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Design and Analysis of 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 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.

Keywords: Internal combustion engine, six-storke engine, cylinder head

1.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 four stroke technology is named as "six stroke engine" (2 + 4 = 6). Functionally, the second piston replaces the valve mechanism of a conventional engine.

2. LITERATURE REVIEW

This prominent lesson 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.

Bokinala raja kumar and Abdul saleem -

The engine weight has reduced by 37 Kg from a base one of 162 Kg (excluding engine oil) .This corresponds to 23% weight reduction.

As shown in the component weight ratio of the materials are 53% steel for the weight-reduced engine (86%in the base engine), 33% (13%) Aluminum alloys,7% (1%) plastics & elastomers, 6% (0%) other light weight materials such as titanium alloys &magnesium alloy, & 1% (0%) ceramics.

The materials substitutions applied for the engine structure component represented by a cylinder is no more than simple weight reduction. But, when applied this to several moving & functional components, it not only weight reduction method but also contributes to improve engines & emission performance.

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Shivam agarwal -

A six stroke engine portrays various extraordinary approaches in the interior ignition engine to catch the squander heat from the four stroke Otto cycle and use it to control an extra power and exhaust stroke of the cylinder.

Just as removing power, the extra stroke cools the engine and expels the requirement for a cooling system making the engine lighter and giving 40% expanded productivity over the Otto Cycle. The cylinders in a six stroke motor go here and there multiple times for each infusion of fuel

G.BahadurVali & Krishna Veni-

They have design an assemble cylinder and cylinder head. They used two different Aluminium alloys 6061 and 7475.

Abhishek Mote -

They analyze of heat transfer crosswise finned surfaces using 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, vivekRaut:-

The aim of this research is to understand the latest trends in internal combustion engine while maintaining its prime focus on six stroke engine.

Mr. Amol S bhagat and prof. Rahul sakarkar :-

Cylinder head is one of the parts of I.C.engine which is responsible for maintain temperature. One end of it close. It contain the inlet and exhaust valves through which the air fuel mixture entered inside cylinder and exhaust gases escape to the atmosphere from the cylinder.

In the combustion chamber there are peaks of combustion pressure and temperature on the order of 15 MPa and 2500K. The heat fluxes and temperature no uniformities lead to thermal stress, which further escalates mechanical loading from combustion pressure.

3.OBJECTIVES

The dramatic 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,Nox,etc.The heat 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.

- To reduce weight to power ratio & will result in producing high specific power.
- To design of cylinder and cylinder head is Aluminum alloy that is LM-13 like 5052.
- To analyze a new six- stroke design which adds a second power stroke, resulting in much more efficiency with less amount of pollution.

3.1 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.)

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4. METHODOLOGY

4.1 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 Head Design

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

4.2 MATERIAL SELECTION

Different types of material composition which play very pivotal role to design a cylinder head of Ic engines .

Material Comparison

PARAMETER	LM12	LM13	LM14
Chemical composition (%)			
Si	2	0.85	0.6
Fe	0.5/1.5	0.8	0.6
Cu	9/10.5	0.5/1.3	3.5/4.5
Mg	0.15/0.35	0.8/1.5	1.2/1.7
Ni	0.5	0.7/2.5	1.8/2.3
Mn	0.6	0.5	0.6
Pb	0.1	0.1	0.05
Mechanical properties			
σ u (N/mm^2)	220 to 268	173 to 252	220 to 283
Brinell Hardness Number (BHN)	100	100	100
Characteristics	1) Good hardness at elevated temperature	1) Good fluidity	1) Excellent strength
	2) Good strength	2) High temperature strength	2) Excellent hardness at elevated temperature
	3) Good resistance to Wear	3) Low coefficient of thermal expansion	
		4) Good resistant to wear& low weight.	

4.3 PRINCIPLE OF SIX STROKE ENGINE

A six stroke engine describes a number of different approaches in the internal combustion engine to capture the waste heat from the four stroke Otto cycle and use it to power an additional power and exhaust stroke of the piston. Designs either use steam or air as the working fluid for the additional power stroke. As well as extracting power, the additional stroke cools the engine and removes the need for a cooling system making the engine lighter and giving 40% increased efficiency over the Otto Cycle. The pistons in a six stroke engine go up and down six times for each injection of fuel .The six stroke engine has 2 power strokes, one fuel, one steam or air. The currently notable six stroke engine designs include Crower's six stroke engine, the Bajulaz engine and the Six-stroke engine The Beare Head engine is called a six stroke by its designer but stands apart from the others. It uses a second opposed piston in each cylinder which moves at half the cyclical rate of the main piston, thus giving six piston movements per cycle. It does not use any additional working fluid. After the exhaust stroke, instead of air/fuel mixture (as in

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case of petrol engines), fresh air is sucked into the cylinder from the air filter, and is removed during the sixth stroke. The valve overlaps have been removed and the additional two strokes have been provided for better scavenging, using air injection. The engine shows 40% reduction in fuel consumption and dramatic reduction in pollution. Its specific power is not less than that of a four-stroke petrol engine. The engine can run on a variety of fuels, ranging from petrol and diesel to LPG. An altered engine shows a 65% reduction in CO pollution when compared with the four stroke engine from which it was developed.

