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Effect of Injection Parameters on the Combustion Characteristics of Diesel Engine Operated with Thevetia Peruviana Methyl Ester

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ABSTRACT

For transportation and power production applications compression ignition (CI) engines are more significant than petrol engines because they have a higher brake thermal efficiency and lower hydrocarbon and carbon monoxide emissions. Several researchers have worked on the concept of increase the brake thermal efficiency and emissions of compression ignition engines while reducing their fuel consumption. The air-fuel combination in diesel engines is very specific. As a result, improvements in air-fuel mixing in compression ignition engines are possible through adjustments in injection strategies. With this concept, experiments are being conducted to determine the impact of injection pressure (IP), injection timing (IT) and nozzle geometry (NG) on CI engine operated with thevetia peruviana methyl ester (TPME). The results showed that using 230 bar IP, 26°BTDC IT, and 5-hole NG gives higher peak pressure rise.

KEYWORDS: Diesel engine, Thevetia peruviana biodiesel, Injection pressure, Injection timing, Nozzle geometry.

I.INTRODUCTION

The most harmful effect of our present day civilization is global warming and environmental pollution. With rapid industrialization and urbanization we are also making our planet unsafe for us and for the generations to come. The vehicle population throughout the world is increasingly rapidly [1]. Recent report says that lower smoke levels and higher thermal efficiencies are offered more by the methyl ester of vegetable oils than neat vegetable oils. Intensive research is going on throughout the globe for a suitable diesel substitute. In this race among different alternatives, vegetable oils have attained primary place as some of their physical, chemical and combustion related properties are nearly similar to that of diesel fuel [2]. Raw vegetable oil cannot be used directly in diesel engine because of their high viscosity. The viscosity may cause blockage of fuel lines, filters and results in poor atomization of fuel into the combustion chamber. To reduce the high viscosity of raw oil transesterification reaction has to be done [3]. Thevetia peruviana, called Bitti or Kaner in Marathi, is a small evergreen tree (3-4 m high) cultivated as an ornamental plant in tropical and subtropical regions of the world, including India. Fruit contains flat gray colored seed, which yield about half liter of oil from one kg of dry kernel. Recent experiments showed that use of thevetia peruviana biodiesel in reactivity controlled compression ignition engine reduces the emission levels drastically [4-8]. Among various injection timings studied advanced injection timing gives better performance of the engine as compared to retarded injection timing when the engine powered with various biodiesel blends [9-16]. Diesel engine performance and emissions are strongly coupled with fuel atomization and spray processes, which in turn are strongly influenced by injector flow dynamics. Modern engines employ micro-orifices with different orifice designs. It is critical to characterize the effects of various designs on engine performance and emissions. The fuel injector orientation plays very important role in fuel air mixing. The geometry of the diesel fuel injection nozzle and fuel flow characteristics in the nozzle significantly affects the processes of fuel atomization, combustion and formation of pollutant emissions in a diesel engine [17]. Among three different nozzles 3-hole nozzle gives higher peak pressure rise and indicated mean effective pressure as compared to 4-hole and 5-hole nozzles when the engine operated with B20 neem biodiesel [18].

II. METHODOLOGY

The biodiesel was extracted from thevetia peruviana feedstock. Transesterification method was used to derive biodiesel from raw oil. After biodiesel was derived different blends of biodiesel were prepared in the proportion of 20% such as B0 (100% pure diesel), B20 (20% biodiesel + 80% diesel), B40 (40% biodiesel + 60% diesel), B60 (60% biodiesel + 40% diesel), B80 (80% biodiesel + 20% diesel) and B100 (100% pure biodiesel). The physical properties of test fuels are provided in Table-1.

