

Design and Analysis of Cylinder and Cylinder Head of 6-Stroke Si Engine for Weight Reduction

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ABSTRACT: The term six-stroke engine has been applied to a number of alternative internal combustion engine designs that attempt to improve on traditional two-stroke and four-stroke engines. Claimed advantages may include increased fuel efficiency, reduced mechanical complexity and/or reduced emissions. These engines can be divided into two groups based on the number of pistons that contribute to the six strokes. The present paper deals with design of cylinder & cylinder head with air cooling system for 6 strokes 6 cylinder SI engine. The main objective of design is to reduce weight to power ratio & will result in producing high specific power. The authors have proposed preliminary design cylinder & cylinder head of a horizontally opposed SI engine, which develops 120 BHP and possess the maximum rotational speed of 6000rpm. Four stroke opposed engine is inherently well balanced due to opposite location of moving masses and also it provides efficient air cooling. For the requirement of weight reduction the material selected for design of cylinder and cylinder head is Aluminium alloy 6063 and aluminium alloy 5052.

KEYWORDS: Internal combustion engine, six-stroke engine, fuel efficiency .

I. INTRODUCTION

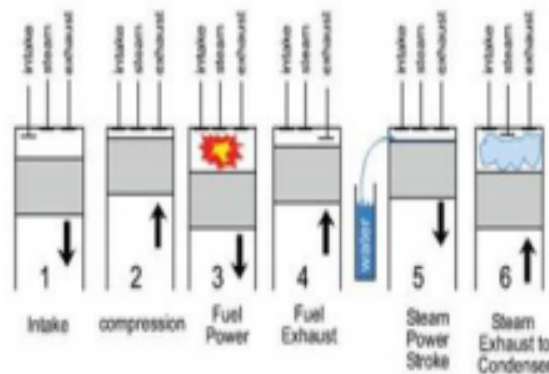
In four stroke engine the inlet valve opens [I.V.O] and the fresh charge of fuel and air mixture is drawn into the cylinder .Then the intake and exhaust valves are closed, and the piston is at its lowest position [B.D.C].During the compression stroke, the piston moves upward compressing the air-fuel mixture. But before the piston reaches its highest position [T.D.C], the spark plug injected the air-fuel mixture and the mixture ignites, increasing the pressure and temperature of the cylinder .The high pressure gases forces the piston down, which in turn forces the crankshaft to rotate, producing a useful work output during the expansion or power stroke. At the end of this stroke, the piston is at its lowest position, and the cylinder is filled with the combustion products .Next the piston moves upward again, purging the exhaust gases through the exhaust valve and down a second time, drawing in fresh air-fuel mixture through the intake valve. Thus the piston completes four stroke which gives two complete revolutions to the crankshaft. But in six stroke engine the exhausted gases which are left after combustion is further used. Then water is injected in super heated cylinder. Through hot gases the water changes its phase into steam as the temperature of the hot gases is high. This steam will works as a working fluid which will forces the piston down. This movement will give a additional two stroke for the same cycle. In this cycle, there is no need of external cooling system as the water will cools the system. Less fuel is needed and also increases its power. It reduces the weight and complexity of the engines head by as much as 50%. Torque is increased by 35% and also increases its efficiency.The four stroke block, pistons and crankshaft remain same. This combination of two stroke and fourstroke technology is named as “six stroke engine” (2 + 4 = 6). Functionally, the second piston replaces the valve mechanism of a conventional engine.

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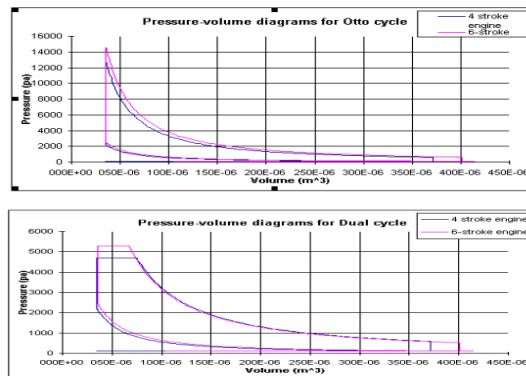
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Schematic diagram of the six stroke engine

Comparison of Six Stroke Engine with Four Stroke Engine:



II. LITERATURE REVIEW

This section explains the beneficial aspects in a six stroke engine which does not exist in a four stroke engine. The major difference between four and six stroke engines are the extra two strokes.

