DEVELOPMENT OF AL-SiC COMPOSITE FOR AUTOMOBILE AIR COMPRESSOR PISTON

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ABSTRACT

Self-propelled machines which includes whole the automobile industries are working for lighter the weight and strengthen the body of machines. Automobile industries are also using material substitution for to build lighter weight, and fuel efficient engines, offering better properties materials of engine components. The piston is a "heart" of the engine and its working condition is the worst one of the key parts of the engine in the working environment. So it is very important for structural analysis of the piston with the acceptable composite material as replacement of now-a-days materials. The present work describes that Al composite as possible alternate materials with its unique capacity to give required properties for engine heart 'piston'. Al MMC are prepared by powder metallurgy and various casting techniques. In this paper a composite is developed by stir casting process by using Aluminum alloy with other Nano particles and substitute sintering operation at 600°C temperature for one hour. Mechanical Tests like microstructure, Hardness, crushing load, surface roughness, etc. are conducted and final analysis on piston will be done.

Keywords: - *MMCs, Stir casting method, Piston, Properties*

1. INTRODUCTION

R. S. Rana, V. K Soni, Rajesh Purohit. [1] has Mechanical properties (Tensile strength, compression strength, hardness) and microstructure of aluminum alloy (5083) – SiC (35µm) composites are fabricated by stir casting method[1]. In stir casting method, Aluminum melt by 760°C and mechanical stirring at 500rpm for 10 min. Using N2 Gas for degassing of melt[1]. Mechanical properties like tensile & compressive strength, and hardness increases with increase in weight % of SiC. Also hardness of composite is higher than unreinforced alloy[1]. R. S. Rana, V. K Soni, & Rajesh Purohit [5] has developed MMCs with Al Automotive cam were developed by using Al (5083) and SiC (35µm- 10% & 40nm-1, 2, 3, 4% weight) composite material having the almost same wear resistance of 10% wt composite and existing steel which has been fabricated by ultrasonic assisted stir casting method[5]. Second Stirring the composite with ultrasonic probe with 1200 watt power & 20.20 kHz frequency were used[5]. Weight of Al-SiC composite cam measured less than the alloy cam. Al- 4% wt. Nano Sic composite shows highest of hardness (79 BHN) which is higher than 10% wt. Micro SiC composite[5].

The piston can get the most common severe piston damage we see - the exhaust side has damage caused from excess heat[7]. This damage looks similar to piston image caused by running straight gas shown in the first image, but with this piston, conditions under the piston looked normal.

This kind of damage can be caused by over-revving the saw, running the carburettor adjustment too lean, by ignoring an air leak in the saw's engine, or a combination of factors[9]. The best way to avoid a such a seizure is to use good quality fuel and mix oil, avoid over-revving the engine, and always stop running a saw that shows signs of a potential air leak. This kind of damage can also be caused by a partially plugged fuel filter, which is another reason fuel filters should be replaced regularly[5]

So, for the better wear resistant we have to concentrate on the increase of the hardness of material using now-a-days.

2. Materials and Experimental details

2.1 Selection of matrix material

Aluminum alloy 6061-T6 has been selected as matrix material for synthesis of MMCs. Aluminum alloy was supplied by Choudhary enterprise, Makarpura, Vadodara. The chemical composition of aluminum alloy are shown in the following table. Al-6061 is a precipitation hardening alloy, containing magnesium and silicon as its major alloying elements. It has significant application in aircraft, marine and automobile industries.

