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Effect of Process Parameter of Stir Casting on Metal Matrix Composites

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Abstract: ***In the present study a modest attempt has been made to develop aluminum based silicon carbide particulate Metal Matrix Composites(MMC) with an objective to develop a conventional low cost method of producing MMCs and to obtain homogenous dispersion of ceramic material. Desired improvements in properties including specific strength, hardness and impact can be achieved by intelligently selecting the reinforcement materials, their size, and shape and volume fraction. It has been observed that melting and pouring conditions have directly or indirectly effect on mechanical properties of cast materials as hardness, percentage elongation, percentage reduction in diameter, toughness and so on. The knowledge of melting temperature of metals and alloys is necessary to estimate their corresponding pouring temperature.***

Keywords: Metal Matrix Composites MMC's, Cu, Silicon Carbide (SiC), SPSS, Stir, Pouring Temperature, UTM, Hardness.

1. Introduction

The increase in strength of composites due to smaller reinforcement particle size has been reported by many authors. Statistically, larger flaws and more defects are more likely to exist in larger particles and, therefore, will deteriorate the strength of composites when compared with the composites containing smaller particles. The smaller grain size in the composites containing smaller reinforcement particles can also contribute to the increase in strength. The mechanical properties such as hardness, impact and strength is increase when grit size of reinforcement of SiC particle increase.

One of the major challenge when processing on 4% Cu + 5% SiC with balanced Aluminum Metal Matrix Composites are achieving a homogeneous distribution of reinforcement in the matrix as it has a strong impact on the properties and the quality of the material.

Among discontinuous metal matrix composites, stir casting is generally accepted as a particularly promising route, currently practiced commercially. Its advantages lie in its simplicity, flexibility and applicability to large quantity production. It is also attractive because, in principle, it allows a conventional metal processing route to be used, and hence minimizes the final cost of the product. The cost of preparing composites material using a casting method is about one-third to half that of competitive methods, and for high volume production, it is projected that the cost will fall to one-tenth. In general, the solidification synthesis of metal matrix composites involves producing a melt of the selected matrix material followed by the introduction of a reinforcement material into the melt, obtaining a suitable dispersion.

2. Experimentation

An open hearth furnace was used for melting and mixing the materials in flat bottom, cylindrical graphite crucible. The fabrication process is conventional mechanical stirring for the distributive mixing of the reinforcement in the matrix. For the work, a new stir caster was developed to fabricate MMC. The mixing equipment for this stage consisted of a driving motor capable of producing a rotation speed within the range of 600rpm, a control part for the vertical movement of the impeller and a transfer tube used for introducing the ceramic powders in the melt.

Balanced aluminium alloy with copper were melted in graphite crucibles. At the same time the SiC particulate was preheated in a muffle furnace set at 1100°C for approximately 2 hour to remove surface impurities and assist in the adsorption of gases. The ceramic particles were then poured slowly and continuously into the molten metal and the melt was continuously stirred at 600 rpm.

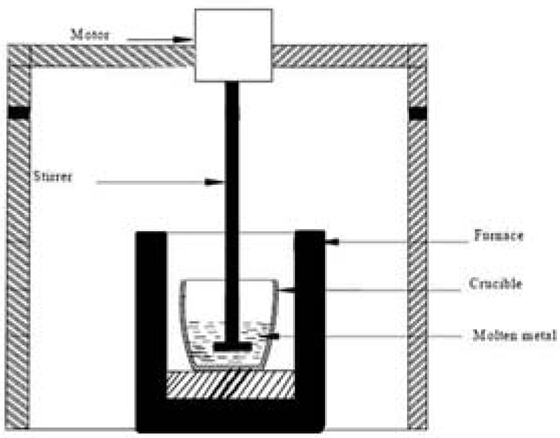


Figure 2.1: Schematic View of Experimental Set Up

Chemical Reaction
Metal matrix composites (Al+4%Cu+5%SiC)

In preparing metal matrix composites by the stir casting method, there are several factors that need considerable attention, including the difficulty of achieving a uniform distribution of the reinforcement material, wettability between the two main substances, porosity in the cast metal matrix composites, and chemical reactions between the reinforcement material and the matrix alloy.

