ratio lack of oxygen and higher speed.

6. CONCLUSIONS

The biodiesel of scum have been analyzed by ASTM standards. The composition of biodiesel was determined by physical properties as viscosity, flash point, fire point and acid number this properties are tested.

- The performance of the engine with biodiesel blend has not provide, grate change than diesel fuel, among the various biodiesel blend B20 show the significantly better results, but there is a little increase of consumption of biodiesel .

- The major pollutants such as HC & CO have been reduced by using neat biodiesel blend and NOx emission, increase. As the milk scum is the by product from diary industry it can replace the diesel.

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