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Modeling & Analysis of Cylinder Block for V8 Engine

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ABSTRACT

Heat losses are a major limiting factor for the efficiency of internal combustion engines. Furthermore, heat transfer phenomena cause thermally induced mechanical stresses compromising the reliability of engine components. The ability to predict heat transfer in engines plays an important role in engine development. Today, predictions are increasingly being done with numerical simulations at an ever earlier stage of engine development. These methods must be based on the understanding of the principles of heat transfer.In the present work V type multi cylinder engine assembly is modeled by CATIA V5. This model is imported to ANSYS and done the steady state Thermal and Structural analysis for predicting thermal stress, temperature distribution by comparing with advance carbon material. (FU4270) from existing material (Aluminum).design a better cooling system. Fast transient heat flux between the combustion chamber and the solid wall must be investigated to understand the effects of the non-steady thermal environment. combustion (IC) engines. Locating hot spots in a solid wall can be used as an impetus to Heat transfer is one major important aspect of energy transformation in internal.

Keywords: Engine, CATIA, ANSYS, Cylinder, Heat flux, Thermal Stress.

1.0 INTRODUCTION

The finite element method (FEM) has now become a very important tool of engineering analysis. Whether a civil engineer designing bridges, dams or a mechanical engineers designing auto engines, rolling mills, machine tools or an aerospace engineer interested in the analysis of dynamics of an aero plane or temperature rise in the heat shield of a space shuttle or a metallurgist concerned about the influence of a rolling operation on the microstructure of a rolled product or an electrical engineer interested in analysis of the electromagnetic field in electrical machinery-all find the finite element method handy and useful. Traditional methods of engineering analysis, while attempting to solve an engineering problem mathematically, always try for simplified formulation in order to overcome the various complexities involved in exact mathematical formulation. The stress analysis in the fields of civil, mechanical and aerospace engineering, nuclear engineering is invariably complex and for many of the problems it is extremely difficult and tedious to obtain analytical solutions. One of the most popular numerical methods used is the Finite Element (FEM) offered by the existing CAD/CAM/CAE[1,2].

A V8 engine is a V engine with eight barrels mounted on the crankcase in two banks of four chambers, much of the time set at a privilege plot to one another yet frequently at a narrower edge, with each of the eight cylinders driving a typical crankshaft. There are two major types of V8 engine engines, which differ by crank shaft. Flat plane the flat plane V8 is like two inline four chambers imparting a solitary crankshaft. At the point when seen from one end, the crankshaft seems to structure a level shape and the same sort of flat plane V8 engine Cross plane The other, significantly more regular sort is the cross plane V8 is demonstrated in Fig which Cadillac concocted in 1923. The principal and fourth wrench pins are 180° separated, and the inward two are 180° separated from one another, and 90° separated from the pins on each one[3,4].

In this article included theoretical calculation, modeling and analysis of Cylinder Block for V8 Engine by using modeling and analysis software CATIA and Ansys.

2.0 THEORETICAL CALCULATIONS

Heat transfer through cylinder walls of an IC engine is followed by forced convection in combustion chamber, conduction in cylinder block, forced convection in coolant jacket and radiation from combustion of fuel (diesel or petrol) and coolant jacket.

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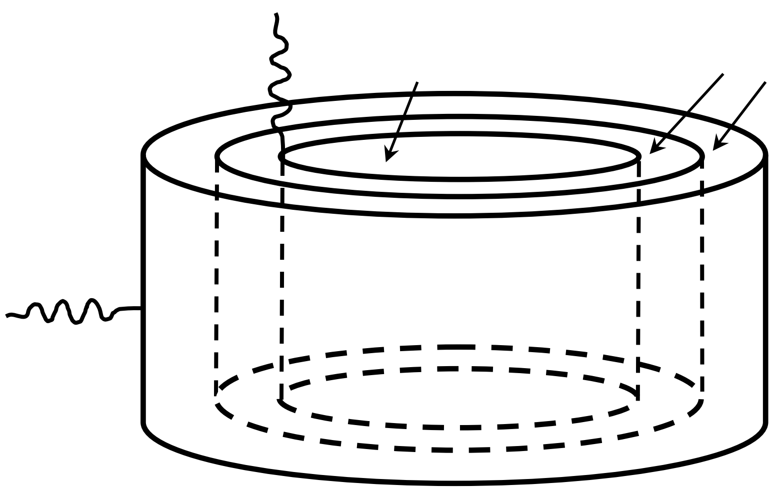


