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ORIGINAL ARTICLE

Effects of Deformation on Microstructure of Cu-Zn-Ni Alloy

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ABSTRACT

The thermal and mechanical effects on microstructure of Cu-12.44%Zn-4.75%Ni (wt%) alloy were investigated. The effects mechanical on both rapidly cooled sample and slowly cooled sample obtained from Cu-Zn-Ni alloy were investigated by using scanning electron microscopy (SEM), X-ray diffraction techniques (XRD). The thermal energy changes of in the alloy were examined by means of differential scanning calorimetry (DSC). As a result of SEM observations, annealing twins structures are observed in rapidly and slowly cooled samples. According to pictures of the SEM and XRD, the stress applied to samples caused to lose existing annealing twins, and led to formation of slip planes lying parallel to each other in between plates. The stress-strain behaviour is associated with applied heat treatment effect to samples. It's shown that the intensities of XRD peaks to be decrease, as a result of the increase in cooling rate. This result indicates that density defects of crystal increases with rapidly cooled in the Cu-Zn-Ni alloy. In both samples of the thermal energy changes, at the process of diffusion transformation eutectoid separation reactions have been proved to exist.

Keywords: Cu-Zn-Ni Alloy, Cooling Rate, XRD, Stress-Strain Behaviour.

1. INTRODUCTION

Metal and alloys exhibit a very surprising property yet fully understood under the various mechanical and thermodynamic conditions. Especially microstructural changes which observed in some metals and alloys exposed physical effects such as thermal, mechanical, thermodynamic, and different combinations of them and desire to change these diversifications accelerate to new studies. Since copper alloys have excellent electrical properties and high corrosion resistance, they are important materials for different industrial applications [1-3]**.** Cu-Zn alloys are used in industrial application as brasses. So it still continuous work on ternary alloy systems in order to develop features of binary alloy systems [1-6]. The purpose of this work is to study, the thermal and mechanical effects on microstructure of Cu-12.44%Zn-4.75%Ni alloy was investigated by SEM, XRD, and compression test. Firstly, the microstructure of the alloy was defined by SEM. Afterwards, compression tests were applied on sample exposed to various cooling rates. The effect of cooling rate on the mechanical behaviour of the Cu-Zn-Ni alloy was discussed. Changes in phase structure of the alloy are also examined by means of XRD technique. In Addition to DSC measurements obtained to the determination of the thermal energy changes of the samples.

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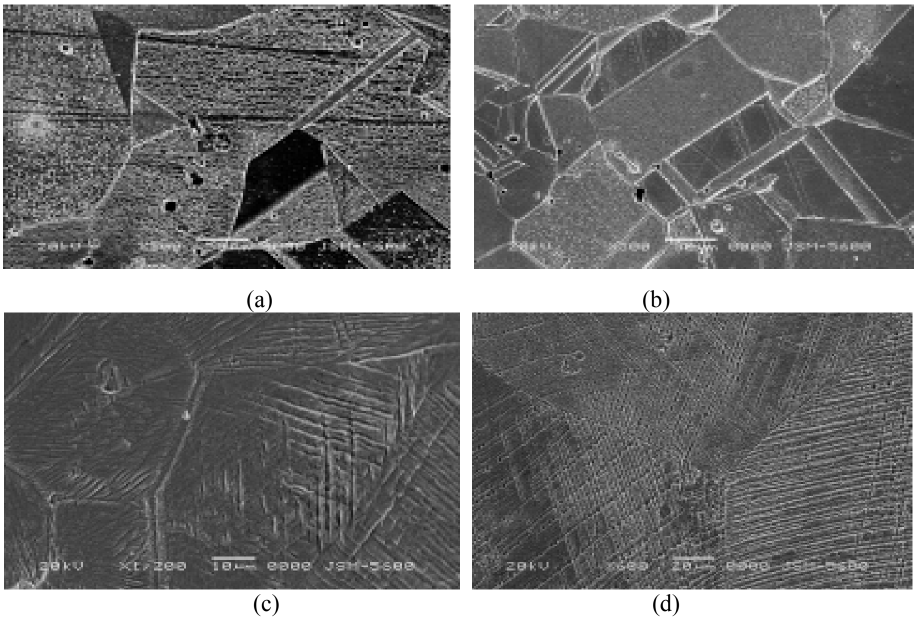
2. EXPERIMENTAL DETAILS

