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Characterization of Al Matrix Composite with SiC Particles

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Abstract

In today's era aluminum alloys are widely used in aerospace and automobile industries as it owes superior strength to weight ratio, high temperature resistance, low density, better corrosion resistance and wear, low thermal coefficient of expansion good mechanical properties as compared to conventional metals and alloy. The objective of designing metal matrix composite is to combine the desirable attributes of metals and ceramics .Our present work is focused on the analysis of physical & mechanical properties of aluminum reinforced with SiC particles and stir casting technique has been adopted .Aluminum (Al6061) and SiC (500-grit size) has been chosen as matrix and reinforcement material respectively. Experiments have been conducted by varying weight fractions of SiC (5%, 10%), while keeping all other parameters constant. Micro hardness test, Impact test and tensile test are performed on the specimens casted by stir casting technique. Hardness tester is employed for the evaluation of the interfacial bonding between the particles and the matrix by indenting the indenter with constant load and constant time.

Aluminum matrix composites have been successfully fabricated through stir casting technique with uniform distribution of SiC particles. The results obtained through stir casting formed Al reinforced with SiC particles are clearly superior to base Al in comparison of Impact strength, Tensile strength & Hardness. Dispersion of SiC particles in aluminum matrix improves the hardness, tensile strength & toughness of the composite. It is also found that elongation tends to decrease with addition of reinforcement, which confirms that SiC addition increases brittleness.

Keywords: Metal Matrix Composite ; Stir Casting ; Tensile Strength

1. Introduction

Ever since the Wright brothers flew their 'heavier-than-air' machine, the aviation industry has grown in great leaps and bounds. Because aircrafts were getting faster and/or bigger, the need to develop newer materials took centre stage- the use of wood and fabric gave way to stronger metallic structures (built predominantly using aluminium and its alloys). However, ceramics and composite materials are slowly replacing these too (E. Starke Jr and J. Staley,1996).

Since the need to develop more efficient aircraft hasn't subsided, the requirement for better materials is still in great demand. This paper explores the possibilities of one such material; aluminium- silicon carbide composite (Al-SiC). Initially, the work will look to identify the

necessary properties of a material that is to be used in the aerospace industry. The reasons for aluminium's extensive application in the aircraft industry will then be identified and the use of metal matrix composites (MMC) to counter the pure element's (aluminium) shortcomings will be advocated. Once a case for Al-SiC MMC has been made, the work will look to explore and understand the different properties like tensile strength, hardness, and toughness of the composite.

2. Review works

Rahman and Rashed (2013) in their work they have studied about the microstructures, mechanical properties and wear characteristics of as cast silicon carbide (SiC) reinforced aluminium matrix composites (AMCs). AMCs of varying SiC content (0, 5, 10 and 20 wt. %) were prepared by stir casting process. Microstructures, Vickers hardness, tensile strength and wear performance of the prepared composites were analyzed. The results showed that introducing SiC reinforcements in aluminum (Al) matrix increased hardness and tensile strength and 20 wt. % SiC reinforced AMC showed maximum hardness and tensile strength. Microstructure observation revealed clustering and non-homogeneous distribution of SiC particles in the Al matrix. Porosities were observed in microstructures and increased with increasing wt. % of SiC reinforcements in AMCs. Pin-on-disc wear test indicated that reinforcing Al matrix with SiC particles increased wear resistance.

Ezatpour et al, (2014) fabricated nano composite Al 6061-Al2O3 by stir casting and then the composites were extruded. On evaluate the extruded samples with the cast samples, the extruded samples showed superior strength and ductility values.

Nair and Joshi (2015) have studied about the how 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.

Suresh and Shenbaga (2013) used stir casting to prepare a metal matrix composite of Al 6061/ TiB2. On studying the wear behavior it was revealed that increasing the amount of TiB2 in the aluminium composite improves its wear resistance. Also, hardness and tensile strength increased with addition of TiB2.

3. Experimental Setup

3.1 Material Selection:

Al 6061 was chosen as the matrix metal and *5% & 10 %* silicon carbide SiC powder (500 mesh size) as the reinforcement. The chemical composition of Al 6061 is given below:

Table-1 Chemical Composition of Al6061

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

Devi et al, (2013) proposed 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 the college mechanical workshop. The Al 6061 + 5% SiC and 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 Computerised Muffle furnace as shown in the figure below.Al starts melting at around 650º C.

