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Experimental Investigation On Performance, Emission And Combustion Characteristics Of Single Cylinder Diesel Engine Running On Bavanchi Oil Or [Psoralea Corylifolia Oil]

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Abstract

Increase in fuel prices and shortage of its supply has promoted the interest in development of the alternative sources for petroleum fuels. In this present work, investigations were carried out to study the performance, emission and combustion characteristics of Bavanchi oil or [Psoralea Corylifolia Oil]. The results were compared with diesel fuel, and the selected Bavanchi oil or [Psoralea Corylifolia Oil] oil fuel blends (5%, 10%, and 15%). For this experiment a single cylinder, four stroke, water cooled diesel engine was used. Initially the engine was run with diesel fuel and the readings were recorded. Then the engine was run with the Bavanchi oil or [Psoralea Corylifolia Oil] oil fuel blends (5%, 10%, and 15%) added by volume basis and the readings were taken. Tests were carried out over entire range of engine operation at varying conditions of load. The engine performance parameters such as specific fuel consumption, brake thermal efficiency, The lower blend of bavanchi oil with diesel is increases the brake thermal efficiency and reduces the specific fuel consumption, the combustion analysis shows that the peak cylinder pressures of B5, B10 and B15 blends are lower than that of the diesel, exhaust gas temperature and exhaust emission (CO, CO_2, HC and NO_x) were recorded. The experimental results proved that the results of blend from bavanchi seeds oil can be used as a biodiesel feedstock

Keywords: *Diesel engine, Bavanchi oil or [Psoralea Corylifolia Oil] oil fuel blends (5%, 10%, and 15%), Performance, combustion, Emission*

1. Introduction

India with the high rate of economic growth and increase in the population is the significant consumer of energy resources. India lacks in sufficient energy reserves and dependent on oil imports, but India has an abundant resource of vegetable oils. The use of vegetable oil in a diesel engine is not a new concept. However due to limited reserves of fossil fuels, escalation nature of diesel fuel prices and increase in environmental pollution, created a renewed interest of research in vegetable oil as substitute fuel for diesel engines. Oil is easily available, renewable and environment friendly. However major disadvantage of vegetable oil is its viscosity, which is much higher than that of diesel [1].

According to the present scenario, diesel engines are used for power generation, automobiles, ships and irrigation pumps etc. The continuous rise in global prices of crude oil, increasing threat to environment due to exhaust emissions, the problem of global warming and the threat of supply fuel oil instabilities have adversely impacted the developing countries, more so to the petroleum importing countries like India. Major portion of today's energy demand in India is being met with fossil fuels. Hence it is high time that alternate fuels for engines should be derived from indigenous sources. As India is an agricultural country, there is a wide scope for the production of vegetable oils from different oil seeds. Only non-edible oils are used as fuel for engines, as the edible oils are in great demand and far too expensive. Vegetable oils are one such alternative source. Diesel engines have the advantages of better fuel economy, lower emissions of HC and CO. However, diesel engines suffered from high emissions of smoke density and NOx, and there is inherent tradeoff between them from the point of view of long term energy security, it is necessary to develop alternative fuels with properties comparable to petroleum based fuels [2].

As we know the life of fossil fuel, it has a limited stock in its earth core as a resource. The main commodity source for bio-diesel in India can be non-edible oils obtained from plant species such as jatropha curcus [ratanjyot], pongamia pinnata (aranja), calophyllum inophyllum [nagchampa], Hevcca brasiliensis [rubber], etc. So it is an attempt to reduce the use of fossil fuel. After a lot of research and studies on alternative fuels most of

works are carried out on vegetable oils (edible and non-edible oils) like jatropha, karanja, neem, castor, cotton seeds, simaruba, tobacco seeds ,rice bran oil ,custurd apple seeds oil etc. To the best of my knowledge there is no work reported on bavanchi seed oil. The botanical name of bavanchi is psoralea corylifolia which is widely available in the forest rang of West Bengal, borders of Andra pradesh, Orissa, and Mumbai etc. Even we have a market in the West Bengal, Andra pradesh, Mumbai which is being exported to the China, Japan, Korea, for its medical values. So bavanchi seed oil is considered for testing performance, combustion and emission characteristics on four stroke diesel engines.

