Performance Characteristics of a Diesel Engine Fuelled with Biodiesel Produced from Mahua Oil Using Turmeric as a Fuel Additive

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Abstract - *The fuel requirement and its consumption of petroleum products increased with vehicles population. According to the existing problem we discussed alternate fuel. Additionally, the alternate fuel need to produce in such a manner that it can be used directly in present engines without any engine alterations. Edible and non-edible oils are the important source for the alternative fuel. Process of Bio-Diesel production consists of several chemical mechanisms. During the experimentation, Engine performance parameters such as brake thermal efficiency, brake power, brake specific fuel consumption and emission characteristics of CO_2, HC, CO, NOx, and smoke density were analyzed from the studies carried out for different loading conditions at constant engine speeds. Experimental result shows that there is a slight improvement in brake thermal efficiency and slight decrease in specific fuel consumption for all the blends compared with Diesel. Adding Turmeric as a fuel additive slight increases engine efficiency and almost reduces emissions like CO, HC, NO_x, and CO_2 when during the loading conditions at constant speed.*

Key Words: Mahua oil, Diesel, Additive, Esterification, Transestrification, Engine performance.

1. Introduction

Energy is considering as a basic component for commercial development, social change and human welfare. Subsequently their analysis, the fossil fuels proceeded as the important conventional energy source by expanding pattern of innovation and industrialization, as world energy requirement is increasing at faster rate to adapt up the expanding energy requirement, greater part of the creating nations import crude oil separated from their domestic production, which puts additional problem on their home economy. Since, it is ultimate significant that the preferences for replacement of petroleum fuels be explored to control the burden of impact on cost.

1.1 Mahua (Madhuca Indica) New Source of Bio-Diesel

Mahua (Madhuca indica) is one of the forest grounded tree-borne this is considered as non-edible oils with great production possible of about 60 million tons annually in India. Essentially the lifeline of ethnic in central India, this tree is generally improved familiar with Indian life in the grasslands. Its flowers are sweat, delicious than other. The tree pick up in support because of the liquid distilled from the flowers, which are used to make vinegar.

Fig-1. 1: Mahua flower, seeds and Tree

The seeds yield fat known as Mahua butter used in contamination of Ghee, cooking, manufacturing of chocolates and even soaps, also action of rheumatism and constipation. Mahua cake generally using for agriculture purpose and also used for fishing.

1.2 Additive

Using additive with Bio-Diesel controls the emission and increases the engine performance. It serves to enhance the combustion properties and reduce the corrosion effects.

1.3 Turmeric oil

Turmeric oil obtained by extracting ginger and dried rootstock of turmeric. Here the measure pigment is curcumin. Turmeric oil using as a fuel additive like A1, A2, and A3. (A1=10ml, A2=20ml and A3=30ml).

Fig -1. 1: Turmeric oil

2. Biodiesel Production

Bio-Diesel production from Mahua seeds was experimentally investigated in the current study. Expeller method was working to extract Mahua oil from its seed, fresh oil is in yellow color, after that commercial oil is in usually greenish yellow by displeasing smell and taste, after crushing so many times (5-6 times) the cake will be produced separately, that cake using for the byproduct of agriculture purposes shown in Fig.3.1, the oil is subjected to two stages transestrification due to the presence of more than 18% of free fatty acid content. For the single stage, the FFA content was reduced to less than 2% by acid esterification using concentrated H_2SO_4 and methanol and followed by base catalyzed transestrification to convert the vegetable oil into Bio-Diesel.

2.1 Esterification Process

Fig -2.1: Esterification Process of Mahua oil

Add 150ml of CH_3OH per liter of oil, with the help of rubber stopper close the conical flask, by using this we can avoid vaporization of methanol from the conical flask. Put the magnet pellet into the flask, switch on the magnetic stirrer. Setup heating control to 60^0C, adjust the speed between 650-850rpm, after 1/2 hour add 1.5 ml of H_2SO_4 and maintain the temperature 60^0C. Switch on the magnetic stirrer to complete mixture in the reaction container at 60^0C for 1-$1^{1/2}$ hour, as shown in the Fig.2.1.

