A Study on Mechanical and Tribological Properties of Aluminium 7075 MMCs Reinforced with Nano Silicon Carbide (SiC), Tur Husk and E-Glass Fiber

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Abstract--- **Aluminium alloy materials found to be the best alternative with its unique capacity of designing the material to give required properties. Aluminium alloy metal matrix composites (MMCs) are gaining wide spread acceptance for automobile, industrial and aerospace application because of their low density, high strength and good structural rigidity. In the present work, an attempt is made to prepare and studies the mechanical and tribological properties of Al-7075 Reinforced with Nano SiC, Tur Husk and E-Glass fiber. The Al-7075 composites were fabricated by liquid metallurgy (stir cast) method by varying different percentages. The composite specimens were machined as per ASTM test standards. It has been observed that addition of Nano SiC, Tur Husk and E-Glass fiber significantly improves ultimate tensile strength along with compressive strength and hardness properties as compared with that of unreinforced matrix. The reinforcement is varied in 3 sets each set comprises of 3 specimens. Nano SiC is kept constant [1% in 1St set, 2% in 2nd set and 3% in 3rd set], tur husk and glass fiber are varied in 1% and 2% in all specimens. The casted composite specimens were machined as per ASTM standards. The mechanical properties like ultimate tensile strength, impact strength and wear behavior of the test specimens were investigated.**

Keywords: **Al-7075; Nano SiC; Glass Fiber; Tur Husk; stir casting; Mechanical and tribological properties**

I. INTRODUCTION

Aluminum is one of the lightest engineering metals and does the third most common element comprise 8% of the earth's crust. Low strength and hardness of aluminum, which limits its use in many engineering applications, could be increased through the addition of nanoparticles. Aluminium matrix nanocomposites (AMNC) have a wider application area because of their low density and high specific stiffness. The properties and quality of the nanocomposite material is directly influenced by achieving a uniform distribution of reinforcement within the matrix. Also, the amount, size and distribution of reinforcing particles in the aluminium matrix play an important role in enhancing or limiting the overall properties of the nano composite material. Metal matrix composites reinforced with nanoparticles also called metal matrix nanocomposites (MMNCs) are very promising engineering materials, which is suitable for a large number of applications. These nanocomposites consist of a metal matrix filled with nanoparticles featuring physical and mechanical properties which is very different from those of the matrix. These nanoparticles can improve the base material in terms of mechanical properties. Metal matrix nanocomposites are very promising materials with high potential for use in a large number of engineering applications.

Al-7075 is an aluminium alloy with Zinc as the primary alloying element. It is strong, with strength comparable to many steels and has good fatigue strength and average machinability, but has less resistance to corrosion than many other Al alloy. Due to its strength, high density, thermal properties and its ability to be highly polished, Al-7075 is widely used in mold tool manufacture. Al 7075 remains the baseline with a good balance of properties required for aerospace applications and it is often used in transport applications, including marine, automotive and aviation, due to their high strength-to-density ratio.

Nano Silicon carbide was originally produced by high temperature electrochemical reaction of sand and carbon, it is a compound of silicon and carbon with a chemical formula SiC. The material has been developed into a high quality technical grade ceramic with very good mechanical properties. It is used in abrasives, refractory, ceramics and numerous high performance applications. Silicon Carbide is the only chemical compound of carbon and silicon. Silicon carbide is also known as "carborundum. Particle size received silicon carbide was in the range of 50nm is used for the experiment.

E-Glass fiber or electrical grade glass was originally developed for standoff insulators for electrical wiring. It was later found to have excellent fiber forming capabilities and is now used almost exclusively as the reinforcing phase in the material commonly known as fiber glass. The length of the fiber used is 6mm.

Tur Husk-India is generating huge amount of low cost byproducts and waste in the form of husk. Presently the use of this husk is only for the cattle feed and possessing very less value. However as this byproduct is biomass and naturally carries carbon content with it so that we can use it in industrial application and hence can be used as reinforcement in MMCs. . One of the major pulse processed in India is Tur (Cajanus cajan) creating large amount of waste in the form of husk. Cajanus cajan husks in their carbon form is still not deliberated and need extensive study for the better application of these husks as composite material. The particle size of Tur husk is 12mm.