2.Experimental set-up

Experiments were performed in the internal combustion engine laboratory, Department of mechanical engineering, PDA College of engineering, Gulbarga. The experimental setup specification consists of single cylinder, four strokes, diesel engine connected to eddy current dynamometer for variable loading etc are specified in the table1. The set as stand- alone type independent panel box consisting of air box, fuel tank, manometer etc. The set up enables study of engine for brake power, BMEP, brake thermal efficiency, mechanical efficiency, specific fuel consumption, volumetric efficiency, A/F ratio, and emission characteristics like CO, CO2, HC and NO_X.

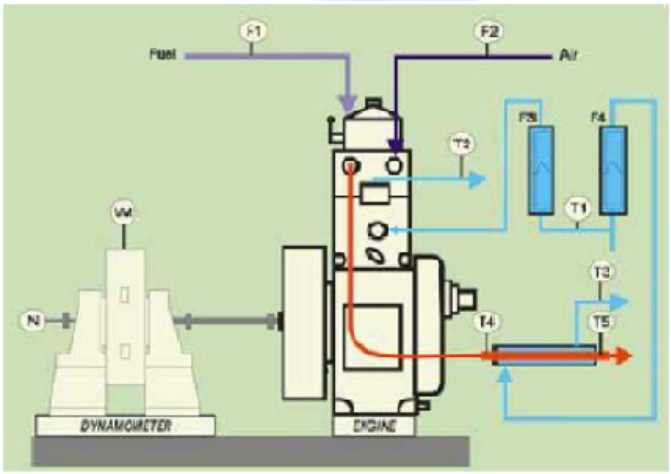

Fig-1 Experimental setup

PT-Pressure Transducer.
N-Rotary encoder.
Wt - Weight.
T1-Jacket water inlet temperature.
T2-Jacket water outlet temperature.
T3--Calorimeter water inlet temperature.
F1-Fuel flow.
F2-Air flow.
F3- Jacket water flow.
T4-Calorimeter water outlet temperature.
T5-Exhaust gas to calorimeter Temperature.
T6-Exhaust gas from calorimeter temperature.

The various components of experimental set up are described in Fig.1 the important components of the system are,

- The engine
- Dynamometer
- Exhaust emission testing machine
- Calorimeter
- Fuel measuring unit
- Pressure sensor
- Temperature sensor
- Rotameter
- Software

Table 1 Technical specifications of the engine.

Manufacturer	Kirloskar Oil Engines Ltd., India
Model	TV–SR II, naturally Aspirated
Engine	Single cylinder, DI, 4 strokes
Bore/stroke	87.5mm/110mm
Compression ratio	17.5:1
Speed	1500 r/min, constant
Rated power	5.2 kW
Injection pressure	240 bar/23° BTDC
Type of sensor	Piezo electric
Crank angle sensor	1-degree crank angle

3. Results and Discussion

3.1 Fuel properties and characteristics

The proprieties of the bavanchi oil and diesel fuel were determined and the results are shown in table: 2

Table 2 Properties of the bavanchi oil and diesel fuel

PROPERTIES	UNITS	EXPERIMENTAL VALUES			
		Psoralea Corylifolia(Bavanchi) Oil	BIODIESL STANDARD VALUE (ASTM)	COMMERCIALLY AVAILABLE DIESEL	PROTOCALL
Kinematic Viscosity @40^{0}C	Centistokes	4.642	1.9-6.0	2.54	ASTM D445
Density	kg/m^3	921	870-900	840	ASTM D4052
Flash Point	^{0}C	231	130	54	ASTM D93
Calorific Value	kJ/kg K	40031.2	37000 to 42500	43500	ASTM D240

