PERFORMANCE AND EMISSION CHARACTERISTICS OF PAPAYA SEED OIL FUELED DI DIESEL ENGINE BY CHANGING PISTON GEOMETRY

R.Senthilkumar [1], R.Laxmishankar [2], P.Prabhakaran, M.E., (Ph.D)., [3]

[1,2,3] Assistant Professor, Department of Mechanical Engineering, J.J.College Of Engineering And Technology, Tiruchirappalli, Tamilnadu, India.

Abstract - Growing concern regarding energy resources and the environment has increased interest in the study of alternative sources of energy. Biodiesels offer a very promising alternative to diesel since they are renewable and have similar properties. Papaya seed oil has lower performance efficiency then diesel, but it has only lower exhaust emissions and low cost compare to diesel. The modifications in DI engine place an important role in the world for all fuels to increase the efficiency of engine. This paper presents the effects of modified piston on combustion and emission characteristics of a diesel engine fuelled with papaya seed oil. Combustion efficiency of CI Engine can be increased by designing combustion chamber. A good swirl promotes fast combustion to improve the efficiency. In order to achieve different swirl intensity to improve combustibility of combustible mixture in the cylinder, the piston was modified for papaya seed as alternate fuel.

Keywords: Papaya oil, Piston bowl, Combustion efficiency, Air swirl, Turbulence

I.INTRODUCTION

The rapidly growing global demand for petroleum products and the consequent depletion of the crude oil reserves in addition to adverse environmental concerns and unstable nature of the international market make imperative the need to explore alternative sources of fuel. Due to increasing concern about fuel shortage and environmental protection several research has been made on improving fuel economy and decreasing exhaust emission. Because of limited resources of petroleum oil, development of alternative fuel engines without modification of existing engine is needed. Alternate fuels are usually clean compared with diesel and gasoline the combustion process.Oils can be used as liquid fuel for combustion in compression-ignition (diesel) engines directly or in a blend with other fuels.

Antony Raj et al concerned with the CFD analysis of incylinder air motion coupled with the comparison of predicted results with the experimental results available in the literature. Four configurations are flat, inclined, center bowl and inclined offset bowl pistons have been studied by using numerical analysis STAR-CD CFD software. It is concluded that a center bowl on flat piston is found to be the best from the point of view of tumble ratio, turbulent kinetic energy, turbulent intensity and turbulent length scale which play very important role in imparting proper air motion, thereby increasing the energy efficiency of the engine [1]. Ayhan Demirbas et al concluded the methyl esters of vegetable oils have several outstanding advantages over other new-renewable and clean engine fuel alternatives. It is renewable, biodegradable, non-toxic, and essentially free of sulfur and aromatics. Biodiesel seems to be a realistic fuel for future, it has become more attractive recently because of its environmental benefits (low emissions) and that can be used in any diesel engine without modification [2]. Bhanu Pratap et al Analyzed to reduce the NOX, HC, CO, and CO2 some modification has been done in piston bowl by cutting three spiral grooves on inner surface of hemispherical bowl and slight increasing in bowl diameter. The spiral grooves increase the air capacity and slight reduce the compression ratio as well as make homogeneous mixing of air and fuel. From results, it is observed the fuel consumption and NOX reduction by 0.1Kg per hour 8.82% respectively and the temperature of exhaust gas is reduced by 4.8 %[3]. Cassia et al investigated the physicochemical characteristics, fatty acid, and carotenoid composition of a crude oil extracted from papaya seeds. The oil yield from the seeds was 29.16. The major fatty acids in total lipid were oleic (71.30%), palmitic (16.16%), linoleic (6.06%), and stearic (4.73%) acid. The Papaya seed oil exhibited a very good oxidative stability without added synthetic antioxidants, the potential utilization of the papaya seeds for oil production seems favourable [4].

