microgroove™ Update

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

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NEW RESEARCH SUPPORTS SIMULATIONS OF AIRSIDE HEAT TRANSFER AROUND MICROGROOVE TUBES

According to the Copper Alliance, important advantages of round tube plate fin (RTPF) coils are ease of cleaning and good condensate drainage.

The "plate fins" of RTPF coils typically are oriented vertically so water drains easily from the top to the bottom of the sheets. The tubes penetrate the sheets at right angles and water easily flows around them. The same holds true for RTPF coils made from smaller diameter copper tubes. There may be more tubes penetrating the plate fins but water flows easily around the smaller diameter tubes.

Airside heat transfer around smaller diameter tubes now can be modeled with unprecedented accuracy. Research supported by the International Copper Association (ICA) and conducted by Optimized Thermal Systems, Inc. (OTS) compares the performance of slit fins and louvre fins for smaller diameter (3 mm to 5 mm) copper tubes.[1,2]

Previously only the largest OEMs could afford to perform coil optimization through CFD modeling. Now, thanks to the Center for Environmental Energy Engineering (CEEE) at the University of Maryland and OTS, techniques for optimizing coil designs are available to users of CoilDesigner®, a highly customizable software tool that allows designers to simulate and optimize the performance of heat exchangers.[3]

OTS works with coil designers around the globe to optimize heat exchanger geometry, including the use of smaller diameter tubes. CoilDesigner includes the latest heat transfer and pressure drop models published in the open literature and users also can plug-in proprietary models. OEM users can shorten product development costs and quickly bring products to market.

RESEARCH ON WAVY FINS

A wavy fin is a plate fin with no holes and so it drains even better. Wavy fin designs have been found to be more effective for heat pumps where the outdoor evaporators may be subject to frosting; and for refrigeration equipment where frosting and condensation cancels the advantages of slit and louvre type fins due to the clogging of the openings. Also, enhanced fins such as slit or louvered fins aggravate the dust accumulation in the condensers of refrigerated display cabinets. Condensers in display cabinets are especially prone to dust accumulation because they are positioned close to the floor.

Supported in part by International Copper Association, researchers at the Institute of Refrigeration and Cryogenics, Shanghai Jiao Tong University, conducted research to examine the feasibility of replacing 9.52 mm copper tubes with 5 mm diameter tubes in the condensers of refrigerated display cabinets.[4]

Wavy fins were chosen for this application because of considerations about dust accumulation. The fin structure was selected by theoretical analysis and the flow path of 5-mm diameter tube heat exchanger was analyzed using a heat exchanger simulation tool to find a suitable balance between heat transfer and pressure drop. The simulation results suggested that cost of the condenser could be reduced by 26 percent using the 5-mm tube with performance the same as the 9.52 mm prototype. The experimental data validated the simulation results, proving the feasibility of applying the small diameter tubes in display cabinets.

In related research, the CEEE investigated the design space for wavy fin heat exchangers having copper tube outer diameters ranging from 2 mm to 5 mm. They found that existing correlations were not applicable to the design space, thus justifying the need for new equations.[5,6]

REFERENCES

1. Shekhar Sarpotdar, Dennis Nasuta, Vikrant Aute, "CFD Based Comparison of Slit Fin and Louver Fin Performance for Small Diameter (3 mm to 5 mm) Heat Exchangers," 16th International Refrigeration and Air Conditioning Conference at Purdue, July 11-14, 2016, Paper 2362.

2. Shekhar Sarpotdar, Dennis Nasuta, Vikrant Aute, "CFD-Based Airside Heat Transfer and Pressure Drop Correlation Development for Small Diameter (3 mm to 5 mm) Louver Fin Heat Exchangers," 16th International Refrigeration and Air Conditioning Conference at Purdue, July 11-14, 2016, Paper 2363.

3. For information on CoilDesigner®, visit the CoilDesigner webpages of CEEE at www.ceee.umd.edu/consortia/isoc/coil-designer; and OTS at www.optimizedthermalsystems.com.

4. Tao Ren, Guoming Wu, Guoliang Ding, Xinqiao Jin, Yongxin Zheng, Yifeng Gao and Ji Song, "Simulation and Application of 5 mm Tube Condenser in Display Cabinet," Fourth IIR conference on sustainability and the cold chain, Auckland, New Zealand, 2016.

5. Daniel Bacellar, Vikrant Aute, Reinhard Radermacher, "Wavy Fin Profile Optimization Using NURBS for Air-To-Refrigerant Tube-Fin Heat Exchangers with Small Diameter Tubes," 16th International Refrigeration and Air Conditioning Conference at Purdue, 2016, Paper 2119.

