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Heat Transfer Analysis of Advanced ic Engine Cylinder

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Abstract: *The function of a cylinder is to retain the working fluid and to guide the piston. The cylinders are usually made of cast iron or cast steel. Since the cylinder has to withstand high temperature due to the combustion of fuel, therefore, some arrangement must be provided to cool the cylinder. The single cylinder engines (such as scooters and motorcycles) are generally air cooled. They are provided with fins around the cylinder. The multi-cylinder engines (such as cars) are provided with water jackets around the cylinders to cool it.IC engine is the most important part in power generation. IC engine is the assembly of many components like piston, connecting rod, crank shaft, cylinder block, cylinder head, etc. So the mileage of the automobile also depends on the weight of the automobile. And the major weight is engine. As the engine is the assembly of many components, we will take the particular component and optimization of weight is done i.e. with respective to its function. IC engine components like cylinders are made of steel because of its good strength. Replacing the steel components with other light weight materials will reduce the weight and heat transfer analysis of an IC Engine cylinder. Therefore if as many as components are replaced then automatically overall weight is reduced therefore the power required to run itself by automobile is reduced resulting in the increase in the mileage. In this project we are taking composite materials like polyethylene, epoxy, crown glass, silicon. The components are designed by using CATIA and analysis is done by ANSYS.*
Keywords*: Optimization, Design, Weight, Heat Transfer analysis, IC Engine*

I. Introduction

An Internal Combustion Engine (ICE) is a heat engine where the combustion of a fuel occurs with an oxidizer (usually air) in a combustion chamber that is an integral part of the working fluid flow circuit. In an internal combustion engine the expansion of the high temperature and high pressure gases produced by combustion apply direct force to some component of the engine. This force moves the component over a distance, transforming chemical energy into useful mechanical energy. A cylinder is the central working part of a reciprocating engine or pump, the space in which a piston travels. Multiple cylinders are commonly arranged side by side in a bank, or engine block, which is typically cast from aluminum or cast iron before receiving precision machine work. Cylinders may be sleeved (lined with a harder metal) or sleeveless (with a wear-resistant coating such as Nikasil). A sleeveless engine may also be referred to as a "patent-before-engine".

Other light weight materials are used for cylinder because of weight saving for its stiffness and strength. Materials like aluminium, nickel, stainless steel etc are used.

II. Design Of A Cylinder

Bore And Length Of The Cylinder:

The bore (i.e. inner diameter) and length of the cylinder may be determined as discussed below:

Let pm = indicated mean effective pressure in N/mm^2
D = Cylinder bore in mm
l = length of stroke in m = 1.5 D mm
A = Cross-sectional area of the cylinder in mm^2
N = Speed of the engine in r.p.m.
n = Number of working strokes per min
(N for two stroke engine = N/2, for four stroke engine).

We know that the power produced inside the engine cylinder, i.e. indicated power,

I.P watts = B.P / mechanical efficiency = 5000/0.8 = 6250 watts.

i.e. I.P = (pm*|*A*N)/60
6250 = (0.35*1.5D*3.14D2*600)/(60*1000*4)
D = 115mm
l = 1.5D = 1.5*115 = 172.5mm

In other words, Length of the cylinder, L = 1.15 x Length of stroke = 1.151
= 1.15*172.5
= 200mm

Thickness of the Cylinder Wall:

The cylinder wall is subjected to gas pressure and the piston side thrust. The gas pressure produces the following two types of stresses:

(a) Longitudinal stress

(b) Circumferential stress

Since these two stresses act at right angles to each other, therefore, the net stress in each direction is reduced. The pistonside thrust tends to bend the cylinder wall, but the stress in the wall due to side thrust is very small and hence it may be neglected.

Let Do = Outside diameter of the cylinder in mm

D = Inside diameter of the cylinder in mm, =115mm

p = Maximum pressure inside the engine cylinder i.e(3.15 N/mm^2)

t = Thickness of the cylinder wall in mm, and

σc = Permissible circumferential or hoop stress for the cylinder material in Mpa or N/mm^2. Its value may be taken from 35 Mpa to 100 Mpa depending upon the size and material of the cylinder.

