FABRICATION AND CHARACTERIZATION OF ALUMINIUM METAL MATRIX COMPOSITES HAVING ALUMINA AS REINFORCEMENTS AND PROCESSED THROUGH STIR CASTING TECHNIQUE

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Abstract –

Metal matrix composites (MMCs) are increasingly becoming attractive materials for advanced aerospace applications because their properties can be tailored through the addition of selected reinforcements. In particular, particulate reinforced MMCs have recently found special interest because of their specific strength and specific stiffness at room or elevated temperatures. It is well known that the elastic properties of metal matrix composites are strongly influenced by micro structural parameters of the reinforcement such as shape, size, orientation, distribution and volume fraction. Light and strong metal matrix composites (MMC) are highly anticipated for aerospace and automotive industries. The MMC's application fields can be significantly expanded if they possess enhanced strength at elevated temperatures also. This paper aims to study about the mechanical characteristics of Metal Matrix Composite (MMC) of Aluminum fabricated by Stir Casting. The MMC of Aluminum consists of Alumina(Al_2O_3) . The Static tests like Tensile, Compression, Bending and Hardness are used in characterize the properties of the MMC.

Key Words: Stir casting, particulate composite, fracture growth.

1.INTRODUCTION

Conventional monolithic materials have limitations in achieving good combination of strength, stiffness, toughness and density. To overcome these shortcomings and to meet the ever increasing demand of modern day technology, composites are most promising materials of recent interest. Metal matrix composites (MMCs) possess significantly improved properties including high specific strength; specific modulus, damping capacity and good wear resistance compared to unreinforced alloys. There has been an increasing interest in composites containing low density and low cost reinforcements. Among various discontinuous dispersion solids used, fly ash is one of the most inexpensive and low density reinforcement available in large quantities as solid waste by-product during combustion of coal in thermal power plants. Hence, composites with fly ash as reinforcement are likely to overcome the cost barrier for wide spread applications in automotive and small engine applications. Now a days the particulate reinforced aluminum matrix composite are gaining importance because of their low cost with advantages like isotropic properties and the possibility of secondary processing facilitating fabrication of secondary components. Cast aluminum matrix particle reinforced composites have higher specific strength, specific modulus and good wear resistance as compared to unreinforced alloys. Casting route is preferred as it is less expensive and amenable to mass production. Among the entire liquid state production routes, stir casting is the simplest and cheapest one. The only problem associated with this process is the non uniform distribution of the particulate due to poor wet ability and gravity regulated segregation.

1.1 Composite Materials: Composite material is a material composed of two or more distinct phases (matrix phase and dispersed phase) and having bulk properties significantly different from those of any of the constituents. Composite materials are engineering materials made from two or more constituent materials with significantly different physical or chemical properties which remain separate and distinct on a macroscopic level within the finished structure. A composite in engineering sense is any materials that have been physically assembled to from one single bulk without physical blending to foam homogeneous material. The resulting material would still have components identifiable as the constituent of the different materials.

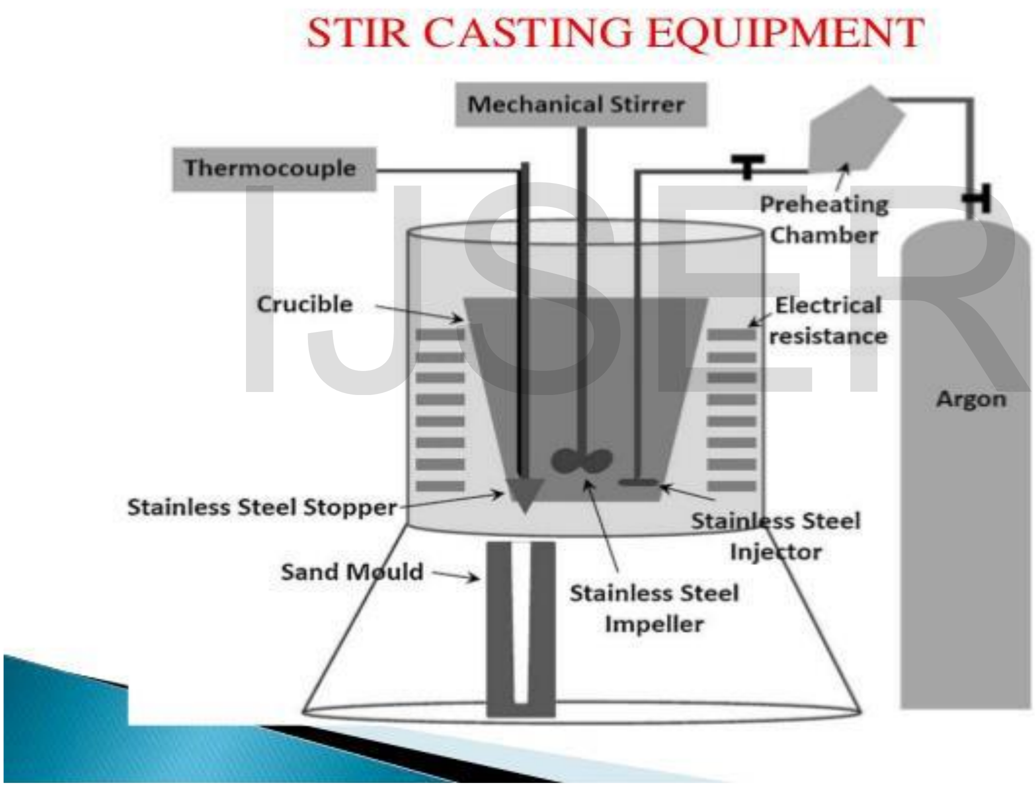
1.2 Reinforcement: Reinforcements basically come in three forms: particulate, discontinuous fiber and continuous fiber. A particle has roughly equal dimensions in all directions, though it doesn’t have to be spherical. Gravel, micro balloons and resin powder are examples of particulate reinforcements. Reinforcements become fibers when one dimension becomes long compared to others. Many of common materials (metal alloys, doped ceramics and polymers mixed with additives) also have a small amount of dispersed phases in their structures, however they are not considered as composite materials since their properties are similar to those of their base constituents.

