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Experimental Study on Mechanical Properties of Aluminum Al-356 Alloy Metal Matrix Hybrid Composites

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Abstract : According to current demand, composites are extensively utilised in many different industries because to their excellent strength, hardness, density, and low weight. A hybrid composite reinforced metal matrix where the metal is either magnesium alloy with a significant amount of aluminium content, aluminium, or an aluminium alloy. The metal matrix contains a hardening agent, which is at least one intermetallic compound of aluminium with at least one additional metal selected from iron, nickel, titanium, zirconium, cobalt, and niobium, in addition to the reinforcement, which is usually alumina. The intermetallic compound(s) can be formed in the composite by adding at least one additional metal as a powder to the molten metal matrix during composite preparation, or they can be introduced as a powder to the metal matrix during composite creation. This research primarily focuses on the experimental investigation of the mechanical properties of AI356 MMC, with a fabrication based on aluminium alloy, silicon carbide, and graphite acting as reinforcement. Based on material and mechanical properties, an experimental study was conducted on hybrid metal matrix composite (Al356 MMC), which is made of aluminium alloy with reinforcements consisting of silicon carbide and graphite in percentages of 3.5, 6.5, and 9.5 %weight each, using a stir casting process. Specimens are prepared and tested using a variety of destructive and micrograph testing techniques in accordance with ASTM Standards.

Index Terms - Composites, Metal Matrix Composites, Stir Casting, AI356 MMC, Optical Microscope

INTRODUCTION

Present scenario rapid developments in engineering and technology have a huge demand for lightweight and high-strength materials with good tensile, wear, and hardness properties for particular use in aeronautical, automobile, medical, marine, and defence departments. Aluminium and their alloys are espoused in enormous applications, in particular aeronautical, automobile, medical, sports, defence, petrochemical engineering, and marine, outstanding to their superb properties like high strength, good thermal conductivity, high wear, and corrosion resistance [1]. Basically, composites are prepared by two or more phases which are bounded together. The choosing of metal matrix composites based on various characteristics is compared with different composites [2-3]. This type of Metal Matrix Composites is mostly preferable because of it have high specific strength, damping capacity, good wearing resistance, specific modulus is significantly improved their properties and compared to reinforced potential properties like more strength, toughness [4].For continuous growth of various applications MMC are basically less weight prepared by various light metal alloys are aluminum, titanium, copper, magnesium, silicon etc. with the reinforced particles, whiskers and fibers [5-6]. Light weight metal based alloys are replaced with MMCs [7]. MMC are development and utilization are based on present and future demand of various applications like aerospace and automotive [8-10]. Aluminum is an abundant element from the earth ores and its is used in composites prepared by various combined properties like mechanical, chemical, and electrical can be combination of properties such as; electrical, mechanical and even chemical can be attained with different reinforcements. Various researchers going on MMC and approach based on the reinforcements [11-13]. Main goal of this experimental investigation work based on reinforcements and this size is affected in MMC properties. Various authors are deposited based on experimental research work and concluded, with and without copper coated SiC particles used to find mechanical behavior of 6061 aluminum alloy reinforced materials[14], increasing the hardness and density of the material through increasing the content of ceramic reinforcement and its leads to decreasing of porosity [15], by using squeeze casting method 5210 Al/SiCp composite are fabricated with 55 vol. % of SiCp[16], The bonding strength is increased as the particle size

is reduced. Larger particle size produces defects and decreases the strength of the material due to formation of larger flaw. By addition of SiC particles are leads to increase the material hardness and modulus of elasticity of A356-10 [17] and addition of magnesium to the composites increases the weld ability. Tensile strength is increases by increasing of particle size throughout the unreinforced aluminum [18]. Al356 is a family of an alloy in AISI with many applications like automotive and aerospace industries. To reaches the required properties kike mechanical and physical by applying heat treatment process.

EXPERIMENTAL METHODOLOGY

Table.1 Chemical compositionofA356 Alloy

Element Wt(%)	Element wt(%)
Si	6.5
Mg	0.4
Cu	0.05
Ti	0.06
Zn	0.03
Fe	0.09
Al	Balance

Table.2 PropertiesofA-356Alloy

Type of Properties	Values
Tensile strength	226-263 MPa
Yield strength	165-185 MPa
Elastic modulus	72.4 Gpa
Elastic modulus	55 Hv
Density	2.68 g/cc
Coefficient of thermal expansion	23.5 µm/m.k
Thermal conductivity	151-155 w/m.k

Proportions of Samples: The following are the proportions of the samples to be prepared for testing as shown in Table.3

Table.3 Various Proportions Samples

Sample Number	Proportions
Proportion (S1)	Pure Al-356
Proportion (S2)	3.5% wt SiCp+3.5% graphite balance Al
Proportion (S3)	6.5% wtSiCp + 6.5% graphite balance Al
Proportion (S4)	9.5 % wtSiCp + 9.5% graphite balance Al

As compare to all casting process in engineering fields, stir casting is suitable method for metal matrix composite because it's economically cost is low and this method is gives better properties like physical and mechanical of aluminum alloy matrix based on applying stirrer speed, soaking time and preheating. During fabrication of the MMC composites, A356 is act as a base metal and reinforcements is done through silicon carbide and graphite with the proportions of are to be considered reinforcements like 3.5, 6.5 and 9.5%.

