ISSN(Print) : 2320 -1967
ISSN(Online) : 2320 -1975

GLOBAL SCIENTIFIC INC.

ChemXpress

Original Article

ChemXpress 5(4), 132-136, (2014)

Precipitation hardening of Cu-Be alloys

Enrique Rocha-Rangel*, José A.Rodríguez-García, Constantin A.Hernández-Bocanegra

Universidad Politécnica de Victoria, Avenida Nuevas Tecnologías 5902, Parque Científico y Tecnológico de Tamaulipas, Tamaulipas, 87138, (MÉXICO)
E-mail: erochar@upv.edu.mx

Abstract : A Cu-Be alloy type B-534 according to the ASTM classification was thermally treated under different aged conditions. Varying the processing temperature (425, 450 and 475°C) and residence times of the alloy at those temperatures (2, 3, 4 and 5h). With these treatments sought to establish the conditions of time and temperature suitable for maximum hardness in the studied alloy. From observations of the microstructure in conjunction with measurements of hardness of the alloy, it has that aged treatments at elevated temperatures (450 and 475°C) for longer periods of time to 2h, result in the overaged of the microstructure, which implies the decrease in the hardness of the alloy. Moreover, aged at 425°C requires long period of treatment (5 hours) to achieve adequate and uniform formation of precipitates in the alloy and therefore reasonable hardness in the same. Treatments at 450°C during 2h, allow good training and distribution of precipitates in the microstructure of the alloy, and the greater hardness of the same.

Keywords : Precipitation; Aged; Cu-Be; Alloys; Hardeness; Microstructure.

INTRODUCTION

Beryllium copper alloys maintain a unique position among all engineering alloys that are now in use[1]. Copper itself is widely used throughout industry because conducts electric power better than any other metal (excluding silver)[2]. However, a major disadvantage of pure copper is its ductility making easily deformed under the action of a mechanical force[2]. To provide some resistance to copper, it is alloyed with other metals and is practiced to some thermal treatments resulting alloy and they practiced some thermal treatments to the resulting alloys[3]. One of the metals used for reaching high strength and hardness in copper is the beryllium. Copper alloys containing beryllium, are the mechanically stronger among the family of copper alloys[4-6]. This high resistance combined with good electrical conductivity makes the copper-beryllium (also known as beryllium bronze) they are particularly used for various electrical applications, such as, in contacts and replacements must open and close a large number times[6]. Although beryllium provides high resistance to copper, is not sufficient simply to add the metal other than copper, but once made the copper-beryllium alloy, it is important to also perform a heat treatment of precipitation hardening. This treatment involves a high temperature heating and quenching to obtain a solid supersaturated solution, and then the alloy is reheated to a lower temperature for some time (aged) to allow the excess solute precipitate out of solid solution thus forming a second stage, thus achieving the required high strength alloy[7].

EXPERIMENTAL DEVELOPMENT

The working alloy was the denominated by the ASTM as B534. This alloy was emptied by the method of the permanent mold, having a melting temperature of 1185°C. The chemical composition of this alloy is the following: 0.4% Be, 0.3% Co, 1.8% Ni, 0.10% Fe, Cu balance. The alloy was heat treated in a muffle furnace (Carbolite brand), which can reach temperatures up to 1200°C. They work with 13 cylindrical samples, which had the following dimensions: 2cm long and 1.5cm in diameter; these samples were applied the following heat treatment: solubilization at 920°C for 1 hour, cooling to room temperature water, and then an aged is performed in accordance with the times and temperatures specified in Figure 1.

After performing the aged treatment, the samples are roughed and subsequently polished, by attacking them for 15 seconds with a reagent with the following composition: 50gr ammonium persulfate and 50ml of distilled water, to reveal the microstructure and may observe that in an optical microscope. Finally, the hardness of the samples was measured using a load of 100Kgf on the Brinell scale.

RESULTS

Microstructure

The microstructure of the sample solubilized at 920°C without aged, it is presented in Figure 2. In this figure microstructure shows no dendritic structure as a result of cooling from the liquid state, so that we it can be determine that this temperature is adequate to achieve a good dissolution in the alloy.

