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FABRICATION DESIGN AND ANALYSIS OF PISTON USING METAL MATRIX COMPOSITES

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Abstract - *Metal-matrix composites (MMCs) are engineered combination of two or more continuous and discontinuous metal fibers in which tailored properties are achieved which cannot achievable in monolithic materials. In general sense the piston is made of aluminum and silicon carbide. Sic gives strength to the piston but by adding fly ash to the Al and Sic it reduces the weight of the piston and Sic give strength to the component .in the present investigation a piston model is analyzed using unigraphics and results are validated by fabricating piston by vortex method using aluminum based mmc containing 5, 10, 15, wt. % and fly ash particulates of 53micro meter. Here we used stir casting technique to get good shape and complexity. And after casting suitable machining is done to the component to get the required shape. Results shows that this technique improve the performance of the automotive*

Key Words: metal matrix composites, vortex method, stir casting, wear test.

1. INTRODUCTION

Metal matrix composites Piston

1.1 METAL MATRIX COMPOSITES

MMC materials have a combination of different superior properties to an unreinforced matrix which are; increased strength, higher elastic modulus, higher service temperature, improved wear resistance, high electrical and thermal conductivity, low coefficient of thermal expansion and high vacuum environmental resistance. These properties can be attained with the proper choice of matrix and reinforcement. The matrix can be selected on the basis of oxidation and corrosion resistance or other properties. Generally Al, Ti, Mg, Ni, Cu, Pb, Fe, Ag, Zn, Sn and Si are used as the matrix material, but Al, Ti, Mg are used widely. Now a day's researchers all over the world are focusing mainly on aluminum because of its unique combination of good corrosion resistance, low density and excellent mechanical properties. The unique thermal properties of aluminum composites such as metallic conductivity with coefficient of expansion that can be tailored down to zero.

1.2 Piston

A piston is a sliding plug that fits closely inside the bore of a cylinder. Its purpose is either to change the volume enclosed by the cylinder, or to exert a force on a fluid inside the cylinder.

The pistons in a gasoline engine compress the fuel and air mixture before ignition and then extract energy from the burned gases after ignition. When the engine is operating, each piston travels in and out of a cylinder with one closed end many times a second. The piston makes four different strokes during its travels. In the first or "intake" stroke, the piston travels away from the closed end of the cylinder and draws the fuel and air mixture into the cylinder through an opened valve. During the second or "compression" stroke, the piston travels toward the closed end of the cylinder and compresses the fuel and air mixture to high pressure, density, and temperature. The spark plug now ignites the fuel and air mixture and it burns. During the third or "power" stroke, the piston travels away from the closed end of the cylinder and the expanding gases do work on the piston, providing it with the energy that propels the car forward. During the fourth or "exhaust" stroke, the piston travels toward the closed end of the cylinder and pushes the burned gases out of the cylinder through another opened valve.

1.2.1 Piston rings

Piston rings provide a sliding seal between the outer edge of the piston and the inner edge of the cylinder. The rings serve two purposes:

1. They prevent the fuel/air mixture and exhaust in the combustion chamber from leaking into the sump during compression and combustion.
2. They keep oil in the sump from leaking into the combustion area, where it would be burned and lost.

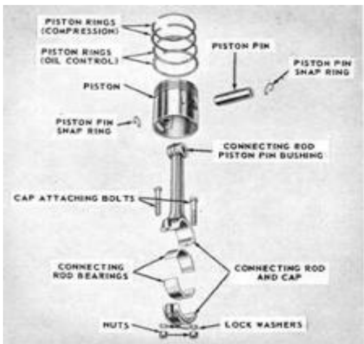


Fig -1: Piston with Connecting Rod

2. MATERIAL SELECTION FOR PISTON

In this work A356 alloy was used for fabrication of pistion.**A356 alloy** was procured from M/s HINDALCO as 20 kg ingots,

Si	Mg	Cu	Ti	Zn	Fe	Al
6.5	0.4	0.05	0.06	0.03	0.09	Balance

Table 1: Chemical composition of A356 alloy, wt. %.

3. Experimental approach of piston
3.1 Design of Piston

The Piston is Designed Based on the following dimensions of Hero-Honda bike Piston. Design of piston is carried out in the catiav5 R20

Sl.no	PARAMETER	VALUE IN MM
1.	Piston length	37
2.	Piston diameter	49.4
3.	Radial thickness of ring	2
4.	Depth of ring groove	2.0
5.	Gap between the rings	2.6
6.	Pinhole external diameter	12.6
7.	Pin hole internal diameter	6.5
8.	Piston ring axial thickness	0.7
9.	Top land thickness	5.5
10.	Thickness of piston at top	6.64
11	Thickness of piston at open end	1.63

