Experimental Investigation Of Performance Of I.C. Engine Using Biodiesel – "Soybean Oil"

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Abstract— *This paper presents testing of a four-stroke single cylinder diesel engine using different blends of soybean oil. 3kg, 6kg, 9kg and 12kg load is given on single cylinder engine with eddy current dynamometer. Soyabean oil blends like 80:20 and 70:30 means 80% diesel and 20% soyabean oil are made and tested on engine combustion. The predicted thermo-physical properties of biodiesels are then provided as fuel property inputs in the biodiesel combustion. The performance of diesel engine is evaluated using parameters like brake power, thermal efficiency and brake specific fuel consumption. The results of biodiesel are compared with pure diesel fuel.*

Keywords— **Brake power, Brake specific fuel consumption, Thermal efficiency, Blends, Thermo-physical.**

I. Introduction

Energy and Fuel are the key aspects for mechanical, modern, social and temperate advancement of any country. Reduction in fossil reserves and higher costing are bringing about a developing requirement for substituting the ordinary fossil fuel with powers inferred from vegetable source otherwise called biodiesel. Biodiesel is an alternative fuel which is derived from biomass. Biodiesel is obtained from the transesterification of fats and oils and this biofuel has a comparable properties to that of diesel fuel acquired from petroleum source. One of the fundamental benefit of biodiesel is that it is biodegradable in nature and might be utilized without adjusting or modification in the current motors or engine and likewise delivers minimum pollutant gas in the exhaust gas discharges. An additional essential thing of biodiesel is that it is miscible with diesel and might be very effectively mixed.[5]. The requirement of any fuel that it must be actually and naturally achievable, satisfactory and monetarily aggressive to give the fuel performance. The transesterification process yields to the biodiesel production by large alludes to a catalyzed synthetic reaction of a vegetable oil and liquor to results in an unsaturated fat alkyl ester and glycerol as byproduct. The unsaturated fat alkyl ester or any unsaturated fat methyl or propyl ester (otherwise known as FAME) is the biodiesel. [4]. this is a reversible reaction, in which excess amount of liquor is utilized to give a maximum yield. Most of the reactions, methanol is the most favourable liquor due to having low comparative cost along with suitable physical and chemical properties.

Among various biodiesel fuels, soybean biodiesel has been widely used as a substitute of fossil diesel due to its availability on the market. However, there are numerous other feedstock fuels under consideration. Effects of the viscosity of cottonseed oil methyl ester (COME), which is decreased by means of preheating, on engine performance and exhaust emissions of a diesel engine were experimentally studied and the test results revealed that preheating COME to 90oC led to favourable effects on brake thermal efficiency and CO emissions. Microalgae, as biomass, are also a potential renewable energy source. The microalgae are grown in photo-bioreactors or in open ponds, and the algae oil is converted to algae biodiesel through a transesterification process [2]. A number of methods have been reported to convert the microalgae to liquid fuel and gas, either using biochemical or thermochemical processes.[1]

II. TEST RIG

The setup consists of single cylinder, four stroke, VCR(Variable Compression Ratio) Diesel engine connected to eddy current type dynamometer for loading. The compression ratio can be changed without stopping the engine and without altering the combustion chamber geometry by specially designed tilting cylinder block arrangement. Setup is provided with necessary instruments for combustion pressure and crank-angle measurements. These signals are interfaced to computer through engine indicator for PΘ-PV diagrams. Provision is also made for interfacing airflow, fuel flow, temperatures and load measurement. The setup has stand-alone panel box consisting of air box, two fuel tanks for duel fuel test, manometer, fuel test, manometer, fuel measuring unit, transmitters for air and fuel flow measurements, process indicator and engine indicator. Rotameters are provided for cooling water and calorimeter water flow measurement.

The setup enables study for VCR engine performance for break power, indicated power, frictional power, BMEP,IMEP, Break Thermal Efficiency, Indicated Thermal Efficiency, Mechanical Efficiency, Volumetric Efficiency, specific Fuel Consumption, A/F Ratio and Heat balance. Lab view based Engine performance analysis software package "EnfinesoftLV" is provided for online performance evaluation. A computerized Diesel injection pressure measurement is optionally provided. [3].

