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Evaluation of Diesel Engine performance parameters fuelled with blends of biodiesel obtained from waste sesame oil

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Abstract:* A large number of researchers are working on sustainable source of fuel because available source of sustainable fuel source is very limited. Cost of sustainable fuel is also increasing at the same time these conventional fuels polluting the environment too. Blends of Bio diesel obtained from waste or used vegetable oil has been tested for diesel engine without any change in design. Some of the significance factors which impacts the performance of diesel engine are efficiency's, fuel consumption and power. In existing exploration different blends of biodiesel obtained from waste sesame oil and menthe oil has been explicated in V.C.R. diesel engine. The important intention of this work is to explore the effect of the blends B20, B40, B60, B80, B100 and pure diesel fuel on performance characteristics of engine. Different Blends are prepared by mixing the Biodiesel obtained from waste sesame oil with virgin menthe oil volumetrically. Performance characteristics of engine has been observed for above mentioned blends at 0% load , 25 % load, 50% load, 75 % load and 100 % load. Performance characteristics of diesel engine in terms of brake thermal efficiency, brake power, brake specific fuel consumption and indicated thermal efficiency were presented graphically. This work describes that brake thermal efficiency, indicated thermal efficiency, brake power is less for blends of waste sesame oil biodiesel and pure menthe oil while Brake specific fuel consumption is higher as compared to pure diesel oil. Blend B20 can be use as fuel in agriculture sector.

Keywords: Waste vegetable oil; Bio diesel; Diesel Engine; Seasme oil; Menthe oil; fuel;

I. INTRODUCTION

Diesel engines are extremely useful machines in transportation and agriculture sector to produce power for different purpose. The important features of diesel engine are strong in construction, simple to use and easy to maintain. Future of diesel engine may not be bright as it was in the start of 19^{th} century due to the shortage of diesel fuel, we will not be in the position to use diesel engine for a very long time. Therefore serious attempts are being made all over the world, to bring out non conventional fuel for use in diesel engine. Brake thermal efficiency, indicated thermal efficiency, brake power and brake specific fuel consumption are the important performance characteristics of diesel engines, by observing these characteristics we can find the suitability of any fuel for diesel engine. It has been seen that using biodiesel resulted in both increasing and decreasing phenomenon regarding BTE **[1]**. BTE was found to be decreased at full load because time taken for complete combustion reduced, oxygen molecules get small time to change its state to atomic oxygen **[2]**. BTE was found to be decreased in some experiments and in such cases higher viscosity and lower cetane index were responsible for poor thermal performance**.**

BTE obtained from biodiesel was found to be less than that of diesel **(3, 4).** The reduction of brake thermal efficiency with biodiesel mixture was attributed poor spray characteristics, poor air fuel mixing, high viscosity, high volatility and lower calorific value **(5)**. The other reason given as smaller ignition delay of biodiesel resulted in initiation of combustion much before TDC causing increase in compression work as well as heat loss and leads to reduction in the efficiency of engine **(6)**. A few others authors **(7)** found no significant difference between biodiesel and diesel as engine converts the chemical energy to mechanical energy with the same efficiency. Some literature **(8)** reported that BTE increased with biodiesel compared to diesel. In this work the effects of biodiesel obtained from waste sesame oil and its blends with menthe oil are experimentally studied on performance characteristics of single cylinder direct injection diesel engine using as a fuel. The table 1 compares some of the important properties of different vegetable oil, which are used as fuel in diesel engine.

TABLE I
PROPERTIES OF VEGETABLE OIL (9)

Properties	Diesel	Sea Lemon oil	Jatropha oil	Cotton seed oil	Tobacco see oil	Waste Sesame oil
Density(KG/M^3)	840	927	918	874	920	878
Calorific Value (KJ/KG)	42390	39650	39774	39648	39400	35207
Cetane Number	45-55	--	45	45	38	53
Viscosity (cst)	4.59	49.7	49.9	50	27.7	4.3
Flash Point (^OC)	75	158	240	210	220	128.2
Carbon Residue (%)	0.1	0.46	0.44	0.55	0.57	0.006

II. MATERIAL AND METHOD

The specification of the selected diesel engine is shown in Table2.

