Volume : 4 | Issue : 10 | Special Issue Oct- 2015 • ISSN No 2277 - 8179

PRODUCTION AND TESTING OF AA 6061 / AL $_2O_3$ PARTICULATE REINFORCED COMPOSITE BY STIR CASTING METHOD

Engineering

KEYWORDS: composite, metal matrix composite(MMC) aluminium metal marix composite(AMMC)

Bhaskar Chandra Kandpal	Department of Mechanical Engineering, Inderprastha Engineering College, Ghaziabad, India
Jatinder Kumar	Department of Mechanical Engineering, National Institute of Technology, Kurukshetra India
Hari Singh	Department of Mechanical Engineering, National Institute of Technology, Kurukshetra India

ABSTRACT

The aluminum based composites are increasingly being used in the transport, aerospace, marine, automobile and mineral processing industries, owing to their improved strength, stiffness and wear resistance properties. The widely used reinforcing materials for these composites are silicon carbide, aluminum oxide and graphite in the form of particles or whiskers. In this paper it is aimed to present the experimental results of the studies conducted regarding hardness, tensile strength properties of Al6061-Al2O3 composites. The composites are prepared using the stir casting process, in which 5-20 wt. %'age of particulates were dispersed in the base matrix .The obtained cast composites of Al6061-Al2O3 and the castings of the base alloys were carefully machined to prepare the test specimens for hardness, mechanical tests and as well as for microstructural studies as per ASTM standards. The Al2O3 resulted in improving the hardness and tensile strength of their respective composites. Further, the increased %'age of these reinforcements contributed in increased hardness and density of the composites. The microphotographs of the composites studied revealed the uniform distribution of the particles in the matrix system. The experimental density values were agreed with that of the theoretical density values of the composites obtained using the rule of mixture for composites. The dispersed Al2O3 in Al 6061 alloy contributed in enhancing the tensile strength of the composites.

INTRODUCTION

Composite material

A "composite" is when two or more different materials are combined together to create a superior and unique material. This is an extremely broad definition that holds true for all composites, however, more recently the term "composite" describes reinforced plastics

1.1 Metal matrix composites-

Metal matrix composites- Metal matrix composites (MMCs) are made of a continuous metallic matrix and one or more discontinuous reinforcing phases. The reinforcing phase may be in the form of fibers, whiskers or particles. The metal matrix composites have various advantages over other types of composites. Such as high strength, high modulus, high toughness and impact properties, Low sensitivity to changes in temperature or thermal shock, high surface durability and low sensitivity to surface flaws, high electrical conductivity. Metal matrix composites (MMC) are generating extensive interest in diverse fields like defense, aerospace, electronics and automotive industries. The mechanical properties of metal matrix composites are deeply influenced by the distribution of reinforcement particulates in the matrix and the morphology of secondary matrix.

1.2 Aluminium metal matrix composites

Aluminium metal matrix composite materials-Aluminium metal matrix composite (AMMCs) refer to the class of light weight high performance aluminium centric material systems. The reinforcement in AMMCs could be in the form of continuous / discontinuous fibres, whisker or particulates, in volume fractions ranging from a few percent to 70%. Properties of AMMCs can be tailored to the demands of different industrial applications by suitable combination of matrix, reinforcement and processing routes. There are various types of AMMCs like Al/ SiC , Al/ Al 2 O 3 , Al. Ti C, etc. which are commonly used in automotive and defense. These AMMCs have greater demand because of their advanced properties like greater strength, improved stiffness, reduced density, improved high temperature properties, controlled thermal expansion coefficient, enhanced and tailored electrical properties, improved abrasion and wear resistance, control of mass ,improved damping capabilities.

