"Investigation of Mechanical properties and Wear rate of Aluminium A356 -SiC MMCs processed by powder metallurgy method"

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Abstract: *Aluminum alloy & silicon carbide metal matrix composites are result applications in automobile, aerospace & common engineering industries due to their high specific strength & stiffness, good wear resistance and high temperature properties, favorable microstructure & there improved mechanical behavior. In the present study, mechanical properties (hardness, density & compressive strength), tribological properties & microstructure of SiC reinforced aluminium A356 matrix is investigated Aluminium alloy A356 and silicon carbide composites were obtained by powder metallurgy process. Silicon carbide content in the alloy was fixed at 0,3,5,7 & 10 weight % during the process. Microstructure exposed an identical distribution of the silicon carbide throughout the matrix. Hardness & compression strength of the composite showed an increased as compared to the alloy without silicon carbide additions.*

Keywords: Aluminium A356, Silicon Carbide, MMCs, powder metallurgy, mechanical properties, wear rate & microstructure.

1. INTRODUTION

Composites are the arrangement of two or more integral material with considerably diverse physical & chemical properties with appearances diverse from individual components. They generally be made of a constant phase called matrix & irregular phase in the form of fibers, whiskers, or particles termed as reinforcement. Due to their features of performance with their high strength to weight ratio. Metal Matrix Composites (MMCs) are materials with metals as the base & separate phase & typically the ceramic phases added as reinforcements to increase the mechanical properties. Excellent mechanical performance, high working temperature, wear resistance, low creep rate etc are the main benefits of MMCs. Greater combination of above declared properties are existing by MMCs in such a manner that today no existing monolithic material can deliver & hence they are increasingly being used in the aerospace & automobile industries.

"Metal Matrix Composites (MMCs)" are generally refers to a composite structure which is based on metal or alloy substrate, joined with metallic or non-metallic reinforcements. MMCs are usually used in aerospace industry & other high technology fields. In the past years, MMCs have been broadly studied, especially as well as the production methods. The number of Aluminium goods is rapidly growing. Since more & more Engineered Materials are meeting the global market. The constant revolution in MMCs will results in the building of Aluminium materials with properties and functionalities. They are going to have positive changes in the lives of our people, be it in Aerospace, Automobile, Electronics, Health, Environment or any other field [12]. Advancement of the growths of MMCs, due to their lowered cost of production & enabled applications of MMCs extended from high technology to automobile industry is done by a variety of developed processes, such as stir casting, semi-solid casting & spray deposition. Request for increasing metal matrix composites is much needed for use in high performance applications such as, Aerospace & Automobiles industries. Aluminium alloy matrix composite attracts much attention towards developed the components, due to their lightness, high thermal conductivity, moderate casting temperature etc...[6].

2. EXPERIMENTALPROCEDURE

In this work, Aluminum A356 alloy is reinforced with 0, 3, 5, 7 &10 wt% of SiC particles to formulate a composite specimen. The composite is made-up by powder metallurgy (P/M) technique. Atomized aluminum powders (99.99% purity, density 2.7 g/cm3) were used as raw material. Aluminum A356 is used as the matrix material. The chemical composition of Aluminium A356 is given in the below table. Silicon Carbide is used as the reinforcement material. The matrix material Aluminium A356 powder was commercially accessible in fine powder form. Samples are produced by compaction method where large loads are applied to the mixed powder. Uni-axial compression testing machine (CTM) is used for preparation of the modules. Sintering of samples was carried out at 600°C. Microstructures of the composites were inspected by using scanning electron microscope (SEM) to detect the phases in Aluminium A356 powder & different, weights of 0, 3, 5, 7 &10% SiC. Mechanical properties like hardness & compressive strength are considered. Density measurements were carried. Hardness experiment were accomplished on prepared models by consuming Rockwell hardness tester. The test load for each model was 100 kg. Results of hardness tests were calculated by be an average of the results of 4 succeeding measurements. The compression experiments were executed by using computerized universal testing machine (UTM) having capacity of 1000kN. Wear tests were carried to study the wear behavior of the composite specimens using pin on disc tester. Design of experiments methodology was used to study wear behavior & Taguchi technique was engaged to study the effect of diverse parameters on wear rate.

Element	Chemical compositions in %
Si	7
Cu	0.02
Mg	0.3
Mn	0.01
Fe	0.2
Zn	0.10
Ni	0.02
Ti	0.01
Al	balance

Table 2.1: chemical composition of A356

3. Results and Discussion

3.1 Experimental density & Theoretical density

By using 'rule of mixtures the theoretical density of sintered specimens' was calculated. By utilizing mass & volume [$\rho = m/v$] relations experimental density is calculated From the below figure it can be noted that the theoretical density & experimental density of reinforced A356 is increased linearly through increase in the volume of SiC reinforcement. In this project, theoretical density & experimental density was extreme at 90% A356 + 10%SiC. The cause behind increase theoretical as well as experimental density is indorsed to adding of reinforcement particles SiC which has high density equated to base metal A356.

