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# Design and Analysis of Composite Material on Piston and Piston Rings

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**ABSTRACT:** The piston is the heart of an engine and its working condition is the most important key parts of the engine in the workplace. It is the moving part that is contained by a barrel and is made gas-tight by piston rings. In this study, first, thermal analysis are done on a piston, made of Cast Aluminium alloy, titanium alloy and AlSiC. Then, structural analyses are performed on piston of AlSiC, titanium alloy & Aluminium alloy material by using ANSYS software. The thermal behaviours of the piston are investigated. The main objective is to investigate and analyze the thermal stress distribution of piston at the real engine condition during combustion process and manufacturing process for composite material (AlSiC) This work is done by utilizing finite element analysis to predict the higher stress and critical areas on the component. In order to find the material property of composite material (AlSiC), titanium alloy, displacement, thermal and stress appropriation of the piston, ANASYS software is used to analyse the piston under the thermal loads and mechanical loads.

**KEY WORDS:** piston and piston ring, Aluminium Alloy, AlSiC, Titanium Alloy, Thermal stress, ANSYS

## I. INTRODUCTION

The Piston is the 'heart' of an automobile engine. It's one of the key components of the engine and is the most hard working component. It is the moving component that is enclosed in the engine cylinder and is made gas-tight by piston rings. Piston works in high temperature, high pressure and high speed. Since piston comes in contact with high temperature gas directly, the instantaneous temperature can rise up to 2500K. Because of the high temperature the top part of the piston can reach upto 600~700K when the piston working in the engine and the temperature distribution is uneven. The top of the piston bears the gas pressure, in particular, the work pressure. Its purpose is to transfer force from expanding gas in the cylinder to the crankshaft via a connecting rod. This working condition may cause the fatigue damage of piston, such as piston side wear, crown cracks and so on. This paper shows the thermal stress distribution on piston of IC engine by using FEA and using ANSYS software, where simulation and stress analysis is performed.

## II. METHODOLOGY

### MATERIAL SELECTION

Sintering (AlSiC), Stir casting (AlSiC), Squeezing (AlSi12) is the process of fusing particles together into one solid mass by using a combination of pressure and heat without melting the materials in the reference. The Bajaj motor cycle piston material is made of cast aluminum alloy (A2618). Comparing it with aluminum silicon carbide, the thermal conductivity and other property value is low in A2618.

### Components

The following components are used in this process. They are aluminum, silicon carbide, die, wax, zinc oxide or aluminum oxide



### III. PROPOSED THEME

#### SINTERING

Sintering is the process of fusing particles together into one solid mass by using a combination of pressure and heat without melting the materials

.Aluminum silicon carbide

The capacity of the die is 33g. Here, we used 24g of aluminum and 9g of silicon carbide.

Mixed it in a bowl for an hour .

Like moulds , dies are generally customized to the item they are used to create.

Products made with dies range from simple paper clips to complex pieces used in advanced technology.



FIGURE

#### DIE

A die is a specialized machine tool used to cut or form material to a desired shape or profile.

Pouring the mixed material (Aluminum siliconcarbide ) into the die .

Fix the die in the Universal Testing Machine (UTM) .

Give the load of 100 KN in UT machine and compress the powder material using the die .



The solid material is kept in the muffle furnace in the temperature of 450 °C for 1 hour of time duration.

**STIR CASTING (Al SiC)**

Stir casting is a liquid state method for the fabrication of composite materials, in which dispersed phase is mixed with a molten matrix metal by means of mechanical stirring.

In order to fabricate the composites, 1g reinforcement SiC powder was encapsulated carefully in an aluminum foil packet for insertion into the molten aluminum in order to fabricate a composite with 3 wt% SiC as reinforcement.

These powders were preheated at 350 C for 4 hours before the casting process to remove the moisture and impurities.

The pure aluminum was heated to various temperatures of 680 and 850 C within a bottom-pouring furnace.

A preheated graphite stirrer was placed below the surface of melt and rotated at a speed of 500 r min<sup>-1</sup>, and simultaneously argon gas of high purity was used as a protective shroud on the melt surface.

The schematic of the setup used for the stir casting process. The composite slurry was poured into a low-carbon steel mold. 1 wt% Mg was added to the melt to increase the wettability between the matrix and the reinforcements.

First, a lower casting duration is economically preferred; Secondly, the reaction between matrix and reinforcement occurs over a period of time, meaning that this detrimental phenomenon could be avoided using a lower stirring period; Thirdly, a higher casting duration might lead to entrapment of a larger amount of porosity after solidification.

