COMPARISON OF MECHANICAL PROPERTIES OF UNS C12200JOINTS BRAZED BY (CU &AG) BASED FILLER METALS

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Abstract - Seamless Copper Tubes grade UNS C12200 used in medical applications were brazed by Copper and Silver – based filler metals to compare the tensile strength and hardness of the brazed joints and to determine the best filler metal alloy to be used in the medical applications. First, the copper tubes were taken from the Zawia Hospital and chemically analyzed. The results of chemical analysis satisfy the EN BS EN 13348. The copper tubes were cut and brazed using RBCuZnAl, BCuP2 & BAg2 filler metals. The brazed joints were tested using tensile and hardness tests and the results showed that the brazed joint by BCuP2 is the hardest joint which make it prone to stress corrosion cracking. While the joint brazed by the filler metal RBCuZnAl has the highest tensile strength and toughness which make it more desirable in medical applications as it can stand the pressure passing through the copper tubes.

Keywords - Welding, Brazing, Copper tubes, Joints.

I. INTRODUCTION

Brazing is a bonding method widely used in many industries, in brazing, a filler metal is heated above melting point and then the molten filler metal is drawn into the gap between closely adjacent surfaces by capillary attraction. The filler metal is brought slightly above its melting temperature while protected by a suitable atmosphere or flux. Bonding results from the intimate contact produced by the dissolution of a small amount of base metal in the molten filler metal, without fusion of the base metal. It is called “Brazing” when the temperature exceeds an arbitrary value namely 800°F (427°C); the term “soldering” is used for temperatures lower than the arbitrary value [1]. Brazing is not like braze welding; welding is a joining process wherein metallic components are joined through fusion (melting) or recrystallization of the base metal by applying heat, pressure or both. This process differs from brazing, where only the filler metal melts during processing [2]. Welding and brazing that require qualified personnel, proper brazing or welding equipment, and proper choice of filler composition. Moreover to avoid oxide formation, a nitrogen flow inside copper tubes during brazing avoids oxide formation.Mechanical assembly, comprising many possible arrangements and include elastomer materials inserted between two metallic surfaces. The sealing material presents contradictory properties: nearly incompressible but with an elasticity (or viscoelasticity) enabling deformation leading to “fill the gap” of clearances between the two solid surfaces. Copper tubes are used in refrigeration circuits to joint different components due to their chemical compatibility with refrigerants. Different copper parts are joined by brazing and brazing with capillary brazed joint fittings. Good brazing joints should be strong, withstand vibration, temperature, and thermal cycling stress [3]. In brazing, the filler metal is distributed by capillary action. Therefore, the joints must have close tolerances and a good fit prior to brazing in order to produce a strong bond. The lap joint is one of the strongest and most frequently used joint in brazing, especially in pipe work. Its primary disadvantage is the increased thickness of the final product. For maximum strength, the overlap should be at least three times the thickness of the metal. A 0.001-inch to 0.003-inch clearance between joint members provides the greatest strength with a silver-based filler metal. With such close tolerances for pipefittings, you need to take precautions to prevent heat expansion from closing joints before the capillary action [3]. The size of a butt joint is limited to the thinnest section, so maximum joint strength is impossible, but you can maximize the available butt jointstrength by maintaining a clearance of 0.001 to 0.003 of an inch in the finished braze. The edges of the joint must be perfectly square to maintain that uniform clearance between all parts of the joint. Butt joints are usually used where it is undesirable to have double thickness. When double metal thickness is objectionable but you still need more strength, the scarf joint is a good choice. A scarf joint provides an increased bond area without increasing the thickness of the joint. The amount of bond area depends on the angle the scarf is cut; usually, an area two to three times the butt joint area is desirable. A 30° scarf angle gives a bond area twice that of a 90° butt joint, and a 19½° scarf angle increases the bond area three times. Long lasting copper tube is a favorite choice for plumbing, heating, cooling and other systems. In the United States, it is manufactured to meet the requirements of specifications established by the American Society for Testing and Materials (ASTM) International [4]. A suitable selection of the filler metal is vital for producing satisfactory brazed joints. The wettability of brazing alloys with base metals

depends on physical properties such as surface tension, density, melting point, and viscosity. Thermal conductivity and electrical resistivity are also important since the filler metal is frequently required to have similar values to those of the base metal [5]. One of the important factors that determine the quality of brazing is the type of the filler metal. The right choice of filler metal depends on the chemical composition of the base metal. The classifying of the filler metals types is basically according to the solidus and melt temperature and the selection of the proper filler metal depend on the joint design. The following tables show the chemical composition of the filler used in this study.

