Study on mechanical properties of different reinforcement on aluminium matrix composite

*Sagram Hembrom
*Assistant Professor, Department of Metallurgical Engg., B.I.T. Sindri, Dhanbad,Jharkhand,India
Correspondence email: hembromsangram@gmail.com

Abstract

Aluminium matrix composites are feasible materials for different applications due to their mechanical properties. The increase of reinforcements into the matrix composite improves the stiffness, specific strength properties compared to the conventional engineering materials. Effect of different reinforcement on aluminium matrix composits of the mechanical properties like tensile strength, hardness etc and study the aluminum based composites with SiC and fly ash, by the applicaton of stir casting process. The weight fraction of fly ash is varied by keeping SiC weight percentage and results showing that better strength and hardness is achieved, by making weight of fly ash increases and increases reinforcement on metal matrix composite.

Keywords - Fly ash, Silicon carbide etc

Introduction

A composite material is made by combining more than two materials in such a way that the resulting materials have desired properties. Recent days composite materials are used for various applications such as aerospace, structural, , marine application etc. Metal matrix composite (MMC), normally particle reinforced aluminum composites are getting more importance. Since it is economical and exhibit isotropic properties. The fly ash which is a waste product in power plant is the cheapest form of reinforcement available in large quantities. Stir casting technique appears to be the best process to introduce fly ash particles into matrix by forming vortex.

Abhishek Kumar et.al. Investigated the characterization of $A359/Al_2O_3$MMC using electromagnetic stir casting method. The increased hardness and tensile strength of MMC and electromagnetic stirring action produces MMC a smaller grain size and then to produced good particulate matrix interface bonding [1]

Park et al. investigated the effect of Al_2O_3 in Aluminium for increasing the volume fractions from 5 to 30% then the increase in volume fraction of Al_2O_3 decreased the fracture toughness of the MMC, due to decrease in inter-particle spacing between nucleated micro voids [2].

Abouelmagd studied the hot deformation and wear resistance of powder metallurgy aluminium metal matrix composites. It was found that the increases the hardness and compressive strength due to addition of Al_2O_3 and Al_4C_3 and also improved the wear resistance of the MMC with addition of Al_4C_3 [3].

Park et al. studied the high cycle fatigue behavior of 6061 Al-Mg-Si alloy reinforced Al_2O_3 microspheres with the increased in volume fraction between 5 to 30 percent. The fatigue strength of the powder metallurgy processed composite was higher than that unreinforced alloy and liquid metallurgy processed composite [4].

H.C.Anilkumar et.al. Studied the behaviour of the Aluminum (6061) metal matrix composites with of Fly ash particles of different size as reinforcement material. They reported that, the mechanical properties such as tensile strength, compression strength and hardness improved for finer particle size. Author observed ductility of the composite decreased with the increase in the weight fraction of reinforcement of fly ash and also decreased with the increase in particle size of fly ash. On the contrary if the weight fraction of fly ash was increased more than 15% the tensile strength started to downfall [5].

Basavaraju.S et.al, studied the behavior of aluminum alloy LM25 as matrix metal and Silicon carbide, Graphite, and Fly ash as reinforced material. When reinforcing, the weight percentage of Silicon carbide was varied, in mean while the weight percentage of graphite and the fly ash were kept constant. It is observed that the hardness of material enhanced due to addition of SiC-Graphite. The highest wear measure was for 8% SiC [6].

NeelimaDevi.C et.al. Experimented the mechanical characterization of aluminum silicon carbide composites. Author prepared the specimens with different Sic weight ratio's and concluded that maximum tensile strength was found at a weight ratio of 15% SiC, also the weight was two times lesser than same dimension of aluminum specimen and also stated that it can be used in aerospace [7].

Sandeep Kumar Ravesh et.al. Conducted an experiment on Hybrid metal matrix composites with A6061 as matrix metal and ceramic metal such as Silicon carbide as reinforcement and Fly ash. Up on experimentation they found out that enhancement in mechanical properties such as tensile strength, hardness, impact strength when silicon carbide weight percentage was varied and weight percentage of fly ash was constant. It was noted that brittleness was increased and elongation was decreased [8].

Experimental:

The precipitation-hardened aluminium alloy, containing magnesium and silicon as its major alloying elements in al 6061. It observed that enhancement of mechanical properties and good weldability. and It is used as reinforcement silicon carbide , fly ash and Aluminum alloy and Al 6061 are used as the matrix elements. The chemical composition of aluminum alloy and fly ash are given below. Silicon carbide is the only chemical compound of carbon and silicon. It is an excellent strength, high elastic modulus, more thermal conductivity, and thermal shock resistance. Fly ash is one of the most expensive and low density reinforcement available in large quantities as solid waste by-product during combustion of coal in thermal power plants. They contain mostly silicon dioxide, aluminum oxide/alumina and iron oxide. Fly ash particles are mostly spherical in shape and range from less than 1μm to 120 μm and having high electrical resistance and low thermal conductivity.

