TOGGLE OR DIRECT-ACTING CLAMPING?

Options for securing a tube for bending

By George Winton, P.E.

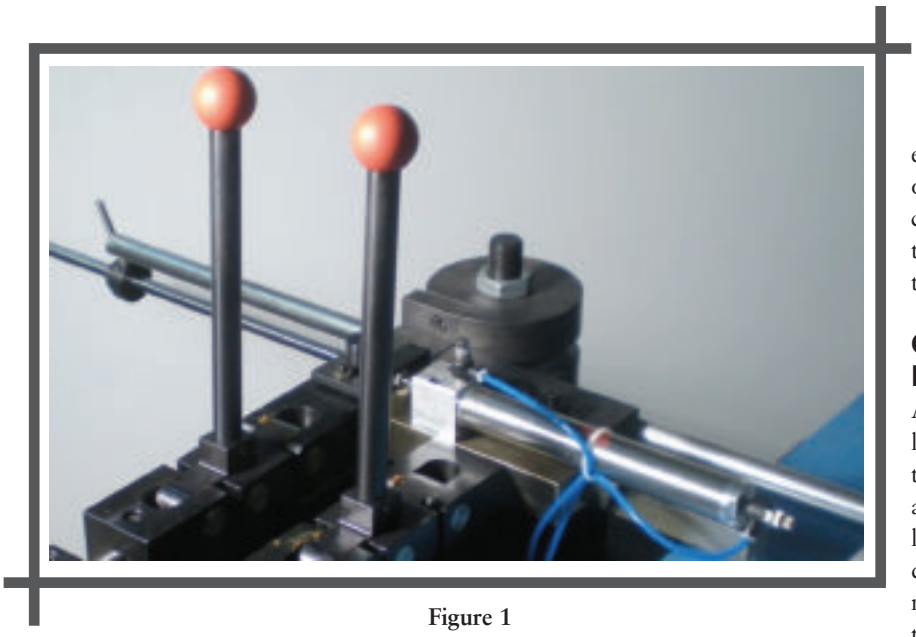

Figure 1

This manual tube bender uses an over-center toggle device to clamp the tube.

OVER the decades tube rotary draw bending machines have made use of numerous devices to clamp a tube in position as it is being bent. For example, the clamp die is designed to clamp the tube firmly to prevent it from slipping relative to the bend die as the bend die rotates. Another example is the pressure die; its primary job is to hold the tube firmly against the bend die while at the same time the clamp die helps pull the tube around the bend die. Yet another device is the split die actuator, which must remain closed while a tube is being bent. All three of these tools must remain rigid under loading.

Machine tool builders predominately make use of one of two approaches to secure the workpiece: a direct-acting cylinder or an over-center toggle mechanism (see **Figure 1**). Understanding the differences between the two approaches can influence bend quality.

DIRECT-ACTING CYLINDER

An example of a direct-acting application is a hydraulic cylinder that pushes directly against a clamp die (see **Figure 2**).

The hydraulic pressure developed by the cylinder has a direct influence on the amount of force that the clamp die exerts against the tube. Increasing the hydraulic pressure increases the clamping force. The amount of clamping force can be controlled easily by a microprocessor, which is advantageous when bending thin-walled tubes.

An alternative uses a ball screw and an electric servomotor. This type allows the operator to adjust the clamping force by changing the amount of power applied to the servomotor. It's a green alternative in that it uses no hydraulic fluid.

OVER-CENTER TOGGLE MECHANISM

An over-center toggle mechanism is similar to a DE-STA-CO clamp. The over-center approach makes use of a mechanical advantage, like that used by any common lever. The amount of clamping force it develops is much larger than the force needed to close it. The clamping force, in turn, can prevent the tube from moving during bending (see **Figure 3**).

Most over-center devices have some sort of pressure adjustment via a manually adjusted screw.

However, this doesn't necessarily provide the fine touch needed to bend thin-walled tubing to a tight centerline radius. A direct-acting clamp or pressure die (or both) allows the small pressure adjustments that often are necessary to make a complex bend successfully.

Despite the lack of fine adjustment, over-center toggle mechanisms have several advantages. First, this type of system gives the operator a visual confirmation that the mechanism is engaged and providing clamping force. Second, it is suitable for a range of wall thicknesses; it works well for thick-walled tubing and can provide the force necessary to pinch thin-walled tubing.

