Aluminum brazing handbook

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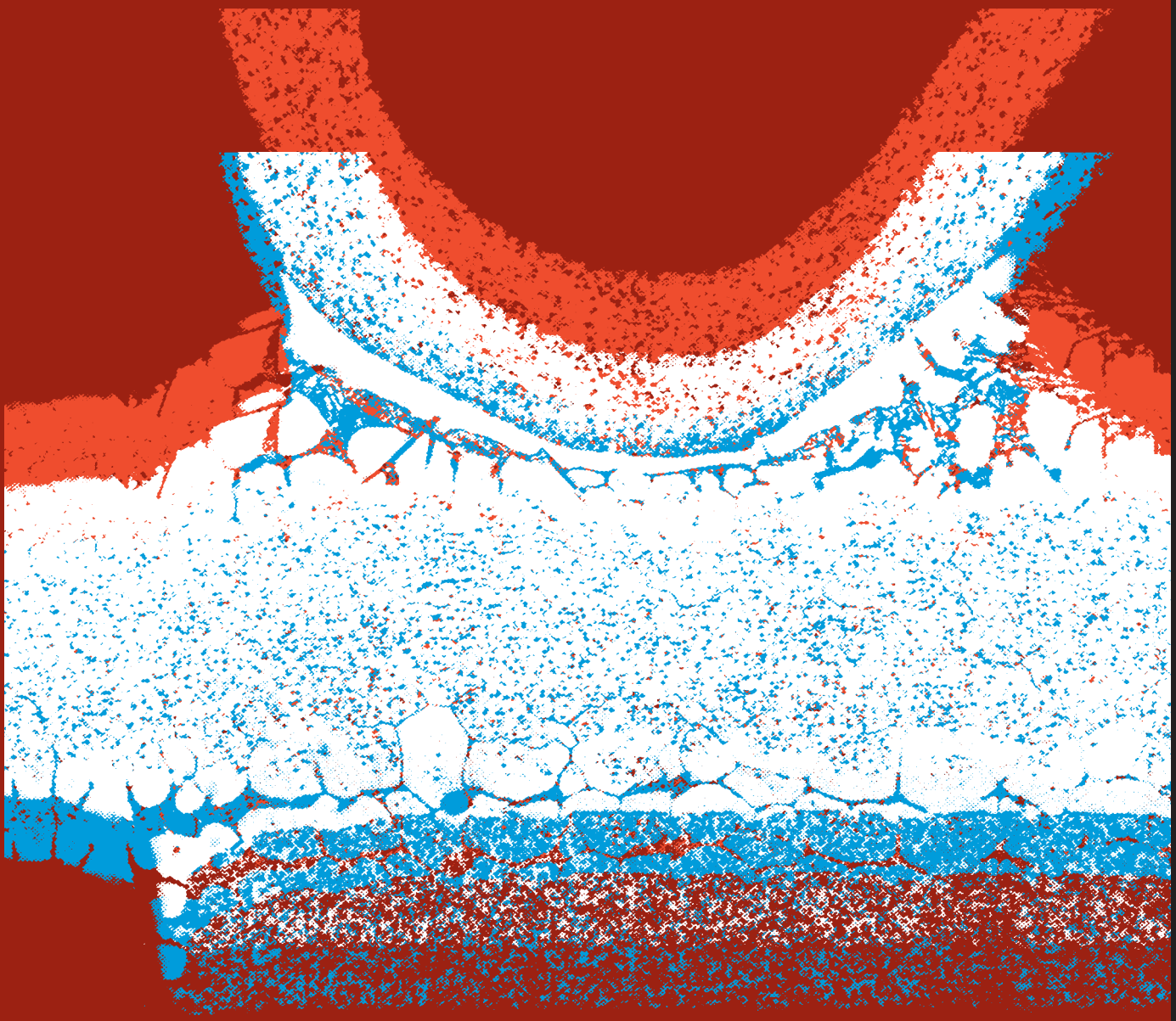

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The member companies of The Aluminum Association, Inc., represent approximately 85 percent of the domestic production of primary ingot and shipments of U.S. aluminum mill products. Mill products include sheet and plate; foil; extrusions; electrical conductor and wire, rod and bar. In addition to producers of primary ingot and mill products, the association's membership also includes secondary smelters, foundries and producers of master alloy and additives.