Sl. No	Element	Weight percentage
1	Ti	0.05
2	Cu	0.29
3	Mg	1.05
4	Mn	0.50
5	Si	0.61
6	Fe	0.16
7	Ni	0.03
8	Zn	0.064
9	Pb	0.02
10	Al	Remainder

Fly Ash	Percentage
CaO	7.82
MgO	1.17
Al_2O_3	20.03
TiO_2	1.13
Fe_2O_3	3.84
SiO_2	Remainder

Sample preparation:

1. Stir Casting Process

The Stir casting process is also known as liquid state technique is used for fabricating of hybrid composite materials in which a dispersed phase is mixed with a molten matrix metal with the help of mechanical stirring. The molten composite material is then cast by conventional casting technique and also by conventional metal forming technologies. Stir casting method is used to fabricate composite consists of an induction furnace and three mild steel stirrer blades and also the reinforcements are distributed into molten aluminium matrix by mechanical stirring. During preheating stage, the reinforcements are heated at about temperature 400°C to 480^{0}C while aluminium is melted in a separate crucible at 560^{0}C-900°C and then preheated reinforcements are mechanically

Aluminium -Fly ash and SiC composites were produced by varying percentage of fly ash by stir casting method . The amount of fly ash of by weight should be measured and kept, then the fly-ash were heated at temperature 440-650^{0}C and maintained at that temperature for about 25 minutes to remove the moisture content. Thereafter aluminium was melted in a crucible at 560-900^{0}C. The molten metal was stirred to create a vortex and the weighed quantity of pre heated fly ash particle were slowly added to the molten metal maintained at greater than 700^{0}C with continuous stirring at a speed of 350-500 rpm for a time of 5-10 minutes. During stirring magnesium about 2% should be added to ensure good wettability. The molten liquid with the reinforced particles were poured in to moulds the poring temperature should be maintained at 680-750^{0}C.

Results and Discussion:

Tensile test:

The tensile strength of a material is the maximum amount of tensile stress that it can take before failure, for example breaking. There are three typical definitions of tensile strength: Yield strength - The stress a material can withstand without permanent deformation. This is not a sharply defined point. Yield strength is the stress which will cause a permanent deformation of 0.2% of the original dimension.

Vol 11, Issue 5,May/2020
ISSN NO:0377-9254

Data:

Sl No	% reinforcement	Dia. (mm)	Initial (mm)	Final (mm)	Change %	Load (KN)	UTS (MPa)
1	Al alloy + 0% reinforcement	8	50	61.85	23.7	16.78	318
2	Al alloy + SiC + 3% FLY ASH	8	50	61.91	23.82	16.29	378
3	Al alloy + SiC + 6%FLY ASH	8	50	59.78	19.56	18.36	400
4	Al alloy + SiC + 9%FLY ASH	8	50	56.94	13.88	18.10	411

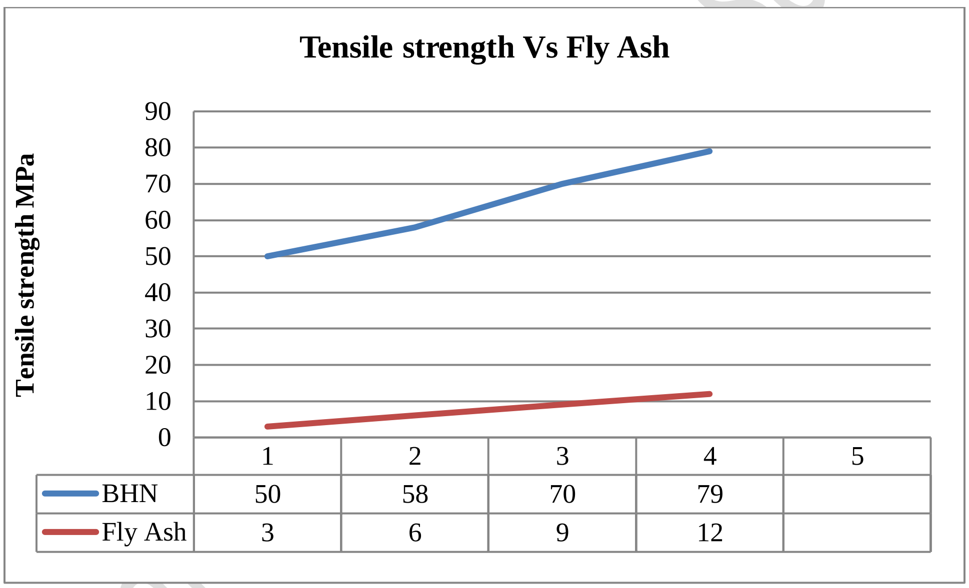

Figure. Tensile Strength V/S fly ash weight %.