The composition of the alloy used in the present study was Cu-12.44%Zn-4.75%Ni (wt%) was prepared by vacuum induction melting under an argon atmosphere from pure (99.9%) alloying elements. After this alloying, product alloy was used in the form of cylindrical bars with 1 cm diameter and 10 cm length. Samples cut from the alloy were heated in evacuated quartz tubes at 950 °C for 60 min in an Ar atmosphere and immediately quenched into iced-brine rapidly cooling or in room temperature slowly cooling for homogenization. Compression tests were applied to the bars cooled in different rates. From the alloy, small bars with dimensions 4 x 4 x 5 mm were cut to produce compression samples. The compression tests were performed at room temperature in an INSTRON machine operated at constant velocity of 0.2 mm/min. For SEM observations, the surfaces of the specimens were first mechanically polished, and afterwards the damaged surface layer was eliminated by etching in composed of 10 mL HCl, 48 mL methanol and 2,5 gr ($FeCl_3$-$6H_2O$) for 8 - 15 seconds. SEM observations were carried out in a JEOL 5600 scanning microscope. Powder specimens for X-ray examinations were prepared by filing the alloy. X-ray diffraction patterns of the powder samples were taken by a Bruker D8 Advance diffractrometer. For these examinations, the monochromatic copper $K\alpha$ radiation with wavelength 1.5418 Å was used, a step size of 0.02°, 2 for the whole scanning range of 2θ from 20° to 100° was chosen. DSC measurements were examined to the determination of the thermal energy changes of the samples. The peaks recorded during cooling and heating were integrated as a function of temperature. The transformation temperatures were determined using DSC by heating/cooling the samples at the rate of 10 °C/min.

3. RESULT AND DISCUSSION

The micrographs belongs to Cu-Zn-Ni alloys are shown in Figure.1. Twin annealing structures are seen in both samples which have been applied process of fast and slow cooling. Hall (1954) represents, in the microstructure analysis of copper and brass samples made of homogenization process, in many particles, annealing twins are visible. Rhaomboid structures of annealing twins can be distinguished by different staining techniques [7]. Observation SEM micrographs were given in Figure 1.

