Analysis of Mechanical Properties for Aluminum 7029 with Zro2 & Graphite Composite

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Abstract- **The present work aims to develop Aluminium metal matrix composites by incorporating of reinforcements such that combination of best properties could be achieved. The metal base selected was Aluminium 7029 and it is reinforced with varying volume percentage of Zirconium dioxide & Graphite. These AMMC were developed by using crucible casting technique, in which predetermined reinforcement is added to the molten matrix is stirred well to obtain desired castings. The Rockwell hardness test revealed that AL85%, Zro215 % & Graphite 5% composite shows highest hardness value of HRB – 61, Impact shows that AL80%, ZrO2 10% & Graphite 10% composite has highest value - 11 Joules/mm2 & highest tensile strength - 113.90 N/mm2. Highly reinforced composites show higher hardness and Lower percentage of reinforcement has high tensile strength and Moderate reinforcement shows high impact strength variations due to the agglomeration of particles.**

Index Terms- **Analysis, Mechanical Properties, AL7029, ZrO2, Graphite**

I. INTRODUCTION

Composite materials are 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. In an advanced society we all depend on composite materials in some aspect of our lives. Fiber glasses were developed in the late 1940s.

The Fiber glass is first modern composite and still the most common. It makes up about 65 per cent of all the composites produced today and is used for boat hulls, surfboards, sporting goods, swimming pool linings, building panels and car bodies. We may well be using something made of fiberglass without knowing it.

Composite materials are formed by combining two or more materials that have quite different properties.

The different materials work together to give the composite unique properties, but within the composite we can easily tell the different materials apart they do not dissolve or blend into each other. Composite Materials has good compressive strength and good tensile strength.

II. MATERIALS USED

2.1. ALUMINUM 7029

Aluminium / aluminum has a density that is about one-third that of steel. It has excellent resistance to corrosion due to the thin layer of aluminium oxide that forms on the surface of aluminium when it is exposed to air. Aluminium / aluminum 7000 series consist of the alloying element - zinc in a larger quantity. Aluminium / aluminum 7029 alloy is a heat treatable wrought alloy.

2.1.1 CHEMICAL COMPOSITION

The following table shows the chemical composition of aluminium / aluminum 7029 alloy.

Element	Content (%)
Zinc, Zn	4.2-5.2
Magnesium, Mg	1.3-2
Copper, Cu	0.5-0.9
Manganese, Mn	0.3 max
Iron, Fe	0.12 max
Silicon, Si	0.1 max
Titanium, Ti	0.05 max
Vanadium, Va	0.05 max
Other (each)	0.03 max
Other (total)	0.1 max
Aluminum, Al	Remainder

2.1.2 MECHANICAL PROPERTIES

The mechanical properties of aluminium / aluminum 7029-T5 alloy are tabulated below.

Properties	Metric	Imperial
Tensile strength	430 MPa	62400 psi
Yield strength	380 MPa	55100 psi
Hardness, Brinell (@load 500 kg; thickness 10.0 mm/1100 lb;0.394 in)	115	115
Hardness, Knoop (converted from Brinell hardness value)	141	141
Hardness, Rockwell A (converted from Brinell hardness value)	43.6	43.6
Hardness, Rockwell B (converted from Brinell hardness value)	71	71
Hardness, Vickers (converted from Brinell hardness value)	128	128

2.1.3 APPLICATIONS

Aluminium / aluminum 7029 alloy is chiefly used in the following areas:

- Automotive industry
- Aviation industry

2.2 Zro$_2$

Zirconium dioxide is one of the most studied ceramic materials.ZrO_2 adopts monoclinic cr ystal structure at room temperature and transitions to tetragonal and cubic at higher temperatures. The change of volume caused by the structure transitions from tetragonal to monoclinic to cubic induces large stresses, causing it to crack upon cooling from high temperatures.

When the zirconia is blended with some other oxides, the tetragonal and/or cubic phases are stabilized.

