Analysis on Mechanical Behaviour of AA 1050/ SiC and AA 1050/Al_2O_3 Composites

Kapil Singh[1] , Mukesh Kumar[2]

[1]Assistant Professor, Arni University, Kathgarh, H.P India

[2]M-Tech Student ARNI University, Kathgarh, H.P India

Abstract: ***In present work, an analysis has been made on mechanical behavior of aluminum metal matrix composites. Aluminum alloy 1050/10 wt% Al_2O_3 and Aluminum alloy 1050/10 wt% SiC composite. Stir casting route has been followed to fabricate these composites. Different tests have been carried out on these two MMC's and base alloy to study the mechanical properties. Furthermore, the effects of reinforced particles sizes on the microstructure of the composites were observed by using SEM. These MMCs are to be used for automobile, aircraft and space industries. Hence a solution is needed to solve the issues like selection of material on the basis their mechanical properties.***

Keywords: Aluminum metal matrix composite, SEM, Mechanical properties, Stir Casting

1. Introduction

Metal composite materials have found application in many areas of daily life for quite some time. These are combination of metal matrix and stiff and hard reinforcing phase. These materials are produced from the conventional production and processing of metals. Materials like cast iron with graphite or steel with high carbide content, as well as tungsten carbides, consisting of carbides and metallic binders i.e., cobalt, also belong to this group of composite materials. For many researchers the term metal matrix composites (MMCs) is often equated with the term light metal matrix composites (LMCs). Aluminum metal matrix composites refer to the class of light weight aluminum centric systems which are characterized by superior physical and mechanical properties.

2. Material Preparation Methodology

The matrix material used in this study is AA1050 (Figure 1). Table 1 shows the chemical composition of AA1050. The reinforcement material added was Al_20_3 and SiC (Figure 2 and 3). The addition of Al_20_3 and SiC particles improves high fracture toughness, wear resistance, hardness, strength, and stiffness. The composite was prepared using stir casting process. AA1050 is kept in graphite crucible inside the muffle furnace. The alloy was melted to the desired heating temperature of 650°C. The preheated reinforcement particles with an amount of 10 wt% of Al_20_3 and SiC particles and size of 20 µm to 40 µm were introduced into the vortex of the molten alloy after effective heating.

Figure 1: Aluminum Alloy 1050

Figure 2: Aluminum Oxide Powder

Figure 3: Silicon Carbide Powder

Table 1: Chemical composition of AA 1050

Alloy	Si+ Fe	Cu	Mn	Mg	Zn	Al
1050	0.25 Si+Fe	0.05	0.05	0.05	0.05	Remainder

Then the stirring was carried out for about 10 minutes at stirring rate of 300 RPM. At this stage, the SiC particles was added manually to the vortex. In the final mixing processes the furnace temperature was controlled within 700 ± 10oC. After stirring process the mixture was pour in the other mould to get desired shape of specimen. Same process was used for specimens with Alumina particles. Compositions of samples are shown in Table 2 and 3

Table 2: Chemical composition of AA1050/Sic MMC

AA1050/Sic MMC	Weight of AA1050	Weight of Sic	Melting Temp. (AA1050) (60mins)	Stirrer Speed (RPM)
10wt% Sic	900 grams	100 grams	646-657 ^{0}C	300

Table 3: Chemical composition of AA1050/Al_2O_3 MMC

AA1050/Al2O3 MMC	**Weight of AA1050**	**Weight of Sic**	**Melting Temp. (AA1050) (60mins)**	**Stirrer Speed (RPM)**
10wt% Sic	900 grams	100 grams	646-657 ^{0}C	300

3. Experimental Work

Tensile tests were used to assess the mechanical behavior of the composites and matrix alloy. The composite and matrix alloy rods were machined to tensile specimens with a diameter of 6mm and gauge length of 30 mm

Table 4: Tensile Strength Results

Serial No	Composite	Yield Strength N/mm2	UTS N/mm2	Elongation (%)
1	Al 1050	103	110	9
2	10% SiC	148	305	1.98
3	10 % Al2O3	138	280	2.7

During tensile testing of a material sample, the stress–strain curve is a graphical representation of the relationship between stress, derived from measuring the load applied on the sample, and strain, derived from measuring the deformation of the sample, i.e. elongation, compression, or distortion. The slope of stress-strain curve at any point is called the tangent modulus; the slope of the elastic (linear) portion of the curve is a property used to characterize materials and is known as the Young's modulus. The area under the elastic portion of the curve is known as the modulus of resilience.

