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Experimental Analysis on Biodiesel Prepared from Non edible Oil Resource to use in small Agricultural Diesel Engine

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ABSTRACT: Biodiesel is receiving increased attention as an alternative, non-toxic, biodegradable, and renewable diesel fuel. The world today is faced with serious global warming and environmental pollution. Besides, fossil fuel will become rare and faces serious shortage in the near future. This has triggered the awareness to find alternative energy as their sustainable energy sources. Biodiesel as a cleaner renewable fuel has been considered as the best substitution for diesel fuel due to it being used in ignition engine without any modification. The main advantages of using biodiesel are its renewability and better quality of exhaust gas emissions. Performance and emission of Jatropha curcas and *Calophyllum inophyllum* biodiesel is one of the most efficient oil bearing crops in terms of oil yield, land utilization, efficiency and productivity. However, competition between edible oil sources as food with fuel makes edible oil not an ideal feedstock for biodiesel production. Therefore, attention is shifted to non-edible oil like Jatropha curcas and *Calophyllum inophyllum*. *Calophyllum inophyllum* oil can be transesterified and being considered as a potential biodiesel fuel. Jatropha biodiesel industry, biodiesel from *Calophyllum inophyllum* is still in a nascent state. Therefore, long term endurance research and tribological studies need to be carried out before *Calophyllum inophyllum* oil base biodiesel can become an alternative fuel in future.

Key words*:* Biodiesel, Jatropha, environmental pollution, reduce the viscosity.

I. INTRODUCTION

Bio-diesel is an alternative to petroleum-based fuels The increasing industrialization, modernization and development have led to high demand of petroleum worldwide. Global energy was growing from 6630 million tonnes of oil equivalent to almost double of the energy consumption which had reached 11,295 [1]. However, the world reserve for fossil fuel such as petroleum has been depleting and causing the price to hit new highest the world today is faced with a serious global warming and environmental pollution. The major sources of greenhouse gas (GHG) emissions are gasoline and diesel fuel from transportation sector. The world is confronted with the twin crises of fossil fuel depletion and environmental degradation [4]. Thus, there is an urgent need to find an alternative renewable energy resource that is renewable, clean, reliable and yet economically feasible. Biodiesel, a cleaner renewable fuel has been considered as the best candidate for diesel fuel substitution due to it can be used in any compression ignition engine without any modification on the engine.

Biodiesel is gradually gaining acceptance in the market as an environmentally friendly fuel and the demand is expected to increase sharply as an alternative renewable energy source in the near future. Biodiesel fuel is mono alkyl ester derived from vegetable or animal and it can be blended with diesel fuel which has characteristics similar to diesel fuel and has lower exhaust emissions [5–7]. On the other hand, the main drawbacks of vegetable oil have to overcome due to the high viscosity and low volatility which will cause a poor combustion in diesel engines. Transesterification is the process successfully employed to reduce the viscosity of biodiesel and improve the other characteristics [8]. Currently, more than 95% of the world biodiesel is produced from edible oil which is easily available on a large scale from the agricultural industry. However, competition of edible oil sources as food with fuel makes edible oil not an ideal feedstock for biodiesel production [9–10]. Therefore, much effort is required to focus in this area to produce biodiesel from non-edible seeds like *Jatropha curcas*, *Pongamia pinnata*, Calophyllum in ophyllum, etc. to become feasible feedstock for biodiesel.

Biodiesel seems to be a realistic alternative renewable fuel in the near future and this review is focus on the possibilities of using palm oil, Jatropha curcas, Calophyllum inophyllum and biodiesel in diesel engine. Besides, the fuel characteristics, processes available, production, performance and emission analysis of biodiesel are discussed by making a comparison on these three different types of biodiesel fuel.