Table I chemical composition for RBCuZn-A alloy [7].

Nominal Composition:	
Copper	59.0% ± 2.0
Zinc	Remaining
Tin	0.625% ± 0.375
Lead	0.05%Max
Aluminum	0.01%Max
Other elements, Total	0.50% Max

Table II chemical composition for BAg-2a alloy [8].

Nominal Composition:	
Silver	30.00 ± 1.0%
Copper	27.0 ± 1.0%
Zinc	23.0 ± 2.0%
Cadmium	20.0 ± 1.0%
Total other Elements	0.15 % Max

Table III chemical composition for BAg-2a alloy [9].

Nominal Composition:	
Phosphorous	7.25 ± 0.25%
Copper	Balance
Total other Elements	0.15 % Max

In the literature survey, there exist a number of papers concerning brazing cupper tubes specially that used in Oxygen transfer in hospitals. For instance, Li Ruifeng et al. [10] presented joining of copper tubes using Ag-Cu filler has been carried out by vacuum brazing technology. Xuerui Wu et al. [11] analyzedmicrostructure and mechanical properties of brazed joints used in electronic devices. Rahul Pahwa et al. [12] presented a general view of the feasible work carried out on brazing as introduction to allied welding processes. Mathew K.J [13] presented a literature survey on the different parameters which affect the successful brazing of components and the different tests used to analyze the parameters. Vishesh Garg et al. [14] present shielded metal arc welding, by developing the electrode composition for the joining process of three different kinds of metals and alloys, without using the oxyacetylene cylinder and other heavy brazing apparatus. A. Hasap et al [15] present exploring the influence of contact pressure as well as the amount of filler metalon the microstructure and strength of Cu-35Zn-3Pb brazing joints. R.J. Mosborg et al. [16] showed mechanical properties and metallurgical studies of a number of types of welded copper joints at various temperatures and by different welding processes. LI Xia-wei et al. [17] Microstructure and mechanical properties of dissimilarpure copper/1350 aluminum alloy butt joints by friction stir welding.

II. EXPERIMENTAL PROCEDURE

Each brazing procedure shall be qualified to establish the properties that are expected to result from its application to production brazements. To qualify a brazing procedure, the following steps are necessary. The samples were cleaned and degreased then heated to the correct brazing temperature. A neutral flame was chosen to give the best results under normal conditions.The samples to be studied were selected using the standard for copper applications in the medical field.

The samples were cut and rigged in length to suit the welding process. The brazing process was performed under the terms of ANSI/AWS A5.8. The continuous nitrogen gas was supplies through the pipes from one end during the brazing process and the tube was capped from other end . this procedure to prevent formation of oxidation inside the tube. Copper and silver – based filler metals (CuZnAl, BCuP2, BAg2) were used to braze the joints. The hardness equipment used is type bulutmakinahardnees with standard specification E384-89 and tensile machine is type Zwick with standard specification ASTM E8.

III. RESULTS AND DISCUSSION

Tests were conducted at the High Vocational center of Casting, where the tensile test, Micro hardness (Vickers) and chemical composition were performed, the amount of tests chemical composition are tabulated as flowing.

3.1 Tensile test.

The tensile test of brazed joints with different filler metals has been done. The tests show the joint brazed by BCuP2 has high tensile stress, and has good resistance for high pressure in tubes. The amount of tensile test for each sample showed in table IV. Figures 1, 2 and figure 3 shows stress-strain curves for joints brazed with different filler metals.

Table IV Tensile test on the samples.

sample	Rb N/mm^2	Reh (upper yield) N/mm^2	Rm(Max.stress) N/mm^2
RBCuZnAl	50.34	30	66.6
BCuP2	64.6	40	66.17
BAg2	16.54	14	33.2

