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# Development of Biodiesel Synthesis by Transesterification from Cottonseed Oil and Performance Test on Diesel Engine

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***Abstract*— This work aims at the performance test on diesel engine to be made to run on biodiesel which is obtained by the transesterification of non-edible cottonseed oil. The combustion characteristics are also noted along with performance and emission details. Blends from B10 to B100 were prepared and tested on the engine setup. On observing the performance characteristics it was found that blend B30 produced the optimum results. Cottonseed oil was chosen for obtaining biodiesel due to its inherent presence of low amount of unsaturated fatty acids which makes the transesterification process greener and efficient. The yield obtained was 84% which could be increased substantially if ionic liquids were used as catalyst as well as solvents. So, a study of ionic liquids was found necessary to fully comprehend the conversion process and its optimization. The catalyst used initially was sodium hydroxide. The properties of cottonseed oil and the biofuel obtained after transesterification were noted. The Fourier Transform Spectroscopy test was performed for the cottonseed oil as well as biofuel which show that the biofuel obtained by transesterification is suitable for being used as an alternative fuel on blending with diesel.**

***Index Terms*—Cottonseed oil, Transesterification, Biofuel, Blend**

## I.INTRODUCTION

Biodiesel is a liquid biofuel obtained by chemical conversion processes from different sources like vegetable oils, animal fats and an alcohol that can be used in diesel engines, alone or blended with diesel fuel thereby acting as an alternative source of energy. Some of the advantages of using biodiesel as a replacement for diesel fuel are

- It is a renewable fuel, obtained from vegetable oils or animal fats
- It is non toxic, in comparison with diesel fuel
- Since it degrades more rapidly than diesel fuel, it minimizes the environmental consequences of biofuel spills
- Lower emissions of contaminants like carbon monoxide, particulate matter, polycyclic aromatic hydrocarbons, aldehydes takes place in the engine
- emissions of carcinogenic substances are reduced
- No oxides of sulphur are formed
- Higher flash point and fire point ensures safety in storage, handling and transport which suits the environmental effect advantages
- May be blended with diesel fuel at any proportion, both fuels may be mixed during the fuel supply to vehicles thus having the same intake manifold
- Excellent nature in lubricity which offers a long life of the engine
- It is the only alternative fuel that can be used in a conventional diesel engine without any modifications in it since the blends easily burn on compression
- Used cooking oils and fat residues can be used as raw materials and also no edible ones

## II.METHOD OF EXTRACTION OF COTTONSEED OIL

The process of extraction of cottonseed oil is by using SCF i.e supercritical fluid. The fluid used usually is carbon dioxide. Dehulled cottonseed is passed through cracking and flaking rolls to yield flakes. The flaked cottonseed is charged into an alloy steel autoclave and extracted. The process may be mechanical as in crushing or pressing or chemical as in solvent extraction. The production steps are as follows

- Seed cleaning

- Cracking
- Flaking
- Cooking
- Expelling
- Refining

*SEED CLEANING*

This process involves getting rid of organic impurity like stems, leaves, hull, rope etc, inorganic impurity like dust, silt, pebbles and metals, oiliness impurity like grain of insects, grain of faultiness, heterogeneity seeds etc. Magnetic Separator, Vibrating Sieve, De-stoner, Decorticator are used in the process.

*CRACKING*

Toothed cracking rollers are used to convert the cotton seeds kernel into right uniform pieces which can keep a moderate block size for squeezing out the oil.

*FLAKING*

This process converts the cracked cotton seeds kernel pieces into uniform smaller flakes. The non oil spilled pinching is done slowly. The pieces are passed through sieve mesh to separate the powder.

*COOKING*

This process is used to add steam into the crushed and flaked seed pieces. It is then dried to get rid of more water content. A vertical stack cooker with five layers is adopted in this process. The temperature reached is 95 to 100 degrees Celsius.

*EXPELLING*

This method uses solvents for extraction of oil. The solvent is used after pre-pressing by oil expellers to get more oil.

*REFINING*

The process involves the following.

*ALKALI REFINING*

The oil and alkali are mixed allowing free fatty acids and alkali to form a soap. The resulting soapstock is removed through centrifuging. This process removes free fatty acids, glycerol, carbohydrates, resins, metals, phosphalides and protein meal.