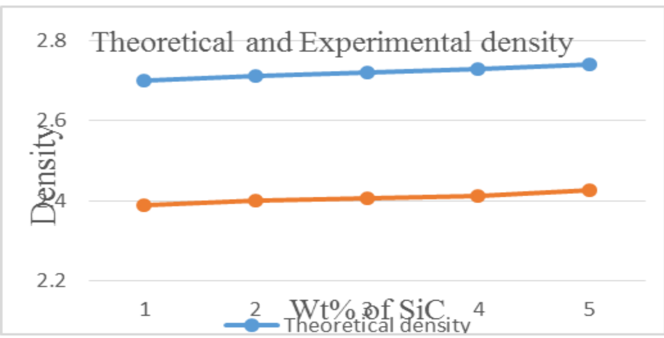


Figure 3.1 : variation of density with different compostions

3.2 Hardness test

In present study of Rockwell, hardness scale is used for evaluating hardness value. Each sample is subjected to hardness test with 2.5 mm ball indenter, 100kgf load and 20 sec of dwell time. The figure 3.2 indicates the variant in the hardness value of samples tested with respect to diverse percentage of reinforcement material & sintering temperature. It was, noticed that hardness value of the prepared composite goes on growing with expansion in the content of SiC particles. The increased hardness for the presence of silicon carbide reinforcement particles which are basically very hard. The identical distribution of SiC in the formed composites is also responsible for increasing hardness of the A356-SiC composite.

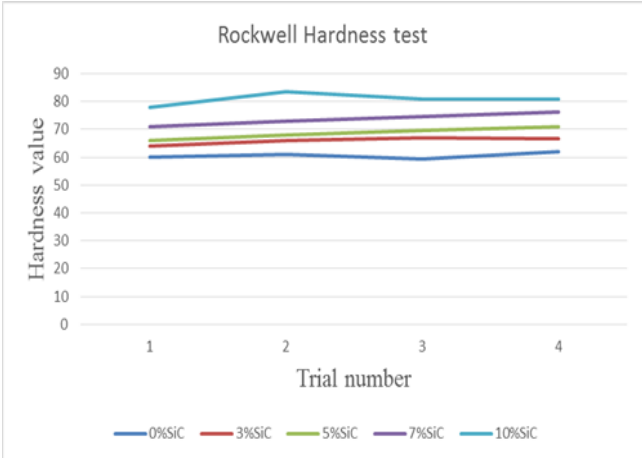


Figure 3.2: variation of hardness number with different trials

3.3 Compression test

The sintered samples are subjected to compression test. For carrying compression test "computerized universal testing machine (UTM)" was employed. Were all the experiments here carried out at the room temperature Since the UTM was computerized one it was capable to get accurate readings of ultimate compressive strength. All tests were carried with 0.5 mm/min cross head speed. The sample was placed on base plate & load was applied until the crack was observed. The reading of load applied to cause a crack in sample was noted. Same method was adapted for all other reinforcement content samples.

Fig. indicates the variation of ultimate compression strength with increase in Wt% of SiC for dissimilar samples. It is seen that the compressive strength of the made-up samples is increased with increase in the content of SiC from 0% to 10%. Ultimate compressive strength gradually increases for higher content of SiC for 10% SiC content at 600°C sintering temperature ultimate compressive strength0 increased from

215.65 to 269.54 MPa. The reason for this may be because of adding of SiC particles to the matrix.

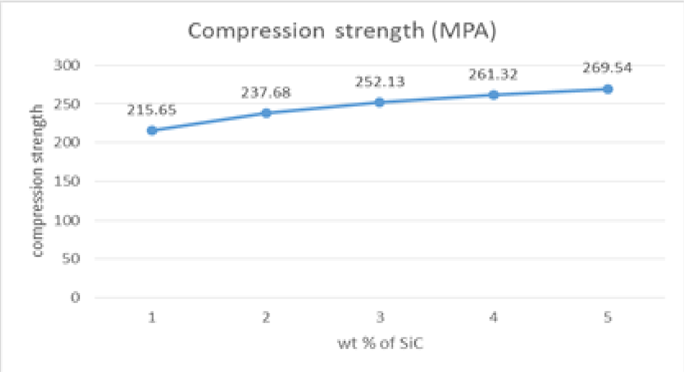


Figure 3.3: Variation of compression strength for different wt% of SiC

3.4 Tribological test results

The wear test was directed for diverse compositions of reinforcement on pin-on-disk machine & analyzed by taguchi technique. The wear behaviors of components are evaluated by conducting diverse set of experimentations. The constraints selected are speed of the rotating disc, Pan loading, material combination & wear distance traversed by the sample. The deviations of the wear outcomes for the conducted samples are as shown in the table 3.1. The experimentations were, accomplished based on the levels & elements elected for orthogonal array. In an experiments showed L9 orthogonal array was preferred. The situation of wear factors are material with 3 diverse levels of load, 3 diverse speed levels & 3 diverse abrading distance.

