International Journal of Research
Available at https://edupediapublications.org/journals

e-ISSN: 2348-6848
p-ISSN: 2348-795X
Volume 04 Issue-17
December 2017

The Performance and Analysis of a Diesel Engine by Using Bio-Diesel as Fuel and by Using Five Different Types of Pistons.

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***Abstract**: as a renewable, sustainable and alternative fuel for compression ignition engine, biodiesel instead of diesel has been increasingly fuelled to study its effects on engine performances and emissions in the recent 15 years. Biodiesel, derived from the transesterification of vegetable oils or animal fats, is composed of saturated and unsaturated long-chain fatty acid alkyl esters. The aim of the present paper is to do a comprehensive review of engine performance and emissions using biodiesel from different feedstock and to compare that with the diesel. From the review it is found that the use of biodiesel leads to the substantial reduction in HC and CO emissions accompanying with the imperceptible power loss, the increase in fuel consumption and the increase in* NO_x *emission on conventional diesel engine with no or fewer modification. However, many further researches about modification on engine, low temperature performance of engine, new instrumentation and methodology for measurements, etc., are recommended while using biodiesel as a substitute of diesel. In this project we are going to perform and analyze the mechanical efficiency brake thermal efficiency and volumetric efficiency and also reducing the pollutant contents like CO,* NO_x, CO_2 *and Chlorofluorocarbons'. By using sunflower oil as bio-diesel and also by using five different types of piston.*

