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Aluminium AA 7075 properties enhanced by Zirconium and Chromium nano particle

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Abstract: The enhancement of mechanical properties of any material can be done by numerous methods. In this research work, tensile tests and hardness measurements were utilized. By growing the content of Zirconium and Chromium in AA 7075 metal matrix composites corrosion resistance is improved and also the hardness material also increased. The metal matrix produced by stir casting method at room temperature. Fabrication of samples composite done by different proportions (Al-97% Cr-2%Zr-1%) ,(Al-95% Cr-4%Zr 1%) and (Al-93% Cr-6%Zr 1%). The experiments result concludes that the enforcement of nano particle in optimum level in matrix material values is increased.
Key words : Aluminium AA 7075, Zirconium and Chromium, stir casting, mechanical property, volume fraction

1. Introduction

A composite material is a macroscopic combination of two or more distinct materials, having a recognizable interface between them. Composites are used not only for their structural properties, but also for electrical, thermal, tribological, and environmental applications. Modern composite materials are usually optimized to achieve a particular balance of properties for a given range of applications [1] Composite is a multiphase material that exhibits a significant proportion of the properties of both constituent phases such that a better combination of properties is realized. This is termed as the principle of combined action. [2] The term "composite" broadly refers to a material system which is composed of a discrete constituent (the reinforcement) distributed in a continuous phase (the matrix), and which derives its distinguishing characteristics from the properties of its constituents, from the geometry and architecture of the constituents, and from the properties of the boundaries (interfaces) between different constituents. Composite materials are usually classified on the basis of the physical or chemical nature of the matrix phase, e.g., polymer matrix, metal-matrix and ceramic composites.

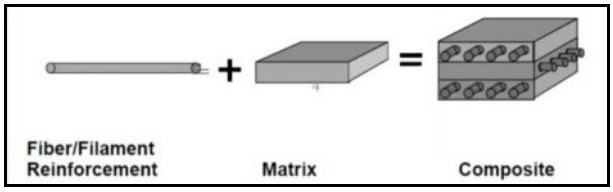

Figure 1. Composite formation model.

Aluminium is a soft, durable, lightweight, ductile and malleable metal, with appearance ranging from silvery to dull gray, depending on the surface roughness Aluminium is nonmagnetic and non-sparking. Aluminium has about one-third the density and stiffness of steel. In our time, weight for on the increase metal matrix composites for use in high performance application, have seen notably increased. Among these composites, aluminium alloy matrix composite attractive property. Various kinds of ceramic materials, e.g. Zirconium and Chromium, Al2O3 etc are extensively used to reinforce aluminium alloy matrices. Superior properties of these materials such as hardness, high compressive strength, wear resistance, etc. makes them suitable for use as reinforcement in matrix of composites. These composites, sometimes, are subjected to subsequent age hardening for improving mechanical properties. [3].

Classification of Composites:

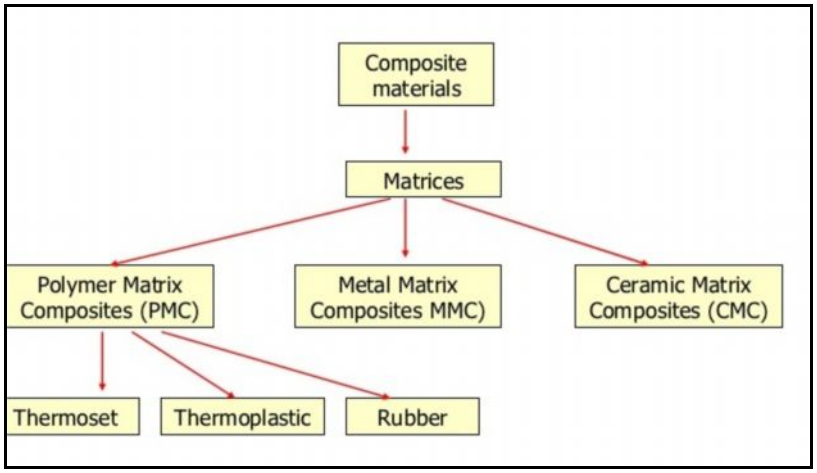

Figure 2. Classification of composite.

Advantages of Composites:

- High resistance to fatigue and corrosion degradation.
- High 'strength or stiffness to weight' ratio. As enumerated above, weight savings are significant ranging from 25-45% of the weight of conventional metallic designs.
- Due to greater reliability, there are fewer inspections and structural repairs.
- Directional tailoring capabilities to meet the design requirements. The fiber pattern can be laid in a manner that will tailor the structure to efficiently sustain the applied loads.
- Improved dent resistance is normally achieved. Composite panels do not sustain damage as easily as thin gage sheet metals.
- It is easier to achieve smooth aerodynamic profiles for drag reduction. Complex double-curvature parts with a smooth surface finish can be made in one manufacturing operation.
- Composites offer improved tensional stiffness. This implies high whirling speeds, reduced number of intermediate bearings and supporting structural elements. The overall part count and manufacturing & assembly costs are thus reduced.
- High resistance to impact damage.

