Biodiesel generation from rice bran oil using transesterification process and experimental investigation on a 4- stroke single cylinder water cooled diesel engine

B.Susmitha[1], M.Geeta Rani[2], M.Nagarjuna[3]
Asst.professors, Andhra Loyola Institue of Engineering and Technology
Vijayawada

Abstract— The Increase of industrialization & motorization of the world led to a steep rise in demand of petroleum products. Although present reserves are sufficient for the near future, continuous usage of the reserves leads to the depletion of conventional fuels. So, the new type of fuels can replace these problems which occur in future. The increasing demand for petroleum products for use in engines of transportation and agricultural machinery had shown its impact on our economy as our country depends on imports to meet the demand. So, increased use of petroleum fuels by automobiles is not only causing fuel scarcity but also causing health and environmental hazards. As a result of overcoming the problem of energy crisis, more and more efforts are being put towards new alternative fuels that can meet today's as well as future energy demands. In this way biodiesel is a promising fuel in terms of reliability and less environmental pollution. This paper deals with the investigation of rice bran oil as an alternative fuel in diesel engines. Present work describes investigation carried on a 4 Stroke single cylinder, water cooled diesel engine with rice bran diesel fuel blends. In the first stage, rice bran oil is transesterified to obtain biodiesel and Fuel properties such as flash point, viscosity and pour point tests are carried out to ascertain the feasibility of fuel. In the second stage, experimental investigations are carried on the same engine with same operating parameters by using different blends of rice bran oil such as B05, B10, and B15and B20. Based on investigations, a comparison is drawn on engine performance with pure diesel operations & with different blends.

Index Terms— Alternative fuel, Biodiesel, Fuel blends, Petroleum products, Rice bran oil, Transesterification, Water cooled diesel engine,

1. INTRODUCTION

The rise in civilization may be closely tied to improvements in transportation. Our present transportation system consists of rail road's, ships, automobiles and planes depend on mechanical power. Practically of all of this power is derived from combustion engines, which convert the chemical energy of the fuel into mechanical energy. Internal combustion engines are one of the important forms of prime movers which run essentially on liquid fuel. In India, the number of CI engines is so large that bulk of available petroleum is consumed in the form of diesel fuel. But Petroleum fuels resources are limited. Need for search of alternate fuels to meet future demand is continuous process since interception of I.C engines.

A.S. ROCHA [1] has conducted experiments on CI engine using jatropha oil. The performance and emission tests were conducted with diesel, preheated jatropha oil, unheated jatropha oil and blends of jatropha oil at different loads and constant speed(1500 rpm),from the experiment results obtained ,jatropha oil is found to be promising alternative fuel for CI engines, G. Lakshmi Narayana Rao [2] used cooking oil methyl esters and blended with diesel at different ratios. Those different blends were used in the diesel engine and performance characteristics were evaluated, Naveen Kumar [3] presented a report on "Production of biodiesel from high FFA rice bran oil and its utilisation in a small capacity diesel engine, Nagarhalli M.V et al [4] used karanja oil blended with diesel fuel at different ratios and used in a diesel engine and the performance parameters like brake thermal efficiency, BSFC, ISFC and CO, CO2, NOX emissions are analyzed. By considering the literature it is concluded that bio fuels can be used as alternate fuels by evaluating its properties and blending them with diesel in small proportions can improve performance parameters and reduce emissions without modifying the engine design .

The fuels such as ethanol, methanol, compressed natural gas (CNG) liquefied petroleum gas (LPG), hydrogen gas, ammonia etc. Substitutes petrol and edible vegetable oils and plant oils like cotton seed oil, palm oil, sunflower oil, weed plant oil, rape seed oil , soybean oil etc. substitutes diesel are thought to be good alternative

2. PREPARATION OF BIODIESEL USING RICE BRAN OIL:

Rice (Oryza sativa Linn) bran is a byproduct, obtained from the outer layers of the brown (husked) rice kernel during milling to produce polished rice. For the preparation of biodiesel a 750 ml of methanol and 15gm of potassium hydroxide are taken and mixed thoroughly and then this mixture is poured into a vessel where 3 litres of rice bran oil is heated at 60-70^{0}c,the mixture is continuously stirred for a period of 8 hours by maintaining the reaction temperature

60-70^0 c and then it is allowed to cool. After it has been cooled, it is seen that glycerol has been settled down at the bottom with methyl esters floating on the top by means of transesterification reaction. The methyl ester was then taken out carefully and then blended with diesel in various concentrations for preparing biodiesel blends to be used in diesel engine for conducting various engine tests.

