New Products

Furukawa Multi-Grooved Tubes

1. INTRODUCTION

Heat exchangers, a key component of room air-conditioners and packaged air-conditioners, make use of tubes with grooves on the inner surface to both improve heat-exchange performance and decrease power consumption. Furukawa Electric markets these as Furukawa Multi-grooved Tubes.

Furukawa multi-grooved tubes are heat transfer tubes with large number of minute grooves formed on the inside surface in spiral form, as shown in Figure 1, and they have a much higher heat transfer coefficient than smooth heat transfer tubes, which have a smooth inner surface.

2. Product Evolution

When tubes with a grooved inner surface were originally developed, the groove configuration was, as shown for Type A in Table 1 featured and outside diameter of 9.52 mm, a shallow groove depth of only 0.15 mm, and an obtuse peak angle.

Toward the late 1980s, however, there was a demand for air-conditioners that were smaller and more energy efficient, leading to the use the widespread use of multi-grooved tubes with an outside diameter of 7 mm in heat exchangers. To gain higher performance per unit of tube,

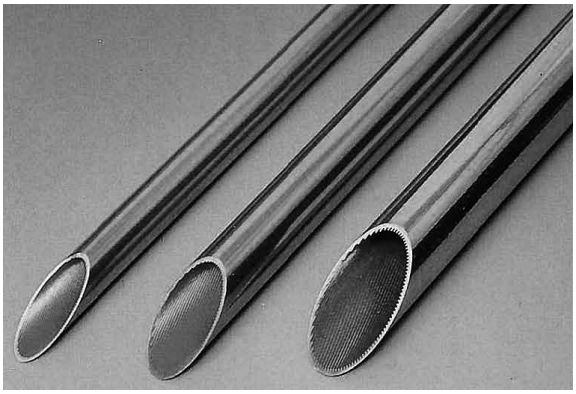
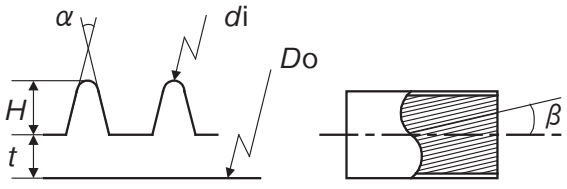


Figure 1 Furukawa multi-grooved tube.

Table 1 Evolution in groove configurations.

Year developed	Type	Outside diameter (mm)	Thickness at trough (mm)	No. of grooves	Lead angle (°)	Depth of groove (mm)	Peak angle (°)	Unit weight (g/m)	Cross sectional configuration
1980	A	9.52	0.28	60	25	0.15	90	89.0	
1988	B	7.00	0.23	56	14	0.26	15	57.8	
2000	C	7.00	0.23	50	30	0.24	15	56.3	



Location of measurements

H : depth of groove
t : thickness at trough
α : peak angle
β : lead angle
Do : outside diameter
di : inside diameter

a method was then adopted whereby multiple grooves having a sharper angle, as shown for Type B, were formed on the inner surface of the tube, thereby increasing internal surface area and improving heat transfer performance, and groove depth was increased to 0.26 mm.

Around 1997 air-conditioners using alternative refrigerants (R410A and R407C) came to the market. These alternative refrigerants were developed from a concern for protecting the environment, and did not present a risk of damage to the ozone layer, in contrast to the CFC (R12) and FCFC (R22) refrigerants that had been used in air-conditioners up till that time. Influenced by this, our company, for its part, marketed the Furukawa multi-grooved tube, having grooves formed in the inside surface. Conventionally, improvements in performance were effected by forming deeper grooves in the inside surface, but in these new tubes, such as Type C, we increased the lead angle (the angle made between the spiral grooves inside the tube and the axis of the tube), effectively agitating the refrigerant flowing through the tube to promote heat transfer, thereby improving performance. Since the replacement refrigerants were mixtures of two or three refrigerants of differing saturation temperatures, the technique of increasing the lead angle to improve performance proved extremely effective. At present, almost all Furukawa multi-grooved tubes in mass production are of this type.

