PREPARATION OF Al 6061/ SiC METAL MATRIX COMPOSITE (MMC) USING STIR CASTING TECHNIQUE

Sharanya Nair[1], Nehal Joshi[2]

[1] *PG Scholar, Mechanical Engineering Department, Shankersinh Vaghela Bapu Institue of Technology, Gujarat, India*

[2] *Assistant Professor, Mechanical Engineering Department, Shankersinh Vaghela Bapu Institue of Technology, Gujarat, India*

ABSTRACT

The expansion of manufacturing industries has somewhere led to the increase in the use of composite materials. Metal Matrix Composites (MMC) are the advanced and new age materials that find application in sectors like automotive, aerospace, rail components, defense etc. because of their light weight, high strength, good corrosion and wear resistance and low thermal coefficient of expansion. Stir casting is one of the simplest and oldest methods of manufacturing MMC. The present research work is about the manufacturing of Aluminium Matrix Composite (AMC) by stir casting technique where Al 6061 is the matrix or the base metal and 10 % silicon carbide (SiC) in powder form is the reinforcement material. Scanning Electron Microscopy was done in order to observe the distribution of SiC particles into the Al matrix.

Keyword: - *Metal matrix composites, reinforcement, stir casting, scanning electron microscopy.*

1. INTRODUCTION

Science and technology has developed to such an extent that now the demand for advanced engineering materials has increased. Various engineering applications now require high strength and low weight new age materials. This requirement can be fulfilled by the exotic composite materials. One such material is the metal matrix composite (MMC). The Aluminium based metal matrix composites are the most preferable choice for aerospace, automotive, military, railway components etc. applications due to their light weight, high strength, stiffness and resistance to high temperature [1].

The Aluminium Matrix Composites (AMC) consists aluminium as the base metal called the matrix while the reinforcement may be silicon carbide (SiC), boron carbide (B4C), titanium carbide (TiC), aluminium oxide (Al2O3). 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 usually processed through powder metallurgy route, 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 aluminium matrix composites, casting method is apt and most economical [3].

Stir casting definition- a process in which by the means of mechanical stirring, the reinforcing particles are distributed into the molten matrix.

Its advantages lie in its simplicity, flexibility and applicability to large quantity production. This liquid metallurgy technique is the most economical of all the available routes for metal matrix composite production and allows very large sized components to be fabricated [4].

2. REVIEW WORKS

S.A. Sajjadi et al [5] in their work prepared micro and nano composites to study their microstructural and mechanical properties where A356 aluminium alloy was takes as the matrix and alumina (Al_2O_3) powder with 50nm and 20µm with different weight percentage was used as the reinforcement phase. The AMC was prepared by two methods namely stir casting and compo-casting. They indicated that the best mechanical properties were obtained by decreasing the alumina particle size and using compo casting method. **Hamid Reza Ezatpour et al [6]** fabricated nano composite Al 6061-Al_2O_3 by stir casting and then the composites were extruded. On comparing the extruded samples with the cast samples, the extruded samples showed superior strength and ductility values. **Shashi Prakash Dwivedi et al [7]** fabricated A356/SiC metal matrix composite with different weight percentage of reinforcement by electromagnetic stir casting technique. The microstructural study of the composite indicated that electromagnetic stir casting lead to grain refinement and homogeneous structure. The mechanical properties upon investigation revealed increase in hardness and toughness, improvement in fatigue strength and decrease in porosity percentage. **S. Suresh and N. Shenbaga [8]** used stir casting to prepare a metal matrix composite of Al 6061/ TiB_2. On studying the wear behavior it was revealed that increasing the amount of TiB_2 in the aluminium composite improves its wear resistance. Also, hardness and tensile strength increased with addition of TiB_2.

3. EXPERIMENTAL SETUP

3.1 Material Selection

Al 6061 was chosen as the matrix metal and 10 % silicon carbide SiC powder (320 mesh size) as the reinforcement. The chemical composition of Al 6061 is given below:

Table 1: Chemical composition of Al 6061

Elements	Si	Cu	Zn	Fe	Mn	Mg	Cr	Ti	Al
Percentage (Wt%)	0.71	0.23	0.09	0.64	0.11	0.88	0.15	0.04	97.019

The reason for choosing Aluminium 6061 as the matrix metal is because of its excellent properties like good corrosion resistance, medium fatigue strength, very good weldability and convincing machinability.

6061Al is widely used in numerous engineering applications including transport and construction where superior mechanical properties such as tensile strength, hardness etc., are essentially required.
Addition of silicon carbide to aluminium matrix enhanced its mechanical properties.

