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Synthesis and Evaluation of Aluminium 6061 Based Hybrid Composites and Validation With Fem

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Abstract

Mica-E-Glass-Al6061 alloy composites having fixed wt%(1wt%,2wt%,3wt%) of Mica and varying wt% of E-Glass (1wt%,2wt%,3wt%) the different alloy composites were fabricated using stir casting method. The plain Al6061 alloy composites were fabricated .The casted specimens were machined as per ASTM standards. After machining the Hybrid based alloy specimens were subjected to solution heat treatment at 480ºc and Artificial ageing .Some of the Mechanical properties of Hybrid based Al6061 Alloy have been evaluated and compared with plain AL606l.

The Evaluated properties of the samples were ultimate tensile strength and it was compared with results of FEM.

Keywords-Al6061,Mica,E-Glass,Al-6061 based Hybrid composites

I. INTRODUCTION

Composite materials sought over other conventional materials in the field of automotive , aerospace , marine applications owing to their excellent improved properties [1]. Composites are heterogeneous in mature . composite material is composed of two or more distinct phases and having bulk properties significantly different from those of any constituents [2]. The composite materials are replaced by cast iron and bronze alloys . But because of their poor wear and ultimate tensile strength they are subjected to many experiments and mechanical properties of these composites were studied and research people are conducting research on these materials to enhance their mechanical properties by adding different hybrid materials . Composite materials in general are well established engineering materials with most of them processing the advantage of higher specific weight and specific modulus and also there thermal stability , fatigue properties and wear resistance compare to many of the metals and alloys.[4]. The mechanical properties of mmc are often related to the anticipated onset of micro structural damage that is the process of initiation and growth of micro cracks and micro cavities which was often related to particles / matrix interaction [1]. Al6061 has has good strength at high temperature , good structural rigidity , dimensional stability , light weight ,low thermal expansion . The various reinforcements that have been tried out to develop the Matrix composites are Graphite, silicon Carbide, titanium carbide,tungsten,boron,Al2o3,flyash,Zirconium,si3N4,Tib2 etc.Fabrication of MMC has several challenges like porosity,formation,poor wet ability and improper distribution of reinforcement. A new technique of fabricating cast Aluminum Matrix composites has been proposed to

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improve wet ability alloy and reinforcement [5]. The extensive use of these composites were limited owing to higher processing cost. This led to use of low cost low density reinforcements[6].A composite Materials can provide superior & unique Mechanical & physical properties because it combines the most desirable properties of constituents while suppressing their least desirable properties[7]. Composites containing 10wt% Zro2 fabricated at 950°c showed the maximum value of Hardness and UTS comparison with other specimens which could be attributed to presence of Zro2 particles, dislocation density increasing and their pile-ups behind the uniformly distributed Zro2 particles[7].During fabrication when flyash is added to Al6061 it increases its wear resistance[6].Increasing the adding of sic proportion fron10% to 15% improves the wear resistance of composites by forming a protective layer between pin &counter face[5].This paper presents preliminary finding on the influence of heat treatment ant artificial ageing for different Materials for aluminum alloy 6061 hybrid composites[8].

II. EXPERIMENTAL DETAILS

A. Material

Al6061 alloy was used an Matrix Material. The chemical composition of Al6061 alloy used in the present work is reported in Table-1

Table-1.
Al6061 Chemical Composition

Composition	Weight(%)
Si	0.809
cu	0.355
Fe	0.155
Mn	0.027
Mg	0.8
Zn	0.008
Pb	0.023
Ti	0.01
Sn	0.01

Table-2. Chemical composition of E-Glass fiber by weight percentage

Sio_2	Al_2O_3	CaO	MgO	B_2O_3
54.3%	15.2%	17.2%	0.6%	8.0%

B. Composite Preparation

Al6061 alloy was melted using a 8kw electrical resistance furnace. It was melted at 800ºc, which is superheated by 480ºc. The melt was degassed using commercially Available chlorine-based tablets(hexachloroethane). The molten metal was agitated by the use of Mechanical stirrer rotating at high speed. Prior to addition 2 Mica Particles were added to improve its wet ability in Molten Metal [2]. E-Glass was also added slowly into the vortex while containing the stirring process. A composite Melt was poured into preheated Metallic Moulds.