3. PRODUCT FEATURES

3.1 Principal Multi-grooved Tube Configurations

Table 2 shows configurations representative of those that Furukawa Electric can mass-produce. In the last few years the effects of the rapidly increasing cost of copper have made reducing the amount of copper used in grooved tubes and other components of air-conditioning systems an important issue. We at Furukawa Electric have reduced tube diameter in an effort to lighten tube weight, and have extended our mass-production capability to outside diameters of 5 mm. If the grooves formed inside the tube are of the same configuration, reducing the outside diameter from 7 mm to 5 mm will result in a reduction in unit weight (weight per unit of length) of about 25 %.

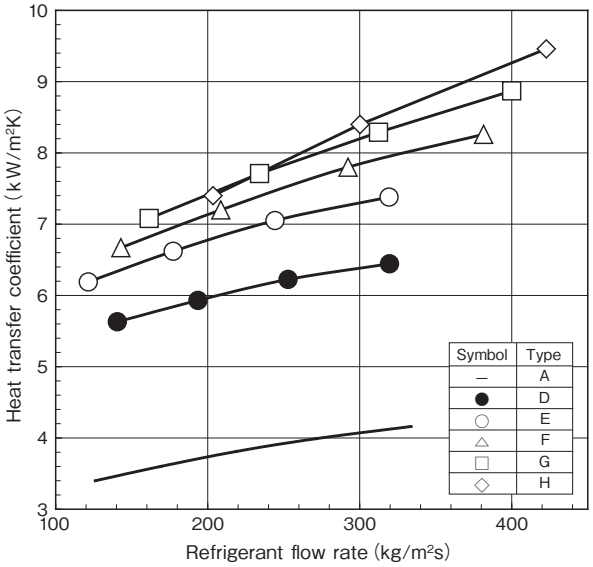


Figure 2 Internal condensing heat transfer coefficient.

Table 2 Measurements and configurations of representative Furukawa multi-grooved tubes.

Type	Outside diameter (mm)	Thickness at trough (mm)	No. of grooves	Lead angle (°)	Depth of groove (mm)	Peak angle (°)	Unit weight (g/m)	Unit weight ratio (%) *	Cross sectional configuration
A (original)	9.52	0.28	60	25	0.15	90	89.0	100.0	
D	9.52	0.28	60	30	0.18	20	81.5	91.6	
E	7.94	0.26	65	30	0.15	12	63.0	70.8	
F	7.00	0.23	65	35	0.15	11	50.9	57.2	
G	6.35	0.23	55	34	0.18	12	47.1	52.9	
H	5.00	0.23	52	38	0.15	13	37.5	42.1	

* As a percent of the unit weight of Type A

3.2 Heat Transfer Performance of Multi-grooved Tubes

Figure 2 shows the internal condensing heat transfer coefficient of the multi-grooved tubes in Table 2. Compared to the tubes as originally developed, performance has been improved by as much as 200 %.

4. PRODUCT DEPLOYMENT

Multi-grooved tubes are primarily used in room air-conditioners for household use and for packaged systems for commercial use, but with greater energy efficiency of various types of heating and cooling equipment, their application has extended to heat exchangers for refrigerators, automated vending machines, showcases, dryers, and so on. More recently that are also used in electric water heaters and “Ecocute” to heat water for a type of air-conditioner that has recently been seen as a promising approach to global warming prevention.

5. CONCLUSION

It is possible to design and deliver multi-grooved tubes that offer the desired performance and unit weight. We are also establishing systems that will enable us to provide technical support for tube expansion processing and other peripheral technologies for multi-grooved tubes.

For more information, please contact:
No. 2 Sales Department, Metals Company, Furukawa Electric
TEL: +81-3-3286-3836 FAX: +81-3-3286-3663