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Effect of Hybrid Reinforcement on Mechanical Behavior of Aluminium Matrix Composite

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***Abstract*— In current industrial scenario composite material has lot of Scope due to its improved mechanical properties like hardness, toughness, compressive strength& tensile strength. Conventional monolithic materials have limitations with respect to composite material. Development of hybrid metal matrix composites has become an important area of research interest in Material Science. Hybrid composite material containing Aluminium alloy Al356 as matrix and fly ash , alumina as reinforcement the reinforcement weight fractions of constant 2%,4%,6%,8%,10% fly ash and varying %wt of 2% ,4%,6%,8%,10% Al_2O_3 .After manufacturing the specimen mechanical behaviour of these specimen were studied by carrying out tensile test, compression test, impact strength ,hardness and wear test.**

Keywords—Aluminum alloys, Matrix, Hybrid Reinforcement, Hybrid composite.

I. Introduction

Aluminium (Al) is the second-most plentiful element on earth and it became an economic competitor in the engineering applications at the end of the 19th century. The emergence of three important industrial revolutions would, by demanding material characteristics consistent with the unique qualities of Aluminium and its alloys, greatly benefit growth in the production hybrid composite materials. Among the most striking characteristics is its versatility. Aluminium alloys and its composite materials are extensively used as the materials in transportation (aerospace and automobiles), engine components and structural applications [1].Thus it becomes all the more vital to study the tribological characteristics of Aluminium alloys and its composite materials. Addition of Silicon to Aluminium gives high strength to weight ratio, low thermal expansion coefficient, and high wear resistance. Hybrid Composite Materials show improved strength and wear properties as the silicon content is increased beyond eutectic composition. Such properties warrant the use of these materials as structural components in automotive industries [2].

The present investigation has been focused on utilization of waste fly ash and alumina in useful manner by dispersing it in aluminium alloy matrix to produce hybrid composite. In the present work, Alumina fly-ash which mainly consists of refractory oxides like silica, and iron oxides, was used as the reinforcing phase and to increase the wettability magnesium and silicon were added. Hybrid Composites were produced with different percentages of reinforcing phase. Further, these composites were characterized with the help of optical micrographic, wet chemical analysis, and image analysis. Mechanical and wear properties of the composites were also evaluated.

Over the last thirty years composite materials, plastics and ceramics have been the dominant emerging materials. The volume and number of applications of composite materials have grown steadily, penetrating and conquering new markets relentlessly. The composites industry has begun to recognize that the commercial applications of hybrid composites promise to offer much larger business opportunities than the aerospace sector due to the sheer size of transportation industry. Thus the shift of composite applications from aircraft to other commercial uses has become prominent in recent years.

II. REVIEW

To enhance mechanical characteristics of the hybrid composite and to change in wear resistance of Composite material with respect to increasing percentage of reinforcement. Therefore this paper concentrates on the Aluminium alloy matrix composites reinforced with hybrid can be successfully synthesized by the stir casting method.

Sharanabasappa R Patil et.al. [1] have investigated the results of an experimental investigation of the mechanical properties of fly ash and Alumina reinforced aluminum alloy (LM25) composites samples, processed by stir casting route. Tensile strength, impact strength & hardness were studied. It was found that the tensile strength & hardness of the aluminum alloy (LM25) composites increases with the increase in %wt of Al_2O_3 upto certain limit. The charpy test shows that as decrease in impact load absorption with increase in %weight reinforcement. The main objective of study is to fabricate the hybrid metal matrix composite successfully by using fly ash and alumina as particulate. Results of hybrid composite are also compared with simple composite and with parent metal.

Sandeep Kumar Ravesh et.al. [2] fabricated hybrid MMCs containing Aluminium 6061,SiC and fly ash .Composites were fabricated by varying wt %fraction of SiC(2.5%,5%,7.5% and 10%)from results ,may found that tensile strength ,hardness & toughness increases with increases with increasing wt percentage of SiC.

Mahendra Boopathi et.al. [3] evaluated physical properties of Al2024 reinforced with SiC and fly ash SiC (5%) + fly ash (10%) and fly ash (10%) + SiC (10%)] . It was observed that tensile strength and hardness were increased as compared to Al-SiC and Al-fly ash composites.

K.K.Alaneme et.al.[4] studied microstructure mechanical properties and corrosion behavior of Al-Mg-Si matrix composites containing 0:10 , 2:8, 3:7,and 4:6 wt percentage bamboo leaf ash and SiC as reinforcement.From the experimental results it was found that hardness ,UTS and percentage elongation decreases the BLA contains increases. Fracture toughness of hybrid composites was higher as compared to single reinforced Al - 10 wt% SiC composite.