2.2 Transestrification Process

Fig -2.2: Transestrification Process of Mahua oil

Heat the oil to 60^0C in a conical flask add 150ml of methanol to a square bottom flask with adding 6gms of sodium hydroxide pellets then stir properly until no solved elements in sodium. Which creates the CH_3O Na solution, then add CH_3O Na to an acid treated oil, maintain the temperature up to 60 ^{0}C in conical flask. Put the magnet pellet into the flask, switch on the magnetic stirrer. Setup heating control to 60^0C, adjust the speed between 600-800rpm. The reaction time will take 1-$1^{1/2}$ hour. Maintain temperature 60^0C otherwise methanol evaporates in the air above 60^0C then switch on the stirring throughout the reaction process. Completion of this process oil color will changes pale yellow to a dark brown. After 1-1 $^{1/2}$ hour, as shown in Fig-2.2, after completion of this process transfer the oil in to the separating funnel.

2.3 Settling Process

Transfer mixture into a separating funnel to allow settling process up to 2-3 hours, after 2-3 hours glycerin is separated bottom of the funnel and Biodiesel split at top layer as shown in Fig 2.3, drain the glycerin layer from the separating funnel carefully and store it separately. Glycerin converted into a glycerol for the use byproduct, and also using for other medical purposes.

Fig- 2.3: Settling Process

2.4 Water Washing

After settling process take the oil into plastic washing funnel, spray 300ml of warm water slowly into Bio-Diesel (water 40^0C). Allow to settle 15min, remove the bottom layer (soap water) carefully. Repeat the above procedure number of times until the Bio-Diesel reaches $7P^H$. After completion of the process water and oil are visible shown in Fig 2.4. First three washes of water will be storing

separately for using other purpose, that water using as byproduct for the cleaning of home and hospitals etc.

Fig -2.4: Water washing process

2.5 Heating Process

Heat the Bio-Diesel to an 110^{0}C in a beaker and maintain this temperature for 10-15min shown in Fig 2.5. This process is to be accompanying to eliminate water particles in the Bio-Diesel. Heating process is to be complete with nonstop stirring, it is done by magnetic stirrer up to 110^{0}C. Allow the Bio-Diesel to cool slowly. Measure the quantity of the Bio-Diesel, store it in a clean and dry container.

Fig- 2.5: Heating Process

3. Experimental Set-Up

Mahua Biodiesel blends (Mahua Bio-Diesel-MB20, MB30 and MB50 adding fuel additive) with Diesel, conducting for this experiment we are using four Stroke single cylinder, water-cooled (Kirloskar) Diesel engine having a rated output of 4.4 kW at 1500 rpm and a compression ratio of 16.5:1. The engine was joined with an eddy current dynamometer to put different engine loads shown in Fig 3.1. Studied performance and exhaust emissions at different engine loads. The engine reach stabilized working condition, emissions like carbon monoxide, Hydrocarbon, Nitrous oxide, carbon dioxide.

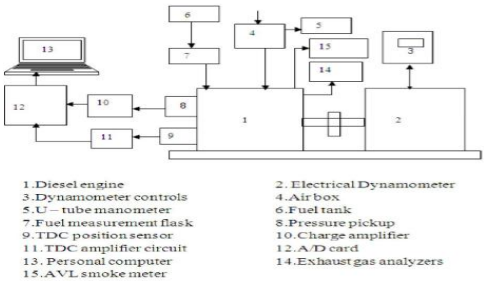

Fig -3.1: Schematic of CI Engine Test Rig

4. Result and Discussion

The different Bio-Diesel blends were prepared and experiment was conducted on Kirloskar, single cylinder, four stroke, water-cooled, direct injection compression ignition engine keeping compression ratio (CR) of 16.5:1 as constant, with injection pressures (IP) of 205bar for various loads. Emission characteristics like CO, HC, NO_x, and CO2 and performance parameters like, ISFC, BSFC, BTE and mechanical efficiency are evaluated.

