EXECUTIVE Report

The International Copper Association, Ltd. (ICA)

is the leading organization for the promotion of the use of copper worldwide. The Association's twenty-nine members represent about 80 percent of the world's refined copper output, and its six associate members are among the world's largest copper and copper alloy fabricators. ICA is responsible for guiding policy, strategy and funding of international initiatives and promotional activities. With headquarters in New York City, ICA operates in 28 worldwide locations through a network of regional offices and copper development associations.

For additional information about the *Cu*proBraze process or ICA's *Cu*proBraze consulting services, please contact the International Copper Association at Alea@copper.org.

Where an aluminum-brazing furnace is no longer needed for production of aluminum heat exchangers, it may be possible to adapt the furnace for the *Cu*proBraze process, provided that the furnace is fitted with a cooling zone.

However, cross-contamination between copper and aluminum may preclude frequent switching back and forth between copper and aluminum processes. Careful cleaning of the furnace is required before switching to another material. This is a problem for aluminum heat exchangers, not for copper heat exchangers, due to mutual nobilities. Switching may be impractical except if done permanently or possibly for seasonal products (because cleaning is difficult and takes time and resources).

*Cu*proBraze trials have been run over the weekend on an aluminum-production furnace. Typically, the product is put on trays that would contain any filler metal or fines that would fall from the brazed core. This prevents furnace contamination from becoming a problem. Short term testing on a few heat exchangers does not contaminate the furnace enough to create a problem.

"The *Cu*proBraze process is flexible and can be adapted to a wide variety of production requirements. The furnaces needed for the job are widely available on a global scale. The furnace is the heart of the process. Radiator manufacturers have a wide range of options in terms of flexibilty and scalabilty," said Anthony Lea, Vice President, International Copper Association.

Some key furnace vendors are listed below. Additional supplier lists are available through ICA. Look for roundups of other key equipment and materials vendors for the *Cu*proBraze brazing process in future Executive Reports. ■

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Factors to consider when selecting a suitable furnace are production volume, part size, available floor space, capital expense and operating cost.

Picking the Right Brazing Furnace

When making plans for the purchase of a furnace as part of a *Cu*proBraze production line, here are a few things to keep in mind. Several furnace makers have already equipped radiator manufacturers with brazing furnaces specifically installed for the *Cu*proBraze process.

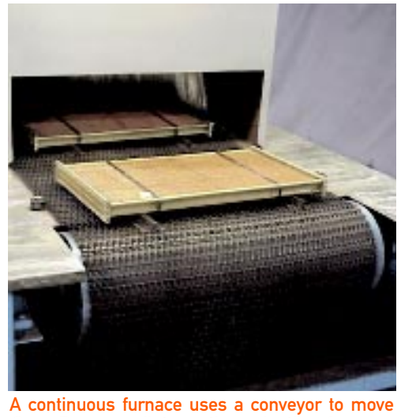
The process is straightforward and allows for considerable latitude in purchasing a furnace. As a result, suitable furnaces are widely available. They can be custom-built or adapted from standard models from numerous vendors worldwide. A partial list of potential furnace suppliers is provided on the back page. Other smaller, local companies not listed may be able to build small-production furnaces as well.

"We have experience with all sizes of production lines, from large plants that will be producing millions of units per year, to small furnaces attractively priced for small production, prototyping, and niche production of specialized heat exchangers," said Jeff Boswell, Vice President of Seco/Warwick in Meadville, Pennsylvania, USA.

Seco/Warwick developed a two-chamber batch type furnace used for its R&D center prototype *Cu*proBraze product. This batch furnace was sold to Astro Air, Inc. who is currently running production brazing.

Seco/Warwick has also supplied a three-chamber semi-continuous furnace to Berry Radiateurs in France. In addition, a continuous *Cu*proBraze furnace is scheduled for shipment to JSC Shaaz, Shadrinsk, Russia in 2002.

Costs can vary from approximately $50–250 thousand (US dollars) for a basic two chamber or vacuum purge batch furnace; to $150–350 thousand dollars for larger semi-continuous furnaces; and to $400–800 thousand for an automated continuous furnace for volume production. By comparison, an aluminum-brazing furnace typically costs up to twice as much, due to longer heating times, the need to contain and eliminate hydrogen fluoride gas generated by the process, and other needs for peripheral equipment.



A continuous furnace uses a conveyor to move *Cu*proBraze radiators through the furnace. (Furnace built by Abbott Furnace Company.)