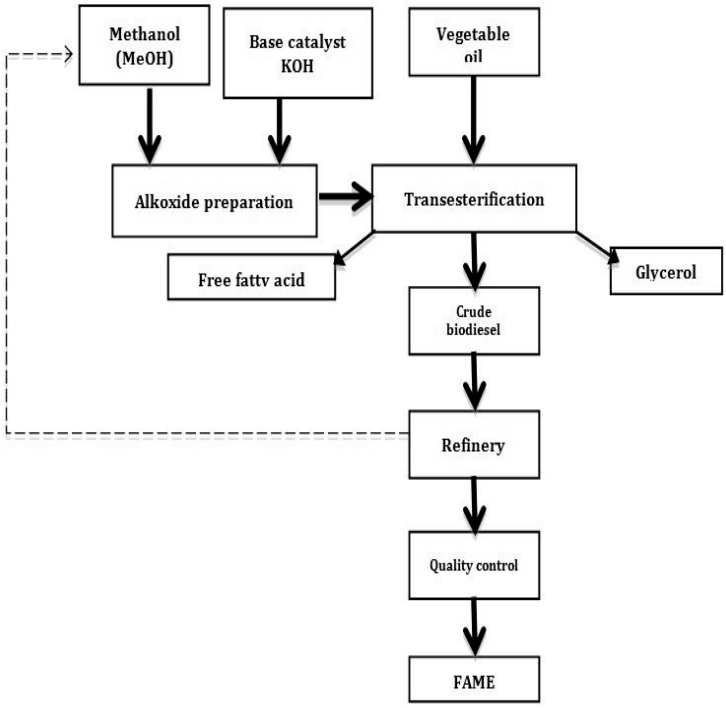
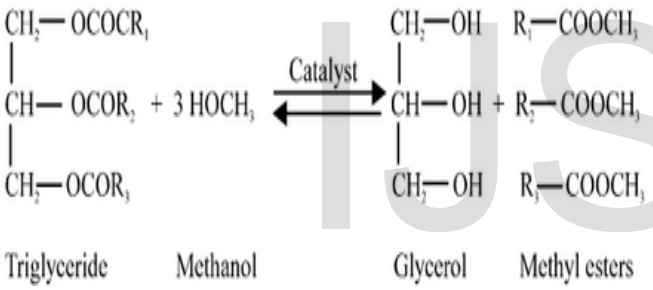


Fig. 1.Flow chart

Transesterification:



Flow chart to prepare biodiesel:

Various biodiesel blends:

Fig. 2. Biodiesel Blends

Advantages of Biodiesel

- Biodiesel reduces carbon dioxide emissions, the primary cause of the greenhouse effect, by up to 100%. Since bio-diesel comes from plants and plants breathe carbon dioxide, there is no net gain in carbon dioxide from using bio-diesel.

- Biodiesel can be used alone or mixed in any amount with petroleum diesel fuel.
- Bio-diesel and there is no "engine conversion." In other words, "you just pour it into the fuel tank
- Biodiesel is more lubricating than diesel fuel, it increases the engine life and it can be used to replace sulfur, a lubricating agent that, when burned, produces sulfur dioxide. The primary component in acid rain. Instead of sulphur, all diesel fuel sold in France contains 5% bio-diesel.
- Biodiesel is safe to handle because it is biodegradable and non-toxic. According to the national bio-diesel board, "neat diesel is as biodegradable as sugar and less toxic than salt."
- Biodiesel is safe to transport. Bio-diesel has a high flash point, or ignition temperature, of about 150°C compared to petroleum diesel fuel, which has a flash point of 52°C.
- Engines running on bio-diesel run normally and have similar fuel mileage to engines running on diesel fuel. Auto ignition, fuel consumption, power output, and engine torque are relatively unaffected by biodiesel

3. PRIMARY INVESTIGATION:

Properties of bio diesel:
The properties of biodiesel according to Indian standards are shown in table 1

