EXPERIMENTAL STUDY ON Al BASE HYBRID METAL MATRIX COMPOSITIES

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Abstract - *A composite material is a material made from two (or) more constituent materials with significantly different physical and chemical properties that, when combined, produce a material with characteristics different from individual components. The individual components remain separate and distinct within the finished structure differentiating composites from mixtures and solids solutions. This is an broad definition that holds true for all composites, however, more recently the term "composites" describes reinforcements plastics. In this paper we present the study on the Al base hybrid metal matrix composites with reinforcements as SiC and Bagasse ash exclusively by stir casting process. Stir casting process is so cost efficient and simple and so we used it in our project. Mechanical properties such as Hardness, Tensile strength, Toughness in pure Al (99.5%), were analyzed. The varying SiC content in AMC's is (5, 10, and 15) and bagasse ash content in AMC's is 5% common to all. Pure Al based metal matrix composite with 5%, 10%, 15% of SiC and 5% of Bagasse ash common to all was successfully fabricated by Bottom type poured `stir casting machine. Test results revealed that incorporation of SiC and Bagasse ash enhances the mechanical properties of magnesium alloy composites. The decrease in impact strength of pure Al was observed upon incorporation of 15% of SiC and 5% of Bagasse ash and so it proves there is improved toughness in 3rd piece. Hardness value shows an gradual increase when compared to 2nd and 3rd sample.*

Keywords: Aluminum metal matrix composites, stir casting, reinforcement, SiC, Bagasse ash.

1. INTRODUCTION

The metal matrix composites are combination of two or more materials with at least one being a metal and another material such as ceramic or organic compound. When at least three materials are present is called Hybrid Composites. To achieve optimum combination or properties of composites. It should produced by controlling morphologies of constituents of properties of any composite depend on the chemical composition or on the properties of constituent phase geometry. Including particles, Size shape and orientation in the matrix [1, 2]. The metal matrix composites (MMCs) is a advance materials that can be used for wide applications within, Aerospace, Automobile, Defense industries, Nuclear power plant, Electronics, Bio-medical, Sporting industries etc. Al composites are mainly reinforced using hard materials like, Silicon carbide(SiC), Alumina (Al_2O_3), Boron nitride (B_4N), Boron carbide (B_4C), AlN, TiB_2 and organic reinforcements are also used like fly ash [3].These reinforcement can provide advantageous properties over base metal alloy these include improved thermal conductivity, Abrasion, Low density, high toughness, higher fatigue endurance, durability, machinability, resistance, creep resistance, dimensional stability, strength-to-weight ratios. They also better high temperature performance[4].Type of reinforcement, % of reinforcement, the particle size of reinforcement, preheating of reinforcement, the temperature of the liquid melt, stirring speed, stirring position, stirring time, mould temperature, holding time, mixing time, pressure, ambient temperature and holding temperature were found significant factors for porosity [5]. The SiC content distribution is partially homogeneous. With increase content of SiC in Al matrix hardness and tensile strength of AMC's is increase compared with unreinforced. The porosity increase with the increase in percentages of the reinforcement whereas the density of hybrid of composites decreases and also SiC addition decreases the ductility. The most important property of Al-SiC with reference to the aerospace industry is its strength to weight ratio is three times more than mild steel [6]. Stir casting process is very cost effective and simple. By controlling various parameters of stir casting process like stirring temperature, stirring speed, stirring time, preheating time, etc. and selection of matrix and reinforcements the quality of components can be improved. Now there is lot of work going on enhancing the capability of stir casting process to make if more efficient [7].