*BLEACHING*

Bleaching clays are used which adsorb the impurities. This eliminates trace metals and other colour bodies.

*WINTERISATION*

In this process the oil is chilled with gentle agitation which causes higher melting fractions to precipitate. The fraction which settles out is called stearin. Care is taken that the oil does not become cloudy.

*HYDROGENATION*

This process involves treatment of oil with hydrogen gas in the presence of catalyst resulting in the addition of hydrogen to the carbon-carbon double bond. It is a selective process that can be controlled to produce various levels of hardening.

*DEODORIZATION*

Deodorization is a steam distillation process carried out under a vacuum. It removes volatile compounds from the oil. The end product has a low level of free fatty acids and has a zero peroxide value. This step also removes any residual pesticides or metabolites that might be present.

*INTERESTESTERIFICATION*

This process is used to rearrange or redistribute fatty acids on the glycerol backbone. It improves the functional properties of the oil. This is most often accomplished by catalytic methods. The oil is heated, agitated and mixed with the catalyst at 90ºC. Enzymatic systems may also be used in this process. It does not change the degree of saturation or isomeric state of the fatty acids.

Figure: Cottonseed hull

Cottonseed oil does not need to be hydrogenated as much as other polyunsaturated oils. Recent technological, social, and environmental changes are forcing the search for new alternatives for both edible and non-edible oil derived fuels. Presently, the first generation biofuels such as biodiesel and bioethanol dominate the biofuel sector. These biofuels can be used in low percentage blends with conventional fuels and can be distributed through the existing infrastructure. Today these fuels are not competitive with fossil fuels and can be seen as an intermediate step to reduce greenhouse gas emissions and to diversify transport energy sources.

## III.EXPERIMENTAL SETUP

The experimental design procedure was used to optimize the following process variables: reaction time, catalyst content and cottonseed oil to methanol molar ratio. The effects of these variables on biodiesel conversion were investigated.

### *PREPARATION OF BIOFUEL*

In this work, 200ml of cottonseed oil was taken in a beaker. Methanol of 50ml was taken and 0.5 grams of sodium hydroxide pellets were dissolved in it. The cotton seed oil and methanol with sodium hydroxide catalyst were mixed and placed on a magnetic hot plate. A magnetic stirrer is introduced into the beaker. A condenser with flowing cooling water is kept on top of the beaker and held firmly in a stand. Electric supply is given to the hot plate. The stirrer automatically stirs the mixture. Heat is supplied for about an hour and the temperature of the mixture reached 70 degrees. The mixture is then cooled in air until the temperature comes down to room temperature. The contents are taken in a separating funnel and left for one day for the separation of biofuel and glycerol. Biofuel is then collected separately after the glycerol is drained. The oil is in the upper portion of the separating funnel and glycerol collects in the bottom. The yield percentage is noted.

The values obtained were as follows:
Input = Cottonseed oil + Methanol + Sodium hydroxide=232.34g
Evaporation loss=5.5g, Yield of Biofuel=193.66g, Glycerol=33.1g
The yielding percentage of bio-oil from the bio-source =83.35%
The experiment was repeated to get a substancial yield of biofuel. Density of cotton seed oil =965 kg/m$^3$

Figure: Biodiesel preparation setup

*Engine Details:*
IC Engine set up under test is Kirloskar TV1 having power 5.20 kW @ 1500 rpm which is 1 Cylinder, Four stroke , Constant Speed, Water Cooled, Diesel Engine, with Cylinder Bore 87.50(mm), Stroke Length 110.00(mm), Connecting Rod length 234.00(mm), Compression Ratio 17.50, Swept volume 661.45 (cc)

*Combustion Parameters:* Specific Gas Const (kJ/kgK): 1.00, Air Density (kg/m^3): 1.17, Adiabatic Index: 1.41, Polytrophic Index: 1.26, Number of Cycles: 10, Cylinder Pressure Referance: 7, Smoothing 2, TDC Reference: 0

*Performance Parameters:* Orifice Diameter (mm): 20.00, Orifice Coefficient of Discharge: 0.60, Dynamometer Arm Legnth (mm): 185, Fuel Pipe dia. (mm): 12.40, Ambient Temp. (Deg C): 27, Pulses Per revolution: 360, Fuel Type: Diesel, Fuel Density (Kg/m^3) : 830, Calorific Value Of Fuel (kj/kg) : 42000

