ISSN: 2277-9655
Scientific Journal Impact Factor: 3.449
(ISRA), Impact Factor: 2.114

IJESRT

INTERNATIONAL JOURNAL OF ENGINEERING SCIENCES & RESEARCH TECHNOLOGY

Preparation of Hybrid Aluminium Metal Matrix Composites by Using Stir Process

V.Chandramohan*, R.Arjunraj
* Assistant Professors, Department of Mechanical Engineering, Nandha Engineering College, Erode, Tamilnadu, India

Abstract
Generally aluminiums are used for various applications in industrial sectors and home based products. Metal matrix composites (MMCs) possess significantly improved properties including high specific strength, specific modulus, damping capacity and good wear resistance compared to unreinforced alloys. The objective of the project is to fabricate Al356/Fly ash, Graphite& Boron Carbide metal matrix composite by using stir process and study the properties of the fabricated composite. Co-continuous alumina/aluminium composite materials with excellent physical and mechanical properties offer great potentials for lightweight, wear resistant, and high-temperature applications. Composite materials prepared from a liquid-phase displacement reaction present a unique microstructure in which each phase is a continuous network penetrated by the network of the other constituent. There has been an increasing interest in composites containing low density and low cost reinforcements. Among various discontinuous dispersions 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.

Keywords: Hybrid Aluminium, Stir process.

Introduction
In many industrial applications, the most important parameter in material selection is specific strength. For example it is the critical design criterion in rotating machinery components. Aluminum is a natural candidate for this type of application because of its low density. However, compared to titanium alloys, the strength of conventional commercial aluminum alloys is too low for aluminum to be a better solution. Owing to the many difficulties encountered in the production and use of titanium alloys, the drive to develop stronger aluminum alloys is very high. Compared with unreinforced metals, metal-matrix. Metal Matrix Composites (MMCs) are suitable for applications requiring combined strength, thermal conductivity, damping properties and low coefficient of thermal expansion with lower density. These properties of MMCs enhance their usage in automotive and many applications. In the field of automobile, MMCs are used for pistons, brake drum and cylinder block because of better corrosion resistance and wear resistance. Composites reinforced with ceramic phases exhibit high strength, high elastic modulus, and improved resistance to wear, creep and fatigue, which make them promising structural materials for aerospace and automobile industries. 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. A very small change in any one of these factors can seriously affect the corrosion characteristics of the metal. Aluminium-fly ash composites offer many potential applications particularly for internal combustion engine pistons and brake rotors due to their density and high mechanical properties. Additionally, the results of hardness and electrical conductivity of the investigated composites show that uniformly dispersed reinforcing phases and adequate machinability are possible. From both an economical and environmental standpoint the use of fly ash for reinforcing aluminium alloys is extremely attractive due to its waste material character and expected low costs of production. The published literature on

ISSN: 2277-9655
Scientific Journal Impact Factor: 3.449
(ISRA), Impact Factor: 2.114

advanced materials, such as Aluminium Fly Ash (ALFA) composites, is rather limited and is primarily concerned with applications of fly ash particles for synthesis of these materials. There is also a lack of information on the influence of fly ash particles on the susceptibility of ALFA composites to corrosion. Therefore, it was thought worthwhile to study

- The micro structural characteristics of aluminium composites reinforced with fly ash particles.
- The relationships between the composite microstructure and corrosion behavior in a typical corrosive environment. The present work is dedicated to such an investigation.
- The particulate composite can be prepared by injecting the reinforcing particles into liquid matrix through liquid metallurgy.

Classification of composite material

- Metal Matrix Composites (MMCs).
- Ceramic Matrix Composites (CMCs).
- Polymer Matrix Composites (PMCs)

Metal matrix composites (MMCs).

