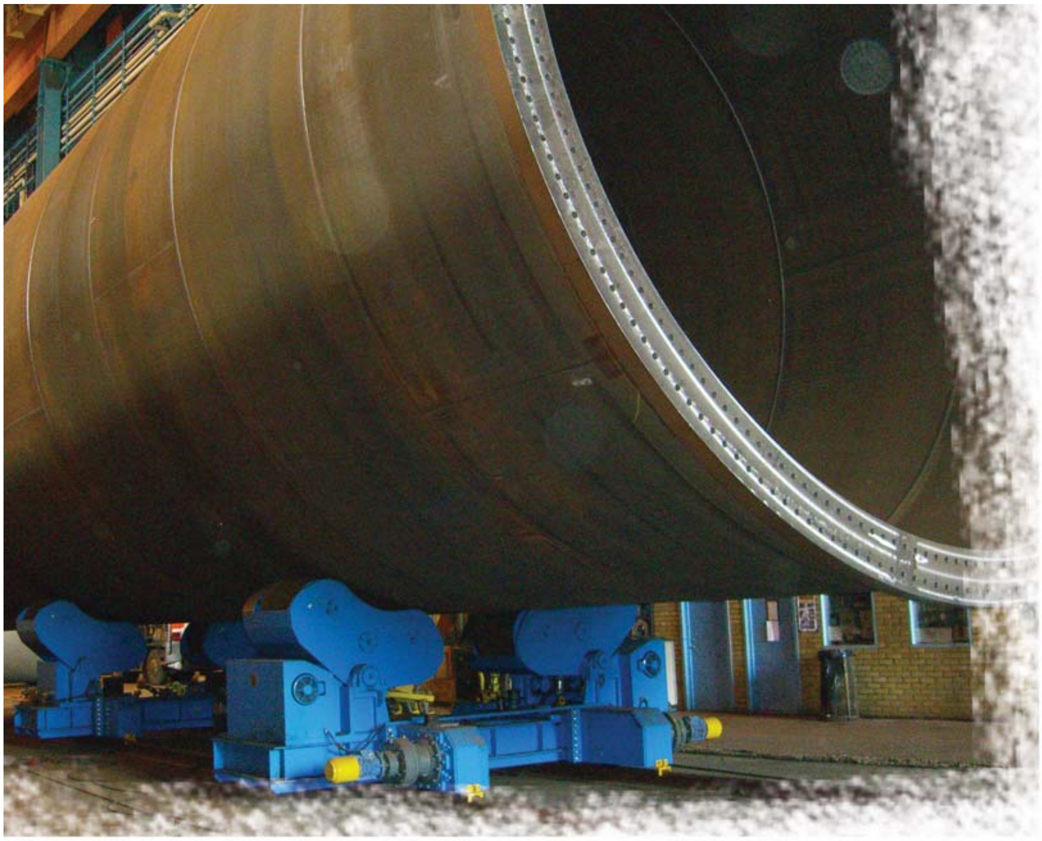

Figure 1 The wind tower industry has placed unprecedented demands on rolling productivity and precision.

ROLLING FOR WIND

Wind tower production requires intensive use of the rolling machine

By Steve Bonnay

Wind towers have gotten their fair share of coverage over the past few years. Much of what's made headlines involves the regulations and tax benefits that promote the technology. What isn't talked about as much is the actual design of the wind towers themselves.

Details get complicated, but their overall design concept is basic. The energy produced by a wind turbine is proportional to the size of the blades mounted around the rotor. The longer the blades, the higher the power output. The generator is mounted over a steel tower, the height of which determines the maximum blade length and, therefore, the amount of energy that can be generated by the wind the system captures.

The power of wind turbines is continually increasing, which means the size of the towers—height, diameter, and plate thickness—is growing too. Because of their large size, rolled sections can't be kept in stock easily. For this reason, wind tower production requires a lean, continuous-flow environment, with sections moving quickly between cutting, rolling, welding, and then painting.

The precision rolling process forms these massive sections (see **Figure 1**). And because of the unique demands of the wind business, rolling machines are now operating at previously unheard-of levels of productivity.