3. Methodology

First of all, the balanced aluminium with 4% Cu was melted in a graphite crucible in an open hearth furnace. After automatic mechanical mixing is carried out for about 3 minutes at normal stirring rate 600 rpm and then poured into sand mould with pouring temperature 700°C, 725°C and 750°C respectively. After that the balanced Al+4%Cu and 5% SiC (400-grit) were took. For this, the base metal Al+4%Cu were preheated at 450°C for 3 hours in a electrical resistance muffle furnace before and mixing the SiC particles were preheated at 1100°C for 2 hours in a electrical resistance muffle furnace to remove the moisture and surface oxidized.

4. Observations of Process Parameters

A. BHN Test

The hardness testing was carried out for all composite specimens. The hardness of the specimen determined by Brinell hardness testing machine with 250 kg load and 5 mm diameter steel ball indenter. The detention time for the hardness measurement was 1 minute.

Figure 2.2: Specimen after BHT

B. Impact Strength

Izod impact strength testing is standard method of determining impact strength. Izod impact test were conducted on notched sample. Standard square impact test specimen measured 75 mm x 10 mm x 10 mm with notch depth of 2 mm and a notch of angle of 45°. The machine could provide a range of impact energies from 0 to 164 Joule. The mass of the hammer was 22 kg. It was carried out for all specimens respectively.

C. Tensile Strength

Tensile strength is defined as a stress, which is measured as force per unit area. In the SI system, the unit is Pascal (Pa) or Newton's per square metre (N/m²). For tensile test, we used Universal Testing Machine. The testing involves taking a sample with a fixed cross-section area, and then pulling it with a controlled, gradually increasing force until the sample changes shape or breaks. The tensile test was carried out for all specimens respectively. The maximum capacity of U.T.M is 400 KN.

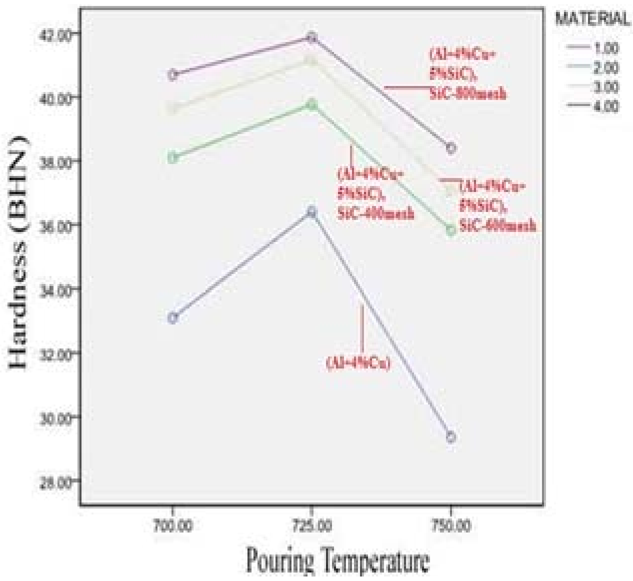
5. Result

The effects of input (independent) variables as pouring temperatures (700°C, 725°C and 750°C) and material type's (varying with grit size of SiC particles) on output (dependent) variables as hardness, impact strength and ultimate tensile strength, statistically analysis were performed by using SPSS 17.0.

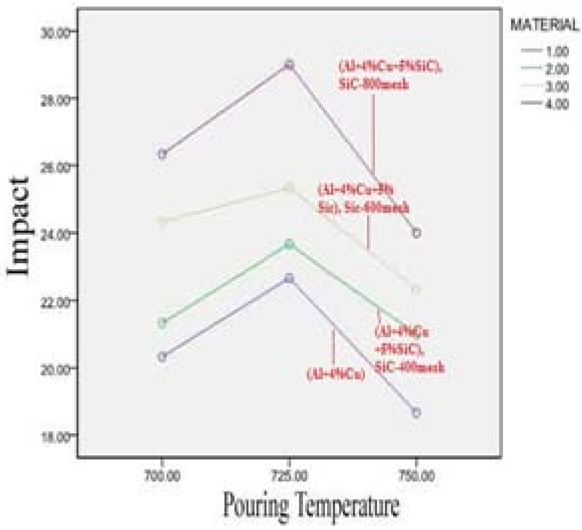
The variations of Izod impact with pouring temperatures are shown in fig-4.2. The impact is increases initially for all composites with pouring temperature at 700°C. It latter attained its maximum value of all material types at pouring temperature 725°C. After that it falls sharply at the pouring temperature 750°C. From the figure, it can be observed that the impact of the composite material-2 (Al + 4% Cu + 5% SiC) is higher than the base matrix material-1 (Al + 4% Cu). Thereafter, the increasing impact with increasing the grit sizes of SiC particles. The maximum impact attained when the reinforcement was 800-grit at pouring temperature 725° C.

