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# Optimization of Hole Diameter on Fins of Si Engine through Numeraical Analysis

**Shaik Nayeem, Gaddavalasa Venkatesh, Givireddi Siva Krishna, Gude Praveen Kumar, Adigarla Jai Sankar**

***Abstract:*** ***Fuel and material cost is increasing day by day in all the industries. In IC engine, engine fails mainly due insufficient of heat transfer from the cylinder wall to the atmospheric air. In SI engine, heat is extracted from the cylinder wall by convection heat transfer through the fins. In this paper optimal hole size on the fins is obtained in order to extract the heat from the engine by numerical method. ANSYS is used to find the temperature distribution on the fins , when there no holes, when there is hole diameter as 2mm, 2.5mm,3 mm, 3.5mm,3.8mm, 4mm and two row holes of 3.5 mm diameter. For this analysis fluid flow (fluent) is chosen, air is circulated on engine with 16.666 m/s velocity and with atmospheric pressure. Temperature value of 800K is applied to the cylinder wall. Temperature is compared with the all hole diameter cases, and it is found that the 3.5 mm diameter hole gives the best results compare to all other hole diameter. The temperature difference 0.04K is obtained between without holes and with 3.5 mm diameter. The 3.5 mm diameter hole fins are used where material cost goes at high rate.***

***Key words: Convective heat transfer, Fins, Hole size, Numerical analysis, Fluid flow, Temperature distribution.***

## I. INTRODUCTION

The IC engines fails due to thermal stresses and melting of components of engine. These heat source is generated due combustion of fuel, so to increase the life of the engine the liberated heat need to be extracted from the cylinder. The three main heat transfer processes are helpful to extract the heat from the engine. These three processes are conduction, convection and radiation heat transfer. The conduction and convection heat transfer processes plays main role in extracting heat. The extraction of heat by radiation heat transfer is very less or sometimes it is consider as negligible. In CI engine water is the main working fluid for extracting heat through conduction and convection process. But in SI engine air is main working fluid for extracting heat through conduction ( from cylinder to fins) and convection( from fins to atmosphere air) process. In these SI engine convection is dominated on conduction process.

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In this paper a attempt is made to find the optimal hole size on the fins, because fins plays a main role extracting most of heat from the cylinder. With the help of numerical analysis, temperature distribution throughout the fins and cylinder can be estimated. ANSYS is the one of the best software which uses numerical technique for solving complex real engineering problems. In this paper temperature distribution is obtained on fins and cylinder for the cases like , when there are no holes and when there are holes of diameters 2mm, 2.5mm, 3mm,3.5mm,3.8 mm, 4 mm and two row holes of 3.5 mm hole .

The heat flux or heat transfer rate is varying with the surface roughness. If the surface roughness is increased, then the heat flux also increases for the same volume of same body [1]. simplified finite element model gasoline spark ignition engine and model with cooling jacket depends upon the choice of suitable material improvement of component and design [2]. FEM analysis on variety of fins, fin pitch, fin layout, wind velocity, fabric and climate situations. Apart from triangular, trapezoid, circular fins with different pitches and the original geometry of fin gives more benefits [3]. Combustion and transient heat transfer process in a two-stroke S.I engine.by varying the fuel mixture influencing and model geometry changing ,they got better performance [4]. Heat transfer rate in conduction is directly proportional to thermal conductivity. Grey cast iron has low thermal conductivity hence the heat transfer rate is comparatively very low, considering other metals cast iron can withstand high temperatures. So it is used in I. C Engine cylinder body [5].

## II. DESIGN PARAMETERS AND CALCULATIONS

From HONDA CB Trigger model
Bore diameter = 57.6 mm, Bore thickness= 10 mm, Stroke length= 58.7 mm, Fin thickness = 3 mm,
Fin fillet radius = 15 mm, Fin length= 107 mm, Number of fins = 8 no, Temperature developed= $600^0$c, Shape of fin= Rectangular, Cylinder material= Cast Iron, Density of cast iron ( ʃ ) = 7300 kg / $m^3$, Specific heat of cast iron ( $c_p$ ) = 460 j / kg.k, Thermal conductivity of cast iron ( k ) =55 w / m.k
Fin material = Aluminium alloy, Density of Aluminium alloy ( ʃ ) = 2700 kg / $m^3$, Specific heat of Aluminium alloy ( $c_p$ )= 921 j / kg.k, Thermal conductivity of Aluminium alloy ( k ) = 205w / m.k

### Design Calculations

### Optimal hole calculations

Thickness of fin = 3 mm, Cross sectional area of hole = $(\pi \div 4) \times (3^2) = 7.068\ mm^2$
Two faces contact with air, so $2 \times 7.068 = 14.137\ mm^2$
This is the area subtract by creating hole in fin , calculate area creating by make holes
$= 2\pi\, r \times T = 2 \times \pi \times 1.5 \times 3 = 28.274\ mm^2$


