Innovative Systems Design and Engineering www.iiste.org
ISSN 2222-1727 (Paper) ISSN 2222-2871 (Online)
Vol 2, No 3

# Analysis of properties of Al-Cu composition using P/M route

Raji Kasiram (Corresponding Author)
Associate Professor of Physics
Holy Cross College (Auto),
Affiliated to Bharathidasan University,
Tiruchirappalli , Tamil Nadu, India.
rajdavey59@yahoo.co.in

Alfred Cecil Raj
Associate Professor of Physics
St.Joseph's College (Auto),
Affiliated to Bharathidasan University,
Tiruchirappalli , Tamil Nadu, India
mkumarudai@yahoo.com

**Abstract**

Aluminium is chemically active metal that owes its stability and corrosion resistance to an ever present protective film of oxide. It is well known that Cu-$Al_2O_3$ composite materials have high potential for use in structural applications in which enhanced mechanical characteristics are required. There fore ,oxidized copper is mixed with aluminium powder in a pot mill and sintered at elevated temperature of 550 $^0$ C. Copper composite with varying amount of 9%,11%,13% by weight of alumina was used to fabricate compact using powder metallurgy route. The blended powder was compacted at optimized load to produce compact of h/d ratio in range of 1.0 / 1.1 and then sintered at a temperature of 550 $^0$ C for 1 1/2 Hours. Green density, sintered density, mechanical properties like hardness, compression test are estimated. The investigation shows that Al and Al matrix composites offer lower density, improved strength and stiffness and wear resistance. The compacts are extruded for further investigation.

**Key Words:** Compacts, Densification, Deformation, Elongation, Strength.

## 1. Introduction

Aluminium finds its widest use when alloyed with small amount of other metals. The addition of small quantity of other alloying element convert this soft, weak metal into a hard and strong metal but retains its light weight. Aluminium is alloyed with nobler metal copper for investigation. Because, Copper based ceramic composites can offer excellent strength properties at elevated temperature because ceramics are thermodynamically stable (Nia, F. and B.L. Davis, 1982), at elevated temperatures. Aluminium matrix composites offer lower density, improved strength, and stiffness and wear resistances. Moreover a small slug of copper placed on top of the component melts during sintering and it is drawn into the pores by capillary action. The reinforcement of metals matrix offers improved strength properties. The experiment carried out based on the above facts by taking copper with higher percentage of aluminium.

## 2. Experiment

### 2.1 *Powder Mixing*

The powder of aluminium is mixed with oxidized copper in proportion of 9 %, 11%, 13 %. Atomized uncoated Aluminium powder is obtained from M/S Metal Powder Company Ltd and the electrolytic copper powder obtained from the same place. The copper powder is put in the muffle furnace for 2 hrs in order to oxidize. These powders sieved using – 180 µ sieve and mixed in the ratio of Aluminium and Copper Oxide as 91:9, 89:11and 87:13. The powders are mixed in a pot mill for 4 hrs in order to get homogeneous mixture .The apparent density, tap density and the compressibility are studied and the observations are tabulated in Table: 1 as classification of densities. Graph: 1 is indicating the characteristics of Tap density ratio for 9%, 11% and 13 %.

### 2.2 *Preparation of Compacts*

The experimental set up is specially designed by us for preparation of compacts consisting dies, punch, lower punch support and ejection block. Lower punch support is placed at the bottom of the die to support the loose powder poured in the cylinder. Molybdenum die sulphide is used for die wall lubrication in order to get the finished compact (Hajra Chouldhury, S.K. 2008) from the die wall easily. Ejection block is used to eject the finished component from the die wall without any damage. A universal testing machine is used for compaction of the Al - Cu composition by single action die compaction and the compacts are prepared at 174 M Pa. The value of compact density and compression ratio are tabulated in the Table: 1.

### 2.3 *Densification*

Densification parameters like theoretical density, tap density, sintered density and green density are studied and the TABLE: 2 shows the values of compressibility ratio for the 9%, 11% and 13% Cu in alumina and the Graph : 2 is the corresponding compressibility plot.

