Research Focuses on Reducing Refrigerant Charge and Increasing Energy Efficiency Using Smaller Diameter Copper Tubes

Manufacturers are highly motivated to cost-effectively manufacture heat exchangers that will operate with low refrigerant-charge and high energy-efficiency. Improved computer simulations and correlations with laboratory experiments are aiding in the development of coils suitable for use with ecofriendly refrigerants.

Computer Simulations

Airflow around smaller diameter tubes faces less resistance than airflow around traditional tubes. 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 such coil optimization through computer 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].

Simulation software uses correlations developed for both airside and refrigerant side heat transfer, building on the research results from many laboratories around the globe. The prediction accuracy of such simulations depends on the availability and accuracy of these correlations.

Laboratory Experiments

The properties of low-GWP refrigerants inside smaller diameter copper tubes are being measured at various laboratories around the world, including the University of Padova, Padova, Italy[4, 5]; Tokyo University of Marine Science and Technology[6]; and Kyushu University, Fukuoka, Japan[7].

The Padova group measured flow boiling heat transfer and pressure drops inside smaller diameter copper tubes. Measurements were made on copper tubes with an outer diameter (OD) of 5 mm for R134a refrigerants[4]; and on copper tubes with an OD of 4 mm for HFO1234ze(E) refrigerant[5].

The Tokyo research measured pressure drops and evaporative heat transfer coefficients for R32 refrigerant passing through 4 mm OD copper tubes with a broad range of internal enhancements, including "microfin" heights of 0.1 mm and 0.2 mm[6].

Meanwhile, the Kyushu group measured heat transfer coefficients for mixtures of R32 with HFOs[7]. These refrigerant blends are likely to play an important role in future air conditioning and refrigeration systems. The microfins in the 4-mm diameter copper tubes had heights of 0.26 mm.

The Future of Refrigerants

Refrigerant cost versus global warming potential (GWP) is coming to a climax. The HFOs have ultralow GWP and factually are less flammable than R32; however, they are currently more costly because production of these compounds has not been scaled up. Meanwhile, R32 is cheaper and more widely available but it is more flammable and has a much higher GWP. 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 requirements in light commercial applications.

References

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