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EFFECT OF RECYCLING ON THE MICROSTRUCTURE AND MECHANICAL PROPERTIES OF BRASS ALLOYS

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Abstract: **In this research work, brass alloys were produced by sand casting using recycled copper and zinc metals. The zinc content was varied from 10 to 50 wt%. Molten brass in a crucible pot, prefabricated (clay graphite) crucible remains static inside the crucible furnace during the full melting cycle. This dedicated crucible pot which also act as pouring ladle eliminate inter-alloy contamination. The brass alloys produced from sand casting were subjected to homogenizing annealing heat treatment. Hardness and tensile tests were carried out on the samples from each composition. Also, the samples were subjected to micro-structural investigation using optical microscopy. The results obtained showed that the hardness, yield strength, ultimate tensile strength, percentage elongation and elastic modulus of the alloys increase with increase in zinc content. Also, the micrographs of the samples reveal the presence of a single solid phase which consists of a solid solution of zinc in alpha copper. It was concluded from the study that brass alloys with good mechanical properties can be produced from recycled copper and zinc metals.**

Keywords: **(Crucible pot; Recycling; Brass alloys; Microstructure; Mechanical properties).**

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1. INTRODUCTION

The universe is made up of matter and all aspects of human life depends on the existence of matter in form of materials. Materials are so important to the extent that improved civilization and development is totally dependent on the utilization of readily available materials and this is attained through investigative studies on nature, existence and properties of materials(1).

In Engineering, metals are indispensable because most machine parts and those used for the construction of buildings are basically metals. Materials engineering is a specialized branch of engineering which involves the study of properties of these materials required for engineering purposes one of which is brass. Besides bronze, the alloys of copper with zinc and brass are the first alloys accompanying the development of mankind. Nowadays, they are widely applied in technology, and next to light metals they belong to the most commonly used alloys in the group of non-ferrous metals (2). These alloys are characterized by a considerable ductility and resistance to corrosion, particularly atmospheric corrosion and corrosion in sea-water. As a potent precipitation-strengthening element in copper, zinc is added to increase their tensile strength, hardness, creep resistance and machinability. Adding 10.0 wt% of zinc to copper will lead to alloys with very high strength and good toughness after subjected to alloys with very high strength and good toughness after being subjected to natural or artificial aging. More importantly, unlike other materials for engineering applications, metals, such as aluminium and magnesium, can be recycled repeatedly without loss of their most inherent properties (3,4). Materials are so important to the extent that improved civilization and development is totally dependent on the utilization of readily available materials and this is attained through investigative studies on nature, existence and properties of materials.

2. MATERIALS AND METHODS

The major materials used during the study are used copper wires, used zinc obtained from the casings of used dry cells, emery papers and etchant. The major equipment used in the study include Crucible furnaces, crucible pot, moulding sand, pattern, hardness tester, universal tensile testing machine, grinding machine, polishing machine and optical microscope.

The brass alloys were produced by sand casting using used copper wire and zinc from used dry cell casings. Five different compositions of the alloy were cast by varying the zinc content from 10 wt% to 50 wt%. The melted alloys were cast into cylindrical rods.. The furnace charge was made using the equation:

$$R_y = (\%\ \text{of Y in the melt})\ T_n \qquad (1,5)$$

where Y= constituent (i.e. Cu or Zn)

R_y = required mass of melted alloy constituent

T_n = Total mass of melt

The furnace charge calculations are as shown in Table 1

Table 1: Furnace Charge Calculation for Cu-Zn alloys

Alloy	**Copper (Kg)**	**Zinc (Kg)**	**Total mass (Kg)**
Cu 10% Zn	2.70	0.30	3.0
Cu 20% Zn	2.40	0.60	3,0
Cu 30% Zn	2.10	0.90	3.0
Cu 40% Zn	1.80	1.20	3.0
Cu 50% Zn	1.50	1.50	3.0

Grouped Samples

Cu 10% Zn Samples

Cu 20% Zn Samples

Cu 30% Zn Samples

Cu 40% Zn Samples Cu 50% Zn Samples

Plate 1 : Raw Cast brass alloys as received form foundry unit of OOCEI Federal Polytechnic Ado-Ekiti.

The capacity of the crucible pot is to hold 10kg of material at a time so the respective percentages of the two metals were based on 1.5kg.

The mould was made in two halves and placed together without misalignment. Patterns that were made provided the exterior (mould) or interior (core) shape of the finished casting and were to be produced in for use in sand mould and core making.

