EXPERIMENTAL INVESTIGATION OF TURBOCHARGED DIESEL ENGINE USING BIODIESEL BLENDS

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Abstract: Power generation in Myanmar, mainly depends on imported fossil fuels. To reduce this decency, the use of biodegradable, renewable and sulphur free biodiesel is receiving attention. Non-edible jatropha oil was selected as biodiesel for use in four strokes, four cylinders turbocharged diesel engine without any modification, was made by the well-known transesterification process domestically. The experiments were carried out using different blends of biodiesel (B7, B12) and conventional diesel oils to investigate the performance characteristics of engine and exhaust emissions. In this research biodiesel blends are more efficient and decrease consumption than conventional diesel. Exhaust emission of carbon dioxide (CO_2) and hydrocarbon (HC) are lower than diesel.
Keywords: biodiesel blends, turbocharged diesel engine, engine performance, emissions

I. INTRODUCTION

Because of the rising cost of mineral diesel is becoming heavy burden on the economy and air pollution emerged from exhaust emissions, there have been great efforts to use alternative fuels in diesel engines for substitution diesel fuel.
Firstly, the use of vegetable oil in a compression ignition engine was demonstrated through Rudolf Diesel who used peanut oil in his diesel engine. Biodiesel as a vegetable oil, biodegradable and non-toxic, has low emission and is environmentally beneficial. [1] Although vegetable oils create various long-term problems in engine components and wear such as ring sticking, injector and combustion chamber deposits, insufficient atomization, lubricating oil dilution. Vegetable oil viscosity is significantly higher than diesel fuel, also volatility and molecular structure different from diesel fuel. Fatty acid methyl esters can be produced by modifying the molecular structure of straight vegetable oils, edible and non-edible, recycled waste vegetable oils and animal fats. [2] Chemical processes such as transesterification; requires heat and a strong catalyst (alkalis, acids, or enzymes) to achieve complete conversion of the vegetable oil into the separated esters and glycerin. During transesterification reaction, glycerin is obtained as a by-product. It is used in pharmaceutical, cosmetic, and other industries. Not only can biodiesel be used alone in neat form but it can also be mixed with diesel fuel in any unmodified diesel engine. Biodiesel can be used in its pure form but many require engine modifications to avoid maintenance and performance problems. Physical and Chemical properties of biodiesel blends can have significant effect on the combustion process, which will impact on engine performance and emissions.
Nowadays it has found that jatropha may display certain antitumor and anti malarial properties and research is advancing related to HIV/ AIDS. Alternative fuels, other than being renewable, are also required to serve to decrease the net production of carbon dioxide, oxides of nitrogen, particulate matter, etc. from combustion sources. [3] This paper aims to run the engine with different blending of biodiesel and diesel to increase the brake thermal efficiency of the engine and to decrease the exhaust emission. The experimental performance will be in the form of brake power, brake thermal efficiency, specific fuel consumption for different speed conditions for three different fuels.

II. BIODIESEL AND THEIR BLENDS

Biodiesel refers to a vegetable oil or animal fat-based diesel fuel consisting of long-chain alkyl (methyl, propyl or ethyl) esters. Biodiesel is typically made by chemically reacting with lipids with an alcohol producing fatty acid esters. Biodiesel can also be used alone or blended with petro diesel. [4] Avoid using peanut oil, coconut oil, tallow and lard. These sources of oil solidify at relatively high temperatures. Biodiesel usually has a lower melting point than the oil it is made from but these oils can still be difficult for beginner. Also avoid olive, peanut, palm, tallow and lard, all contain more acids than in the recommended neutral oils. These extra acids can interfere with the reactions that take place to create the biodiesel. Non-edible jatropha oil can be produced by domestically. Blends of biodiesel and conventional hydrocarbon-based diesel are used known as a word “B” factor to state the amount of biodiesel in any fuel mixture:

- 100% biodiesel is referred to as B100
- 20% biodiesel is referred to as B20
- 5% biodiesel is referred to as B5

Blends of 20% biodiesel and lower can be used in diesel equipment with no or only minor modifications. If the use of pure biodiesel forms B100 may require certain modification to avoid maintenance and performance problems.

