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Synthesis of bio-diesel from Kenaf seed oil and performance analysis of bio-diesel blends on four stroke, CI engine.

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ABSTRACT
Biodiesel has attracted attention towards world because of its eco-friendly nature, low pollution emitting and non-toxic properties. Globally, there are hundreds of crops which can be used as a biodiesel feedstock. Use of biodiesel reduces dependence fossil fuels. Oils generally have high viscosity, high density and high flash point and therefore they are not suitable to be used as fuel in diesel engine. Various process are used in order to synthesize bio-diesel from oil to make its properties similar to that of conventional diesel. In present study, base catalyzed transesterification process has been used in order to get biodiesel from kenaf seed oil. Properties of kenaf seed oil and bio-diesel are comparative to that of conventional diesel. Biodiesel can either be used alone(B100) without any blending or it can be blended with conventional diesel according to ASTM specifications so as to ensure safe operation of CI engine which has been designed for conventional diesel fuel. In present study, objective is to analyze performance of kenaf seed bio-diesel and its blends. n-butanol will be used as an additive. Use of additive will enhance properties of diesel. Engine performance parameters such as brake power (BP), brake specific fuel consumption (BSFC), brake thermal efficiency (BTE), brake specific energy consumption (BSEC) have been measured under various load conditions for different bio-diesel blends and these performance parameters have been compared to that of conventional diesel
Keywords – Bio-diesel, Kenaf seed oil, Base catalyzed transesterification, Blending, Additive, n-butanol

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I. INTRODUCTION

Continuous use of conventional fuel resources since last two centuries combined with increase in energy demand has spurred interest for research in area of alternative fuels or biodiesel. Use of biodiesel will result in reduction of pollutants being released due to continuous use of fossil fuels. Biodiesel is generally obtained from renewable energy sources [1]. Petroleum consumption is increasing day by day. A major portion of petroleum is refined to diesel which is mainly used for transportation purpose. Biodiesel production in large scale can help to meet increasing fuel demands. An important factor which favors production of biodiesel is that it will result in reduction in emission of greenhouse gases. Continuous combustion of petroleum products has resulted in increase of emissions of carbon dioxide and other greenhouse gases into environment [2]. These greenhouse gases are majorly responsible for global warming, resulting in rise in mean temperature of earth and global warming. If conventional diesel is completely substituted by biodiesel, it will reduce carbon dioxide emissions by 78%.

1.1 BIODIESEL

Biodiesel can be defined as long chain alkyl (methyl, ethyl or propyl) esters of fatty acids. Lipids i.e. oil is made to react with alcohol in presence of a catalyst producing fatty acids ester. Biodiesel can be used effectively in standard diesel engines and their properties are quite different from straight oil. Biodiesel can either be used alone i.e. in form of B100 or it can also be blended with diesel in different proportions. Biodiesel obtained either from vegetable oils or animal fat should meet ASTM D 6751 specifications. Common source of biodiesel includes jatropha, sunflower, mustard, soya bean, palm, jojoba, groundnut, peanut, canola, camelina, cottonseed oil and waste cooking oil [3]. Biodiesel has good lubricating properties and low cetane rating as compared to diesel fuel. Fuels having higher lubricity may increase life of fuel injection equipment that depends on fuel for lubrication.

1.2 HISTORY OF BIO-DIESEL

Transesterification of a vegetable oil was first carried out in 1853 by Patrick Duffy, forty years after which first diesel engine became functional. Rudolf Diesel’s prime model ran for first time on 10 August 1893 using diesel oil. That day has been declared as International Biodiesel Day. Despite large scale use of diesel fuels obtained from petroleum, interest in vegetable oils as fuels for internal combustion engines was observed in early 1900s. Since density and viscosity of vegetable oil is high as compared to diesel, it results in poor distribution of fuel in combustion chamber and incomplete combustion. In order to overcome this problem, heating of oil, blending of oil with diesel fuel or alkyl alcohol, pyrolysis has been carried out. In 1937, alcoholysis was carried out for separating fatty acids and glycerol. In 1977, patent was submitted for first ever industrial production of biodiesel in large scale.

Research work in area of application of transesterified sunflower oil was first carried out in year 1979. In early 1990's, many developed countries started biodiesel production in large scale, blended it with 5% of diesel and started using it for public transportation. Some manufacturers have developed certified vehicle engines that make use of biodiesel blended with biodiesel in equal proportions. By end of 1990's, there were twenty one countries having projects on biodiesel. Now, there are several service stations in Europe where B100 is available.