Foluso et al attempted to synthesize biodiesel from Carica papaya seed oil and has found that the oil exhibits a potential for biodiesel production. The trans-etherification process improved the fuel properties of the papaya seed oil. The seed has sufficient oil content and the oil has suitable properties which are comparable with other oils that have been applied for biodiesel production. High pour point and cloud point was, however, observed for papaya seed oil but can be addressed by using papaya seed oil as blend with petroleum diesel [5]. Marfo et al analyzed defatted and undefatted seeds of papaya for proximate composition, some toxicants, sugar composition, mineral content, physicochemical properties of the seed oil and the fatty acid spectrum of the seed oil. The result shows, papaya seed is a rich source of nutrients. However, it has a considerable drawback which is the presence of toxicants in both the seed and the oil, In order to utilize this rich source of food[6]. Li et al investigated the effect of piston bowl geometry was on combustion characteristics of biodiesel at medium load for three bowl geometries, namely Hemispherical Combustion Chamber, Shallow depth Combustion Chamber and Omega Combustion Chamber. SCC has a higher indicated work in comparison with HCC and OCC, indicating a better performance. The performance of OCC is better than that of HCC and SCC from medium to high engine speeds [7]. Prabhakaran et al investigated while water cooled DI diesel engine that injection pressure is maintained at 220 bars and vary the injection timing of 23° before BDC operating under part load condition with papaya seed oil as bio fuel. The combustion characteristics heat release rate, cylinder pressure marginally reduced for all cases. 22° before BDC crank angle significantly reducing the emission characteristics of the engine per blend with minor modification of the engine. The effect of change in injection timing NOX marginally reduced compared to diesel fuel [8]. Prasad et al investigated the high swirl inducing piston bowl from two piston configurations are piston bowl with base line injector and piston bowl with sac-less injector. The simulation results indicated that the selected piston bowl geometry could actually be reducing the in-cylinder swirl and turbulence. The emission reduction may be entirely due to the introduction of the sac-less injector. A highly re-entrant piston bowl and without a central projection was found to be the best for swirl and Thermal Kinetic Energy intensification around TDC. An injection timing of 8.6^0 BTDC was found to be optimum since it led to a 27% reduction in NOX emissions and 85% reduction in soot levels as compared to the baseline configuration [9]. Prasad et al investigated Influence of the air swirl in the cylinder upon the performance and emission of a single cylinder diesel direct injection engine with three different configurations of piston i.e. in the order of number of grooves 3, 6, 9**.** In order to achieve the different swirl intensities in the cylinder, three design parameters have been changed: the cylinder head, piston crown, and inlet duct. In this way, the piston crown is modified i.e. alteration of combustion chamber to enhance the turbulence in the cylinder. From the results the GP 9 is the best trade-off between performance and emissions [10].

Puangsri et al determined the physicochemical properties of oil from Carica papaya following extraction with petroleum ether and aqueous-enzymatic methods. The use of enzymes in oil Extraction should be encouraged because solvent extraction for oil processing poses environmental problems. There is the possibility of using enzymatic modification to improve the fluidity of the oil so that it may become highly desirable to the food and culinary industries[11]. Shadi et al investigated the effects of ultrasound-assisted extraction variable (namely time, temperature, ultrasound power and solvent to sample ratio) condition on the yield, antioxidant activity and stability of the oil from papaya seed. Ultrasound-assisted extraction provided a relatively high oil recovery (≈73%) from papaya seed. The ultrasound extraction at the elevated temperature using high ultrasound power and low solvent ratio was the most desirable extraction condition resulting in the reliable oil recovery, antioxidant activity and stability [12]. Syed et al found the compositions of papaya seed oil to be Protein (28.1%), Ash (8.2%), crude fiber (19.1%) and total carbohydrate (25.6%). The papaya seed oil consists of iodine value (65.5), saponification value (155.5), unsaponifiable matter (1.37%) and free fatty acid (0.32%). The major fatty acid of papaya seed oil were oleic acid (72.5%) followed by palmittic acid (13.2%) and stearic acid (4.5%)[13].