III. EXPERIMENTAL SETUP

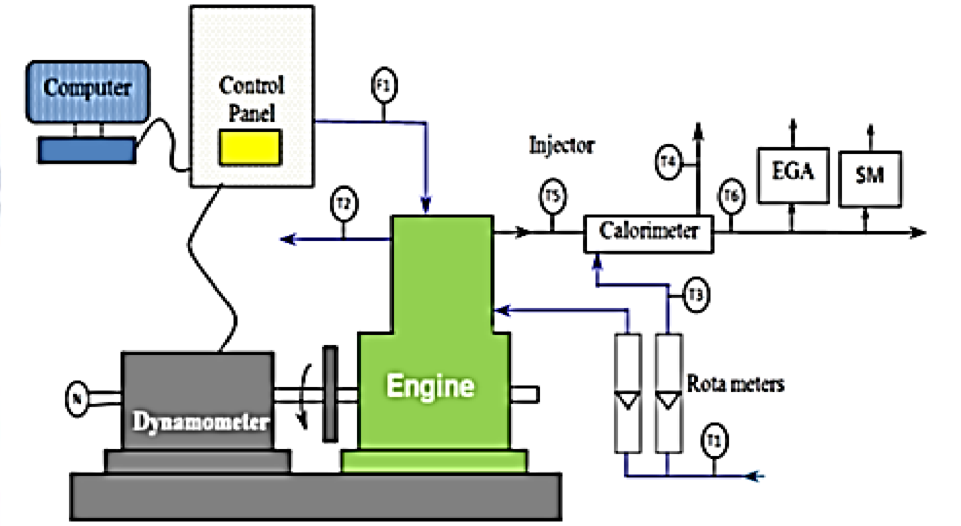
The entire experimentation was conducted on Kirloskar, TV1, water cooled, direct injection diesel engine as shown in Figure-1. Initially, the engine was operated with diesel to attain warm-up condition and to get baseline data at 210 bar injection pressure, 23° BTDC injection timing and 3-hole injection nozzle. Afterwards, the engine was operated with all biodiesel blends. Next, the injection pressure was increased from 210 bar to 250 bar in the step of 20 bar with all test fuel blends and optimized injection pressure was found.

In the next step, optimized 230 bar injection pressure was kept constant and injection timings varied as 20° BTDC and 26° BTDC with all test fuel blends and optimized injection timing was found. For the next step, optimized injection pressure 230 bar and optimized injection timing 26° BTDC were kept constant and injection nozzle varied as 4-hole and 5-hole with the same fuel blends. At last optimized injection nozzle was found. The area of 3-hole, 4-hole and 5-hole injection nozzles are 0.0615 mm^2, 0.0415 mm^2 and 0.03141 mm^2 respectively. The detailed test engine specifications are provided in Table-2.

IV. RESULTS AND DISCUSSIONS

Figure-2 shows variation of peak pressure rise with injection pressure. As the injection pressure increased from 210 bar to 230 bar peak pressure rise was increased. This is due to, fine atomization of fuel particles takes place which enhanced the energy generated inside the combustion chamber and it leads to increased peak pressure rise. As the injection pressure increased from 230 bar to 250 bar peak pressure rise was decreased. This is due to, injection pressure increased beyond the limit and accumulation of fuel particles was higher so that fuel consumption was higher and it leads to lower peak pressure rise in case of 250 bar injection pressure. From various fuel blends studied B100 blend resulted in lower peak pressure rise. This is due to, heavier and sticky molecular structure of pure biodiesel which leads to lower thermal efficiency and peak pressure rise was lower in case of B100 biodiesel blend.

Table-1. Physical properties of test fuel blends						
Property	B0	B20	B40	B60	B80	B100
Density (kg/m³)	829	835	839	841	843	846
Viscosity at 40°C (CSt)	3.52	3.76	3.96	4.09	4.22	4.71
Flash Point (°C)	53	68	77	81	83	87
Fire Point (°C)	59	75	86	89	92	95
Calorific Value (MJ/kg)	42.19	41.82	41.45	41.18	40.92	40.31



T_1, T_3 – Water inlet temperature, T_2 – Engine water jacket outlet temperature, T_4 – Calorimeter outlet temperature, T_5 – Exhaust gas temperature before calorimeter, T_6 – Exhaust gas temperature after calorimeter, F_1 – Fuel flow differential pressure unit, N – Speed encoder, EGA – Exhaust gas analyzer, SM – Smoke meter

