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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$^{-1}$

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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 <u>30 % for excess</u> (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
<u>30 % for excess</u> (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 <u>30 % for excess</u>
(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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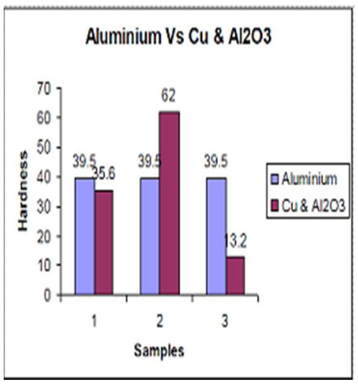
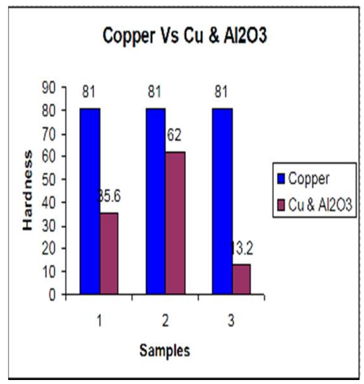
*3) Verification of Composite Materials*

| 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- $a^2$
- $(10 – 2)^2$
ˉ64mm$^2$

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

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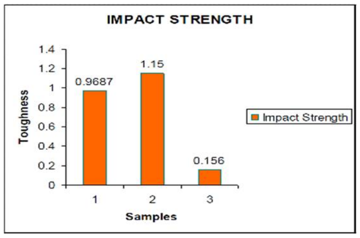
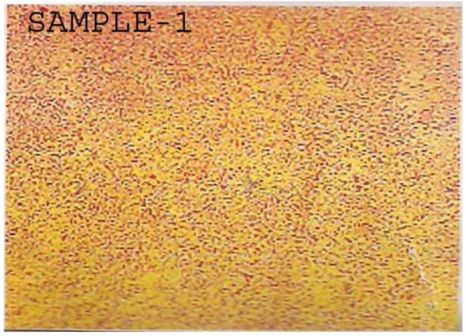
Energy Observed = 62J/mm2
= 62/64 = 0.9687 J/mm2
COMPOSITION II :
80%-20% Cu and Al2O3
I = K/A J/m2
Energy Observed = 74J/mm2
= 74/64 = 1.15 J/mm2
COMPOSITION III:
70%-30% Cu and Al2O3
I = K/A J/m2
Energy Observed = 10J/mm2
= 10/64 = 0.156 J/mm2
COMPARISON GRAPH



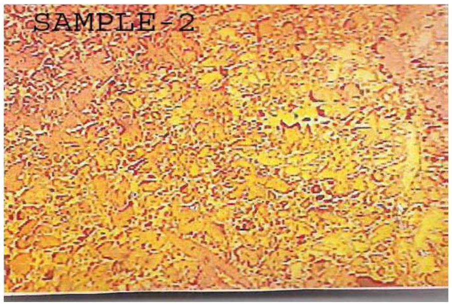

Sample 1 : 90% Cu 10% Al2O3
Sample 2 : 80% Cu 20% Al2O3
Sample 3 : 70% Cu 30% Al2O3

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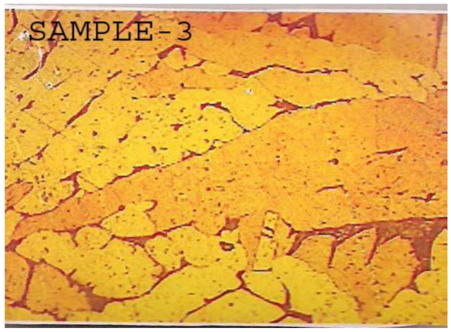
The matrix large grains of alpha in a matrix of beta solid solution. The matrix also shows the intergranular voids. This may also due to shrinkage defect taken place during casting.

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

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

COMPOSITION II :

90%-10% Cu and Al2O3

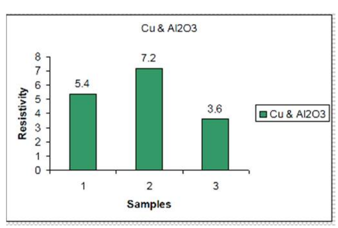
$$= \frac{0.4 \times 1620}{90} = 7.2 \text{ Ohms}$$

COMPOSITION III:

90%-10% Cu and Al2O3

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

*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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