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.
are only slightly conical. Conical rolls aren’t necessary. In systems can keep tolerances at less than 0.008 in., as de-
roll tilt can match precisely the angle required by the con-
independent bearings supporting each roll, so that the
rolls’ degree of tilt must be preset automatically and
tower’s conical angle, and to prevent off-center loading,
roll than the other. To maintain consistency of the wind
(see Figure 3). Figure 3 A numerical control continually adjusts proportional valves at either end of the roll to ensure the roll tilt angle remains
countant throughout the roll operation.

to compensate for the deflection the machine will expe-
rience when 1-in. plate is put into the machine. The di-
ameter 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 per-
cent 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.

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 accom-
plished 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 con-
cical wind tower sections while maintaining full support,
even in the tilted orientation. Electronic balancing sys-
tems can keep tolerances at less than 0.008 in., as de-
manded 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. How-
ever, because wind tower sections are only slightly coni-
cal, 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
dges from friction.

Increasing Productivity

Various additions to plate rolling systems can boost pro-
ductivity. 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 ca-
pacity 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 previ-
ous 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 en-
tire 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). Figure 5 A feed table with staggered rollers and lateral align-
ment cylinders positions nonrectangular plate as it is rolled into a slightly conical section.

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.

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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, like 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 hap-
pen to be at the very leading and trailing edges of the rolled plate.

These edges remain flat, and the only way to eliminate them
totally is to reroll the section after welding or cut off the flat sec-
ton, 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 thick-
ness. This means there will be 3 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, is-
sues 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.