In making sand moulds for the small sized castings, they were made in a moulding box. The mould was made in two or more parts in order that the pattern may be removed. Sand was mixed with clay and water and then packed or rammed around the pattern to form a mould half. The two halves were joined together to make the mould a rigid cavity that provided the required shape for the casting.

Molten metal was prepared in a air and oil-fired crucible furnaces used for small batch melting of copper alloys. In the foundry, air and oil-fired furnace was used with the aid of an air blower to increase the supply of oxygen to the furnace. To save cost of producing the five brass samples, about 10 liters of used engine oil was utilized in firing the furnace for each cast of five brass alloy rods. No thermometer was attached to the furnace to determine the temperature of the molten metal in it, therefore the copper wire metal was given an appreciable amount of time of about 2 hours to melt completely before adding the zinc battery casings were added to dissolve in the molten copper metal. The mixture was allowed in the furnace for about 30 minutes before taking the crucible pot out which was later skimmed using an iron rod so as to separate the slag from the molten metal surface. The choice of which was determined by the quality, quantity and throughput required.

Molten metal was poured into moulds using a ladle. When the metal had cooled sufficiently for the casting to hold its shape, it was separated from the mould by mechanical or manual method. Because sand moulds were used, the process is referred to as shakeout or knockout, and large amounts of dust was generated.

After casting, these extraneous pieces of metal were removed and collected for re-melting. They were removed by sawing using a hack saw. A range of finishing processes were undertaken. These included:

i. Cleaning the test samples to remove residual sand and surface scale with wire brushing.

ii. Removal of excess metal or surface blemishes from the five test samples by grinding.

3. RESULTS AND DISCUSSION

3.1 Hardness Test

Figure 1 shows the results of the Brinell hardness test for the Cu-Zn alloys. This can be observed from the figure, for all the cast alloys produced, the hardness value increases with increase in zinc content. Therefore, an increase in the hardness values of the cast alloys with increase in zinc content is attributed to hardening power caused by the zinc solute atoms.

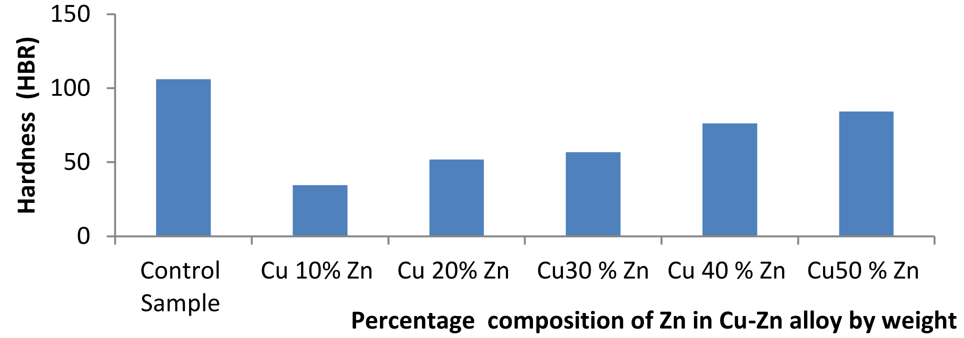

Figure 1: Variation of hardness value of the Cu-Zn Alloys with Zinc Content

From the result obtained it is noticed that the control sample has a highest brinell hardness number of 107 HBR, the brass cast sample Cu 10% Zn has a brinell hardness number of 34.6 HBR and the brass cast sample Cu 50% Zn has a brinell hardness number of 84.3 HBR. Also the brass cast sample Cu 20% Zn has a brinell hardness number of 51.8 HBR, which showed that an increase in the zinc content of the brass cast sample brought about an increase in the brinell hardness number, thus indicating an increase in the hardness of the brass cast samples.

3.2 Tensile Test

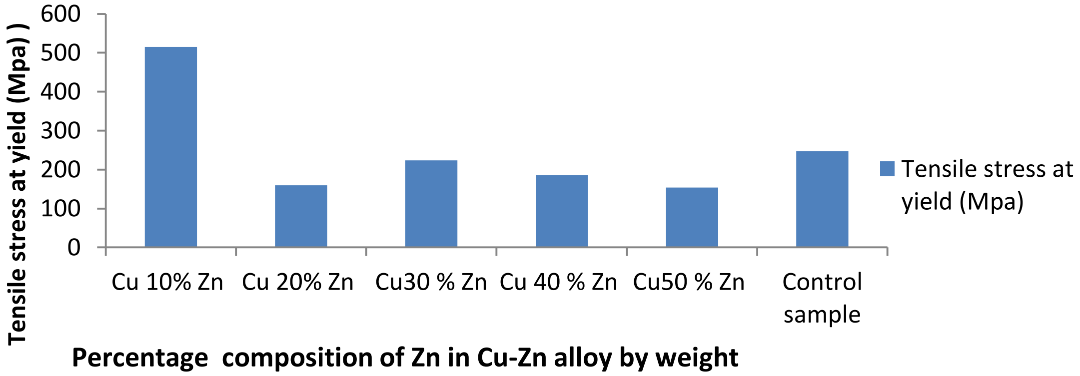

Figure 2: Variation of Tensile stress at yield of the Cu-Zn Alloys with Zinc Content

