microgroove™ Update

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

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2017 ATMOsphere America Conference
Jun 5-7, 2017
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San Diego, California
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"Construction of Small Diameter Copper Tube-Fin Heat Exchangers"
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"Effective Design of Small Diameter Copper Tube-Fin Heat Exchangers"
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MICROGROOVE GAINS MOMENTUM IN REFRIGERATION APPLICATIONS FOR SUPERMARKETS AND CONVENIENCE STORES

This grocery store reach in cooler uses MicroGroove Technology with R290. (Courtesy of MTL Cool.)

MicroGroove has a proven track record for air-conditioning applications, especially for residential AC units. Smaller-diameter, inner-grooved copper tubes have been successful in outdoor condenser units and indoor evaporators as well as window-type air conditioners. These are manufactured in high volume and millions sold globally.

More recently, MicroGroove has also been adopted in refrigeration applications. In general, there are two broad types of refrigeration applications where smaller-diameter copper tubes are uniquely well suited to the application. Interestingly, these applications involve the use of eco-friendly, low Global Warming Potential (GWP), natural refrigerants, especially propane (R290 with a GWP of three); and carbon-dioxide (R744 with a GWP of one).

Research and legislation relating to these applications has been underway for many years now and these technologies are on the brink of changing the industry. Indeed, the prediction that MicroGroove technology would be a game-changer in refrigeration is proving out to be true.

Typically, R744 is being used as a refrigerant in larger supermarket applications, while propane is being used as a refrigerant in a wide array of smaller-scale product applications. However, there are also cases where R744 is used in smaller convenience store coolers, particularly in Japan; and propane is being considered for use in larger systems.

SUPER-SIZED, SUPER-STRONG COILS

Large supermarkets are adopting R744 at an rapid pace. The heat exchangers involved are typically large gas coolers, which may be 10 feet wide and 15 feet in length. Already thousands of CO2 refrigeration systems have been installed in Europe and North America too is accelerating the adoption of CO2 refrigeration systems in supermarket applications.

The reasons are simple. Older types of refrigerants have extremely high GWP and supermarket refrigeration systems tend to be plagued with leaks. As restrictions are placed on high GWP refrigerants, maintaining a high-GWP refrigeration system becomes impractical.

These systems today typically use 5/16 in. (7.9 mm) copper tubes which is at the upper range of what is considered "smaller diameter" MicroGroove copper tubes. In some cases already, 1/4 in. (6.25 mm) tubes are used; and gas coolers have also been built with 5 mm copper tubes.

A huge advantage of the smaller diameter tubes is that, for a given tube wall thickness, the hoop strength increases as the diameter decreases. Thus it is possible to make a gas cooler rated for 2000 psi operating pressure (or 6000 psi burst strength). Operating pressures for CO2 are typically three times higher than the operating pressures for HFC refrigerants such as R134, R507, R407, R410 and other refrigerants that will eventually be banned because of their high GWPs.

A supercritical fluid has both gas-like and liquid-like properties. In the transcritical refrigeration cycle, the R744 refrigerant is not condensed into a liquid but rather it behaves like a supercritical fluid. Large transcritical refrigeration systems are under development for a growing number of applications, including supermarkets as well as other industrial and commercial applications.

Gas coolers now require an ambient temperate below 87 ^{0}F (or 31 ^{0}C). In warmer climates, unfortunately, outdoor temperatures can climb above 87 ^{0}F (or 31 ^{0}C); in such cases, the gas cooler can be connected to a booster system. The evaporator of the booster system can be connected to gas cooler keeping the temperature of the gas cooler at 50 ^{0}F (or 10 ^{0}C) or below.

Gas coolers for supermarkets tend to be very large units. Dimensions of 90 inches (7.5 ft., or 2.29 m) by 174 inches (14.5 ft., or 4.42 m) are not unusual for gas coolers with 5/16 inch tubes. Evaporators, which operate at lower pressures, can afford to use larger diameter tubes such as 3/8 inch tubes.