Formulas:

qg = hg(Tg-Tw) ;   qgr = hgr(Tg-Tw) ;   qw = k(Tw-Tc) ;   qc = hc(Tc-Ti) ;

qcr = hcr(Tc-Ti);

Since hgr = ϵ □((Tg) 2+ (Tw) 2) (Tg+Tw)

hcr = ϵ □((Tc) 2+(Ti)2) (Tc+Ti) from Arora Domkundwar

Total heat flux induced in cylinder block q = Q/A = qg+qgr+qw+qc+qcr

Value of qcr is negligible due to forced convection of water

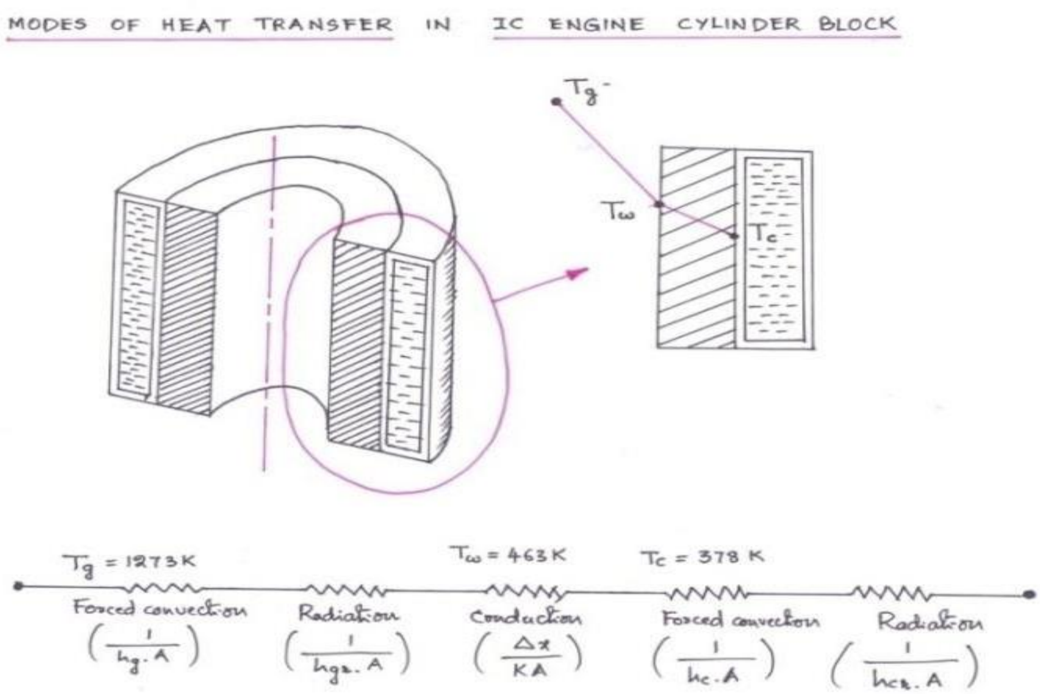
q= qg+qgr+qw+qc

q = U (Tg-Tc)

Therefore overall heat transfer coefficient

$U = \frac{1}{\frac{1}{hg}+\frac{1}{hgr}+\frac{\Delta x}{k}+\frac{1}{hc}}$ Where

qg & qc = Convective heat flux of combustion products and coolant jacket



qgr & qcr = Radiation heat flux produced by combustion products and from coolant jacket

qw = Conductive heat flux of cylindrical wall

hg & hc = Convective heat transfer coefficient of combustion products and coolant jacket

hgr & hcr = Radiation heat transfer coefficient combustion products and from coolant jacket

