Investigational Assesment of Cu-Al_2O_3 Composite Material with Dissimilar Configuration

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Abstract - Alumina (Al2O3) retains auspicious physical and chemical properties such as high strength, hardness, elastic modulus and excellent resistance to thermal and chemical environments. However, its solicitations are slightly partial because of underprivileged sturdiness and substandard updraft resistance [1]. On the other hand, most structural ceramics existent poor electrical conductivity. It has been testified that the integration of some amounts of small-size metal elements into an Al2O3 matrix, as in the case of Al2O3, Cu (90%-10%) [2], Al2O3, Cu (80%-20%)[3] and Al2O3, Cu (70%-30%) composites, can suggestively progress both the robustness and electrical properties.

1. INTRODUCTION

Composite materials are materials made from dual or more fundamental materials with ominously different physical or chemical properties which remain distinct and distinct on a macroscopic level within the complete configuration. In an progressive society like ours we all depend on composite materials in some aspect of our lives. Fiber glass, developed in the late 1940s, was the first modern composite and is still the most common. It makes up about 65 percent of all the omposites produced today and is used for boat hulls, surfboards, sporting goods, swimming pool linings, building panels and car bodies. You may well be using something made of fiberglass without knowing it. Composite materials are formed by combining two or more materials that have quite different properties. The different materials work together to give the composite unique properties, but within the composite you can easily tell the different materials apart – they do not dissolve or blend into each other. Put more technically, it has both good compressive strength and good tensile strength. Composites exist in nature.

2. METAL MATRIX COMPOSITE

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 claims 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. In comparison with conventional polymer matrix composites, MMCs are resistant to fire, can operate in wider range of temperatures, do not absorb moisture, have better electrical and thermal conductivity, are resistant to radiation, and do not display out gassing. On the other hand, MMCs tend to be more expensive, the fiber-reinforced materials may be difficult to fabricate, and the available experience in use is limited.

3. COMPOSITION

MMCs are made by dispersing a reinforcing material into a metal matrix. The reinforcement surface can be coated to prevent a chemical reaction with the matrix. For example, carbon fibers are commonly used in aluminum matrix to synthesize composites showing low density and high strength. However, carbon reacts with aluminum to generate a brittle and wate the surface of the fiber. To prevent this reaction, the carbon fibers are coated with nickel or titanium boride. Over recent decades many new composites have been developed, some with very valuable properties. By carefully choosing the reinforcement, the matrix, and the manufacturing process that brings them together, engineers can tailor the properties to meet specific requirements. They can, for example, make the composite sheet very strong in one direction by aligning the fibres that way, but weaker in another direction where strength is not so important. They can also select properties such as resistance to heat, chemicals, and weathering by choosing an appropriate matrix material.

4. MATRIX

The matrix is the monolithic material into which the reinforcement is embedded, and is completely continuous. This means that there is a path through the matrix to any point in the material, unlike two materials sandwiched together. In structural applications, the matrix is usually a lighter metal such as Aluminium, magnesium, or titanium, and provides a compliant support for the reinforcement. In high temperature applications, cobalt and cobalt-nickel alloy matrices are common.

5. 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).

6. PROPERTIES AND APPLICATIOS OF MATRIX(Cu)

Copper is a chemical element with the symbol Cu and atomic number 29. It is a ductile metal with very high thermal and electrical conductivity. Pure copper is rather soft and malleable and a freshly-exposed surface has a pinkish or peachy color, which (besides gold and cesium) is unusual for metals, which are usually silvery or grayish. It is used as a thermal conductor, an electrical conductor, a building material, and a constituent of various metal alloys.

7. PROPERTIES OF COPPER

Copper is easily worked, being both ductile and malleable. The ease with which it can be drawn into wire makes it useful for electrical work in addition to its excellent electrical properties. Copper can be machined, although it is usually necessary to use an alloy for intricate parts, such as threaded components, to get really good machinability characteristics. Good thermal conduction makes it useful for heat sinks and in heat exchangers. Copper has good corrosion resistance, but not as well as gold. It has excellent brazing and soldering properties and can also be welded, although best results are obtained with gas metal arc welding.

