Fig 2.1: Separation of biodiesel and glycerine

2.3 Various Properties of Bio Fuel

CI engines are basically designed to run with Diesel as fuel, therefore it is necessary that the alternative fuels have properties close to that of diesel, because the large variation in properties of fuel may lead to erratic running of engine and may cause damage to the engine and poor performance.

Table 2.1: Property test results of Diesel, Safflower Biodiesel, Methanol, Ethanol.

Properties	Density (kg/m^3)	Calorific value (KJ/kg)	Kinematic viscosity (mm^2/sec)	Flash point (°c)
Diesel	830	42800	3.6	86
Methanol	792	19800	.68	12
Ethanol	790	28500	1.5	17
Safflower Biodiesel	860	32629	5.67	176

Properties of Safflower biodiesel is tested from Raipur institute of technology, Raipur (C.G.). The testing method of Calorific value, kinematic viscosity, Flash point is ASTM D240, ASTM D445, ASTM D93 respectively.

2.4 Preparation of Blends

Total six different blends are produced and properties test is done for all blends sample.

The blends are;

Blend A (5% Methanol + 5% Safflower biodiesel + 90% Diesel),

Blend B (5% Methanol + 10% Safflower biodiesel + 85% Diesel),

Blend C (5% Methanol + 15% Safflower biodiesel + 80% Diesel),

Blend D (5% Ethanol + 5% Safflower biodiesel + 90% Diesel),

Blend E (5% Ethanol + 10% Safflower biodiesel + 85% Diesel),

Blend F (5% Ethanol + 15% Safflower biodiesel + 80% Diesel)

The below table show the properties of six different blends.

Table 2.2: Properties of six different blends

Type of blend	**Amount of Methanol/ Ethanol over 1000 ml**	**Amount of Biodiesel over 1000 ml**	**Amount of Diesel over 1000 ml**	**Density (kg/m^3)**	**Calorific value (KJ/kg)**
Diesel	0	0	1000	830	42800
Blend A	50	50	900	829.6	41141.45
Blend B	50	100	850	831.1	40632.9
Blend C	50	150	800	832.6	40124.35
Blend D	50	50	900	829.5	41576.45
Blend E	50	100	850	831	41067.9
Blend F	50	150	800	832.5	40559.35

2.5 Performance Test

Engine performance is an indication of how well the engine performs its assigned task, i.e. the conversion of the chemical energy contained in the fuel into the useful mechanical work. The engine performance parameters, which we going to use in this thesis works are;

Brake power, Brake thermal efficiency, Brake Specific fuel consumption, Brake Specific Energy Consumption.

- **Brake power (BP)**

The power developed at the output shaft of the engine is termed as Brake Power; it is the power available at the crankshaft of the engine.

- **Brake thermal efficiency (BTE)**

It is the ratio of output shaft power (Brake power) to the Heat input supplied to the engine. It can also understand as brake power of a heat engine as a function of the thermal input from the fuel. It is used to assess how well an engine converts the heat from a fuel to mechanical energy.

2.7 Formulae used

Formula used for calculation of various parameters is described below:

1) Quantity of fuel used,

$$m_f\ (kg/sec) = \frac{X\ (ml)}{t(sec)} \times \frac{S.G.}{1000}$$

Where X (ml) = Volume of fuel consumed
"t" = time taken for X(ml) of fuel consumed
S.G. = Specific gravity of fuel

2) Brake power output,

$$B.P. = \frac{2\pi NT}{60000} \quad (KW)$$

Where, T = Torque in (N-m) = P × r × 9.81
P = Net load in (kg)
r = Distance between dynamometer shaft centre of spring balance (meter)
N = Rated RPM of the engine

3) Brake specific fuel consumption,

$$B.S.F.C. = \frac{m_f \times 3600}{B.P.} \quad (kg/KW\text{-}hr)$$

4) Heat Supplied to the engine,

$$Q_f = m_f \times C.V. \quad (KW)$$

Where, C.V. = Calorific Value of fuel (KJ/kg)