4.4 MODIFICATION IN SIX STROKE ENGINE

Modifications are done to specific parts of conventional four stroke engine so that the new engine with six strokes works successfully.

These modifications are:

1) Crankshaft to Camshaft Ratio Modification:- In conventional four stroke engine, the gear at crankshaft must rotate 720o while the camshaft rotates 360o to complete one cycle. For six-stroke engine, the gear at the Crankshaft must rotate 1080o to rotate the camshaft 360o and complete one cycle. Hence their corresponding gear ratio is 3:1.

2) Camshaft Modification:- In the six stroke engine the 360 degree of the cam has been divided into 60 degree among the six-strokes. The exhaust cam has 2 lobes to open the exhaust valve at fourth stroke (first exhaust stroke) and at the sixth stroke to push out the steam.

3) Cam follower modification :-The bottom shape of regular follower has the flat pattern, which is suitable with the normal camshaft for four stroke engine. When reducing the duration of valve opening from 9000 to only 6000 the shape of the follower must be changed from flat to roller or spherical shape.

4.5 WORKING OF SIX STROKE ENGINE

Different working strokes of a six stroke engine are:

1st stroke (suction stroke):- The inlet valve is kept open. Due to cranking, Piston moves downward which results in the formation of a pressure difference due to which pure air enters the cylinder.

2nd stroke (compression stroke) :-The inlet valve closes and the heating chamber valve opens. The piston moves upward due to cranking forcing air into heating chamber. The air at this stage is converted to high pressure.

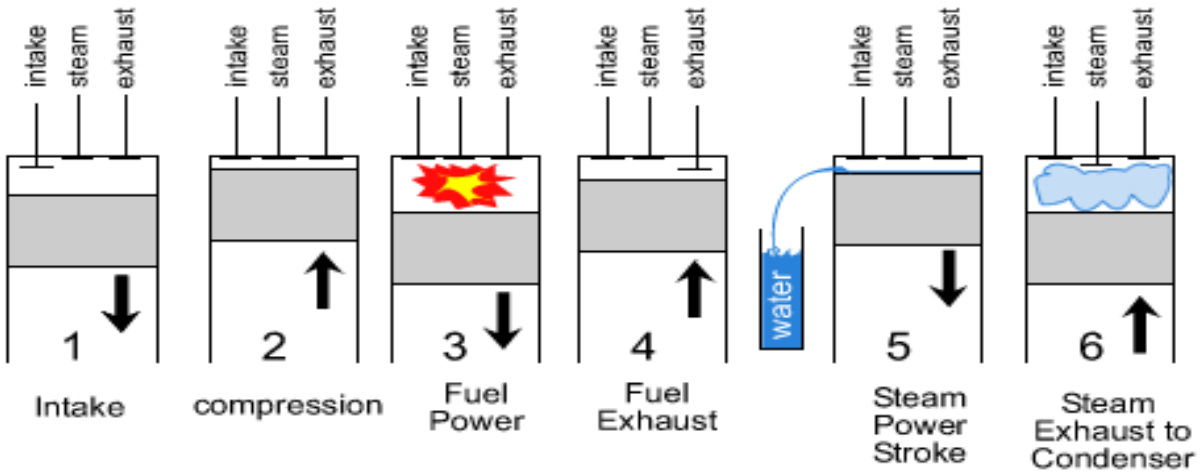
3rd stroke (1st power stroke):- The combustion chamber valve opens and gases of combustion enter the cylinder.

4th stroke (exhaust stroke):- The exhaust valve opens. The piston moves upwards and the exhaust gases are removed via this valve.

5th stroke (2nd power stroke):- The chamber valve opens and the pure air now at high pressure and high temperature enters the cylinder which does work on the piston and hence it moves downward resulting in the 2nd power stroke.

6 th stroke (2nd exhaust stroke) :-Finally the combustion chamber valve opens. The piston moves upwards forcing the pure air into the combustion chamber.

