International Journal of Advances in Engineering and Management (IJAEM)
Volume 4, Issue 7 July 2022, pp: 1534-1543 www.ijaem.net ISSN: 2395-5252

Development and Characterization of Aluminium Reinforced with MWCNT and Fly-Ash Using Stir Casting Technique

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Submitted: 15-07-2022 Revised: 27-07-2022 Accepted: 29-07-2022

ABSTRACT
The main Goal or Intention of this study is to develop MWCNT and Fly ash reinforced aluminium composites by using Stir Casting process. Aluminium reinforced with MWCNT And Fly- ash via Stir Casting (SC) technique can provide a very distinct advantage. The prepared composites are characterized by the mechanical properties, structural properties on MWCNT and Fly ash.
Composite Material plays a vital role in the present modern industrial sectors. Preparation of metal-matrix composite which are light weight, high strength, extremely hard materials which are used for industrious areas like aerospace, motor vehicle industries, mechanical tools manufacturing industries due to its advantages in properties like, light in weight, flexibility, hardness, simplicity and easily applicable and so on. The project focuses on developing an Aluminium/Fly ash-MWCNT hybrid compositewith two nanoscale reinforcements (fly ash and MWCNT). Stir casting will be used to create the hybrid composites, which had different weight fractions of fly ash (1, 2, 3, 4, and 5 wt. %.) and a fixed MWCNT content of 2 wt.%. The influence of varying fly ash content with fixed MWCNT content on density, microstructure, hardness, and wear on hybrid MMC's will investigate. Hardness and wear test will carry out as per ASTM E384 and G99 standards. Microstructure showed a relatively uniform dispersal of reinforcements (Fly ash and MWCNT) in pure Al matrix. The study will reveal that Al/Fly ash/MWCNT hybrid composites hardness is higher than that of pure aluminium. The increase in hardness and addition of reinforcements lead to a significant reduction in wear rate. Wear surface morphology studies will report that pure aluminium will undergo an adhesion wear mechanism, whereas Al/Fly ash/MWCNT hybrid composites will undergo abrasion wear. Various testing will be carried out on this reinforced material and the difference in properties before and after reinforcement will examined.

Keywords – MWCNT: Multiwalled Carbon Nanotubes, Al: Aluminium, MMC: Metal Matrix Composite

I. INTRODUCTION

Aluminium is one of the lightest engineering metals and does the third most common element comprise 8% of the earth's crust. Low strength and hardness of aluminium, which limits its use in many engineering applications, could be increased through the addition of microparticles. Multi walled Carbon nanotubes are nano materials, which are gaining popularity as good reinforcements due to their distinctive properties. MWCNTs are attractive reinforcement materials for composites not only due to their high strength and elastic modulus, but also due to their exceptionally small diameters. Multi walled carbon nanotubes reinforcement would possess better tensile and compressive properties compared to pure Aluminium.

Aluminium matrix based composite materials are well known, and a lot of research has gone into understanding their mechanical and wear

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properties. This is because that Al is light in weight, reasonably feasible, amenable for fabrication by various processing technique and possess good corrosion resistance and have high strength.

1. MMCs are one of the most promising composite materials and find their way in a wide range of applications in the fields of strengthening, heat flow, energy storage, sensing, thermal & electrical conductivity, electronics etc Moreover, MMCs are toughened materials which do not lose their native properties even in severe environments.
2. MMCs come with different metal matrices, each having a different set of qualities.
3. Al and its alloys are the most widely used materials for structural applications, after steel and iron.
4. fly ash and MWCNT-based reinforcements are one of the most explored and promising materials to enhance the material properties of Al composites.
5. By considering the extraordinary potential of fly ash and MWCNT-based reinforcements, we have designed this review to showcase the achievement of these materials to improve material properties in Al-MMCs.
6. MMC's can be fabricated in the liquid state and also in the solid-state. Liquid state fabrication of MMCs consists of squeeze casting.
7. Composite materials enable to obtain desirable properties after uniting two or more distinct phases which offer superior to those of its constituent materials.
8. Particles reinforced aluminum matrix composites are used in aerospace, automobile and structural application due very high strength to weight ratio, superior wear resistance, high stiffness, higher fatigue resistance controlled co-efficient of thermal expansion and better stability at elevated temp.
9. Which makes it suitable for design of an extensive range of components in advanced applications. Selection of processing of technique plays a vital role over the property of the composite.