1.3 KENAF SEED OIL

Kenaf plant, Hibiscus Cannabinus, belongs to Malvaceae family. It is also known as Deccan hemp or Java jute. This plant is mostly found in southern Asia but its origin is still unknown. Fiber obtained from Kenaf plant has characteristics similar to that of jute. Kenaf is a biennial herbaceous plant near about 1.5 to 3 metre tall. Stems of kenaf have diameter in range of 1 to 2 cm. Its leaves are 10 to 15 cm long having variable shape. Flowers of kenaf have diameter in range of 8 to 15 cm. Their color can either be white, yellow or purple. Fruit is in form of capsule having 2cm diameter. Kenaf seeds are obtained from its fruit. Kenaf is cultivated for its fiber in various countries like India, USA, South Africa, Vietnam, parts of Africa and in some parts of Europe. Kenaf seed oil has a dark brown color and it is quite bitter in taste. It can be used as edible oil and also finds application in cosmetic and lubricant industry. Properties of kenaf seed oil have attracted have attracted attention towards its use for making biodiesel or biofuel. Kenaf seed contains 20% of oil by weight [4]. Oil extracted from kenaf seed has been found to contain significant amount of epoxy acid as glyceride. Various fatty acid contents have been identified in kenaf seed oil such as linoleic acid, oleic acid, palmatic acid, stearic acid and 9-hexadonic acid and traces of arachidic acid.

Figure 1.3.1: Kenaf fruit and Kenaf seed

Composition(g/100g)	Mean Value ± SD
Moisture content	9.1±0.5
Crude protein	21.8±0.6
Fats/oil	20.8±0.1
Crude Fibre	13.6±0.2
Ash content	5.9±0.1

Table 1.3.1: Composition of Kenaf seed (gram per 100 gram)

Fatty acid	Composition (%)
Linoleic acid	41
Oleic acid	30
Palmitic acid	19
Epoxyoleic acid	5
9-hexadeconic acid	1
Archidic acid	Traces

Table 1.3.2: Fatty acid composition of kenaf seed oil

II. LITERATURE REVIEW

Md. Hasan Ali, Mohammad Mashud, Md. Rowsonozzaman Rubel, Rakibul Hussain Ahmed [1] They analysed properties of biodiesel obtained from neem oil. 3:1 molar ratio of methanol and oil at temperature range of 55 to 61°C in presence of 1 atmospheric pressure has been found as condition for equilibrium. Kinematic viscosity was found to be 5.96 which is higher than diesel but met ASTM D 6751 specifications. Thus, neem oil was found to have properties for being used as an alternative source of fuel.

Ihsanullah, Sumaira Shah, Muhammad Ayaz, Iftikar Ahmed, Murad Ali, Naveed Ahmed and Irshad Ahmed[2] They synthesised biodiesel from algae. They made use of transesterification process in order to produce biodiesel. Maximum amount of oil was extracted from algal biomass using combination of n-hexane and di-ethylene. Maximum extracted oil was 0.09 fraction of biomass by using blend of both solvent, solvent to biomass ratio of 3:5, algal biomass size of 0.4mm and contact time of 24 hours. Maximum yield of biodiesel was 95% and it was obtained at a temperature of 60°C, oil to methanol ratio of 8 reaction time of 25 minutes and catalyst amount of 0.5% by weight of oil. Flash point of synthesised biodiesel was in range of 120-180°C which is higher as compared to petroleum diesel. Viscosity of biodiesel was found to be in range of 4-6mm^2/sec which was higher than petroleum diesel and was reduced by blending it with diesel. Biodiesel obtained from algae has capability to be a future fuel.

Lay L. Mint, Mahmoud M. El-Halwangi [3] They analysed and optimized production of biodiesel from soya bean oil. They emphasized on recycling of by products in order to optimise biodiesel production process and reduce cost of biodiesel production. Mass and energy integration studies were performed to reduce consumption of heating and cooling utilities, to conserve fresh water and to reduce waste water recharge. It was observed that product cost depends mainly on soya bean oil and accounts for 90% of total cost. They evaluated break – even point for this biodiesel production process.