Rigopoulos et al investigated the effect of varying the combustion chamber geometry and engine rotational speed on the gas flow and temperature field, using a new quasi-dimensional engine simulation model, for three alternative piston bowl geometries and three rotational speeds. The quasi-dimensional model solves the general transport equation for the conservation of mass and energy by a finite volume method throughout the entire in-cylinder volume. From the comparison of calculated results, the quasi-dimensional model with the proposed simplified air motion model is capable of capturing the physical effect of combustion chamber geometry and speed on the in-cylinder velocity and temperature field, while needing significantly lower computing time compared to the more detailed and accurate CFD model[14]. Vijaya et al Analyzed using both fossil and renewable fuels with varied piston geometries are hemispherical piston bowl and flat piston without any change in clearance volume. The varied piston geometry of hemispherical piston enhances the turbulence and this is due to better air-fuel mixing process. The thermal efficiency is increased and whereas SFC and soot emissions are reduced. The NOX emissions are reduced because of better mixing and a faster combustion process. The brake thermal efficiency has been increased for hemispherical piston is 31.8% and for flat piston is about 30.8%. The indicated thermal efficiency has been increased for hemispherical piston is 30.99% and for flat piston is 35.96%. Volumetric efficiency is reduced by hemispherical piston is 98.11% and flat piston by 99.37%[15]. Vaibhav et al investigated Influence of air swirl in the combustion chamber upon the performance and emission of a diesel engine. In order to achieve different swirl intensity to improve combustibility of combustible mixture in the cylinder, three different configurations of piston i.e. in the order of number of grooves 4, 8 and 12 are used to intensify the swirl for the better mixing of fuel and air and their effect on the performance and emission are recorded. The result shows NP 12 configuration has lowest fuel consumption among all piston configurations, improvement in mechanical efficiency is about 14.8% with brake thermal efficiency is increased by about 7.2% and maximum reduction in exhaust gas temperature with low NO_X, hydrocarbon, Carbon monoxide emissions [16].

Papaya seed oil

Mature Carica papaya fruits were collected. The fruits were cut into two longitudinal halves and seeds removed by hand. The tastes of the seeds were removed by squeezing the seeds between two fingers. The seeds were dried in an oven at 60ºC. The dried seeds were stored at -10ºC until required for analysis.

Papaya (Carica papaya L.) is a plant that grows wild in many parts of the tropics. Papaya is important for its fruit and it is cultivated mainly for this purpose. Papaya is also grown for papain production. The seeds of papaya fruits are generally discarded. However, in order to make a more efficient use of papaya, it is worth investigating the use of the seeds as a source of oil

Table I Composition of papaya seeds as percent of weight

Proximate composition	Weight (%)
Moisture	7.2 ± 0.0
Oil	30.7 ± 0.7
Protein	28.3 ± 0.8
Ash	8.2 ± 0.1
Crude fiber	19.1 ± 0.2
carbohydrate	25.68

Modified piston

The radial holes in piston bowl increase the swirl velocity of air inside the combustion chamber. This influence of swirl creates high turbulence intensity in the cylinder, so complete mixing and increasing the temperature of air-fuel mixture are takes place. These changes in combustion chamber increases the combustion efficiency of diesel engine and reduce the exhaust emissions. For solvent extraction, 150 g of ground seeds were placed in a cellulose paper cone and extracted using light petroleum ether (40-60ºC) in a 5-L Soxhlet extractor for 8 hrs. The oil was recovered by evaporating the solvent using a rotary evaporator and the residual solvent was removed by drying in an oven at 60ºC for 1hr and by flushing with 99.9% nitrogen.

Fig.1. Modified piston geometry

Table II Specifications of AVL Di Gas Analyzer

Make	AVL
Type	AVL Di Gas 444
Power Supply	11...22 volage≈ 25 W
Warm up time	≈ 7 min
Connector gas in	≈ 180 I/h, max.over pressure 450 hPa
Response time	$T_{95} \leq 15s$
Operating temperature	5...45 °C
Storage temperature	0...50 °C
Relative humidity	≤ 95%, non-condensing
Inclination	0...90°∠
Dimension (w x d x h)	270 x 320 x 85 mm^3
Weight	4.5 kg net weight without accessories
Interfaces	RS 232 C, Pick up, oil temperature probe

Table III. Specification of the Test Engine

Type	Vertical, water cooled, Four stroke
Number of cylinder	1
Bore Diameter	87.5 mm
Compression ratio	17.5:1
Maximum power	5.2 kW
Speed	1500 rpm
Dynamometer	Eddy current
Injecting timing	23° before TDC
Injection pressure	220 kgf/cm^2

II. EXPERIMENTAL SETUP

The filters of the engine are replaced and the injectors were cleaned and calibrated according to the desired specifications. The AVL gas analyzer and smoke meter were installed. The input to the gas analyzer was taken from the exhaust port of the engine.