C. Heat treatment:

Aluminum A16061 alloy were subjected to heat treatment using an Electrical resistance furnace equipped with programmable temperature of 480º c for a duration of 1hour followed by the quenching in water media. Artificial ageing was performed by varied ageing duration from 1hours to 5hours in steps of 2hours after solutionizing. Artificial ageing is carried out at 175ºc.

D. Tensile test:

Test specimens were prepared according to ASTM Standard. Specimens were loaded in universal testing machine. The specimens were loaded until the failure of specimens occurs. Tests were conducted on composites of different combinations of reinforcing materials and Ultimate tensile and % elongation were measured to obtain information regarding the behavior of given material under gradually increasing stress-strain conditions. Fig-1 shows tensile test specimen after testing .

E. Hardness Test

Hardness test were performed on as cast and Composites to know the effect of Mica and E-glass in material. The polished specimens were tested using Brinell hardness testing system. A load of 60kgf for a period of 10seconds was applied on specimens.

F. Micro Structure

Micro structure studies were carried out on polished and etched(Keller's reagent) specimen of heat treat A16061 alloy using a optical Microscope. The magnification used was 50X, 100X, 200X.

III. RESULTSAND DISCUSSION

A. Microstructure studies

Aluminum-alloy 6061/ Mica / E-glass fabricated by stir casting the optical

Micrographs. A16061 Metal Matrix Alloy composites, shows in figure-1 reveal that there is fairy uniform distribution of A16061-Mica and E-glass. It is reported that it has good Hardness and it is associated with lower porosity. The particles clustering of porosity were observed in cast A16061-Mica-E-glass.

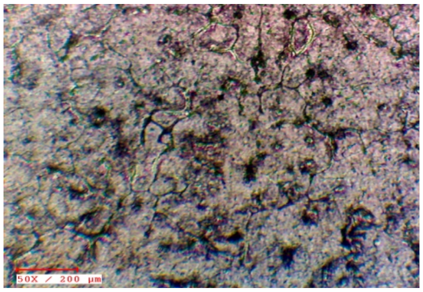

Figure 1. Microstructure showing good interfacing bonding between A16061-Mica- glass.

B.Tensile Test:

Tensile testing is a fundamental materials Science test in which a sample is subjected to uni-axial tension until failure. The results from the test are commonly used to select a material for an application for quantity control, and to predict how a material will react will other types of forces in table-3.

TABLE 3 VALUES OF UTS FOR DIFFERENT CONDITIONS OF ARTIFICIAL AGING

Samples	plain	Artificial aging(1hour)	Artificial aging(3hour)	Artificial aging(5 hour)
A0	134.52	160.07	180.03	191.63
A1	160.07	169.07	191.63	197.33
A2	169.07	170.55	197.51	199.33
A3	170.55	176.38	204.08	206.43
A4	176.38	179	204.68	217
A5	179.00	180	206.45	221
A6	180.33	191.63	210	223
A7	191.63	194	217	231
A8	194.00	196	221	223
A9	194.67	199.3	231	253

C. Hardness:

Hardness is defined as the resistance to indentation and is determined by measuring the permanent depth of the indentation. Hardness is carried out by using brinell hardness test. The Hardness number is determined by the load over the surface area of the indentation and not the area normal to the face as in table 4

TABLE 4 BRINELL HARDNESS VALUES FOR DIFFERENT COMPOSITION.

Samples	plain	Artificial aging(1 hour)	Artificial aging(3 hour)	Artificial aging(5 hour)
A0	64.78	70.22	73.205	76.36
A1	66.08	71.69	78.012	79.71
A2	67.43	74.75	79.73	81.52
A3	67.70	75.55	80.26	82.02
A4	70	76.43	81.52	83.33
A5	71.68	77.41	82.02	83.85
A6	70.95	78.02	84.26	85.16
A7	71.69	78.89	85.16	85.95
A8	72.44	79.73	86.14	87.14
A9	73.205	78.89	85.16	88.13

IV. FINITE ELEMENT MODELING:

The basic procedure in FEA is that the body or structure is divided into smaller elements of finite dimensions called “Finite elements”.