Figure 3 show the microstructure of the aged sample at 425°C as a function of time. In this figure is that for the sample aged for 2 hours the formation of precipitates homogeneously distributed in the grains was observed. In the microstructure of the sample aged for 3 hours there is an increase of precipitates in the grains also it can be appreciated some precipitates at the grain boundaries. For the sample aged for 4 hours it is observed a fine microstructure with precipitates homogeneously distributed in the matrix, the distribution is in all grains, which will surely give greater hardness to the sample. Finally, the microstructure of the sample aged for 5 hours has a larger formation of precipitates that are themselves distributed evenly in the matrix. Moreover, in this sample are reached to see

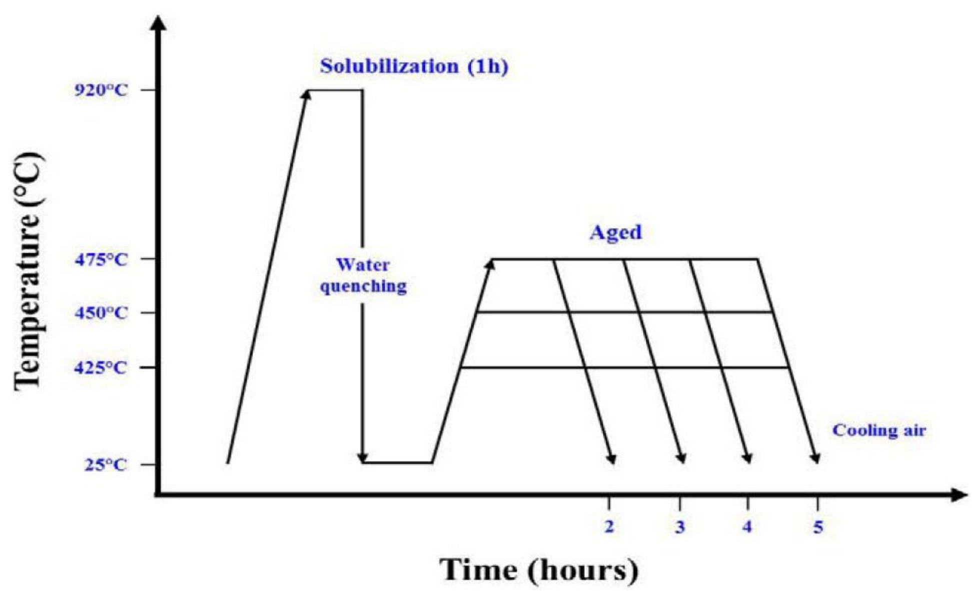

Figure 1 : Diagram showing the heat treatment to which samples were subjected, to obtain the maximum hardness as a function of time and temperature.

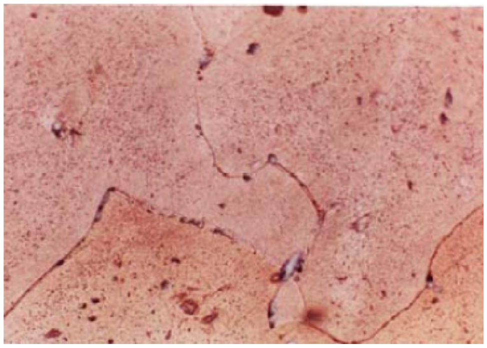

Figure 2 : Microstructure of ASTM-B534 alloy. Solubilized at 920°C for 1 hour.

some precipitates tend to accumulate in the grain boundaries, which may be indicative of initiation of an overaged of the microstructure due to the long treatment times.