A. Gnanapraksham, V.M. Siva Kumar, A. Surendhar, M. Thirumarimurugan, T. Kannadasan[4] They described biodiesel production from waste cooking oil and various parameters which influences biodiesel production process. They made use of waste cooking oil, generally left after frying, as raw material. They used base catalyzed transesterification process in order to synthesize biodiesel. They found out that fatty acid content in waste cooking oil could be reduced by pre-treating waste cooking oil with acid catalyst. Methanol to oil ratio for acid catalyzed reaction was found to be dependent on amount of free fatty acid. Amount of catalyst was found to be dependent on type of catalyst, whether homogenous or heterogeneous. For base catalyzed reaction, they found optimum molar ratio of methanol and oil to be 6:1.

A. Arun Shankar, Prudhvi Raj Pentapati, R. Krishna Prasad [5] they synthesized biodiesel from cotton seed oil using homogeneous alkali catalyst and heterogeneous multi walled carbon tubes. The transesterification process for conversion of cotton seed oil to biodiesel was performed by varying various factors such as amount of NaOH used, alcohol to molar ratio and reaction time. They analyzed effects of various parameters on yield of biodiesel and biodiesel yield was founded highest at 110°C for alkali concentration of 0.75 g NaOH/l of oil at an alcohol to oil ratio of 7:1. Maximum biodiesel yield was 95%. Properties of biodiesel such as calorific value, flash point, viscosity, density and pour point were found to be satisfactory as per ASTM standards.

III. BIO-DIESEL SYNTHESIS PROCESS

Direct use of oils in engine can lead to various problems like clogging of filter, improper mixing of air and fuel mixture, incomplete combustion due to high density and high viscosity of fluid. Biodiesel can be synthesized from oils using four different process which are as follows:

1. Pyrolysis
2. Micro-emulsification
3. Dilution
4. Transesterification process

3.1 TRANSESTERIFICATION PROCESS

Process of transesterification can be classified as follows:

1. Acid catalyzed transesterification process
2. Base catalyzed transesterification process
3. Lipase catalyzed transesterification process
4. Super critical transesterification process

In this process, reaction of oil and alcohol is carried out in presence of catalyst such as Sodium hydroxide (NaOH) or potassium hydroxide (KOH) in order to produce alkyl esters (biodiesel) and glycerol. High yield of biodiesel can be obtained from this process. Catalysts such as alkaline metal oxide and hydroxide or metal carbonates can also be used. This process is carried out in temperature range of 60-70 degree Celsius. Base catalyzed transesterification process can be used to carry out both small batch as well as high batch production [6].

IV. MATERIAL SELECTION

Kenaf seeds have been selected as a raw material for biodiesel synthesis. Kenaf trees are found in Dhamtari and Gariyabandh districts of Chattisgarh. Seeds were obtained from fruits of kenaf tree and they were dried with help of sunlight for about 15 days. Seeds were dried in order to completely remove moisture content from seeds. Seeds are feed in oil extraction machine and oil is extracted from it. Extracted oil contains small particles in it. Oil is filtered so as to remove particles from it. Filtered oil is used to synthesize biodiesel by making use of base catalyzed transesterification process.

V. TRIALS PERFORMED

In first trial, oil sample of 200 ml was taken, 40 ml of ethanol (20% by weight) and 4 gram

(2% by weight of sodium hydroxide) were used in order to synthesize biodiesel but biodiesel was not obtained. Glycerol was obtained but biodiesel was not obtained in this trial.
In second trial, methanol and potassium hydroxide were used in order to synthesize biodiesel and biodiesel and glycerol was obtained. Following are the steps performed in order to make biodiesel:
1. Take oil sample of 200 ml in a flask.
2. Heat oil at 60°C for 30 minutes and stir it regularly with time interval of 5 minutes.

Fig 5.1: Oil sample being heated

3. Mix methanol and potassium hydroxide (KOH) with each other by shaking them together manually in a bottle.
4. Once oil gets heated, add mixture of methanol and KOH to oil and stir them with magnetic stirrer for 15 minutes.
5. Pour mixture in separating funnel and left it undisturbed for 3 hours. Since biodiesel is lighter than glycerol, glycerol will settle down at bottom and biodiesel will float at top.

Fig5.2 Biodiesel and glycerol separation

6. Boil tap water at 100°C for 30 minutes.
7. Mix biodiesel and boiled water in equal proportions.
8. Left mixture undisturbed for 3 hours. Since water is heavier than biodiesel, water will settle down at bottom and washed biodiesel will float at top.
8. Biodiesel obtained from first wash has soap contents present in it.
9. Wash biodiesel again with hot water.
10. Triple wash biodiesel with hot water in order to completely remove soap content from biodiesel.