Table. 1. Properties of biodiesel according to Indian Standards

Density (Kg/m^2)	860-900
Kinematic viscosity (centistokes)	5-6
Flash point(0^0 c)	120
Fire point (0^0 c)	130
Heating Value (KJ/Kg)	37270
Specific gravity	0.86-0.90

The Properties of methyl esters with different blends:
The properties of biodiesel with different blends are shown in table 2

Table. 2. Properties of methyl ester

Blend	Kinematic viscocity (centistokes)	Flash point(0^0c)
B0	5.03	56
B5	5.032	90
B10	5.81	107
B15	6.18	110
B20	6.2	120

From preliminary investigation some of the properties like viscosity, flash point of the transesterified product (biodiesel) compare well with accepted biodiesel standards.

4. SECONDARY INVESTIGATION:

Experimental setup

Table. 3 Specifications of a 4-Stroke Engine

Maker	field marshal
Bore	114.3mm
Stroke	139.7mm
Rated speed	660rpm
Maximum brake power	6HP
Compression ratio	16.5:1
Orifice diameter	20 mm
Brake drum radius	0.24m

Description of test rig:

This is water cooled four stroke single cylinder vertical diesel engine which is coupled to a rope brake dynamometer arrangement to observe the power produced, necessary weights and spring balance are included to apply load on the brake drum. Suitable cooling arrangement for the brake drum is provided. Thermocouples are provided for measuring temperatures a fuel tank mounted on the stack burette and a three way cock. Air consumption is measured by using MS tank, which is fitted with the standard orifice and a u-tube manometer which measures the pressure inside the gas.

PERFORMANCE TEST RESULTS:

Table 4.Performance of Four Stroke Water Cooled Diesel Engine with Blend B0 (Pure Diesel):

LOAD (kg)	B.P (kw)	I.P (kw)	m_f (kg/sec)	η_{mech} (%)	η_{bth} (%)	η_{ith} (%)	η_{vol} (%)	BSFC (kg/kw.hr)	ISFC (kg/kw.hr)
0	∞	.92	$9.8*10^{-5}$	∞	∞	22.1	∞	∞	0.383
3	0.397	1.317	$9.8*10^{-5}$	30.1	9.55	31.7	58.8	0.886	0.287
5	0.635	1.55	$1.15*10^{-4}$	40.83	13.02	31.8	57.7	0.878	0.267
8	1.03	1.95	$1.22*10^{-4}$	52.8	19.92	37.7	56.8	0.426	0.225
10	1.26	2.18	$1.29*10^{-4}$	57.7	23.04	39.8	57.6	0.368	0.213

Table 5.Performance of Four Stroke Water Cooled Diesel Engine with Blend B10 (10% Biodiesel & 90% Diesel)

LOAD (kg)	B.P (kw)	I.P (kw)	m_f (kg/sec)	η_{mech} (%)	η_{bth} (%)	η_{ith} (%)	η_{vol} (%)	BSFC (kg/kw.hr)	ISFC (kg/kw.hr)
0	∞	1.19	$9.32*10^{-5}$	∞	∞	29.4	59.1	∞	0.278
3	0.396	1.58	$9.11*10^{-5}$	25	10.03	40.05	57.3	0.828	0.207
5	0.474	1.66	$1.06*10^{-4}$	25.3	10.32	36.1	57.5	0.806	0.2303
8	1.028	2.218	$1.2*10^{-4}$	46.3	19.7	42.68	58.4	0.420	0.195
10	1.26	2.45	$1.39*10^{-4}$	51.4	21	40.7	57.9	0.395	0.204

Table 6.Performance of Four Stroke Water Cooled Diesel Engine with Blend B15 (15% Biodiesel & 85% Diesel)

LOAD (kg)	B.P (kw)	I.P (kw)	m_f (kg/sec)	η_{mech} (%)	η_{bth} (%)	η_{ith} (%)	η_{vol} (%)	BSFC (kg/kw.hr)	ISFC (kg/kw.hr)
0	∞	0.65	$5.66*10^{-3}$	∞	∞	27.7	58.5	∞	0.3123
3	0.397	1.047	$1.144*10^{-4}$	37.9	8.3	22.06	35.22	1.035	0.3935
5	0.636	1.286	$1.16*10^{-4}$	49.45	13.22	26.74	57.86	0.656	0.3247
8	1.02	1.67	$1.26*10^{-4}$	61.07	19.48	31.90	58.36	0.446	0.2716
10	1.25	1.9	$1.41*10^{-4}$	65.78	21.3	32.43	58.4	0.406	0.2671

