The Study on Microstructure and Mechanical Properties of Silver alloy 58.4% for Jewelry Manufacturing

Thanatip. Salanay, Sirichai Torsakul
Department of Industrial Engineering, Faculty of Engineering,
Rajamangala University of Technology Thanyaburi, Pathumthani 12110
Corresponding Author: taihoo2009@hotmail.com

Abstract

The research involved the characterization of the properties of silver alloys -bearing copper and zinc. The alloys composed of 58.4% silver 20.85-41.76% copper and 0-20.83% zinc, respectively. When comparing the characteristics of this alloy and sterling silver 925, the alloy specimen had mechanical properties better than the sterling silver 925. The alloy tests presenting the mechanical values of the hardness, shear bond strength, elasticity of the specimen were in a range of 54.6-95.3 HV1, 209.5-379.3 MPa., 100.6-193.8 MPa. and 32.1-51.7%, respectively. While the mechanical values of sterling silver 925 were 52.8 HV1, 193.5MPa., 96.0 MPa. and 29.8%, respectively. Besides these, the microstructure of the alloy specimen showed the dendrite structure. We found that this structure decreased when the concentration copper in the specimen increased. After adding zinc into the alloys, the high amount of zinc caused the zinc-rich (alpha) phase changed to Eutectic phase, together with the significantly increased area of alpha phase. These effects, therefore, brought up the better various mechanical properties of the alloys. At the same time, the another test specimen composed 58.67% Ag 39.20% Cu and 2.14% zinc. The color level of this specimen was close typically to the sterling silver 925, with the difference of Da at 0.236 and Db only at 5.268. Additionally, the higher copper concentration in the alloy provided a value tentatively increased but b value decreased. However, more remarkable results were that the zinc showed opposite effects from the copper.

Key words: Sterling silver, Silver alloy, Copper, Zinc.

1. Introduction

Silver sterling 925 has at least 92.5% (wt/wt) silver as a major alloy component whereas other additional metal alloys usually are less than 7.5%. Among them, preferably added alloys are a copper metal. Copper alloys provide significantly better hardness to the metal as well as it is low cost, so the copper metal is mostly preferred to be added in the silver sterling. More than that, to obtain preferable properties, not only copper base alloys, but other alloy metals can also be added. The sterling silver 925, in view of the fact, is low-priced and is usually used as the main component of the jewelry and accessories. Additionally, its reasonable cost catches the attention of practically all consumers.

At the present of crisis situation, the high cost of most raw materials seriously affects the increase of the productivity cost. These introduce numerous works on searching for the possible alternative approach in reduction the upcoming cost of the raw materials. In the most case, for example, the alternative silver alloys was made by using lower silver content, silver alloy 58.4% (14k) used in most jewelry accessory production. Since this alloy still preserves major acceptable properties, those are mechanical properties and physical appearance (color level), close to sterling silver 925, this alternative silver alloy type can also be significantly another new optional material for the customers in which its product obtained could help increase the possibly pick up the pace of the business based competition potential. From all above, therefore, in this study, we aimed to understand the characteristics of silver alloys 58.4% composed of copper and zinc. This alloy type will be further utilized for silver jewelry and accessories.

2. Procedures

1. Make the alloys by fusing 58.40% silver together with 20.85-41.76%, copper, and 0-20.83% zinc with the vacuum casting machine.

2. Find all chemical components in the alloys by Atomic absorption spectrometer

3. Test for the mechanical properties including strength test, tension test and microstructures of the alloys.

4. Measure the color level of the specimens and thus estimate the color differences of the alloys with the control sterling silver 925.).

3. Results and discussion

3.1 Characterization of the chemical composition of the alloys

From Table 1, the results showed the chemical characteristics of specimen by Atomic absorption spectrometry. We found that there was at the average of 26.2% of zinc content loss. This caused the increase of the chemical compositions of silver and copper in the alloys.

Table 1 The results of the chemical components characterized in the alloys

Specimen type	Chemical components (%wt)		
	Cu	Zn	Ag
AgCu1	6.30	-	Balance
AgCu2	41.55	-	Balance
AgCu3	39.20	2.14	Balance
AgCu4	35.47	5.79	Balance
AgCu5	31.57	9.57	Balance
AgCu6	26.88	13.82	Balance
AgCu7	22.17	18.45	Balance

3.2 The test for mechanical properties

3.2.1 The test for hardness

From the figure 1, we obtained the specimen has the hardness between 54.6-95.3 HV1, in which the specimen 59.38%Ag 22.17%Cu 18.45%Zn showed the hardest. The sterling silver 925 (93.71%Ag 6.30%Cu) could provide the hardness only at 52.8 HV1, however, more added zinc caused the hardness tentatively increased.

