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SYNTHESIS AND EVALUATION OF MECHANICAL PROPERTIES OF ALUMINIUM A356 ALLOY REINFORCED WITH MICA AND TITANIUM DI OXIDE HYBRID COMPOSITE AT DIFFERENT AGING CONDITIONS

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Abstract: *There is always a need for a material which can be replaced for the conventional materials in the field of engineering where performance is key parameter. Researchers have suggested such materials in the form of composites which is the combination of two different materials having different chemical and physical characteristics. Aluminium and its alloy are one such material which when incorporated with suitable reinforcement's changes its properties and enhances the mechanical properties. In this present investigation, a metal matrix is prepared with aluminium A356 as matrix combined with varied percentage (1%, 2%, 3%, 4% and 5%) of mica and titanium di oxide (TiO_2) which are the reinforcements by using stir casting method. The prepared casting was then investigated for its tensile property and hardness. Significant improvement in hardness and tensile strength of the prepared hybrid composite was observed. Further the prepared specimen was heat treated and tested for different aging conditions.*

Keywords: *composites, A356, Mica, TiO_2, Aging conditions*

1. INTRODUCTION

There is a vast change in the field of engineering and technological area which constantly demands for more powerful material. A monolithic material does not always provide such though rough performance. Hence a need for hybrid materials is explored around the world through research and development. A composite material fills this demand with its high strength to weight ratio, low density, machinability and other various properties.

In this present study, aluminium A356 is the matrix material and reinforced with mica and TiO_2 with equal weight percentage. A356 belong to a group of hypo eutectic Al-Si alloy and has a wide field of application in automotive and avionics industries [1]. Alloy A356.0 has great elongation higher strength and considerably higher ductility than 356.0. Impurities less and hence have wide application in airframe casting, machine parts, truck chasses [2]. Titanium dioxide, also known as titanium is the naturally occurring oxide of titanium. It has a wide range of applications, from paint to sunscreen to food coloring. Mica is a complex aluminosilicate mineral. Mica is plate or sheet like structure. Mica has high toughness, good physical, thermal, mechanical properties. Many investigations on composites are done by researchers.

Mohsen Hajizamani et al. studied the mechanical properties of A356 reinforced with Al_2O_3 and ZrO_2 nano particles and concluded with addition of reinforcement, density decreased and ultimate and compressive strength increased. [3].

Sorna kumar T and Ravindra. D et al. studied the effect of nano TiO_2 ceramic fillers of polymer matrix composites and concluded that hand layup method was successfully used for the manufacture of composite, tensile, flexural and shear strength of GFRP improved very much with the addition of nano TiO_2 fillers. [4].

Hiregoudar Yerrennagoudar and Dyanand M. Goudar et al. studied the wear behavior of aluminium 6061 alloy reinforced with Al_2O_3 and mica reveals hardness increases with increasing reinforcement. [5].

2. AIM OF THE PRESENT STUDY

In this present investigation, Aluminium A356 alloy based hybrid composite is been prepared by using TiO_2 and mica particles as reinforcement by stir casting method. The outcome of reinforcement weight fraction on microstructure and mechanical properties of hybrid composites are investigated.

3. MATERIAL SELECTION

3.1 Matrix Material

For the present experimental investigation, Aluminium A356.0 was used as a matrix material whose chemical composition (in wt %) is listed in table 2.1. A356 alloy has good cast ability, mach inability, weld ability, heat treatable and corrosion resistance properties. The main chemical composition is silica with up to 7.5% wt % which provides greater hardness.

Table: 3.1 Chemical Composition of the Aluminium A356 Alloy

Chemical Compositions	Si	Fe	Cu	Mn	Mg	Zn	Ti	Others	Aluminium A356
Percentages (%)	6.5-7.5	0.20	0.20	0.10	0.25-0.45	0.10	0.20	0.15	Remainder

3.2 Selected Reinforcement Material

3.2.1 Titanium Di Oxide (TiO_2)

The purpose of selecting Titanium dioxide is due its low density, easily blend with Aluminium Alloys to improve mechanical property and low cost.