Figure 4 show the microstructure of the sample aged at 450°C during different times. In this figure is that for the sample aged 2 hours precipitates distribution is homogeneous, plus they are very fine. On the aged sample to 3 hours thickening in the grain boundaries is observed, likewise must be about the same is beginning to appreciate the exhaustion of the matrix. The microstructure of the sample aged 4 hours occurs

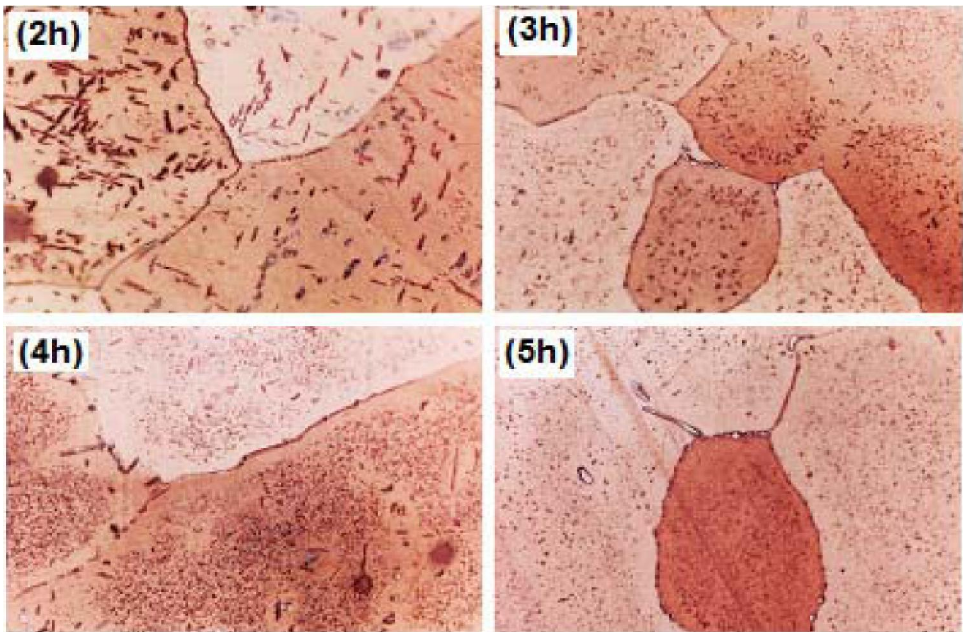

Figure 3 : Microstructure of sample aged at 425°C at different times.

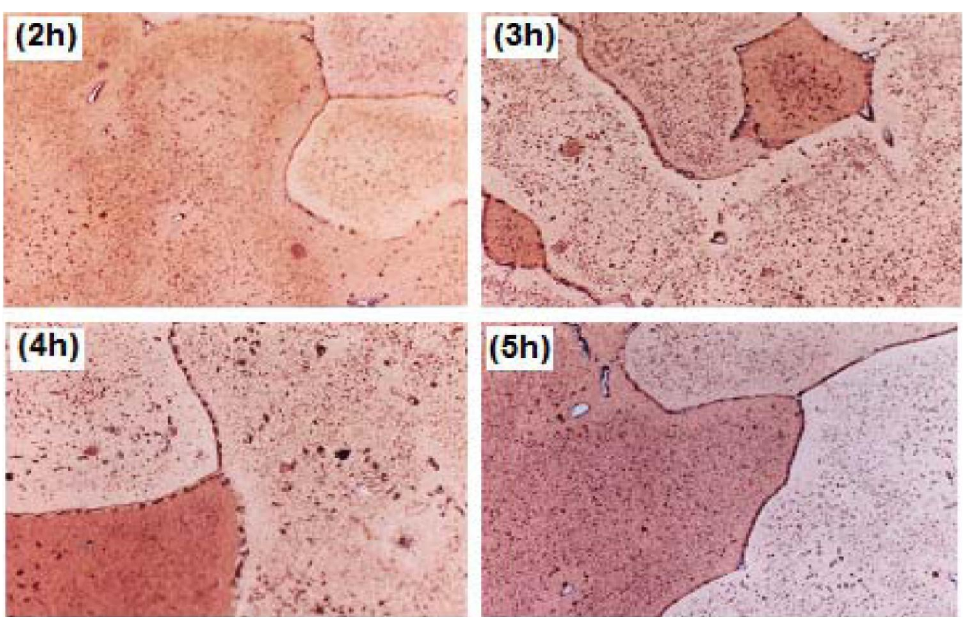

Figure 4 : Microstructure of sample aged at 450°C during different times.

around grain boundaries that depletion of the matrix is evident, so that the growth of the precipitates is large; also thickening grain boundaries are clearly visible. With increasing aged time 5 hours, a more heterogeneous microstructure with the formation of small islands of beryllium (light blue particles) is observed.