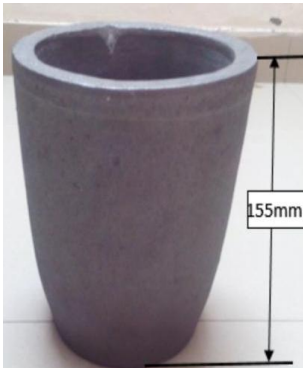


Figure 1: Front view of graphite crucible

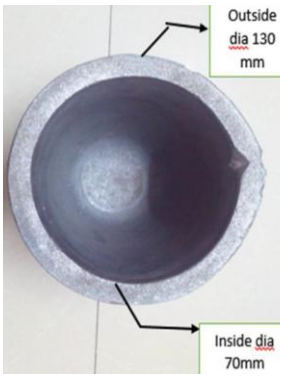


Figure 2: Top view of graphite crucible

Figure 3: Melting of Al 6061 in muffle furnace

Step 2: Addition of SiC powder into molten Al

Into the molten matrix, 5% and 10% (by weight) SiC powder of 500 grit size respectively was added.

Step 3: Stirring of the Al + SiC mixture

Stirrer was combined with thermocouple and which was used for the purpose of stirring of SiC particles in the molten aluminium alloy Al6061.

Figure 4: stirrer with Thermocouple**.**

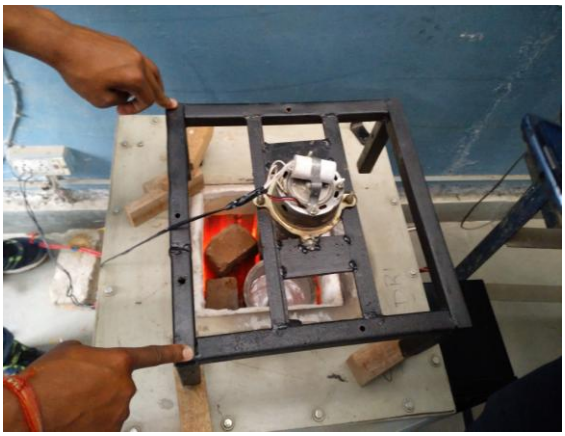


Figure 5: Stirring of Al+SiC Particles with thermocouple.

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.

Figure 6: Pouring of molten Al into mould.

The AMC specimens are casted by stir casting have dimension: 55mm diameter & 10mm thickness-for hardness can be seen in figure 7(a & b) and specimens casted for charpy impact test have dimensions 10mm*10mm*75mm can be seen in figure 8 and specimens for tensile strength having dimensions(in figure9) shown in figure 10.

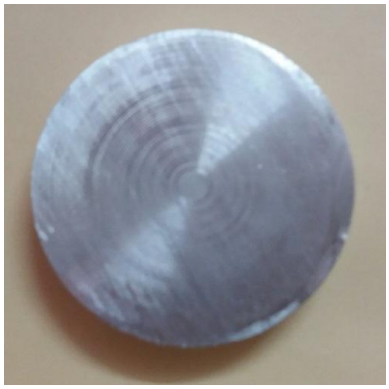


Figure 7(a): Specimen Casted for Hardness test of Al6061+0%SiC.

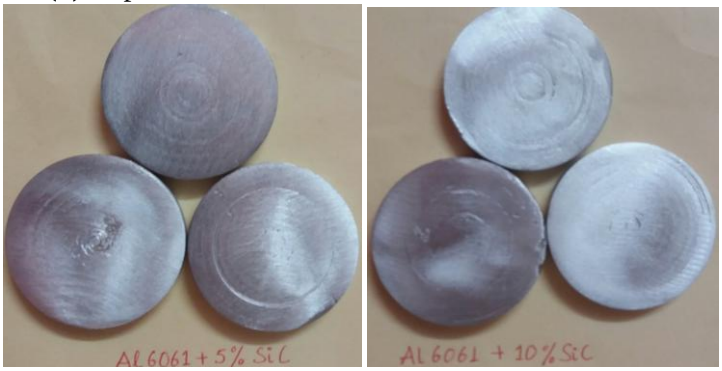


Figure 7(b): specimens with specifications.

Figure 8: specimens with specifications.

