RESEARCH ARTICLE OPEN ACCESS

Heat Transfer Analysis of different Composite Materials in Engine cylinder

C.Rajaravi[1], L.Santhosh[2], R.Iyappan[3], A.Annaidasan[4]

1Assistant Professor, 2 Student
[1,2]Department of Mechanical Engineering, Veltech Multitech Dr.Rangarajan Dr.Sakunthala Engineering College, Chennai-68, Tamilnadu, India,)

Abstract:

In this paper, at present metal alloy and super alloys are used in piston cylinder. It is subjected to high thermal stress on the cylinder. It reduces overall performance. Thus, to overcome this, propose different alternative composites for engine cylinder. Carbon-Carbon Composite (C-C) and Metal Matrix Composites (Al/TiB_2) are designed and thermal analyses are carried out by using ANSYS. The analytical result of the proposed design is compared with existing engine cylinders.

Keywords — **Carbon-Carbon Composite, Metal Matrix Composite, Engine cylinder, ANSYS.**

I. INTRODUCTION

Aluminum metal matrix composites are being widely used in automotive and aerospace industries, due to their excellent mechanical properties such as high stiffness, wear resistance and thermal stability [1]. Aluminum titanium boride (Al-TiB_2) is particularly attractive because it exhibits High elastic modulus and hardness and High melting point and good thermal stability. Wear resistance without any apparent loss of thermal expansion coefficient. TiB_2 particles do not react with aluminium and thereby avoid the formation of brittle reaction products at the reinforcement-matrix interface [2].

Carbon-Carbon(C-C) Composite materials with a spectrum of properties and applications in various areas. The carbon fibres have proved to be the main reinforcement for advanced composites for a wide range of applications. The majority of products still belong to high technology space and aeronautics [3]. Composite materials potentially offer an efficient solution for these design problems due to their high strength to weight characteristics and their high heat resistant properties [4].

The conventionally used aluminium is selected as the material and it is very important to check whether the alternate composite cylinder will serve the purpose of heat distribution the wear rate is not too high so that they may used for different composite cylinder [5].

ANSYS Mechanical technology incorporates both structural and materials non linearity’s. ANSYS Multiphysics software includes solver for thermal, structural, CFD, electromagnetic, and acoustics and can couples these separate physics together in order to address multidisciplinary applications. ANSYS software is also used in Civil Engineering (ANSYS/CivilFEM), Electrical Engineering, physics and chemistry design [6].

In this work combustion chamber is designed by pro-E and thermal analyses are carried out by using ANSYS. The ANSYS result of existing model is compared with proposed model.

II. PROPOSED RESEARCH WORK

A. Design of cylinder

The Fig.1 shows the cylinder is constructed using a concentric tube design. It is modelled after the design of several different engine .The inner shells, the flame tube, is made of 22-gauge perforated steel. Air flow from the compressor is fed through the flame tube as well as around its sides. The air in the flame tube is burned with the propane, while the air on the outside of the flame tube is used to cool the products of combustion before they enter the cylinder. The Table 1 shows the properties of different composite.

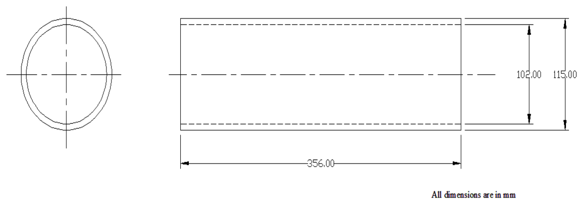

Fig.1.Chamber shell

TABLE I

PROPERTIES OF DIFFERENT COMPOSITE

S. No	Materials	Density Kg/m^3	Specific heat J/Kg.K	Thermal conductivity (W/m.K)
1	Carbon fiber	1928	$921x10^{-6}$	4
2	Carbon matrix	1800	$712x10^{-6}$	10
3	Al/TiB_2	3420	$790x10^{-6}$	19

B. Typical theoretical for calculation for C-C

The thermal calculation for Carbon-Carbon composite as shown in Fig.4 the calculations are given below.

