IOSR Journal of Applied Physics (IOSR-JAP)
e-ISSN: 2278-4861.Volume 8, Issue 6 Ver. IV (Nov. - Dec. 2016), PP 15-19
www.iosrjournals.org

Experimental Procedure for Synthesis and Characterization of Aluminium-Graphite Composite

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Abstract: *It is known that aluminium and its alloys are of low modulus and medium strength. In order to improve the modulus and strength the composites are made by adding reinforcement in the aluminium and its alloys. Reinforcement can be in fibre form as well as in particulate form. Both have their own advantages. Fibers provide greater strength than particulate while particulate provide isotropic properties. In the present work. MMC has been prepared by reinforcing graphite particles of 50-350 ASTM size range into the base matrix alloy. The base matrix alloy (LM 11 alloy) has the composition as follows, Pb - 2.4%, Cu - 4.3%, Fe - 0.2%, Si - 0.4%, Al - remaining The base alloy was melt in a vertical furnace. Melt was stirred and the preheated graphite powder (at 7000C) was added into it. The bottom pouring was done and then the melt was squeezed with 5 Tone load till it solidified. From the compocastings, samples were subsequently prepared for metallography examination, resistivity measurement, x-ray analysis, hardness and tensile test and deep drawing test. Examination of the composites under optical microscope and SEM reveals that graphite particles are found to be uniformly distributed in aluminium alloy matrix. Quantitative metallography reveals that the composites produced have 5 and 20 volume % of graphite particles in the matrix. X-Ray analysis of the composites reveals the phases CuAl2 apart from Al & graphite. Hardness of the composite material has reduces as compared to base alloy. The tensile strength of the composite material has considerably improved as compared with the tensile strength of the base alloy. The draw ability of the samples studied was very poor as compared to the base alloy. The resistively of the composite is found to be greater than base alloy.*

Keyword: *Reinforcement, MMC,X-Ray Analysis, Tensile test, Deep drawing test, drawability*

I. Introduction

Aluminium alloy-graphite casting composites have potential applications where weight to strength ratio is of important. In this investigation Tensile testing specimens were prepared and ultimate tensile strength and % elongation were determined. Samples were prepared for metallographic studies characterization include micro structural study, Hardness testing , X-ray diffractmeter and deep drawability tests. Resistivity studies of the composites are determined. All the properties are compared with the base alloy.

II. Materials

To prepare the composites LM11 aluminium alloy matrix is chosen and to reinforce in the matrix, graphite particles.

Matrix Material:-

Base alloy –LM11aluminim alloy was procured from RRL, Trivandrum. Composition of the alloy was found out by the Atomic Absorption spectrometer and chemical analysis wt % was found as follows:

Si-0.975%, Fe-0.2%, Cu-4.3%Pb-2.4%, Al-remaining

No. 1 micron, Type Lavigated, Grade-III) paste .After wheel polishing, etching was carried out with Keller's etching reagent [i. e, HCl (conc.) 1.5 ml, HF (conc.)-1.0 ml, HNO_3(conc.)-2.5 ml, H_2O-95 ml for duralumin type alloy for 10-20 sec].

Optical microscopy:-

After the preparation of the metallographic specimens the micrographs were obtained to study the graphite particle distribution. The microscope used for the study is which also has an auxiliary camera to take micrographs. The magnifications used were 50x and 200x.

Scanning Electron Microscopy:-

For the surface analysis of the samples, scanning electrons microscopy study carried out at University Science and Instrumentation Centre with a camera attached to take micrographs and a printer is also attached to take print outs.

Graphite particles embedded in matrix were observed under electron microscope.

III. Mechanical Testing

Hardness

The hardness testing was done on both the vertical and horizontal surface. For this purpose, the surfaces were flattened over the belt grinder then on emry paper, Vickers hardness testing machine with a load of 5 kg was used and the diagonal of indentation was measured by an attached vernier and the hardness value was taken from the table, corresponding to the length of diagonals. The hardness can also be calculated by the following formula

Hardness number = 1.85 x load / $(\text{diagonal})^2$

Tensile Testing:-

The compocasting were taken to lathe for machining to machine the tensile specimens. After machining on lathe the specimen of 21 mm (at the gauge length of Al-5% graphite) were prepared.

