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Comparison of Engine Performance of Mixed *Jatropha* and Cottonseed Derived Biodiesel Blends with Conventional Diesel

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ABSTRACT : In this report , biodiesel was synthesized from jatropha oil and cottonseed oil at 60°C using KOH catalysed transesterification. The resulted biodiesels after purification were blended with conventional petroleum diesel. Mixed blends (JCB40 and JCB60) were tested for various engine loads and the engine performance parameters like brake specific fuel consumption, brake power, indicated power, fuel consumption, brake thermal efficiency and mechanical efficiency were determined for the two blends using a single cylinder four stroke water cooled diesel engine. It was found that specific gravity, calorific values and engine performance for both blends were close to conventional diesel.

Keywords: Jatropha oil, Cottonseed oil, Biodiesel, Blends, Engine performance

LIST OF ABBREVATIONS

Brake Specific Fuel Consumption	bsfc
Brake Power	bp
Indicated Power	ip
Fuel Consumption	fc
Brake thermal efficiency	η_{bth}
Mechanical efficiency	η_{mech}

I. INTRODUCTION

The use of vegetable oils as alterative fuels has been around since 1900 when the inventor of the diesel engine Rudolph Diesel first tested peanut oil in his compression ignition engine [1]. Although transesterification of a vegetable oil was conducted as early as 1853 by scientists E. Duffy and J. Patrick, many years before the first diesel engine became functional, It was only on August 31, 1937 that G. Chavanne of the University of Brussels (Belgium) was granted a patent [2] for a 'Procedure for the transformation of vegetable oils for their uses as fuels'. This appears to be the first account of the production of what is known as 'biodiesel' today.

The oil shock in 1973 was beginning of petroleum shortage and later on prices spurt during Iran-Iraq war in 1980, pull the international interest in the use of vegetable oil as a diesel fuel substitute. A number of reports using vegetable oil as neat and its modified form have appeared [3]. These studies have shown that vegetable oil can be used in its neat form but not preferable [4]. Majority of problems were associated with high viscosity of vegetable oils, leading to poor atomization on the fuel. Reduction in viscosity of vegetable oil can be achieved by its transesterification and thus its conversion to biodiesel.

Biodiesel has been gaining worldwide popularity as a renewable, biodegradable and non-toxic fuel alternative to conventional fossil fuels. Biodiesel contains almost no sulfur, no aromatics and contains about 10% oxygen. It can be used in all conventional diesel engines with very few or no modification. It can be used in pure form (B100) or may be blended with petroleum diesel at any concentration. Biodiesel is a methyl or ethyl ester of fatty acid made from renewable biological resources such as vegetable oils (both edible and nonedible), recycled waste vegetable oil and animal fats [5]. Some excellent reviews are available on biodiesel and its production from various sources [6-9].

In this report, synthesis of *Jatropha* oil and cottonseed oil derived biodiesels and engine performance comparison of mixed biodiesel blends with conventional diesel is documented.

II. MATERIALS AND METHODS

Jatropha oil and cottonseed oil was purchased from local market. Petrodiesel was purchased from Indian Oil filling station. Methanol and NaOH were of analytical grade. All material was used as obtained. Engine used for measuring engine performance parameters has the following characteristics:

Make:	Kirloskar
Type:	Single cylinder, four stroke,
	DI, Water cooled
Bore and Stroke:	80 × 110 mm
Compression Ratio:	16.5:1
Rated Power:	3.7 KW at 1500 rpm
Injector opening pressure:	210 bar

Important Pre-processing considerations

1. *Quality of oil:* Fresh and filtered oil sample should be used.
2. *Preparation of Sodium methoxide:* Sodium methoxide solution should be prepared by carefully dissolving 4–7g, NaOH into 250ml methanol. It is based on total fatty acid content of particular oil.
3. *Temperature and stirring:* The temperature of the oil during esterification should be around 60^{o}C with smooth and continuous stirring, so that there should not be overheating or splashing.
4. *Washing and drying:* Complete NaOH should be removed after washing and the pH of the resulted biodiesel should be around 7.00 ± 0.25. Drying of biodiesel can be performed by heating around 110^{o}C for 10 min.

