SSRG International Journal of Mechanical Engineering Volume 6 Issue 6, 3-6, June 2019
ISSN: 2348 – 8360/doi:10.14445/23488360/IJME-V6I6P102

Study of Mechanical Properties and Microstructure of the Composition Al7075/Al_2O_3 Metal Matrix Composites

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Abstract

Aluminum alloys are widely used in aerospace and automobile industries due to high strength to low weight ratio and good mechanical properties such as better corrosion resistance and wear resistance, low thermal expansion, and other metals. Our work's main objective is to check the mechanical properties such as tensile strength, the hardness of aluminum-based Metal Matrix Composite, and its relation with the Alumina particulate (Al_2O_3) reinforced in the aluminum matrix. Aluminum 7075 alloy is chosen as matrix alloy, in which aluminum is the base element. The work has been processed for two different weight proportions of Al_2O_3 to the aluminum matrix (weight fractions are 3% and 7%), and the processing of the metal matrix composite is to be processed with a stir casting setup.

Keywords — *Metal Matrix Composites, Al7075, Al_2O_3, Stir Casting.*

I. INTRODUCTION

Aluminum alloys have high thermal conductivity, sufficient strength characteristics, low density, durability, recyclability, and especially low ductility and high corrosion resistance. Therefore, it can be widely used in many industry areas such as aerospace, architectural construction, marine industries, and automotive applications. Nowadays, demand increases daily, especially in the automotive industry, and aluminum does not satisfy some cases. Two or more materials. One of these materials is called reinforcement, and the other one is called a matrix. Whiskers are examples of reinforcements, metals, plastics, or ceramics are examples of the matrix material. In metal matrix composites systems, aluminum and its alloys have been drawn attention, especially for the last 20 years. This project deals with the fabrication and analysis of aluminum metal matrix composites in which Al and Al_2O_3 are used as reinforcement material. So that the production industry has begun to look for alternative engineering materials. One of the engineering materials is composite. Composite materials consist of

II. MATERIALS AND METHODOLOGY

A. *Stir Casting*

Stir casting machine is mainly used for the manufacturing of MMCs. The constituent materials are to be melted in the casting machine's furnace and solidify to provide the required composites. It is one of the simplest and cost-effective method adopted for the production of Metal Matrix Composites. Figure 1 is the layout of the stir casting apparatus. It consists of cylindrical shaped Graphite crucible for the fabrication of AMCs, as it withstands high temperature, which is much more than the required temperature. Along with that, Graphite will not react with aluminum at these temperatures. This crucible is placed in a muffle, which is made up of high ceramic alumina.

Fig. 1 Stir Casting Machine

Aluminum Alloy was melted in a crucible by heating it in a furnace at 850°C for three to four hours. The Alumina particles are preheated at 475°C for one to two hours to make their surfaces oxidized. The furnace temperature was first raised above the aluminum liquid near about 850°C to melt the Al alloy completely and was then cooled down just below the liquid's temperature to keep the slurry in a Semi-solid state. The stirrer mechanism is used to mix the two phases. The stirrer mechanism is placed near the furnace & the height of the stirrer is adjusted by changing the position of the motor connected with the stand. The stirrer is immersed into a molten state inside the crucible to provide sufficient vortex for mixing. The stirrer is maintained at 700 rpm by the controls of the dimmer stat. The preheated Al_2O_3 particles are dropped into the crucible in small amounts while stirring. After allowing the particles to mix thoroughly, then adding procedures are continued. Completing the addition of Al_2O_3 powder, the stirring process is continued for 15 minutes.

B. *Rockwell Hardness Test*

The hardness values for the matrix alloy are calculated using the Rockwell hardness testing machine. This test is performed on the polished samples of composites according to the ASTM E 03-1 & ASM Hand Book Volume-9. Rockwell hardness test at a load of 0.5Kg load for 10s is carried out on the composite samples. Various indentations at a gap of 1mm have been made, and the average of hardness readings has been taken as hardness value.

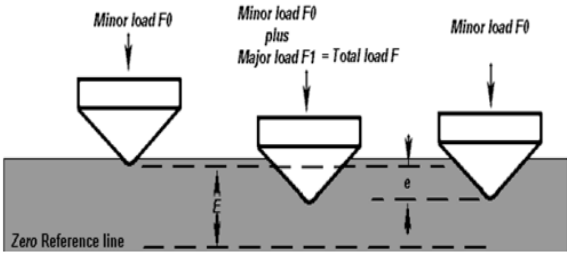

Fig. 2 Rockwell Hardness Principle

HR=E−e

Fig. 3 Specimen for Hardness Test

C. *Tensile Strength Test*

The tensile strength for the fabricated composite and Al7075 alloy is measured through the universal testing machine. The tensile test is carried out as per the ASTM 370: 2016 standard. The applied load is varied and evaluate at a crosshead speed of 50 mm/min. It is done in UTM.

Fig. 4 UTM

Fig. 5 Specimen for Tensile Test

III. RESULT AND DISCUSSION

D. *Rockwell Hardness of MMC*

Table 1: Hardness test Values of MMCs

Specimen	Rockwell Hardness(HR)
Al7075	53.5
Al7075+3wt%alumina	49
Al7075 +7wt%alumina	50

E. Tensile Strength of MMC

Table 2: Tensile Strength values of MMCs

Specimen	Yield strength (N/mm^2)	Ultimate tensile strength (N/mm^2)	% Elongation
Al7075	503	572	11
Al7075 +3wt%alumina	245.207	308.634	18.20
Al7075 +7wt%alumina	251.191	280.872	16.60

F. Microstructure Studies

*1) **Composition-1 (** Al7075 + 3%Al_2O_3)*

Figure 6 and figure 7 shows the Al7075/3%Al_2O_3 MMCs microstructure in horizontal and vertical position of specimen in the Microscope.

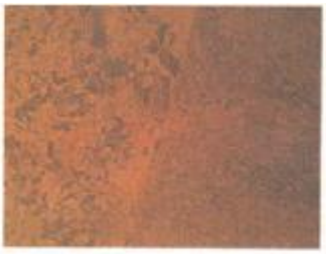

Fig. 6 The Optical Micrograph of the Al7075/3%Al_2O_3 Horizontal position of specimen in the Microscope.

Fig. 7 The Optical Micrograph of the Al7075/3%Al_2O_3 Vertical position of specimen in the Microscope.

*2) **Composition – 2 (** Al7075+7% Al_2O_3)*

Figure 8 and figure 9 show the Al7075/7%Al_2O_3 MMCs microstructure in the horizontal and vertical position of specimen in the Microscope.

Fig. 8 The Optical Micrograph of the Al7075/7%Al_2O_3 Horizontal position of specimen in the Microscope.

Fig. 9 The Optical Micrograph of the Al7075/7%Al_2O_3 Vertical position of specimen in the Microscope.

IV. CONCLUSIONS

The conclusions drawn from the present investigation are as follows

- The addition of Al_2O_3 particles in the aluminium matrix improves the hardness of the matrix material.
- It is found that elongation tends to decrease with increasing particle weight Percentage, which confirms that Alumina addition increases brittleness.
- It appears from this study that the Yield strength trend starts increases with an increase in weight percentage of Al_2O_3 in the matrix.

ACKNOWLEDGMENT

We thank our colleagues from the Eranad Knowledge City Technical campus who provided insight and expertise that greatly assisted the research. However, they may not agree with the entire conclusion of this paper. We thank our Head Of department, Prof. Mr Fazludheen Chemmala. We thank all the people who helped us.

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