"DEVELOPMENT AND ANALYSIS OF Al-Al_2O_3 METAL MATRIX COMPOSITE"

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Abstract: MMCs are made by dispersing a reinforcing material into a metal matrix. Metal matrix composites (MMC) have become a leading material among composite materials, and in particular, particle reinforced aluminum MMCs have received considerable attention due to their excellent engineering properties. These materials are known as the difficult-to-machine materials because of the hardness and abrasive nature of reinforcement element-like aluminum oxide particles (Al_2O_3). In this study, the following experimental studies are carried out in the present investigation. Development of aluminum Al_2O_3 composite are made via stir casting route using graphite mold. The composites are fabricated with Al_2O_3 in rang of 2.5 wt. %, 7.5 wt. % and 12.5 wt. %. And microstructure studies are carried out of weight % of Al_2O_3 and effect of composite, by using of advance microscope. The microstructure analysis reveals uniform distribution of reinforcement Al_2O_3.

***IndexTerms* –** Metal matrix composite, Al- Al_2O_3, Stir cast, Microstructure analysis.

1. INTRODUCTION

In the current situation, due to emerging trends and the ever-changing technology, it is necessary to introduce novel material which comprises required properties. [1] In recent years, aeronautical and transport industry utilizes composite materials for their structural and nonstructural applications, thanks to their superior mechanical and thermo physical properties.[2,3] Application of Alumina (Al_2O_3) particles as reinforcement has been reported to result in high specific hardness, improved mechanical properties at high temperatures and excellent resistance to oxidation [4]. Stir casting method is a conventional process for manufacturing MMCs, which consist of severe stirring of melt, creating vortex and introducing ceramic particles to the melt. After introduction of reinforcing particles, molten alloy is stirred for a specified time and the melt is subsequently poured into mold with a conventional casting method [5]. The aim of this study was to composite formation by reinforcement of Al_2O_3 into aluminum matrix by stir casting. Microstructure and optical emission spectroscopy of composite, as well as microstructure study of the composite were characterized with help of energy dispersive x-ray spectroscopy. And then hardness test of Al- Al_2O_3 composite sample.

Aluminium metal matrix composites (AMMCs) are the composites in which aluminium is used as the matrix and several reinforced materials are embedded into the matrix. Here we are use the base metal is pure aluminium and reinforcement is alumina (Al_2O_3).

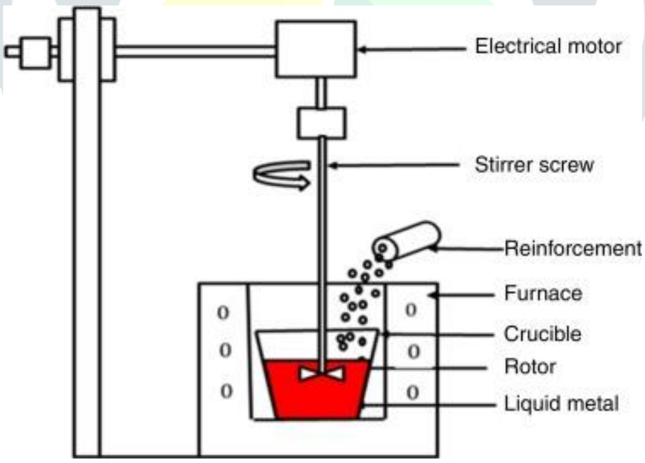

Fig 1 schematic diagram of stir casting process

2. EXPERIMENTAL PROCEDURE

2.1 Choice of material

We are used matrix material in this study is pure aluminum with 99.020% of purity. And used reinforced particle is Al_2O_3 (alumina). Average particle size is 50 um. These al2o3 particles with varying amounts of 2.5, 7.5and 12.5wt% are being used as reinforce material in preparation of composite.

