A Review on Tribological and Mechanical Characterization of Al6061 Reinforced with MoS_2

[1] Mailareppa Marachakkanavar, [2] Shubham Patil, [3] Rakesh Rao, [4] Harshad Patil, [5] Ganesh Banne
[1]Professor, [2]Student, [3]Student, [4]Student, [5]Student
[1]Department of Mechanical Engineering, Sinhgad Institute of Technology & Science, Narhe, Pune-411041, Maharashtra, India.,

Abstract— The expansion of manufacturing industries has somewhere led to increase in the use of composite materials. Nowadays metal matrix composite (MMC) are because of their light weight, high strength, good corrosion, wear resistance and low thermal coefficient of expansion. Stir casting is one of the easiest and oldest methods of manufacturing MMC. The present research work is about the manufacturing of aluminum matrix composite (AMC) by stir casting technique where Al6061 is the matrix or the base material and molybdenum disulphide (MoS_2) in powder form is the reinforcement material. Numbers of mechanical tests are performed on prepared composite specimen and then compare the result of different percentage composition with the base alloy. Optical microscope is used for microstructure studies.

IndexTerms—Metal Matrix Composite, Reinforcement, Stir Casting, Optical Microscope.

I. INTRODUCTION

Science and technology has developed to such an extent that now the demand for advanced engineering materials have increased. Various engineering applications now require high strength and low weight new era materials. This requirement can be fulfilled by the composite materials. One such material is the metal matrix composite (MMC). The Aluminum based metal matrix composites are the most desirable choice for aerospace, automotive, defense, railway components etc. applications due to their high strength to weight ratio, stiffness and resistance to high temperature [1]. The AMC also known as aluminum metal matrix contains of aluminum as the base metal and while the reinforcement may be silicon carbide (SiC), boron carbide (B4C), titanium carbide (TiC), aluminum oxide (Al_2O_3). The reinforcements may be in the form of whiskers, fibers or particulates. MMCs are fabricated using many processes such as casting, forging and extrusion [2]. They are mainly processed by powder metallurgy, liquid cast metal technology or by using special manufacturing process. The processing cost of powder metallurgy process is quite high and the size of the components that can be procured also has certain restrictions. Therefore for the processing of aluminum matrix composites, casting method is apt and most economical [3]. In Stir casting, by the means of mechanical stirring, the reinforcing particles are distributed into the molten matrix. It has advantages like simplicity, flexibility and applicability to large quantity production. This liquid metallurgy technique is the most cheap and efficient of all the available methods for manufacturing of metal matrix composite and it allows very large sized components to be fabricated [4].

II. LITERATURE REVIEW

Mailareppa Marachakkanavar et al [5] in their work prepared a composite to study their micro structural and mechanical properties where Al6061 was taken as the matrix and iron ore powder with different weight proportion was used in the reinforcement phase. The AMC was preparing by stir casting method. They indicated that there was an increase of 38% in ultimate tensile strength and 45% increase in hardness as compared to the base material.

Bhargavi Rebba et al [6] produced Al 2024 –MoS_2 composites of combinations 1%, 2%, 3%, 4% & 5% through stir casting method. They also conducted an optical micrography which revealed that MoS_2 particles were well distributed in AMM. By XRD analysis, it was determined a homogenous dispersion was seen on MoS_2 particles in the composite.

M.N.Wahab et al [7] carried out the Preparation and characterization of aluminum metal matrix reinforced with aluminum nitride. It was found significant increase in hardness of the alloy matrix.

Kalidaas D. et al [8] suggested that the optical micrograph of composites by stir casting methodology such that the allocation of MoS_2 particulate in the metal matrix is homogeneous. The porosity of the test material increases with in different weight fraction of reinforcement particles.

III. MATERIAL AND METHODS

A. Selection of matrix material

In the present work, Aluminum 6061 alloy is used as a matrix and composition is shown in Table 1. Al6061 is chosen because it is used in aerospace and high temperature applications due to its characteristics such as excellent weld ability and its light weight.

Table 1 Composition of Al6061 Matrix Metal

Element	Cu	Mg	Si	Fe	Mn	Zn	Ti	Cr	Al
Percentage (%)	0.19	0.82	0.67	0.19	0.06	0.03	0.07	0.08	Balance

B. Selection of reinforcement material

The MoS_2 (75 microns) is used as reinforcement material because it has excellent lubricity. By adding 0%, 5%, 10%, 15% by weight of MoS_2 into the matrix composite specimens are prepared. We can change properties like hardness, tensile strength, density, yield strength and properties of composite. Composition of MoS_2 is shown in Table 2.

Table 2: Composition of MoS_2

Element	Mo	S
Percentage (%)	59.94	40.06

C. Preparation of composite by stir casting

In a stir casting technique, the reinforcing phases are distributed into molten metal matrix with the use of mechanical stirring. This technique of casting of metal matrix composites was first conducted in 1968, when S. Ray introduced alumina particles into aluminum melt by stirring molten aluminum alloys containing the non-metallic powders. Mechanical stirring in the furnace is an important element of this process. The resultant molten alloy, with non-metallic particles, can then be used for die casting, permanent mold casting, or sand casting. [4].