Mixtures of ceramics and metals, such as cemented carbides and other cermet's. Aluminum or magnesium reinforced by strong, high stiffness fibers. Metal matrix composites possess some attractive properties, when compared with organic matrices. These include

- Good strength at higher temperatures,
- Higher transverse strength,
- Excellent electrical conductivity,

However, the major disadvantage of metal matrix composites is their higher densities and consequently lower specific mechanical properties compared to polymer matrix composites. Another notable difficulty is the high-energy requirement for fabrication of such composites.

Literature survey

Anilkumar, H.C.Hebbar, H.S. and Ravishankar, K.S. "Mechanical properties of fly ash reinforced aluminium alloy (Al359) composites". In this study the stir casting method used to prepare the composites could produce uniform distribution of the reinforced fly ash particles. The Tensile Strength, Compression Strength and Hardness increased with the increase in the weight fraction of reinforced fly ash and decreased with increase in particle size of the fly ash. Bienias, J.Walczak, M.Surowska, B.Sobczaka, J. "microstructure and corrosion behavior of aluminum fly ash composites". In this study addition of fly ash particles as reinforcement in metal matrix composites and synthesis of ALFA composites by squeeze casting technology in comparison with gravity casting are advantageous for obtaining higher structural homogeneity with minimum possible porosity levels, good interfacial bonding and quite a uniform distribution of reinforcement. Kwiecin´skaa, B.Petersenb, H.I. "Graphite, semi-graphite, natural coke, and natural char classification-ICCP system". This document presents the International Committee for Coal and Organic Petrology (ICCP) classification of four organic components that cannot be included into any of the three material group's vitrinite, inertinite and liptinite. Graphite; Semi graphite; Natural coke; and Natural char. Ming Qiu Zhang, Min Zhi Rong, Da Lei Yue and Gui Cheng Yang Key Laboratory for Polymeric Composite and Functional Materials of Ministry of Education, Zhongshan University, Guangzhou 510275, P. R. China 2Materials Science Institute, Zhongshan University, Guangzhou 510275, P. R. China 3Department of Polymers, School of Materials Science and Engineering, South China University of Technology, Excessively high concentrations of NaOH solution and NaOH pretreatment and reaction temperature significantly affect the extent of reaction temperature do not result in further benzylation.R.S. Mishra, Z.Y. Ma, I. Charit, "Friction stir processing: a novel technique for fabrication of surface composite", FSP was applied to create surface metal-matrix composite. By controlling processing parameters, surface Al_ SiC composite layers of 50_ 200 mm with well-distributed particles and very good bonding with aluminum substrate were generated. The micro hardness (HV) of the surface composite was doubled with _ 27 vol. % of SiC particles. Mustafa Boz, Adem Kurt, "The effect of Al_2O_3 on the friction performance of automotive brake friction materials", In this study, five different friction materials were produced through powder metallurgy route (one of them is solely bronze based and the others contains different amounts of Al_2O_3) and their friction and wear characteristics were investigated using a friction coefficient test rig (according to SAE-J661).Patrick B. Berbon, William H. Bingel, Rajiv S. Mishra, Clifford C. Bampton and Murray W. Mahoney, "friction stir processing: a tool to homogenize nano composite aluminum alloys", Friction Stir processing of nano phase aluminum alloys led to high strength, ;650 MPa with good ductility above 10%. The FSP technique is amenable to produce ductile, very high specific strength aluminum alloys, such as the Al-Ti-Cu and Al-Ti-Niinvestigated.Radhikal,N.Subramanian,R.VenkatPra

ISSN: 2277-9655
Scientific Journal Impact Factor: 3.449
(ISRA), Impact Factor: 2.114

sat,S."Tribological Behavior of Aluminium/Alumina/Graphite Hybrid Metal Matrix Composite Using Taguchi's Techniques". In this study on dry sliding wear test using Taguchi's technique. Sliding distance (46.8%) has the highest influence on wear rate followed by applied load (31.5%) and sliding speed (14.1%) and for coefficient of friction, the contribution of sliding distance is 50%, applied load is 35.7% and sliding speed is 7.3%.

