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Preparation and Characterization of Heat Treated Nickel Silver for Marine Applications

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ABSTRACT

Copper is one of the first metal ever extracted and used by humans. As a result, copper was important to early humans and continues to be a material of choice for a variety of domestic, industrial, and high technology applications even today. Copper–nickel-Zinc (Nickel silver) is one of the alloys of copper. Nickel silvers 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. A variety of nickel silvers of different compositions have found in commercial use, with most ranging from 20% to 30% of copper and 5% to 10% of zinc by weight, the remaining mass being copper. However, the varying percentages of Copper, Nickel, Zinc and other alloying elements may lead to a large difference in microstructure and performance of Nickel silver. Heat treatment of these alloys is always a challenge to make the material to suit for a particular application. Moreover, there is always a scope for study of processes which enhances the properties of material. In the present investigation specimens of nickel silver were prepared with 30%Ni & 5% Zn and 25Ni & 5% Zn. The prepared specimens were subjected to solutionizing followed by aging heat treatment at 350°C & 450°C for 1 hr. and hardening followed by tempering heat treatment at 500°C & 600°C for 1hr. respectively for first and second compositions. Different experiments were conducted and concluded with the findings of study and provided with suitable recommendations for future studies.

Keywords : Nickel Silver, Corrosion, Heat Treatment, Microstructure

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, and 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 Cu30Ni5Zn and Cu25Ni5Zn by using Solutionizing followed by ageing heat treatment and hardening heat treatment followed by tempering process. Microstructural changes are also outlined in this paper.

In the present investigation, the effects of heat treatment on properties such as tensile strength, compression strength, hardness, and microstructure variations on nickel silver have been studied. The results of heat treated specimens from various tests were compared with the base metal.

II. EXPERIMENTAL DETAILS

Preparation

30cm long and 2cm in diameter nickel silver rods of composition as given in Table 1 were prepared via sand casting by dissolving a measured amount of the nickel and zinc pieces in a measured molten copper in a fired pit furnace, Stirred and cast. Fig 1 shows the casted rods of chosen compositions.

The casted nickel silver is machined for the desired size and shape according to the ASTM standards to conduct mechanical tests like tensile, compression and hardness.

Table 1 Chemical composition of nickel silver developed.

Composition #	Copper	Nickel	Zinc
1	65%	30%	5%
2	70%	25%	5%

(a) (b)

Fig 1: Cast rod of composition #1 (a) and composition #2

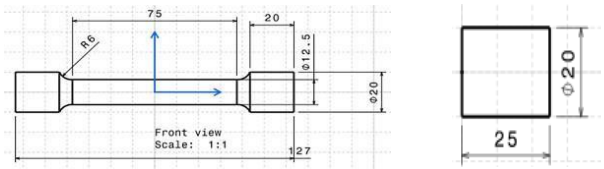
Heat Treatment

Heat treatment process is carried out as below: **Specimens of composition # 1** are heat treated by solutionizing followed by ageing at the temperature of 350°C & 450°C for 1 hr.

Specimens of composition # 2 are heat treated by hardening followed by tempering at the temperature of 500°C & 600°C for 1 hr.

Tensile, Compression, Hardness and Microstructure Tests

The machined and heat treated specimens were subjected to tensile and compression tests which was conducted in a Universal Testing Machine (UTM). The specimen dimensions used for tensile and compression tests are as shown in Fig 2.



(a) (b)

Fig 2: Sketch of Standard Tensile (a) and compression (b)Specimen

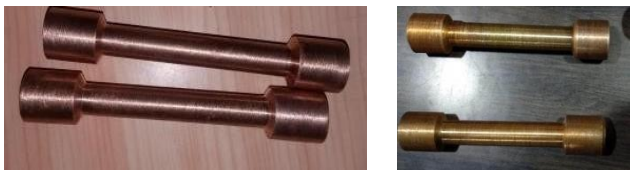


Fig 3: Specimens for tensile test

Fig 4: Specimens for compression test

The heat treated nickel silver specimens were subjected to hardness test. Hardness is a characteristic of material and 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 used with 5mm ball at 250 kg load.

Fig 4: Specimens for hardness

Microstructure test was conducted in metallurgical optical Microscope. Microstructure consists of alpha solid state. The sample is roughened with belt polish and fine polished with various emery papers from 80, 120, 400, 600 grades.

III. EXPERIMENTAL RESULTS

Tensile strength of specimen heated at 500□C was found to be greater than the tensile strength of specimens heat treated at different temperatures. With further increase in temperature of the material to 600□C, the tensile strength of specimen was found to be decreased with compare to other temperatures. Hence, the ideal heat treatment temperature for nickel silver was found to be 500□C in order to enhance its mechanical properties.

Tensile test				
Parameter	350°C	450°C	500°C	600°C
Yield stress, MPa	209.3	233.6	245.1	205.3
Ultimate load	16.77	18.54	20.44	16.11
Tensile strength, MPa	255.3	281.7	298.6	253.5
% Elongation	10.37	9.93	10.78	6.80
Compression test				
Compression load, kN	85.09	90.39	98.15	89.11
Compression strength, MPa	752.3	799.2	798.74	758.66
Hardness test				
Ball dia, mm	5	5	5	5
Applied load. kg	250	250	250	250
BHN	84.83	98.53	102.33	93.6

It was observed the compression strength and hardness of specimen heat treated at 500°C is comparatively greater than other specimens.

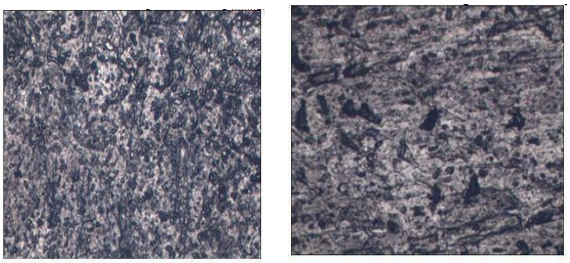


Fig 4: Microstructure of specimens treated at 350°C and 450°C

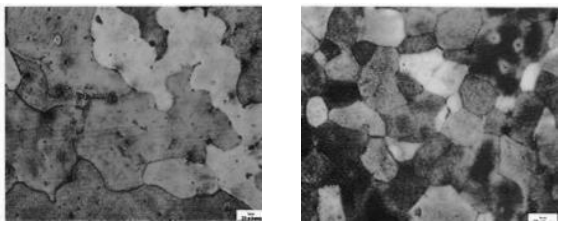


Fig 4: Microstructure of specimens treated at 500°C and 600°C

IV. CONCLUSION

After understanding the literature and conducting some of the mechanical tests on heat treated specimens, we made the following conclusions from the present work.

- Tensile strength of material treated at 500□C is comparatively greater than other specimens.
- Compression strength of specimen heat treated at 500°C is slightly comparable with other specimens.
- Increase in hardness of material is observed up to 500□C and further decreases at 600□C. It is observed that 500°c is ideal temperature for heat treatment of nickel silver.
- Due to increase in temperature to a certain extent i.e. up to 500°C the atoms start vibrating and the homogeneity between alloying elements 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 positions which cause reduction in tensile strength and hardness.

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