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Materials for the models:
Cylinder: Cast iron (solid), Fins: Aluminium(solid), Enclosure : Air (fluid)

## III. GEOMETRIC MODELING AND NUMERICAL ANALYSIS

In the fluid flow (fluent) a geometry is created as for the design values which is consist of cylinder and fins as shown in the fig.1 these are designed as solid. Enclosure is created with the dimensions : 60 mm x 60 mm x 60 mm as shown in the fgi2 and it is defined as fluid. Similarly geometry is created for fins and cylinder with holes on fins ( Different diameters: 2 mm, 2.5 mm, 3mm, 3.5 mm, 3.8 mm and 4 mm) as shown in the fig.3.

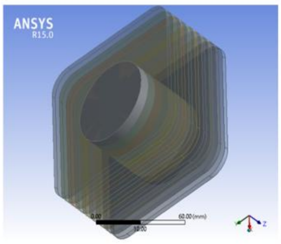


Fig.1: 3D geometry of IC engine cylinder and fins without holes on fins

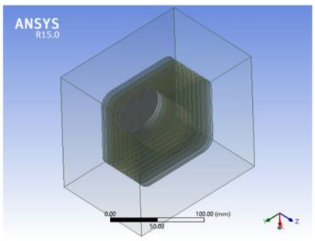


Fig.2: 3D geometry of IC engine and enclosure without holes on fins

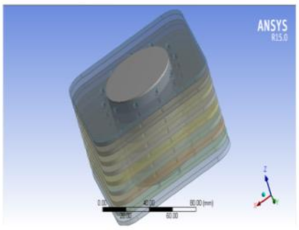

Fig.3: 3D geometry of IC engine cylinder and fins with holes on fins

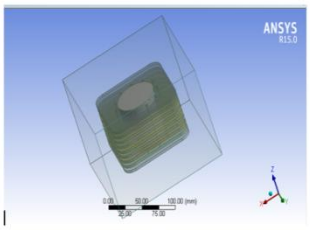

Fig.4: 3D geometry of IC engine and enclosure with holes on fins

Fine Mesh is generated with 83627 nodes , 303865 elements ( Triangular shape) and with 3.0 mm minimum edge length for IC engine and enclosure.

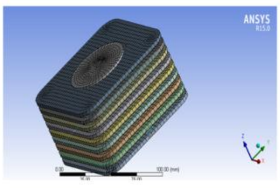

Fig.5: IC engine and cylinder meshed part without holes on fins

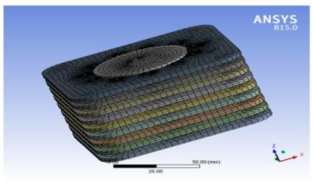

Fig.6: IC engine and cylinder meshed part with holes on fins

**Boundary Conditions:**

(i) For Enclosure :Air inlet velocity =16.666 m/s, Pressure inlet = 101325 Pa

IC engine: Cylinder temperature = 800 k

In the fluid flow (fluent) , k-epsilon is used as fluid flow and boundary conditions are applied on ic engine and enclosure as given above data. Analysis is completed for geometry when no holes, when hole diameter 2 mm, 2.5 mm, 3 mm, 3.5 mm, 3.8 mm, 4 mm and when two rows of 3.5 mm diameter holes. Temperatures are taken on plane surface at the position x=0,y=0,z=0 for all the cases.