II. BIODIESEL

The concept of using biofuel in diesel engines is not a radically new idea, an inventor named Rudolph Diesel demonstrated his first developed compression ignition (CI) diesel engine using peanut oil as a fuel at the World Exhibition at Paris in 1900 [11–12]. However due to abundant supply of diesel and vegetable oil fuel were moreexpensive than diesel, research and development activities on vegetable oil were not seriously pursued [13]. There is a renewed interest in vegetable oil in this decade when it was conclusively realized that petroleum fuel are dwindling fast and environmental friendly renewable substitutes must be identified [14]. Biodiesel gaining more and more interest as an attractive fuel due to the depleting nature of fossil fuel resources and environmental protection reason. Vegetable oil which also known as triglycerides have the chemical structure as shown in comprise of 98% triglycerides and small amounts of monoand diglycerides [15]. Biodiesel is defined as the mono alkyl esters of vegetable oil or animal fats. It is the process of reacting triglyceride with an alcohol in the presence of a catalyst to produce glycerol and fatty acid esters [14]. Vegetable oil contains fatty acid, free fatty acids, phospholipids, phosphatides, carotenes, to copherols, sulphur compound and traces of water [16]. The fatty acids commonly found in vegetable oil are stearic, palmitic, oleic,linoleic and linolenic and thesummaryof the fatty acid composition of some the common vegetable oil is shown in Table 1 [9,12,16–17]. Vegetable oil can be used as liquid engine fuel in various ways such as straight vegetable oil, oil blends, pyrolysis, micro-emulsification and transesterification in diesel engine [18]. Biodiesel which has combustion characteristics similar to diesel and biodiesel blends has shorter ignition delay, higher ignition temperature and pressure as well as peak heat release compare to diesel fuel [5]. Moreover, the engine power output and brake power efficiency was found to be equivalent to diesel fuel. Biodiesel and diesel can reduce smoke opacity, particulate matters, un-burnt hydrocarbons, carbon dioxide and carbon monoxide emissions but nitrous monoxide emissions have slightly increased [17]. However, the main drawback of biodiesel fuel is their high viscosity and low volatility, which causes poor combustion in diesel engines including formation of deposits and injector cocking due to poorer atomization upon injection into the combustion chamber. Transesterification of the oil reduces the viscosity of the oil to a range of 4–5mm^2/s closer to that of diesel and hence improves combustion [2]. Biodiesels or fatty acid esters are efficient, clean and natural energy alternative to petroleum fuel. The use of biodiesel has grown dramatically during the last few years. Feedstock costs account for a large portion of the direct biodiesel production costs, including capital cost and return.

III. 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)

A. Combustion Parameters: Specific Gas Const (kJ/kgK) : 1.00, Air Density (kg/m^3) : 1.17, Adiabatic Index : 1.41, Polytrophic Index : 1.18, Number Of Cycles : 10, Cylinder Pressure Referance : 6, Smoothing 2, TDC Reference : 0

B. Performance Parameters: Orifice Diameter (mm) : 20.00, Orifice Coeff. 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) : 880, Calorific Value Of Fuel (kj/kg) : 42673

IV. IC ENGINE SOFT TEST REPORT

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).

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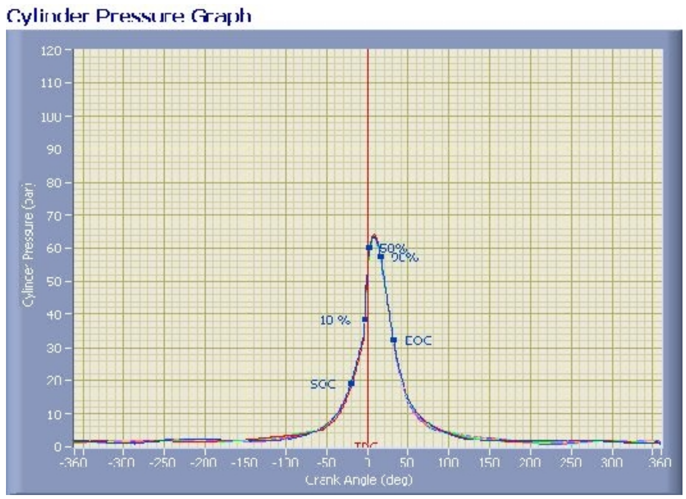
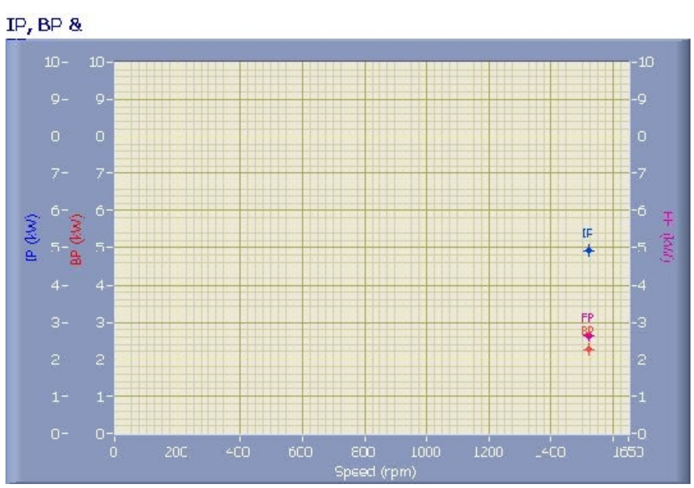
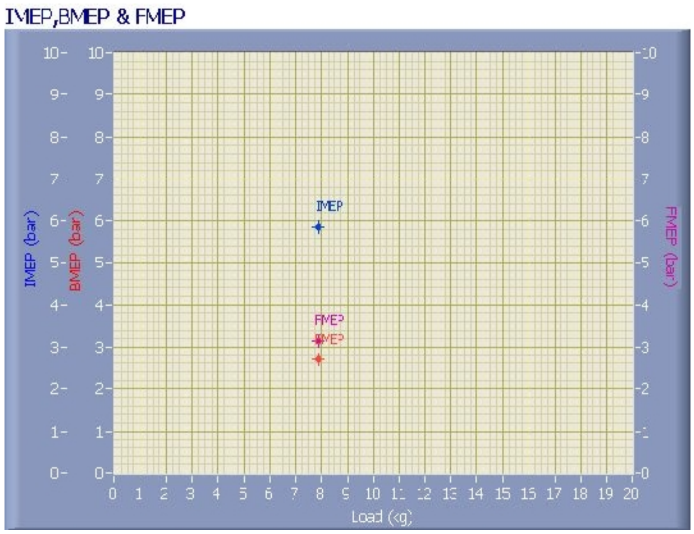