TABLE 2
TECHNICAL SPECIFICATION OF THE ENGINE

Make	**Kirloskar**
Model	TAF1
Rated Brake Power (kW)	3.5
Rated Speed (rpm)	1500
Number of Cylinder	1
Bore x Stroke (mm)	87.5x110
Displacement volume (cc)	661 cc
Compression Ratio	17.5:1
Cooling System	Water Cooled
Starting system	Manual hand start (with handle)

A single cylinder four stroke water cooled diesel engine developing 3.5 KW at 1100 RPM used for this work. Eddy current dynamometer with a control system is coupled with engine. Blends of biodiesel obtained from waste sesame oil and menthe oil are shown in table3.

TABLE 3
Classification of different blends

S/N	Sample	Biodiesel from waste sesame oil	Menthe oil	Diesel	Blends
1	Sample 1	200 ml	800ml	00 ml	B20
2	Sample2	400ml	600ml	00 ml	B40
3	Sample3	600ml	400ml	00 ml	B60
4	Sample4	800ml	200ml	00 ml	B80
5	Sample5	1000 ml	000ml	00 ml	B100
6	Sample6	1000ml	000ml	1000 ml	D100

Brake thermal efficiency, indicated thermal efficiency, brake power and break specific fuel consumption were recorded at 0%, 25%, 50%, 75% and 100 % load for each and every blend at steady state operation of engine.

III. RESULT AND DISCUSSION

Blends of waste sesame oil bio diesel and menthe oil has significant effect on the performance of diesel engine. An increase in the percentage of biodiesel in the blend is found to be effect the brake thermal efficiency, indicated thermal efficiency, brake specific fuel consumption and brake power at different load.

A. Performance parameters

Brake thermal efficiency, fuel consumption, brake power and indicated thermal efficiency of diesel engine fuelled with blend B20, B40, B60. B80, B100 D100 are shown in figure1, figure2, figure3 and figure4 respectively. Engine performance parameters are directly related to fuel properties such as oxygen content, viscosity, density, HHV and fuel injection system (10). Generally fuel property affects combustion process and spray formation during fuel injection process (11).