Fig. 5.3: Separation of biodiesel and water after final wash

11. Heat biodiesel at 100°C for 30 minutes in order to completely remove traces of water present in it.

Fig. 5.4: Heating of biodiesel

Thus, biodiesel obtained at end doesn't contain any impurities in it can be further used according to requirement. It can either be used alone or blended to modify some of its properties.
Following table shows different amounts of biodiesel obtained when methanol was used in varying amount keeping quantity of oil(200 ml) and amount of catalyst i.e. potassium hydroxide(4 gram) constant.

Serial No.	Oil sample	Amount of methanol	Amount of catalyst	Biodiesel obtained
1	200 ml	20 ml	4 gram	120 ml
2	200 ml	30 ml	4 gram	150 ml
3	200 ml	40 ml	4 gram	185 ml
4	200 ml	50 ml	4 gram	175 ml
5	200 ml	60 ml	4 gram	180 ml
6	200 ml	70 ml	4 gram	195 ml
7	200 ml	80 ml	4 gram	197 ml

Table 5.1: Biodiesel obtained from conversion process

From above table, it can be inferred that yield of obtained biodiesel was minimum when 20 ml of methanol was used i.e. 10% by volume and yield of biodiesel was maximum when 80 ml of methanol was used i.e. 40% by volume.

In third trial, amount of potassium hydroxide was changed keeping quantity of methanol and quantity of oil sample unchanged. When 6 grams and 8 grams of potassium hydroxide were used as catalyst instead of 4 grams, separation of biodiesel and glycerol didn't take place.

VI. BIO-DIESEL PROPERTIES

Properties of kenaf seed biodiesel have been described below:

Property	Unit	Method	Value
Acid value	mg KOH/g	ASTM D664	1.13
Calorific Value	KJ/Kg	ASTM D240	37434.9
Density(at 15°C)	Kg/m^3	ASTM D1298	0.879
Flash point	°C	ASTM D93	130
Viscosity(at 40°C)	mm^2/s	ASTM D445	3.77

Table 6.1: Kenaf seed biodiesel properties

VII. ADDITIVE PROPERTIES

Following are some of properties of additives:

Additive	Calorific Value (KJ/kg)	Density (kg/m^3)	Kinematic viscosity at 40°C (mm^2/sec)	Flash point(°C)
Ethanol	27333	791	1.14	12.77
Methanol	19620	790	0.59	11.11
Diethyl ether	33890	712	0.22	-45°C
n-Butanol	34330	812	3.0	35

Table 7.1: Properties of some additives

VIII. BLEND PREPARATION

Following are eight different blends which have been made and will be tested:

Blend A: (5% kenaf biodiesel+90% diesel+5% n-butanol)
Blend B: (10% kenaf biodiesel+85% diesel+5% n-butanol)
Blend C: (15% kenaf biodiesel+80% diesel+5% n-butanol)
Blend D: (20% kenaf biodiesel+75% diesel+5% n-butanol)
Blend E: (25% kenaf biodiesel+70% diesel+5% n-butanol)
Blend F: (30% kenaf biodiesel+65% diesel+ 5% n-butanol)
Blend G: (35% kenaf biodiesel+ 60% diesel+ 5% n-butanol)
Blend H: (40% kenaf biodiesel+ 55% diesel+5% n-butanol)

Amount of biodiesel, diesel and n-butanol in different 200 ml test sample blends are as follows:

Blend Name	Amount of biodiesel in 200 ml blend	Amount of diesel in 200ml blend	Amount of n-butanol in 200 ml blend
Blend A	10 ml	180 ml	10 ml
Blend B	20 ml	170 ml	10 ml
Blend C	30 ml	160 ml	10 ml
Blend D	40 ml	150 ml	10 ml
Blend E	50 ml	140 ml	10 ml
Blend F	60 ml	130 ml	10 ml
Blend G	70 ml	120 ml	10 ml
Blend H	80 ml	110 ml	10 ml

Table 8.1: Sample Blends

IX. PERFORMANCE ANALYSIS

9.1 TEST SETUP

Fig. 9.1: Test setup

It consists of diesel engine i.e. four stroke Compression Ignition engine which is connected to hydraulic dynamometer. Load test can be performed on setup. It is water cooled type. Other arrangement includes fuel measuring system, air measuring system and thermocouple is used in order to measure temperature.