## IV.RESULTS AND DISCUSSION

TABLE-1: IP, BP, FP BY SPEED AND LOAD VARIATION

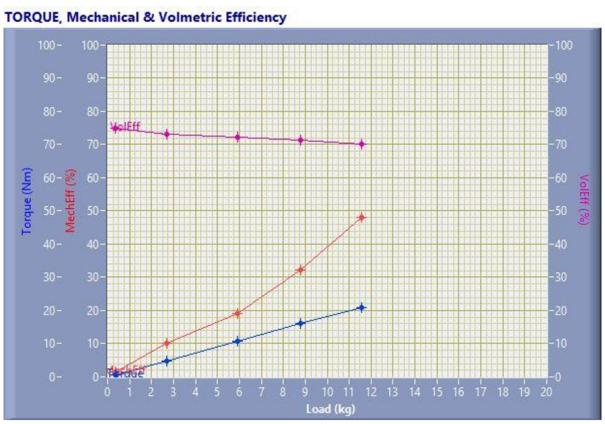
| Speed (rpm) | Load (kg) | IP (kW) | BP (kW) | FP (kW) |
|---|---|---|---|---|
| 1533 | 0.35 | 6.67 | 0.10 | 6.57 |
| 1526 | 2.69 | 7.79 | 0.78 | 7.01 |
| 1507 | 5.90 | 8.87 | 1.69 | 7.18 |
| 1488 | 8.80 | 7.69 | 2.49 | 5.20 |
| 1476 | 11.56 | 6.76 | 3.24 | 3.51 |

TABLE-2: IMEP, BMEP, FMEP by Speed and Load variation

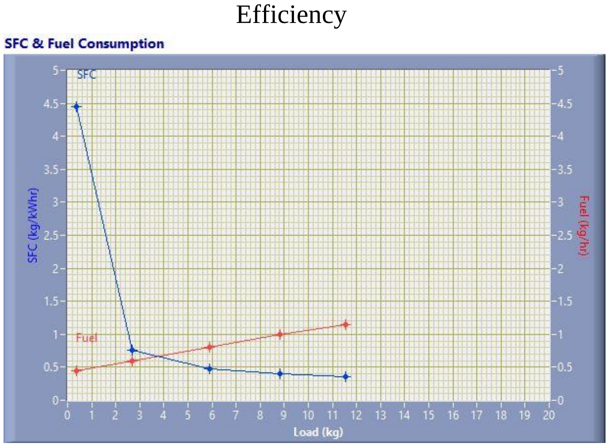
| Speed (rpm) | Load (kg) | IMEP (bar) | BMEP (bar) | FMEP (bar) |
|---|---|---|---|---|
| 1533 | 0.35 | 7.89 | 0.12 | 7.77 |
| 1526 | 2.69 | 9.26 | 0.93 | 8.33 |
| 1507 | 5.90 | 10.68 | 2.04 | 8.64 |
| 1488 | 8.80 | 9.37 | 3.03 | 6.34 |
| 1476 | 11.56 | 8.31 | 3.99 | 4.32 |

TABLE-3: BTHE, ITHE, MechE by Speed and Load variation

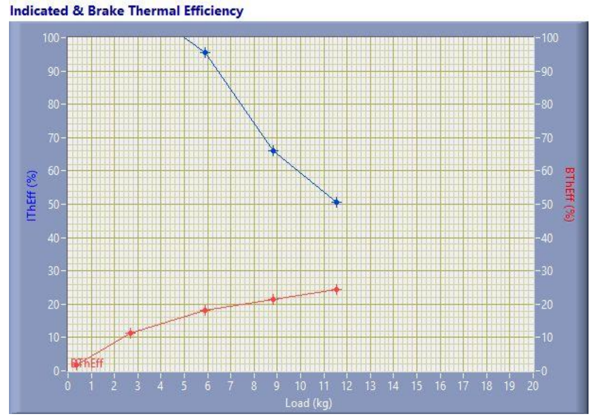
| Speed (rpm) | Load (kg) | Torque (N-m) | BMEP( Bar) | IMEP (bar) | BTHE (%) | ITHE (%) | Mech Eff. (%) |
|---|---|---|---|---|---|---|---|
| 1533 | 0.35 | 0.63 | 0.12 | 7.89 | 1.93 | 127.54 | 1.51 |
| 1526 | 2.69 | 4.88 | 0.93 | 9.26 | 11.20 | 111.74 | 10.02 |
| 1507 | 5.90 | 10.72 | 2.04 | 10.68 | 18.19 | 95.42 | 19.07 |
| 1488 | 8.80 | 15.97 | 3.03 | 9.37 | 21.42 | 66.17 | 32.37 |
| 1476 | 11.56 | 20.98 | 3.99 | 8.31 | 24.27 | 50.56 | 47.99 |



