FABRICATION AND INVESTIGATION OF MECHANICAL PROPERTIES OF AL-FLY ASH COMPOSITES

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Abstract - *A Metal matrix composites (MMCs) constitute an important class of design and weight-efficient structural materials that are encouraging every sphere of engineering applications. There has been an increasing interest in composites containing low density and low cost reinforcements. Among various discontinuously dispersed solids used, fly ash is one of the most inexpensive and low density reinforcement available in large quantities as solid waste by-product during combustion of coal in thermal power plants. Hence, composites with fly ash as reinforcement are likely to overcome the cost barrier for wide spread applications in automotive and small engine applications. To produce Al matrix cast particle composites, wet ability of the ceramic particles by liquid Al is essential.*

The present investigation has been focused on the utilization abundant available industrial waste fly ash in useful manner i.e. Fly ash used as a different weight percentages such as 5%,10%,15%,20% and 25% by dispersing it into aluminum/fly ash to produced composites by liquid metallurgy route. Wide size range (0.1-100μm) fly ash particles were used. The worn surfaces and wear debris were analyzed using optical microscope and scanning electron microscope. The mechanical properties such as hardness, toughness and tensile strength have been investigated.

Key words*: composite materials, aluminum, fly ash stir casting SEM.*

1.INTRODUCTION *(Size 11 , cambria font)*

Conventional monolithic materials have limitations in achieving good combination of strength, stiffness, toughness and density. To overcome these shortcomings and to meet the ever increasing demand of modern day technology, composites are most promising materials of recent interest. Metal matrix composites (MMCs) possess significantly improved properties including high specific strength; specific modulus, damping capacity and good wear resistance compared to unreinforced alloys.There has been an increasing interest in composites containing low density and low cost reinforcements. Among various discontinuous dispersoids used, fly ash is one of the most inexpensive and low density reinforcement available in large quantities as solid waste by-product during combustion of coal in thermal power plants. Hence, composites with fly ash as reinforcement are likely to overcome the cost barrier for wide spread applications in automotive and small engine applications.

Composite material is a material composed of two or more distinct phases (matrix phase and reinforcing phase) and having bulk properties significantly different from those of any of the constituents. Many of common materials (metals, alloys, doped ceramics and polymers mixed with additives) also have a small amount of dispersed phases in their structures, however they are not considered as composite materials since their properties are similar to those of their base constituents (physical property of steel are similar to those of pure iron) . Favorable properties composites materials are high stiffness and high strength, low density, high temperature stability, high electrical and thermal conductivity, adjustable coefficient of thermal expansion, corrosion resistance, improved wear resistance etc.

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

2. RESEARCH SIGNIFICANCE

From the literature, it is found that, In this investigation an attempt has been made to study the The toughness test, split tensile strength for the given materials . testes are conducted in laboratory.

3. EXPERIMENTAL PROGRAM

Raw materials

The matrix material used in the experiment investigation was commercially pure aluminum. The fly ash was collected from
NCS POWER PLANT, India. The particle size of the fly as received condition lies in the range from (0.1-90 μm).

Mechanical properties observation 750kgs and indenter was a steel ball of 5 mm diameter.

Tensile test : The tensile testing of the composite was done, on Instron testing machine. The sample rate was 9.103pts/sec and cross-head speed 5.0 mm/min. Standard specimens with 30mm guge length were used to evaluate ultimate tensile strength. The comparison of the properties of the composite material was made with the commercially pure Al. The comparison of the properties of the composite material was made with the commercially pure Al. Tensile testing, also known as tension 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 quality control, and to predict how a material will react under other types of forces. Properties that are directly measured via a tensile test are ultimate tensile strength, maximum elongation & reduction in area.

Toughness test: The toughness is the energy requires breaking the material. The energy is calculated in jouls. The energy consumed is calculated by the difference between total energy supplied to the energy available at the end. The measure of toughness can be found with the help of Charpy and Izod impact tests.

4. RESULTS AND DISCUSSION

Fly ash analysis:

Table 1: Composition of fly ash used as reinforcement in wt%

Compounds	Percentages (%)
SiO_2	67.2
Al_2O_3	29.6
Fe_2O_3	0.1
CaO	1.4
MgO	1.7

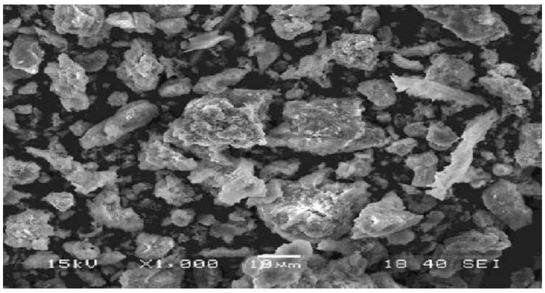


Fig1:SEM Micrograph of fly ash used in the study.

