Experimental and Investigation of Performance Test on Diesel Engine by Changing Triangular Shape Piston Crown

S. Mathivanan , A. Hakkim Zikhath, J. Mohamed Azarudeen, M. Pasupathi
Dept. of Mechanical Engineering, Hindusthan Institute of Technology - 641032, Tamilnadu, India

***Abstract*:- The cylinder air motion in internal combustion engines is one of the most important factors controlling the combustion process. It governs the fuel-air mixing and burning rates in diesel engines. In this present work the experimental investigation of air swirl in the cylinder upon the performance and emission of a single cylinder diesel direct injection is presented. This intensification of the swirl is done by the cutting grooves on the crown of the piston; by different configurations of Triangular shape and normal pistons are investigating performance and emission characteristics. Also performance is predicted to compare the previous model with new triangular piston crown model. Experiments are carried out on a diesel engine using Modified different configuration piston which is a four stroke single cylinder air cooled and constant speed engine. Performance parameters such as brake power, specific fuel consumption and Thermal efficiency are calculated based on experimental analysis of the engine. Emissions such as carbon monoxide, carbon dioxide and un burnt hydrocarbons are measured.**

Key words: Triangular Piston, Brake Power, Specific Fuel Consumption and Thermal Efficiency

INTRODUCTION

In an engine, its purpose is to transfer force from expanding gas in the cylinder to the crankshaft via a piston rod and/or connecting rod. As an important part in an engine, piston endures the cyclic gas pressure and the inertial forces at work, and this working condition may cause the fatigue damage of piston, such as piston side wear, piston head/crown cracks and so on. The investigations indicate that the greatest stress appears on the upper end of the piston and stress concentration is one of the mainly reason for fatigue failure.

On the other hand piston overheating seizure can only occur when something burns or scrapes away the oil film that exists between the piston and the cylinder wall. Understanding this, it’s not hard to see why oils with exceptionally high film strengths are very desirable. Thermal analysis is a branch of materials science where the properties of materials are studied as they change with temperature.

TYPES OF ENGINES

- In line
- Horizontally opposed
- Radial
- V head

HEAT ENGINES

Any type of engine or machine which derives heat energy from the combustion of fuel or any other source and coverts this energy into mechanical work is termed as a heat engine. Heat engines may be classified as:

- External Combustion Engines
- Internal Combustion Engines

External combustion engines (E.C. engines)

In this case, combustion of fuel takes place outside of the cylinder as in case of steam engines where the heat of combustion is employed to generate steam which is used to move a piston in a cylinder.

Internal Combustion Engines (I.C. Engines)

In this case, combustion of the fuel with oxygen of the air occurs within the cylinder of the engine. The internal combustion engines group includes engines employing mixtures of combustible gases and air, known as gas engines, those using lighter liquid fuel or spirit known as petrol engines and those using heavier liquid fuels, known as oil compression or diesel engines. Even though internal combustion engines look quite simple, they are highly complex machines. There are hundreds of components which have to perform their functions satisfactorily to produce output power. There are two types of engines.

- Spark ignition engine (S.I engine)
- Compression ignition engine (C.I engine)

MATERIAL SELECTION

PISTON MATERIAL AND SELECTION

Piston head is exposed to heavy pressure when the engine is operating under load. The Expanding gases of combustion apply forces on the piston head. At the same time, the flame front crosses the piston head also exert forces with higher magnitude. The force differentials caused by the expanding combustion gases and the flame front crossing exert forces the piston head can reach two to three times this force. Due to the reciprocating movement of the piston from To Dead Centre (TDC) to Bottom Dead Centre (BDC) and high temperature fluctuations during operation, this can be called as thermal cycle loading.

The temperature of the initial flame front during combustion exceeds 2200oC. When the piston is subjected to this temperature for a short span of time, the thermal stress and expansion of the piston head are to be considered as serious factors. In addition to these forces and thermal fluctuations incurred by the piston, the piston changes its direction inside the cylinder bore. Design, 4 material selection and manufacturing of piston are to be considered to satisfy these operating conditions. Aluminum silicon alloy is used as a piston material.

- Reduces solidification and hot cracking
- Increases fluidity
- Improves corrosion resistance

Typical functional variation of increase in silicon content Al-Si is presented. From the figure it can be understood that 12% of silicon improves the durability and strength. If the percentage of silicon exceeds 13% then the alloy exhibits extreme difficulties in machining.