The microstructure of the sample aged at 475°C for different times is presented in Figure 5. In the microstructure of the sample aged for 2 hours there is an increase of precipitates in the matrix grains, is the accumulation of precipitates at the grain boundaries, so these conditions will reach the peak of aged. On the simple aged 3 hours growth of precipitates within the grains is visible, which also happen to occupy space on the grain boundaries, this can result in the decrease of hardness, and here you have a typical microstructure of overaged. In the following microstructure 4 hours of aged growth of precipitates on the grain boundaries is evident, further that the distribution thereof is not uniform; this sample is already fully overaged. In the sample treated for 5 hours, it is observed that there is a thickening in the grain boundaries typical of a structure overaged.

Hardness

After heat aged treatment for different conditions of study, the following results were obtained: The witness specimen (solubilized in 920°C during 1 hour) has a hardness of 19.25 on the Brinell scale. The results of hardness measurements on the various samples are shown in Figure 6. Thus it follows that at the aging temperature to 425°C, the hardness of the sample increases as the aged time is greater. Otherwise occurs on samples aged at 450 and 475°C where in a higher aged times have decreased hardness in the same. However, this is important to note that hardness reached 97.8 for both samples aged at 450 and 475°C for 2 hours, while the maximum hardness reached by the sample aged at 425°C for 5 hours is 98.5, values very similar in the three cases. The hardness decreased in the aged samples at higher temperatures and longer times can be explained by the fact that the microstructure in these cases is undergoing an overaged, making the microstructure grows in size and distribution of non-uniform precipitates. In the case of the sample aged at 425°C has to be not too high this temperature is achieved good formation and distribution of the precipitates, but this only to long periods of time to achieve acceptable levels of hardness. What in the production process would not be profitable for the low productivity that involves working these samples for more than 100% of the time it requires only a sample is heated over 25°C to achieve the same hardness in the material. In this way it is possible to establish that aged at 450°C for 2 hours is the condition where is reached the best hardness values in the studied Cu-Be alloy.

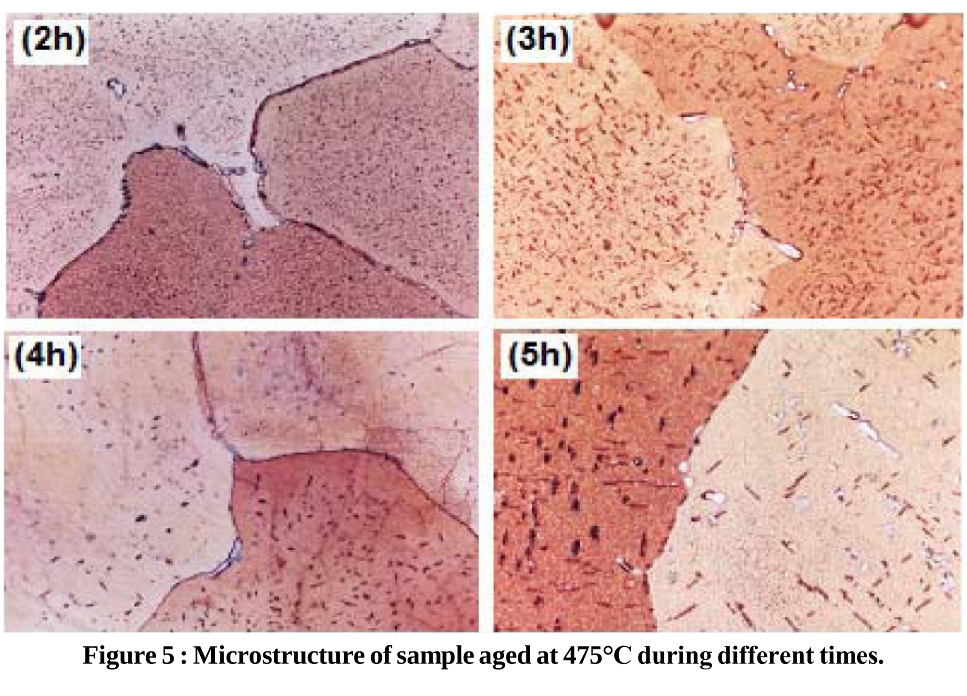

Figure 5 : Microstructure of sample aged at 475°C during different times.

