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Performance and Experimental Analysis of the mixture of Roselle & Safflower oil as Bio-diesel Blend on Four Stroke Single cylinder water cooled vertical Diesel Engine

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Abstract - *Biodiesel is an environment-friendly as well as appropriate source, to meet the upcoming energy crises. Due to continuous growth in the need on fossil fuel, its price because of fast reduction of petroleum resource and increasing environmental pollution have supported to shift toward green energy sources such as another renewable fuel which is obtained from biomass and animal fats. The main aim of this experimental analysis is to reach a tentative goal, how this fuel can be utilized with a maximum effective approach. This work investigates the reliability of using easily obtainable edible vegetable seed oils to produce biodiesel. The oil has been converted to biodiesel by the familiar base catalyst transesterification process. It is found that physical and chemical properties of Roselle & Safflower oil and biodiesel are much related to fossil diesel. For safe operation Combined with petroleum diesel in any percentage blends in any CI engine designed to be worked on petroleum diesel. The aim of this experimental investigation is to optimize the performance of a mixture of Roselle & Safflower biodiesel and its blends with Diesel. Here oxygenate additive Methanol and Ethanol are used for attractive the combustion quality. Its blends are measured and valued in four strokes, single cylinder diesel engine. Factors like the speed of the engine (RPM) and fuel consumption were measured at different loads for pure diesel and various mixtures of biodiesel blends. This investigation gives the comparative measures of brake power (BP) and brake specific fuel consumption (BSFC), brake specific energy consumption (BSEC), brake thermal efficiency (BTE) were calculated and also matched with ordinary diesel which is also known as petro diesel. From the inspection, it can be presumed that biodiesel can be developed as another option to diesel in a compression ignition engine without any engine changes.*

***Key Words*: The mixture of Roselle & Safflower oil, Transesterification, Biodiesel-Blend, Additive, Diesel Engine.**

1. INTRODUCTION

The principal source of global warming and thus greenhouse gas (GHG) emission is human activity, most significantly the burning of fossil fuels, the need for discovering renewable sources of energy has been increasing rapidly. On the additional side, biomass use is becoming more popular due to its short span of the life cycle which makes it a carbon-neutral source **[1].** Through the socio-economic growth of the society, the energy requirement has increased Multifood globally as the consumption pattern in a specific country depends upon the availability of energy resources. The various sectors that require energy from some sources are industry, transport, agriculture, domestic etc. Different energy sources are wood, coal, petroleum products, nuclear power, solar; wind etc. **[2-4]**

1.1 Overview of Roselle & Safflower Biodiesel

Roselle -A rain-fed wasteland evergreen eatable oil and vegetable plant, Hibiscus sabdariffa is commonly known as 'Roselle' or 'Sorrel' or 'Ambadi' in Hindi. There are more than 300 species of hibiscus around the world, one of them is Roselle (Hibiscus sabdariffa Linn.), which is a member of the plant family Malvaceae.

Safflower-Safflower oil is prepared from untreated and treated seeds. Untreated seeds are bitter in taste. The oil extracted from untreated seeds is used in the production of linoleum floor tile, soap, paint solvent etc. This oil is not eatable. Preserved seeds remain additional two types and both are eatable. One covers monounsaturated fatty acids and second covers polyunsaturated fatty acids.

Roselle seed

Safflower seed

1.2 Biodiesel & there advantage & disadvantage

Biodiesel can be produced from edible or non-edible oil like straight vegetable oil, animal fats/oil, tallow and waste cooking oil. The process used to convert this oil to biodiesel is called transesterification. Bio-diesel is renewable petroleum, recyclable and non-toxic.

Advantage-

- Biodiesel made from renewable sources, so it is renewable fuel and recyclable.

- Biodiesel is better for the atmosphere because it has lower emissions compared to other.
- It is free from Sulphuric, aromatic hydrocarbons, metals or crude oil remains.
- It is less toxic than table salt and biodegrades as fast as honey.
- It has larger lubrication capabilities and rises engine life.
- Biodiesel can be used in existing engines without any adjustments or buy any special vehicles.
- Different fossil fuels, the use of biodiesel does not contribute much to global warming

Disadvantages-

- It is costly in comparison to standard petro diesel.
- Biodiesel has expressively higher viscosity and low energy content compared to standard petro diesel.
- Biodiesel is responsible for higher NOx emission compared to petro diesel.

