IOSR Journal of Mechanical and Civil Engineering (IOSR-JMCE)
e-ISSN: 2278-1684,p-ISSN: 2320-334X, Volume 10, Issue 2 (Nov. - Dec. 2013), PP 53-57
www.iosrjournals.org

A Study of Performance and Emissions of Diesel Engine fuelled with neat Diesel and neat Hydnocarpus Pentandra biodiesel

R. Karthikeyan[1], Dr. C. Solaimuthu[2] and N. Balakrishnan[3]

[1] *Assistant Professor, Department of Aeronautical Engineering, Er. Perumal Manimekalai College of Engineering, Hosur – 635 117, Tamil Nadu, India*

[2] *Professor cum Director (Research), Department of Mechanical Engineering, Er. Perumal Manimekalai College of Engineering, Hosur – 635 117, Tamil Nadu, India*

[3] *Professor and Head, Department of Mechanical Engineering, Gnanamani College of Technology, Namakkal – 637 018, Tamil Nadu, India*

Abstract: *A comparison analysis between neat diesel (petro-diesel) and neat Hydnocarpus Pentandra (Marotti) biodiesel has been carried out on a direct injection diesel engine. The biodiesel has been produced from raw Hydnocarpus Pentandra oil by transesterification process by adding methanol and base catalyst. The optimum nozzle pressure of 250 bar and static injection timing of 20° bTDC are considered because these conditions only were found to give minimum emissions and better performance. The engine performance and emissions of diesel engine fuelled with neat diesel and neat Hydnocarpus Pentandra (Marotti) (or) Marotti Oil Methyl Ester (MOME) results are compared and presented. From the test results, it could be noted that, neat MOME gives lower emissions such as hydrocarbon and oxides of nitrogen as compared to neat diesel for all load under steady state condition of the engine.*

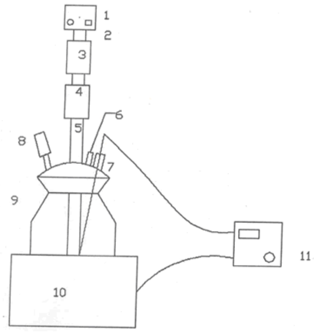
Keywords: *Diesel Engine, Performance, Emissions, Marotti Oil Methyl Ester, Neat Diesel*

I. Introduction

Every country in the world is improving their infrastructure rapidly. With the improvement of roads for transport facility world over, the automobile sector is witnessing a gigantic growth. Particularly diesel engines are used widely for in-sea and on-land transportation. At the fillip side, the diesel engine has become the major source of air pollution as its emissions contain harmful waste like black smoke, hydrocarbon and oxides of nitrogen (NO_x) apart from causing noise pollution. The diesel engine emissions contribute heavily for the depletion of ozone layer, green house effect and acid rain productions which become causes for many human diseases and the degradation of the environment. This scenario has led to a renewed interest in the use of vegetable oils for making biodiesel because of their bio degradable, non-toxic, less polluting and renewable nature. Worldwide biodiesel is produced mainly from edible oils, but in India, non-edible oil seeds are available in abundance such as Marotti (Hydnocarpus Pentandra), Pongamia (Pongamia Pinnat), Jatropha (Jatropha Curcas), Mahua (Madhuca Indica), Neem (Azadirachta Indica), and Rubber seed (Hevea Brasiliensis) oil etc., which can be tapped for biodiesel production. Narayana Reddy and Ramesh [1] investigated performance and emissions of diesel with Jatropha oil biodiesel fuel. They concluded that Jatropha oil biodiesel gives similar performance and emissions as diesel when its injection timing is optimum. Venkatraman and Devaradjane [2] investigated performance and emission characteristics of diesel engine with pungam oil methyl ester (PME) diesel blends. They concluded that PME 20 could be as alternative fuel for diesel engine with compression ratio of 19:1. Vijayashree et al., [3] highlighted overview of global energy scenario. They concluded that experience from all over the world has shown that improving end use efficiency will be hands down winner in economic terms when compared to capacity addition. Clark et al., [4] performed the diesel engine with soybean biodiesel. They concluded that soy bean biodiesel gives higher specific fuel consumption and lower emissions except NO_x. Kapilan and Reddy [5] performed the diesel engine with bio diesel. They concluded that, the impact of pure bio diesel is lower than that of pure diesel. Puhan et al., [6] performed engine tests with Mahua biodiesel in naturally aspirated diesel engines. They used neat diesel and neat biodiesel. Emissions are measured and reported that the impact of biodiesel (B100) is lower than that of diesel (B0). Puhan et al., [7] reported the biodiesel preparation and discussed its performance and emission characteristics of diesel engine with B0 and B100 fuel. They made the conclusion that the Mahua oil methyl ester (B100) burn more efficiently than diesel (B0) and the emissions of B100 is lower than that of B0. Raheman and Ghadge [8] considered Mahua biodiesel blended with fossil diesel and discussed extensively the engine performance obtained by blend with different volumetric ratios. They concluded that biodiesel 20% by volume with 80% diesel formed an optimum mixture for their engine parameters. Balusamy and Marappan [9] evaluated the performance of a direct injection diesel engine was carried out with methyl ester of thevetia peruviana oil having an injection timing of 27° bTDC and injection pressure of 225 bar. It was found to give lowest HC, CO, smoke density, and higher brake thermal efficiency.

