microgroove™ Update

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

Vol. 1, Issue 1 • May 2011

UPCOMING PRESENTATIONS

WEBINARS

Achieving Higher Energy-Efficiency with Smaller-Diameter Copper Tubes
14:00 Brussels Time (GMT+2)
Tues 14 June 2011

Boost ACR Energy Efficiency with Copper MicroGroove Tubes
1 pm New York Time (GMT-4)
Wed 22 June 2011

TECHNICAL PAPERS

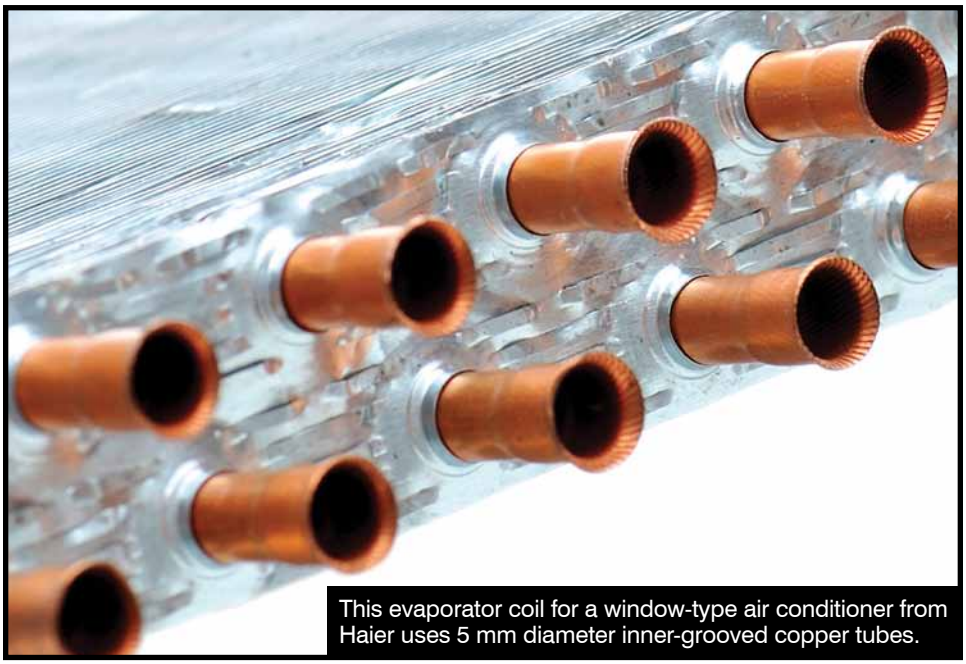
"Simulation-Based Design Method for Room Air Conditioner with Smaller Diameter Copper Tubes"
By G.L. Ding, T. Ren, X.Y. Zheng and Y.F. Gao
Paper to be presented at 23rd IIR International Congress of Refrigeration, Prague, Aug 23-26

"Improving Performance of Refrigeration Systems"
By John Hipchen
Paper to be presented at ASHRAE
2011 Annual Conference
Monday, June 27, 2011
from 11:00 AM to 12:00 PM

EXHIBITS

23rd IIR International Congress of Refrigeration
Prague, Aug 23-26

OEMS USE SMALLER-DIAMETER COPPER TUBES IN NEW ACR PRODUCTS



This evaporator coil for a window-type air conditioner from Haier uses 5 mm diameter inner-grooved copper tubes.

Product designers increasingly are using smaller diameter copper tubes in air-conditioning and refrigeration (ACR) products. This trend is fast becoming the norm as OEMs pay attention to the competitive advantages of MicroGroove technology.

Speaking from ICA's MicroGroove exhibit at the "China Refrigeration Expo" (CR-2011) in Shanghai, China, ICA's Deputy Director of Technology Wenson Zheng said, "The International Copper Association has been cooperating with OEMs on design strategies for increasing the performance of evaporator and condenser coils. The most spectacular gains in heat transfer efficiency have been realized by decreasing the diameter of the copper tubes in these coils."

Coils from five different OEMs, including Gree, Haier, Midea, Chigo and HiSense Kelon were on display at the MicroGroove booth in Shanghai. The samples are representative of both condensers and evaporators, for window-type air conditioners as well as for split units.

"Most of these coils are taken from actual production models of residential air conditioners," said Mr. Zheng. "We are proud of the accomplishments of the small-tube-copper consortium in China, and research continues on the design and manufacture of coils with small diameter copper tubes."

OEMS SEEK ANSWERS

Several years ago, ICA began working with universities, OEMs and tube suppliers in China, searching for the answer to one overarching question:

How can we increase the energy efficiency of ACR products without increasing the material content?

For those already making ACR products with high energy efficiency, the question is

How can we use less material?

Experiments were conducted on heat transfer coefficients; cut-and-try coils were made, directly substituting smaller diameter tubes in place of conventional tubes in coil designs; and computer simulations were made to optimize coil circuitry and fin design.

Inevitably, the answer obtained was "make the tube diameter smaller." This conclusion is expected to have huge economic consequences for the ACR industry.

