EXPERIMENTATION AND STRENGTH ANALYSIS OF HYBRID ALUMINIUM 6061 METAL MATRIX COMPOSITE REINFORCED WITH SiC AND FLY ASH

Hari Kiran Vuddagiri[1], Majji Hema Satya Sai[2], Thutta Durga Prasad[3]

[1]Associate Professor, [2,3]Student
Department of Mechanical Engineering,
Avanthi Institute of Engineering and Technology, Makavarapalem.

***Abstract*: Aluminum metal matrix composite is widely used now days in aerospace, automobile and structural application because of low production cost and has good mechanical properties. This paper deals about the preparation of hybrid metal matrix composites and evaluation of mechanical strength by introducing the micro size SiC reinforced particles and Fly ash in 6061 aluminum alloy. Stir casting method is used to produce composites. After the casting process, specimens are machined as per ASTM standards. Tensile, fluxeral, hardness and impact test are conducted to find out the mechanical properties at room temperature. Hardness and impact properties have been observed after testing. Those values have improved by increasing the weight particles Sic and fly ash.**

***Keywords*: Hybrid Metal matrix composites, stir casting method, mechanical properties.**

Introduction

Aluminum alloy is widely used in mechanical application and wear application due to high specific strength, low thermal conductivity, low density, high wear resistance and low thermal conductivity. Due to these properties, they are used in the aerospace industries, marine industries, aerospace industries etc. In an alloy, aluminum helps us to enhance the creep performance, strength of the material and wear resistance of the alloy that is to be used. [1,2]. 6061- T6 aluminum alloy is used in aircraft industries, shipping industries and automobile industries due to its corrosion properties, high strength and light weight properties. But the disadvantage of this alloy is it evince inferior tri-biological characteristics when used immensely [3, 4]. By incorporating the reinforcement materials like SiC and Al2O3 ceramic particles, these aluminum based composite material will become brittle. Because of such characteristics, these aluminum based composites are used in components like breaks, impellers, gears, bearing and bushes [6, 7]. To develop many reinforced metal matrix composites, there are various techniques to produced, such techniques are powder metallurgy [8], SiTu [9] and stir casting [10]. From the above techniques, stir casting techniques is the most effective technique in the reinforced metal matrix composites [11]. In the aluminum alloy AA7075, the pre-ageing retrogression temperature is made to improve the tensile strength of the alloy and hardness of the aluminum alloy [12]. In the room temperature, the hardness of the specimen is measured by using the Rockwell hardness test [13]. And this test is done prior to the wear test. By increasing the volume fraction of SiC and B4C reinforced composites the magnitude of the hardness will increase[14]. Using stir casting technique, hybrid composites such as SiC+Gr and SiC+Al2O3 is reinforced with the aluminum alloy 6061-T6. With this stir casting technique, the wear properties of the hybrid metal matrix composites will increase as well as the existence of the ceramic particles such as SiC and Al2O3 will increase the micro hardness of these particles [15].The hardness of the aluminum alloy will increase by adding alumina and boron carbide [16].

Experimental Procedure

In this present work, Silicon carbide material (SiC) is used as the reinforcement particle, where as the aluminum alloy 6061 is used as the base material. The composition of the aluminum alloy AA6061 is shown in the below table. The reason for choosing AA6061 is because it the aluminum alloys has mainly magnesium and silicon as the alloying material of the aluminum. AA6061 has better mechanical properties and thus resulting in good welding condition. AA6061 is most common alloys of the aluminum for day today use. 1 to 3 wt % of fixed weight percentage of Sic and 1% fly ash is used in this experiment.