Fig.1: Test set up

TABLE 1
OBSERVATION TABLE

Fuel	Load in Kg	Speed in rpm	F.C. time in sec	t_1	t_2	t_3	t_4	t_5	Q1	Q2	H
Diesel	3	1567	95	25.5	31.5	37.5	28.5	195	350	175	40
	6	1552	84.16	25.25	30.75	17.5	29.25	219	350	175	40
	9	1546	72.5	25.5	31	25.5	30	246	350	175	40
	12	1510	62.5	25.75	32.75	25.5	31.75	288	350	175	40
B20	3	1558	92	27	30.25	27.25	27.75	186	350	175	40
	6	1552	75	27.75	30.75	27.25	28.25	204	350	175	40
	9	1548	60	26.25	31	26.25	28.75	219	350	175	40
	12	1526	45	27.5	32.5	27.5	29.75	267	350	175	40
B30	3	1563	105	26.75	30	26.75	27.5	189	350	175	40
	6	1554	60	26.75	30.5	26.75	28	213	350	175	40
	9	1541	55	27	31.75	27	29	246	350	175	40
	12	1526	48	27.25	32.5	27.25	29.75	276	350	175	40

FORMULAE USED

$$B.P. = \frac{2\pi NW}{60 \times 10^3} \times \frac{D + d}{2} \times 9.81$$

$$mf = \frac{cc \times 10^{-6}}{Time} \times \rho f$$

$$B.S.F.C. = \frac{mf \times 3600}{B.P.}$$

$$Heat\ Input = mf \times Cv$$

$$\eta th = \frac{B.P.}{Qs} \times 100$$

$$Qw = mw \times Cpw \times \Delta tm$$

$$\% \, Heat \ in \ cooling \ water = \frac{Qw}{Qs} \times 100$$

$$mg \times Cpg = \frac{\mathrm{mcv} \times 4.18 \times (\mathrm{t}_2 - \mathrm{t}_1)}{(\mathrm{t}_5 - \mathrm{t}_4)}$$

$$Qg = mg \times Cpg \times (\mathrm{t}_5 - \mathrm{t}_1)$$

$$\% \, Heat \ in \ exaust \ gas = \frac{\mathrm{Qg}}{\mathrm{Qs}} \times 100$$

$$Qa = [Qs - (Q \, BP + Qw + Qg)]$$

$$\% Heat \ Unaccounted = \frac{Qa}{Qs} \times 100$$

TABLE2
RESULT TABLE FOR 100% DIESEL

Sr. No.	Parameter	Load			
		3 kg	6 kg	9 kg	12 kg
1.	Brake Power	0.8934	1.77	2.64	3.44
2.	Brake sp. fuel consumption	0.8905	0.507	0.394	0.35
3.	Thermal efficiency	9.6250	16.88	21.76	24.37

TABLE3
RESULT TABLE FOR B 20

Sr. No.	Parameter	Load			
		3 kg	6 kg	9 kg	12 kg
1.	Brake Power	0.8882	1.7697	2.6477	3.4802
2.	Brake sp. fuel consumption	0.9200	0.5675	0.4741	0.4810
3.	Thermal efficiency	9.5956	15.5554	18.6183	18.3542

TABLE4
RESULT TABLE FOR B 30

Sr. No.	Parameter	Load			
		3 kg	6 kg	9 kg	12 kg
1.	Brake Power	0.8911	1.77	2.63	3.48
2.	Brake sp. fuel consumption	0.7877	0.6935	0.510	0.4417
3.	Thermal efficiency	11.2797	12.81	17.45	20.11

TABLE 5
HEAT BALANCE SHEET FOR CONVENTIONAL DIESEL

Sr.No.	Credit			Expenditure		
	Detail	In KW	Sr.No	Detail	In KW	In %
1.	Heat Input Qs = mf×cv	14.11	1. 2. 3. 4.	Heat In B.P. Heat In cooling water Heat In exhaust gas Heat Unaccounted	3.44 2.84 2.88 4.95	24.37 20.12 20.41 35.08
	Total Credit	14.11		Total Expenditure	14.11	99.98

