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EVALUATION OF MECHANICAL PROPERTIES OF AL 7075-ZRO_2 METAL MATRIX COMPOSITE BY USING STIR CASTING TECHNIQUE

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Abstract: Metal matrix composites (MMCs) are rapid increase in research and becoming attractive material for advanced aerospace application because their properties can be tailored through the addition of selected reinforcement. The addition of reinforcement materials like metals or ceramics into metal matrix improves its mechanical properties like tensile, hardness and fatigue.

Compared to other conventional material. In this work Zirconium is used as reinforcement in Al 7075 and metal matrix composites are prepared by using stir casting process. In this four specimens are considered [100% Al 7075,95 %Al 7075+ 5% ZrO2, 90% Al 7075 + 10% ZrO2 , 85% Al 7075 + 15% ZrO2]for finding the tensile strength, impact strength and hardness properties. Here, both physical and mechanical behaviour of aluminium reinforced composites with the effect of the particle size changes, effects after reinforcement and other processing and fabrication methods have been discussed. To prepare the Aluminum alloy AL 7075 - Zro2 metal matrix composite by stir casting method and experimentally investigate its mechanical properties.

Keywords: Composite, Casting, Reinforcement, Ceramics

1. Introduction

Nano composites through liquid route with AZ91 Magnesium alloy and Silicon Carbide. Moreover, mechanical and metallurgical characterizations are made for evaluating its performance.

2. Experimentation

a. Stir Casting Process

Stir Casting is a liquid state method of composite materials fabrication, in which a dispersed phase (ceramic particles, short fibres) is mixed with a molten matrix metal by means of mechanical stirring. The liquid composite material is then cast by conventional casting methods and may also be processed by conventional Metal forming technologies.

Figure 1.2 Stir casting process

b. Infiltration:

Infiltration is a liquid state method of composite materials fabrication, in which a preformed dispersed phase e.g. ceramic paroles, fibres, are soaked in a molten matrix metal, which fills the space between the dispersed phase inclusions. The motive force of an infiltration process may be either capillary force of the dispersed phase or an external pressure applied to the liquid matrix phase.

Infiltration is one of the methods of preparation of tungsten-copper composites.

The principal steps of the technology are as follows:

- Tungsten powder preparation with average parole size of about 1-5 micron.
- Optional step: Coating the powder with nickel. Total nickel content is about 0.04%.
- Mixing the tungsten powder with a polymer binder.
- Compacting the powder by a melding method. Compaction should provide the predetermined porosity level of the tungsten structure.
- Solvent rebinding and sintering the green compact at 1204-1315°C in hydrogen atmosphere for 2 hrs. Placing the sintered part on a copper plate or powder in the infiltration/sintering furnace.
- Infiltration of the sintered tungsten skeleton porous structure with copper at 110-1260 °C in either hydrogen atmosphere or vacuum for 1 hour.

c. Gas Pressure Infiltration:

Gas pressure infiltration is a forced infiltration method of liquid phase fabrication of metal matrix composites, using a pressurized gas for applying pressure on the molten metal and forcing it to penetrate into a preformed dispersed phase. Gas Pressure Infiltration method is used for manufacturing large composite parts. This method allows using non-coated fibers due to short contact time of the fibers with the hot metal. In contrast to the methods using mechanical force, Gas Pressure Infiltration results in low damage of the fibers.

d. Squeeze Casting Infiltration:

Squeeze casting infiltration is a forced infiltration method of liquid phase fabrication of metal matrix composites, using a ram for applying pressure on the molten metal and forcing it to penetrate into a dispersed phase, placed into the lower fixed mold part. Infiltration method is similar to the squeeze casting technique used for metal alloys casting.

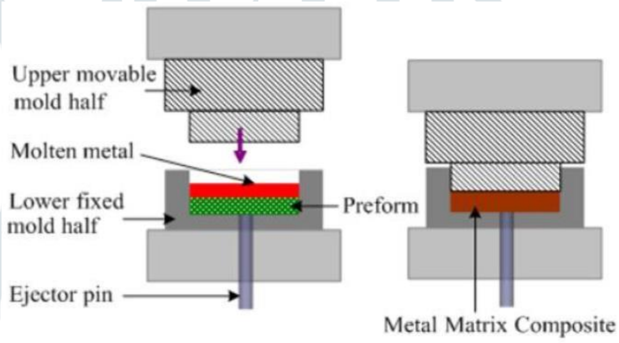

Figure1.4 Squeeze casting

Squeeze casting infiltration process has the following steps:

- A perform of dispersed phase is placed into the lower fixed mold half.
- A molten metal in a predetermined amount is poured into the lower mold half. ➢ The upper movable mold half (ram) moves downwards and forces the liquid metal ➢ to infiltrate the perform.
- The infiltrated material solidifies under the pressure.
- The part is removed from the mold by means of the ejector pin.

e. Pressure Die Infiltration:

Pressure Die Infiltration is a forced infiltration method of liquid phase fabrication of Metal Matrix Composites, using a Die casting technology, when a preformed dispersed phase is placed into a die which is then filled with a molten metal entering the die through a sprue and penetrating into the perform under the pressure of a movable piston.

