EXPERIMENTAL INVESTIGATION ON MECHANICAL TESTING OF AL7085/ALUMINA NANO COMPOSITES BY USING STIR CASTING METHOD

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Abstract - *Demand for aluminum hybrid metal matrix composites has recently increased due to improved mechanical properties to meet the needs of advanced engineering applications. The performance of these materials is greatly influenced by the choice of the right combination of reinforcement materials. Alumina is the most common reinforcement used in the manufacture of these composites. In this publication, an attempt was made to produce an Al7085 Nano composite fortified with particles of different weight fractions of Al_2O_3 by a stir casting process. Experimental studies were performed on the composites prepared to study the mechanical properties of the addition of some reinforcements. Compare the mechanical properties of the proposed composites Ultimate tensile strength, yield strength, impact strength, hardness with those of the unreinforced Al7085. The experimental study also aims to observe changes in properties with changes in the weight fraction of the Al_2O_3 reinforcement*

***Key Words*: 7085Al alloy; Al_2O_3; Composite; Fabrication; AMMCs; Stir Casting; Micro analysis**

1. INTRODUCTION

A material is a substance that makes up a product or a combination of two or more substances. In all industries, materials are the primary input for manufacturing final products. Due to the current competitive situation in the market, almost all industries plan to improve the quality of their products with minimal effort. Therefore, all industries adopt the principles of materials science to select or manufacture materials that improve the quality of the final products manufactured. It is based on atomic bonds, structures, physical, chemical, thermal and electrical properties. This classification facilitates the selection of materials for a variety of industrial applications. Recently, the use of composites in the technical field has increased significantly due to their improved properties compared to existing materials. Stress fracture is the net cross-sectional fracture of a part or deterioration of the composite on a micro scale when one or more layers of the composite are disrupted by the stress of the matrix or the fracture of the bond between the matrix and the fibre. It may be some composites. Composites are made up of two or more different materials that are chemically and physically different from each other. Composites are completely different from alloys. In alloys the two elements form a homogeneous solid solution, whereas in composites the two elements are separate and distinct in the finished structure. In general, composites are made up of two main components: matrix and reinforcement. Reinforcing material is a material that is added to the matrix to increase its strength. A metal matrix composite material (MMC) is a composite material of two or more constituent materials, the matrix material must necessarily be a metal or a metal alloy, and the other materials are also metals or ceramics or any organic compound. When there are three or more materials in a composite, it is called a hybrid composite. The liquid manufacturing process is the most widely used method for manufacturing metal matrix composites due to its cost effectiveness. In this process, the metal matrix is melted by heating it in a furnace, then the molten matrix is poured over the reinforcement or the reinforcement is added to the molten matrix. Various techniques in the liquid state manufacturing process are stir casting, die casting, composite casting, infiltration, and in-situ manufacturing.

2. METHODOLOGY

Literature reviews provided insights into alloy research work and the gaps found there, allowing them to identify problem areas and find solutions to achieve their goals through experimental methodologies. The first step is to select the material for the casting and focus on the application of the material. Then proceed to the stirring casting process. This process requires the material to be prepared by calculating the weight and weight Precent of the composite. After the stirring casting process is complete, the ingots are collected and moved to the machining process according to Compare the mechanical properties of the proposed composites Ultimate tensile strength, yield strength, impact strength, hardness with those of the unreinforced Al7085.

3. EXPERIMENTAL DETAILS

3.1 Al7085 Aluminium alloy

In this project, Al7085 Aluminium alloy is chosen as matrix material. It has high strength to weight ratio, better hardness and good yield strength. Table-1 represents the composition of Al7085 alloy.

Table-1: Composition of Al7085 alloy

Composition	percentage
Zn	7.0 – 8.0
Si	0.06
Fe	0.08
Ti	0.06
Cu	1.3- 2.0
Mn	0.04
Mg	1.2 – 1.8
Cr	0.04
Others	0.65
Balance	Al

3.2 Alumina Nano powder

Alumina is an important material widely used in ceramics, electrical devices, metallurgy and composites. The most common methods are milling machines, chemical vapour deposition, vapour deposition, hot water and incinerator processes. Al_2O_3 is important for use in the manufacture of aluminium metals, as an abrasive for hardness, and as a refractory for its high melting point (2072 °C). Table -2 shows the characteristics of the alumina powder APS 20-30 nm alumina Nano powder purchased from the market.