### 2.4 *Extrusion*

For any alloy it is a matter of trial to determine the actual conditions of speed and temperature which will give the best results. Ordinary commercial grades of aluminium extrude readily requiring only low pressures ( Raymond Higgins, H. 1976 ) and having a long plastic range upwards from about 370 ˚ C and in our case we recommended 450 ˚ C and 550 ˚ C. Number of extrudes are produced and number of tensile specimens are produced from the extrudes.

### 2.5 *Deformation*

The plastic flow of metals is perhaps their most important behaviour (Alexandrov, I.V. and R. Z. Valiev, 2001) , the one that distinguished them most sharply from other materials of construction. They produce amazing changes in the properties of metals. The magnitude of these changes is different for different properties. As deformation proceeds, the grains of the metal originally oriented at random ( Cottrell, A. H.1983 ) gradually elongate and at the same time they orient themselves in an orderly fashion with respect to the direction of flow and a fiber structure (Valiev R.Z., 2000 ) develops in the metal. The ductility is purely depending on the elongation and percentage of reduction in area and it is tabulated in the TABLE: 3

## 3. Results

1. The Tap density ratio is increasing with number of taps irrespective of composition of alloys in the present case which is neatly depicted in the Graph: 1

2. The densification parameter is unique in the sense that it takes into account the theoretical density, sintered density and green density. In case of composites of Cu –Alumina there is a continuous fall in densification parameter and it is evident from the Graph: 3.

3. Mechanical properties like elongation, percentage of reduction in area and ultimate tensile strength are decreasing with the increase in copper reinforcement (Zuhailawati Husain and Koay Han Keong, 2005), of aluminium matrix and it is represented with the help of a diagram shown in the Graph: 4

## 4. Conclusion

During Tensile Test , it is noted that the process of plastic deformation of specimen, the specimens become progressively thinner but despite this the metal retains the capacity for carrying the full increased load without further elongation .In other words as a result of deformation it has been hardened. The common tensile test on a ductile material has given a fruitful data on yield strength, ultimate tensile strength, percent elongation and percent reduction in area. The total elongation of the specimen up to the point of fracture was 25 % is noted during the study.

## Acknowledgement

The technical contribution of Regional Engineering Lab, Tamil Nadu, is gratefully acknowledged and also the author thanks the UGC, India for granting FDP Award.

## Reference

Alexandrov, I.V. and R. Z. Valiev, (2001), Scripta Mater, 44, P 1605-1608

Cottrell, A. H. (1983), Theoretical Structural Metallurgy, The English Language

Book Society, P 93

Hajra Chouldhury, S.K. (2008), Materials Science and Processes, Indian Book Distributing Co, India, Chapter 8, P147.

Nia, F. and B.L. Davis, (1982), Production of Al Cu and Al-Cu-Si alloys by PM products, Powder Metallurgy, Vol 25, P 209 – 213

Raymond Higgins, H. (1976) Engineering Metallurgy- Part II, Hodder and Stoughton Ltd, Toronto, P 211

Valiev R.Z., R.K.Islamgaliev and I. V. Alexandria, (2000), Progressive metallurgy Science, 45, P 103-189.

Zuhailawati Husain and Koay Han Keong, (2005), Studies on alumina Dispersion – strengthened Copper composite, Journal Teknologi, Vol. 43, P 1-10

Table: 1 Classification of Densities

| Composition | Compact density $10^{-3}$ gm/ cc | Apparent density gm / cc | Tap density $10^{-3}$ gm/ cc | Compression ratio | Sintered density $10^{-3}$ gm/ cc | Green density gm/ cc |
|---|---|---|---|---|---|---|
| 9% | 2.4711 | 0.8719 | 1.4955 | 2.8340 | 2.4516 | 3.9613 |
| 11% | 2.5037 | 0.898 | 1.5981 | 2.7880 | 2.6957 | 4.0959 |
| 13% | 2.3681 | 0.9199 | 1.5009 | 2.5742 | 2.5677 | 4.309 |