8. PROPERTIES OF COPPER

PROPERTY	SI/METRIC
Density(gm/cc)	8.92
Color	Brown
Elastic Modulus(GPa)	117
Poisson's Ratio	0.35
Ultimate Tensile Strength(MPa)	220
Melting Temp (°C)	1084.62
Boiling point(°C)	2562

Table 5.2: Physical Data of Copper

CONTENTS	PROPERTIES
Name	copper
symbol	Cu
Number	29
Standard atomic weight	$63.546 g.mol^{-1}$
Electron configuration	$[Ar]\ 3d^{10}\ 4s^1$
Electrons per shell	2, 8, 18, 1

Table 5.3: General Properties of Copper

9. PROPERTIES AND APPLICATION OF ALUMINUM (Al2O3)

Aluminum 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 aluminum and its alloys are vital to the aerospace industry and are very important in other areas of transportation and building. Its reactive nature makes it useful as a catalyst or additive in chemical mixtures, including ammonium nitrate explosives, to enhance blast power. Despite its prevalence in the environment, aluminum salts are not known to be used by any form of life. Also in keeping with the element's abundance, it is well tolerated by plants in soils (in which it is a major component), and to a lesser extent, by animals as a component of plant materials in the diet (which often contain traces of dust and soil). Soluble aluminium salts have some demonstrated toxicity to animals if delivered in quantity by unnatural routes, such as injection. Controversy still exists about aluminium's possible long-term toxicity to humans from larger ingested amounts.

10. CHARACTERISTICS

Aluminum is a soft, durable, lightweight, ductile and malleable metal with appearance ranging from silvery to dull gray, depending on the surface roughness. Aluminum is nonmagnetic and non-sparking. It is also insoluble in alcohol, though it can be soluble in water in certain forms. The yield strength of pure aluminum is 7–11 MPa, while aluminum alloys have yield strengths ranging from 200 MPa to 600 MPa.[6] Aluminum has about one-third the density and stiffness of steel. It is easily machined, cast, drawn and extruded.

Fig 6.1: Etched Surface of Aluminum

Etched surface from a high purity (99.9998%) aluminum bar, size 55×37 mm.

Corrosion resistance can be excellent due to a thin surface layer of aluminum oxide that forms when the metal is exposed to air, effectively preventing further oxidation. The strongest aluminum alloys are less corrosion resistant due to galvanic reactions with alloyed copper.[6] This corrosion resistance is also often greatly reduced when many aqueous salts are present, particularly in the presence of dissimilar metals. Aluminum atoms are arranged in a face-centered cubic (fcc) structure. Aluminum has a stacking-fault energy of approximately 200 mj/m2.

Aluminum is one of the few metals that retain full silvery reflectance in finely powdered form, making it an important component of silver paints. Aluminum mirror finish has the highest reflectance of any metal in the 200–400 nm (UV) and the 3,000–10,000 nm (far IR) regions; in the 400–700 nm visible range it is slightly outperformed by tin and silver and in the 700–3000 (near IR) by silver, gold, and copper. Aluminum is a good thermal and electrical conductor, having 62% the conductivity of copper. Aluminum is capable of being a superconductor, with a superconducting critical temperature of 1.2 Kelvin's and a critical magnetic field of about 100 gauss (10 milliteslas).

11. PROPERTIES OF ALUMINUM

Table no 11.1 Physical Data of Aluminum

PROPERTY	SI/METRIC
Density (g/cm3)	2.6898
Specific Gravity	2.7
Melting Point (°C)	660.2
Boiling Point (°C)	2480
Modulus of Elasticity (GPa)	68.3
Poisson's Ratio	0.35

Table 11..2 General Properties of Aluminum

CONTENTS	PROPERTIES
Name,	Aluminum
Symbol	Al
Number	13
Standard atomic weight	26.9815386g.mol−1
Electron configuration	[Ne] 3s2 3p1
Electrons per shell	2, 8, 3
Material Requirement for Various Ratios	
Requirement size	100 X100 X18
Volume	10X10X1.8=180cm3
Mixing ratio	90%&10% (Copper and Aluminum)
Volume of copper	180X0.90=162 gm
Volume of Aluminum	180X.10=18 gm
Density of copper=8.9gm/cc	180X.10=18 gm
Weight of copper	162X8.9=1441.8 gm =1.441kg
Density of aluminum	2.7gm/cc
Weight of Aluminum	18X2.7= 48.6 gm

TOTAL WEIGHT OF MIXTURE

30 % for excess (Runner riser, slag)	
Copper=1441.8 gm +410 gm	1851.8 gm

Aluminum	48.6+15=63.6 gm
Mixing ratio-	80%&20 %(Copper and Aluminum)
Volume of copper	180X0.80=144 gm
Volume of Aluminum	180X.20=36 gm
Density of copper	8.9 gm/cc
Weight of copper	144X8.9=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+360g=	1641.6gm
Aluminum	97.2+30=127.2 gm
Mixing ratio	70%&30 %(Copper and Aluminum)
Volume of copper=	180X0.70=126 gm
Volume of Aluminum	180X.30=54 gm
Density of copper	8.9gm/cc
Weight of copper	126X8.9=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

12. BASIC PROCESS

- Place a pattern in sand to create a mold.
- Incorporate the pattern and sand in a gating system.
- Remove the pattern.
- Fill the mold cavity with molten metal.
- Allow the metal to cool.
- Break away the sand mold and remove the casting.

