All-electric tube benders in control

A look under the hood at characteristics, applications

By Terry Pickering

All-electric tube bending machines have performance characteristics that provide software-based control over the bending process, which provides high accuracy combined with short and repeatable machine set up, plus low power consumption and no toxic waste problems.

All-Electric Architecture

All-electric technology was developed to eliminate the need for the ‘black art’ usually required to set up a tube bending machine. Under certain circumstances, tools can be changed and a new part made in less than three minutes, for instance.

In order to achieve this, all-electric machines use electric closed-loop servo-motor axes to control the motion and speed of the bend tooling, providing programmable control over the complete range of each axis. This allows operators to make machine adjustments to the bending process from the control screen, instead of with a wrench. Otherwise, the machines employ the same basic design concept of a hydraulic tube draw bender - which has not changed significantly for 50 years.

Rotary or draw bending produces a smooth, high quality bend on a tube by means of a set of die tools, plus a flexible mandrel inserted into the tube which protects against distortion and collapse. The dies used are: a former - or bend die - around which the tube is bent; a clamping die which holds the tube in place against the former while it rotates; a pressure die which follows the tube as it bends around the former; and a wiper die which smoothes the material as it flows to create the bend, preventing wrinkling. The pressure die has two axes of control, one to react to the bending force applied, and one to allow it to follow the tube. In an all-electric machine, programmable control over the following movement profile provides a powerful degree of flexibility to help optimize tube bending. Machines also have programmable control over the carriage position (which holds the tube) and carriage rotation, which is applied as necessary between bends to create the desired 3-D shape.

Precise Control

With servo motors, built-in position and velocity feedback loops ensure that the position and movement of the tooling on the axis is always maintained to a very fine resolution, regardless of variations in operating conditions such as temperature. This control can, for example, allow positioning to 1/100th of a millimeter when the motor drives a ball screw to position the tool. This fine control over the position of axes can be an advantage in precision fabrication applications such as in aerospace manufacturing.

Additionally, electric servo-motors allow the operator to control the torque of the motor during the tooling motion. Often, this can be used to advantage to prevent finished part damage, by varying clamp forces at different positions in the cycle. It can provide an ‘encapsulating’ grip on a delicate shape, for instance. This can be helpful when bending a tube which has a delicate end-formed structure or shape. Any clamping system that simply drives to a mechanical stop under pressure can easily distort or damage such a structure. By programming the all-electric machine to apply, say, just 10% of the force available, delicate items can be protected.

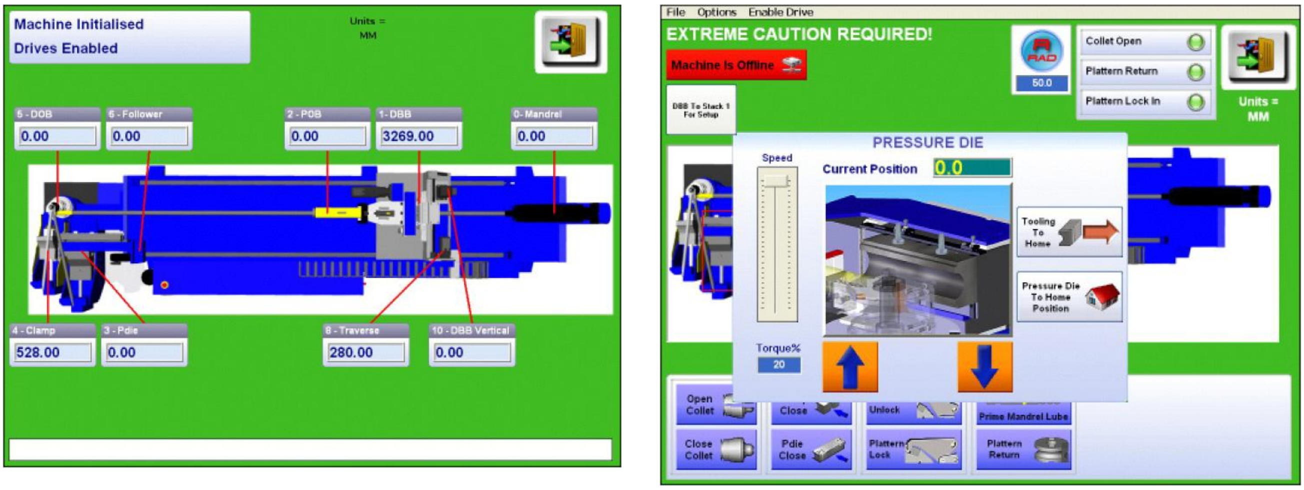

Figure 1. The detailed position of every axis can be controlled on an all-electric machine, providing the means to optimize the bending process, and recall the configuration at will to make a repeat part.

