Fabrication of Aluminum alloy 2219 by using Stir Casting Process and Comparison of Micro structural and Mechanical Properties of Alloy 2219 with the Industrial based fabricated Alloy

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ABSTRACT

High strength aluminum alloys have been used in aircraft and space industries for many years due to its supplementary advantages. Alloy commonly used as an aerospace material due to its characteristics such as excellent weld ability as well as weld strength. The optimum strengthening of Al is achieved by varies fabrication methods and ***heat treatment processes****. The present work is to develop the aluminum alloy 2219 by adding different chemical composition. Stir casting process has been used to fabricate the alloy 2219 by taking weight percentage followed by forging operation with 400 kg of forging load. Then the specimens are heated in muffle furnace and these specimens treated in solution followed by aged to 240°C ,270°C and 310°C. After heat treatment the specimens have been analyzed in micro structural and mechanical tests, these properties have been studied on heat treated specimens to compare these results with the parent aluminum and aluminum alloy which is fabricated by the industrial methods.*

Key words: *Fabrication, Heat treatment processes, Stir casting, Micro structural and Mechanical properties.*

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1. INTRODUCTION

Aluminium is a chemical element in the boron group with symbol **Al** and atomic number 13. It is a silvery-white, soft, nonmagnetic, ductile metal. Aluminium is the third most abundant element in the Earth's crust (after oxygen and silicon) and its most abundant metal. Aluminium makes up about 8% of the crust by mass, though it is less common in the mantle below. Aluminium metal is so chemically reactive that native specimens are rare and limited to extreme reducing environments. Instead, it is found combined in over 270 different minerals. The chief ore of aluminium is bauxite.

Aluminium is remarkable for the metal's low density and for its ability to resist corrosion due to the phenomenon of passivation. Structural components made from aluminium and its alloys are vital to the aerospace industry and are important in other areas of transportation and structural materials, such as building facades and window frames The most useful compounds of aluminium, at least on a weight basis, are the oxides and sulphates.

Despite its prevalence in the environment, no known form of life uses aluminium salts metabolically. In keeping with its pervasiveness, aluminium is well tolerated by plants and animals. Owing to their prevalence, the potential beneficial (or otherwise) biological roles of aluminium compounds are of continuing interest. Aluminium is a relatively soft, durable, lightweight, ductile and malleable metal with appearance ranging from silvery to dull gray, depending on the surface roughness. It is nonmagnetic and does not easily ignite. A fresh film of aluminium serves as a good reflector (approximately 92%) of visible light and an excellent reflector (as much as 98%) of medium and far infrared radiation. The yield strength of pure aluminium is 7–11 MPa, while aluminium alloys have yield strengths ranging from 200MPa to 600 MPa. Aluminium has about one-third the density and stiffness of steel. It is easily machined, cast, drawn and extruded.

Aluminium atoms are arranged in a face-centered cubic (fcc) structure. Aluminium has a stacking-fault energy of approximately 200 mJ/m^2.

Aluminium is a good thermal and electrical conductor, having 59% the conductivity of copper, both thermal and electrical, while having only 30% of copper's density. Aluminium is capable of being a superconductor, with a superconducting critical temperature of 1.2 kelvin and a critical magnetic field of about 100 gauss (10 milliteslas)

2. EXPERIMENTAL PROCEDURE

2.1 Composite Preparation

For alloy development pure aluminium ingot, copper, magnesium and aluminium oxide average particles sizes were prepared. The aluminium ingot was melted in a graphite crucible and alloyed with required quantity of Cu-Zn-Mg metals. The details of the theoretically selected alloy composition (design composition) and manufacturing processing are given Table and Figures.