4.1 Brake Thermal Efficiency (BTE)

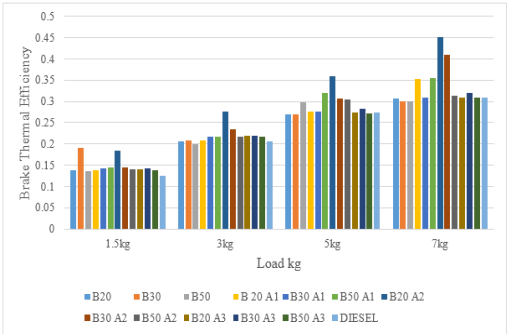

Chart- 4.1: BTE for IP of 205bar& 16.5:1CR vs. Load

Chart- 4.1 indicates that the variation of BTE with different loads, for various blends of Biodiesel. In all the loading conditions BTE is increased due to reducing the heat loss with increase in loading condition. The maximum BTE is achieved for this experiment is MB20 A2 at all the loads for IP of 205bar. Considering the viscosity, the maximum Brake Thermal efficiency for MB20 A2 is 45% which is higher than Diesel (30%) From chart 4.1, it is found that BTE of Bio-Diesel is increases 15% with comparing with Diesel on CI engine.

4.2 Brake Specific Fuel Consumption (BSFC)

SFC is defined as the amount of fuel consumed for each unit of brake power developed per hour. It is a clear indication of the efficiency with which the engine develops power from fuel.

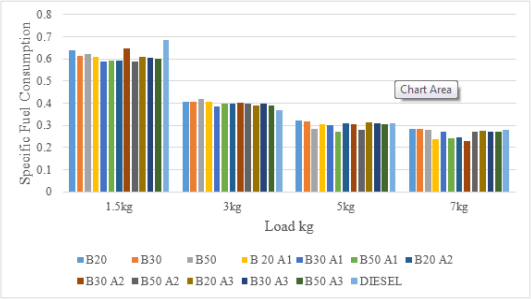

Chart- 4.2: BSFC for IP of 205bar &16.5:1CR vs. Load

Chart-4.2 indicates that variation of BSFC different loading conditions for various blends of Mahua diesel, diesel with fuel additive for IP of 205bar. It is observed that the SFC for the blend of MB30 A2 is slight decreasing as compare with the Diesel at maximum load. However adding Mahua Biodiesel with additive in the blend decreases SFC comparing with the Diesel at B30 A2 at maximum load, the reason for that combined properties of lower heating value and the higher fuel flow proportion due to high density of the blends.

4.3 Carbon Monoxide Emission

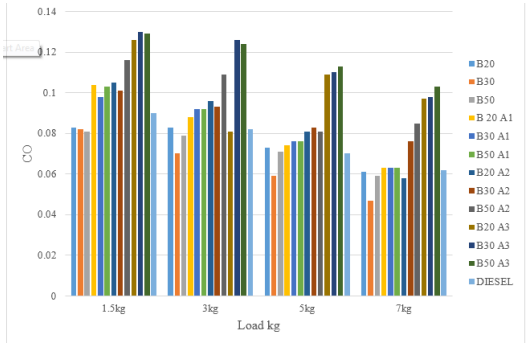

Chart- 4.3: CO Emission vs. Load for IP of 205bar& 16.5:1CR

The emissions of CO remain toxic. The analysis observed from the chart.4.3 shows Bio-Diesel blends give the more CO as comparing with Diesel because of incomplete combustion. While the percentage of Bio-Diesel blend decreases, CO almost reduces. This is because of less quantity of oxygen contented in the Bio-Diesels. This is due to the production of Biodiesel from acid treatment process, CO emission increases in lower loading condition and slight decrease for the higher loads. Eliminating the acid treatment process we can reduce CO with adding fuel additive.

4.4 HC Emission

HC is measured or defined through an exhaust analyzer in parts per million. We know that, HC is produced from unburned fuel that residues as a result of a misfire.

