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EXPERIMENTAL INVESTIGATION AND ANALYSIS OF PISTON BY USING HYBRID METAL MATRIX

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ABSTRACT

Composite materials are those that are framed by the mixing of two or more materials to accomplish properties that are better than those of its constituents. Aluminum metal matrix composites are increasing across the board acknowledgement for vehicles, modern, aviation applications in view of their low thickness, high quality and great structural unbending nature. In the present work a specimen is made to Al-Sic-graphite contained in particulate metal matrix composites by stir casting method. The expansion level of graphite being Varied from 3-5wt% in venture of 1wt% and the rate of SiC is consistent (i.e. 5%). Brinnel hardness, tensile properties and impact strength of the composites were tested according to the norms. Micro structural portrayal uncovered genuinely uniform appropriation in the network. The hardness number of the composite is found to increase with an increase in graphite up to 5% and then decrease. The tensile strength of the composites was likewise found to build affirming the scattered graphite in Al amalgam contributed in upgrading the rigidity of the composites. The Piston is modeled using CATIA modeling and Finite Element analysis is done for same model utilizing ANSYS software for Aluminium (Pure) and Al-SiC-graphite and the results were discussed.

Keywords: Aluminium (Pure), Silicon carbide, Graphite

INTRODUCTION

Engine Piston is most important part contrasted with different parts in an automobile division. Still part of exploration works have been leading on cylinder with respect to material structure, geometry and manufacturing technique. The purpose of the internal combustion engine piston is to transfer force from expanding gas in the cylinder to the crankshaft via a piston rod and/or connecting rod In this research the piston is made up of hybrid metal matrix, for some analysts term metal matrix composites are maintained with the term light weight metal matrix composites (MMCs).Substantial advance in the development of light metal framework composites has been attained to in late decades, so they could be introduced into the most important applications. In engineering applications, particularly in the automobile industry, MMCs has been utilized monetarily in fibres reinforcement pistons and crank cases with high strength cylinder surfaces.

The hybrid metal matrix composite like Al/SiC-Gr MMC is one of the composites which have numerous extraordinary properties over Al/SiC-MMC or Al-Gr-MMC[2]. Due to addition of graphite molecule to al-sic-gr, this helps to improve the wear resistant. The change of wear safety id because of the upgrade of grease tribo-layer made out of a chemical mixture of graphite and also SiC particles and some fine particles containing aluminum. In this research composite particle, for example, graphite (Gr) are basically included as a second fortification material in hybrid metal matrix composite to an increase in hardness, strength and wear resistance.

OBJECTIVE

Aluminium-siliconcarbide-Graphite composite material are prepared by mixing of Silicon carbide and graphite powder in solid liquid slurry of hypoeutectic, eutectic and hypereutectic compositions of pure aluminium. A measured sum (1000 g) of charge comprising of monetarily pure Aluminum and measured sum of Silicon Carbide powder (50 g) and graphite powder (30 g) was included separately. After completion of mixing, crucible having the liquid composite slurry was getting to the induction furnace and the liquid composite slurry was poured into the permanent die casting dies and solidifies it, finally solidified composite specimen was taken from the dies for the further study[1].

Microstructure analysis of cast aluminium- silicon carbide and graphite specimen has 30g of graphite particulates. The mixing of melt previously, then after the fact presenting particles has brought about

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breaking of dendrite formed structure into squared with structure, it enhances the wet ability and fuse of particles inside the melt furthermore it causes to scatter the particles all the more consistently in the lattice.

PREPARATION OF AL-SIC-GRAPHITES SPECIMEN

Stir Casting technique is a method of producing composite materials, in which a scattered stage (fired particles, short filaments) is blended with a liquid metal by method for mechanical mixing with the help of stirrer. The liquid state composite material is cast by permanent die casting method. In this Stir casting technique has been used to prepare the work-piece samples of Al-Sic-Graphite hybrid metal matrix Composite material and accomplish the required properties of that composite material. The vortex stir casting is best approach to create an accurate mixing of the silicon carbide and graphite material in the matrix, the aluminium material was stacked in a crucible and it was placed into a resistance furnace at various temperature levels.