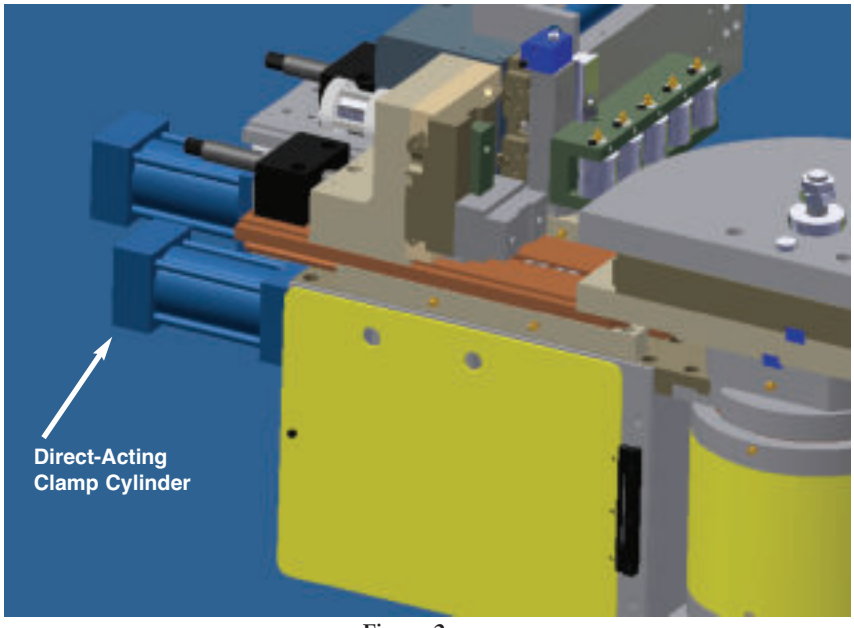

Figure 2
This direct-acting clamp cylinder uses hydraulic pressure to apply clamping force.

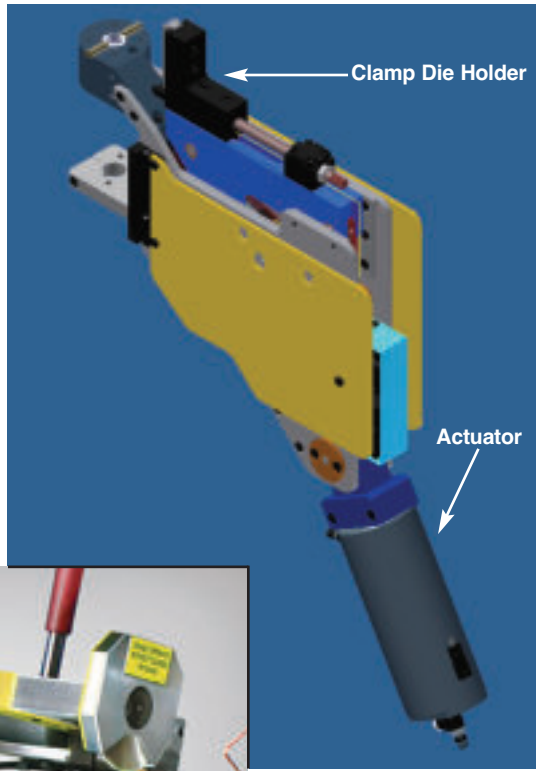

Figure 3
On most toggle-type mechanisms, the actuator is mounted below the clamp die holder and therefore is not direct-acting.

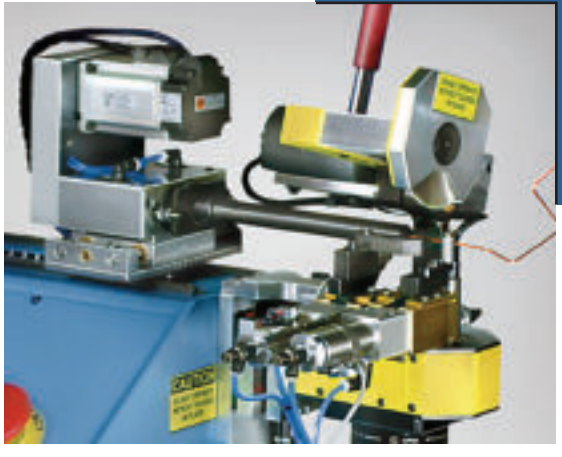

Figure 4
A pneumatically powered, direct-acting clamp and pressure die are suitable for bending ⅛-in. copper tubing. Increasing the workpiece size or material hardness decreases the likelihood that pneumatic power will be sufficient.

PRODUCING THE HOLDING FORCE

Whether the clamp is direct-acting or over-center, three types of actuator commonly are used to create the holding force: pneumatic, hydraulic, or all-electric. They have a variety of pros and cons.

A direct-acting pneumatic actuator requires an air source and generates substantial noise. Also, because air is compressible, the air may compress in the middle of a bend (allowing the clamping cylinder to move), which can lead to wrinkles in the bend zone.

A hydraulic system can run quieter and maintains pressure, but uses hydraulic fluid, so it comes with the costs associated with purchasing and disposing of the fluid and the time spent cleaning up occasional spills. An electric system is the quietest of the three types and doesn't use hydraulic fluid, but it comes with a higher initial price tag and requires a different set of troubleshooting skills.

A pneumatically powered, direct-acting clamp die may work well when working with an easily bent material, such as ⅛-in. copper tubing (see **Figure 4**). The tubing is light and malleable, and 80-pounds-per-square-inch (PSI) shop air is sufficient for applications of this sort. However, 80 PSI wouldn't handle 1-in.-dia. steel tubing on a 2-D bend. The air's compressibility may be the cause of several process problems.

An over-center toggle mechanism works well for most bending applications. However, some cases require the gentle touch of a direct-acting mechanism. When considering purchasing a bending machine, it's important to consider the requirements of the bending applications, the capabilities of the machine, and the versatility of the clamping system.

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