*Cu*proBraze® Executive Report

Number 19

Research Confirms Advantages of *Cu*proBraze Technology

Several new technical papers about the underlying materials science governing the properties and use of *Cu*proBraze alloys have been published this past year.

This latest research corroborates, clarifies and amplifies more than a decade of intense research, which began in the early nineties and led to the introduction of a new class of copper and brass materials for heat exchanger applications.

The State of the Technology

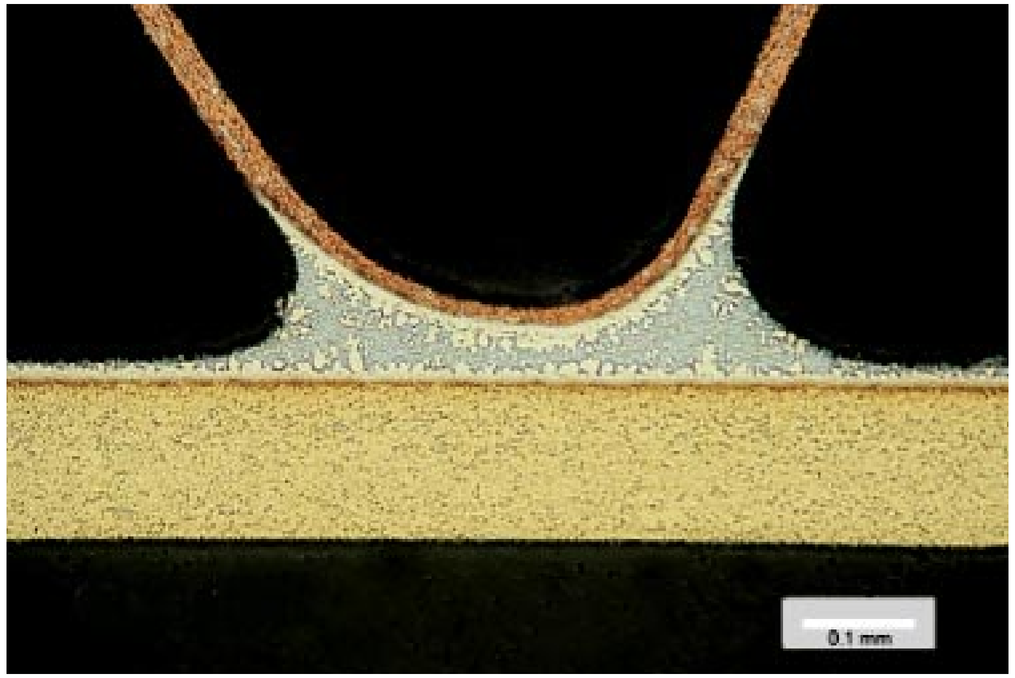
A concise "state of the technology" address was presented by Johan Scheel and Bengt Gustafsson at the Truck and Bus Meeting and Exposition in December 2000 and is now available in the SAE Technical Paper Series (2000-01-3456).

This vital reference lists all of the important physical properties of copper and aluminum side-by-side, making a compelling case in favor of the use *Cu*proBraze alloys in mobile heat exchanger technology.

Briefly, the greater strength and thermal conductivity of copper and brass compensate for their higher density compared to aluminum. Other properties such as thermal expansion, specific heat, melting point, energy consumption, corrosion resistance and reparability favor the copper alloys for radiators and heat exchangers.

When manufacturing processes are

This latest research corroborates, clarifies and amplifies more than a decade of intense CuproBraze development.



The microstructure of the joint between the anneal-resistant copper fin and the anneal-resistant brass tube shows that alloying does not influence the heat performance of the heat exchanger.

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.

Corrosion Resistance

Electrochemical processes can be extremely complicated and hence the external and internal corrosion resistance of *Cu*proBraze radiators has been the subject of much research in recent years. The most recent research is described in a paper co-authored by Olof Forsén, who is a Professor at the Laboratory of Corrosion and Materials Chemistry, Helsinki University of Technology.

Brazed aluminum radiators were included in this study of four different types of accelerated corrosion tests. The conclusion is that the corrosion resistance of *Cu*proBraze radiators is clearly better than that of soldered copper/brass radiators and very competitive with that of brazed aluminum radiators. Details can be found in SAE Paper Number 2001-01-1718.

Conclusion

These SAE papers can serve as a good entrance point for accessing the broader body of literature on their respective topics.

Taken together they provide an excellent foundation for a comprehensive understanding *Cu*proBraze materials and manufacturing processes.