III. GENERAL PROCEDURE FOR TRANSESTERIFICATION OF OIL

1 Lt of the oil was heated to 60^{o}C in a 2Lt capacity borosil beaker. Methoxide solution was prepared by dissolving 35.5g of NaOH in 450ml of CH_3OH. The methoxide solution (250 ml for *Jatropha* oil and 200ml for cotton seed oil) was slowly added to the hot oil while stirring with a magnetic stirrer. The mixture was stirred at 60^{o}C for an hour. The heating was suspended and mixture was allowed to cool to room temperature for settling and separation of glycerine at the bottom. The upper layer was separated and washed several times with water in a separatory funnel (until pH for *Jatropha* biodiesel was found to be around 7.0 and for cotton seed biodiesel at 7.00 ± 0.25). The resulted biodiesel was heated at 110^{o}C for 10 min. to remove traces of water and coolled to room temperature before use.

IV. RESULTS AND DISCUSSION

The fuels (Mineral diesel, *Jatropha* oil, cottonseed oil, jatropha biodiesel, cottonseed biodiesel and mixture blends JCB-40 and JCB-60) were analyzed for several physical, chemical and thermal properties and results are listed in Table 1-4.

Two blends (JCB-40 and JCB-60) were obtained by mixing jatropha methyl esters and cottonseed methyl esters with conventional diesel in the proportions by volume :

JCB-40: 20% Esterified jatropha + 20% esterified cottonseed + 60% diesel

JCB-60: 30% Esterified jatropha + 30% esterified cottonseed + 40% diesel

Engine performance parameters like brake specific fuel consumption, brake power, indicated power, fuel consumption brake thermal efficiency and mechanical efficiency were determined for the two blends and are documented in table 3 and 4, respectively.

It was found from Table 1 that average biodiesel recovery was better for cottonseed than for jatropha. From Table 2, it was revealed that cottonseed methyl ester has highest calorific value but also has highest pour and cloud point than other fuels being tested. Higher cloud and pour points reflect that cottonseed biodiesel may be unfit as fuel in cold climate conditions. It was found that specific gravity, calorific values and pour points of JCB-40 and JCB-60 blends were very close to that of diesel. Flash and fire points of blends JCB-40 and JCB-60 were found higher than the diesel, hence these two blends are safer to handle than diesel [10].

Table 1: Average recovery of methyl esters and glycerine.

Oil	Biodiesel recovery (%)	Glycerine as byproduct (%)
Jatropha	92.5	10.6
Cotton seed	96.0	14.0

Table 2: Fuel properties for conventional diesel, biodiesels and mixture of two blends.

Fuel Properties	Diesel	Jatropha methyl esters	Cottonseed methyl esters	JCB-40	JCB-60
Calorific value (MJ kg^{-1})	43.0	35.5	47.02	41.24	40.93
Specific gravity	0.840	0.890	0.930	0.857	0.866
Viscosity at 40^{oC}	3.5	4.6	4.9	5.3	5.9
Flash Point (^{o}C)	56	158	179	77	80
Fire Point (^{o}C)	63	240	—	84	87
Pour Point (^{o}C)	–10	–9	4	–15	–15.8
Cloud Point (^{o}C)	–4	–4	11	–4	–4.5

Engine performance data for the blends JCB-40 and JCB-60 is documented in Table 3 and Table 4, respectively. The experimental set up for measuring engine performance is given in Fig. 1. The fuel tank was attached with a graduated burette for determination of fuel consumption. For determination of consumption rate, only the volume of fuel consumed from the graduated burette was measured. The time taken for a particular volume of fuel consumed was recorded to find the consumption rate. It was found that for the same load, brake specific fuel consumption (Bsfc) was more for JCB-60 blend than with JCB-40 blend. This may be attributed to the lower calorific value of former blend compared to that of later [11].

Table 3: Engine performance data for JCB-40 blend.

W Load (Kg)	η_{bth} (%)	$\eta_{mech\ (\%)}$
1.2	6.02	15.52
3.4	14.04	35.46
5.0	19.92	47.02
6.5	22.97	54.07
8.2	25.84	60.14
10.0	28.05	64.88
13.2	32.36	70.81
14.0	29.92	71.52

Table 4: Engine performance data for JCB-60 blend.