Problem identification

Generally metal matrix materials are fabricated by using die casting process methods than other methods. In die-casting process methodology there is a need of using high compression capacity apparatus in order to acquired better bonding strength. At the same time it is difficult to achieve perfect mixing ratio with its ingredients. These are the consequence it may lead to mechanical failure of material. In order to overcome these kinds of problems we have to put our attention with stir casting methodology. It is the simplest method and also the fabrication process comes under the knowledge of manufacturer.

Methodology

Fig.1 shows the methodology of this study which is started with the availability of the different metal matrix composites, identification of problem with in the metal matrix composites then it is ended with the different material testing methods.

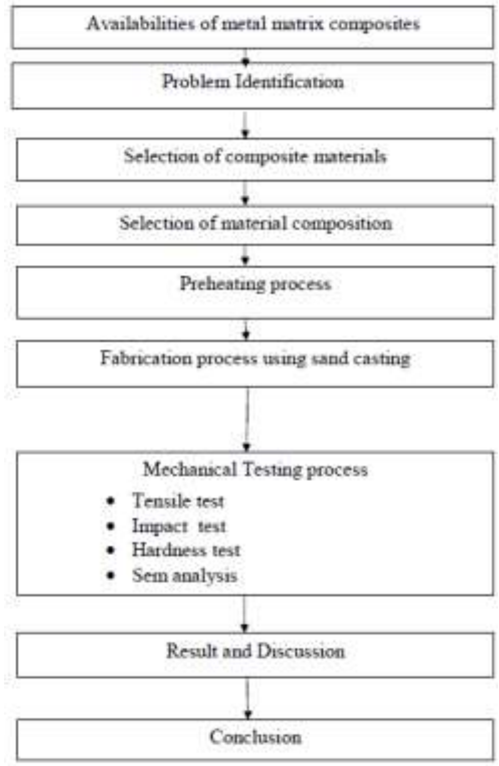

Fig.1 Methodology

Fabrication and testing process

Stir process

Liquid state fabrication of Metal Matrix Composites involves incorporation of dispersed phase into a molten matrix metal, followed by its Solidification. In order to provide high level of mechanical properties of the composite, good interfacial bonding (wetting) between the dispersed phase and the liquid matrix should be obtained.

Fig.2 Stir Casting Setup

Wetting improvement may be achieved by coating the dispersed phase particles (fibers). Proper coating not only reduces interfacial energy, but also prevents chemical interaction between the dispersed phase and the matrix. The simplest and the most cost effective method of liquid state fabrication is Stir Casting. Stir

ISSN: 2277-9655
Scientific Journal Impact Factor: 3.449
(ISRA), Impact Factor: 2.114

Casting is a liquid state method of composite materials fabrication, in which dispersed phase (ceramic particles, short fibers) is mixed with a molten matrix metal by means of mechanical stirring. The liquid composite material is then cast by conventional casting methods and may also be processed by conventional Metal forming technologies.

Stir Process Characteristics

- Content of dispersed phase is limited (usually not more than 30 %).
- Distribution of dispersed phase throughout the matrix is not perfectly homogeneous.
- There are local clouds (clusters) of the dispersed particles (fibers).
- There may be gravity segregation of the dispersed phase due to a difference in the density of the dispersed and matrix phase.
- The technology is relatively simple and low cost.

Sand casting

The Sand casting process offers simple medium for production, sand castings are suitable in all Aluminium, Zinc, and Copper Alloys. The sand casting process is chosen for the production of, small numbers of castings for complex shaped casting requiring intricate cores and large non-ferrous castings.