"Fig 1.Electric resistance casting furnace"

Two-step mixing process is a recent development in stir casting. In this technique, the matrix material is heated to above its melting temperature so that the metal is totally melted. The melt is then cooled down to a temperature between the liquids and solidus points and kept in a semi-solid state. At this step, the already preheated particles are added and mixed together. The slurry is heated again to a fully liquid state and mixed systematically. This two-step mixing process has been applied in the fabrication of aluminum.

Amongst the all well-established metal matrix composite fabrication methods, stir casting is the most economical one. For that reason, Nowadays stir casting is the most popular commercial method of producing aluminum based composites. In this process metal matrix alloy (Al6061) is superheated above its melting temperature. Then preheated MoS_2 is added to molten Al6061 and stirred well by using stirrer. After this the melted and superheated composite material is poured into die of cylindrical shape and kept for cooling. Then the testing made on fabricated specimens for determining mechanical properties. [6]

IV. PREPARE MECHANICAL AND TRIBOLOGICAL CHARACTERIZATION

A. Tensile Test

A tensile test is probably the most fundamental type of mechanical test performed on material. As the material is being pulled along its axis we can find tensile strength of material. In tensile testing due to continuous pull on the material it will breaks and obtain a good, complete tensile profile. The point of highest load is called as its "Ultimate Tensile Strength". The stress applied to the material at which plastic deformation starts to occur when the material is loaded is called as yield strength of material.

B .Hardness Test

Hardness test is defined as the resistance of material to permanent deformation of its surface. The deformation may be in the form of scratching wear indentation of cutting. Indenters are in the form of sphere and cones are used. A hardness test consists of pressing the surface of materials with a sharp edge indenter.

C. Wear Test

Wear test is defined as damage to a solid surface, most of time in the form of gradual material removal from a surface by the action of relative motion with a contacting substance. Wear is caused by disintegrating of interacting machine components as a result of over stressing of material in the immediate vicinity of the material. It may result in dimensional change of the components or surface damage and this cause secondary problem such as vibration or misalignment.

V. MICRO STRUCTURAL CHARACTERIZATION

Microscopic analysis of the matrix metal and composite samples can be performed by optical microscopy. An Image analyzer is generally used to examine the distribution of the reinforcement particles within the aluminum matrix. The mechanical properties of any particle reinforced metal matrix composites depend on the particle distribution, particle size, particle flaws, surface irregularities and particle matrix bonding. It is therefore, necessary to conduct a microscopic analysis on the new material in order to gain better understanding of its micro structural characteristics.

VI. SUMMARY

The literature survey shows physical and mechanical properties of aluminum alloys improved by using different types of reinforcement. Reinforcement like MoS_2 increases physical and mechanical properties of composite. Stir casting technique is used to prepare the composite of

Al6061 and MoS_2. Different types of mechanical test are carried out on composite specimens. The result of each composition is compared with base alloy. A further study in this respect is needed particularly by varying weight percentage and particle size of reinforcement.

VII. REFERENCES

[1] S.Gopalakannan, T. Senthilvelan, "Application of response surface method on machining of Al–SiCnanocomposites", Measurement 46 (2013) 2705–2715.

[2] Pragya Shandilya, P.K. Jain, "RSM and ANN modeling approaches for predicting average cutting speed during WEDM of Sicp/6061 Al MMC" , Procedia Engineering 64 (2013) 767-774.

[3] Muhammad Hayat Jokhiyo, Muhammad Ibrahim Panhwar, Mukhtiar Ali Unar, "Manufacturig of aluminium composite material using stir casting process", Mehran University Research Journal Of Engineering and technology, Volume 30, No.1, January,2011[ISSN 0254-7821].

[4] Rajeshkumar Gangaram Bhandare, Parshuram M. Sonawane, "Preparation of Aluminum Matrix Composite by Using Stir Casting Method", International Journal of Engineering and Advanced Technology (IJEAT) ISSN: 2249 –8958, Volume-3, Issue-2, December 2013.

[5] Mailareppa Marachakkanavar, Sanjay S.J, D.N. Korade, K.R.Jagtap, "Experimental Investigation of Mechanical Properties of Al6061 Reinforced with Iron ore", [ICAAMM-2016].

[6] Bhargavi Rebba, N.Ramanaiah, "evaluation of mechanical properties of Aluminum alloy (Al2024) reinforced with Molybdenum Disulphide (MoS2) metal matrix composite", [ICMPC-2014]

[7] M.N.Wahab, A.R.Daud, M.J.Ghazali, "Preparation and characterization of stir cast-aluminum nitride reinforced aluminum metal matrix composites", Vol.4, No.2, 115-117, [IJMME-2009].

[8] Kalidas D., Ragupathy k., "Experimental Investigation of Al6061/SiC/MoS2 Hybrid Composites Wear Behavior by using Stir Casting Method", Vol.3, Issue01, [IJSRD-2015].