3.2Performance characteristics

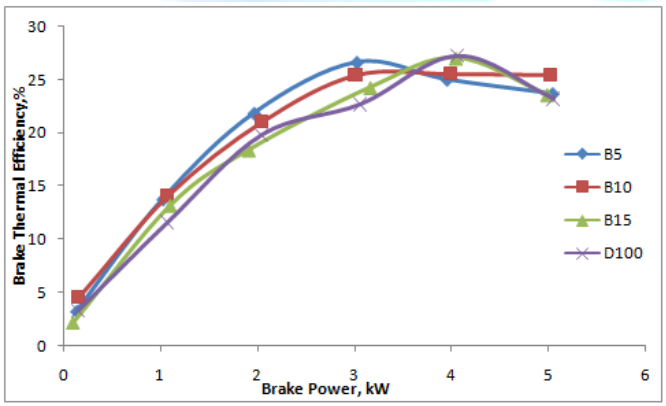

Fig 2 Variation of brake thermal efficiency with respect to brake power

The brake thermal efficiency is increasing with increasing brake power for all the blends of bavanchi seed oil and diesel. It may be due to reduction in heat loss and increase in power with increase in load. It may be because of the presence of oxygen in bavanchi-blend diesel which enhances the combustion as compared to diesel and bavanchi-blend diesel is more lubricant than diesel that provides additional lubrication. From figure 2 it is found that brake power at 3.06 the brake thermal efficiency is 22.69 for almost all the blends. The brake thermal efficiency of B15 is closer to the D100. Maximum brake thermal efficiency is 27.22 for D100 which is identical to B15 at a brake power of 4.06. The maximum brake thermal efficiency of B5 and B10 is 26.4 and 25.48 against the 27.22 of D100.

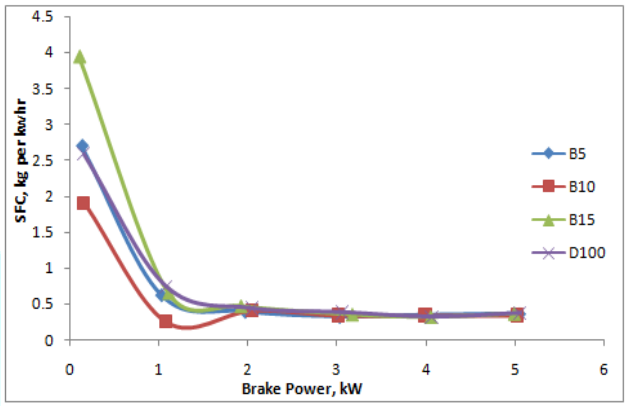

Fig 3 Variation of specific fuel consumption with respect to brake power

Specific fuel consumption [SFC] with respect to brake power for bavanchi oil blend diesel fuel and diesel in the test engine is shown in the figure 3. SFC of the blend B5 is closer to the diesel followed by B10. The SFC of bavanchi oil blend diesel fuel is expected to increase as compared to the consumption of diesel fuel at initial load. SFC decreased sharply with increase in load for all fuel samples. As the SFC is calculated on weight basis, so higher densities resulted in higher value of SFC that can be seen in blend of B15 which contain 15% of Bavanchi seed oil and 85% of diesel at initial loads. Minimum SFC is observed to B5 blend which is 0.252 kg/kW hr. The SFC is approximately identical after BP 2kW for all the blends and decreases to minimum of 0.37kg/kW hr

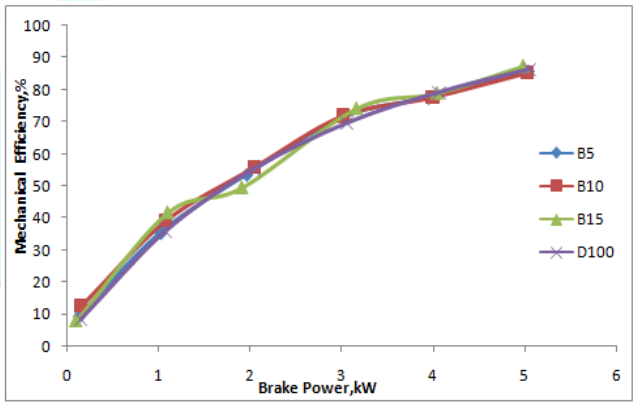

Fig 4 Variation of mechanical efficiency with respect to brake power

The variation of mechanical efficiency with brake power for pure diesel and bavanchi oil -blend are shown in figure 4. In this case the pure diesel and bavanchi blend diesel are almost closer to each other. From the graph it is evident that as the brake power increases the mechanical efficiency goes on increasing. The mechanical of B5, B10

and B15 are slightly higher than pure diesel. This happens due to lower calorific value of bavanchi-blend diesel compared to pure diesel

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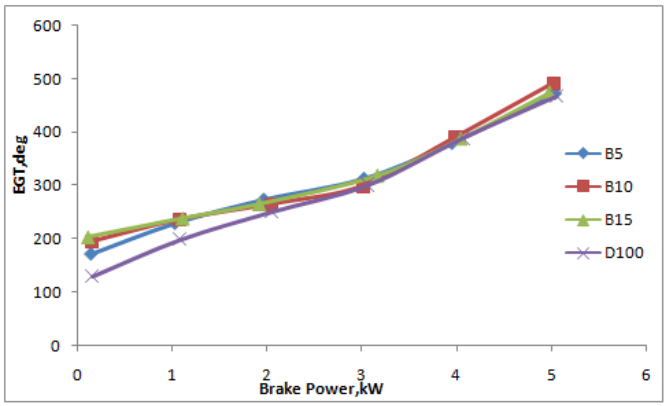

