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RESEARCH ARTICLE

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MECHANICAL PROPERTIES OF ALUMINUM BASED COMPOSITE MATERIALS

P. NAGABHARAM[1], L. RADHAKRISHNA[*2], DHEERAJ JOSHI[3]

[1, 2, 3] Department of Mechanical Engineering, SR Engineering Collage, Warangal, Telangana

P. NAGABHARAM

ABSTRACT

Now a day's composite materials are generally used for buildings, bridges and structures such as boat hulls, swimming pool panels, race car bodies, shower stalls, storage tanks, imitation granite and cultured marble sinks and counter tops. Components made of pure metals like aluminum have less hardness and tensile properties. In order to reduce this problem, addition of different materials at different percentages to the pure metal. For this study, materials such as aluminum, glass powder and titanium dioxide of different sizes are taken for preparation of composite materials. Aluminum is used as a parent metal and by varying the percentages of additives and the aluminum various properties are studied. By conducting various tests like Tension test, Rockwell hardness test and Impact test, and the result is compared with the pure aluminum.

Keywords: hardness, Impact test, Tension test, composite material.

1. INTRODUCTION

Composite materials are made from two or more constituent materials with significantly different physical or chemical properties, when combined, produce a material with different characteristics from the individual components. The individual components remain separate and distinct within the finished structure [1]. The new material may be preferred for many reasons: common examples include materials which are stronger, lighter or less expensive when compared to traditional materials. The conventional material may not always be capable of meeting the demand such environments. Hence new materials being created for meeting these performance requirements and composite materials form one class of such materials developed [2].The technology has progressed to a stage where newer composite materials are being considered, on an experimental basis for numerous applications in various fields. Such as aircraft, satellite launching vehicles, rocket missiles, railways, automobiles, energy, construction, medical, biomedical, marine, sports etc.,[3]. For this study, we made a composite material by varying different percentages of different materials at different conditions by using casting process. Mechanical properties of those composite materials are tested by using impact test, UTM, and Rockwell hardness.

2. Materials and Methods:

2.1 Materials used:

- Aluminum
- Titanium dioxide
- Glass Powder

2.2 Experimental details:

A mould is prepared as per the dimensions of the pattern and its geometric shape. Molten metal is then poured in to the mould, it holds the material in shape as it solidifies and metal casting is created.

Steps involved in preparation of composite material:

Firstly the selected materials should be taken as per the required quantity needed for the preparation of the composite specimen. A wooden pattern is prepared as per the dimension of the casting i.e 210 X 12 X 7mm.As aluminum is the base metal, it is melted until it reaches melting point temperature i.e, it gets converted in to molten state. Now the other two materials are added which are of minute quantities, in to the molten aluminum metal. They are mixed thoroughly until proper mixing of materials takes place. It is collected in to beaker and poured in to the mould cavity of the required shape. It is allowed to cool at room temperature until it gets completely solidified. It is removed by opening the two halves of the die and the required specimen is collected.

Fig 1(a) (b) & (c): Preparation of composite material by casting process

2.3 Tensile Test:

A tensile specimen is a standardized sample cross-section. It has two shoulders and a gauge (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. The shoulders of the test specimen can be manufactured in various ways to mate to various grips in the testing machine as shown in the figure 2.

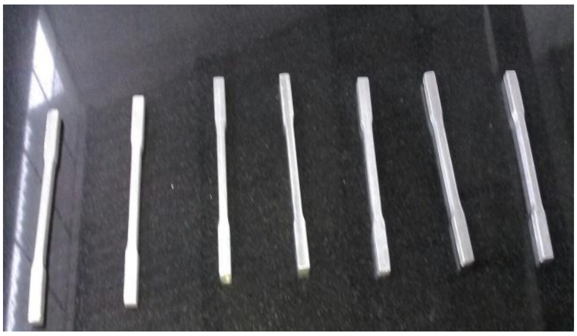

Fig 2: Tensile specimens as per standard dimensions

The test process involves placing the test specimen in the testing machine and slowly extending it until it fractures. During this process, the elongation of the gauge section is recorded against the applied force. The data is manipulated so that it is not specific to the geometry of the test sample. The elongation measurement is used to calculate the engineering strain, ε, using the following equation:

Stress = load / original cross sectional area

Strain = increment in length / original gauge length

2.4 Hardness Test:

The Rockwell scale is a hardness scale based on indentation hardness of a material. The Rockwell test determines the hardness by measuring the depth of penetration of an indenter under a large load compared to the penetration made by a preload. There are different scales, denoted by a single letter, that use different loads or indenters.

2.5 Impact test:

In mechanics, an impact is a high force or shock applied over a short time period when two or more bodies collide. Such a force or acceleration usually has a greater effect than a lower force applied over a proportionally longer time period of time. The effect depends critically on the relative velocity of the bodies to one another. charpy test is also known as the V-notch test, is a standardized high strain-rate test which determines the amount of energy absorbed by a material during fracture. This absorbed energy is a measure of a given material's notch toughness and acts as a tool to study temperature-dependent ductile-brittle transition. It

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is widely applied in industry, since it is easy to prepare and conduct and results can be obtained quickly and cheaply

According to ASTM A370, the standard specimen size for charpy test is 10 mm × 10mm × 55mm. Sub size specimens are: 10 mm × 7.5 mm × 55mm, 10 mm × 6.7 mm × 55 mm, 10 mm × 5 mm × 55 mm, 10 mm × 3.3 mm × 55 mm, 10 mm × 2.5 mm × 55 mm. Details of specimens as per ASTM A370 (Standard Test Method and Definitions for Mechanical Testing of Steel Products).