C = Allowance for reboring (0.1)

Hence thickness of cylinder is calculated as

T = D((C*p)/ σc)1/2

= 115((0.1*3.15)/42)1/2

= 10mm.

III. Methodology

Iron and aluminum are the two materials used for the blocks that hold the cylinders. Most engines have cylinders liners made of cast iron. Some cylinder liners or cylinders are also coated with high resistance to wear materials such as nickel, silicon carbide, boron nitride, etc depending on the application. Generally the temperature inside an IC engine cylinder ranges from 600 to 2000^{0}c.

Grey cast iron is the first and most material used for manufacturing of engine blocks. Though the aluminum alloy also contain many similarities with low weight, it is still used in the manufacturing of diesel engine blocks because their internal stresses are higher. Grey cast iron contains 2.5-4 % of carbon, 1-3 % of silicon, 0.2-1 % manganese, 0.02-0.25 % of sulfur, and 0.02-1 % of phosphorous. It has a excellent damping absorption, good wear and thermal resistance, and it is easily machinable and less cost due to its availability.

Geometry of Cast Iron Cylinder:

Length X - 0.25m

Length Y - 0.25m

Length Z - 0.2m

Volume - 7.8544e^{-004}m^3

Mass - 5.6225kg

Thermal conductivity – 83 w^-1 c^-1

Density - 7200 kgm^-3

Specific hest - 165 j kg^-1 c^-1

IV. Modeling

Units:

Unit system - Metric(m, kg, N, s, V, A) Degrees ad/s Celsius

Angle - Degrees

Rotational velocity - rad/s

Temperature - Celsius

The cylinder is designed in catia by given dimensions into the modeling software. The cylinder designed is imported to ansys software in the IGES format.

Geometry:

Length X - 0.25m

Length Y - 0.25m

Length Z - 0.2m

PARTS: The cylinder consists of two parts, inside cylinder of cast iron and the outside with other light weight materials like aluminium, nickel, stainless steel etc.

Material Properties:

Grey Cast Iron

Youngs modulus (GPa)	Poisson's Ratio	Density (kg/m^3)	Thermal conductivity
124	0.26	7340	53.3

Aluminum

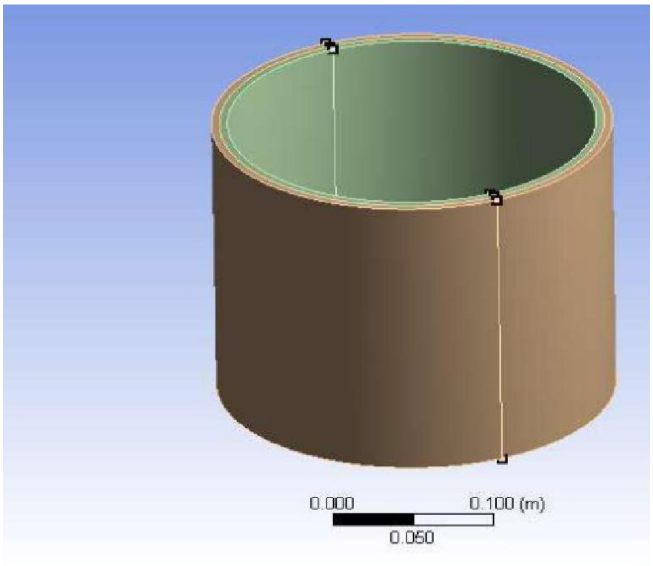
Youngs modulus (GPa)	Poisson's Ratio	Density (kg/m^3)	Thermal conductivity
69	0.334	2700	205

Stainless Steel

Youngs modulus (GPa)	Poisson's Ratio	Density (kg/m^3)	Thermal conductivity
180	0.31	7700	26

Nickel

Youngs modulus (GPa)	Poisson's Ratio	Density (kg/m^3)	Thermal onductivity
220	0.315	8.95	91



Cylinder model with two materials

Meshing:

The whole cylinder is meshed in ansys

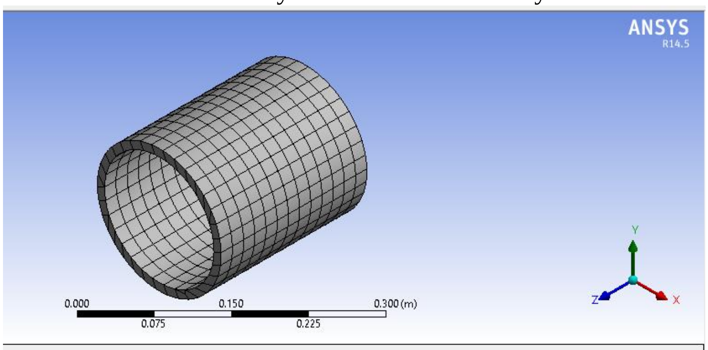


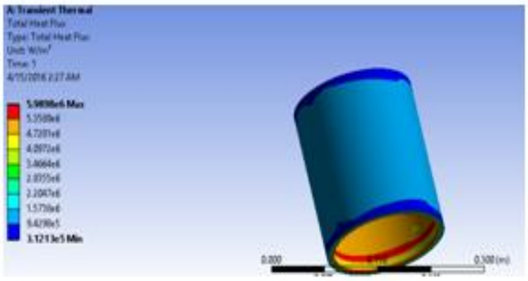
Fig. meshed cylinder

Transient Thermal Analysis

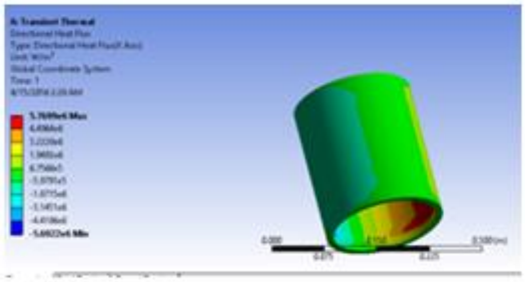
Thermal analysis is analysed by maintaining cylinder's outside temperature at room temperature i.e, around 22^{o}c and the temperature inside is maintained at 600^{o}c, 1000^{o}c, 2000^{o}c for different composite materials. The directional heat flux and total heat flux are observed and obtained.

V. Result And Discussion

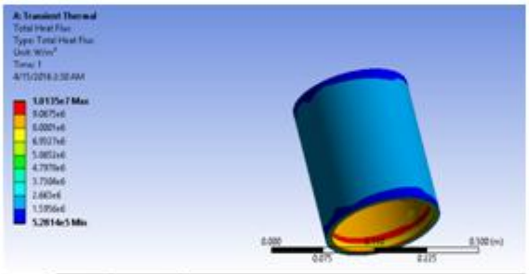
Cast Iron:



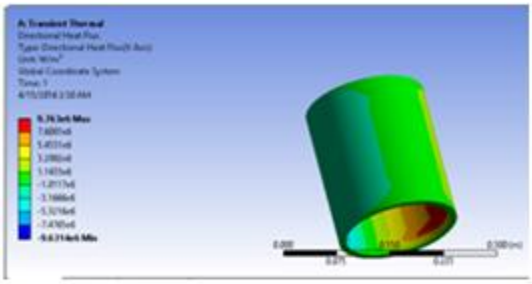
Total heat flux at 600^0 c



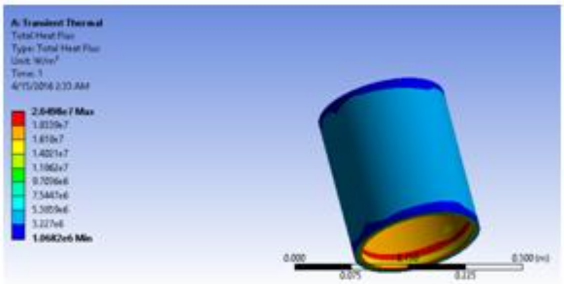
Directional heat flux at 600^0 c



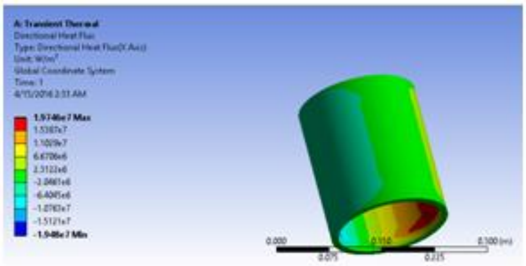
Total heat flux at 1000^0 c



Directional heat flux at 1000^0 c

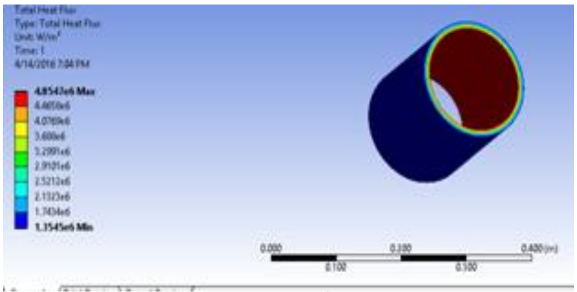


Total heat flux at 2000^0 c

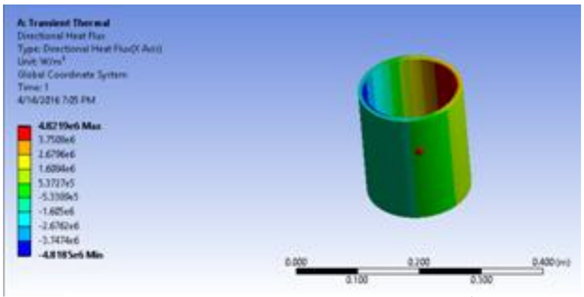


Directional heat flux at 2000^0 c

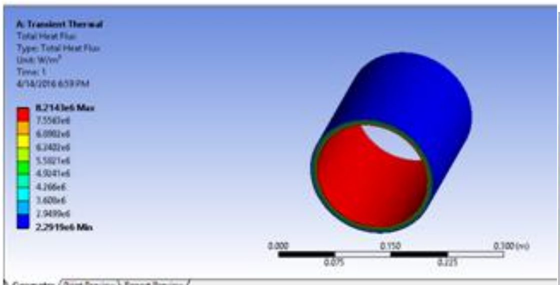
GRAY CAST IRON:



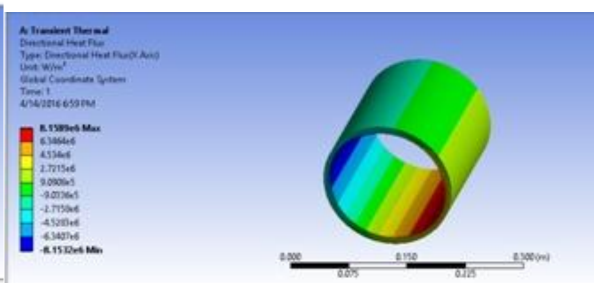
Total heat flux at 600^0 c



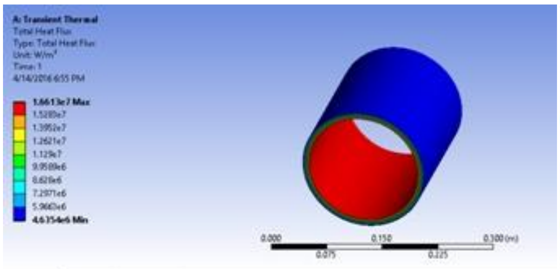
Directional heat flux at 600^0 c

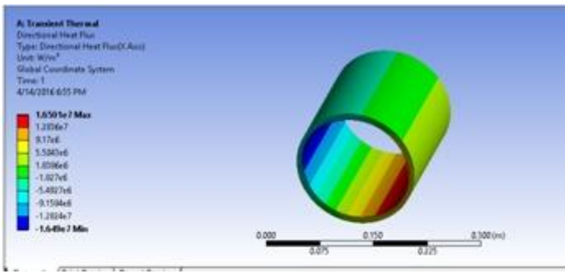


Total heat flux at 1000^0 c



Directional heat flux at 1000^0 c

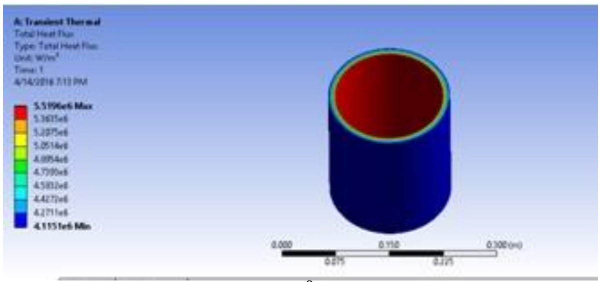




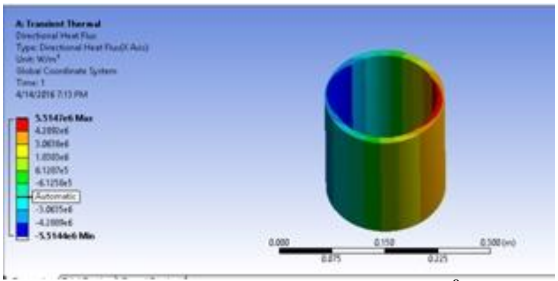
Total

heat flux at 2000^0 c   Directional heat flux at 2000^0 c

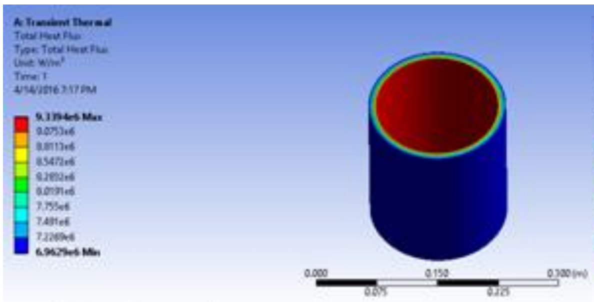
ALUMINIUM:



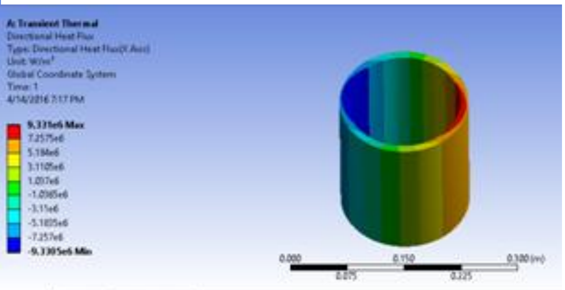
Total heat flux at 600^0 c



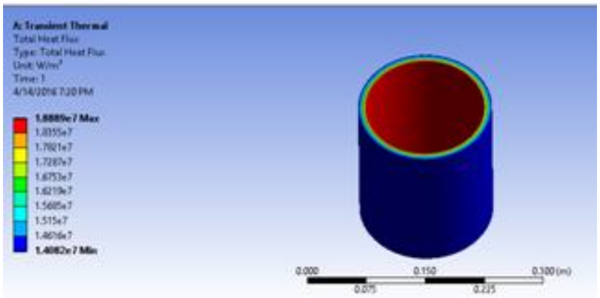
Directional heat flux at 600^0 c



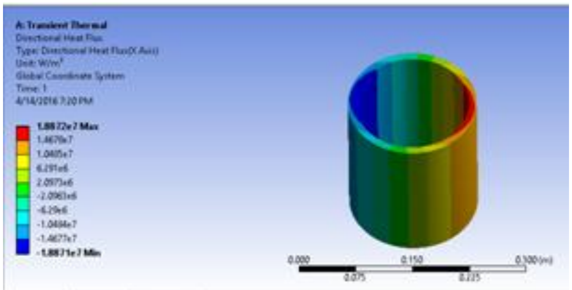
Total heat flux at 1000^0 c



Directional heat flux at 1000^0 c

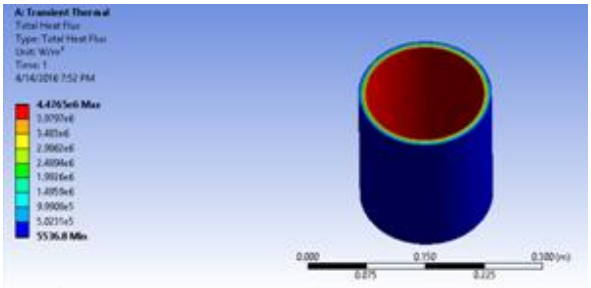


Total heat flux at 2000^0 c

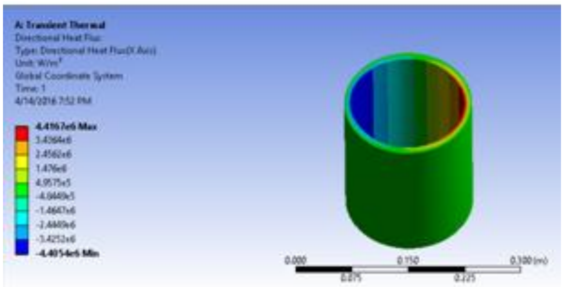


Directional heat flux at 2000^0 c

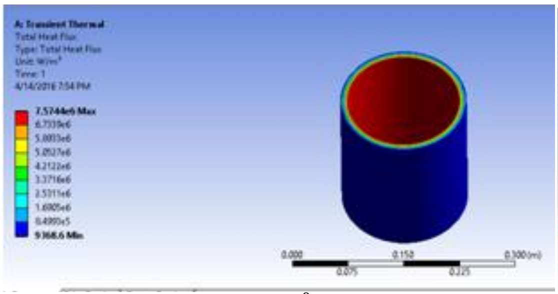
STAINLESS STEEL:



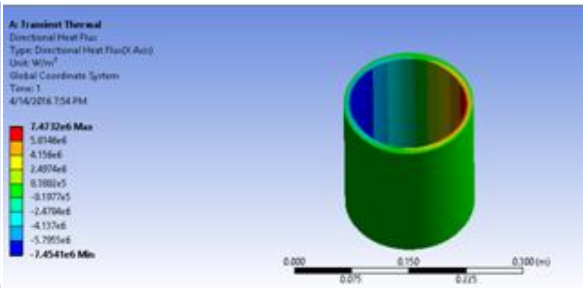
Total heat flux at 600^0 c



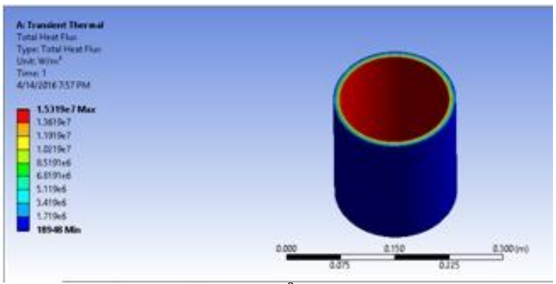
Directional heat flux at 600^{0C}



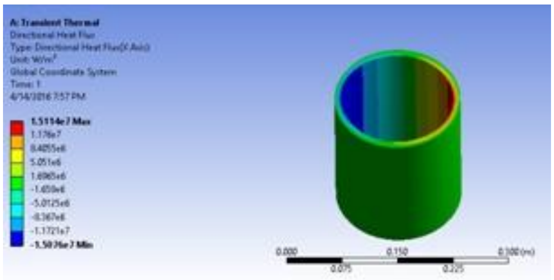
Total heat flux at 1000^{0}c



Directional heat flux at 1000^{0}c

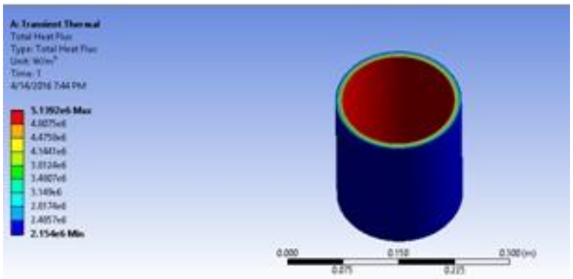


Total heat flux at 2000^{0} c

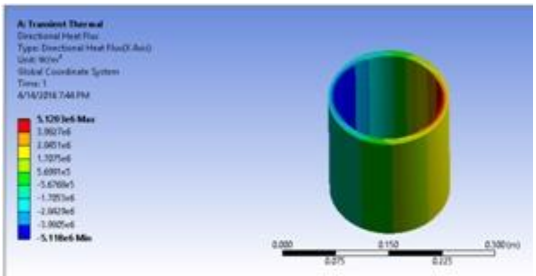


Directional heat flux at 2000^{0}c

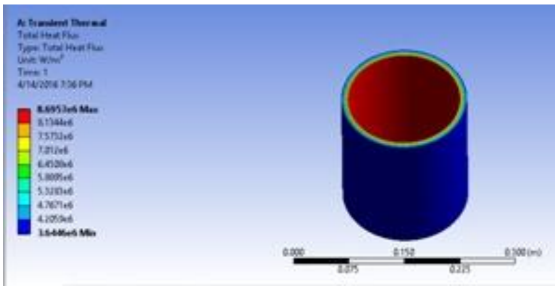
NICKEL:



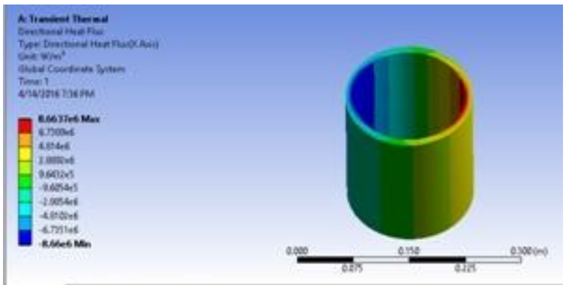
Total heat flux at 600^{0} c



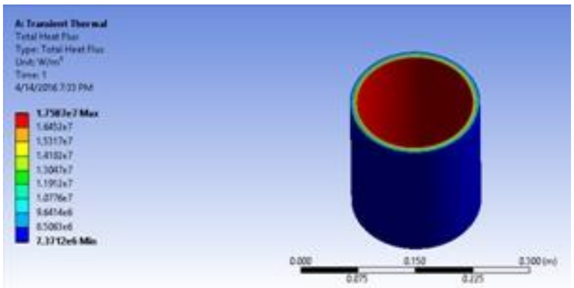
Directional heat flux at 600^{0} c



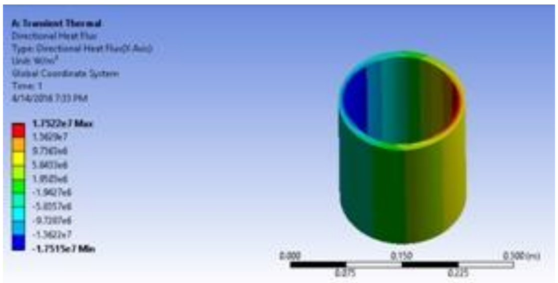
Total heat flux at 1000^{0} c



Directional heat flux at 1000^{0} c

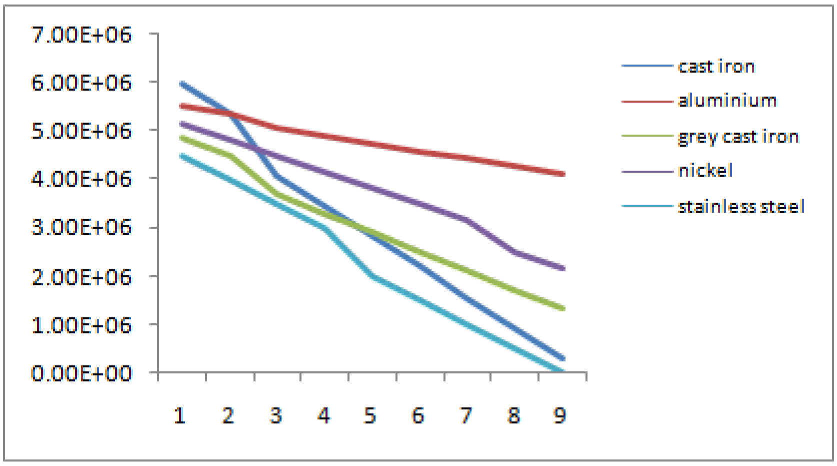


Total heat flux at 2000^{0} c

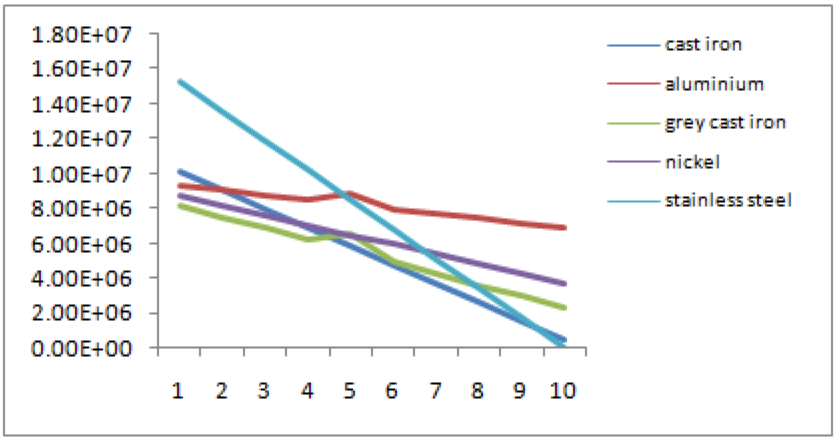


Directional heat flux at 2000^{0} c

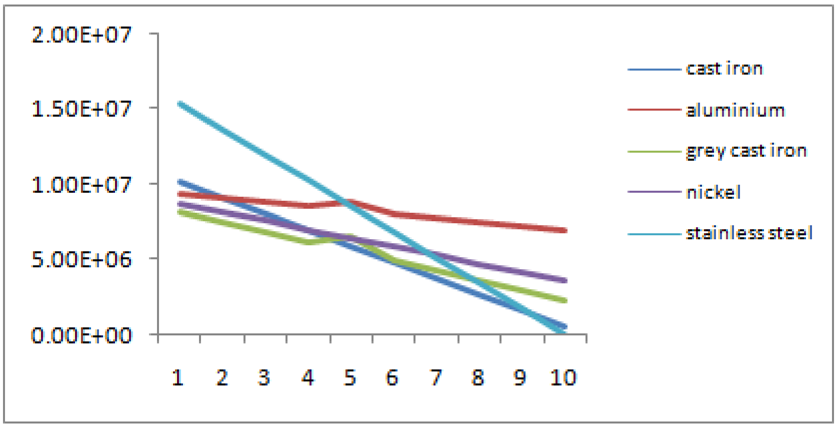
GRAPHS



Time vs total heat flux at 600^0c



Time vs total heat flux at 1000^0c



Time vs total heat flux at 2000^0c

VI. Conclusions

- Generally 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 & the cost is less compared. So it is mainly used in I. C Engine cylinder.
- Even though it gives reasonable heat transfer rate, its weight is more & cannot be used in all cases.
- In previous observations, we observed that aluminium & some other light weight materials are used instead of cast iron for weight optimization

- Due to the use of other light weight materials as an insulation around cast iron by reducing thickness of cast iron 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 can be achieved.

Cylinder made of different materials like stainless steel, aluminium, nickel are analyzed using CATIAV5R20 package for modeling and same can be imported to ANSYS for analysis. Depending on the thermal conductivity of the materials, heat transfer rate is analysed. With the advancement in material science, very light weight materials with good thermal and mechanical properties can be used for safe desugn of the IC engines.