3.2.2 Mica

Mica is one of the naturally obtained mineral which when added as the reinforcement is considered to change the machinability of the material prepared. Some of the characteristics of the mica are high chemical resistance, elasticity, machinability and flexibility. The chemical, physical and mechanical properties are mentioned in the below tables.

Table 3.2: Chemical Composition of Mica

Compositions	%Composition
Silica	45.57
Alumina	33.10
Potassium Oxide	9.87
Ferric Oxide	2.48
Sodium Oxide	0.62
Titanium oxide	Traces
Calcium Oxide	0.21
Manesia	0.38
Phosphorus	0.03
Sulphur	0.01
Graphitic Carbon	0.44
Moisture at 100º	0.25
Loss on ignition	2.74

Table 3.3: Physical composition of mica

Physical Properties	Range
Density	2.6-3.2(gm/cc)
Melting Point	600ºC-1200ºC
Thermal Conductivity	Very Low

Table 3.4: Mechanical Properties of Mica

Mechanical Properties	Range
UTS	1750(kgf/cm2)
Shear Strength	2200-2700(kgf/cm2)
Modulus of Elasticity	1400-2100(kgf/cm2)

4. METHODOLOGY

The materials selected based on the literature review and other properties, the experimental procedure is carried out accordingly and are as follows.

In this process, the specimens were prepared using stir casting technique. Aluminium A356 alloy was taken as the matrix material. Titanium and Mica were chosen as the reinforcement to form the hybrid composite material. Initially A356 alloy was heated to 700ºC so as to obtain the molten material in an electric furnace. The prepared mica and TiO_2 particles having mesh size in the range 100-250µ was preheated to a temperature of 450ºC for at least 1hr to remove the moisture content and absorbed gases in the particles. Degassing of molten metal was evacuated by adding hexachloro- ethane tablets. Liquid metal temperature was maintained at 700°C with sufficient viscosity. The liquid metal was stirred at a speed of 500 rpm for 10 – 15 minutes with the help of impeller to create sufficient vortex. The stir speed chosen is high enough to get a sufficient vortex for proper mixing of the reinforcement particles with the liquid metal. At the same time, stir speed is low enough to avoid the gas and air entrapment in the molten metal. The 1% weight preheated particles were incorporated laterally in to the vortex of the molten metal. 1% magnesium was added to the molten metal to increase the wettability of the particles with the molten material. Stirring speed was maintained at 500 rpm for next 15 minutes to ensure the proper mixing. After this stage, the molten mixture was drained in to the mould. To accomplish the uniform solidification of the molten metal, the mould was preheated to 250°C for 30 minutes. Thus, particles are incorporated successfully to form hybrid composite material by using the stir casting technique. Later 2%wt, 3%wt, 4%wt and 5%wt by equal weight proportions of mica and TiO_2 were replaced to prepare the test specimen and tested for different aging condition.

4.1 Heat Treatment Procedure

i) Solutionizing: Solutionizing at 540°C for 6 hrs followed by quenching in to water at room temperature was executed on the prepared specimens.

ii) Stretching and straining: This is a particular condition where, instantaneously after the heat treatment and quenching, before precipitation starts and the hybrid composite material become harder. One set of prepared samples is permanently deformed by 8 % to 10 % by applying external force (before 5 Hrs).

iii) **Single Aging:** once quenching is done, the specimens are heated to a temperature of 140ºC for about 12hrs is carried out.

iv) Double Aging: In this process, the specimens are heated to a temperature of 200ºC for about 12 hrs is carried out.

5. RESULTS AND DISCUSSION

Once the cast is solidified, it is machined to obtain the ASTM standards for the purpose of testing. The various prepared specimens were also solutionized and heat treated. The final hybrid composite was then investigated for their mechanical properties.

5.1 Microstructure Analysis

The microscopic analysis is used to check the uniform distribution of reinforcement in the matrix material. Higher microscopic magnification can help to determine the various distribution of reinforcement. Some qualitative evidences of particle distribution of combined mica and TiO_2 quality of bonding between two particles and matrix are obtained. Pre microscopic analysis, the prepared specimen was grinded, polished by using emery papers, washed with water and finally etched with Keller's reagent. Thus the specimens are ready for their investigation through the microscope.