SCHEMATIC DIAGRAM OF SIX STROKE



Source: Nemak

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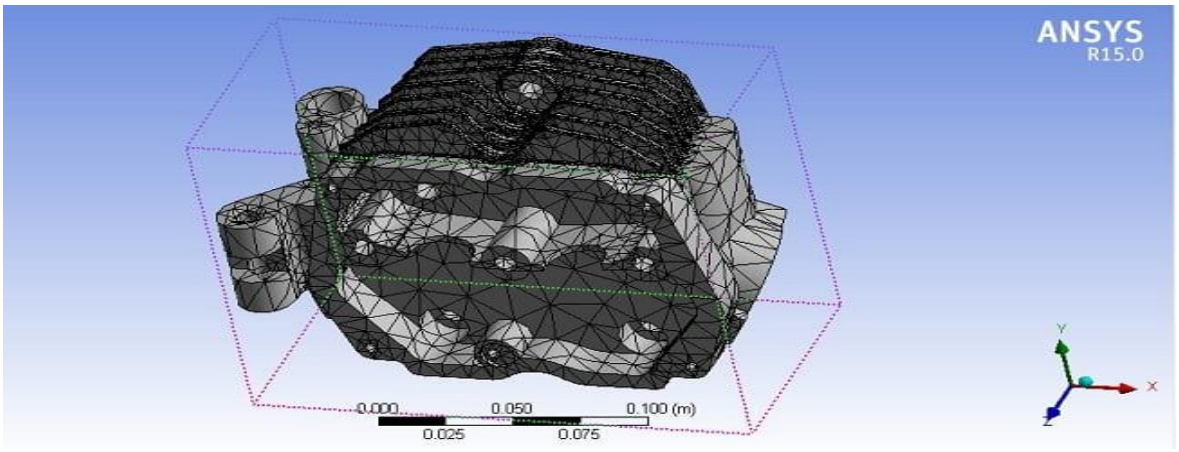
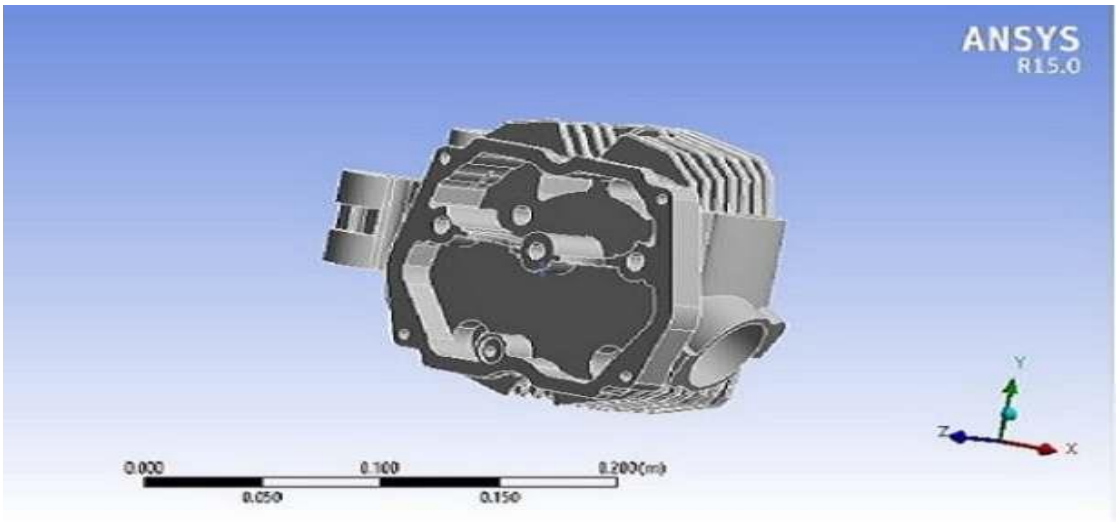
5. RESULTS AND DISCUSSION

5.1 ANALYSIS RESULTS FOR ENGINE CYLINDER HEAD

A geometrical model of the engine cylinder head was developed based on the geometry of the actual object.



MESHED GEOMETRY



ANSYS IMPORTED MODEL

5.2 TABULATION OF RESULTS (ENGINE CYLINDER HEAD)

Relation between material ,Temerature,Total heat flux and Directional heat flux.