Fig.3 sand casting process

The Sand casting process is the most popular casting process employed in industry. In general the sand used in making sand castings has fine, round grains that can be closely packed to form a smooth surface. The sand casting process involves pouring molten zinc, aluminium or copper into a sand mould. The designer should take into account the limitations of the sand casting process such as low casting rates, a 3-5mm minimum wall thickness, poor linear tolerance (e.g. 4mm/m.) and coarse grain size. As well as other considerations such as the finish and machining allowances.MRT Casting offer a one-stop die casting shop, getting us involved at the beginning stage of designing so casting component can save time and money.

Fig.4 Specimen after Casting

Tensile test

Test specimens were prepared according to ASTM E8-82 standards, each specimen having 8mm in diameter and 60mm gauge length, as shown if Figure. The specimen was loaded in Hounsfield Universal Testing Machine until the failure of the specimen occurs.

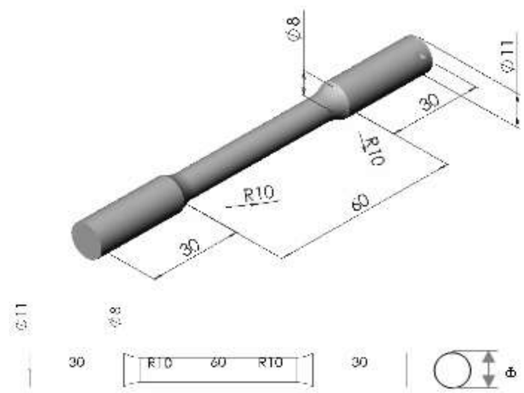

Fig.5 Tensile test specimen

Tests were conducted on composites of different combinations of reinforcing materials and ultimate tensile strength and ductility were measured. For conducting a standard tensile test, a specimen that has been measured for its cross-sectional area and gauge length is placed in the testing machine and the extensometer is attached. Simultaneous readings of load and elongation are taken at uniform intervals of load. Uniaxial tensile test is conducted on the fabricated specimen to obtain information regarding the behavior of a given material under gradually increasing stress strain conditions.

Fig.6 Tested tensile samples

ISSN: 2277-9655
Scientific Journal Impact Factor: 3.449
(ISRA), Impact Factor: 2.114

Tensile test is carried out at room temperature using universal testing machine. In this study it can be noted that the addition of graphite and Fly Ash particles improved the tensile strength of the composites. It is apparent that an increase in the volume fraction of Fly Ash particle results in an increase in the tensile strength.

Impact test
The Charpy impact test, also known as the Charpy v-notch test, is a standardized high strain- rate test which determines the amount of energy absorbed by a material during fracture.

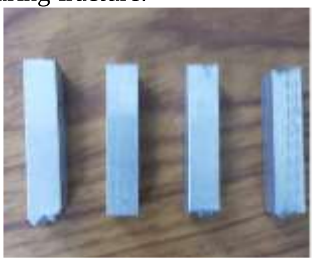

Fig.7 Impact test specimen

Hardness test
In the Brinell test, a hardened steel ball indenter is forced into the surface of the metal to be tested. The diameter of the hardened steel indenter is 10mm.The standard loads are maintained as a constant for 10-15 seconds.

Fig.8 Hardness test specimen

Bulk hardness measurements were carried out on the base metal and composite samples by using standard Brinell hardness test. Brinell 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.

Evaluation of microstructure
In general, SEM is used to observe the topography and morphology of a specimen. The function of SEM is as a mapping device which probed by a beam of electron scanned across the surface.

Fig.9 Specimen for SEM analysis

A scanning electron microscope (SEM) is a type of electron microscope that produces images of a sample by scanning it with a focused beam of electrons. The electrons interact with atoms in the sample, producing various signals that can be detected and that contain information about the sample's surface topography and composition.