Machine Selection

One rolling machine running intensively over two or three shifts every working day can produce about 6,000 rolled sections a year, enough for 200 towers. Any unscheduled shutdown can be a disaster. Ideally, one rolling machine can produce one conical section in less than 30 minutes. This time includes aligning, rolling, and tack welding.

Speed is the name of the game. A machine with insufficient horsepower for rotation either produces insufficient torque, which creates quality problems, or insufficient speed, which lengthens production times. In the wind business, both are simply unacceptable. Therefore, in this specialized field, plate rollers usually require above-average horsepower to drive the rolls.

Because of their high volume and speed requirements, most wind tower production facilities use fixed-geometry, four-roll systems. Fixed-geometry machines have lower rolls that are positioned in a certain way for a given design. They can be moved up and down, either with a linear slide (straight motion) or a swing arm (curved motion). On a fixed-geometry machine, the lower rolls always move up and down in the same pattern. The rotating top roll cannot be repositioned. Though fixed-geometry machines may have less flexibility than variable-geometry designs, they do offer high precision and speed, which are paramount for a wind tower operation.

For shops that do not specialize exclusively in wind towers—those who take on overflow work from other tower manufacturers, for instance—a three-roll, variable-geometry machine may be an option. These machines allow operators to move the lower rolls horizontally and the top roll vertically. This allows a shop that usually does, say, pressure vessel work to take on occasional work involving thicker rolled sections (2 in. or more). A variable-geometry machine allows operators to move the rolls to adjust for this increased thickness. In many of these cases, the higher versatility of the variable-geometry machines compensates for their slightly lower output rate.

Correct Crowning

The precision of a rolled conical tower section is measured by the size of the flat ends at the leading and trailing edges, after prebending (see **Rolling Basics: Minimizing the Flat** sidebar); the level of barrel or hourglass effects over the full range of thicknesses; and the overall consistency of the cone angle.

The barrel and hourglass effects usually occur because of either improper crowning or an undersized machine. A crowned roll is designed to work with a specified thickness range. If the material is too thin for the roll's crown, the roll doesn't deflect quite as much. So it's bent a bit too much in the center, producing a rolled section with a slight hourglass shape. If the material is too thick, the roll will deflect too much, so it will bend less in the center than at the ends. In this case, the finished product looks a little like a barrel. An operator can shim either at the two ends (for thicker material) or at the center (for thinner material) to eliminate these effects. But this can slow production significantly, which can be a burden, especially for a wind tower manufacturer.

A machine crowned for 1-in. material consists of rolls with the middle slightly larger in diameter than the ends,

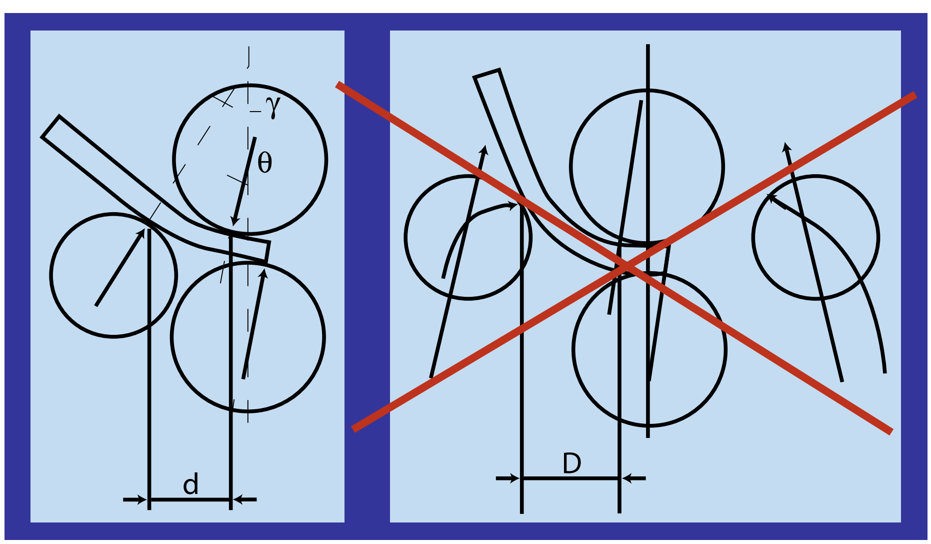

Figure 2 Precision rolling systems have a tight roll configuration, with the bend points as close together as possible.