LITERATURE REVIEW

Rajesh kumar Gangaram Bhandare, Parshuram M. Sonawane[1] found that stir casting process is mainly used for manufacturing of particulate reinforced metal matrix composite (PMMC). Manufacturing of aluminum alloy based casting composite by stir casting is one of the most economical methods of processing MMC. Properties of these materials depend upon many processing parameters and selection of matrix and reinforcements. In their work they discussed about stir casting process, process parameter, & preparation of AMC material by using aluminium as matrix form and SiC, Al2O3, graphite as reinforcement by varying proportion. In their work S.A. Sajjadi , H.R. Ezatpour , M. Torabi Parizi[2], nano and micro-composites (A356/Al2O3) with different weight percent of particles were fabricated by two melt techniques such as stir-casting and compocasting. The mechanical results showed that the addition of alumina (micro and nano) led to the improvement in yield strength, ultimate tensile strength, compression strength and hardness. It was indicated that type of fabrication process and particle size were the effective factors influencing on the mechanical properties. Decreasing alumina particle size and using compo-casting process obtained the best mechanical properties. Subhranshu Chatterjee, Amitava Basu Mallick[3]discussed about the influence of material processing conditions for preparing aluminium based metal matrix nanocomposites through stir casting route. The role of particle size with respect to Brownian motion, Stoke's settling velocity and strengthening mechanism was assessed from theoretical understandings. Variation of microstructural features and mechanical properties of the nano composites were predicted from theoretical concepts and related mathematical models. Experiments conducted to validate the theoretical predictions showed that grain refinement strengthening mechanism remain operative which was the key to the improved strength property of the nanocomposites.S. Suresha N. Shenbaga Vinayaga Moorthib[4]experiments were conducted by varying weight fraction of TiB2 (0%, 4%, 8% and 12%), while keeping all other parameters constant. The wear mechanism was studied through worn surface and wear analysis as well as microscopic examination of the wear tracks. This study revealed that the addition of TiB2 improves the wear resistance of aluminium composites. The results showed that increasing the mechanical properties, such as

tensile strength, wear resistance and hardness caused by the percentage of TiB2 present in the samples. Rabindra Behera,Nihar Ranjan Mohanta,G.Sutradha[5] found that the mechanical properties of metal matrix composites were deeply influenced by the distribution of reinforcement particulates in the matrix and the morphology of secondary matrix. They investigated the distribution of SiC particulates in a stepped (3-step) cast LM6-SiCp metal matrix composites, which were reinforced by SiCp at different weight fraction i.e. 5, 7.5,10 & 12.5wt%. The experimental results showed that the mechanical properties and forgeability of cast MMCs were different at different step of castings. The morphology of cast MMCs indicated that the distribution of SiCp is not uniform throughout the casting and it changed on changing the thickness of the casting.S. Gopalakrishnan , N. Murugan [6] studied about Al–TiCp castings with different volume fraction of TiC which were produced in an argon atmosphere by an enhanced stir casting method. Specific strength of the composite has increased with higher % of TiC addition. Dry sliding wear behaviour of AMC was analysed with the help of a pin on disc wear and friction monitor. The present analyses revealed the improved specific strength as well as wear resistance. P. Shanmughasundaram, R. Subramanian, G. Prabhu[7] found that Fly ash (SiO2, Al2O3, Fe2O3 as major constituents and oxides of Mg, Ca, Na, K etc. as minor constituents) is one of the most inexpensive and low density material which is abundantly available as solid waste byproduct during combustion of coal in thermal power plants. Their investigation focused on the utilization of fly ash in useful manner by dispersing it into aluminium to produce composites by a two step stir casting method to overcome the cost barrier for wide spread applications in automotive systems. An attempt was also made to investigate its microstructure, mechanical, wear and corrosion behaviour of composites.M. N. Wahab, A. R. Daud and M. J. Ghazali[8] discussed about the preparation and characterization of aluminum metal matrix composites reinforced with aluminum nitride .Morphology of the composite and particle distribution were investigated by optical microscopy. The reinforcing particles were clearly shown present at the edges and around grains of silicon primary, silicon needles and inter-metallic compound of FeMg3Si6Al8. The result of hardness test was 44 Hv for Al-Si matrix and increased to 89 Hv for an Al-Si composite reinforced with 5% wt. % AlN powder. The higher values in hardness indicated that the AlN particles contributed to the increase of hardness of the matrix..In this paper Ajay Singh , Love Kumar ,Mohit Chaudhary ,Om Narayan ,PallavSharma,Piyush Singh ,Bhaskar Chandra Kandpal ,Som Ashutosh [9] fabricated aluminium base metal matrix composites using stir casting process and evaluated their mechanical properties. They found that as the percentage of reinforcement material which was alumina was increased from 5 to 10 % there was increase in tensile strength and hardness but % elongation was decreased.

