Production of Biodiesel From Hybrid Oil (Dairy Waste Scum and Karanja) and Characterization and Study of Its Performance on Diesel Engine

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***Abstract*— Depletion of petroleum derived fuel and environmental concern has promoted to look over the bio fuel as an alternative fuel source. But a complete substitution of petro diesel by bio fuel is impossible with the use of edible and non edible oil; hence, in the present study dairy waste scum oil and karanja oil (in equal quantities) is used to produce hybrid oil biodiesel by transesterification process using sodium hydroxide as catalyst. This way of using dairy waste scum reduces the cost of production of bio-diesel and the problem related to the disposal of dairy scum. Karanja seeds are the other raw material used which is economical and easily available around. The physiochemical properties of hybrid oil biodiesel (HOBD) is studied and compared with scum oil biodiesel (SOBD) and karanja oil biodiesel (KOBD). Tests have been conducted at different blends of biodiesel with standard diesel on a four stroke diesel vertical single cylinder engine, modelTAF1 produced by kirloskar oil engines. This engine has a compression ratio of 17.5:1, and its performance is studied.**

Keywords*— Biodiesel, diesel engine, hybrid oil, transesterification, performance

I.INTRODUCTION

Fuels derived from renewable biological resources for use in diesel engines are known as biodiesel [10]. Biodiesel is environmentally friendly liquid fuel similar to petrol-diesel in combustion properties. Due to few strategies like, the rising population, and the growing energy demand from the transport sector, bio fuels can be assured of a significant market in India [22]. Since no food producing farmland is required for producing the non edible bio fuel, it is considered the most politically and morally acceptable choice among India's current bio fuel options. Biodiesel is rapidly replacing both kerosene (which was used illegally and inefficiently) and diesel as a more efficient, cheap, and clean alternative for large engines.

Biodiesel is a biodegradable and nontoxic diesel fuel consisting of long polymeric chains of alkyl esters [14, 16]. Biodiesel contains no petroleum, but it can be blended at any proportion diesel fuel to be used in diesel engines with little or no modification [23, 25]. Fuel grade biodiesels are produced through the transesterification process conforming to strict specifications such as ASTM D6751 in order to ensure proper performance and quality [17].

The 'National Bio fuel Policy' aims to meet 20% of India's diesel demand. Biodiesel-blends are being used to run state transport corporation buses in Karnataka. The Karnataka government has distributed several million saplings of Pongamia to farmers for planting along borders of farmland and in waste lands.

Annual production of milk in India is 150 million tons per year. Thousands of large dairies are engaged in handling this milk across the country. In large dairies while cleaning the equipments, the residual butter and related fats which are washed and get collected in effluent treatment plant as a scum [15, 19]. A large dairy, which processes 5 lakh liters of milk per day, will produce approximately 200–350 kgs of effluent scum per day, which makes it difficult to dispose [26].

Pongamia pinnata is a non-edible species capable of growing in almost all types of land. In India the estimated oil from seeds is about 50,000 tones. The yield from a single tree would be around 25 to 100 kg of seed containing around 30 to 40% of oil [10]. This karanja seeds is found abundantly in tropical and subtropical areas and also at a cheaper rate.

II.MATERIALS AND METHODOLOGY

A. Materials:

Scum:

The Milk Scum is a waste product (effluent) obtained from the wash water of the milk dairy. The Milk scum is produced by the sequential order of processes involving dairy wash water collection and its treatment in Effluent treatment plant (ETP). The Milk scum was collected from the Karnataka Milk Federation, Mallasandra, Karnataka. The milk scum was heated and filtered to remove waste particle like sand, packing materials, insects and other impurities present in the scum. Thus the scum oil is made ready [23].

Karanja:

Pongamia pinnata is a non-edible species capable of growing in almost all types of land. Pongamia pinnata is a species of family Leguminasae, native in tropical and temperate Asia including part of India, China, Japan, Malaysia and Australia. Commonly it is called as Indian Beech, karanja (in Hindi), pongam (in Gujarat), Honge (Kannada), Pungai (Tamil), Kānuga (Telugu), Naktamāla (Sanskrit). Pongamia pinnata is one of the promising feedstock suitable for providing oil for biodiesel production, which conforms to international standards. This tree species is found to be well spread through out India, excluding temperate regions. Pongamia seeds are known to contain 30%-35% oil. The seed cake available after oil extraction is used as organic fertilizer. The good seeds are selected and are taken for oil extraction. The oil can be extracted by mechanical expeller and by soxhlet extraction method.

Mixture of Karanja and Milk Scum Methyl Ester was made by mixing of produced karanja oil and Milk Scum oil in equal proportion on weight basis.