Calculations

Tg = Gas temperature = 1000 ˚c + 273 =1273K

Tc = Coolant temperature = 190 ˚c +273 = 463 K

Tw = Cylinder wall temperature = 105˚c + 273 = 368 K

Ti = Inlet temperature of water = 15 ˚c + 273 =298 K

Velocity of water =20 m/s

hg = 50 W/m2K

Δx = 0.025 m

Stefan-Boltzmann constant □ = 5.67 x 10-8 W/m2K4

Є = 1 (assuming black surface)

Radiation heat transfer coefficient

hgr = ϵ □((Tg) 2+(Tw)2)(Tg+Tw)

=1x5.67x10-8((1273)2 + (463)2) (1273+463) = 180.611 W/m2K

3.2 Convective heat transfer coefficient of coolant Jacket

hc = (Nu . K)/L

Where Nu = 0.59 Re0.25

L = characteristic length

Re = (ρ v D)/ μ

Where D = 0.1 m and length l = 0.091 m

Mean temperature Tf = (Tc +Ti)/2 = (105 + 15)/2 = 60 ˚C

At 60 ˚C water properties in heat transfer data book

ρ = 983.3 kg/m3 k = 0.654 Pr = 3.01 μ = 4.71 x 10 -4

Re = (983.3 x 20 x 0.1)/ 4.71 x 10 -4

= 4175371.55

Since it is laminar flow (106 -109)

Nu = 0.59 Re0.25 = 26.67

hc = (Nu . K)/L = (26.67 x 0.654)/0.091 = 191.67 W/m2K

Aluminum

Thermal conductivity is 28 W/m K

$$U_{al} = \frac{1}{\frac{1}{hg}+\frac{1}{hgr}+\frac{\Delta x}{k}+\frac{1}{hc}}$$

$$= \frac{1}{\frac{1}{50}+\frac{1}{180.611}+\frac{0.025}{28}+\frac{1}{191.67}}$$

Ual = 31.59875

qtotal = Ual (Tg - Tc)

= 31.5975 x (1273-378)

qtotal = 28280.88 W/m

FU 4270

Thermal conductivity is 40 W/m K

$$U_{al} = \frac{1}{\frac{1}{hg}+\frac{1}{hgr}+\frac{\Delta x}{k}+\frac{1}{hc}} = \frac{1}{\frac{1}{50}+\frac{1}{180.611}+\frac{0.025}{40}+\frac{1}{191.67c}} \frac{1}{\frac{1}{50}+\frac{1}{180.611}+\frac{0.025}{40}+\frac{1}{191.67}}$$

Ual = 31.8683842

qtotal = Ual (Tg - Tc)

= 31.8683842 x (1273-378)

qtotal = 28522.203 W/m2

FU 2451

Thermal conductivity is 60 W/m K

$$Ual = \frac{1}{\frac{1}{hg}+\frac{1}{hgr}+\frac{\Delta x}{k}+\frac{1}{hc}}$$

$$= \frac{1}{\frac{1}{50}+\frac{1}{180.611}+\frac{0.025}{60}+\frac{1}{191.67c}} \frac{1}{\frac{1}{50}+\frac{1}{180.611}+\frac{0.025}{40}+\frac{1}{191.67}}$$

= 32.0814

qtotal = Ual (Tg - Tc)

= 32.0814 (1273-378)

qtotal = 28712.835 W/m2

the thermal conductivities of the carbon materials FU 4270 and FU 2451 and for existing material Aluminum alloy and the total heat transfer obtained from the above mathematical calculations are shown

Theoretical values of Thermal Conductivity and Heat Transfer of materials

Material	Thermal Conductivity k (W/m K)	Heat Transfer q' (W/m2)
Aluminum	28	28280.88
FU 4270	40	28522.203
FU 2451	60	28712.835

3.0 MODELING OF CYLINDER BLOCK

Machine Aided Design is a procedure in which man and machine are mixed into critical thinking group, personally coupling the best qualities of each [6]. The aftereffect of this mix meets expectations better than either man or machine would work alone , and by utilizing a multi discipline approach, it offers the focal points of incorporated cooperation. circle or tape for the recovery at the later date for the use in some other plan.