NEW TECHNOLOGY ON DISPLAY

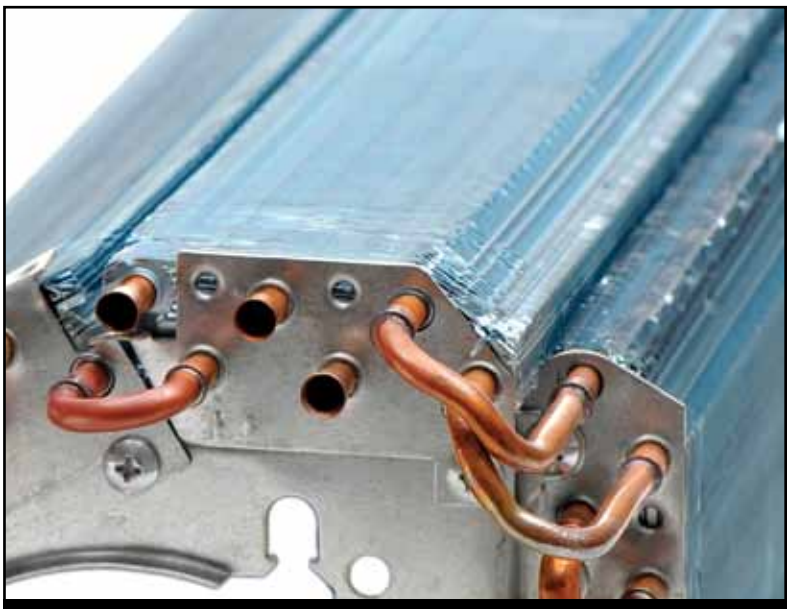
Tubes were researched and coils were developed for and by select OEMs. Eight technical papers are now available online. The R&D clearly shows that lighter, more compact heat exchanger coils could be made to provide the heat transfer capacity required for high energy efficiency products.

The technology is already in production. MicroGroove products were on display at several 2011 industry trade shows. Even if you missed ICA's MicroGroove exhibit in Shanghai and Las Vegas this year, you can still see video and photographs of the coil samples that were on display at AHR Expo and China Refrigeration.

That's a brief recap of the latest news about MicroGroove technology for this premiere issue of the MicroGroove Update. If you are still not sure about what the MicroGroove advantage means to you and your company then it's time you contacted one of the MicroGroove contacts listed in the new online Supplier Directory.

Thanks for your interest in this technology! ICA and its members wish you much success and prosperity in your development of energy efficiency ACR products.

These smaller-diameter copper tubes with inner grooves provide high-efficiency and reduced size and weight. This is one section of a condenser coil from Midea.



This evaporator coil for a Chigo split-type air conditioner uses smaller-diameter copper tubes.

MICROGROOVE IS ONLINE

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Visit MicroGroove online for the latest information about webcasts, technical papers and exhibits.

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Vol. 1, Issue 2 • August 2011

UPCOMING PRESENTATIONS

WEBINARS

Webinars now archived.
See "Webinars" page at
www.microgroove.net

TECHNICAL PAPERS

23rd IIR International
Congress of Refrigeration
Paper by Professor
G.L. Ding of SJTU *et alia.*
Wednesday, August 24.
See "Events" page at
www.microgroove.net

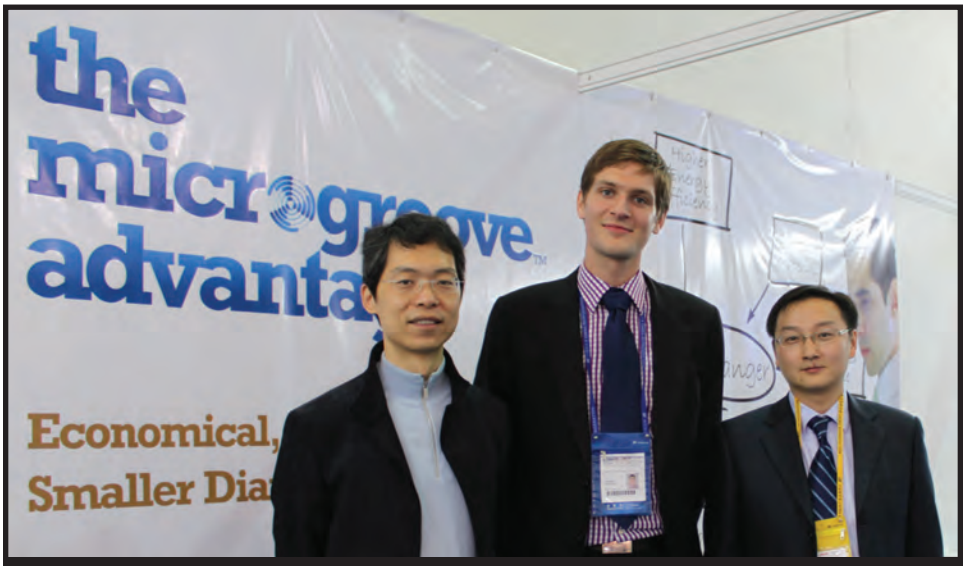
EXHIBITS

23rd IIR International
Congress of Refrigeration
Prague, Aug 23-26
See "Events" page at
www.microgroove.net

ABOUT THE CONGRESS

The International Congress of Refrigeration is the most important and prominent forthcoming event of the International Institute of Refrigeration (IIR, www.iifiir.org). More than 600 papers will be presented at the Congress, which is held every four years. The theme for this year is "Refrigeration for Sustainable Development." The International Institute of Refrigeration (IIR) is a scientific and technical intergovernmental organization enabling pooling of scientific and industrial know-how in all refrigeration fields on a worldwide scale.

MICROGROOVE TECHNOLOGY ON DISPLAY AT REFRIGERATION CONGRESS IN PRAGUE



Wenson Zheng (left) and Kerry Song (right) from ICA's Shanghai office will be available to answer questions about MicroGroove Technology at the International Congress on Refrigeration in Prague. Here they are at the China Refrigeration Expo last April.