The incorporation of FA particles strengthening mechanisms are identified. FSP is a suitable process to produce FA reinforced MMCs regardless of the type of matrix material used [8]. After the introduction of MMC many combination of material like Al, SiC, graphite, Mg, etc., is been tested, resulting and got improvement in physical, thermal, chemical mechanical properties and also reduction of weight at great extent directly effect on fuel economy [9]. Grindability indices, which take into account single machinability characteristics such as forces, wheel degradation and work piece surface roughness, have been used to define a Total Grindability Index that has allowed to compare the Grindability of different MMC when grounded using different abrasive wheels [10]. The major deformation in matrix happens due to its relatively lower Young's modulus compared with the reinforcing SiC particles. The stresses in the particles are much higher and concentrate on the cluster particles, especially at the sharp corners, particle-matrix interfaces and the edges along the loading direction. The stress in the matrix concentrates along 45° to the loading direction [11]. As the reinforcement ratio increased an increment on the surface roughness values was monitored while the thrust force values were declined [12]. It not only leads to more tortuous crack paths which contributes to the surface energy dissipation but also significantly promotes plastic deformation in the ductile matrix. The probability of interface deboning increases with decreasing reinforcement volume fraction, lower yield stress of the matrix, as well as properly balanced interface bonding energy [13]. Analytical and numerical estimates of effective elastic and elastic-plastic properties of two-phase MMC have been analyzed and compared to the available experimental data. A comprehensive analysis of the predictions of isotopic elastic property provided by several existing mean-field estimates that have been performed [14].In this present work of Aluminum base hybrid metal matrix composite, we mixed the reinforcement such as SiC and Bagasse Ash with base metal (Al).Test results revealed that incorporation of SiC and Bagasse ash enhances the mechanical properties of magnesium alloy composites. The decrease in impact strength of pure Al was observed upon incorporation of 15% of SiC and 5% of Bagasse ash and so it proves there is improved toughness in 3rd piece. Hardness value shows a gradual increase when compared to 2nd and 3rd sample.

2. SELECTION OF MATERIAL

The aluminium is used because of its light weight and low density compared to steel and also its easily breakable. So we are used Al as a base metal and combine with SiC & bagasse ash to increase hardness, toughness and elongation.

2.1 MATERIAL PROPERTIES

Table - 1: shows the properties of silicon carbide and bagasse ash

Aluminum	Silicon Carbide
Melting point 650°C	Melting point 2830°C
Density 2.70 g/cm^3	Density 3.16 g/cm^3
Boiling point 2470°C (at 25°C)	
Thermal expansion :23.1μm/m-K	
Thermal conductivity 237 W/m-K	

2.2 PREPARATION OF BAGASSE ASH AND SiC

The bagasse ash brought from Kothari sugar mill and SiC is brought in stores, initially the bagasse ash and SiC weighting 1kg after that it was preheated upto 300°C @ one hour through electrical oven for the reason of removing moisture content present in ash and SiC. Finally the bagasse ash particles and Sic are drying with elevated temperature and using sieve to separate a particle size of 100mm.

(a) (b)

(c)

Fig – 1: (a) Oven, (b) Bagasse ash, (c) SiC

3. EXPERIMENTAL WORK

The pure Al alloy ingots are preheated for a temperature of 550°C @ 30 minutes after the temperature raises up to 700°C with an inert atmosphere, because of its oxidation process. After that pure Al alloy ingots are fully melted. The bagasse ash and SiC was added into above mentioned proposing with a speed of 400 rpm @10 minutes. Pure Al alloy, SiC, Bagasse ash composite prepared by Bottom type pouring automatic stir casting machine, because of its reduces below holes and porosity. After the casting process pure Al alloy composite were cleaned and machined as per test requirements. Initially the bagasse ash and SiC preheated at 300°C @ 1m through electric furnace for the purpose of removing moisture content. Then the pure Al ingots are melted at 700°C through electrical furnace. The reinforcement alloy was added into pure Al alloy for a speed of 400 rpm. The both base metal and reinforcement are mixing together.

3.1 IMPACT, HARDNESS & TENSILE TEST

Pure Al matrix composite samples are machined by Impact testing machine, each samples having prepare three trials and finally each test sample is fixed with impact notch and pendulum was released, the readings are observed and noted. Table 2 shows the impact test readings of pure Al matrix composite samples.

The Pure Al matrix composite samples are tested with Rockwell Hardness machine. Initially sample was fixing the lower end and the load 100KgF to be applied under 20 sec time interval, the readings are noted and tabulated. Finally all the samples are tested with three indentations for each. Table 3 shows the hardness test readings of pure Al matrix composite samples.

The Pure Al matrix composite machined samples as per ASTM dimensions and the each sample having tested with micro-tensile machine. Initially test samples are holding to upper jaw and lower jaw of both ends and load can be applied, that the reaction can be noted as ultimate strength and total elongation. Table 4 shows the tensile test readings of pure Al matrix composite samples.