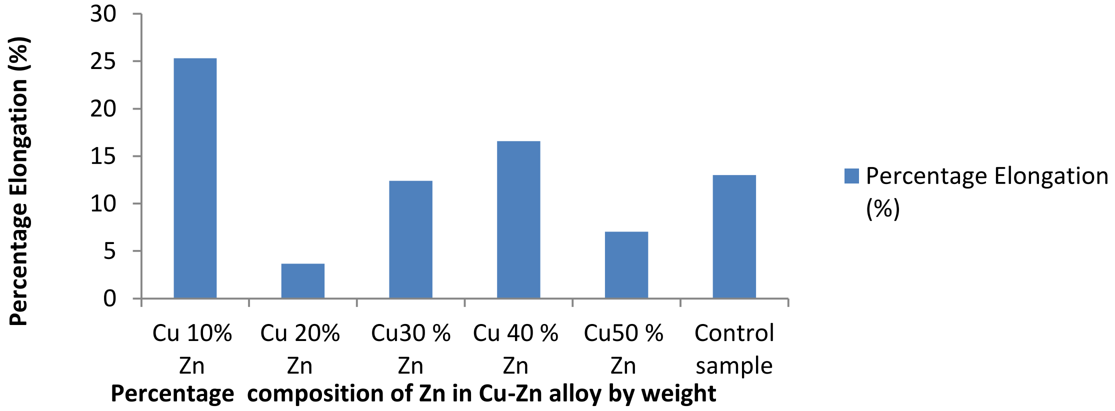

Figure 3: Variation of Percentage Elongation (%) of the Cu-Zn Alloys with Zinc Content

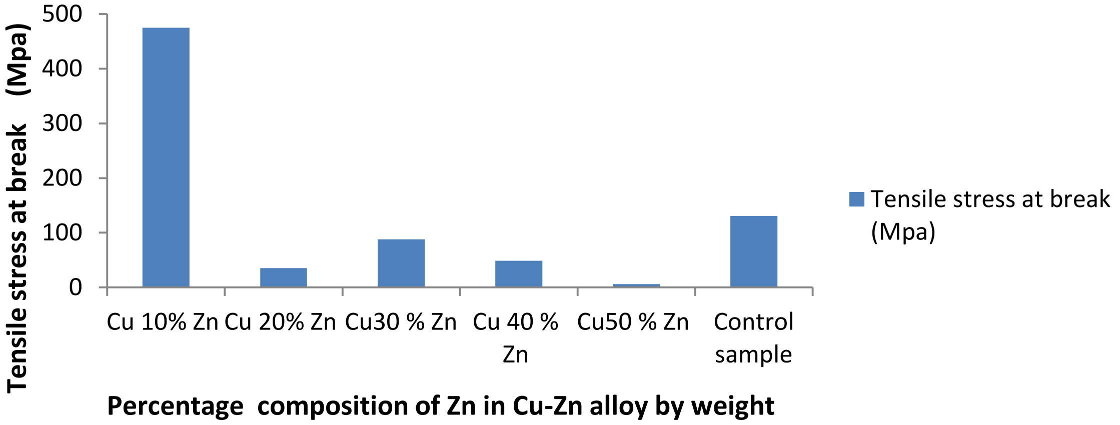

Figure 4: Variation of Tensile stree at break of the Cu-Zn Alloys with Zinc Content

From the graphs it can be observed that there was an increase in the tensile strength of the brass samples at 10%Zn, and 15%Zn addition. Equally, a decrease in the tensile strength began at the 20% Zn addition and also occurred at the 30% Zn addition respectively. From this it can be deduced that the addition of a certain percentage of zinc to copper can increase the tensile strength of the copper alloy but excessive addition can also result to a reduction in the tensile strength of brass.

3.3 Microstructure

From Plates 3.1 to 3.6, micrographs of the various alloys reveal the presence of a single solid phase which consists of a solid solution of zinc in alpha copper.