Figure-1. Schematic representation of conventional engine setup

Table-2. Test engine specifications	
Engine Parameter	Specifications
Engine Type	Kirloskar
No. of Strokes	4
No. of Cylinders	1
Type of Cooling	Water Cooling
Type of Injection	Direct Injection
Bore	87.5 mm
Stroke	110 mm
Compression Ratio	17.5:1
Rated Power	5.2 kW
Rated Speed	1500 rpm

Figure-3 shows variation of peak pressure rise with injection timing. As the injection timing increased from 20° BTDC to 26° BTDC bar peak pressure rise was increased. This is due to, ample of time available to mix pilot fuel with air which leads to better combustion and hence peak pressure rise increased. From various fuel blends studied B0 resulted in higher peak pressure rise. This is due to, superior characteristics of B0 which leads to higher thermal efficiency and peak pressure rise was higher in case of B0 fuel.

Figure-4 shows variation of peak pressure rise with injection nozzle. As the injection nozzle increased from 3-hole to 5-hole the peak pressure rise was increased. This is due to, fuel discharge was reduced as the number of nozzle holes increased as area of the nozzle holes was reduced which resulted into higher thermal efficiency and increased peak pressure rise. Among various fuel blends studied B100 blend resulted into lower peak pressure rise. This is due to, lower calorific value of B100 blend which exhibited improper combustion and hence peak pressure was reduced for the blend.