TABLE: 2 COMPRESSIBILITY PLOT $\rho = \rho_c / \rho_{the}$

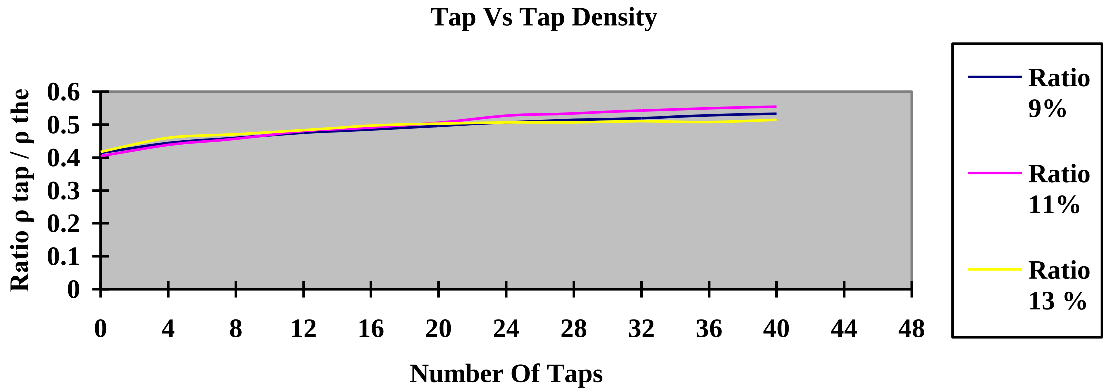
| S.NO | LOAD IN TONS | ρ for 9% | ρ for11% | ρ for13% |
|---|---|---|---|---|
| 1 | 0 | 0.2921 | 0.3564 | 0.3525 |
| 2 | 2 | 0.6361 | 0.6094 | 0.5805 |
| 3 | 4 | 0.7304 | 0.7142 | 0.6774 |
| 4 | 6 | 0.7759 | 0.7641 | 0.7281 |
| 5 | 8 | 0.8073 | 0.8013 | 0.7593 |
| 6 | 10 | 0.8292 | 0.8364 | 0.7838 |
| 7 | 12 | 0.8468 | 0.8534 | 0.7982 |
| 8 | 14 | 0.8670 | 0.8684 | 0.8115 |

TABLE: 3 Properties of tensile specimen

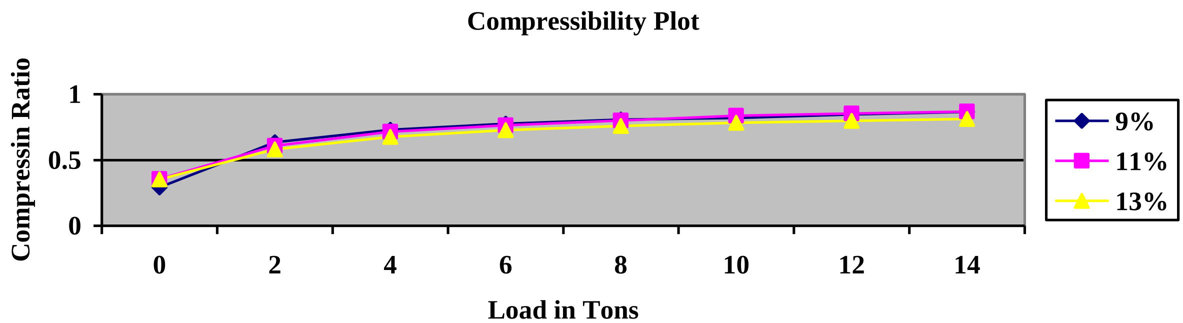
| COMPOSITION % Of Cu in Al | TEMPERATURE $C^0$ | ELONGATION mm | REDUCTION IN AREA $Mm^2$ | UTS IN M Pa |
|---|---|---|---|---|
| 9% | 450 | .1535 | 10.11 | 130.72 |

| | | | | |
|---|---|---|---|---|
| 11% | 450 | .1075 | 8.01 | 129.64 |
| 13% | 450 | .0958 | 7.03 | 124.31 |