Element	Si	Fe	Mn	Mg	Cu	Zn	Ti	Cr	Al
% Percentage	0.52	0.14	0.05	1.1	0.30	0.03	0.015	0.20	97.645

Table-1 Composition of Aluminum alloy 6061-T6

Properties	Values
Density	2.7 g/cm3 (169 lb/ft3)
BHN (500kg_10mm Ball)	95
Rockwell B Hardness	60
Vickers Hardness	107
Ultimate tensile strength	260-310 MPa
Yield tensile strength	240-270 MPa
Shear strength	210 MPa
Modulus of Elasticity	70 GPa
Poisson's ratio	0.33
Melting point Temp.	580-650ºC
Elongation (%)	10-12 %

Table-2 Properties of Aluminum alloy 6061-T6

2.2 Selection of reinforcement particles

The reinforcement may be Fibers, particles or whiskers which increases strength, stiffness, temperature resistance, wear resistance, hardness, etc. Particulates are most common reinforcement materials. The SiC particulate reinforcement Al-MMCs have good combination for use as wear resistance and also lead to a favorable effect on properties such as hardness, strength, fatigue resistance, surface roughness, radial crushing load. In the present work 1200 mesh silicon carbide particulates were used as reinforcement material. 1200 mesh silicon carbide was supplied by Parshwanath hardware store, Ahmedabad.

Product Name	Grit size (Mesh)	SiC	Free Carbon	Fe2o3
F200-F400	200-400	98.5	0.3	0.5
F400-F600	400-600	97.5	0.4	0.7

F800-F1200	800-1200	96.5	0.4	0.7
F1600-F1800	1600-1800	95.5	0.5	0.7

Table-3 Composition of Silicon carbide black powder

Properties	Values
Density	3.2 g/cm^3
Color	Black
Melting point Temp.	2700º C

Table-4 Properties of SiC Powder

2.3 Preparation of Aluminum-SiC MMCs

The following steps has been followed for stir casting Process:

1. Heating and melting of Al-6061-T6 Alloy by around 750°C which is above the melting point temperature of the alloy which is shown in Fig-1 (A)
2. Fig-1 (B) illustrates the feeding process of preheated silicon micron particles (0, 5 and 10% of micron SiC) for the preparation of the composites.
3. When the alloy reaches to a semi-pasty stage, the surface is covered with flux agent coverall-11 about 5 grams of the flux was added to the molten metal for the degassing process.
4. Fig-1 (C) describes mechanical stirring at 200rpm for 20 min for the uniform distribution of the particles. Before the mechanical stirring manual stirring is required for better distribution of silicon carbide particles in the molten metal.
5. Degassing of melt with N2 gas for removing the air inclusion in the material.
6. In Fig-1 (D) sand mold is ready for the making specimen components for MMCs.
7. Pouring of molten metal of aluminum alloy 6061 and 1200 mesh SiC powder to the pre prepared sand mold
8. .Removal the specimen of composite material.

Fig-1 Synthesis of development MMCs

3. RESULTS AND DISCUSSION

3.1 Microstructure test

Microstructural examination were doing scanning electron microscope for testing the microstructure of sample, its surface and distribution of Micron particles in aluminium alloy 6061. The specimen for the scanning microscopy were polished using a series of ranging grit sizes emery papers. A 0.5% HF solution was used for etching process for 3-6 min before experimental testing. All samples were developed by using stir casting technique by taking 5 & 10 % weight fraction. Figures shows micrographs of samples containing different weight fractions. It clearly shows the resulting homogeneous distribution of particles in the samples.