Fig 5 Variation of exhaust gas temperature with respect to brake power

The variation of exhaust gas temperature with respect to brake power for different bavanchi oil-blend fuel are shown figure 4.4. This graph shows that exhaust gas temperature of the fuel blends are higher than the diesel fuel for a particular load and there is a little variation in the bavanchi oil-blends fuel at all load conditions. The exhaust gas temperature variation depends upon the flash point temperature and the viscosity of the fuel. The bavanchi oil-blend diesel has higher flash point and viscosity than the diesel fuel and also lower volatility. So the bavanchi blends have higher exhaust gas temperature

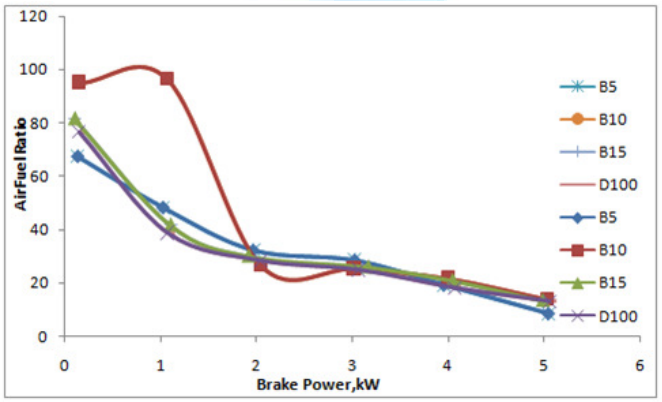

Fig 6 comparison of A/F ratio with respect to brake power

In the comparison of A/F ratio with respect to brake power for pure diesel and Bavanchi-blend fuel is shown in figure 6. It is observed that A/F ratio decrease with increase in brake power there is a higher air fuel ratio at initial brake power. There is slightly variation in the range of 0 to 2kW B10 bavanchi oil-blend diesel has higher A/F ratio compared to B5, B10 and pure diesel this happens because of air fuel mixing process is affected by the difficulty in atomization of bavanchi blend fuel due to its higher viscosity.

3.3 Emission Characteristics

The plots of carbon monoxide (CO) emissions of bavanchi oil blend and diesel fuel operated at different load conditions are shown in figure 7. The plots show reducing CO emissions up to 4kw power. The decrease in carbon monoxide emission for bavanchi blend fuel is due to more oxygen molecule present in the fuel and more atomization of fuel as compared to that of diesel. The decrease in CO emission may be due to better vaporization biodiesel fuel and more oxygen present in the biodiesel, resulting in complete combustion up to the power 4kw but after that with increase in power there is a slightly increase in CO emission by 0.01 % for D100 and B5. But for B10 and B15 there is a large increase is observed after power 4kw