I.INTRODUCTION

Now a day for any country petroleum based fuels have become important for its development. Products derived from crude oil continue to be the major and critical sources of energy for transportation sector all over the world. However, petroleum reserves are non renewable and are depleting day by day. Fuel consumption was projected to increase from 83 million barrels per day in 2004 to 118 million barrels per day by 2030. Two-thirds of the increment was projected for use in the transportation sector. Over the next 20 years, demand for petroleum and other liquid fuels is expected to increase more rapidly in the transportation sector than in any of the other end-use sectors. India's transportation energy use is projected to grow at an average rate of 3.3 percent per year compared with the world average of 1.7 percent per year. In India Diesel is mainly consumed in the transport, industrial and agricultural sectors. The cost of transportation influences the economics of all other daily need commodities that reach common people. For a growth of any country, it is strongly depends on transportation and power generation. Thus, for India it has become a major challenge in facing fuel crisis. Hence there is a need to have a long-term plan for development of renewable energy sources. Therefore it has become important priority in evaluating use of available land and manpower resources. It is important to identify suitable alternate fuel as substitution in place of diesel fuel. Any alternate fuel which finds suitable as substitute to diesel is comparatively inferior to diesel in both performance and combustion characteristics. Hence there is a need to improve and optimize the fuel properties and operating parameters respectively.Liquid fuels are more suitable fuels because of their high energy content per unit volume, ease of handling and distribution. The most suitable and available alternative fuels are alcohols and vegetable oils, where they are derived from renewable biomass source. Due to low cetane number alcohols are not suitable for direct use in diesel engines. Majority of the vegetable oils having properties closer to diesel fuel prompted to use directly in existing C.I engines. Vegetable oils typically have large molecules, with carbon, hydrogen and oxygen being present. They have a chemical structure similar to diesel fuel, but differ in the type of bond structure leads to higher molecular mass and viscosity. The viscosity increases the work necessary to spray vegetable oils in diesel engines and also makes it difficult to break them up into fine droplets. The carbon residue of vegetable oils is higher than that of diesel. This leads to a smoky exhaust in a diesel engine. The presence of oxygen in vegetable oils raises the stoichiometric fuel air ratio. Contrary to fossil fuels, vegetable oils are free from sulfur. The heating value of vegetable oils is approximately 90% of that of diesel fuel. A serious objection to the use of vegetable oils as fuels in C.I engine is their high cost. At present, the market prices of vegetable oils are higher than that of diesel. However, it is anticipated that in due course the cost will be reduced as a result of developments in agricultural methods and oil extraction techniques. Even now it is possible in certain localities to purchase a number of non-edible oils at fairly low prices. Due to the wide variations in climate, soil conditions and competing uses of land, different nations have to consider different vegetable oils as potential fuels.A number of vegetable oils have been tested all over the world to evaluate their performance in diesel engines. Some of them like rapeseed oil, neem oil, palm oil, karanji oil, coconut oil, cottonseed oil, etc. have been found viable.The main problems associated with the use of vegetable oils were high viscosity and poor volatility. In this connection different methods can be adopted to overcome these problems in using vegetable oils effectively. Some of them are preheating, transesterification with alcohols, blending with diesel/alcohol, use of semi adiabatic engine components, combustion chamber design, dual fuelling with gaseous and liquid fuels and use of additives. The previous project were used different types of vegetable oils. Among them many are edible oils. Use of edible vegetable oils will in turn create shortage of food for consumption. Hence in this work an attempt is made in search new kinds of non-edible vegetable oils for diesel engines. In view of the dilemma of the energy crisis, the new oils like safflower oil are identified. The experiments are conducted after converting these vegetable oils into biodiesels through esterification. The physical and chemical properties these estrified vegetable oils are determined before testing the Performance, emission and combustion characteristics. To enhance some of these characteristics of base engine and five different configurations of piston are designed by considering experience of previous project. The problems associated with vegetable oils like high viscosity, filter clogging, flame propagation has led to more alternative by researchers. There is limited reserve of the fossil fuels and the world has already faced the energy crisis of seventies concerning uncertainties in their supply. Fossil fuels are currently the dominant global source of CO2 emissions and their combustion is stronger threat to clean environment. Increasing industrialization, growing energy demand, limited reserve of fossil fuels and increasing environmental pollution have jointly necessitating in exploring some alternative to conventional liquid fuels. Internal combustion engines particularly of the compression ignition (CI) type are playing a major role in transportation, industrial power generation and in the agricultural sector. There is a need to search in using alternative fuels. These fuels are to be renewable and emit low levels of gaseous and particulate pollutants in internal combustion engines. In the case of agricultural applications, fuels that can be produced in rural areas in a decentralized manner, near the consumption points will be favored. The permissible emission levels can also be different in rural areas as compared to urban areas on account of the large differences in the number density of engines. Fuels like vegetable oils, biodiesel (transesterified vegetable oils-methyl esters of vegetable oils), alcohols, natural gas, biogas, hydrogen, liquefied petroleum gas (LPG), etc. are being investigated by researchers for engine applications. Among the possible options of the liquid fuels, vegetable oils have been considered as appropriate alternative due to prevalent fuel properties [147]. In view of the potential properties large number of investigations has been carried out internationally in the area of vegetable oils as fuel. Some of the vegetable oils from the farm and forest origin have been identified. The most predominantly Sunflower, Soybean, Jatropha Curcas, Cottonseed, Canola and Peanut oil have been reported as an appropriate substitute of petroleum based fuels [85]. The vegetable oils can be used in diesel engines by various techniques such as fuel modification by transesterification, diesel-vegetable blends, vegetable oil heating, etc. This has stimulated recent interest in alternative sources for petroleum based fuels. Generally vegetable oils were proven to be high viscosity fuel than diesel. As the heating temperature of fuel increased the viscosity of fuel will be reduced. In order to reduce the viscosity of the vegetable oils, three methods were found to be effective - transesterification, mixing with lighter oil and heating [27].For decades world energy consumption has been increased, there was a period like oil crisis in the years1973 and 1979. According to “BP statistical review of world energy 2005” energy consumption of the world in the year 2004 was 10224 million, 4.3% growth compared to 2003 year. The point at which maximum oil production will takes place is known as Hubert peak. Reaching Hubert point indicates that in future production will be declined with increase in demand.

