microgroove™ Update

Attain High Energy Efficiency with Less Materials Using Smaller-Diameter, Inner-Grooved Copper Tubes

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PRESENTATIONS

TECHNICAL PAPERS

ACRA: Sixth Asian Conference on Refrigeration and Air Conditioning Aug 26-28 2012, Xi'an, China

1. Experimental Investigation of Heat Transfer Characteristics of Louver Fin-And-Tube Heat Exchanger with 5 mm Diameter Tubes under Wet Conditions by Wei Wu, Guoliang Ding, Yifeng Gao, Ji Song.

More info on "Events" page

EXHIBITIONS

Chillventa

Oct 9-11, 2012
Nuremberg, Germany

Suppliers of small diameter copper tube will exhibit at this event.

Burr OAK Tool Inc. will exhibit new equipment: Hall 2, Booth 2-512

AHR Expo 2013

Jan 28-30, 2013
Dallas, Texas
Visit the MicroGroove Exhibit
Booth 5524

More info on "Events" page

IN THE NEWS

MicroGroove Technology Makes Inroads

The ACHR News, June 4, 2012

Designing for Efficient Heat Transfer

A step-by-step procedure for optimizing the use of small diameter tubes in eco-friendly AC designs

Appliance Design, July 2012

COOL TECHNOLOGY: Small copper tubes make a big impact on air-conditioner efficiency

Machine Design, August 23, 2012

RESEARCHERS AROUND THE WORLD EXAMINE ROUND COPPER TUBES IN ACR APPLICATIONS

The international conference held at Purdue University in July was rich in presentations on the use of copper tubes in air conditioning and refrigeration applications.

Hailing from around the world, researchers met in West Lafayette, Indiana this summer to present the results of their investigations on properties of smaller copper tubes and their performance in round-tube, plate-fin (RT-PF) heat exchanger (HX) coils.

Copper tubes figured prominently in the research and several papers focused on the properties of smaller diameter copper tubes in particular. In fact, copper tubes were discussed in at least seven sessions over four days, including sessions on HX frosting; HX performance and optimization; heat transfer; HX modeling; HX maldistribution and fouling; HX wetted; and HX performance and enhancement.

Authors included researchers from prestigious universities such as the Federal University of Santa Catarina, Brazil; Kyushu University, Japan; Oklahoma State University at Stillwater; University of Michigan; University of Illinois at Urbana-Champaign; University of Incheon, Republic of Korea (South Korea); University of Maryland, College Park; Shanghai Jiao Tong University, Shanghai; and the Technical University of Denmark.

OEM researchers contributing to the papers were from Daikin Industries, Japan; Danfoss, Germany; Embraco Compressors, Brazil; Johnson Controls, Norman, Oklahoma; and Refrigeration and Air-Conditioning, Offenbach, Germany.

Other research participants were from Exel Consulting, Creative Thermal Solutions and Oak Ridge National Laboratory. Two of the papers were supported by the Copper Alliance, through the ICA Shanghai Office and the Copper Development Association in the USA.

Several papers compared the performance of copper tubes with microchannel tubes. In many cases, superior performance was obtained from the copper tubes, especially with regard to maldistribution of refrigerant flow, drainage, frosting, wetting and deluge cooling.

All told, a wide range of topics were covered over the four days of the conference, providing an excellent snapshot of current research activities into the properties and performance of copper tubes in ACR applications.

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Table 1 lists a selection of papers from the conference and provides links to them online. The remainder of this article comments briefly on select papers. The interested reader is encouraged to read the original papers and join our discussion in the MicroGroove group on Linked In.

