

# Analysis on Mechanical Behaviour of AA 1050/ SiC and AA 1050/ $\text{Al}_2\text{O}_3$ Composites

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**Abstract:** *In present work, an analysis has been made on mechanical behavior of aluminum metal matrix composites. Aluminum alloy 1050/10 wt%  $\text{Al}_2\text{O}_3$  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

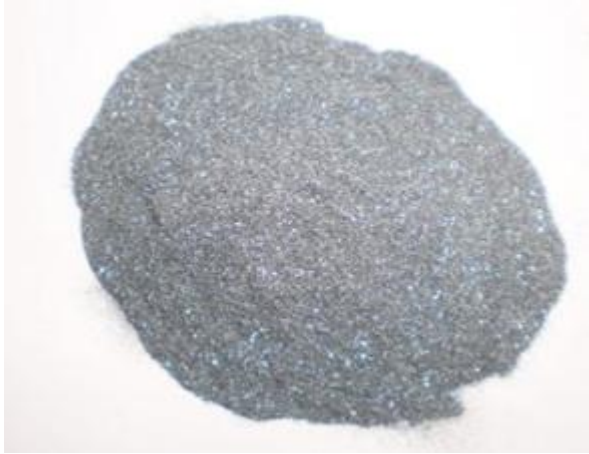
The matrix material used in this study is AA1050 (Figure 1). Table 1 shows the chemical composition of AA1050. The reinforcement material added was  $\text{Al}_2\text{O}_3$  and SiC (Figure 2 and 3). The addition of  $\text{Al}_2\text{O}_3$  and SiC particles improves high fracture toughness, wear resistance, 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  $\text{Al}_2\text{O}_3$  and SiC particles and size of 20  $\mu\text{m}$  to 40  $\mu\text{m}$  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  $700 \pm 100^\circ\text{C}$ . 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 $^\circ\text{C}$	300

**Table 3:** Chemical composition of AA1050/Al<sub>2</sub>O<sub>3</sub> MMC

AA1050/Al <sub>2</sub> O <sub>3</sub> MMC	Weight of AA1050	Weight of Sic	Melting Temp. (AA1050) (60mins)	Stirrer Speed (RPM)
10wt% Sic	900 grams	100 grams	646-657 $^\circ\text{C}$	300

### 3. Experimental Work

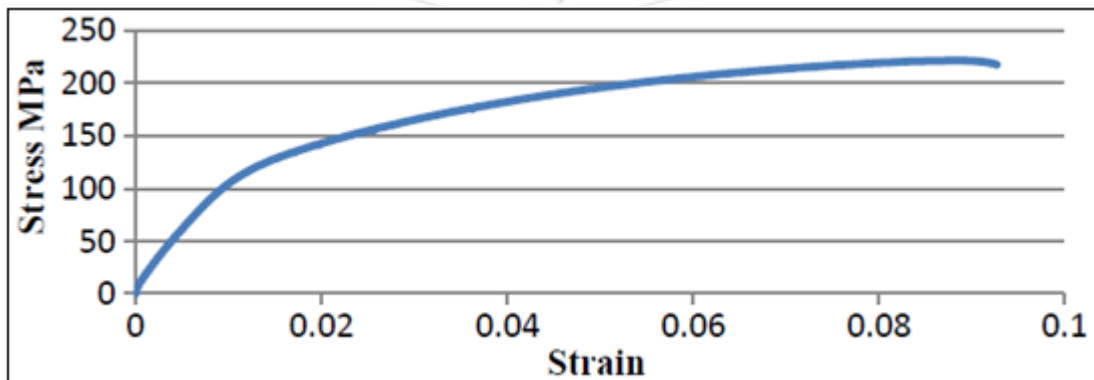
Tensile tests were used to assess the mechanical behavior of the composites and matrix alloy. The composite and matrix alloy rods were machined to tensile specimens with a diameter of 6mm and gauge length of 30 mm

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.