II.EXPERIMENTAL PROCEDURE

All experiments are carried out at the rated speed of 1500 rev/min at different load conditions. Readings are always taken after the engine attained stability of operation. Exhaust gas analyzers are switched on and allowed to stabilize before measurements. Instruments are periodically calibrated. Initially, experiments are conducted using diesel, methyl esters of mutton tallow, palm stearn, safflower with different pistons of combustion geometry at the rated speed under variable load conditions. Load, speed, air flow rate, fuel flow rate, exhaust gas temperature, exhaust emissions of unburnt hydrocarbon ,carbon monoxide, carbon dioxide, and oxides of nitrogen are observed. Cylinder pressure and top dead center (TDC) position signals are recorded for processing the data to obtain combustion parameters. In the second phase, based on the optimum combustion geometry, the performance, emission and combustion parameters of engine using methyl esters of mutton tallow, palm stearn, safflower as fuels are analyzed and compared with neat diesel operation.In the third phase, methyl esters of mutton tallow, palm stearn, safflower as fuels are used in the LHR developed engine Performance, emissions and combustion parameters are analyzed and compared with neat diesel and methyl esters of mutton tallow, palm stearn, safflower as fuels operation. In this work five different piston configurations are developed.

Fig.1 Experimental set up


Fig. 2. Schematic layout of the test setup


a b

Fig.3 (a) Hemi Spherical Open Combustion Chamb
Fig. 3 (b) Re-entrant Open Combustion Chamber

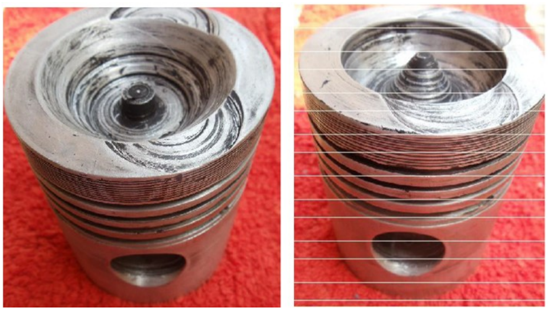

c d

Fig.3 (c) Double Wedge Shallow Open Combustion Chamber
Fig.3 (d) Toroidal Open Combustion Chamber


Fig 3. (e) Shallow Depth Open Combustion Chamber

III.METHODOLOGY

Study on Diesel Oil with Different Configurations of Piston Geometry

During experimentation five different configurations of piston geometry are used on the test engine with three kinds esterified vegetable oils with an objective of to find the performance, emissions and combustion parammetres. After a thorough review of literature, these different configurations and other alternative fuels are choosen. The hemispherical bowl cavity in the piston head is chosen as a base engine. Then different configurations of piston geometry are used to conduct experiments using the diesel fuel and three different esterified vegitable oils separately. The properties of esterified oils are computed and found to be almost same as that of diesel and hence they used in diesel engine directly with no modifications. The five different configurations of piston geometry and three esterified oils used in this work are given below with their notations.

Notation	Type
Piston-1	Toroidal
Piston-2	Shallow depth
Piston-3	Hemispherical
Piston-4	Re-entrant
Piston-5	Double wedge shallow

Notation-Oil Type D : Diesel
SME: Safflower methyl ester

A Series of exhaustive investigations are carried out on all these different configurations of piston geometry using diesel in this chapter. And the processed results are presented in the form of graphs. A set of experiments are conducted separately with diesel fuel with respective individual configurations of piston geometry. The analyses of experimental results are presented in this chapter.

Results Pertaining To Diesel with Different Configurations Of

Piston Geometry

In the present work experiments are conducted at different loads to study the performance, emission and combustion characteristics using diesel fuel alone. In this investigation are determined by changing pistons of different configurations.

Brake Thermal Efficiency

The variation of break thermal efficiency with break power output is shown in Fig. 3.1.1 for different configurations of pistons using diesel as fuel. It is observed that for low & medium loads the break thermal efficiency has increased for all configurations. However for the piston-4 the break thermal efficiency is also increased for higher loads. This is due to air moment within the cylinder for its swirl motion. The break thermal efficiency obtained for piston-2 is less compared to other pistons.