3.1 CATIA Models of Cylinder Block Modeling of cylinder block in CATIA Part Design Module

sketch with dimensions of the cylinder block To enter sketcher select sketch icon, select a plane as sketching plane

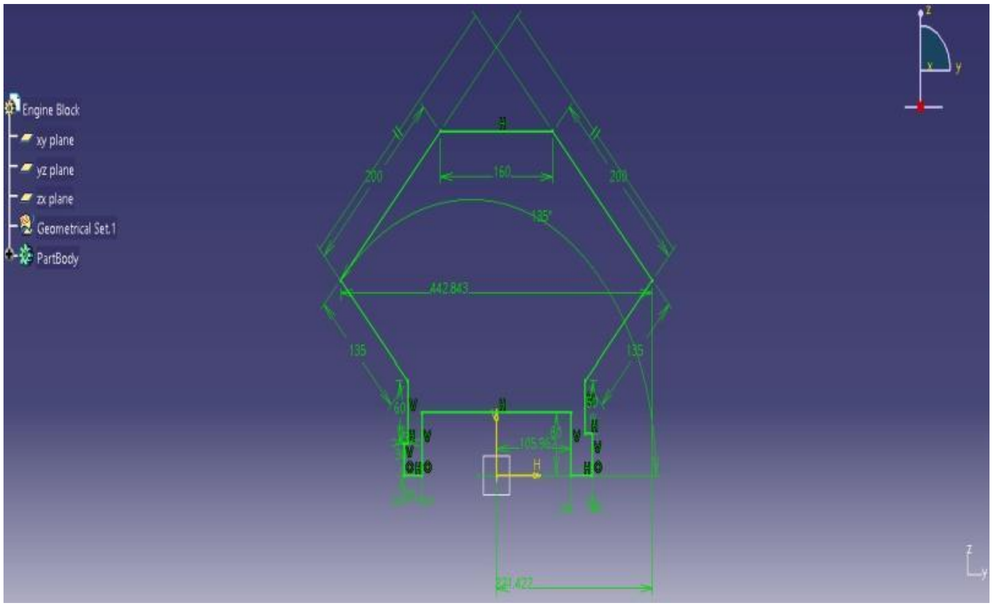


Fig 1 Sketch of a Cylinder Block

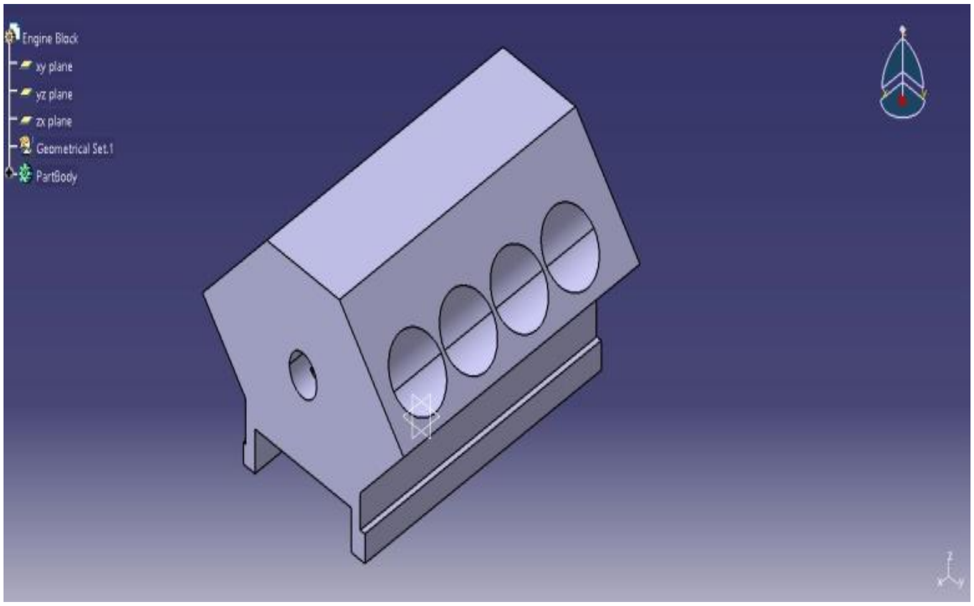


Fig 2 Model a of Cylinder Block

4.0 ANALYSYS OF CYLINDER BLOCK

In the present chapter analysis is done using ANSYS WORK BENCH for the completed cylinder block modeled in CATIA V5 and the analytical values of equivalent stress, heat flux, normal stress and deformation are tabulated.