Element	Al	Mg	Si	Fe	Cu	Cr	Zn	Ti	Mn
Wt%	95.85-98.56	0.8-1.2	0.40-0.8	0.00-0.7	0.15-0.40	0.04-0.35	0.0-0.25	0.0-0.25	0.0-0.15

Preparation of Composites

Stir casting method is used in the preparation of the metal matrix components. To achieve uniform distribution of the reinforcement of the metal matrix using the stir casting method, vortex condition is created in the molten metal. The reinforced particle Sic and Fly ash is used with the base material AA6061 to create hybrid metal matrix composite. In a graphite crucible, 600 grams of aluminum alloy is taken and heated in a high temperature electric furnace. In the electric furnace the aluminum alloy is heated above the melting temperature ($650^{o)}$ for straight one hour. The reinforcement particle Sic and Fly ash is preheated in the temperature of $450\text{-}550^{o}$. This is done to remove the moisture in the particle. Once the aluminum alloy is melted it is stirred using mechanical stirrer and the speed of the stirrer is maintained at the speed of 550 RPM to 1100 RPM. In the vortex phase of the reinforced particles SIC ad Fly ash is added slowly to the molten metal and stirred continuously and the speed of the stirring is increased and 5 minutes duration is maintained. The molten metal is made to solidify in the preheated mould and casting material is achieved.

Fig: Heat Treatment Process

In a muffle furnace to an accuracy of $_{-}^{+}1^{o}$ the casting and composite ingots are heated at a temperature of 529^{o} and water is treated to the composite material to end the process and later it is aged at a temperature of 159^{o} C for 8 hours. Once the heat treatment process is complete, the casting material is machined for testing and made it in to a required dimension.

Testing Methods

There are three types of testing methods done to the composite specimen. They are hardness testing, tensile testing, flexural testing and impact testing.

Tensile testing

As per the ASTM E 08 standards, the dimension of the specimen of length 100mm and diameter 12mm is taken. The ultimate tensile strength (UTS) of the specimen is calculated using computerized universal testing machine.

Fig 1: Tensile test specimen.

UTM testing of prepared HMMC specimens which indicates Max load, Break load, Yield stress, Yield strain for specimens consisting of varying constituents where one of the constituent was kept at constant in the case of these particular specimens Fly ash was kept at constant and SiC was varied in preparation (Al+1% SiC+1% Fly ash),(Al+2% SiC+1% Fly ash),(Al+3% SiC+1% Fly ash) HMMC specimens .

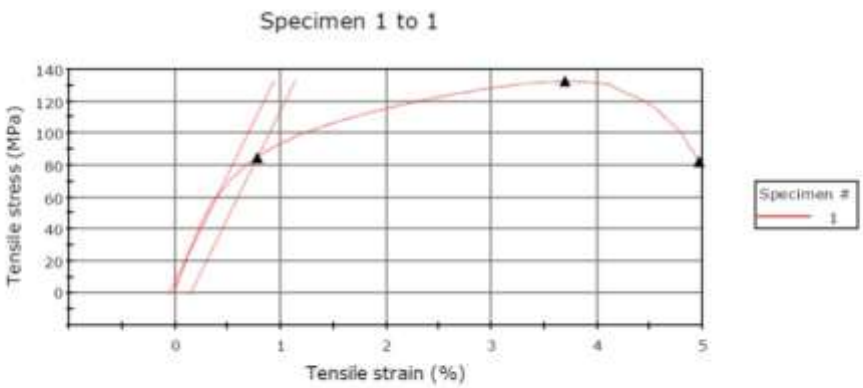


Fig2: Stress-strain curve of 1%SiC+1%Flyash

The above image gives us brief understanding that it depicts stress strain curve and their relation while x axis represents Tensile strain, y axis represents the Tensile stress for Stress-strain curve of 1%SiC+1%Flyash, at the point of 60MPa elasticity is observed that the linear stress is at the elastic limit and from 84.87MPa it exhibits yield stress and from there at 130.9MPa ultimate tensile strength it was observed resulting a breaking point and from there the stress dropped.