**Table 4:** Tensile Strength Results

Serial No	Composite	Yield Strength N/mm <sup>2</sup>	UTS N/mm <sup>2</sup>	Elongation (%)
1	Al 1050	103	110	9
2	10% SiC	148	305	1.98
3	10 % Al <sub>2</sub> O <sub>3</sub>	138	280	2.7

During tensile testing of a material sample, the stress–strain curve is a graphical representation of the relationship



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

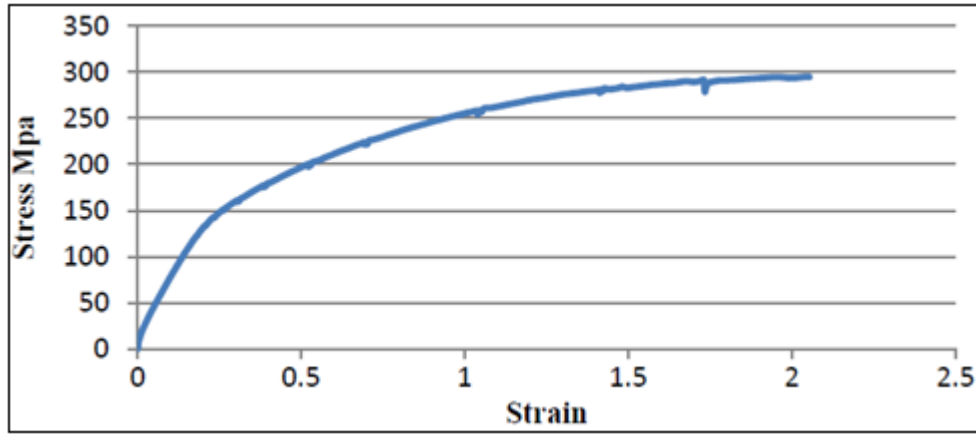


Figure 5: Stress vs. Strain Curves for Aluminium 1050 with 10% Al<sub>2</sub>O<sub>3</sub>

**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

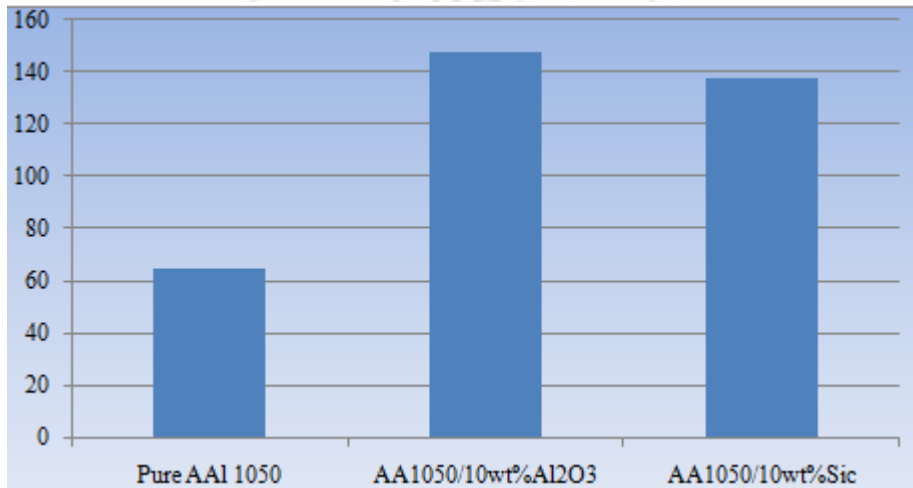


Figure 6: Comparison the Yield Strength with AA1050/10wt%SiC & AA1050/10wt% Al<sub>2</sub>O<sub>3</sub>