The given below are the selected compositions of master alloys in grams for manufacturing of composite materials

Table 2.1 weight of the components

Elements	Grams
Aluminum:	2775
Copper:	177
Iron:	09
Magnesium:	12
Manganese:	6
Silicon:	0.6
Titanium:	4.5
Vanadium:	0.3
Zinc:	0.6
Zirconium	7.5
Residuals:	4.5

The developed alloys were purged with N2 gas for few seconds. The required quantities of "Al2O3" particles were added in 2.5, 5, 10 and 15% weight percent's. The ceramics particles were mixed in a designed mixer by stirring for few minutes and cast in a steel mold consist 15 mm dia and 300mm length. The casting temperature was maintained at 750^{o}C. The cast samples were machined to prepare standard samples.15 standard samples were prepared. 20 samples were solution heat treated at 535^{0}C for 1 hour and age hardened at 120^{o}C for 24 hours in a muffle furnace. Tensile strength, elongation was determined using universal tensile testing machine. The details of the mechanical properties such as tensile strength, hardness and elongation are given in Figs.

Fig. 2.1. *Melting of alloys*

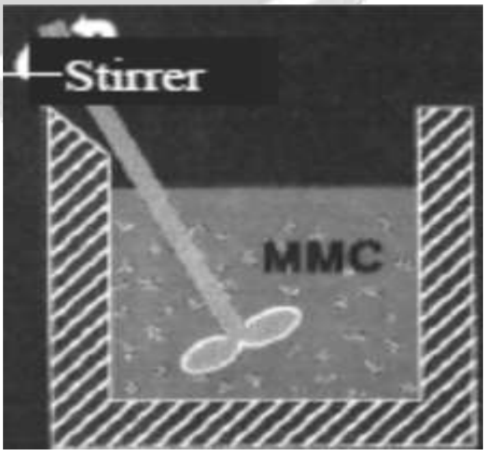


Fig. 2.2. *Stir casting process*

Fig 2.3: *Casting Of Samples In Metal Mold*

Fig 2.4 Prepared Samples By Using Stir Casting

3. RESULTS AND DISCUSSION

3.1 Tensile test results

Tensile strength is the ability of the material to withstand bending forces applied parallel to its longitudinal axis. The following figures shows the variation of strain as the stress increases and also the variation of displacement based on the applied of load.

BASE METAL

Graph3.1 (a) of base metal (prepared composition)