PISTON CROWN

Piston crown forms the lower part of the combustion chamber in a marine diesel engine. It seals the cylinder and transmits the gas pressure to the connecting rod. Below considerations should be taken designing a piston. As per the engine requirement, different types of crowns are used. The Piston comprises of two pieces, the crown and the skirt. The crown is subject to the high temperatures in the combustion space and the surface is liable to be eroded/burnt away. For this reason, the material from which the crown is made must be able to maintain its strength and resist corrosion at high temperatures.

Types of Piston Crown

- Flat head
- Concave head
- **Convex head**

PISTON CROWN MAINTENANCE

The corrosion was in the form of etching and grooving that created a pitted surface with small local cavities. During the casualty investigation, the preventative maintenance schedule and maintenance procedures for the pistons were discussed with the Chief Engineer. The piston overhaul procedures appeared to be limited to visual checks of all exposed surfaces A dye checking procedure is not used unless abnormalities are seen first. Furthermore, the piston crowns were not removed for inspection during the piston overhaul periods. Measures have been introduced by Mitsubishi to improve the performance of piston crowns. This measure will reduce thermal corrosion and wear on the flame side of crowns. However, if carbon is allowed to build up and adhere to the cooling surface side of the piston crown, the build-up will decrease the cooling effect of the cooling oil and may result in failure of the crow**.**

SELECTION OF PISTON CROWN NORMAL PISTON

A piston is a component of reciprocating engines, reciprocating pumps, gas compressors and pneumatic cylinders, among other similar mechanisms. It is the moving component that is contained by a cylinder and is made gas-tight by piston rings. In an engine, its purpose is to transfer force from expanding gas in the cylinder to the crankshaft via a piston rod and/or connecting rod. In a pump, the function is reversed and force is transferred from the crankshaft to the piston for the purpose of compressing or ejecting the fluid in the cylinder. In some engines, the piston also acts as a valve by covering and uncovering ports in the cylinder.

Fig1.Normal Piston

DIMENTION OF THE NORMAL PISTON

Diameter of the piston - 80mm
Crown diameter of the piston - 50mm Area of the crown - 981.74mm
Length of the piston - 105mm

STIR CASTING

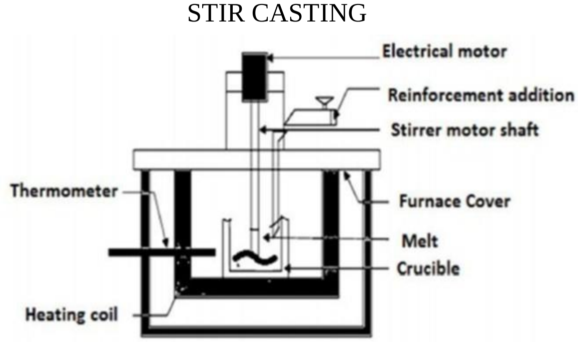

Fig 2.Stir Casting

Stir casting set-up mainly consists a furnace and a stirring assembly shown in figure In general, the solidification synthesis of metal matrix composites involves a melt of selected matrix material followed by the introduction of a reinforcement material into the melt, obtaining a suitable dispersion. The next step is the solidification of the melt containing suspended dispersions under selected condition to obtain the desired distribution of dispersed phase in the casting. In order to achieve the optimum properties of metal matrix composites, the distribution of reinforcement material in the matrix alloy must be uniform and the wettability or bonding between these substances should be optimized. The porosity levels needs to be minimized. Steps involved for fabrication of metal matrix composites (Al-6061/SiC) are as follows:

1. Firstly, silicon carbide particles are preheated in the induction resistance furnace at 11000 c for 1 to 3 hours to make their surfaces oxidized.
2. Aluminum alloy (circular rod) is heated to the temperature of 950 (above the liquids temperature of alloy) for 30 minutes.
3. The furnace temperature was first raised above the liquids to melt the alloy scraps completely and was then cooled down just below the liquids to keep the slurry in a semi-solid state. At this stage the preheated Sic particles were added and mixed manually.
4. After sufficient manual mixing is done, the composite slurry is reheated

MACHINING & WORKING PROCESS

VERTICAL MILLING CENTER

Milling is the machining process of using rotary cutters to remove material from a work piece advancing in a direction at an angle with the axis of the tool. It covers a wide variety of different operations and machines, on scales from small individual parts to large, heavy-duty gang milling operations. It is one of the most commonly used processes in industry and machine shops today for machining parts to precise sizes and shapes.