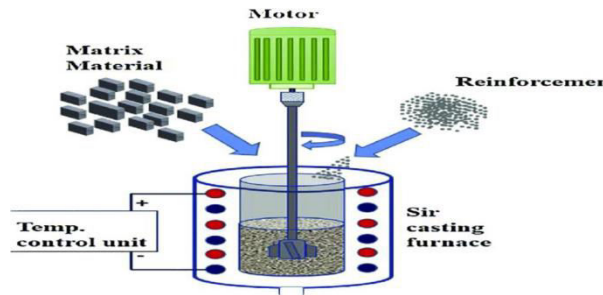


Figure 7 STIR CASTING

**PISTON AND PISTON RINGS DESIGN DIAGRAM**

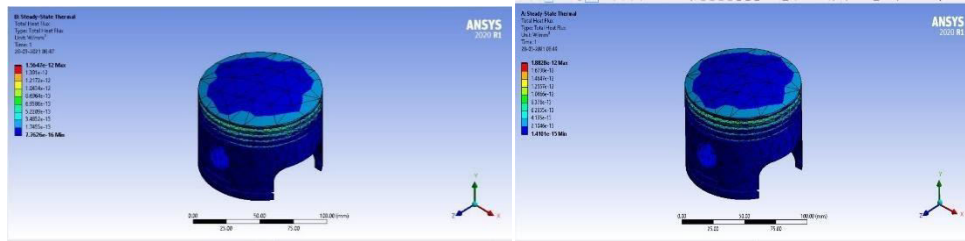


Figure 9 PISTON AND PISTON RING

**IV. RESULT AND DISCUSSION**

**STEADY STATE ANALYSIS**

The piston is divided into the areas defined by a series of grooves for sealing the rings. The boundary conditions for mechanical simulation were defined as the pressure acting along the entire piston head surface (maximum pressure inside the engine cylinder). It is necessary to load certain data on materials that refer to both its mechanical and thermal properties to do the coupled Thermo-mechanical calculations. The temperature load is applied on different areas and pressure applied on piston head. The areas like piston head and piston ring are applied with large amount of heat (160°C-200°C). The convection values on the piston wall ranges from 232W/mK to 1570W/mK. The working pressure is given as 3.3Mpa.



MATERIALS	HEAT FLUX
Al2618	2.0297e <sup>-12</sup>
AlSiC(70% ,30% )	2.4391 e <sup>-12</sup>
AlSiC(80% ,20% )	1.8828e <sup>-12</sup>
AlSiC (85% ,15% )	1.5647e <sup>-12</sup>
TITANIUM ALLOY	1.0873 e <sup>-12</sup>

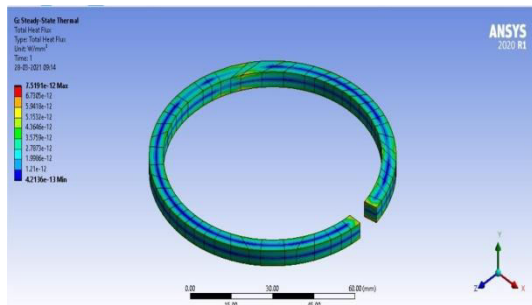


figure 3 steady state analysis Al2618

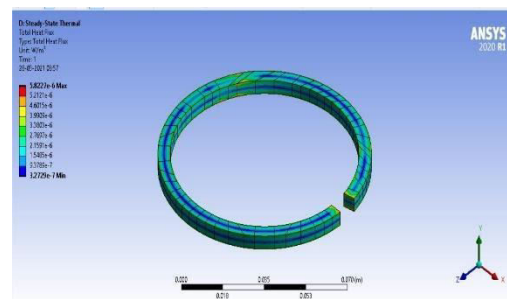


figure 4 steady state analysis AlSiC

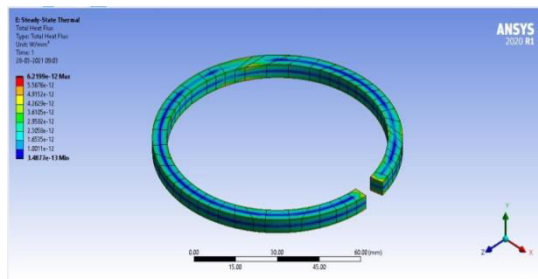


figure 5 steady state analysis AlSiC (80,20)