G. Bahadur Vali & Krishna Veni [1] in this project they have design an assemble cylinder and cylinder head. They used two different Aluminum alloys 6061 and 7475.

Abhishek Mote et al [2] they analyze of heat transfer crosswise finned surfaces using CFD software. they thought that experiment based research done by different researchers in the past is a time consuming process.

B. MR. Krishna Kanth .M. and Mr. Srinivas.D: A cycle of six strokes out of which two are useful power strokes due to its thermodynamic cycle and a modified cylinder head with two supplementary chambers: combustion and an air heating chamber, both independent from the cylinder. Several advantages result from this, one very important being increases in thermal efficiency. F. Chinmayeekarmalkar, vivek Raut: The aim of this research is to understand the latest trends in internal combustion engine while maintaining its prime focus on six stroke engine

III. PROBLEM IDENTIFICATION

The problem is faced in the conventional engine is that when high temperature present inside the combustion chamber some of the fuel may unburn so emissions is high. It involves emissions like HC, CO, NO_x, etc. The heat

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produced inside the combustion chamber is conducted to all engine parts. Due to this thermal efficiency is reduced. The weight of an engine is also increased.

VI.FINITE ELEMENT METHOD

The principle of the method is to replace an entire continuous domain by a number of sub domains in which the unknown function is represented by simple interpolation functions with unknown coefficients.

1. Discretization or subdivision of the domain
2. Selection of the interpolation functions (to provide an approximation of the unknown solution within an element)
3. Formulation of the system of equations (also the major step in FEM. The typical Ritz variational and Galerkin methods can be used.)
4. Solution of the system of equations (Once we have solved the system of equations, we can then compute the desired parameters and display the result in form of curves, plots, or colour pictures, which are more meaningful and interpretable.)

BASIC ENGINE DESIGN

Design of Cylinder:

Design parameters	Calculated value
D	78mm
L	78mm
Bmep	11.76 bar
Imep	13.85 bar
Pmax	138.5 bar
Volume	1500cc
Indicatedpower	141.176 HP
Friction Power	21.176 HP
Mechanical Efficiency(assumed)	85%
Break power	120 HP

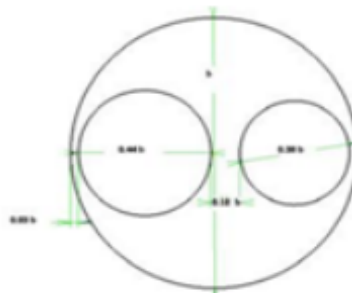
Cylinder Thickness Design:

Thickness of Cylinder is 5 mm.

Cylinder Head Design:

Deign Parameter	Calculated values
Cylinder wall thickness t	5 mm
Cylinder head thickness t'	9 mm

Valve Spacing On Cylinder Head



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Figure shows the empirical relation for inlet & exhaust valve spacing.

Clearance between valve & bore = 2.3 mm
Space between valves (inlet & exhaust) = 9.36 mm
Inlet Valve Seat Design:-
Thickness of valve seat (t)_i = 3.517 mm
Height of valve seat (h)_i 9.0558 mm

Exhaust Valve Seat Design:-

Diameter of valve seat (D)_e:- 24.57 mm
Thickness of valve seat (t)_e = 3.003 mm
Height of valve seat (h)_e = 7.37 mm