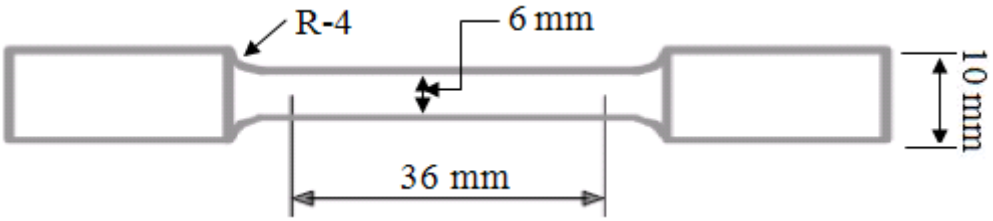


Figure 9: Standard Tensile Specimen

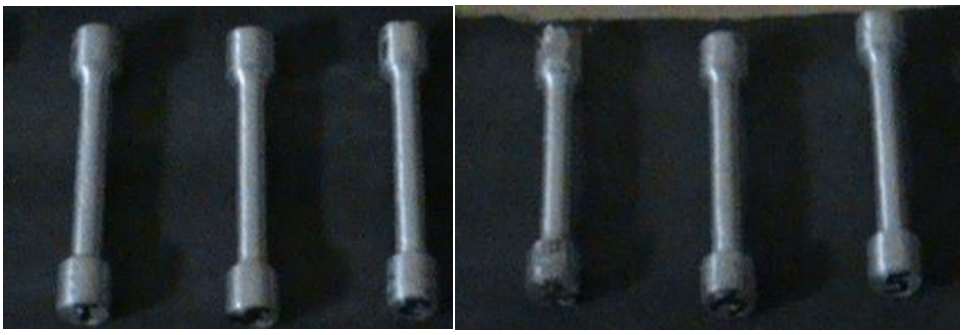
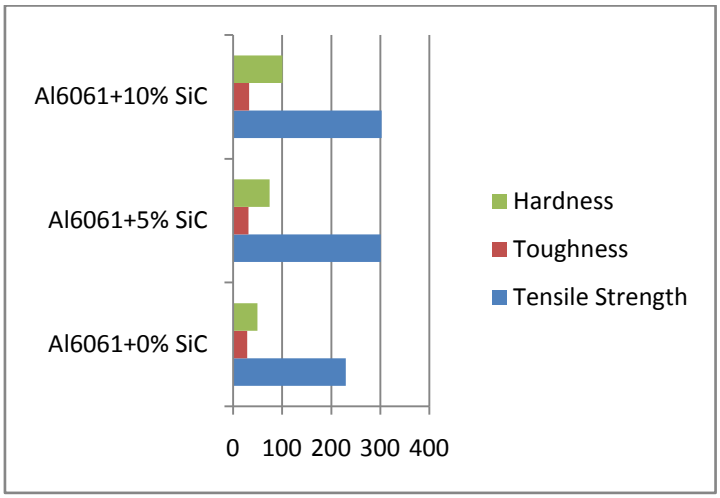


Figure 10: Tensile Specimens (Al6061+5%SiC) and (Al6061+10%SiC)

4. Result and discussion

The Electromagnetic stirring is seen to be the cheapest method of producing MMC compared to other methods such as powder metallurgy and simple stirring process. However the main MMC fabrication problems such as wet ability between substances, the chemical reaction between them, the distribution of the reinforcement particles in the matrix and also the porosity content in the matrix still remain and research continues aiming to solve them. In normal stir casting technique, cast MMC is produced by melting the matrix materials then the molten metal is stirred thoroughly to form a vortex and the reinforcement particles are introduced through the side of the vortex formed. Research related to this type of cast MMC producing method is broad and still going on. However the main approach used remains the same as mentioned above. The toughness of Al 6061+0%SiC is less than the Al 6061+10%SiC composite as it is clearly seen through the help of tests performed on computerized UTM (Universal testing machine)i.e. the toughness also increases after addition of SiC particles in the matrix. It is also seen in results that stir formed Al 6061+5% SiC composite have less tensile strength as compared to Al 6061+10%SiC composite

i.e. the tensile strength increases after addition of SiC particles in the matrix. On moving forward we could also make out that the toughness of Al 6061+5%SiC composite is clearly superior to Al 6061+10%SiC composite in the levels of toughness i.e. the toughness also increases after addition of SiC particles in the matrix. All the results are very much shown in the graph below.



Graph 1: Comparison of results obtained through the testing of specimens.

5. Conclusion

Aluminium based metal matrix composite was prepared using the stir casting technique where Al 6061 was the matrix metal & 5%SiC and 10% SiC powder was added as the reinforcement. The results confirmed that stir formed Al alloy 6061 with 10% SiC particles reinforced composites is clearly superior to base Al alloy 6061 in the comparison of micro hardness , toughness & tensile strength i.e.; the micro hardness ,toughness as well as tensile strength increases after addition of SiC particles in the matrix.. Stir casting method is the simplest and most economical method to produce good quality composite materials.

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