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Investigation Of Heat Transfer In The Cylinder Head of 2-Stroke SI Engine

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Abstract: ***The importance of heat transfer in design of two stroke engine is important to make sure the engine will perform to expectation during actual working conditions. For this a prediction is done on the various heat distributions that might occur during a normal operation of the engine. The finite element model was evolved with many boundary conditions that are predicted from theoretical studies. This is to see the general heat transfer of the engine and whether or not the engine will withstand the thermal loads occurring during the theoretical operation. Assumptions are made by approximating temperature to the actual operating condition of the engine. Heat transfer was modeled with conduction and convection as the main source of heat transfer and neglecting radiation. The values are to be verified when the actual engine is operating with correct boundary conditions. It is hoped that the engine will not come to the boundary applied as it is assumed very high compared to actual condition. The study is a transient study with assumption that the engine is running at 6000 rpm for 60 seconds and generating the boundary heat from theoretical calculations. First thermal analysis was done and analyzed the temperature distribution over the fin area. In the second stage structural analysis was carried out using the thermal loads obtained in the first stage.***

Keywords: two stroke engine, transient heat, thermal analysis, structural analysis

INTRODUCTION

Heat transfer is a very wide field used in analysis of internal combustion engine heat transfer effect parameter such as performance, emission and also efficiency. It is said that for a given mass of fuel higher the heat transfer to the combustion wall will reduce the average combustion pressure and temperature, this indirectly reduces the work done by the piston per cycle and these effects the specific power. Today the IC engines have synthesized the basic knowledge of many disciplines like thermodynamics, thermal engineering, fluid flow, combustion, chemical kinetics and heat transfer as applied to a system with both spatial and temporal variations in state of non-equilibrium. With the availability of sophisticated computers multidimensional mathematical modeling the electronic instrumentation have added new refinements to the engine design.

Engine is the mechanism in which conversion of energy in one state to other state of energy, while during this process of conversion of energy efficiency is considered as important parameter. Hence majority of the engines are called as Heat engines, because they convert thermal or heat energy into mechanical work. Further heat engines are defined as machine which transforms chemical energy of fuel (petrol/diesel or biofuels) into heat energy and uses this heat energy to perform work. Two principle types of heat engine are as: outer burning engine (OBE) and inside burning engine (IBE). The popular engines in today's world are of reciprocating engines. The engines either it may be internal combustion or external combustion engine it has been classified as rotary engine and reciprocating engine.

The rotary internal combustion engine consists of open cycle gas turbine and Wankel engine and reciprocating internal combustion engines are Gasoline engine and Diesel engine. The reciprocating external combustion engine consists Steam engine and Stirling engine and reciprocating external combustion engines are Steam turbine and Closed cycle gas turbine. The reciprocating internal combustion engine has advantage that it does not require any heat transfer devices as it is required in steam turbines.

TWO STROKE CYCLE ENGINE (PETROL ENGINE)

In two stroke cycle engines, the whole sequence of events i.e., suction, compression, power and exhaust are completed in two strokes of the piston i.e. one revolution of the crankshaft. There is no valve in this type of engine. Gas movement takes place through holes called ports in the cylinder. The crankcase of the engine is air tight in which the crankshaft rotates.

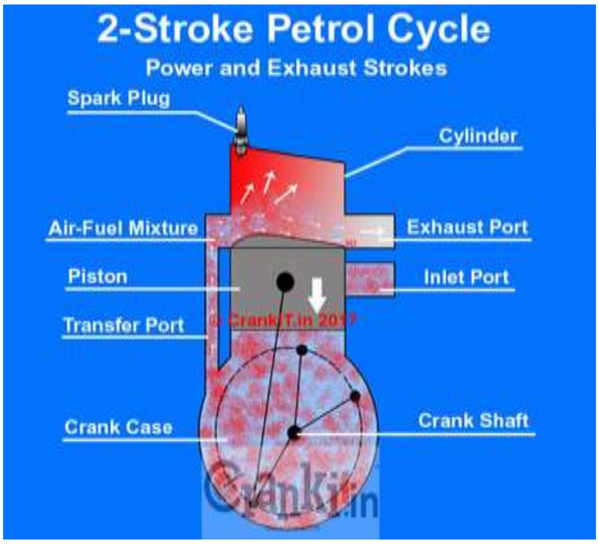


Fig: 1- stroke Petrol Cycle

I. LITERATURE REVIEW

PulkitAgarwalet.al presented that an air-cooled motorcycle engine releases heat to the atmosphere through the mode of forced convection. To facilitate this, fins are provided on the outer surface of the cylinder. The heat transfer rate depends upon the velocity of the vehicle, fin geometry and the ambient temperature. Many experimental methods are available in literature to analyses the effect of these factors on the heat transfer rate. However, an attempt is made to simulate the heat transfer.