**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.

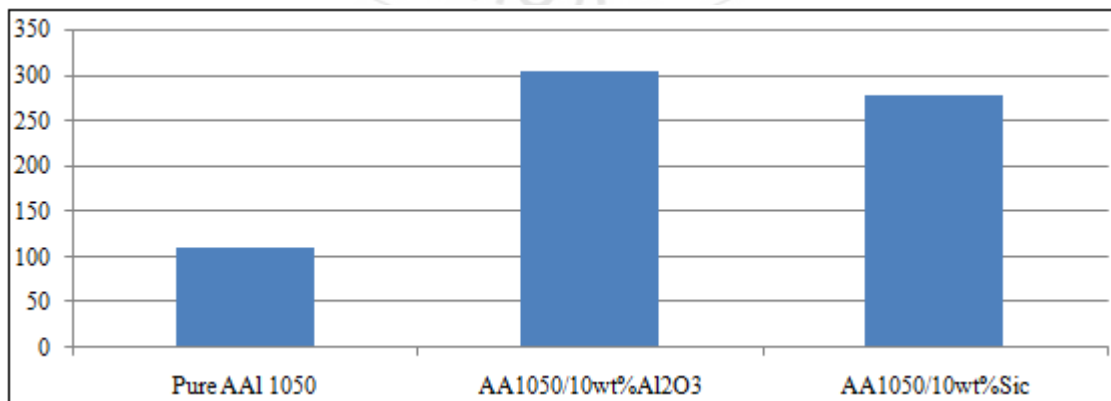


Figure 7: Comparison the Yield Strength with AA1050/10wt%SiC & AA1050/10wt% Al<sub>2</sub>O<sub>3</sub>

**Hardness Test**

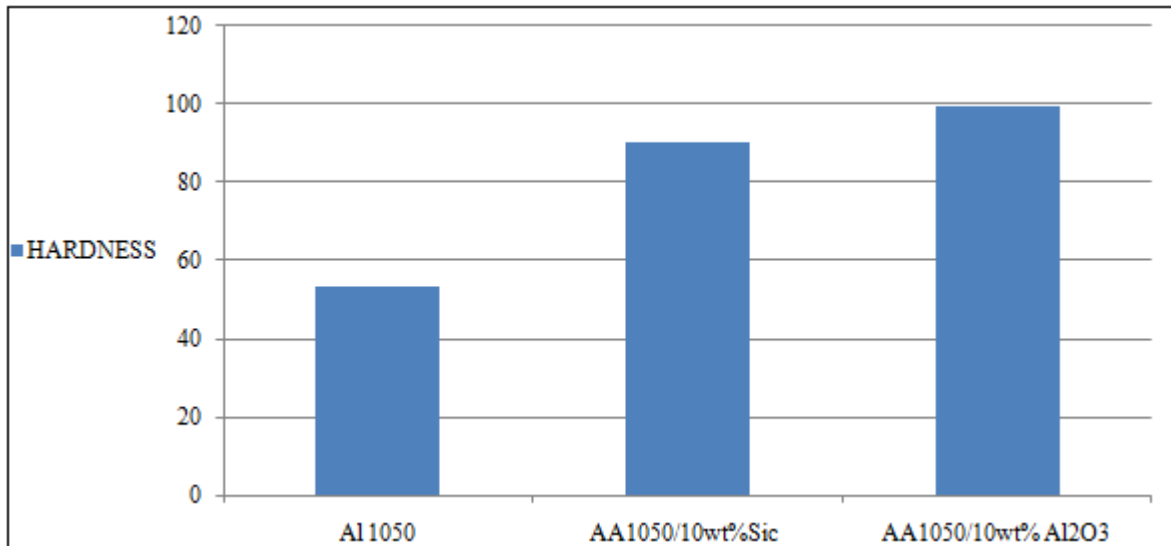
A Rockwell hardness tester machine used for the hardness measurement. The surface being tested generally requires a metallographic finish and it was done with the help of 100,