DESUPERHEATING ZONE

In two outstanding papers, Pega Hrnjak and Chieko Kondo carefully examined the condensation behavior of R410a and R744 in 6.1 mm copper tube with and without inner fins. They found that a very thin film of condensate forms even in the desuperheating zone and that this film affects heat transfer in that zone. (ID 2503 and 2566)

SMOOTH VERSUS INNER GROOVES

Ryuhei Kaji of Daikin Industries compared three types of copper tubes, including smooth and inner grooved tubes, by viewing R744 flow inside the tubes through glass. It was found that inner grooving can be effective in removing oil away from the inner surface of the tubes and thus enhancing performance. (ID 2347)

OVAL SHAPES WITH INNER MICRO-FINS

In research from South Korea, condensation heat transfer coefficients (HTCs) and pressure drops were measured for 7-mm diameter copper tubes. HTCs were measured for various aspect ratios of oval-shaped tubes and oval shaped tubes with inner microfins. (ID 2580)

FROSTING AND DRAINAGE

Newly tenured professor Lorenzo Cremaschi compared frosting and drainage of coils made with smaller diameter (5 mm and 7 mm) and conventional diameter (9.5 mm) copper tubes with microchannel tubes. The copper tubes showed excellent water drainage and good performance in frosting operating conditions compared to the microchannel tubes. (ID 2193)

OIL FOAM AND BOILING FLOW

Seongho Kim and Professor Hrnjak observed through a visualization experiment on 11.2 mm diameter copper tubes that oil-induced foam can nucleate boiling in R744 and enhance HTCs under conditions where convective boiling is dominant. Inner grooves obviate the need for such foam enhancement. (ID 2519)

INTERLACED OR FACE SPLIT

Martin Ryhl Kaern examined airflow in residential air conditioners. He modified the U-bend connections of a 17.58 kW evaporator, reconfiguring the RTPF tube circuitry of the evaporator from interlaced to face split. Tube diameters were 9.52 mm. Performance is better for face-split circuitry if the refrigerant flow can be controlled in each circuit. Coauthored by Thomas Tiederman from Danfoss in Offenbach, Germany, this paper references Kaern's 2011 doctoral thesis from Technical University of Denmark. (ID 2178)

DELUGE WATER COOLING

Researchers from the University of Maryland developed apparatus to examine the cooling capacities and airside pressure drops for a round-tube heat exchanger with louver fins and a frontal area of one-quarter of a square meter. The tube diameters were 10.6 mm. The heat exchanger was tested for wet and dry cases; for two air flow rates; and for angles-to-the-vertical of 0 and 21 degrees. According to the authors, the experimental facility could be used for more comprehensive studies. (ID 2331)

PERIPHERAL FINS

An exotic new fin design consists of radial fins with bases attached to the round copper tubes and a peripheral, hexagonal fin at a distance from the tube. The honeycomb arrangement allows for ice to form around the tube while still allowing for airflow around the tubes and heat conduction through the radial fins. (ID 2143)

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IN THE SPOTLIGHT



ALL COPPER EVAPORATORS ON SHANGHAI BUSES

Copper and many of its alloys are used for antimicrobial touch surfaces such as door handles, hand rails, taps and light switches and there is a growing interest in antimicrobial copper for heating, ventilating and air conditioning systems. Shanghai is leading the way with the deployment of antimicrobial copper HVAC systems on its buses. Evaporator coils with aluminum fins were replaced with units with copper fins, which can eliminate bacterial, fungal and viral growths. Their surface remains cleaner for longer, offering a greatly expanded service life and contributing to improved air quality.

Exploring the potential of these systems, the Shanghai Municipal Center for Disease Control and Prevention (SCDC) undertook testing between 2010 and 2012. Buses operating in similar conditions (e.g. time and location) were fitted with coils made with either copper or aluminum fins, and the level of contamination on each was monitored.

It was found that microbial levels on the copper surfaces were significantly lower than those on the aluminum, which concurs with a recently-published US study investigating the same subject in a laboratory environment.