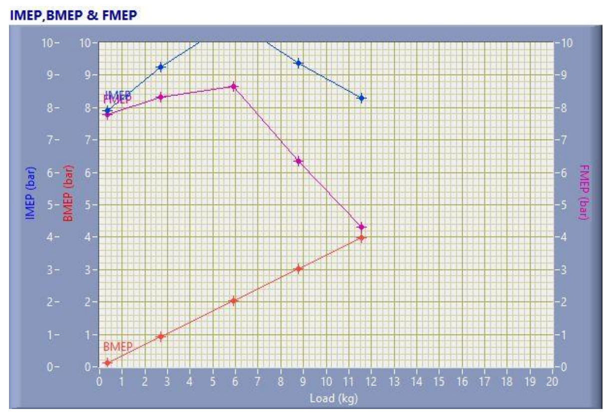

Graph-1: Torque, Mechanical & Volumetric Efficiency




Graph-2: SFC & Fuel Consumption




Graph-3: Indicated & Brake Thermal Efficiency




Graph-4: IMEP, BMEP & FMEP

## V.CONCLUSION

In this work, the performance test and combustion characteristics of biodiesel while tested on diesel engine were noted. The blends prepared for biodiesel were from B10 to B100. Out of all these blends while noting the performance and combustion characteristics, it was found that the blend B30 gave the optimum performance. The biodiesel was prepared from cottonseed oil through the transesterification conversion process. Cottonseed oil is low in unsaturated fatty acids and therefore the reaction time taken is lesser than for most other oils. The yield obtained has been 84%. A Study of Ionic liquid was undertaken to research into the possibilities of increasing the yield further and to shorten the reaction time. Also the conversion process could be made environmentally safe and green. It was noted that for the commercialization of this biodiesel blend which was optimized, Ionic Liquids would play a large role rather than conventional Sodium Hydroxide catalyst.

Ionic Liquids are also Organic Solvents which help in extraction process too of Cottonseed oil from cottonseed. All the parameters affecting engine performance were noted and presented in graphical form.

REFERENCE

[1] Fangrui, Ma, Milford, A., Hanna, (1999). Biodiesel production: a review, *Bioresource Technology*, p.1

[2] Hoda, N, (2010). Optimization of Biodiesel Production from Cottonseed oil by Transesterification Using NaOH and Methanol, *Energy Sources*, p. 434

[3] Duple, Sinha, Murugavelh, S., (2016). Biodiesel Production from Waste cotton seed oil using low cost catalyst: Engine performance and emission characteristics, *Perspectives in Science*, p.1

[4] Nawshad, Muhammad, (2014). An overview of the role of ionic liquids in biodiesel reactions, *Journal of Industrial and Engineering Chemistry*, p.1

[5] Dragan, Z., Troter (2016). Application of ionic liquids and deep eutectic solvents in biodiesel production: A review, *Renewable and Sustainable Energy Reviews, 2016,* p.473

[6] Umer, Rashid, Farooq, Anwar, Gerhard,Knothe, (2009). Evaluation of biodiesel obtained from cottonseed oil, *Fuel Processing Technology*, p.1157

[7] Royon, D., Daz,M., Ellenrieder,G., Locatelli,S., (2006). Enzymatic production of biodiesel from cottonseed oil using t-butanol as a solvent, *Bioresource technology*, p.648

[8] Eevera, T., Pazhanichamy, K., (2013). Cottonseed oil: A feasible oil source for biodiesel production, *Energy Sources Part-A*, p.1118