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Experimental and Analysis of Aluminum –CU Composite with Different Composition

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Abstract-Copper-aluminum alloy or brass is known for their corrosion resistance. Brasses are stronger and more ductile than red and semi red brasses. They have high wear resistance and low friction coefficient against steel. The room temperature phase transformations are slow and usually do not occur; therefore these alloys are single phase alloys. The bronzes are used in bearings, gears, piston rings, valves and fittings. Aluminum is added to copper in order to improve mach inability and toughness. Aluminum increases the tensile strength and ductility of the copper, but the composition can be adjusted to balance mach inability and strength requirements. These alloys have a slow fail mechanism that temporarily prevents galling and seizing. In this project we have been added aluminum 10%, 20%, and 30% and which one is the best mechanical properties for automobile, aircraft component. In order that some experimental investigation conducting and finally concluded the best mechanical property in this composition.
Keywords-Al-Cu composites, Hardness test, Impact test, Microstructure test, Electrical Resistivity test.

I. INTRODUCTION

A. Introduction

Composite materials are materials made from two or more constituent materials with significantly different physical or chemical properties which remain separate and distinct on a macroscopic level within the finished structure. The greatest advantage of composite materials is strength and stiffness combined with lightness. By choosing an appropriate combination of reinforcement and matrix material, manufacturers can produce properties that exactly fit the requirements for a particular structure for a particular purpose.

II. METAL MATRIX COMPOSITE

A. Introduction

Metal matrix composite (MMC) is composite material with at least two constituent parts, one being a metal. The other material may be a different metal or another material, such as a ceramic or organic compound. MMCs are nearly always more expensive than the more conventional materials they are replacing. As a result, they are found where improved properties and performance can justify the added cost. Today these applications are found most often in aircraft components, space systems and high-end or ―boutique‖ sports equipment. The scope of applications will certainly increase as manufacturing costs are reduced.

B. Reinforcement

The reinforcement material is embedded into the matrix. The reinforcement does not always serve a purely structural task (reinforcing the compound), but is also used to change physical properties such as wear resistance, friction coefficient, or thermal conductivity. The reinforcement can be either continuous, or discontinuous. Discontinuous MMCs can be isotropic, and can be worked with standard metalworking techniques, such as extrusion, forging or rolling. In addition, they may be machined using conventional techniques, but commonly would need the use of polycrystalline diamond tooling (PCD).

III. PROPERTIES OF MATRIX

A. General Properties Of Copper

1) General Properties

Name, symbol, number-copper, Cu, 29
Standard atomic weight-63.546g·mol−1
Electron configuration-[Ar] 3d10 4s1
Electrons per shell 2, 8, 18, 1

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2) Physical Properties

Phase	solid
Density (near r.t.)	8.94 g·cm−3
Liquid density atm.p.	8.02 g·cm−3
Melting point	1357.77 K1084.62 °, C1984.32 °, F
Boiling point	2835 K2562 °, C4643 °, F
Heat of fusion	13.26 kJ·mol−1
Heat of vaporization	300.4 kJ·mol−1
Specific heat capacity	(25 °C) 24.440 J·mol−1·K−1

3) Atomic Properties

Oxidation states	+1, +2, +3, +4
(Mildly basic oxide)	
Electro negativity	1.90 (Pauling scale)
Ionization energies	
(More)	1st: 745.5 kJ·mol−1
	2nd: 1957.9 kJ·mol−1
	3rd: 3555 kJ·mol−1
Atomic radius	128 pm
Covalent radius	132±4 pm
Van der Waals radius	140 pm

4) Miscellanea

Crystal structure	face-centered cubic
Magnetic ordering	diamagnetic
Electrical Resistivity	(20 °C) 16.78 nΩ·m
Thermal conductivity	(300 K) 401 W·m−1·K−1
Thermal expansion	(25 °C) 16.5 µm·m−1·K−1
Speed of sound(thin rod)	
(r.t.) (annealed)	3810 m·s−1
Young's modulus	110–128 GPa
Shear modulus	48 GPa
Bulk modulus	140 GPa
Poisson ratio	0.34
Mohs hardness	3.0
Vickers hardness	369 MPa
Brinell hardness	874 MPa
CAS registry	
Number	7440-50-8