2. Experimental Procedure

Stir Casting Process:

Stir casting method is one of the outstanding and economical route for improvement and processing of metal matrix composites materials. Literature reveals that most of the researchers are using 7075 aluminium matrix reinforced with Zirconium and Chromium particles for high corrosive properties. Aluminium alloys A7075 were chosen as the matrix and Zirconium and Chromium as nano-particles, with an average diameter of 50nm, as reinforcements. The stir casting technique was used to fabricate the composite specimen as it ensures a more uniform distribution of the reinforcing particles. This method is most economical to fabricate

composites with discontinuous fibers or particulates. In this process, matrix alloy (Al 7075) was first superheated above its melting temperature. Then keep the matrix alloy in the semisolid state. At this temperature, the preheated Cr particles of 2 % (by weight) and Zr particle of 1% (by weight) were dropped into the slurry and mixed using a graphite stirrer. The composite slurry temperature was increased to fully liquid state and automatic stirring was continued to about five minutes at an average stirring speed of 300-350 rpm under protected organ gas. The Cr particles help in distributing the particles uniformly throughout the matrix alloy. The melt was then superheated above liquids temperature and finally poured into the cast iron permanent mould for testing specimen. The size of the fabricated billet composite is100 mm length and 100 mm width and 10mmthickness

Figure.3. Pouring metal into the mould cavity

Base material: Aluminium AA7075
Nano particle: Zirconium and Chromium
Nano particle size: 50nm.
Fabrication method: stir casting (at atmospheric condition)

Table1 Chemical composition of aluminium AA7075

Constituents	Al	Mg	Fe	Mg	Zr	Zn	Cu	Si	Cr	Ti
(%in weight)	91.4	2.9	0.5	0.3	0.25	6.1	2.0	0.4	0.28	0.2

Rule of Mixtures

Density

dc = dm*Vm + df*Vf
Where
dc, dm, df – densities of the composite, matrix and dispersed phase respectively;
Vm,Vf – volume fraction of the matrix and dispersed phase respectively

Process Variables and Their Effects on Properties

- Speed of Rotation
- Pouring Temperature
- Pouring speed
- Mould Temperature
- Preheating temperature
- Stirring time

Table 2 Composition of aluminium- nano-particles.

Aluminium 7075 alloy (g)	Zirconium nano-particles(%.vol)	Chromium nano-particles(%.vol)	Total weight(g)
970	1	20	1000
950	1	40	1000
930	1	60	1000

3. Results and Discussion

Mechanical Properties:

Tensile test:

The reinforced aluminium AA7075 and aluminium oxide nano-particles various volume fraction composite at room temperature as obtained from tensile test shown in table

Table 3 Observed readings in Tensile Test

Compositions	Initial Length in (mm)	Percentage of Elongation in (%)	Tensile load in (N)	Ultimate Tensile strength in (N/mm 2)
Al-97% Cr-2%	25	4.6	33500	188
Al-95% Cr-4% Zr-1%	25	4.3	32400	185
Al-93% Cr-6% Zr-1%	25	4.5	31400	182

Hardness measurement:

From the experiment it is cleared that aluminium AA7075-C (Al-93%, Cr-6%, Zr 1%) has the highest hardness number than other two compositions. Therefore by increasing the content of chromium in the aluminium AA7075-C alloy the hardness can be increased gradually. Macro hardness of extruded composite higher compared the unreinforced aluminium

Table 4 Rockwell hardness number of fabricated composite.

Composition AA7075	Load (kgf)	Load (N)	Penetrator	Scale	Dial Reading	Rockwell Hardness Number
Al-97% Cr-2% Zr-1%	100	9.81	1/16”Ball Point	B	65 60 63	63
Al-95% Cr-4% Zr-1%	100	9.81	1/16”Ball Point	B	65 68 70	68
Al-93% Cr-6% Zr-1%	100	9.81	1/16”Ball Point	B	69 72 75	73

Figure.5 Fabricated and tested composites.

4. Conclusion

Aluminum alloy AA7075 matrix can be developed effectively reinforced with Zirconium and Chromium and using stir casting route. Results show that "Zirconium and Chromium "particles up to aluminum alloy 93%, Cr-6%, Zr-1% increase the tensile strength 31400 N.

1. The tensile properties of composite were considerably improved by the addition of and Chromium nano-particles, however tensile value of the composite was much higher than the unreinforced nano particles.
2. The distribution of nano-particles measured by using of microstructure test therefore stir casting was found as a suitable method for fabrication of this kind of composite and also hardness of fabricated composite value improved
3. Finally composite contain Al-93%,Cr-6%,Zr 1%fabricated composite showed improved properties such tensile and hardness in comparison with other specimens.

5 .Future work

Composite of Aluminium reinforced with different volume fraction of Zirconium and Chromium Nano Particles (40-60 nm) which is preheated at different temperature is produced by stir casting method.

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