The samples were made from fabrication lab and after the preparation of the tensile test samples, the tensile tests were carried out on computerized Houndsfield Tensile test machine in the materials laboratory and the data were obtained in the form of the graph at the display and then print out were taken. After the fracture the gauge length was measured for the % percentage elongation calculations.

Deep Drawing Characteristics:-

A saw cutter with hexa blade was used to cut the sample of dimensions 70mm x 70 mm and thickness 1 mm and 2 mm. The samples were then polished to make the surface smooth. Sheet metal testing apparatus was used to determine the Enrichen number i.e the deep drawability of the composite. After proper lubrication to the specimen is applied, it is pressed against the matrix by means of the annular holder. A free motion for the thickness of the sheet is adjusted by means of scale,0.05 mm (zero setting).After the thumb screw is lightened,the clutch ring is pressed against the spindle with the left hand and then by means of the hand wheel the ball is slowly pressed with constant speed of 0.1 to 0.3 mm/sec.The path of the stamper from the zero point till the beginning of tearing off of the specimen as observed by the mirror attached in the equipment represent the deep drawing capacity.

X- Ray Diffraction Analysis:-

The powder produced while cutting the samples from the casting was used for the X-ray diffraction analysis. X-Ray diffraction was done at USCIC on the X-Ray diffractometer PW 1140/09 other details are as follows:

Target – Cu, Filter-Ni , Chart speed -1 cm/min ,Intensity-2 KC/second, GM speed-1^0/min and scanning range is 5^0 to 100^0.From the diffraction patterns obtained, the 2Θ values corresponding to peak intensity value are noted. The value is calculated from the Bragg's law is $n\lambda=2d\sin\Theta$,where, λ is the wavelength of the X-ray, this is the interplanar distance and Θ is the Bragg angle. The peak value are normalized height wise and area wise is I/I_0 and A/A_0 where , I is the height of the peak and A_0 is the area of the highest peak from the available d, I/I_0 and A/A_0 value phase present are identified from GCPDS-ASTM data cards available for metal, alloys organic and inorganic materials.

Resistivity Measurement:-

Resistivity measurement were carried out with the four probe method. The apparatus consisted of four sharp, zinc coated and spring loaded electrodes. Current was passed through two inner outer electrodes. The floating potential on the surface is measured by the two electrodes. The equipment also consists of a multi range digital volt meter with a minimum resolution of 100 μm and a constant current source with a minimum resolution of 10 μA.

Each sample was first washed in water followed by alcohol. They were then placed on a thin mica sheet with the help of forceps. The probes were the firmly placed on the upper surface of the sample. The device was switched on and the variation of voltage with current was noted. The formula used for calculation resistivity ρ is :

$$\rho = \sum\left(\frac{V}{I}\right) 2\pi s/G7\left(\frac{W}{S}\right)$$

Where,

S is interprobe distance

W is the thickness of sample,and

G7 is correction for probes on a thin slice with a non calculating bottom surface.

Precaution:-

Atmost cleanliness was maintained while handling the samples and the problems . The probes placed symmetrically both longitudinal by and sectionally on the sample to get a uniform reading on the surface.
The voltmeter was always adjusted to zero potential and maintained.
Therefore some time before starting measurement, so as to stabilize the readings the current was increased and decrease very gradually to prevent any surge of current and hence any localized heating in the sample. Also prevent any over heating in the sample, the current was not increased beyond 800 mA.