6. Daniel Bacellar, Vikrant Aute, Reinhard Radermacher, "CFD-Based Correlation Development for Air Side Performance of Wavy Fin Tube Heat Exchangers using 2mm-5mm Tube Diameters," 16th International Refrigeration and Air Conditioning Conference at Purdue, 2016, Paper 2120.

IN THE SPOTLIGHT

SUPER RADIATOR COILS BUILDS COILS FOR LOW-GWP REFRIGERANTS

There is little doubt that the use of hydrofluorocarbons (HFCs) will be phased down. It is only a matter of how soon. Low refrigerant volumes are universally desirable because of the flammability of low-GWP refrigerants. One of the advantages of smaller diameter copper tubes is that they allow for a reduction in refrigerant volume.

Although classified according to ASHRAE 34 as Group A3 (flammable) refrigerant, R-290 is allowable for refrigeration and air-conditioning applications under certain conditions, according to rulings by the US EPA as well as regulatory agencies in other countries. Notwithstanding specific regulations under development, R-290 is expected to be an important eco-friendly refrigerant for the foreseeable future. Safety standards include such requirements as limiting the refrigerant mass per refrigerant loop, eliminating nearby sources of ignition and prohibiting the use of such equipment near points of egress.

The U.S. Environmental Protection Agency's (EPA's) Significant New Alternatives Policy (SNAP) program has proposed to list as acceptable, subject to restrictions, the use of propane in certain commercial refrigeration applications.[1]

MicroGroove technology can help meet the regulatory requirements for R-290 because refrigerant volumes can be greatly reduced by using smaller-diameter copper tubes. Already, in the US, cold display cases and freezers are meeting safety requirement in light commercial applications; furthermore, propane is gaining acceptance for use in room air-conditioning systems too.

A recent article from the Institute of Refrigeration and Cryogenics, Shanghai Jiao Tong University, Shanghai, China reviews research on R290 condensation and evaporation.[2] According to the authors, this review paper is a starting point for future R290 studies and R290 applications in air conditioning systems.

In an R290 air-conditioner condenser application from Super Radiator Coils, MicroGroove allowed for a reduction in refrigerant charge and maintained high burst pressures with thinner walls.[3] Copper usage was reduced up to 26 percent while increasing capacity up to 6.5 percent as tube diameters were decreased from 9.52 mm (3/8 in.) and 7.94 mm (5/16 in.) to 5 mm; and tube walls were thinned from 0.41 mm (16 mils) and 0.33 mm (13 mils) to 0.25 mm (10 mils), respectively.

In another application from Super Radiator Coils, smaller-diameter (5 mm) copper tubes were used rather than conventional-diameter (9.52 mm) copper tubes in a heat exchanger design for an R290 refrigeration system.

According to Dr. Jian Yu, Director of Product Development at Super Radiator Coils, Richmond, Virginia, tube weight was reduced by 30 percent, fin weight by 47 percent and internal volume for refrigerant by 50 percent, [The smaller diameter tubes had an outer diameter of 0.197 inches, or 5 mm and wall thickness of 0.010 inch; the conventional-diameter tubes had an OD of 3/8 inch, or 0.375 inches, or 9.52 mm; and wall thickness of 0.015 inch.]

Manufacturers oftentimes can offer eco-friendly R290 refrigeration systems at the nearly the same cost as refrigeration systems using conventional technology. In other words, thanks to the more efficient, smaller diameter tubes, less material is required to build eco-friendly systems on par with conventional systems of the same cooling capacity.

"The use of MicroGroove smaller-diameter tubes is unlocking the potential for higher efficiencies and less materials usage in many industry sectors, including small and large refrigeration systems as well as residential and commercial air conditioning systems," says Nigel Cotton, MicroGroove Team Leader for the International Copper Association. Manufacturers are seeing the many benefits of harnessing new copper tube technologies in the development of improved ACR systems.

1. SNAP Fact Sheet, EPA Press Release, 29 March 2016. https://www.epa.gov/sites/production/files/2016-03/documents/snap_action_factsheet.pdf

2. Cichong Liu, Ziyang Sun, Ziqi Zhang, Junye Shi, Jiangping Chen, "Review of Condensation and Evaporation of R290," Purdue 2016, Paper 2413.

3. Yoram Shabtay, Jian Yu, Nigel Cotton, "New copper-tube technologies for heat exchangers: R290 condenser coil and R744 gas cooler," Light Commercial Refrigeration Panel, 2016 ATMOsphere America, Chicago, Illinois.