RESULT AND DISCUSSION

Result For Rockwell Hardness Test

Types: Rockwell Hardness

Major Load Applied: 100Kgf

Types of Indenter used: 1/16 "

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

Table: Verification of Composite Materials

S.No	Material	Trial 1	Trial 2	Trial 3	Mean
1	Cu – 90% Al_2O_3 – 10%	55	55	56	55.3
2	Cu – 80% Al_2O_3 –20%	60	60	60	60
3	Cu – 70% Al_2O_3 – 30%	12	16	14	14

Comparison Graph: Hardness of the Materials

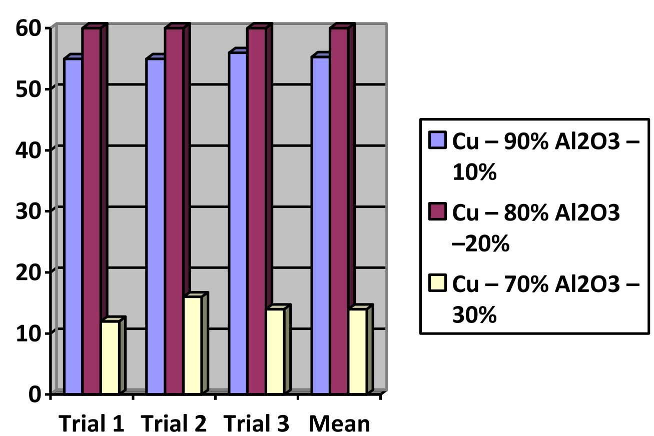


Fig. Comparison graph of Hardness Al Vs CU & Al2O3

Fig. Comparison graph of Hardness CU Vs CU & Al2O3

Sample 1: 90% Cu 10% AL2O3

Sample 2: 80% Cu 20% AL2O3

Sample 3: 70% Cu 30% Al2O3

Impact Strength

Specification of the Machine

Energy Range = 0 – 168 J

Least Count (1 Division) = 2J

Specimen length = 75 mm

Size = 10sqmm

Notch = v notch (45o included angle)

Fall angle = 90o

Specimen supporting = cantilever beam setup

Notch depth = 2mm

Area = a2

= (10 – 2)2 = 64mm2

COMPOSITION I: 90%-10%

Cu and Al2O3

I = K/A J/m2

I = Impact Strength

K = Energy Observed

A = Area

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

Impact Test Result

90%-10% = 0.9687 J/mm2

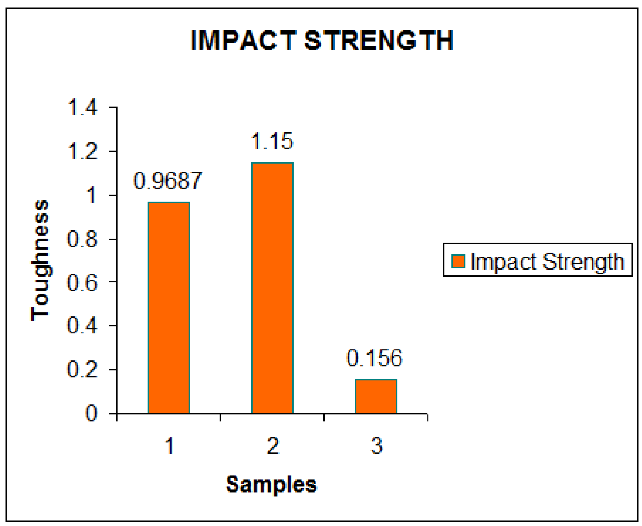
Result:

80%-20% = 1.15 J/mm2

Result:

70%-30% - 0.156 J/mm2

Comparison graph: Toughness of the Materials



Comparison graph of Impact Strength CU & Al2O3

Sample 1: 90% Cu 10% al_2o_3

Sample 2: 80% Cu 20% al_2o_3

Sample 3: 70% Cu 30% al_2o_3

Electrical Resistivity

S.No	Sample	Size	Resistance
1	$Cu\text{-}Al_2O_3$ at 90%-10%	90x90	0.3
2	$Cu\text{-}Al_2O_3$ at 80%-20%	90x90	0.4
3	$Cu\text{-}Al_2O_3$ at 70%-30%	90x90	0.2

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

COMPOSITION I:

90%-10% Cu and Al_2O_3

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

COMPOSITION II:

80%-20% Cu and Al_2O_3

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

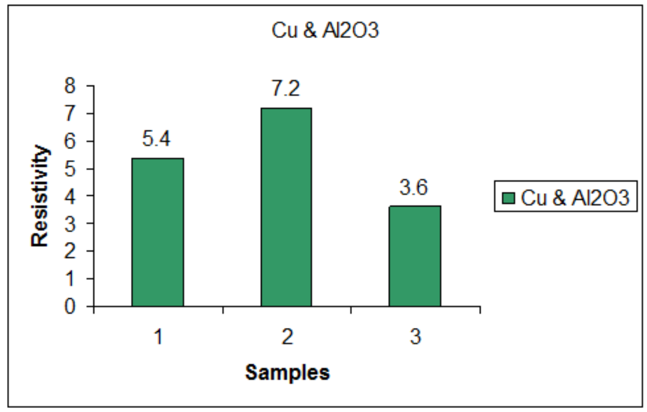
COMPOSITION III:

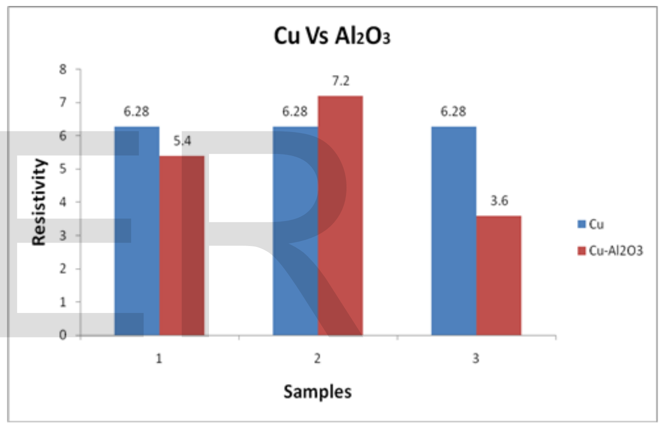
70%-30% Cu and Al_2O_3

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

Comparison graph: Resistivity of the Materials

Comparison graphs of Resistivity CU & Al_2O_3





Comparison graphs of Resistivity CU & Al_2O_3

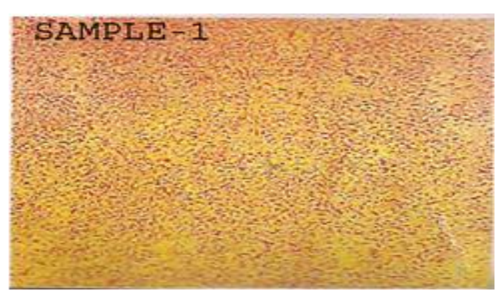
Sample 1: 90% Cu 10% al_2o_3

Sample 2: 80% Cu 20% al_2o_3

Sample 3: 70% Cu 30% al_2o_3

Microstructure Results

Microstructure of $Cu\text{-}Al_2O_3$ at 90%-10%



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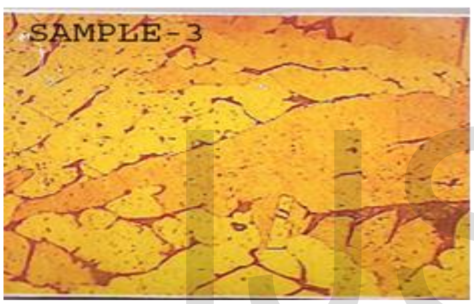
Microstructure of Cu-Al_2O_3 at 80%-20%

Microstructure of Cu-Al_2O_3 at 80%- 20%

Microstructure of Cu-Al_2O_3 at 70%-30%



Microstructure of Cu-Al_2O_3 at 70%-30%

Verification of (Cu – 90%Al_2O_3 – 10%)

Elements	Actual values%	Elements	Actual values%
Zinc	0.138	Cobalt	<0,0004
Lead	0.118	Antinomy	0.005
Tin	>0.330	Manganese	<0.0001
Iron	0.010	Silicon	<0.0001
Phosphorous	0.0005	Sulphur	0.33
Nickel	0.011	Chromium	<0.002
Aluminium	<0.0003	Copper	99.334

Verification of (Cu – 80%Al_2O_3 – 20%)

Elements	Actual values%	Elements	Actual values%
Zinc	0.121	Cobalt	<0.0004
Lead	0.120	Antinomy	0.005
Tin	>0.330	Manganese	<0.0001
Iron	0.051	Silicon	0.004
Phosphorous	0.001	Sulphur	0.041
Nickel	0.011	Chromium	<0.0002
Aluminium	<0.0003	Copper	99.307

13. CONCLUSION

Composite materials specifically Cu-Al2O3 composites having good mechanical properties are paralleled with the conservative materials. It is used in various engineering solicitation and these materials having light heaviness along with high rigidity. It endure high consignment when paralleled with the existing provisions and are most appropriate in the engineering products as an alternative of existing materials. Finally, we determine that the proportion of Aluminum upsurges spontaneously, the hardness and wholly all the factors are increasing. If the proportion of copper and aluminum increases the rigidity of the material, resistivity of the products manufactured proliferations and it improves the overall efficiency.

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