9.2 PERFORMANCE PARAMETERS

In order to analyze performance of engine upon use of biodiesel blends, performance parameters are required. Following are performance parameters which will be used in this work:

Brake power:

Power developed by engine at output shaft is known as brake power. It doesn't include power loss caused by gear, friction and other factors.

Brake Specific fuel consumption:

It is ratio of rate of fuel consumption to power output. It denotes fuel efficiency of engine which makes use of fuel and delivers power, which may be shaft power or rotational power.

Brake Specific energy consumption:

It is ratio of energy obtained from fuel per unit time to brake power obtained from shaft. It indicates how effectively energy is obtained from fuel used.

Brake thermal efficiency:

It is defined as ratio of brake power obtained to heat supplied to engine. It evaluates efficiency of an engine to convert thermal energy of fuel to mechanical energy.

9.3 FORMULAS USED

Following are formulas used for calculating performance parameters:

1. Amount of fuel consumed:

$$m_f = \frac{X}{t} \text{ X } \frac{Specific\ Gravity}{1000}$$

where, m_f is amount of fuel consumed in kg/sec

X is volume of fuel consumed in ml

t is time required to consume X(ml) of fuel in seconds

2. Heat supplied to engine:

$$Q_f = m_f \text{ x C.V.}$$

Where, Q_f is heat supplied to engine

C.V. is calorific value in KJ/Kg

3. Brake Power,

$$\text{B.P.} = \frac{2\pi NT}{60000}$$

Where, B.P. IS Brake Power in kilowatts

T is torque in N.m.

T = P x r x 9.81

P is net load in kg

r is distance between canter of spring balance and center of spring shaft

4. Brake Specific Fuel Consumption:

$$\text{B.S.F.C.} = \frac{mf\ X\ 3600}{Brake\ power}$$

Where B.S.F.C is Brake Specific Fuel Consumption in Kg/KW-hr

5. Brake Specific Energy Consumption:

$$\text{B.S.E.C} = \frac{B.S.F.C\ X\ Calorific\ Value}{1000}$$

B.S.E.C is Brake Specific Energy Consumption in MJ/Kw-hr

6. Brake thermal Efficiency:

$$h = \frac{Brake\ Power}{Heat\ Supplied}$$

Where, h is Brake thermal efficiency and is unit less.

9.4 PERFORMANCE ANALYSIS

In order to analyze performance, different performance parameters are needed to be calculated under varying load conditions. It is needed to record data such as time required to consume 20 ml of fuel, speed of shaft. Test is first performed with pure diesel and values are recorded. Test is then performed with other blends i.e. Blend A, Blend B, Blend C, Blend D, Blend E, Blend F, Blend G and Blend H.

All data obtained after performing tests and calculated values have been recorded in tabular form as follows:

Pure diesel i.e. 100% diesel

S No.	Load on engine(Kg)	Time taken to consume 20 ml of fuel sample	Speed of shaft (RPM)
1	0	109	1584
2	1	102.4	1563
3	2	91.2	1530
4	3	82	1519
5	4	74.8	1508
6	5	69	1500

Table 9.4.1: Data for 100% diesel

S No.	Brake Power(KW)	Brake Specific Fuel Consumption(Kg/Kw-hr)	Brake Specific Energy Consumption(MJ/Kw-hr)	Brake Thermal efficiency(%)
1	_	_	_	_
2	0.54	1.11	50.1	7.2
3	1.07	0.63	28.59	12.6
4	1.59	0.47	21.32	16.9
5	2.11	0.39	17.61	20.4
6	2.62	0.34	15.37	23.4

Table 9.4.2: Calculated performance parameters for 100% diesel

Blend A (5% biodiesel+ 90% diesel+ 5% n-butanol)

S No.	Loadon engine(Kg)	Time taken to consume 20 ml of fuel sample	Speed of shaft (RPM)
1	0	111.2	1658
2	1	102	1612
3	2	96	1550
4	3	89	1510
5	4	78.8	1472
6	5	70.4	1446

Table 9.4.3: Data for Blend A

S No.	Brake Power(KW)	Brake Specific Fuel Consumption(Kg/Kw-hr)	Brake Specific Energy Consumption(MJ/Kw-hr)	Brake Thermal efficiency(%)
1	_	_	_	_
2	0.56	1.07	47.6	7.6
3	1.08	0.59	26.3	13.7
4	1.58	0.44	19.4	18.6
5	2.06	0.38	16.74	21.5
6	2.52	0.34	15.08	23.5

