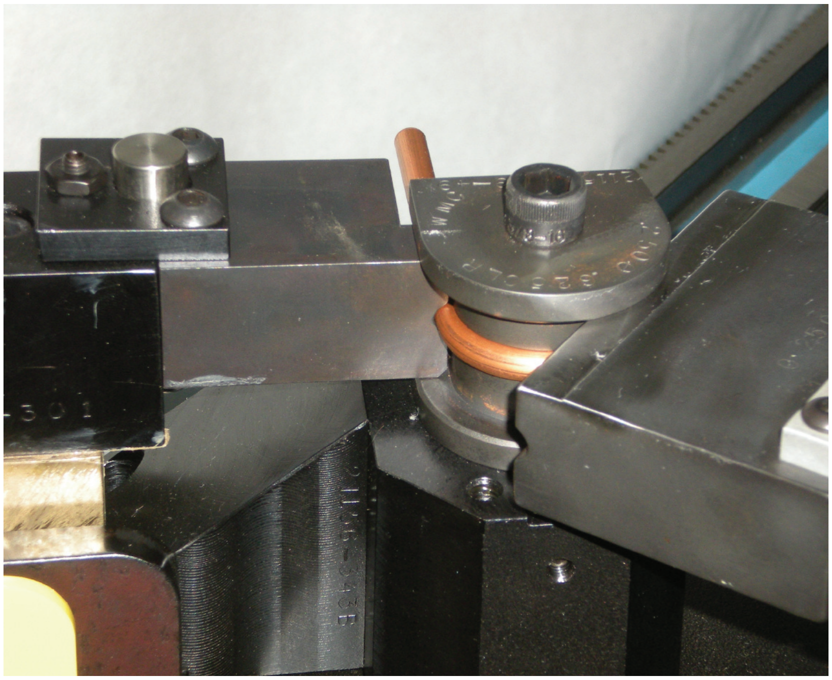
BENDING SMALL-DIAMETER COPPER TUBING

Preventing wrinkles

By George Winton, P.E.



COPPER, which is one of the softest metals, is used to make tubing for many applications, such as refrigeration, laboratory, and processing. Soft metals are easier to bend than hard medals, but softness is a disadvantage when making a tight-radius bend. A soft metal can be especially troublesome when bending tubing smaller than 3/4 inch in diameter

A tight-radius bend for copper is any bend with a radius equal to or less than approximately 2.5 times the tube's OD (that's 2.5D in tube fabricating jargon). The D of bend is the result of dividing the bend's centerline radius (CLR) by the tube's OD. For example, a bend with a 1.25-in. CLR on ½-in.-OD tubing equates to 2.5D of bend. A small CLR uses less material than a large CLR, and therefore is a big advantage concerning the cost of goods.

So, when can you use a bend radius of 2D and when should you consider a larger radius? The answer lies, in part, in a tube characteristic known as the wall factor.

WALL FACTOR FACTS

The wall factor is simply the ratio of the tube's OD to its wall thickness, abbreviated D/t.

In other words, when you compare several tubes with the same diameter but different wall thicknesses, thinner-walled tubes have larger wall factors than heavier-walled tubes. For example, a ½-in.-OD tube with 0.035-in. wall thickness has a wall factor 0.5/0.035, or 14.3; a ½-in.-OD tube with 0.050-in. wall thickness has a wall factor 0.5/0.050, or 10. As the wall thickness increases, the wall factor decreases.

The wall factor provides a way to predict a tube's likely reaction to bending forces. When you bend copper to a tight radius, a wall factor greater than 15 is likely to result in wrinkles on the inside of the bend. Increasing the CLR increases the likelihood of a successful bend. Therefore, the wall factor should not exceed 15 when bending copper tubing to a 2D radius without a mandrel.

It is possible to bend such a tube to a smaller radius, but for consistent production results, keeping the D of bend greater than 2 can prevent several long-term headaches.

OTHER FACTORS

Other factors affect the bend quality, of course. The material's yield strength directly influences the likelihood of wrinkles. The compressive forces on the inside of the bend in copper tend to give way sooner than for harder metals as the CLR becomes smaller. For example, a ½-in.-OD aluminum tube with a 0.035-in. wall often can be bent to a tighter radius than a copper tube of identical size. This is because the aluminum can withstand greater compressive forces on the inside of the bend before the inside wall starts to wrinkle.

Also, the carriage position on a CNC bender can influence wrinkles in copper. If the carriage is too far from the pressure die during nonmandrel bending, wrinkles may develop. This is related to the copper's softness. Therefore, adjusting the carriage to a greater CLR can eliminate wrinkling. This becomes evident when a CNC tube bender's carriage releases the tube before the last bend is made. After the tube is released, the carriage no longer supports the tail end of the tube, and wrinkles result.

Plotting the relationship between the CLR and the tube's diameter reveals a line of demarcation that runs through the graph (see **Figure 1**). CLR and tube diameter combinations in the lower right-hand half of the graph are prone to wrinkles;

combinations in the upper left-hand half of the graph are not. With the right tooling, you can bend copper successfully to 2D up to ½ in dia. If the diameter is greater than 9⁄16 in. and the wall factor is greater than 15, a minimum CLR of 2.5D is recommended.

When bending tube to 2D, it may be necessary to use some type of crown tooling, which prevents flattening on the outside of the tubing in the bend zone. Flattening usually is a problem on the outside diameter as the CLR decreases for a given tube diameter and wall thickness. TPJ

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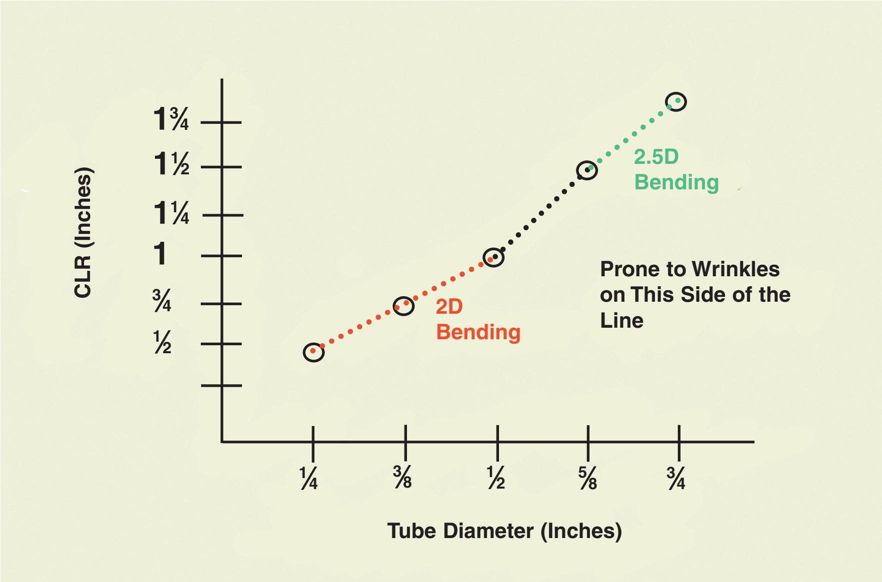

Figure 1
Preventing wrinkles in copper tubing is a matter of finding the right combination of two main factors, centerline radius (CLR) and tube diameter. Other factors that influence the likelihood of wrinkles include the D/t ratio (wall factor) and bender setup.