Effective do pants include magnesium oxide (MgO), yttrium oxide (Y_2O_3, yttria), calcium oxide (CaO), and cerium(III) oxide (Ce_2O_3). Zirconia is often more useful in its phase 'stabilized' state. Heating, zirconia undergoes disruptive phase changes by adding small percentages of yttria, these phase changes are eliminated, and the resulting material has superior thermal, mechanical, and electrical properties.

2.3 Graphite

Graphite will be used as soft reinforcement on account of its low coefficient of friction, excellent thermal conductivity and corrosion resistance. Also, Graphite will act as a solid lubricant for frictional applications. Preparing composites with built in solid lubricating characteristics is of major importance for antifriction applications. The formation of third-body films comprised of solid lubrication layers or particulate reinforcement of solid lubricants plays a vital role during practical application of the composite. Graphite prepared in the form of powder at a grain size of 100 microns.

III. CASTING

In this project we have used sand mold casting to produce the requirement size. Sand casting, also known as sand molded casting, is a metal casting process characterized by using sand as the mold material. It is relatively cheap and sufficiently refractory even for steel foundry use. A suitable bonding agent (usually clay) is mixed or occurs with the sand.

The mixture is moistened with water to develop strength and plasticity of the clay and to make the aggregate suitable for molding. The term "sand casting" can also refer to a casting produced via the sand casting process. Sand castings are produced in specialized factories called foundries. Over 70% of all metal castings are produced via a sand casting process.

There are six steps in this process:

1. Place a pattern in sand to create a mold.
2. Incorporate the pattern and sand in a gating system.
3. Remove the pattern.
4. Fill the mold cavity with molten metal.
5. Allow the metal to cool.
6. Break away the sand mold and remove the casting.

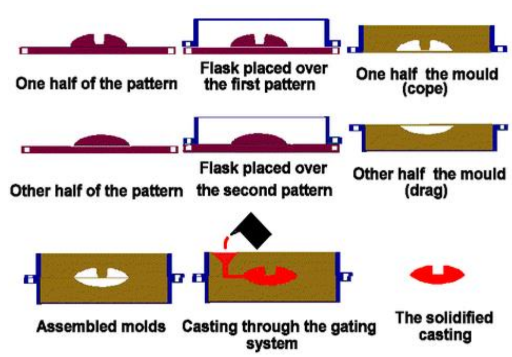

Fig. 3.1 Steps in Casting Process

IV. DESTRUCTIVE TEST

4.1 ROCKWELL HARDNESS TEST

1. Rockwell Hardness systems use a direct readout machine determining the hardness number based upon the depth of penetration of either a diamond point or a steel ball. Deep penetration indicated a material having a low Rockwell Hardness number.
2. However, a low penetration indicates a material having a high Rockwell Hardness number. The Rockwell Hardness number is based upon the difference in the depth to which a penetrator is driven by a definite light or “minor” load and a definite heavy or “Major” load.
3. The ball penetrators are chucks that are made to hold 1/16” or 1/8” diameter hardened steel balls. Also available are ¼” and ½” ball penetrators for the testing of softer materials.

Sl .No	Composition	Impact Strength Joules/mm^2
1	AL-90%, ZrO_2-5% ,Graphite-5%	9
2	AL-80%, ZrO_2-10% ,Graphite-10%	11
3	AL-85%, ZrO_2-15% ,Graphite-5%	8

4. There are two types of anvils that are used on the Rockwell hardness testers. The flat faceplate models are used for flat specimens. The “V” type anvils hold round specimens firmly.

5. Test blocks or calibration blocks are flat steel or brass blocks, which have been tested and marked with the scale and Rockwell number. They should be used to check the accuracy and calibration of the tester frequently.

Using the “C” Scale;

a. Use a Diamond indenter

b. Major load: 107.5 Kgf, Minor load: 10 Kg

c. Use for alloy metal.

d. Do not use on hardened steel

Hardness Value

S.No	Material	HRB
1	AL-90%, ZrO_2-5% , Graphite-5%	43
2	AL-80%, ZrO_2-10% , Graphite-10%	52
3	AL-85%, ZrO_2-15% , Graphite-5%	61

4.2 IMPACT STRENGTH

Izod impact strength testing is an ASTM standard method of determining impact strength. A notched sample is generally used to determine impact strength. Impact is a very important phenomenon in governing the life of a structure. In the case of aircraft, impact can take place by the bird hitting the plane while it is cruising during take - off and landing there is impact by the debris present on the runway an arm held at a specific height (constant potential energy) is released.