TABLE 6
HEAT BALANCE SHEET FOR B20

Sr. No.	Credit			Expenditure		
	Detail	In KW	Sr.No	Detail	In KW	In %
1.	Heat Input Qs = mf×cv	18.96	1. 2. 3. 4.	Heat In B.P. Heat In cooling water Heat In exhaust gas Heat Unaccounted	3.48 2.03 2.05 11.39	18.35 10.71 10.81 60.11
	Total Credit	18.96		Total Expenditure	18.96	99.99

TABLE 7
HEAT BALANCE SHEET FOR B30

Sr. No.	Credit			Expenditure		
	Detail	In KW	Sr. No	Detail	In KW	In %
1.	Heat Input Qs = mf×cv	17.30	1. 2. 3. 4.	Heat In B.P. Heat In cooling water Heat In exhaust gas Heat Unaccounted	3.48 2.13 2.13 9.55	20.11 12.31 12.31 55.20
	Total Credit	17.30		Total Expenditure	17.30	99.93

III. RESULT AND DISCUSSION

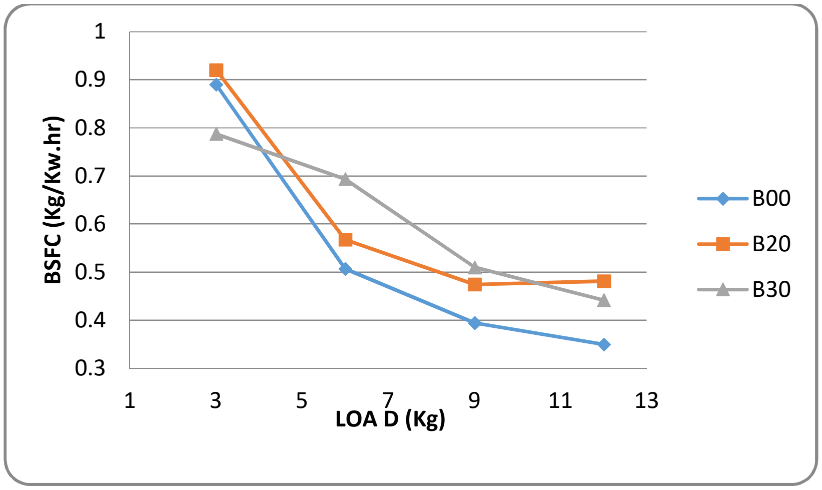

Fig.2: Performance Of Soybean Oil For BSFC

- Experimental investigation shows that for BSFC B30 blending gives best results.
- Optimum result may be obtained with B20.

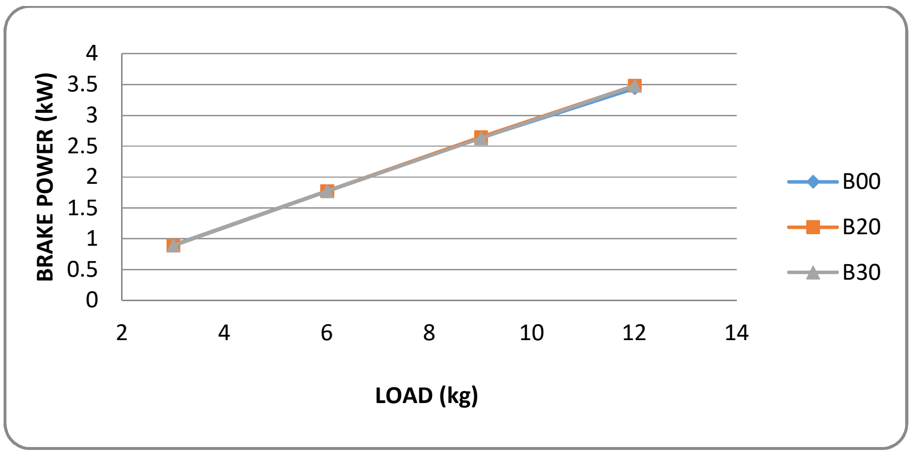

Fig. 3:. Performance Of Soybean oil For Brake Power

- From graph to experimental investigation for B.P. shows B20 with highest B.P. followed by B20 and B00 i.e. conventional diesel. For conventional diesel as we increase load up to 10kg the brake power starts decreasing with minimum value.
- For B30 and B20 brake power is directly proportional to load.