Table -2: Impact testing readings

S.no	Composition	Internal Energy(E1) in Joule	Residual Energy (E2) in Joule	Absorb Energy (E1-E2) in Joule	Area of cross Section (Size $10x10=100mm^2$	Impact strength in J/mm^2	Status
1	Pure Al+5% SiC+5% B.Ash	300	44	256	100	2.56	Bend
		300	52	248	100	2.48	Bend
2	Pure Al+10 % SiC+5% B.Ash	300	42	258	100	2.58	Bend
		300	56	244	100	2.44	Break
3	Pure Al+15 % SiC+5% B.Ash	300	57	243	100	2.43	Bend
		300	45	255	100	2.55	Bend

Table-3: Hardness testing readings

S.no	Composition	Loads	Penetrate	Scale	Hardness	Mean
[1]a	Pure Al+5% SiC+5% B.Ash	100KgF			74RHN	104RHN
B		100KgF			114RHN	
C		100KgF			124RHN	125RHN
[2]a	Pure Al+10% SiC+5% B.Ash	100KgF	1/16th Ball	B	144RHN	
B		100KgF			162RHN	
C		100KgF			70RHN	133RHN
[3]a	Pure Al+15% SiC+5% B.Ash	100KgF			103RHN	
B		100KgF			155RHN	
C		100KgF			140RHN	

Table-4: Tensile testing readings

S.nO	Composition	Area	Ultimate force	Ultimate stress	Total elongation
1	Pure Al+ 5% SiC	34.5	2830	82.1	20.1
2	+ 5% B.Ash	36.2	2790	77	18.6
3	Pure Al+ 10%	42.3	3030	71.5	21.6
4	SiC+ 5% B.Ash	45	2660	59.1	22.2
5	Pure Al+ 15%	42.8	3060	71.8	28.5
6	SiC+ 5% B.Ash	35.3	2840	80.4	18.3

4. RESULTS

Chart 1 shows the impact result and it indicates gradual decrement in Pure Al matrix composites with reinforcement of various percentages of Bagasse ash and Sic. The decrease in energy absorbing capability may be due to the effective interfacial bonding between the nano-particles of reinforcement and pure Al. Pure Al- 15% of SiC and 5% of Bagasse ash composite is found to have impact strength of 2.49 J/mm². This corresponds to and decreases in impact strength compared to pure Al.

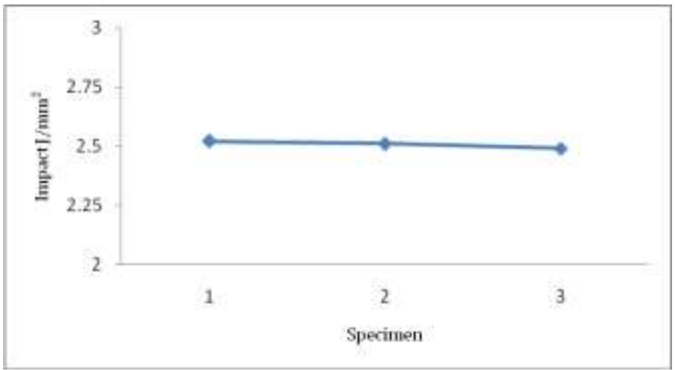

Chart – 1: Impact test results

Chart 2 shows the hardness teat result of Pure Al matrix composite samples are tested with Rockwell Hardness machine. Initially sample was fixing the lower end and the load 100KgF to be applied under 20 sec time interval, the readings are noted and tabulated. Finally all the samples are tested with three indentations for each and we concluded that there is a gradual increase in hardness property from 2nd to 3rd piece.

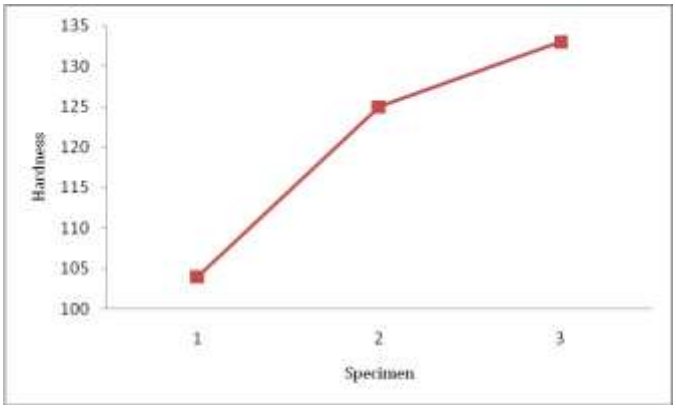

Chart – 2: Hardness test results

Chart - 3 shows the tensile strength in pure Al alloy composite. It is evident that addition of silicon carbide and bagasse ash in Pure Al. It is proved that tensile shows marginal decrease and increase.