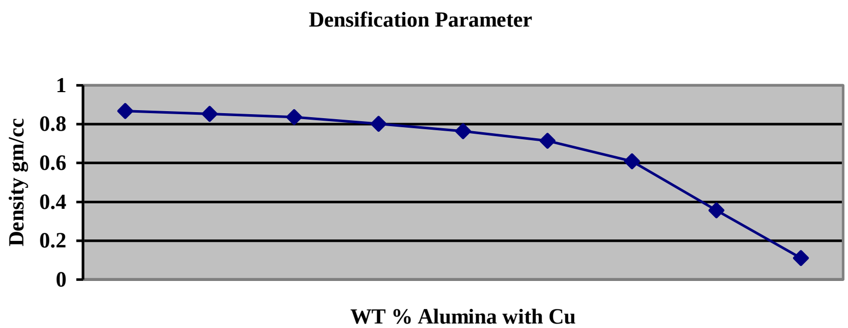
**Graph: 1 Tap Density ratio for 9%, 11%, 13 % Composition**



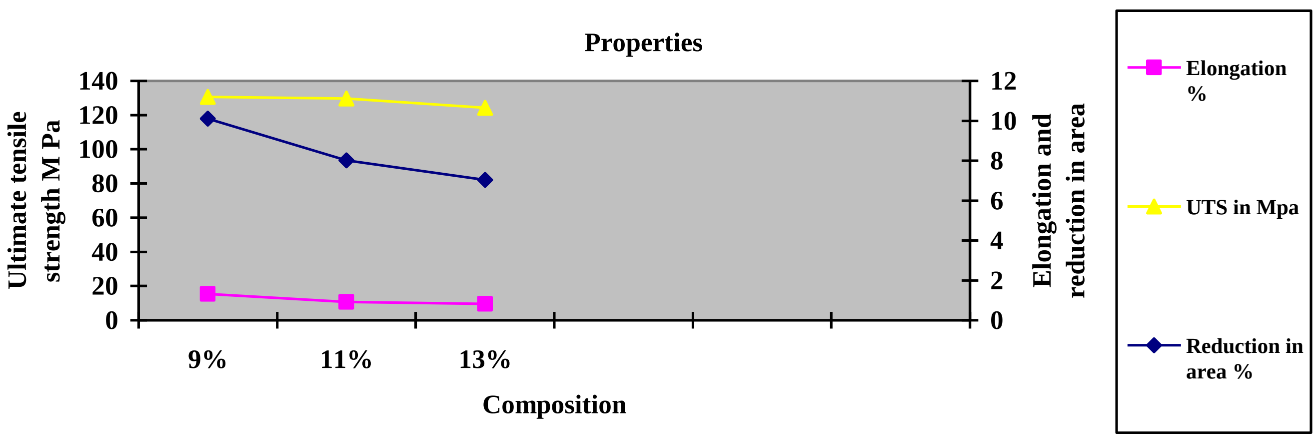

**Graph: 2 Compressibility Plot**




**Graph: 3 Densification Parameter**




**Graph: 4** **Mechanical Properties**



This academic article was published by The International Institute for Science, Technology and Education (IISTE). The IISTE is a pioneer in the Open Access Publishing service based in the U.S. and Europe. The aim of the institute is Accelerating Global Knowledge Sharing.

More information about the publisher can be found in the IISTE's homepage: http://www.iiste.org

The IISTE is currently hosting more than 30 peer-reviewed academic journals and collaborating with academic institutions around the world. **Prospective authors of IISTE journals can find the submission instruction on the following page:** http://www.iiste.org/Journals/

The IISTE editorial team promises to the review and publish all the qualified submissions in a fast manner. All the journals articles are available online to the readers all over the world without financial, legal, or technical barriers other than those inseparable from gaining access to the internet itself. Printed version of the journals is also available upon request of readers and authors.

**IISTE Knowledge Sharing Partners**

EBSCO, Index Copernicus, Ulrich's Periodicals Directory, JournalTOCS, PKP Open Archives Harvester, Bielefeld Academic Search Engine, Elektronische Zeitschriftenbibliothek EZB, Open J-Gate, OCLC WorldCat, Universe Digtial Library , NewJour, Google Scholar