References

[1] Dimitov L(2001), "*Principle of mechanical engineering design*".
[2] Mcvey(1955), "*material in engine design*".
[3] A text book on *Machine Design,* V.Bandari- TMH publishers.
[4] A text on *machine design* by SMD Jallaludin, Anuradha publications.
[5] *Design of machine elements* by pandya and shah.
[6] Timoshenko(1947),"*strength of materials*".
[7] A text book on *IC engines,* Mathur and Sharma- dhanpath rai and sons publications.
[8] A text book on *fundamentals of heat and mass transfer* by RC Sachdeva, new age international publication.
[9] SAE paper on "*weight reduced engine*"(1992) volume 101 "*journal of engine section-3*"
[10] Release 11.0 documentation for ANSYS work bench, ANSYS Inc., Canorsburg PA(2007).
[11] Ravindra R. Navthar and Prashant A. Narwade, " *Design and Analysis of Cylinder and Cylinder head of 4- Stroke SI Engine For Weight Reduction*" Material Selection ,International Journal of Engineering Science and Technology, vol 4 No.03 march 2012.
[12] Shiang Woei Chyuan, "*Finite element simulation of a twin-cam 16-valve cylinder Structure*", Finite Elements in Analysis and Design 35, 2000
[13] ANSYS element reference, *ANSYS 6.0 documentation*, ANSYS, Inc.
[14] 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, 2012