Once every four years, the world's leading experts in various sciences and technologies relating to refrigeration converge on the International Congress of Refrigeration (ICR).

This year, the 23rd IIR ICR event will be held in Prague, Czech Republic at the Prague Congress Centre where MicroGroove technology will be on display at Booth 11, which is situated on the first floor in the halls near the conference rooms. The MicroGroove exhibit will run for the entire five days of the Congress from August 21-26. If you are attending this Congress, visit Booth 11 and ask about MicroGroove technology.

Attending the booth will be representatives from the European office. In addition, several representatives from the Shanghai Office of the International Copper Association will attend the Congress, including Wenson Zheng, Frank Gao and Kerry Song. They have in-depth technical knowledge and will be happy to meet with you, to discuss current applications of MicroGroove technology as well as ICA-sponsored research.

MicroGroove technology refers to the use of smaller-diameter copper tubes with inner grooves in the design of ACR products. The higher local heat transfer coefficients of such tubes compared to larger diameter copper tubes means that evaporators and condensers made with MicroGroove tubes can deliver a specified cooling capacity using less material, including less tube, less fin and less refrigerant. Consequently, air conditioners and refrigeration products can be made more energy efficient without increasing manufacturing costs.

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JOINT PAPER WITH SJTU DESCRIBES OPTIMIZATION OF RESIDENTIAL AIR CONDITIONERS WITH SMALLER DIAMETER COPPER TUBES

ICA and Shanghai Jiao Tong University (SJTU) conducted joint research on the optimization of coil designs made with smaller diameter copper tubes. Simulation-based design methods were applied to minimizing total system costs of a unit with a nominal cooling capacity of 3450 watts. Costs were reduced by 17 percent compared to systems made with larger diameter tubes.

A paper titled "Simulation-Based Design Methods for Room Air Conditioners with Smaller Diameter Copper Tubes" is slated for presentation at 9:00 am on Wednesday, August 24 at the International Congress of Refrigeration in Prague. Coauthors include Professor G.L. Ding and T. Ren of the Institute of Refrigeration and Cryogenics at Shanghai Jiao Tong University (SJTU) in Shanghai, China; and Wenson Zheng and Frank Gao of the International Copper Association.

The design goal was to minimize the total cost (including costs of materials, processes and labor) for manufacturing an air conditioner of a given capacity. The parameters to be optimized included heat exchanger length, fin pitch, number of paths and other physical and geometrical design factors. System cooling capacity did not vary by more than one percent.

"The simulation-based design method allows for many heat exchanger designs to be explored more efficiently than traditional cut-and-try methods," explained Wenson Zheng, Deputy Director of Technology for ICA.

The design methodology encompasses a heat-exchanger simulator as well as a knowledge-based evolution method (KBEM). The simulator performs heat exchange calculations to determine system performances based on physical properties and geometrical design parameters, while the KBEM eliminates unfeasible or impractical designs, before the simulations are performed, allowing for a more efficient sampling of the design space.

In a case study using the design method, optimized coils were designed using smaller diameter inner grooved tubes. System costs were lowered by 17 percent compared to designs that used larger diameter tubes. The design method and case study will be discussed at the presentation in Prague. For more information about MicroGroove technology and technical papers, visit www.microgroove.net.

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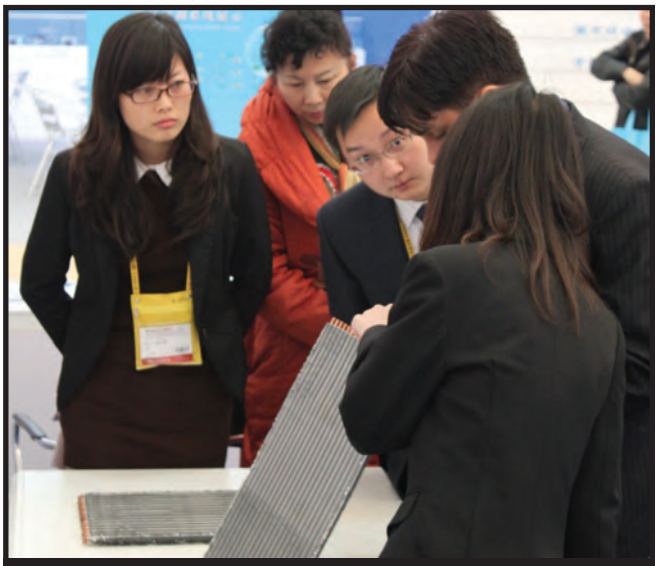
Nigel Cotton, Global OEM Team Leader for the ICA, will also be at the Congress. He says, "MicroGroove technology is already increasing the energy efficiency of AC products on global markets. Yet the potential for saving energy using this technology is just beginning to be realized. The IIR Congress provides an ideal venue to introduce its advantages to ACR researchers and product design engineers throughout the world."

Several papers will be presented at the Congress on the design of heat exchanger coils using smaller-diameter copper tubes. For more information about MicroGroove Technology, including technical papers, visit MicroGroove (Booth 11) at the Congress during the exhibit hours, or visit www.microgroove.net.



Coils from OEMs were on display at the MicroGroove booth in Shanghai. The samples are representative of both condensers and evaporators, for window-type air conditioners as well for split units. Coils will also be on display in Prague.