From the previous studies, it could be observed that most of the studies are mainly related to the performance, combustion and emission characteristics of diesel engine using neat vegetable biodiesel and neat diesel as fuel. Therefore not much work has been carried out on Marotti biodiesel and its blends of fuel. In this paper a detailed analysis of performance and emissions of diesel engine with optimum nozzle pressure of 250 bar and static injection timing of 20° bTDC for all loads have been used using neat Diesel (B0) and neat Marotti biodiesel (B100) as fuel is presented.

II. Preparation Of Biodiesel



1.Stirrer Motor, 2.Stirrer Rod, 3.Coupling, 4.Stirrer Lubricant reservoir, 5.Glass stirrer, 6.Funnel, 7.Thermocouple, 8.Water condenser, 9.Glass Tank Reactor, 10.Heating Mantle, 11. PID Temperature controller

Figure 1 Biodiesel Production Setup

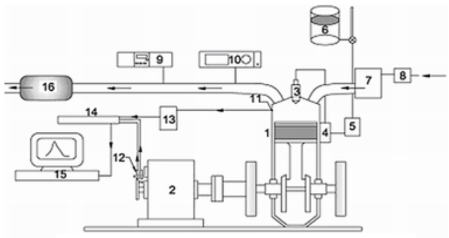
Figure 1 shows the biodiesel production set up. It can be produced by a two step acid-base process from raw Marotti oil using methanol as reagent and H_2SO_4 and KOH as catalysts for acid and base reactions respectively. 10% of methanol mixed with 0.3% of H_2SO_4 acid by volume was prepared as acid solvent. Acid solvent was added to one litre of raw Marotti oil with 62° C and stirring rate of 30 rpm for 30 minute for separating the residues of the solution. The final solution can be separated by using separating funnel. In the secondary step to prepare base process, 20% of methanol mixed with 0.54% of KOH by volume solvent was prepared as base solvent. Base solvent was added to one litre of Marotti oil which is derived from acid process, heated up to 64°C for 30 min. Final solution can be separated from the glycerol by separating funnel. The final solution may be having some soap content. This may be removed by using the bubble washing by adding 50% of water with final solution which is derived from base reaction process. This solution may be heated up to 100°C for removing water content which is available in the solution. The biodiesel (mixture of alkyl esters) is the end product of this process. Equation 1 shows the chemical route of biodiesel production from raw Marotti oil.

$$\underset{\text{triglyceride}}{\begin{matrix} H_2C-OCOR' \\ | \\ HC-OCOR'' \\ | \\ H_2C-OCOR''' \end{matrix}} + 3\ \underset{\text{alcohol}}{ROH} \xrightleftharpoons{catalyst} \underset{\text{mixture of alkyl esters}}{\begin{matrix} ROCOR' \\ + \\ ROCOR'' \\ + \\ ROCOR''' \end{matrix}} + \underset{\text{glycerol}}{\begin{matrix} H_2C-OH \\ | \\ HC-OH \\ | \\ H_2C-OH \end{matrix}} \qquad (1)$$