W Load (Kg)	η_{bth} (%)	$\eta_{mech\ (\%)}$
1.2	6.03	13.07
3.4	13.21	28.95
5.0	19.32	47.93
6.5	2301	48.61
8.2	26.04	54.88
10.0	27.82	59.07
13.2	32.27	65.14
14.0	30.72	66.61

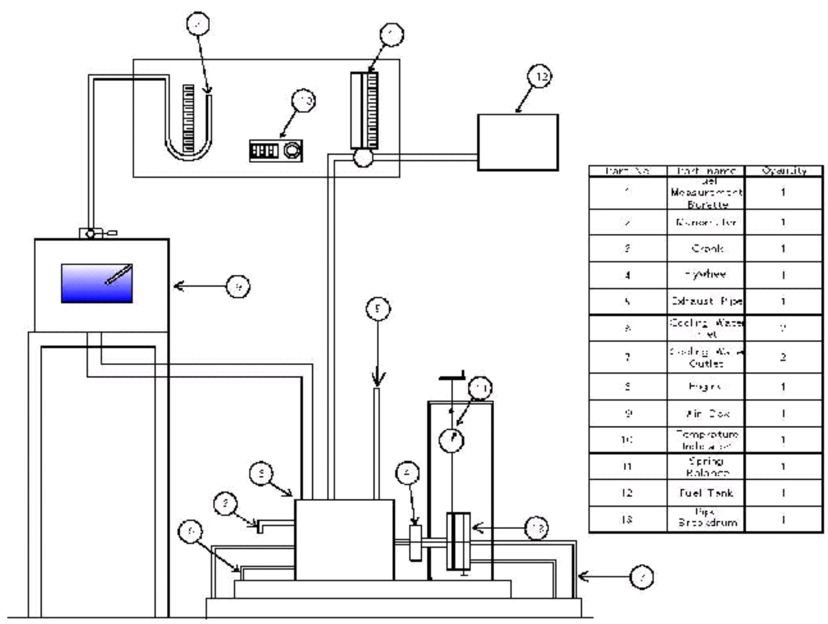

Fig. 1. Experimental set-up to determine engine performance.

The graphs (efficiency η vs. load W) for engine performance for both mixed blends JCB-40 and JCB-60 are given in Fig 2 and Fig. 3, respectively. The brake thermal efficiency (η_{bth}) was found to be nearly identical for both the blends , whereas mechanical efficiency (η_{mech}) was little superior for JCB-40 blend compared to that for JCB-60 blend.

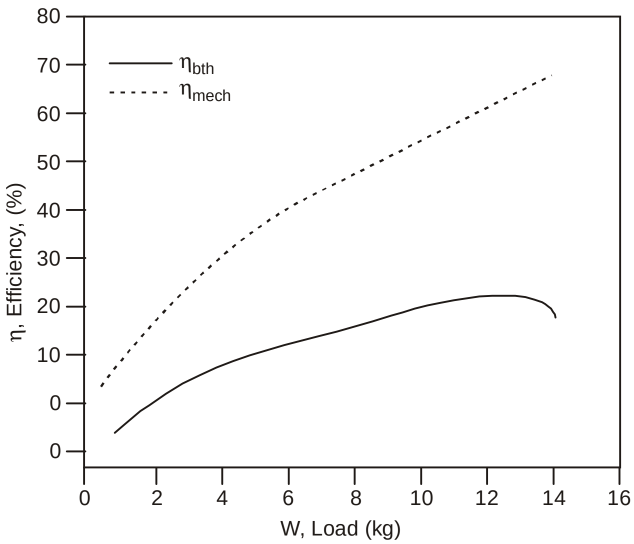

Fig. 2. Engine Performance for JCB-40 blend.

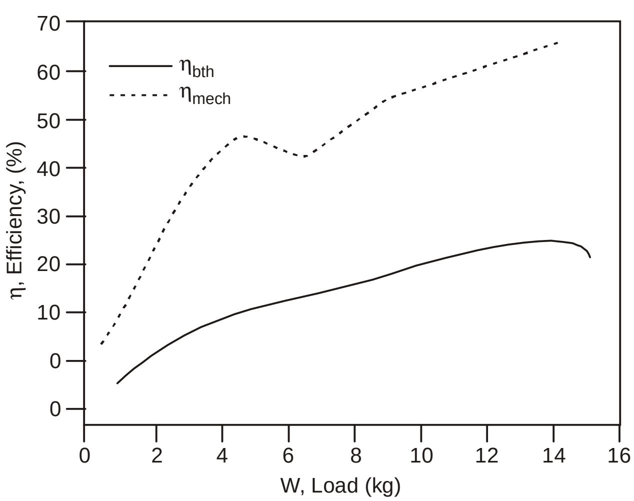

Fig. 3. Engine Performance for JCB-60 blend.

V. CONCLUSION

Mixtures of conventional diesel with *Jatropha* derived biodiesel + cottonseed derived biodiesel (JCB-40 and JCB-60 blends) were explored as engine fuels for a diesel engine without any modification. It was found that specific gravity, calorific values and engine performance for both blends were close to conventional diesel. This study reveals a green technology using plant based biodiesels as alternative to fossil fuels.

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