Multi walled Carbon nanotubes are nano materials, which are gaining popularity as good reinforcements due to their distinctive properties. MWCNTs are attractive reinforcement materials for composites not only due to their high strength and elastic modulus, but also due to their exceptionally small diameters. This is because, when the same weight of MWCNTs is contained in composites, the number of MWCNTs in composite increases as the diameter of MWCNTs becomes smaller. And, when the MWCNTs are uniformly dispersed in the composites, the respective matrix domains enclosed by the MWCNTs become extremely small. It is expected that the Aluminium composites with Multi walled carbon nanotubes reinforcement would possess better tensile and compressive properties compared to pure Aluminium.

The hardness of the obtained composites is also expected to be greater than that of pure aluminium. The Al-MWCNT composite is found to be affluent in improving the mechanical properties such that even for a small amount of MWCNT addition the response ineffective. The improvement in strength primarily depends on the dispersive phenomenon of MWCNTs and the bonding between the reinforcement (MWCNT) and matrix. The improvement in mechanical properties of Al-MWCNTs also depends upon nature of processing techniques, microstructure, grain size, amount and type of reinforcement.

Composite materials are playing vital and major role in research and development of various engineering and aeronautical sectors. In the past three decades composite materials are replaced most of the traditional materials because of obtaining superior properties such as higher specific strength, high hardness, high wear resistance, high thermal resistance and low density. For obtaining best result of mechanical properties specifically aluminium metal matrix composites have preferred in aeronautics, marine and automotive industries.

Stir Casting

Stir casting is a suitable processing technique to fabricate aluminium matrix composites and hybrid matrix composites as it is an economical process and preferred for mass production. The first step of stir casting involves melting of matrix material. During melting, aluminium melt reacts with the atmosphere and moisture and forms a layer of aluminium oxide (Al_2O_3) as given by $2Al+3H_2O \Leftrightarrow Al_2O_3+6H$.

In this process, the matrix material is kept in the bottom pouring furnace for melting. Simultaneously, reinforcements are preheated in a different furnace at certain temperature to remove moisture, impurities etc. After melting the matrix material at certain temperature, the mechanical stirring is started to form vortex for certain time period then reinforcements particles are poured by the feeder provided in the setup at constant feed rate at the centre of the vortex, the stirring process is continued for certain time period after complete feeding of reinforcements particles.

The molten mixture is then poured in preheated mold and kept for natural cooling and solidification. Further, post casting process such as heat treatment, machining, testing, inspection etc. has been done. There is various impeller blade geometry are available. Melting of the matrix material is very first step that has been done during this process.

APPLICATIONS

Preparation of metal-matrix composite which are light weight, high strength, extremely hard materials. The ubiquitous demand for affordable, efficient, and lightweight stiff materials has shifted research focus away from base alloys and toward composite materials in recent decades. Metal matrix composites (MMCs) are commonly used because they have an excellent combination of mechanical qualities. The development of hybrid aluminum metal matrix composites has Fly-ash own, and some of the industrial applications, oil-less bearing, automotive transmission gears, armour piercing projectiles, electrical contacts, nuclear power fuel elements, orthopaedic implants, business, machines, high temperature filters, aircraft brake pads, rechargeable batteries, and jet engine components.