3.2 Fabrication of Al 6061- SiC AMC by stir casting

The stir casting setup was prepared at Makarpura GIDC, Baroda. The Al 6061 + 10% SiC AMC was prepared by stir casting technique wherein aluminium is the matrix and SiC powder is the reinforcement. The stepwise procedure of stir casting is discussed below:

- **Step 1: Melting of base metal -Al 6061in furnace**

First of all, Al 6061 was melted in a graphite crucible placed inside the pit furnace as shown in the figure below. Al starts melting at around 650º C.

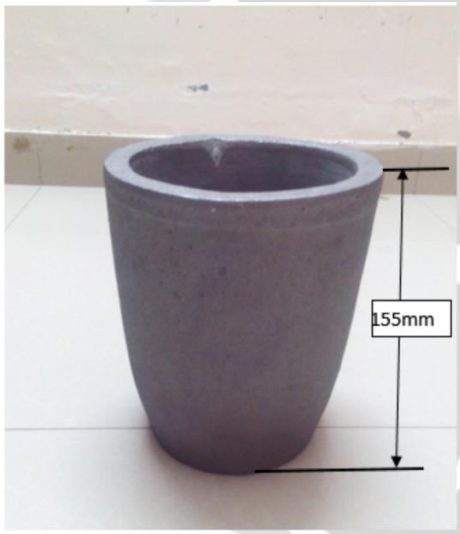

Fig 1: Front view of graphite crucible

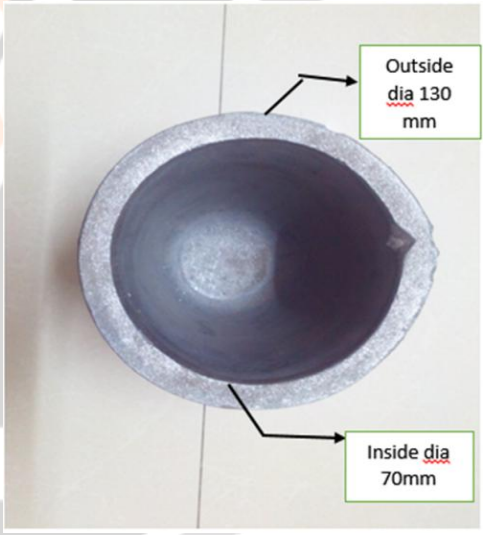

Fig 2: Top view of graphite crucible

Fig 3: Melting of Al 6061 in pit furnace

- **Step 2: Addition of SiC powder into molten Al**

Into the molten matrix, 10% (by weight) SiC powder of 100 mesh size was added. 1% Magnesium powder was also added in order to improve the wettability and decrease the porosity.

Fig 4: Addition of SiC powder into molten Al

- **Step 3: Stirring of the Al + SiC mixture**

First of all, a stirrer was made out of graphite rod of 100mm length and 25mm diameter for stirring. External threading was done on the stirrer as shown. An internally threaded 3 feet long stainless steel rod was fitted over this stirrer.

Fig 5: Graphite Stirrer

The mixture was mechanically stirred using a motor of around 250 RPM for 10 minutes before pouring into the mould.

Fig 6: Stirring of Al+ SiC mixture using motor

- **Step 4: Pouring of Al-SiC mixture in to mould and solidifying**

The AMC mixture was poured into the mould and allowed to solidify for some time. The final cast AMC slabs were taken out once they cooled