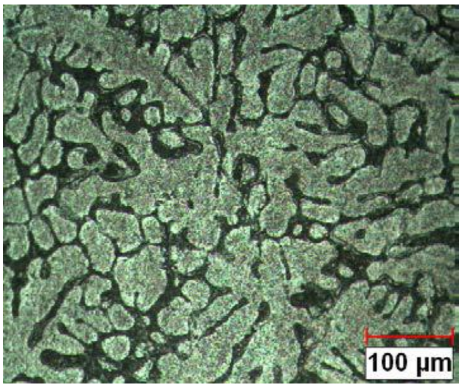


Fig. 5(a) As Cast

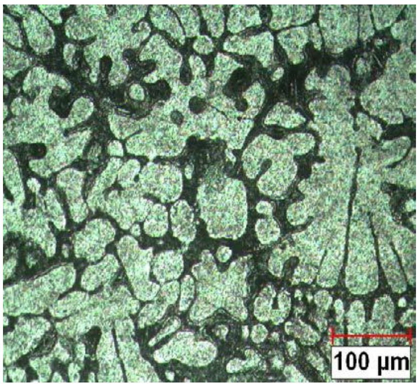


Fig. 5(b) Single Age

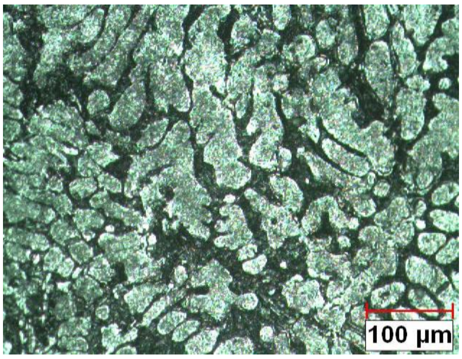


Fig. 5(c) Double aged

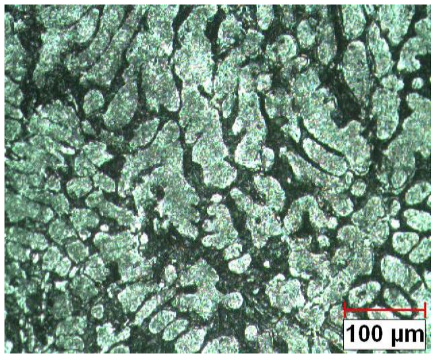
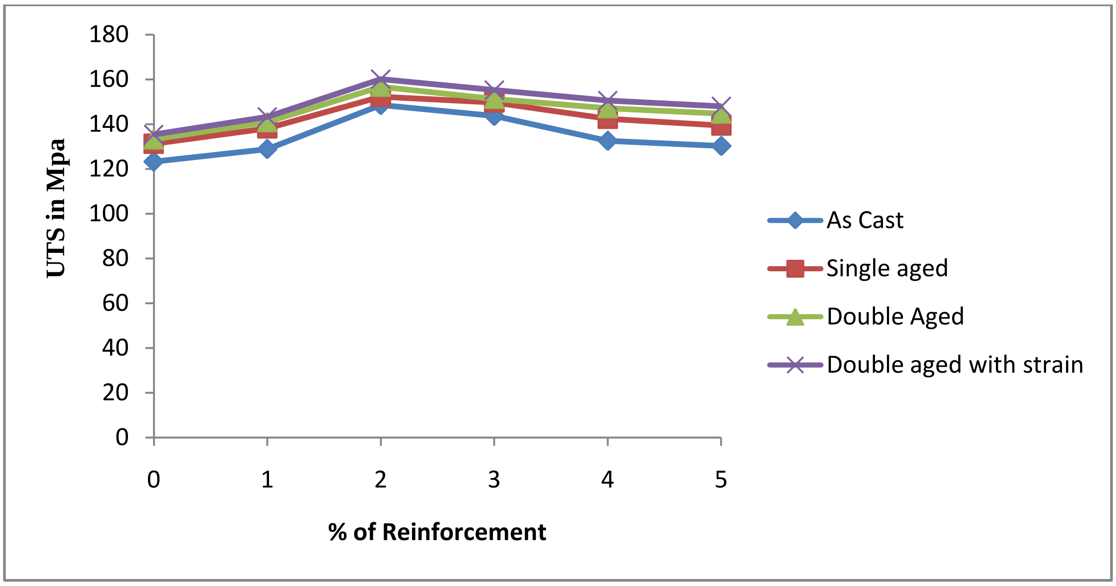