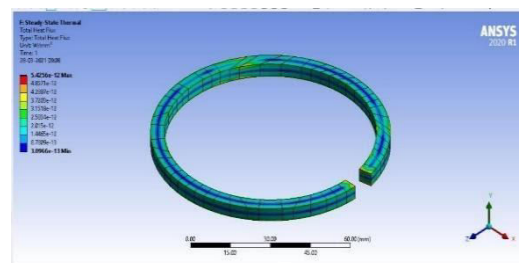


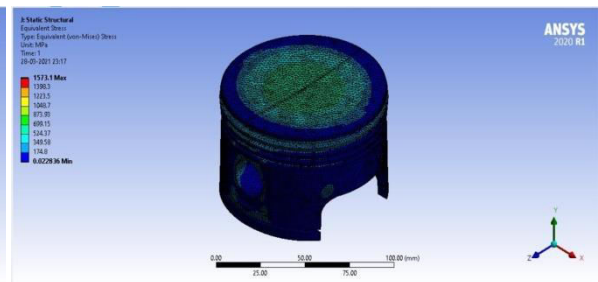
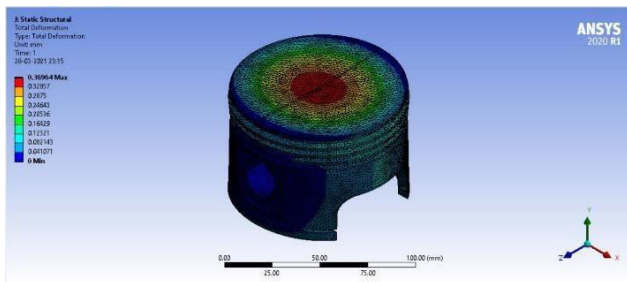
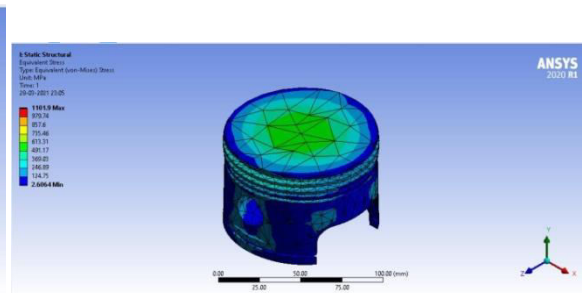
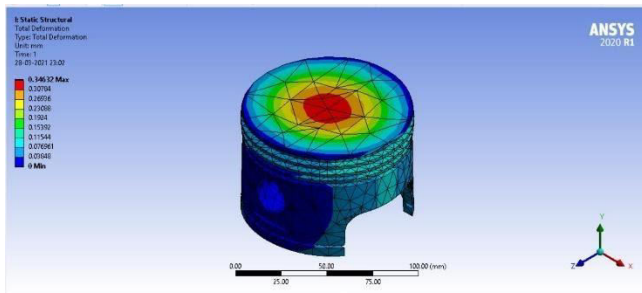
figure 6 steady state analysis (85,15)



MATERIALS	HEAT FLUX
Al2618	7.5191e^-12
AlSiC (70% ,30% )	6.53e^-12
AlSiC (80% ,20% )	6.2199e^-12
AlSiC (85% ,15% )	5.4256e^-12
TITANIUM ALLOY	5.4256e^-12

**STATIC STRUCTURAL ANALYSIS**

Structural analysis is performed on the piston by applying temperature distribution from the thermal analysis as body loads using Ansys. Also a pressure of 3.3Mpa on the piston head is given. As we are coupling thermal analysis with structural analysis, this analysis is called couple field analysis.





MATERIALS	TOTAL DEFORMATION (mm)	EQUIVALENT STRESS (MPa)
Al2618	0.34632	1101.9
AlSiC (70% ,30%)	0.36964	1573.1
AlSiC (80% ,20%)	0.89258	1474.2
AlSiC 85% ,15%)	1.0009	1631.3
Titanium alloy	0.32777	564.64

### V. CONCLUSION

Based on the above test results the design of piston and piston rings is done in SolidWorks and Static analysis and Thermal analysis is done using ANSYS software. The design file is converted into IGS format and then imported into ANSYS. For static structure the pressure on the piston top is applied as a magnitude of 8MPa with three different materials in Ansys workbench. From the above tests the results of total deformation, stresses are tabulated and thus compared graphically. The thermal analysis is carried out at a temperature of 300deg on both piston and piston rings for the above three materials. The temperature and total heat flux of three different materials are tabulated and compared. The results are also compared with the existing system on the basis of thermal analysis. In future for the betterment of the results, the design and material properties can change. For the further work, the constraint condition of the piston pin can be improved much better, hoping that it can be closer to the real situation of piston. And in the conditions allowed, the experimental approach can be used to determine the convection coefficient of the piston to get the realistic temperature field.

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