CONSIDERATION ABOUT DEFORMABILITY OF BIMETAL BRAZING JOINTS

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Abstract: Brazing is realized by joining the added material to the base material thus it is realised a solid joint between materials. The degree of dissolution of materials used in assembly is very important in realization of sustainable bimetallic joints that can be stamped successfully. The stamping creates areas where joints can give the size and material compression degrees because its variation. A better stamping of these bimetallic brazed plates can be obtained through the exactly determination of these material areas.

Keywords: brazing, joint, dissolution rate, deformability, material

1. INTRODUCTION

Brazing is realized by many procedures, most common are the torch brazing, the furnace brazing and the induction brazing [1]:
- *the torch brazing* - is a method frequently used, the added material being heated until brazing temperature with flame. That method is very used because are simply and is realized manually or automatically;
- *the furnace brazing* - the heating of added material is realized with a furnace continually or discontinuous, with or without controlled atmosphere, or even with vide;
- *the induction brazing* - that type of brazing use a current from an induction coil and is directed to added material until the flow temperature.

We can choose a brazing process according to the joined materials, the brazing flows used for filler material and the properties of adhesion to the base materials also considering the economic aspect. In this paper we propose the determination of the wetting degree of the plates in the brazing process. Also we propose to choose the correctly brazing materials and to determine areas where the joint is more vulnerable in the brazing process. All these factors are interrelated and the knowledge of them leads to a better deepening of the phenomena.

2. EXPERIMENTAL SETUP

Considering that we have to braze two materials Fe-Al type with Cu joining material, in the joining area a landing will occur. This will highlight the concentrations of the two materials, as the brazing temperature is around 650°C. To carry out experiments normal carbon steel and a Cu type added material was used [2].

In advance Fe-Al based materials were prepared by finishing and degrease to achieve fusion.

The two pieces of base material are attached to a clamping device for a later introducing into the brazing furnace where it will be heated at a temperature about 650°C (Figure 1).

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The area influenced by temperature was measured in the joint area. It is about 20 μm around connecting cord.

This type of Fe – Cu – Al joint has performed well in terms of diffuseness of added material into the base material, thus achieving a sustainable joint.

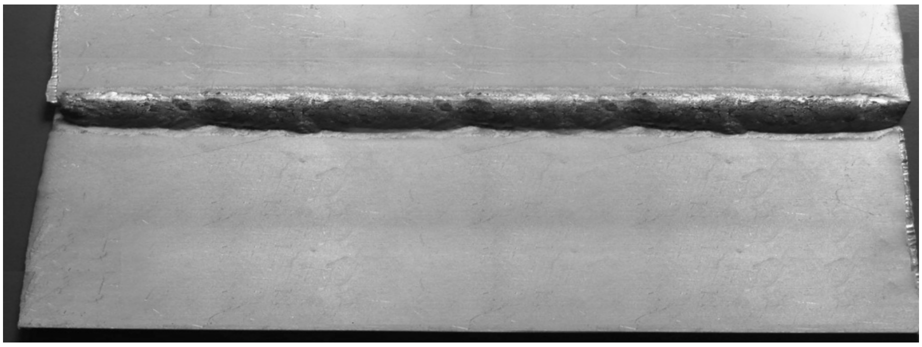

Fig. 1. Fe–Cu–Al brazing joint.

Tensile tests made with brazed samples were satisfactory. The material was strong in the joint area. The maximum pressure of 150 MPa was established for the yield of this joint type.

3. DISSOLUTION RATE OF Cu LAYER IN Al-Fe TYPE BASE MATERIALS

We must know the degree of diffusion of filler material (Cu) in the base materials (Fe-Al), the bonding parameters and the thickness of the filing material, depending on the thickness of plate material.

All these parameters should be considered to predict and control the level of dissolution. To decide the appropriate layer thickness and the parameters of reactive brazing contact it is necessary to know the rate of dissolution of the Cu layer.

Eutectic reaction that occurs between the base material and the filler generate a complete dissolution of the copper layer and its adherence to two base materials. For this reason the joints will be sustainable and can be deformed without breaking the joint.

Copper dissolution is performed in the liquid phase. Practically its atoms adhere to the base material better than if it had been made in the solid phase.

Molecular diffusion of molecules means displacement of fluid from one region to another one. Between the two regions it should be a different concentration than a concentration gradient for the occurring of the phenomena. The diffusion phenomena occur in the region with higher concentration than in the one with lower concentration because the decreasing concentration.

For the study of molecular diffusion phenomena we will admit that diffusion occurs after one direction (Ox). The concentration volume of copper, c_{Cu} and the volume of the fluid molecules will be considered a function only of x and t, this way $c_{Cu} = c_{Cu}$ (x,t). Considering Fick's second law [3] and analyzing it for the three Fe-Cu-Al materials that must be joined, the equation can be written as:

$$\frac{\partial c_{Cu}}{\partial t} = D_{Cu} \frac{\partial c_{Cu}}{\partial y^2} \tag{1}$$

where:

- D_{Cu} – diffusion coefficient;
- y – distance between the two contact areas.