5) Most Stable Isotopes

Main article: Isotopes of copper

iso	NA	half-life	DM	DE (MeV)	DP
63	Cu	69.15%	^{63}Cu is stable with	34 neutrons	

B. General Properties of Aluminium

1) General Properties

Name, symbol, number- aluminium, Al, 13

Standard atomic weight-26.9815386g·mol^{-1}

Electron configuration-[Ne] $3s^2$ $3p^1$
Electrons per shell 2, 8, 3

2) Physical Properties

Phase	solid
Density (near r.t.)	2.70 g·cm−3
Liquid density atm.p.	2.375 g·cm−3
Melting point	933.47 K660.32.°, C1220.58 °, F
Boiling point	2792 K2519 °, C4566 °, F
Heat of fusion	10.71 kJ·mol−1
Heat of vaporization	294.0 kJ·mol−1
Specific heat capacity	(25 °C) 24.200 J·mol−1·K−1

3) Atomic Properties

Oxidation states	3,2,1
(Mildly basic oxide)	
Electro negativity	1.61 (Pauling scale)
Ionization energies	
(More)	1st: 577.5 kJ·mol−1
	2nd: 1816.7 kJ·mol−1
	3rd: 2744.8 kJ·mol−1
Atomic radius	143 pm
Covalent radius	121±4 pm
Van der Waals radius	184 pm

4) Miscellanea

Crystal structure	face-centered cubic
Magnetic ordering	paramagnetic
Electrical Resistivity	(20 °C) 28.2 nΩ·m
Thermal conductivity	(300 K) 237 W·m−1·K−1
Thermal expansion	(25 °C) 23.1 µm·m−1·K−1
Speed of sound(thin rod)	
(r.t.) (annealed)	5000 m·s−1
Young's modulus	70 GPa
Shear modulus	26 GPa
Bulk modulus	76 GPa
Poisson ratio	0.35
Mohs hardness	2.75
Vickers hardness	167 MPa
Brinell hardness	245 MPa
CAS registry	
Number	7429-90-5

5) Most Stable Isotopes

Main article: Isotopes of copper

iso	NA	half-life	DM	DE (MeV)	DP
27Al	100	^{27}Al is stable with 14 neutrons			

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IV. MATERIAL REQUIREMENT FOR VARIOUS RATIOS

Requirement size -100 x 100 x18
Volume=10x10x1.8=180cm^3

A. Mixing ratio-90%&10% (Copper and Aluminium)

Volume of copper=180*0.90=162 gm
Volume of Aluminum=180*.10=18 gm
Density of copper=8.9gm/cc
Weight of copper 162*8.9=1441.8 gm =1.441kg
Density of aluminum=2.7gm/cc
Weight of Aluminum =18x2.7= 48.6 gm 30 % for excess (Runner&riser,slag)
Total weight of mixture
Copper=1441.8 gm +410 gm= 1851.8 gm
Aluminum=48.6+15=63.6 gm

B. Mixing ratio-80%&20%(Copper and Aluminium)

Volume of copper=180*0.80=144 gm
Volume of Aluminum=180*.20=36 gm
Density of copper=8.9 gm/cc
Weight of copper 144*8.9=1281.6 gm/cc=1.281kg
Density of aluminum=2.7gm/cc
Weight of Aluminum =36x2.7=97.2 gm
30 % for excess (Runner&riser, slag) Total weight of mixture
Copper=1281.6Kg+360 g= 1641.6gm Aluminum=97.2+30=127.2 gm