II. RESULTS & DISCUSSIONS

Table 1.1 Hardness value of composites

Sl no	Composition by weight percentage	Rockwell Hardness Number	% Improvement in Hardness
01	AL 100%	12	Nil
02	AL80%-MWCNT20%	14.66	14.52
03	AL70%-MWCNT20%-FLYASH10%	12.66	12.58
04	AL60%-MWCNT20%-FLYASH20%	15.33	15.33
05	AL50%-MWCNT20%-FLYASH30%	17	17.13
06	AL30%-MWCNT20%-FLYASH50%	16	16.23

It was observed that the hardness values were increased with increase in composition of Fly ash in Aluminium-Fly ash and MWCNT composite. Initially the hardness is12 and it was increased to 17.13 on increasing the fly ash percentage.

Scanning Electron Microscope (SEM) of reinforced Al/Fly-ash/MWCNT

Fig. Scanning Electron Microscope

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Scanning electron microscope (SEM) is a tool for the characterization of materials fromnanometer to micrometer scale. It is one of the most versatile instruments that are available fortheexamination and analysis of themicrostructure morphology.

Before observing the microstructure, the surface is prepared. the specimen surface was cleanedusing a cotton swab and ethyl alcohol. After this, polish the section on 800Fly-ash its emerypaper in single direction and note that no excess pressure is applied during the process as it mayleadtopermanentscarringonthesurface.Thespecimenisrotatedby90˚andthesameprocedureis followed ona1000Fly-ash its sand paper.

The surface is cleaned at each stage with cotton swab and ethyl alcohol before taking a finerEmerypaper(1200,1500,1800,and2000Fly-ashitsize).Thecleaningwithethylalcoholis necessary to make sure that abraded particles or the soot do not get embedded on the specimensurface.

Afterachievinganearsmoothsurface,further polishingisdoneusingavelvetclothanddiamond paste. The diamond paste is applied to the surface to be polished; velvet cloth is fixed toa disc spinning at a fixed rpm. The specimen with the applied diamond paste is pressed againstthe rotating velvet cloth. Due to the friction, the diamond paste polishes the surface. This processiscarried out till the required finish is obtained.