Table -2: Properties of Alumina Nano powder

Engineering Property	values
Density (g/cc)	3.72
Elastic Modulus (GPa)	370
Melting point (^{0}C)	2015
Poission ratio	0.26
Hardness(kg/mm2)	1500
Compressive Strength(MPa)	2560

3.3 Stir casting setup

Fig -1: Stir Casting Setup

The Al7085 aluminium alloy plate was cut to the required mass and placed in a graphite crucible. The crucible was placed in an induction furnace together with the base metal and heated to a temperature of 650 ° C. Once the base material had melted, a degassed tablet was added to remove impurities and gaseous inclusions present in the base material. After that, impurities generated on the surface of the molten metal were removed. To increase the wettability between the Al7085 and Al_2O_3 reinforcements, 1% magnesium (Mg) powder [2] was added to the molten metal and the alumina Nano powder was preheated to 700 ° C. After adding 1% magnesium powder, preheated Al_2O_3 powder was added to the molten metal. The stirring blade was slowly inserted into the molten metal and stirred at a rate of 235 rpm for 15 minutes until the temperature dropped to 520 ° C., during which time the mixture reached a slurry state. After stirring again for 15 minutes, the mixture was heated again to 680 ° C. to reach a molten state. Finally, the molten metal was poured into a mould having a length of 10 cm, a width of 10 cm, and a thickness of 15 mm. The Al7085 / Al_2O_3 Nano composites were manufactured by varying the fortification rates by 0.5%, 1%, and 1.5% in a stirring casting setup, as shown in Figure -1.

4. TESTING OF COMPOSITES

4.1 Tensile Test

Materials used in engineering applications are typically selected based on properties such as tensile strength, yield strength, and modulus of elasticity. Tensile testing is the most common method for determining these mechanical properties. In this study, tensile tests were conducted on a universal testing machine (UTM), and the developed hybrid composite material samples A, B, and C were prepared according to ASTM standards. The average tensile strength and yield strength values measured for samples A, B and C were 247 MPa, 256 MPa and 268 MPa, respectively, in Figures 4 and 5.

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4.2 Hardness Test

In this study, the hardness of samples A, B, and C of the Alumina nano composite was measured using a Brinell hardness tester with an indenter diameter of 5 mm. A load of 5 kN was applied to each sample for 30 seconds. The BHN values obtained for samples A, B and C were 128, 139 and 132, respectively.

4.3 Impact Strength Test

The impact strengths obtained for Samples A, B and C were 1.83J / mm^2, 1.85J / mm^2 and 1.80J / mm^2, respectively. Performed on a pendulum tester using a cantilever test piece with a length of 75 mm, a cross section of 10 mm x 10 mm, a standard notch of 45 °, and a depth of 2 mm. The impact strengths obtained for Samples A, B and C were 1.83J / mm^2, 1.85J / mm^2 and 1.80J / mm^2, respectively.

5. RESULTS AND DISCUSSION

5.1 FABRICATED COMPOSITES

The composites were prepared using stir casting techniques with two different compositions of 0.5 wt%, 1 wt%, and 1.5 wt% reinforced alumina nanoparticles, respectively, as shown in Figures 2 and Figure 3

Fig -2: Al 7085 + 0.5 % Al_2O_3 and Al 7085 + 1 % Al_2O_3

Fig -3: Al 7085 + 1.5 % Al_2O_3

The values of mechanical properties of Al7085 alumina nano particles given in the table.-3

Table -3: Mechanical properties of the proposed Alumina Nano MMC for different specimens

MATERIAL	**Pure Al7085**	**AL7085 +0.5% Al2O3**	**AL708 5+1% Al2O3**	**AL7085 +1.5% Al2O3**
YIELD STRENGTH (MPa)	130	142	158	150
BHN	120	128	139	132
UTS (MPa)	230	247	256	268

5.2 Tensile Strength

The ultimate tensile strength of Nano composites depends on the amount of reinforcement. This is shown in Figure 4 and figure 5. The extreme tensile strength values for Samples A, B, and C shown in Table 6.1 indicate that the ultimate tensile strengths for Samples B and C are significantly increased compared to the base metal. The tear strengths of Samples A, B and C are increased by 7.39%, 11.30% and 16.52%, respectively, compared to the base metal. The slight improvement in the strength of sample A may be due to inadequate adhesion between the reinforced particles and the matrix compared to the other two samples of the aluminum Nano composite. In the graph variation of tensile strength in different percentages is shown in **Chart -1.**

Fig -4: Before Testing of specimens A,B and C

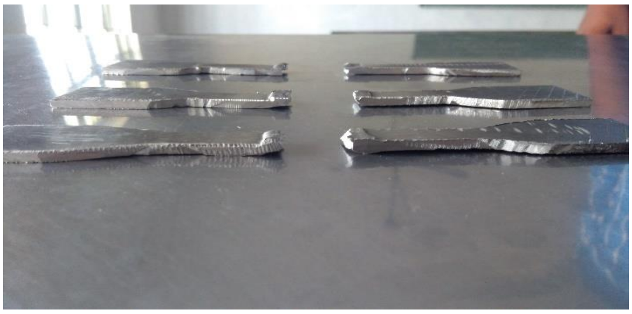

Fig -5: After Testing of specimens A,B and C

5.3 Hardness

The hardness of Samples A and C increased by 6.6% and 10%, respectively, compared to the non-reinforced metal matrix (base material). However, for Sample B, the hardness was dramatically improved by 15.8% compared to the unreinforced metal matrix. Chart -2 shows that the BHN value of hybrid composites is higher with 1% reinforcement. It also shows that increasing the amount of reinforcement reduces the BHN value.