Because servo-motors are used to control each axis of the bending machine, it also is possible to link the motion of the axes together. For instance, an operator might need to run a part slowly during one point of the operation to check for collision or to prevent clamp slippage because of a large tube overhang. The machine will automatically set up each axis to compensate for this, so there is no need to adjust the motion of axes by hand, or to run the part all the way through the operation at a slower speed.

This control also provides a means to overcome the common problem of clashes between a part and the tooling, when there are very tight radius bends, and/or bends with very short intervening distances. All-electric machines can be programmed to perform a couple of intervening adjustments to clamp position and tube rotation between bends, for example, to avoid interference.

Repeatability. The basic 3-D bending data required to make a part is similar for both all-electric and hydraulic machines, enabling the same database to be used. The major difference is that the all-electric machine's control software can set up the bending machine automatically. The operator selects the material to be used from a database and then just loads the 3-D shape data into this file and saves it as a new part. The machine's control software can then automatically set the clamp position, clamp force, pressure die position, the pressure die's following boost force/profile, mandrel position, and anticipated withdrawal of the mandrel (which happens close to the end of the bending process). The software also sets the normal bend angle, position, tube push and tube rotation required to make the part. Once configured, settings can be saved and recalled to make a new part or batch.

Often, this approach allows a good quality part to be made the first time, or with only one piece of scrap, if there is a significant difference in spring-back from the reference material used to create the reference database, or if the application is particularly demanding (such as very tight radius bending on thin wall tubing).

Power Consumption. A significant feature of all-electric tube benders is their low power consumption. This is because all-electric machines consume only a significant amount of energy when they are actually performing a bend.

Noise Levels. All-electric tube bending machines typically produces only 55 to 60 decibels of noise—similar to noise produced in an office environment.

Environmental Benefits. As well as reduced power consumption and reduced noise levels, there are no waste products to be disposed of, such as oil. As many companies now operate strict environmental policies, all-electric tube bending machines fit well with the goals behind these.

Applications

Because the cost for each axis of an electric machine is relatively high, the initial capital cost of a small all-electric machine is higher than that of a hydraulic bender—approximately up to 25 percent more. However for larger, more complex machines, the capital costs can be the same or less.

All-electric tube benders are especially suitable for tube fabrication operations requiring a high degree of precision; small batch quantities; high-value equipment; and for parts made of expensive or exotic materials. Fast set ups, high repeatability, low energy consumption, and the absence of toxic waste to eliminate may compensate for those potentially higher capital costs over the life of the machine.

New Developments

Since the initial launch of all-electric tube bending technology in the mid 1990s, the number of manufacturers offering all-electric tube benders has expanded. Note that not all 'electric' machine manufacturers use the same methods of control, and that sometimes the term is applied to hybrid machines using a combination of electric servos and hydraulics.

Recent electric machine developments have been in the areas of report generation and diagnostics. For example, the use of a PC controller with networking has made it possible to introduce interesting diagnostics capabilities, such as a web cam and a 'history' file that automatically stores the last 500 operations (see **lead image**). Users anywhere in the world can access these resources via the internet, allowing a service engineer to provide expert support rapidly.

The availability of a wide range of digital information on the detail of the tube bending process also can be used to isolate the source of problems. For example, an aircraft manufacturer recorded the servo motor torque data it used to produce a part to highlight variations in material composition, eliminating the need to send samples to a laboratory. By comparing torque graphs from different material batches, the manufacturer was able to pinpoint differences in its tube supplies. This helped resolve a long-standing quality issue that previously been blamed on the aircraft manufacturer's machine operators or on the varying performance of the tube bending machines. In this situation, the titanium tubing cost savings have been very significant, and batch times were also reduced from 18 hours to 3.5 hours. In addition, for the first time, the fabricator was able to make a single part without scrap. This enabled the aerospace manufacturer to amortise the cost of the all-electric machine in 16 weeks for this application.

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Lead: New all-electric tube bending machine developments have been in the areas of report generation and diagnostics. The use of a PC controller with networking has made it possible to introduce many interesting diagnostics capabilities, such as a web cam and a ‘black box’ history file that automatically stores the last 500 operations.