MicroGroove Faces Off Against Aluminum in OEM Product Development

Copper Proves Its Superiority as a Heat Exchanger Material

New York, New York (15 January 2018) – According to the International Copper Association, Inc. (ICA), MicroGroove consistently has been proven to be better than MicroChannel in many respects.

For many decades aluminum wanted to position itself as a possible substitute for copper in heat exchangers for air-conditioning applications. In the 1970s, round-tube, plate-fin (RTPF) coils made from aluminum tubes and aluminum fins rapidly corroded and deteriorated and equipment failures were widespread. All-aluminum RTPF coils did not last long in real world environments and OEMs quickly reverted back to copper.

It would be several decades later before aluminum advocates would try again. Aluminum resurfaced in the form of extruded "multichannel" or "MicroChannel" tubes. OEMs began to experiment with aluminum multichannel coils, which were marketed as an alternative to copper. The suggested advantages of the smaller channels, i.e., high thermal heat transfer coefficients and reduced refrigerant volume, were heavily advertised.

Strange Comparisons

Strangely, comparisons were consistently made between aluminum multichannel and *conventional* large copper tubes, thus skewing performance comparisons between copper and aluminum. Yet the march toward smaller diameter MicroGroove copper tubes was already underway. And the comparisons were not what they seemed.

The disadvantages of multichannel aluminum were studiously underplayed by its supporters. These disadvantages include maldistribution of refrigerants, large header volumes, difficulty with defrosting and poor drainage. Cleaning of serpentine-style fins squeezed between the ribbon-like multichannel tubes is difficult and fouling and clogging is problematic. Fouling leads also to more corrosion.

The True Story

In recent years, MicroGroove has dominated the global residential window air-conditioner marketplace. The optimization of heat exchangers made with MicroGroove tubes has been underway for more than a decade now, especially in China. Today, tens of millions of window-type residential air-conditioners are made every year with MicroGroove smaller diameter tubes and central AC (ducted) air-conditioning systems are also commonly made with MicroGroove RTPF coils.

MicroGroove In, MicroChannel Out

ICA recently supported a design study for an OEM, to examine the effects of replacing MicroChannel with MicroGroove in OEM heat-pump systems, including a 2-ton residential and a 10-ton commercial system.

The objective was to maximize capacity and to minimize airside pressure drop for drop-in replacements. Geometric constraints were placed on coil height, width, and depth; other design criteria included fin density, refrigerant pressure drop and refrigerant charge.

Initially, currently available wavy- and louvered-fin patterns for 5-mm tubes were used. For commercial replacement condensers, the airside pressure drop increased 15 to 38 percent for wavy fins and 29 to 42 percent for louvered fins, while maintaining less than a four percent decrease in heating capacity compared to the baseline multichannel aluminum commercial condenser.

The air pressure drop for the residential replacement condensers increased 23 percent for the wavy fins and 16 percent for louvered fins, while maintaining a negligible (less than 0.2 percent) decrease in heating capacity as compared to the baseline multichannel aluminum residential condenser.

The material mass of the commercial heat exchangers was reduced by approximately 26 percent for the louvered fin designs and as much as 35 percent for the wavy fin designs. The baseline residential design used much less material than the baseline commercial design because it had about half the depth and half the face area as well as lower fin density. On the other hand, in the case of the RTPF replacement designs, the residential and commercial designs both used two-row coils with fixed horizontal spacing so the materials savings for the residential design was not as pronounced as for the commercial design.

System level performance was evaluated using vapor-compression-cycle design and simulation software. The condensers were used to evaluate overall COP changes that would occur from replacing the MicroChannel coils with MicroGroove coils. The louvered fin design decreased the COP by one percent while wavy fin designs decreased the COP by 4 percent.

New Fin Patterns

To improve airside pressure drop, an optimization study for tube-fin condensers with 5-mm copper tubes was conducted to explore new fin patterns. The design space consisted of variable ranges consistent with current manufacturing capabilities. This optimization found 5-mm tube-fin designs that were competitive with the baseline aluminum multichannel condenser.

The additional degrees of freedom allowed the optimizer to find designs with similar airside pressure drop and capacities to that of the baseline. The best design within this optimization study demonstrated a reduction of approximately 28 percent in material mass while maintaining the same airside pressure drop and capacity as the baseline.

The 5-mm commercial designs had capacity increases of up to 3 percent and airside pressure drop decreases of up to 19 percent while maintaining other performance metrics within the OEM's specified constraints. The 5-mm residential designs had negligible capacity increases (0.2 percent) and airside pressure drop decreases of up to 20 percent while maintaining the OEM's constraints.

Conclusion

The copper industry continues to march forward with advances in MicroGroove technology. Copper lends itself well to smaller diameters because of its strength, ductility and corrosion resistance. Copper performs better as the tube diameters are reduced. Copper delivers on the promise of increased heat transfer efficiency of the coils and reduced refrigerant volume.

Moreover, the equipment for tube handling and tube expansion is readily available.
Although multichannel aluminum supporters predicted rapid market penetration, MicroGroove proved itself highly competitive in key applications. Ironically, one of the most successful applications has been in the low-cost, high-volume residential air conditioners.

More recently some attempts have also been made to revive round aluminum tubes, but these are difficult to process at smaller diameters; and they are again subject to corrosion despite the use of specialized coatings that add cost to the tubes and coils.

OEMs expect to see comparisons of aluminum-tube MicroChannel heat exchangers technology with copper MicroGroove technology. The choice is no longer between MicroChannel and conventional copper. In application after application, MicroGroove copper is asserting its value.

"We can expect that copper will remain the dominant material for air conditioning and refrigeration systems," said Nigel Cotton, MicroGroove Team Leader for the International Copper Association. "Whether simulated on computers or built into actual products, MicroGroove tubes and coils are becoming established in refrigeration, air-conditioning and heat pump applications."

The website www.microgroove.net includes additional data relating to heat exchanger design and manufacturing technology. It also includes links to the MicroGroove series of webinars. A technical literature section provides links to technical papers relating to laboratory experiments, tube circuitry optimization, fin design and manufacturing equipment.

About ICA

ICA brings together the global copper industry to develop and defend markets for copper and to make a positive contribution to society's sustainable-development goals. Headquartered in New York, the organization has offices in four primary regions: Asia, Europe and Africa, Latin America and North America. Copper Alliance® programs and initiatives are executed in nearly 60 countries through its regional offices. For additional information please visit copperalliance.org.

# # #