Table 2:Dimensions of the piston

3.2 Fabrications of piston

In the present investigation, aluminum based hybrid metal matrix composites containing 5, 10 and 15wt% SiC and Fly-ash particulates of 53μm were successfully synthesized by vortex method. The matrix materials used in this study was Al-Si alloy (A356) whose chemical composition was shown in table 1

The synthesis of these composites was carried out by stir casting technique. The cylindrical fingers (18 mm Φ and 170 mm length) of A356 alloy were taken into a graphite crucible and melted in an electric furnace. After maintaining the temperature at 770 °C, a vortex was created using mechanical stirrer made of graphite. While stirring was in progress, the preheated particulates SiC and Flyash at 300^{0}C for 2 hrs were introduced into the melt. Care has been taken to ensure continuous and smooth flow of the particles addition in the vortex. The molten metal was stirred at 400 rpm under argon gas cover. Still, the melt with reinforcement was in stirring condition the same was bottom poured into preheated (200 ^{0}C) S.G. iron mould of 65 mm diameter and 90 mm height. Cast ingots of both alloy and composites were homogenized at 200 ^{0}C for 24hrs to get relieve the internal stresses and minimize the chemical in homogeneities which may be present in the cast condition

Fig-2: Stir Casting by Vortex Method

The fabricated model after machining process the required as shown in below.

Fig-3: Fabricated model of piston

4. ANALYSIS OF PISTION

The design model of the piston is designed in catia VR 5 20 and imported in to the IGES FILE. it has to be analysis is done in ansys software package. The imported model is as shown below.

