DESIGN AND ANALYSIS OF PISTON BY COMPOSITE MATERIAL

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ABSTRACT

This paper deals with Design and analysis of Piston by Composite Material.Since the temperatures withstand inside the Engine cylinder should be very high,hence we are using the Aluminium silicon carbide as composite material . The piston are made of Aluminum for lightweight, thermal conductivity. But ithas poor hot strength and high coefficient of expansion makes it less suitable forhigh temperature applications A 3D model is made by CATIA V5 and static and thermal analysis is made by ANSYS16.0 .In this project, Aluminum Silicon Carbide (AlSiC),an aluminum matrix composite is used as an alternative for aluminium.ComparedwithtoAluminium, AlSiC has better abrasion resistance, creep resistance, dimensionalstability, exceptionally good stiffness-to-weight and strength-to-weight ratios andbetter high temperature performance. Fabrication of piston using AlSiC is alsoeasier than using Aluminium.

I INTRODUCTION

The piston is a component of reciprocating pumps and pneumatic cylinders it is the moving component contained by a engine cylinder and gas tight is mabe by pistonrings. In an engine its purpose is to transfer force from expanding gas in the cylinder to the crankshaft via piston rod.In this paper we are using composite material as aluminium silicon carbide.Aluminium-Silicon Carbide is a metal-ceramic composite material consisting of silicon carbide particles dispersed in a matrix of aluminium alloy. Itcombines the benefits of high thermal conductivity of metal and low CTE(coefficient of thermal expansion) of ceramic.With its composite features,Al-SiC is an advanced packaging material for high technology thermalmanagement. Al-SiC is compatible with a wide range of metallic and ceramicsubstrate and plating materials used in microelectronic packaging for aerospace,automotive, microwave applications.Microstructure Of AlSiC. A 3D model is made by CATIA v5 and static and thermal analysis are made byANSYS16.0.

Table 1:Material Properties

The table1shows that the material properties of piston for the composite material. From the table the properties such as elastic modulus, density, specific stiffness, thermal conductivity, specific heat, tensile strength & yield strength, should be maintained as per limits

Property	Units	Al/SiC Metal Matrix Composite			A356-T6 Aluminium
SiC concentration	Vol%	20%	30%	40%	
Matrix		359Aluminium	359Aluminium	359 Aluminium	
Elastic modulus	MSI Gpa	14.3 99	17.4 120	21.3 147	10.5 72
Density	lb/in^3 g/cm^3	0.0989 2.74	0.1011 2.8	0.1040 2.81	0.0970 2.69
Specific stiffness	$in*10^9$ $Gpa\text{-}cm^3/g$	144.6 36.1	172.1 42.9	205.4 51.2	108.2 26.7
Mean CTE(to212F) (to100C)	ppm/F ppm/C	9.1 17.5	8.1 14.6	6 11.9	11.9 21.4
Thermal Conductivity	BTU/ft-hr-F W/m-C	107 185	107 185	107 185	88 152
Specific Heat	BTU/lb-F J/kg-K	0.2 837	0.19 795	0.17 763	0.21 900
Tensile Strength	KSI Mpa	52 359	31.4 216	32.7 226	38 762
Yield Strength(0.2%)	KSI Mpa	44 303	30.5 210	28.9 199	27 186
Elongation	%	<1.0	<1.0	<1.0	5