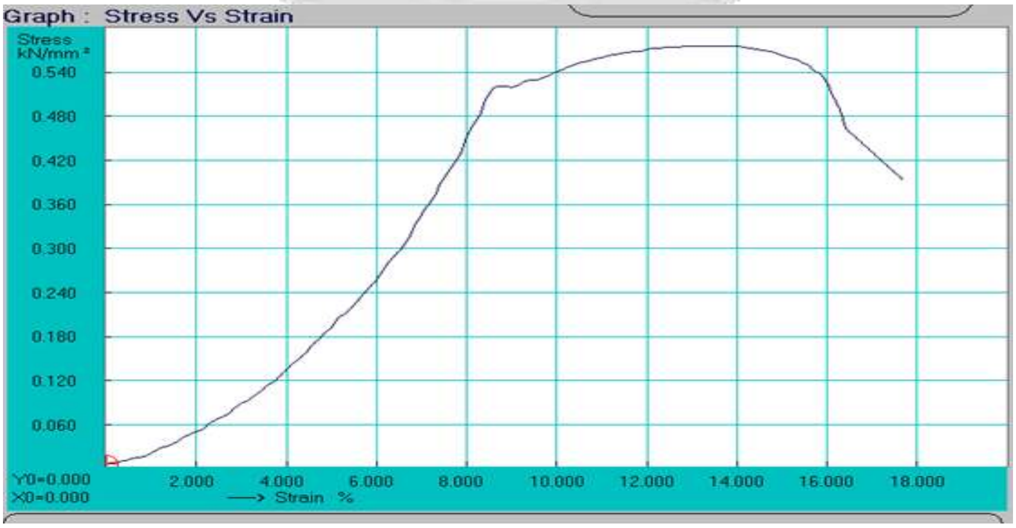
1st specimen

Graph 3.1(b) stress-strain diagram for 1st specimen

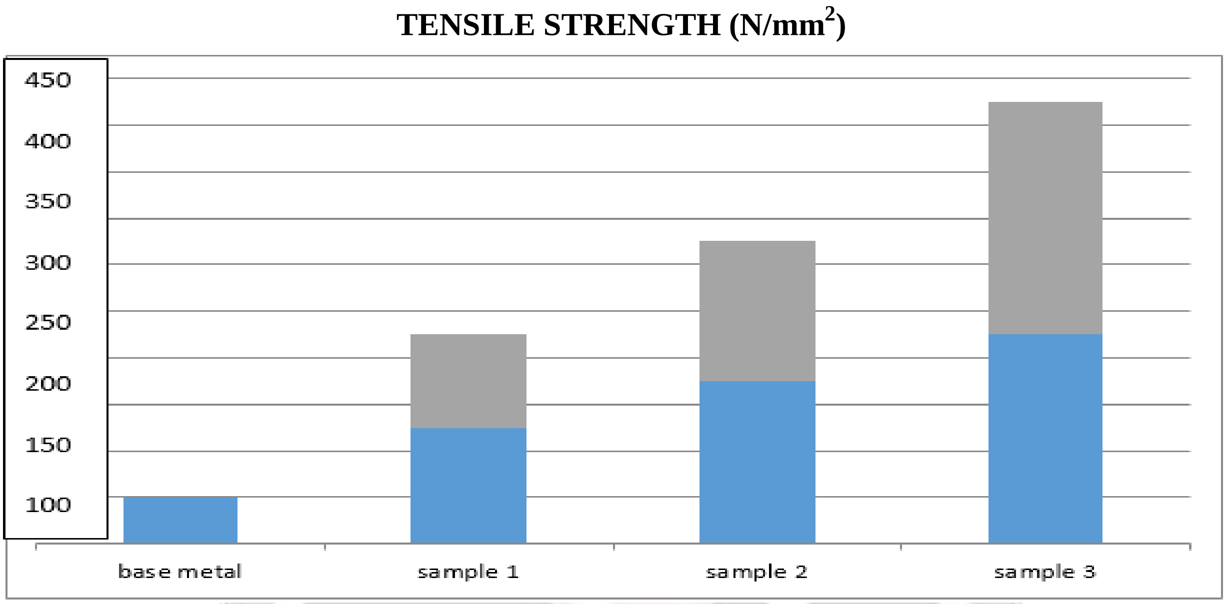
2nd specimen

Graph3.1(c) stress-strain diagram for 2nd specimen

3rd specimen



Graph 3.1(d) Stress-strain diagram for 3rd specimen



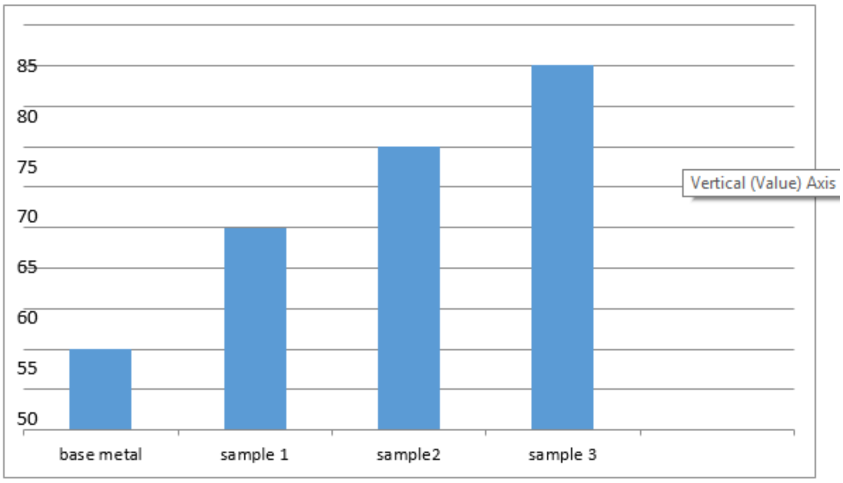
Graph 3.1(e) Comparison of all samples

Figure 3.1(f) Specimens after tensile test

Table 3.2 Hardness Test Results

Specimen	Indentation diameter X-axis (mm)	Indentation diameter Y-axis (mm)	Average diameter of indentation (d)	Ball diameter (D)	BHN
Base metal	0.8	0.8	0.8	1.58	63.87
240^0c	0.8	0.8	0.8	1.58	72.5
270^0c	0.8	0.7	0.75	1.58	81.3
310^0c	0.7	0.7	0.7	1.58	87.2