Experimental procedure

Fly ash reinforced Aluminium alloy (Al359) composites, processed by stir casting route was used in this work. The three types of stir cast composites had a reinforcement particle size of 4-25, 45-50 and 75-100 µm each. The required quantities of fly ash (5, 10 and 15 Wt. %) were taken in powder containers. Then the fly ash was heated to 450ºC and maintained at that temperature for about 20 min. then weighed quantity of Al (359) alloy was melted in a crucible at 800ºC which is more than 100ºC above liquid us temperature of the matrix alloy. The molten metal was stirred to create a vortex and the weighed quantity of preheated fly ash particles were slowly added to the molten alloy. A small amount of Gr and B_4C (5 wt. %) was added to ensure good surface of particles with molten metal. After mixing the melt was poured into a prepared mould for the preparation of specimen. It shows the chemical composition of the Al (359)

Table.1 Chemical Composition of Al359

Mg	Si	Fe	Cu	Ti	Cr	Zn	Mn	Al
1	0.8	0.3	0.2	0.1	0	0.1	0	Balance

Table.2 Chemical composition of fly ash

Al_2O_3	SiO_2	Fe_2O_3	TiO_2	Loss Ignition
28.44	60	8.85	2.75	1.43

Results and discussions

The various tests used for testing the specimen and their results are as follows. The tensile strength of Sample 3(Al359+5%Graphite+10%F.A.) is 53.17 N/mm2 and this value increases to a maximum of 95.54 N/mm2 for Sample 4

ISSN: 2277-9655
Scientific Journal Impact Factor: 3.449
(ISRA), Impact Factor: 2.114

(Al359+5%Graphite+15%F.A.) which is about 30% improvement on that of Sample 3.

Tensile test

Table.3 Results for tensile test

Sample	Sample description	Tensile strength (N/mm^2)
1	Al 359+5% Graphite+5% B_4C	93.51
2	Al 359+5% Graphite +5% B_4C +5% Fly Ash	79.49
3	Al 359+5% Graphite+5% B_4C +10% Fly Ash	53.17
4	Al 359+5% Graphite+5% B_4C +15% Fly Ash	95.54

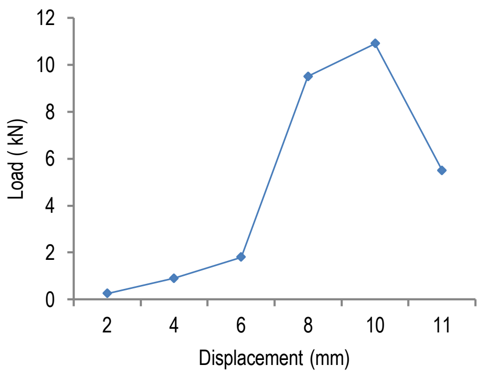

Fig.10 Elongation of Sample 1 (Al 359 +5% Graphite)

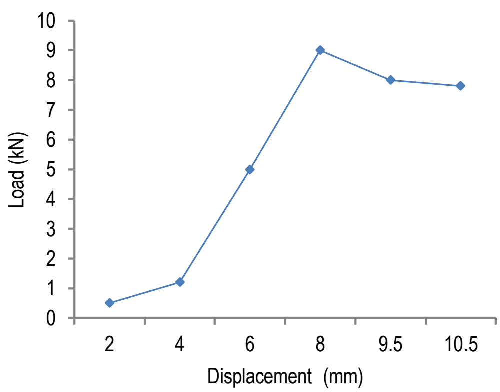

Fig.11 Elongation of Sample 2 (Al 359+5% Graphite +5% B4C +5% Fly Ash)

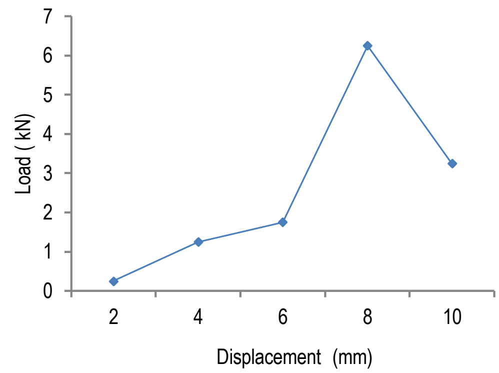

Fig.12 Elongation of Sample 3 (Al 359+5% Graphite +5% B_4C +10% Fly Ash)