1.3 Aim and Objectives

- To change the Roselle & Safflower oil to biodiesel by the process of transesterification, and to test the performance of the biodiesel from these oils at various blend ratios with diesel using the Compression Ignition Engine. To establish the optimum blend of the biodiesel.

2 Transesterification process:

The transesterification is the procedure utilized for arrangement of Biodiesel utilizing vegetable oils. It separates the particles of vegetable oils into constituent atoms shaping biodiesel as the principle item and glycerin as the result. There are three fundamental courses to biodiesel generation frame oils-

Oil or Fat + alcohol ⟶ Esters + Glycerol

3 Properties of biodiesel utilized as a part of test motor:

Density - A thickness of a fluid is characterized as mass per unit volume of the fluids. The thickness was estimated at room temperature and is estimated with the assistance of an instrument called hydrometer. Unit of thickness is kg/m3

Specific gravity - Specific gravity is additionally called as relative thickness which is characterized as the proportion of the weight of the fluid example and weight of the standard fluid at given temperature. For the part, refined water is picked as standard fluid. Particular gravity is a dimensionless amount. A thickness of water is taken as 1000 kg/.

Flash point and Fire point - Streak purpose of a fuel is characterized by the temperature at which vapours of the material will touch off when presented to a fire or start. The fire purpose of oil is the base temperature at which the vapour will continue consuming in the wake of having been lighted and the start source has been evacuated. At the point when the oil is presented to high-temperature benefit, it is important to know the glimmer point and fire purpose of the fuel keeping in mind the end goal to be sheltered against the danger of a flame.

Viscosity - Viscosity is the property of the fluid that opposes an adjustment in its shape, it is likewise alluded to as inner grinding or we can state that consistency is the measure of a liquids protection from the stream. It depicts the intermolecular powers of a moving liquid. A liquid with substantial consistency opposes movement in light of the fact that intermolecular powers of fascination are solid inside a liquid. A liquid with less consistency implies intermolecular powers of fascination inside a liquid are frail. A consistency of liquid dependably diminishes with increment in temperature. Unit of consistency is a balance, stirs/centistokes.

Calorific value - The calorific value is the estimation of warmth or vitality delivered and is estimated either as gross calorific esteem or net calorific esteem. Calorific esteem chooses warm vitality discharged amid burning and is characterized as of warmth freed in KJ or Kcal by the entire ignition of 1 Kg of fuel. The distinction is controlled by the inert warmth of build-up of the water vapour created amid the ignition procedure. Net calorific esteem (GCV) expect all vapour delivered amid the ignition procedure is completely consolidated. Net calorific esteem (NCV) expects the water leaves with the ignition items without completely being dense. Powers ought to be thought about in light of the net calorific esteem.

Cetane number - Cetane number is a measure of the start nature of diesel fuel; higher this number, the simpler it is to begin a standard diesel motor. It is a converse capacity of a fuel's start delay, and the day and age between the beginning of infusion and the main identifiable weight increment amid ignition of the fuel. In a specific diesel motor, higher cetane powers will have shorter start postpone periods than bring down cetane fills.

Pour point - The pour point is the temperature of the fluid at which it moves toward becoming semi-strong and loses its stream qualities. In raw petroleum, a high pour point is for the most part connected with high paraffin content, commonly found in rough getting from a huge extent of plant material.

Cloud point - Cloud point is the temperature beneath which wax in diesel or bio shine in biodiesels shapes a shady appearance. The nearness of hardened waxes thickens the oil and stops up fuel channels and injectors in motors. The wax likewise aggregates on chilly surfaces (delivering, for instance, pipeline or warmth exchanger fouling) and frames an emulsion with water. In this way, cloud point demonstrates the inclination of the oil to plug channels or little holes at icy working temperatures.

The Engine - The engine used to bring out research is a single cylinder, four strokes, vertical, water cooled, Kirloskar makes CI engine.

Figure 1: Experimental rig

Make	Kirloskar
Speed	1500 rpm
No. of cylinder	01
Compression ratio	16.5:1
Bore	80 mm
Stroke	110 mm
Brake Horse Power	5 H.P.
Cooling	Water cooled
Loading	Hydraulic Dynamometer

Table 1: Specification of Engine

The hydraulic dynamometer remains used for the research. Loads increased by closing the regulator of dynamometer loads calculated through spring balance and the distance between dynamometer shafts centre to centre of spring balance in meters is 0.34. This distance can be used for control of torque.

Dynamometer - The hydraulic dynamometer remains used for the research. Loads increased by closing the regulator of dynamometer loads calculated through spring balance and the distance between dynamometer shafts centre to centre of spring balance in meters is 0.34. This distance can be used for control of torque.