Table 9.4.4: Calculated performance parameters for Blend A

Blend B: (10% biodiesel+ 85% diesel+ 5% n-butanol)

S No.	Load on engine(Kg)	Time taken to consume 20 ml of fuel sample	Speed of shaft (RPM)
1	0	114.2	1620
2	1	102	1578
3	2	88	1530
4	3	76.2	1512
5	4	68.8	1493
6	5	60.4	1468

Table 9.4.5: Data for Blend B

S No.	Brake Power(KW)	Brake Specific Fuel Consumption(Kg/Kw-hr)	Brake Specific Energy Consumption(MJ/Kw-hr)	Brake Thermal efficiency(%)
1	_	_	_	_
2	0.55	1.1	48.34	7.4
3	1.07	0.65	28.7	12.6
4	1.58	0.51	22.41	16
5	2.08	0.43	18.9	19.1
6	2.56	0.4	17.6	20.6

Table 9.4.6: Calculated performance parameters for Blend B

Blend C: (15% biodiesel+ 80% diesel+ 5% n-butanol)

S No.	Load on engine(Kg)	Time taken to consume 20 ml of fuel sample	Speed of shaft (RPM)
1	0	140	1616
2	1	124	1572
3	2	105.6	1554
4	3	90	1538
5	4	80.4	1512
6	5	70.4	1506

Table 9.4.7: Data for Blend C

S No.	Brake Power (KW)	Brake Specific Fuel Consumption(Kg/Kw-hr)	Brake Specific Energy Consumption(MJ/Kw-hr)	Brake Thermal efficiency(%)
1	_	_	_	_
2	0.55	0.9	39.33	9.1
3	1.08	0.54	23.52	15.3
4	1.61	0.42	18.29	19.4
5	2.11	0.36	15.68	22.7
6	2.63	0.33	14.49	24.4

Table 9.4.8: Calculated performance parameters for Blend C

Blend D: (20% biodiesel+ 75% diesel+ 5% n-butanol)

S No.	Load on engine(Kg)	Time taken to consume 20 ml of fuel sample	Speed of shaft (RPM)
1	0	134.8	1650
2	1	116	1610
3	2	101.2	1583
4	3	88	1552
5	4	84	1518
6	5	74	1504

Table 9.4.9: Data for Blend D

S No.	Brake Power (KW)	Brake Specific Fuel Consumption (Kg/Kw-hr)	Brake Specific Energy Consumption(MJ/Kw-hr)	Brake Thermal efficiency(%)
1	_	_	_	_
2	0.56	0.95	40.92	8.7
3	1.1	0.55	23.87	15.1
4	1.62	0.42	18.13	19.3
5	2.12	0.35	14,95	24.1
6	2.62	0.32	13.7	26.3

Table 9.4.10: Calculated performance parameters for Blend D

Blend E: (25% biodiesel+ 70% diesel+ 5% n-butanol)

S No.	Load on engine(Kg)	Time taken to consume 20 ml of fuel sample	Speed of shaft (RPM)
1	0	121.6	1700
2	1	110.4	1650
3	2	103.6	1590
4	3	89.8	1550
5	4	78.8	1414
6	5	67.2	1482

Table 9.4.11: Data for Blend E

S No.	Brake Power(KW)	Brake Specific Fuel Consumption(Kg/Kw-hr)	Brake Specific Energy Consumption(MJ/Kw-hr)	Brake Thermal efficiency(%)
1	_	_	_	_
2	0.58	0.97	41.43	8.7
3	1.11	0.54	22.89	15.7
4	1.62	0.43	18.53	19.4
5	2.12	0.37	15.83	22.7
6	2.59	0.35	15.16	23.7

Table 9.4.12: Calculated performance parameters for Blend E

Blend F: (30% biodiesel+ 65% diesel+ 5% n-butanol)

S No.	Load on engine(Kg)	Time taken to consume 20 ml of fuel sample	Speed of shaft (RPM)
1	0	123.6	1688
2	1	108	1640
3	2	94	1624
4	3	83.6	1564
5	4	74.4	1524
6	5	68.6	1500

Table 9.4.13: Data for Blend F

S No.	Brake Power (KW)	Brake Specific Fuel Consumption (Kg/Kw-hr)	Brake Specific Energy Consumption(MJ/Kw-hr)	Brake Thermal efficiency(%)
1	_	_	_	_
2	0.57	1	42.55	8.4
3	1.14	0.58	24.5	14.7
4	1.64	0.45	19.1	18.9
5	2.13	0.39	16.54	21.8
6	2.62	0.34	14.56	24.7

