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Analysis of effect of reinforcement on properties of aluminum based composites

Rajesh Manhas
Department of Mechanical engineering, Arni University, Kathgarh, Indora

Abstract- **Composites have important role various engineering fields. Here in this work Al 356/SiC composite is fabricated and variation of percentage reinforcement is analyzed in respect of effect on mechanical properties. With reinforcement of SiC in matrix of alloy the properties of Al356 alloy are significantly improved. A comparison of the mechanical properties and the microstructure of Al 356 alloy with Al 356/SiC metal matrix composite containing different % by weight of reinforcement was done in present work.**

Index Terms- **Al 356 alloy, stir casting, Al 356/MgO Metal matrix Composite (MMC), Aluminium Matrix Composite (AMC)**

INTRODUCTION

Composite materials have important place in engineering industry. Properties of composites such as strength and stiffness, wear resistance, thermal and mechanical fatigue and creep resistance. Up to now various composites have been successfully fabricated and utilized for different applications. Metal matrix composite (MMCs) is a improvement in fabrication of composites.[1-15] Casting is commonly used method in production of composites. Powder metallurgy is other widely used method for production of MMC. One of the problem in use of MMC in various applications is its counterparts. But MMCs are preferred in many cases due to High strength; fracture toughness and stiffness are offered by metal matrices than those offered by their polymer counterparts. [3-5].

Here in MMC matrix of metal or alloy & some reinforcement material is used to produce composite. Matrix is the base material in the composite. Among the various alloys, aluminium and its alloys are widely used in the production of composites. Various aluminium based MMCs with various reinforcement materials have been reported so for. Reinforcement of aluminium alloy by hard and soft reinforcements such as SiC, MgO, graphite, Si-rice husk, Frreocrome slag and many more is continue in research industry and in production in many cases. Wide range of applications and requirement of metal matrix composites in industry for different applications put many researchers in finding a cost effective production methods for these composites. [1-2, 16-20]

Commonly used matrix metals that offers good matrix for fabrication of MMCs are Titanium, Aluminium and magnesium. Modulus of reinforcements is a important parameter which decides the properties of MMC. High modulus of reinforcement results in high strength. Operating temperature of composite is decided by frequency of its properties.[6-9] [21-39]

In this paper comparison of properties of aluminium alloy Al 356 and its composite using SiC as reinforcement. Stir casting method was used in fabrication. Mechanical & micro structural study has been performed.

MATERIALS & METHODS

Materials

Al 356 aluminium alloy which acts as matrix was used. The detail of properties and composition of aluminium alloy Al 356 are listed below:

Chemical Composition

S.NO.	ELEMENT	Wt%
1	Cu	0.20
2	Mg	0.25 to 0.45
3	Mn	0.10
4	Si	6.5 to 7.5
5	Fe	0.20
6	Zn	0.10
7	Ti	0.20
8	Al	Balance

Table 3.1: Chemical composition of Al 356 alloy

Mechanical Properties

Property	Tensile strength (MPa)	Hardness (BHN)	Toughness (joule)	Fatigue strength (1 × 10^7 MPa)	Endurance Limit	Modulus of Elasticity	Shear strength
Value for Al 356	230	75	6	120	56	71	120

Table 3.2: Mechanical properties Al 356 alloy.

Thermal Properties

Property	Latent heat of fusion	Specific heat	Liquidus temperature	Solidus temperature
Value for Al 356	389kJ/kg	963 J/kg	615ºC	555ºC

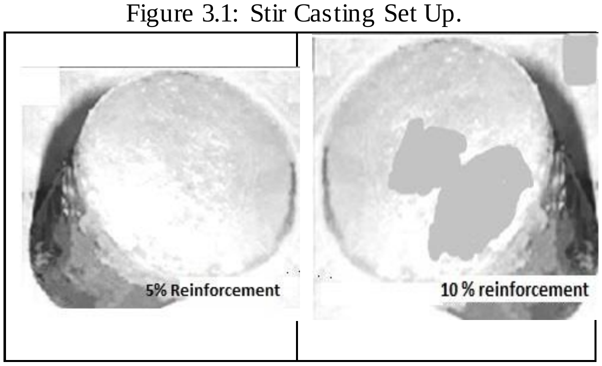
Table 3.3: Thermal properties Al 356 alloy.

Applications of Al 356 alloy

High strength airframe and space frame structural parts, machine parts, truck chassis parts, high velocity blowers and impellers.

SiC (particle) are use as reinforcement.

Figure 3.1: Stir Casting Set Up.



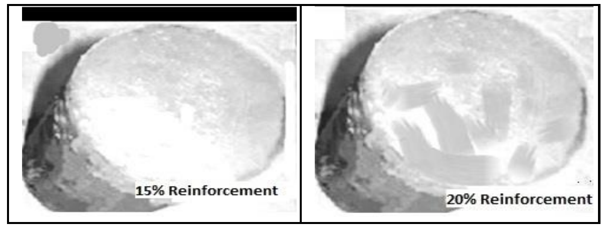


Figure 3.2: Al 356/Alumina Metal matrix composite samples.