1.3 Metal Matrix Composite (MMC): A metal matrix composite (MMC) is composite materials with at least two constituent parts, one being a metal necessarily; the other material may be a different metal or another material, such as a ceramic or organic compound. When at least three materials are present, it is called a hybrid composite. An MMC is complementary to cermets.

2. PREPARATION OF COMPOSITES

In the present investigation, the materials tested were MMCs based on aluminum alloy 7075and containing Alumina. The aluminum 7075 and composites were prepared by the vortex method. The composites of mg and zinc used for preparation of the composites were 0.5%,1% and 1.5% and 2% Addition into the molten aluminum 7075 alloy, melt above its liquids temperature 6500C, was carried out by creating a vortex in the melt using a mechanical graphite stirrer. The melt was rotated at a speed of 500 rpm in order to create the necessary vortex. The particles were preheated to 6000C and added to the melt through the vortex at the rate of 0.1 kg/min. The melt was thoroughly stirred and subsequently degassed by passing nitrogen through at the rate of 2-3 I/min. The molten metal was then poured into pre-heated permanent moulds for casting. Chemical composition of cast aluminum is as shown in table. The mould is prepared from mild steel flat plates in the shape of flat rectangle which is having size of 220mm X 45mm X 6mm.

2.1 Stir casting machine: In a stir casting process, the reinforcing phases are distributed into molten matrix by mechanical stirring. Stirring is done by introducing the stirrer in to the crucible and making it to rotate using motor. By the stirring action the reinforcement added will distribute into the metal matrix. The process of stir casting used in the metal composites with up to 30% volume fraction of reinforcement. Modeling of high strength and abrasive wear resistance aluminum alloy based casting composite materials and it's development via conventional casting(foundry method) require a wide range of experimental data concerned with composition and mechanical properties (specially the strength and abrasive wear). Data be available for optimum design and development of cast aluminum composite material.



All tests were conducted in accordance with ASTM (American Society for Testing and Materials) standards. Tensile tests were conducted at room temperature using a universal testing machine (UTM) in accordance with ASTM Standard E 8-82. The tensile specimens as shown in the machined from the cast composites with the gauge length of the specimens parallel to the longitudinal axis of the casting.