Indicated Thermal Efficiency

The trends obtained as same as that of break thermal efficiency. However it is shown that at maximum loads indicated thermal efficiency obtained for individual pistons is constant. The thrust created by combustion gases with respect to cross section irregularities may be the reason for variation at low and high operations. The indicated thermal efficiency obtained with configuration of piston-4 is maximum compared to other pistons.

Mechanical Efficiency

The Fig. 3.1.3 shows the comparison between break power and mechanical efficiency. The mechanical efficiency is gradually increased for medium and low load operations, whereas at closer to rated load the mechanical efficiency is almost constant with respect to individual pistons. However the piston-4 the mechanical efficiency is low compared to other pistons. This may be due to improper flame propagation with respect to air fuel mixture moment in the cylinder.

Specific Fuel Consumption

The Fig. 3.1.4 is drawn between the break power vs specific fuel consumption for diesel fuel. It is observed that specific fuel consumption is high at low load operations for all configurations of piston geometry. The specific fuel consumption is less with piston-5 compared to other pistons at closure to rated load operation. This is due to optimum mixing of air fuel mixture and the heat release rate is maximum.

Volumetric Efficiency

The graph is drawn for comparison of volumetric efficiency and break power is shown in Fig. 3.1.5. For this basic engine the volumetric efficiency is gradually in decreasing mode from zero loads to rated load operation. The volumetric efficiency is varying from about 93% to 89% for all configurations of pistons. This is due to exhaust gas operating temperature at higher loads compared to low load operations. The volumetric efficiency is almost constant for base engine operating with piston-4, because of its added advantage of its configuration which is responsible for its air moment with in the cylinder.

Exhaust Gas Temperature

the variation of exhaust gas temperature with brake power for all configurations of piston geometry using diesel as fuel. It is observed that the exhaust gas temperature increases as the engine output increases. At medium load operation the exhaust gas temperature is almost same for configurations of piston geometry except with piston-4. At closer to rated load operation for piston-5 & piston-1 the exhaust gas temperature obtained is more or less same compared to conventional piston. However gas temperature and gas velocity vary significantly across the combustion chamber. This is due to heat flux distribution over the combustion chamber walls.

Carbon Monoxide

The graph is drawn between break power and carbon monoxide as shown in Fig. 3.1.7. It is learnt that there is no much variation of carbon monoxide emissions levels at medium load operation for all configurations of pistons geometry. However at closer to rated load the carbon monoxide emission levels are high for piston-1 and piston-2 compared to other pistons. This is due to inadequate air moment, where relative velocity between the fuel droplets and air effected.

Hydro Carbon

The variation of brake power with hydro carbon emissions are shown in Fig. 3.1.8. At low and medium load operations the hydro carbon emissions levels are constant with respect to individual configurations of piston geometry. The HC emission level is high for piston-2 compared to piston-5 and is about 5 times to that of piston-2. This may be reason of disturbance in combustion spay cone.

Oxygen Levels

The Fig. 3.1.9 shows the variation of oxygen levels with brake power for all configurations of piston geometry. In this oxygen levels are observed to be in decreasing trend from low load operation to rated load operation. However the oxygen levels are low for piston1 compared to piston-4. This is taken place due to improper utilizing of air and fuel vapour in the cylinder.

Carbon Dioxide

The variations of carbon dioxide emission levels with brake power are shown in Fig. 3.1.10 the carbon dioxide emissions are gradually increased linearly with brake power for all configurations of piston geometry. The carbon dioxide emission levels are high for the piston1 compared to other pistons but the carbon dioxide emission levels are less for piston-4 and piston-5. This occurred due to concentration levels of oxygen in the mixture after dilution.

NO_X Emissions

The graph as shown in Fig. 3.1.11 gives the comparision between nitrogen oxides levels with brake power. The nitrogen oxides emissions are high at closer to rated load operations with all configurations of piston geometry. The nitrogen oxides emission levels are high for the piston-3 compared to other pistons geometry. This is due to increase in overall equivalence ratio and also due to the non uniform fuel distribution.