EXPERIMENTAL WORK

3.1 Selection of matrix and reinforcement

Matrix- The aluminium alloy 6061 was used as matrix phase in this composite material which is used in various structural applications and defence applications.

TABLE 1 – Chemical composition of aluminium alloy 6061

Mg	Si	Fe	Cu	Mn	Cr	Zn	Al	Al
0.85	0.68	0.7	0.22	0.32	0.06	0.07	Bal.	Bal.

3.2 Reinforcement

Aluminium oxide was used as reinforcement. It is widely used ceramic in production of aluminium based metal matrix composite matetial other than Silicon carbide, boron carbide, etc.

3.3 Selection of weight percentage and size of Al2 O3

Various percentages of aluminium oxide 5%,10%,15% and 20% were used for used in the present work to select the best out of them.

3.4 Fabrication of 6061Al alloy / Al2O3 composite

Stir casting process

Aluminum based metal matrix composite was produced by an indigenously developed stir casting process as shown in Fig. 1. This process helps to minimise the production related problems associated with the conventional stir casting process.

Fig.1 Stir casting set up

Cleaned AA6061 was placed inside the crucible. Temperature was set at 30 °C above the melting point of AA6061. After the complete melting of aluminium, once again the temperature was raised to 50°C further to compensate the cooling effect produced due to stirring. Aluminim oxide particles were introduced in the during the mechanical stirring. Two step stirring method was adopted to ensure a thorough mixing of reinforcement. Magnesium (1%) was added during the stirring to improve the wettability of Al 2 O 3 with the molten aluminium. Argon gas was used to prevent reaction of molten aluminium with an atmosphere after the addition of Magnesium.

Difficulty associated with material pouring was also drastically reduced in this process. The crucible used for the composite production . The molten composite material was poured in preheated mould. Manual stirring was done during the pouring of molten material. The reason for the selection of low % of addition (5- 20 %) is to have good weldability. Otherwise, formation of fine particles in the weld zone may offer brittle interface after welding.

Casted samples of aluminium based metal matrix composites are prepared with different percentages of reinforcement as discussed here

a. AMMC with 5% aluminium oxide
b. AMMC with 10% aluminium oxide
c. AMMC with 15% aluminium oxide
d. AMMC with 20% aluminium oxide

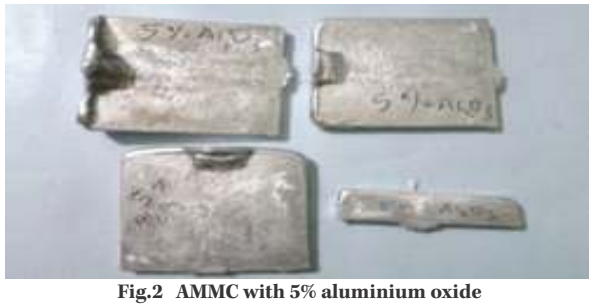

Fig.2 AMMC with 5% aluminium oxide

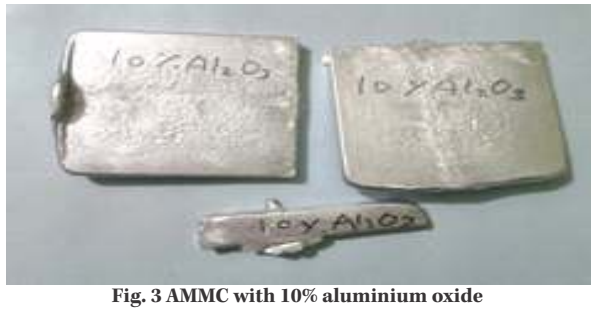

Fig. 3 AMMC with 10% aluminium oxide

Volume : 4 | Issue : 10 | Special Issue Oct- 2015 • ISSN No 2277 - 8179

Fig. 4 AMMC with 15% aluminium oxide

Fig. 5 AMMC with 20% aluminium oxide

Spectrography test of composte material

From the spectrograph test reports it was found that as the percentage of aluminium oxide increases from 5 % to 20 %, the percentage of aluminium increase in composite material. As a results the mechanical properties also got changed

Mechanical testing of samples-

The tensile test and hardness test were carried out to test the mechanical properties of fabricated composite samples. After the fabrication of aluminium based metal matrix composite with stir casting process, the tensile test specimens were made with wire cut Electrical Discharge Machining process as per ASTM : E8/ E8 M – standard as shown in figure. The tensile test is carried out on a universal tensile testing machine. The results were tabulated in table as shown here.