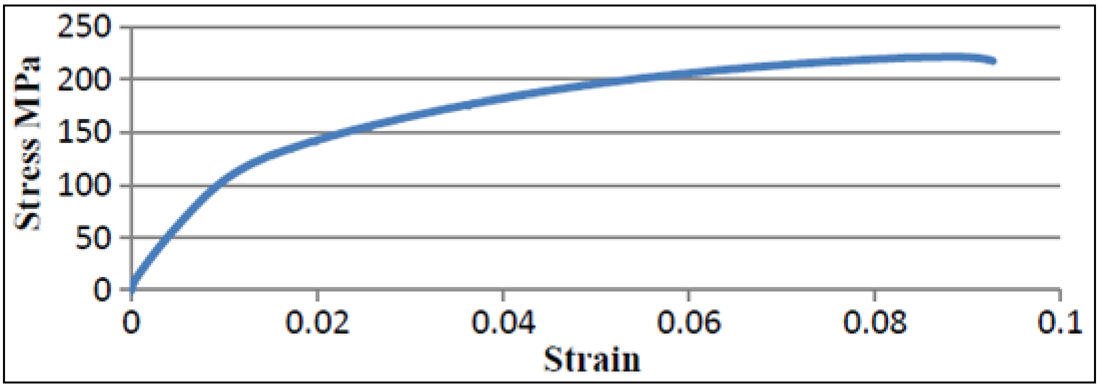

Figure 4: Stress vs. Strain Curves for Aluminium 1050 with 10% SiC

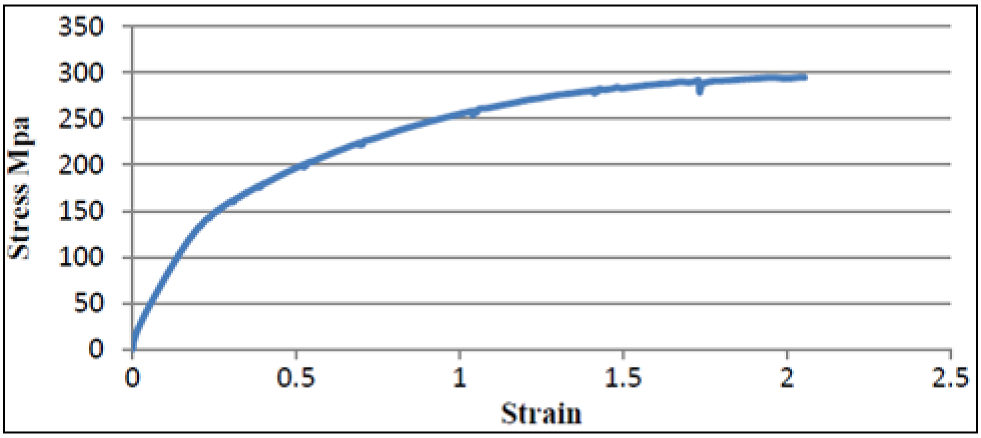

Figure 5: Stress vs. Strain Curves for Aluminium 1050 with 10% Al2O3

Yield Strength Comparison

As shown in Figure number 6 results predict that as the reinforcement wt.% Yield Strength is increases. This happens may be due to dispersion of SiC & Alumina which create hinderance to dislocation motion. To move this defect (plastically deforming or yielding the material), a larger stress must be applied. This may results increase in tensile strength of reinforced LM6 alloy

