Small-Diameter Round Tube Plate Fin Manufacturing Goes High Tech

The round tube plate fin (RTPF) coil has a long and rich history within the ACR industry. More recently, ACR product efficiency has been increased using smaller-diameter copper tubes in RTPF coils and highly sophisticated equipment for handling such tubes has been developed.

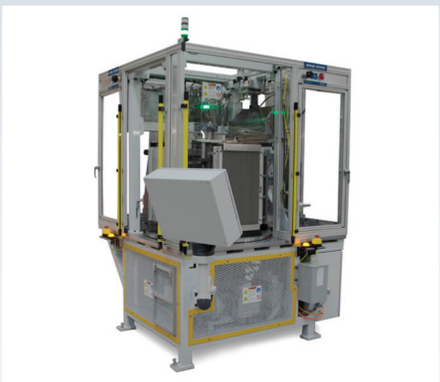
Now the technology is about to take a huge step forward with the introduction of new equipment for pressure expansion from Burr OAK Tool Inc. This new equipment already has been launched in China, Japan, Thailand and India and will be the focus of OAK's exhibit at the AHR Expo in Orlando in January.

"The development of the manufacturing equipment to build RTPF heat exchangers in high volume has changed the face of the ACR industry and laid a firm foundation for the continued use of smaller diameter copper tubes," says Nigel Cotton, MicroGroove Team Leader at the International Copper Association. "We welcome equipment advances such as Burr OAK's pressure expansion equipment, which will make the production of MicroGroove coils more efficient and open the door to new applications."

Tube Expansion, Bullet Method

The preferred method for joining tubes and fins is through a process of tube expansion to generate an interference fit between the tube and the extruded fin collar. This expansion is typically performed using a spherical "bullet" that is pushed through the tube by a smaller diameter rod. The bullet diameter is larger than the original tube inside diameter, causing the tube to expand.

Early adopters of small diameter tubes faced challenges in the expansion process, which led to development of "limited-shrink" expansion by OEMs. This approach enabled successful expansion by placing the tube in tension to prevent buckling and to control shrinkage. The proper balance of bullet friction force and tube tension also allows zero shrinkage of the tube.



The **Phoenix** expands smaller-diameter copper tubes using high pressure. (Photograph Courtesy of **Burr OAK Tool Inc.**)

Non-Invasive Tube Expansion Breakthrough

The method of using pressure to expand tubes is commonly used in the hydroforming industry where containment for the final tube shape is determined with dies that encapsulate the material. In the case of expanding MicroGroove tubes into fins, the fin collar provides the necessary containment, resisting expansion and establishing a secure bond between the tube and fin.

Jason Halling, Manager of Business Development & Marketing at Burr Oak Tool Inc., explains that pressure expansion is not a new process to the HVAC industry. Some manufacturers routinely use pressurized fluids to expand coils. "This solution has inherent benefits that the industry will use to take MicroGroove to the next level," states Halling.

Zero Shrink Process

Pressure expansion is inherently a zero shrink process. Lévy-Mises equations describing plastic flow in material are used to show that a tube experiences zero lateral strain while pressure is applied to expand the tube diameter plastically[1]. In effect, the internal pressure that causes hoop stress in the tube resulting in expansion of the tube diameter also places tension on the tube, in the precise amount needed, to prevent the tube from shrinking.

Better Contact with Fins

Tang, Li, and Peng of the School of Mechanical Engineering in Shanghai have studied the effect of collar compression[2]. Test results indicate improvements in the tube-to-fin contact of coils that are expanded with the non-invasive pressure approach rather than mechanical bullet expansion.

