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INFLUENCE OF HEAT TREATMENT AND DEFORMATION ON THE MICROSTRUCTURE AND MECHANICAL PROPERTIES Cu-Ni-Sn ALLOY

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ABSTRACT

This article present about studying on effect heat treatment and strain on mechanical properties of Cu-7Ni-7Sn alloy. This alloy is high elasticity alloy, advance characteristics of this alloy can obtain when associate heat treatment and deformation. The article ejected advance heat treatment and deformation behavior for its. Before processing hardness, strength, the elastic limit of this alloy have a small value. The hardness obtains about 90 - 95HB; the strength obtains about 200MPa; the elastic limit obtain about 100MPa.After heat treatment and deformation, hardness, strength, elastic limit of alloy ascend to multiple; the hardness obtains 294 – 302HB; the strength obtains 1000MPa; the elastic limit obtains 600 – 700MPa. This fact could explain by two mechanisms: deformation mechanism and spinodal transition. Deformation mechanism is to pull small grain lichen, increasing the strength of this alloy. Spinodal decomposition is a mechanism by which a solution of two or more components can separate into distinct regions (or phases) with distinctly different chemical compositions and physical properties. This mechanism differs from classical nucleation in that phase separation due to spinodal decomposition is much more subtle, and occurs uniformly throughout the material not just at discrete nucleation sites. The fineness of spinodal structures is characterized by the distance between regions of identical composition, which is of the order of 50 to 1000 A°.

KEYWORDS

spinodal decomposition, bronze alloy, microstructure, heat treatment process, deformation

1. INTRODUCTION

Present, on electronic engineering, mechanical engineering, need about products are created from copper alloy require high strength, high elastic, well electrical conduction, and anti-corrosion. Furthermore, these products are used with a special purpose to create weapons. In the military industry, the copper alloys with the high strength, high elasticity, and corrosion resistance are also important materials in the production of all kinds of shells, detonators of bombs, mines, bullets, unexploded ordnance, and no electric spark. Many details in the electrical equipment of aircraft, missiles, radar are also made from copper alloys with high strength, stability, corrosion resistance in tropical conditions or marine environment, to be able to Long-term preservation and combat readiness. In the maritime field, copper alloys are widely used. Details such as a shaft, electrical systems on board ... are made from copper alloys. With the high strength and must withstand corrosion in long-term seawater conditions. Some details also require elasticity. The mechanisms' copper alloy need high strength and elastic, well electrical conduction in the electric transport equipment are usually created by copper alloy about 2% beryllium. However, deficiency of this alloy is refractory; berrili is poisonous and noble. So the study new copper alloys have equally behavior to copper-beryllium alloy is demand necessary.

In the world, there have been some studies on other systems to replace beryllium alloys such as Cu - Ni - Sn system, Cu - Ni - Zn system with curvature Ni, Sn, Zn smaller than 10 - 15%. These alloys in terms of strength, elasticity and electrical conductivity through heat treatment can be nearly as close as beryllium, but they are lower melting temperature, non-toxic, available materials and cheaper prices [1-3]. So that requirement, the authors of this article carry out a study copper-nickel-tin alloy. This alloy about strength, elastic and electric conduction adopt heat treatment, and strain can adequate numerically copper-beryllium, but facile melting, non-poisonous and the material find out the essay and cheaper.