C. Mixing ratio-70%&30%(Copper and Aluminum)

Volume of copper=180*0.70=126 gm Volume of Aluminum=180*.30=54 gm Density of copper=8.9gm/cc
Weight of copper 126*8.9=1121.4 gm =1.121kg Density of aluminum=2.7gm/cc
Weight of Aluminum =54x2.7=145.8 gm 30 % for excess
(runner &riser, slag) Total weight of mixture
Copper=1121.4g+300 g= 1421.4gm=1.421kg
Aluminum=145.8+45=190.8gm

V. DESTRUCTIVE TEST

A. Rockwell Hardness Test

1) Hardness Details

TYPES: Rockwell Hardness
Major Load Applied: 100Kgf
Types of Indenter used: 1/16 —

2) Verification of Raw Materials

S.No	Material	Trial 1	Trial 2	Trial 3	Trial 4	Trial 5	Mean
1	Pure Aluminum(LM4)	39	41	48	40	40	39.5
2	Pure Copper	81	79	78	83	83	81

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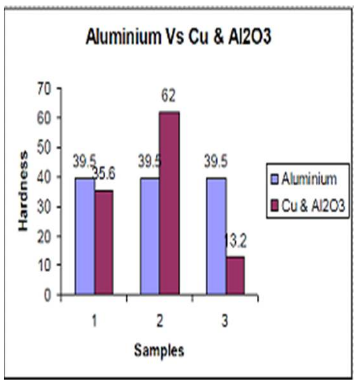
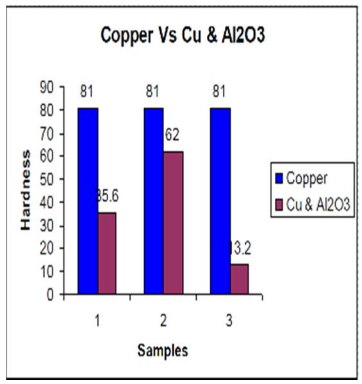
3) Verification of Composite Materials

S.No	Material	Trial 1	Trial 2	Trial 3	Trial 4	Trial 5	Mean
1	Cu – 90%- Al_2O_3 – 10%	35	39	33	32	39	35.6
2	Cu – 80%- Al_2O_3 – 20%	54	58	60	69	68	62
3	Cu – 70%- Al_2O_3 – 30%	12	16	14	13	11	13.2

4) Comparison Graph





Sample 1 : 90% Cu 10% Al_2O_3
Sample 2 : 80% Cu 20% Al_2O_3
Sample 3 : 70% Cu 30% Al_2O_3

B. Impact Test

a) Impact Strength

Izod method.
Specification of the Machine :
Energy Range = 0 – 168 J
Least Count (1 Division) = 2J
SPECIMEN LENGTH-75 mm
SIZE-10Sqmm
NOTCH- V NOTCH (45^O Included Angle)
FALL ANGLE-90^O
SPECIMEN SUPPORTING- Cantilever Beam setup
NOTCH DEPTH-2mm
AREA- a^2
- $(10 – 2)^2$
-64mm^2

COMPOSITION I:
90%-10% Cu and Al2O3
I = K/A J/m2
I = Impact Strength
K = Energy Observed
A = Area

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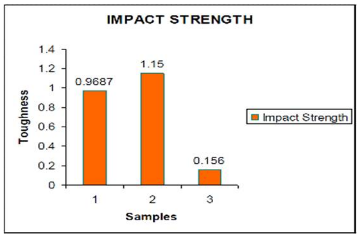
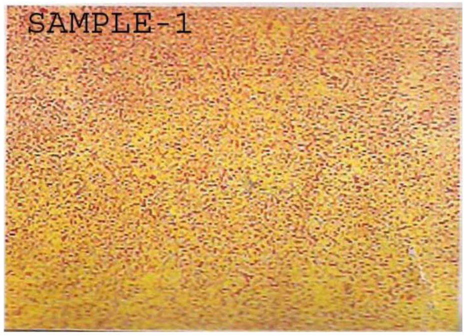
Energy Observed = 62J/mm2
= 62/64 = 0.9687 J/mm2
COMPOSITION II :
80%-20% Cu and Al2O3
I = K/A J/m2
Energy Observed = 74J/mm2
= 74/64 = 1.15 J/mm2
COMPOSITION III:
70%-30% Cu and Al2O3
I = K/A J/m2
Energy Observed = 10J/mm2
= 10/64 = 0.156 J/mm2
COMPARISON GRAPH