S.No	MATERIAL	TEMPERATURE °C	TOTAL HEAT FLUX W/m2	DIRECTIONAL HEAT FLUX W/m2
1	Aluminium alloy 6063	3579.9	5.7409E5	5.4549E5
2	Aluminium alloy 5052	3568.3	5.7262E5	5.4421E5

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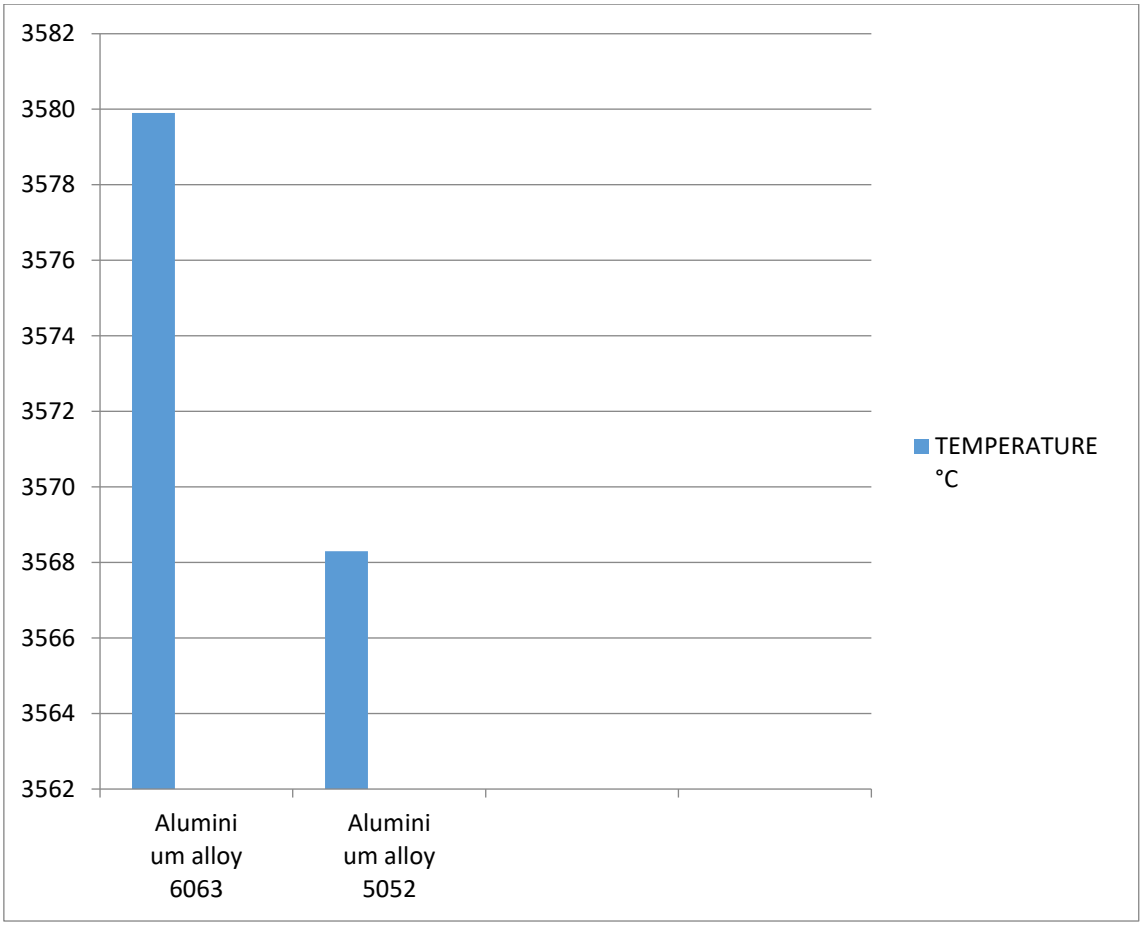
5.3 COMPARISON CHART