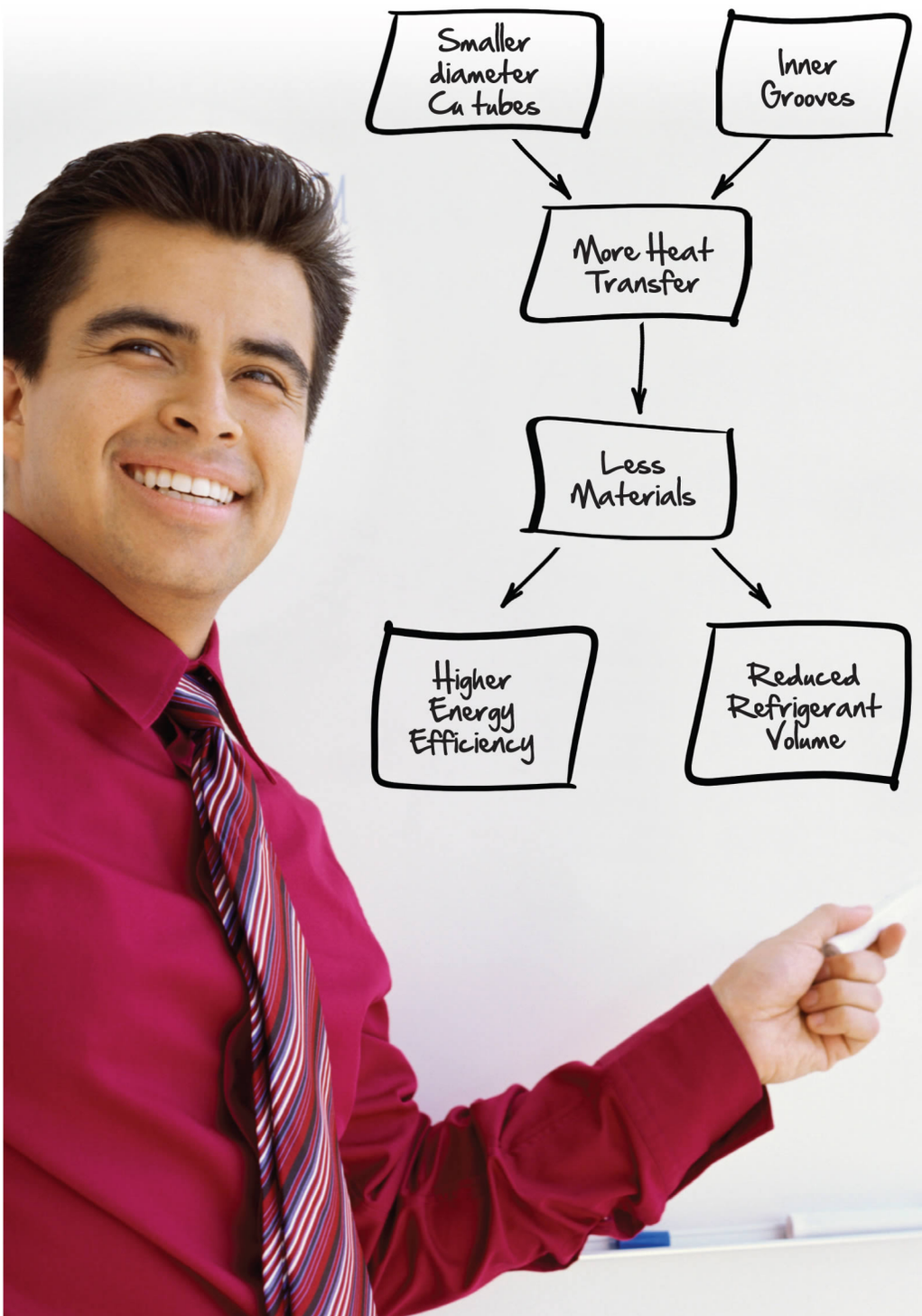
No Deformation of MicroGrooves

Another advantage of using pressure to expand tubes is that the internal tube enhancements are not disturbed as they are when using a mechanical bullet. For the bullet method, the stresses exerted in the internal enhancements of the tube are significant. The bullet method could deform the tops of fragile types of inner fins. Expanding tubes with pressure enables tube manufacturers and researchers to explore new designs of surface enhancements.

It can be seen then that the use of a non-invasive expansion process opens the door to the use of more delicate inner-fin structures. The immediate effect is that existing enhancements will be unaffected by the manufacturing process. This phenomenon is already being tested in joint research by the ICA, OTS and BOTI, to determine what effects, if any, the method of expansion method has on the performance of surface enhancements and the values of heat transfer coefficients[3].

1. Frank L. Kraft and Tommy L. Jamison, "Mechanical Behavior of Internally Pressurized Copper Tube for New HVACR Applications," *Journal of Pressure Vessel Technology, ASME*, December 2012, Vol. 134 / 061213-1.
2. Ding Tang, Dayong Li, Yinghong Peng, "Optimization to the tube–fin contact status of the tube expansion process," *Journal of Materials Processing Technology*, 211 (2011) 573–577.
3. "A Review of the Influence of Microfin Enhancements on the Condensation Heat Transfer Coefficient for Small Diameter Tubes," unpublished report from OTS and Burr Oak Tool Inc., 2015. Available from microgroove.net.

the microgroove™ advantage



IT'S A GAME CHANGER

MicroGroove™ technology is changing the game of air conditioning and refrigeration (ACR) OEM product design.

OEMs are going back to their drawing boards. They are designing ACR products with high energy-efficiency, while minimizing materials usage and reducing refrigerant volume.

The resulting ACR products are smaller and lighter yet can be produced using familiar manufacturing methods.

It's a whole new game!

For more information, or to join a free webinar, visit

www.microgroove.net.

Join us on LinkedIn via microgroove.net

SEE US AT BOOTH 1293

2016 JAN 25-27 AHR EXPO ORLANDO

International Copper Association
Copper Alliance






Available from a range of suppliers.
For more information visit:
www.microgroove.net