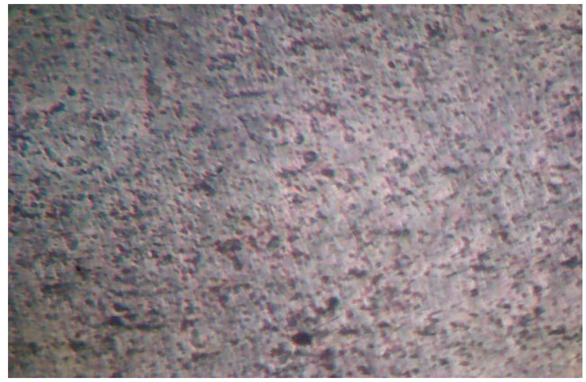


Figure 3.3: Micrograph of Al 356 alloy without reinforcement

Figure 3.4: Micrograph of MMC (Al 356 alloy with reinforcement).

RESULTS AND DISCUSSION

Microstructure

Figure 3.3-3.4 shows micrographs of samples of SiC reinforced Al 356 composites with different combinations. Samples were observed under microscope at different magnifications (upto x1000) in order to select best one. Observations show that the SiC particulates are visible and also ensure maximum dispersion of particulates in MMC. All samples show this parameter perfectly. All this shows good efficiency of the production technique.

Hardness measurement

With Load applied 100 Kgf, Diameter of ball 2.5mm, testing time 30 seconds [37-39], we have obtained an increase in hardness with increasing percentage of reinforcement. This is due to increase in amount of particulates of SiC in metal matrix. As SiC is known for high hardness value of particles, that let it to be used in various machining applications etc.. So with increasing percentage of reinforcement, hardness of MMC increases.

S.No.	Alumina particle wt%	Hardness
1	0%,	75.00
2	5%,	85.5
3	10%,	93.0
4	15%	96.6
5	20%	100.3

Table 3.4: Hardness testing results of Al 356/SiC MMC

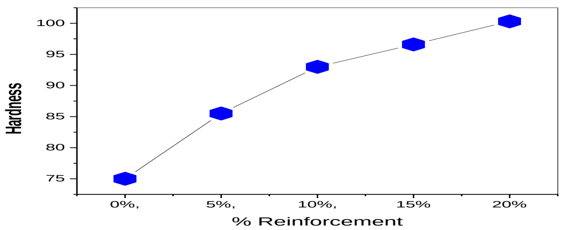


Figure 3.5: Hardness Vs percentage reinforcement.

Toughness measurement

S.No.	Alumina particle wt%	Toughness (Joule)
1	0%,	6.14
2	5%,	7.4
3	10%,	10.5
4	15%	13.8
5	20%	14.9

Table 3.5: Toughness testing results of Al 356/Alumina MMC.

From impact test it is observed that there is increase in toughness with increasing percentage of reinforcement. It is clear from figure 3.11 that large increase in value observed when going from 5 to 10 % reinforcement. Increase in toughness i.e. energy absorbed with increasing percentage of reinforcement is due to fact that SiC particles acts as brittle material so requires more energy for plastic deformation.

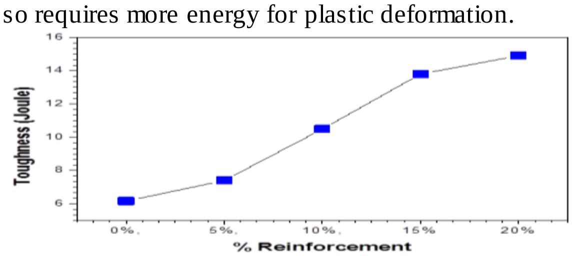


Figure 3.6: Toughness Vs percentage reinforcement

Tensile Testing

S.No.	Alumina particle wt%	Tensile strength(MPa)
1	0%,	232
2	5%,	254.96
3	10%,	271.45
4	15%	287.0
5	20%	309.11

Table 3.6: Tensile strength testing results of Al 356/SiC MMC

From figure 3.13 it is clear that tensile strength increases with increasing percentage of SiC reinforcement. Similar behavior i.e. increases in tensile strength with increasing percentage of hard reinforcement particles reported by many researchers. This verifies accuracy of our results [36-39].

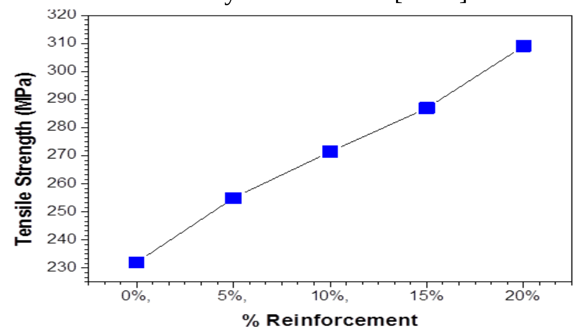


Figure 3.7: Tensile strength Vs percentage reinforcement

CONCLUSIONS

Reinforcement of SiC particles in Al 356 alloy matrix results in composite that have hardness greater than Al 356 alloy. Hardness of MMC increases with increase in percentage of SiC reinforcement. Increasing percentage of SiC particles results in amount of energy absorbed by MMC material to be increase, hence the toughness of MMC. Study of tensile strength behavior confirms that SiC reinforcement increases strength of Al 356 alloy. This increase in strength continues with increase in percentage of SiC in MMC. Microstructure study confirms formation of SiC particulate in Al 356/ Al2O3 MMC. This show feasibility of production technique. Overall one can control the mechanical properties by properly selecting and utilizing reinforcement and can easily choose MMC with desired hardness by simply varying the reinforcement amount.

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