***Figure 1**:Furnace*

Silicon carbide and Graphite powder preheated before mixing of aluminium metal molt, the four blades Stirrer was designed in order to produce the sufficient homogenous particle circulation throughout the matrix material[5]. After getting the homogeneous mixing of silicon carbide, graphite powder and aluminium composite molten metal was poured into the permanent dies. In casting process die are filled with a lubricating material to reducing sticking of the casting metal to the die. The vent holes are provided with the casting for escaping hot gas into the out. The casting was removed from the die; the casting will be too hot, so that casting must be cooled in order to reduce the oxidation process. The casting material is cooled by the water quenching process. This process contains the rapid cooling of the casting material by treating with the water. The casting is dipped in to a water to reduce the heat and to get a solid form of the composite specimen.

Figure 2.specimen of Al-Sic-Graphite

TESTING OF AL-SIC-GRAPHITES SPECIMEN

After completing the machining process the final product of hybrid metal matrix specimen is going too tested. The testing is conducted to calculate the properties of machined specimen. In this research we are calculated the hardness number, impact strength, tensile strength, and density. The micro structures of the graphite present in the hybrid metal matrix are shown in the Optical microscope. The following are the tests conducted on the composite specimen.

- Tensile Test
- Brinnel Hardness Test
- Impact Test
- Microstructure Analysis

The hybrid metal matrix of Al-Sic-Graphite specimen is experiences to the mechanical tests mentioned above. It demonstrates that hardness of the crossover metal lattice material has been enhanced to a greater extent. The surface of Al-Sic-Graphite is shown with help of optical microscope and getting the micro structure of graphite present in hybrid metal matrix.

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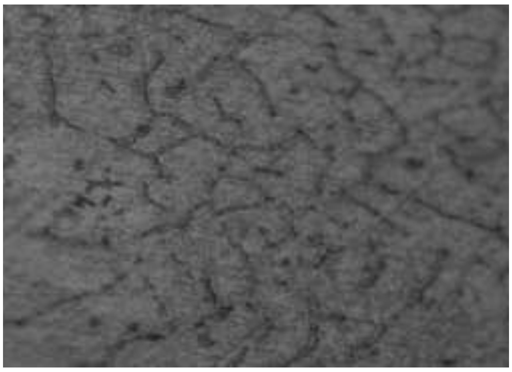

Figure 3.*Microstructure of Graphite*

Table 1. Material Properties of Aluminium (Pure)

Young's Modulus	7e+10 Pa
Poisson's Ratio	0.35
Density	2700 Kg/m^3
Tensile strength	121.1 MPa
Percentage of elongation	10-15
BHN	60-65
Thermal Conductivity	237 $W/m\ ^0C$
Specific Heat	910 $J/Kg\ ^0C$

These Aluminium (Pure) Properties are taken from the source[1].

Table 1. Material Properties of Al-Sic-Graphite

Young's Modulus	7.4e+10 Pa
Poisson's Ratio	0.34
Impact Strength	87 J
Percentage of elongation	7.5
Density	2711.4 Kg/m^3
Tensile Strength	193.38 MPa
BHN	68
Thermal Conductivity	180 $W/m\ ^0C$
Specific Heat	826 $J/Kg\ ^0C$

The martial composition for hybrid metal matrix is in presence of silicon carbide (50g) and graphite (30g). The hardness test report demonstrates the hardness of the metal matrix material increment by including the SiC and graphite, by increasing the hardness of the composite specimen and decrease the deformation. The brinnel hardness number is increases in the Al-Sic-Graphite sample compared to the pure aluminium. The impact strength value has been increased by adding the graphite in the metal matrix. Impact strength is decrease with increase graphite more than 30 grams. In this metal matrix percentage of elongation decreases with addition of graphite. Tensile strength has been increases by adding the Sic and graphite in composite material. The Young's modulus value of the hybrid metal matrix is higher compared to the aluminium. This demonstrates the Al-Sic-Graphite is better in all the perspectives when compared to the pure Aluminium.