4.1 Analysis Results of Cylinder Block for Aluminum

Geometry of the cylinder block imported to Ansys.

Meshing of the Cylinder Block the Meshing of the cylinder block by with individual elements.

Steady State Thermal Analysis of Cylinder Block

The above Fig shows the steady state thermal analysis and temperature is applied in three areas A, B and C.

Total Heat Flux of the Cylinder Block

Imported Body Temperatures

Equivalent Stress generated in Cylinder Block The above Fig 5.6 shows Equivalent Stress is generated in the cylinder block along the axial direction and max stress is generated as 75.172MPa and min stress as 0.0014682 MPa

Total deformation generated in cylinder block

The above Fig 5.7 Total Deformation will be generated in the cylinder block and maximum and minimum deformations are marked.

Analysis Results of Cylinder Block for FU 4270

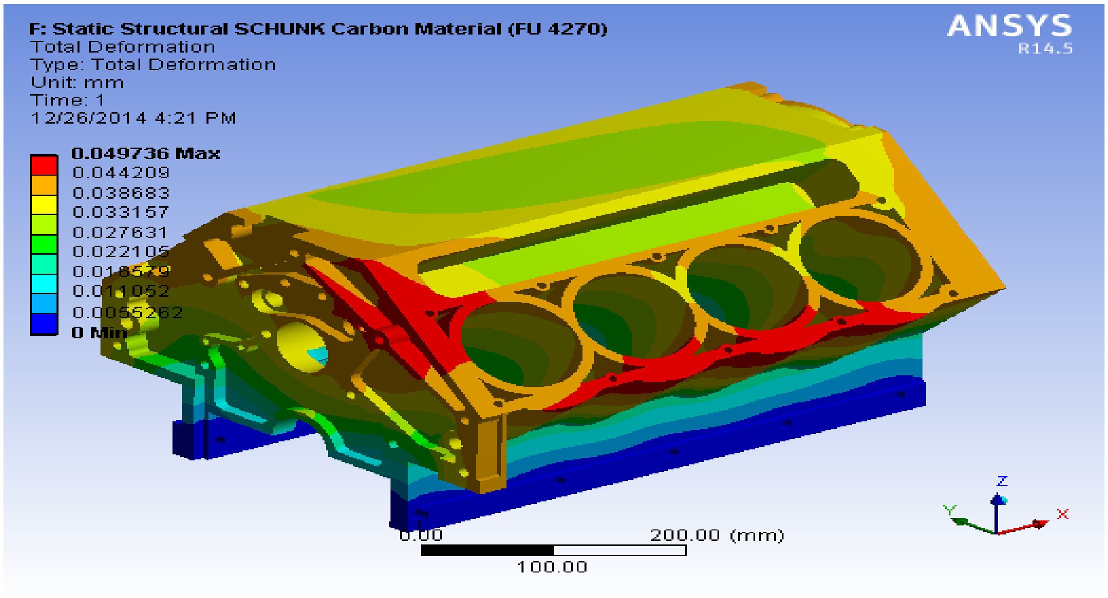


Fig 3 Analysis Results of Cylinder Block for FU 4270

shows the maximum temperature distribution for cylinder block

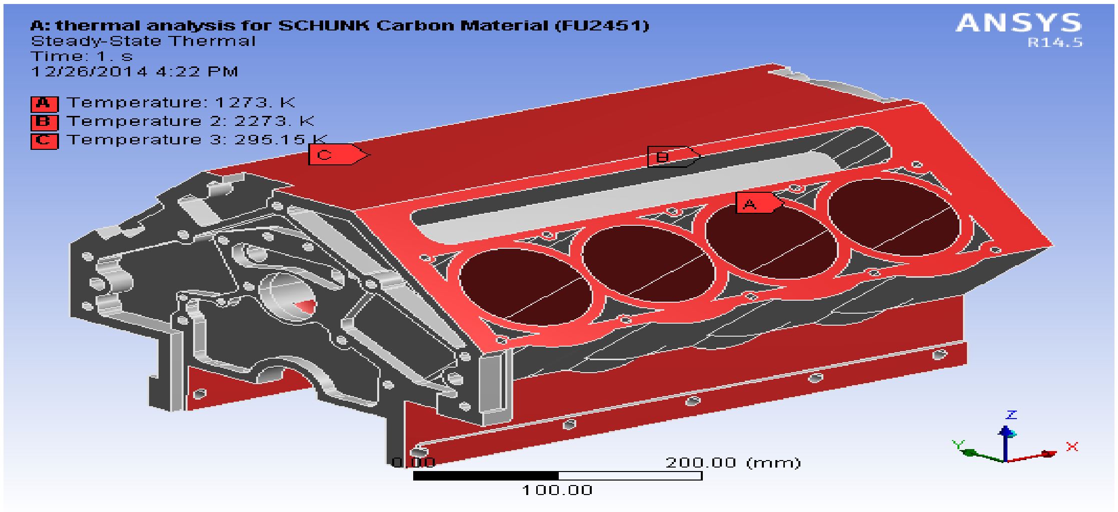


Fig 4 Analysis Results of Cylinder Block for FU 2451

Temperature distribution for Cylinder Block of FU 2451

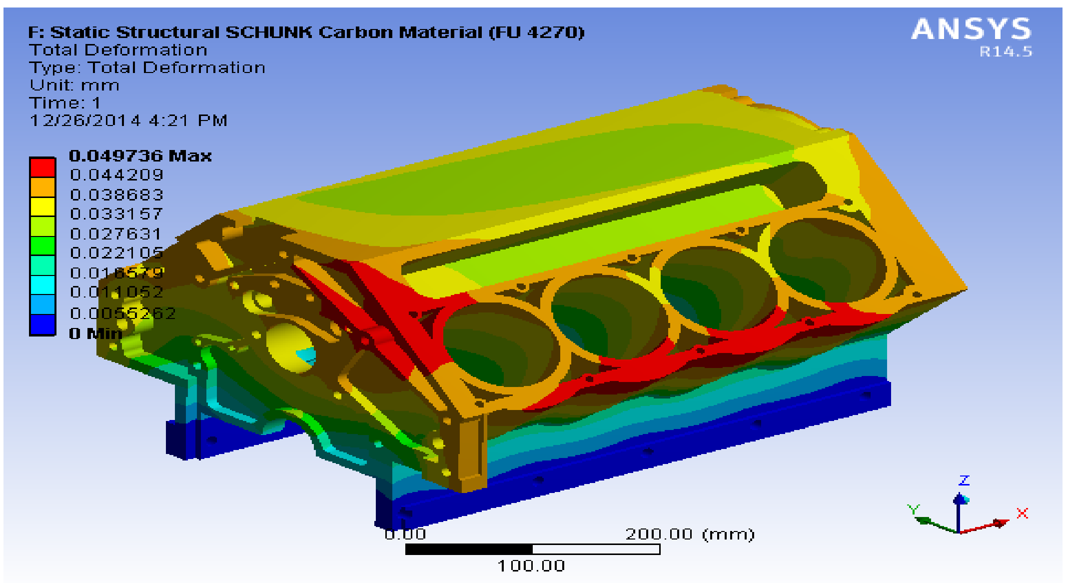
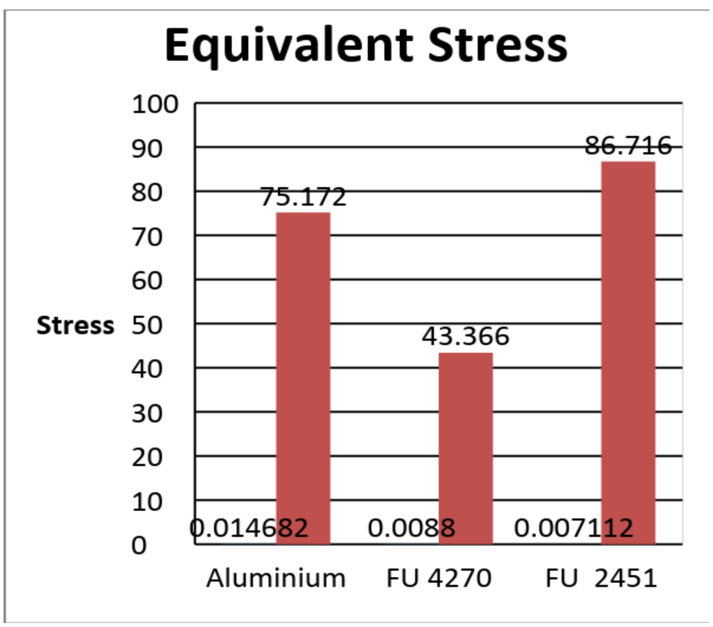