III. Experimental Setup And Procedure

Table 1 Specification Details of the Diesel Engine

Make	Kirloskar TV – I
Type	Single Cylinder Tangentially Vertical DI Diesel Engine
Compression Ratio	17.5:1
Bore × Stroke	(87.5 x110) mm
Rated Brake Power	5.2 kW
Rated Speed	1500 rpm
Cooling System	Water Cooled
Nozzle Opening Pressure	250 bar (Modified)
Static Injection Timing	20° bTDC (Modified)



1. Kirloskar TV1 Engine
2. Eddy Current dynamometer
3. Injector
4. Fuel pump
5. Fuel filter
6. Fuel tank
7. Air stabilizing tank
8. Air filter
9. AVL smoke meter
10. AVL Di-gas analyzer
11. Pressure transducer
12. TDC Encoder
13. Charge amplifier
14. Indimeter
15. Monitor
16. Exhaust silencer

Figure 2 Schematic diagram of the engine test setup

Table 2 Properties of Diesel and Marotti Biodiesel

S. No	Name of the Properties	Neat Diesel (B0)	Neat Marotti Biodiesel (B100)
1	Kinematic Viscosity at 40ºC in cSt	2.6	6.12
2	Flash Point in ºC	65	165
3	Fire Point in ºC	70	176
4	Cloud Point in ºC	-15	12.5
5	Specific Gravity	0.82	0.86
6	Gross Calorific Value in MJ/kg	45.59	42.34
7	Cetane Number	46	52.2

The schematic of the engine setup is shown in Figure 2. Specifications of the engine are presented in Table 1. The optimum static injection timing of 20° bTDC and nozzle opening pressure of 250 bar are used for the entire experiments for all load conditions. Smoke density is measured using standard AVL 437 smoke meter. AVL 444 di-gas analyzer is used for the measurement of exhaust emission of HC and NO_x. All the readings have been taken under steady state condition of the engine.

IV. Results And Discussion:

4.1 SPECIFIC FUEL CONSUMPTION:

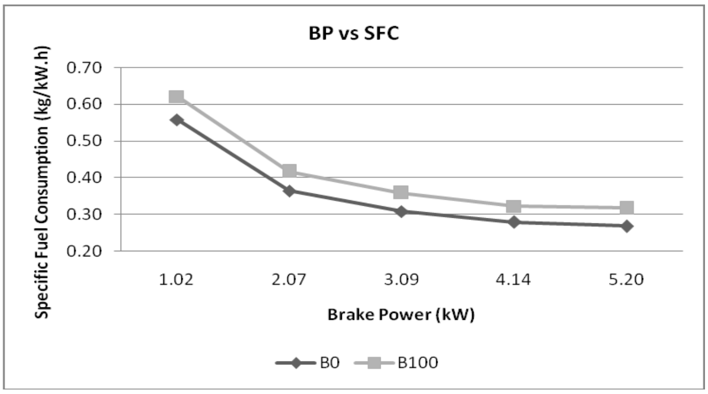


Figure 3 Brake Power vs Specific Fuel Consumption

Figure 3 shows variation of specific fuel consumption with respect to brake power for B0 and B100. It could be seen that, there is a decreasing trend observed with respect to brake power for both B0 and B100. It could also be observed that, there is a little higher in the case of B100 as compared to B0 for all loads. The percentage increase in specific fuel consumption in the case of B100 for no load, 0.25, 0.50, 0.75 and full load are 10.15%, 11.91%, 13.95%, 13.66% and 16.25% respectively as compared to B0. This may be due to lower calorific value of B100 as compared to B0. This could be observed from table 2.

