**New Research on MicroGroove Copper Tubes Points to Performance Advantages**

*Experimenters Identify at Least Three Mechanisms for Efficient Refrigerant-Side Heat Transfer*

**New York, New York (15 September 2018)** – Smaller diameter copper tubes are being applied in a wide variety of refrigeration and air-conditioning applications, providing impetus for in-depth research on their performance characteristics, according to the International Copper Association (ICA). A good indicator of the increased interest in MicroGroove technology is the many high quality research papers presented at the 2018 Herrick Conferences.

“There has been an increase in research papers on smaller diameter copper tubes commensurate with their use in household appliances and commercial equipment,” says Nigel Cotton, MicroGroove Team Leader for ICA.

The Herrick Conferences at Purdue University are comprised of three concurrent international conferences, including the Seventeenth International Refrigeration and Air-Conditioning Conference. Papers are now openly available by searching for the paper number or key words in the Conference Tool.

<https://www.conftool.com/Purdue2018/sessions.php>.

**Tube Side Experiments**

There is no substitute for experimentally measuring heat-transfer coefficients and pressure drops for various tube sizes, refrigerant mixes and microfin geometries. Data from these experiments can then be used in simulation software to predict the performance of heat exchangers with high accuracy. Conventional models often do not apply to smaller diameter tubes; hence there is a need for new experiments.

In the academic literature, the inner grooves of copper tubes are commonly referred to as “microfins.” Four papers on smaller-diameter copper tubes were presented in Session R-39 on “Heat Transfer in Microfin Tubes and Microchannels.” The experiments from Tokyo University of Marine Science and Technology (TUMSAT) were especially intriguing because they showed the combined effects of flow rates and microfin geometry on heat transfer coefficients and pressure drops (Papers 2542 & 2511). As the refrigerant evaporates along the length of a tube, distinct flow types could be identified. Paper 2511 helps to understand how the optimal tube enhancements may be different for different flow rates and flow types.

Paper 2469 from Padova University reported on R1233zd(E) and R245fa flow boiling heat transfer and pressure drop inside a microfin tube. An excellent paper from Nagasaki University and the Research Center for Next Generation Refrigerant Properties (NEXT-RP) at Kyushu University measured heat transfer and pressure drop of R1123/R32 flow in horizontal microfin tubes during condensation and evaporation (ID 2164).

Two additional papers from Padova University (ID 2204 and ID 2205) examined the behavior of low-GWP refrigerants inside smaller diameter copper tubes for flow boiling and condensation, respectively. The refrigerants tested are reflective of the large number of papers dealing with new low-GWP refrigerants in general and HFO blends in particular. Indeed at least five papers were presented by authors from Chemours or Honeywell and at least eight papers were published with “R1234” in the title. Many presentations opened with an overview of the timetables for phase out of high-GWP refrigerants as required by the Kigali agreement and European F-Gas legislation.

**Airside Simulations**

There are four measurements of vital importance in heat exchanger design. There is the refrigerant-side pressure drop and heat transfer inside the tube, which are functions of type of refrigerant, flow rates and internal tube enhancements. Then there are also the airside pressure drop and heat transfer on the outside, which are functions of air flow rates, fin and tube geometries and fin design.

The optimization of such parameters as fin design, fin spacing, tube spacing, tube circuitry, and so forth can significantly improve heat transfer efficiency, allowing for energy savings in new product designs.

A research program conducted by Optimized Thermal Systems (OTS) with support from the Copper Alliance developed new air-side correlations for fins with smaller-diameter tubes based on thousands of CFD simulations, and then validated these new correlations against experimental data. CoilDesigner software from OTS now includes such correlations, allowing designers to predict the performance of MicroGroove coils with good accuracy. The research underpinning these correlations is discussed in the Paper 2582 titled “Experimental Validation of CFD-Based Correlations for 5 mm Louver- and Slit-Fin Heat Exchangers: Lessons Learned,” an OTS paper delivered in Session R-15: Air-Side Heat Transfer Characterization.

In the words of the authors, “Several sample heat exchangers were acquired from manufacturers in China, India, and the US. These sample coils employed slit and louver fins with a range of fin densities and tube patterns. The major dimensions of these HXs are outlined in Table 3. All tested HXs had tubes with 5 mm nominal diameters.”

Deviations between CFD predictions and experimental observations were attributed to inaccurate modeling of the thermal contact resistances between fin and tube. Nonetheless, the author’s concluded, “This method of combining numerical exploration of the design space with limited experimental testing and validation can be used to rapidly develop new, comprehensive correlations in a cost-effective manner.”

Readers and researchers interested in learning more about Multiple Objective Genetic Algorithm (MOGAs) in coil design will be interested two papers delivered in the session R-08: Heat Exchanger Optimization:

ID 2598: “Tube-Fin Heat Exchanger Circuitry Optimization Using Integer Permutation Based Genetic Algorithm” from the Center for Environmental Energy Engineering (CEEE) consortium at the University of Maryland.

ID 2532: “Optimization of MicroGroove Copper Tube Coil Designs for Flammable Refrigerants” from the Copper Alliance, OTS, Sub-Zero and HTT.

The latter paper showed how OTS applied MOGA to the optimization of new designs of MicroGroove heat exchangers for residential refrigeration products made by Sub-Zero. It was presented by Yoram Shabtay, President of Heat Transfer Technologies, who assisted in this application. The slideshow presentation, which is available in the “Technical Literature” landing page of microgroove.net, includes Sub-Zero’s experimental verification of the MOGA results.

Another topic of perennial interest is defrosting of the evaporator coils of residential heat pumps. Several papers were presented on this topic in Session R-12: Heat Exchanger Frost Impacts and Control. For example, Paper 2258 titled “Alternative Defrost Strategies for Residential Heat Pumps” was presented by Cara Martin of Optimized Thermal Systems and supported by the Electric Power Research Institute and the International Copper Association.

“One thing is certain about the state of research in HVAC&R as seen through the vast array of original papers presented at the Herrick Conferences,” says Nigel Cotton. “Coils made from MicroGroove copper tubes will play a key role in the refrigeration and air-conditioning products for the foreseeable future.”

For more information, visit [www.microgroove.net](http://www.microgroove.net). Join the MicroGroove Group on LinkedIn to share your ideas about research directions and product development. [www.linkedin.com/groups/Microgroove-4498690](http://www.linkedin.com/groups/Microgroove-4498690).

**About ICA**

The International Copper Association, Ltd. (ICA) is the leading organization for promoting the use of copper worldwide. ICA’s mission is to promote the use of copper by communicating the unique attributes that make this sustainable element an essential contributor to the formation of life, to advances in science and technology, and to a higher standard of living worldwide. Visit [www.copperinfo.com](http://www.copperinfo.com) for more information about ICA.