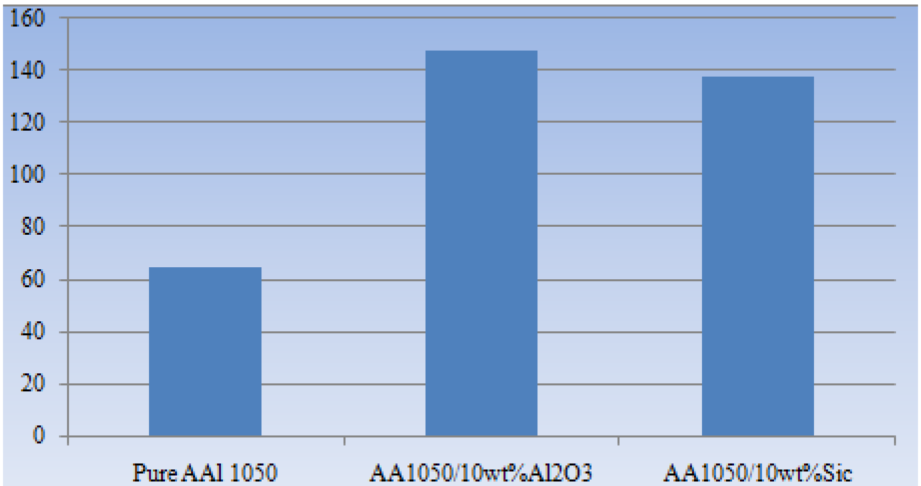

Figure 6: Comparison the Yield Strength with AA1050/10wt%Sic & AA1050/10wt% Al_2O_3

Ultimate Tensile Strength Result

As shown in Chart Figure number 7 results predict that as the reinforcement wt.% UTS is also increases. This happens may be due to dispersion of SiC & Alumina which create hinderance to dislocation motion. This may results increase in tensile strength of Al1050 alloy.

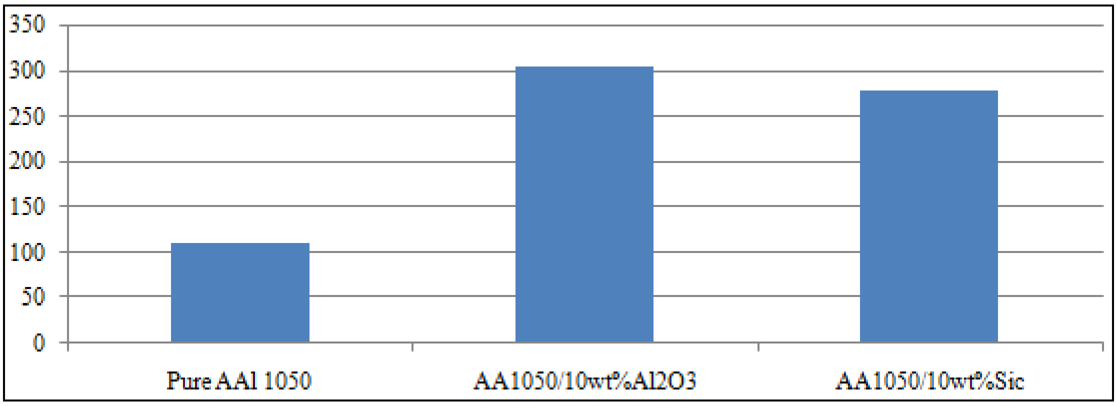

Figure 7: Comparison the Yield Strength with AA1050/10wt%Sic & AA1050/10wt% Al_2O_3

Hardness Test

A Rockwell hardness tester machine used for the hardness measurement. The surface being tested generally requires a metallographic finish and it was done with the help of 100, 220, 400, 600 and 1000 grit size emery paper. Load used on Rockwell's hardness tester was 250 grams at dwell time 25 seconds for each sample. The result of Rockwell's hardness test wt.% variation of different reinforcements such as SiC/ Al_2O_3 are shown in Table number 5.