II CATIA MODEL OF PISTON

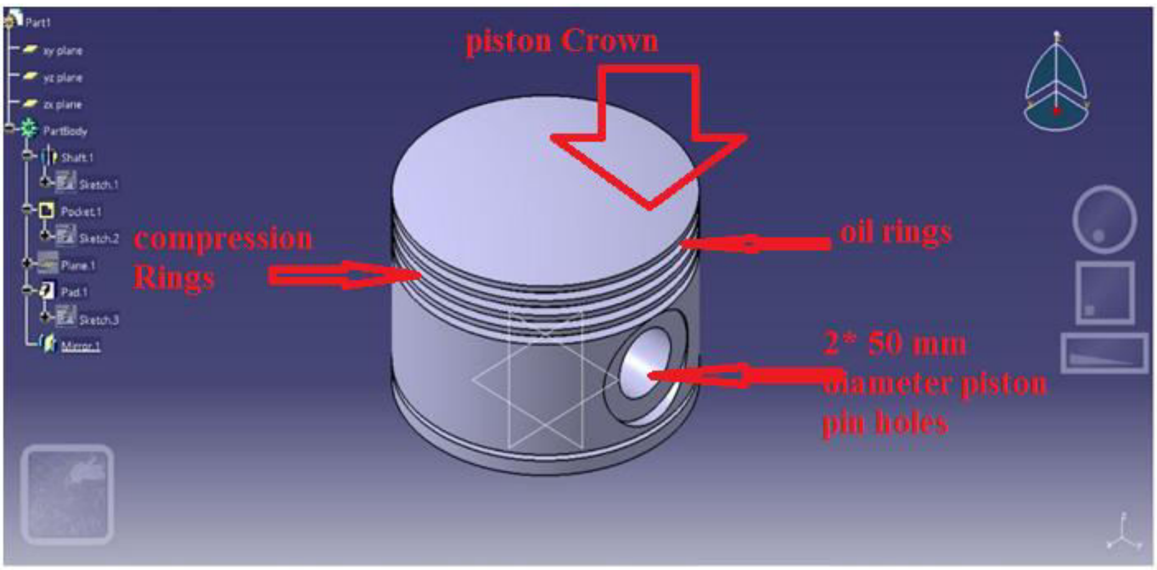

Figure.1: 3D model OF piston using Catia v5

The figure1 shows that the Piston modeled using Catia V5.The parts drawn and assembeled here as follows a)compression rings b)oil rings c) 2* 50 mm diameter holes respectively.The features used here to model the product is Extrude ,revolve& mirror the Complete Piston .

III STATIC STRUCTURAL ANALYSIS

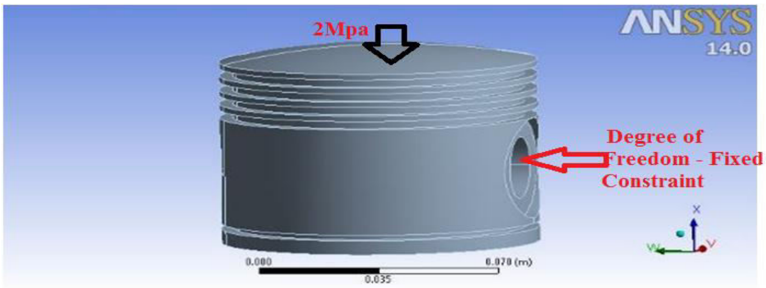

Figure.2:Static Stuctural Analysis

The figure 2 is the static model of the piston which was made for the static analysis of the piston . here piston undergoes some load on the surface of piston head.So that the static stress and strain are created.The material aluminum silicon carbide is applied for the component. A static structural analysis determines the displacement stress strain and force in structures or components caused by loads that do not induce significant inertia and damping effects. [3] discussed about a disclosure which is made regarding a driving alert system which is designed in the form of a neck cushion which has the capability to sense the posture of the drivers neck position so as to identify whether the driver is alert and if he is dozing of. The system is made intelligent to obtain data from the movement so as to produce triggers to alert the user and to keep him/her awake to avoid accidents. The system is also linked to a mobile computing device so as to provide a report of the analysis done. The drivers location can also be tracked using the same.Steady loading and response conditions are assumed that is the loads and structure's response are assumed to vary slowly with respect to time. [6] discussed about a disclosure which is made regarding a gear blocking gear cover for the four wheeler vehicle where the protective cover has been with touch sensors and biometric sensors. Here in case of theft even if the car is started without a key the gear system is locked using biometric locks which can read the palm of the user to unlock the gear system thus protecting the vehicle against any form of theft. This device can be attached to any type of four wheeler vehicle.Static structural load can be performed using the ANSYS. The types of loading that can be applied in a static analysis include:

1.Externally applied forces and pressures.
2.Steady state inertial forces (such as gravity or rotational velocity).
3.Imposed (non zero) displacements.
4.Temperatures (for thermal strain).