5) Brake Thermal Efficiency,

$$\eta_{BTE} = \frac{B.P.}{Q_f}$$

6) Brake specific Energy Consumption,

$$B.S.E.C. = \frac{B.S.F.C. \times C.V.}{1000} \quad (MJ/KW\text{-}hr)$$

2.8 Performance Evaluation

To assess the present condition of the engine a constant speed test with diesel as a fuel was carried out and base line data were generated. Now for the different loads time taken for consumption of 10 ml of fuel, RPM of shaft and temperature values are noted down. After performing test with fuel pure diesel, the test were performed with Blend A (5% Methanol + 5% Safflower biodiesel + 90% Diesel), Blend B (5% Methanol + 10% Safflower biodiesel + 85% Diesel), Blend C (5% Methanol + 15% Safflower biodiesel + 80% Diesel), Blend D (5% Ethanol + 5% Safflower biodiesel + 90% Diesel), Blend E (5% Ethanol + 10% Safflower biodiesel + 85% Diesel), Blend F (5% Ethanol + 15% Safflower biodiesel + 80% Diesel).

3 RESULTS AND DISCUSSIONS

3.1 Performance Characteristics for Diesel as compared with Blend A, Blend B and Blend C

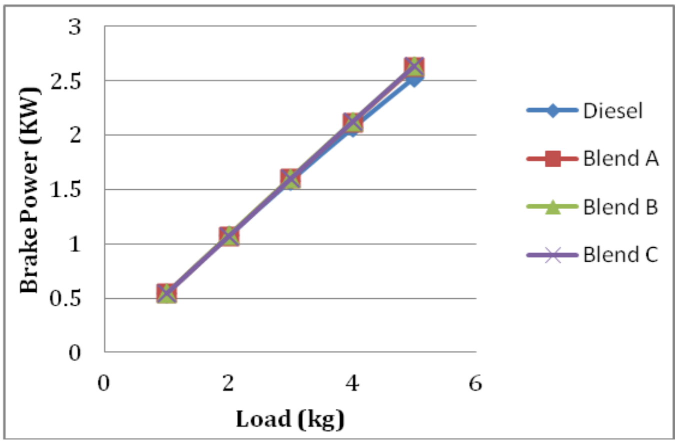

Figure 3.1: BP v/s Load for Diesel, Blend A, Blend B, Blend C

Figure 3.1 shows the variation of brake power with respect to load for different biodiesel blends. The results show that Brake power of biodiesel blends, Blend A and Blend B and Blend C shows approximately same value and it is very close to diesel. But when load increased BP of all three Blends indicates somewhat more value of BP as compare to Diesel.

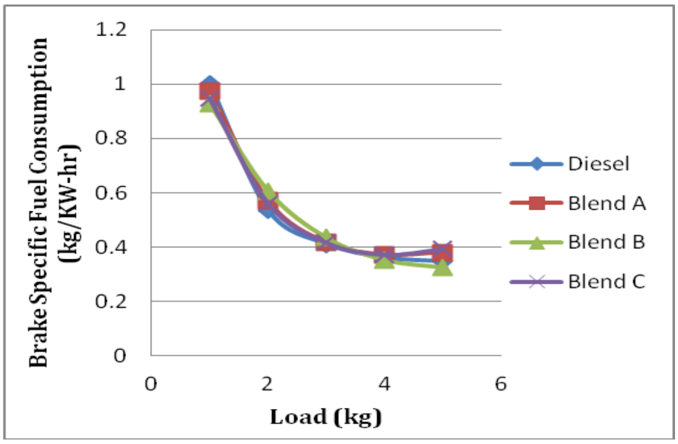

Figure 3.2: BSFC v/s Load for Diesel, Blend A, Blend B, Blend C

Figure 3.2 shows the variation of brake specific fuel consumption with respect to load for different blends. The brake specific fuel consumption for all blends of biodiesel shows the same trend as diesel fuel whereas the

BSFC for Blend A and Blend C is more than Blend B. And BSFC for Blend B is even more than diesel at middle load conditions but at higher loads Blend B shows least BSFC.