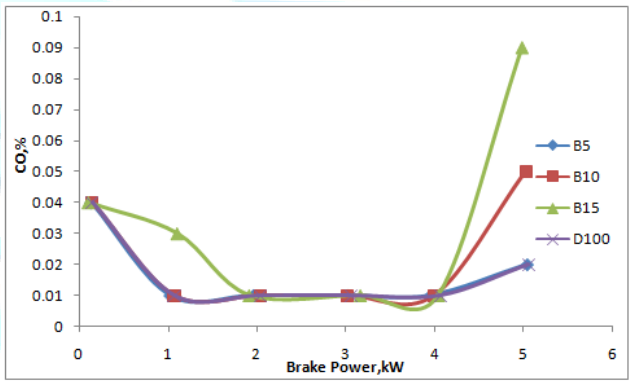

Fig -7: Variation of carbon monoxide with brake power

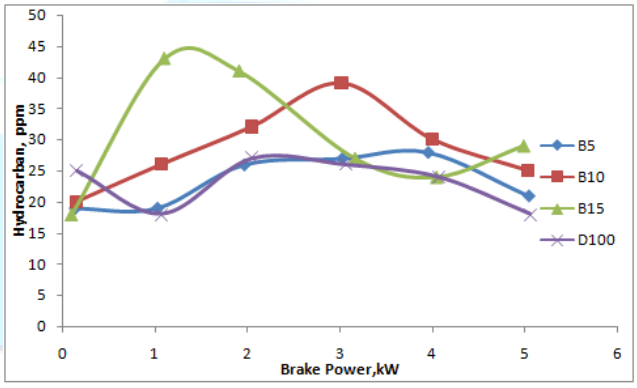

Fig 8 Variation of HC emission with Brake power

The variations of HC emission for diesel and bavanchi blend fuel are shown in the figure 8. It has been observed that HC emissions are nearly identical in B5 and D100. In the blend B10 and B15 we can see higher HC emission, the reason for this may be incomplete combustion. Lower HC emissions in the exhaust gas of the engine may be attributed to the efficient combustion of bavanchi oil blend diesel and due to the presence of fuel bound oxygen and warmed-up conditions at higher loads.

This is due to the reason that at lower loads the lower cylinder pressure and temperatures were experienced that was caused by lower rate of burning. This feature results in higher HC emissions

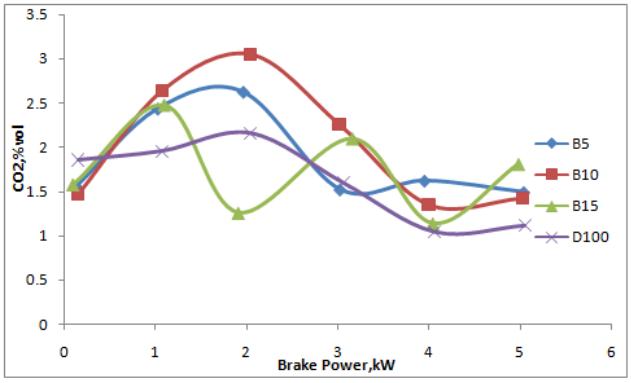

Fig 9 Variation of carbon dioxide with brake power

The variation of CO_2 produced at different engine brake power is shown in figure 9. For different bavanchi-blends oil increases initially and then it decreases this may be due to complete combustion of the fuel at a higher brake power or at higher loads. The one more reason for the formation of the CO_2 is the presence of oxygen in the bavanchi oil which has a higher amount of oxygen compare to the diesel which lead to the formation of carbandioxide in the exhaust gases

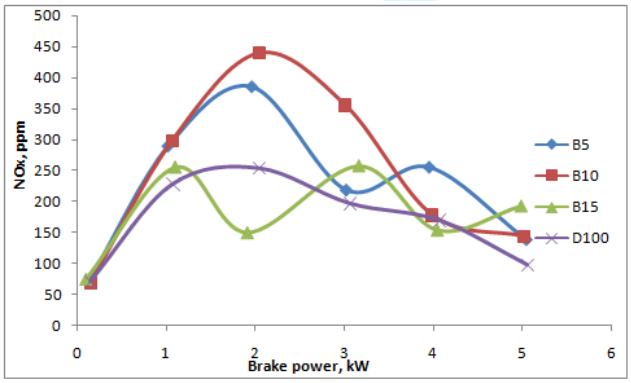

Fig 10 Variation of NOx with brake power

Figure 10 shows the variation of oxides of nitrogen with engine power output. The main reason for the formation of oxides of nitrogen in an IC engines are high temperature and availability of oxygen. At maximum load, NOx emission for bavanchi blend diesel fuel is higher. The operating conditions are in favor of NO species and such as the availability of oxygen in the fuel itself other than the oxygen available in the air and high temperature which enhance the NO species formation.