Fig-3: ansys model piston

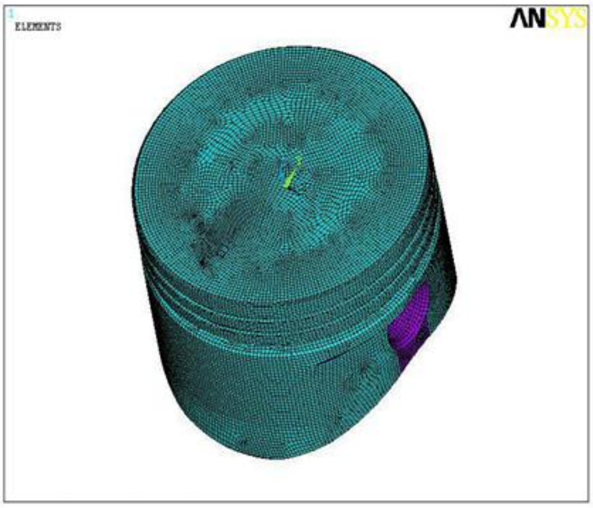


Fig-4: Meshed model of the piston

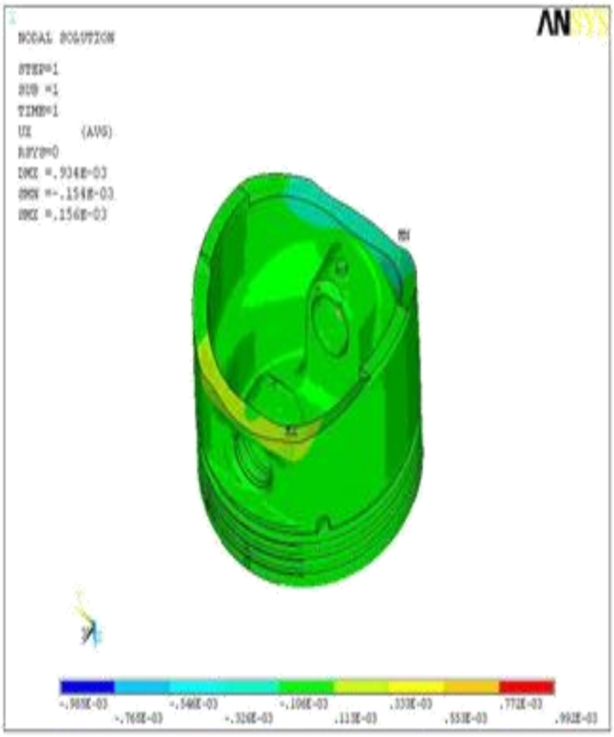


Fig-5: Deflection in x- direction

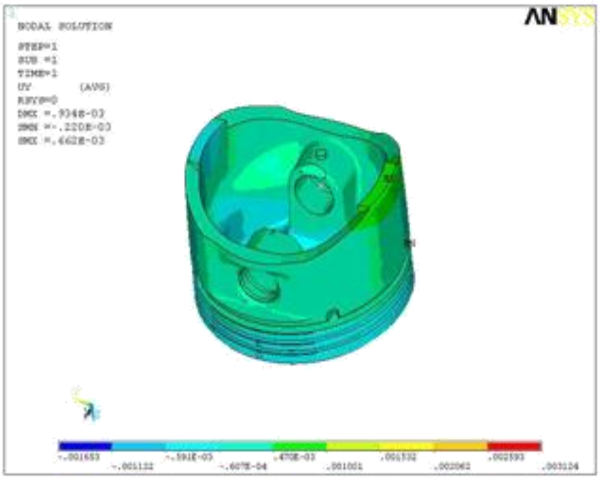


Fig-6: deflection in y-direction

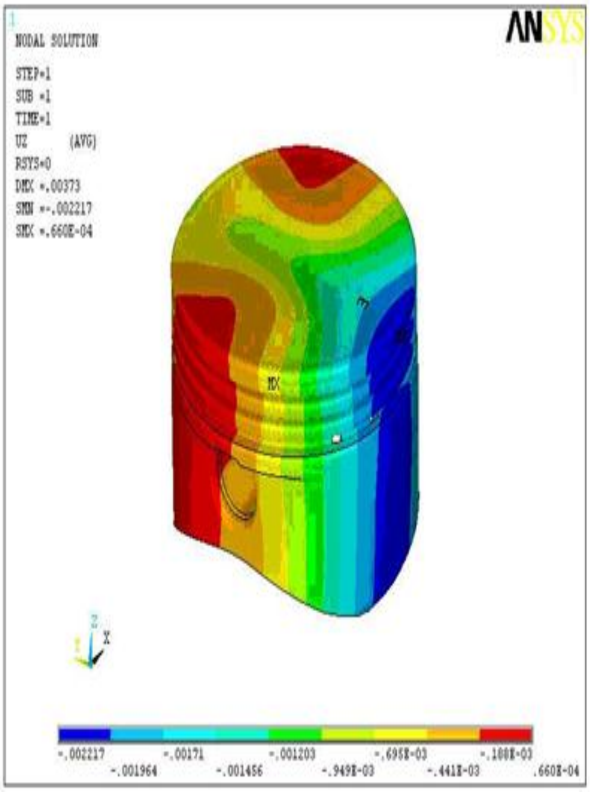


Fig-7: deflection in z-direction

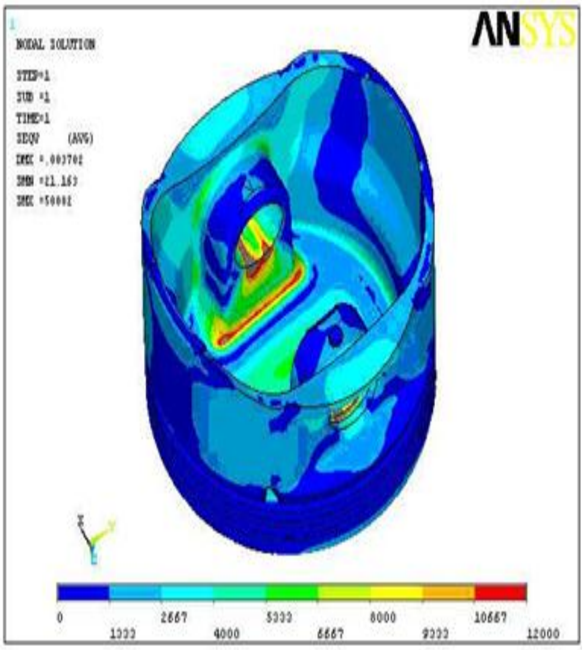


FIG-8: VONMISES STRESS IN PISTON

5. RESULTS AND DISCUSSION

5.1 The required model we get the stress it has to be formed deflection in different orientations and also vonmises stress the values of max and minimum points

Sl.no	Direction	Minimum	maximum
1	X-direction	-0.154E-3	0.156E-3
2	y- direction	-0.220E-3	0.662E-3
3	Z-direction	-0.685E-3	0.196E-4

Table-3:

5.2VARIOUS TESTS ON FABRICATED PISTON:-

- Wear is related to interactions between surfaces and specifically the removal and deformation of material on a surface as a result of mechanical action of the opposite surface.
- **Wear** is erosion or sideways displacement of material from its "derivative" and original position on a solid surface performed by the action of another surface.
- Wear rate is strongly influenced by the operating conditions. Specifically, normal loads and sliding speeds play a pivotal role in determining wear rate. Different oxide layers are developed during the sliding motion. The layers are originated from complex interaction among surface, lubricants, and environmental molecules.