The milling process removes material by performing many separate, small cuts. This is accomplished by using a cutter with many teeth, spinning the cutter at high speed, or advancing the material through the cutter slowly; most often it is some combination of these three approaches. The speed at which the piece advances through the cutter is called feed rate, or just feed; it is most often measured in length of material per full revolution of the cutter.

Fig3.Vertical milling machine

DIMENTIONAL OF THE TRIANGULAR PISTON

Diameter of the piston	-	80mm
Triangular length	-	40mm
Depth	-	15mm
Length of the piston	-	105mm
Area of the Triangle	-	800mm

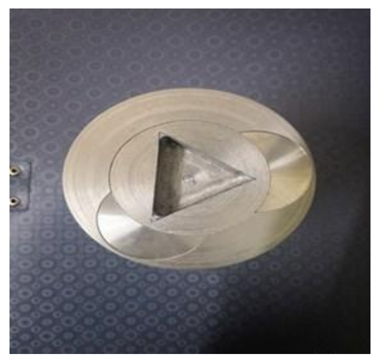

Fig 4 .Triangular piston

WORKING ON PISTON CROWN

Engine pistons are one of the most complex components of marine industries. The engine can be called the heart of a ship and the piston may be considered the most important part of an engine. There are lots of research works proposing, for engine pistons. The purpose of this project is to performance and characteristics of a piston crown for a large two-stroke diesel marine engine. They are used in railroad, marine or stationary services. Our aim to achieve, the optimal shape of the piston crown to obtain maximum performance. The crown takes a very important part in the whole process. It is the upper most part of piston that supports most of the loads and heat. Now the main reason behind these shapes for better combustion of fuel. When the chemical reaction takes place at the time of combustion a flame front will produce which will affect the knocking factor.

The other reason is when fuel comes inside the cylinder due to low pressure; It'll have some kinetic energy. So the triangular type shape onto the piston will absorb most of fuel's kinetic energy and try to settle down the situation. Also the shape helps in reducing the overall weight of the piston because some amount material has been reduced and reducing weight in automobiles is always advantageous. The main reason behind different shapes of piston heads is to allow proper distribution of the fuel-air mixture around the cylinder through turbulence and a phenomenon known as swirl. It is important to facilitate proper distribution of fuel-air mixture to prevent pre- ignition and knocking.

EXPERIMENTAL TESTING PERFORMANCE TESTING PROCEDURE

Before starting the engine, the fuel injector is separated from the fuel system. it is clamped on the fuel injection pressure tested and operates the tester pump. Observe the pressure reading from the dial. At which the injector starts spraying. In order to achieve the required pressure by adjusting the screw provided at the top of the injector .This procedure is repeated for obtaining the various required pressures. As first said, diesel alone is allowed to run the engine for about 30min, so that it gets warmed up and steady running conditions are attained. Before starting the engine, the lubricating oil level in the engine is checked and it is also ensured that all moving and rotating parts are lubricated.

The performance test was conducted in a single cylinder four stroke diesel engine. Complete experimental setup for determining the effects of Hanne oil blend on the performance and emission characteristics of compression ignition engine. It consists of a single cylinder four stroke water cooled direct injection diesel engine connected to an eddy current dynamometer. The fuel injection pressure can be varied from 200 bar and 220 bar. It is provided with temperature sensors for the measurement of water jacket, calorimeter water, and calorimeter exhaust gas inlet and outlet temperature. It is also provided with pressure sensors for the measurement of combustion gas pressure and fuel injection pressure. An encoder is fixed for crank angle record. The signals from these sensors are interfaced with a computer to an engine indicator to display and fuel injection pressure. The provision is also made for the measurement of volumetric fuel flow. The built in program in the system calculates indicated power, brake power, thermal efficiency, and volumetric efficiency. The procedure followed during the experiments is given below.

- ❖ The Experiments were carried out after installation of the engine
- ❖ The injection pressure is set at 180 bar for the entire test.
- ❖ Always the engine was started with no load condition
- ❖ The engine was started at no load condition and allowed to work for at least 10 minutes to stabilize.
- ❖ Initially engine was run with the pure diesel with the injection pressure of 180 bar.
- ❖ Engine was run from no load to full load condition with an increment of 20% of load in each run.
- ❖ Engine was then run on blends of Hanne oil and diesel mixed in 50% by volume represented by B50, respectively. Performance parameters and the emissions were noted.
- ❖ Whole set of experiments were repeated for fuel injection pressure 200 bar and 220 bar.
- ❖ After completion of test, the load on the engine was completely relieved and then the engine was stopped.
- ❖ The results were calculated as follows. The above experiment is repeated for various loads on the engine.
- ❖ The experimental procedure is similar as foresaid. While starting the engine, the fuel tank is filled in required fuel proportions up to its capacity. The engineis allowed to run for 30 min, for steady state conditions, before load is performed.

