Effect on Hardness by the Addition of Al_2O_3 and Sic of Al6063 Based Mono and Hybrid Composites

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Abstract— *the present work includes the effect of addition of alumina and sic for improving the properties of Al 6063 composites using the stir casting method. This work is based on development of Al 6063 based mono and hybrid metal matrix composite reinforced with varying weight percentage of Al_2O_3 and Sic (i.e. 5%, 10% and 15%). The composite of composition Al 6063 with 15% Al_2O_3+ Sic shows the greatest improvement in vicker hardness and composition Al 6063 with 15% Al_2O_3 give highest BHN number. Investigation also predicts that hardness increase due to varying addition of alumina and Sic.*

Keywords— Metal Matrix Composite, Stir Casting Technique, Vicker Hardness Number (VHN), Brinell Hardness Number (BHN)

I. Introduction

The development of composite materials is one of the major innovations in the field of science and engineering. Composites of varying types and sizes based on different materials have been developed through the ages of their evolution. Aluminium silicon alloys and composites are being used in automotive applications like pistons, brake rotors and engine block cylinder liners. Tribological behaviour is an important aspect in the use of aluminium metal matrix composites in automotive applications. They can be tailored to have superior properties such as high specific strength and stiffness, increased wear resistance, and enhanced high temperature performance, better thermal and mechanical fatigue and creep resistance than those of monolithic alloys. Although the hybrid MMC encompasses the composite system containing two types of alloys to produce laminated structures, current focus is on the former type only. Studies have shown that hybridization of reinforcements enhanced the structural, physical, mechanical and tribological behavior of hybrid composites than mono MMCs. In this study, nine composites of alumina and Sic, namely, Al 6063/Sic 5%, Al 6063/Sic 10%, Al 6063/Sic 15%, Al 6063/Al_2O_3 5%, Al 6063/ Al_2O_3 10%, Al 6063/ $Al_2O_3$15%, Al 6063/Sic/Al_2O_3 5%, Al 6063/Sic/Al_2O_3 10%, Al 6063/Sic/Al_2O_3 15%, have been produced with the stir casting technique. The changes in the mechanical and tribological properties caused by the addition of alumina and Sic are studied.

II. Literature survey

A. Chennakesava, studied mechanical properties for different metal matrix composites produced from Al 6061, Al 6063 and Al 7072 matrix alloys reinforced with silicon carbide particulates. The ductility of Al/SiC metal matrix composites are in the descending order of Al 6061, Al6063 and Al 7072 matrix alloys. Mg has improved the wettability between Al and SiC particles by reducing the SiO2 layer on the surface of the SiC. The fracture mode is ductile in nature. The objective of developing metal matrix composite materials is to combine the desirable properties of metal and ceramics. The major advantages of aluminium matrix composites compared to unreinforced materials are greater strength, improved stiffness, reduced density, improved temperature properties, controlled thermal expansion and improved wear resistance.

Md AI Mehediet al. In this study Al-3.73Mg alloy is reinforced with different ratios of hybrid particulate mixture of SiC and Al_2O_3 and the tribological property is investigated. The investigation reveals that with the increase of % volume SiC, the wear rate decreases in case of hybrid composite at different loads and sliding velocity. The increase of load reduces the wear and increase of sliding velocity increases the wear rate.

III. Gaps found from the literature

The extensive review of literature carried out for the present study reveals that a lot of work has been reported to enhance the properties of aluminium based metal matrix composites fabricated through stir casting technique. It was observed from the review of available literature following gaps are identified:

1) Very limited work on combined effect of alumina and silicon carbides on aluminum matrix composites properties have done.
2) Very limited work has been reported which explains the factors affecting mechanical properties like hardness and tensile strength of aluminum matrix composites.
3) Utilization of cheap reinforcements for the fabrication of composites, as the cost of reinforcement affects its commercialization.
4) Design of stirrer for the fabrication of new metal matrix composites.

IV. Method and methodology

A. Matrix Alloy

For the present investigation Aluminum alloy (Al 6063) will be used as matrix alloy. This alloy can be cast in permanent and sand mold cast.

Alloy	Chemical compositions (wt. %)								
	Si	Mg	Fe	Cu	Mn	Zn	Ti	Others	Al
Al6063 (min.)	0.2%	-	-	-	0.45%	-	-	0.05%	Bal
Al6063 (Max.)	0.6%	0.10%	0.35%	0.10%	0.9%	0.10%	0.10%	0.15%	97.6%

Table 1: Composition of Al6063

Property	Al6063 Alloy	Property	Al6063 Alloy
Density	2.70g/cm^3	Thermal conductivity	201W/m.K
Melting point	655^{0}C	Electrical resistivity	033x10^{-6}ohm.m
Thermal expansion	23.5x10^{6}ohm/k		
Modulus of elasticity	69.5GPa		

Table 2: Thermos Physical properties of Al 6063

B. *Reinforcement*

In the present investigation single types of reinforcement's particles will be used: Aluminum oxide of particle size 220µm.

Property	Reinforcements
	$SiC_{(p)}$
Melting point (ºC)	2072
Density (g/cc)	3.9
Hardness (Kg/mm^2)	1440
Thermal conductivity (W/m ºC)	35
Coefficient of thermal expansion (10^{-6}/ ºC)	8.4
Specific heat capacity (J/Kg ºC)	880
Color	White

Table 3: Property of Alumina

C. *Silicon Carbide*

Silicon Carbide (SiC) is highly wear resistant and also has good mechanical properties with low density, including high temperature strength and thermal shock resistance. Silicon carbide (SiC), also known as carborundum, is a compound of silicon and carbon with chemical formula SiC. It was originally produced by a high temperature electro-chemical reaction of sand and carbon. Silicon carbide is an excellent abrasive and has been produced and made into grinding wheels and other abrasive products for over one hundred years. Today the material has been developed into a high quality technical grade ceramic with very good mechanical properties. It is used in abrasives, refractories, ceramics, and numerous high-performance applications.