Dimensions of valve seats

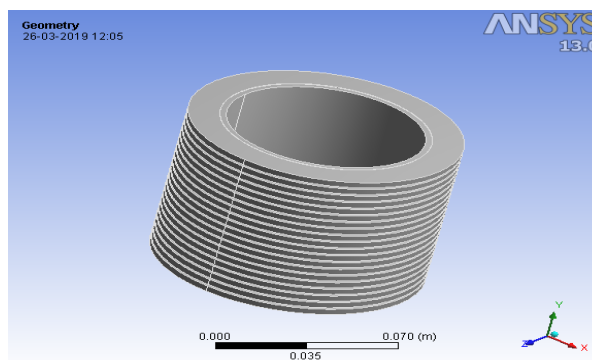
PARAMETE R (mm)	INLET VALVE SEAT	EXHAUST VALVE SEAT
D	30.186	24.57
t	3.517	3.003
h	9.0558	7.37

Dimensions of cooling fins

Required parameter	Calculated value
Root thickness of the fin,	3 mm
Space between two fins	3.96 mm
Number Of fins	24
length of fin	25 mm

VIII.ANALYSIS RESULTS

ANALYSIS RESULTS FOR ENGINE CYLINDER



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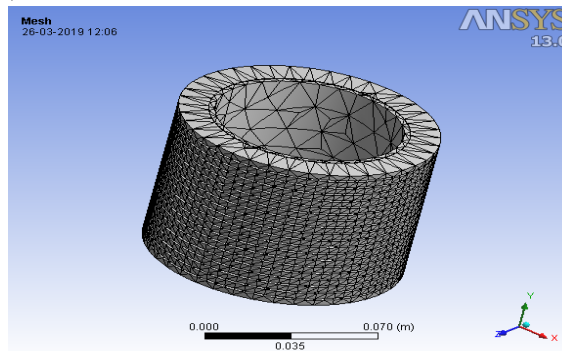
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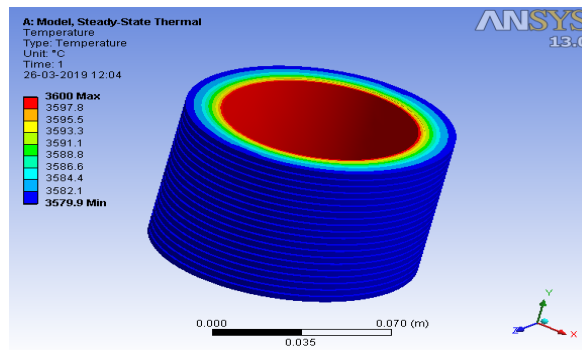
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3D MODEL OF CYLINDER