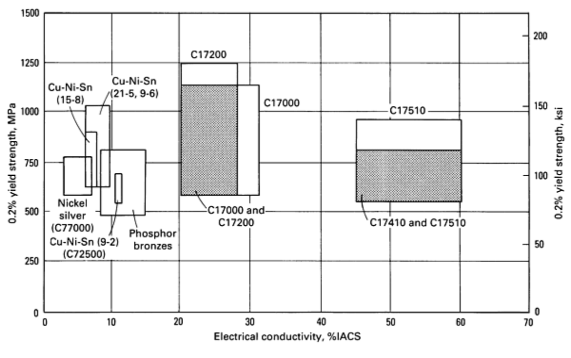

Figure 1: Strength and electrical conductivity for copper alloys

Copper and nickel dissolve unlimited, Ni and Sn almost don't dissolve at the room temperature. On the ternary alloy phase diagrams, the stable metal phases are created among copper and tin, or nickel and tin: Ni_3Sn; Ni_3Sn_3; Ni_3Sn_4. These are also the metastable phase for the alloy. When the study for this alloy, people usually take about the binary phase diagrams with the axis is tin, the axis is copper and nickel compound with the fixed content. (figure 1). On the profile of ternary alloy phase diagrams, at the temperature profile, the studied alloy lasts at the solid solution. This article shows the initial research results about alloy Cu-7Ni-7Sn.

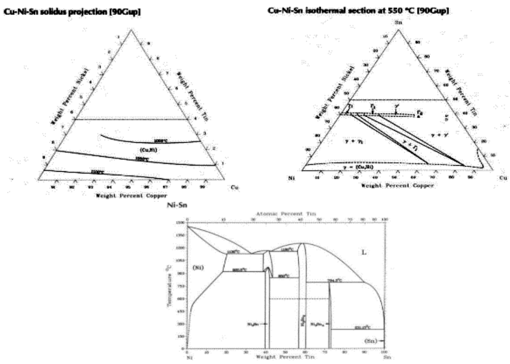

Figure 2: The cross-section diagram of Copper-nickel-tin alloy

The special cause makes for copper-nickel-tin alloy obtain high strength is right heat treatment, in this alloy take place spinodal decomposition. Spinodal transformation is a rather characteristic transformation of Cu-Ni-Sn alloy system. Therefore, this system is called the spinodal. Because, there is spinodal transformation, this alloy system can adjust the properties such as strength, elasticity, ductility, to apply the high mechanical and mechanical requirements of manufacturing. Cu-Ni-Sn alloy system is used to replace beryllium more and more. The Cu-Ni-Sn copper system is a testament to the significance of spinodal transformation in practice [2,4,5].

Most of the alloys by copper are strengthened by the increase in solid solutions, cold machining, increased phase savings, or by a combination of these durable mechanisms. Particularly, the Cu-Ni-Sn three-alloy alloy, high durability is achieved by the heat treatment process called spinodal transformation processing. Spinodal structures are composed of a fine, homogeneous mixture of two phases that form by the growth of composition waves in a solid solution during suitable heat treatment is called spinodal structure. The phases of the spinodal product differ in composition from each other and the parent phase but have the same crystal structure as the parent phase. The fineness of spinodal structures is characterized by the distance between regions of identical composition, which is of the order of 50 to 1000 A^{o} [3,6-9].

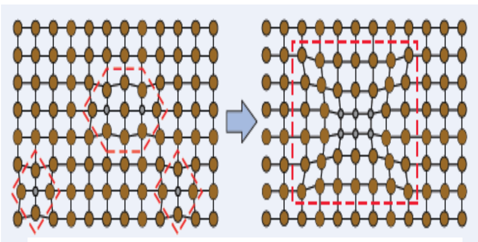

Figure 3: Spinodal diagram

Spinodal transformation is a mechanism in which a solid solution of two or more constituents can be divided into different basic areas of chemical and mechanical properties. This transformation mechanism differs from the classical phase transition in that the separation phase due to spinodal differentiation is much harder to detect, occurring simultaneously and uniformly throughout the material, not only in separate phase transition positions [10-12]. Spinodal transformation is of interest for two main reasons. First, it is one of several phase transitions in a solid form based on reasonable theory. Since there is no thermodynamic barrier to the reaction of the spinodal region, the transformation is determined by diffusion only. Thus, the transformation is considered completely a problem of diffusion; many characteristics of transformation are described by solving the approximate generalized diffuse problem [9,13,14]. Secondly, nucleation theory related to thermal fluctuations and diffusion problems related to germ growth is difficult to explain because of non-realistic properties when linearizing diffusion functions.In practical terms, spinodal transforms make sense to create a small microstructure that is finely dispersed and increases the physical properties of materials.