The association is a primary source of statistics, standards, and economic and technical information on aluminum and the aluminum industry in the United States.

ALUMINUM BRAZING HANDBOOK

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The Aluminum Association
Technical Advisory Panel on Welding and Joining

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Errata for Table 3.1 on p. 83.

Foreword

Each year millions of aluminum parts are joined by brazing. They may be found in automobiles, trucks, airplanes, submarines, spaceships, liquefaction plants, missiles, TV sets and other artifacts of our civilization ad infinitum.

Aluminum assemblies ranging in thickness from thin sheet to heavy plate and castings are routinely brazed in thousands of shops around the world. When desired, tolerances are held to better than ± 0.002 inch (.05 mm); distortion is kept close to zero. Temper in heat treatable alloys can be restored by post-brazing thermal treatment.

Brazed joints are strong, vacuum tight and neat. The fillets formed by brazing have good fatigue resistance. Properly dip-brazed aluminum units can withstand vibration and shock to 125 G.

Brazing is no longer an art. It is now an established science, and therefore warrants serious consideration by all those who have need to join aluminum to itself and to other metals.

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Chapter One

Introduction to Aluminum Brazing

Brazing's Advantages

Strong, uniform, leak-proof joints can be made rapidly, inexpensively and even simultaneously by modern brazing techniques. Joints that are inaccessible and parts, which may not be joinable at all by other methods, often can be joined by brazing.

Complicated assemblies with thick and thin sections, odd shapes and differing wrought and cast aluminum alloys can be turned into one integral, all-aluminum component by a single pass through a brazing furnace or a dip pot. Metal as thin as 0.006 inch (.15 mm) and as thick as 6 inches (15.2 cm) can be brazed.

Brazed joint strength is very high. The nature of the inter-atomic bond (metallic) is such that even a simple joint, when properly designed and made, will have equal or greater strength than that of the as-brazed base metal.

Heat-treatable aluminum alloys can be solution heat treated by quenching immediately after brazing, and thus can be strengthened by aging alone.

Brazed aluminum assemblies are all aluminum with excellent corrosion resistance when properly cleaned of any residual chloride flux. Brazed aluminum joints generally resist corrosion as well as welded aluminum joints.

Brazed aluminum assemblies conduct heat and electricity uniformly. Brazed aluminum heat exchangers, evaporators and similar complex fabrications are therefore long lasting and highly efficient.

The meniscus surface formed by the fillet metal as it curves across corners and adjoining sections is ideally shaped to resist fatigue.

Complex shapes with greatly varied sections are brazed with little distortion. Aluminum's excellent thermal conductivity assists in providing even distribution of the relatively moderate temperature required for brazing.

Precise joining is comparatively simple with brazing. Unlike welding, in which the application of intense heat to small areas acts to move the parts out of alignment, parts joined by furnace and salt pot techniques are heated fairly evenly. Part alignment is easier with brazing. Brazed joints with tolerances of ± 0.002 inch (0.05 mm) are commonplace in microwave component production.

Properly brazed joints are leak tight. A vessel, sealed by brazing and evacuated to 2×10^{-5} torr (2.7 mPa), was observed for 100 hours. After that time, leakage increased internal pressure to only 1.6×10^{-4} torr (21.3 mPa), which is excellent for any metal joint.

Finishing costs are negligible. The capillary action that draws the filler metal into the joint also forms smooth concave surfaces. Little mechanical finishing, if any, is required. When using a flux brazing method, removal of residual chloride flux is required. The color match between parent metal and filler is generally good.

Personnel training is minimal. Production brazing equipment has been refined to where semi-skilled and non-skilled people suffice for most operations. Mechanically adept personnel can be trained in a few hours to torch braze.

Basic Phenomenon

Bring two pieces of metal within 4 Angstrom units (Å = 10^{-10} meter) of each other and inter-atomic attraction will bind them together in permanent metallic bond. This is the basis of brazing and soldering and is accomplished by "wetting" the metals to be joined with molten metal, which on cooling forms the joint.

If the temperature of the wetting metal is above 800°F (426°C), the process, by accepted American Welding Society definition, is called brazing and the molten metal is called brazing filler metal. If the temperature is below 800°F (426°C), the process is called soldering and the molten metal is called solder. Welding differs in that the base metals to be joined are molten at the moment of joining.