However, there is an industry trend toward smaller diameter tubes , especially quarter inch and 5 mm. Any increase in pressure drop can be easily compensated for by using more circuits.

In the gas cooler there is no liquid state so the gas moves through the tubes with relatively low resistance and relatively low pressure drop.

"Currently, there are several hundred transcritical supermarket systems in use in the US but that number is expected to dramatically increase in the next few years," says Nigel Cotton, MicroGroove Team Leader for the International Copper Association. "This application is especially well suited for copper tubes. As the technology develops, we expect to see smaller diameter tubes being used in all of the components, including the gas coolers, boosters and evaporators."

CO2 is also a candidate refrigerant for smaller scale applications, particularly in Japan, as described in the March issue of *ACCELERATE* "Will CO2 Continue to Surge in Japan?

MICROGROOVE DOMINATES HYDROCARBONS

At the other end of the size scale are the refrigeration systems made with 150 grams of propane (R290). This application has already been quite successful and has widely proliferated in the past few years. Practically every major manufacture of "reach in" cool display cases is offering models with propane as a refrigerant.

The reasons are not hard to see. With a GWP of three, propane is extremely attractive as an ecofriendly refrigerant. It is affordable and readily available.

Smaller diameter copper tubing (typically 5 mm) is exactly what's needed to reduce the refrigerant charge. As a bonus, the efficiency of the system increases. The compressors for this application are widely available. Propane was widely adopted by manufacturers in 2016. Many OEMs have completely revamped their product lines to make way for the increased demand for propane-based refrigeration systems. One of the first was True Manufacturing of O'Fallon, Missouri. Other companies adopting propane include Beverage Air, Fogel, Liebherr. Minus Forty Technologies Corp., Traulsen, Turbo Air and Welbilt (formerly Manitowoc).

See the story "OEMs Flock to Hydrocarbons" in March 2017 issue of *ACCELERATE* for more about OEMs who have adopted propane into their product mix. Also, see this month's "In the Spotlight" focus on MTL Cool. Major brands and store chains too are aligning with this eco-friendly refrigerant.

MOTIVES FOR SWITCHING TO PROPANE

The phasedown of HFCs by such regulations as the F-Gas regulations of the European Union, the SNAP process of the EPA and the Kigali Amendment to the Montreal Protocol contributed the interest in low-GWP hydrocarbons such as propane.

Yet it is the attractive physical properties of propane that have led to its quick adoption, once the regulatory hurdles in favor of propane and against HFCs were in place. Its excellent thermodynamic properties and the fact that it is readily available and affordable are important factors. Refrigeration systems that use propane as a refrigerant have high-efficiency and high-performance. They have also proven to be extremely reliable.

Although propane is classified as an A3 flammable refrigerant, it is safe to use when proper protocols are followed. Propane is not a drop-in replacement. The refrigeration systems must be specifically designed for R290 and comply with the charge limit of 150 grams. The low-charge limit restricts the use of propane to refrigeration systems with fractional horsepower compressors. This is okay for convenience store applications but for large applications multiple independent refrigeration circuits must be used.

Currently, a working group within the International Electrotechnical Commission (IEC) is developing a standard that would allow for 500 grams of propane to be used in refrigeration systems. If accepted, the new standard could be published in 2018 and as a reference standard it could influence standards issued in the U.S. for example by the EPA and Underwriters Laboratories (UL).

We can expect that propane will play a key role in refrigeration systems for many years to come. As MicroGroove tubes and coils are uniquely suited for use with propane, particularly with respect to reduced refrigerant charge, the upsurge in the use of propane will also establish smaller diameter copper tubes in the supply chain and contribute to broader use of MicroGroove technology in all types of refrigeration, air-conditioning and heat pump applications.

