HOT SEAT

Jack Titus
Director of Process and Developmental Engineering
AFC-Holcroft

Copper brazing, in theory, is not a difficult process. However, proper braze joint fit-up, mesh belt furnaces using disassociated ammonia, and vacuum furnaces have their own important considerations.

BRAZING IS A GENRE OF HEAT TREATING that doesn't receive a lot of attention unless it's related to aerospace or commercial aviation. However, a myriad of items like chain saw clutch housings, lawn mower parts, stainless steel heat exchanger, and dozens of commercial components contain assemblies that have copper-brazed components.

Brazing is the process of joining two or more parts or subassemblies by melting a metal or alloy at the fabricated seams to act like glue, permanently connecting the items to form a complete assembly. The copper for this discussion can be a paste, solid pellet, or washer-shaped element positioned between parts. When the copper melts, it can flow and completely fill the space between parts, forming a solid and sealed bond.

In principle, the process sounds simple. However, great care must be taken to assure that the gap between the joining parts is sufficiently large to hold enough copper, but not so large that copper flows out of the joint. Copper melts at approximately 1,998°F (1,092°C). Therefore, the complete assembly must be heated to about 2,050°F (1,121°C) in a furnace or induction machine.

In batch furnace brazing, the typical procedure will heat the charge to 1,950°F (1,065°C), allow a soak for uniformity, and then heat rapidly to 2,050°F (1,121°C) and soak for approximately three to five minutes; then cool. Holding too long at brazing temperature will allow the molten copper to flow out of the joint, resulting in a weak assembly. Conversely, a short soak will not allow the copper via capillary action to flow completely into joint volume.

Mild- or low-carbon steel and austenitic stainless steels are the most common materials brazed. Since the components are heated to such a high temperature, rarely are the parts quenched after brazing, so there's no need for alloy steel. Having said that, there are instances where the assembly for faster processing is quenched. In that case, the temperature is lowered after brazing to solidify the braze metal and to reach the austenitic soak temperature, which is held for equalization and then quenched in gas or oil.

Two types of protective atmospheres have been used for copper brazing: DA (dissociated ammonia, which is 75 percent hydrogen and 25 percent nitrogen) in atmosphere furnaces and vacuum-purged partial pressure batch systems.

Historically, continuous mesh belts and hump-back furnaces have been popular for copper brazing employing a DA atmosphere. Where production requirements dictate, batch vacuum furnaces have satisfied much of the demand because DA is an extremely explosive gas. Also, the service life of the mesh belt operating at 2,050°F (1,121°C) is not long — months not years. Another issue facing the mesh belt and batch system is part vibration during loading a motion through the furnace. Depending on the component design, some parts may not retain the proper spacing traveling through the furnace. In these cases, the assemblies, such as stainless steel oil heat exchangers, must be bolted together, necessitating an anti-size compound on the bolted fixture to keep the threads from seizing. Attention must be paid to the composition of the thread lube so any outgassing or vaporizing does not contaminate the atmosphere. A case in point involved applying milk of magnesia to bolt and nut fasteners. Even though time was allowed for the milk of magnesia to dry, the hygroscopic nature allowed the milk of magnesia to re-absorb water on humid days, releasing water into the atmosphere. In the past, changing to alumina (aluminum oxide) solved the issue.

Hump-back mesh belt furnaces have been popular for copper brazing because the hot zone is located in the elevated hump. The belt traverses an incline up to the horizontal hot zone and then descends back down to the cooling section for discharge. The hump provides an ideal isolation for the DA atmosphere by trapping the gas in the hump, thereby increasing the pressure as the gas is forced to exit at the lower ends.

Taking over the majority of copper brazing today, single chamber vacuum furnaces eliminate the explosive hazard of the DA. A typical cycle will include evacuating the vessel to below 50 microns (0.066 millibar) in graphite-lined furnaces and less than 10 microns (0.0133 millibar) in non-graphite-lined furnaces when processing ferrous or mild steel assemblies. When copper brazing stainless steel, a hydrogen partial pressure will be required to de-pacify the chromium oxide and allow the molten copper to "wet" the stainless steel.

When brazing mild steel or stainless steel, the process is the same except for the partial pressure gas. The furnace is evacuated, as mentioned above, and then heated to 1,950°F (1,065°C). At approximately 1,500°F (815°C), the partial pressure is enabled to 500 to 700 microns (0.66 to 0.93 millibar) while heating to 1,950°F (1,065°C) and soaking for uniformity. Rapidly heat to 2,050°F (1,121°C), braze, and cool completes the process. Maintaining a partial pressure is a critical part of the process for two reasons. It's important for de-pacifying stainless steel with hydrogen and with nitrogen for mild steel and to keep from vaporizing the molten copper — another misfortune experienced by an inexperienced staff of a trucking company that's brazing engine valves when they brazed the hot zone door closed. With no partial pressure and the very low vacuum level achieved by the oil diffusion pump that clearly is not required for copper brazing, the molten copper can vaporize and condense on the first cool surfaces it encounters.

ABOUT THE AUTHOR: Jack Titus can be reached at (248) 668-4040 or jtitus@afc-holcroft.com. More information can be found online at www.afc-holcroft.com or www.ald-holcroft.com.