M.Sreenivasa Reddy et.al .[6] fabricated Hybrid Metal Matrix Composites (MMCs) constitute an important the different compositions of E-glass and fly ash particulates with Aluminium alloy (7075) by stir casting method .Tensile testing of the specimen were carried out and it was observed that was tensile strength of the hybrid MMC is better than Al7075.

Indumati B. Deshmanya et.al[9] performed experimental work model tensile behaviour i.e ultimate tensile strength (UTS) and percentage elongation of the as-cast Al7075/Al2O3 in terms of size and % fraction of Al2O3, holding temperature and holding time; using factorial design of experiments (DoE). Adequacy of the models was tested using Fisher's F-test. UTS of the composite was increased by 20%compared to that of matrix and % elongation was reduced by around 30%.

Ashok Kr. Mishra et.al [13] studied the wear and frictional properties of the metal matrix composites by Al6061 reinforced with SiC particles (10% and 15%) using dry sliding wear test using a pin-on-disc wear tester. Experiments were conducted based on the plan of experiments generated through Taguchi's technique. A L9 orthogonal array was selected for analysis of the data. Effect of applied load, sliding speed and sliding distance on wear were studied and coefficient of friction.

N. Radhika et.al [15] studied wear behaviour aluminium alloy (Al-Si10Mg) reinforced with alumina (9%) and graphite (3%) fabricated by stir casting process. The wear and frictional properties of the hybrid metal matrix composites was studied by performing dry sliding wear test using a pin-on-disc wear tester. Experiments were conducted based on the plan of experiments generated through Taguchi's technique. A L27 Orthogonal array was selected for analysis of the data. Investigation to find the influence of applied load, sliding speed and sliding distance on wear rate, as well as the coefficient of friction during wearing process was carried out using ANOVA and regression equations for each response were developed.

From the literature review it is observed that, many researchers have done research on hybrid composite and they have successfully casted material at different % of reinforcement material. They have experimentally investigated and characterized the different test. They found that different mechanical and wear properties of hybrid composites are enhancing with increasing % of reinforcement.

III. MANUFACTURING PROCEDURE

The aluminum alloy Al356+ fly ash + Alumina (Al_2O_3) hybrid metal matrix composite was prepared by stir casting route. For this we took 3000 gm of commercially pure aluminum and desired amount of fly ash particles. The fly ash particle was preheated to 450^0C for three hour to remove moisture. Aluminum alloy Al356 was melted in a resistance furnace. The melt temperature was raised up to 720^0C and it was degassed by purging hexachloroethane tablets. Then the melt was stirred with the help of a mild steel turbine stirrer. The stirring was maintained between 5 to 7 min at an impeller speed of 200 rpm .The melt temperature was maintained 700^0C during addition of fly ash and alumina particles. The dispersion of fly ash particles were achieved by the vortex method. The melt with reinforced particulates were poured into the preheated permanent metalic mold. The pouring temperature was maintained at 680^0C.The melt was then allow to solidify the moulds. The composites were made with a different amount of fly-ash+Alumina(i.e.2-2, 4-4, 6-6,8-8,10-10 wt %), Magnesium and silicon were added to increase the wettability of fly ash particles.fig.4.4 Shows the stir casting set with all accessories.

Fig.1 Stir casting lab set up

MECHANICAL PROPERTIES OF CAST COMPOSITES

1. Tensile Test

The tensile testing of the hybrid composite was carried out, on Universal testing machine. Standard specimens with 62.5 mm gauge length were used to evaluate ultimate tensile strength, yield strength, % elongation. The comparison of the properties of the composite material was made with the commercially pure Al356.

Tensile strength dictates how the material will react to forces being applied in tension. Tensile test is fundamental test of mechanical where a carefully prepared specimen is loaded in a very controlled manner while measuring the applied load and the elongation of specimen over some distance. All this test specimens are prepared by reference standard EN1706:1998/BS 1490:1988.

2. Ultimate tensile strength

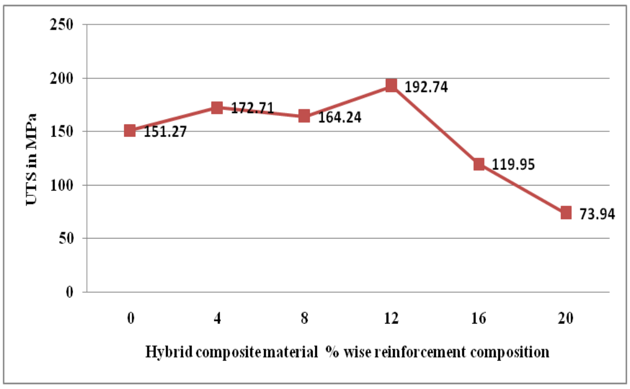

Fig. 2 Ultimate tensile strength Vs %wise increase in reinforcement

Fig.2 graph shows tensile test of hybrid composite material from the graph it is found that Ultimate tensile strength is increasing from 151.27 Mpa to192.74 Mpa while the % of reinforcement increasing, upto 12% of reinforcement .After certain limit while the percentage of hybrid reinforcement increases the ultimate tensile strength also decreases in U.T.S.