IN THE SPOTLIGHT

MTL COOL RAMPS UP PRODUCTION OF "NATURAL-REFRIGERANT" REFRIGERATION SYSTEMS USING MICROGROOVE TECHNOLOGY

A few years ago, the engineers at MTL Cool recognized a golden opportunity to meet a demand for high efficiency, low-GWP cooling systems using MicroGroove smaller diameter copper tubes. They recognized two important trends in the refrigeration sector:

1. Progression to smaller diameter tubes for higher efficiency
2. The use of low-GWP natural refrigerants.

Once the EPA SNAP rules that allowed for 150 grams of propane went into effect, the playing field was wide open. The engineers got to work designing the refrigeration systems for supermarket and convenience store applications. MTL Cool developed a complete line of refrigerated cabinets from scratch, including "reach-in" coolers, with or without glass doors. These cooling cabinets are sometimes sold to the store owners; and sometimes branded and sold to the companies that make packaged goods products.

Smaller diameter copper tubes were already being used in the manufacture of residential air conditioning systems. Could the same technology be adapted for use in refrigeration systems using natural refrigerants? MTL Cool had a lot of know-how in the design of process cooling systems, including various types of industrial cooling systems. When its engineers saw the growing market demand for a new generation of commercial refrigeration systems, they began developing a completely new line of products.

The small self-contained coolers from MTL Cool are easy to install and use as bottle coolers or for displaying deli meats, sandwiches and other refrigerated food products. They typically maintain temperatures between 36 ^{0}F and 41 ^{0}F (that is, –1 ^{0}C to 5 ^{0}C).

MANUFACTURING EXPERTISE

According to Mark Bedard, CEO of MTL Cool, the manufacturing of the MicroGroove system is not much different than any other system. There are certain nuances with regard to the cabinet design for enclosing a propane-based refrigeration system. For example, metal-bladed fans or electrical components that could generate sparks cannot be used in the system. Since metal-blade fans are rarely used nowadays anyways, that was an easy requirement to meet.

MTL Cool approached Super Radiator Coils for the coil design and SRC was able to provide prototype heat exchangers for both the evaporator and the condenser.

When the system is charged with refrigerant, it has to be sealed using a (flameless) ultrasonic welding system. Also, the heat exchangers must be thoroughly leak tested. Various other standards must be followed in the cabinet design as outlined in industry standards.

While cost of materials was not a driver in the selection of coil materials, it was happily noted by Bedard that smaller diameter tubes result in a less consumption of materials. Also, reliability was improved because smaller-diameter tubes are stronger tubes.

Initially, there was a shortage of refrigeration technicians and contractors who could service propane-based coolers. This issue has now been remedied and qualified technicians can be found in the field in most regions of the United States, where MTL Cool currently sells most of its products. Furthermore, propane can be vented to the air. It does not have to be recycled because it has a very low GWP and low cost.

The engineers at MTL Cool briefly looked at microchannel aluminum for use as a coil material. However, among other drawbacks, the tendency for lubricant oil to become entrapped in the channels was a major issue.

Overall, MTL Cool has more familiarity with copper and its engineers were more comfortable with its track record for reliability.

NEW FACILITY

MTL Cool is rapidly expanding to meet the demand for its propane-based MicroGroove cooling systems. A new factory under construction in Chambly, Quebec, outside of Montreal, is slated to go into production in the summer of 2017. As the volumes, increase the company may consider bringing the coil manufacturing inside. "For now, we are content with buying our coils from trusted suppliers, including Super Radiator Coils," says Bedard.

There may be a point where production volumes are high enough to consider investing in coils manufacturing equipment. According to Bedard, the 150 gram limit still allows for the use of propane-based refrigeration systems in a wide range of applications. This amount is sufficient for most of the refrigeration needs in convenience stores, which is a huge market, and many grocery store applications, where individual cabinets each with its own compressor can be installed. If the propane weight limit is increased to 500 grams, which has a good chance of happening, then a whole array of additional products could be manufactured with MicroGroove technology.