

Solving the Problems Inherent to Torch Brazing Aluminum

Substituting aluminum for copper in thermal-transfer products challenges manufacturers to rethink their brazing techniques, filler metals, and fluxes

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The volatility in the price of copper has removed cost certainty for manufacturers of copper heat-transfer devices. This market instability and the escalating warranty claims associated with formicary corrosion have caused some manufacturers to consider making their thermal-transfer devices out of aluminum. While a change to aluminum offers significant material cost savings, brazing aluminum presents several serious concerns.

Unlike brazing copper-to-copper assemblies using phosphorus-containing filler metals, the brazing of aluminum components requires the use of a flux. This raises several questions: What are the basic requirements of the flux? What fluxes are available? And, how should the flux be applied?

Another major problem is the close thermal proximity between the melting temperatures of the brazing filler metal and base metals. Frequently there is less than a 100°F difference between the liquidus temperature of the braze alloy and the solidus temperature of the aluminum. The opportunity for successful brazing is further complicated when a thermal-transfer device has a dense population of components. This type of design tends to shield some of the braze joints from proper heat exposure — Fig. 1.

The manufacturer considering a change from copper to aluminum must resolve three important factors affecting the brazing operation:

1. Choose the right flux to use for the application.
2. Determine how to apply the flux to the part.
3. Decide how to manage the small



Fig. 1 — Air-conditioning coils are one example of a high-volume assembly currently manufactured out of aluminum.

thermal window between the melting temperature of the brazing filler metal and thermal damage to the base metals.

Selecting the Correct Flux

The first requirement of an aluminum brazing flux is to be chemically effective. Fluxes are categorized as active (corrosive) and inert (noncorrosive). Active fluxes — generally consisting of potassium chloride with numerous proprietary additives — create sound brazements. The appearance of the part after brazing is bright

and shiny. However, the postbrazing residues must be properly removed to prevent the occurrence of electrolytic corrosion. Simply rinsing the part in water is not sufficient. These fluxes require a significant exposure to hot water to remove the corrosive flux residue. Attention must be given to chemicals on the outside of the assembly and to any residues that have migrated to the inside of the part. Obviously, a simple water rinse cannot adequately remove flux chemicals that, due to migration, are shielded from contact with the rinse water. If not removed, these chemi-

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Fig. 2 — ChannelFlux products contain the noncorrosive flux in a groove formed in the wire.



Fig. 3 — The pictured return bend was delivered preloaded with a flux ring. This enabled the brazing facility to eliminate all labor in the application of flux and braze metal.

calcs can cause postbrazing corrosion.

Noncorrosive fluxes alleviate any concern regarding postbrazing activity. These fluxes include the higher-temperature potassium aluminum fluoride options and the lower activated cesium fluorides. Noncorrosive fluoride fluxes do not require any postbrazing cleaning or treatment; however, these fluxes do leave a white, gritty residue on the part. The residue is primarily a cosmetic issue, but it can make subsequent brazing in the region more difficult. If this residue can be tolerated, the use of a noncorrosive flux is highly recommended.

Fluxes must be thermally matched to the melting phase of the braze filler metal. One key to the success of NOCOLOK® flux is its thermal activation proximity to the 4xxx aluminum-silicon filler metals. Cesium fluoride options have been developed that provide the same noncorrosive performance at a substantially lower temperature.

Applying the Flux to the Part

A major component of a successful aluminum brazing project is the convenient application of flux and braze filler metal. While this is accomplished in controlled-atmosphere brazing (CAB) processes with a recirculating flux spray system and clad

base metals, this option is not practical for many flame brazing projects.

Listed below are the most common methods of presenting controlled amounts of flux to optimize torch brazing results.

1. Dispensable fluxes utilize standard flux chemicals with an added binder or suspending agent. The mixture remains homogenous and can be automatically applied to the part. Dispensable fluxes can be used in conjunction with wire feed or preforms as a two-step system of material deposition.

2. Paste is a blend of alloy filler metal in powder form, flux, and a neutral suspending agent. Paste enables the flux and the alloy to be dispensed in a single step using pneumatic or positive-displacement devices.

3. Flux/powder metal (PM) fabrication uses PM principles to form solid rings made from powdered metal and flux. Control of powder mesh size dispersion is critical to ensure lot-to-lot consistency.

4. Flux cored wire starts with a flat strip to which noncorrosive flux is applied. The strip is then rolled to create a wire with a flux core. Typically, these wires have flux voids that can reduce their effectiveness.

5. ChannelFlux® is a rectangular wire featuring a groove filled with a noncorrosive flux. This product offers precise placement of both brazing alloy and flux — Figs. 2, 3.

Enlarging the Thermal Processing Window with 78Zn 22Al

Addressing the narrow thermal processing window is perhaps the biggest concern when contemplating an aluminum brazing project. The problem, simply stated, is that the aluminum base metals melt at about the same temperature as the brazing filler metal. Table 1 provides the melting ranges of several of the more common materials used in brazing applications.

Note that the solidus temperature, the

Table 1 — Melting Range of Al Base Metals (°F)

Grade	Solidus	Liquidus
1100	1190	1215
3003	1190	1210
6061	1100	1205
6063	1140	1205

Table 2 — Melting Range of Al Filler Metals

Grade	Solidus	Liquidus
4047	1070	1080
78 Zn-Al	826	905

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last temperature at which the alloy is completely solid, marks the point where damage begins to occur in the base metals. The lowest melting option of the standard BAISi brazing alloys (4047) is 1070°–1080°F.

Table 2 shows a comparison between the melting temperature of the brazing alloy and the point at which the base metal is damaged illustrates the challenge. There is no margin for error.

The availability of cesium fluoride fluxes and their very-low melting range of 788°–842°F have ignited renewed interest in Zn-Al brazing alloys. The 78Zn 22Al is specifically designed for use on thermal-transfer devices. The low melting phase of this alloy (826°–905°F) is perfectly matched to the thermal activity of the Cs fluxes. The lower melting temperature (as compared to 4047) provides a substantial thermal window for most brazing applications. This is especially true for 6xxx series aluminum.

Postbrazing residues must be properly removed to prevent the occurrence of electrolytic corrosion

Tensile strength and burst tests with the 78Zn 22Al consistently show the braze joints demonstrate greater durability than the base metals. Saltwater spray testing to ASTM B117 for 2000 h showed no signs of visible corrosion and no deterioration of mass. While we might expect certain applications where the high-zinc filler metal might be sacrificially offered, independent tests indicate that this process is quickly

arrested by the almost immediate formation of aluminum oxide.

Conclusion

This article presents a number of options to enable a manufacturer to conveniently apply aluminum brazing materials. The method selected should utilize a flux that meets the cleanliness and corrosion-resistance requirements of the part and be thermally matched to the filler metals.

The acceptance of cesium-based fluxes has created a developing opportunity to investigate Zn/Al alloys as a low-temperature alternative to the popular aluminum-silicon products.

The use of a flux-containing single-step material application with a low-melting filler metal enables the manufacturer to properly address the most significant challenges found in the torch brazing of aluminum thermal-transfer devices. ♦