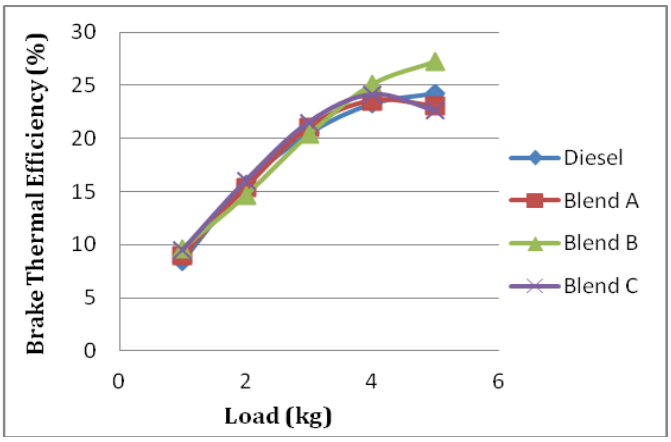

Figure 3.3: BTE v/s Load for Diesel, Blend A, Blend B, Blend C

Figure 3.3 shows the variation of brake thermal efficiency with respect to load for different blends. The results show that brake thermal efficiency for all blends of biodiesel shows the same trend as diesel fuel whereas the BTE for Blend B is less than among Blend A and Blend C. But BTE for Blend B is even less than diesel at middle load condition but at higher loads BTE of Blend B is highest.

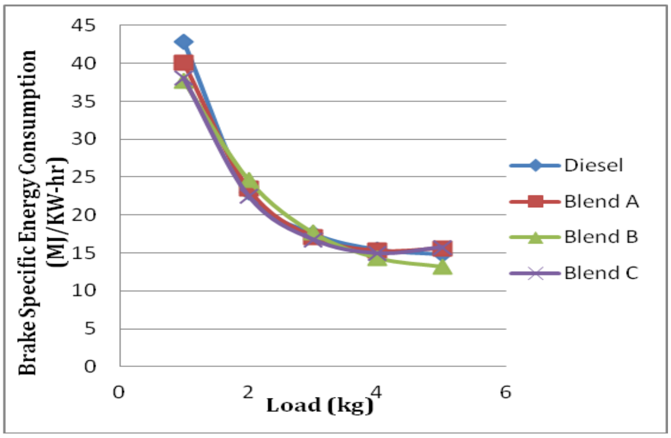

Figure 3.4: BSEC v/s Load for Diesel, Blend A, Blend B, Blend C

Figure 3.4 shows the variation of brake specific energy consumption with respect to load for different blends. The results show that brake specific energy consumption for all blends of biodiesel follow the same trend as diesel fuel whereas the BSEC for Blend A Blend B and Blend C is less then Diesel at low load condition. At middle loads

Blend B shows the more brake specific energy consumption with respect to all but at higher loads BSEC is lowest.

3.2 Performance Characteristics for Diesel as compared with Blend D, Blend E and Blend F

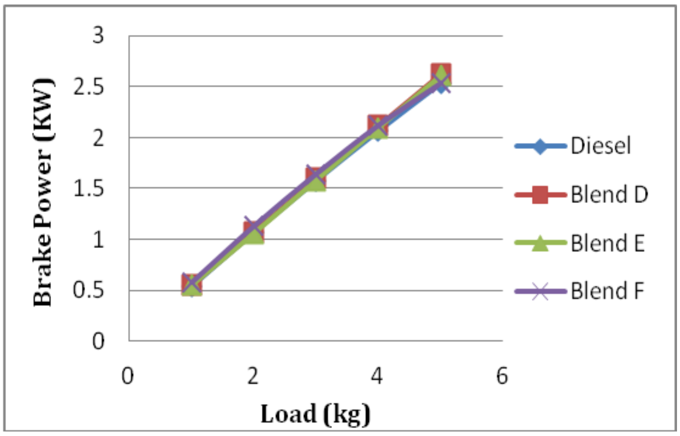

Figure 3.5: BP v/s Load for Diesel, Blend D, Blend E, Blend F

Figure 3.5 shows the variation of brake power with respect to load for different blends. Brake power of all biodiesel blends say Blend D, Blend E and Blend F are found approximately same and very close to diesel.