Fly ash from NCS POWER PLANT (India) had a wide particle size distribution. The particle size of the fly as received condition, lies in the range from (0.1-90 μm).The SEM micro- graph of the fly ash is shown in fig4.1. The major components of fly ash as received from the source and used for reinforcement are listed in Table 4.1 in wt%. The fly ash consist mainly Al2O3 (29.6 wt %) and SiO2 (67.2wt %). Fly ash is heated at225^{0}c for removed moisture content by using hot air oven maintained minimum 3 hours after that we mixed with pure aluminum in different wt % prepared specimens.

Fig:2. Optical microstructure of cast composites

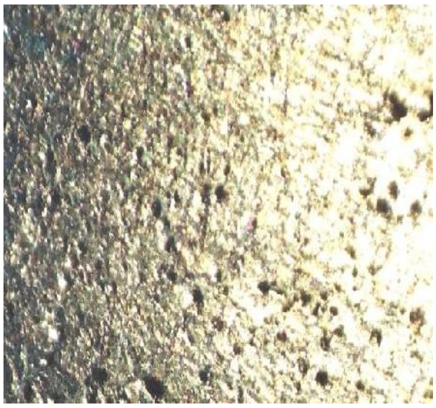


Fig.3- Al+ 5% fly ash composite

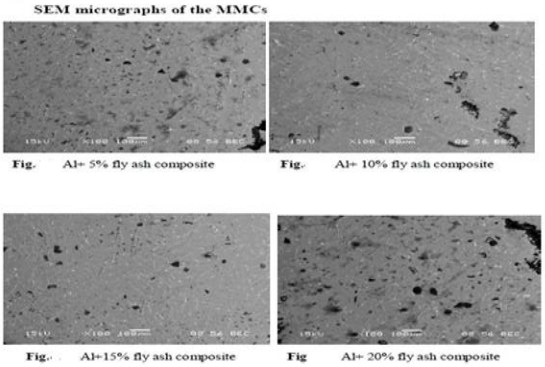


Fig:4 SEM micrographs of Al-fly ash composites are shown in fig .

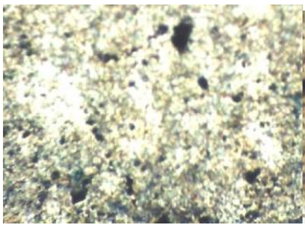
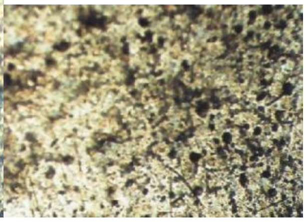