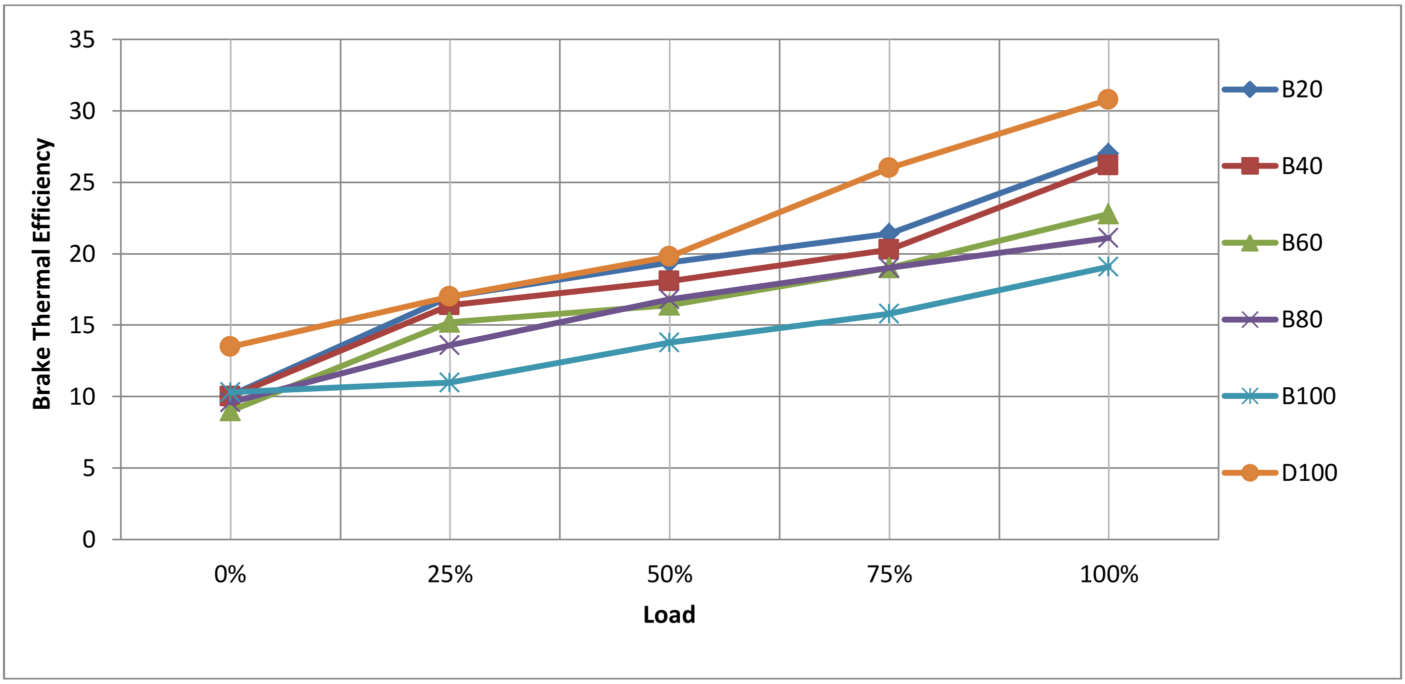

Fig 1: Variation in Brake Thermal Efficiency Of different blends at various loads.

