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MICROGROOVE EXCELS IN HEAT PUMP APPLICATIONS

PRESENTATIONS

UPCOMING EVENTS

2017 ATMOSphere America Conference

Jun 5-7, 2017
Loews Coronado Bay Resort, San Diego,
California, USA

IEA Heat Pump Conference

May 15-18, 2017
The World Trade Centre, Rotterdam, The
Netherlands (More info on "Events" page)

<https://www.microgroove.net/events>

WEBINARS

"Advantages of Small Diameter Copper
Tube-Fin Heat Exchangers"
Webinar #1 in the OTS-ICA Educational
Outreach Program (EOP)
View Recorded Webinar
<https://www.microgroove.net/webinars>

"Construction of Small Diameter Copper
Tube-Fin Heat Exchangers"
Webinar #2 in the OTS-ICA EOP
View Recorded Webinar
<https://www.microgroove.net/webinars>

"Effective Design of Small Diameter Copper
Tube-Fin Heat Exchangers"
Webinar #3 in the OTS-ICA EOP
Wednesday, May 24, 2017
Registration
<https://www.eventbrite.com/e/effective-design-of-small-diameter-copper-tube-fin-heat-exchangers-tickets-32742622064>

For more information, see the MicroGroove
"Webinars" webpage
<http://www.microgroove.net/webinars>

Also see MicroGrooveTech YouTube channel
for archive of past webinars
<https://www.youtube.com/user/MicroGrooveTech>



This outdoor heat exchanger for a heat pump benefits from the use of MicroGroove copper tubes. (Courtesy of Lordan.)

Heat pumps offer superior energy efficiency compared to other methods of heating such as boilers, furnaces or electrical-resistance heaters.

The "heat out" of a heat pump is typically several multiples of the "work in." That's because the "heat out" includes the energy "picked up" at the evaporator as well as the "work in" by the compressor. Consequently the coefficients of performance (COPs) for heat pumps are several multiples of one and can be quite high indeed depending on the design of the heat pump and the heat exchangers in the system.

HEAT EXCHANGERS FOR HEAT PUMPS

Both condensers and evaporators often use round tube plate fin (RTPF) heat exchanger technology. The higher heat-transfer coefficients of smaller-diameter tubes compared to larger-diameter tubes allows for one or more of the following advantages: smaller overall size, higher system performance, less copper tube and less refrigerant volume.

For space heating and space cooling, the condenser and evaporator both benefit from the known MicroGroove advantages, including the ability to easily shed the condensate from the evaporator. In a combined AC/HP system, this advantage exists in both heat exchangers since their functions change as the operating mode changes from air conditioner to heat pump. For the air-conditioner mode, the evaporator is indoors. For the heat pump mode, the evaporator is outdoors.

A hot water heat pump (HWHP) typically includes a heat exchanger for the evaporator, which collects heat from ambient air sources; and a heat exchanger either wrapped around the outside of the water tank or submersed inside the water tank. For HWHPs, smaller diameter tubes make sense only if multiple tubes are used in parallel, to alleviate the higher pressure drop of smaller diameter tubes in long lengths.

CANDIDATE APPLICATIONS

Possible candidates for adopting MicroGroove technology in heat pump applications include the following:

- Residential HP for space heating and cooling
- Residential HPWHs
- Commercial HPWHs
- HP with eco-friendly refrigerants
- HP with natural or chemical-free refrigerants
- HP with phase-change materials

ADVANTAGES OF MICROGROOVE

MicroGroove increase the COP of heat pumps, in several ways. In the case of an air-to-air HP, the advantages are the same as for AC unit. In the case of HPWH, the unit will benefit from a MicroGroove evaporator. In both cases, MicroGroove heat exchangers offer high heat-transfer coefficients, more compact coils, and lower power requirements for fans.

MicroGroove is especially competitive with MicroChannel in heat pump applications. That's because a heat pump with a MicroGroove condenser and evaporator will have no problem shedding condensate in either AC or HP mode of operation, unlike a MicroChannel heat exchanger. 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.

The open structure of a round tube plate fin (RTPF) is a major advantage of MicroGroove heat exchangers compared to aluminum microchannel heat exchangers. That's why MicroGroove heat exchangers are commonly used in the outdoor evaporators of heat pumps especially in colder climates where frosting may be an issue.

HEAT PUMP RESOURCES

Previously, Professor Guoliang Ding presented a technical paper at the Eleventh International Energy Agency Heat Pump Conference (IEA HPC) in Montreal, Canada, which was titled "Experimental investigation and structure optimization of distributors used in heat pump air conditioner with microgroove tubes."

This Spring, Yoram Shabtay will present a paper titled "Advanced round-tube, plate-fin (RTPF) heat-exchanger coils contribute to the high efficiency of heat pumps" at the Twelfth IEA HPC in Rotterdam, The Netherlands, May 15-18 2017.