Figure 2: Dynamometer

3.1 The formula used for calculation of various parameters is defined below:

1) A quantity of fuel used,

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

Somewhere X (ml) = Volume of consumed fuel

"t" = time occupied used for X (ml) of the fuel expended

S.G. = Specific gravity of the fuel

2) Brake power output,

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

Anywhere, T = Torque in (N-m) = P × r × 9.81

P = Disposable load in (kg)

r = Distance among dynamometer channel center of spring stability (meter)

N = Valued/Rated RPM of the engine,

3) Brake specific fuel consumption,

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

4) Heat Supplied to the engine,

$$Q_f = m_f \times C.V. \text{ (KW)}$$

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,

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

Table -2: The below table shows the properties of Diesel, Roselle Biodiesel, Methanol and Ethanol.

Property	Diesel	The mixture of Roselle & Safflower Biodiesel	Methanol	Ethanol
Density(kg/m³)	840	857	796	792
Viscosity(mm²/s)	4.4	5.44	0.6	1.1
Calorific value(KJ/kg)	43910	30971.63	19678	26795
Flash point(°c)	65	174	11.11	12.77

Table -3: 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/m³)	Calorific value (KJ/kg)
Diesel	-------	-------	1000	840	43910.00
Blend A	50	100	850	839.5	41404.563
Blend B	50	200	750	841.2	40110.726
Blend C	50	300	650	842.9	38816.889
Blend D	50	100	850	839.3	41760.413
Blend E	50	200	750	841	40466.576
Blend F	50	300	650	842.7	39172.739

- **Blend A** (5% Methanol + 10% the mixture of Roselle & Safflower biodiesel + 85% Diesel),
- **Blend B** (5% Methanol + 20% the mixture of Roselle & Safflower biodiesel + 75% Diesel),
- **Blend C** (5% Methanol + 30% the mixture of Roselle & Safflower biodiesel + 65% Diesel),
- **Blend D** (5% Ethanol + 10% the mixture of Roselle & Safflower biodiesel + 85% Diesel),
- **Blend E** (5% Ethanol + 20% the mixture of Roselle & Safflower biodiesel + 75% Diesel),
- **Blend F** (5% Ethanol + 30% the mixture of Roselle & Safflower biodiesel + 65% Diesel),

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

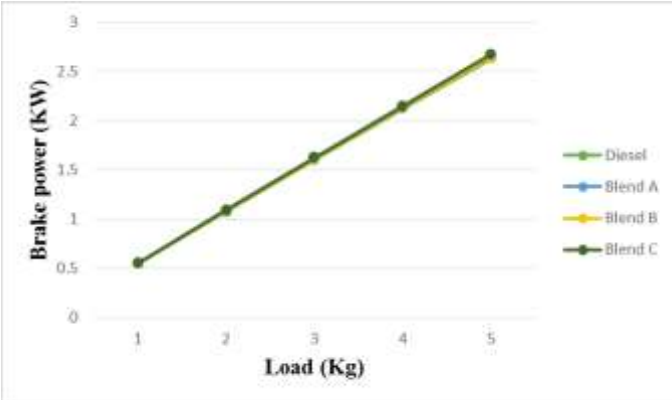

Figure 3: BP v/s Load for Diesel, Blend A, Blend B, and Blend C

Figure 3 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, Blend B, and Blend C shows approximately same value and it is very close to diesel. But when load increased BP of all Four Blends indicates somewhat more value of BP as compare to Diesel where blend C show the highest value in the curve.

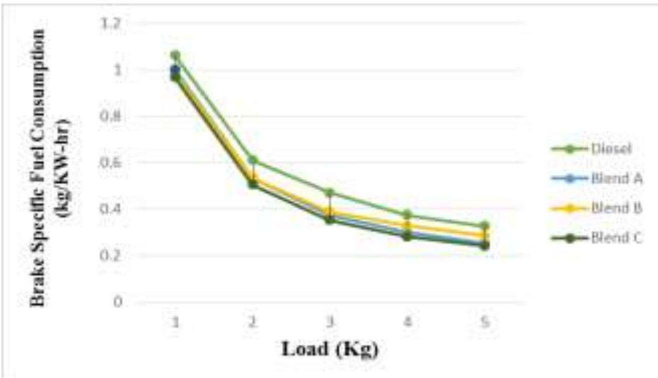

Figure 4 : BSFC v/s Load for Diesel, Blend A, Blend B & Blend C

Figure 4 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 similar trend as diesel fuel whereas the BSFC for Blend A, Blend B & Blend C show the least value as compare to Diesel, but BSFC for Blend C show lowest value at higher load conditions.