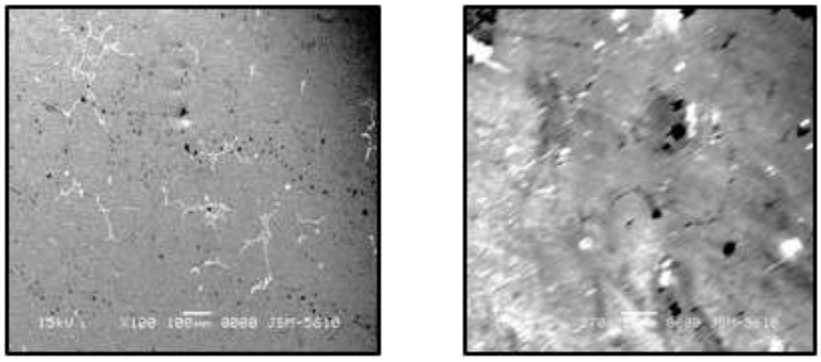


Fig-2 SEM micro graphs of Al6061-5% SiC

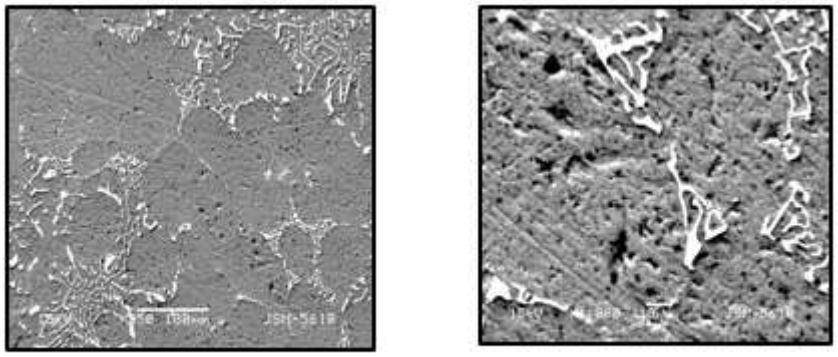


Fig-3 SEM micro graphs of Al6061-10% SiC

3.2 Chemical analysis

Chemical analysis of Aluminum alloy 6061 and Al6061-5% SiC and Al6061-10% SiC were measured by using chemical spectrometer. In this test, analysis of weightage percentage of magnesium and silicon which are main alloying elements of aluminum alloy. Test revealed that by increasing silicon powder contents weight fraction will be increase silicon contents in the metal matrix composite materials.

Elements	Al6061 0% SiC	Al6061 5% SiC	Al6061 10% SiC
Al + Other	98.38	95.706	90.382
Si	0.52	3.364	6.473
Mg	1.10	0.930	1.145

Table-5 Chemical analysis of MMCs

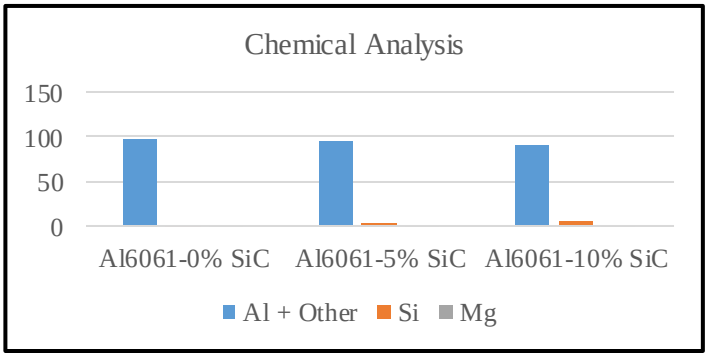


Chart-1 Chemical analysis comparison of MMCs

3.3 Density test

Density is the physical properties that reflects one of the important characteristics of composites. The theoretical densities were calculated in this study of Al-6061 aluminum alloy and cast MMCs with 5% SiC and 10% SiC reinforcement with Al-6061 matrix alloy. Following graph and table describes the value of calculated density of pure aluminum and metal matrix composite with 5% and 10% Silicon carbide MMCs. Density was increased with increasing weight fraction of the silicon carbide powder reinforcement.