Cylinder Pressure

The Fig. 3.1.12 to 3.1.16 are pressure plots drawn for variation of cylinder pressure with crank angle for all configurations of piston geometry by variation of load from zero load to closure to rated load operation. The Fig. 3.1.17 is also shown, which indicates the single plot drawn for various load operations. It is observed that as the break power increases the cylinder pressure is also increased for all configurations of piston geometry. The cylinder pressure is minimum for the piston-1 for all loads of operation using diesel fuel. This is due the phenomena of formulation in combustion mixture. The experiments are carried out at constant speed, hence the effect of engine speed ignition delay are small. However the swirl ratio is changed due to configuration of piston geometry. It is observed that there is variation in cylinder pressures with different configurations of the piston geometry.

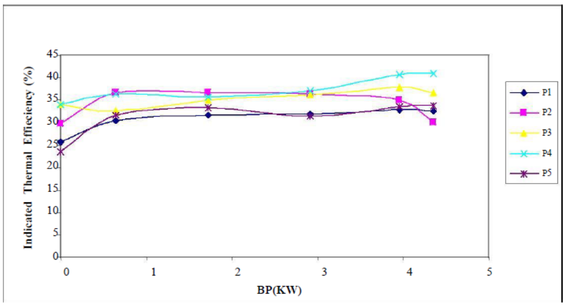


Fig.3.1.1 Break power vs break thermal efficiency

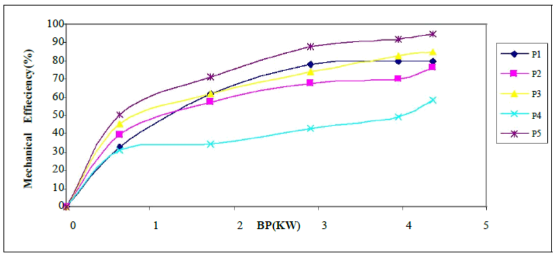


Fig.3.1.2 Break power vs indicated thermal efficiency

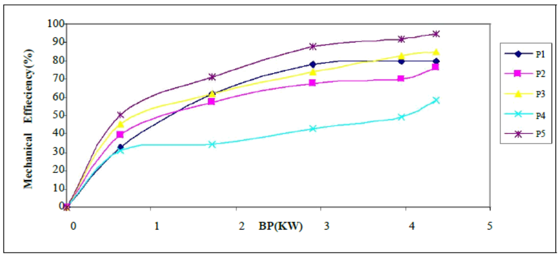


Fig.3.1.3 Break power vs mechanical efficiency

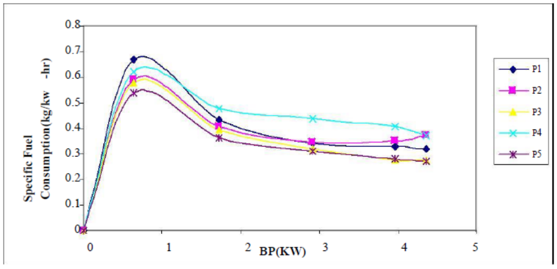


Fig.3.1.4 Break power vs specific fuel consumption

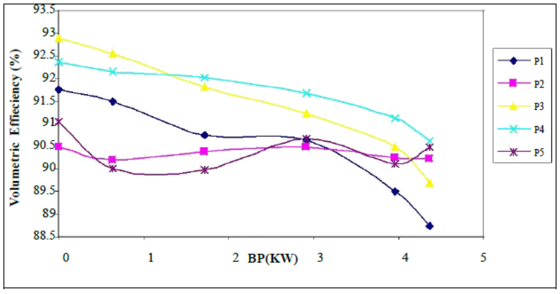


Fig.3.1.5 Break power vs volumetric efficiency

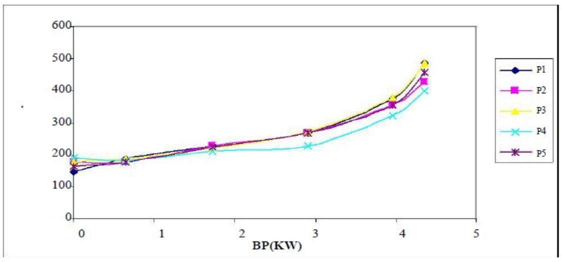


Fig.3.1.6 Break power vs exhaust gas temperature

Experimental Study on Esterified Safflower Methyl Ester Oil with Different Configurations of Pistons