MICROGROOVE RESEARCH

Several years ago, ICA began working with universities, OEMs and tube suppliers to increase the energy efficiency of ACR product without increasing the material content. Today, that technology is already in production. If you are still not sure about what the MicroGroove advantage means to you and your company then it's time to visit www.microgroove.net and introduce yourself to one of the MicroGroove contacts listed in the new online Supplier Directory.

ICA and its members wish you much success and prosperity in your development of energy efficient ACR products.

Thanks for your interest in this technology!

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Vol. 1, Issue 3 • December 2011

PRESENTATIONS

WEBINARS

Boost ACR Energy Efficiency with Copper MicroGroove Tubes

Presented by *THE NEWS* and *Appliance Design*.

Speaker: John Hipchen, President, Exel Consulting Group

View archived webinar free with registration.

More info on "Webinars" page
www.microgroove.net/webinars

EXHIBITS

2012 AHR Expo, Booth 2729

January 23 to 25, 2012

Chicago, Illinois

More info on "Events" page
www.microgroove.net/events

Also see "Map Your Show"
http://ahr12.mapyourshow.com/5_0/exhibitor_details.cfm?exhid=10457AHR

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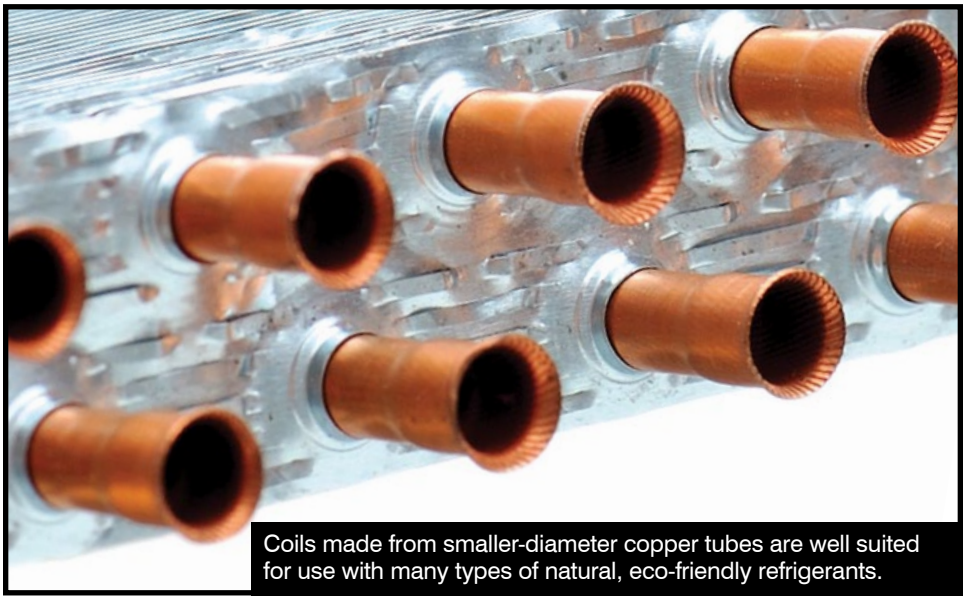
NATURAL REFRIGERANTS PERFORM BEST WITH MICROGROOVE TECHNOLOGY



Coils made from smaller-diameter copper tubes are well suited for use with many types of natural, eco-friendly refrigerants.

Natural refrigerants such as carbon dioxide and propane are fast becoming more attractive to OEMs and end-users for ACR and heating applications as technology advances.

Also known as R744, carbon dioxide is used as a refrigerant in a growing number of applications ranging from vending machines and refrigerated supermarket display cases to ice-skating rinks. Another natural refrigerant under consideration for use in air conditioner systems is propane, which is also known as R290. Propane is an eco-friendly hydrocarbon (chemical formula C_3H_8) with outstanding thermodynamic properties that make it well suited as a refrigerant for residential air conditioners.

The advantages of copper tubes in these applications include high thermal conductivity, corrosion resistance and strength. Smaller diameter copper tubes have even higher burst strengths and they allow for lower overall refrigerant volumes.

Copper is a proven technology with a well-established supply chain, including a network of trained installers with the know-how to ensure safety and reliability.

More on R744

In the transcritical refrigeration cycle pioneered by Gustav Lorentzen in the late eighties, the thermodynamic process after the compressor does not condense the gas into a liquid but merely cools the gas. Hence, the heat exchangers for this step are

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called "gas coolers" rather than condensers. Technological improvements with respect to high-pressure compressors, high-pressure expansion valves (HPEVs) and other components such as controls, pipework and heat exchangers have contributed to the feasibility of R744 as an eco-friendly refrigerant. A comprehensive 492-page Handbook details the science and technology of R744, including components such as compressors and heat exchangers [1]

More recently, researchers from LU-VE S.p.A. in Uboldo, Italy, presented a paper about heat exchangers for R744 applications at the International Congress of Refrigeration in Prague [2]. Their gas cooler tubes were made of a copper alloy and the evaporator coil was an off-the-shelf design made of copper tubes. This example highlights the trend toward smaller diameter tubes. Further improvements in heat transfer could be obtained using inner-grooved tubes.

For R744 as a refrigerant, gas cooler pressure is very high, typically in the range of 120 bar and burst pressure ratings may be several times higher. Maximum working pressures for the evaporation step in the transcritical cycle are less, typically in the 45 to 60 bar range. Traditional heat exchanger coil technology with copper tubes is well suited for both the gas cooler and the evaporator in R744 applications. The main requirement is that the thickness of the tube wall and header should be sufficient to withstand the high pressures. Interestingly, burst pressure increases as tube diameter decreases, so smaller diameter tubes would be especially appropriate for R744 applications.