CAD model is created as per the standard tensile specimen. Figure 2 shows the cad model of the tensile specimen.

Meshing is convenient to select the free mesh because the tensile specimen has sharp curves, so that shape of the object will not alter. To mesh the tensile specimen the element type must be decided first. Here, the element type is solid187 solid modeling. The element length is taken as 2mm. Figure 3 shows the meshed model of the tensile specimen.In the present work, tensile specimen is modeled as solid elements.

ELEMENT TYPE:

SOLID: solid187 structural solid

Solid element, type solid187 modeled. The element is defined by eight nodes having three DOF at each node: translations in the nodal x, y and Z directions. The element has plasticity, creep, swelling, stress stiffening, large deflection, and large strain capabilities.

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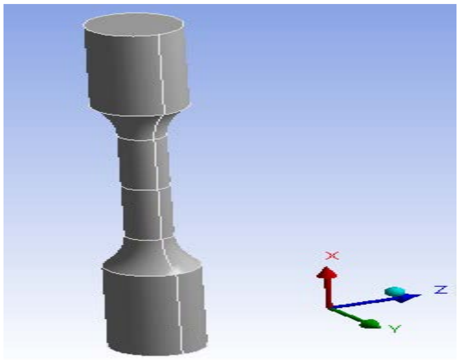

Figure 2: Cad model of tensile specimen

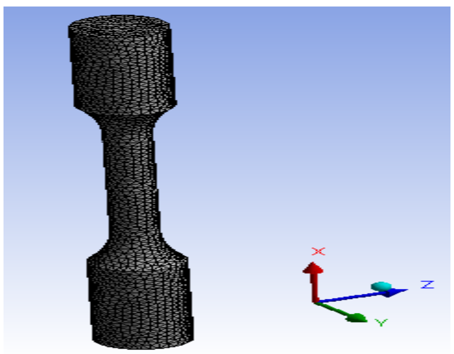

Figure 3: FE model of tensile specimen specimen

TABLE 5 COMPARISION OF DIFFERENT UTS VALUE

LOAD CASE	UTS OBTAINED BY EXPERIMENTAL RESULTS(N/mm2)	UTS OBTAINED BY FEM (VON-MISES STRESS)(N/mm2)	UTS OBTAINED BY FEM (MAXIMUM PRINCIPAL STRESS)(N/mm2)
1	197.53	197.62	202.82
2	180.33	177.57	182.25
3	176.38	174.94	179.55
4	169.07	168.37	172.8
5	204.68	204.54	209.92
6	191.63	189.41	194.4
7	170.55	169.02	173.47
8	134.52	132.19	135.67
9	206.45	206.51	211.95
10	160.07	160.7	165.17
11	199.33	199.94	205.2

Table 5 shows the results obtained by Experimental method and FEM method . It is observed that UTS has increased with an increase in reinforcement material.
An increase in UTS is noticed with increase in ageing duration. This improvement may be attributed to finer grain boundaries which serve as obstructions to the movement of dislocations. The experimental results of UTS are validated using FEM and the results were found to with close agreement

V.CONCLUSION

Detailed experiments were carried out to study the influence of varying percentages of mica and e-glass on the structure and tensile properties of Al 6061 based hybrid composites.

In addition, the influence of solution heat treatment and ageing at different durations on the above composites was also studied.

The following conclusions have been drawn based on the results of the above extensive experimental investigation:

1. Microstructure studies indicate, there is uniform distribution of the reinforcement in the matrix and that the as-cast has course grain structure.
2. After heat treatment and ageing, grain structure has refined to fine structure with no voids.
3. The Brinell hardness number has increased as there is increase in the reinforcement. It is also evidenced that there is substantial increase in the after solutionising and ageing at different durations.

4. The increase in hardness is attributed to the precipitation and the denser morphology of the grains.
5. It is observed that UTS has increased with an increase in reinforcement material.
6. An increase in UTS is noticed with increase in ageing duration. This improvement may be attributed to finer grain boundaries which serve as obstructions to the movement of dislocations.
7. The experimental results of UTS are validated using FEM and the results were found to with close agreement.

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