Fig.2 pure aluminium ingot

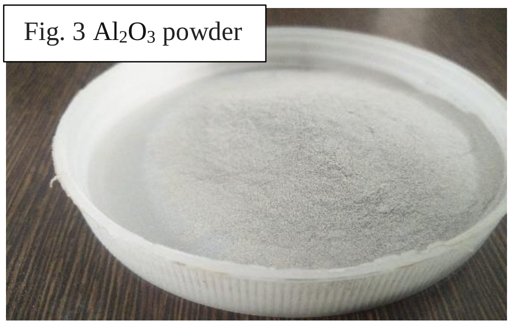

Fig. 3 Al_2O_3 powder

2.2 Stir casting

Stir casting is an economical process for fabrication aluminium matrix composite. It is liquid state method of fabrication of composites, the aluminium Al_2O_3 metal matrix composite was prepared by stir casting. There are many parameters in this process which affect the final microstructure and mechanical properties of the composites. This we took different composition of composite that are given below.

1). Pure aluminium
2). Pure aluminium-2.5wt% of Al_2O_3
3). Pure aluminium-7.5wt% of Al_2O_3
4). Pure aluminium-12.5wt% of Al_2O_3

The alumina particle were preheated before to remove the moisture. The aluminium ingot was melt in furnace, melting temperature raised up to 860^0 C. and then after adding of Al_2O_3 particle. Then melt was stirring with help of stirrer machine and stirring was maintained 7 to 8 minute after the adding the reinforced material in melted aluminium. Stirring helps in two ways (i) maintain particles in suspension state and (ii) transfer the particles into the melt. Alumina particles distribution by the vortex.[6,7] The melt with reinforced particles were poured into the preheated graphite mould. Then after melt was solidify in the mould.

Fig. 4 Experimental setup

Fig. 5 Experimental setup

2.3 Microscopy and Optical emission spectroscopy

Microscopy analysis of metals characterizes the surface and structure of the material. Metallurgical microscopes are used for metallurgical inspection. A microscope is an instrument capable of producing a magnified image of a small object. Here we used bench top type microscope. This is accomplished by using the optical emission spectroscopy. Optical emission spectroscopy using arc and spark excitation is the preferred method for trace metal analysis to determine the chemical composition of metallic sample.[8]

Fig. 6 OES testing machine

2.4 Scanning electron microscopy (SAM) and energy dispersive spectroscopy (EDS)

Scanning electron microscopy (SAM) magnifies a specific sample region using a high energy focused beam of electrons. The sample is under vacuum to ensure the electron beam stays focused and does not interact with particles in the air. When the beam of electron hits the sample, it cause secondary electron to be released from the sample which are detected to provide an image base off the topography of the surface. The sample region evaluated with SAM analysis can also be analyzed to determine the specific element that comprise the sample region by utilizing energy dispersion spectroscopy (EDS). X-rays are also released from the surface of the sample that carry a unique energy signature that are specific to element found in the sample. These X-rays are detected with the EDS detector to give elemental information about the sample.[9]

2.5 Hardness test

Hardness measurement were carried out on the pure aluminum metal ant composite sample by using Vickers hardness test machine. The basic principle, as with all common measures of hardness, is to observe a materials ability to resist plastic deformation from a standard source. The unit of hardness given by the test is known as the Vickers pyramid number (HV) or diamond pyramid hardness. The hardness number is determine by the load over the surface area of the indentation.[10]

3. RESULT AND DISCUSSION

3.1 Microstructure study

Fabrication of metal matrix composite with Al_2O_3 particles by using stir casting processes is usually difficult because of the very low wettability of alumina particles and agglomeration phenomena which results in non-uniform distribution and weak mechanical properties. In the current work, aluminum- Al_2O_3 matrix composites with micro alumina (Al_2O_3) particles were produced by stir casting method with three stages mixing combined with preheating of the reinforcing particles. The magnitude of Al_2O_3 (alumina) powder used in the composite were 2.5, 7.5 and 12.5wt % alumina.

Fig 7 experimental sample

Optical micrographs were using advance microscope. Fig. 8 shows the pure aluminium microstructure and fig. 8, 9, 10 and 11 photographs of pure Al with 2.5wt% of Al_2O_3 (fig. 9), 7.5wt% of Al_2O_3 (fig 10) and 12.5wt% of Al_2O_3 (fig. 11) particles. Fig. 10 (7.5wt% of Al_2O_3) reveals good distribution of particles. Al_2O_3 particle are not present in 2.5wt% of Al_2O_3 (fig. 9).