3.4 Combustion Characteristics

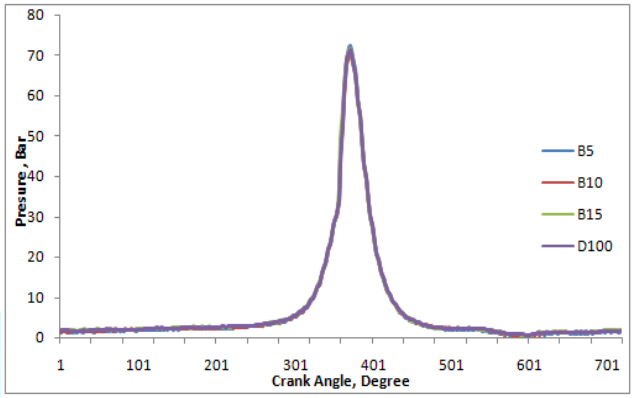

Fig -11: Variation of pressure with crank angle

In a CI engine, cylinder pressure depends on the fraction of fuel burned during the premixed burning phase. Cylinder pressure crank angle variation at maximum load with pure diesel and bavanchi oil-blend diesel is given. bavanchi oil blend diesel follows the trend, similar to pure diesel pressure diagram. Same trend is followed for other loads. The cylinder peak pressure is highest with B5 followed by pure diesel. It is observed that the occurrence of peak pressure moves away with B5 compared to pure diesel at crank angle 369^0C with cylinder pressure 72.04 bars. This indicates that the ignition delay is longer with B5 compared to pure diesel as shown in the figure 11. Longer ignition delay means more fuel is injected. Due to high viscosity, poor volatility, poor spray characteristics and lower heating value of B5 leads to less fuel being prepared for rapid combustion result in lower peak pressure compared to pure diesel. This is also a reason for reduction in maximum rate of pressure raise (MRPR) with B5

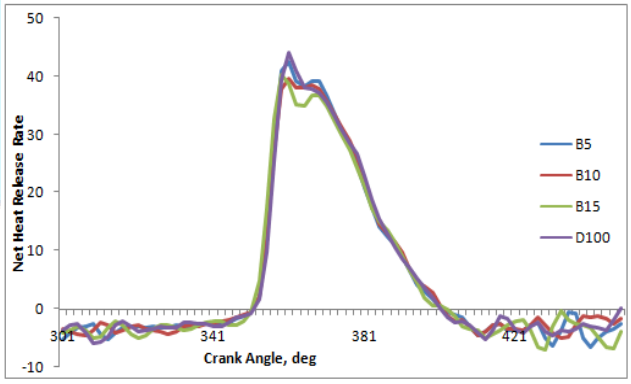

Fig 12 Show the variation of net HRR with crank angle

The variation of net heat release rate with crank angle in figure 12 found that The heat release rate for all other tested fuel was slightly less than that of diesel this

may be attributed to low vaporization, high viscosity and low peak pressure of blends as compared to that of diesel.

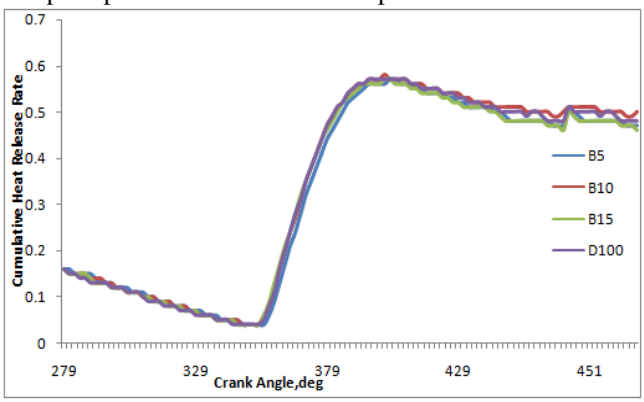

Fig -13: Variation of cumulative heat release rate with

The variation of cumulative heat release rate with crank angle is shown in figure 13 describes that the diesel and blend values are same in all loads. The two main phases of the combustion process, premixed and diffusion are clearly seen in the rate of heat release curve. If all heat losses (due to heat transfer from the gases to the cylinder walls, dissociation, incomplete combustion, gas leakage) are added to the apparent heat release characteristics, the fuel burn characteristics are obtained.

4.Conclusions

Experimental investigations are carried out on a single cylinder diesel engine to examine the suitability of bavanchi seeds oil as an alternate fuel. The performance, combustion and emission characteristics of blends are evaluated and compared with diesel. No difficulty was faced at the time of starting the engine and the engine ran smoothly over the range of engine speed. From the above investigation, the following conclusions are drawn.

- Bavanchi seeds oil satisfies the important properties as per ASTM standards.
- Bavanchi seeds oil can be directly used in diesel engines without any engine modifications.
- Engine works smoothly on bavanchi seeds oil with Performance comparable to diesel operation.
- Brake thermal efficiency curve of B10 blend is nearly similar to diesel compared to other blends
- The exhaust gas temperature is decreased with the bavanchi seeds oil Specific fuel consumption is decreased at lower loads and equal in full load.
- Combustion characteristic of all blends of bavanchi seeds oil is almost same as that of diesel.
- The emission characteristics like CO_2 and HC are increases and CO levels are decreases.
- By observing all results of biodiesel from bavanchi seeds oil can be used as a biodiesel feedstock.

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