Figure:-

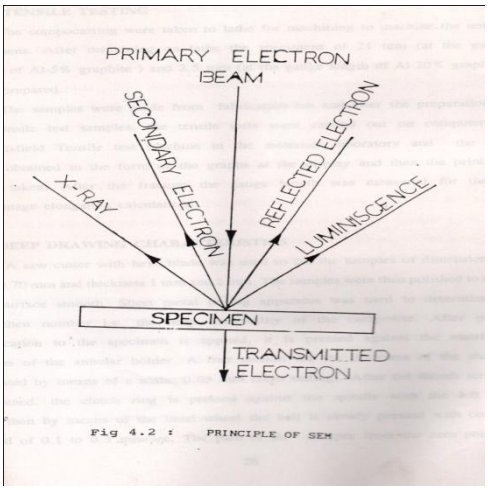

Fig 4.2 : PRINCIPLE OF SEM

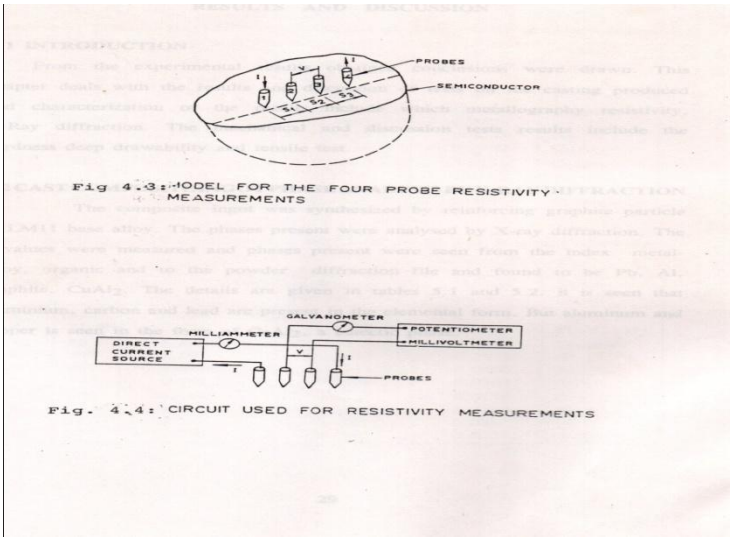

Fig 4.3: MODEL FOR THE FOUR PROBE RESISTIVITY MEASUREMENTS

Fig. 4.4: CIRCUIT USED FOR RESISTIVITY MEASUREMENTS

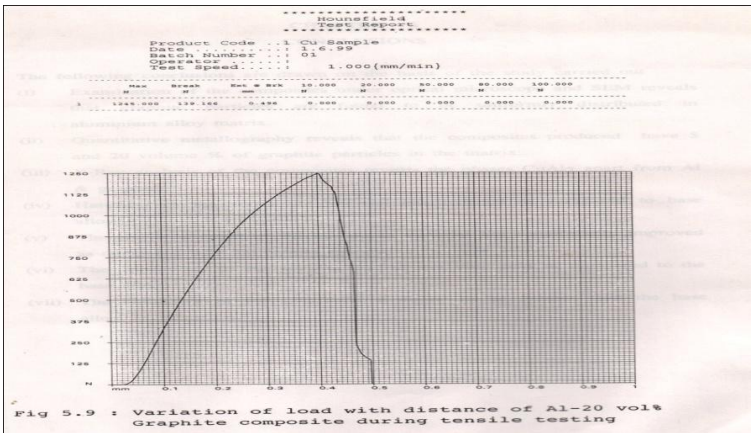

Fig 5.9 : Variation of load with distance of Al-20 vol% Graphite composite during tensile testing

