The Brazer's Question: Paste or Preforms?

The pros and cons of each method for applying filler metal to brazed joints are outlined

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Which form of filler metal is better to use, paste or preforms? That question prompts a spirited debate among manufacturers involved in copper brazing in controlled-atmosphere furnaces.

Furnace brazing differs from hand brazing and many types of open-air brazing in that the filler metal must be preplaced on the part. Furnace brazing is done in a controlled-atmosphere brazing furnace. This furnace type uses a stainless steel mesh belt that carries the product through a heated muffle containing the furnace atmosphere. Typically, the furnace atmosphere is neutral-to-reducing in nature. The atmosphere in the furnace usually contains significant amounts of hydrogen and nitrogen, which allow high-temperature brazing to be accomplished without oxidation and minimal-to-no flux.

A copper braze paste consists of copper powder blended into a neutral suspending agent — Fig. 1. The product has a semisolid consistency, somewhat similar to toothpaste.

A preform is a solid piece of copper (or any braze alloy) that has been preengineered to provide an exact volume and shape to accommodate a particular part or application — Fig. 2.

Preforms made from wire include rings, ring segments, wire segments, and four-slide fabrications of limitless geometries. Preforms manufactured from flat stock include washers, shims, and a wide variety of stamped configurations.

What, then, are the relative advantages and limitations of paste vs. performs?

Filler Metal Placement

One key factor in brazing process efficiency is how easily the brazing filler metal can be applied to the assembly. In most cases, paste has an advantage over preforms in its ability to be rapidly applied to the joint area. Depending on the method of application, paste can be applied with different levels of control and precision.

Four categories of paste applicators are commonly used:

1. **Squeeze bottles.** Similar to a condiment dispenser, a plastic bottle is squeezed, extruding a deposit of paste into the joint area. The amount and placement of the paste deposit is completely operator dependent in this basic paste application method, which was once very common. A hidden cost is the time lost due to the frequent transfer of product from pail to bottle. Finally, the threat of operator injury due to carpal tunnel syndrome complicates this method as a feasible option for production.

2. **Pneumatic.** In this method, air pressure systems attach to a syringe or caulking cartridge filled with paste. The deposit size can be controlled by adjusting air pressure, needle orifice size, and the duration of the air pressure cycle (timer). Paste must be transferred into the syringe or cartridge or be purchased prepackaged. When packaged at the factory, the packaging doubles or triples the cost of the copper paste.

3. **Positive Displacement.** In this system, paste is purchased in bulk and stored in a pressurized reservoir. The paste is fed into an applicator gun that meters out a precise volume of copper paste. This method is more economical than pneumatic systems as it minimizes transfer time and packaging costs. It is best at making either dots or stripes of paste, but since it cannot be programmed, it is difficult for one gun to make different size deposits on the same part.

Fig. 1 — Copper brazing paste.

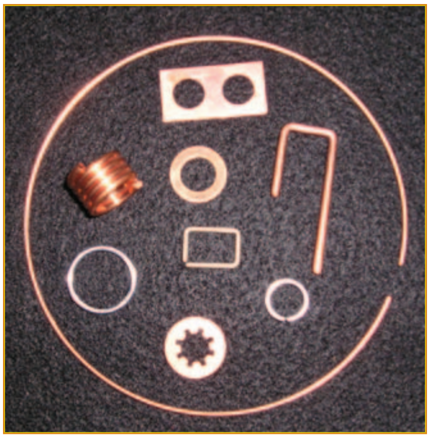

Fig. 2 — Common types of copper preforms.

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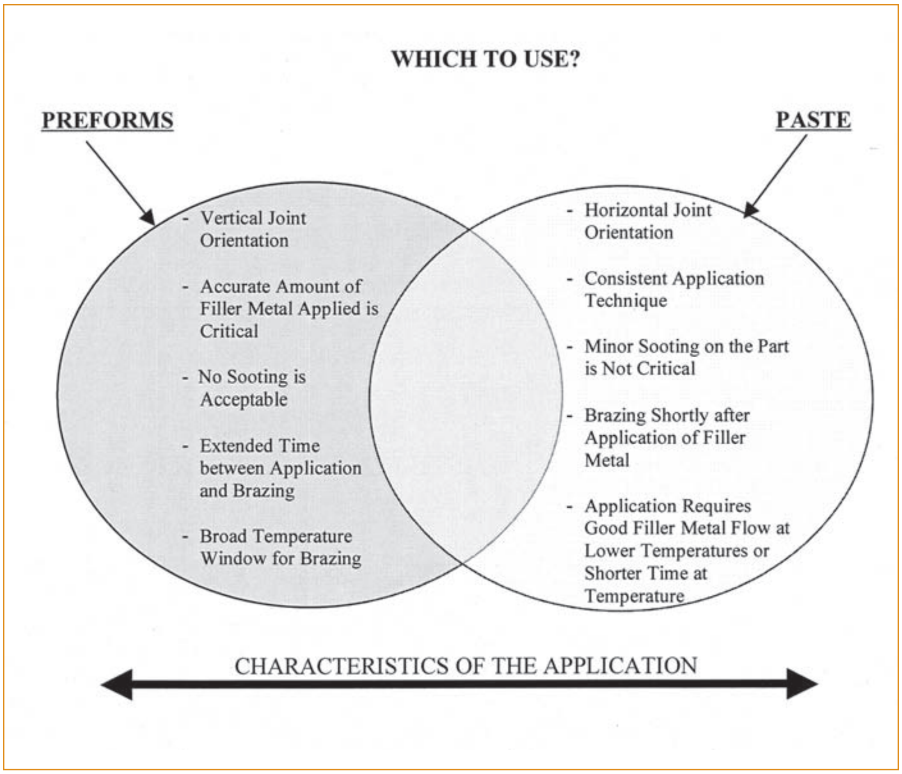

Fig. 3 — This schematic shows the characteristics of each filler metal method.