	Al6061 0% SiC	Al6061 5% SiC	Al6061 10% SiC
Density(g/cm^3)	2720	2690	2770

Table-6 Density of MMCs

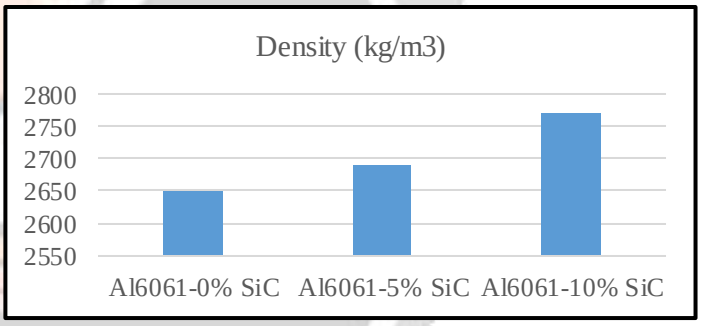
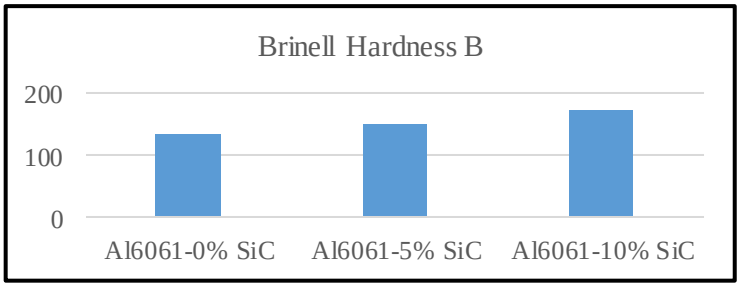


Chart-2 Density comparison of MMCs

3.4 Hardness test

In hardness test, first of all samples of 20mm diameter and 15mm length in cylindrical round bar were developed from manufacturing process. The specimens were fabricated by filing for making perfectly parallel before hardness testing. Samples were polished by using different types of emery papers and tests were carried out by using Brinell hardness tester with load of 100kg at room temperature condition. Hardness values were obtained in three various sections are given in table and figure shows increase hardness with increasing SiC particles. Also observe that the hardness of the composite is greater than its cast matrix alloy.



	Al6061 0% SiC	Al6061 5% SiC	Al6061 10% SiC
Hardness (HRB)	133	150	172

Table-7 Brinell Hardness of MMCs

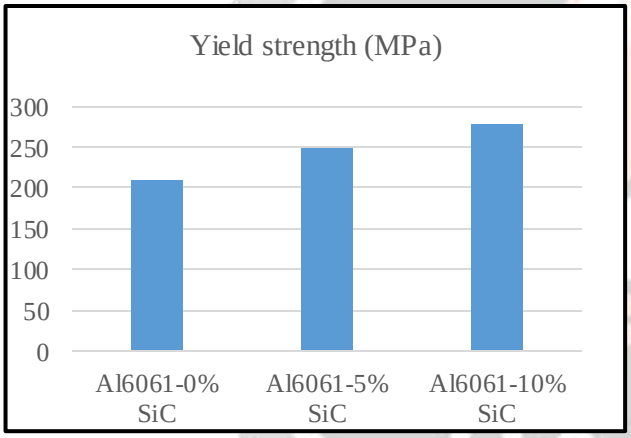


Chart-3 Hardness Comparison of MMCs

3.5 Tensile test

The tensile test was carried out an accordance with the gauge diameter of the test specimen was 10 mm and the gauge length of the test specimen was 50 mm. Tensile properties of the Al-6061 and composite materials were measured. During the tests the load and %elongation data were also measured by software. It is observed that the ultimate tensile strength and yield tensile strength increased with an increase in SiC volume percentage. Figure shows variation of ultimate strength and yield strength with increase in percentage of SiC particles.

	Al6061 0% SiC	Al6061 5% SiC	Al6061 10% SiC
Yield strength (MPa)	209	249	278

Table-8 Yield strength of MMCs

Chart-4 Yield strength Comparison of MMCs

	Hardness (HRB)	**Yield strength (MPa)**	**Density (g/cm^3)**
ZL108	90	186	2720
Al+5% SiC	112	249	2690

Al+10% SiC	134	278	2770

Table-10 Properties comparison with different materials

4. CONCLUSION

The Al6061-SiC MMCs with 5% and 10% weight fraction produced by stir casting method and the microstructure, chemical composition, density, hardness, tensile strength were measured and compared with ZL108 which is using now-a-days.

- Hardness, Density, yield strength, are increases with the increase reinforcement particles of silicon carbide.
- Development of Al-SiC MMCs for making automobile air compressor piston is possible by comparing different properties with existing materials which are used to making the same. Automobile air compressor piston is manufactured with casting and forging processes and it is possible both processes after developing MMCs for making automobile air compressor piston

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