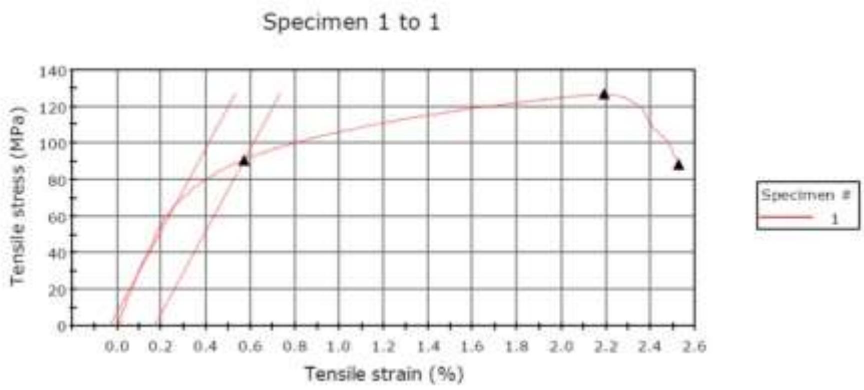


Fig 3: Stress-strain curve of 2%SiC+1%Flyash

The above image gives us brief understanding that it depicts stress strain curve and their relation while x axis represents Tensile strain, y axis represents the Tensile stress for Stress-strain curve of 2%SiC+1%Flyash, at point 70MPa it is observed that linear stress is at elastic limit and from point 90.79MPa it exhibited yield stress and from there at 127.9MPa ultimate tensile strength it was observed resulting a breaking point and from there the stress dropped .

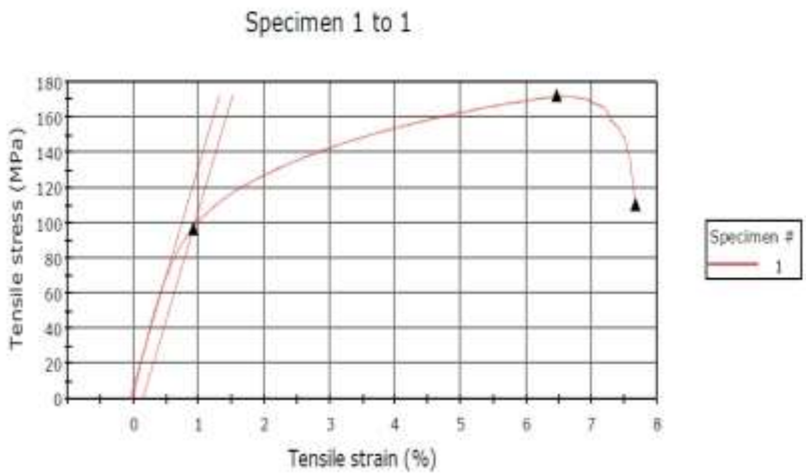
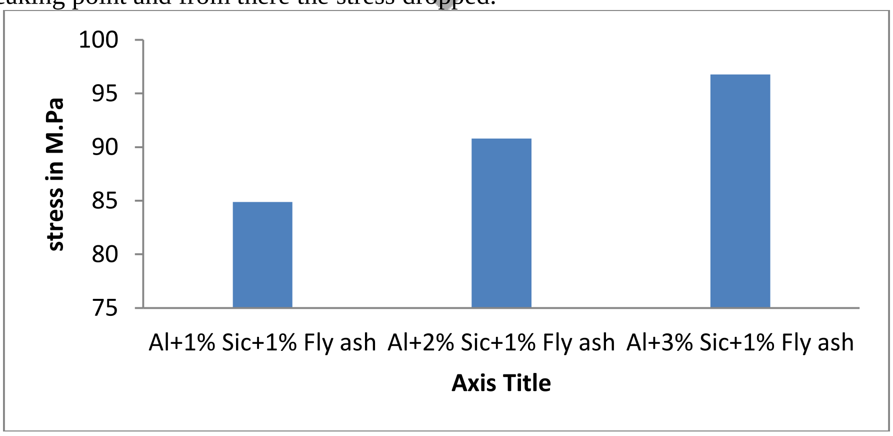


Fig 4: Stress-strain curve of 3%SiC+1%Flyash

The above image gives us brief understanding that it depicts stress strain curve and their relation while x axis represents Tensile strain, y axis represents the Tensile stress for Stress-strain curve of 3%SiC+1%Flyash, at point 70.91MPa it is observed that linear stress is at elastic limit and from point 96.77MPa it exhibited yield stress and from there at 170MPa ultimate tensile strength it was observed resulting a breaking point and from there the stress dropped.