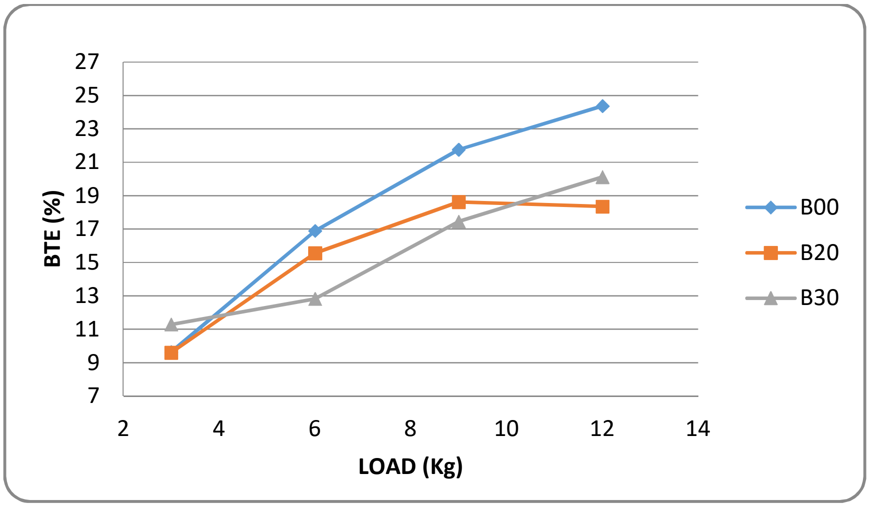

Fig4:. Performance Of Soybean For Brake Thermal Efficiency

- From the graph 3 experimental investigation shows conventional diesel blend gives maximum brake thermal efficiency.
- With B30 blend continuously increasing brake thermal efficiency obtained
- For B20 as load increases brake thermal efficiency decreases.

IV. CONCLUSION

In an increase of soyabean oil in the blend may decrease the brake thermal efficiency. 20.11and 17.45 are the maximum brake thermal efficiencies shown by B30 and mineral diesel respectively. Among all tested fuels its noticed that B30 is the best tested fuel which gave the same performance results and will reduce emissions as compared to pure diesel operation. A very good agreement was obtained between the results and the available theoretical and experimental results of other researchers.

From overall experiment investigation it is concluded that for optimum result B20 blend is best choice as compare to convectional diesel.

ABBREVIATIONS

t_1	Cooling water temp at engine inlet in °C
t_2	Cooling water temp at engine outlet in °C
t_3	Cooling water temp at calorimeter inlet in °C
t_4	Cooling water temp at calorimeter outlet in °C
t_5	Exhaust gas temp at calorimeter in °C
Q1	Water flow rate to the engine (lit/min)
Q2	Water flow rate to the calorimeter (lit/min)
H	Air box manometer reading (m of H2O)
F.C.	Fuel consumption
$B.P$	Brake power in Kw
N	Engine speed in rpm
W	Load on dynamometer in kg
D	Outside diameter of cylinder in m
d	Inside diameter of cylinder in m
mf	Mass of fuel in Kg/s
cc	Cubic capacity in m3
ρf	Density of fuel in kg/m3
$B.S.F.C.$	Brake specific fuel consumption in Kg/kW.hr
Cv	Calorific value in KJ/Kg.K
ηth	Brake thermal efficiency
Qs	Heat input in Kw
Qw	Heat supplied to water in Kw

mw	Amount of water kg/s
Cpw	Specific heat of water in kJ/Kg.K
Δtm	Temperature difference in 0c
Qg	Heat in exhaust gas Kw
Qa	Heat unaccounted in kW

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