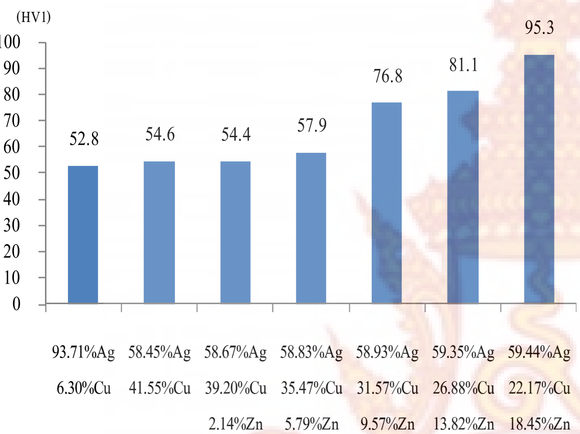


Figure 1 The graph representing the hardness (HV1) of the alloy specimen

3.2.2 The test for tensile strength

From the data test of ASTM E8M-99 [1], the data represented in figure 2 demonstrated that the tensile strength was between 209.5-379.3 MPa. Particularly, the specimen 59.44%Ag 22.17%Cu 18.45%Zn provided the highest tensile strength, whereas sterling silver 925 showed the tensile strength only at 193.5 MPa. Additionally, more zinc adding caused the tensile force increase.

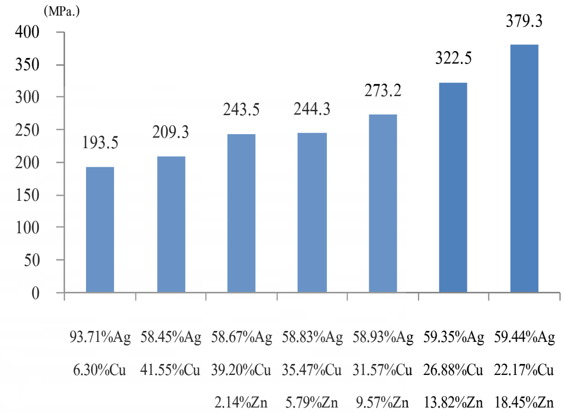


Figure 2 The graph representing the tensile force of the alloy specimen (MPa)

In figure 3, the data of all specimens showed the yield strength between 100.6-193.8 MPa. The specimen Particularly, the specimen 59.44%Ag 22.17%Cu 18.45%Zn also provided the highest yield strength, whereas sterling silver 925 showed the value only at 96.0 MPa. More zinc adding tentatively caused the yield strength increase.

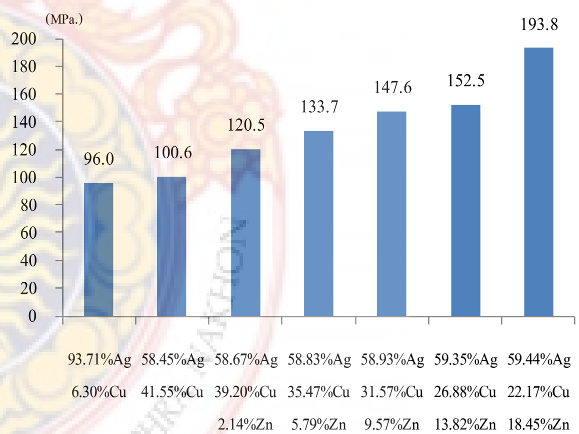


Figure 3 The graph representing the yield strength (MPa.)

From figure 4, the data of the specimen tested for the elongation revealed that the elongation was between 32.1-51.7%. The specimen 59.44%Ag 22.17%Cu 18.45%Zn provided the best elongation value, whereas sterling silver 925 showed the elongation value only at 29.8 %. More zinc adding could cause better elongation, but adding zinc more than 13.8% could not help make particular different.

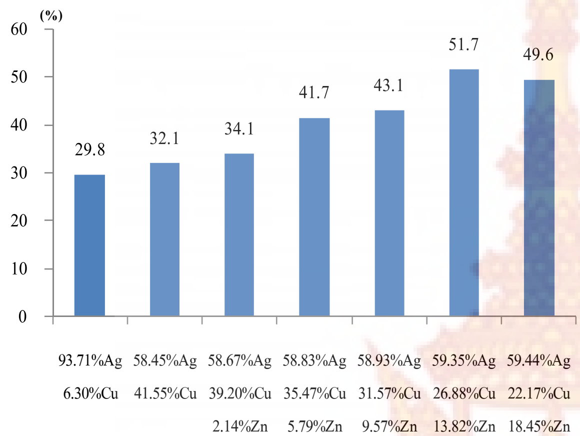
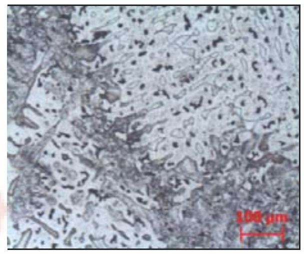