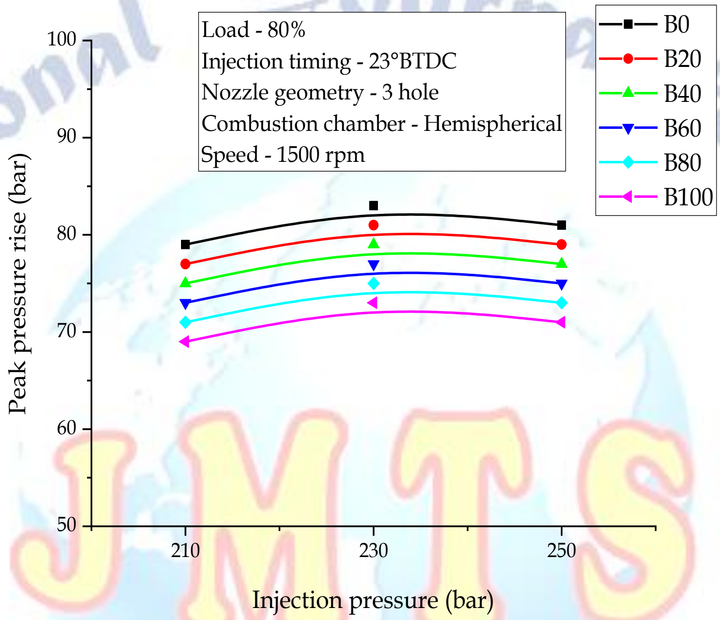


Figure-2. Variation of peak pressure rise with injection pressure

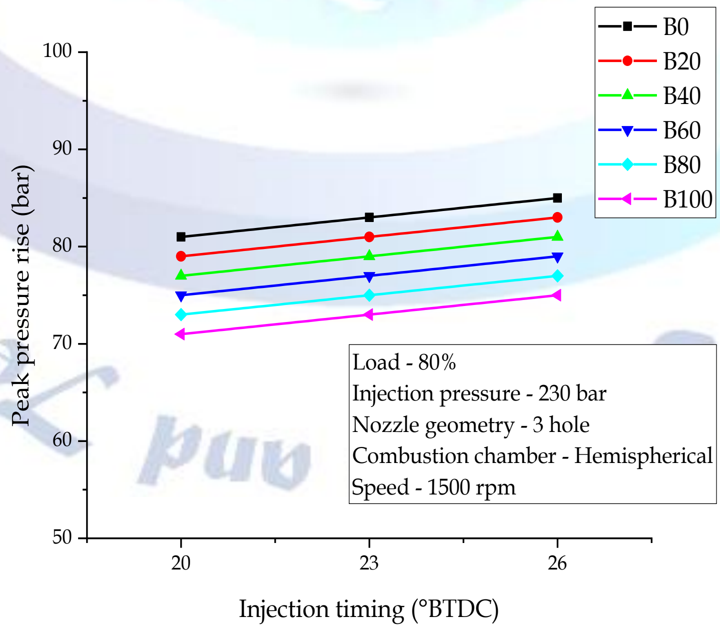


Figure-3. Variation of peak pressure rise with injection timing

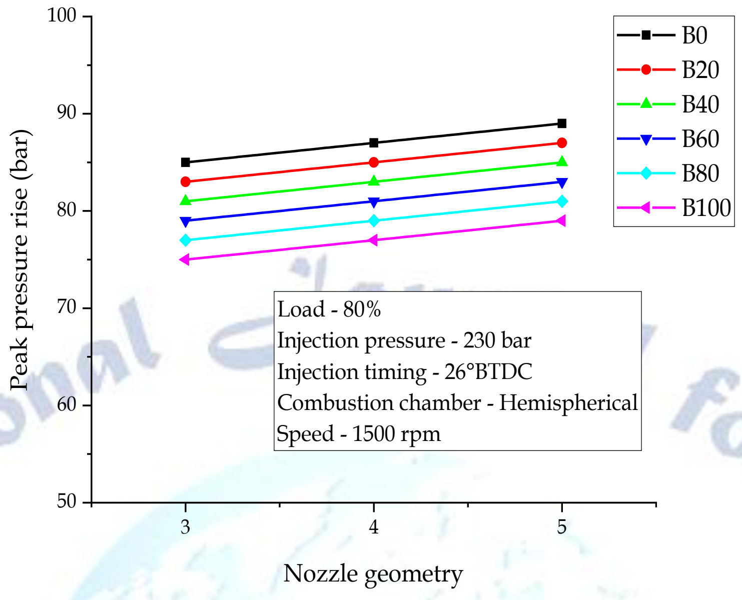


Figure-4. Variation of peak pressure rise with nozzle geometry

V. CONCLUSIONS

Based on the observed results following conclusions are drawn.

- Among various injection pressures studied 230 bar injection pressure gives higher peak pressure rise as compared with 210 bar and 250 bar injection pressures.
- From various injection timings studied 26° BTDC gives higher peak pressure rise as compared with 20° BTDC and 23° BTDC injection timings.
- Among various injection nozzles studied 5-hole nozzle gives higher peak pressure rise as compared with 3-hole and 4-hole injection nozzles.
- From various fuel blends studied B0 blend gives higher peak pressure rise as compared with B20, B40, B60, B80 and B100.

REFERENCES

[1] Harari P.A., Akshatha D.S., Manavendra G., Simarouba biodiesel as an alternative fuel for CI engine: review, International Journal of Innovative Research in Science, Engineering and Technology, 4(3), 2015, 1059-1063.

[2] Harari P.A., Mahua biodiesel as an alternative fuel for CI engine: review, International Journal of Modern Engineering Research, 5(4), 2015, 24-31.

[3] Harari P.A., Akshatha D.S., Manavendra G., Effect of injection pressure and nozzle hole diameter on combustion parameters of CI engine fuelled with B20 neem blend, International Journal of Innovative Research in Science, Engineering and Technology, 4(5), 2015, 2857-2870.

[4] Chavan M., Sutar A., Bhatkande R., Gurav R., Mulla M., Deokar A., Harari P., Experimental studies on production of biodiesel from thevetia peruviana feedstock, International Journal of Engineering and Management Research, 8(2), 2018, 46-49.

[5] Harari P.A., Yaliwal V.S. Banapurmath N.R., Experimental investigation on the effect of gaseous fuels energy share on reactivity controlled compression ignition mode of combustion operated with gaseous fuels and liquid fuels, Materials Today Proceedings, 2021, https://doi.org/10.1016/j.matpr.2021.11.006.