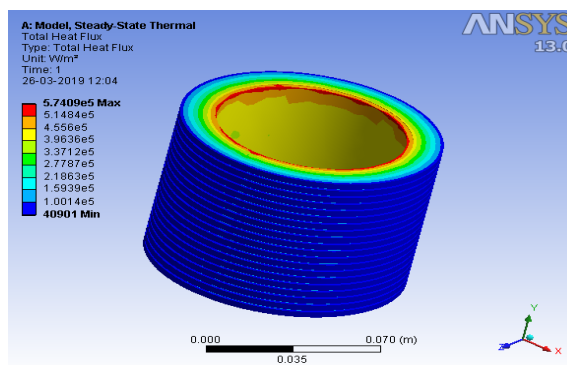
MESHING IMAGE OF CYLINDER



ALUMINIUM ALLOY 6063 RESULTS TEMPERATURE



TOTAL HEAT FLUX



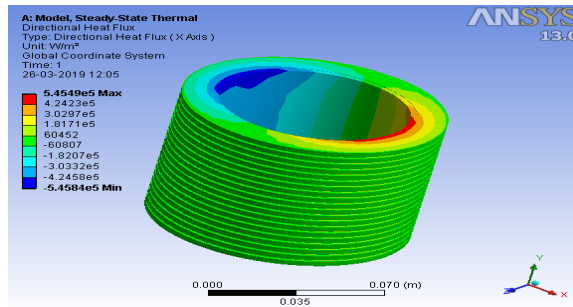
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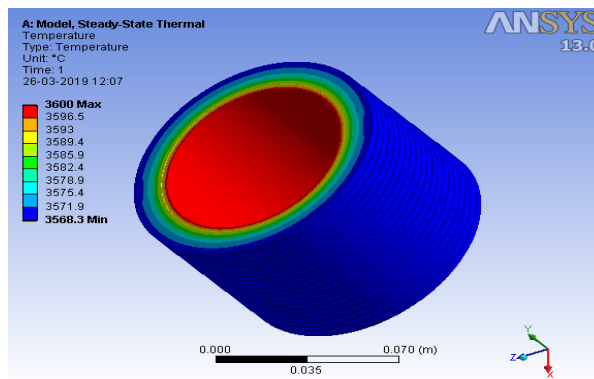
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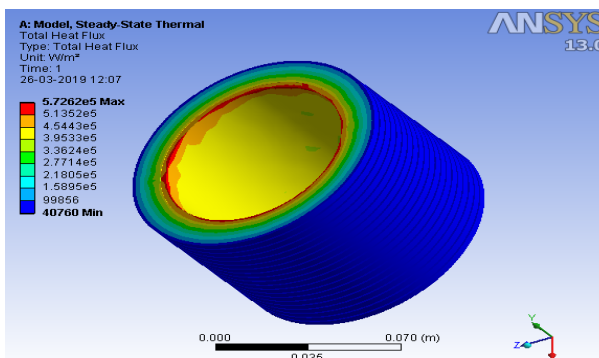
DIRECTIONAL HEAT FLUX



ALUMINIUM ALLOY 5052 RESULTS TEMPERATURE



TOTAL HEAT FLUX



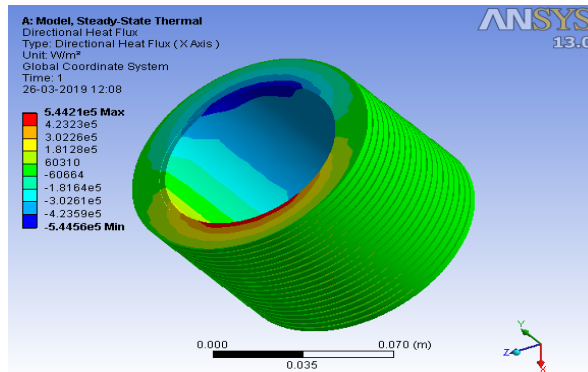
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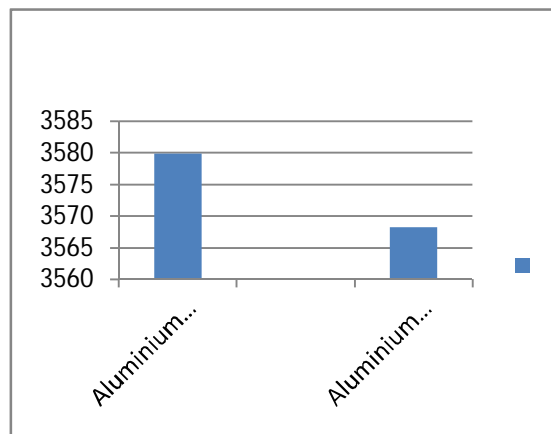
DIRECTIONAL HEAT FLUX



Tabulation of results(Engine cylinder)

S. No	Material	TEMPERATURE °C	TOTAL HEAT FLUX W/m ²	DIRECTIONAL HEAT FLUX W/m ²
1	Aluminium alloy 6063	3579.9	5.7409E5	5.4549E5
2	Aluminium alloy 5052	3568.3	5.7262E5	5.4421E5