5.2.1Types of wear:

Different types of wear process are these

1. Adhesive wear
2. Abrasive wear
3. Surface wear
4. Fretting wear
5. Erosive wear
6. Corrosion oxidation wear

5.2.2FRICTION FACTOR

Friction factor can refer to:

- Darcy friction factor
- Fanning friction factor
- Atkinson friction factor (ventilation of mines)

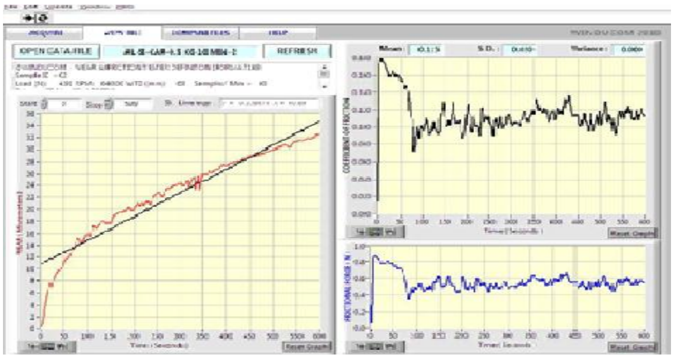
WEAR TESTIN MACHINE

A tribometer is an instrument that measures tribological quantities, such as coefficient, friction force, and wear volume, between two surfaces in contact.

Fig-9:wear testing machine

Sl.N0	TIME	WEAR	FRICTION FACTOR
1	0.9810	0.43	0.07
2	1.9600	0.53	0.29
3	2.9400	0.69	0.54
4	3.9210	1.01	0.78
5	4.9020	1.46	0.85
6	16.6660	6.47	0.84
7	32.3510	9.13	0.79
8	39.2120	9.79	0.79
9	45.0930	10.21	0.78
10.	69.6010	13.43	0.67
11	87.2470	14.23	0.44
12	113.7150	17.24	0.45
13	147.0450	0.43	0.07
14	159.7890	0.53	0.29
15	598.9560	0.69	0.54

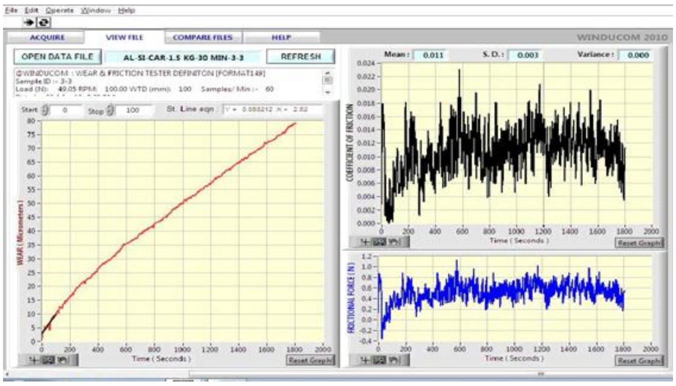
Table-4: For 0.5KG-10MIN load wear and friction factor



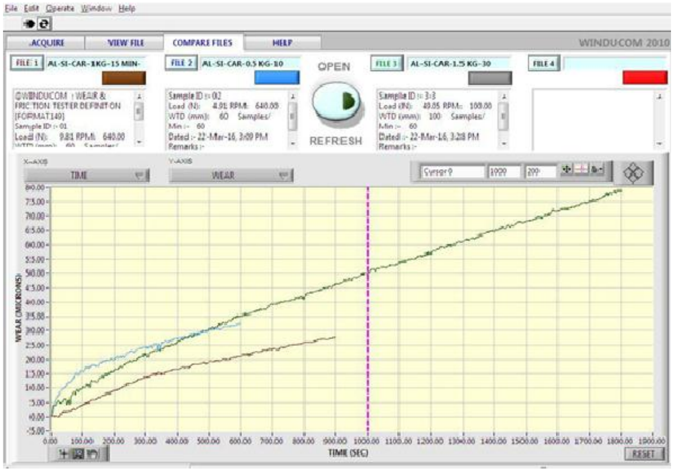
Graph-1: wear &coefficient friction and friction factor vs time

Sl.N0	TIME	WEAR	FRICTION FACTOR
1	0.9090	0.32	0.14
2	1.8200	1.19	0.52
3	2.7290	1.99	0.77
4	3.6390	2.85	0.78
5	4.5480	3.64	0.79
6	32.7470	4.71	-0.12
7	39.1130	5.56	0.03
8	45.4810	6.25	-0.11
9	69.1310	7.98	0.13
10	121.8880	10.94	0.45
11	683.1200	38.33	0.67
12	786.8150	41.63	0.19
13	873.2300	44.97	0.61
14	1020.5870	51.43	0.77
15	1088.8080	52.80	0.63

Table-5: For 1.5KG-30MIN load wear and friction factor



Graph-2: wear &coefficient friction and friction factor vs. time



Graph-3: comparison of wear vs time of both 0.5kg-10min and 1.5kg-30 min.

6. Conclusion

It is concluded that the modified model of the piston is giving better results than the original model. The stresses are reduced in the modified model. And also this model the weight of the piston is reduced and the reliability of the piston increases. By the different tests conducted on it give us the hardness and wear and friction factor is how it varies from normal model to the modified model.

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