Fig. 6-Tensile test specimen

TABLE 2- Tensile properties of composite material

S. No.	Material	UTS(M Pa)
1	MMC with 5% Al_2O_3	150
2	MMC with 10% Al_2O_3	190
3	MMC with 15% Al_2O_3	240
4	MMC with 20% Al_2O_3	310

It was revealed that as the percentage of reinforcement increases in composite material the tensile strength and micro hardness increases because of the presence and uniform distribution of Al 2 O 3 particles. The micro hardness test was carried out on Vickers hardness testing machine.

TABLE 3 Hardness property of composite material

S.No	Material	VHN
1	MMC with 5% Al_2O_3	61.15
2	MMC with 10% Al_2O_3	64.21
3	MMC with 15% Al_2O_3	79.04
4	MMC with 20% Al_2O_3	89.91

CONCLUSION

In the present work , AA 6061/ Al 2 O 3 , AMMC s were successfully fabricated using newly developed stir casting set up. The spectroscopy results were revealed that the percentage of aluminium increased due to addition of aluminium oxide in composite material. The mechanical testing was done to evaluate the mechanical properties of composite material. It was found that both tensile strength, UTS and hardness was improved as the percentage of reinforcement increased from 5 % to 20 %. But the percentage of elongation was decreased. The increase in Al 2 O3 content shifted the fracture mode from ductile to brittle.

Acknowledgment

We are very thankful for financial support given to us by Inderprastha engineering college, Ghaziabad, U.P. and NIT Kurukshetra, Harayan in our research work.

REFERENCE

[1] Rajesh kumar Gangaram Bhandare, Parshuram M. Sonawane(2013), Preparation of Aluminium Matrix Composite by Using Stir Casting Method ,International Journal of Engineering and Advanced Technology (IJEAT) ISSN: 2249 – 8958, Volume-3, Issue-2. | [2] S.A. Sajjadi , H.R. Ezatpour , M. Torabi Parizi(2012) , Comparison of microstructure and mechanical properties of A356 aluminum alloy/Al2O3 composites fabricated by stir and compo-casting processes,Materials and Design 34,106–111. | [3] Subhranshu Chatterjee, Amitava Basu Mallick(2013), Challenges in manufacturing aluminium based metal matrix nanocomposites via stir casting route,Materials Science Forum Vol. 736, pp 72-80. | [4] S. Suresha N. Shenbaga Vinayaga Moorthib(2013), Process development in stir casting and investigation on microstructures and wear behavior of TiB2 on Al6061 MMC , Procedia Engineering 64 (2013) 1183 – 1190. | [5] Rabindra Behera,Nihar Ranjan Mohanta,G.Sutradha(2012),Distribution of SiC particulates in stir cast Aluminium alloy Metal matrix composites and its effect on mechanical properties ,International Journal of Emerging trends in Engineering and Development ISSN 2249-6149, Issue 2, Vol.1. | [6] S. Gopalakrishnan , N. Murugan (2012),Production and wear characterisation of AA 6061 matrix titanium carbide particulate reinforced composite by enhanced stir casting method,Composites: Part B 43,302–308. | [7] P. Shanmughasundaram, R. Subramanian, G. Prabhu(2011), Some Studies on Aluminium – Fly Ash Composites Fabricated by Two Step Stir Casting Method European Journal of Scientific ResearchISSN 1450-216X Vol.63, No. 2, pp.204-218. | [8] M. N. Wahab, A. R. Daud and M. J. Ghazali(2009), Preparation and characterization of stir cast-aluminum nitride reinforced aluminum metal matrix composites, International Journal of Mechanical and Materials Engineering (IJMME), Vol. 4 (2009), No. 2, 115-117.| [9] Ajay Singh , Love Kumar ,Mohit Chaudhary,OmNarayan allavSharma,Piyush Singh ,Bhaskar Chandra Kandpal ,Som Ashutosh(2013), International conference in ITM university, Haryana, India.