3. Results and Comparison

a. Tensile Test:

Tensile testing, also known as tension testing, is a fundamental materials science test in which a sample is subjected to a controlled tension until failure. The results from the test are commonly used to select a material for an application, for quality control, and to predict how a material will react under other types of forces. Properties that are directly measured via a tensile test are ultimate tensile strength, maximum elongation and reduction in area. From these measurements the following properties can also be determined Young's modulus, Poisson's ratio, Yield strength and strain hardening characteristics. Uniaxial tensile testing is the most commonly used for obtaining the mechanical characteristics of isotropic material, for anisotropic materials, such as composite materials and textiles, biaxial tensile testing is required.

The test process involves placing the test specimen in the testing machine and applying tension to it until it fractures. During the application of tension, the elongation of the gauge section is recorded against the applied force.

The elongation measurement is used to calculate the engineering strain, ε, using the following equation:

$$\varepsilon = \frac{\Delta L}{L_0} = \frac{L - L_0}{L_0}$$

Where,

ΔL is the change in gauge length, L0 is the initial gauge length, and L is the final length. The

$$\sigma = \frac{F_n}{A}$$

force measurement is used to calculate the engineering stress, σ, using the following equation:

Where,

F is the force and A is the cross-section of the gauge section.

The machine does these calculations as the force increases, so that the data points can be graphed into a stress-strain curve.

b. Hardness Test

Hardness is a measure of how resistant solid matter is to various kinds of permanent shape change when am force is applied. Macroscopic hardness is generally characterized by strong intermolecular, but the behavior of solid materials under force is complex; therefore, there are different measurements of hardness: scratch hardness, indentation hardness, and rebound hardness. Hardness is dependent on ductility, elastic stiffness, plasticity, strain, strength, toughness, viscoelasticity, and viscosity.

Hardness increases with decreasing particle size. This is known as the Hall-Pitch relationship. However, below a critical grain-size, hardness decreases with decreasing grain size. This is known as the inverse Hall-Pitch effect. Hardness of a material to deformation is dependent on its micro durability or small-scale shear modulus in any direction, not to any rigidity or stiffness properties such as its bulk modulus or Young's. Stiffness is often confused for hardness. Some materials are stiffer than diamond (e.g. osmium) but are not harder, and are prone to spelling and flaking in squamosal or a circular habit.

3.3 IMPACT TEST:

Impact tests are designed to measure the resistance to failure of a material to a suddenly applied force such as collision, falling object or instantaneous blow. The test measures the impact energy or the energy absorbed prior to fracture. The most common methods of measuring impact energy are

- Charpy test
- Izod test

3.3.1 CHARPY TEST

Impact Testing of metals is performed to determine the impact resistance or toughness of materials by calculating the amount of energy absorbed during fracture. The impact test is performed at various temperatures to uncover any effects on impact energy. These services provide test results that can be very useful in assessing the suitability of a material for a specific application and in predicting its expected service life.

The **Charpy Test** method determines the toughness or impact strength of the material in the presence of a flaw or notch and fast loading conditions. This destructive test involves fracturing notched impact test specimens at a series of temperatures with a swinging pendulum. The amount of energy absorbed by the material during fracture is measured. Charpy V notch or U notch test specimens are used.

3.3.2 IMPACT ENERGY

Impact is a very important phenomenon in governing the life of a structure. For example, in the case of an aircraft, impact can take place by a bird hitting a plane while it is cruising, or during takeoff and landing the aircraft may be struck by debris that is present on the runway, and as well as other causes. It must also be calculated for roads if speed breakers are present, in bridge construction where vehicles punch an impact load, etc.

Impact tests are used in studying the toughness of material. A material's toughness is a factor of its ability to absorb energy during plastic deformation. Brittle materials have low toughness as a result of the small amount of plastic deformation they can endure. The impact value of a material can also change with temperature. Generally, at lower temperatures, the impact energy of a material is decreased. The size of the specimen may also affect the value of the charpy impact test because it may allow a different number of imperfections in the material, which can act as stress risers and lower the impact energy.

SPECIMEN : AL 7075-ZRO2

4. Conclusion

The conclusions drawn from the present investigation are as follows:

(ZRO) can be successfully used as a reinforcing material to produce metalmatrix composite (MMC) component in Aluminium alloy AL 7075 – ZRO. It can be successfully replaceable in the place of conventional aluminium alloy AL 7075 – ZRO which improve the mechanical properties.

The result from the tensile test gives the clear idea about the composition properties. We can say that 10% of the (ZRO) compositions with metal matrix have higher tensile strength than pure Aluminium alloy AL 7075.

Comparing to Aluminium alloy AL 7075 – ZRO with reinforced metal matrix composites has the highest HARDNESS which improves the wear behaviour. Comparing the HARDNESS, the composition of 10% (ZRO) with AL 7075 – ZRO is higher. The HARDNESS of the composite is linearly increasing with addition of (ZRO).

The result from the impact test gives the clear idea about the composition properties. We can say that 5%,10% of the (ZRO) compositions with metal matrix have equal t strength than pure Aluminium alloy AL 7075.

Overall comparison between the Aluminium alloy AL 7075 – ZRO and reinforced Aluminium alloy AL 7075 – ZRO has good mechanical properties including tensile strength, Hardness, impact.

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