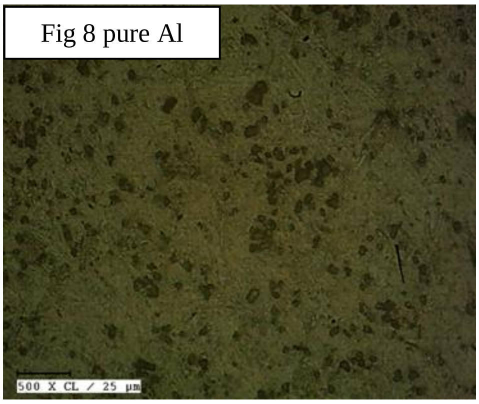

Fig 8 pure Al

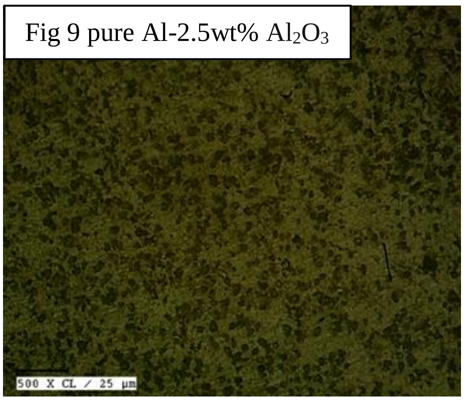

Fig 9 pure Al-2.5wt% Al_2O_3

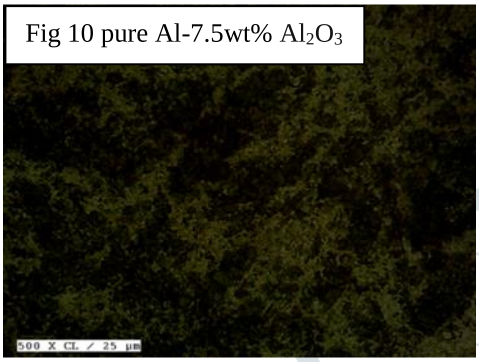

Fig 10 pure Al-7.5wt% Al_2O_3

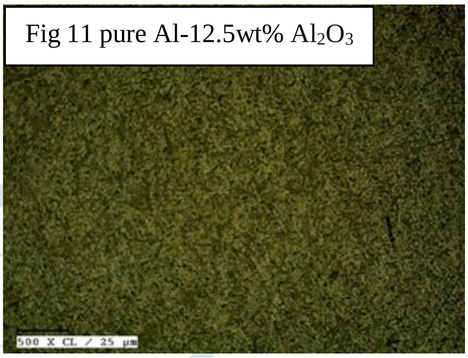

Fig 11 pure Al-12.5wt% Al_2O_3

3.2 optical emission spectroscopy test

To investigate the chemical composition of metal matrix composites by using optical emission spectroscopy (OES) method. Aluminium is a chemical element with symbol Al and atomic number 13.We have two sample, one is pure aluminium and another is 2.5wt% of al2o3 for chemical analysis. Pure aluminium has 99.020 % of al and AL-2.5wt% of Al_2O_3 has element is Fe-1.160%, Mn-0.068%, Cr-0.069%, Zn-0.288% and AL-98.900%.