Fig.5-Al+15% fly ash Fig.6:-Al+20% fly ash

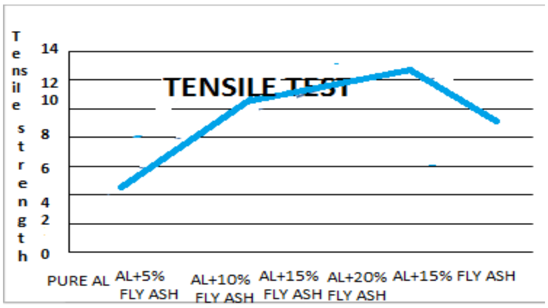


Fig 7(a) Tensile test

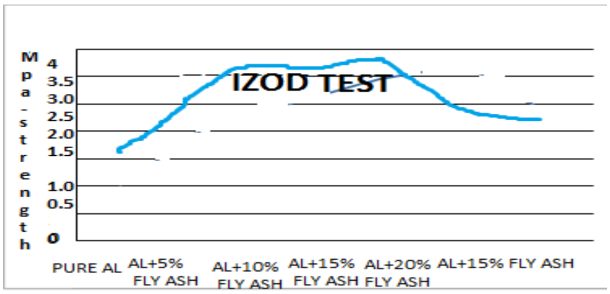


Fig 7(b) Izod test

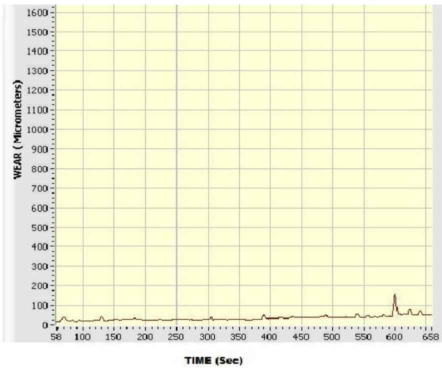
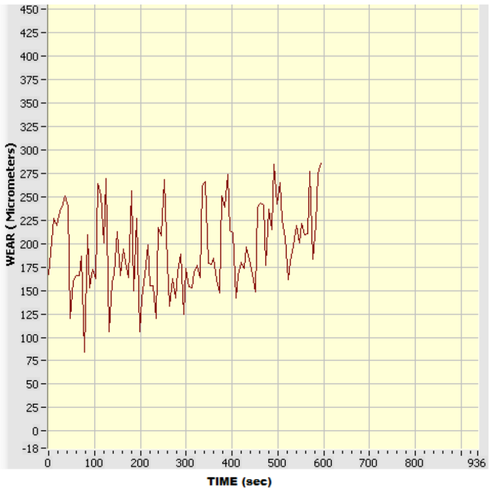


Fig7(C) Fabrication and Investigation of Mechnical Properties of Al-flyash-SiC Composites



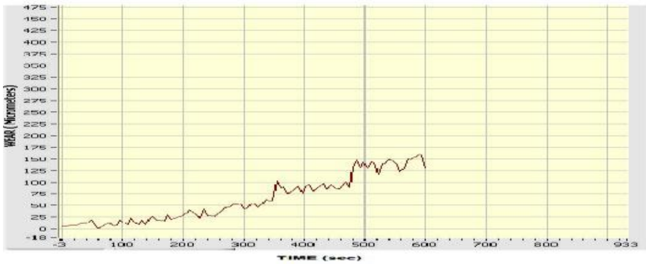


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Figure . Variation of Frictional force for Al+ (5%) fly ash at 300 rpm and at 20 N.

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Results of hardness clearly indicate that reinforcement has high effect on hardness and Al+SiC+fly ash composites are harder than Al+fly ash and Al+SiC composites.

The size, density, type of reinforcing particles, and its distribution have a pronounced effect on the properties of particulate composites. The variables affecting the distribution of particles are solidification rate, fluidity, type of reinforcement, and the method of incorporation. It is essential to get particles uniformly throughout the casting during particulate composite production. The first task is to get a uniform distribution of particles in the liquid melt and then to prevent segregation/agglomeration of particles during pouring and progress of solidification. One of the major requirements for uniform distribution of particles in the melt is its wettability.

Toughness Test: The toughness is the energy requires breaking the material. The energy is calculated in jouls. The energy consumed is calculated by the difference between total energy supplied to the energy available at the end. The measure of toughness can be found with the help of Charpy and Izod impact tests. The standard specimen size for Charpy impact testing is 10mm×10mm×55mm. and for Izod impact testing 10mm×10mm×75mm.

(a) Charpy Specimen (b) Izod Specimen

Fig8: (a) Izod (b) Charpy Test Specimen Before and After Testing.

Compared to the penetration made by a preload. Bulk hardness measurements were carried out on the base metal and composite samples by using standard Brinnel hardness test. Brinnel hardness measurements were carried out in order to investigate the influence of particulate weight fraction on the matrix hardness. Load applied was 750kgs and Indenter was a steel ball of 5 mm diameter.

Tensile Test: The tensile testing of the composite was done, on Instron testing machine. The sample rate was 9.103pts/sec and cross-head speed 5.0 mm/min. Standard specimens with 30mm gage length were used to evaluate ultimate tensile strength. The comparison of the properties of the composite material was made with the commercially pure Al. Tensile testing, also known as tension 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 quality control, and to predict how a material will react under other types of forces. Properties that are directly measured via a tensile test are ultimate tensile strength, maximum elongation & reduction in area.

Tensile strength of long-fiber reinforced composite in longitudinal direction $\sigma c = \sigma m*Vm+ \sigma f*Vf$ Where , σc, σm, σf – tensile strength of the composite, matrix and dispersed phase (fiber) respectively.