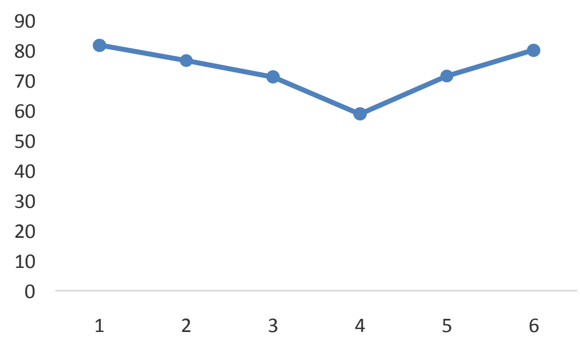

Chart – 3: Tensile test results

5. CONCLUSION

Pure Al based metal matrix composite with 5%, 10%, 15% of SiC and 5% of Bagasse ash common to all was successfully fabricated by Bottom type poured `stir casting machine. Test results revealed that incorporation of SiC and Bagasse ash enhances the mechanical properties of magnesium alloy composites. The decrease in impact strength of pure Al was observed upon incorporation of 15% of SiC and 5% of Bagasse ash and so it proves there is improved toughness in 3rd piece. Hardness value shows a gradual increase when compared to 2nd and 3rd piece. But tensile shows only marginal increase or decrease.

REFERENCES

1. William D. Callister Jr, Material Science and Engineering Introduction, seventh, John Wiley & Sons Inc., New York, 2007.
2. George E. Totten, D. Scott Mackenzie, Handbook of Aluminium Alloy Production and Materials Manufacturing volume. 2, Marcel Dekker Inc., New York.
3. Akash kumar and Prabhutosh kumar; A review on the mechanical properties, tribological behavior and the micro structural characterization of Aluminium metal matrix composites (AMMCs)ISSN 2229-5518; international journal of Scientific & Engineering Research, Volume 6 Issue 6, June-2015.
4. P.O Babalola, C.A Bolu, A.O Inegbenebor, Development of Aluminium matrix composites; A review ISSN 2346 7452; volume; PP.1-11; April 2014.
5. Jigar, Suthar, Kaushik Patel; Identification, screening and optimization of significant parameters for stir cast hybrid metal matrix composite; Heliyon 4 (2018) e00988. doi: 10.1016/ j. Heliyon 2018. e00988.
6. Manish Shukla, S.K. Dhakad, Pankaj Agarwal, M.K. Pradhan; Characteristic Behavior of Aluminium Metal Matrix Composites; Materials today: Proceeding 5 (2018) 5830-5836.
7. Bhaskar Chandra Kandpal, Jatinder kumar, Hari Singh; Manufacturing and technological challenges in stir casting of metal matrix composites; Materials today: Proceeding 5 (2018) 5-10.
8. Issac Dinaharan, Esther Titilayo Akinlabi; Low cost metal matrix composites Al, Mg and Cu reinforced with fly ash prepared using friction stir processing; Composite communication 9 (2018) 22-26.
9. P. Shiva Shanker; A review on properties of conventional and metal matrix composite materials in manufacturing of disc brake; Materials today: Proceeding 5 (2018) 5864-5869.
10. Antoniomaria Di Ilio; Francesso Lambiasse; Alfonso Paoletti: Grindability assessment of metal matrix composites; Procedia CIRP 67 (2018) 313-318.
11. Qi Wu, Weixing Xu, Liangchi Zhang; Micro-structure based modelling of fracture of particulate reinforced metal matrix composites. Proceeding- S1359-8368(18)30913-2.
12. Emin Salur, Abudullah Aslan, Mustafa Kuntoglu, Aydin Gunes, Omar Sinen Sahin; Experimental study and analysis of machinability characteristics of metal matrix composites during drilling. Proceeding-S1359-8368(18)33937-4.
13. Yan Li, Jun Cao, Cyril Williams; Competing failure mechanisms in metal matrix composites and their effects on fracture toughness: Proceeding- S2589-1529(19)30034-1.
14. M. Kursa, K. Kowalczyk-Gajewska, M.J. Lewandowski, H.Petryk; Elastic-plastic properties of metal matrix composites: validation of mean-field approaches; Proceeding-S0997-7538(17)30599-5.