Table 9.4.14: Calculated performance parameters for Blend F

Blend G: (35% biodiesel+ 60% diesel+ 5% n-butanol)

S No.	Load on engine(Kg)	Time taken to consume 20 ml of fuel sample	Speed of shaft (RPM)
1	0	117.2	1590
2	1	104.6	1558
3	2	95.2	1536
4	3	86.6	1529
5	4	79.6	1508
6	5	72	1498

Table 9.4.15: Data for Blend G

S No.	Brake Power(KW)	Brake Specific Fuel Consumption(Kg/Kw-hr)	Brake Specific Energy Consumption(MJ/Kw-hr)	Brake Thermal efficiency(%)
1	_	_	_	_
2	0.54	1.09	45.9	7.8
3	1.07	0.6	25.4	14.2
4	1.6	0.45	18.8	19.1
5	2.11	0.37	15.57	23.3
6	2.62	0.33	13.79	26.1

Table 9.4.16: Calculated performance parameters for Blend G

Blend H: (40% biodiesel+ 55% diesel+ 5% n-butanol)

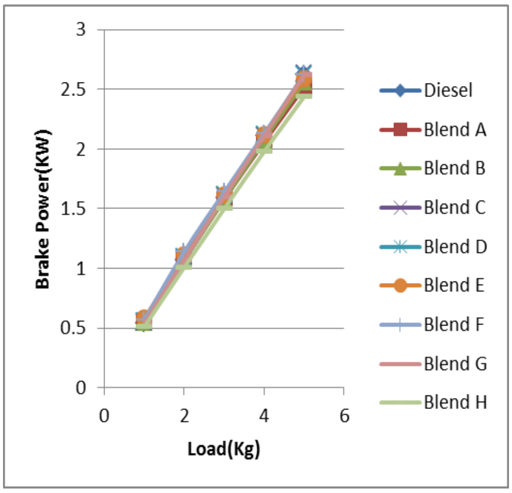
S No.	Load on engine(Kg)	Time taken to consume 20 ml of fuel sample	Speed of shaft (RPM)
1	0	126.4	1478
2	1	114	1463
3	2	104	1448
4	3	90	1428
5	4	72.4	1419
6	5	60	1396

Table 9.4.17: Data for Blend H

S No.	Brake Power (KW)	Brake Specific Fuel Consumption(Kg/Kw-hr)	Brake Specific Energy Consumption(MJ/Kw-hr)	Brake Thermal efficiency(%)
1	_	_	_	_
2	0.51	1.06	44.36	8.1
3	1.01	0.59	24.61	14.6
4	1.5	0.46	19.07	18.9
5	1.98	0.43	17.77	20.2
6	2.44	0.42	17.61	20.4

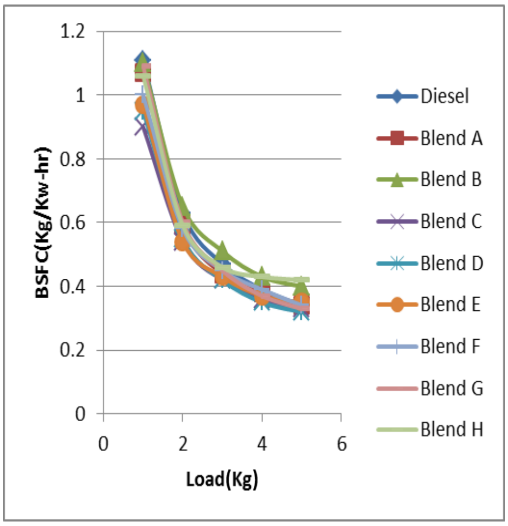
Table 9.4.18: Calculated performance parameters for Blend H

X. RESULTS AND DISCUSSIONS



Graph 10.1: BP versus Load

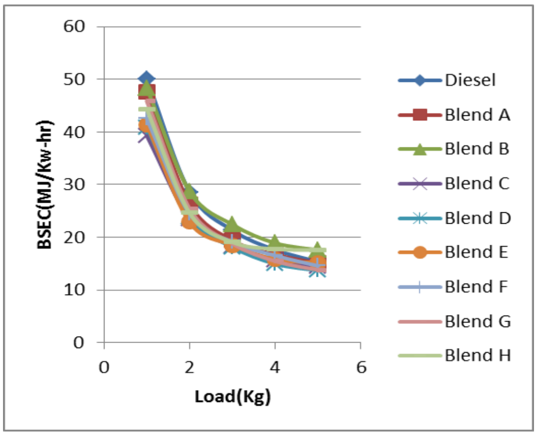
Graph 10.1 shows variation of brake power with load for diesel and all biodiesel blends. Biodiesel blends have shown performance characteristics similar to that of diesel. Brake Power of Blend D is higher than diesel for load conditions of 1, 2, 3 and 4 Kg whereas brake power of Blend H is lower than diesel for all load conditions.