GEOMETRY

Safflower seed technically known as ACHENE consists of fibrous hull protects kernel. Generally safflower seeds are in cream to white color and the oil is pale yellow colour. Safflower oil exhibits the highest level Linolenic fatty acid. Safflower oil has been examined as a possible feedstock of bio diesel. The main problems attributed with its properties can be overcome by transisterification of safflower oil with short chain alcohols to corresponding ethers. It is one of the known as the most promising solutions using safflower methyl ester as a suitable alternative fuel to diesel fuel. In safflower methyl ester the significant improvement in both physical and chemical properties has been observed. in this chapter the investigations are carried out on CI diesel engine using safflower methyl ester as a fuel. The exhaustive experiments have been conducted with five different configurations of piston geometry viz.piston-1, piston-2, piston-3, piston-4 and piston-5.

Results Pertaining To Safflower Methyl Ester (SME) With Different Configurations Of Piston Geometry.

Experiments are carried out to examine the suitability with different configurations of piston geometry using SME as fuel. In this process performance, emission and combustion charecteristics are determined and evaluated.

Break Thermal Efficiency

The variation of Break thermal efficiency with engine output is shown in Fig. 4.1.1 for different pistons. The break thermal efficiency is increased linearly as engine output increases. The break thermal efficiency is observed to be at low load operation. The break thermal efficiency obtained is less in case of piston-2 compared to other pistons. This is due to variation in rate of heat release and mean gas temperature.

Indicated Thermal Efficiency

Fig. 4.1.2 shows the comparison between break power and indicated thermal efficiency. The indicated thermal efficiency is increased from zero loads to closer to rated load operation. The indicated thermal efficiency obtained is maximum for the configurations of piston-4 and the efficiency obtained is about 35.79%. This is occurred because of proper mixing of air and fuel vapour mixture in the cylinder. Hence rate of combustion might be the reason for maximum efficiency.

Mechanical Efficiency

The graph is drawn between brake power and mechanical efficiency is shown in Fig. 4.1.3 the trends of graphs obtained for all the configurations of pistons is same as that of break thermal efficiency. The mechanical efficiency obtained is low in case of piston-2 and is about 71.39%. The mechanical efficiency obtained for piston-2 is very much less compared to piston-5 and is about 20.38%. This is due to flame propagation speed with respect to piston moment variation in the cylinder.

Specific Fuel Consumption

The variation of specific fuel consumption with break power is shown in Fig. 4.1.4. The specific fuel consumption is less at closer to rated load, for the piston-4 and piston-5. The specific fuel consumption is maximum for the piston-2. This is because of increase in combustion gases and their temperature. It is also observed that specific fuel consumption is very high at low load operations with respect to any individual configuration of piston.

Volumetric Efficiency

The graph is plotted between volumetric efficiency and break power for all configurations of piston geometry using SME as fuel and is shown in Fig. 4.1.5. It is observed that the volumetric efficiency is decreases as the engine output increases. The volumetric efficiency obtained is low for the piston-3. This is due to mixture temperature influencing the heat transfer rate. The volumetric efficiency obtained is high for piston-4 at closer to rated load operation. This is due to variation in variables of quasi steady in nature of CI engine concepts.

Exhaust Gas Temperatures

The comparison between exhaust gas temperatures with engine output is shown in Fig. 4.1.6. It is observed that a closer to rated load, the exhaust gas temperature increases more compared to low and medium load operations. In this also the exhaust gas temperature increases from no load to rated load operation. The exhaust gas temperature obtained is minimum with piston-4 and is maximum for piston-1. This is due to minimum heat loss during the compression because of lower surface area to volume ratio.