III. PHYSICAL PROPERTIES OF TESTED FUELS

All physical properties of the conventional diesel and blends (B7, B12) fuels from jatropha oil were tested at No.1 Refinery, Thanlyin, Myanmar Petrochemical Enterprise as shown in Table I. From the viscosity result, it is found that blends have higher than diesel. The heating value of biodiesel blends are lower than conventional diesel fuel harmful emissions from combustion of diesel fuel are tending to decrease with biodiesel. The nitric oxide (NOx) emissions are increasing because of advancing phenomenon of the injection start that originates from the physical properties of the biodiesel. The total hydrocarbon (THC) and carbon monoxide (CO) emissions are tending to decrease because of the oxygen content and the enhanced cetane number of biodiesel which helps for a more complete combustion.

TABLE I: Physical Properties of Tested Different Fuels

No.	Property	Fuel		
		Conventional Diesel (B0)	Biodiesel 7% (B7)	Biodiesel 12% (B12)
1.	Lower Calorific Value in MJ/kg.	42.74	40.08	38.61
2.	Density at 60°C in kg/m^3	848	856	859
3.	Kinematic Viscosity at 40°C in cst	3.79	3.8	3.81
4.	Cetane Index	52.3	55.4	55.5

Data from No.1 Myanmar Petrochemical Enterprise (Thanlyin) Sep 2016

IV. EXPERIMENTAL SETUP AND PROCEDURE

The performance tests were conducted with a four-stroke, four cylinders and turbocharged intercooler diesel engine. The engine was connected to a Froude SG 14 Hydrokinetic Dynamometer and specifications are shown in table II. For measuring load, Rinstrum R320 Digital Indicator was used and the load is displayed digital number with kilogram unit according the load cell. The exhaust line was connected with EDIBON Exhaust Gas Analyzer and data displayed with PC Computer. Both engine performance and exhaust emission results were worked out with variable speed. The engine specifications are shown in table III. Engine performance results of torque, brake power, brake specific fuel consumption and brake thermal efficiency can be got according the measuring of fuel consumption time, load and speed. The value of emission gases (CO, CO2, HC and O2) are recorded by exhaust gas analyzer.

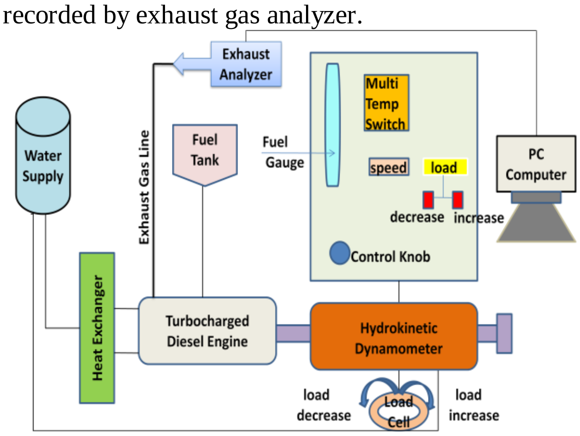

Fig. 1. Diagram of Experimental Setup

TABLE II: Specifications of Dynamometer

Model	Froude SG14
Type	Hydrokinetic
Water Flow Rate for Recirculation Systems	39 Liters/kW/hr
Water Inlet Temperature	≤ 32°C
Water Outlet Temperature	≤ 65°C
Water Inlet Pressure (up to 4500 rpm)	1.0 bar
Water Inlet Pressure (from 4500 to 6500 rpm)	1.7 bar
Water Inlet Pressure (from 6500 to 9000 rpm)	2.7 bar
Acidity	8 ~ 8.4 pH
Time for max to min load	2 minutes

TABLE III: Test Engine Specifications

Engine Model	Ford XLD 418T
Engine Type	Turbocharged, Indirect Injection, CI Engine
Cooling System	Water Cooled
Working Cycle	Four Stroke Diesel
Number of Cylinders	4, In Line
Bore	82.5 mm
Stroke	82.0 mm
Compression Ratio	21.5 : 1
Maximum Power	55 kW at 4500 rpm
Maximum Torque	152 Nm at 2200 rpm
Idle Speed	850 rpm
Connecting Rod Length	130 mm
Crank Radius	41 mm

Fig. 2. Turbocharged Diesel Engine Test Bed with Exhaust Analyzer

V. RESULT AND DISCUSSION

A. Brake Power

Figure 3 shows the effect of engine speed variation on brake power. It can be seen that brake power output increases with increasing engine speed until 3000 rpm and then power start to drop due to the effect of higher friction force. The maximum brake power obtained by diesel, B7 and B12 are 55.474, 53.517 and 52.7 kW respectively at 3000 rpm. It is well known that the heating value of fuel affects the power of an engine. The lower the energy level of the biodiesel blends causes some reductions in the engine power when it is used in diesel engine without any modification.

