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Tensile Properties Analysis of Aluminum Reinforced with Hematite Particulate Composites

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ABSTRACT

In the present paper, the report has been made to study the tensile properties of Aluminum composites reinforced with hematite. The percentage of reinforcement varies from 0, 2, 4, 6 and 8 percent. The specimens were prepared using the vertex method. As the weight percentage of hematite is increased, there is an increase of tensile strength along with Young's modulus, but the ductility has been decreased with the addition of hematite. The reinforcement particle size and the casting temperature is also an important parameter of study for mechanical strength. The initiation and propagation of crack through the matrix is observed. Fracture behavior greatly affected by reinforcement.

Key words: *Aluminum, Fracture, Hematite, Tensile Properties.*

1. INTRODUCTION

The weight to strength ratio is the primary requirement for the engineering materials, along with enhanced specific strength and stiffness [1]. In the recent past high performing metal matrix composites are gaining importance over the conventional metals. The metal matrix composites reinforced with ceramic materials show various advantages like high strength, high specific strength and modulus.

Unique characteristics like electrical conductivity, corrosion resistance, and mechanical strength along with low density are the advantages of Aluminum alloys for engineering applications [2]. The compatible ceramic particles like mica, graphite, silica, zircon, silicon carbide and alumina effectively utilized by researchers as reinforcement [3].

The advantages like good weight to strength ratio, low cost and easy availability, easy to manufacture are important parameters to select particles of ceramics as reinforcement. The metal matrix composites find a very wide range of application in the field of automobile, particularly for piston, liners and brake rotors [4].

The ceramic reinforced metal matrix composites have good compatibility; the matrix microstructure is not affected. But when the percentage of reinforcement is large it affects a little. The mechanical bonding between the matrix and reinforcement is good enough to exhibit enhanced mechanical properties.

The manufacturing of ceramic reinforced metal matrix composites is easy and economical as well as suitable for wide range of engineering high strength applications. The researchers are keen in understanding the behavior of these materials. A huge work by scientists is in progress to understand the behavior of ceramic reinforced composites, still lot of gap exist for the reinforcement of non-ceramic reinforcements. An attempt has been conducted to analyse the effect of non-ceramic particle on its fluidity, tensile strength and fracture of the composites.

2. EXPERIMENTAL PROCEDURE

2.1 *Processing of Composites*

Hematite particles added to the matrix from 0 to 8% by weight. The base metal heated to melting temperature of about 620^{0}C, then the reinforcement added with preheating for about 500^{0}C. The mixing is done using stainless stirrer with a speed of about 150

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rpm. Proper care is taken to avoid air trapping in the molten metal. The specimens were prepared using permanent mould. Table 1 depicts the composition of Aluminium alloy used for preparing the composites.