Carbon Monoxide

The Fig. 4.1.7 shows the variation of carbon monoxide emission levels with break power for all configurations of piston geometry. It is observed that the carbon monoxide emission levels are increasing as the engine output increases after the medium load operation. However it is also observed that at no load condition the carbon monoxide emissions levels are high compared to medium load operation for all configurations five of piston geometry.

Hydrocarbon

The variation of Hydrocarbon emission levels with break power is shown in Fig. 4.1.8. It is learnt that the hydro carbon levels are increased as the engine output increases. The hydro carbon emission levels obtained for piston-5 and piston-3 are less compared to other pistons. This is due to disturbance in combustion spray phenomena.

Oxygen Levels

The graph is plotted between break power and oxygen levels for configuration of five pistons is shown in Fig. 4.1.9. It is observed that oxygen levels are decreased as break power increases. For the piston-3 oxygen levels obtained are greater than piston-1. The combustion gas temperature variation with pressure in the cylinder variation leads to increase in oxygen levels.

Carbon Dioxide

The comparison between carbon dioxide and engine output is shown in Fig. 4.1.10. It is observed that carbon dioxide emission levels are increased as engine output increases. The carbon dioxide emissions are less with piston-4 compared to other pistons and are about 6.27 where as carbon dioxide emissions are more with piston-1 compared to other pistons. This variation is due to presence of oxygen levels in the mixture of combusted gasses. Particularly, when in a flue gas contains free oxygen as well as combustibles like carbon monoxide owing to inefficient combustion.

NO_X Emissions

The variation of oxides of nitrogen with brake power is shown in Fig. 4.1.11 for all configurations of piston geometry. The oxides of nitrogen emission levels are less and almost same at low load operations. These levels have been increased gradually w.r.t. engine output. At closer to rated load, it is observed the oxides of nitrogen levels obtained are maximum with piston-5. The oxides of nitrogen emissions are less with piston-4. This is due to increase in out of a engine displacement leads to decrease the inlet air density.

Cylinder Pressure

The comparison of in cylinder pressure and crank angle for all configuration of piston at different loads of operation are shown in Fig. 4.1.12 to 4.1.17. Whereas the Fig. 4.1.18 is integrated plot drawn for all configurations of piston and the loads of operation. It is learnt that the cylinder pressure is high for all pistons compared to other pistons and is also increasing as engine output increases. An increase of the cylinder pressure because the ignition took place under the condition of decreasing pressure caused by the downward movement of the piston. The cylinder pressure obtained with piston-4 is max. of 95.48 bar at closer to rated load operation. It is known that the injection timing corresponding to distance from the nozzle to cavity wall piston are varied due to its configuration of combustion geometry.

