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CODEN: IAASCA **ORIGINAL ARTICLE**

Tensile And Hardness Behavior Of Aluminum 7075 And Zinc And Chromium Metal Matrix Composite By Stir-Casting Route

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ABSTRACT
Aluminium 7075 is an aerospace aluminum bar with cold finished or extruded aluminum wrought alloy with high strength, adequate machinability and improved stress corrosion control. Fine grain control results in good tool wear. Aluminium 7075 is one of the highest strength aluminum alloys. It has good fatigue strength and average machinability. Often used where parts are highly stressed. It is not weld able and has less corrosion resistance than other aluminum alloys. The mechanical properties depend on the temper of the material. Aluminium 7XXX series based on Zinc material and have a good corrosion properties so used especially in aero space applications. The mechanical properties Aluminium 7XXX material improved by adding zinc based materials. By adding different volume fraction of Zinc which leads to improve the properties materials.
Keywords: Tensile, Aluminum 7075, Zinc And Chromium, Stir-Casting Route

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INTRODUCTION

Riding on steady, sustained growth in worldwide consumption since the 1950s, aluminium today is the leading non-ferrous metal in use, finding ever more ingenious applications in sectors as varied as aeronautics, beverage containers, construction and energy transportation. This success, based on making the most of the natural properties of aluminium and its alloys, is due also to the harnessing of specific technology and know-how, which allows the improvement and performance of these materials to meet expressed needs.

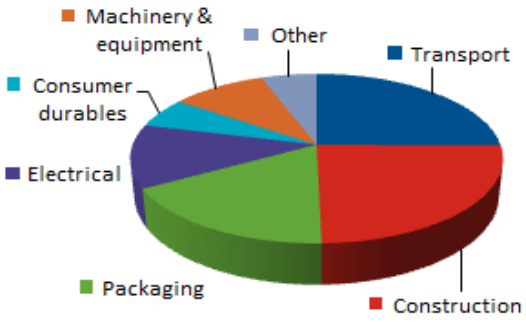


Figure 1. Consumption of aluminium

Table.1 Consumption of aluminium

Market Sector	%
Transport	25%
Construction	25%
Packaging	17%
Electrical	12%
Machinery & equipment	10%
Consumer durables	6%
Other	6%

Source: CRU www.crugroup.com

Selection of aluminium :

Aluminum comes in many different shapes and grades. The type of aluminum grade you choose ultimately depends on how you intend to use the metal. The following things in mind while choose an aluminum grade.

- Formability or Workability
- Weldability
- Machining
- Corrosion Resistance
- Heat Treating
- Strength of the Aluminum
- Typical end user applications

Quick Reference Chart – Choosing an Aluminum Grade

	Formability or Workability	Weldability	Machining	Corrosion Resistance	Heat Treating	Strength	Typical Applications
Alloy 1100	Excellent	Excellent	Good	Excellent	No	Low	Metal Spinning
Alloy 2011	Good	Poor	Excellent	Poor	Yes	High	General Machining
Alloy 2024	Good	Poor	Fair	Poor	Yes	High	Aerospace Application
Alloy 3003	Excellent	Excellent	Good	Good	No	Medium	Chemical Equipment
Alloy 5052	Good	Good	Fair	Excellent	No	Medium	Marine Applications
Alloy 6061	Good	Good	Good	Excellent	Yes	Medium	Structural Applications
Alloy 6063	Good	Good	Fair	Good	Yes	Medium	Architectural Applications
Alloy 7075	Poor	Poor	Fair	Average	Yes	High	Aerospace Applications

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 Zinc and Chromium particles for high corrosive properties. Aluminium alloys A7075 were chosen as the matrix and Zinc 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 Zinc particle of 1% (by weight) were dropped into the slurry and mixed using a graphite stirrer. 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