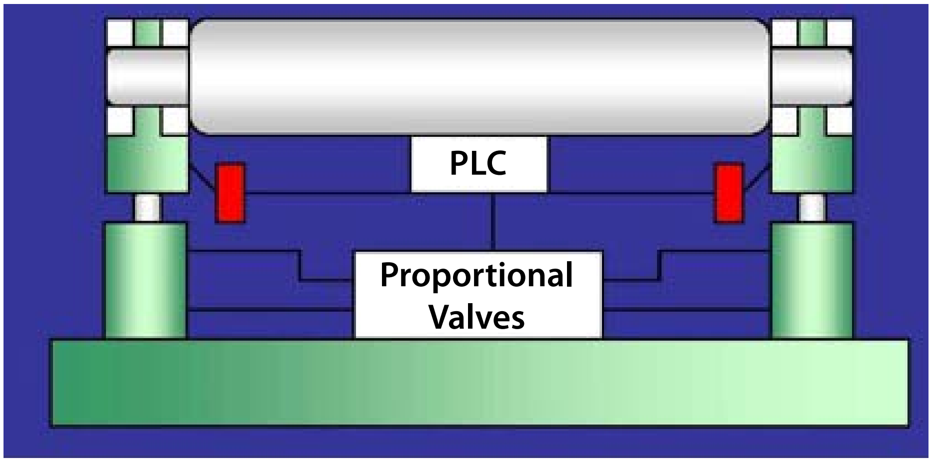

Figure 3 A numerical control continually adjusts proportional valves at either end of the roll to ensure the roll tilt angle remains constant throughout the roll operation.

to compensate for the deflection the machine will experience when 1-in. plate is put into the machine. The diameter difference is slight, measured in thousandths of an inch. This bulge, or crown, counteracts the material deflection as it forms up through the rolls.

Precision rolling machines can be designed with the side bending rolls positioned as close as possible to the lower center roll (pinch roll)— almost touching, in fact (see **Figure 2**). The top roll, pinch roll, and side rolls all are larger than on conventional rolling machines. This added mass guarantees reduced deflection under load. The larger rolls require less crowning, so they are able to roll a wider range of thicknesses. In fact, rolls that are 20 percent larger than normal can help minimize deflection by nearly 100 percent, which means operators don't need to use shims to adjust for various plate thicknesses.

Figure 4 A support beam positioned above the roll set can prevent the rolled section from distorting, especially when working with thinner material.

Conical Considerations

Because wind towers are conical, rolling machines must tilt rolls slightly to put more pressure on one end of the roll than the other. To maintain consistency of the wind tower's conical angle, and to prevent off-center loading, the rolls' degree of tilt must be preset automatically and kept constant throughout the rolling cycle.

This constant tilting, or balancing, ideally is accomplished with numerical control, which can send continual adjustments to hydraulic proportional valves on either end of the rolls (see **Figure 3**). Some machines have four independent bearings supporting each roll, so that the roll tilt can match precisely the angle required by the conical wind tower sections while maintaining full support, even in the tilted orientation. Electronic balancing systems can keep tolerances at less than 0.008 in., as demanded by precision wind tower work.

Unlike other cone applications, tower cone sections are only slightly conical. Conical rolls aren't necessary. In conventional cone rolling, the contrast die—a wheel or hardened steel piece mounted to the machine frame—contacts the small-diameter portion of the cone, so it can be rolled slower than the large-diameter portion. However, because wind tower sections are only slightly conical, the plate never comes in contact with the contrast die. And since the sections are formed with a cylindrical rolling operation, there is also no damage to their beveled edges from friction.

Figure 5 A feed table with staggered rollers and lateral alignment cylinders positions nonrectangular plate as it is rolled into a slightly conical section.

Increasing Productivity

Various additions to plate rolling systems can boost productivity. For instance, plate supports allow a machine to operate without an overhead crane. A support beam on a vertical column, positioned above the roll set, can hold the material and prevent the cone from distorting (see **Figure 4**). For wind towers, this top beam can be tilted according to the cone angle. The top beam's capacity should be between 5 and 20 tons, depending on the size of the heaviest section.