FINITE ELEMENT ANALYSIS

The molding of piston for the analysis was prepared by using the CATIA V5.

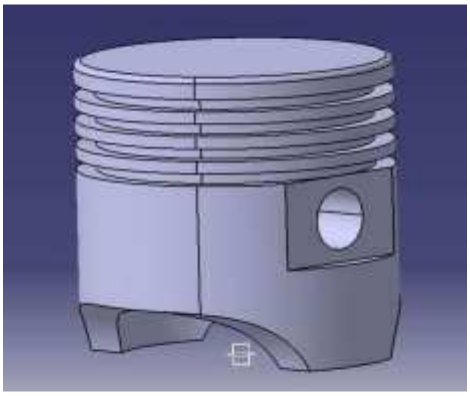

Figure 4.Catia modeling

The static and thermal analysis for the piston was done by finite elements method using ANSYS software. For ANSYS simulation the CATIA geometry is separated into elements. In this elements are interlinked to one another at a point called as Node. In present examination work we have used FEA for the Thermal and Structural analysis of aluminium/silicon carbide/graphite piston. The CATIA V5 software is used to prepare the piston. After completing CATIA modeling, the model is saved in IGES file then IGES file is imported to ANSYS software for the finite element analysis.

Loading and boundary Condition

In this research the effect of side thrust force is negligible but in reality it have some impact on deformation and stress on piston but pressure force and inertia force are taken in record and assumed that temperature is uniform. The pressure force 1.5 MPa is applied on piston crown as shown in figure5.

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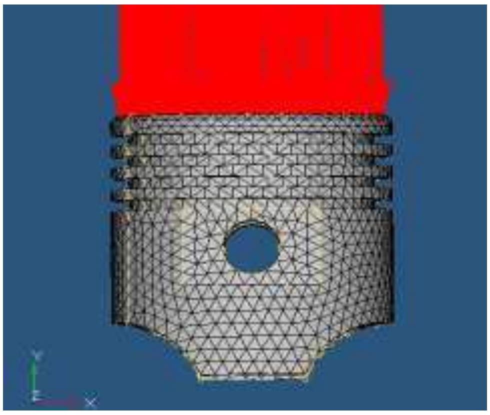

Figure 5.Loading Condition on Piston

With the help of piston pin, piston and connecting rod are associated and no relative motion between piston pin and piston. Hence the piston pin holes are fully constrained for all degrees of freedom (DOF) as shown in figure6.

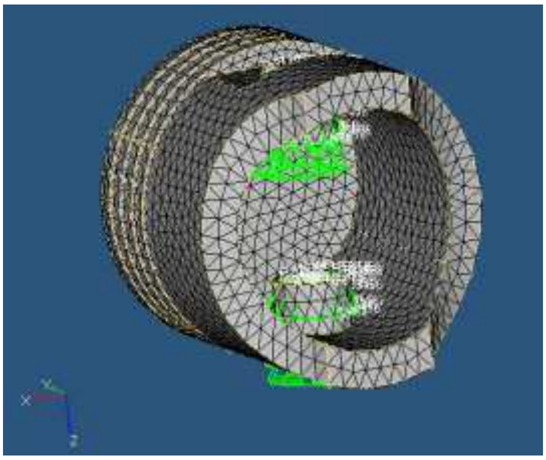

Figure 6.Boundary Conditions on Piston

Meshing

The piston is meshed by using the hyper mesh soft ware because of easy to mesh compared to ansys software. It comprises of 22970 nodes, 18845 elements and element size 4.

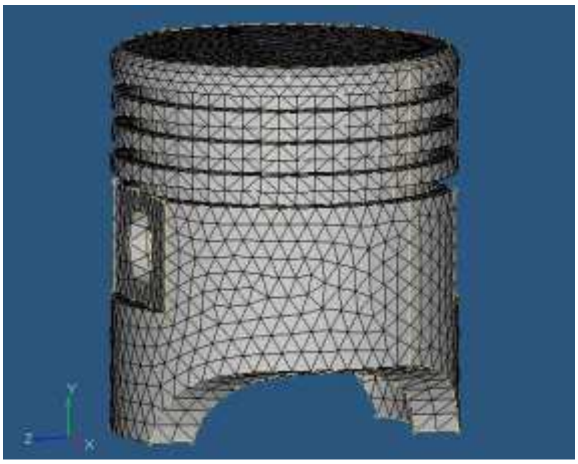

Figure 7.Meshing on Piston

ANSYS SIMULATION

Static Analysis

The static analysis is used to find out the total deformation, von mises stresses and strain. The static analysis of piston is done by ANSYS software. For the combustion pressure of 1.5 MPa is applied on piston crown[3].