ORIGINAL ARTICLE

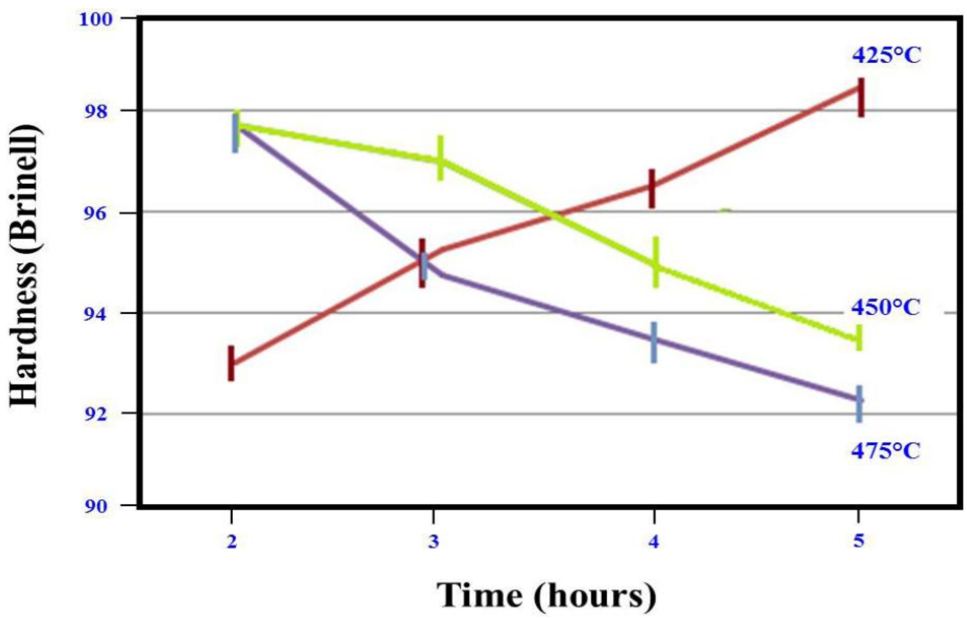

Figure 6 : Hardness of the aged samples at different temperatures depending on the aged time.

CONCLUSIONS

A solubilization temperature of 920°C during 1 hour proved to be adequate to remove the cast structure in Alloy. While aged at elevated temperatures (450 and 475°C) for longer periods of time up to 2 hours resulting in overaged microstructure, which results in the decrease in the hardness there of. Moreover, aged at 425°C requires a long term treatment (5 hours) to achieve adequate and uniform formation of precipitates in the alloy and therefore reasonable hardness in the same. These long terms treatment process reduces productivity. So the best aged conditions for these alloys are; 450°C during 2 hours, where the better formation and distribution of precipitates in the microstructure of the alloy and where the greater hardness of the same is obtained.

REFERENCES

[1] Materials Science and Technology; Structure and Properties of Non Ferrous Alloys, K.H.Matucha, (Ed); Wiley VCH, NY, USA, **8**, **(1996)**.

[2] William F.Smith; Fundamentos de la ciencia e ingeniaría de materials, Second Edition, Mc. Graw - Hill, México, **(1990-1993)**.

[3] Alloys; Preparation, Properties, Applications, Hathi Habashi, (Ed); Wiley VCH, NY, USA, **(1998)**.

[4] Metals Handbook; Properties and Selection: Nonferrous Alloys and Special Purpose Materials, 10th Edition, ASM, NY, USA, **2**, **(2010)**.

[5] Alloying; J.R.Davis, (Ed); ASM International, Ohio, USA, **(2001)**.

[6] Alan M.Russell, Kok Loong Lee; Structure-Property Relations in Nonferrous Alloys, Wiley, NY, USA, **(2005)**.

[7] Handbook of Mechanical alloy Design; George E.Totten, Lin Xie, Kiyoshi Funatani, (Eds); Marcel Dekker, Inc., NY, USA, **(2004)**.