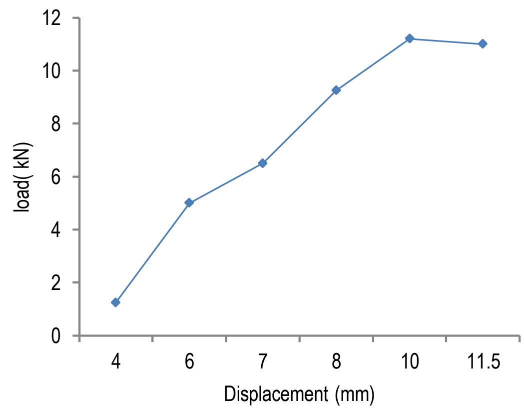

Fig.13 Sample 4 (Al 359+5% Graphite +5% B4C +15% Fly Ash)

Fig.14 shows the comparison chart for tensile strength of the composites with the different weight fractions of fly ash particles. The tensile strength of sample 4 having highest value of 95.78 $N/mm^{2.}$

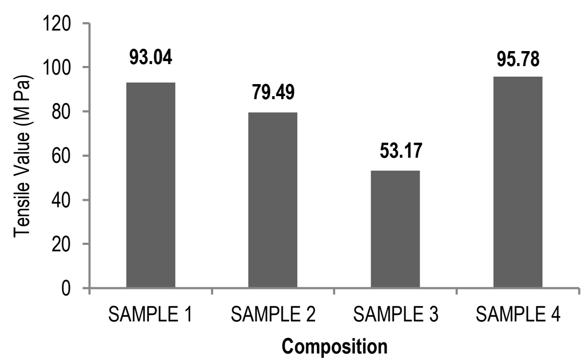

Fig.14 Comparison chart for tensile test

ISSN: 2277-9655
Scientific Journal Impact Factor: 3.449
(ISRA), Impact Factor: 2.114

Impact test
This absorbed energy is a measure of a given material's toughness. Table.4 shows results of impact test.

Table.4 Results for impact test

Sample	Sample description	Absorbed energy (J)
1	Al 359+5% Graphite+5% B_4C	4
2	Al 359+5% Graphite +5% B_4C +5% Fly Ash	4
3	Al 359+5% Graphite+5% B_4C +10% Fly Ash	2
4	Al 359+5% Graphite+5% B_4C +15% Fly Ash	4

Hardness test
In the hardness test, a hardened steel ball indenter is forced into the surface of the metal to be tested. The tested values are given below.

Table.5 Results for hardness test

Sample	Sample description	Hardness (BHN)
1	Al 359+5% Graphite+5% B_4C	54
2	Al 359+5% Graphite +5% B_4C +5% Fly Ash	58.5
3	Al 359+5% Graphite+5% B_4C +10% Fly Ash	50.5
4	Al 359+5% Graphite+5% B_4C +15% Fly Ash	60.9

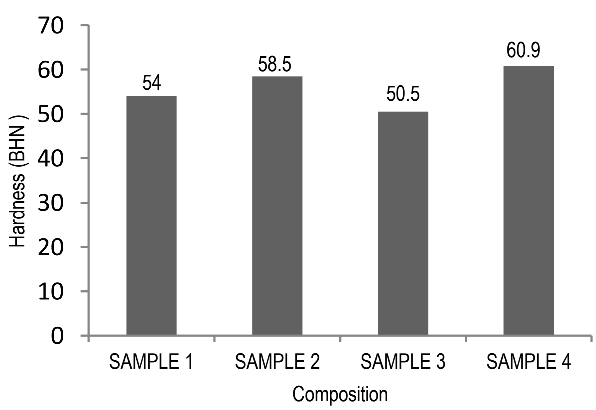

Fig.15 Comparison chart for hardness test

Evaluation of microstructure
The following figures showed the various microstructures of four samples.

