

Influence of heat treatment on mechanical properties of Cu-Ni-Zn alloys

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Abstract: Copper–nickel–Zinc (Cu–Ni–Zn) alloys are widely used materials for utility in marine and chemical environments for ship and boat hulls, desalination plants, Heat exchangers, seawater and hydraulic pipelines, oil rigs and platforms, fish farming cages, seawater consumption displays etc. because of their superior corrosion resistance, higher electric conductivity, heat conductivity and mechanical properties. However, the varying percentages of Copper, Nickel, Zinc and other alloying elements may lead to a large difference in microstructure and performance of copper alloy (Nickel silver). Heat treatment of these alloys is challenge to make the material to suit for a particular application. Moreover, there is always a scope for study of processes which enhance the properties of material. Hence, this paper discovers the effect of heat treatment parameters such as temperature and time on its mechanical properties. Finally, this paper would conclude with the findings of study and provide recommendations for further studies.

Keyword: Nickel Silver, Microstructure, Corrosion resistance, Conductivity

I. INTRODUCTION

Nickel Silvers also called nickel brasses are alloys containing copper, nickel, and zinc. Though they do not contain silver, they have an attractive silver luster, moderately high strength and good corrosion resistance. They are used to make food and beverage handling equipment, decorative hardware, electroplated tableware, optical and photographic equipment and musical instruments. Focused research investigations carried out by scientists, researchers and technologists, since last few decades have provided a wealth of new scientific knowledge about the heat treatment techniques, its advantages and applications on different metals / alloys. From the study of recent investigations, it is observed that very little work has been done on heat treatment on alloys, in particular copper alloys. In this regard an attempt is made to study of effect of heat treatment parameters on properties of Cu25Ni5Zn by using hardening heat treatment followed by tempering process. Microstructural changes are also discussed in this paper.

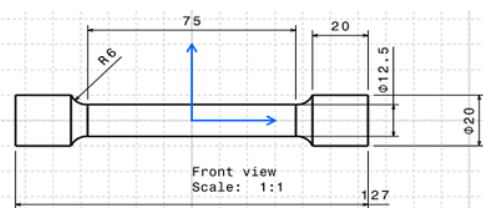
II. EXPERIMENTAL DETAILS

Alloy of Copper, Nickel and Zinc is prepared using sand casting technique with 25Ni, 5%Zn and rest of Cu. The cast rods of Cu-Ni-Zn alloys were machined to the required dimensions as required for different tests. All necessary care was taken to maintain ASTM standards while preparing the specimens. In order to enhance the properties of alloy, these prepared specimens were subjected to hardening heat treatment followed by tempering.

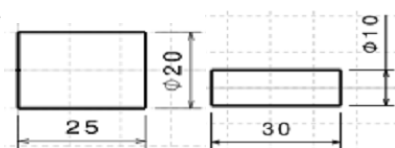
Three sets of specimens were prepared. First set of specimens were kept as untreated. Second set of specimens were subjected to hardening heat treatment process at 500°C for 60 minutes followed by tempering at 180°C for 60 minutes. Third set of specimens were subjected to hardening at 600°C for 60 minutes followed by tempering at 180°C for 60 minutes. Muffle furnace was used to heat treatment.



Cast rod of Cu-Ni-Zn alloy



Tensile specimen



Compression and wear specimens



Untreated alloy



HT at 500°C



HT at 600°C

Tensile test

Tensile test is nothing but the process in which specimen is subjected under controlled tension until it breaks. This test is done to know the tensile strength of the material. From this test, mechanical properties such as tensile strength, yield strength, percentage elongation of material can be determined. By knowing the strength of the materials, it can be used for various applications.



Tensile tester



tested specimen

Hardness test

It is a characteristic of material. Hardness is defined as the resistance to indentation by the materials and it can be measured by permanent depth of the indentation. Brinell hardness test is carried out for this project. In this test 10mm diameter ball indenter is used and 1000kg load is applied.



Brinell hardness tester



tested specimen

Wear test

Wear test is carried out to know or to predict the wear performance of materials. For wear test which we had done, we took 2kg i.e. 19.62N applied load. This test was done for the duration of 600 Seconds. The track radius was measured to 75mm and the sliding distance of 1884m.



Pin on disc wear tester



tested specimen

Microstructure test

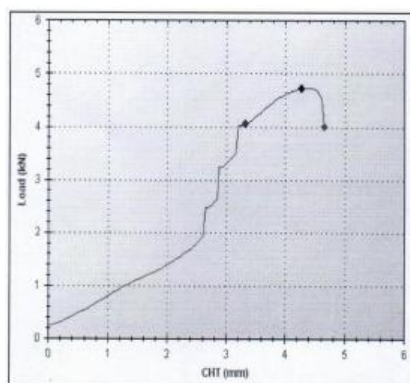
After completion of machining, heat treatment and surface finish the specimens were subjected to microstructure test. Microstructure test is conducted in order to know the grain distribution or say surface grain structure. Optical Metallurgical Microscopy (Model: NIKON Epiphot 200) is used for the above mentioned.