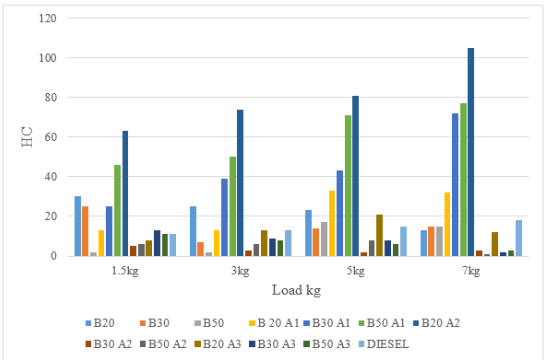

Chart-4.4: HC emission vs. Load for IP of 205bar& 16.5:1CR

Chart-4.4 indications the difference of HC emission with different loading condition for the blends. It is observed from the result of HC emission of various blends it reduces at lower load and also reduces for higher load when adding 3% of fuel additive, but HC almost increases adding 2% of fuel additive, was lower at partial load. This is due to superior combustion of Bio-Diesel inside the combustion chamber because of the availability of extra contented of oxygen in a Bio-Diesel blends comparing with Diesel.

4.5 Nitrous Oxide Emission

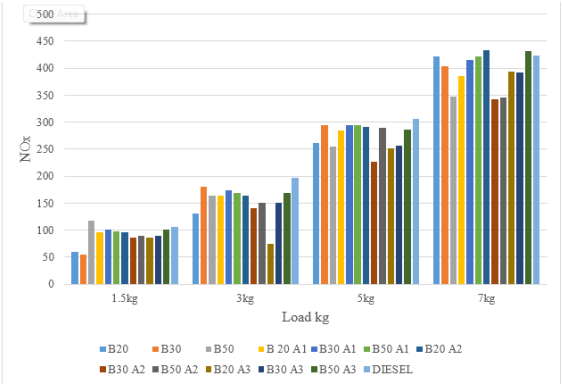

Chart- 4.5: NO_x emission vs. Load for IP of 205bar& 16.5:1CR

NOx emissions is particularly unwanted. Three situations which favor NOx creation of more combustion temperature, high oxygen contented and quicker response rate. From the above situations are achieved in Bio-Diesel combustion is actual fast as comparing with Diesel. Since, NOx formations for the Bio-Diesel blends always lesser than the Diesel. Observed from the Chart-4.5 that more power output situations, because of highest temperatures, the NOx values are probable more for both Bio-Diesel and also for Diesel fuel. Using fuel additive to the blends NO_X

reduces when increasing loading condition. This is one of the advantage of adding additive to the blends for reducing the NO_X emission it is hazardous to human health.

4.6 Carbon Dioxide Emission

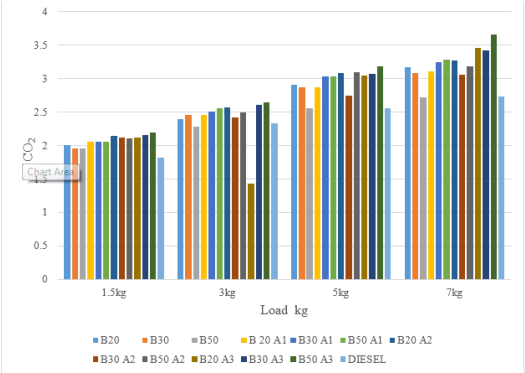

Chart-4.6: CO_2 emission vs. Load for IP of 205bar& 16.5:1CR

The chart-4.6 indicates that the emission stages for CO_2 at various blends Biodiesel and Diesel. Experiment measurements exposes that the CO_2 emission of all the blends were high as comparing with Diesel for all the loading conditions. The increasing development of CO_2 emission with load because of the more fuel entry when the load at maximum. Bio-fuels have higher carbon contented as comparing with Diesel, hence the CO_2 emission is relatively more.