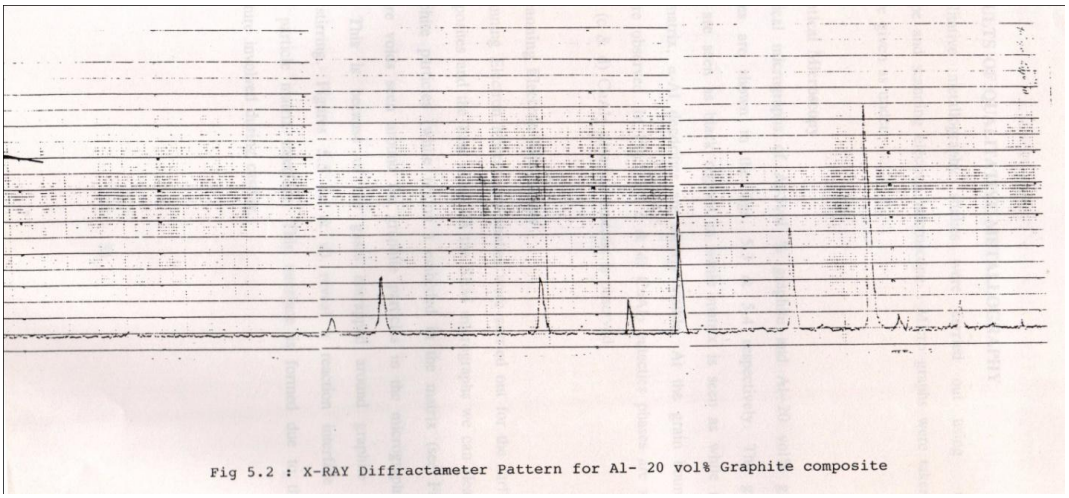

Fig 5.2 : X-RAY Diffractameter Pattern for Al- 20 vol% Graphite composite

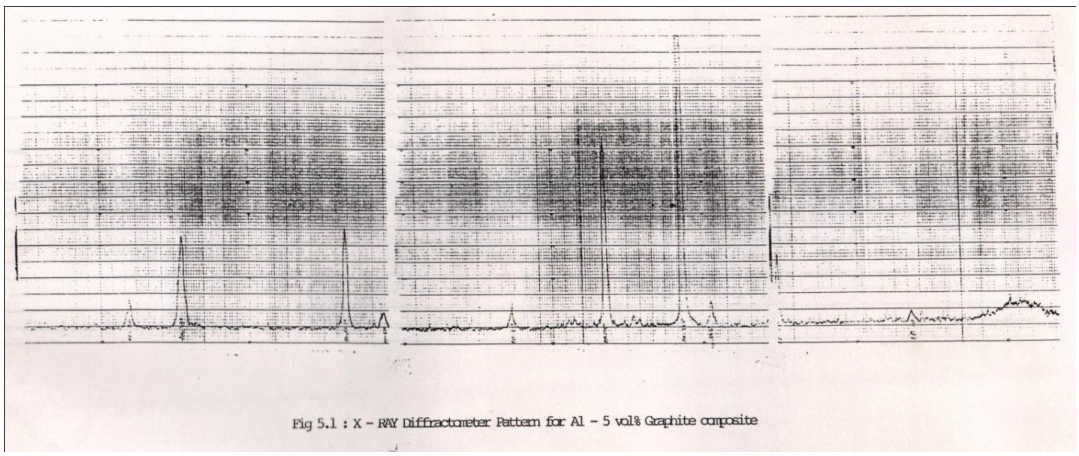

Fig 5.1 : X - RAY Diffractometer Pattern for Al - 5 vol% Graphite composite

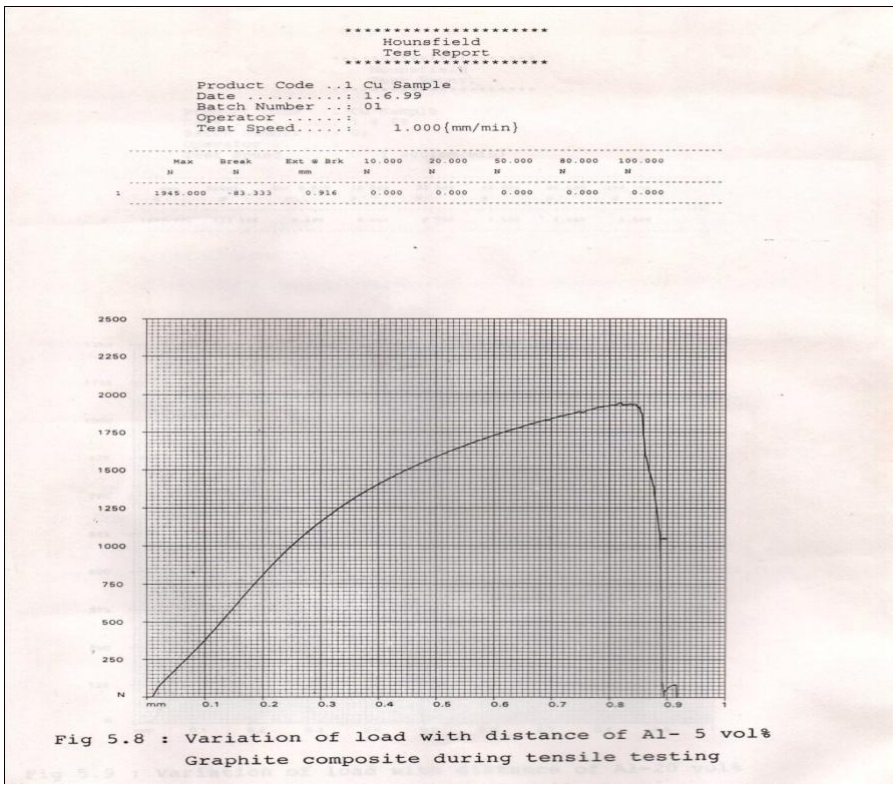

Fig 5.8 : Variation of load with distance of Al- 5 vol% Graphite composite during tensile testing

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