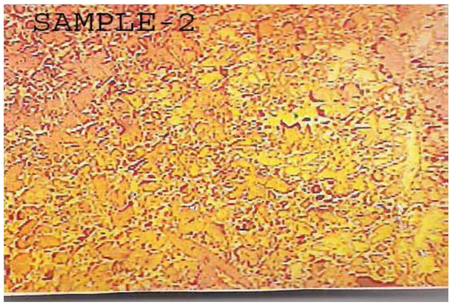
Sample 1 : 90% Cu 10% Al2O3
Sample 2 : 80% Cu 20% Al2O3
Sample 3 : 70% Cu 30% Al2O3

C. Microstructure

1) *Microstructure Results:* Microstructure of Cu-Al_2O_3 at 90%-10%



The matrix shows completely fine transformed beta as the matrix. Some equi-axed alpha also present in the matrix of beta.
Microstructure of Cu-Al_2O_3 at 80%-20%



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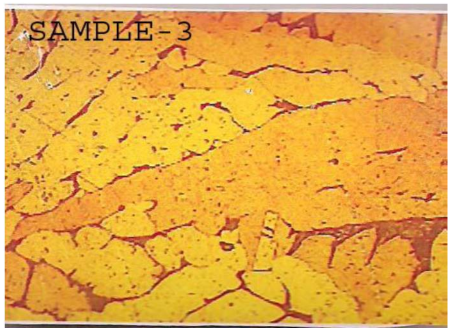
The matrix large grains of alpha in a matrix of beta solid solution. The matrix also shows the intergranular voids. This may also due to shrinkage defect taken place during casting.

Microstructure of Cu-Al_2O_3 at 70%-30%



The matrix shows cast fine inter-dendritic grains of alpha and beta. The matrix is beta and the presence of alpha solid solution is about 20% in a matrix of beta solid solution. Void shows the material is cast and due to shrinkage defect

D. Electrical Resistivity

Electrical Resistivity

S.NO	sample	size	Resistance
1	Cu-Al2O3 at 90%-10%	90x90	0.3
2	Cu-Al2O3 at 80%-20%	90x90	0.4
3	Cu-Al2O3 at 70%-30%	90x90	0.2

$$\text{Resistivity} = \frac{\text{Resistance x Area}}{\text{Length}}$$

COMPOSITION I :

90%-10% Cu and Al2O3

$$= \frac{0.3 \text{ x } 1620}{90} = 5.4 \text{ Ohms}$$

COMPOSITION II :

90%-10% Cu and Al2O3

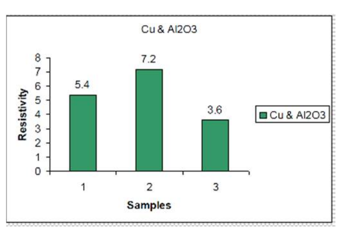
$$= \frac{0.4 \text{ x } 1620}{90} = 7.2 \text{ Ohms}$$

COMPOSITION III:

90%-10% Cu and Al2O3

$$= \frac{0.2 \text{ x } 1620}{90} = 3.6 \text{ Ohms}$$

COMPARISON GRAPH



VI. CONCLUSION

Composite materials especially Cu-Al_2O_3 composites having good mechanical properties compared with the conventional materials. It is used in various industrial application these materials having light weight along with high hardness .It with stand high load

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compare with the existing materials are most applicable in the engineering products instead of existing materials.