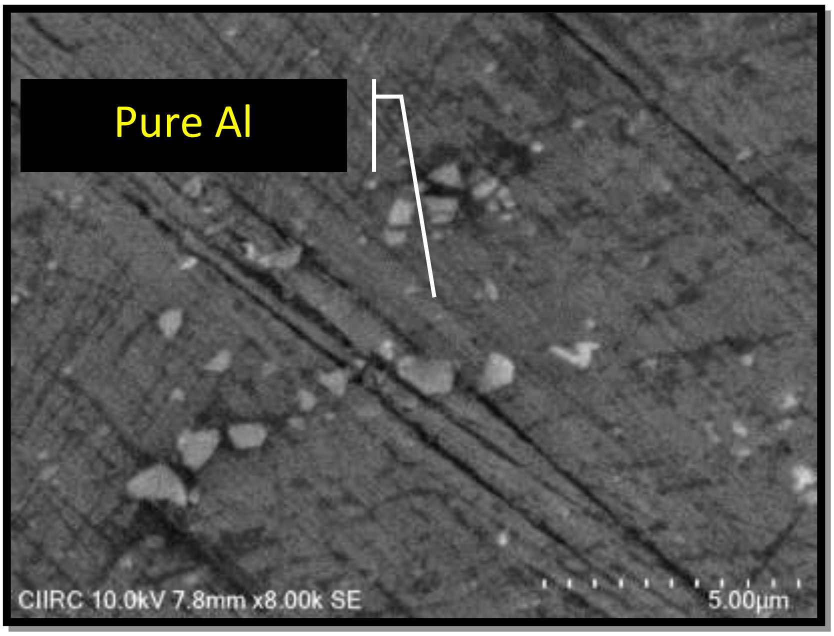

Fig. no. 4.8.1 (0) Micrograph of Pure Al

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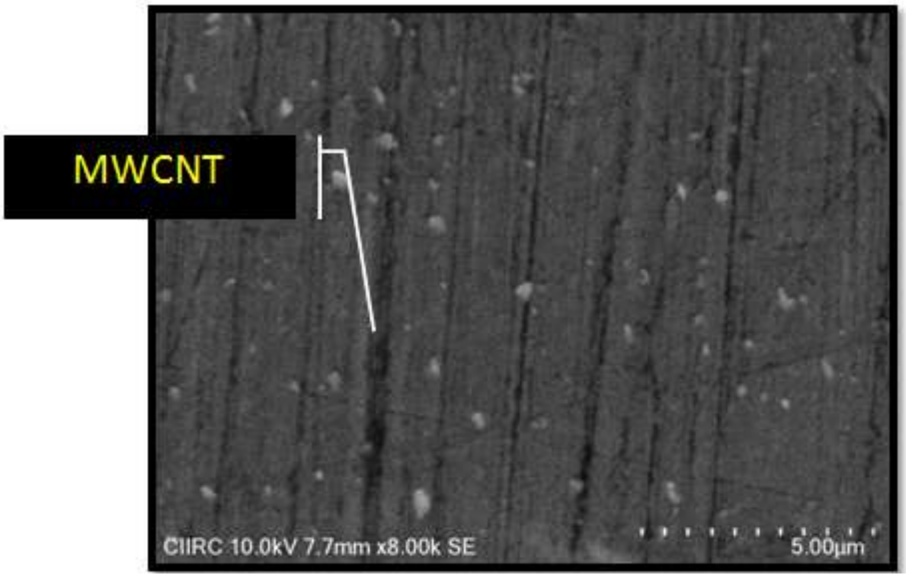