Matkar M.V et.al. calculated the heat transfer rate and the temperature behaviour for the same object with the different material (like copper and aluminium). They have concluded that observe that heat flow rate of copper fin (19.2W) is less than the heat flow rate of the aluminum fin (56.99 W). The copper gets stable at the lowest temperature. And hence here conclude that the copper is best material suitable for fin than the aluminum.

G.Rajuet.al. investigated maximization of heat transfer through an internal combustion engine cylinder, under one dimensional, steady state condition with conduction and free convection modes. They used non-traditional optimization technique, namely, binary coded Genetic Algorithm to obtain maximum heat transfer and their corresponding optimum dimensions of rectangular and triangular profile fin arrays.

A. Rajkumar et.al carried out the transient analysis with assumption that the engine is running at 6000 rpm for 60 seconds. First thermal analysis was done and analysed the temperature distribution over the fin area. In the second stage structural analysis was carried out using the thermal loads obtained in the first stage. They found that for material A413.0, the maximum stress was 386.094 MPa. For material C443.0, the maximum stress was 363.354 Mpa. For material B390.0, the maximum stress was 42.236 Mpa and calculated the factor of safety for all three materials was 0.3367 for A413.0, 0.266 for C443.0 and 1.032 for B390. They concluded that the B390.0 was the best material among all because it has more Factor of Safety than other two and the FOS should always more than one.

N. Nagaraniet.al. analysed the heat transfer rate and efficiency for circular and elliptical annular fins for different environmental conditions. Elliptical fin efficiency is more than circular fin. If space restriction is there along one particular direction while the perpendicular direction is relatively unrestricted elliptical fins could be a good choice. Normally heat transfer co-efficient depends upon the space, time, flow conditions and fluid properties. If there are changes in environmental conditions, are changes in heat transfer co-efficient and efficiency also.

Denpong Sood phakdeeet.al Compared the heat transfer performance of various fin geometries. These consist of plate fins or pin fins, which can be round, elliptical, or square. The plate fins can be continuous (parallel plates) or staggered. The basis of comparison was chosen to be a circular array of 1mm diameter pin fins with a 2mm
pitch. The ratio of solid to fluid thermal conductivity for aluminium and air is quite high, around 7000, permitting the fins to be modelled as isothermal surfaces rather than conjugate solids. The CFD simulations were carried out on a two-dimensional computational domain bounded by planes of symmetry parallel to the flow. The air approach velocity was in the range of 0.5 to 5 m/s. The staggered plate fin geometry showed the highest heat transfer for a given combination of pressure gradient and flow rate.

Fernando Illan Simulated the heat transfer from cylinder to air of a two-stroke internal combustion finned engine. The cylinder body, cylinder head (both provided with fins), and piston have been numerically analysed and optimized in order to minimize engine dimensions. The maximum temperature admissible at the hottest point of the engine has been adopted as the limiting condition. Starting from a zerodimensional combustion model developed in previous works, the cooling system geometry of a two-stroke air cooled internal combustion engine has been optimized in this paper by reducing the total volume occupied by the engine. A total reduction of 20.15% has been achieved by reducing the total engine diameter *D* from 90.62 mm to 75.22 mm and by increasing the total height *H* from 125.72 mm to 146.47 mm and the aspect ratio varies from 1.39 to 1.95. In parallel with the total volume reduction, a slight increase in engine efficiency has been achieved.

Bassam A and K Abu Hijleh investigated the problem of cross-flow forced convection heat transfer from a horizontal cylinder with multiple, equally spaced, high conductivity permeable fins on its outer surface numerically. Permeable fins provided much higher heat transfer rates compared to the more traditional solid fins for a similar cylinder configuration. The ratio between the permeable to solid Nusselt numbers increased with Reynolds number and fin height but tended to decrease with number of fins. Permeable fins resulted in much larger aerodynamic and thermals wakes which significantly reduced the effectiveness of the downstream fins, especially at $\theta < 90°$. A single long permeable fin tended to offer the best convection heat transfer from a cylinder

II PROPOSED WORK

The detailed procedure of performance of the test and it involves several parameters and methods adopted for measurement of important parameters as per the plan are given below. An experimental setup is designed and developed to carry out the experimental investigation on cylinder head of two stroke SI engine. Insulating syporex blocks are used to reduce the leakage of heat from bottom and sides of the fin array.