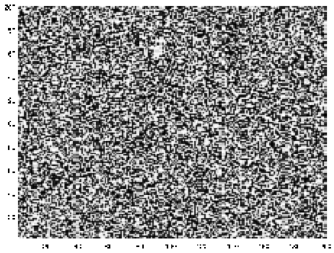

Figure 4: Creating Cahn - Hilliard microstructure structure, showing coarse and phase separation.

Copper-7Niken-7tin alloy at the high temperature last below form copper solid solution nickeliferous and stanniferous. The temper, solid solution can last at the room temperature with the unstable state. When tempering, unstable solid solution decompose to lichen-rich tin atom clusters have nano size, homogeneous distribution increase strength for the alloy. This is important characteristic to help this mechanism of copper alloy obtains equally copper-beryllium alloy. So that spinodal decomposition occurs to necessary must to take heat treatment state to assemble with strain.

1.1 Experimental Procedure

The studied alloy has a component as table 1

Table 1: Chemical properties of the sample

Cu, % mass	Ni, % mass	Sn, % mass	Impurities, % mass
84.7	7	7	1.3

After casting, the sample is quenched, strained and tempered by a different state.

Figure 5: Tension Specimen

The sample is quenched at 750 temperature (water cooling to creat an unstable solid solution) After quenching the depth of sample is 14mm, is hot-rolled down 2.5mm depth, continual cold-rolled at 40%, then tempering at 350^{0}C in the 1h and 2h order solid solution decomposition. Before and after treatment state, samples are tested photomicrograph on the Axiovert 100A microscope, hardness test on the Mitutoyo with the HV hardness numerals and steady load 1KG and tested strength.

2. RESULTS AND DISCUSSION

The study alloy show: After casting, the microstructure of alloy have fish-bone form, the component is uniform, the grain size is bigger about 200µm. The average hardness value 92.6HB.

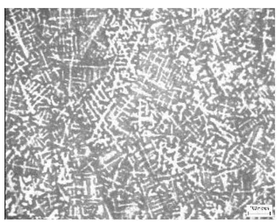

Figure 6: Photomicrograph casting x100

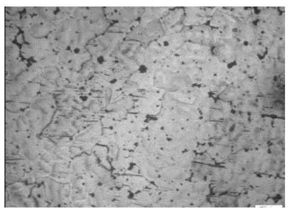

Figure 7: Photomicrograph quenching x100

Table 2: Hardness value (HB) after casting and quenching

	N1	N2	N3	Medium
Casting	92.9	95.0	89.8	92.6
Quenching	119.0	108.0	112.0	113.0

After quenching the microscopy of the alloy is uniform, the grain size is less than after casting about 150µm. The hardness value is increase about 113HB. Possible, the microstructure uniform and minor ascended strength for alloy because on the photomicrograph have an only solid solution. After strain microstructure and behavior of alloy change positive.

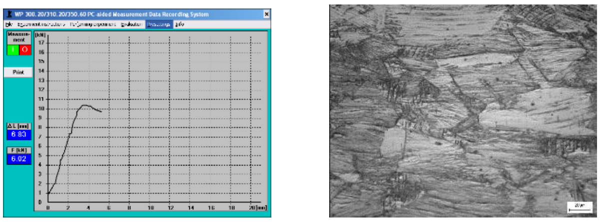

Figure 8: Strength diagram and photomicrograph x500

On the microstructure have a sliding surface, don't see a dimple. The average grain size is 60-70µm. On the microscopy of grain have twinning. The mechanism is that the sample is strained 40%, the thick's sample is 1.48mm, the area of the cross section is 10x 1.48=14.8mm^2. The tensile strength is 953.7MPa, the elastic limit is 694.4MPa. After strain, the average hardness value is 309HB. This fact indicated transition microstructure, minor grain, more resistance to sliding, the sample is cold-hardened, harden, reinforcing above after quenching. The mechanism of modification is more robust when assembling quenching, strain, and tempering.