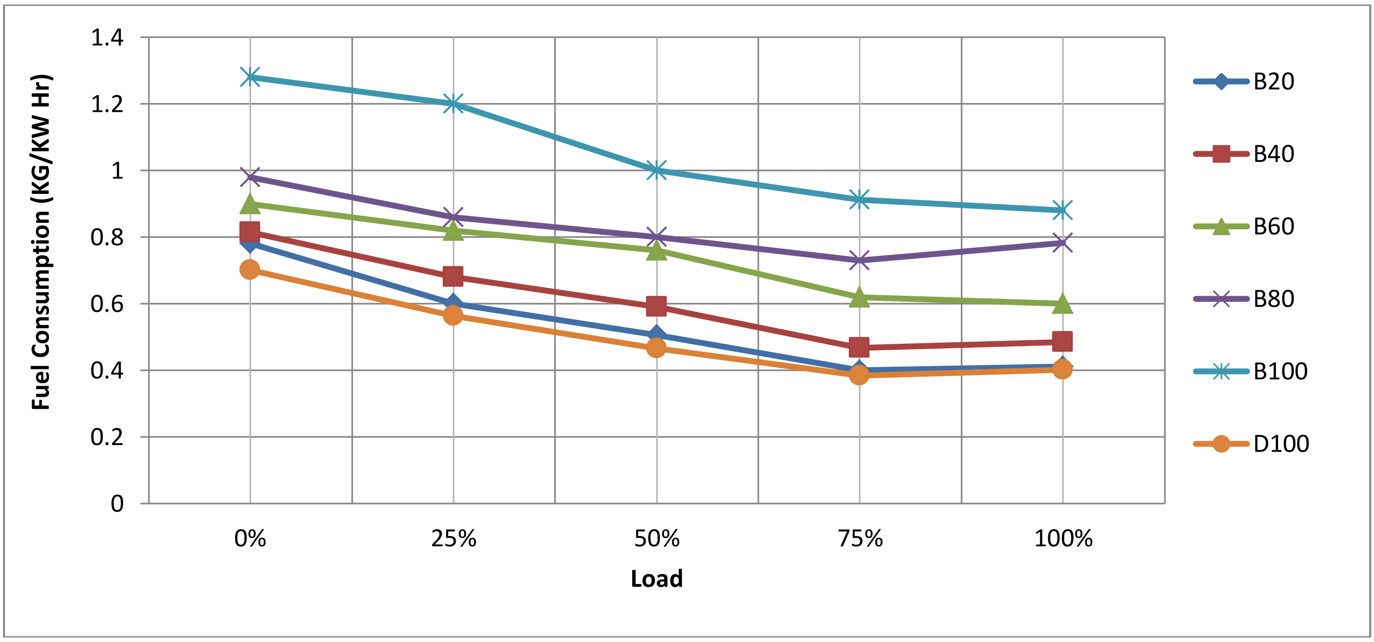

Fig 2: Variation in fuel consumption (KG/KW. Hr) of engine with different blends at various loads.

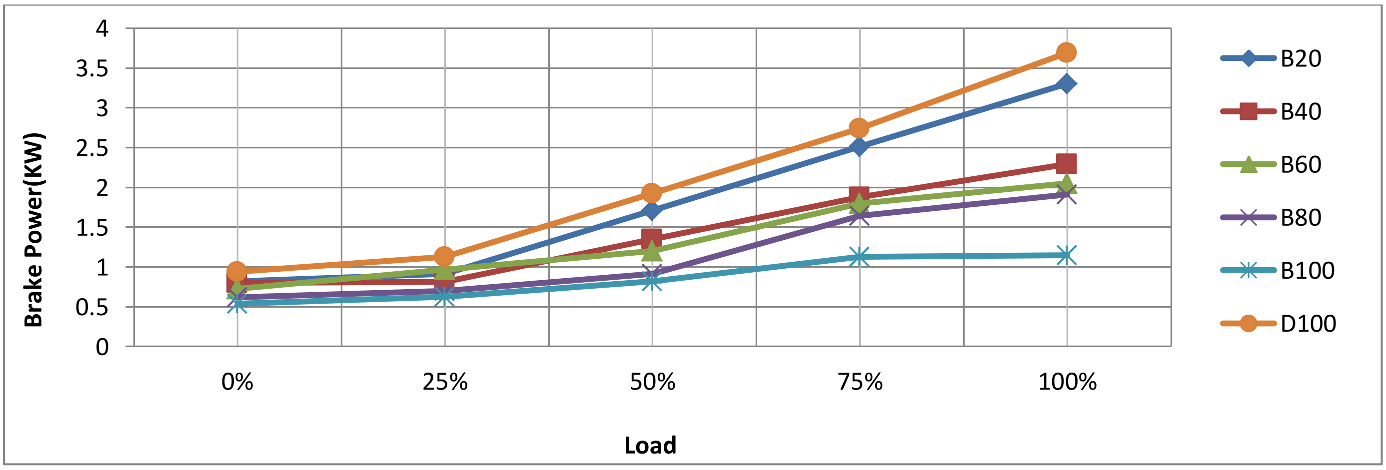

Fig 3: Variation in Brake Power (KW) of engine with different blends at various loads.