The fuel tank was filled with diesel and the engine was run for various loads from 0 to 100%. For different loads various observations like specific fuel consumption, Time taken for 10cc fuel consumption, smoke density, speed of engine are noted. The readings of gas analyzer and smoke meter were noted in each case. After all the observations were taken, Do the various calculations for observed readings and draw graphs. The leftover diesel was drained out of the tank and biodiesel (papaya seed oil blends) was poured. Same steps were taken and the readings were noted down for the bio-diesel

III.EXPERIMENTAL RESULTS

The 4 stroke diesel engine is run by papaya seed oil withstand without modification in the piston, the observations were took for different loads like 20%, 40%, 60%, 80%, 100% for different amounts of papaya seed oil blends with diesel (B25, B100). From these observations specific fuel consumption, brake power, mechanical efficiency and brake thermal efficiency were calculated

Fig.2. Photographic View of Experimental Setup

From the experimental results of papaya seed oil fuelled diesel engine, the graphs were drawn to compare the different amounts of papaya seed oil blends with diesel for different loads are shown in following figures. Figure 3 shows the correlation between Brake thermal efficiency and brake power without piston modification for diesel, B25, B50 and B100. From figure 4 to 11 shows various results of papaya seed oil fuelled DI diesel engine with piston modification. Figure 4 shows the correlation between specific fuel consumption and brake power for B50 and B100 (with and without modification). From this results, the mechanical and brake thermal efficiency increases for piston medication.