Uniformly distribution of reinforcements takes places in the form of powder around 120 microns through this process for aluminum alloy matrix is notices during this process.

Figure.1 Electrical Arc Furnace with Stir Casting Method

The crucible container is heated to around the temperature and melting of aluminum alloy is 750^{0}C and 630–650^{0}C.Whenever reach this temperature reinforcements is mixed with the molten metal by stirrer with 700 rpm by continued for about 60sec. Five reinforced metal matrix hybrid composite sample are obtained by applying stress reliving process temperature and time is 100^{0}Cand 9 to 11hrs. Finally, composite specimens of Wt% of 3.5, 6.5 and 9.5% reinforced aluminum alloy hybrid MMC are obtained.

Figure.2 Prepared Specimens

Microstructure Analysis: The samples required for the microstructure analysis are of about 10 to 18 mm in length. Preparatory specimens like polished surface is obtained from belt grind and polished about 15mm. and various then these are polished with the help of emery papers likes 1/0, 2/0, 3/0 and 4/0.

RESULTS AND DISCUSSION

Various microstructures are observed, reinforcements are uniformly distributed. In Pure Al-356 it is notice that microstructure is looks like dendrite, and by addition of the reinforcement, the reinforcements are uniformly distributed. Black spots appear in the microstructure due to increases the reinforcement is shown in the Figures 3 to 6.

Figure.3: Sample(S1) of Pure A-356

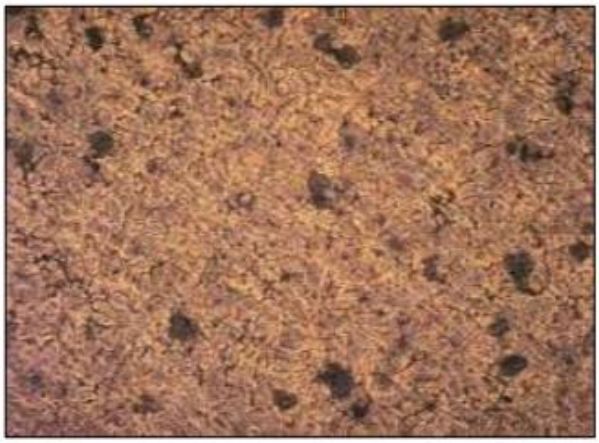

Figure.4: Sample (S2) of 3.5% wtSiCp3.5% wt Graphite.

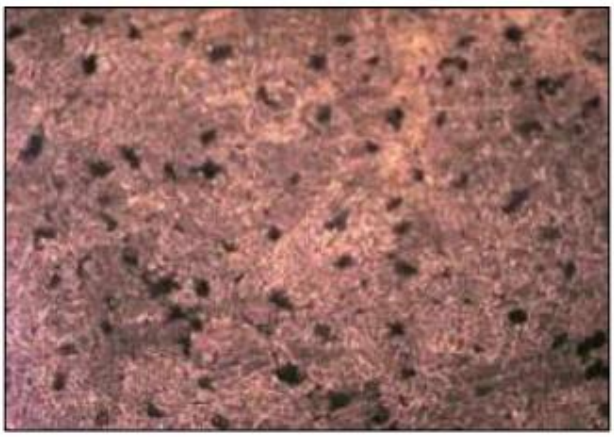

Figure.5: Sample (S3) of 6.5% wtSiCp 6.5% wt Graphite

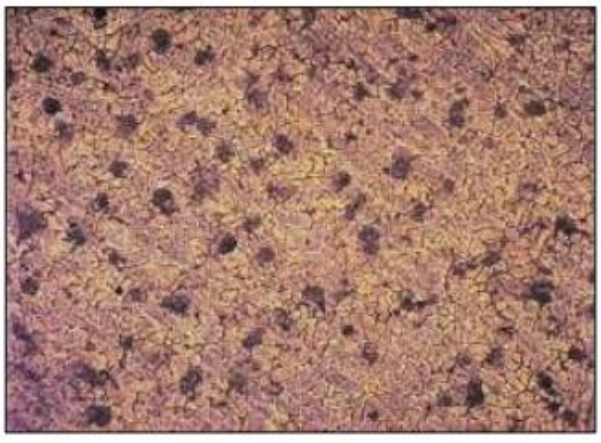

Figure.6: Sample (S4) of 9.5% wtSiCp 9.5% Graphite

Hardness

The unit of hardness given by the test is known as the Vickers Pyramid Number (HV) or Diamond Pyramid Hardness (DPH).