The engine which is studied in this research is single cylinder, air-cooled and two-stroke which its technical specifications are provided. In order to estimate fuel consumption, fuel delivery system is fabricated with the assistance of scaled one litre storage tank. Specific measurement instruments are used in all experimental studies. In this research, temperatures are measured by K-type thermocouples and digital thermometer. These types of thermocouples can be used with a service temperature range between -200 and +1350 . The sensitivity and Measurement accuracy of these thermocouples are 41 and 2.2 respectively . The tip of these thermocouples has the width of 3mm and it works on the basis of the Seebeck effect which will convert the temperature gradient into electricity.

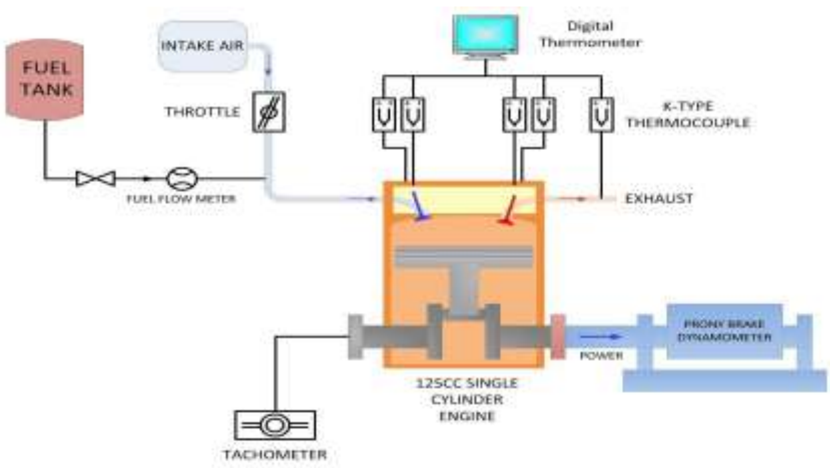


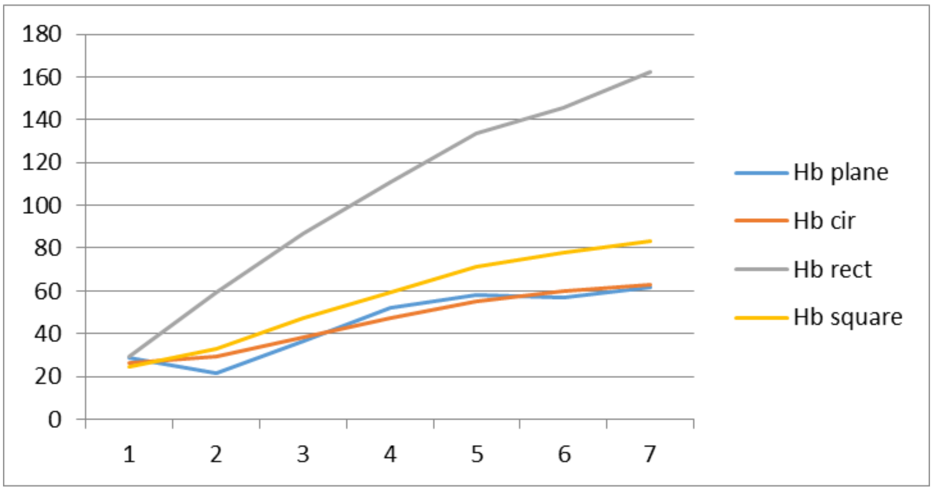
Fig 2. Schematic of experimental set up

1. The cylinder head of two stroke SI Engine is setup to control weather condition .
2. Various thermodynamics properties temperature, pressure and performance efficiency are plotted .
3. Heat dissipation through the fins of cylinder head is improved by using insulating material across the fins.
4. First ,whole assembly is run on no load conditions. Graph and reading calculation is plotted at this stage .RPM are measured with the help of tachometer.
5. By changing the clearance gap between the fins and break power with load condition engine trial run is conducted.
6. Mathematical calculation , final readings are plotted on the basis of trial.
7. From the graphical presentation towards upward direction which shows optimized improvement in the efficiency of heat dissipation.