Finally I conclude that the percentage of Aluminum increases automatically the hardness and all the parameters are increasing

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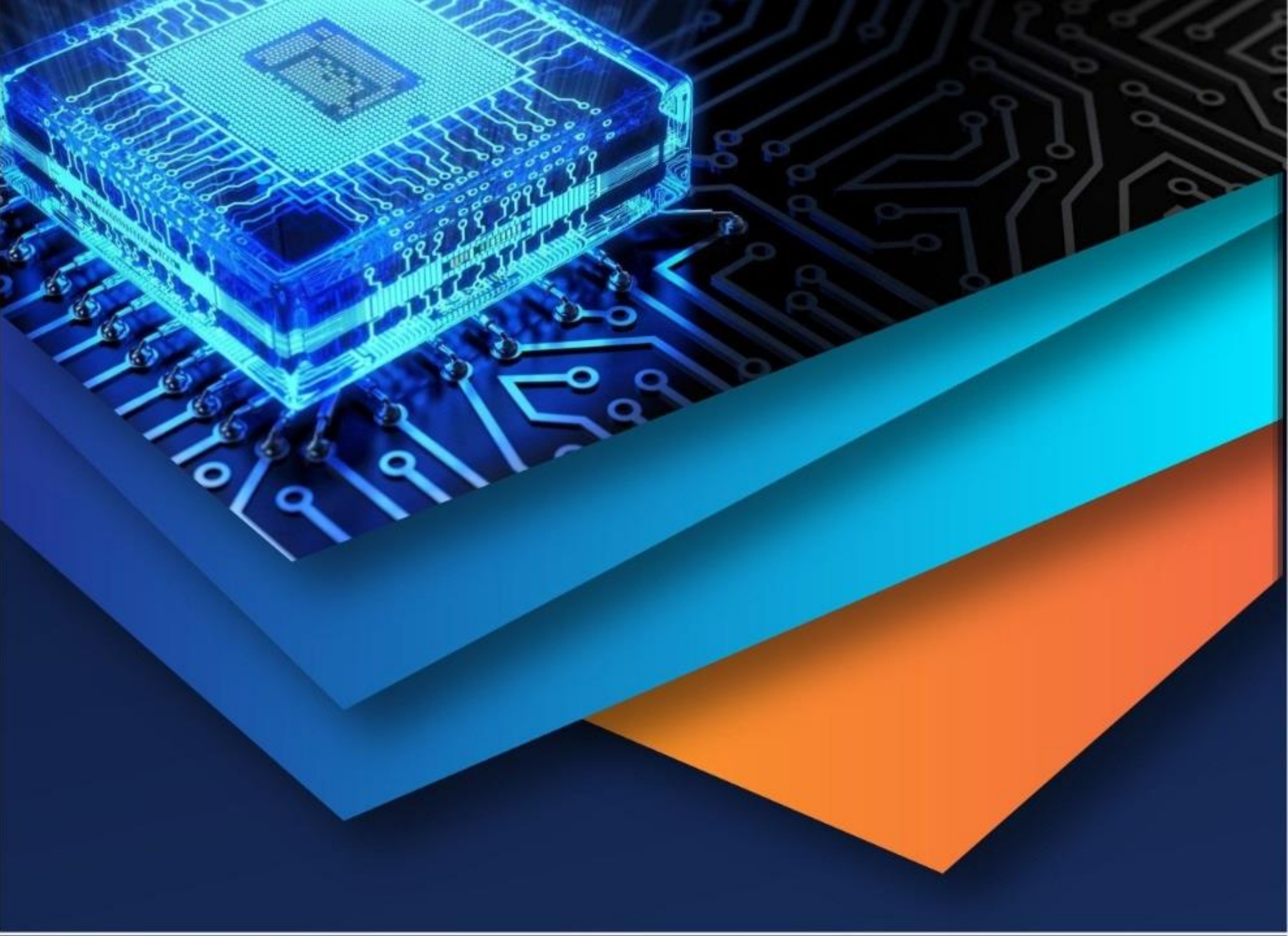

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