Fig 7: Pouring of molten Al into mould

The AMC plates casted by stir casting have dimension: 110mm*110mm* 15mm*

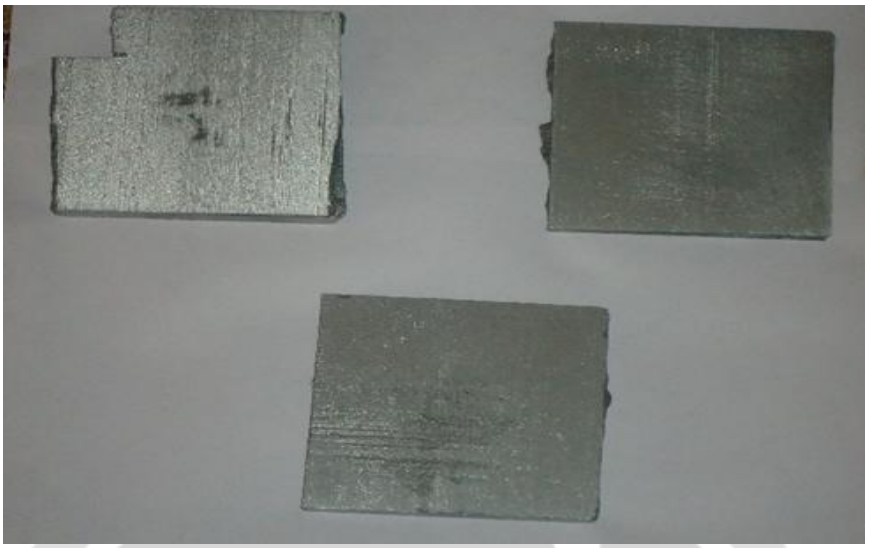

Fig 8: Al6061 + 10% SiC Metal matrix composite

4. RESULT AND DISCUSSION

Processing of composites comes along with the challenge of homogeneous distribution of the reinforcement phases into the matrix for a defect- free microstructure. The segregation of reinforcing particles in to the matrix is of major concern which is caused by the settling of the reinforcement particles during the melting and casting process. In order to observe the segregation pattern of the reinforcement particles in to the matrix, Scanning Electron Microscopy (SEM) is conducted. The SEM image of composites material (Al6061+10%SiC) is shown in Fig 9. From the image it is observed that the reinforcement particles silicon carbide are distributed throughout Al6061 matrix alloy and there also exist a good bond between matrix and particles.

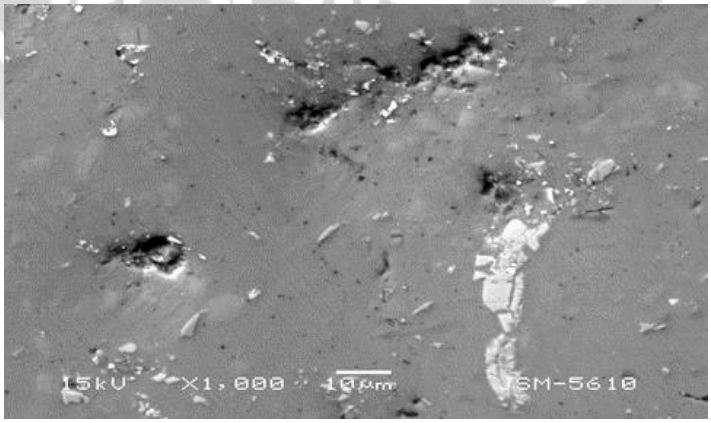

Fig 9: Distribution of SiC in Al

5. CONCLUSION

Aluminium based metal matrix composite was prepared using the stir casting technique where Al 6061 was the matrix metal and 10% SiC powder was added as the reinforcement. The SEM micrographs show good distribution of SiC particles. The magnesium powder on adding reduced the porosity and improved wettability. Stir casting method is the simplest and most economical method to produce good quality composite materials.

REFERENCES

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

[2] Pragya Shandilya, P.K. Jain, N.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 Jokhio, Muhammad Ibrahim Panhwar, Mukhtiar Ali Unar, "Manufacturing of Aluminum Composite Material Using Stir Casting Process", Mehran University Research Journal of Engineering & Technology, Volume 30, No. 1, January, 2011 [ISSN 0254-7821].

[4] Rajeshkumar Gangaram Bhandare, Parshuram M. Sonawane, "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, December 2013.

[5] S.A. Sajjadi, H.R. Ezatpour, M. Torabi Parizi, "Comparison of microstructure and mechanical properties of A356 aluminum alloy/Al2O3 composites fabricated by stir and compo-casting processes", Materials and Design 34 (2012) 106–111.

[6] Hamid Reza Ezatpour, Seyed Abolkarim Sajjadi, Mohsen Haddad Sabzevar , Yizhong Huang, "Investigation of microstructure and mechanical properties of Al6061-nanocomposite fabricated by stir casting", Materials and Design 55 (2014) 921–928.

[7] Shashi Prakash Dwivedi, Satpal Sharma, Raghvendra Kumar Mishra, "Microstructure and Mechanical Properties of A356/SiC Composites Fabricated by Electromagnetic Stir Casting", Procedia Materials Science 6 (2014) 1524 – 1532.

[8] S. Suresh, N. Shenbaga Vinayaga Moorthi, "Process development in stir casting and investigation on microstructures and wear behavior of TiB2 on Al6061 MMC", Procedia Engineering 64 (2013) 1183 – 1190.