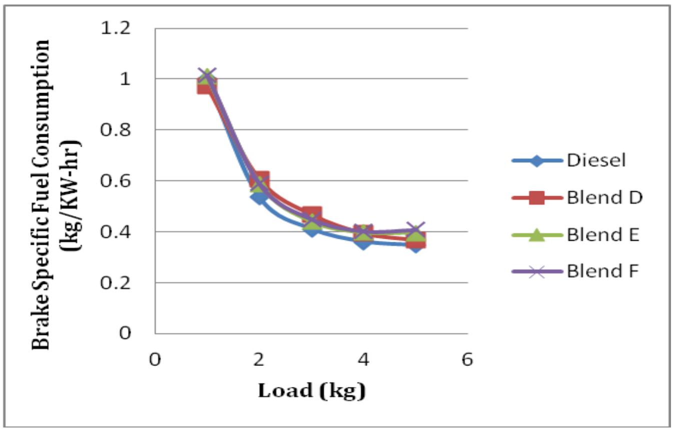

Figure 3.6: BSFC v/s Load for Diesel, Blend D, Blend E, Blend F

Figure 3.6 shows the variation of brake specific fuel consumption with respect to load for different blends. The brake specific fuel consumption for all blends of biodiesel follows the same trend as diesel fuel at initial conditions. Pure Diesel shows the least brake specific fuel consumption as compared to Blend D, Blend E and Blend F. And BSFC for Blend D is close to diesel when compared with Blend E and Blend F at higher loads.

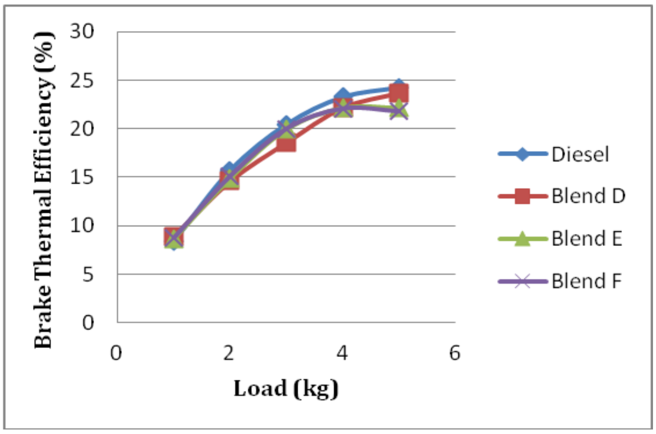

Figure 3.7: BTE v/s Load for Diesel, Blend D, Blend E, Blend F

Figure 3.7 shows the variation of brake thermal efficiency with respect to load for different blends. The brake thermal efficiency for all blends of biodiesel follows the same trend as diesel fuel at low load conditions. Pure Diesel shows the highest brake thermal efficiency as compared to Blend D, Blend E, Blend F. BTE for Blend D is close to diesel when compared with Blend E and Blend F at higher loads.

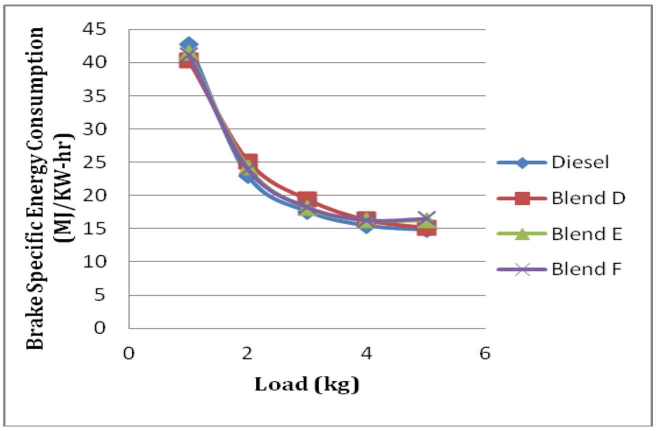

Figure 3.8: BSEC v/s Load for Diesel, Blend D, Blend E, Blend F

Figure 3.8 shows the variation of brake specific energy consumption with respect to load for different blends. The brake specific energy consumption for all blends of biodiesel follows the same trend as diesel fuel at low load. Pure Diesel shows the least brake specific energy consumption as compared to Blend D, Blend E, Blend F at middle load. BSEC of Blend D is close to diesel when compared with Blend E and Blend F at higher load.

4. CONCLUSIONS

The performance characteristics of a single cylinder four stroke diesel engine with blend of Safflower biodiesel, Diesel and additive as fuel are experimentally investigated and compared with diesel. It is observed that, the viscosity and density of the blend goes up with increased percentage of biodiesel. However its calorific value is reduced and it gives reduced energy per litter as the biodiesel percentage increases. The salient observations are,

- Safflower biodiesel + diesel can be directly used in diesel engine without any engine modification.
- Brake Power increases with an increase in biodiesel concentration with load increases.
- Brake Specific fuel Consumption decreases in the case of blend A and blend C, but it is increases with rest of them.
- Brake Thermal Efficiency increases in the case of blend B and blend D.
- Brake Specific Energy Consumption decreases in the case of blend B, but it's approximately same as diesel in rest of them.

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