$$\mathrm{BHN} = \frac{2P}{\pi D\left(D - \sqrt{D^2 - d^2}\right)}$$



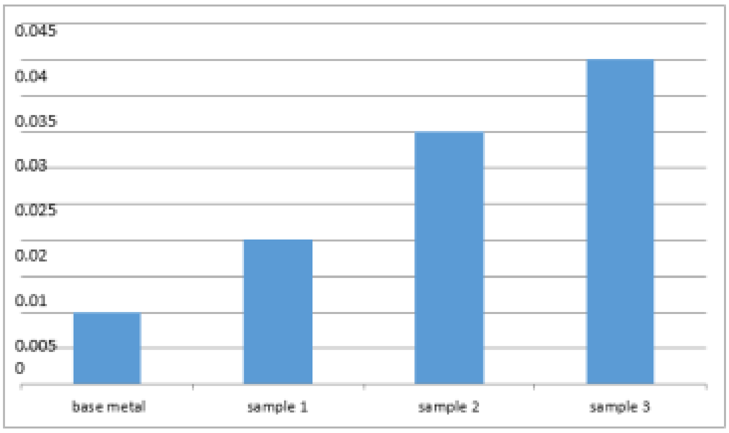
Graph 3.2.1 Comparison of all specimens

Fig 3.2.2 Specimens after Performing Hardness Test

3.3 IMPACT STRENGTH

Impact test were performed on AL2219 base alloy and heat treated alloys at 240^{0}c, 270^{0}c, 310^{0}c .These pieces are machined by using power hacksaw as per dimensions. this test was conducted by applying was conducted by applying 100kgf load on AL2219 and developed composites. due to sudden load on work piece the impact strength is calculated.

IMPACT STRENGTH

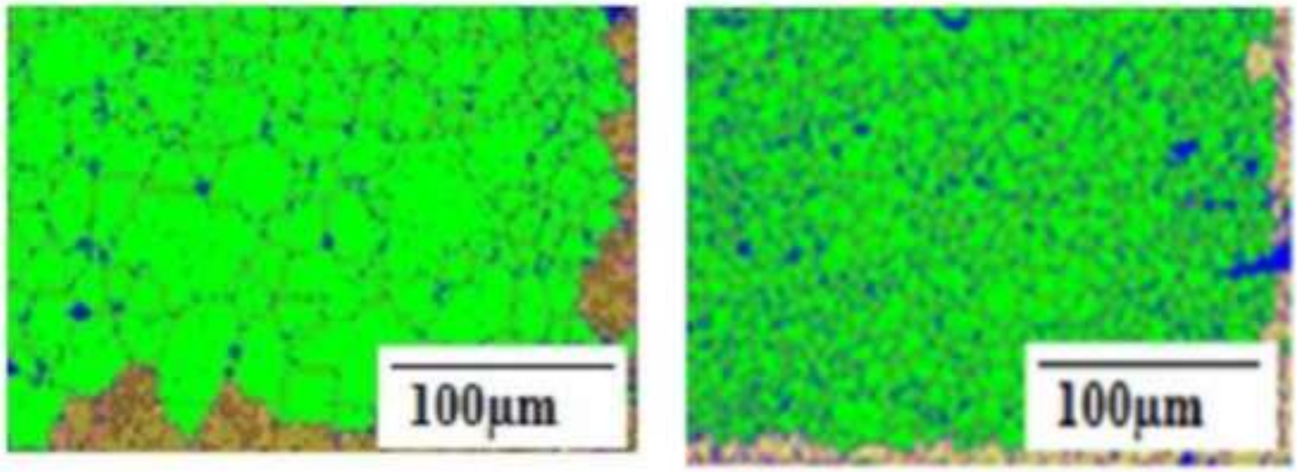


Graph 3.3.1 Comparison of all specimens

The above figure shows the variation of the impact strength levels of base metal and their samples. In the above graph shows that, the impact strength levels are increased with increase in composition. Generally, the impact strength will increase with increase in content of the reinforcement composition.