COMPARISON CHART TEMPERATURE



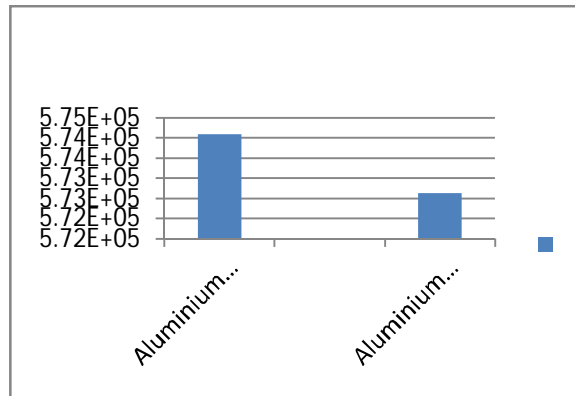
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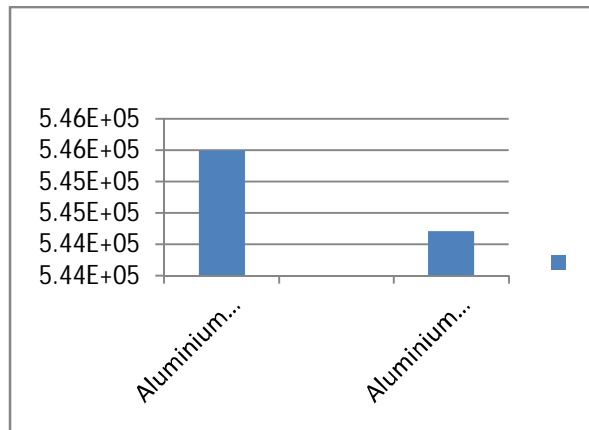
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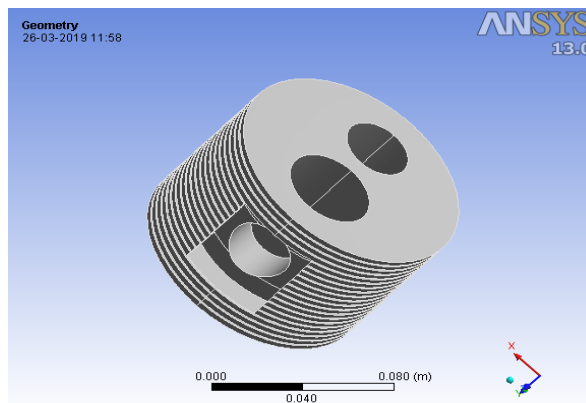
TOTAL HEAT FLUX



DIRECTIONAL HEAT FLUX



ANALYSIS RESULTS FOR ENGINE CYLINDER HEAD 3D MODEL OF CYLINDER HEAD



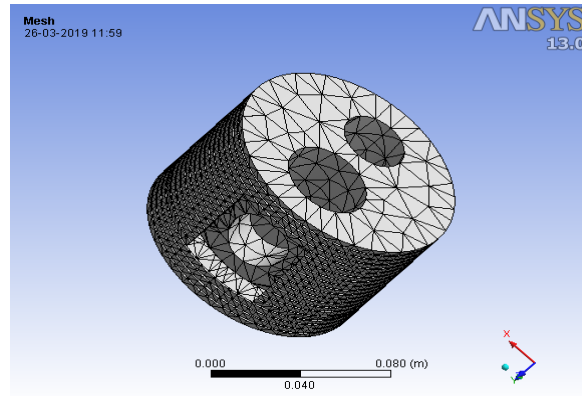
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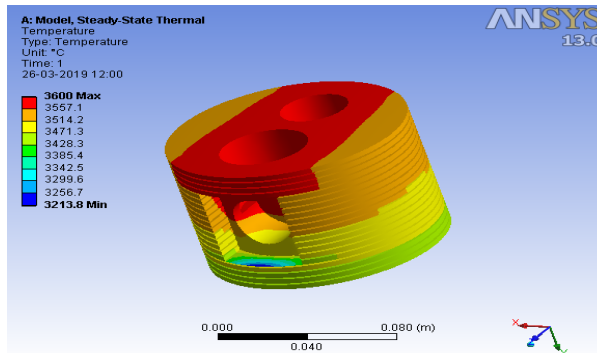
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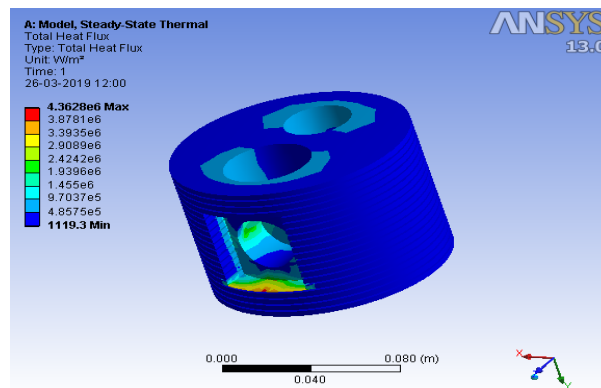
MESHING IMAGE OF CYLINDER HEAD