4.2 BRAKE THERMAL EFFICIENCY

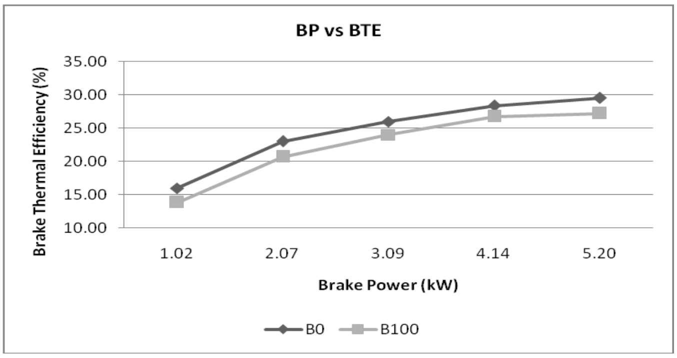


Figure 4 Brake Power vs Brake Thermal Efficiency

Figure 4 shows variation of brake thermal efficiency with respect to brake power for B0 and B100. It could be seen that, there is an increasing trend observed with respect to brake power for both B0 and B100. It could also be observed that, there is a little lower in the case of B100 as compared to B0 for all loads. The percentage reduction in brake thermal efficiency for B100 for no load, 0.25, 0.50, 0.75 and full load are 13.33%, 11.53%, 7.69%, 5.61% and 7.82% respectively as compared to B0.

4.3 SMOKE DENSITY

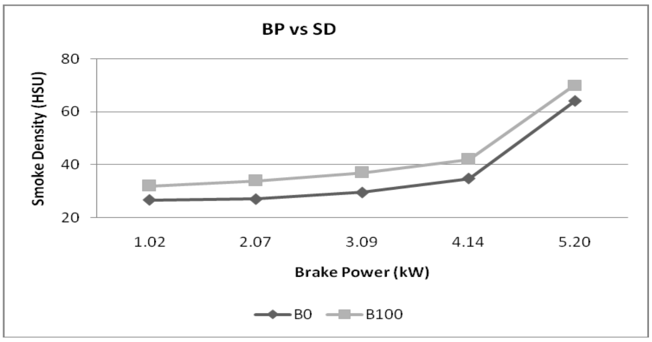


Figure 5 Brake Power vs Smoke Density

Figure 5 shows variation of smoke density with respect to brake power for B0 and B100. It could be seen that, there is an increasing trend observed with respect to brake power for both B0 and B100. It could also be seen that B100 gives higher smoke density than that of B0 for all loads. The percentage increase in smoke density in the case of B100 for no load, 0.25, 0.50, 0.75 and full load are 16.56%, 20.29%, 20.01%, 17.14% and 12.23% respectively as compared to B0.

4.4 HYDROCARBON

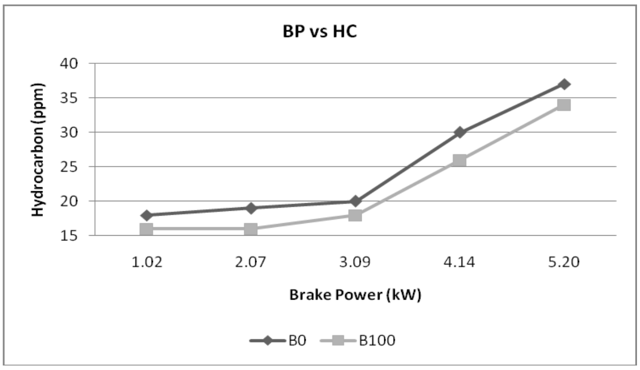


Figure 6 Brake Power vs Hydrocarbon

Figure 6 shows variation of hydrocarbon with respect to brake power for B0 and B100. It could be seen that B100 lower hydrocarbon than that of B0 for all loads. The percentage decrease in hydrocarbon in the case of B100 for no load, 0.25, 0.50, 0.75 and full load are 11.11%, 15.79%, 10.02%, 13.33% and 8.11% respectively as compared to B0. The B100 gives lower hydrocarbon as that of B0. This may be due to higher cetane number for B100 as that of B0. This could be observed from table 2.