Many manufacturers prefer a semi-continuous, three-chamber furnace for intermediate volume production. (Furnace built by SECO/ WARWICK.)

Selecting a Furnace

Factors to consider when selecting a suitable furnace are production volume, part size, available floor space, capital expense, and operating cost. Based on the specifications outlined above, the *Cu*proBraze radiators can be processed in batch, semi-continuous or continuous furnaces.

A batch furnace uses the same door to load and unload the part. These furnaces can only produce one batch at a time. A load is purged with nitrogen then moved into the brazing chamber, which is already at temperature and with the correct atmospheric conditions. After brazing, the load is moved back into the purge chamber where it is cooled. It is necessary for the heating chamber to have the proper atmosphere before the load enters. If the atmosphere has high oxygen concentrations, the product will oxidize and brazing will not occur. This is why a purge chamber or a vacuum purge is required in a batch application.

A semi-continuous furnace uses separate entry and exit doors. Parts are indexed from the loading area to the purge chamber, where the part is purged with nitrogen and then moved into the next chamber. The furnace simultaneously moves the purged part into the brazing chamber and a new part into the purge chamber. In a semi-continuous furnace, it is possible to have a part or batch of parts in each zone. This type of furnace is suitable for large parts or intermediate volume production.

A continuous furnace uses a conveyor to continuously move parts through the furnace where they are continuously purged with nitrogen, brazed and then cooled. This type of furnace is for high volume production.

All these furnaces have heating and cooling sections. Batch furnaces and semi-continuous furnaces are suitable for any part size but limited with respect to production volume. Continuous furnaces are suitable for volume production.

Fuels and Effluents

It is possible to heat all three types of furnaces with electricity, natural gas, or propane/butane. In many countries, natural gas and propane are a cheaper source of energy than electricity, but they require more maintenance and have a higher initial cost. Gas burners also require a gas-tight barrier between the combustion products and the brazing atmosphere. Such a barrier can be radiant tubes or a muffle.

Effluent is generated when the binder is volatized during the first part of the heating cycle. This effluent must be properly managed to prevent contamination of the atmosphere in the furnace. The constant flow of nitrogen normally expels the effluent from the brazing atmosphere. When these fumes exit the furnace the gases must either be burned or diluted with ambient atmosphere, according to the local specification. The law changes from country to country and state to state, so one must check with the local authorities before designing a means of effluent treatment.

Normally no cleaning is needed after the brazing operation.

Brazing Operations

Selecting a suitable furnace requires knowledge of the temperature, time and atmospheric conditions of the process. Because the temperature of brazing is much higher than that of soldering, an inert atmosphere is needed to prevent oxidation of the parent and filler materials.

Recommendations for the furnace conditions

The *Cu*proBraze brazing center in Västerås, Sweden employs a batch furnace in the production of prototype heat exchangers. (Furnace built by Sarlin.)

are as follows. The primary function of the brazing atmosphere is to prevent oxidation. Furnaces today use high purity nitrogen to displace oxygen from inside the furnace. The atmosphere of the furnace must have a dew point of less than – 40 °C and oxygen content of less than 20 ppm. If moisture and oxygen levels are higher than these levels, the powder and the base material will be oxidized at temperatures exceeding about 200 °C and brazing will not be complete.

The furnace must be able to heat the load between 550 °C and 650 °C with a ramp rate greater than 30 °C per minute. The furnace should be able to cool the load at a maximum rate of 150 °C per minute to 250 °C.

Typical Brazing Cycle

The time above 600 °C should be limited to a maximum of 3 to 4 minutes. The heat exchanger will lose thermal performance if the temperature is too high or held too long above 600 °C. On the other hand, the part will not braze if the temperature is too low or the time above 600 °C is too short.

The governing factor for the brazing cycle is the brazing of the tube-to-header joints. The effect of the brazing cycle on the tube-to-header joints cannot be seen by the naked eye. During optimization of the brazing cycle, overshooting of the brazing temperature can sometimes happen yet not cause a noticeable visual effect on the brazed heat exchanger.

Conclusion

The brazing furnace is the single largest equipment investment for a *Cu*proBraze process line. It is the most essential part of a *Cu*proBraze manufacturing line. Various other assembly and production steps can be performed with a balance of equipment and human labor according to the economies of manufacturing. However, there is no substitute for a brazing furnace.

A double layer of radiators is being brazed in a *Cu*proBraze furnace.

The furnace is the heart of the *Cu*proBraze process.