ALUMINIUM ALLOY 6063 RESULTS TEMPERATURE



TOTAL HEAT FLUX



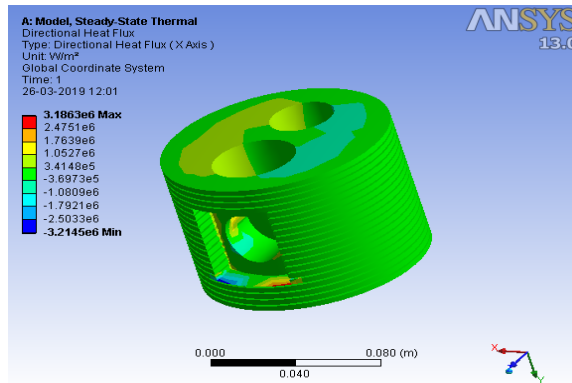
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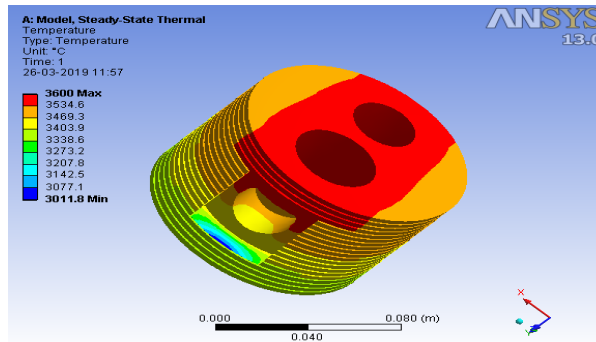
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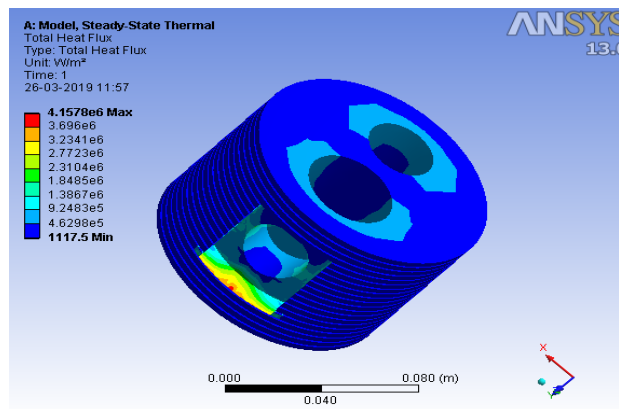
DIRECTIONAL HEAT FLUX