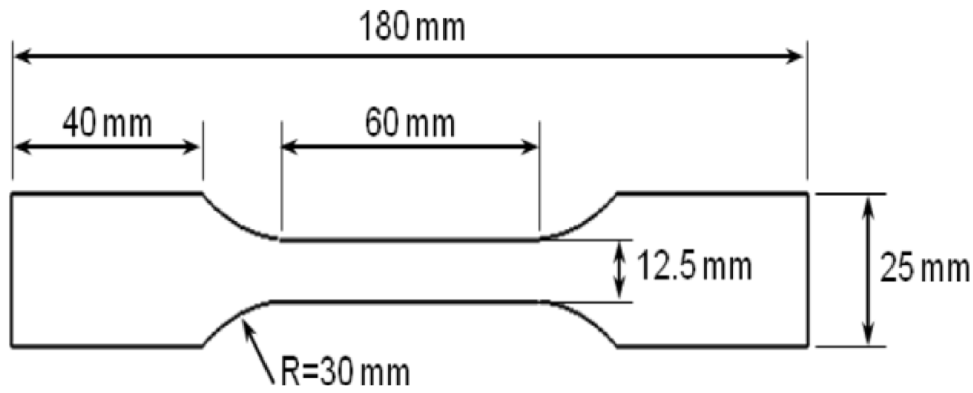


Figure selection of sample for testing

3. Tensile test: The X-Y plots are obtained. However the computer can also plot an engineering stress-strain curve directly, using the appropriate conversion factors and specimen area and gauge length. After the specimen is broken, the final length and diameter are measured. The fracture type and the fracture surface are investigated, in order to determine the fracture mode.

Figure tensile test specimen

Table -1: TENSILE TEST

Specimen	Ultimate tensile Strength (N/mm2)	% of Elongation	Yield Stress(N/mm2)
AL7075+Al2O3=0.5%	126.625	1.62	100.057
AL7075+Al2O3=1.0%	152.648	3.94	133.395
AL7075+Al2O3=1.5%	146.175	2.12	115.546
AL7075+Al2O3=2.0%	206.712	3.22	170.465

3.1 COMPRESSION TEST: A compression test determines the characteristics of materials under crushing loads. The sample is compressed and deformation at various loads is noted. Compressive stress and strain was calculated and plotted as a stress strain diagram which is used to determine elastic limit, proportional limit, yield strength and yield point. Compression Tests are of extremely high importance, because it helps to calculate the different material properties that are applicable to hot as well as cold metal forging employed for different metal forming applications. It becomes important to find the suitable load to carry out the operations. Load depends on the materials and flow stress. Flow behavior of aluminum at different strain rate can be determined by establishing a relationship between flow stress, strain and strain rate.

Table -1: COMPRESSION TEST

Specimen Description	Compression strength(N/mm2)	Load at peak(N)
AL7075+Al2O3=0.5%	27.227	2747.00
AL7075+Al2O3=1.0%	18.398	1849.00
AL7075+Al2O3=1.5%	26.340	2671.00
AL7075+Al2O3=2.0%	29.012	2907.00

A compression test is any test in which a material experiences opposing forces that push inward upon the specimen from opposite sides or is otherwise compressed, “squashed”, crushed, or flattened. The test sample is generally placed in between two plates that distribute the applied load across the entire surface area of two opposite faces of the test sample and then the plates are pushed together by a universal test machine causing the sample to flatten. A compressed sample is usually shortened in the direction of the applied forces and expands in the direction perpendicular to the force. A compression test is essentially the opposite of the more common tension test. 3.2 Hardness test Hardness is the property of a material that enables it to resist plastic deformation, usually by penetration. However, the term hardness may also refer to resistance to bending, scratching, abrasion or cutting. The Vickers hardness method applies a predetermined test load to pyramid shape penetrator of fixed diameter which is held for a predetermined time period and then removed. The resulting impression is measured across at least two diameters usually at right angle to each other and these results averaged.

Table -1: HARDNESS TEST

Specimen Description	Hardness(HV 0.1)
AL7075+Al2O3=0.5%	102.6
AL7075+Al2O3=1.0%	104.6
AL7075+Al2O3=1.5%	109.3
AL7075+Al2O3=2.0%	111.3

Hardness and compression (in terms of percentage elongation) obtained for the composites containing various amounts of particles. Each value represented is an average of three measurements. The results are repeatable in the since that each individual result did not vary the mean value. All the results are represented are graphically shown.