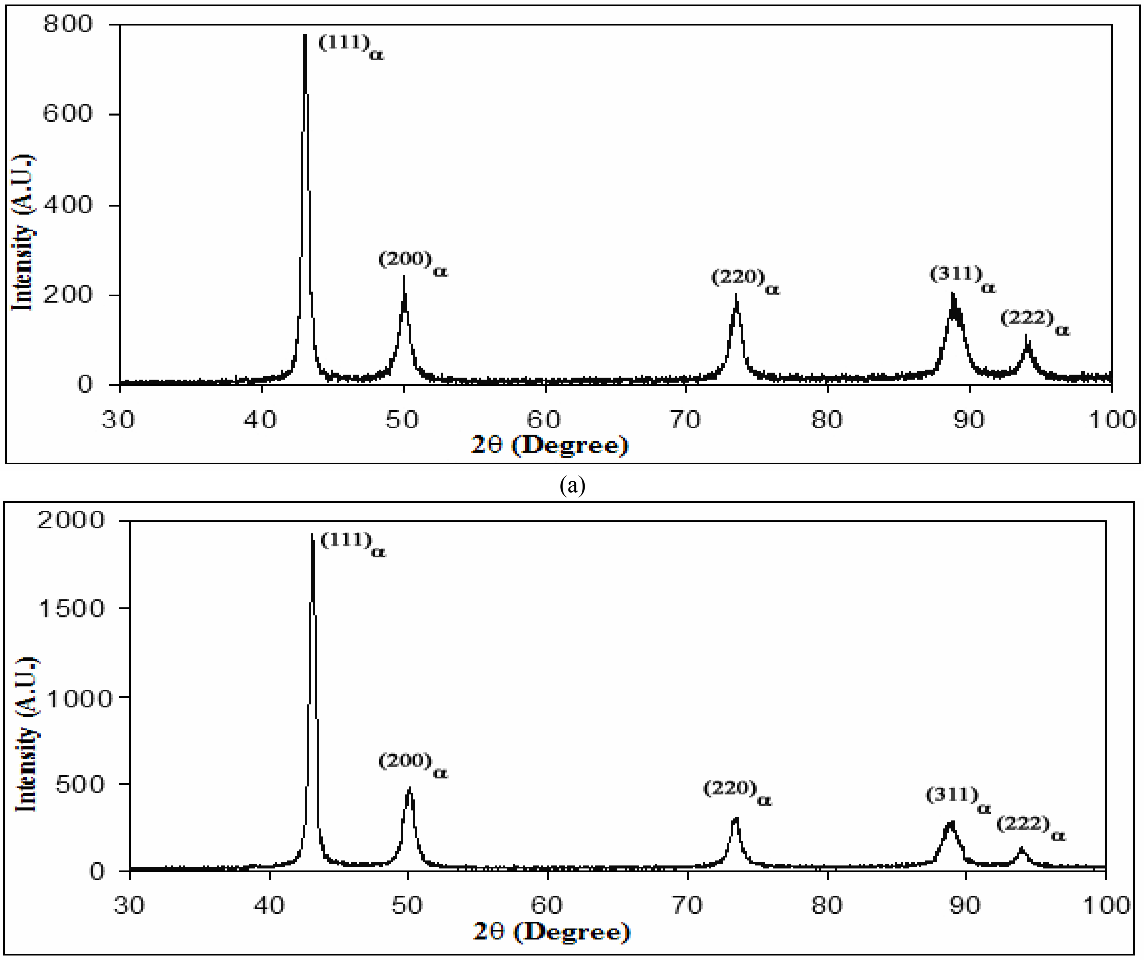

(a) (b)

(c) (d)

Figure 1. SEM micrographs of samples which are applied heat treatment and mechanical effects. (a) sample rapidly cooled with iced-brine water (b) sample slowly cooling in furnace (c) compression stress after rapidly cooling process and (d) compression stress after slowly cooling process.

Askeland (1998) has defined, a twin border is, along the plane its disorder of crystal form orientation is a mirror image of a plane. Annealing twins may occur along the twin border when the shear force effect, and also it causes a shear out at the position of atoms. Twining occurs as certain metals change or during heat treatment after force (tension) and annealing process almost any metal or alloy. In copper based alloys having fcc crystal structures, these structures can be able to occur [7, 9, 10]. Rollasen (1992) also represent, in particular metals especially copper and tin as defined in the annealing twin maybe associated with deformation caused by the sear movement [11]. As it can be seen from SEM images which were obtained after heat treatment and deformation have led to less of annealing twins, occurring in the surface observation. After mechanical effects, structures (seen in the Figure 1.c-d photos) have glide plane which is compatible with literature. In the system dislocation occurs with sears consist of similar to carpet roll. Mainly sear movement is a forward movement which assumed to occur dislocation movement along the glide plane. Glide planes usually extends between planes and parallel to each other. Dislocation is a part of not formed property in the crystal lattice geometry. This area as seen in Figure 1. c-d separates the area is exposed to shear and the area is not [12]. Dvorak and Howbolt (1975) has examined transformation on Cu-Zn-Sn alloys at the plastic area and they presented that %1.5 force on a sample causes shape distortion [13,14].