5.4 Yield strength

The yield strength of a hybrid composite depends on the amount of reinforcement. This is shown in Chart -3. The yield strength values for Samples A, B, and C shown in Table 6.1 indicate a significant increase in the yield strength for Samples B and C compared to the base material. The yield strengths of Samples A, B, and C are increased by 9.2%, 21.5%, and 15.38%, respectively, compared to the base metal.

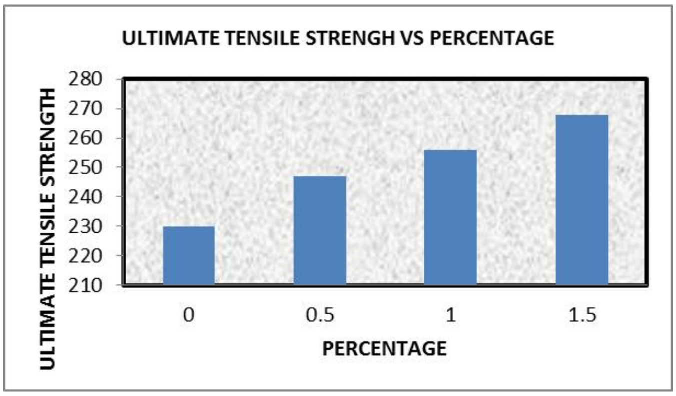

Chart -1: Ultimate tensile strength vs Percentage

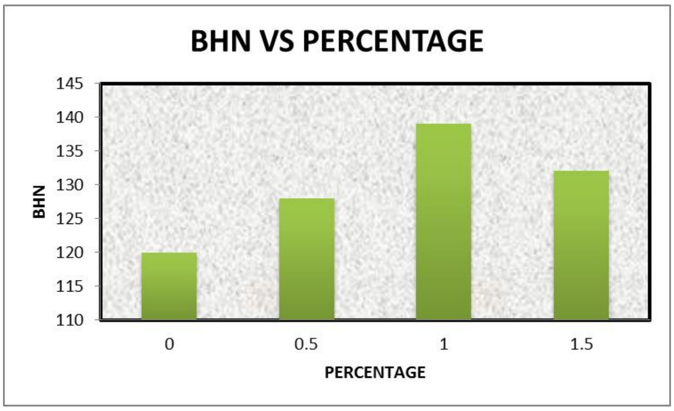

Chart -2: Hardness(BHN) vs Percentage

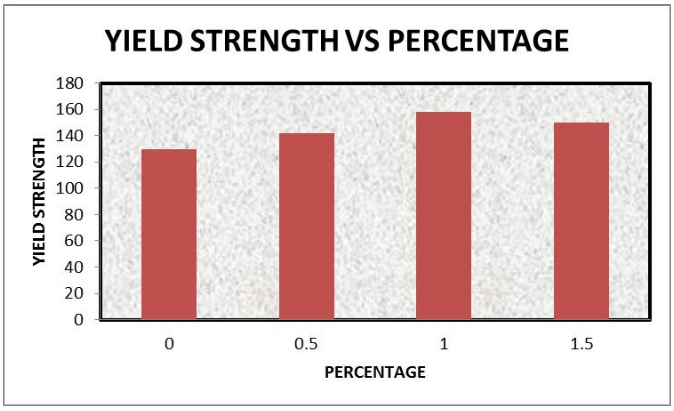

Chart -3: Yield Strength vs Percentage

6. CONCLUSIONS

This experimental study aims to produce non-metal ceramic reinforced materials Al_2O_3 and Al7085 Nano metal matrix composites using stirring casting techniques and to investigate their mechanical properties. The density of the proposed composite was reduced, and mechanical properties such as hardness, tensile strength, and yield strength were slightly reduced compared to those of the Al7085 NMMC reinforced with a single ceramic reinforcement. Made with equal amounts of Al_2O_3 (0.5 wt%, 1 wt%, 1.5 wt%), NMMC has a tensile strength of 247 MPa, a yield strength of 142 MPa and a hardness of 128 BHN. This study is limited to observing changes in mechanical properties while increasing the weight fraction of Al_2O_3 in three steps (0.5 wt%, 1 wt%, 1.5 wt%, respectively). The following remarks are possible. SEM images showed that the Al_2O_3 reinforced particles were completely wet with the Al7085 matrix material. Brinell hardness tests have shown that the hardness increased from 128BHN to 132BHN and the composite strengthening rate increased by 0.5% to 1.5%. The results of the tensile test show that the tensile strength increased from 247MPa to 268MPa and the reinforcement ratio of the composite increased from 0.5% to 1.5%. The results of the yield strength test showed that as the composite reinforcement rate increased from 0.5% to 1.5%, the yield strength increased from 142MPa to 150MPa. Compared to the base material Al7085, the proposed composite shows good improvements in tensile strength, yield strength, and hardness.so the best composition occurs Al7085 +1% Al_2O_3 of However, there is no significant change in impact strength.

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