(i) Heat transfer per unit area (heat flux),

$Q = (T_1 - T\infty)/((1/hi.A)+(L/k.A))$

$= 1273-303/((6.75\times10^{-3}/11.5)+(1/50))$

$Q = 47117.212$ W/m²

(ii)Temperature at the outer surface,

$Q = (T_1 - T_2)/(L/k.A)$ 47117.212

$= (1273 - T_2)/(6.75\times10^{-3}/11.5)$

$= 1245.34$ K

$T_2 = 972.34$ °C

(iii) Thermal gradient,

$-dT/dx = (1000-972.34)/6.75\times10^{-3}$

$= -4097.77$ °C/ m

C. Typical Design of C-C Composite

There are five types preference, pre-processor, Meshing, solution and post processor are given below.

1) Preferences >Thermal>ok.

2) pre-processor > i) Element type>add>solid>quad 4node55>ok.ii) Material properties>temperature units>Celsius>ok. iii) Material models1>Thermal>conductivity>isotropic> KXX = 4 W/m K, C = 921e-6 J/Kg K, ρ = 1928 Kg/m³.iv) Material models 2>Thermal>conductivity>isotropic> KXX = 10 W/m K, C = 712e-6 J/Kg K, ρ = 1800 Kg/m³.v) Modelling>create>area>rectangle>by two corners, Width = 6.75e-3, Height = 6.75e-3m, vi) Modelling>create>area>circle>solid circle > radius = 0.2e-3m,vii) Modelling>operate>Booleans>subtract>ok. viii) Modelling>operate>Booleans>glue>ok.

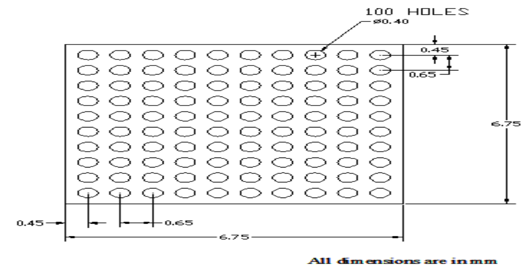

Fig.2. Modelling diagram for c-c composite

3. Meshing>mesh attributes>picked areas>material model1>selected area>ok. x) Meshing>mesh attributes>picked areas>material model2>selected area>ok.xi) Meshing >mesh tool>mesh>ok.

4. Solution> I) define load>apply>Thermal,i) Temperature > = 1000°C.ii) Convection>Film coefficient = 50 W/m² K. Bulk temperature = 30°C. iii) Heat generation>on lines>pick lines>ok Heat generation = 3, 83, 74,678 W/m³. II) Solve>current LS>ok.4. General post processor>I) plot results>contour plot> i) Nodal solution>DOF > temperature distribution>ok.ii) Nodal solution>thermal gradient>ok.iii) Nodal solution>thermal flux>ok,iv) Element solution>geometry>volume>ok,.v) Element solution>heat flow>ok.

III. RESULTS AND DISCUSSION

The figure 3 and 4 shows that the distribution of Temperature and heat flux of the Al/TiB2 MMCs induced within the cylinder materials in simulation results are maximum total heat flux in the obtained 48.24 MW/m^2 and 1000 ˚C respectively.