Static Analysis of Aluminium

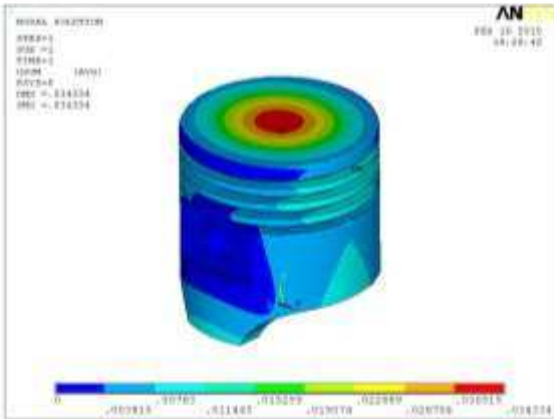

***Figure 8.Total deformation* of Aluminium**

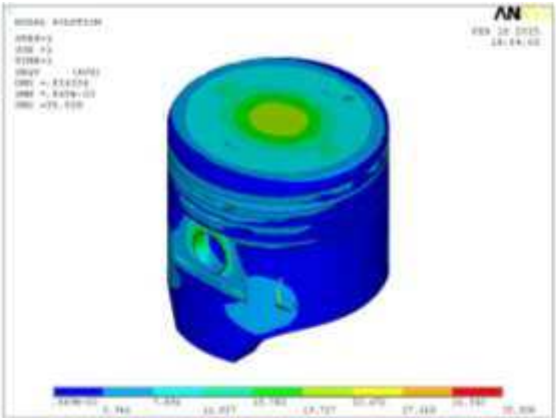

***Figure 9.Von misses stress* of Aluminium**

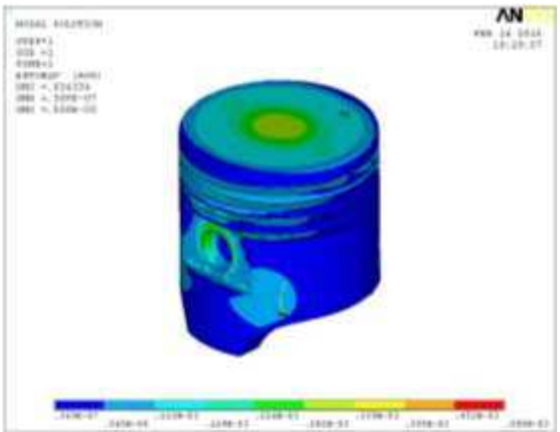

***Figure 10.Strain* of Aluminium**

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The maximum deflection induced in the piston is 0.034334 mm, at the top of the piston. The maximum von mises stress is 35.508 MPa is developed in the inner boss fillet area which due to stress concentration effect and pressure application on top face of the piston. The stress is observed at inner side of the piston pin boss fillet area.