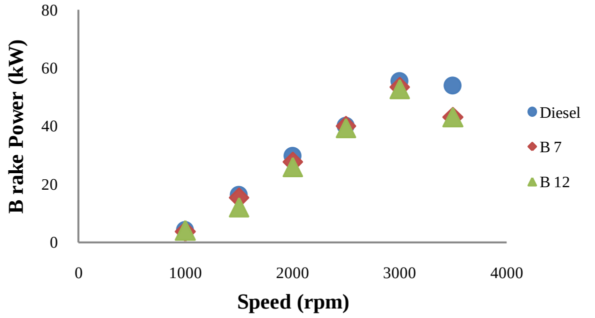

Fig. 3. Brake power vs engine speed

B. Brake Torque

Figure 4 shows the variation of torque for the three fuels with different speeds. Generally, the torque reduces for every increase of speed after their maximum torque. The brake torque for diesel fuel is higher than B7 and B12.

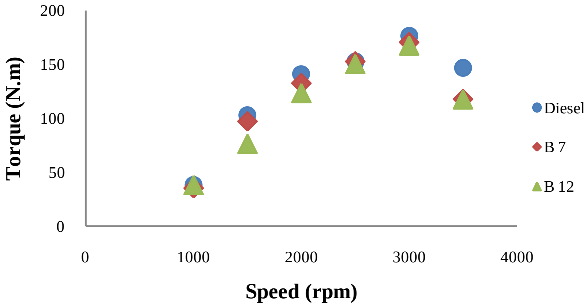

Fig. 4. Torque vs engine speed

C. Brake Specific Fuel Consumption

The variations of brake specific fuel consumption of three different fuels are presented in Figure 5. At low speed, the brake specific fuel consumption of B12 is lower than diesel and B7. The brake specific fuel consumption increased at high speed that indicates good combustion occurs at high speed. The economic point occurs in B12 with 0.196 kg/kW.hr at 2500 rpm.

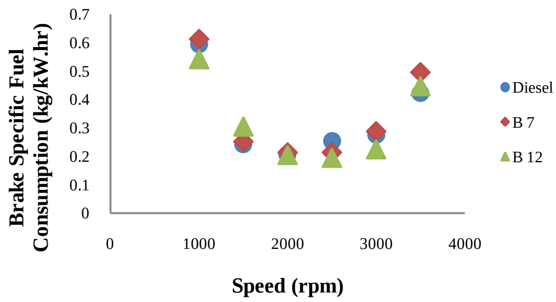

Fig. 5. Brake specific fuel consumption vs engine speed

D. Brake Thermal Efficiency

Figure 6 illustrates that the efficiency varies between the speed of 1000 to 3500 rpm. Biodiesel blends prove that more efficiency than diesel and the efficiency starts to drop when the speed increase 2500 rpm. The speed 2500rpm B12 gained almost 25% higher brake thermal efficiency.

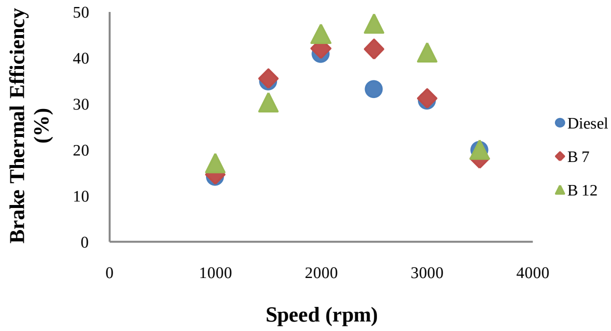

Fig. 6. Brake thermal efficiency vs engine speed

E. Exhaust Emission

The carbon dioxide, oxygen and hydrocarbon emissions of different fuels at 2500rpm are shown in figure 7. Carbon dioxide is the major constituent in the exhaust emissions of the engines, which contributes to too many problems like global warming, green house effects, etc. The exhaust emission of carbon dioxide CO2 and hydrocarbon HC of blends are lower than diesel. The higher the blends, the less emission produce. CO2 emission of B12 is 20% and HC emission of B12 is almost 50% less than diesel.