5. Conclusion

The following conclusions are drawn from this analysis,

- The conversion of Mahua oil was found to be 80-82 %. (Yield of Bio-Diesel was 800-820 ml for 1000 ml of Mahua oil).
- Produced Mahua using esterification and Transestrification will be gives the significant fuel properties according to ASTM specification of Bio-Diesel.
- The current Diesel engine achieves acceptably for using Bio-Diesel fuel any important engine alterations.
- Engine performance for the Bio-Diesel fuel does not vary significantly it gives same result as compare to Diesel fuel. The MB20 A2 gives better performance as compare to all the blends and also diesel fuel.
- Adding fuel additive to the blends engine performance almost increases for all the loading conditions as compare to diesel.
- Exhaust emissions HC and NOx almost reduces as compare to the diesel fuel, CO and CO_2 slight decreases, when increases load CO gradually reduces.
- Among all the blends, MB20 A2 blend gives the better engine performance, for the emission characteristics MB30 A2 blend shows better result comparison with Diesel at different loading conditions.

5.1 Scope of Future Work

Some of the features work are recognized for the present work are existing below.

- Bio-Diesel production technology required further study in the aspects of elimination of Bio-Diesel purification process by using esterification (Acid treatment Process). Transestrification process gives good result.
- Along with Mahua Bio-Diesel increasing the fuel additives can gives more Performance characteristics and reduces the emission.
- For the same production procedure, Turmeric fuel additive can also be used in other non-edible like as Karanja, Jatropha, Azadireacta indica and Simaruba oils.

REFERENCES

[1] A.V. Krishna Reddy et al.,*"Experimental determination of brake thermal efficiency and brake specific fuel consumption of Diesel engine fuelled with Bio-Diesel"* International Journal of Engineering and Technology Vol.2 (5), 305-309, 2010.

[2] Ayhan Demirbas., *"Bio-Diesel fuels from vegetable oils via catalytic and non-catalytic supercritical alcohol transesterifications and other methods: a survey"* Energy Conversion and Management 44, 2093–2109, 2003.

[3] M. C. Navindgi, Maheswar Dutta, B. Usher Perm Kumar, "*Performance of a CI Engine with Different Blends of Mahua (Madhuca Long folia) Bio-Diesel under Varying Operating Conditions"* International Journal of Engineering and Technology, Volume 2 No. 7, July, 2012.

[4] GautamKumar, AnoopKumar, *"Engine Performance Characteristics of Diesel Engine Using Mahua Bio-Diesel as Fuel"* Accepted 17 April 2013, Available online 1June 2013, Vol.3, No.2 (June 2013).

[5] Shashikant Vilas Ghadge, Hifjur Raheman. *"Bio-Diesel production from mahua (Madhuca indica) oil having high free fatty acids"* Biomass and Bioenergy pp. 601–605 2 March 2005.

[6] M. Pugazhvadivu and G. Sankaranarayanan, *" Experimental studies on a Diesel engine using Mahua oil as fuel"* Indian Journal of Science and

Technology Vol. 3 No.7 ISSN: 0974- 6846,(July 2010) .

[7] Sukumarpuhan et al, *"Mahua (Madhuca Indica) seed oil: "A source of renewable energy in India"* Journal of Scientific & Industrial Research, vol64, pp- 890 896, November, 2005.

[8] Padhi, S.K, Singh R.K, *"Optimization of esterification and transesterification of Mahua (Madhuca Indica) oil for production of Bio-Diesel"* Journal of Chemical and Pharmaceutical Research, pp: :599-608, ISSN No: 0975-7384 CODEN (USA) J. Chem. Pharm. Res., 2010.

[9] Hariram.V and Vagesh Shangar.R *"Characterization and Optimization of Bio-Diesel Production from Crude Mahua Oil by Two Stage Transesterification"* Volume-03, Issue-11, pp-233-239 AJER 2014.

[10] Purna C. Mishra, Swarup. K. Nayak *"Performance Characteristics of a Diesel Engine Fuelled with Bio-Diesel Produced from Mahua Oil Using Additive"* e-ISSN: 2278-1684, p-ISSN: 2320-334X, Volume 8, Issue 2, July. - Aug. 2013.

[11] Ashish W. Bhagat, Prof. S.R.Karale *"Madhuca Indica and Turmeric as Fuel in CI Engine: A Review"* International Journal of Advance Research in Science and Engineering, Vol. No.3, Issue No.10, October 2014.