Table 5: Shows Hardness test results

Serial No	Composites	Trial			Total force Nm	Average Force Nm
		1	2	3		
1	Al 1050					6
2	10% SiC	8.4	9.2	8.5	26.1	8.7
3	10 % Al2O3	7.5	6.8	7.1	21.4	7.13

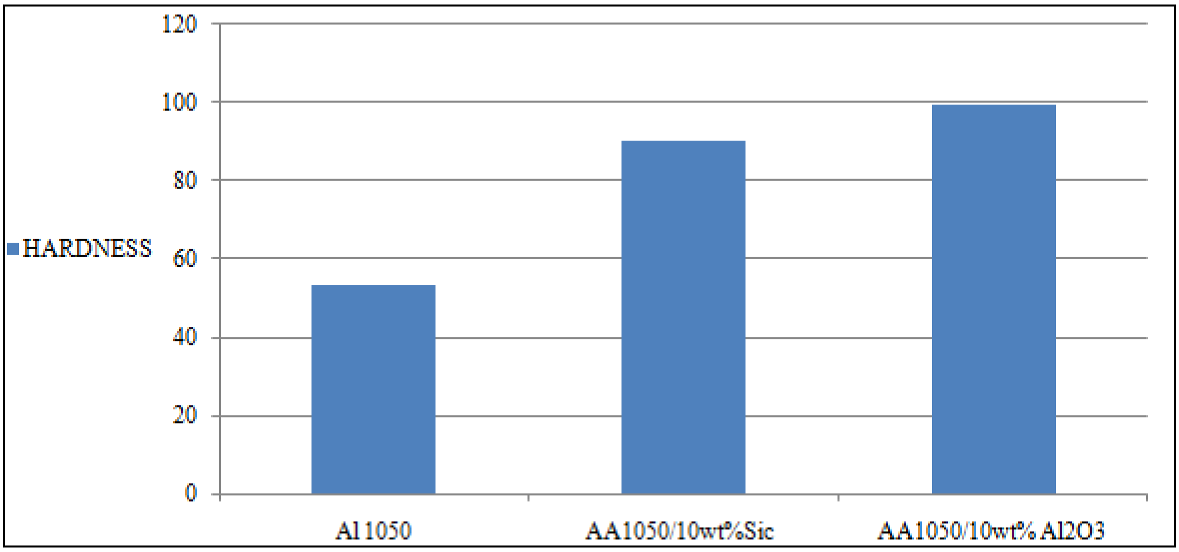

Figure 8: Comparison the Hardness of Al1050 ,AA1050/10wt%Sic & AA1050/10wt% Al_2O_3

In Figure number 8 results predict that uniform increase in hardness is also seen. This is due to increase in resistance to deformation by adding SiC and Alumina as reinforcement in Al1050