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

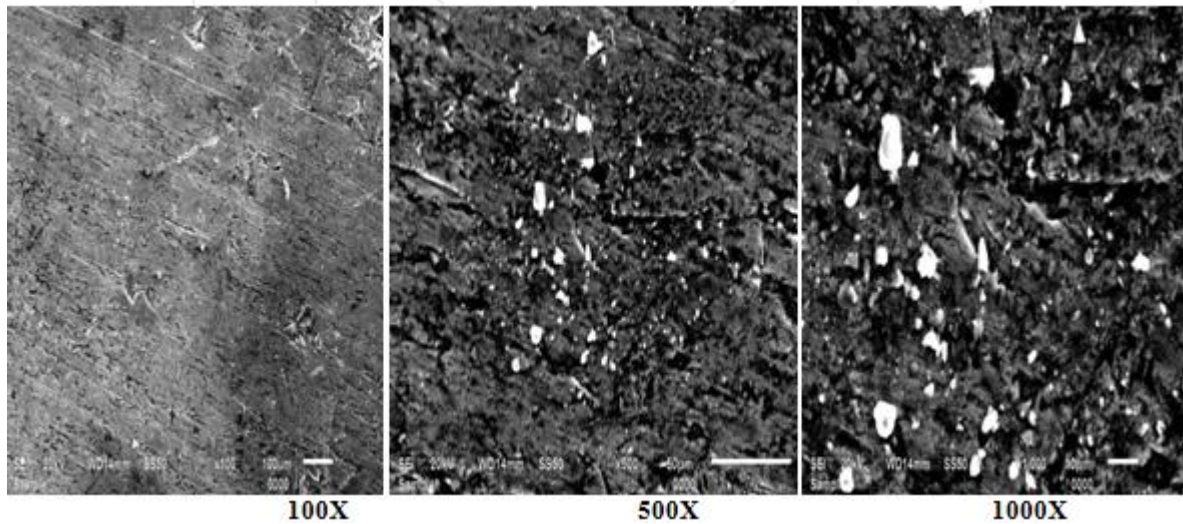
Serial No	Composites	Trial			Total force Nm	Average Force Nm
		1	2	3		
1	Al 1050					6
2	10% SiC	8.4	9.2	8.5	26.1	8.7
3	10 % $Al_2O_3$	7.5	6.8	7.1	21.4	7.13



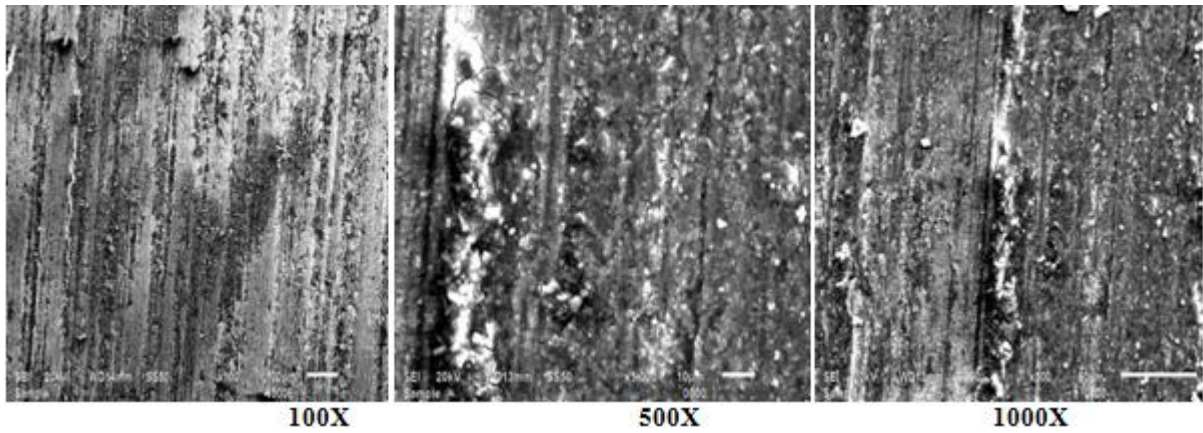
**Figure 8:** Comparison the Hardness of Al1050 ,AA1050/10wt%SiC & AA1050/10wt%  $Al_2O_3$