Fig 5 Deformation induced in Cylinder Block for FU2451

Parameters	Aluminum(k= 28)		FU 4270 (k= 40)		FU 2451 (k= 60)	
	Max	Min	Max	Min	Max	Min
Temperature (K)	2274.6	295.15	2274.6	295. 35	2274.6	295.15

Total Heat Flux(W/m2)	0.028106	0	0.028336	0	0.028624	0
Imported Body Temperature (K)	2274.6	295.15	2274.6	295.15	2274.6	295.15
Equivalent Stress(MPa)	75.172	0.014682	43.366	0.0088	86.716	0.007112
Normal Stress(MPa)	31.15	-31.583	18.701	-18.972	34.88	-26.101
Shear Stress(MPa) at XY Plane	14.521	-12.03	8.7421	-7.7247	11.518	-17.515
Total Deformation(mm2)	0.081694	0	0.049736	0	0.077175	0



Graphical representations for resultant values

By doing the steady state thermal analysis using ANSYS work bench 14.5 V and by calculating the convective heat transfer amount through cylinder walls from the theoretical calculations, and calculated the heat flux and equivalent stress, normal stress and the total deformation produced for the cylinder block for Aluminum FU 4270 and FU 2451 along with their thermal conductivities, and their results analytical Results (FEA) for Aluminum, FU 4270, and FU 2451

Validation of Heat Flux by Mathematical and Analytical calculations the theoretical heat flux and mathematical heat flux values for the all the three materials and their resultant percentage of between the two values. theoretical calculations and analytical calculations (FEA), and the results are showing within ±1%. So from the above values by plotting results for two different materials with existing material it compared thermal Stress, temperature distribution and Heat Flux are lower in FU 4270 Material so this is best material for fast transient heat transfer between the combustion chamber and the solid wall.

Graphical representations for resultant values graphs can be drawn by using temperature distribution, heat flux, and equivalent stress and normal stress and finally draw the graph for Mathematical calculations and Analytical calculations.

Stress comparison for Aluminum, FU 4270, and FU 2451 comparison of Equivalent Stress for Aluminum, FU 4270, FU 2451.Resultant Graph between Analytical Flux Vs Mathematical Heat Flux shows the graph comparison for analytical heat flux and mathematical heat flux for Aluminum, FU 4270 and FU 2451.

From the above graphs by comparing for the FU 4270 and FU 2451 carbon materials with existing material Aluminum alloy, it is concluded that thermal stress, temperature distribution and heat flux are lower in FU 4270 Material, so this is best material for quick transient hotness exchange between the burning chamber and the cylindrical wall.

4. CONCLUSION

It is important transient hotness exchange between the burning chamber and cylinder wall in V8 engine, transient hotness exchange depends largely on the materials of the cylindrical block. In the present work transient hotness exchange between the burning chamber and cylinder wall is compared for three different materials. For this first modeling of V8 cylinder block was done using CATIA V5, and analysis was done using ANSYS. Theoretical values of the thermal stresses, temperature distribution, normal stresses, heat flux and deformation are also calculated, and compared with ANSYS values.By comparing for the FU 4270 and FU 2451 carbon materials with existing material Aluminum alloy, it is concluded that thermal stress, temperature distribution and heat flux are lower in FU 4270 Material, so this is best material for quick transient hotness exchange between the burning chamber and the cylindrical wall

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