Table 1: Aluminum alloy 6061 composition in grams

Copper	Silicon	Magnesium	Chromium	Balance
0.25	0.60	1.00	0.25	7.90

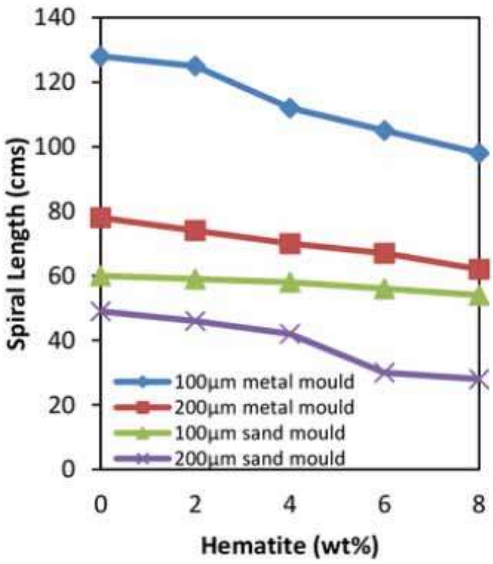

Fig. 1 Spiral length v/s hematitewt% content at 700°C

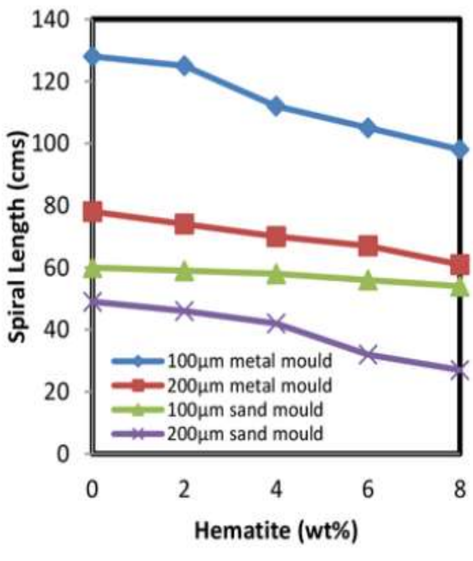

Fig. 2 Spiral length v/s hematitewt% content at 720° C

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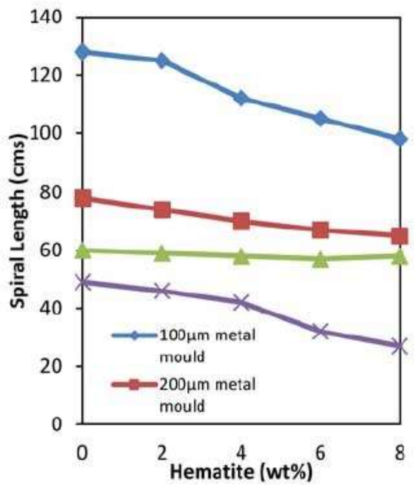

Fig. 3: Spiral length v/s hematitewt% content at 740°C

2.2 *Testing of specimens*

As per the literature fluidity tests as per ASTM were done using straight flow channels. The same has been replaced by spiral test to avoid disadvantages like huge length and straight flow channel sensitivity. Solidified spiral length is the measure of fluidity. Four specimens were prepared with three temperature levels of 700, 720 and 740^{0}C. The particle size was 100 and 200 µm.

Computer controlled Universal Testing Machine (UTM) has been used for tensile test. The specification for tensile specimen is 10 mm and gauge length 75 mm. The size of the specimen is ten, to take care of the even distribution of reinforcement. Percentage of elongation is obtained using UTS and values of ductility.

3 RESULTS ANALYSIS.

Various properties like fluidity, ductility, UTS, elastic modulus were analysed figure 1 to 4, to revel the effect of hematite particle.

3.1 Fluidity

The distance travelled by molten metal before solidification is fluidity. The Flowability (dynamic analysis) of molten metal measurement is fluidity. Freezing of metal is the combined effect of heat and mass flow. Fluidity is determined by the size and shape of castings. Hematite as a function of fluidity for temperature 700,720 and 740^{0}C were shown in graph at each point as the four spiral with average length. The variation of each value is about 2% in comparison with mean value. Fluidity decrement is observed with addition of hematite particles. Viscosity greatly affected by hematite particles there by decreases fluidity [6, 7].
The size of reinforcement is also an important parameter which affects viscosity thereby fluidity [8]. The spiral length [fig 1-3] is more in metal molds, whereas little less is observed in sand molds due to sand particles resistance.

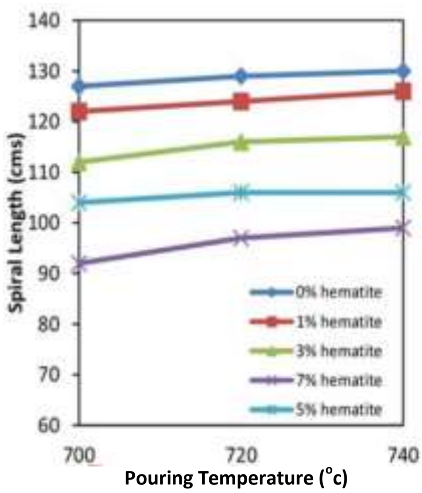

Fig. 4: Spiral length under condition of 100µm metal mold

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Flowability is proportional to pouring temperature, may be due to less viscosity at higher temperature [9-10]. Flowability mainly depends on pouring temperature. The results of Flowability using metal molds with 100 µm reinforcement sizewere shown in figure 4.

3.2 Mechanical behavior

The property of the composite materials depends on the mechanical properties of matrix as well as the reinforcement, and also it depends on bonding between matrix and reinforcement. The ultimate tensile stress values are plotted for as cast specimens in fig 5, where the mean values of 10 test values with identical testing conditions were taken. With the increment of reinforcement from 0 to 8% there is increment of UTS by 29%. Dispersion strengthening [11, 12] is mainly responsible for this effect. The same has led to the decrement in ductility [13, 14] by 64%. The young's modulus [15-20] increased by 53%.