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

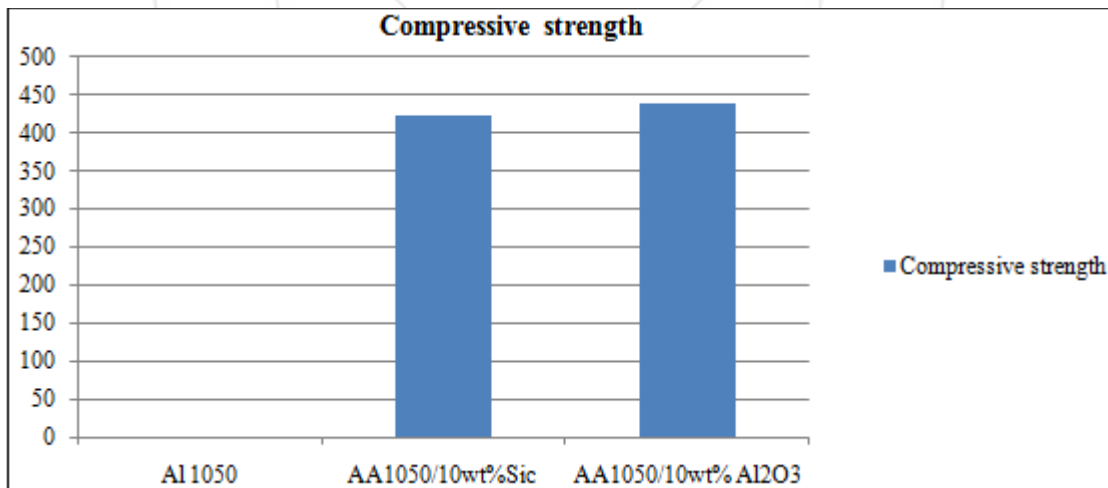
Figures 9 and 10 are presented with the microphotographs of Cast Al 1050-SiC and Alumina composites respectively. From figures it can be observed that, the distributions of reinforcements in the respective matrix are fairly uniform. Further these figures reveal the homogeneity of the cast composites. The microphotograph also clearly reveals 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<sub>2</sub>O<sub>3</sub> 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 % Al <sub>2</sub> O <sub>3</sub>	439.4	441.12	438.75	1319.27	440



**Figure 11:** Comparison of Compressive Strength Al1050 ,AA1050/10wt%SiC & AA1050/10wt% Al<sub>2</sub>O<sub>3</sub>

Figure 11 shows that with the increase in SiC & Al<sub>2</sub>O<sub>3</sub> constituent Impact strength is increases w.r.t base metal. This is due to proper dispersion of SiC & Al<sub>2</sub>O<sub>3</sub> into the matrix or strong interfacial bonding in between the Al alloy and SiC& Alumina interfaces.

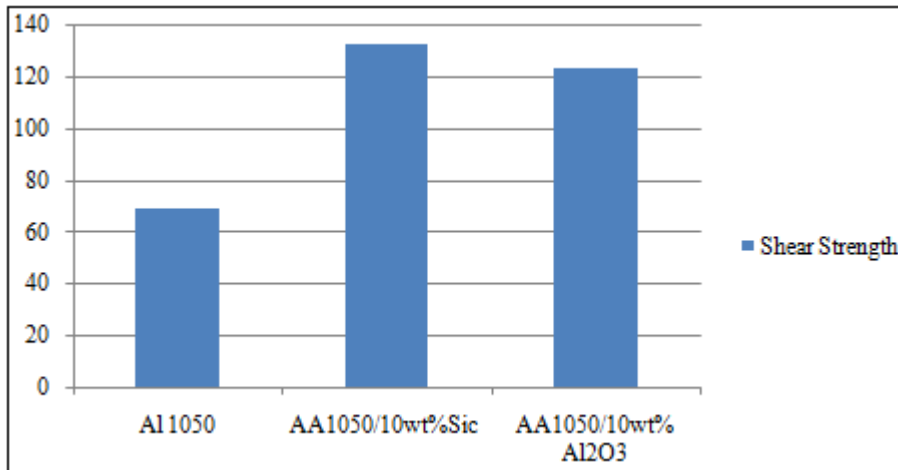
### Shear Test Results

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<sub>2</sub>O<sub>3</sub>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 <sub>2</sub> O <sub>3</sub>	126.42	123.67	122.85	372.94	124 MPa



**Figure 12:** Comparison of Shear Strength Al1050 ,AA1050/10wt%SiC & AA1050/10wt% Al<sub>2</sub>O<sub>3</sub>

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<sub>2</sub>O<sub>3</sub> 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/Al<sub>2</sub>O<sub>3</sub> 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<sub>2</sub>O<sub>3</sub>.
- 3) Impact strength is increase by adding SiC & Al<sub>2</sub>O<sub>3</sub>.
- 4) It appears from this study that UTS and Yield strength increases with 10% weight percentage of SiC and Al<sub>2</sub>O<sub>3</sub> 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.

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