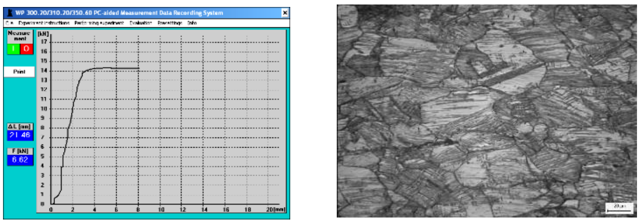

Figure 9: Strength diagram and microscopy after tempering 1h x500

The thick's sample is 1.6mm, the area of the cross-section is 10x 1.6=16mm^2, the tensile strength is 893.7MPa. After tempering, the average hardness value is 370HB. Above after casting and quenching, show after tempering the sample have strength limit (on the diagram that limits concurrent is the elastic limit) and hardness increases. This fact approved to have a transition in the structure increasing strength and hardness for alloy but the product of transition doesn't detect when a show by the optical microscope. On the optical microscope, after quenching and tempering, microstructured on many different. Possible, the component grows strength have very small dimension, and the possible is a spinodal structural cluster so that confirms this fact must do with the testings with the modern machine that is carried out a draw at 2h with the sample.

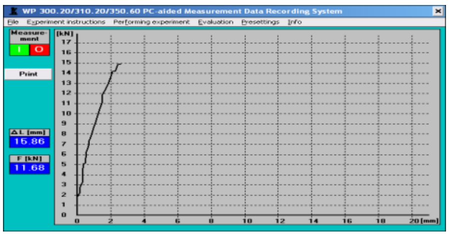

Figure 10: Strength curve after tempering 2h

The thick's sample is 1.58mm, the area of the cross-section is 10x 1.58=15.8mm^2, the tensile strength is 949.4MPa. This value is equal to an elastic limit of the sample. After tempering, the average hardness value is 367HB. After tempering the hardness value is constant but the elastic limit value increases indicate have changed about strain and ductility. Furthermore, in the microscopic microstructure have twining.

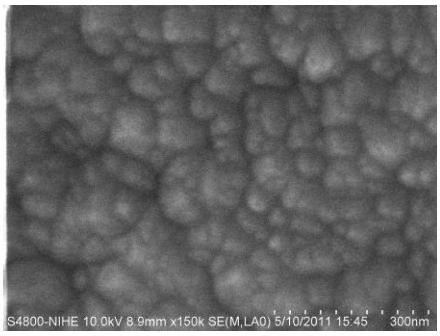

Figure 11: Microstructure of sample after deformation and strength**:**

Sample microstructure analysis on FESEM equipment found that after deformation and senescence, particles with extremely fine size appeared from 10nm to 100nm; In addition, there are also atoms that can be surmised that it is the structure of spinodal decomposition when performing microhardness measurements, it was found that the hardness of the material increased significantly; Carry out the test to see the elongation of the material (8% elongation). It is these claims that the process of elongation and elongation of the material is based on small particle size and spinodal decomposition

3. CONCLUSIONS

After strain and tempering, the elastic limit and hardness value is increased. This fact approved to have a transition in the microstructure of increasing hardness for the alloy. The transition is conjectured spinodal decomposition. After curing the elastic limit of the material is very higher. This fact is very well for element behavior on the high elastic limit condition. The results can compare with some sample

Table 3: Mechanical properties of Cu-7Ni-7Sn

Sample	Strength (MPa)	Elastic limit (MPa)
Cu-7Ni-7Sn	949.4	949.4
High strength low alloy steel (A565 grad 1)	695	552
Duyra (2024)	470	325

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