Fig.No.4.8.2 (0) Micrograph of Al + MWCNT

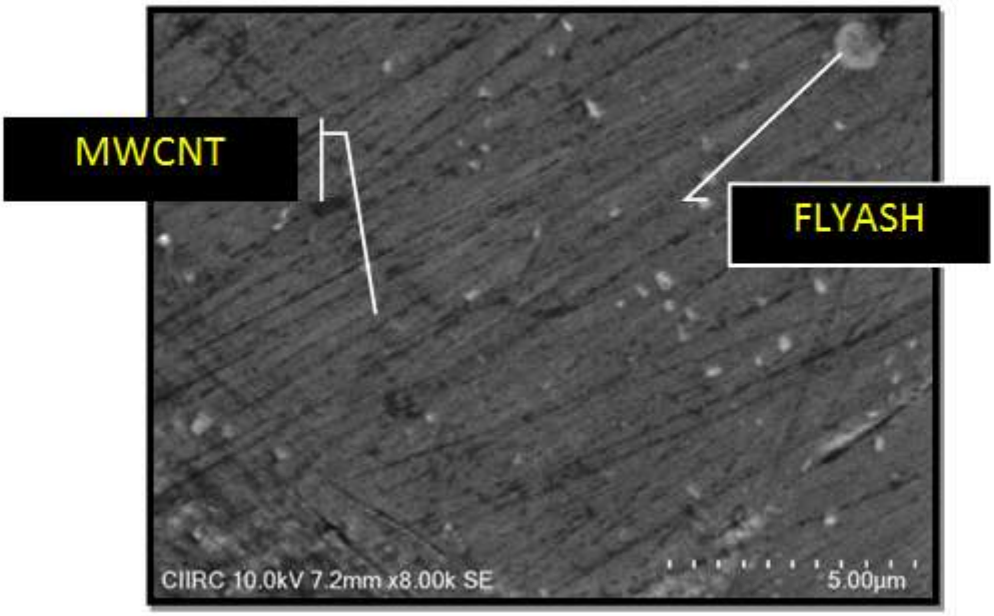

Fig. no. 4.8.3 (0) Micrograph of Al +2wt.% MWCNT + 1 wt.% FlyAsh

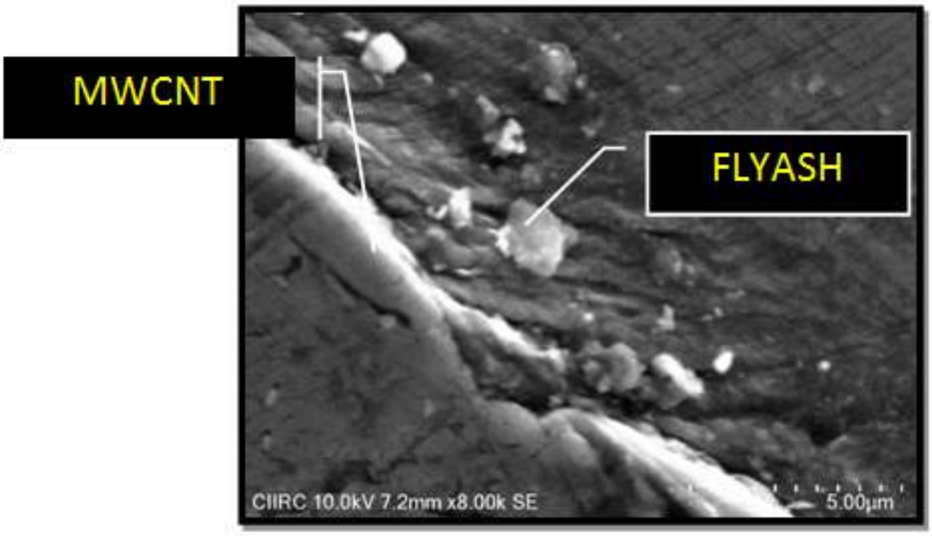

Fig. no. 4.8.4 (0) Micrograph of Al+2wt.% MWCNT + 2wt.% FlyAsh

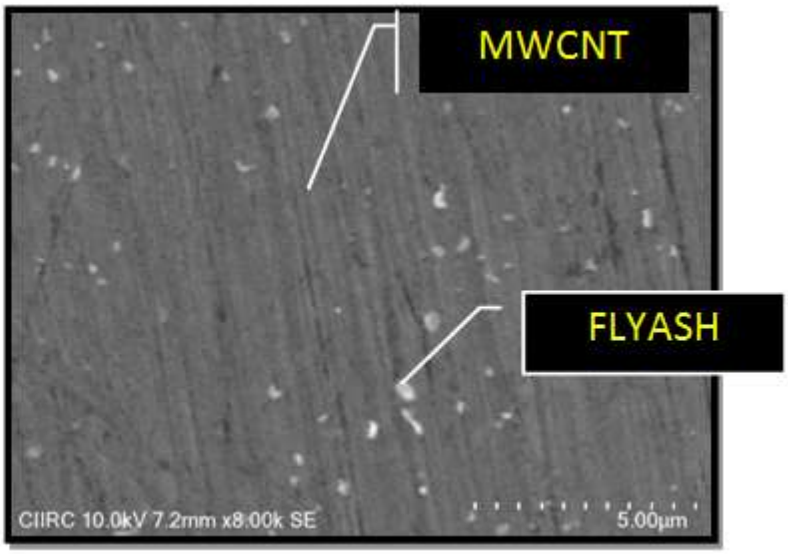

Fig. no. 4.8.5 (0) Micrograph of Al + 2wt.% MWCNT + 3wt.% FlyAsh

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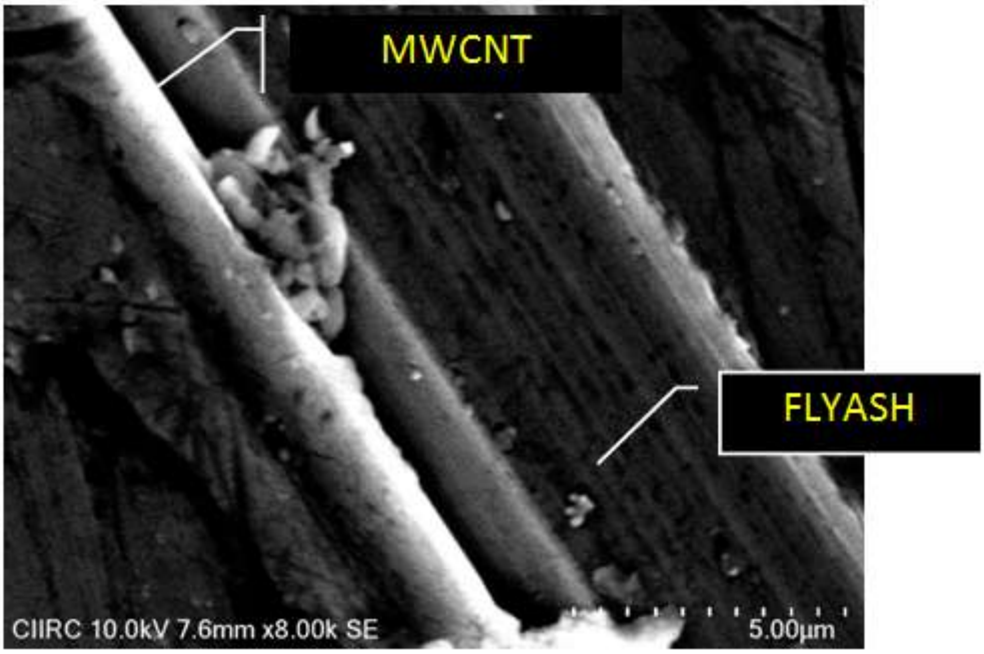


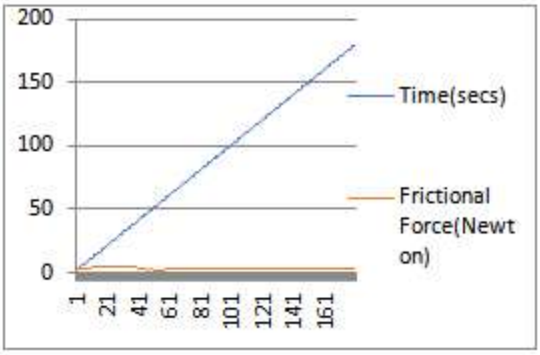
Fig. n. 4.8.6 (0) Micrograph of Al + 2wt.% MWCNT + 4wt.% FlyAsh

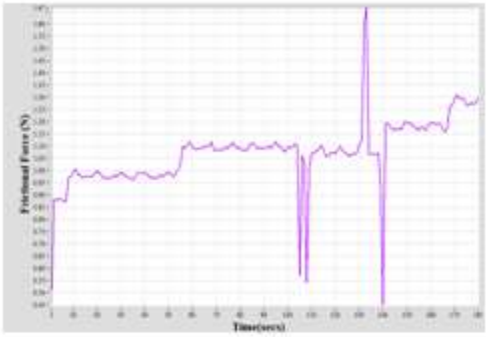
Wear Test

Wear testing is a method for assessing erosion or sideways displacement of material from its "derivative" and original position on a solid surface performed by the action of another surface. This test is commonly used as a simple measure of workability of material in service. Materials behave differently in friction state so it may be important to perform mechanical tests which simulate the condition the material will experience in actual use. Wear testing is typically carried out on the A356 alloy. wear test will carry out as per G99 standard.Wear tests of the selected alloy is a critical parameter for determining the quality of these materials. The loads and forces acting on these materials while in service are compressive in nature and their ability to withstand such loads and forces without failure is a measure of their reliability.