4. **Automated robot systems.** Although very expensive, costing from $40,000 to more than $150,000, these systems maximize the potential of paste by placing controlled deposits of varying sizes and dimensions in a high-production environment.

A couple of other comments about the placement of brazing alloy are worth noting. First, the braze alloy must be in position to braze the joint when it reaches the melting temperature of copper in the furnace. Many paste deposits, especially if placed on a vertical surface, can lose viscosity (similar to motor oil) during preheat temperatures and slump out of the desired location. When a paste deposit slumps out of its desired location, the result will almost always be a rework and can often result in furnace maintenance issues. The paste can cause brazing and melting of the stainless steel belt. If deposits of the paste are allowed to collect in the bottom of the furnace muffle, the belt can become snagged and torn by the deposits.

Second, if the paste is applied manually, the quantity may not be consistently correct. If too little paste is positioned at the appropriate location on the joint, the braze will not take place resulting in reworking of the component. However, too much paste can also be a problem. The excess paste may result in "flashing." This is a condition in which the paste is not totally utilized in the formation of the braze joint and begins to wet the surface of the part. The result can be a rejected part in some applications.

Preforms are often placed on parts by hand. When individually handled, it takes longer to place a preform on a part than to make a paste deposit. But when included in automation, preforms can be vibratory fed and placed via automated pick-and-place machines or vacuum transfer units. Preforms can also be preplaced into joints during the assembly process and brazed at a later date or location. Prepasting a part is often more difficult as most oil-based formulas droop out of position while solvent-based formulas tend to dry and flake off the part.

The labor advantage of paste is somewhat offset by the additional requirement to transfer the paste from the shipping pails to the dispensing reservoirs. Paste also generates more cleanup duty as feed lines and work areas require frequent attention.

Filler Metal Cost

The true cost of a brazing operation is a complex issue that is determined more by the amount of first-time throughput and efficient use of belt space than by minimal cost differences between paste and preforms. Generally speaking, paste and wire forms tend to be priced about the same while stamped preforms tend to be more expensive. Preforms manufactured from wire are always less expensive than products manufactured from strip. This is due to the higher raw material cost associated with copper in strip form, the necessity for tooling, and the fact that stamped products generate scrap.

Preforms are part-specific pieces with each joint having its own engineered shape and volume. Paste products are often more generic and can often be used on joints of different configurations. The cost effectiveness of paste depends on whether the precise amount of material can be applied in the correct location. The paste method usually leaves the amount of material deposited up to the operator's discretion. Frequently, well-meaning operators apply substantially more material than a joint requires. The true material cost comparison is not the cost per gram of the various products but the actual cost per part. This must include control over the volume of alloy applied and which method produces the most rework and scrap. It is therefore necessary to understand how these products respond in a furnace brazing environment.

Paste and Preform Differences

While copper preforms are 100% solid metal, all pastes utilize binders and suspending agents. Interestingly, when a manufacturer states that a paste is 75% metal by weight, this is a weight ratio, not a statement about volume. The distinction is very important. The metal component has a much greater apparent density than do the binders and suspending agents. As a result, the actual volumetric ratio of copper to binder is usually much closer to 50–50. This explains why a large portion of a paste deposit seems to vanish. The nonmetallic binders are burned off and leave the furnace at the charge end in the form of an exhaust stream.

The binder does afford one benefit to the paste. It results in a filler material that melts at a lower temperature than a preform. This means that the temperature and/or time required to braze with the paste may be slightly reduced over that of a preform. This may result in a reduced operating cost and increased production rate.

Most of the problems associated with paste are related to the binder and suspending agents. If any separation of the paste or settling of the powder has occurred, it is necessary to stir the paste to restore homogeneity. Otherwise, the deposits will vary in the ratio of copper to binder creating inconsistent results. Paste binders often leave a carbon residue on the braze joint. This residue is usually cleaned or removed at the discharge end of the furnace adding to the responsibilities of the inspection personnel.

Paste binders are often composed of cellulose gels, glycerine, glycols, and other proprietary chemicals. It is important to inspect the MSDS to make sure that none of the chemicals used in the paste or the exhaust fumes resulting from the burn-off of the binder is toxic to plant personnel.

Control of the oxygen potential within the furnace atmosphere is also important. The furnace atmosphere must be sufficiently reducing for the reduction of the oxides at the joint to allow filler metal flow and alloying, while providing enough oxidizing potential to react with the carbon residue that is left by the paste. Technologies such as moisture additions to the injected furnace atmosphere, injection of water into the furnace, and direct air injection are a few approaches that have been and are currently being explored.

Summary

Paste is a versatile method of copper application. One formula may be suitable for use on multiple parts and assemblies. It can be rapidly dispensed and is often the specified product for maximizing production. Stability issues accompanying the use of paste include settling of the copper powder, temperature sensitivity, and limited shelf life. Performance-related problems need to be managed. These include slumping of the paste deposit from the desired location, operator-dependant variations in the volume applied to the joint, reduction in volume due to binder burnoff, and the creation of carbon residue on the part.

Preforms are preengineered pieces of copper designed to provide the exact volume for a specific part. The preform is a dedicated part for a particular braze joint. Preforms are solid metal and are most efficient when preloaded on or into the part. Although certain complex preforms can be more expensive, a properly designed preform will not slump out of the joint, will leave no residue, and provides for 100% usable volume to the braze joint.

Both preforms and paste have their places in today's industrial furnace brazing environment. Knowing the advantages and disadvantages of each (Fig. 3) are critical to the specification of the correct form of filler metal for each application.♦