More on R290

For propane (R290), the pressure requirements are much less. Perhaps the only drawback of propane is its flammability so the volume of refrigerant needs to be minimized compared to the room air volume to be cooled; and certain safety features must be included in the product designs.

In a recent study supported by ICA, a three-dimensional distributed parameter model was used for simulation and a knowledge-based evolution method (KBEM) optimizer was applied to optimize air conditioner heat exchangers with smaller diameter tube. Refrigerant charge was dramatically reduced using smaller diameter tubes. The experimental results confirmed the simulation results, demonstrating that smaller diameter copper tubes are suitable for developing safe room air conditioners with R290.

"Key technologies are maturing for bringing products with eco-friendly refrigerants to the marketplace," says Nigel Cotton, Global OEM Team Leader for ICA. "Smaller diameter copper tubes are an excellent match for many of these new refrigerants."

MicroGroove uses simple and familiar techniques well-known to manufacturers. The process is flexible and versatile because it does not require investment in complex brazing furnaces, and yet it results in superior products.

References

[1] "Natural Refrigerant CO2," a handbook edited by Walter Reulens, ATMOsphere 2009. Master Module 8 on "Components" was written by Professor Ezio Fornasieri *et alia* of the University of Padova. Compressors are described in Section 8.1 (pp. 348-382) and heat exchangers are described in section 8.2 (pp. 383-410) of the Handbook, available online free of charge as a PDF here: www.atmosphere2009.com/files/NaReCO2-handbook-2009.pdf

[2] Stefano Filippini and Umberto Merlo, "Air Cooled Heat Exchangers for CO2 Refrigeration Cycles," IIR 23rd International Congress of Refrigeration, August 2011, Paper 295.

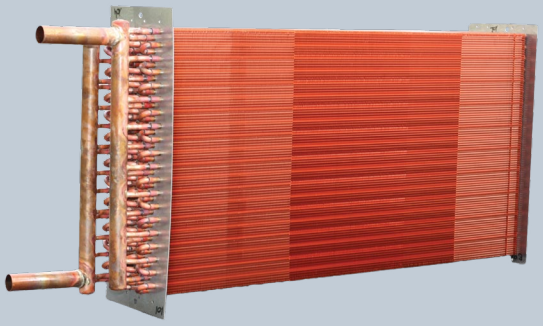
IN THE SPOTLIGHT

ANTIMICROBIAL MATERIALS

OEM companies such as the Chinese air-conditioning giant Chigo and Hydronic in France have already developed all-copper products expressly for their antimicrobial properties.

The use of all copper coils is not new but their use expressly to inhibit the growth of fungi and bacteria is a recent development that is expected to be an important factor in the development of innovative air conditioning and refrigeration products.

Bio build up on the coil may be reduced by using all copper coils, helping to maintain high levels of energy efficiency for longer times and avoiding energy efficiency drop off over time.



This ground-breaking antimicrobial copper coil air handling unit will harness the antimicrobial properties of copper in hospital applications. It is made in Europe by French manufacturer Hydronic in association with Centre d'Information du Cuivre-Laitons et Alliages (CICLA).

microgroove™ Update

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

Vol. 2, Issue 1 • January 2012

TRENDS IN COOLING TECHNOLOGY AND COIL DESIGN

Nearly 110 years have passed since the first installation of air conditioning in 1902. Although thermodynamics is widely considered a complete science today, new designs of heat pumps, air conditioners and refrigerators are flourishing.

Why has interest in the design of air-conditioning and refrigeration (ACR) products intensified so much in recent years?

A Climate of Innovation

Many factors are contributing to a climate of innovation in the ACR industry today, including

- Phase out of high-ODP and high-GWP refrigerants
- Use of eco-friendly refrigerants
- Energy efficiency standards
- Sustainable development
- Computer simulation of components and system performance
- Responsiveness to needs and wants in the marketplace

The phasing out of popular CFC and HCFC refrigerants has been a major factor in spurring innovations in cooling technology in the past 20 years. Likewise, energy efficiency and sustainability have necessitated invention. End-users have their eyes on energy efficiency ratings and OEMs are highly motivated to use less material in their products.

Computer modeling is now commonly used to simulate total system design. Decisions about refrigerants, coils and components are now made with the assistance of increasingly accurate performance simulations.

Advances in Coil Design

Redesign of the coil has seen the use of smaller diameter copper tubes with inner-grooves increasing the internal heat transfer coefficient and raising COPs. Such improvements in coil performance may also be favorable for the use of new refrigerants, less materials, higher operating pressures (due to the smaller diameter tubes) and variable refrigerant flow (due to the increased number of branches).

System design is dramatically changed for the better by using smaller diameter, inner grooved copper tubes in the coil designs.

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PRESENTATIONS

WEBINARS

Upcoming MicroGroove Webinar

The Manufacture of ACR Coils with Smaller Diameter Copper Tubes

Tuesday, March 27, 2012 at 1:00 pm ET

Presented by *THE NEWS* and *Appliance Design*.

Speaker: John Hipchen, President, Exel Consulting Group

Past MicroGroove Webinars

View Free Now on YouTube. No Registration Required!