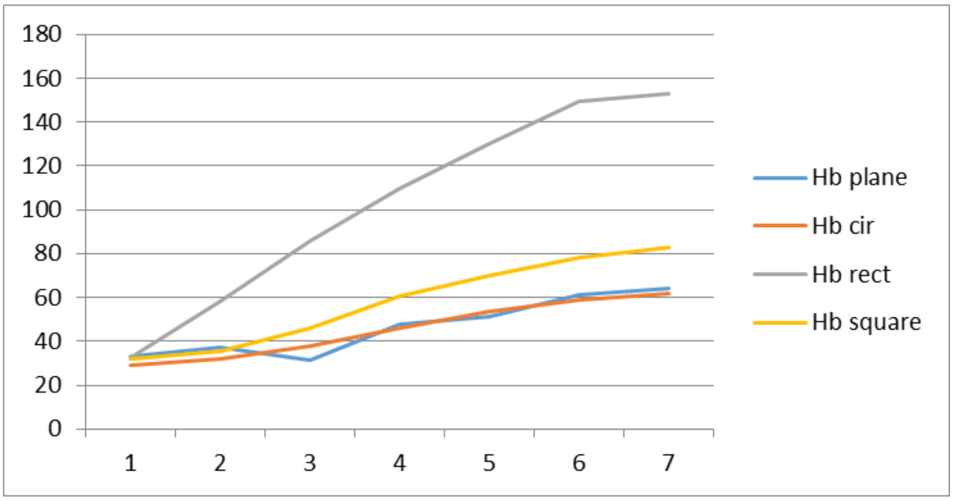
III RESULTS AND DISCUSSIONS

In this final step of data analysis, the experimental data converted into the interpretable form is now analysed in this process in order to arrive at logical results. Keeping this view in mind discussions are made under the various results obtained from CFD Analysis.

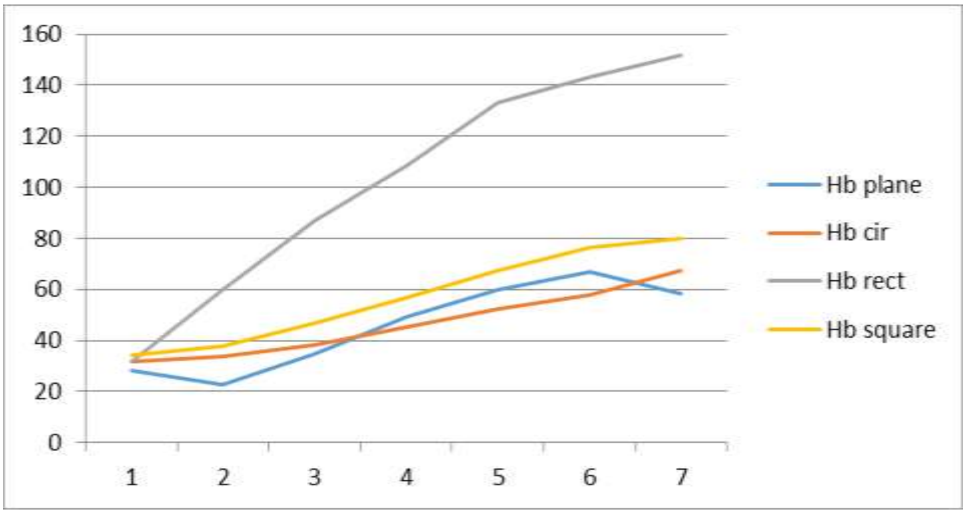
Qualitative Analysis of Data for various Fins



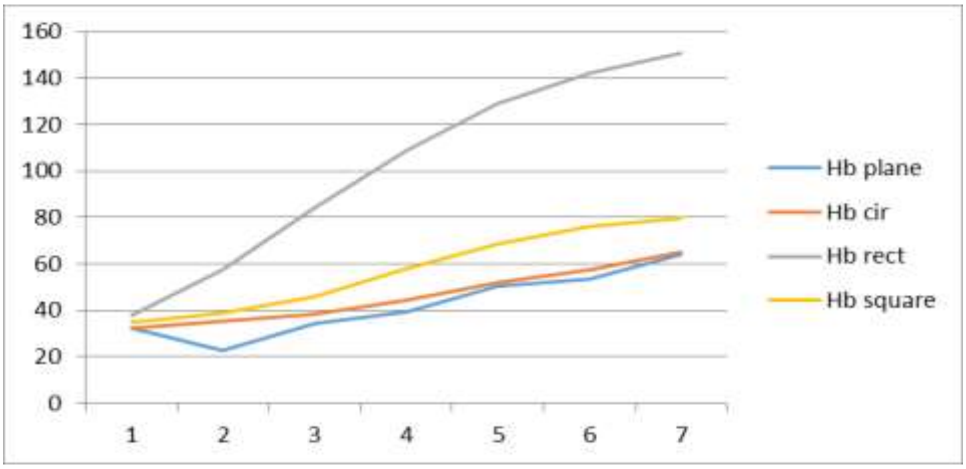
Graph 1: Variation in heat transfer vs. air velocity of various fins for 1250 W/m2 heat flux.