The website www.microgroove.net includes additional Q&A's relating to MicroGroove 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. A special landing page has been established with the focus on the heat pump applications of MicroGroove technology. <http://www.microgroove.net/heat-pumps>

MICROGROOVE ADVANTAGES FOR HEAT EXCHANGERS IN HEAT PUMP APPLICATIONS

Outdoor evaporator	High efficiency and the ability to easily shed condensate
Outdoor condenser	Same advantages as in an AC
Indoor evaporator	Same advantages as in an AC plus the ability to easily shed condensate
Indoor condenser, ATA	Same advantages as in an AC
Indoor condenser, HPWH	Advantage for designs with tube wrapped around water tank currently under investigation

FRIEDRICH AND OTS OPTIMIZE AC COIL WITH COILDESIGNER®



Friedrich and OTS used simulation software to design a drop-in replacement coil for this air conditioning unit.

It has been demonstrated time and again that the use of MicroGroove smaller diameter copper tubes in air conditioning systems results in higher coefficient of performance (COP), less materials consumption, and reduced refrigerant volume. Currently the supply chain for the design and manufacture of high efficiency MicroGroove coils is well established. OEMs today have many options available as they strive to make the transition from large diameter copper tubes to smaller diameter copper tubes.

Friedrich recently engaged with Optimized Thermal Systems, Inc. (OTS) to explore the design space for a drop-in replacement coil for an existing 1.5-ton air-conditioning unit.

As described in an earlier "In the Spotlight" column¹, CoilDesigner includes the ability to design with MicroGroove tubes. In other words, the correlations for both the airside and tube side performance have been programmed into the simulation software, allowing for accurate simulations to be performed for a wide range of tube sizes and types as well as for a wide range of fin designs.

Using the new correlations available for CoilDesigner, Friedrich and OTS began tackling the problem of how to improve the COP of existing products. A drop-in replacement was desirable so that the system COP could be rapidly improved

without redesigning the whole system. Friedrich wanted to determine which designs made the most sense in terms of lowering materials costs and increasing COP for a drop-in replacement coil.

The existing design for the window-type air conditioner consisted of three rows of conventional copper tubes with 17 tubes per row. These conventional tubes had outer diameters (ODs) of 5/16 inch (7.93 mm). Friedrich needed to increase the EER of the baseline unit in order to meet the regulatory requirement for this type of air conditioning system.

Simulations and experiments showed that a quick solution would be to add another row of conventional tubes, which would increase the EER by 3.5 percent. But the mass of copper tubes (excluding u-bends and connecting tubes) would be increased from 3.97 pounds to 5.29 pounds (1.80 kg to 2.40 kg). That's a 33 percent increase in the amount of copper in the system! The mass of the coil, including copper plus aluminum, was increased from 9.5 pounds to 12.7 pounds (4.3 kg to 5.7 kg, an increase of 34 percent).

As a result, OTS proposed a number of configurations made with 5-mm OD MicroGroove tubes, which were simulated in CoilDesigner. Friedrich had access to suppliers who could make the coils with either slit fins or louver fins. Working with OTS and supported in part by the International Copper Association (ICA), many coils were simulated and several of the best candidates were built to confirm the performance through laboratory testing.

The MicroGroove coils typically had four rows of tubes with 25 tubes per row for a total of 100 tubes. Compared to the baseline design, one configuration reduced the total internal volume of the tubes from 0.041 cubic feet to 0.032 cubic feet (1.16 liters to 0.91 liters) while

pushing the COP up by 4 percent; and, at the same time, the total mass of the coil was reduced from 3.97 pounds to 3.21 pounds (reduction of 19 percent). The total mass of the coil (including aluminum plus copper) was reduced from 11.01 pounds to 6.98 pounds (4.50 kg to 3.16 kg, a reduction of 36 percent).

The upshot is that the smaller diameter tubes reached the target COP while decreasing the amount of copper by nearly one-fifth; rather than increasing the amount of copper by one-third.

The simulation software also compared louver-fin designs with slit-fin designs and variations of fin pitches. The final choice of fin design will be dictated by manufacturing considerations and discussions with suppliers. Also, the simulations favored circuitry with five circuits rather than four.

The final choice will be made by Friedrich. Using the CoilDesigner software, this choice can be made with confidence that the final product will meet the desired performance criteria.

"We are seeing more and more manufacturers making the transition to MicroGroove. What is optimal in terms of fin design and circuitry differs from OEM to OEM, depending on the positioning of their products in the marketplace," says Nigel Cotton, MicroGroove Team Leader for the International Copper Association. "What seems to be universally accepted is that MicroGroove tubes offer compelling advantages both in term of COP and materials usage."

REFERENCES

1. *MicroGroove Update*, Vol 5, Issue 1, "CEEE'S CoilDesigner Now Includes Microgroove"