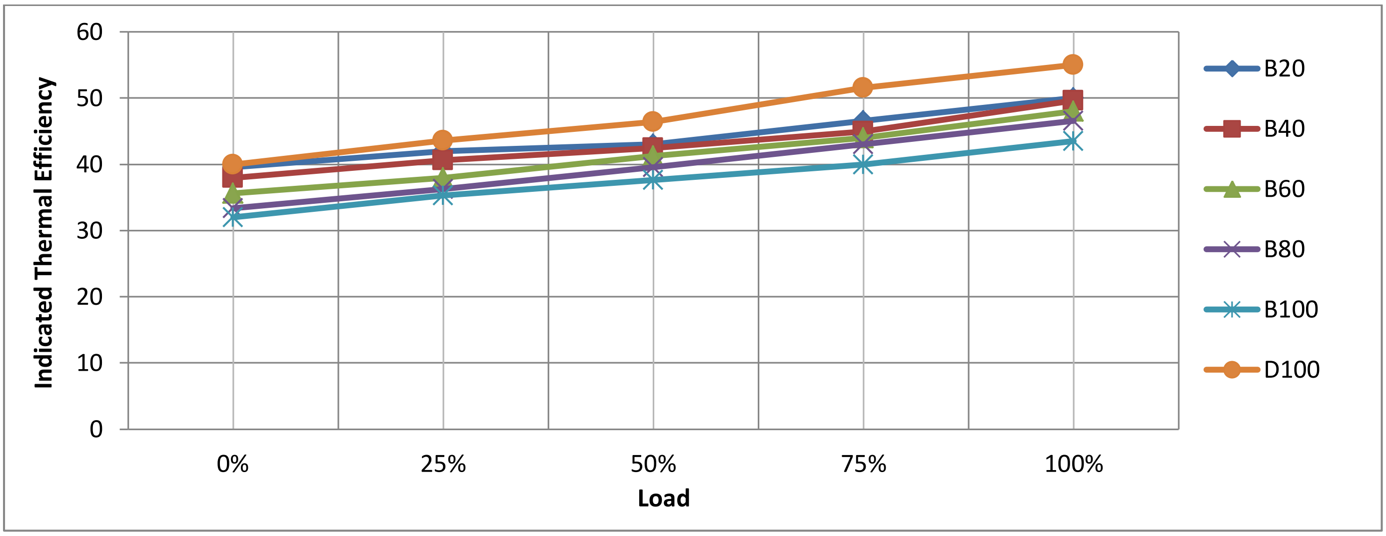

Fig 4: Variation in Indicated Thermal Efficiency Of different blends at various loads.

B. Brake Thermal Efficiency (BTE):

All the blends are tested under similar steady state condition of diesel engine. Variation in Brake Thermal Efficiency Of different blends at various loads is shown in figure1. Brake thermal efficiency is defined as brake power of engine as a function of heat input by fuel (12). The BTE of the engine depends primarily on the calorific value of the fuel used (13). Brake thermal efficiency for all five blends and pure diesel increases as load increases from 0 % to 100% but the net change in efficiency when load is increased by 0% to 100% is different for different blends. The rise in BTE for blend B20 & B40 when load changes from 0% to 100% is approximately same i.e. 17%, BTE for neat diesel is also increased by 17% for the same condition. Brake thermal efficiency for blend B60, B80 and B100 is increases by 13.8%, 11.5% and 8.8% when load changes from minimum to maximum which is less than B20, B40 and pure diesel. In terms of brake thermal efficiency B20 and B40 are performing well and close to neat diesel. Brake thermal efficiency of any blend is less than brake thermal efficiency of diesel at any load. B20 & B40 shows maximum gain in brake thermal efficiency as load increases, the reason behind the gain of brake thermal efficiency for these blends are lower viscosity, higher calorific value and higher cetane number. Fuel spray characteristics, better fuel air mixing, lower viscosity, low volatility and higher calorific value of B20 and B40 fuel are responsible for complete combustion, which results in higher brake thermal efficiency. More utilization of heat generated due to complete combustion is possible for lower blends. Other blend B60, B80 and B100 does not have such a significant gain in brake thermal efficiency. Incomplete combustion due to poor fuel spray characteristics and ignition delay may be responsible for lower BTE.

C Brake Specific Fuel Consumption

Figure (2) represent the relationship in between the brake specific fuel consumption and load for different blends. BSFC is the fuel consumed by an engine to produce one unit brake power output, it depends upon density, viscosity, HHV, engine operating condition and fuel injection system. Specific fuel consumption for diesel is lower than the blends of waste cooking oil biodiesel and menthe oil. BSFC for biodiesel blends are higher than diesel **(12)**.This may be due to the higher viscosity and density of biodiesel **(14)**. The decrease in volumetric efficiency and increase in frictional losses may be the reason for higher brake specific fuel consumption **(12)**. Higher mass low rate due to the higher viscosity and density of biodiesel blend has been observed in mechanical controlled fuel pump **(15).** Fuel consumption increases as the volume of biodiesel increases in blend at any load. Diesel engine fuelled with blends of biodiesel consumes more fuel at any load in comparison to diesel fuel at same power.