Table 6.Performance of Four Stroke Water Cooled Diesel Engine with Blend B20(20% Biodiesel & 80% Diesel)

LOAD (kg)	B.P (kw)	I.P (kw)	m_f (kg/sec)	η_{mech} (%)	η_{bth} (%)	η_{ith} (%)	η_{vol} (%)	BSFC (kg/kw.hr)	ISFC (kg/kw.hr)
0	∞	1.4	1.05	∞	∞	32.4	58.96	∞	0.270
3	0.38	1.78	1.05	21.3	8.83	41.28	59.02	0.992	0.212
5	0.65	2.05	1.15	31.7	13.7	43.3	58.7	0.636	0.201
8	1	2.406	1.25	41.8	19.58	46.8	58.70	0.45	0.1875
10	1.23	2.62	1.35	46.5	22.3	47.2	58.78	0.395	0.1854

Secondary investigation gives the performance of four stroke water cooled diesel engine with different blends and to know appropriate biodiesel blend suitable for this engine to give better efficiency

RESULTS AND CONCLUSIONS:

Fig.4. Load Vs Indicated Thermal Efficiency:

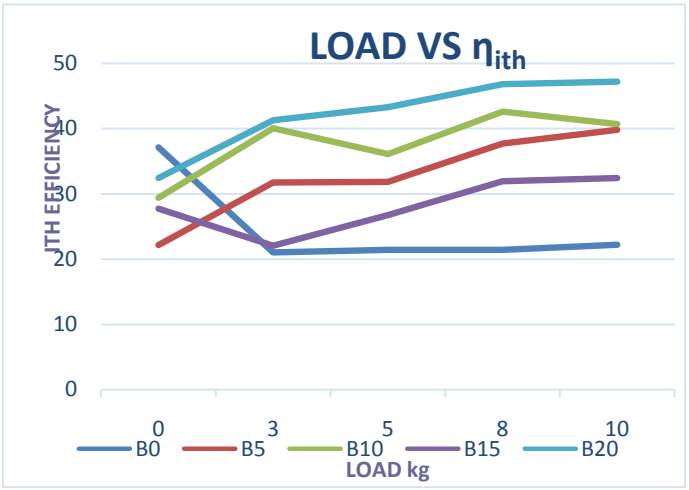


Fig.5. Load Vs Brake specific fuel consumption:

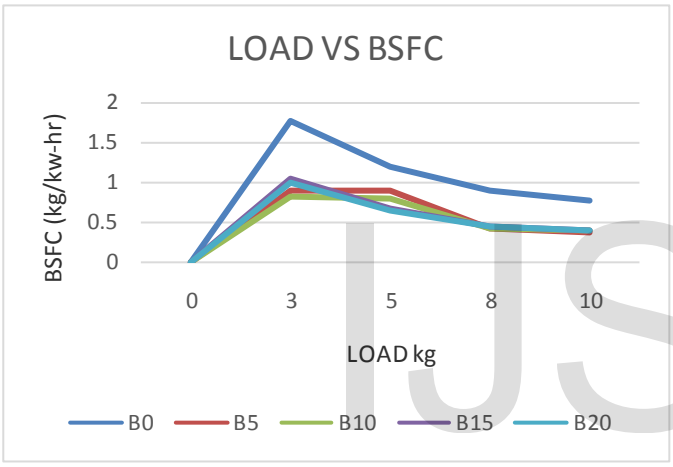


Fig.6.Load Vs Indicated specific fuel consumption

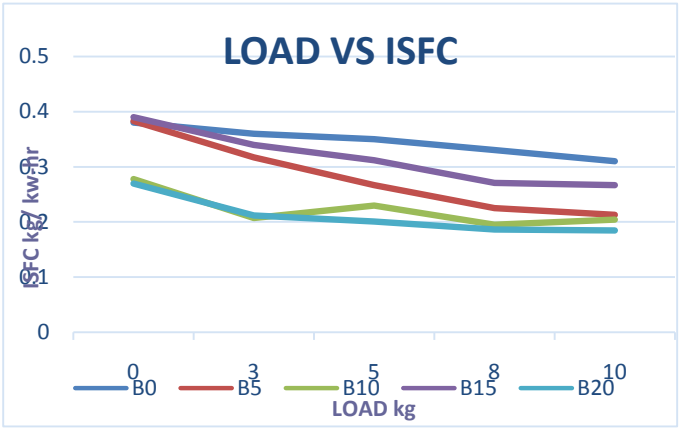


Fig.7.Load Vs Brake Thermal Efficiency

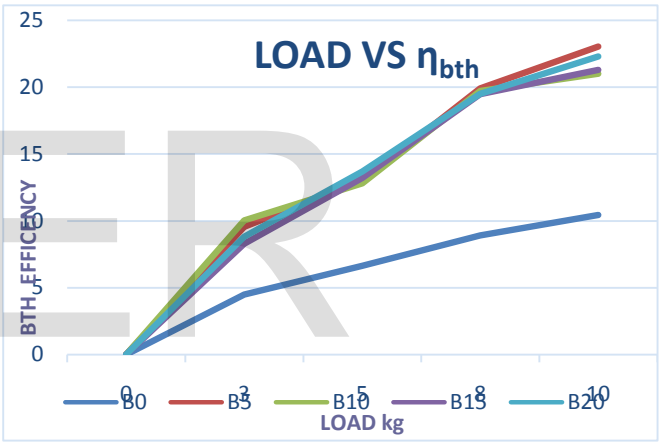


Fig.8.Load Vs Mechanical Efficiency

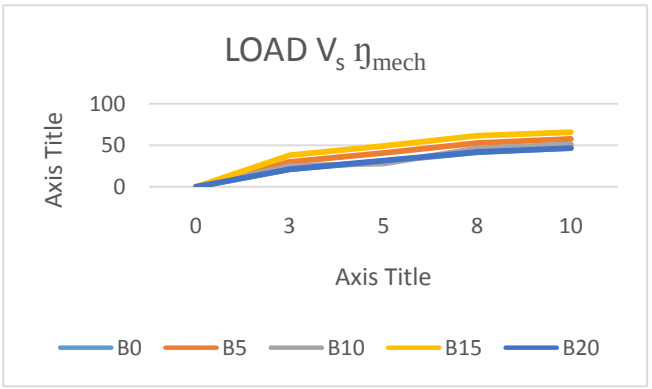
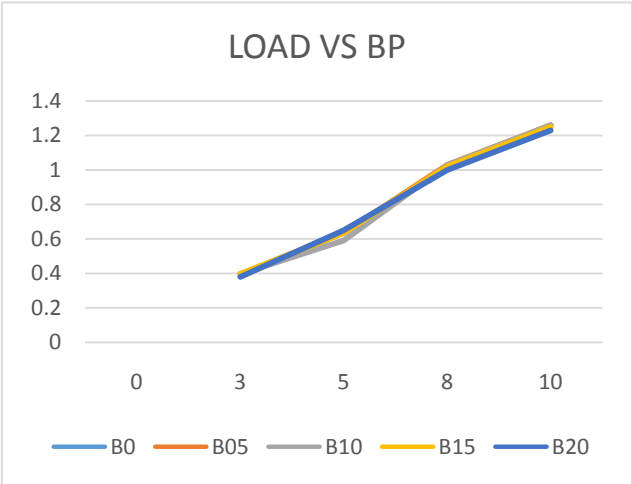


Fig.9.Load Vs Brake Power



CONCLUSION:

When primary and secondary investigations are done using biodiesel blends,

- The fuel properties like viscosity, flash point, of the transesterified product (biodiesel) compare well with accepted biodiesel standards i.e Indian biodiesel standards.
- High flash point and hence safe to transport and store, Oxygenated fuel and hence clean burning.
- Low viscosity and hence improved injection and atomization, Ceatane no. of esters is greater, reduced emissions, 90% reduction in cancer risk, Provides domestic, renewable energy.
- The calorific value of the blends is decreasing as the percentage of rice bran oil in the blends is increasing.
- The indicated thermal efficiency of the engine increases for percentage increase of biodiesel under varying loads
- The brake power and indicated power of the diesel engine increases under varying loads and different biodiesel blends.
- The engine can operate under decreasing of brake thermal specific fuel consumption and also indicated specific fuel consumption.

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