Table 1: Showing variation in MP-BHN-UTS with Change in Poring Temperature

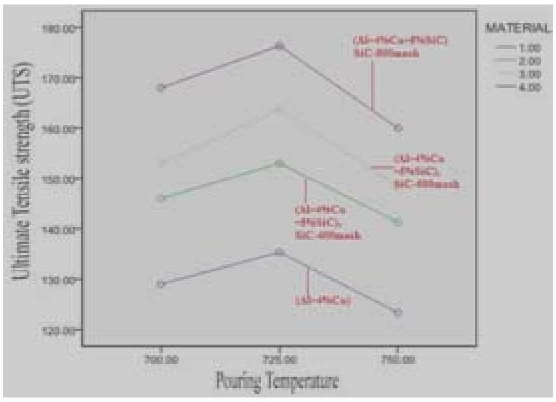
Serial no.	*Pouring Temperature (C)*	*Impact Strength(MP*	*Hardness (BHN)*	*UTS*
1.	700	26.00	41.00	164.00
2.	725	29.56	41.96	175.00
3.	750	24.45	39.87	162.34



Graph A: Hardness vs. Poring Temperature



Graph B: Impact vs. Poring Temperature



Graph C: UTS vs. Pouring Temperature

Variation in the UTS with Different Pouring Temperature.

6. Conclusions

The significant conclusions of the studies carried out on balanced (Al + 4% Cu + 5% SiC) composites are as follows:

- Cast balanced (Al + 4% Cu + 5% SiC) composites were prepared successfully using liquid metallurgy techniques (stir rout).
- Hardness of the composites found increased with increased grit size of SiC.
- Impact (Izod) of the composites found increased with increased grit size of SiC.
- The tensile strength of the composites found increased with increased grit size of SiC.
- The pouring temperature at 725°C which gave the best optimum value of hardness, impact strength and ultimate tensile strength. When the pouring rate kept constant at 2.5 cm/s for all composites.

7. Scope for Future work

- We only consider three grit sizes (400, 600, and 800); chances may be that with further reduction in grit size mechanical properties of composite may decline.
- We added only 5% SiC, however with further addition of SiC particles mechanical properties may improved as investigated by *Singla M. (2009)* for Al and SiC casting.
- Wear resistance may be the parameter which defines the hardness and abrasive property of composite is the scope for future work.
- Experiments are performed on open hearth furnace chances of inclusion and blow holes may measure.

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Author Profile

Shubham Mathur, I am currently pursuing Bachelor of Technology in Mechanical Engineering Final year Student from Integral University, Lucknow, India. I'm a creative thinker. I like to explore alternative solutions to problems and have an open mind about what will work best. I am a keen learner. I have inclination towards solving practical industrial problems. Enthusiasm towards new endeavors and passion towards my work are my motivational factors. I like to commit myself towards my work. I love the challenges of my life and believe that they help me to learn something new and improve myself as well.

Alok Barnawal, I am a very passionate man when it comes to applying knowledge to real world problems. I am a good leader, with excellent communication skills. I'm a people person. I really enjoy meeting and working with a lot of different people. I'm a perfectionist. I'm a creative thinker. I like exploring alternative solutions to problems and have an open mind about what will work best. I enjoy solving problems, troubleshooting issues, and coming up with solutions in a timely manner believe in honesty and try to get my tasks more organized. Humility and ambition is what I always follow.