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Evaluation of mechanical and corrosive properties of aluminium AA7075 metal matrix composites

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Abstract

Composites are most successful materials used for recent works in the industries. Metal composites possess significantly improved properties including high tensile strength , toughness, hardness, low density and good wear resistance compared to alloys or any other metals .By increasing the content of Zirconium and Chromium in AA 7075 metal matrix composites corrosion resistance is increased. Modified stir casting method is used for the even distribution of Zirconium and Chromium in AA7075 metal matrix composites. Ultimate tensile strength of AA7075 metal matrix composite improved by increasing the content of Zirconium and compared with unreinforced alloy of aluminum. Hardness and tensile strength of AA7075 composites is increased where ductility is decreased .Hence composites AA7075 metal matrix to enhance the mechanical and physical properties for widely used in the automobile and spacecraft applications to improve fuel efficiency. Aluminum metal matrix composites are being used in place of cast iron and steel due to their light weight and high strength.

Keywords— Aluminum AA7075, Zirconium and Chromium, Stir Casting, Volume fraction, Salt Spray Test.

I. INTRODUCTION

The search for new and improved materials and processes goes on continuously for a multitude of applications. Higher temperature materials, higher strength-to-weight ratio materials, highly corrosion-resistant materials have attracted a great deal of attention from scientists and engineers all over the world. Aluminum Composite materials have been considered the "material of choice" in some applications of the automotive and aircraft industries by delivering high-quality surface finish, styling details, and processing options [1]. Improvement of mechanical and corrosive properties of aluminum can be achieved through creating metal matrix composites by increasing the content of Zirconium and Chromium. Composites have improved strength, increased wear resistance, low density, corrosion resistance and high stiffness over metal matrix composites. Cooling conditions during solidification strongly influence the evolution of finer grain structure in the composites [2]. An improvement in the corrosive properties of Aluminum MMCs has been successfully attained by introducing ceramic particles using different routes, such as stir-casting, squeeze casting, in-situ and powder metallurgy [3] [4].The metal matrix composites of three compositions are casted and Its corrosive rate, tensile properties, hardness and grain size were also evaluated and compared with matrix alloy.

II. EXPERIMENTAL PROCEDURE

A. Aluminium 7075(Al):

Aluminum alloy 7075 is an aluminum alloy, with zinc as the primary alloying element. It is strong, with strength comparable to many steels, and has good fatigue strength and average mach inability, but has less resistance to corrosion than many other Al alloys. Its relatively high cost limits its use to applications where cheaper alloys are not suitable.

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

B. Zirconium (Zr):

Zirconium is a very strong, malleable, ductile, lustrous silver-gray metal. Its chemical and physical properties are similar to those of titanium. Zirconium is extremely resistant to heat and corrosion. Zirconium is lighter than steel and its hardness is similar to copper. Zirconium does not dissolve in acids and alkalis.

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Table 2

Properties of Zirconium

Melting point	1855◦c
Boiling point	4409◦c
Density	6.52g/cm³

C. Chromium (Cr):

Chromium is a lustrous, brittle, hard metal. Its colour is silver-gray and it can be highly polished. The strengthening effect of forming stable metal carbides at the grain boundaries and the strong increase in corrosion resistance made chromium an important alloying material. The high heat resistivity and high melting point makes chromate a material for high temperature refractory applications.

Table 3

Properties of Chromium

Melting point	1907◦c
Boiling point	2671◦c
Density	7.19g/cm³

D. Stir casting process:

An open hearth furnace was used for melting and mixing the materials in flat bottom, cylindrical graphite crucible. The fabrication process is conventional mechanical stirring for the distributive mixing of the reinforcement in the matrix. For the work, a new stir caster was developed to fabricate MMC. The mixing equipment for this stage consisted of a driving motor capable of producing a rotation speed within the range of 600rpm, a control part for the vertical movement of the impeller and a transfer tube used for introducing the ceramic powders in the melt.

Figure (a) Electric furnace

Balanced aluminum alloy with copper were melted in graphite crucibles. At the same time the Cr particulate was preheated in a stir furnace set at 1100°C for approximately 2 hour to remove surface impurities and assist in the adsorption of gases. The ceramic particles were then Poured slowly and continuously into the molten metal and the melt was continuously stirred at 600 rpm. [5]

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.(b) Pouring metal into the mould cavity

Simple vice die sets are used as mould cavity. The die sets are made by good strengthened and temperature resisted materials. Initially die sets are correctly positioned and locked using screw clamp arrangement. After clamping molten metal will be poured inside the mold cavity. The composite metal after been ejected from the mold is then cooled. After molding process casted pieces will be machined. Depending upon the type of test conducted machining shape will be varied.

Table 4

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

III. RESULTS AND DISCUSSION

MECHANICAL PROPERTIES:

A. Corrosion Test:

The salt spray test was conducted for all three compositions of the samples of AA7075-C. (Al-97% Cr-2%Zr-1%) ,(Al-95% Cr-4%Zr 1%) and (Al-93% Cr-6%Zr 1%) are kept in the salt spray chamber .The salt spray chamber contained distilled water 95parts and sodium chloride 5parts.The pH of the salt spray chamber is maintained 6.5 to 7.2 at the temperature of 35◦C for 24 hours. Among these three prepared compositions all the three samples are resistance to the corrosion. There is no corrosion are formed in these three compositions of AA7075-C.