V. Experimental Methodology

The material used in the present investigation consists of Aluminium alloy (Al6063) as the base matrix alloy. The aluminium matrix was reinforced with Al2O3 of 46 microns in varying percentage of 5%, 10% and 15%. The composite were cast using stir casting process as it ensures uniform distribution of the reinforcement. Stir casting process is a special type of casting in which stirring action is carried out in the furnace itself.

- Step 1: Aluminium alloy is melted at 850^{0}C in muffle furnace for two hours
- Step 2: Alumina is melted at 150^{0}C in another muffle furnace for same time period
- Step 3: Melted Aluminium & Alumina are mixed in the graphite crucible and 5gm of coverall, nucleant & degasser are added in the melt

1) Coverall: It is a complex of KCl+HNO_3, avoids oxidation
2) Nucleant: salt tablets. It enhances good grain structure
3) Degasser: Hexa-chloroethane tablets, it removes the gases present in molten metal

- Step 4: After adding all these, the crucible is kept inside the furnace
- Step 5: The molten metal are stirred at speed of 220rpm for 10minutes
- Step6: At the same time, dies are preheated at 250^{0}C in another muffle furnace for 2 hours.

VI. Result and Testing

A. *Hardness Measurement*

Hardness test was carried out at room temperature using Rockwell hardness tester with at least three indentations of each sample and then the average values were utilized to calculate hardness number. Load used on Rockwell's hardness tester 150 Kg at dwell time of 20 sec. for each sample. The hardness of MMCs varies with variation in the volume fraction of particulate in the alloy matrix. The added amount of SiC & alumina particles enhances hardness, as these particles are harder than Al alloy, which render their inherent property of hardness to soft matrix.

S. No.	Nomenclature	HV1	HV2	HV3	HV Average
1.	Al 6063+Sic- 5%	38	36	37	37.0
2.	Al 6063+Sic-10%	47	45	46	46.0
3.	Al 6063+Sic-15%	52	54	55	53.7
4.	Al 6063+Al_2O_3-5%	61	59	62	61
5.	Al 6063+Al_2O_3-10%	51	49	50	50
6.	Al 6063+Al_2O_3-15%	62	59	59	60
7.	Al 6063+Al_2O_3+Sic- 5%	54	53	56	54.3
8.	Al 6063+Al_2O_3+Sic-10%	58	59	60	59.0
9.	Al 6063+Al_2O_3+Sic-15%	60	62	61	61

Table 4: Vickers hardness

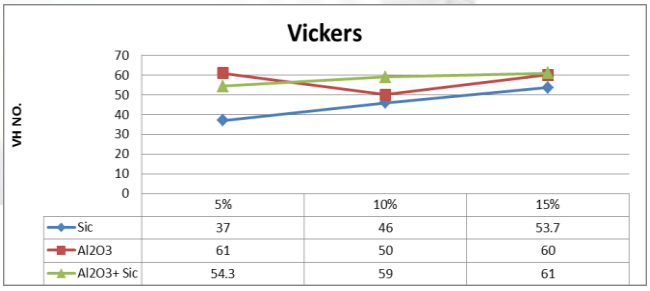

Fig. 1: VHN

S. No.	Nomenclature	HB1	HB2	HB3	HB Average
1.	Al 6063+Sic- 5%	35	36	36	**35.7**
2.	Al 6063+Sic-10%	44	45	44	**44.3**
3.	Al 6063+Sic-15%	51	50	52	**51.0**

4.	Al 6063+Al_2O_3-5%	58	57	57	**57.3**
5.	Al 6063+Al_2O_3-10%	47	46	58	**50.3**
6.	Al 6063+Al_2O_3-15%	57	58	59	**58.0**
7.	Al 6063+Al_2O_3+ Sic- 5%	56	55	55	**55.3**
8.	Al 6063+Al_2O_3+ Sic-10%	58	57	58	**57.7**
9.	Al 6063+Al_2O_3+ Sic-15%	35	36	36	**35.7**

Table 5: Brinell hardness

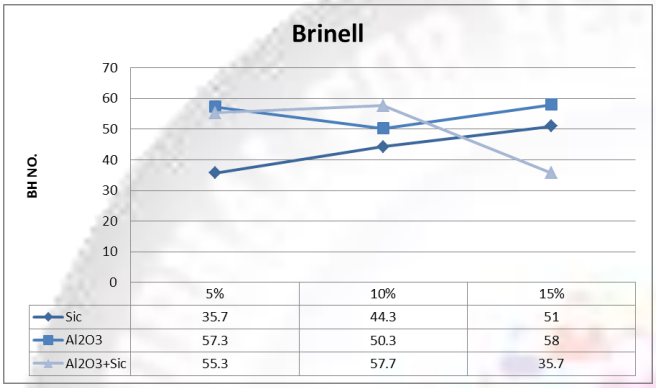

Fig. 2: BHN

VII. Conclusion

In this research work, Al 6063/ SiC/ Al_2O_3 composites are fabricated using the stir-casting technique and the mechanical behaviour of the metal matrix composites were studied. The following important observations can be noted:

1) Vickers and Brinell hardness of Al 6063 with silicon carbide (SiC), Alumina (Al_2O_3) and Metal Matrix Composites (MMCs) are increases when increasing the weight percentage of SiC.
2) The best result of Vickers Hardness has been obtained at 15 % weight of SiC+Al_2O_3 and 5% weight of Al_2O_3.
3) The best result of Brinell Hardness has been obtained at 15 % weight of Al_2O_3.

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