According to EN 10045-1 standard specimen sizes are 10 mm × 10 mm × 55 mm. Sub size specimens are: 10 mm × 7.5 mm × 55 mm and 10 mm × 5 mm × 55 mm.

According to ISO 148, standard specimen sizes are 10 mm × 10 mm × 55 mm. Sub size specimens are: 10 mm × 7.5 mm × 55 mm, 10 mm × 5 mm × 55 mm and 10 mm × 2.5 mm × 55mm.

3. Results and Discussions:

3.1 Tensile stress Calculations:

The resistance offered by unit area of cross-section against the increase in dimensions.

$$\text{Tensile stress } (\sigma) = \frac{load\ \ at\ yield\ \ point}{cross-sectional\ \ area}$$

Area = b x t

Where, b = breadth =7mm;

t = thickness = 6mm

Specimen no	Load at yield point(KN)	Tensile stress(N/mm^2)
1	9	$\sigma = \frac{9\ X\ 10^3}{6\ X\ 7} = 214.28\ N/mm^2$
2	9.4	$\sigma = \frac{9.4\ X\ 10^3}{6\ X\ 7} = 223.81\ N/mm^2$
3	9.3	$\sigma = \frac{9.3\ X\ 10^3}{6\ X\ 7} = 221.42\ N/mm^2$
4	9.8	$\sigma = \frac{9.8\ X\ 10^3}{6\ X\ 7} = 233.33\ N/mm^2$
5	9.7	$\sigma = \frac{9.7\ X\ 10^3}{6\ X\ 7} = 230\ N/mm^2$
6	9.9	$\sigma = \frac{9.9\ X\ 10^3}{6\ X\ 7} = 235.7\ N/mm^2$
7	9	$\sigma = \frac{9\ X\ 10^3}{6\ X\ 7} = 241.19\ N/mm^2$

Table 1: Stress Calculations

3.2 Impact Strength Calculations:

The resistance of a material to fracture by a blow, expressed in terms of the amount of energy absorbed before fracture.

$$\text{Impact strength J} = \frac{K}{A}$$

Where, k= impact energy; A= area of cross section = 10 X 10 mm = $10^2 mm^2$

Specimens	Impact energy(k)	Impact strength(J)
1	28 X 2	$\frac{28\ X\ 2}{10^2\ X\ (10^{-3})^2} = 560\ KJ/\ m^2$
2	30 X 2	$\frac{30\ X\ 2}{10^2\ X\ (10^{-3})^2} = 600\ KJ/\ m^2$
3	50 X 2	$\frac{50\ X\ 2}{10^2\ X\ (10^{-3})^2} = 1000\ KJ/\ m^2$
4	60 X 2	$\frac{60\ X\ 2}{10^2\ X\ (10^{-3})^2} = 1200\ KJ/\ m^2$
5	62 X 2	$\frac{62\ X\ 2}{10^2\ X\ (10^{-3})^2} = 1240\ KJ/\ m^2$
6	32 X 2	$\frac{32\ X\ 2}{10^2\ X\ (10^{-3})^2} = 640\ KJ/\ m^2$
7	44 X 2	$\frac{44\ X\ 2}{10^2\ X\ (10^{-3})^2} = 880\ KJ/\ m^2$

Table 2: Strength Calculations

3.3 Hardness test: It is the ability of the material to resist the depth of penetration or indentation.

$$\textbf{RH = 100 - } \frac{depth\ of\ penetration}{0.002}$$

Specimen no	Depth of penetration	Rockwell hardness number
1	55	$100 - \frac{55\ X\ 10^{-3}}{0.002} = 72.5$
2	60	$100 - \frac{60\ X\ 10^{-3}}{0.002} = 70$
3	64	$100 - \frac{64\ X\ 10^{-3}}{0.002} = 68$
4	68	$100 - \frac{68\ X\ 10^{-3}}{0.002} = 66$
5	61	$100 - \frac{61\ X\ 10^{-3}}{0.002} = 69.5$
6	64	$100 - \frac{64\ X\ 10^{-3}}{0.002} = 68$
7	60	$100 - \frac{60\ X\ 10^{-3}}{0.002} = 70$

Table 3: hardness of the composite material

4. Conclusions

Pure aluminum's tensile stress is about 90mpa and its hardness number is about 54 and it is impact strength is very low, and it is about 2-3 X 10^4 J/m^2. When compared to pure aluminum our composite's tensile stress is increased about 3 times. Impact strength is increased about more than twice. So it is obvious that, aluminum when used in combination with any other metals which are having good mechanical properties, gives excellent mechanical properties like hardness, tensile stress, impact strength etc.

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