[6] Harari P.A., Banapurmath N.R., Yaliwal V.S., Soudagar M.E.M., Khan T.M.Y., Mujtaba M.A., Safaei M.R., Akram N., Goodarzi M., Elfasakhany A., Seesy A.I., Experimental investigation on compression ignition engine powered with pentanol and thevetia peruviana methyl ester under reactivity controlled compression ignition mode of operation, Case Studies in Thermal Engineering, 25, 2021, 100921, https://doi.org/10.1016/j.csite.2021.100921.

[7] Harari P.A., Yaliwal V.S., Banapurmath N.R., Effect of CNG and CBG as low reactivity fuels along with diesel and TPME as high reactivity fuels in RCCI mode of combustion by varying different loads, Materials Today Proceedings, 47(10), 2021, 2491-2494, https://doi.org/10.1016/j.matpr.2021.04.557.

[8] Harari P.A., Banapurmath N.R., Yaliwal V.S., Khan T.M.Y., Soudagar M.E.M., Sajjan A.M., Experimental studies on performance and emission characteristics of reactivity controlled compression ignition (RCCI) engine operated with gasoline and Thevetia Peruviana biodiesel, Renewable Energy, 160, 2020, 865-875, https://doi.org/10.1016/j.renene.2020.07.009.

[9] Pushparaj M., Vishal J., Harari P.A., Pattanashetti A., Jagatap S., Bhuimbar S., Meti V., Performance parameters of B20 neem blend in CI engine by varying injection timing and nozzle hole diameter, 5(2), 2016, 1434-1442.

[10] Harari P.A., Pattanashetti A., Experimental investigation on the effect of injection timing, carburetor type and exhaust gas recirculation on compression ignition engine fuelled with diesel–compressed biogas and rice bran oil methyl

ester–compressed biogas, Integrated Research Advances, 4(2), 2017, 29-36.

[11] Harari P.A., Effect of injection timing on the performance and emissions of dual fuel engine operated with compressed biogas and calophyllum inophyllum methyl ester, International Journal of Research in Advent Technology, 7(4), 2019, 1-8.

[12] Harari P.A., Deokar A.J., Jadhav S.D., Narvekar R.P., Nimbalkar P.Y., Kamble V.A., Effect of injection timing on compression ignition engine fuelled with thevetia peruviana biodiesel, 8(5), 2019, 5744-5754.

[13] Harari P.A., Banapurmath N.R., Yaliwal V.S., Khan T.M.Y., Badruddin I.A., Kamangar S., Mahlia T.M.I., Effect of injection timing and injection duration of manifold injected fuels in reactivity controlled compression ignition engine operated with renewable fuels, Energies, 2021, 14, 4621, https://doi.org/10.3390/en14154621.

[14] Karthik T., Banapurmath N.R., Basavarajappa D.N., Ganachari S.V., Kulkarni P.S., Harari P.A., Effect of injection timing on the performance of dual fuel engine fueled with algae nano-biodiesel blends and biogas, Materials Today Proceedings, 2021, https://doi.org/10.1016/j.matpr.2021.11.156.

[15] Gaddigoudar P.S., Banapurmath N.R., Basavarajappa Y.H., Yaliwal V.S., Harari P.A., Nataraja K.M., Effect of injection timing on the performance of Ceiba Pentandra biodiesel powered dual fuel engine, Materials Today Proceedings, 2021, https://doi.org/10.1016/j.matpr.2021.08.009.

[16] Deokar A.J., Harari P.A., Effect of injection pressure, injection timing and nozzle geometry on performance and emission characteristics of diesel engine operated with thevetia peruviana biodiesel, Materials Today Proceedings, 47(10), 2021, 2622-2626, https://doi.org/10.1016/j.matpr.2021.05.198.

[17] Harari P.A., Patil J.S., A review on effect of nozzle hole geometry on the performance combustion and emission parameters of CI engine fuelled with diesel and biodiesel, International Journal of Engineering and Management Research, 6(3), 2016, 39-48.

[18] Harari P.A., Manavendra G., Experimental investigation on the combustion parameters of B20 neem blend in CI engine by varying injection timing and nozzle hole diameter, International Journal of Advance Research and Innovative Ideas in Education, 1(4), 2015, 503-510.