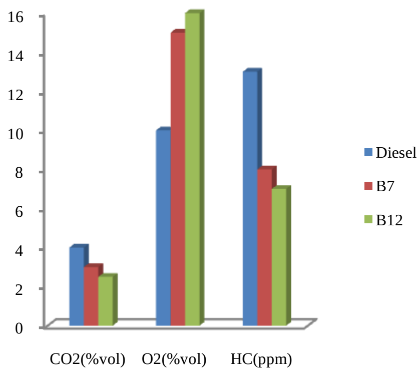

Fig. 7. Exhaust Emission with Different Fuels at 2500rpm

VI. CONCLUSION

In this study, conventional diesel and biodiesel blends (B7, B12) were tested in four cylinders turbocharged intercooler diesel engine. It was found that in the use of biodiesel blends, the engine operated smoothly with no notable problems. The performance characteristic of B7 was closer to those of diesel fuel. Blends prove that they are more efficient and decrease consumption than conventional diesel. At 2500 rpm B12 gained 25% higher brake thermal efficiency and brake specific fuel consumption was 20% lower. Jatropha biodiesel is an oxygenated fuel and it can be used in diesel without any modification. The carbon monoxide CO, carbon dioxide CO2 and hydrocarbon HC emissions are reduced by increasing ratio of biodiesel in fuel. Since the biodiesel is almost free from sulphur so the engine are free from SOx when the engine is fed with its blends. As the lubricating properties of biodiesel are better, the engine life may be increased.

REFERENCES

[1] Shay, E.G, “Diesel Fuel From Vegetable Oils: Status and Opportunities” Biomass and Bio energy, Vol.4, 1993.

[2] Md A. Hossain, Shabab M. Chowdhury, Yamin Rekhu, Khandakar S. Faraz, Monzur UI Islam, “Biodiesel from Coconut Oil: A Renew able Alternative Fuel for Diesel Engine” World Academy of Science and Technology, 68, 2012.

[3] Kazi Mostafijur Rahman, Mohammad, Md. Roknuzzaman and Asadullah Al Galib, “Biodiesel from Jatropha Oil as an Alternative Fuel for Diesel Engine” International Journal of Mechanical and Mechatronics Engineering IJMME-IJENS Volume-10, No.03.

[4] E. M. Shahid and Y. Jamal, “Performance Evaluation of a Diesel Engine Using Biodiesel”, Pak. J. Engineering and Application Science, Vol.9, July, 2011.

[5] Laukik P, ” Computer Simulation of CI Engine for Diesel and Biodiesel Blends”, Raut International Journal of Innovative Technology and Exploring Engineering (IJITEE) ISSN: 2278-3075, Volume-3, Issue-2, July 2013 82

[6] A.E. Atabani, A.S. Silitonga, H.C. Ong, T.M.I. Mahlia, H.H. Masjuki, Irfan Anjum Badruddin, H. Fayaz, “Non-edible Vegetable Oils: A Critical Evaluation if Oil Extraction, Fatty Acid Compositions, Biodiesel Production, Characteristics, Engine Performance and Emission Production”, Renewable and Sustainable Energy Reviews, 2013.

[7] A.E. Pillay, “Engine Emissions and Performance with Alternative Biodiesels: AReview”, Journal of Sustainable Development, Vol.5, No.4, April, 2012.

[8] Pravin V. Jadhav, Vinod M. Wankar, “An Experimental Study on Diesel Engine Performances Using Biodiesel from Used Frying Oil”, International Journal of Modern Engineering Research (IJMER), pp-169-171 ISSN: 2249-6645, Vol.3, Issue.1, Jan-Feb. 2013.

[9] Gaurav Dwivedi, M.P. Sharma, “Performance Evaluation of Diesel Engine Using Biodiesel from Pongamia Oil”, International Journal of Renewable Energy Research, Vol.3, No.2, 2013.

[10] www. Bioenergy. Psu.edu, “Renewable and Alternative Energy Fact Sheet”, November, 2009.

[11] A. Siva Kumar, D. Maheswar, K. Vijaya Kumar Reddy, “Comparison of Diesel Engine Performance and Emissions from Neat and Transesterified CSO”, Jordan Journal of Mechanical and Industrial Engineering, Vol.3, September, 2009.

[12] S. Chuepeng, Kasetsart University of Thailand, “The Use of Biodiesel in Diesel Engines”, 2011.