4.5 OXIDES OF NITROGEN

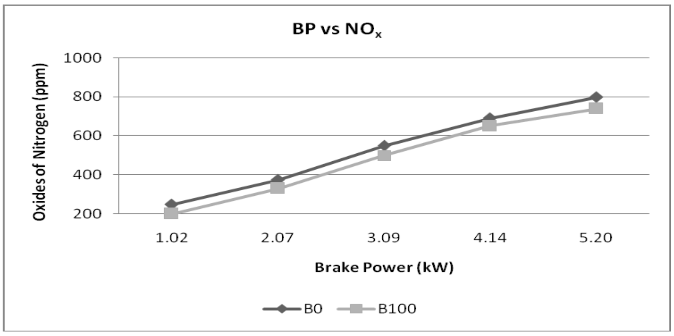


Figure 7 Brake Power vs Oxides of Nitrogen

Figure 7 shows variation of oxides of nitrogen with respect to brake power for B0 and B100. It could be seen that B100 lower oxides of nitrogen than that of B0 for all loads. The percentage reduction in hydrocarbon in the case of B100 for no load, 0.25, 0.50, 0.75 and full load are 20.01%, 12.02%, 9.09%, 8.79% and 7.51% respectively as compared to B0. The neat biodiesel (B100) gives lower hydrocarbon as that of neat diesel (B0). This may be due to the oxygen content and cetane number of the blend. Since the neat biodiesel based fuel contains oxygen in the fuel itself and it acts as a lesser combustion promoter inside the cylinder [7].

V. Conclusions

From these findings, it could be concluded that the neat Marotti biodiesel gives slightly lower brake thermal efficiency, higher smoke density, lower in hydrocarbon and oxides of nitrogen as compared to neat diesel for all load conditions. Hence, Marotti (Hydnocarpus Pentandra) biodiesel could be suitable for DI diesel engine without any modification on the existing condition.

References

[1] J Narayana Reddy and A. Ramesh, *Experimental investigation on a compression ignition engine fuelled with bio diesel of jatropha oil International Journal of Green energy, energy and environment, 1(3),* 2010, 1-6.

[2] M Venkatraman M and G. Devaradjane, Experimental *investigation of performance and emission characteristics of diesel–pungam oil methyl esters (PME) diesel blends fuelled D.I diesel engine at optimum engine operating parameters International Journal of Green energy, energy and environment* 1, 2010, 7-12.

[3] Vijayashree, P. Tamilporai and V. Ganesan, *Global energy scenario – an overview, International Journal of Green energy, energy and environment, 1(1),* 2010, 1-12.

[4] S J Clark, L. Wanger, M.D. Schrock and P.G. Piennaar, *Methyl and ethyl soybean esters as renewable fuels for diesel engines, J Am Oil Che Soc, 61 (10),* 1984, 1632-1638.

[5] N Kapilan and R.P. Reddy, *Evaluation of methyl esters of mahua oil (madhuca indica) as diesel fuel, Journal - American Oil Chemists Society 85,* 2008, 185-188.

[6] S Puhan, N. Vedaraman, V. Boppana, B. Ram, G. Sankaranarayanan and K. Jeychandra *Mahua oil (madhuca indica seed oil) methyl ester as biodiesel preparation and emission characteristics, Biomass and Bioenergy 28,* 2005, 87-93.

[7] S Puhan S, N. Vedaraman, G. Sankaranarayanan, V. Boppana and B. Ram, *Performance and emission study of mahua oil (madhuca indica oil) ethyl ester in a 4 stroke natural aspirated direct injection diesel engine, Renewable Energy*, *30,* 2005, 1269-1278.

[8] H Raheman and S.V. Ghadge, *Performance of compression ignition engine with mahua (madhuca indica) biodiesel, Fuel, 86*, 2007, 2568-2573.

[9] T Balusamy and R. Marappan, *Effect of injection time and injection pressure on a CI engine fuelled with methyl ester of thevetia peruviana seed oil, International Journal of Green Energy, 7,* 2010, 93- 100.

[10] V. Ganesan, *Internal Combustion Engines* (Tata Mc-Graw Hill, India, 2000).