Boost ACR Energy Efficiency with Copper MicroGroove Tubes (22 June 2011)

Achieving Higher Energy-Efficiency with Smaller-Diameter Copper Tubes (14 June 2011)

Small Tubes of Copper in ACR Applications (15 Dec 2010)

More info on "Webinars" page
www.microgroove.net/webinars

EXHIBITS

2012 AHR Expo, Booth 2729
January 23 to 25, 2012
Chicago, Illinois

More info on "Events" page
www.microgroove.net/events

Or search for "MicroGroove" in the AHR Expo Exhibitor Directory
www.ahrexpo.com

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Natural Refrigerants

Natural refrigerants such as carbon dioxide and propane are fast becoming more attractive to OEMs and end-users for ACR and heating applications as technology advances.

Also known as R744, carbon dioxide is used as a refrigerant in a growing number of applications ranging from vending machines and refrigerated supermarket display cases to ice-skating rinks.

Another natural refrigerant under consideration for use in air conditioning systems is propane. Known as R290, propane is an eco-friendly hydrocarbon (chemical formula C_3H_8) with outstanding thermodynamic properties that make it well suited as a refrigerant for residential air conditioners.

The advantages of copper tubes in these applications include high thermal conductivity, corrosion resistance and strength. Smaller diameter copper tubes have even higher burst strengths and they allow for lower overall refrigerant volumes.

Copper is a proven technology with a well-established supply chain, including a network of trained installers with the know-how to ensure safety and reliability.

Antimicrobial Materials

Another factor influencing the design of air conditioning and refrigeration systems is new published research on copper's efficacy against the spread of fungi in air conditioning systems.

OEM companies such as the Chinese air-conditioning giant Chigo and Hydronic in France have already developed all-copper products expressly for their antimicrobial properties.

The use of all copper coils is not new but their use expressly to inhibit the growth of fungi and bacteria is a recent development that is expected to be an important factor in the development of innovative air conditioning and refrigeration products.

Bio build up on the coil may be reduced by using all copper coils, helping to maintain high levels of energy efficiency for longer times and avoiding energy efficiency drop off over time.

The Most Important Factor

Perhaps the most important factor driving the development of new products is a better understanding of attitudes toward comfort and refrigeration in different climates and cultures. ACR product developers are responding better to the real needs and wants of end users in the built environment. They are right-sizing air conditioning and refrigeration products to allow for precise temperature and humidity control in specific zones without waste.

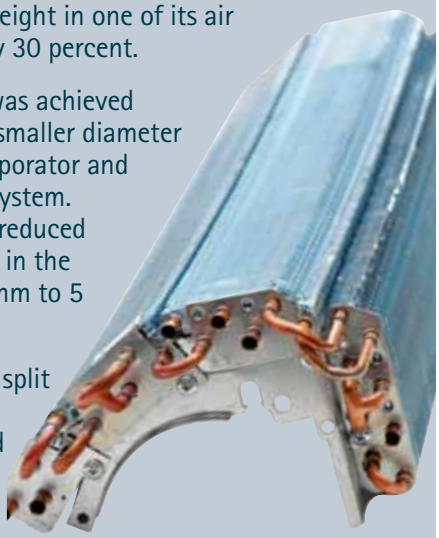
This ground-breaking antimicrobial copper coil air handling unit will harness the antimicrobial properties of copper in hospital applications. It is made in Europe by French manufacturer Hydronic in association with Centre d'Information du Cuivre, Laitons et Alliages (CICLA).

The result is that end-users will enjoy healthy, eco-friendly products that deliver cooling capacity with high energy efficiency when as well as where it is most desirable.

For more information about MicroGroove smaller-diameter, inner grooved copper tubes, visit www.microgroove.net. There you can find technical papers and recently archived webinars as well as a supplier directory.

IN THE SPOTLIGHT

The air conditioner manufacturing giant Chigo has reduced the tube weight in one of its air conditioning systems by 30 percent.



This weight reduction was achieved simply by switching to smaller diameter copper tubes in the evaporator and condenser coils of the system. The tube diameter was reduced from 9.52 mm to 5 mm in the condenser and from 7 mm to 5 mm in the evaporator.

The air-conditioner is a split system with a cooling capacity of 2500 W and a COP of 3.2, or EER of 10.9. [Note: The energy efficiency ratio (EER) in units of Btu/hr per W is obtained from the coefficient of performance (COP) in units of W/W by multiplying by 3.412 since 1 W = 3.412 Btu/hr.]

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Vol. 2, Issue 2 • March 2012

PRESENTATIONS

WEBINAR

Manufacturing ACR Coils with MicroGroove Tubes

Tuesday, March 27, 2012 1:00 pm ET

Presented by *THE NEWS* and *Appliance Design*

Moderator: Kyle Gargaro, Editor-in-Chief of *THE NEWS*

Speakers: John Hipchen, President, Exel Consulting Group; Ned Haylett, VP Sales, Burr Oak Tool Inc.; and Randly Sible, R&D Manager, Burr Oak Tool Inc.

(More info on "Webinars" page)

EXHIBITS

MicroGroove Booth EG321 China Refrigeration 2012

Beijing, April 11 to 13

(More info on "Events" page)

TECHNICAL PAPERS

Papers on MicroGroove submitted for upcoming conferences:

2012 IIR Gustav Lorentzen Conference
Delft, Netherlands, June 25 to 27

2012 Purdue Conferences
West Lafayette, Indiana, July 16 to 19

(More info on "Events" page)

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MAKING COILS WITH MICROGROOVE TUBES

Manufacturers are using familiar equipment to make coils with smaller-diameter round copper tubes.