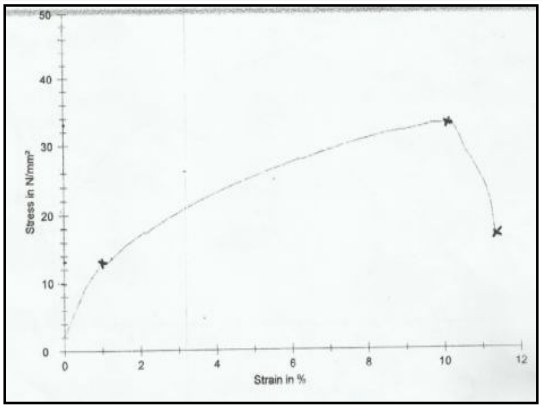


Figure1: Stress-strain curve for BAg2

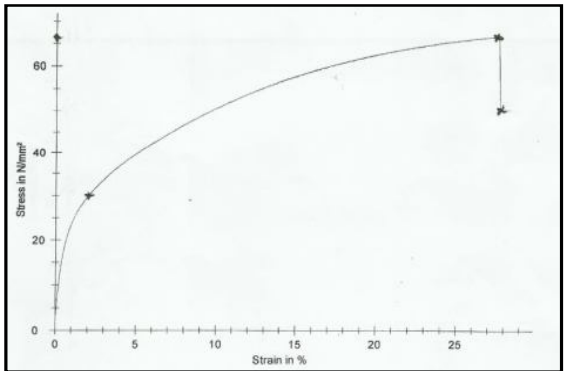


Figure 2: Stress-strain for CuZnAl.

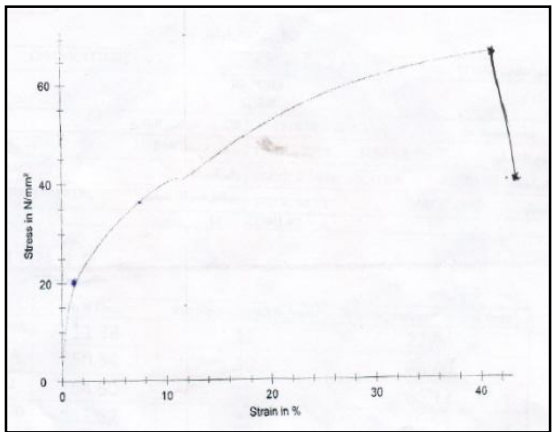


Figure 3: Stress-strain for BCuP2

3.2 Micro hardness (Vickers) test.

The values of micro hardness Vickers Hardness, VH tests for each sample are shawn below in table V. Figure 4 shows that the average hardness for each sample with different filler metals in joint zone. It can be seen that the joints brazed by BCuP2 has highest VH micro hardness.

Table V Micro hardness test on CuZnAl.

Laboratory sample CuZnAl .			
No	Value	Test method	Result
1	63.18	HV1	Low
2	64.32	HV1	Low
3	70.53	HV1	Low
Up./low.limit	Average	Std.Deviation	Result
140/ 24*10E9	66.01	3.96	Low

Table VI Micro hardness test on BCuP2.

Laboratory sample BCuP2.			
No	Value,Mpa	Test method	Result
1	67.55	HV1	Low
2	76.17	HV1	Low
3	76.04	HV1	Low
Up./low.limit	Average	Std.Deviation	Result
140/24*10 E9	73.25	4.94	Low

Table VII Micro hardness test on BAgA2.

Laboratory sample BAgA2 .			
No	Value	Test method	Result
1	60.74	HV1	Low
2	47.6	HV1	Low
3	44.75	HV1	Low
Up./low.limit	Average	Std.Deviation	Result
140/ 24*10E9	51.03	8.53	Low

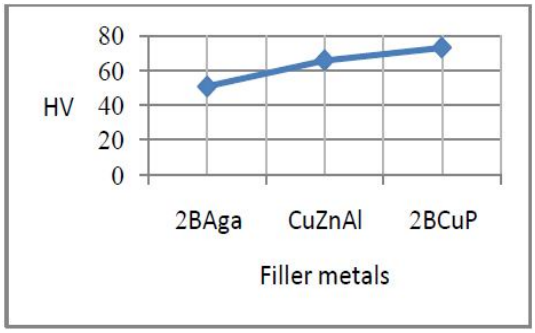


Figure 4 Average micro hardness (Vickers) for filler metals in joint zone.

3.3 Chemical composition for metal cupper tubes.

Chemical composition by spectrophotometer for Cupper tubes has been taken with considers, to making sure that the tubes was satisfied with the EN 13348:2001 standard. Table VIII shows the percentage of chemical composition.

Table VIII the chemical analysis of the Cupper tubes.

Ave	Cu 99.7	Zn 0.065	Pb 0.120	Sn 0.202	P 0.213	MN 0.002	Fe 0.103	MG 0.009
Ave	Ni 0.131	Al 0.048	Sb 0.156	Cr 0.060	As 0.005	Bi 0.001	Be 0.001	Ag 0.062
Ave	Co 0.004	Cd 0.019	B 0.001	Zr 0.002	Se 0.001	Te 0.005	Si 0.112	S 0.079
Ave	Au 0.040							

CONCLUSION

Brazing has an important place in many recently industrials especially in copper tubes applications. The joint brazed by BCuP2 has the hardest vicker value. While the highest tensile strength was recorded for the joint brazed by BCuP2 filler metal making it the most recommended filler metal for the medical cupper tubes application.

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