Tensile strength of short-fiber composite in longitudinal direction (fiber length is less than critical value Lc) 14 $Lc = \sigma f*d/\tau c$ Where d – diameter of the fiber; τc –shear strength of the bond between the matrix and dispersed phase (fiber). $\sigma c = \sigma m*Vm + \sigma f*Vf*(1 – Lc/2L)$ Where L – length of the fiber

Tensile strength of short-fiber composite in longitudinal direction (Fiber length is greater than critical value Lc)
$\sigma c = \sigma m*Vm + L* \tau c*Vf/d$

Fig 10: before testing

As earlier studied that we required a light weight composite material which will be used in the automobile and aerospace industries, this AL- Fly Ash composites are best for this applications doe to their low density. Fig.8 shows the effect of fly ash on the density and grain size of the composites we fabricated. Fig. shows the effect of fly ash on the density. As the ash content increases the density of the composites reduces which is good for us as they used in the light weight applications. Fig. shows the

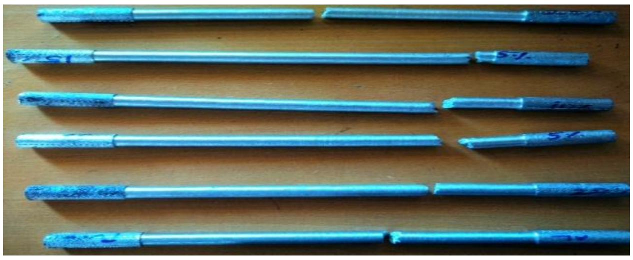


Fig:9 After testing

effect of fly ash on the grain size of composite. As we increases the ash content the grain size of composites also increases due to the coarse nature of ash. on composites,

SAMPLE IN WT %	ZODTEST (j/mm^2)	CHARPY TEST (j/mm^2)	TENSILE TEST (mpa)	HARDNESS(HRB)
PURE AL	1.95	1.76	4.11	19
AL 95+FLYASH 5	3.18	3.56	8.39	42
AL 90+FLYASH 10	3..7	3.6	10.07	59
AL 85+FLYASH 15	3.72	3.71	11.81	65
AL 80+FLYASH 20	2.62	3.16	12.85	60
AL 75+FLYASH 25	2.47	2.36	9.18	40

7(a) & 7(b) shows for izod and charpy. From both of graphs, we can conclude that as the as content increases strength of the composites also increases but up to some level and after this it reduces. The level up to it increases is the 30gm of ash content for one sample of Al - fly ash composite Fig.7 shows the effect of fly ash on the strength of AL.As we earlier studied about the tests we made

Fig 11:Hardness Test Specimen
(a) Before and (b) After Testing

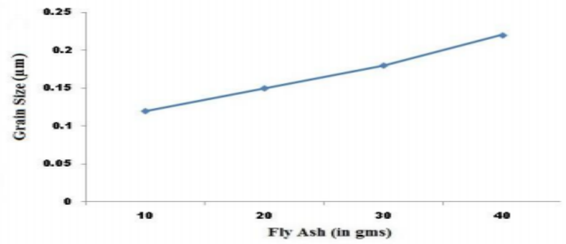
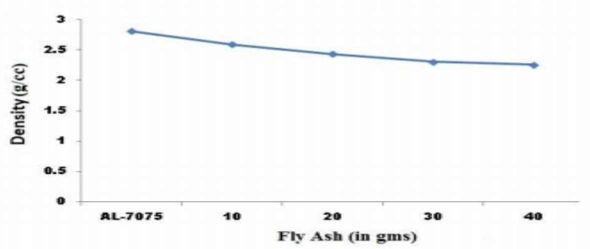


Fig 12: SEM micrographs of Al-fly ash composites



8. CONCLUSIONS

Here we successfully fabricated the AL-Fly Ash Composites by using Stir Casting arrangement with proper distribution of ash particles all over the specimen. We have drawn various conclusions from the various calculations based on the diff. experimental testes:

a) Toughness of the composites was determined by using Izod and Charpy tests. As we increase the amount of ash the toughness value gradually increased up to some level i.e. Sample2 but after this it diminishes.

b) Hardness and tensile strength of the composites also showed the same results as like of toughness. As we increased the amount of ash up to Sample2 it increases and after that goes down.

c) The density of the composites decreased with increasing ash content. Hence these light weight composites can be used where weight of an object maters as like in the aero and space industries.From the experimental results the mechanical properties such as hardness, toughness and tensile strength have been investigated

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