IV EQIVALENT STATIC STRESS

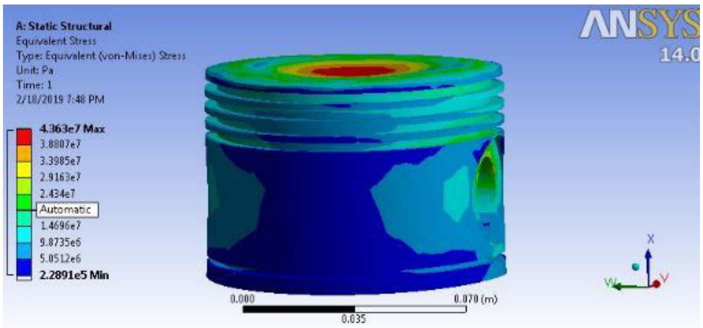

Figure 3:Static Stress

The figure 3 shows that static stress analysis of piston . The load of 2 Mpa is applied on upper surface of the piston and the constrain (fixed point) is arrested on the 2 holes inorder to hold the gases tightly.Hence degree of freedom is arrested over the uppersurfaces and lower surfaces provided in the holes.

V EQUIVALENT ELASTIC STRAIN

Strain is the measure of the deformation of the material

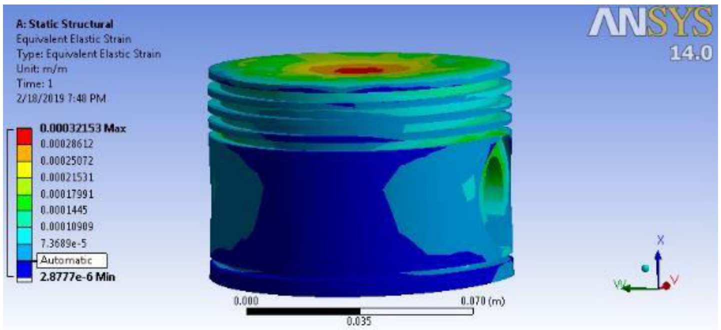

Figure.4:Static Strain

VI STATIC STRUCTURAL DEFORMATION

- Red colour indicates maximum deformation
- Blue colour indicates minimum deformation