ENGINE SPECIFICATION

Make	Kirloskar Model AVI
Bore	80mm
Stroke	110mm
Rated Speed	1500rpm
Orifice Diameter	30mm
Fuel	Diesel
Density Of Diesel	0.83 Kg/m^3
Calorific Value Of Diesel	45350 KJ/Kg

PERFORMANCE OF DIESEL ENGINE

PERFORMANCE FOR CONVENTIONAL PISTON

1	10	5	5	49.05	1450	41	0.73	0.77	0.08	0.85	90.58
2	15	5	10	98.10	1405	32	0.93	1.49	0.17	1.66	89.75
3	20	5	15	147.15	1360	27	1.11	2.16	0.26	2.42	89.24

PERFORMANCE FOR TRIANGULAR SHAPE PISTON

1	**10**	**5**	**5**	**49.05**	**1420**	**48**	**0.62**	**0.75**	**0.11**	**0.86**	**87.22**
2	**15**	**5**	**10**	**98.10**	**1385**	**37**	**0.80**	**1.47**	**0.22**	**1.69**	**87.01**
3	**20**	**5**	**15**	**147.15**	**1305**	**32**	**0.93**	**2.07**	**0.31**	**2.38**	**86.90**

EMISSION TESTING

INDUS model PEA205 is a 5-gas analyzer meant for monitoring CO, CO2, HC, O2 and NO in automotive exhaust. It meets OIML Class-I specifications. CO, CO2 and HC (Hydrocarbon residue) are measured by NDIR technology and O2 and NO by electrochemical sensors. It is also supplied as a 4-gas analyzer which can be upgraded easily to 5-gas version by the addition of an NO sensor. It has many control features to prevent faulty measurements. A built-in dot matrix printer is provided to print out a hard copy of the results. It conforms to TYKA gasoline engine analytical testing center.

EMISSION TEST ON DIESEL ENGINE

Test / Fuel	C_O %	HC (PPM)	CO^2 %	O_2 %
Conventional shape	**0.05**	**13.20**	**1.42**	**18.66**
Triangular shape	**0.04**	**13.18**	**1.40**	**18.65**

APPLICATION

- Using automobile components
- Combustion engines.

CONCLUSION

Comparing performance testing using by different configurations of the cutting grooves on the crown of the piston triangular shaped and normal pistons was investigated. By analyzing the theoretical and practical results, the obtained performance test using brake power, specific fuel consumption and Thermal efficiency are calculated. So, far the taken crown shape obtained results, are within the standard and design is safe. Finally piston head changing the triangular indent piston crown is having better design using automobile application.

- The maximum increase in brake thermal efficiency for triangular indent piston compared to normal piston was found to be respectively.
- The reduction in the brake specific fuel consumption for triangular indent piston compared to normal piston was found to be respectively.
- The maximum increase in Volumetric efficiency for triangular indent piston compared to normal piston was found to be respectively

From the above conclusions, the triangular indent piston configuration can be suggested on diesel engine compared with the other piston configurations.

REFERENCE

[1] Ammar A Al-Rousan (2008), "Study on Improvement of Fuel Economy and Reduction Emission for a Gasoline Engines by Homogeneity Enhancement of the Charge", Australian Journal of Basic and Applied Sciences, Vol. 2, pp. 1012- s1020, INS Inet Publication.

[2] Arturo de Risi, Teresa Donateo and Domenico Laforgia (2003), "Optimization of the Combustion Chamber of Direct Injection Diesel Engines", SAE2003-01- 1064.

[3] Blair G P (1999), "Design and Simulation of Four-Stroke Engines", SAE, Warrendale, USA.

[4] Corcione F E, Annunziata Fusca and Gerardo Valentino (1993), "Numerical and Experimental Analysis of Diesel Air Fuel Mixing", SAE931948. Ganesan V (2004), Internal Combustion Engine, 2nd Edition, Tata-McGraw Hill.

[5] 8.A. R. Bhagat, Y. M. Jibhakate,"Thermal Analysis and Optimization of I.C. Engine Piston Using Finite Element Method", International Journal of Modern Engineering Research (IJMER), Vol. 2, Issue 4, pp. 2919-2921,2011.