Feed tables also help speed production, reducing the need for overhead cranes. While the machine is rolling one part, the feed table can set the next one precisely where it's needed, so it's ready to go as soon as the previous roll shape is finished.

The conical shape of these wind tower sections does make the infeed process a bit more complicated, because the blank isn't a perfect rectangle. Instead, a slight radius is cut on either side of the plate. Feed tables therefore must ensure that plate is properly aligned during the entire rolling process. This can be accomplished in various ways. One design feeds material in flat and uses three sets of lateral cylinders that slide horizontally to ensure the blank remains aligned as it goes through the machine (see **Figure 5**).

These technologies can reduce rolling time to between 5 and 10 minutes per section. Note, however, that this is just the rolling time and doesn't include other operations in the production cycle, such as tack welding. Tack welding these sections at the end of the roll keeps these machines occupied for another 10 minutes. So realistically, you can expect an output of about two to three rolled sections per hour with one operator, without rerolling.

Shaving Downtime

Wind turbines may be one piece of the puzzle to solve our global energy crisis. Some bleeding-edge work has pushed wind towers to become more efficient and larger—incredibly larger, in fact. Some now rise 300 feet into the air and hold fan blades that span the length of a football field or more. It's ironic that such bleeding-edge work rests (literally) on a tower formed with one of the most mature of all metal fabrication processes.

Such production, however, has pushed rolling to new levels of productivity. You can't change the physics of metal. The fundamentals of rolling haven't changed. What has changed is the level of precision and uptime, with minimal time spent moving work to and from the operation. When wind tower production is in full swing, it's rare to see a rolling machine sit idle for long. FAB

Steve Bonnay is product manager for Faccin USA, 907 S. U.S. Hwy. 301, Tampa, FL 33619, 813-664-8884, www.faccin.com. Photos courtesy of Faccin USA. Portions of this article are adapted from Steve Bonnay, "The True Value of a Plate Bending Roll," presented at Wind Energy: Opportunities for Fabricators Conference, Sept. 15-16, 2009, Elgin, Ill., sponsored by the Fabricators & Manufacturers Association Intl., www.fmanet.org.

Rolling Basics: Minimizing the Flat

Choosing a machine that matches the required roll geometry and thickness minimizes the flat portions at the beginning and end of the rolled sections. The rolls grab the lead-in plate edge and, once the plate is in the correct position, commence prebending to minimize the flat portion at the start of the roll. This operation takes considerably more power than rolling; typically a machine that can roll 1.25-in. plate may only have enough power to prebend 1-in. plate.

To prebend, rolls act like a press brake in reverse. The bottom rolls rise, pushing the plate against the top roll to create the initial bend. After rolling, the rolls do the same thing at the plate's trailing edge. The problem is that during each bending operation, the rolls must hold onto the plate somewhere, and these pinch points happen to be at the very leading and trailing edges of the rolled plate.

These edges remain flat, and the only way to eliminate them entirely is to reroll the section after welding or cut off the flat section, both of which hamper productivity. Rerolling also demands serious power from the rolling machine. For this reason, the best approach usually is to purchase a rolling machine that leaves a minimal amount of flat and can produce products that meet quality standards *without* rerolling.

As always, the application dictates which machine is best. Consider a four-roll machine designed for 1-in. plate. The machine will produce flat sections that are 1.5 to 2 times the material thickness. This means there will be 2 in. of flat on a cylinder of 1-in.-thick plate, which is acceptable for most applications.

However, if the next job happens to be for 0.25-in. plate, issues can arise with a fixed-geometry system. Its lower rolls can be adjusted only up and down, not side to side, so it still produces a 2-in.-wide flat section at the end of the rolled section. That's eight times the material thickness on 0.25-in. material, which typically isn't acceptable at all. In this case, a variable-geometry system would fit the bill, because it allows operators to position the lower rolls wherever needed to maintain the minimum width of flat at the leading and trailing edges of the rolled section for a wide range of material thicknesses.