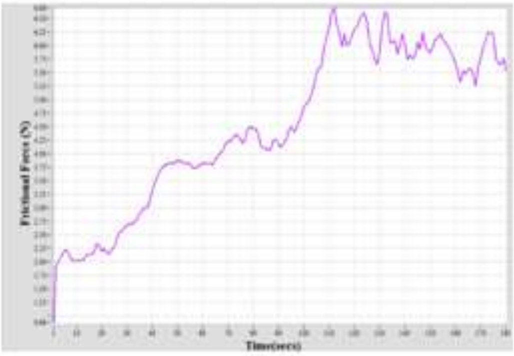
v/s	Time In Sec			
Frictional Force in Newton		60	120	180
	0	-	-	-
	1	1.10	1.08	1.30
	2	2.77	2.26	2.51
	3	2.68	2.70	2.89
	4	3.88	2.84	2.65
	5	3.00	2.98	2.39

Table No. 4.11.1 Wear – Time v/s Frictional force

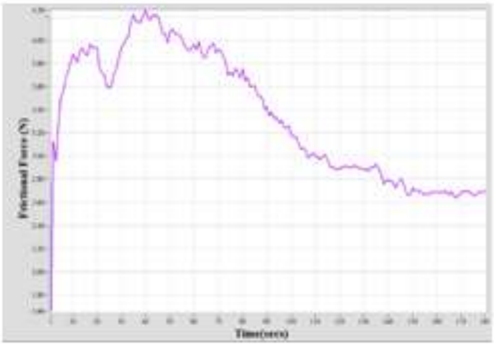




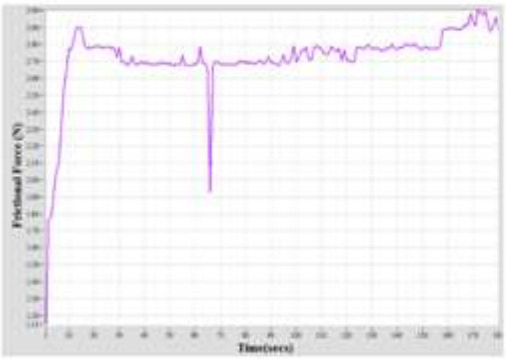
Graph No. 4.11.1 (0) Micrograph of Pure AlGraph No. 4.11.2 (1) Micrograph of Al+MWCNT



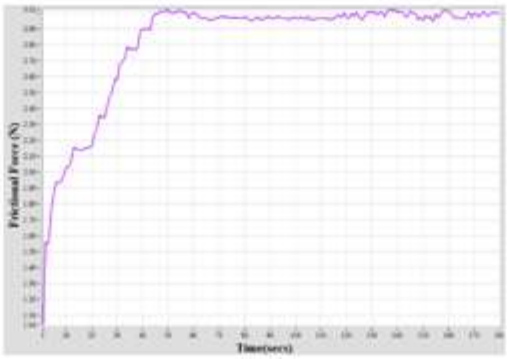
Graph No. 4.11.3 (2) Micrograph of Al +2wt.% MWCNT + 1 wt.% FlyAsh



Graph No. 4.11.4. (3) Micrographof Al+2wt.% MWCNT + 2wt.% FlyAsh



Graph No. 4.11.5. (4) Micrograph of Al+2wt.% MWCNT + 3wt.% FlyAsh



Graph no. 4.11.6. (5) Micrograph of Al+2wt.% MWCNT + 4wt.% FlyAsh

III. CONCLUSIONS

Present study has highlighted the need for developing aluminium reinforcement multiwalled carbon nanotubes and fly ash composites have been prepared by using Stir Casting. The industrial waste fly ash and multiwalled carbon nanotubes are turn into industrial wealth by light weight composites with high strength. Determining the mechanical properties of the prepared composites. Microstructure of the aluminium reinforcement composite has been studied.The specimen has been fabricated for experimentation and observed under scanning electron beam microscope for microstructure study. The experimentation of compression strength is conducted on the specimens and found the ultimate compression strength. Understand the variation in mechanical properties before and after reinforcement to the aluminium.

The specimens of aluminum reinforcement multi-walled carbon nanotubes and Fly-ash reinforced composites has been prepared by using Stir Casting method. Microstructure of the aluminum reinforcement composite has been studied.The specimens has been fabricated for experimentation and observed under scanning electron beam microscope for microstructure study. The experimentation for compression strength is conducted on the specimens and found the ultimate compression strength.After Conducting the several experiments, we can conclude that the reading of 4th specimen is better among all other specimen.

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