In Cu-Zn-Ni alloys, when diffraction patterns of the samples which are obtained after heat treatment in order; rapidly cooling in salted ice water (Figure 2.a.) and slow cooling in furnace (Figure 2.b.) were compared, in both samples are the same phase and have same crystalline structure, is observed. According to the present situation, considering applied heat treatment, cooling rate does not change phase structure of this alloy can be expressed [6,10]. Also when the Figure 2. examined, slowly cooling sample has been found to give more intense peaks. At the end of process of fast cooling, the reduction in the peaks' intensity indicates many defects. In the current crystal form [6, 15] analysis results related to the peaks determined from the diffraction pattern of sample both N1 and N2 is given in the Table 1. These peaks, by Sahu and colleagues (2004) El-chiekh and colleagues (2005) regarding Cu-Ni-Sn and Cu-Ni-Zn, Cu-Ni-Cd alloys revealed their XRD patterns have been observed to coincide with [16, 17].



(a)

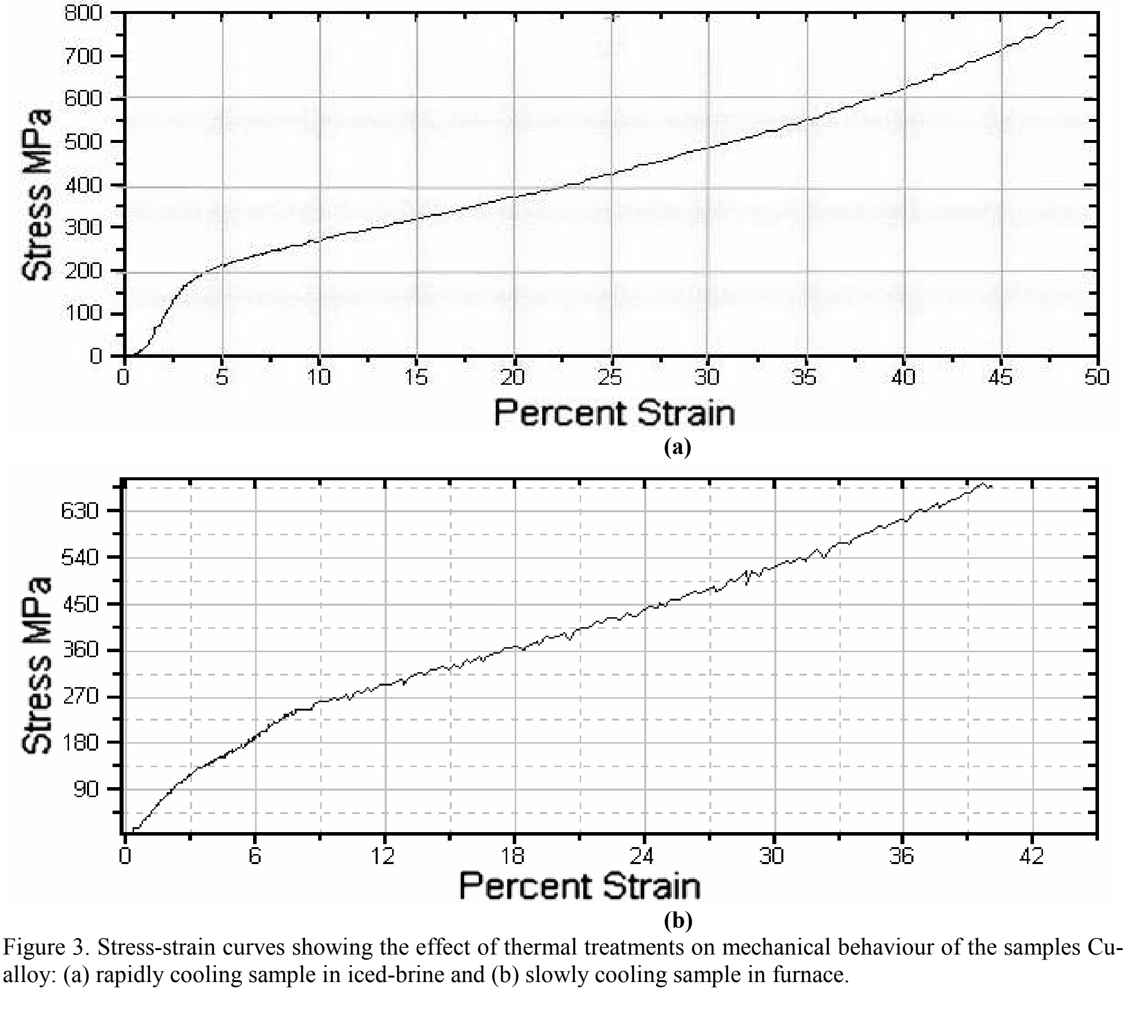
(b)