For more information, visit www.antimicrobialcopper.com

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DESIGN PRINCIPLES

Professor Guoliang Ding from Shanghai Jiao Tong University (SJTU) was a coauthor of a research report delivered by Ji "Kerry" Song from the Shanghai Office of the International Copper Association. Conference attendees were treated to illustrations of new software programs for optimizing coils with smaller diameter copper tubes. The software was developed by ICA in cooperation with consortium of OEMs representing the majority share of production or room air conditioners globally. Kerry described a step-by-step procedure for optimizing heat exchanger design and illustrated the principles with case studies. (ID 2223)

MICROGROOVE MEETS MICROCHANNEL

Until now, there have been few studies comparing smaller-diameter copper tubes directly with aluminum microchannel technology. For that reason, ICA sponsored a research project with Exel Consulting and Optimized Thermal Systems to allow for meaningful comparisons of the performance of these disparate systems. The method of comparison is simple: A search was made for a state-of-the-art, best-in-class brazed aluminum multichannel (BAM) heat exchanger. The performance specifications were then identified and set as a target for the RTPF heat-exchanger with smaller diameter copper tubes. The design space was searched for candidate RTPF designs that met the performance specification. The simulations were performed at Optimized Thermal Systems, College Park, Maryland. (ID 2464)

LOOKING AHEAD

The Purdue Conferences have become a tradition in the world of refrigeration and air-conditioning. As indicated by the above sampling of papers, original and creative work continues to be produced by university and industrial laboratories globally. The increased research on smaller diameter copper tubes was clearly in evidence at West Lafayette this year as the copper industry has demonstrated a path toward high efficiency and reduced materials use, as well as options for using low GWP refrigerants such as propane and R744.

Join our discussion on LinkedIn as we look ahead to continued research on MicroGroove technology.

Download papers free-of-charge online. Simply search for the Session or Paper ID on this webpage: www.conftool.com/2012Purdue/sessions.php

Sessions	Paper ID	Title	Affiliations
R-5: HX Frosting	2193	Frosting Performance of Fin-and-Tube Evaporators with Small Copper Tubes Diameter	Oklahoma State University; Johnson Controls
R-8: HX Performance and Optimization	2143	Optimization of Peripheral Finned-Tube Evaporators Using Entropy Generation Minimization	Federal University of Santa Catarina, Brazil; Embraco Compressors, Brazil; University of Michigan
R-14: Heat Transfer III	2347	The Effect of Inner Grooved Tubes on the Heat Transfer Performace of Air-Cooled Heat Exchangers of CO2 Heat Pump System	Daikin Industries, Japan
	2519	Effect of Oil on Flow Boiling Heat Transfer and Flow Patterns of CO2 in 11.2 mm Horizontal Smooth and Enhanced Tube	University of Illinois at Urbana-Champaign
	2580	Condensation heat transfer and pressure drop in flat tubes having different aspect ratio	University of Incheon, South Korea
R-15: HX Modeling	2187	New Generation of Air Cooled Heat Exchanger 1 kW Module Design Optimization	CEEE, University of Maryland, College Park; Oak Ridge National Laboratory
	2503	Heat Rejection in Condensers: Desuperheating, Condensation in Superheated Region and Two Phase Zone	University of Illinois; CTS - Creative Themal Solutions; Kyushu University, Japan
R-18: HX Maldistribution and Fouling	2178	Compensation of Airflow Maldistribution in Fin-and-Tube Evaporators	Technical University of Denmark, Denmark; Refrigeration & Air-Conditioning, Offenbach, Germany
R-21: HX Wetted	2331	Enhancement of Round Tube and Flat Tube-Louver Fin Heat Exchanger Performance Using Deluge Water Cooling	University of Maryland
R-25: HX Performance and Enhancement	2223	Principle of Designing Fin-and-Tube Heat Exchanger With Smaller Tube for Air Condition	Institute of Refrigeration and Cryogenics, Shanghai Jiao Tong University, Shanghai; International Copper Association Shanghai Office, Shanghai, China
	2464	Simulation-Based Comparison of Optimized AC Coils Using Small Diameter Copper and Aluminum Micro-Channel Tubes	Exel Consulting Group; Copper Development Association; Optimized Thermal Systems
	2566	Effect of Microfins on Heat Rejection in Desuperheating, Condensation in Superheated Region and Two Phase Zone	University of Illinois; CTS - Creative Thermal Solutions; Kyushu University, Japan