Static Analysis of Al/Sic/Graphite

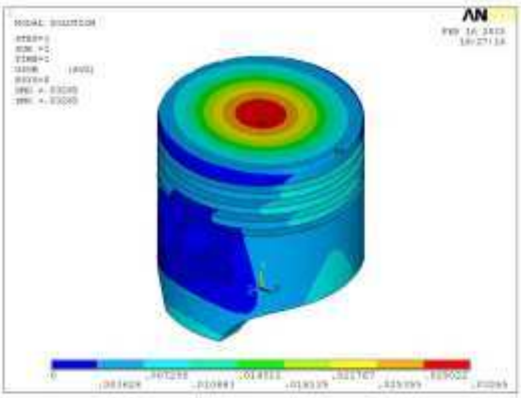

***Figure 11.Total deformation* of Al/Sic/Graphite**

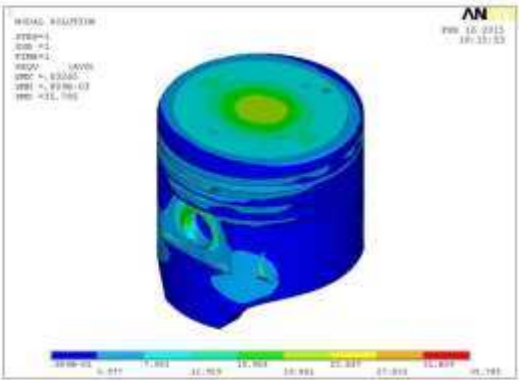

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***Figure 12.Von misses stress* of Al/Sic/Graphite**

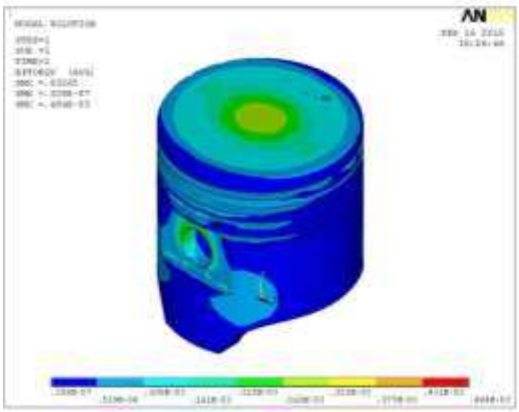

***Figure 13.Strain* of Al/Sic/Graphite**

The maximum deflection induced in the piston is 0.03265mm, at the top of the piston. The maximum von mises stress is 35.785 MPa is developed in the inner boss fillet area which due to stress concentration effect and pressure application on top face of the piston. The stress is observed at inner side of the piston pin boss fillet area.

Thermal Analysis

ANSYS is chosen for thermal analysis of aluminium/silicon carbide/graphite composite material for piston to find the suitability at maximum temperature. The maximum temperature 400^0C and minimum temperature 30^0C is applied on piston for thermal analysis[4].

Thermal Analysis of Aluminium

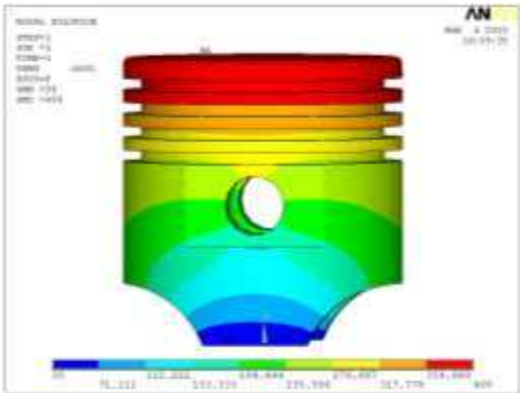

Figure 14.Temperature distribution of Aluminium

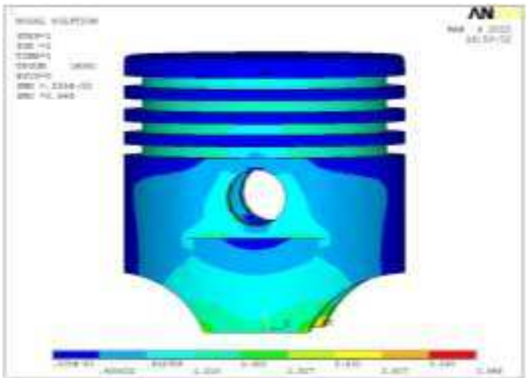

Figure 15.Total Heat flux of Aluminium

Figure14 shows the heat flux generation on piston under the given temperatures. The heat flux generation in piston is under safe condition, it is mention by blue color region shon in figure15. The red color region is not accessible which shows that restriction of thermal stresses is not accessible and design and material is safe.