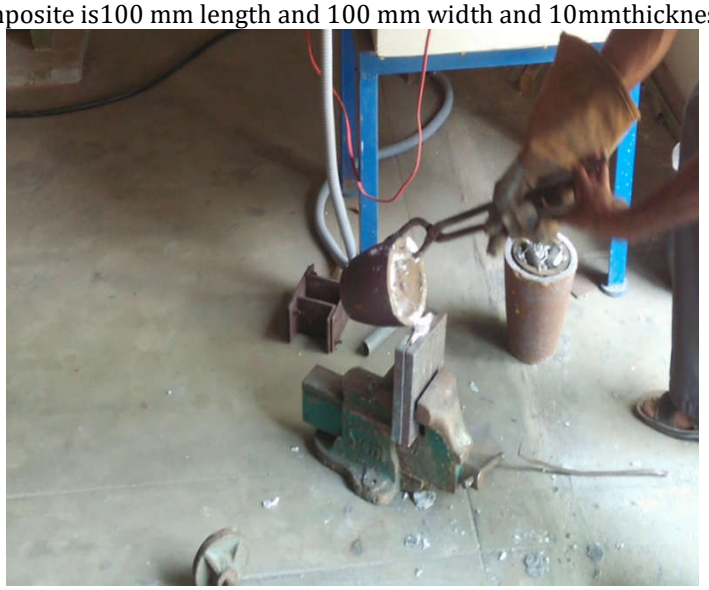


Figure.2. Pouring metal into the mould cavity

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

Table2: 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

Table 3: Composition of aluminium- nano-particles.

Aluminium 7075 alloy (g)	Zinc nano-particles (%.vol)	Chromium nano-particles(%.vol)	Total weight(g)
970	10	20	1000
960	10	30	1000
950	10	40	1000
940	10	50	1000
930	10	60	1000

Process flow chart.

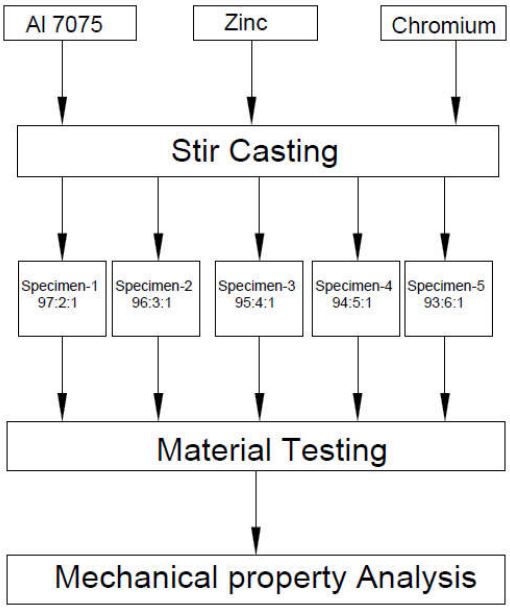


Figure.3. Process flow chart

Materials testing

Material testing is measurement of the characteristics and behavior of such substances as metals, ceramics, or plastics under various conditions. The data thus obtained can be used in specifying the suitability of materials for various applications. Mechanical testing measures the strength and ductility of materials under various conditions, such as temperature, tension, compression and load. Metallurgical testing includes microhardness testing and microscopic and macroscopic examinations to evaluate surface and internal features, defects and material characteristics.

- *Chemical Analysis* – Instrumental and classical wet chemistry
- *Mechanical Testing* – Wide-range of tests to measure material strength, ductility, hardness, fatigue, fracture toughness and more
- *Metallurgical Testing* – Microscopic, macroscopic and microhardness examinations, sample preparation
- *Corrosion Testing* – Accelerated intergranular corrosion, salt spray, humidity, passivation and more
- *Nondestructive Testing* – Ultrasonic, hydrostatic pressure, X-ray, magnetic particle, liquid penetrant

Tensile test

Mechanical testing plays an important role in evaluating fundamental properties of engineering materials as well as in developing new materials and in controlling the quality of materials for use in design and construction. If a material is to be used as part of an engineering structure that will be subjected to a load, it is important to know that the material is strong enough and rigid enough to withstand the loads that it will experience in service. The tensile test is an excellent example of mechanical testing that may be used either to determine the yield strength of a material for use in design calculations or to ensure that the steel complies with a particular set of specifications. There are many types of testing machines.