Figure 2. In Cu-Zn-Ni alloys, XRD diffraction pattern belongs to samples were applied (a) slowly cooling and (b) rapidly cooling process.

Table 1. The results of XRD diffractions in Cu-Zn-Ni alloy

a) Rapidly Cooling				b) Slowly Cooling			
α-phase				α-phase			
2θ/(°)	(hkl)	I/I_0	d(Å)	2θ/(°)	(hkl)	I/I_0	d(Å)
43.04	111	776	2.1015	43.04	111	1919	2.1015
50.12	200	227	1.8200	50.12	200	466	1.8200
73.60	220	167	1.2869	73.60	220	242	1.2869
89.24	310	148	1.0975	89.24	311	200	1.0975
94.38	222	66	1.0508	94.38	222	91	1.0508
a = 3.64 Å							

Stress-strain graphics obtained from Cu-Zn-Ni triple alloy system is subjected to after-heat treatment deformation yield strength of rapidly and slowly cooling samples have been identified as 240 Mpa and 180 Mpa. When stress-strain graph were compered, samples are left to be cooled quickly were more brittle, slowly cooling sample exhibit a linear increase approval for ductile materials, can be seen from the Figure 3. graph. In addition, both curves, rate of plastic part is long. That shows samples were applied different cooling speed indicates ductile properties when cooling speed increases also density of defects increases. When alloy is cooled rapidly especially at high temperatures, equilibrium will not have enough time for the formation, this increases the concentration voids. These voids will be reduced when it is cooled slowly [18]. Also, decreasing in yield strength is observed in sample cooled slowly can be associated with result of the current annealing twins can direct planes of atoms.