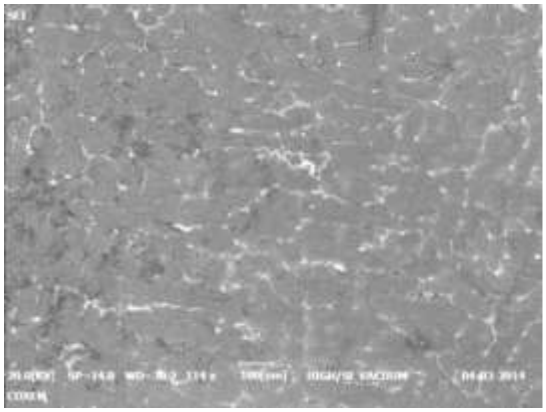

Fig.16 Microstructure of Al 359+5% Graphite +5% B_4C

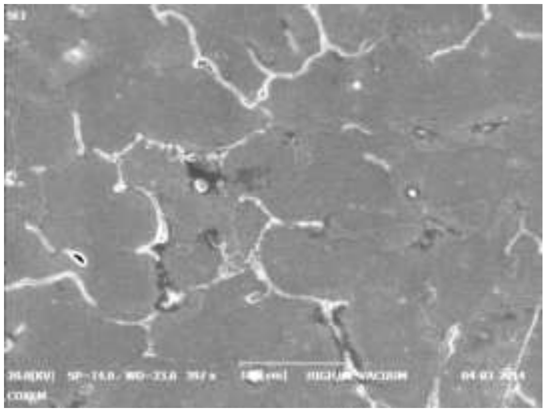

Fig.17 Microstructure of Al 359+5% Graphite +5% B_4C+5% Fly Ash

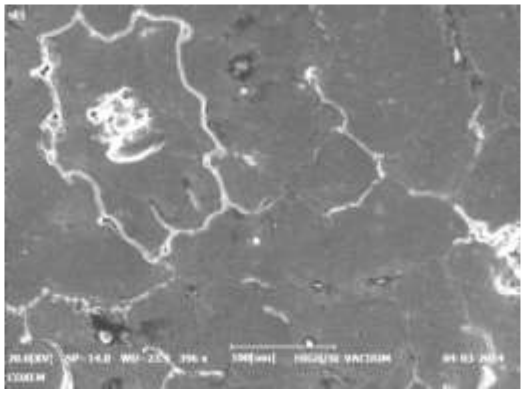

Fig.18 Microstructure of Al 359+5% Graphite +5% B_4C+10% Fly Ash

ISSN: 2277-9655
Scientific Journal Impact Factor: 3.449
(ISRA), Impact Factor: 2.114

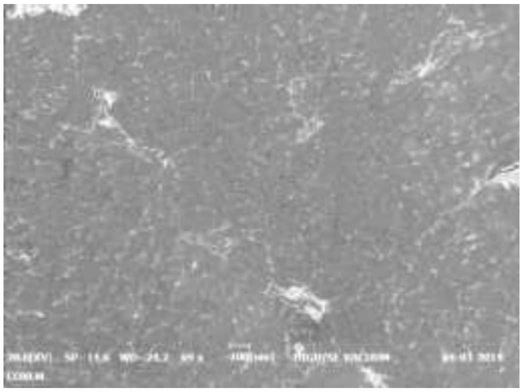

Fig.19 Microstructure of Al 359+5% Graphite +5% B_4C+15% Fly Ash

Conclusion

Research have been done for the proper MMC fabrication technique and selected as stir process. Material selection for matrix material composite has done based on the availability and the required properties .Microstructure determination of fly ash has done using scanning electron microscope. Based on the study conducted on the fly ash, Graphite containing Al359composite material, the following conclusions can be made, Using sand casting method, fly ash and Graphite can be successfully introduced in the Al359 alloy matrix to fabricate hybrid composite material .From the microstructure analysis it is evident that the composites fabricated have fairly even distribution of reinforcements in the composite material. The tensile of composite material compared to the as cast Al359 alloy, increased significantly by 60-70%; the improvement in compressive strength is also observed but it was marginal. Further improvement in compressive behavior of composite can be achieved by incorporating fabrication method other then sand casting method. The hardness of the composite material also increased with increase in wt% of fly ash content in the composite. This is due to the strengthening of Al359 alloy matrix by the fly ash particles.