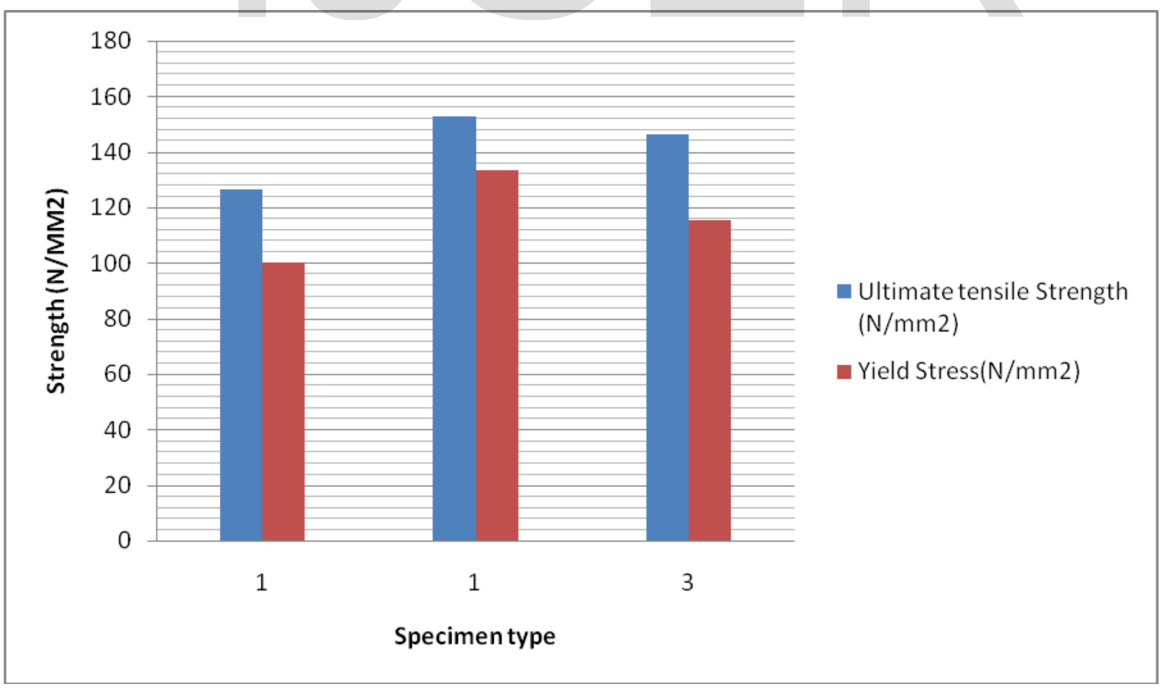


Fig. Tensile Test

The preparation of test specimens depends on the purposes of testing and on the governing test method or specification. A tensile specimen is usually a standardized sample cross section. It has two shoulders and a gage (section) in between. The shoulders are large so they can be readily gripped, whereas the gauge section has a smaller cross section so that the deformation and failure can occur in this area.

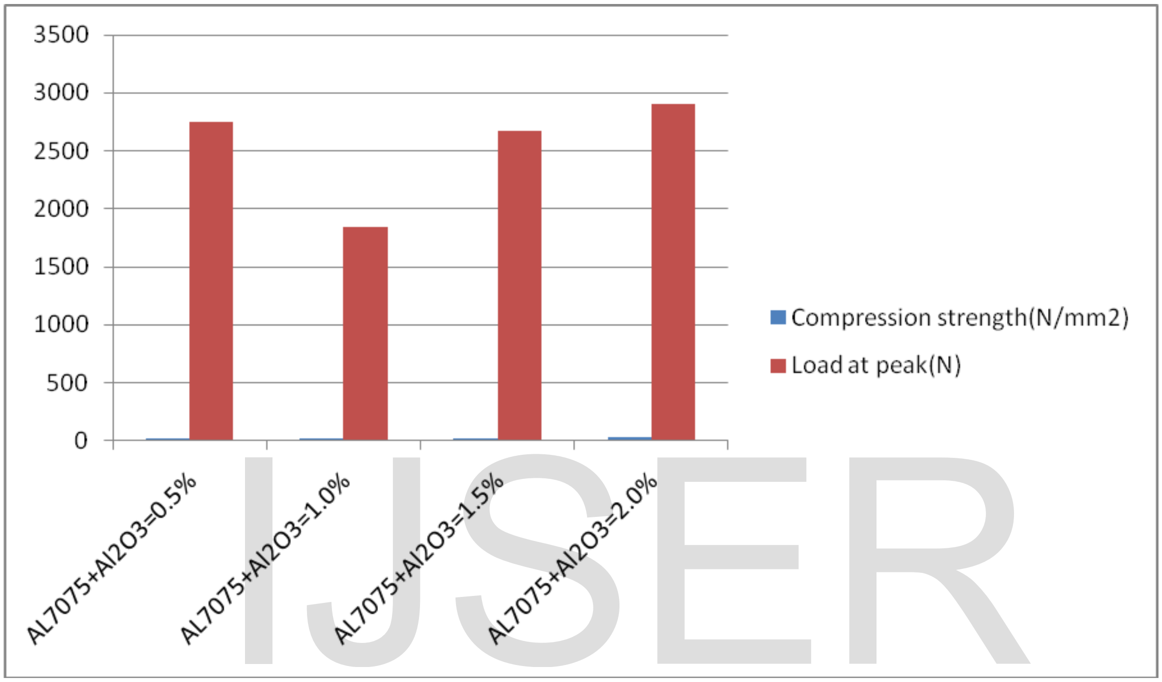


Fig. compression test

The goal of a compression test is to determine the behavior or response of a material while it experiences a compressive load by measuring fundamental variables, such as, strain, stress, and deformation. By testing a material in compression the compressive strength, yield strength, ultimate strength, elastic limit, and the elastic modulus among other parameters may all be determined. With the understanding of these different parameters and the values associated with a specific material it may be determined whether or not the material is suited for specific applications or if it will fail under the specified stresses.