B. Ultimate Tensile test:

In the tensile test, the ends of each testing pieces are fixed into the grips connected to a straining device and to a load measuring device of Universal Testing Machine (UTM). The prepared specimens of three compositions are tested in UTM of model FUT 40 of accuracy 100% and operating ambient temperature of machine was 33◦C. From the tensile test (Al-97% Cr-2%Zr-1%) composition specimen possessed higher ultimate tensile strength than (Al-95% Cr-4%Zr 1%) and (Al-93% Cr-6%Zr 1%).It is cleared that when the content of Chromium increases in AA7075-C lead to decrease in the ultimate tensile strength . Stress-strain behaviour of reinforced aluminium and nano-particles various volume fraction composite at room temperature as obtained from tensile test shown in fig.3

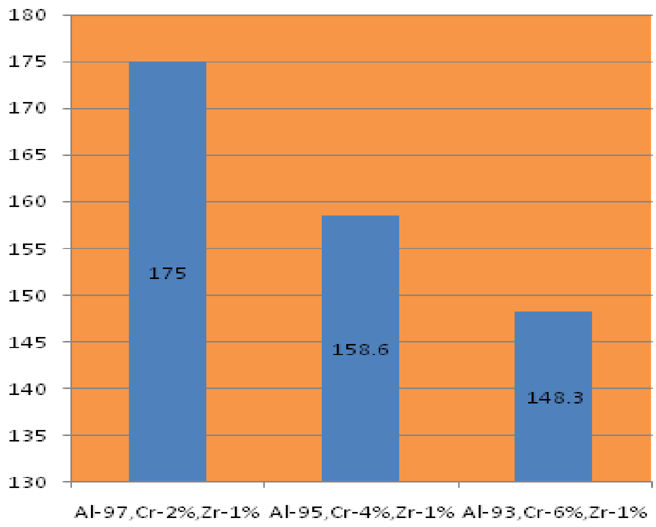

Figure.(c) Ultimate tensile strength

Table 5

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% Zr-1%	25	4.8	33600	175.0
Al-95% Cr-4% Zr-1%	25	-	31400	158.6
Al-93% Cr-6% Zr-1%	25	4.8	30400	148.3

C. Hardness measurement (Rockwell)

Hardness of Aluminium AA7075 (Al-97% ,Cr-2%,Zr-1%) ,(Al-95%,Cr-4%,Zr 1%) and (Al-93%,Cr-6%,Zr 1%) are tested with help of 100-kilogram loaded 1/16" diameter steel ball and the hardness is read on the "B" scale. From the test 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.

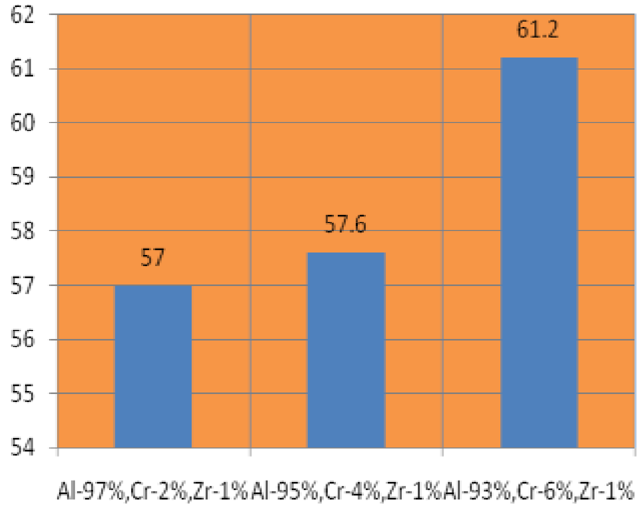

Figure (d). Hardness Test (Rockwell) value

Table 6

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	59 55 56	57
Al-95% Cr-4% Zr-1%	100	9.81	1/16"Ball Point	B	52 56 61	57.6
Al-93% Cr-6% Zr-1%	100	9.81	1/16"Ball Point	B	64 61 60	61.2

c. Micro structure test

Microscopic examination extremely used to study and characterization of material and mechanical fracture, and also nano-particles distribution of in the fabricated composites.

Figure. (e)Microstructure of Al-93% Cr-6% Zr-1%Nano-particles of composite

Figure.(f) Fabricated and tested composites.

IV. CONCLUSION

Aluminium AA 7075 alloy reinforced with various volume fraction of Zirconium and Chromium was successfully fabricated via stir casting method. Mechanical behaviour of composite has been experimentally analyzed, leading following conclusions.

(i) 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.

(ii) 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

(iii) Finally composite contain Al-93%,Cr-6%,Zr 1%fabricated composite showed improved properties such tensile and hardness in comparison with other specimens.

V .FUTURE WORK

Composite of Aluminium AA 7075 reinforced with different volume fraction of Zirconium and Chromium which is preheated at different temperature is produced by stir casting method.

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