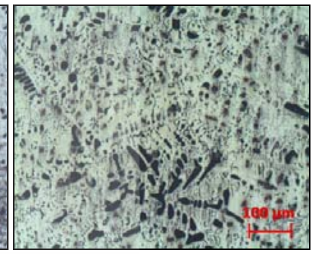
Figure 4 The graph represents the elongation (%)

3.3 Microstructures of the specimens

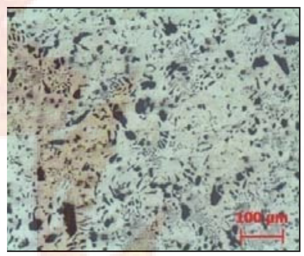
From figure 5, the specimens showed the microstructures in the dendrite structure like since the specimen was quick cooled down faster than at the balance condition. This situation thus caused the alloy containing poor mechanical properties. Nevertheless, more copper added to the specimen, it showed the dendrite structure tentatively reduced (b), in which we could clearly see the grain structures and β phase, eutectic, and α phase. When comparing the microstructures of silver alloys composed of silver – copper with the one composed of silver – copper – zinc, the gradually adding zinc at small amount caused no differences in the microstructures. However, adding zinc caused significant change of αphase to Eutectic phase and increase α phase area in the specimen. These results were possibly explained that zinc added could affect the decrease in melting temperature. As a result, it caused the alloy cooling down at better balance condition so obtained alloy harbored better mechanical properties.



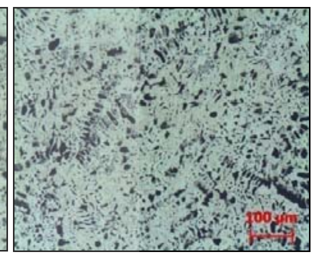
a) 93.71%Ag 6.30%Cu



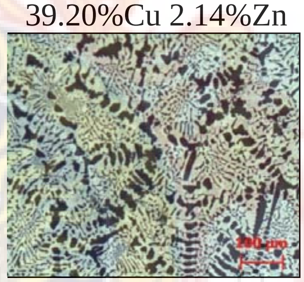
b) 58.45%Ag 41.55%Cu



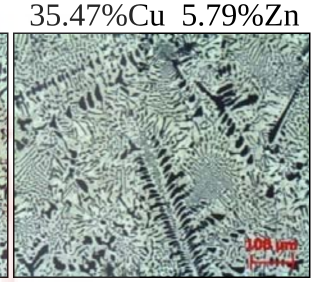
c) 58.67%Ag 39.20%Cu 2.14%Zn



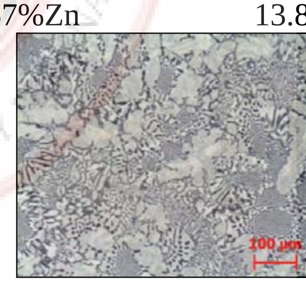
d) 58.83%Ag 35.47%Cu 5.79%Zn



e) 58.93%Ag 31.57%Cu 9.57%Zn



f) 59.35%Ag 26.88%Cu 13.82%Zn



g) 59.44%Ag 22.17%Cu 18.45%Zn

Figure 5 The microstructure of the alloy specimen

4. Conclusions

From the study, the characteristics of silver alloys 58.4%, used for silver jewelry and accessories were composed of copper and zinc as a major and a minor alloy. All these results could be concluded as follows

1. The data of chemical compositions by Atomic absorption spectrometry indicated the more zinc lost, especially at the average 26.2%, due to the fusion method.

2. The alloy tests for the mechanical properties including the hardness, shear bond strength, tensile force as well as elongation of the specimen were in a range of 54.6-95.3 HV1, 209.5-379.3 MPa., 100.6-193.8 MPa. and 32.1-51.7%, respectively. If more zinc was added, the alloys would have better mechanical properties.

3. The microstructure of the sterling alloy 925 had the dendrite structure like, but more copper added to the specimen caused the dendrite structure reduced. When added more zinc caused αphase change to Eutectic phase and uncertainly increase α phase area in the specimen and finally made the obtained alloy had better mechanical properties.

5. Acknowledgements

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6. References

[1] Thai Industrial Standards Institute (2521). TIS. 21-2515 Product industrial standard for silver ware. Industry, BKK.
[2] ASTM Section 3 (1999). Metals Test Methods and Analytical Procedures. American Society for Test and Materials.