Cylinder Pressure Crank Angle Data.

	Cycle 1	Cycle 2	Cycle 3	Cycle 4	Cycle 5	Cycle 6	Cycle 7	Cycle 8	Cycle 9	Cycle 10	Average Cycle
0.0	1.85	1.30	1.11	1.08	1.09	1.22	1.23	1.81	1.57	1.73	1.40
1.0	1.84	1.31	1.12	1.09	1.09	1.17	1.24	1.39	1.55	1.71	1.35
2.0	1.82	1.32	1.13	1.09	1.09	1.17	1.19	1.43	1.53	1.69	1.35
3.0	1.81	1.33	1.14	1.09	1.09	1.16	1.14	1.38	1.51	1.67	1.33
4.0	1.79	1.34	1.16	1.10	1.09	1.15	1.09	1.36	1.49	1.65	1.32
5.0	1.78	1.35	1.17	1.10	1.09	1.14	1.15	1.34	1.47	1.63	1.32
6.0	1.76	1.36	1.18	1.11	1.09	1.13	1.15	1.32	1.45	1.61	1.32



Speed (rpm)	Load (kg)	IP (kW)	BP (kW)	FP (kW)
1522.00	7.88	4.92	2.28	2.64



Speed (rpm)	Load (kg)	IMEP (bar)	BMEP (bar)	FMEP (bar)
1522.00	7.88	5.87	2.72	3.15

V. FUEL CONSUMPTION

At high idling conditions brake specific fuel consumption for Jatropha biodiesel blends increased compare to diesel fuel. As blend percentages of biodiesel increased fuel consumption increased. Increase in fuel consumption for JB10 and JB20 for idling mode 1 were 21.05% and 26.3%, for idling mode 2 were 17.4% and 26.1% and for idling mode 3 were 3.33% and 6.66% respectively. Compared to engine running at 100% load and 2000 RPM, fuel consumption for diesel, JB10 and JB20 at three idling modes were [18] 35e44%, 38.5e 48% and 41.2e51.4% respectively. The study of effect of injection timing along with engine operating parameters in Jatropha biodiesel engine is important as they significantly affect its performance and emissions. The present paper focuses on the experimental investigation of the influence of injection timing, load torque and engine speed on the performance, combustion and emission characteristics of Jatropha biodiesel engine. For this purpose, the experiments were conducted using full factorial design consisting of (33) with 27 runs for each fuel, diesel and Jatropha biodiesel. The effect of variation of above three parameters on brake specific fuel consumption (BSFC), brake thermal efficiency (BTE), peak cylinder pressure (Pmax), maximum heat release rate (HRRmax), CO, HC, NO emissions and smoke density were investigated. It has been observed that advance in injection timing from factory settings caused reduction.

A. Cylinder pressure history

It can be observed from that the change of injection timing significantly affects the cylinder pressure trends of diesel as well as Jatropha biodiesel for different operating condition. It is observed that the start of combustion occurs a little earlier in the case of Jatropha biodiesel as compared to that of diesel operation for any given injection timing, load and speed. [18] This is due to shorter ignition delay characteristics of Jatropha biodiesel. In general, advanced injection timing causes increased cylinder pressure histories obtained through steeper curve as compared to pressure curves at rated injection timing.

This is because of faster burn at initial stage of combustion (premixed combustion) due to relatively longer ignition delay period. However the retarded timing causes reduced cylinder pressure histories through slow burn at initial stage of combustion (premixed combustion) which makes

the pressure curve flatter due to relatively shorter ignition delay period. Also it can be noted from these figures that the pressure

histories of Jatropha biodiesel at retarded injection timing (350CAD) is different prior to ignition than in the post-ignition period for 15 N m load and 1800 rpm speed At retarded timing, the delay period is very short. This leads to injection of fuel continued after the start of ignition due to the exceeded injection duration over the ignition delay period. This causes heat losses due to vaporization after the ignition and resulting in reduced pressure histories during the post ignition period. However, prior to ignition, higher cylinder pressure histories are evident due to shorter ignition delay caused by late injection timing, Jatropha's ignition characteristic and reduced density due to increased temperature environment.