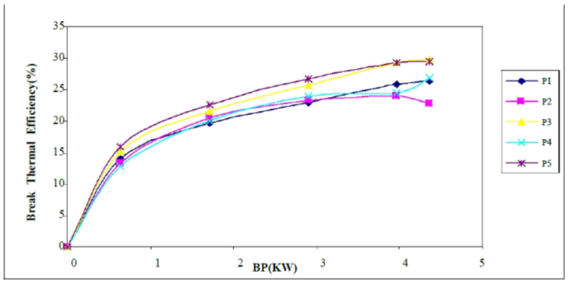


Fig. 4.1.1 Break power vs break thermal efficiency

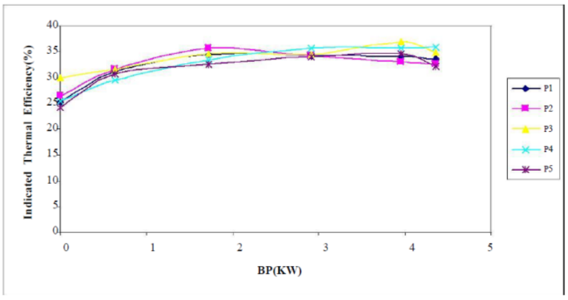


Fig. 4.1.2 Break power vs indicated thermal efficiency

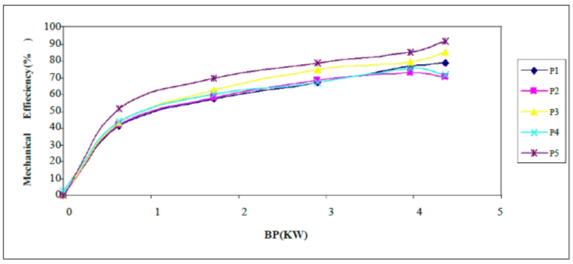


Fig. 4.1.3 Break power vs mechanical efficiency

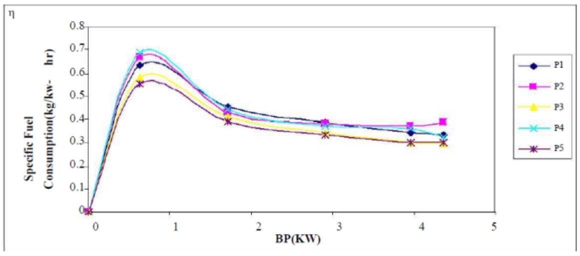


Fig. 4.1.4 Break power vs specific fuel consumption

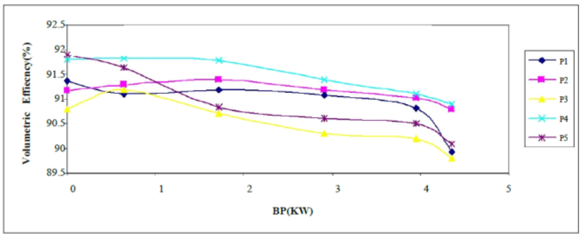


Fig. 4.1.5 Break power vs volumetric efficiency

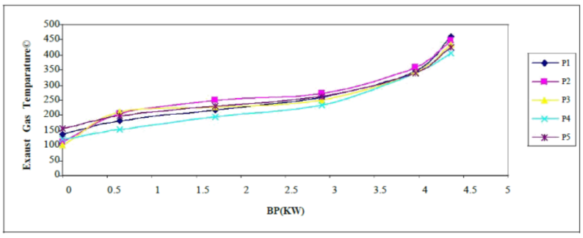
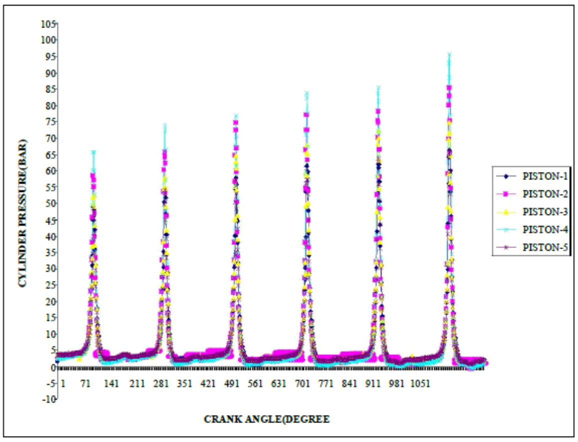


Fig. 4.1.6 Break power vs exhaust gas temperature



Conclusion

Experiments are carried out to examine the suitability with different configurations of piston geometry using diesel as fuel. In this process performance, emission and combustion characteristics are determined and evaluated. However the piston-4 the mechanical efficiency is low compared to other pistons. the volumetric efficiency is gradually in decreasing mode from zero loads to rated load operation. Experiments are carried out to examine the suitability with different configurations of piston geometry using SME as fuel. In this process performance, emission and combustion characteristics are determined and evaluated. The break thermal efficiency obtained is less in case of piston-2 compared to other pistons. The mechanical efficiency obtained for piston-2 is very much less compared to piston-5 and is about 20.38%. The volumetric efficiency obtained is low for the piston-3. This is due to mixture temperature influencing the heat transfer rate. The volumetric efficiency obtained is high for piston-4 at closer to rated load operation. The hydro carbon emission levels obtained for piston-5 and piston-3 are less compared to other pistons. The combustion gas temperature variation with pressure in the cylinder variation leads to increase in oxygen levels. The oxides of nitrogen emissions are less with piston-4.

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