The graph shows the results, it is evident that the increased in tensile strength as well as weight percentage of reinforcement increases due to the present of reinforcement particles by holding the molecules in the matrix and thereby resisting the deformation of the material.

Hardness test: Brinell hardness test uses a hardened steel ball indenter that is pushed into the material under a specified force. The diameter of the indentation left in the surface of the material is measured. The hardness is expressed in Brinell hardness number computed by dividing the load in kilograms by the area of indentation made by the ball measured in square millimeters

Sl.No	% reinforcement	Load	BHN
1	Al alloy + 0% reinforcement	250	50
2	Al alloy + SiC + 3% Fly Ash	250	58
3	Al alloy + SiC + 6%Fly Ash	250	70
4	Al alloy + SiC + 9% Fly Ash	250	79

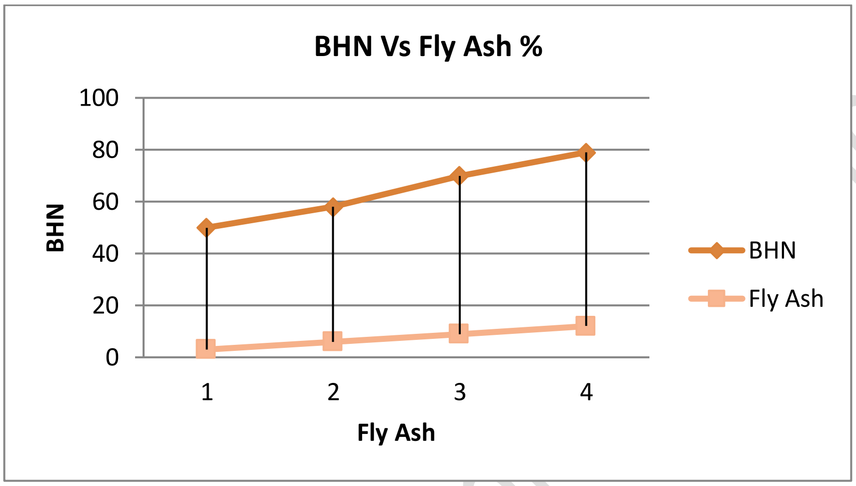

Figure: BHN Vs fly ash Weight %.

The graph shows the results of hardness with varying percentage of fly ash. It can be observed that the hardness value increases with increasing the percentage of fly ash and silicon carbide, it may be due to the harder particle of fly ash and SiC in the matrix and also due to the good bonding between the matrix and reinforcements.

Conclusion:

Hardness of Al alloys is increased from 50 to 80 Brinell hardness number due to the present of fly ash. The increase in fly ash content thereby enhancement of Ultimate tensile strength whereas ductility has decreased with increase in fly ash content.

References

[1] Abhishek Kumar, Shyam Lal, Sudhir Kumar Noida, In: JMRTEC-40 (WHERE,WHEN),

[2]. B.G. Park, A.G.Crosky and A.K.Hellier // Composites: Part B 39 (2008) 1270.

[3] G.Abouelmagd // Materials Processing Technology 155 (2004) 1395.

[4]. B.G. Park, A.G. Crosky and A.K. Hellier // Composites: Part B 39 (2008)1257.

[5] H.C.Anil Kumar, "Mechanical Properties of Fly ash reinforced Aluminum Alloy (Al6061) Composites", International Journal of Mechanical Engineering (IJMME), Vol.6 2011, 41-43.

[6] Basavaraju. S, "Studies on Mechanical Properties and Tribological Characteristics of LM25-Graphite-Silicon Carbide and LM25-Flyash- Silicon Carbide - Hybrid MMC's", International Journal of Innovative Research in Science, Engineering and Technology Vol. 1, Issue 1, November 2012.

[7] Neelimadevi.C, "Mechanical characterization of Aluminium silicon carbide composite". International Journal of Applied Engineering Research, Dindigul, Volume 1, No 4, 2001 .

[8] Sandeep Kumar Ravesh,"Preparation and Analysis for some Mechanical property of Aluminum Based Metal Matrix Composites Reinforced with SiC& Fly Ash" International Journal of Engineering Research and Application (IJERA) ISSN: 2248-9622.