## IV. RESULTS AND DISCUSSIONT

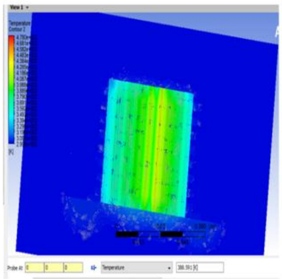

Fig.7: Temperature distribution on plane when there are no holes

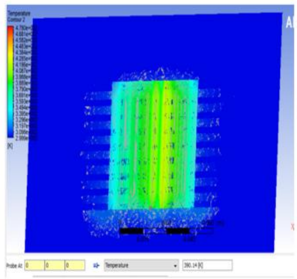

Fig.8: Temperature distribution on plane when hole diameter is 2 mm

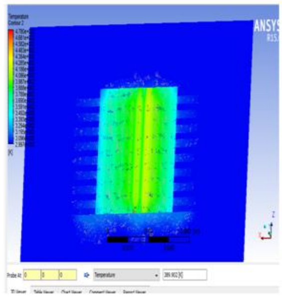

Fig.9: Temperature distribution on plane when hole diameter is 2.5 mm

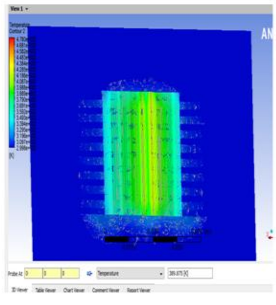

Fig.10: Temperature distribution on plane when hole diameter is 3 mm

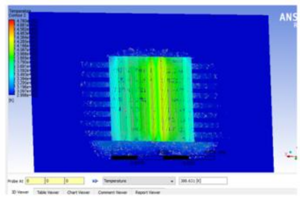

Fig.11: Temperature distribution on plane when hole diameter is 3.5 mm

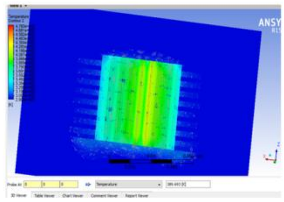

Fig.12: Temperature distribution on plane when hole diameter is 3.8 mm

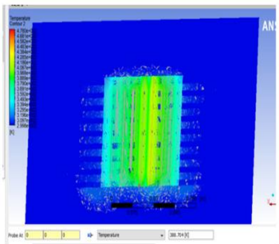

Fig.13: Temperature distribution on plane when hole diameter is 4 mm

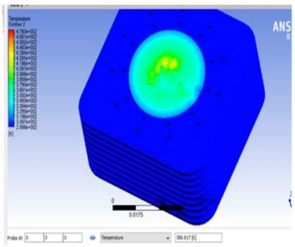

Fig.14: Temperature distribution on plane when two rows of hole with 3.5mm hole diameter

**Table1:Camparison of temperatures at different hole diameters**

| S.No | | Temperature Distribution on Plane(at x=0,y=0,z=0),K |
|---|---|---|
| 1 | No holes | 388.591 |
| 2 | For 2 mm diameter hole | 390.14 |
| 3 | For 2.5 mm diameter hole | 389.902 |
| 4 | For 3 mm diameter hole | 389.875 |
| 5 | For 3.5 mm diameter hole | 388.631 |
| 6 | For 3.8 mm diameter hole | 389.693 |
| 7 | For 4 mm diameter hole | 388.704 |
| 8 | For two rows of holes of 3.5 mm diameter hole | 388.817 |

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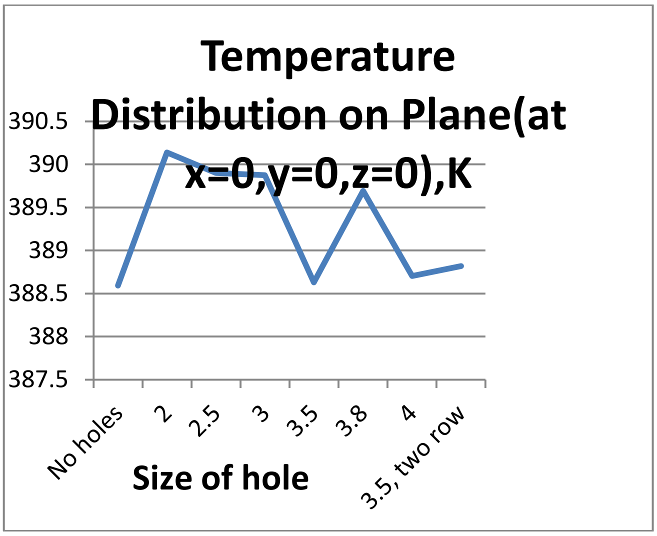


**Fig.15: Comparison of temperature between different hole diameters**

From the optimal theoretical design calculation 3 mm hole diameter is obtained. From the numerical analysis is started with 3 mm hole diameter and moved in backward and forward hole values (from 2 mm to 4 mm diameter hole). At the 3.5 mm optimal temperature is obtained(388.631 K) among the other hole diameters. Optimal temperature(388.591K) is also obtained when there are no holes on fins. There is only 0.04 K temperature difference is there from no holes to holes with 3.5 mm diameter.

## V. CONCLUSION

A attempt is made for finding optimal hole diameter for fins for convective heat transfer. Numerical analysis is conducted when there are no holes, when 2 mm, 2.5 mm, 3 mm, 3.5 mm , 3.8 mm ,4 mm and two rows of holes with 3.5 mm diameter. Temperature distribution is obtained on plane surface at x=0,y=0,z=0. Optimal temperature( 388.631 K )is obtained at 3.5 mm hole diameter, it is only 0.04 k more than the temperature (388.591K) obtained when there are no holes on the fins. This attempt is useful for future research where there is optimization of material more important than the heat transfer rate.

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