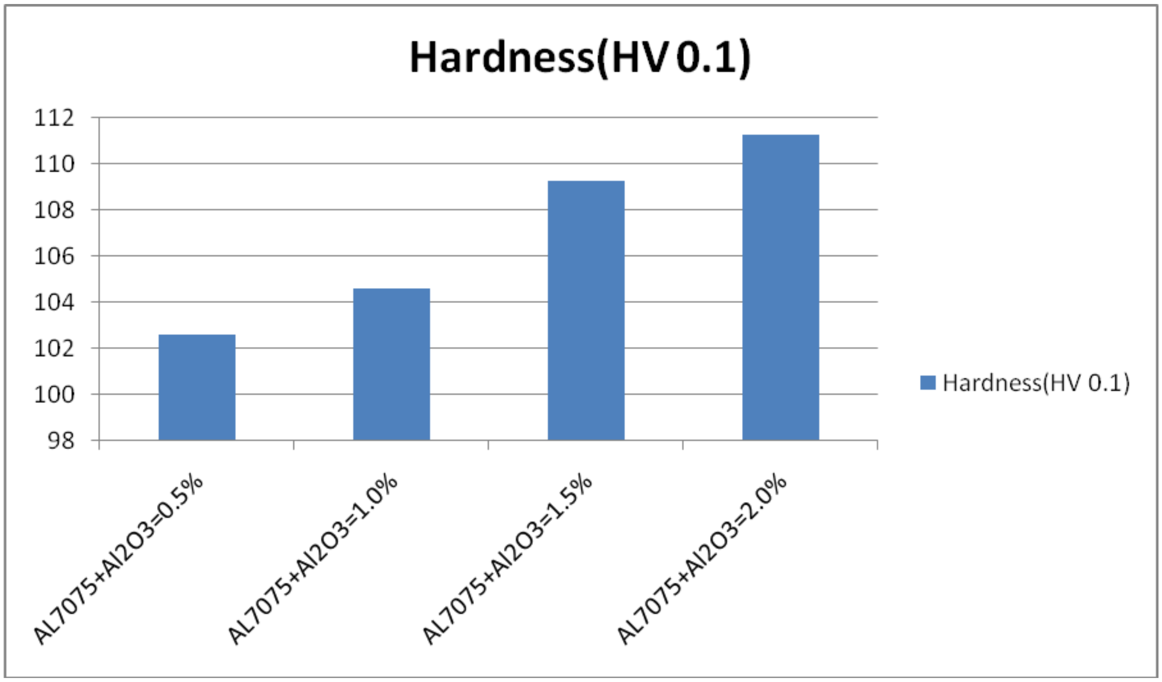


Fig. Hardness test

The Vickers test is often easier to use than other hardness tests since the required calculations are independent of the size of the indenter, and the indenter can be used for all materials irrespective of hardness. The basic principle, as with all common measures of hardness, is to observe the questioned material's ability to resist plastic deformation from a standard source. The Vickers test can be used for all metals and has one of the widest scales among hardness tests. The unit of hardness given by the test is known as the Vickers Pyramid Number (HV) or Diamond Pyramid Hardness (DPH). The hardness number can be converted into units of Pascal's, but should not be confused with pressure, which uses the same units. The hardness number is determined by the load over the surface area of the indentation and not the area normal to the force, and is therefore not pressure

4. CONCLUSIONS

Pouring temperature plays a major role in the strength of the cast. Blow holes tend to reduce the strength of the cast. The percentage of Alumina plays a major role in determining the strength of the cast. More the percentage of Magnesium, more care should be taken during casting and sintering because Magnesium tends to catch fire, vaporizes other reinforcements as well. The results confirmed that stir formed Al alloy with (Al_2O_3) reinforced composition is clearly giving the best results. The aluminum metal matrix composites sought over the conventional materials in the field of aerospace, automotive and marine application owing to their excellent improved properties such as hardness and tensile strength at room and elevated temperatures and hence metal matrix composites are being extensively used. These materials are of much interested to researches from few decades.

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