Reprints can be ordered (and PDF-files can be downloaded) by visiting the SAE Web site (www.sae.org) or by calling SAE customer service at 1-877-606-7323 (North America) or 1-724-776-4970 (International) from 8 a.m. to 5 p.m. Eastern Time. ■

Recently Published SAE Papers on *Cu*proBraze Research

SAE Paper Number	Title
2001-01-1726	Interactions between the materials in the tube-fin-joints in brazed copper-brass heat exchangers
2001-01-1718	External Corrosion Resistance of *Cu*proBraze® Radiators
2001-01-1754	Electrochemical Tests with Copper / Brass Radiator Tube Materials in Coolants.
01HX-18	OCP – Materials
01HX-19	*Cu*proBraze Manufacturing – Plant Design – Lock Seam Tubes
2000-01-3456	*Cu*proBraze Mobile Heat Exchanger Technology

COPPER
International Copper Association, Ltd.

International Copper Association, Ltd.
260 Madison Avenue, 16th Floor, New York, NY 10016-2401
Tel: 212.251.7240, Fax: 212.251.7245

The new brazing facility in Västerås, Sweden is a center for *Cu*proBraze research and development activities.

The high copper content of the tubes contributes to improved resistance against stress corrosion cracking and dezincification.

considered, CuproBraze technology emerges as a winner.

Materials Science

For those interested in a deeper explanation of the metallurgy of CuproBraze alloys, a new SAE paper by Falkenö and Ainali serves as a good introduction (SAE Paper Number 01HX-18).

This paper describes anneal-resistant copper alloys for fins, anneal-resistant brass alloys for tubes and brazing materials for joining fins and tubes.

It describes why chromium is used as an alloying element in copper fins. In summary, coherent precipitates induced during rolling deformation serve as nuclei for the growth of larger precipitates during subsequent annealing. These precipitates, which are about three nanometers in size, effectively prevent softening at temperatures as high as 650 °C. In comparison, conventional copper alloys for radiators can only withstand soldering processes of 450 °C (842 °F).

Electrical conductivity is restored to 92 percent of the unalloyed value when precipitates form in the fin alloy. Since heat conductivity closely tracks electrical conductivity, this copper alloy is well suited for use in the fins of heat exchangers. The combination of strength and thermal conductivity allows the construction of lightweight radiators for use in automobiles as well as trucks.

Similarly the new brass alloy developed for tubes also resists softening at elevated temperatures. The tubing alloy consists of 85% copper and 15% zinc plus about 1 percent iron, which forms particles about 200 nanometers in size. The latter particles prevent re-crystallization of grains even at elevated temperature. The high copper content contributes to improved resistance against stress corrosion cracking and dezincification. The new SAE paper presents charts that compare the strength of this anneal resistant brass alloy with conventional alloys.

Finally, this paper describes copper-nickel-tin-phosphorus brazing materials, which melt at 600 °C. This filler material is typically converted to a powder, which is mixed with a binder to form a brazing paste. The special attributes of this brazing powder are its relatively low melting point, its compatibility with fin and tube materials and its compatibility with existing manufacturing processes.

Together these three alloys enable the CuproBraze processes for the manufacture of heat exchangers. A companion paper (01HX-19) by the same authors (Falkenö and Ainali) describes the differences in manufacturing processes between conventional soft-soldering process and CuproBraze.

Data is also given comparing the corrosion potentials of the fin, tube and joint materials. These three different materials exhibit nearly identical corrosion potentials; the absence of galvanic differences explains the exceptional resistance of CuproBraze heat exchangers against bimetallic corrosion.

Interaction between Materials

Those interested in probing even deeper into the microstructure of CuproBraze materials will be delighted by the recent research results on the interactions between the materials in the tubes, fins and joints.

Extensive testing was performed on fin-tube joints prepared in a laboratory furnace. The purpose of this testing was to measure the degree of interaction of the joining material with the alloys of the fin and tubes.

The times above 600 °C (melting temperature of the brazing materials) and the maximum temperature were varied over a wide range of values, and then the amount of alloying with the fin and tube was measured by examining the microstructure of the joints.

The paper even gives a section of the ternary Cu-Sn-P phase diagram with 15 percent tin, as part of the discussion of the interactions between the fin and joint materials.

The conclusion of the paper is that some alloying does occur but that the process can be controlled and optimally adjusted so this alloying does not influence the heat performance of the heat exchanger.

Details can be found in SAE Paper Number 2001-01-1726.

Professor Olof Forsén of Helsinki University of Technology recently published research showing that the corrosion resistance of *Cu*proBraze radiators is very competitive with that of brazed aluminum radiators.