II. LITERATURE SURVEY

[1]Md. HasibulHaque, Ramin Ahmed, Md. Muzahid Khan, ShadmanShahriar (2016) “Fabrication, Reinforcement and Characterization of Metal Matrix Composites (MMCs) using Rice Husk Ash and Aluminium Alloy(A-356.2)”reported that MMCs were prepared by addition of 2,4,8 wt% through stir casting technique. The result reveals that the hardness of aluminium alloy decreases with increases in weight fraction of RHA particles and increases the ductility of composites. [2] Deepak Singla, and S R Mediratta reported that, with increase in value of fly ash, toughness, hardness and tensile strength was increased compared to the base metal and the density got decreased, so these composites can be used in automobile and space industries due to their light weight. [3]G. B. Veeresh Kumar, C. S. P. Rao, N. Selvaraj, M. S. Bhagyashekar, conducted experimental results of the studies conducted regarding hardness, tensile strength and wear resistance properties of Al6061-SiC and Al7075-Al2O3 composites. In the result it shows that, The SiC and Al2O3 resulted in improving the hardness and density of their respective composites.[4]Deeparaj.E, Vivek.B, Hariprasath.D Mechanical Properties of MMCs of AL7075 and Silicon Carbide. It is observed that the hardness of the composite is increased with increase of reinforced particle weight fraction. The tensile strength and impact strength both are increased with rising of reinforced weight fraction compared to pure metal. Different mechanical tests were conducted and presented by varying the weight fractions of SiC.

III. EXPERIMENTAL PROCEDURE

A. Material preparation

The matrix material used in the present experimental investigation is Al 7075 whose chemical composition (in weight %) is listed below in Table 1.

The materials used to prepare specimens are Al 7075, Nano SiC, tur husk and glass fiber. The specimens are prepared by machining the stir casted parts. For stir casting induction furnace is used. First the base metal is taken in a furnace and heated to 600°C. When base metal melts at that temperature the reinforcements are added to the molten base metal. Then to have self stirring process temperature of the furnace is raised to 800°C and also the stirring is done with the help of stirring mechanism at normal speed. Then the molten metal is poured in the form of round cylindrical rods of diameter 20mmX160mm length using reinforcing materials as Glass fiber, Tur husk, Nano SiC by varying weight percentages about then the casted rods were rapidly cooled to room temperature.

B. Specimen preparation

The test specimen was prepared by machining casted cylindrical rods according to ASTM standards. For tensile test the specimens were machined with dimensions 12mm dia X 100mm length in size. The dimensions for impact test were machined to 10mmX10mmX55mm with 2mm deep V-notch at the Centre and for wear test the specimens with 5.9mm dia X 32mm length were prepared.

IV. RESULTS AND DISCUSSION

A. Tensile Testing

A tensile test, also known as tension test, is probably the most fundamental type of mechanical test you can perform on material. The tensile testing specimen was machined according to ASTM standard. The tensile tests were conducted on these samples at room temperature using a Universal Testing Machine. The specimen dimensions are overall length 100mm, gauge length 50mm, grip section length 25mm,grip dia 12mm, The repeat tests were performed for composites with different percentage of reinforcement in specimens. Table 3 shows the result of tensile tests. Among all tested samples the specimen Z8 with composition AL-7075 + 3% Nano SiC + 1% Tur husk + 1%Glass Fiber gives better ultimate tensile i.e., 139.38N/mm².

B. Impact Testing

Impact testing is also known as Charpy impact test/Charpy V-notch test, is a standardized high strain-rate test which determines the amount of energy absorbed by a material during fracture.The specimen was machined according to ASTM A370. Impact tests were carried out at room temperature and the readings were taken by breaking specimen due to impact of pendulum. Table 4 shows the results of impact test. Among all tested samples specimen Z5 with composition 2% Nano SiC +1%tur husk+1%Glass fiber gives high Impact strength i.e., 40 joules.

C. Wear Testing

Wear is a process of material removal phenomena. When two surfaces with a relative motion interact with each other, due to friction it results in the progressive loss of material from contacting surfaces in relative motion. The prepared specimens were subjected to wear against a rotating EN-32 pin on disc under dry sliding wear testing machine. The tests were carried out at room temperature without lubrication for 300sec.In this test, track Dia = 60mm and time = 300sec are kept constant while load and speed are varied. The characteristics are determined by the comparison of the alloys for varying percentages of SiC along with aluminium. The results shows at 300rpm at 2kg weight, specimen Z5 (Al-7075+2%Sic+1%Tur Husk+1%Glass Fiber) shows less wear 11µm and specimen Z3 (Al-7075+1%Sic+2%Tur Husk+1%Glass Fiber) shows highest wear 820µm.Table 5 shows the results of wear test.

Figure 1: Casted parts taken out after cooling

Figure2: Tensile Test Specimens

Figure 3: Impact Test Specimens

Figure 4: Wear Test Specimens

Components	Weight (%)
Manganese (Mn)	0.1
Iron (Fe)	0.3
Copper (Cu)	1.6
Magnesium (Mg)	2.5
Silicon (Si)	0.2
Zinc (Zn)	5.5
Chromium (Cr)	0.22
Titanium (Ti)	0.1
Aluminium (Al)	89.48

Table1. Chemical Composition Of Al-7075 In (Wt%)