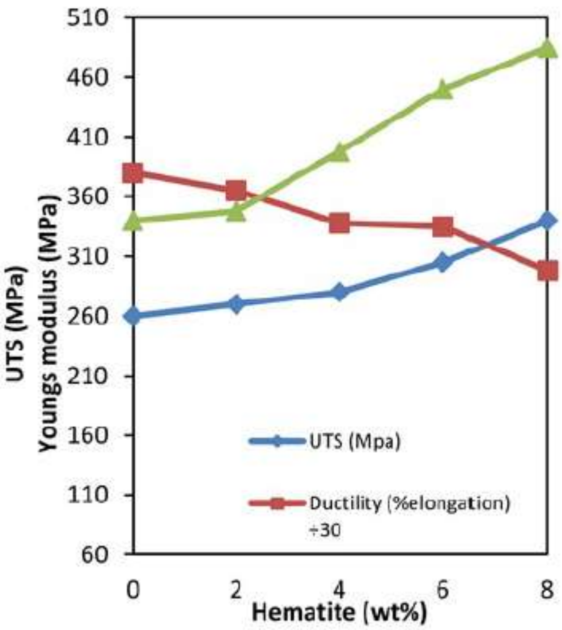

Fig. 5: UTS of Aluminum v/s hematitewt% composites

4 FRACTURE ANALYSIS

Scanning electron microscope (SEM) photographs of fractured surfaces of 6-8% reinforced composites were examined. As per the literature the metal matrix composites fracture may be due to any one of the following mechanism [21], such as matrix/reinforcement interaction, cracking of reinforcement, microstructural inhomogeneity etc. The MMC fracture mechanism is a very complex phenomenon to analyze the contribution of individual mechanism. The dominant failure mechanism may be identified studying SEM in detail.

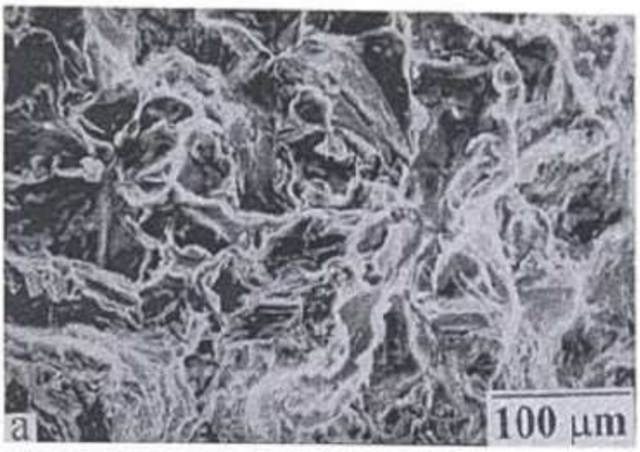

Fig. 6- SEM photograph of 5 wt% hematite composite tensile test specimen.

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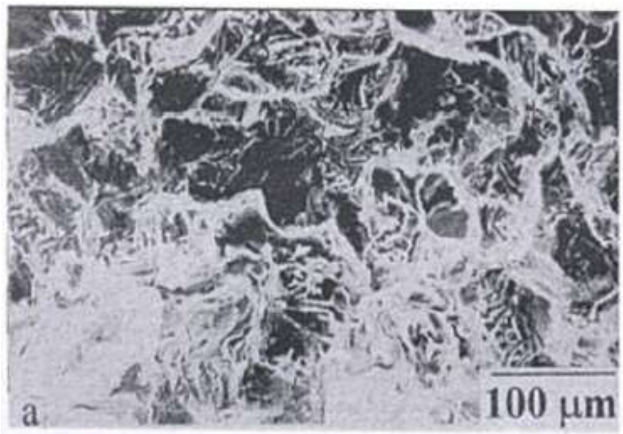

Fig. 7- SEM photograph of 7 wt% hematite compositetensile specimen

Void nucleation and growth were observed at instability area of plastic zone for pure matrix specimens [20, 21]. Few tear edges were observed in figure 6&7, which may be due to ductile fracture in micro level. Anyhow the voids are the result of cracking of reinforcing particles and surrounding matrix. The formation of voids is uniform distributed over the fractured surface.

5 CONCLUSION

The conclusions drawn from the present investigation are listed below.

- Aluminum matrix reinforced with hematite particles results in fluidity decrement, whereas higher pouring temperature increases fluidity.
- Ductility decreases with the increase in percentage of reinforcement.
- Mechanical strength (UTS, Young's modulus) enhances with the wt% of hematite.
- Limited ductility is observed in the composites.

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