Fig. 5(d) Double aged with strain

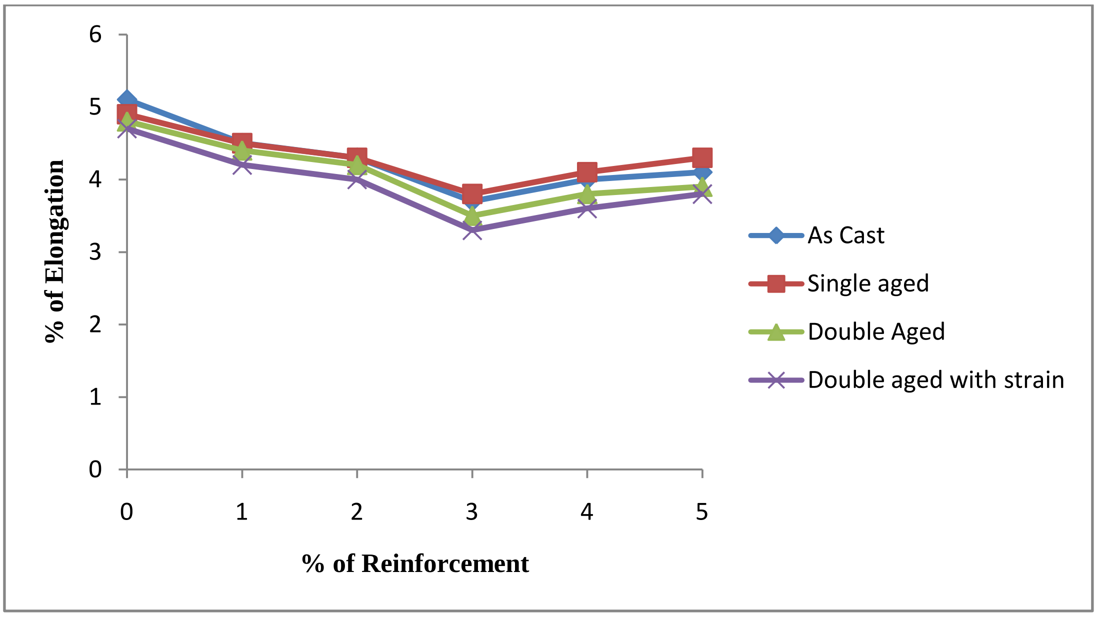
The figures 5(a) represents the microscopic view of the as cast specimen with 3% Mica particles and 3% TiO_2. Figure 5(b) and 5(c) represents the microstructure of the aged hybrid composite. Figure 5(d) shows the microstructure of 3% Mica particles and 3% TiO_2. This analysis demonstrated the uniform distribution of spherodized particles of mica in double aged with strain compared to dendrite structure observed in as cast specimen, double aged with strain and single aged with strain specimens.

5.2 Tension Test

The prepared sets of specimens are tested for the tensile strength in the universal testing machine. All the specimens are machined as per the ASTM E8 standards and loaded uniformly by the UTM until the material fails. Tensile investigation was conducted for the different specimens prepared and finally noted for the percentage elongation and ultimate tensile strength.



Graph 1. Evaluation of UTS for samples with various Mica and TiO_2 Compositions and Aging conditions