Thermal Analysis of Al/Sic/Graphite

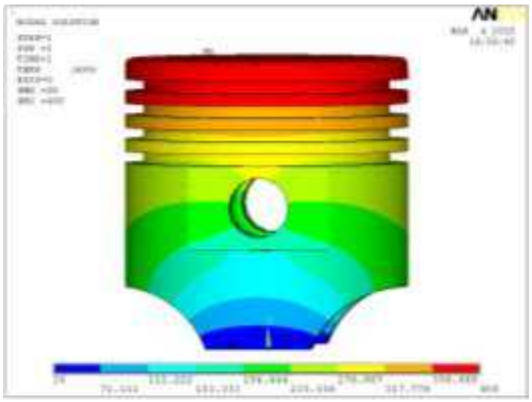

Figure 16..Temperature distribution of Al/Sic/Graphite

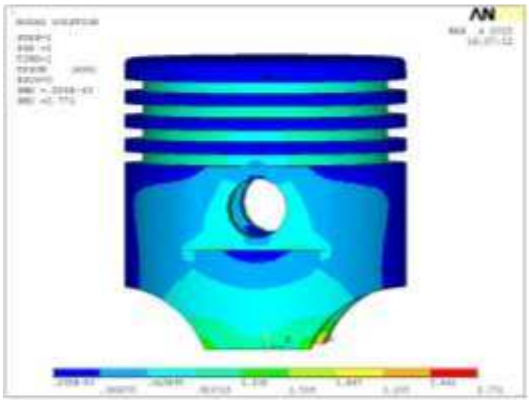

Figure 17.Total Heat flux of Al/Sic/Graphite

Figure16 shows the heat flux generation on piston under the given temperatures. The heat flux generation in piston is under safe condition, it is mention by blue color region shon in figure17. The red color region is not accessible which shows that restriction of thermal stresses is not accessible and design and material is safe.

Table 3.Static analysis of piston

Material	Total deformation mm	Von mises stress MPa	Strain
Aluminium	0.034334	35.508	0.508E-03
Al/Sic/Graphite	0.03265	35.785	0.484E-03

Table 4.Thermal analysis of piston

Material	Temperature ^{0}C	Total heat flux W/mm^2
Aluminium	400^{0}C	3.648
Al/Sic/Graphite	400^{0}C	2.771

CONCLUSION

- The composites containing Al-SiC-Graphite particulates were effectively incorporated by melt stirring method utilizing three stages mixing joined with preheating of the silicon carbide and graphite particles.
- The micro structural analysis of composite material produced by stir casting technique shows genuinely uniform dispersion of Sic and Graphite particulates in the Al metal matrix.
- The experimental densities were discovered to be lower than theoretical densities because of the vicinity of porosities in all the composites. The Experimental density is decreases by 10% compared to the theoretical density.
- The tensile strength of pure aluminum is 121.1MPa later while adding the graphite to the aluminum the tensile strength is increases from 121.1 MPa to 193.38MPa. An improvement of nearly 70% in tensile properties was noticed.
- It was revealed that the hardness of composite samples increases by adding the graphite. And then decreases more amount of graphite.
- It was revealed that the Impact strength is of composite samples increases up by adding the graphite (30g). And then decreases by the adding of more amount of graphite.
- The static analysis of aluminium piston having the maximum deflection induced in the piston is 0.034334 mm.
- The maximum von mises stress is 35.508 MPa is developed in the inner boss fillet area which due to stress concentration effect and pressure application on top face of the piston and the stress is observed at inner side of the piston pin boss fillet area.
- The static analysis of aluminium/silicon carbide/graphite piston having the maximum deflection induced in the piston is 0.03265mm, at the top of the piston.
- The maximum von mises stress is 35.785 MPa is developed in the inner boss fillet area which due to stress concentration effect and pressure application on top face of the piston and the stress is observed at inner side of the piston pin boss fillet area.
- The maximum temperature 400^{0}C and minimum temperature 30^{0}C is applied on piston for thermal analysis.
- The total heat flux generation in aluminium piston is 3.648 W/mm^2 and

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total heat flux generation in a Al/Sic/Graphite piston is 2.771 W/mm^2.

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