Graph 10.2: BSFC versus Load

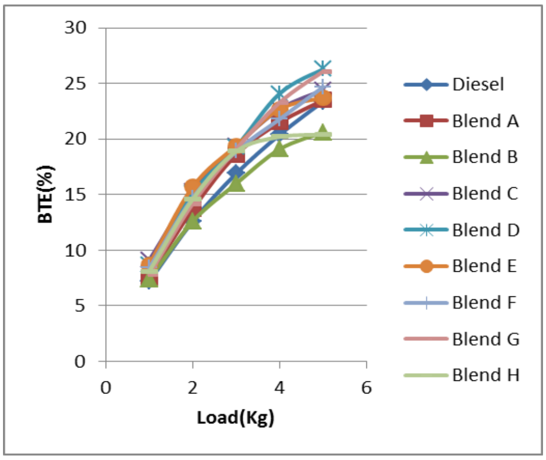
Graph 10.2 shows variation of Brake Specific Fuel Consumption with load for all diesel and biodiesel blends.

Brake Specific Fuel Consumption for all biodiesel blends is lower than that of diesel for load condition of 1 kg whereas it is higher than diesel for Blend B, E and H at load condition of 5 Kg.



Graph 10.3: BSEC versus Load

Graph 10.3 shows variation of Brake Specific Energy Consumption with load for diesel and all biodiesel blends. BSEC for all blends is lower than diesel at load condition of 1 Kg whereas Brake Specific Energy Consumption for Blend B is higher than diesel for load conditions of 2, 3, 4 and 5 Kg.



Graph 10.4: BTE versus Load

Graph 10.4 shows variation of Brake Thermal Efficiency with load for diesel and all biodiesel blends. Brake Thermal Efficiency for all blends is higher than diesel at load condition of 1 kg whereas Break Thermal Efficiency for Blend B and Blend H is lower than that of diesel at load condition of 4 Kg and 5 kg.

XI. CONCLUSION

Kenaf seed based biodiesel has all desirable properties of fuel which makes it a good option for alternative source of fuel.98.5% of biodiesel yield has been obtained from kenaf seed oil when 40% of methanol (by volume) is used for base catalyzed transesterification process. All biodiesel blends of Kenaf seed biodiesel with diesel and n-butanol have shown comparable performance characteristics at middle load conditions of 2, 3 and 4 kg. Performance characteristics of Blend C were best at load condition of 1 kg whereas performance characteristics of Blend D were best at load condition of 5 Kg.

REFERENCES

[1]. Van Gerpen J. Biodiesel processing and production. Fuel process Technol 2005; 86: 1097-107
[2]. Dowaki K., Ohta T., Kasahara Y., Kameyama M, Sakawaki K., Mori S. 2007. An economic and energy analysis on bio-hydrogen fuel using gasification process. Renewable Energy: 32:80-94
[3]. S.P. Singh, Dipti Singh. Biodiesel production through use of different sources and characterization of oils and their esters as substitute of diesel. Journal of renewable and sustainable energy reviews: 14: 200-216, 2010.
[4]. K.L. Nyam, C.P. Tan, O.M. Lai, K. Long, Y.B. Che Man. Physiochemical properties and bioactive compounds of selected seed oils: 42: 1396-1403
[5]. Ibrahim Aslan Resitoglu, Kemal Altinisik, Ali Keskin.The pollutant emissions from diesel engine vehicles and exhaust after treatment systems. Clean Techn Environ Policy(2015): 17: 15-27.
[6]. Meher LC, Sagar DV, Naik SN. Technical aspects of biodiesel production by transesterification- A review. Renewable Sustainable Energy Rev 2006; 10(3): 248-68.
[7]. S Madiwale, A Karthikeyan, V. Bhojwani. A comprehensive review of effect of biodiesel additives on properties, performance and emission. IOP Conf. Series: 197(2017).

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