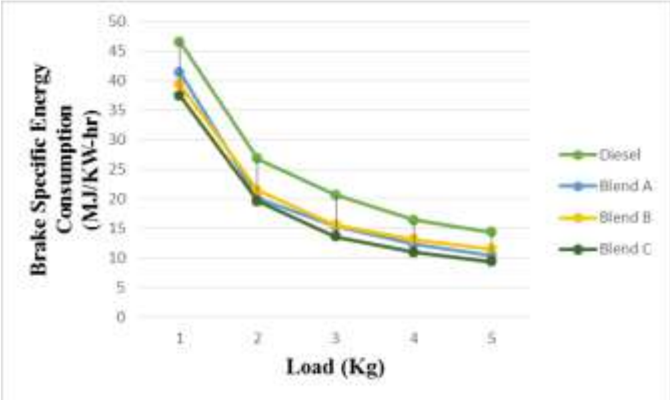

Figure 5: BSEC v/s Load for Diesel, Blend A, Blend B & Blend C

Figure 5 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 shows the similar trend as diesel fuel. The BSEC for Blend A, Blend B and Blend C is less then Diesel at high load condition but at higher loads BSEC of Blend C shows least value.

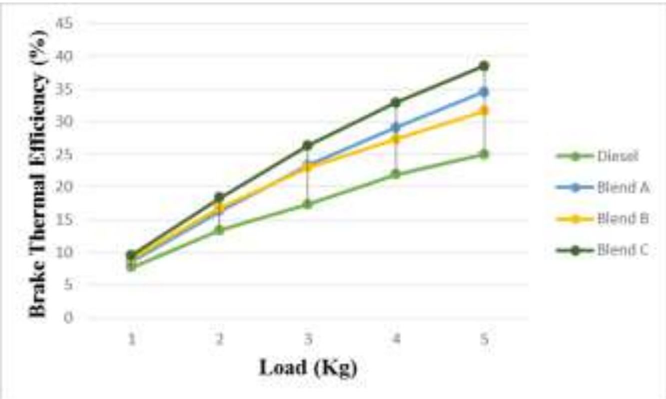

Figure 6: BTE v/s Load for Diesel, Blend A, Blend B & Blend C

Figure 6 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 similar trend as diesel fuel whereas the BTE for Diesel is less than among Blend A, Blend B and Blend C. But BTE for Blend C show highest value at higher load condition.

4.2 Performance Characteristics for Diesel as compared with Blend D, Blend E & Blend F.

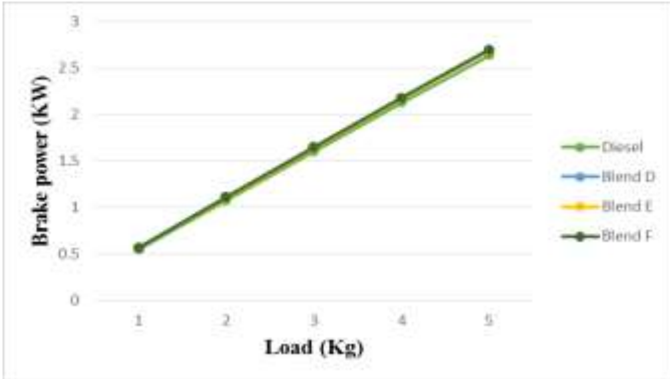

Figure 7: BP v/s Load for Diesel as compared with Blend D, Blend E & Blend F,

Figure 7 shows the variation of brake power with respect to load for different blends. Brake power of all biodiesel blends Follows same trend as diesel. When the load is increased brake power of Blend F is show higher value.

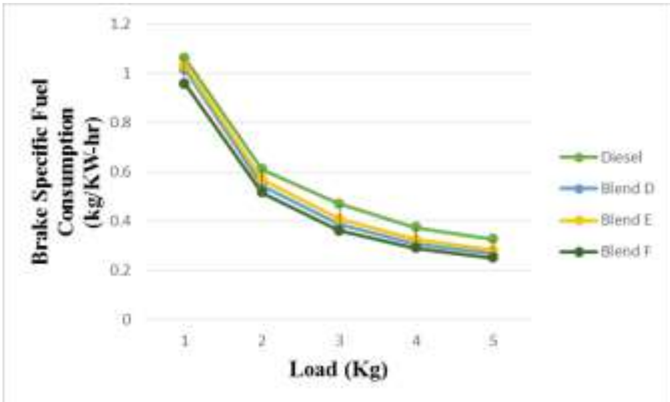

Figure 8: BSFC v/s Load for Diesel as compared with Blend D, Blend E & Blend F

Figure 8 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 similar trend as diesel fuel at initial conditions. Pure Diesel shows the highest brake specific fuel consumption as compared to Blend D, Blend E and Blend F. And BSFC for Blend F show least value at higher loads.