Performance simulations and prototype designs of heat exchangers with smaller diameter copper tubes are indeed impressive. The savings in materials and reduction of refrigerant volume cannot be denied.

But practical high volume manufacturing is another matter.

Fortunately, Microgroove copper tube technology is compatible with production methods and equipment already familiar to the HVAC industry. Equipment makers have made the necessary adjustments for producing smaller-diameter tubes and assembling them into coils. Such manufacturing equipment has proven production-worthy at major companies such as Haier, Midea, Kelon, Chigo and Goodman who have mastered the manufacturing and now are marketing products globally.

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Typical Processes

The principles of tube insertion and tube expansion have been utilized in the industry for decades. The equipment used today expands the tubes circumferentially, i.e., the circumference of the tube is increased without changing the length. This "non-shrinkage" expansion allows for better control of tube lengths in preparation for subsequent assembly operations.

Tubes are inserted, or laced, into the holes in a stack of precisely spaced fins. Specially designed expanders are inserted into the tubes and the tube diameters are increased slightly until mechanical contact is achieved between the tubes and fins. The high ductility of copper allows for this process to be performed accurately and precisely. Heat exchanger coils made in this manner have excellent durability and heat transfer properties.

Modern Manufacturing

Modern designs of the tube expansion equipment allow for tight tolerances and exact specifications using smaller diameter copper tubes. Otherwise the equipment and production lines closely resemble the existing equipment lines that have a long and successful history.

"Manufacturing in general has become more precise and accurate and the equipment for working with smaller diameter tubes is no exception," says Nigel Cotton, MicroGroove Team Leader for the International Copper Association. "Manufacturers can quickly recoup the costs of equipment upgrades because the use of smaller diameter coils allows them to make higher value products with less material."

For more information about MicroGroove technology, visit www.microgroove.net.

WEBINAR UPDATE

Burr Oak Tool Inc. to Co-Present at MicroGroove Webinar

Representatives from Burr Oak Tool Inc. have agreed to copresent the next MicroGroove webinar. They will review typical processes used in the manufacture of coils and then describe the state-of-the-art manufacturing solutions for making coils with MicroGroove smaller diameter tubes.

The one-hour webinar takes place on Tuesday March 27, 2012 at 1 pm ET and will continue to be available for viewing free of charge.

Register today at www.microgroove.net/webinars for this free webinar.

IN THE SPOTLIGHT

Mechanical Expander

The mechanical expander from Burr Oak Tool Inc. boasts short cycle times with expansion speeds over 50 fpm. That means a 36 inch coil can be expanded in 15 seconds, or a 120 inch coil can be expanded in 35 seconds. All tubes can be expanded in a single cycle. According to the company, the equipment can be customized for short- or long-run production environments.

The "overbuilt" structure ensures accuracy and longevity. It is designed for tube diameters from 5 mm to 1 inch; and coil widths up to 60 inches standard (and 72" special).

The precision of this mechanical expander allows for coil lengths repeatable to 1/16 inch. Many options are available to enhance production rate and operator ergonomics, including options to assist in coil handling, to control coil movement and to contain the coil during expansion.

For more information, contact

Ned Haylett, VP Sales, Burr Oak Tool Inc.
Phone: +1 (269) 651-9393 ext. 249.
Email: ned@burroak.com
Website: www.burroak.com

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Vol. 2, Issue 3 • June 2012

NEW RESEARCH UNDERSCORES BEST PRACTICES IN COIL DESIGN

Computer simulations and design case studies illustrate how to design heat exchangers using smaller diameter copper tubes. The International Copper Association supports several research initiatives that are exploring the design space for coils made from smaller diameter copper tubes both in the US and China.

New research results are slated for presentation at two international conferences this year, including the Tenth Gustav Lorentzen Conference on Natural Refrigerants in June (GLC); and the Fourteenth International Refrigeration and Air Conditioning Conference in July (Purdue).

Evolving Design Principles

Professor Guoliang Ding of the Institute of Refrigeration and Cryogenics (IRC) at SJTU has been researching ways to minimize refrigerant volume for safe room air conditioners with R290. Ding and his colleagues will present simulations and case studies of recent research at both GLC and Purdue. In both case studies, the refrigerant volume is significantly reduced by reducing the diameter of the copper tubes while still meeting performance objectives.

From this research, various design principles have emerged of great value to anyone seeking to optimize material usage in air conditioning and refrigeration applications, whether for an evaporator or a condenser. The design and optimization of heat exchangers requires the use of computational fluid dynamics (CFD) methods to analyze the airflow around the tubes and fins and also involves computer simulations of refrigerant flow and temperatures inside the tubes. Professor Ding and his group have refined useful design principles as applied to smaller diameter copper tubes. The knowledge based evolution method (KBEM) has been developed into a step-by-step procedure that simulates and optimizes every aspect of the heat exchanger design, from tube spacing to fin type to tube circuitry.

Professor Ding will present a new case study on an R290 room air conditioner with 5 mm tubes at GLC and his student Wei Wu will describe these design principles along with another new case study on a split system at the Purdue Conferences.