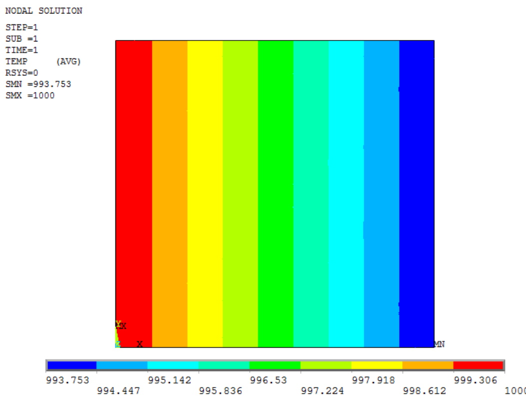

Fig. 3.Temperature distribution for Al/TiB_2 MMC

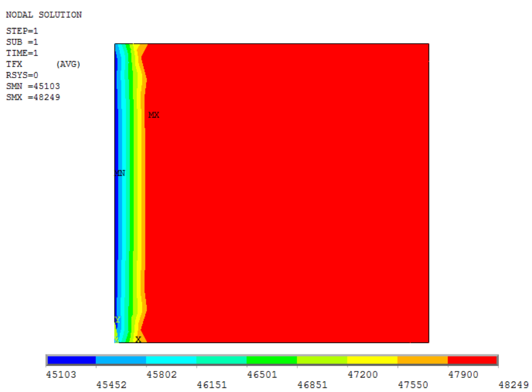

Fig. 4 Heat flux for Al/TiB2

The figure 5 and 6 shows that the distribution of Temperature and heat flux of the C-C composite induced within the cylinder materials in simulation results are maximum total heat flux in the obtained 47.9 MW/m^2 and 1000 °C respectively.

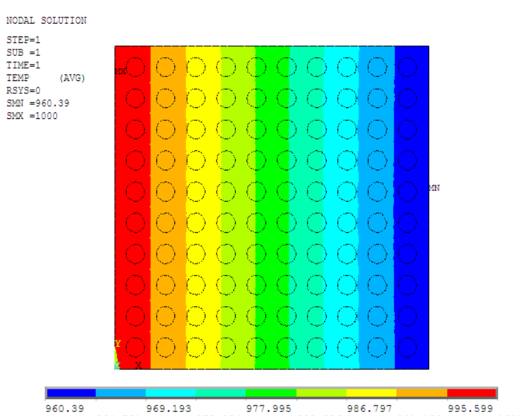

Fig. 5. Temperature distribution for C-C

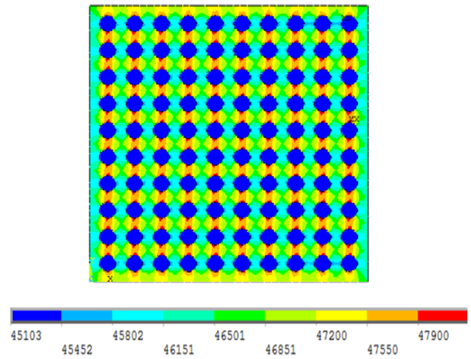

Fig. 6 Heat flux for C-C

Figure.7 shows the comparison of Thermal flux with different composite material. The Thermal flux is found to be very low in C-C composite material when compare to Al/TiB2 MMCs and alloy. Because it is heat restricted in carbon fibre is more.

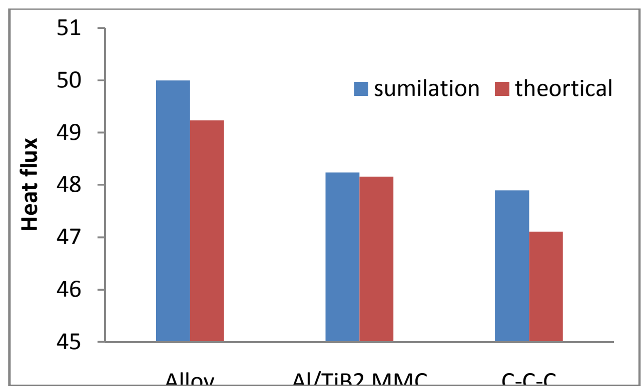

Fig. 7 Total Heat Flux Comparison

Table.2 shows The heat flux comparison of simulation results and theoretical results. It shows therictical and simulatation values are come to close. It attained % of error maximum 1.7% only. It reduce the temperature distribution of cylinder without insulation condition

TABLE III

COMPARISON OF DIFFERENT COMPOSITE

S.No	Material	Total heat Flux (MW/m2)		% of error
		Theoretical	Simulated	
1	Alloy	49.24	50.1	1.7
2	Al/TiB2	48.16	48.24	0.6
3	C-C-C	47.11	47.9	1.6

IV. CONCLUSIONS

From the analysis results of different material on cylinder is observed that total heat flux reduces in Carbon-Carbon composite compared to Al/TiB_2. Results comparison between theoretical and analysis simulated done and found approximately same. So the Carbon-Carbon composites are more suitable for the engine cylinder.

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