Graph1: Effect of SiC on Ultimate tensile strength

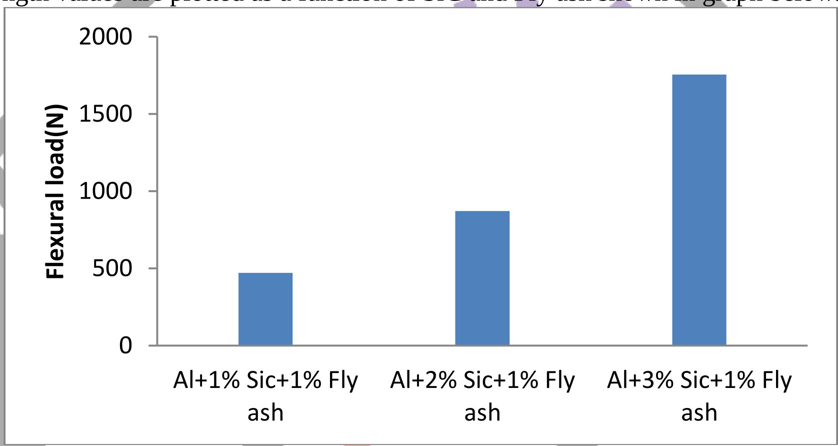
From the above plotted graph we are be able to know what is the effect of SiC Content varied in percentages for prepared HMMC specimens according to experimentation that were tested by help of UTM testing machine, readings were noted and tabulated from which a graph was plot which depicts that increase in SiC content was resulting indirectly for increased tensile yield strength of that particular specimens, it was also observed from the following graph that decrease in SiC content resulted in drop of tensile yield strengths of that particular specimens hence it was made clear that SiC constituent was able to effect the yield strength for prepared HMMC specimens.

Flexural testing

From UTM testing of prepared specimens which indicates Flexure load, Flexure stress, Extension for specimen consisting of varying constituents where one of the constituent was kept at constant in the case of these particular specimens Fly ash was kept at constant amount in percentage and SiC was varied in preparation (Al+1% SiC+1% Fly ash), (Al+2% SiC+1% Fly ash),(Al+3% SiC+1% Fly ash) specimens.

Fig 5: flexural testing specimen.

Flexural modulus and strength values are plotted as a function of SiC and Fly ash shown in graph below.



Graph 2: Effect of varied wt% of SiC on Flexural strength

From the above plotted graph we are be able to know what is the effect of SiC Content varied in percentages for prepared specimens according to experimentation that were tested with the help of UTM Testing machine, readings were noted, from which a graph was plotted that depicts that increase in SiC content is resulting indirectly for increased Flexural strength of that particular specimens, it was also observed from the following graph that decrease in SiC content resulted in drop of Flexure load capacity of that particular specimens hence it was made clear that SiC constituent was able to effect the Flexural strength for prepared HMMC specimens.

Impact testing

Using Izod impact testing machine, the impact test is performed. As per the ASTM E-23 standards size, the test specimen from the casting materials is machined. For this test a single square cross section of dimension (10mmX10mmX55mm) with a single V-notch is taken. The angle of the V-notch is 45^{o} and has depth of about 2 mm. In the impact testing machine, the impact roughness is detected when the fracture occurs.

