BY ALEXANDER E. SHAPIRO

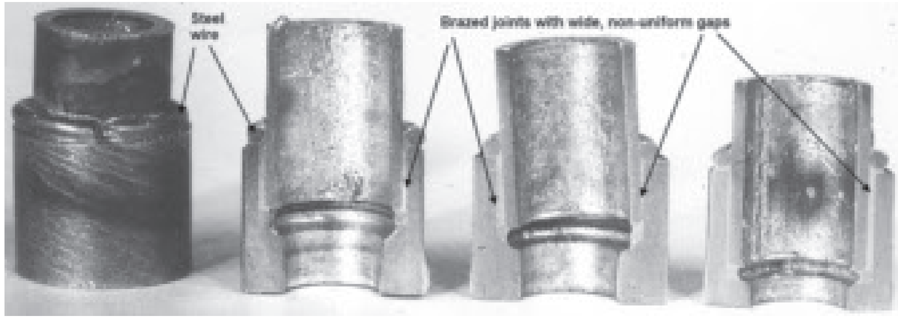

Fig. 1 — Steel tubes brazed with two wire rings that close the wide joint clearance from both sides.

Q: Many times in our repair business, we encounter the problem of brazing steel tubes that have deviations in diameters, so there is no consistency in the size of the joint clearance of the joints to be brazed. Sometimes the tubes match each other and the joint clearance is small, but often they do not match and the joint clearances are extensive, and often the centering of tubes is far from symmetrical. In these cases, we get voids on the side of the wider joint clearance. What can be done to braze wide nonuniform joint clearances properly, without these voids that cause leakages and require rebrazing after testing under pressure? We use torch and induction brazing with BAg-1a for carbon steel tubes and BAg-22 for stainless steel tubes.

A: Successful brazing or soldering requires a capillarity force in the joint clearance between the parts to be joined. In your case, the joint clearance should be in the range of 0.004–0.008 in. (0.1–0.2 mm) for induction or torch brazing in air, or 0.002–0.006 in. (0.05–0.015 mm) for furnace brazing in a shielding atmosphere.

In mass production, manufacturers are obliged to meet these rigid specifications, but in the individual production or in repair business, as in your case, sometimes it is impossible or economically inefficient. Therefore, one can try special adjustments to the process, change the joint design, or apply some "tricky" methods to braze wider joint clearances.

There are many methods known in industrial practice to braze parts having noncapillary joint clearances. However, capillarity is necessary in order to hold the liquid braze alloy in the joint at brazing temperature. Therefore, all these methods involve a complete or at least partial formation of a capillary system in the wide joint clearances.

Let's start with the methods applicable for brazing in air. The easiest way is to put a thin steel mesh or even steel turning in the joint clearance in order to form a cap-

Fig. 2 — Macrostructure of a wide joint clearance, steel tubing joint brazed with a composite filler metal that includes up to 40% of not-melted powder. This powder forms a capillary system in the joint clearance.

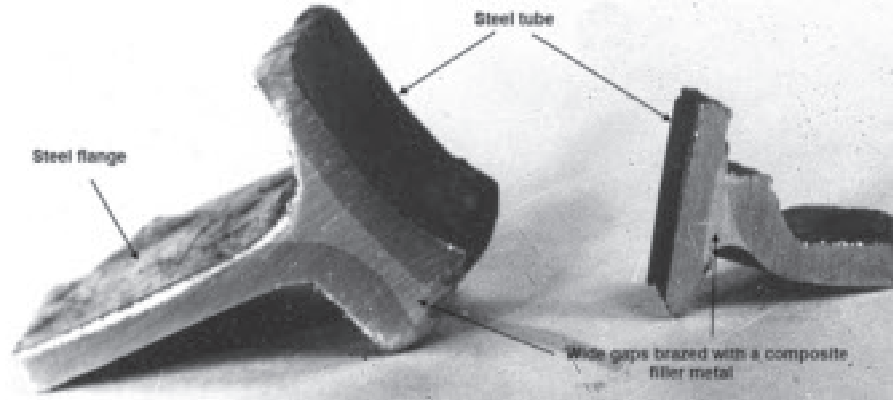

Fig. 3 — Ultrawide joint clearances of asymmetric geometry brazed with a composite filler metal containing 60% braze alloy and 40% iron powder.

illary system there. Firstly, both the mesh and the turning should be carefully cleaned in acetone and alcohol. Secondly, the mesh should have large cells, preferably bigger than 0.08 × 0.08 in. (2 × 2 mm) in order to create conditions for flow of liquid flux and braze alloy into the joint, as well as to provide free evacuation of gases and slag. Appropriately, the capillary system made with the steel turning should provide the same.

Two drawbacks of this method are the practically inevitable porosity of the joint metal, and bad fillet formation. This means that this approach can be recommended only for joining tubes that do not work under fatigue loading or need to be air- and leakproof.

The next method is more complicated because it includes preparation of two additional parts and a change of the joint design, but it is more reliable. You can make two rings (Fig. 1) from steel wire that have a diameter bigger than the width of your largest joint clearance to be brazed. The inside diameter of the rings should fit the OD of the tube as shown in Fig. 1. Both wire rings are fixed at the edges of the joint when you assemble the tubes before brazing. Then, you can braze the steel tubes using your regular process either by induction or torch brazing with the flux. Wire rings form local capillary gaps in the entrance and exit of the wide joint clearance. These local capillaries hold liquid filler metal inside the wide joint clearance. After two or three trials, you should find the process parameters that give the best fully dense joints. Placing a part of the filler metal and flux inside the joint clearance before heating usually helps.

The third approach is most widely used in the industry; however, it is suitable only for furnace brazing. The filler metal is prepared in the form of paste containing the brazing alloy powder and a filler powder. The filler has melting temperature higher than that of the braze alloy. For example, the brazing paste comprises 60% of yellow brass powder as the braze alloy and 40% of steel or iron powder as the filler. The iron particles in the filler do not melt at brazing temperature and form a capillary system in the joint. The filler is infiltrated with the liquid braze alloy, and the resulting joint metal has a composite macrostructure. Figure 2 shows a typical structure of a wide joint clearance brazed with this type of composite brazing paste. Figure 3 illustrates that even ultrawide joint clearances of different shapes can be brazed using this method.

This method is successfully used for brazing stainless steel or superalloy joints having asymmetric configurations such as for repairing compressor or turbine blades, nozzles, etc. Brazing is done in vacuum furnaces, and the composite braze mixture or paste comprises a nickel-based eutectic alloy as the melting phase and a base metal or similar alloy powder as the not-melting filler. The advantages and drawbacks follow from the nature of this process. On the one hand, one can easily adjust the ratio between the braze and filler particles in the paste in order to densify joint clearances of any width and shape. On the other hand, there are no standard applications, and the user always has to test and optimize the composition of such double-phase brazing materials experimentally.♦

This column is written sequentially by TIM P. HIRTHE, ALEXANDER E. SHAPIRO, and DAN KAY. Hirthe and Shapiro are members of and Kay is an advisor to the C3 Committee on Brazing and Soldering. All three have contributed to the 5th edition of AWS Brazing Handbook.

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