ALUMINIUM ALLOY 5052 RESULTS TEMPERATURE



TOTAL HEAT FLUX



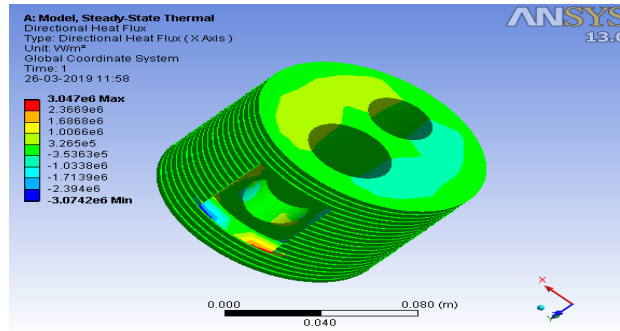
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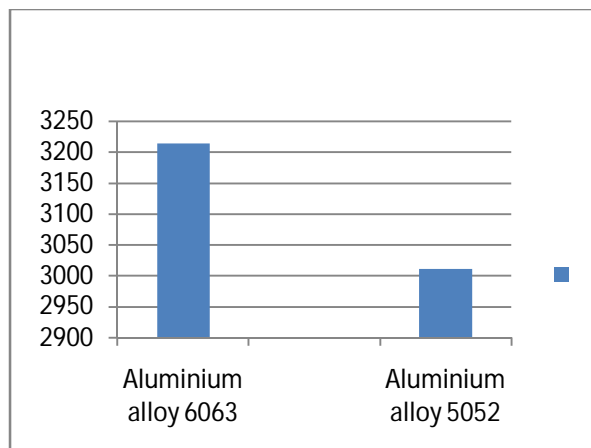
DIRECTIONAL HEAT FLUX



Tabulation of results(Engine cylinder head)

S.No	Material	TEMP °C	TOTAL HEAT FLUX W/m ²	DIRECTI ONAL HEAT FLUX W/m ²
1	Aluminium alloy 6063	3213.8	4.3628E6	3.1863E6
2	Aluminium alloy 5052	3011.8	4.1578E6	3.047E6

COMPARISON CHART: TEMPERATURE:



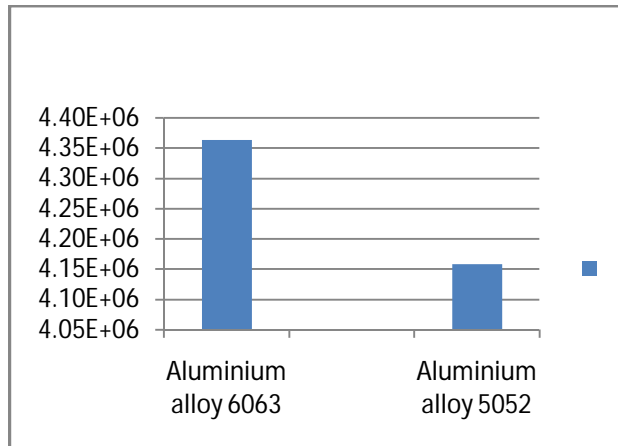
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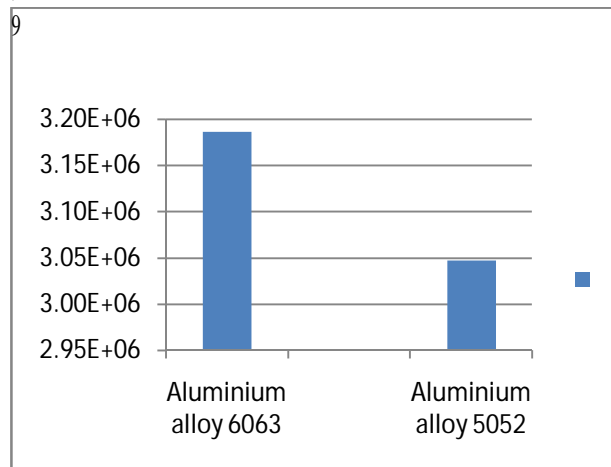
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TOTAL HEAT FLUX:



DIRECTIONAL HEAT FLUX:



IX. CONCLUSION

The six stroke engine cylinder and cylinder head has been analyzed under thermal analysing for different materials. Aluminium alloy 5052 is compared with the existing material which is Aluminium alloy 6063. In thermal analysis among the two materials, Aluminium alloy 5052 was good compared to other material. In modal analysis, Aluminium alloy 5052 has obtained good results compared to Aluminium alloy 6063 material.

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