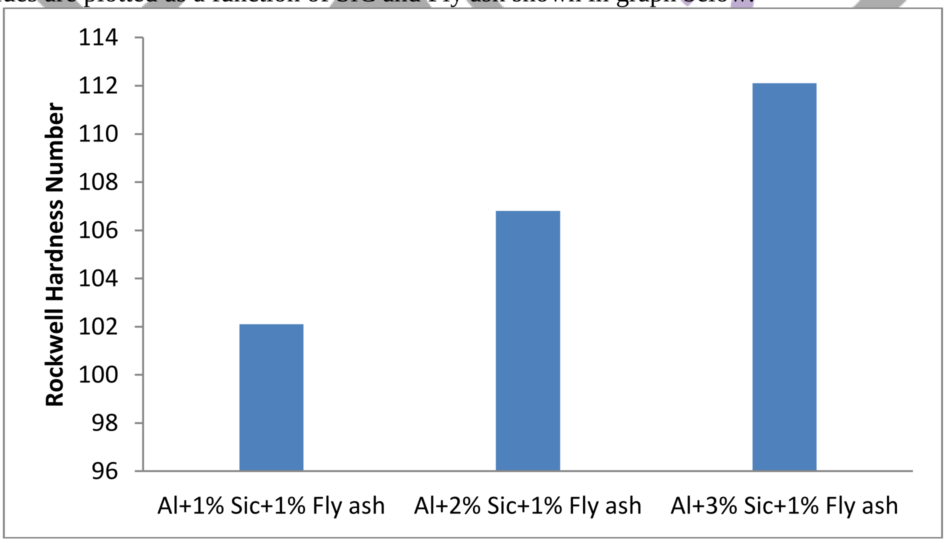
Fig 6: specimen for impact testing.

Hardness testing

To find the hardness of the specimen, Rockwell hardness testing is experimented. As per the ASTM E-18 standard sizes, 1/16 ball indenter is used for testing the hardness of the specimen. In five various locations and average value of the specimen is used to test the hardness.

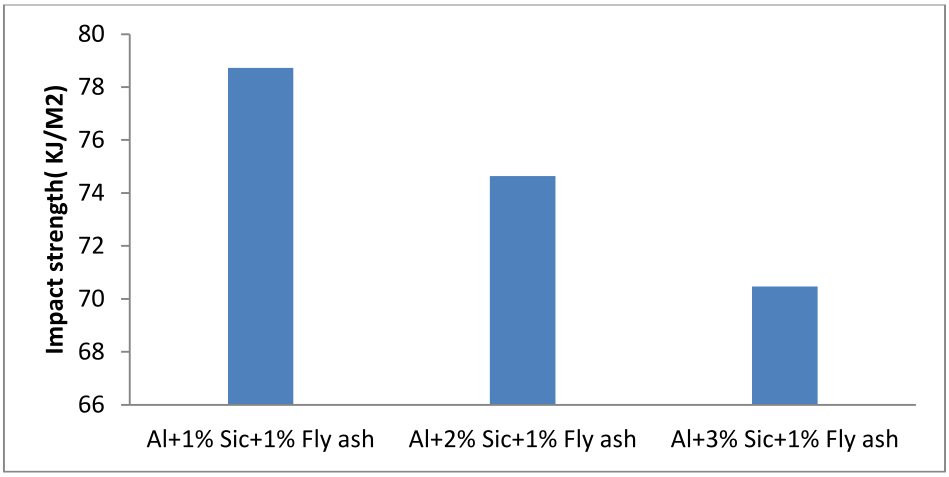

Fig 7: specimen for hardness testing.

Hardness number values are plotted as a function of SiC and Fly ash shown in graph below.



Graph 3: Effect of varied wt% of SiC filler on Hardness

From the above plotted graph we are be able to know what is the effect of SiC Content varied in percentages for prepared specimens, according to experimentations that were performed on Rockwell hardness apparatus, readings were noted and tabulated from which a graph was plot which depicts that increase in SiC content was resulting indirectly for increase of toughness and ductility for that particular specimens, it was also observed from the following graph that decrease in SiC content resulted in poor performance of toughness and ductility of that particular specimens hence it was made clear that SiC constituent was able to effect the Hardness number for prepared HMMC specimens.



Graph 4: Effect of varied wt% of SiC filler on Izod impact strength

From the above plotted graph we are be able to know what is the effect of SiC Content varied in percentages for prepared specimens according to experimentation that were performed on Izod impact apparatus, readings were noted and tabulated from which a graph was plot which depicts that increase in SiC content was resulting indirectly for decrease of toughness and ductility for that particular specimens, it was also observed from the following graph that decrease in SiC content resulted in better performance of toughness and ductility of that particular specimens hence it was made clear that SiC constituent was able to effect the Impact strength for prepared HMMC specimens.