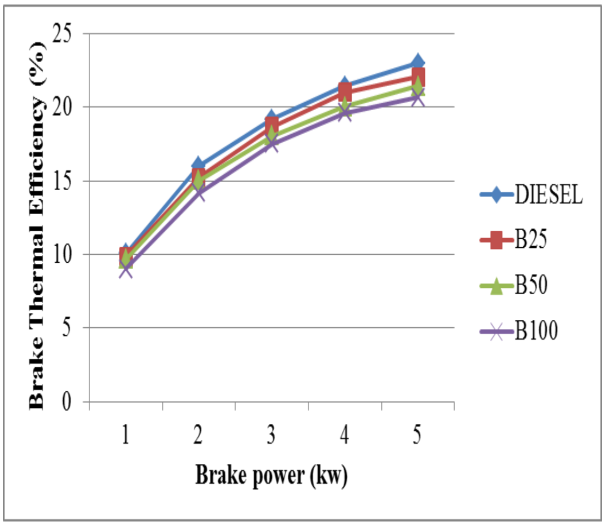

Fig.3. Variation of brake thermal efficiency with brake power

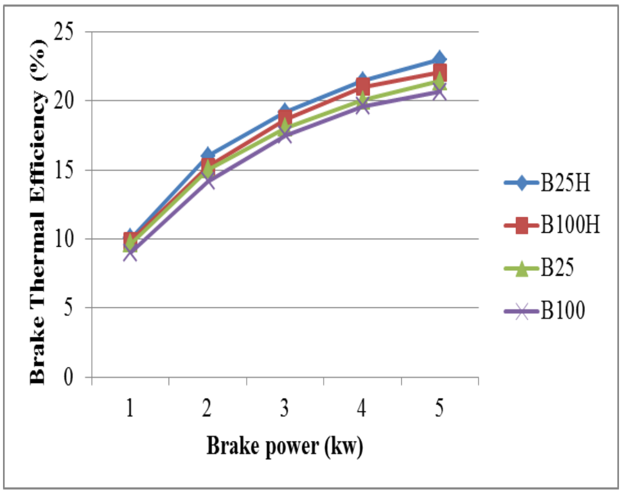

Fig.4. Variation of brake thermal efficiency with brake power

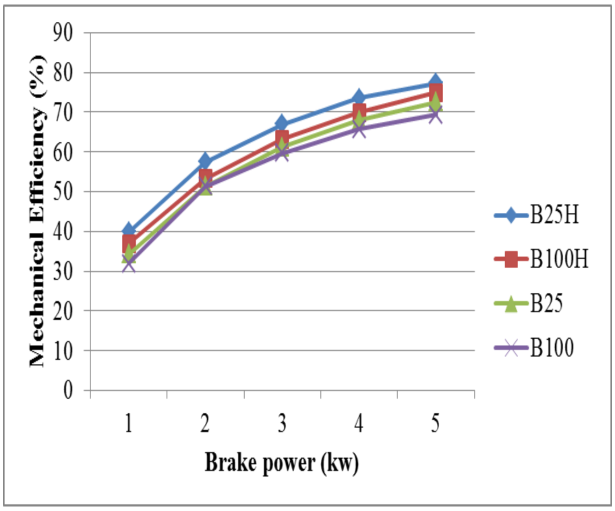

Fig.5.Variation of mechanical efficiency with brake power

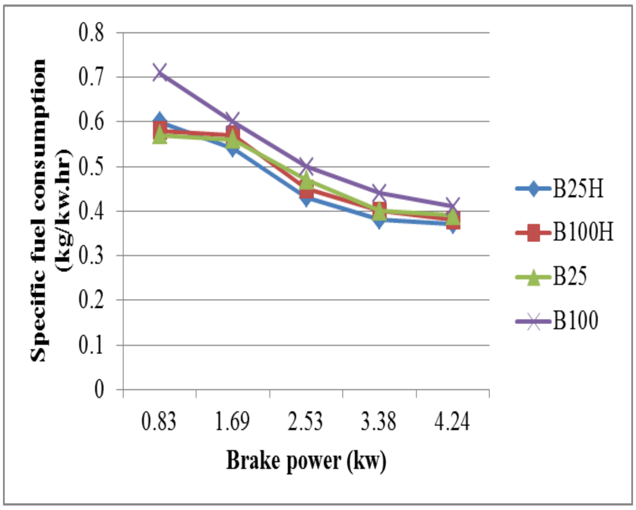

Fig.6. Variation of specific fuel consumption with brake power

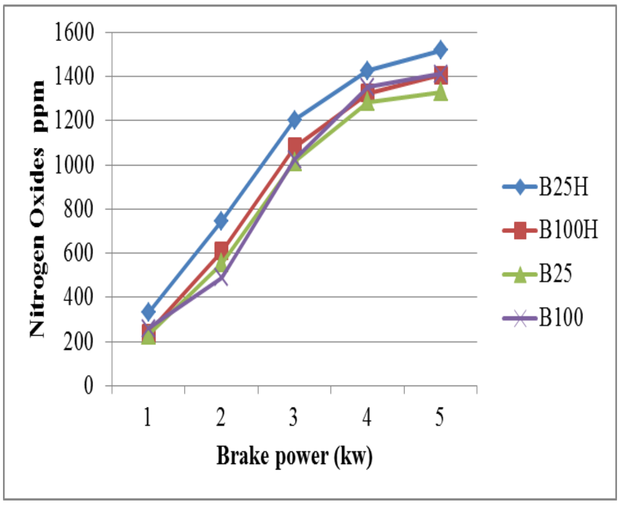

Fig.7. Variation of NO_X Emission with brake power

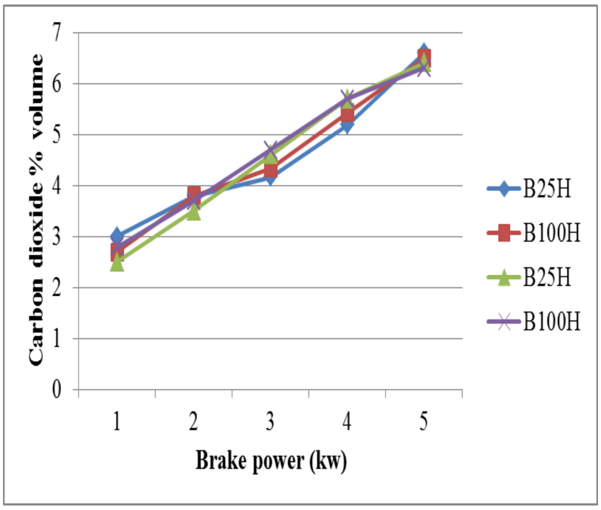

Fig.8. Variation of CO_2 Emission with brake power

From Figure 7 to 11 shows the correlation between exhaust emissions (NOX, CO2, HC, CO, smoke density) and brake power for B25, B100 (with and without piston modification). These results from graphs shows the engine run with modified piston reduce the emissions compare normal piston with papaya seed oil as alternative fuel.