Table.4 DensityValues from Theoretical and Measurement

Sample Number	Theoretical Density (g/cc)	Measured Density (g/cc)
1	2.685	2.685
2	2.687	2.643
3	2.742	2.684
4	2.770	2.705

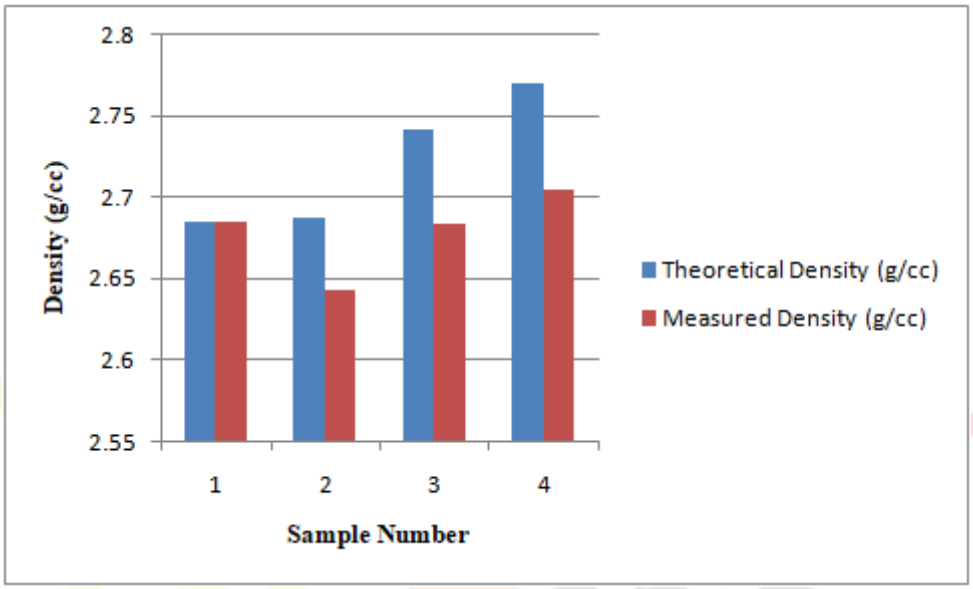

Figure.7 Density Vs Sample Number

It is notice that from the Figure.7 the density will decrease due to adding of reinforcement in pure alloy material. The porosity of the different samples can be summarized in the following Table.5It is notice that reinforcement is increased its lead to increase the material porosity.

Table.5 Porosity of Different Samples

Sample Number	Porosity
1	1.42
2	1.66
3	2.11
4	2.36

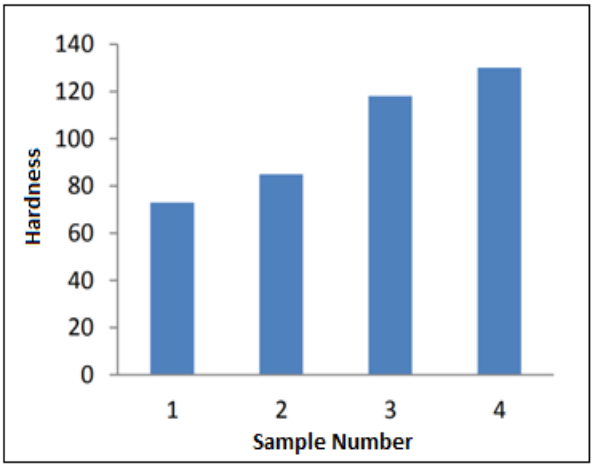

Figure.8 Hardness Vs. Sample Number

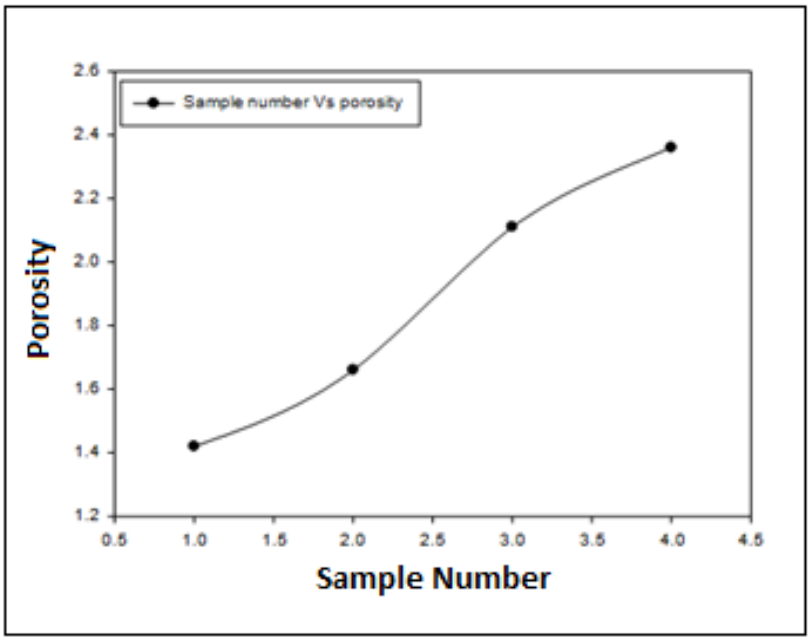

Figure.9 Porosity Vs. Sample Number

Hardness and Porosity shown in the Table.5 and Figure.8 and 9 tabulated the bulk densities of the alloy and composites in as-cast condition and from calculations. In the cast condition, composites show a lower density values than the calculated values by rule of mixture. Further, it's observed by increasing reinforcement concentrations its leads to various densities found in the materials.

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