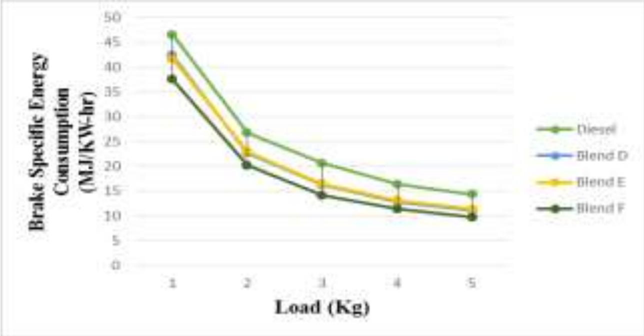

Figure 9: BSEC v/s Load for Diesel as compared with Blend D, Blend E and Blend F,

Figure 9 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 similar trend as diesel fuel. Blend F shows the least brake specific energy consumption as compared to Diesel and Blend D, Blend E.

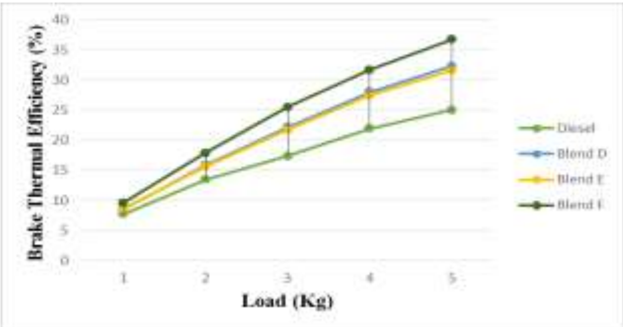

Fig -10 : BTE v/s Load for Diesel as compared with Blend D, Blend E and Blend F,

Figure 10 shows the variation of brake thermal efficiency with respect to load for different blends. Blend F shows the highest brake thermal efficiency as compared to The Diesel and Blend D, Blend E, when the Load is increase.

5. CONCLUSIONS

- When diesel fuel compared with Blend A, Blend B & Blend C; Blend 'C' shows the least Brake Specific Fuel Consumption, Brake Specific Energy Consumption and highest Brake Thermal Efficiency among all. Moreover, the Brake Power of all blends is approximately similar and close to diesel.

- When diesel fuel compared with Blend D, Blend E & Blend F, Blend 'F' shows better performance than other blends (Blend D & Blend E). Blend 'F' has least Brake Specific Energy Consumption, highest Brake Power and highest Brake Thermal Efficiency among all blends when the load is increases but pure Diesel shows better Brake Specific Fuel Consumption than other blends.

- When diesel fuel compared with Blend A and Blend D, Blend 'D' shows better performance than diesel fuel and Blend A. Blend 'A' has least Brake Specific Fuel Consumption, Brake Specific Energy Consumption, Brake power and highest Brake Thermal Efficiency than pure Diesel and Blend D, i.e. Methanol blend shows better results than Ethanol blends.

- When diesel fuel compared with Blend C and Blend F, Blend 'C' shows least Brake power, Brake Specific Fuel Consumption, Brake Specific Energy Consumption and highest Brake Thermal Efficiency than pure Diesel and Blend F, but Brake Power of Blends are close to diesel, i.e. Methanol blend shows better results than Ethanol blends.

6. SCOPES FOR FUTURE WORK

- An additional investigation can be carried out to find out the best mixing ratio of Roselle & safflower Oil Methyl Ester with diesel and alcohol.
- An experimental study can be performed for the emission characteristics of different biodiesel blends.
- Further studies can be carried out for making proper use of the by-products from crude Roselle & safflower biodiesel.
- Further investigation can be carried out for the production of biodiesel from Roselle & safflower oil from different alcoholic groups to conduct various engine tests.
- On the basis of the cost analysis, we consider that is a lot of option for the stable price of petroleum.

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