References

1. Ahlatci, H, Candan, E, Cimenoglu, H. (2004). Abrasive wear and mechanical properties of Al-Si/SiC composites, Wear, Page no (257, 625-632).
2. Anilkumar, H.C. Hebbar, H.S. and Ravishankar, K.S. (2010)“mechanical properties of fly ash reinforced aluminium alloy (al359) composites”. (Received 28 June 2010, Accepted 13 September 2010) page no (41-42).
3. Basavarajappa, S., Chandramohan, G, Dinesh, A. (2004), Mechanical properties of mmc’s- An experimental investigation, Int. symposium of research on Materials and Engineering, IIT, Madras, December 20, Page no(1-8).
4. Bienias, J. Walczak, B. Surowska, Sobczaka, J. (2003) “microstructure and corrosion behavior of aluminum fly ash composites”. (Received April 11, 2003; accepted May 8, 2003) page no (493-494).
5. Charles, S., Arunachalam, V.P. (2004), Property analysis and Mathematical modeling of machining properties of aluminium alloy hybrid (Al-alloy/SiC/fly ash) composites Produced by liquid metallurgy and powder metallurgy techniques, Indian Journal of Engg. & Material Science, 11, Page no (473-480).
6. Hebbar, H.S., Ravindra K.G., (2008). Study of the Mechanical and Tribological Properties of Aluminium Ally- SiCp Composites Processed by stir casting method, IISc Centenary- International Conference on Advances in Mechanical Engineering(IC-ICAME), Bangalore, India, July, Page no (2-4).
7. Kwiecin´skaa, B. Petersenb, H.I. (2003) “Graphite, semi-graphite, natural coke, and natural char classification—ICCP system”. Received 18 August 2003; received in revised form 19 September 2003; accepted 23 September 2003 page no (100-110).
8. Kwiecin´skaa, B. Petersenb, H.I. (2003) “Graphite, semi-graphite, natural coke, and natural char classification—ICCP system”. Received 18 August 2003; received in revised form 19 September 2003; accepted 23 September 2003 page no (100-110).
9. Mahagundappa, M.B., Shivanand, H.K., Muralidhara, M. (2006). Influence of Reinforcements and Thermal Ageing on the Mechanical Properties of Al (6061) Based Hybrid Composites, India Foundry Journal, 52, Page no (20-43).
10. Mahendra, K.V., Radhakrishna, K. (2007), Fabrication of Al-4.5% Cu alloy with fly ash mmc and its characterization, Material science Poland, 25, Page no (57-68).
11. Ming Qiu Zhang2*, Min Zhi Rong1, Da Lei Yue1 and Gui Cheng Yang2 1Key Laboratory for Polymeric Composite and Functional Materials of Ministry of

ISSN: 2277-9655
Scientific Journal Impact Factor: 3.449
(ISRA), Impact Factor: 2.114

Education, Zhongshan University, (2003) Page no (15-18).
12. Miracle, D.B. (2005). Metal Matrix composites-From science to technological significance, Composites Science and Technology, 65, Page no (2526-2540).
13. R.S.Mishra, Z.Y. Ma, I. Charit, (2011) "Friction stir processing: a novel technique for fabrication of surface composite," Page no (26-29).
14. Mustafa Boz, Adem Kurt, (2009) "The effect of Al2O3 on the friction performance of automotive brake friction materials "Page no (56-59).