4. Results of Sem

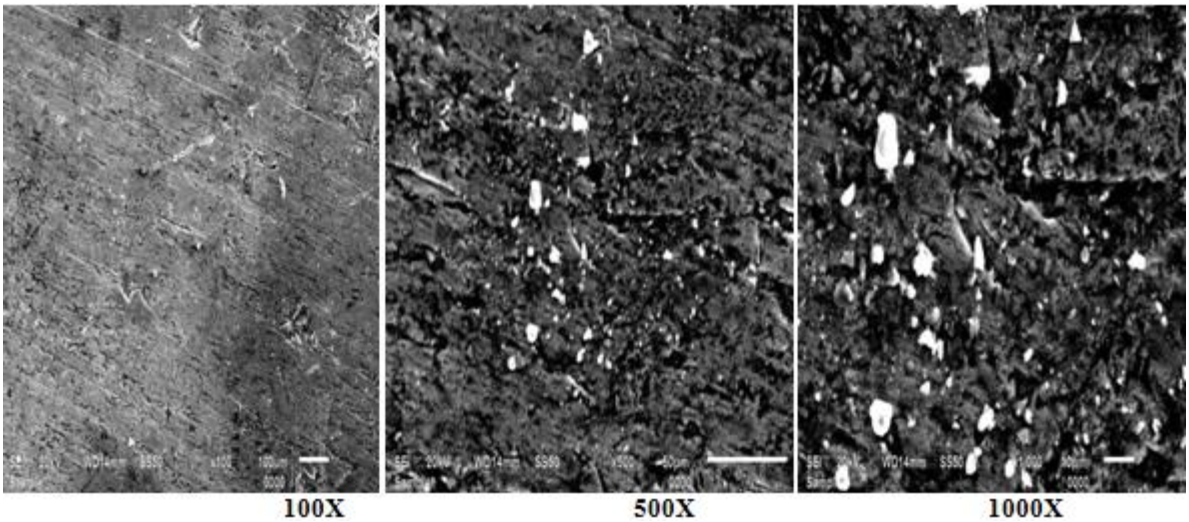

Figure 9: Microscopic View of 10 % SiC Reinforced in Al1050 100 X, 500 X, 1000X

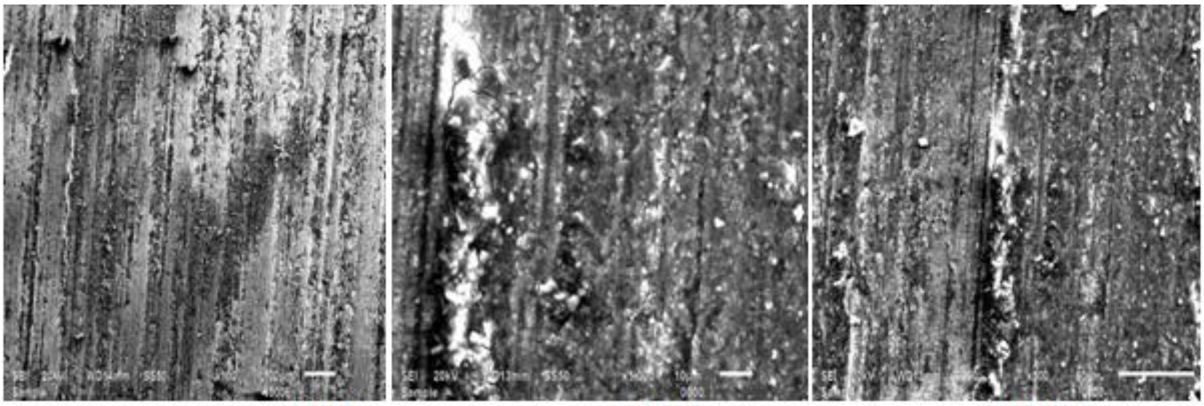

Figure 10: Microscopic View of 10 % Alumina Reinforced in Al1050 100 X, 500 X, 1000 X

Figures 9 and 10 are presented with the microphotographs of Cast Al 1050-SiC and Alumina composites respectively. From figures it can be observed that, the distributions of reinforcements in the respective matrix are fairly uniform. Further these figures reveal the homogeneity of the cast composites. The microphotograph also clearly revels the increased filler contents in the composites. Cracks are also seen in the microstructure.

5. Compression Test Results

Compression tests were used to assess the mechanical behavior of the composites and matrix alloy. The composite and matrix alloy rods were machined to tensile specimens with a diameter of 19mm gauge length of 22 mm. Universal testing machine used for the Compressive Strength measurement. The result of test wt.% variation of different reinforcements such as SiC/ Al_2O_3 are shown in Table number 6.