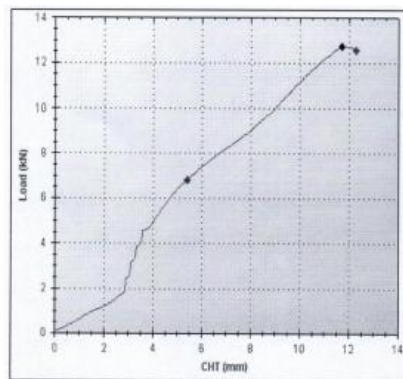
Optical Microscope

III. EXPERIMENTAL RESULTS AND DISCUSSION

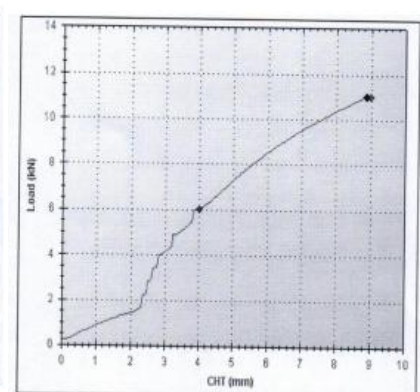
Tensile strength of specimen heated at 500°C was found to be greater than the tensile strength of untreated specimen. With further increase in temperature of the material to 600°C, the tensile strength of specimen was found to be decreased with compare to that of the specimen treated at 500°C but it is greater than that of untreated one. Hence, the ideal temperature was found to be 500°C in order to enhance the mechanical properties of Cu-Ni-Zn alloy.



Untreated specimen



Heat treated at 500°C

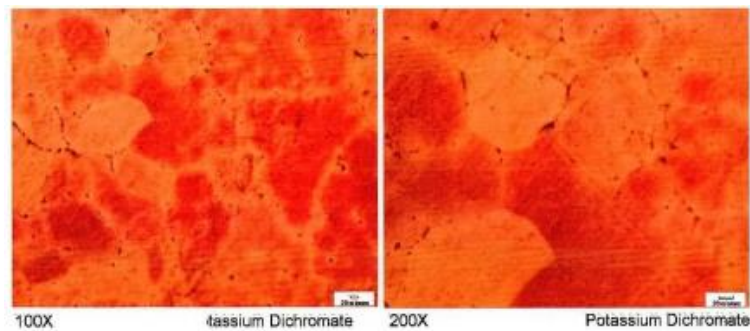
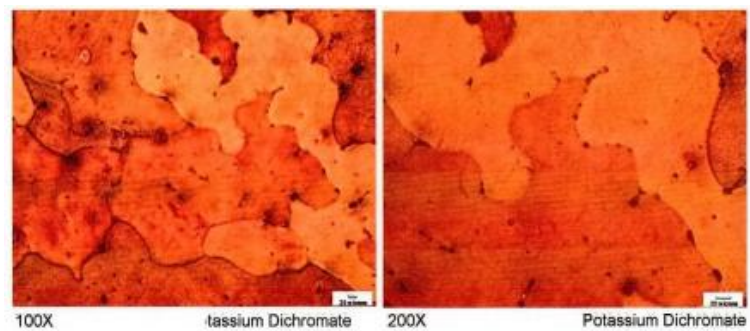
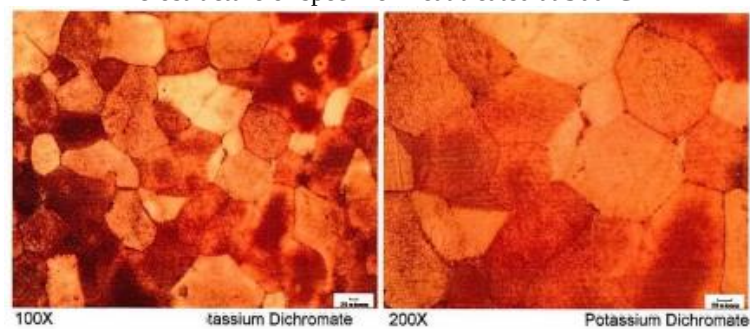


Heat treated at 600°C

Load v/s cross head travel for

Tensile Test			
Parameters	Results		
	Untreated	Heat treated at 500°C	Heat treated at 600°C
Yield load	4.02kN	6.75kN	5.99kN
Elongation at yield	3.210mm	5.350mm	3.960mm
Yield Stress	33.163N/mm ²	55.092N/mm ²	48.039N/mm ²
Load at peak	4.730kN	12.70kN	11.030kN
Elongation at peak	4.470mm	11.89mm	8.960mm
Tensile strength	39.550 N/mm ²	103.655N/mm ²	88.460N/mm ²
Load at failure	4.010kN	12.540kN	11.010kN
% Elongation	2.2%	5.78%	2.80%
Hardness Test			
BHN	46.5	52.3	47.3
Wear Test			
Wear rate	0.066mm ³ /Nm	0.0083mm ³ /Nm	0.016mm ³ /Nm

From microstructure test, the grain distribution of specimen treated at 600°C was found to be more homogenous in nature than that of untreated and that of the specimen treated at 500°C.



IV. CONCLUSION

The following conclusions are made by the present work.

- Tensile strength of material heated at 600°C is more than untreated and less than treated at 500°C.
- Hardness of material heated at 500°C increases and further decreases at 600°C.
- Wear rate of material heated at 500°C decreases and further increased at 600°C same as untreated.
- Normally molecules and/or atoms of a material oscillate due to their internal energy; temperature is an expression of this energy. The tensile strength depends from the mean distance between the molecules/atoms of the material.
- Due to increase in temperature to a certain extent i.e. up to 500°C the atoms start vibrating and the homogeneity between the atoms of Cu, Ni & Zn is achieved.
- Bonding between the atoms of different elements become strong. But due to further increase in temperature i.e. at 600°C, mean distance between the atoms increases and the bond strength decreases. Atoms cannot maintain their mean position which cause reduction in tensile strength, hardness and increase the wear rate of the alloy.

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