VI. CONCLUSION

The influence of effect of engine operating parameters and fuelinjection timing on performance and emission characteristics of Jatropha biodiesel engine has been investigated experimentally using full factorial design with 27 runs. Advancing the injection timing angle degree from factory settings causes reduction and smoke and increase in peak cylinder pressure, emission with Jatropha biodiesel operation. However, 5 crank angle degree retard in injection timing causes increase and smoke and reduction in peak pressure, At any given injection timing, load torque and speed, peak pressure and are with Jatropha biodiesel than that of diesel. However, and smoke for Jatropha biodiesel are lower than that of diesel. The best injection timing for Jatropha biodiesel operation with minimum and smoke and with maximum peak pressure, max is found to be Nevertheless, minimum emission yielded an optimum injection timing of Therefore a proper injection timing tuning process can lead to significant benefits in terms of performance and emissions, when the diesel engine is operated with Jatropha biodiesel.

REFERENCES

[1]. Fairless D. The little shrub that could – may be. *Nature* 2007;**449**: 652–5.

[2]. Staat F, Gateau P. The effects of rapeseed oil methyl ester on diesel engine performance exhaust emissions and long-term behavior – a summary of three years of experimentation. *SAE technical paper*, 950053.

[3]. Desantes JM, Arregle J, Ruiz S, Delage A. Characterization of the injection– combustion process in a D.I. diesel engine running with rape oil methyl ester. *SAE technical paper*, 1999-01-1497.

[4]. Altõn R, Cetinkaya S, Yucesu HS. The potential of using vegetable oil fuels as fuel for diesel engines. *Energy Convers Manage* 2001;**42**: 529–38.

[5]. Agarwal AK. Biofuels (alcohols and biodiesel) applications as fuels for internal combustion engines. *Prog Energy Combust Sci* 2007; **33**: 233–71.

[6]. Senthil Kumar M, Ramesh A, Nagalingam B. An experimental comparison of methods to use methanol and Jatropha oil in a compression ignition engine. Biomass Bioenergy 2003; **25**: 309–18.

[7]. Shroff HD, Hodgetts D. Simulation and optimization of thermodynamic processes of diesel engine. *SAE technical paper*, 740194.

[8] Satake K, Monaka T, Yamada S, Endo H, Yamagisawa M, Abe T. The rapid development of diesel engine using an optimization of the fuel injection control, Mitsubishi Heavy Industries Limited. *Tech Rev* 2008; **45**: 6–10.

[9]. Mukherjee I, Ray PK. A review of optimization techniques in metal cutting processes. *Comput Indus Eng* 2006; **50**: 15–34.

[10]. Alonso JM, Alvarruiz F, Desantes JM, Hernandez L, Hernandez V, Molto G. Combining neural networks and genetic algorithms to predict and reduce diesel engine emission. *IEEE Trans Evol Comput* 2007;**11**: 46–55.

[11]. Sahin B, Yakut K, Kotiioglu I, Celik C. Optimum design parameters of a heat exchanger. *Appl Energy* 2005; **82**: 90–106.

[12]. Yakut K, Alemdaroglu N, Sahin B, Celik C. Optimum design parameters of a heat exchanger having hexagonal fins. *Appl Energy* 2006; **83**: 82–98.

[13]. Yakut K, Sahin B, Celik C, Alemdaroglu N, Kurnuc A. Effects of tapes with double-sided delta-winglets on heat and vortex characteristics. *Appl Energy* 2005; **80**: 77–95.

[14]. Win Z, Gakkhar RP, Jain SC, Bhattacharya M. Investigation of diesel engine operating and injection system parameters for low noise, emissions and fuel consumption using Taguchi methods. *Proc I Mech E, Part D, J Automob Eng 2005*; **219**: 1237–51.

[15]. Anand G, Karthikeyan B. An investigation and engine parameters optimization of a spark ignition engine with gaseous fuels. In: 4th Dessau gas engine conference, WTZ RoBlau gGmbH, Germany, June 02–03; 2005.

[16]. Gardner TP, Henein NA. Diesel starting: a mathematical model. *SAE technical paper*, 880426.

[17]. Harris HD, Pearce F. A universal mathematical model of diesel engine performance. *J Agr Eng Res* 1990;47:165–76.

[18]. Tamilporai P, Balusamy N, Mannar Jawahar P, Subramaniyam S, Chandrasekaran S, Vijayan K. Simulation and analysis of combustion and heat transfer in low heat rejection diesel engine using two-zone combustion model and different heat transfer models. *SAE technical paper*, 2003-01-1067.