Table 6: Compression Test Results

Serial No	Composites	Trial			Total	Average Compressive Strength in Mpa
		1	2	3		
1	Al 1050					
2	10% SiC	423.62	424.16	422.45	1270.23	423
3	10 % Al2O3	439.4	441.12	438.75	1319.27	440

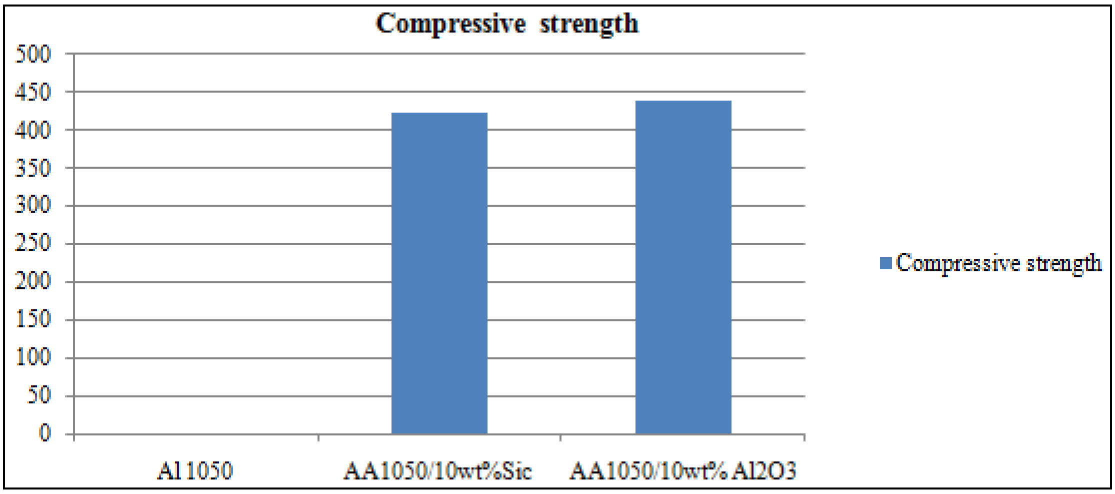

Figure 11: Comparison of Compressive Strength Al1050 ,AA1050/10wt%Sic & AA1050/10wt% Al_2O_3

Figure 11 shows that with the increase in SiC & Al_2O_3 constituent Impact strength is increases w.r.t base metal. This is due to proper dispersion of SiC & Al_2O_3 into the matrix or strong interfacial bonding in between the Al alloy and SiC& Alumina interfaces.

Shear Test Results

Shear tests were used to assess the mechanical behavior of the composites and matrix alloy. The composite and matrix alloy rods were machined to tensile specimens with a diameter of 19mm. Universal testing machine used for the Shear Strength measurement The result of test wt.% variation of different reinforcements such as SiC/ $Al_2O_3$are shown in Table number 7.

Table 7: Shear Test Results

Serial No	Composites	Trial			Total	Average Shear Strength
		1	2	3		
1	Al 1050					69 MPa
2	10% SiC	132.19	133.95	132.13	398.27	133 MPa
3	10 % Al_2O_3	126.42	123.67	122.85	372.94	124 MPa

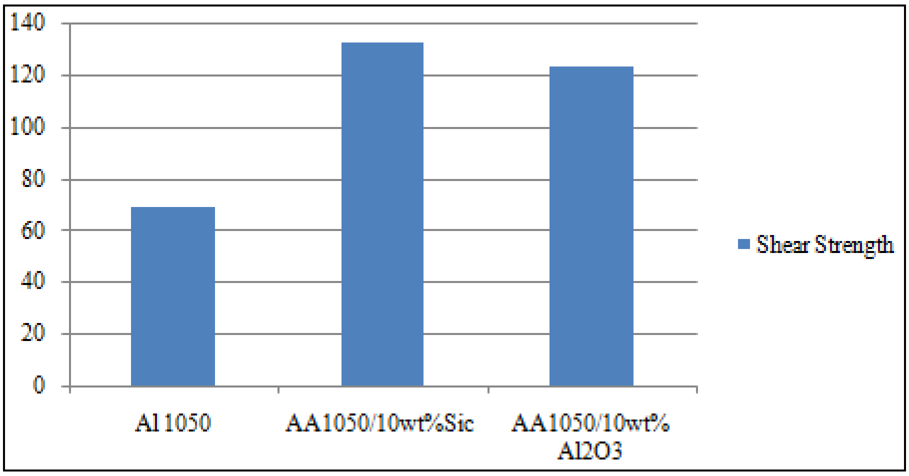

Figure 12: Comparison of Shear Strength Al1050 ,AA1050/10wt%Sic & AA1050/10wt% Al_2O_3

As shown in Figure number 12 results predict that as the reinforcement wt.% Shear Strength is increases. This happens may be due to dispersion of SiC & Alumina into the matrix.

