Performance Evaluation of a Single Cylinder Compression Ignition Engine using Diesel and Bio-Diesel

Dr. Prashant Pandit Bornare[1] Dr. Dheeraj Sheshrao Deshmukh[2] Prof. Dr. V. S. Patil[3] Dipak Chandrakant Talele[4] Tejas Galu Patil[5]
[1,5]Assistant Professor [2]Principal [3]Professor [4]Research Scholar & Assistant Professor
[1,4,5]Department of Mechanical Engineering [3]Department of Chemical Engineering
[1,4,5]S.S.B.T.'s, C.O.E.T., Bambhori, Jalgaon, Maharashtra, India [2]Vidarbha Institute of Technology, Nagpur, Maharashtra, India [3]University Institute of Chemical Technology, Jalgaon

Abstract— The world is getting modernized and industrialized day by day. The transportation sector is one of the most fossil energy consuming sectors and the combustion of fossil fuels contributes to increased greenhouse gas concentrations in the atmosphere. The Depletion of the petroleum reservoir on the earth increases concerns about the environment which leads to the quest for fuels which are eco-friendly and safe for human beings. The use of bio-fuels helps to stabilize the greenhouse gas levels in the atmosphere also the dependency of fossil fuels could be deceased. This situation leads to seek an alternative fuel for diesel engine. Biodiesel is an alternative fuel for diesel engine. The esters of vegetables oil animal fats are known as Biodiesel. Effective utilization of fuel at various engine operating conditions, without adversely affecting the engine performance, it is economically possible to reduce exhaust emissions from old engines also, rather than going for engine modifications. In this paper, the biodiesel produced from the seeds of the Jatropha plant is used to evaluate the Performance of a single cylinder C.I. engine performance.
Key words: Performance, Biodiesel, Jatropha, Greenhouse

I. Introduction

Diesel engines have provided power units for road transportation systems, ships, railway locomotives, equipment used for farming, construction and in almost every type of industry due to its fuel efficiency and durability. However, Diesel engines are the major sources of NO_x and particulate matter emissions which are environmental concerns. For automotive industry the reduction of NO_x and PM emission is the most important task. National governments are imposing stringent emissions on automotive sector to reduce NO_x and PM emissions. Also global house warming gases (GHG) are going to receive more focus from future auto sector. Therefore, the stringent emission regulation requirements give a major challenge to comply emission targets while maintaining its performance, drivability, durability, and fuel economy. The use of alternative fuels for internal combustion engines has attracted a great deal of attention due to fossil fuel crisis and also GHG impact. Alternative fuels should be easily available, environment friendly, and techno economically competitive. Successful alternative fuel should fulfill environmental and energy security needs without sacrificing engine operating performance [1].

Renewable resources offer the opportunity to tap local resources and reduce dependency on fossil energy resources. Most biodiesel oils, particularly of the nonedible type can be used as fuel in diesel engines. They contain significant amount of oxygen [2, 3]. The idea of using vegetable oils as fuel for diesel engine is not new. When Rudolf diesel invented diesel engine and demonstrated in the 1900 world exhibition in Paris, using peanut oil and presented that "The use of vegetable oils for engine fuels may seem insignificant today, but such oils may become in course of time as important as petroleum and coal tar products of present times" [4].

One of the promising alternative fuels considered for diesel engine is biodiesel. Biodiesel fuels are renewable, as the carbon released by the burning of biodiesel fuel is used when the oil crops undergo photosynthesis. Biodiesel also offers the advantage of being able to readily use in existing diesel engines without engine modifications [5-9]. Even though biodiesel has many advantages, because of engine problems its use is restricted to maximum 20% only [10, 11]. Also when biodiesel is used as fuel in existing engines, there is decrease in power, drop in thermal efficiency, increase in specific fuel consumption, and higher NO_x emissions [12-15].

In order to overcome these problems various modifications in engine operating parameters are suggested. The various modifications suggested are varying the compression ratio [16-18], injection pressure [19-21], use of multiple injections, oil preheating, and so forth [22-24].

Table 1 Presents the comparison of properties of Jatropha oil.

Sr. No	Properties of Jatropa Oil	Values
01	Density at 150C g/cm3	0.852
02	Kinematic viscosity at 400 C cSt	2.781
03	Water content % volume	0.055
04	Rams bottom carbon residue %wt.	0.10
05	Pour Point ^{0}C	20
06	Flash point ^{0}C	49
07	Cetane number	46
08	Sulphur content %wt.	0.0165
09	Ash content %wt.	0.010
10	Acid value mg KOH/g	0.104
11	Oxidation stability g/100ml	0.01
12	Copper strip corrosion	1a
13	Calorific value(gross) kJ/g	45.013
14	IBP/FBP 0C	139/370

Table 1: Properties of Jatropha oil

1	Make	Kirloskar Make, single cylinder,4-stroke compression ignition on engine
2	Rated power output	5H.P.
3	Speed	1500 R.P.M.