Figure 3.3.2 specimens after performing impact test

3.4 MICRO STRUCTURE STUDIES



Grain structure of base metal | **Grain structure of final specimen**

4.CONCLUSION

2219 alloy was prepared by stir casting process. Mechanical working process and heat treatment process had better results in improvement of mechanical properties of alloy.

5.REFERENCES

1.Dudas, J.H. and D.B. Thompson, 1970. Improved Sintering Procedures for Aluminum P/M Parts. Aluminum Company of America, USA.

2.Dumont, D., A. Deschamps and Y. Brechet, 2003. On the relationship between microstructure, strength and toughness in AA7050 aluminum alloy. Mater. Sci. Eng. A, 356: 326-336.

3.Dwight, J., 1999. Aluminum Design and Construction. Taylor and Francis Group, New York.

4.Garrett, G.G. and J.F.Knott, 1978. The influence of compositional and microstructural variations on the mechanism of static fracture in aluminum alloys. Metal. Mater. Trans. A, 9: 1187-1201.

5.Hatch, J.E., 1984. Aluminum: Properties and Physical Metallurgy. American Society of Materials, Metals Park, Ohio.

6.Jabeen, I. and R. Ahmad, 2007. A study of aging effects on hardness and tensile properties 2219 aluminum alloy. Proceedings of the International Conference of Materials Science and Technology and Exhibition (MS and T Partner Societies), Sept. 16-20, American Society for Materials, USA., pp: 1429-1438.

7.Kovacs, I., J. Lendvai, T. Ungar, T. Turmezey and G. Groma, 1977. The properties of an AlZnMg alloy deformation strengthened by Guinier-Preston zones. Acta Metall., 25: 673-680.

8.Li, X.Z., V. Hansen, J. Gjonnes and L.R. Wallenberg, 1999. HREM study and structure modeling of the η phase, the hardening precipitates in commercial Al-Zn-Mg alloys. Acta Mater., 47: 2651-2659.

9.Melander, A. and P.A. Persson, 1978. The strength of a precipitation hardened AlZnMg alloy. Acta Metall., 26: 267-278.

10.Mondolfo, L.F., 1976. Aluminum Alloys: Structure and Properties. Butterworths, Boston, London.

11.Mukhopadhyay, A.K., Q.B. Yang, S.R. Singh, 1994. The influence of zirconium on the early stages of aging of a ternary Al-Zn-Mg alloy. Acta Metall. Mater., 42: 3083-3091.

12.Raghavan, V., 1998. A First Course Materials Science and Engineering. Prentice Hall of India (Pvt.) Ltd., India, pp: 212-123.

13.Ringer, S.P. and K. Hono, 2000. Microstructural evolution and age hardening in aluminium alloys: Atom probe field-ion microscopy and transmission electron Mater. Charact., 44: 101-131.

14.Rosen, M., E. Horowitz, S. Fick, R.C. Reno and R. Mehrbian, 1982. An investigation of the precipitation-hardening process in aluminum alloy 2219 by means of sound wave velocity and ultrasonic attenuation. Mater. Sci. Eng., 53: 163-177.

15.Rosen, M., E. Hotowitz, L. Swartzendruber, S. Fick and R. Mehrabian, 1982. The aging process in aluminum alloy 2024 studied by means of eddy currents. Mater. Sci. Eng., 53: 191-198.

16.Shanmugasundaram, T., B.S. Murty and V. Subramanya, 2006. Development of ultrafine grained high strength Al-Cu alloy by cryorolling. Scripta Materialia, 54: 2013-2017.

17.Smith, W.F., 1981. Structure and Properties of Engineering Alloys. McGraw-Hill, New York.

18.Smith, W.F., 1993. Structure and Properties of Engineering Alloys. 2nd Edn., McGraw-Hill Inc., New York, USA.