6. Conclusions

The conclusions drawn from the present investigation are as follows:

1) The results confirmed that stir formed Al 1050 with SiC/Al_2O_3 reinforced composites is clearly superior to base Al 1050 in the comparison of tensile strength, Impact strength as well as Hardness.
2) Dispersion of SiC/Al2O3 particles in Al 1050 improves the hardness of the matrix material. It appears from this study AA1050/10wt%Sic is more harder AA1050/10wt%Al_2O_3.
3) Impact strength is increase by adding SiC & Al_2O_3.
4) It appears from this study that UTS and Yield strength increases with 10% weight percentage of SiC and Al_2O_3 in the matrix.
5) Dispersion of SiC & Alumina into the Al 1050 increases the shear strength.
6) It appears from this study that strong interfacial bonding of Al 1050 with SiC & Alumina increases the compressive strength.

References

[1] L.Ceschini, “Tensile and fatigue properties of the AA6061/20% volume Al2O3p and AA7005/10% volume Al2O3p composites”, Composites Science and Technology 66 (2006) 333–342.
[2] http://en.wikipedia.org/wiki/Aluminium.htm on date 1/4/2011
[3] http://www.eaa.net/eaa/education/TALAT/index.htm on date 6/5/2011. .
[4] Sanjeev kumar, “Effect of thermal ageing on Al-SiC Metal Matrix”, ME Thesis Thapar University Patiala, 2010.
[5] http://www.substech.com/dokuwiki/doku.php?id=liquid_state_fabrication_of_metal_matri x_composites.htp on date 15/4/2011
[6] Divecha, “Silicon carbide reinforced aluminum - A formable composite” Journal of Metals. Vol. 33, pp. 12-17. Sept. 1981
[7] Hashim, “Metal matrix composites: production by the stir casting method”, Journal of Materials Processing Technology 92-93 (1999) 1-7.
[8] Joseph Goldstein, Scanning electron microscopy and x-ray microanalysis, Plenum Publishers, 2001.
[9] Manoj Singla, “Development of Aluminium Based Silicon Carbide Particulate Metal Matrix Composite”, Journal of Minerals & Materials Characterization & Engineering, Vol. 8, No.6, pp 455-467, 2009.
[10] D.J.Lloyd, “Particle reinforced aluminium and magnesium matrix composites”, International Materials Reviews 1994 Vol. 39 No.1.
[11] S.V. Prasad, “Aluminum metal–matrix composites for automotive applications: tribological considerations”, Tribology Letters, Vol. 17, No. 3, October 2004.
[12] S. Balasivanandha Prabu, “Influence of stirring speed and stirring time on distribution of particles in cast metal matrix composite”, Journal of Materials Processing Technology 171 (2006) 268–273.
[13] M. Kok, “Production and mechanical properties of Al2O3 particle-reinforced 2024 aluminium alloy composites”, Journal of Materials Processing Technology 161 (2005) 381– 387.
[14] G.B.Veeresh Kumar, “Studies on Al6061-SiC and Al7075-Al2O3 Metal Matrix Composites”, Journal of Minerals & Materials Characterization & Engineering, Vol. 9, No.1, pp.43-55, 2010.
[15] J. R. Davis, “Aluminum and aluminum alloys”, ASM International, 1993
[16] Sudipt Kumar, “production and characterisation of Aluminium-Fly Composites using Stir Casting Method”, Department of Metallurgical & Materials Engineering National Institute of Technology Rourkela, 2008.