Sample	Composition
Z1	Al-7075 Pure
Z2	Al-7075+1%Sic+1%Tur Husk+1%Glass Fiber
Z3	Al-7075+1%Sic+2%Tur Husk+1%Glass Fiber
Z4	Al-7075+1%Sic+1%Tur Husk+2%Glass Fiber
Z5	Al-7075+2%Sic+1%Tur Husk+1%Glass Fiber
Z6	Al-7075+2%Sic+2%Tur Husk+1%Glass Fiber
Z7	Al-7075+2%Sic+1%Tur Husk+2%Glass Fiber
Z8	Al-7075+3%Sic+1%Tur Husk+1%Glass Fiber
Z9	Al-7075+3%Sic+2%Tur Husk+1%Glass Fiber
Z10	Al-7075+3%Sic+1%Tur Husk+2%Glass Fiber

Table 2: Sample Specification

Sample	Tensile Strength N/mm²
Z1	119.32
Z2	74.08
Z3	105.37
Z4	89.96
Z5	121.24
Z6	128.34
Z7	114.75
Z8	**139.38**
Z9	130.96
Z10	119.32

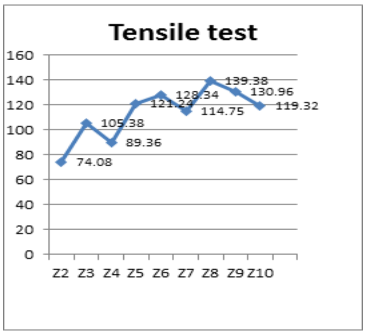
Table 3: Results of Tensile Test

Sample	Energy Absorbed(Joules)
Z1	22
Z2	20
Z3	20
Z4	29
Z5	**40**
Z6	29
Z7	27
Z8	19
Z9	11
Z10	14

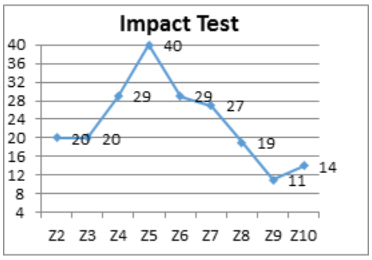
Table 4: Results of Impact Test

Sample	Wear in µm
Z1	370
Z2	110
Z3	820
Z4	170
Z5	11
Z6	53
Z7	34
Z8	48
Z9	182
Z10	160

Table 5: Results of Wear Test



Graph 1: Shows the Tensile test of all samples



Graph 2: Shows the Impact test of all samples

Graph 3: Shows wear test of sample Z2,Z3,Z4

Graph 4: Shows wear test of sample Z5, Z6, Z7

Graph 5: Shows wear test of sample Z8, Z9, Z10

V. CONCLUSIONS

From the experiments conducted to study the effects of adding various volumes fractions of Nano SiC, Tur Husk and E-Glass fiber to Al-7075. Following conclusions can be drawn.

– Composites material AL-7075 alloy reinforced with Nano SiC ,Tur husk and glass fiber were successfully casted by stir casting method.

– When 1% SiC is kept constant and the % of tur husk and glass fiber are varied(1%,2%)the results of 2% tur husk and 1% glass fiber gives better ultimate tensile strength.

– When 2% SiC is kept constant and % of tur husk and glass fiber are varied (1% & 2%) the results of 2% Tur Husk and 1% glass fiber gives better ultimate tensile strength.

- When 3% SiC is kept constant and % of tur husk and Glass fiber are varied (1% & 2%) the results of 1% Tur husk and 1% Glass Fiber gives better ultimate tensile strength.
- The best result of ultimate tensile strength has been obtained in sample Z8 at the weight percentage of Al-7075+3%SiC+1%Tur husk+1%glassfiber.
- When samples Z2,Z3,Z4 are compared in which 1%SiC is kept constant while tur husk and glass fiber weight percentage are varied. The result of 1%tur husk and 2% glass fiber gives better impact strength.
- When samples Z5, Z6, Z7 are compared in which 2%SiC is kept constant while tur husk and glass fiber weight percentage are varied. The results of 1%tur husk and 1%glass fiber gives better impact strength.
- When samples Z8, Z9, Z10 are compared in which 3%SiC is kept constant while tur husk and glass fiber weight percentage are varied. The results of 1%tur husk and 1%glass fiber gives better impact strength.
- The best result of Impact strength has been obtained in sample Z5 at weight percentage of Al-7075+2%SiC+2%Tur husk+1%Glass fiber.
- For wear test, the testing was conducted at a speed of 300rpm and 2kg weight, specimen Z5 (Al-7075+2%Sic+1%Tur Husk+1%Glass Fiber) shows less wear 11µm and specimen Z3 (Al-7075+1%Sic+2%Tur Husk+1%Glass Fiber) shows highest wear 820µm.

VI. SCOPE FOR FUTURE WORK

Other methods of production such as powder metallurgy, die casting etc. should be used. We can further extend the research by varying geometrical angle of stirrer and by varying stirring speed. Results can be varied by varying different weight percentages of reinforcements. By varying reinforcement Grain Size, results can be varied. Heat treatment can be done to improve the properties

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