D Brake Power:

Relationship between brake power and load for various blends is shown in figure (3). Diesel engine fuelled with blends of biodiesel produces less power than diesel fuel. Higher blends (B60, B80, B100) produce less power than lower blends (B20, B40). Blend B20 & B40 has significant rise in brake power at every load. More quantity of waste cooking oil biodiesel in blend will result in less power. B20 & B40 are very close to diesel fuel. Biodiesel having higher Cetane Number and presence of oxygen in biodiesel always provides better quality combustion. In naturally aspirated internal combustion engine, volumetric efficiency of engine decreases, which reduces the oxygen content in combustion chamber. In this condition oxygen content of biodiesel helps to perform a complete combustion, which results a higher brake power. Using biodiesel in lower portion can increase the brake power. But in full load condition effect of oxygen content of the fuel becomes pale because engine reaches the smoke limit, while the effect of low heating value becomes a bold feature, so by increasing the portion of biodiesel in fuel blends, brake power decreases. Brake power increases as load increases at constant engine speed, reason behind the increase in BP is reduced heat loss **(13).** It has been seen that the engine power decreases with increases in the percentage of biodiesel in a blend and increasing load similarly the same trend in the effect of engine speed on engine power, apart from rare exceptions **(16)**. However, the maximum brake power with traditional diesel was found to be 25% higher than biodiesel from waste cooking oil **[17].** Increasing the BSFC reduces the thermal efficiency of engine (18).

E Indicated Thermal Efficiency:

Variation in Indicated Thermal Efficiency for different blends at various loads is shown in figure4. Indicated thermal efficiency for the blends of waste cooking oil biodiesel is less than diesel. B20 & B40 has remarkable rise in indicated thermal efficiency for any load, while the other blends does not show such rise in indicated thermal efficiency. ITE of diesel engine for B20 and B40 is close to diesel fuel. Indicated thermal efficiency for B60, B80 and B100 is very less in comparison to diesel fuel at every load. Blends contain less quantity of biodiesel having higher indicated thermal efficiency. The peak ITE occurs around 0.4-0.6 Mpa IMEP, because heat release phase is late at high load. Compared with D100 , ITE of B100 is lower at low load but higher at high load B20 has the highest ITE during the load sweep due to highest combustion efficiency and shortest combustion duration **(19).**

IV.CONCLUSIONS

A single cylinder diesel engine was fuelled with the blends of waste sesame oil biodiesel and pure Menthe oil B10, B20, B40, B60, B80, B100 and D100. Performance characteristics were recorded at 0 %, 25%, 50%, 75% and 100% at constant speed of 1500 RPM. Brake thermal efficiency, Brake specific fuel consumption, Brake power and indicated thermal efficiency were recorded and compared with pure diesel oil. The following conclusions could be summarized as :

I. Thermal efficiency of blends of waste sesame oil biodiesel and pure Menthe oil were lowered to diesel fuel.
II. Brake specific fuel consumption of blends of waste sesame oil biodiesel and pure Menthe oil were higher to diesel fuel.
III. Brake Power of blends of waste sesame oil biodiesel and pure Menthe oil were lowered to diesel fuel. Blend B20 in terms of brake power was very close to pure diesel oil.
IV. Indicated Thermal efficiency of blends of waste sesame oil biodiesel and pure Menthe oil were lowered to diesel fuel. Blend B20 in terms of indicated thermal efficiency was very close to pure diesel oil.
V. Blend B20 and B40 can be used as a fuel in agriculture sector where in general old and rough diesel engines are used for different purpose.

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