The arm hits the sample and breaks it. From the energy absorbed by the sample, its impact strength is determined. The North American standard for Izod Impact testing is ASTM D256. The results are expressed in energy lost per unit of thickness (such as ft-lb/in or J/cm) at the notch. Alternatively, the results may be reported as energy lost per unit cross-sectional area at the notch (J/m² or ft-lb/in²). In Europe, ISO 180 methods are used and results are based only on the cross-sectional area at the notch (J/m²).

The dimensions of a standard specimen for ASTM D256 are 4 x 12.7 x 3.2 mm (2.5" x 0.5" x 1/8"). The most common specimen thickness is 3.2 mm (0.125"), but the width can vary between 3.0 and 12.7 mm (0.118" and 0.500").The Izod impact test differs from the Charpy impact test in that the sample is held in a cantilevered beam configuration as opposed to a three point bending configuration.

4.3 TENSILE TEST & ELONGATION

4.3.1 Tensile Test

Friction processed joints are evaluated for their mechanical characteristics through tensile testing. A tensile test helps determining tensile properties such as tensile strength, yield strength, percentage of elongation, and percentage of reduction in area and modulus of elasticity. The welding parameters were randomly chosen within the range available in the machine. The joints were made with random parameters and evaluate tensile strength and burn off. Then the joints were made and evaluate the mechanical and metallurgical characteristics. The friction welded specimens were prepared as per the ASTM standards. The test was carried out in a universal testing machine (UTM) 40 tones FIE make.

4.3.2 Elongation

Deformation in continuum mechanics is the transformation of a body from a reference configuration to a current configuration. A configuration is a set containing the positions of all particles of the body. Contrary to the common definition of deformation, which implies distortion or change in shape, the continuum mechanics definition includes rigid body motions where shape changes do not take place A deformation may be caused by external loads, body forces (such as gravity or electromagnetic forces), or temperature changes within the body. Strain is a description of deformation in terms of relative displacement of particles in the body.

Different equivalent choices may be made for the expression of a strain field depending on whether it is defined with respect to the initial or the final configuration of the body and on whether the metric tensor or its dual is considered. In a continuous body, a deformation field results from a stress field induced by applied forces or is due to changes in the temperature field inside the body. The relation between stresses and induced strains is expressed by constitutive equations, e.g., Hooke's law for linear elastic materials.

Deformations which are recovered after the stress field has been removed are called elastic deformations. In this case, the continuum completely recovers its original configuration. On the other hand, irreversible deformations remain even after stresses have been removed. One type of irreversible deformation is plastic deformation, which occurs in material bodies after stresses have attained a certain threshold value known as the elastic limit or yield stress, and are the result of slip, or dislocation mechanisms at the atomic level. Another type of irreversible deformation is viscous deformation, which is the irreversible part of visco elastic deformation

Sample	Diameter mm	Yield Strength N/mm^2	Tensile Strength N/mm^2	Elongation mm
1	16.08	50.26	113.90	8.62
2	16.19	48.46	98.76	7.36
3	15.97	51.10	108.19	10.32

4.3.3. Tensile Strength & Elongation

V. RESULT & CONCLUSION

The present work was based on the development of aluminum alloy with the additions of different reinforcements in terms of varying volume percentages. Developed composites were characterized by mechanical testing in terms of hardness, tensile and impact strength. Following points can be concluded from the work carried out. The Rockwell hardness test revealed that AL85%, $Zro_2$15 % & Graphite 5% composite shows highest hardness value of HRB – 61, Impact shows that AL80%, ZrO_2 10% & Graphite 10% composite has highest value - 11 Joules/mm^2 & highest tensile strength - 113.90 N/mm^2. Highly reinforced composites show higher hardness and Lower percentage of reinforcement has high tensile strength and Moderate reinforcement shows high impact strength variations due to the agglomeration of particles.

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