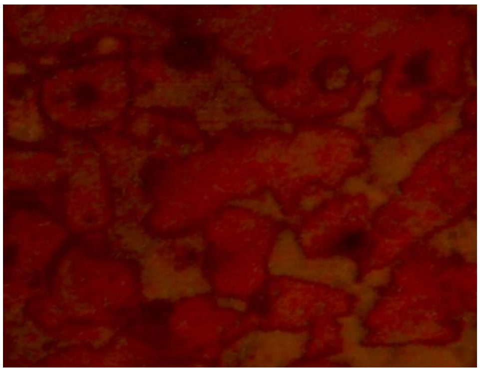

Plate 3.1: Micrograph of the as-received Cu-Zn alloy (X400)

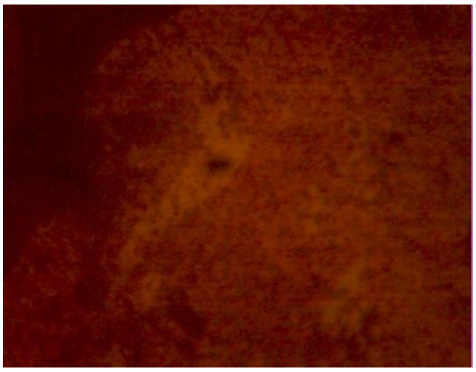

Plate 3.2: Micrograph of Cu 10% Zn alloy (X400)

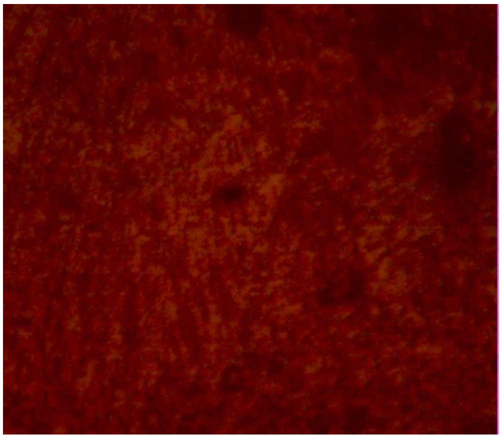

Plate 3.3: Micrograph of Cu 20% Zn alloy (X400)

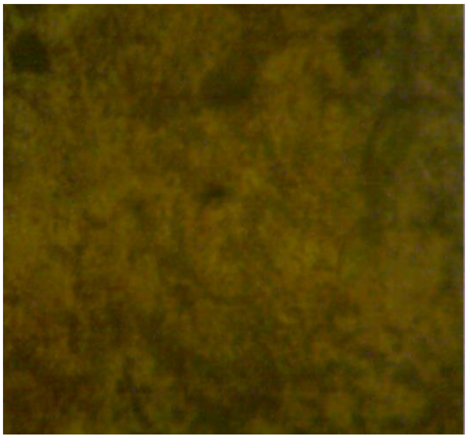

Plate 3.4: Micrograph of Cu 30% Zn alloy (X400)

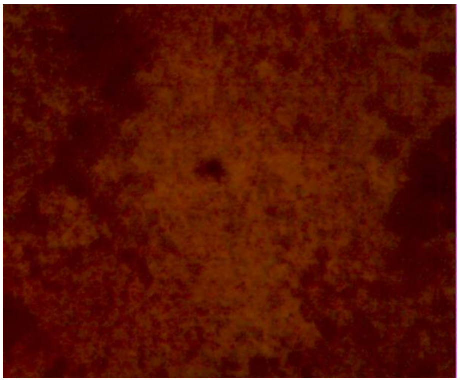

Plate 3.5: Micrograph of Cu 40% Zn alloy (X400)

Plate 3.6: Micrograph of Cu 50% Zn alloy (X400)

The microstructures of brass alloys revealed a single solid phase which consists of a solid solution of zinc in alpha copper were presented in Plate 3.1 to 3.5. The microstructure of the as-received Cu-Zn alloy sample showed ferrite in the grain boundaries of the acicular pearlite grains. For this reason, the microstructure of the as-received Cu-Zn alloy can be described as having a ferrite-austenite duplex phase (Plate 3.1). Also, the microstructure of the brass alloys produced from sand cast yielded a uniform fine grained microstructure of ferrite and pearlite with small grain sizes (Plate 3.2 to Plate 3.6)

4. CONCLUSION

An increase in percentage composition of zinc content in brass alloys obtained from recycled copper and zinc metals leads to improved high yield strength, ultimate tensile strength, hardness, and ductility of the alloys. Brass alloys with improved mechanical properties can be obtained from recycled copper and zinc metals.

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