TEMPERATURE

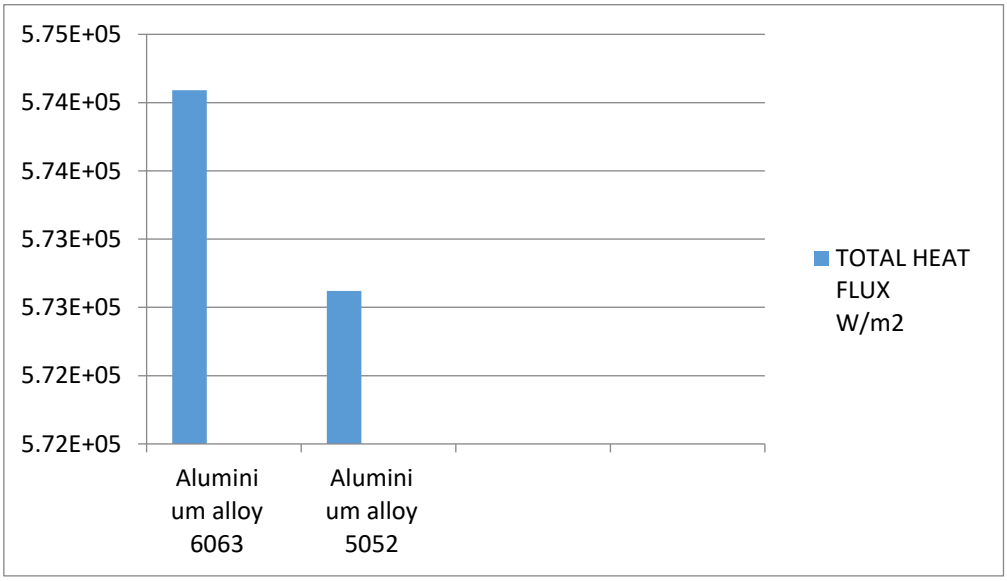
When temperature is applied on material like as aluminium alloy 6063 ,5052.



5.4 COMPARISON CHART

TOTAL HEAT FLUX (W/m2)

When temperature is applied on specific area material like as aluminium alloy 6063 ,5052.



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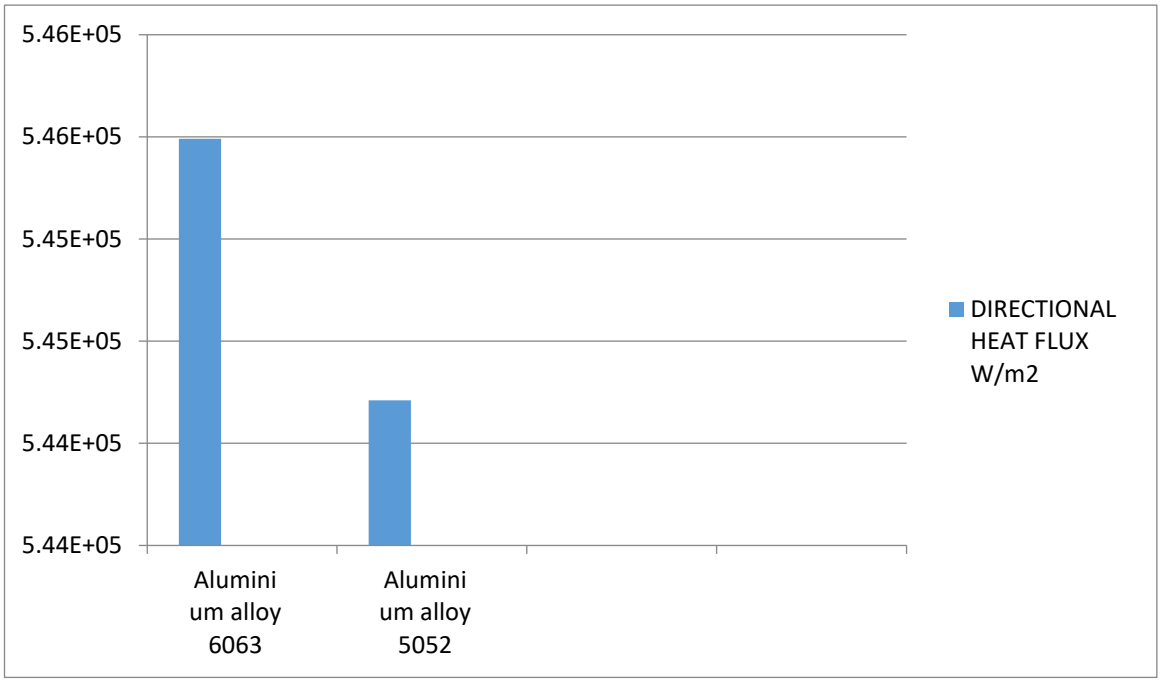
5.5 COMPARISON CHART

When temperature is applied on specific area material like as aluminium alloy 6063 ,5052.

DIRECTIONAL HEAT FLUX (W/m2)



6. CONCLUSIONS

- 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.
- From the analytical factual results & the analysis result we get the values of stresses produced in cylinder and cylinder head due to application of temperature and pressure are within permissible limit.
- Hence we concluded that the basic design of cylinder and cylinder head is safe with reference of pressure and temperature basis. Due to the use of light weightmaterial i.e. LM-13 with 6065,5052 cylinder bore coating, we can effectively reduce the weight of cylinder and cylinder head with improved strength. Also due to the use of air cooling system an efficient and faster cooling of engine achieve.

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