Wear parameters were evaluated using the software Minitab version 18 to find out principal parameters that control the wear. The parameters elected were speed of the rotating disc, Pan loading, material and combination, wear distance traversed by the sample based on the plots of signal to noise ratio & the ranked components on those values for each parameter.

From the investigation of the wear factors based on the outcomes from Taguchi technique it concludes that from the plots of SN ratio we can notice that for material condition 10% SiC, speed of rotating disc 300rpm, the traversing distance of 300m and pan loading of 10N shows the minimum wear.

Level	material	Load	Speed	Distance
1	19.31	22.24	14.53	21.34
2	14.86	21.13	20.96	14.79
3	22.87	13.67	21.55	20.92
Delta	8.01	8.57	7.02	6.55
Rank	2	1	3	4

Table 3.1: wear response for signal-to-noise ratio.

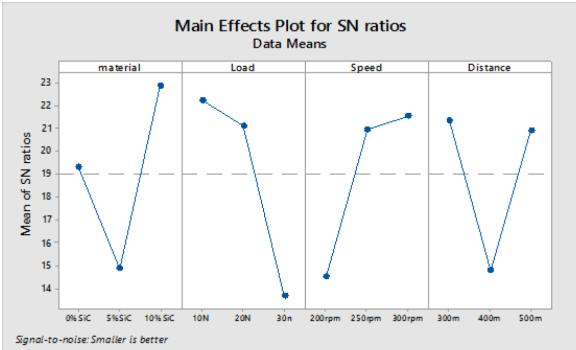
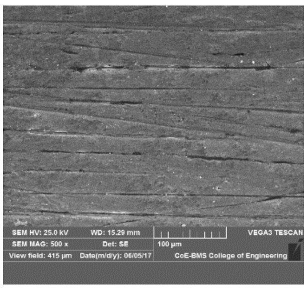


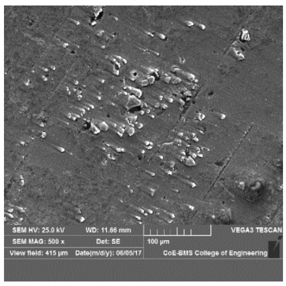
Figure 3.4: Wear response plot for Signal to Noise ratio of test specimens.

3.5 Microstructure observations

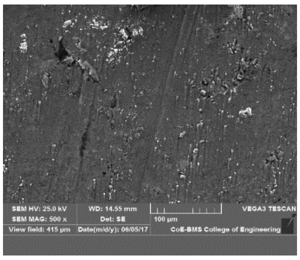
In order to observe the microstructure of the fabricated sample, the samples were cleaned & polished thoroughly. Then these sample's microstructure was considered using Scanning Electron Microscope (SEM) of resolution of 3nm at 30 KN (high vacuum) & high magnification of 5X to 1000X was used. From the figure 3.6 of microstructure of the produced sample, it can be discovered that there is a equitably constant distribution of the reinforcement particles in the fabricated composite



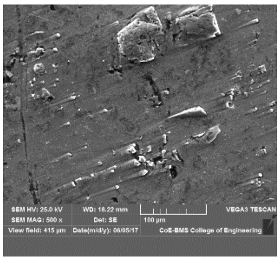
A356+0% SiC



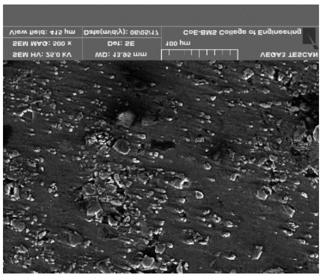
A356+3% SiC



A356+5% SiC



A356+7% SiC



A356+10% SiC

Figure 3.5: Microstructure observations 0%, 3%, 5%, 7% and 10% SiC reinforced Aluminium A356 alloy by SEM

4. CONCLUSIONS

Aluminium & its alloy based MMCs are the most fortunate materials for the future automobiles, aviation & other applications. The fabrication & experimentation of aluminium alloy A356 reinforced with different weight fractions of Silicon carbide successfully synthesized by using powder metallurgy technique.
The following conclusions can' be given from this' attempt

- A356 alloy MMCs reinforced with diverse weight percentages of SiC particles (0, 3, 5, 7 &10%) have been creditably formed by P/M method. The prime conditions of production process were that compaction load accounted is 60 KN with sintering time of 2 hours at temperature of 600°c.
- Density studies discovered that there was increases with increase in % SiC content from 0% to 10%.
- Compression strength results revealed that ultimate compressive strength increases with increases in % SiC from 0% to 10%.
- Hardness test results discovered that there was increases with increase in % SiC content from 0% to 10%.
- Wear results showed that adding of wt% SiC increased wear resistance significantly. From Taguchi analysis it was found that minimum wear was noticed at 10% SiC, 10N load, 300 rpm speed & 300 m distance
- The microstructure observations discovered that fair uniform distribution of SiC can be seen in the base material.

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