It will result:

$$c_{Cu}(x,t) = C_1 + C_2 \cdot erf\left(\frac{x}{\sqrt{4D_{Cu}t}}\right) \quad (2)$$

where C_1 and C_2 are the constants determined by boundary conditions.

If we consider the constant K_1 as determined by Al-Cu binary phase diagram and W_0 is the initial width of the liquid phase necessary for dissolution, it results [3]:

$$W_0 = K\sqrt{4D_{Cu}t} \quad (3)$$

and:

$$t = \frac{W_0^2}{4K^2 D_{Cu}} \quad (4)$$

Since the initial time of dissolution is correlated with W_0, in this case the diffusion coefficient is [3]:

$$D_{Cu} = 8.1 \cdot 10^{-7} \exp\left(\frac{-38900}{RT}\right) \quad (5)$$

where:

R – molar gas constant;
T – temperature, [K].

In this case, W_0 = 20 µm, T = 923 K, K = 0.15 determined by binary phase diagram of Al-Cu. Dissolution of copper layer will take place in about 0.5 sec. Thus the interlayer dissolution rate of copper (v_{Cu}) equation can be written as:

$$v_{Cu} = K\sqrt{\frac{D_{Cu}}{t}} \quad (6)$$

If we consider the combination of three materials it will result a copper dissolution rate of 3.5×10^{-4} m/s.

It is difficult to determine experimentally the dissolution rate with the base material. Using Eq.4, for three temperatures around the brazing temperature 650°C (923K), will result the diagram of copper dissolution speed in the base metal layers variation (Figure 2), neglecting the temperature of dissolution.

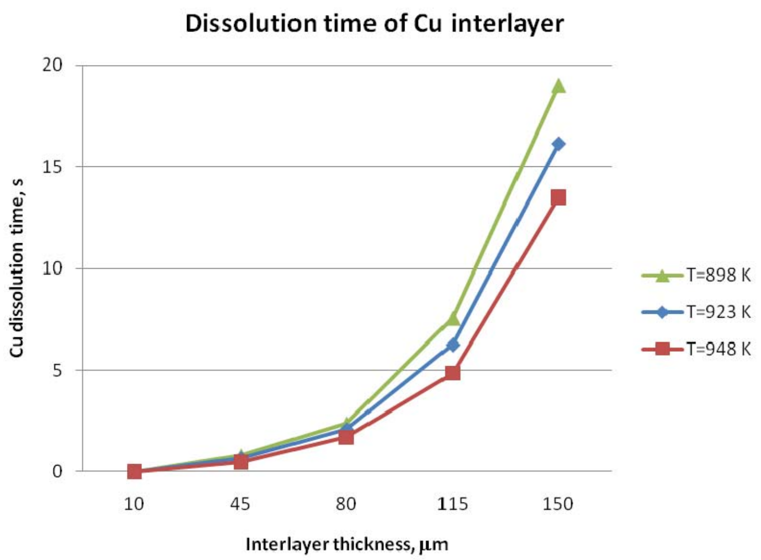

Fig. 2. The dissolution time of Cu interlayer.

4. DEFORMABILITY OF A PLATE BRAZING JOINTS

Essential qualitative drawbacks of bimetal brazed stamped plate (Figure 3) are: appearance of wrinkles on the sidewalls of the piece; excessively thin walls in the connection between the bottom and sidewall and that on the sidewall; deviations from the corresponding cross-sectional size and breaking joints due to stamping forces.

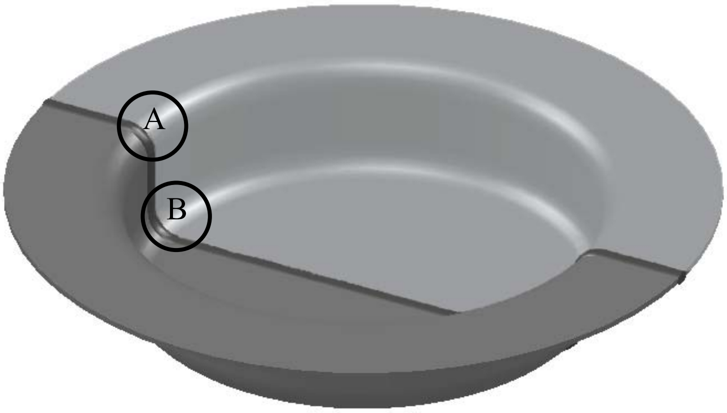

Fig. 3. Bimetal Fe-Al brazed stamped plate.

For an element realized by stamping the dangerous areas (A, B) are made by brazing joint. Areas such compression occurring tensile forces are areas where the connection may fail. In those areas the brazed joint between materials is required within cracks. The cracks can occur if these materials weren't chosen properly.

5. CONCLUSIONS

For the realization of brazing joints of sheets with different sizes and materials in order to achieve stamped elements it should be considered how these materials interact with each other to achieve durable joints.

These plates joined by brazing must then be able to withstand forces that appear during stamping. There is a danger of cracks appearance in the joint area because of stretching and compression forces in the yielded material. To prevent cracks in these joined materials their choice must be done in order that it can realize a durable brazing cord that resist stamping. Basically they must act as base material.

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