3.3 Scanning electron microscopy (SAM) and energy dispersive spectroscopy (EDS) analysis

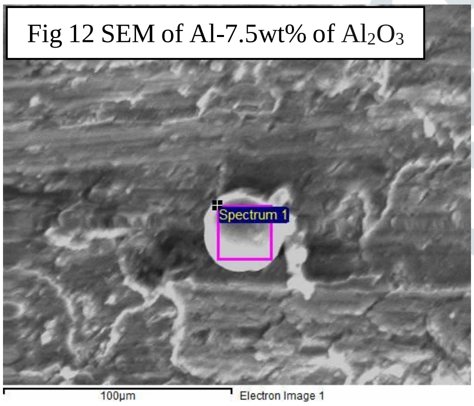

Fig 12 SEM of Al-7.5wt% of Al_2O_3

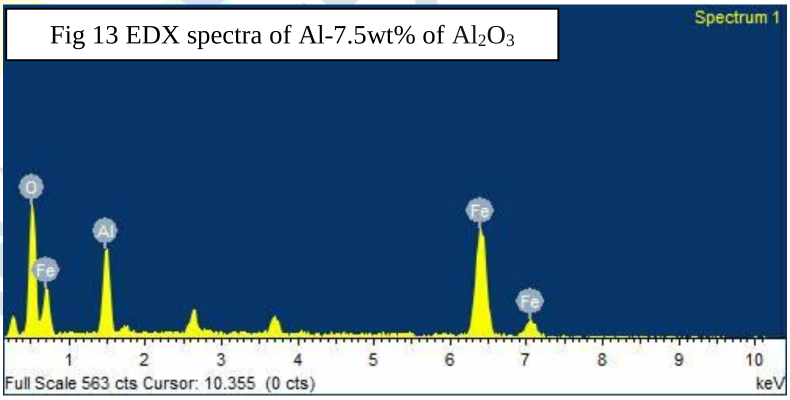

Fig 13 EDX spectra of Al-7.5wt% of Al_2O_3

Fig 12 shows the magnification SEM micrographs of aluminium sample reinforced with alumina particles. Due to small size of reinforcing particles, observation of SEM & EDX of Al-7.5wt% of Al_2O_3, fig. 13 shows the distribution of Al_2O_3 reinforcing particles in aluminium metal matrix. As can be seen many of reinforcing particles are distributes within the grain. We need to concentrate on aluminium (Al) and oxygen (O_2) because we adding the reinforcement was Al_2O_3 (alumina).and elements percentage is oxygen 12.25% and aluminium is 13.07%, Fig 12 and 13 shows the SEM & EDX spectra the iron (Fe) element in present in the interaction layer at the interface of Al-7.5wt% of Al_2O_3 composite. It happens at particular portion maybe due to melting of stir impeller body.

3.4 Hardness test

Fig. (14) Shows the comparison of hardness of pure aluminium metal matrix and composite material with composition of 2.5, 7.5 and 12.5wt% of Al_2O_3 particles. The hardness of the composite is higher than that of pure aluminium and hardness of composites increases with increasing weight percent of the particles up to 7.5wt% of Al_2O_3 than after decrease hardness at 12.5wt% of Al_2O_3 particles. Composites with 12.5wt% content of al2o3 represent lower hardness than sample 7.5wt% of Al_2O_3. This may be arisen from the presence of more porosity in composite with the higher content of Al_2O_3.

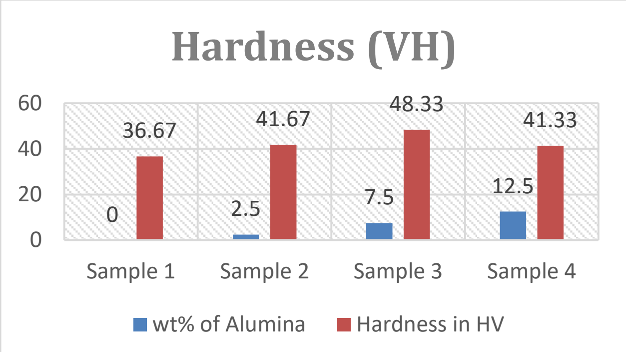

Fig 14 Variation of Hardness with different wt. % of alumina (Al_2O_3)

4. CONCLUSION

1. Aluminium metal matrix composite containing various wt. % of Al_2O_3 particles were successfully produced by stir casting process.
2. Reinforcement particles were well distributed in matrix of composite. However, particles agglomeration was observed in composites with content of Al_2O_3.
3. The microstructure studies revealed the uniform distribution of the particles in the matrix system.
4. From optical emission spectroscopy (OES) it is found that the chemical composition of pure aluminium is good.
6. Form SEM and EDX image show good distribution of particles and the amount of Al and O2 respect to 13.20% and 15.20%. And the iron (Fe 74.38%) element in present in the interaction layer at the interface of Al-7.5wt% of Al_2O_3 composite. It happens at particular portion maybe due to melting of stir impeller body.
5. Hardness of metal matrix composites is increases with increases weight percent of the particles up to 7.5wt% of Al_2O_3 than after decreases hardness at 12.5wt% of Al_2O_3. Because of presence of more porosity.

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