B.Preparation of blended biodiesel:

The Karanja oil and the milk scum oil has been blended using stirrer at a high temperature of about 120°C for about an hour. Then the oil is tested for free fatty Acids (FFA). Since the FFA is found slightly higher a two step transesterification process is chosen to convert the non-edible blended oil to its methyl ester. The first step acid catalyzed esterification reduces the FFA value of the oil to about 2%. The second step, alkaline catalyzed transesterfication process converts the products of the first step to its mono-esters and glycerol.

In acid esterification, 1liter blended oil is heated to about 50 °C, to this oil 150 ml methanol and 2% H_2SO_4 is also 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 (alkaline esterification). In alkaline catalyzed esterification, the lower layer product of first step is again heated to about 65 to 70 °C. To this mixture, 6.5 g 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 blended (karanja+ Scum) biodiesel is obtained.

III. RESULTS TABULATION

A. Comparison of Hybrid oil biodiesel (HOBD) properties with karanja oil biodiesel (KOBD) and scum oil biodiesel (SOBD).

Table 1. Comparison of fuel properties with ASTM standards

Sl No	Table Properties	HOBD	SOBD	KOBD	Protocol
1	Viscosity at 40°C(Cst)	4.1	3.7	5.6	ASTM D445
2	Specific gravity	0.88	0.87	0.89	ASTM6751
3	Calorific Value(kj/kg)	39,428	39,940	36,601	IS:1448(P6)
4	Flash Point(°C)	155	132	168	IS:1448
5	Pour point	7	5	6	IS:1448(P10)
6	Cloud Point(°C)	15	4	8	IS:1448(P10)
7	Carbon residue(Rams bottom) %w/w	Nil	Nil	Nil	IS:1448(P8)
8	Ash, %w/w	Nil	Nil	Nil	IS:1448(P4)

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 3 Issue 7, July - 2014

B. Engine Performance:

Brake specific fuel consumption (BSFC):

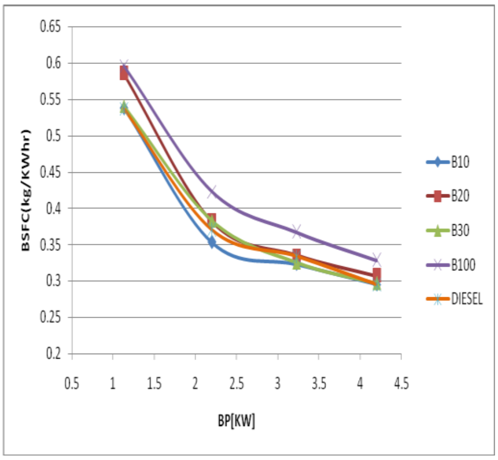


Fig.1Variation of BSFC with BP

Brake thermal efficiency (BTE)

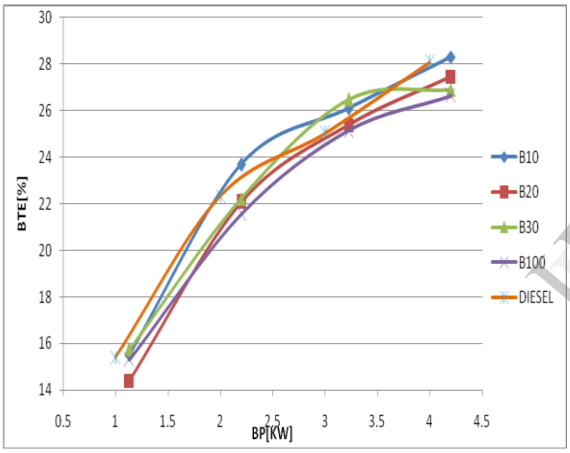
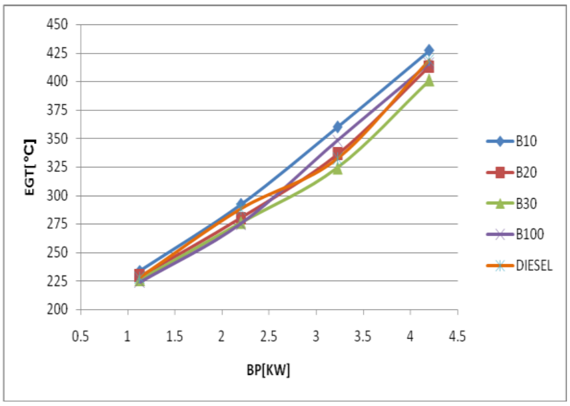


Fig.2 Variation of BTE with BP

Exhaust gas temperature (EGT)



Fi g.3 Variation of EGT with BP

C. Exhaust Emissions:

Emissions are major criteria in selecting engine fuel. This section will focus on characterizing the emission behaviour of the engine under the different brake powers.