Graph 2: Variation in heat transfer vs. air velocity of various fins for 2500 W/m2 heat flux.



Graph 3: Variation in heat transfer vs. air velocity of various fins for 3750W/m2 heat flux.



Graph 4: Variation in heat transfer vs. air velocity of various fins for 5000W/m2 heat flux.

From above graphs it is seen that heat transfer obtained for rectangular fins is more than the other shapes of fins. By changing heat input to the fins heat transfer coefficient is analysed.

CFD Results

From the experimental analysis, a set of data is collected when the engine is running at the specific speed. The data will be used as the boundary condition in the numerical analysis. The data result from the experimental analysis for the 1061 rpm speed is shown in Figure 3. The cylinder pressure data was measured from the experiment is shown in Figure 4. The data from the experiment will be compared with the simulation data for the validation.

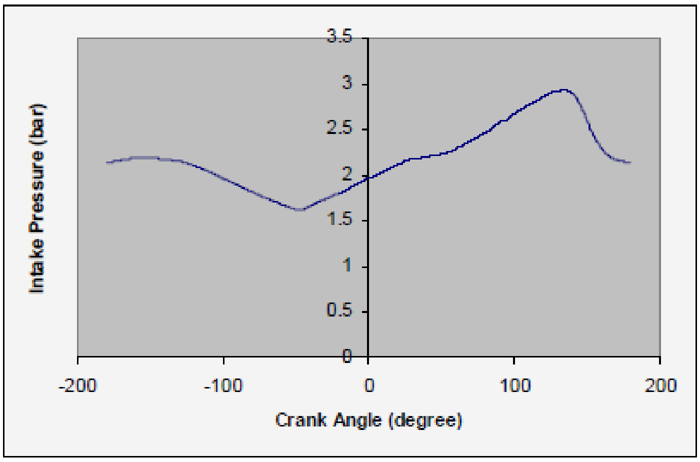


Fig 3 The experimental data as boundary condition in numerical analysis for 1061rpm speed

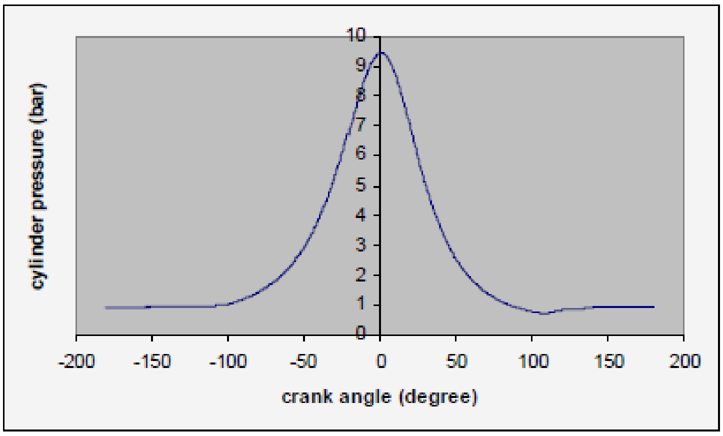


Fig 4: The in cylinder pressure from the experimental analysis for 1061 rpm

Analysis from CFD results

- Experimental results and CFD Results obtained for plane fin array are compared for validation process.
- It is realized that a close match, with deviation within 15% .
- After achieving match between the experimental and CFD results, an analysis is made for various values of velocities and heat flux.
- From above graphs of heat transfer v/s shape of fins for various heat input it is clear that rectangular fin is giving higher heat transfer rate.
- From above fig it is seen than temp distribution over volume for different types of Fins.
- Also temp distribution over a fins are shown by using contours for various velocity & heat input.

IV CONCLUSION

The overall performance of the four different heat sinks with different shaped pin-fin structures was studied in this paper for different velocities varying from 0.1,0.3,0.5,0.7,1.05&1.15 m/s. The paper presents simulation and thermal analysis of heat transfer in the cylinder head of two stroke SI engine. To find out best heat sink designs, the fin profiles were investigated for enhancing the heat dissipation rate and some thermal improvements as well as space reduction and material savings were attained. Improvements on heat sink designs are possible by the use of CFD. Eventually it is possible to finish up with a new heat sink design which has better thermal performance and uses less material. The selected material for heat sink is aluminium because of its high thermal conductivity and it's lightweight. From computational result it is clear that rectangular pin fin with 14 mm fin spacing has better performance than the others shapes of fins and the maximum temperature obtained is 347.11 K at 0.1 m/s lower than other cases at 1250W/m2 heat input.

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