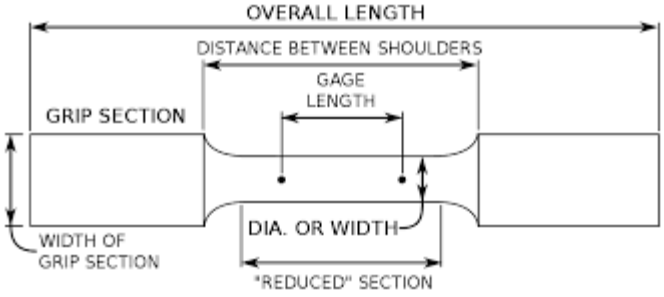


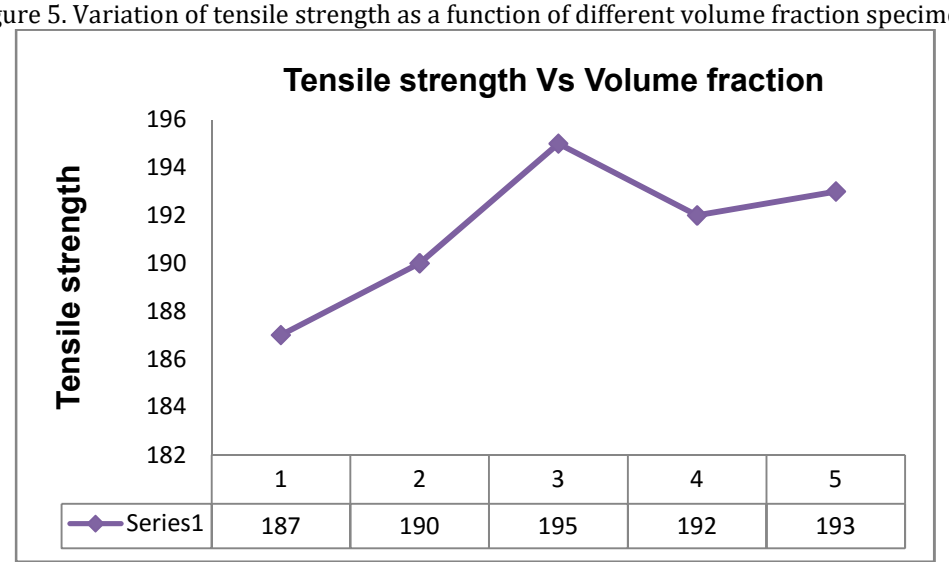
Figure 4. Tensile specimen details.

The most common are universal testing machines, which test materials in tension, compression or bending. The primary use of the testing machine is to create the stress-strain diagram. Once the diagram is generated, a pencil and straight edge or computer algorithm can be used to calculate yield strength, Young's Modulus, tensile strength or total elongation

Table 4: Observed reading in tensile test.

Details	Specimen-1 (Al-97% Cr-2% Zn-1%)	Specimen-2 (Al-97% Cr-3% Zn-1%)	Specimen-3 (Al-97% Cr-4% Zn-1%)	Specimen-4 (Al-97% Cr-5% Zn-1%)	Specimen-5 (Al-97% Cr-6% Zn-1%)
Length (mm)	100	100	100	100	100
Width (mm)	100	100	100	100	100
Thickness(mm)	10	10	10	10	10
Gauge length(mm)	25	25	25	25	25
Tensile load in (N)	33500	34500	34950	34880	34800
% of Elongation	4.6	4.5	4.6	4.4	4.3
Ultimate Tensile strength in (N/mm 2)	187	190	195	192	193

Figure 5. Variation of tensile strength as a function of different volume fraction specimen.



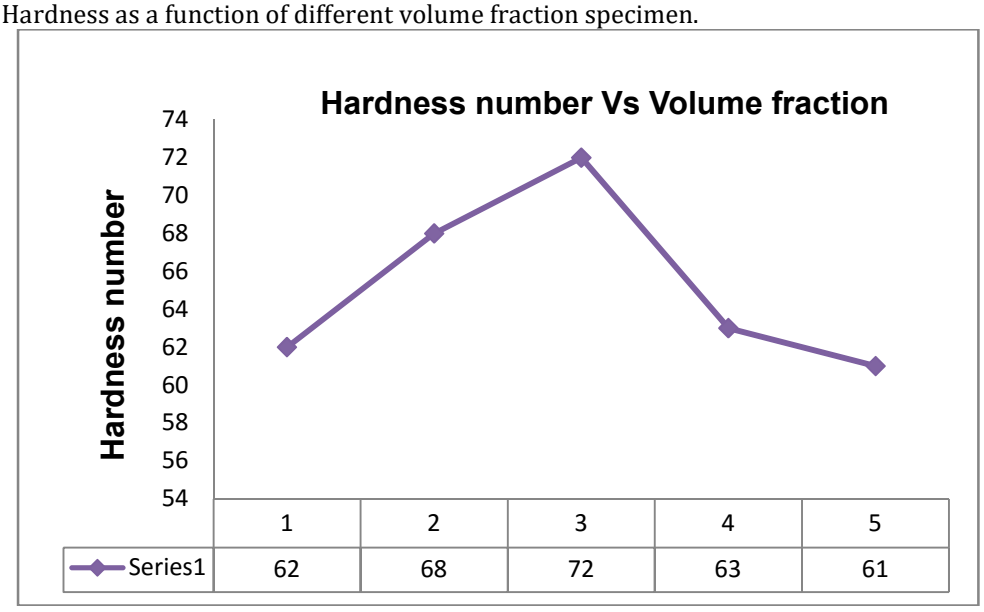
Hardness test:

Hardness is also so called crushing strength. Hardness tests are substantially simpler than other mechanical tests. Specially prepared specimens are not needed. Hardness tests can be used for many engineering applications to achieve the basic requirement of mechanical property. The hardness is measured according to the depth of indentation, under a constant load. The Rockwell scale is a hardness scale based on the indentation hardness of a material. Hardness measurements widely used in laboratory and as industrial tests (widely used on castings and forgings) as a tool characterizing the mechanical properties of materials. It can be used to classify the materials or to identify a material in a group. Rockwell hardness numbers are based on the difference of indenter depths from two load applications. Initially, a minor load is applied, which serves as a starting position. Then a major load is applied for a certain period of time, which increases the penetration depth. After a specified dwell time for the major load, the major load is removed, but the minor load is still maintained. The difference in depth is the Rockwell hardness number. The initial application of the minor load increases the accuracy of the testing, since it eliminates the effect of surface layers, which may not be representative of the bulk material. In this test, Rockwell hardness tests performed on unknown specimen with the intent of identifying the metals. The result of our experiment , shown in table below, correlated to several possible composition.

Table 5: Observed reading in hardness test

Composition AA7075	Load (kgf)	Load (N)	Penetrator	Scale	Dial Reading	Rockwell Hardness Number
Specimen-1 (Al-97% Cr-2% Zn-1%)	100	9.81	1/16"Ball Point	B	64 62 61	62
Specimen-2 (Al-97% Cr-3% Zn-1%)	100	9.81	1/16"Ball Point	B	66 70 69	68
Specimen-3 (Al-97% Cr-4% Zn-1%)	100	9.81	1/16"Ball Point	B	69 72 75	72
Specimen-4 (Al-97% Cr-5% Zn-1%)	100	9.81	1/16"Ball Point	B	65 62 63	63
Specimen-5 (Al-97% Cr-6% Zn-1%)	100	9.81	1/16"Ball Point	B	62 60 62	61

Figure 6. Hardness as a function of different volume fraction specimen.



MICROSTRUCTURE TEST

During microscopic examination or microstructure analysis, the structure of a material is studied under magnification. The properties of a material determine how it will perform under a given application and these properties are dependent on the material's structure. Proper preparation of the specimen and the material's surface requires that a rigid step-by-step process be followed. The first step is carefully selecting a small sample of the material to undergo microstructure analysis with consideration given to location and orientation. This step is followed by sectioning, mounting, grinding, polishing and etching to reveal accurate microstructure and content. Examination of the microstructure of a material provides information used to determine if the structural parameters are within certain specifications. The analysis results are used as a criterion for acceptance or rejection. SEM can be used to understand the microscopic structure of products allowing improvements to performance to be engineered. SEM/EDX is an extremely high magnification microscope which provides images and elemental analysis of materials or chemicals top down or in cross-section. The specimen must Be free from scratches, stains and others imperfections which tend to mark the surface. Reveal no evidence of chipping due to brittle inter metallic

compounds and phases. All technological properties of materials are directly connected to their microstructure. Among these properties are their strength and deformation characteristics, their wear and high temperature behavior, and also their corrosion behavior and the failure behavior under fatigue loads. Some of these properties can be changed dramatically by slight changes in the microstructure.

RESULT AND DISCUSSION

Aluminium alloy 7075 reinforced with nano-sized zinc 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 Znic nano-particles, however tensile value of the composite was much higher than the unreinforced aluminium alloy. And also hardness of fabricated composite value improved

(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.

(iii) Finally composite contain (Al-97%Cr-4%Zn-1%) fabricated composite showed improved properties such tensile and hardness in comparison with other specimens.

FUTURE WORK

Composite of Aluminium 7075 reinforced with different volume fraction of Zinc Nano Particles (40-80nm) which is preheated at different temperature is produced by stir casting method.

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