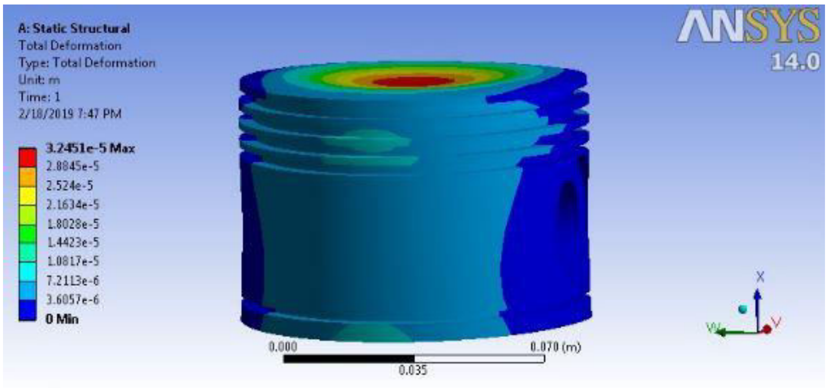

Figure.5:Total Deformation

VII THERMAL STRUCTURAL ANALYSIS

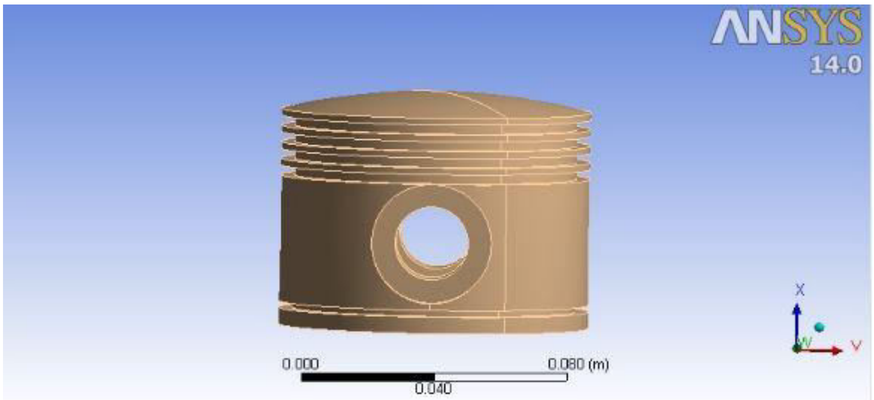

Figure.6:Thermal Analysis Component

Thermal analysis is a group of techniques by using this technique the physical property variation of the component is measured. As the piston undergoes high temperature in the combustion chamber ,the material should be with low coefficient of thermal expansion(CTE).So we are using aluminium silicon carbide which was metal matrix composite material. It was lighter thanaluminium and can withstand high temperature. The maximum temperature acts on the surface of the piston.

VIII TEMPERATURE DISTRIBUTION

The FIGURE7 shows the temperature distribution of the piston

- Red colour indicates the maximum temperature.
- Blue colour indicates the minimum temperature

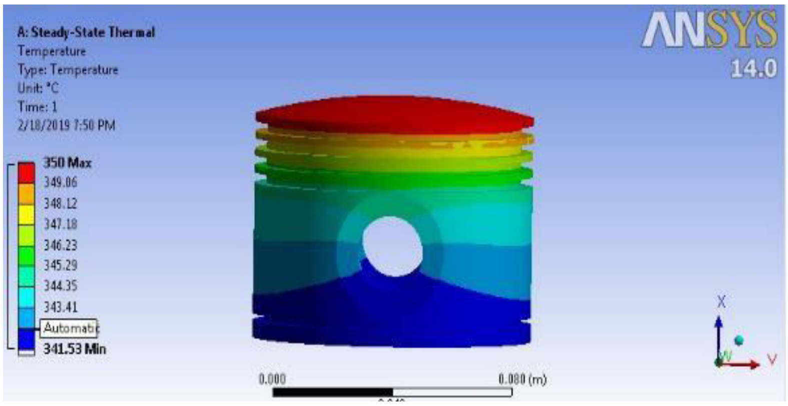

Figure.7:Temperature Distribution

The Figure 7 shows that temperature distribution (Thermal analysis) of piston in order to calculate the coefficient of linear expanison and toevaluate the thermal analysis obtained vs standard limits. From the results it was clearly understood the obtained results are lower than standard values.

TOTAL HEAT FLUX

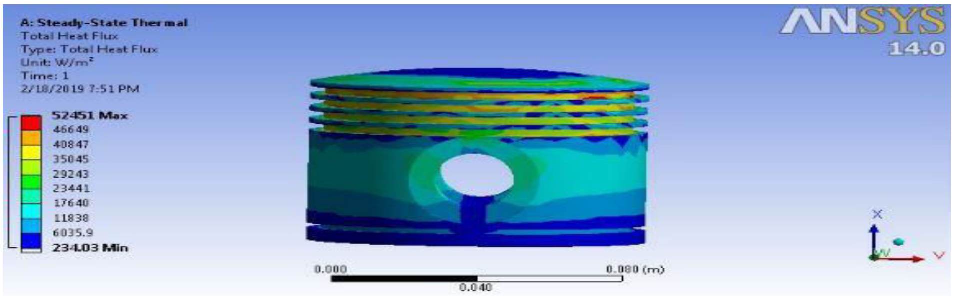

Figure.8:Total Heat Flux

The figure 8 shows that total heat flux obtained from piston crown including piston rings.Heat liberated is less than standard limits.

IX RESULTS AND CONCLUSION

From the above results.(Figure 2,3,4,5)Static analysis shows that the stress induced for composite material is less than standard allowable stress and deformation is low as compared to standard deformation.The figure 6,7,8 shows that thermal stress analysis of piston for composite material.It was clearly understood that Co efficient of Thermal expansion is low as compared to other material,Hence we are suggested to use Aluminium silicon carbide material for design and recommended to use.

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