4	Stroke length	110 mm
5	Bore diameter	80mm
6	Loading type	Water resistance type load, With copper element and load changing arrangement
7	Moment arm-	0.2 meter
8	Orifice diameter (for air box)	25mm
9	Co-efficient of discharge of orifice	0.64

Table 2: Engine specifications

II. EXPERIMENTAL SETUP

A typical 3.5 kW single-cylinder 4-stroke water-cooled diesel engine at 1500 rpm was used for the research work, and Table 2 presents engine specifications. The schematic diagram of the experimental set up is shown in Figure 1. An eddy current dynamometer was used for load control on the engine. The piezoelectric pressure transducer was mounted on cylinder head. Various thermocouple temperature sensors were installed at appropriate locations to measure water inlet and outlet, manifold air temperature, exhaust outlet, and heat exchanger outlet temperatures. A temperature thermocouple was installed on the surface of high pressure fuel pipe. A precision crank angle encoder was coupled with the main shaft of the engine. Two openings were made in exhaust gas pipeline for sampling purposes. Fuel metering was done using a burette fitted with a three-way valve measuring unit installed on fuel tank as shown in Figure 1. The mass flow rate of intake air was measured with an orifice meter connected to a manometer. A surge tank was used to damp out the pulsations produced by the engine, for ensuring a steady flow of air through the intake manifold. An gas analyzer was used for measuring the CO, HC, and NOx emissions and the smoke density was measured using AVL 437 smoke meter. The engine was warmed up prior to data acquisition. All the engine test runs were carried out in fair constant ambient conditions. During the tests with Jatropha biodiesel, the engine was started with diesel until it was warmed up and then fuel was switched to biodiesel. After finishing the tests with biodiesel, the engine was always switched back to diesel fuel and the engine was run until the biodiesel had been purged from the fuel line, injection pump, and injector. This was done to prevent starting difficulties at the later time. Initially the test engine was operated with base fuel diesel for about 10 minutes to attain the normal working temperature conditions. After that the baseline data was generated and the corresponding results were obtained. The engine was then operated Jatropha biodiesel. At every operation the engine speed was checked and maintained constant. The different performance and emission parameters analyzed in the present investigation were brake thermal efficiency (BTE), brake specific fuel consumption (BSFC), exhaust gas temperature (EGT), carbon monoxide (CO), unburned hydrocarbons (UHC), nitrogen oxides (NOx), and smoke opacity. For baseline data, the engine compression ratio was set to 17.5 and fuel injection pressure (Pinj) was maintained at 180 bar. Then compression ratio was increased from 17.5 to 19.5 in the step of 1 and fuel injection pressure was varied from 180 bar to 220 bar in the step of 20 bar.

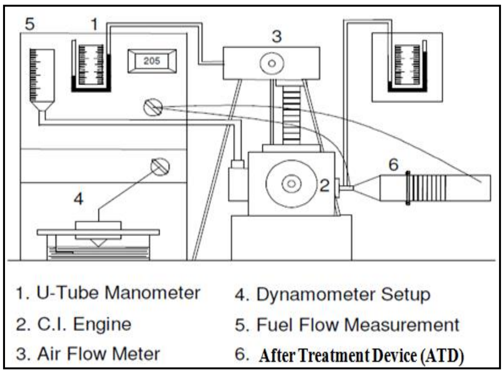

Fig. 1: Experimental Set-up

III. RESULTS & DISCUSSION

A. *Engine Performance for Diesel and Biodiesel*

The engine performance indicators considered were brake thermal efficiency (B_{th}) and Fuel flow rate in Kg/hr. Figure 2 shows variation in thermal efficiency for diesel and biodiesel. It was observed that for all the brake power, the Biodiesel fuel showed higher thermal efficiency as compared with Diesel. The thermal efficiency was increased by 1 % to 4 % for various brake powers, respectively, than that of diesel. Figure 3 shows the fuel flow rate plots for diesel and biodiesel at different brake power. Fuel flow rate is a measure of volumetric fuel consumption for any particulate fuel. Fuel flow rate is higher for diesel than that of biodiesel. The increase in Fuel flow rate may be due to less energy content (lower heating value).

1) *Brake Thermal Efficiency*

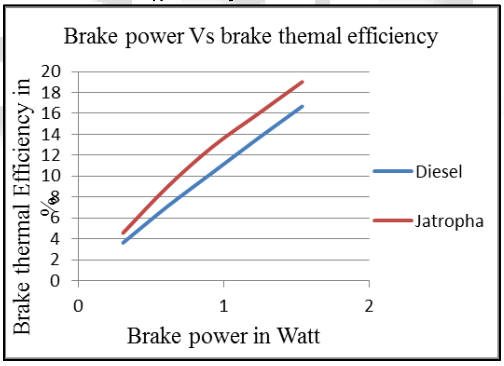

Fig. 2: Brake power Vs brake thermal efficiency for Diesel and Jatropha oil.

In Figure 2, it indicates that brake thermal efficiency is higher for Jetropha oil compared to diesel at different brake power.

2) *Fuel Flow Rate*

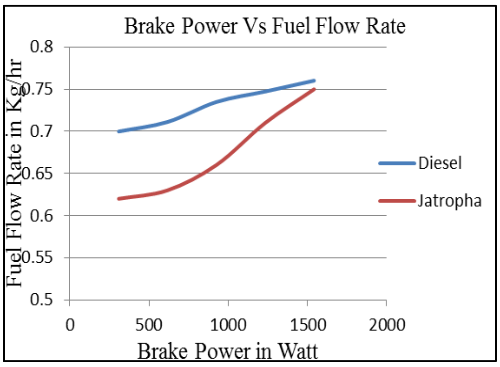

Fig. 3: Brake power Vs fuel flow rate for Diesel and Jatropha oil.

In Figure 3, it indicates that fuel flow rate is lower than the diesel for Jatropha oil at different brake powers. This is due to complete combustion, as addition oxygen is available from fuel itself.

IV. CONCLUSION

Performance of a single cylinder C.I. engine using Diesel and Bio-diesel invested experimentally. The investigation of Single-cylinder diesel engine requires no modification in hardware during testing. Brake thermal efficiency is higher for Jatropha oil compared to diesel at different brake power. Also fuel flow rate is lower than the diesel for Jatropha oil at different brake powers. Jatropha oil may be an alternative fuel for diesel.

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