3. Measures of Ductility (Elongation)

The ductility of a material is a measure of the extent to which a material will deform before fracture. The amount of ductility is an important factor when considering forming operations such as rolling and extrusion. It also provides an indication of how visible overload damage to a component might become before the component fractures. Ductility is also used a quality control measure to assess the level of impurities and proper processing of a material. Like elongation, it is usually expressed as a percentage.

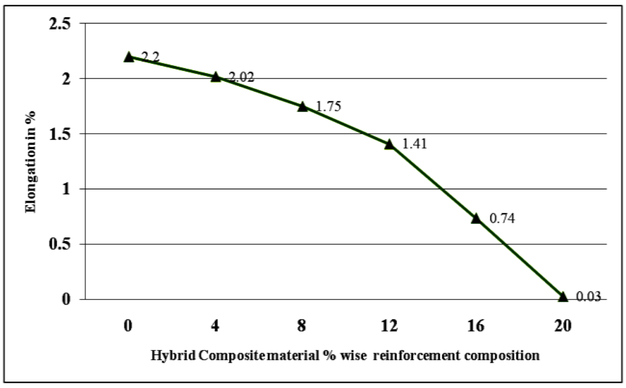

Fig.3 Graph of % Elongation Vs % of hybrid reinforcement

From fig.3 it is observed that as % age of hybrid reinforcement increases the ductility of composite material decreases from 2.2 % to .03%. In that test we have taken three trial test for each reading. Average is taken that three reading. all these tests are conducted by reference standard EN1706:1998/BS 1490:1988.

4. Compressive strength

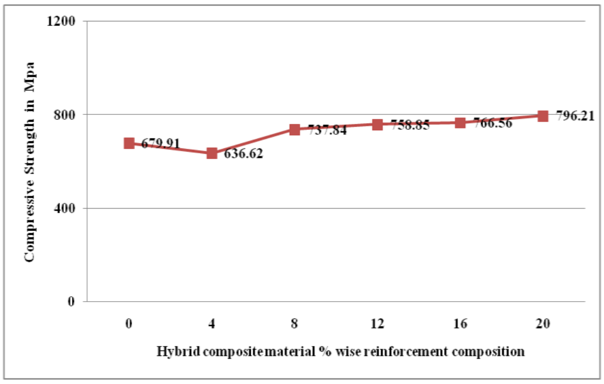

Fig.4 variation in compressive strength Vs composition of MMCs

From fig.4 it is found that the reinforcement percentage of material increases the compressive strength increases from 679.91Mpa to 796.21Mpa. The above table shows that incorporation of fly ash particles in Aluminum matrix causes reasonable increase in hardness. The strengthening of the composite can be due to dispersion strengthening as well as due to particle reinforcement.

5. Hardness

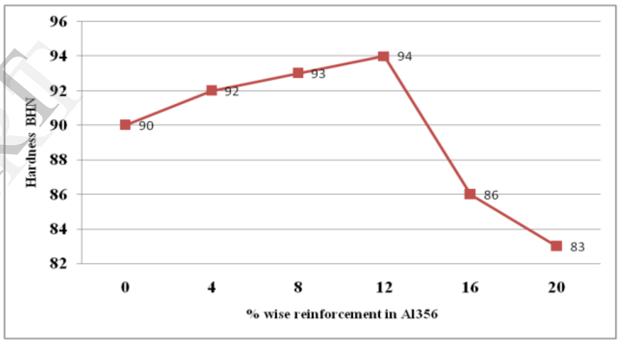

Fig.5 Graph of Hardness Vs composition of HMMCs

From fig.5 shows that while the hybrid reinforcement increases the hardness of composite material also increases from 90BHN to 94BHN, but for Al356 +8%Al2O3+8%Fly Ash hardness decreases due to ASTM grain size is 8.95 . Then for 16% & 20% hybrid composite material the hardness decreases due to porosity and strength.

CONCLUSIONS

The conclusions drawn from the present investigation are as follows:

1) Aluminum matrix composites have been successfully fabricated by stir casting technique with fairly uniform distribution of Fly ash & Al_2O_3 particles.

2) Tensile test :

From tensile test it is found that

- UTS increases from 151.27 Mpa to 192.74 Mpa upto 12% of reinforcement ,after 12% it decreases up to 73.94.
- Elongation decreases from 2.2% to 0.03.

3) Compression test:

From compression test it is observed that compression strength increased from 679.91 to 796.21 Mpa.

4) Hardness :

It appears from this study that hardness of Hybrid composite increases with increase in weight percentage of Fly ash & Al_2O_3 from 90 BHN to 94BHN, after 12% it decreases up to 83BHN.

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