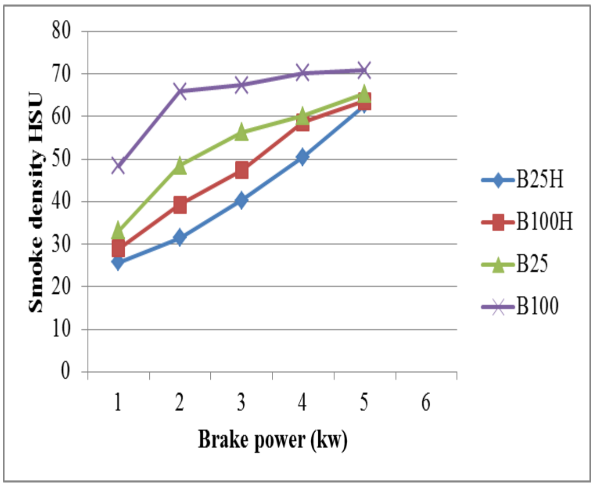

Fig.9. Variation of smoke density with brake power

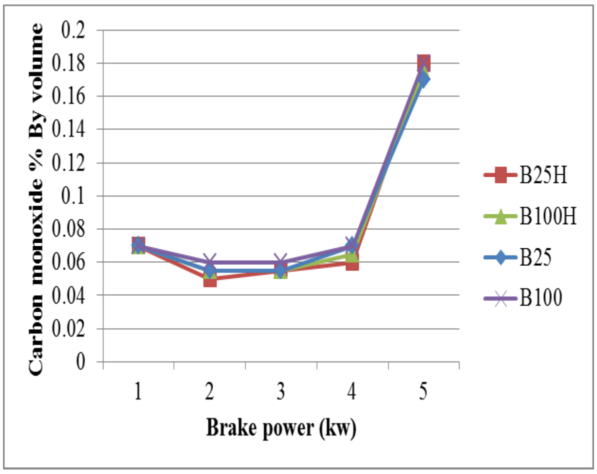

Fig.10. Variation of CO Emission with brake power

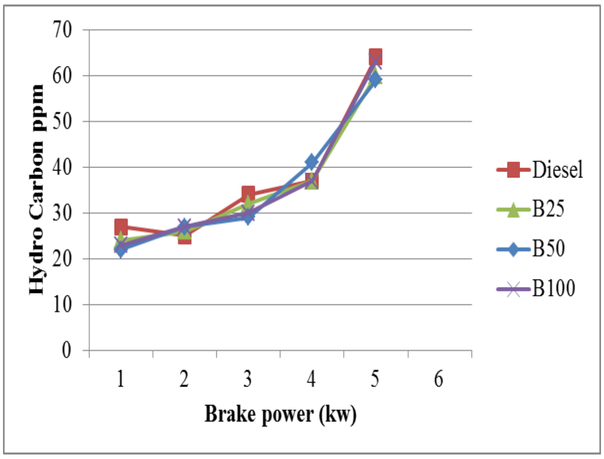

Fig.11. Variation of HC Emission with brake power

IV.CONCLUSION

This paper explained about the performance and emission parameters using both diesel and papaya seed oil for modified piston. The engine with modified piston give better efficiency with papaya seed oil as alternative fuel. Performance efficiency of diesel engine fuelled by papaya seed oil is low compared with diesel in normal pistons and exhaust emissions also higher then diesel for papaya seed oil. Engine with modified piston increases the combustion efficiency due to swirl and turbulence creation inside combustion chamber .High combustion efficiency reduces the exhaust emissions.

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