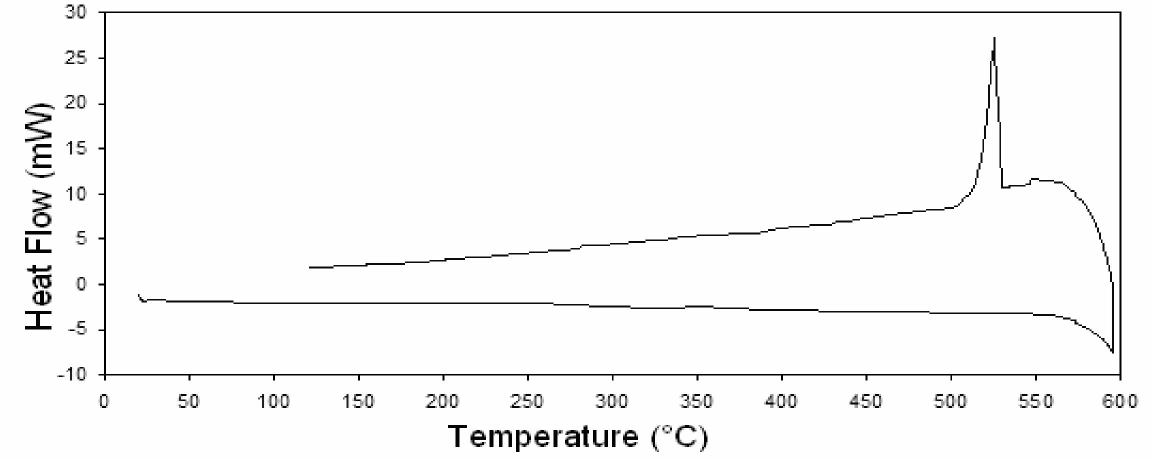


(a)

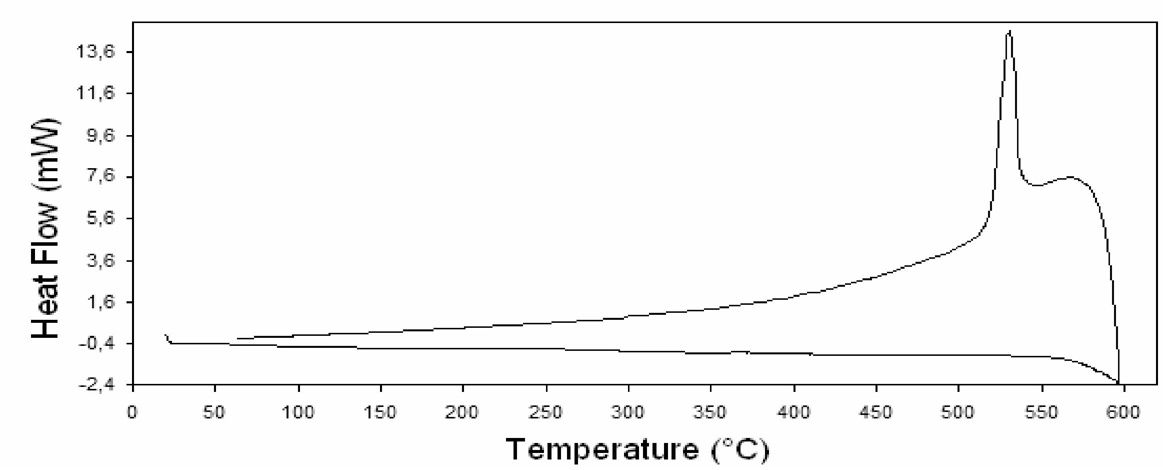
(b)

Figure 3. Stress-strain curves showing the effect of thermal treatments on mechanical behaviour of the samples Cu-Zn-Ni alloy: (a) rapidly cooling sample in iced-brine and (b) slowly cooling sample in furnace.

When the results of DCS relating to samples were subjected to processes of rapidly cooling by leaving into iced-brine and slowly cooling in the furnace, are examined, respectively peaks are clearly visible which indicate eutectoid reaction in the temperature range of 519 °C- 545 °C and 514 °C- 540 °C.



(a)



(b)

Figure 4. The heat flow as a function of temperature; (a) rapidly cooling N1 sample and (b) slowly cooling sample N2 after homogenization at 950 °C.

In Cu-based alloys, the most important results of fast cooling in a change of concentration of point defects and atomic form. Cooling process in alloy can produce permanent changes such as internal hard, dislocation and state of equilibrium deposition. The presence of voids play important roles to cooling Cu-based, remembering Figure alloys [19]. When cooling rate increases, also density of defects increases and lattice structure changes. Especially alloys are cooled fast at high temperature; enough time will not be for the formation of equilibrium. This increases the concentration of voids. These voids will be reduced when it is cooled slowly. As a result of occurring crystal structure which its interstitial atoms' resolution is less, atoms in crystal do not find enough time for diffusion, the large lattice tensions may occur because they must keep their positions in lattice. The vacancy density is important when the matter is suddenly cooled from a high temperature [18, 20].

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