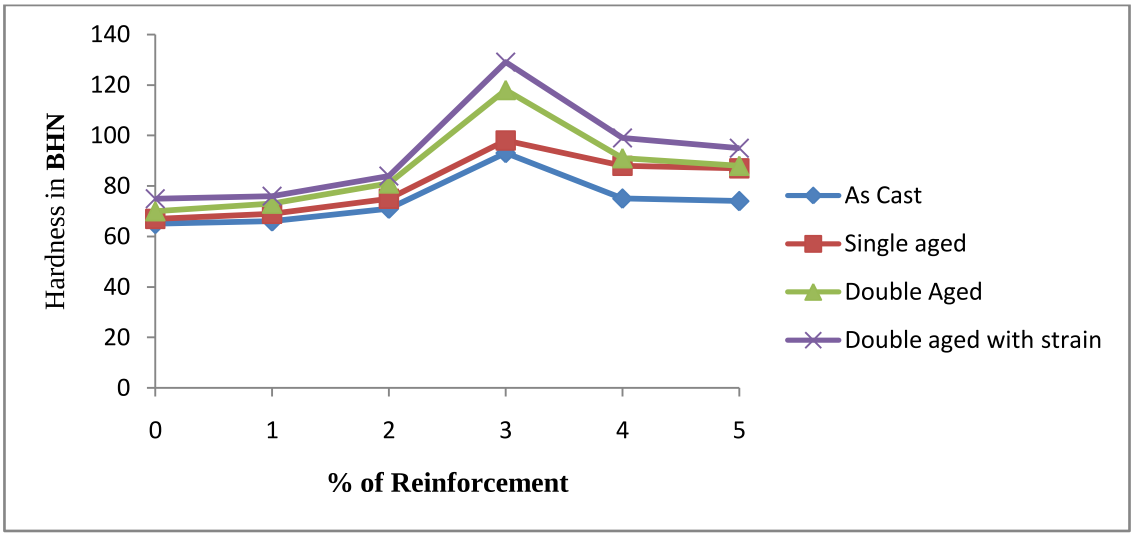


Graph 2. Percentage Elongation for samples with various Mica and TiO_2 Compositions and Aging conditions

Graph 1 indicates the ultimate strength of specimens with various compositions of reinforcement. Noticing this graph, there is an increase in the ultimate tensile strength with the increase in the percentage of the reinforcement and achieves the highest value for 3% weight of reinforcement for the double aged with strain specimen which is due to the effective bonding between the matrix and reinforcement. Graph 2 indicates the % elongation decreases with the increase in weight percentage of reinforcement particles.

5.3 Hardness Test

The hardness of the prepared materials was tested with Brinells hardness testing machine. The test specimens were machined to 20mm thickness as per the standards for the testing in Brinells machine. A steel ball indentor with 2.5mm diameter and a load of 60kgf was used to produce an indentation on the surface of the test specimen. The indentation was then calculated for its exact length in diameter to identify the hardness value for different reinforcements for as cast, single aging, double aging and double aging with strain test specimens. From the Graph 3, we can justify that the hardness value increases to its peak at 3% weight reinforcement. The highest hardness value is obtained for the specimen which is double aged with strain due to the increase in the mica particles and placing of grain particles closure and uniform making the composite material harder.



Graph 3. Evaluation of Hardness for samples with various Mica and TiO_2 Compositions and Aging conditions

6. CONCLUSION

The aluminium A356 alloy was successfully produced by vortex or stir casting method for different weight percentage of reinforcement for as cast, single aging, double aging and double aging with strain. After the conduction of the experiments, following conclusions have been drawn:

i. From stir casting method, Mica and TiO_2 particulates can be successfully introduced in the aluminium A356 matrix alloy material to fabricate hybrid composite materials.

ii. From the microstructure analysis, it is noted that the reinforcement particles are uniformly and evenly distributed in the matrix.

iii. The bonding between the matrix and reinforcement is denser in double aged strain specimen due to the nucleation of precipitates.

iv. When the percentage of Mica and TiO_2 increases in the composite, the UTS also increases. UTS is significantly affected by the heat treatment process and aging procedure. Thus, results obtained of the specimens who undergo double aging with strain have peak values.

v. If the reinforcement in the composite increases, then the hardness of the specimens also increases. Peak values for Hardness of material and specimens after double aging with strain and they are noticeably affected by the Heat treatment and aging procedures.

vi. However, beyond three percentages of reinforcement, loss of reinforcements has started taking place due to floating of the reinforcements. Further, it was difficult to stir and mix them in the molten metal uniformly due to increase in volume.

vii. Hence we can conclude that the mechanical properties have much significant role and is obtained in the specimen which is double aged and strained as compared to as cast specimen.

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