Hydrocarbon (HC) Emission

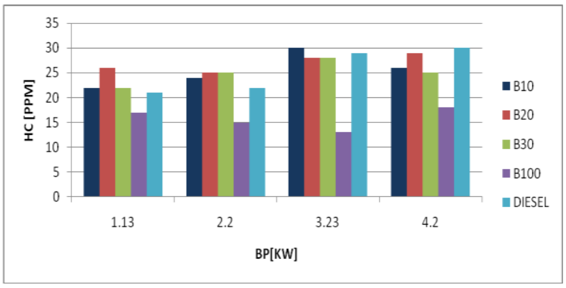


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Fig.4 Variation of HC(ppm) with BP(KW)

Carbon Monoxide (CO)

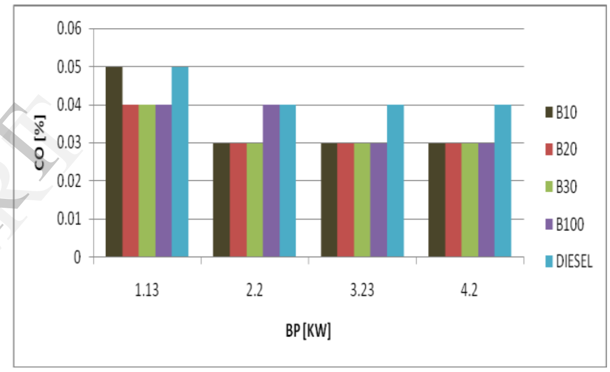

Fig.5 Variation of CO(%) with BP (KW)

Oxides of Nitrogen (NOx)

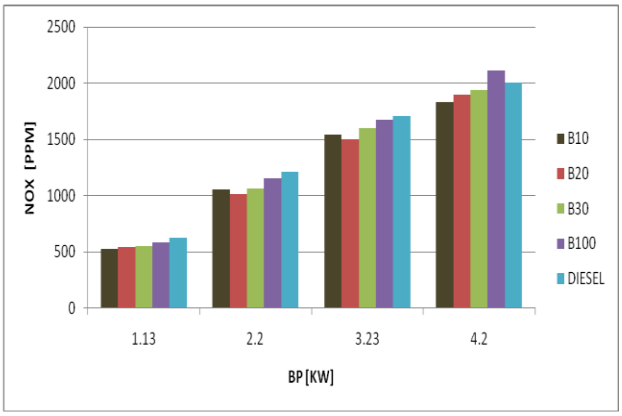

Fig.6 Variation of NO_X (PPM) with BP (KW)

Carbon Dioxide (CO2)

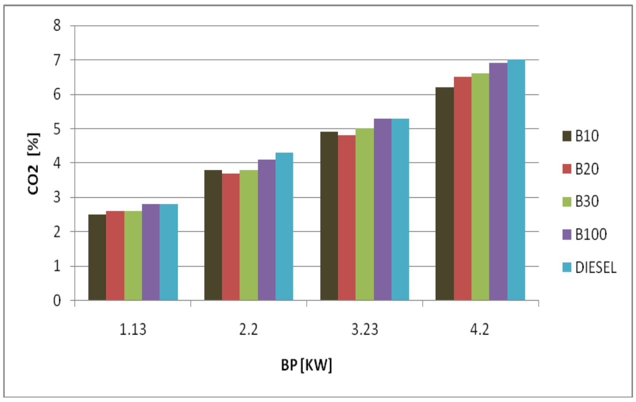

Fig.7 Variation of CO_2 (%) with BP (KW)

IV. CONCLUSIONS

The following are the conclusions drawn from the above work.

- Biodiesel is produced from hybrid oil (dairy waste milk scum and karanja). Some important properties like flash point, fire point, density, calorific value, kinematic viscosity, are determined as per the Indian standards and were found to be within the limits of biodiesel standards.
- The Brake thermal efficiency of diesel fuel is increased about 1.44% when compared to that of neat biodiesel at 100% load[Fig.2]. The Brake thermal efficiency of B10 is very close to that of diesel fuel at full load condition. By increasing the load of the engine, the brake thermal efficiency also increases for all the tested fuel types.
- The specific fuel consumption of biodiesel and its blends at all loads is higher than diesel fuel [Fig.1]. As the load increases, BSFC decreases for all fuel blends. The BSFC of B10 is very close to that of diesel fuel at full load condition. A little increase in fuel consumption is often encountered due to the lower calorific value of the biodiesel.
- The EGT of B30 is very close to that of diesel fuel at full load condition [Fig.3].
- Engine performance with biodiesel and its blends does not differ greatly from that of diesel fuel.
- Most of the major exhaust pollutants such as HC, CO and CO_2 are reduced with the use of biodiesel and its blends with diesel fuel compared to that of neat diesel fuel at full load except NO_X.
- Cost of biodiesel can be reduced by using low cost raw material like dairy waste scum oil, karanja and can be further reduced by adopting mass production.
- In terms of fuel properties and exhaust emission characteristics, HOBD is regarded as an alternative fuel. Bio-diesel has become more alternative recently because of its environmental benefits and the fact that it is made from renewable resources.
- Dairy industries can use these kinds of projects to solve their ecological problems in scum disposal and to improve their economy.

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