Conclusion

The work is mainly concentrated on aluminum '6' series such as Al 6061 and influence of SIC and Fly ash on above specified aluminum. Tensile, hardness, flexural and impact strength on Al 6061 reinforced with 1%, 2%, 3% of silicon carbide and 1% fly ash. Tensile test conducted on INSTRON, Rockwell hardness test conducted on hardness tester and impact strength conducted on IZOD impact operator. The respective tests are successfully completed on above specified equipment's. The addition of reinforcement on above specified composition of aluminum 6061 materials tensile strength is continuously increases. 1% of SiC with 1% of Fly ash specimen exhibits brittle factor during the tensile testing. Hardness of the specimen is continuously increasing if we add the SiC and Fly ash as reinforcement. Flexural strength analysis is performed on specified specimens and flexural strength is continuously increasing by adding more compositions. The impact strength will decrease by increasing the reinforcement. The presence of SiC particles in these hybrid aluminum matrix composites enhances the mechanical properties. Finally, it was concluded that 3% of SiC with 1% of fly ash to aluminum 6061 having more hardness and good tensile strength. And it can be useful for place where the wear rate is more in the components.

References

[1] Yang et al, The Tribological characteristics of A 3562 alloy-Gr composites," Wear, 2004,257,941-952.
[2] Butoz, S, Abrasive wear ofAlO3 reinforcement Aluminium Based MMCs, Compos.Sci.Technol,2001, 61,2381-2392.
[3] Benjamin D, Metals handbook, volume-2. Metals Park, ASM; 1979. pp 3–23.
[4] D, Subramanian N, Microhardness and microstructure studies on laser surface alloyed aluminium alloy with Ni–Cr. Mater Manuf Process 2000-15:pp-395– 404.
[5] Clyne TW, Withers PJ. An introduction to metal matrix composites. Cambridge: Cambridge University Press; 1993.
[6] Surappa et al, Friction and wear behavior of aluminum alloy coconut shell particulate composite,Wear, 1982,80,pp- 149-158.
[7] Surappa et al,Effect of sliding speed on wear behavior of A356-Al30% wt. SiCp MMC, Wear,1997, 206,pp- 33-38.
[8] Wang Z. G et al, Low Cycle Fatigue Behaviour of SiCp Reinforced Aluminum Matrix Composite at Ambient and Elevated Temperature, Scr. Metall. Mater.,1995, 32,11, pp-1739 1745.
[9] Fine M. E, Tribological Properties of Aluminium Alloy Matrix TiB2 Composite Prepared by In-Situ Processing. Metall. Mater. Trans,1997, pp-491-502.
[10] Boq Kong, H, The Interfacial Compounds and SEM Fractography of Squeeze-Cast SiCp -6061 Al Composites,Mater. Sci. Eng , pp-110-119.
[11] Hashim J, Metal Matrix Composites: Production by the Stir Casting Method, Mater.Process Technol,1999- pp-92- 93.
[12] Fen Wangb et al, Microstructure and Mechanical Properties of HoAl-Al2O3-Ti Al Composite, Materials and Manufacturing Processes, 2011,pp- 559-561.
[13] V.C.Uvaraja, Comparison on Al6061 and Al7075 alloy with sic and B4C reinforcement hybrid metal matrix composites, IJART, 2012, pp- 6602 -3127.
[14] D. Y., Kim, The study on characteristics of heat treatment of the direct squeeze cast 7075 wrought Al alloy. Materials Science and Engineering, 2001-pp- 721-726
[15] N.Natarajan et al,Tribological Characterization of StirCast Hybrid Composite Aluminium 6061 Reinforced with Sic and B4C Particulates, Vol.76 No.4 -2012, pp-539- 552.
[16] V. Ramnath et al,Evaluation of mechanical properties of aluminium alloy alumina boron carbide metal matrix composites, Materials & Design,2014, Vol.58, pp-332-338.