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PRESENTATIONS

TECHNICAL PAPERS

The Tenth IIR Gustav Lorentzen Conference on Natural Refrigerants

1. "Developing Low Charge R290 Room Air Conditioner by Using Smaller Diameter Copper Tubes" by Guoliang Ding, Wei Wu, Tao Ren, Yongxin Zheng, Yifeng Gao, Ji Song, Zhongmin Liu and Shaokai Chen

The Fourteenth International Refrigeration and Air Conditioning Conference

1. "Principle of Designing Fin-And-Tube Heat Exchanger with Smaller Diameter Tubes for Air Conditioner" by Wei Wu, Guoliang Ding, Yongxin Zheng, Yifeng Gao and Ji Song

2. "Simulation-Based Comparison of Optimized AC Coils Using Small Diameter Copper and Aluminum Microchannel Tubes" by John Hipchen, Robert Weed, Ming Zhang, Dennis Nasuta.

More info on "Events" page
www.microgroove.net/events

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Boost ACR Energy Efficiency with Copper MicroGroove Tubes

Achieving Higher Energy-Efficiency with Smaller-Diameter Copper Tubes

Small Tubes of Copper in ACR Applications

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RTPF or BAM

Given set of performance criteria, a round tube plate fin (RTPF) heat exchanger made with smaller diameter tubes can be made smaller and lighter than one made with conventional tubes. Now new research also compares a RTPF heat exchanger with a brazed-aluminum multichannel (BAM) heat exchanger. The method of comparison was simple. A search was made for a state-of-the-art, best-in-class BAM heat exchanger. The performance specifications were then identified and set as a target for the RTPF heat-exchanger. The design space was searched for candidate RTPF designs that met the performance specification were identified. The simulations were performed at Optimized Thermal Systems, College Park, Maryland and the research results will be presented at the Purdue Conferences in July.

This latest research is considered vital by many system designers who wish to compare the best RTPF designs directly with the best BAM designs in terms of size, weight and refrigerant charge reduction. Other factors such as manufacturing costs, durability and drainage must also be considered when selecting a heat exchanger for any particular application.

Step-by-Step Design

A methodical approach to the design of heat exchangers using smaller diameter copper tubes is summarized by the following steps.

Step 1: Determine the best ratio of transverse tube pitch to longitudinal tube pitch by fin efficiency analysis.

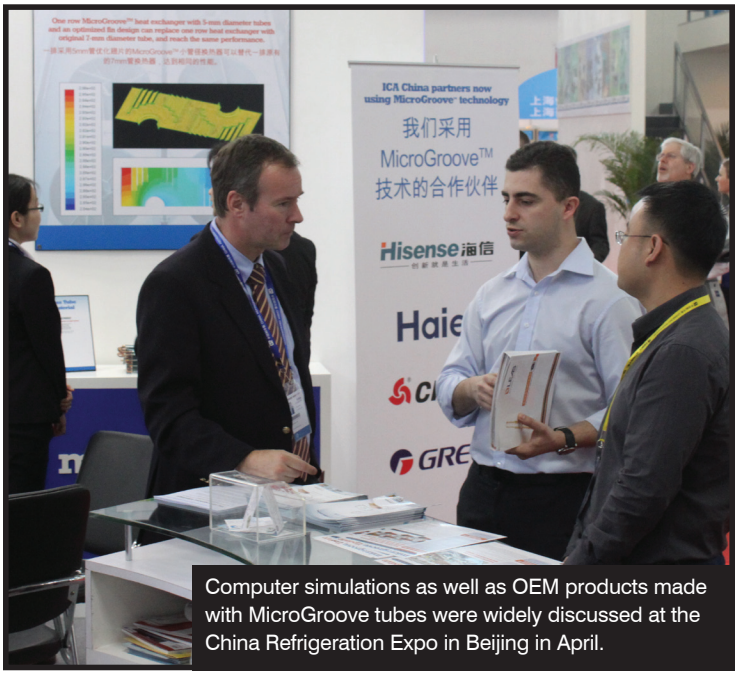
Step 2: Optimize transverse tube pitch and longitudinal tube pitch by analysis of performance and material cost.

Step 3: Optimize fin pattern by comparing performances of fins with different patterns through CFD-based simulations.

Step 4: Test the performance of heat exchanger with smaller diameter tubes.

Step 5: Develop empiric equations for predicting performance of heat exchanger with smaller diameter tubes.

For details about the design principles, attend the Gustav Lorentzen Conference or the Purdue Conferences and see the conference proceedings. Visit www.microgroove.net for information about smaller diameter copper tubes and where to obtain them.



Computer simulations as well as OEM products made with MicroGroove tubes were widely discussed at the China Refrigeration Expo in Beijing in April.

IN THE SPOTLIGHT

Professor G.L. Ding

The Institute of Refrigeration and Cryogenics at Shanghai Jiao Tong University

DING Guoliang (G. L. Ding) was graduated from the Institute of Refrigeration and Cryogenics at Shanghai Jiao Tong University (SJTU) in 1993 and subsequently promoted to professor in 1998. He is the chairman of the Department of Power and Energy Engineering, SJTU; the president of Shanghai Society of Refrigeration; and the editorial board member of three international journals and three domestic journals. At various times, he worked as a post-doctoral researcher and a visiting professor at the University Karlsruhe, in Germany; and as a visiting professor at the University of Tokyo, in Japan.

Professor Ding has published 11 books, about 100 domestic journal papers, and about 80 international journal papers. These publications collectively have received more than 2000 citations. He owns 30 Chinese patents and 4 international patents. His major contributions are simulation and optimization techniques for refrigeration and air conditioning systems. The simulation and optimization techniques developed in his research group have been implemented with significant impact at many of top refrigeration and air conditioning companies in the world.

For more information, visit
www.sjtuirc.sjtu.edu.cn/en/

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