Leveling flat-rolled strip

How roller levelers handle the task

By Ken Shoop

Many users of flat-rolled strip are demanding material with exceptional flatness. One reason is the increased use of lasers, robots, and other manufacturing techniques that are intolerant of height deviations and springback in material. In addition, applications such as automotive, appliance, and office furniture always have strict requirements for flatness because of visual appearance.

Why Leveling Is Required

Generally speaking, flat-rolled strip needs to be leveled because the rolling mills that produce it aren't perfect.

Flat-rolled strip is produced by squeezing a steel slab between rotating mill rolls, which make the slab thinner and longer. Ideally, the rolling mill would apply equal pressure across the entire width of the strip, which would produce equal elongation and perfectly flat strip. But in reality, mill rolls deflect under load, creating more pressure and elongation at the edge of the strip and producing a shape defect known as *edge wave*.

To counteract mill roll deflection, steelmakers grind the rolls with a "crown," making the middle of the roll larger in diameter than the edges. When these crowned rolls deflect under load, they theoretically create equal pressure and elongation across the full width of the strip.

If the rolls have too much crown, they will create more pressure and elongation at the center of the strip, which produces a shape defect known as *center buckle*. Modern steel mills have improved, but they're not perfect, and it's a pretty safe bet that a lot of the material they produce will need to be leveled.

Several methods are available for leveling strip, including flatteners and straighteners with fixed backup rolls, tension levelers, stretcher levelers, skin pass rolling mills (often called temper mills), and roller levelers.

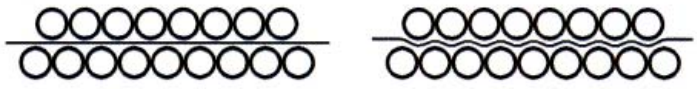
How a Roller Leveler Works

In the stamping industry, roller levelers are the most commonly used type of leveler.

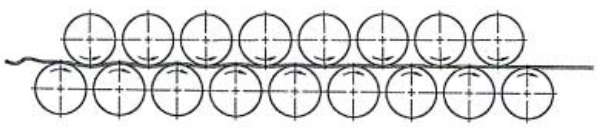
A roller leveler stretches the short areas of the material to match those parts that were elongated too much by the mill. This is accomplished by nesting the rolls, which increases travel distance through part of the leveler (see **Figure 1**). Because only certain areas need to be stretched, multiple flights of backups give increased nesting in just the desired area. For the strip to come out flat, nesting must occur primarily at the entry end and be feathered to zero at the exit end (see **Figure 2**).

To correct complex shape problems with a roller leveler, operators have to remember that good is bad, and bad is good. That is, they correct shape by leaving the bad-looking area alone, and increase work on the area that looks good.

A leveler operator will tell you that he usually runs the machine with a "frown" or a "smile." To correct material with edge wave, he stretches the center of the strip by forcing the work rolls into a frown. To correct material with center buckles, he stretches the edges of the strip by forcing the work rolls into a smile.



▲ **FIGURE 1** A roller leveler stretches the short areas of the material to match those parts elongated by the mill by nesting the rolls, which increases travel distance through part of the leveler.



▲ **FIGURE 2** For the strip to come out flat, nesting must occur primarily at the entry end and be feathered to zero at the exit end.

Functions That Limit Roller Leveler Capacity

The capacity of a roller leveler is determined primarily by work roll diameter, addition of intermediate rolls, and the method of backup adjustment.

Work Roll Diameter. Work roll diameter and center distance in a roller leveler determine the machine's thickness capacity (see **Figure 3**). Minimum thickness is determined by how small of a radius the material can be bent into with a given roll size. Maximum thickness is determined by the maximum load a given roll can safely and reliably handle.

Addition of Intermediate Rolls. Full-length intermediate rolls can be added to a roller leveler to suit the type of material being run. A four-high leveler (see **Figure 4**) has no intermediate rolls, so the backup rolls act directly on the work rolls, simplifying roll bending and shape correction. This machine does the best job of leveling, but it has the potential to mark or stripe the top and bottom of surface-critical material.

A five-high leveler (see **Figure 5**) has one row of full-length intermediate rolls on the top of the strip. The adjustable backups are underneath and act directly on the work rolls, so this leveler does a good job of leveling and preventing striping on the top of the strip.

A six-high leveler (see **Figure 6**) has two rows of full-face intermediate rolls located above and below the strip. The adjustable backups have to act on intermediate rolls to bend the work rolls, so it is difficult to correct poor shape, but it does prevent striping on the top and bottom of the strip.

Backup Adjustment. Roller levelers can be broken down into two categories based on their method of backup adjustment. Both use multiple flights of backups to adjust roll bending and nesting. The difference between the two is that mechanical levelers use wedges, and hydraulic levelers use cylinders to move the backups (see **Figure 7**).

A mechanical leveler has a jack connected to a pair of wedges at each backup flight. The jack moves the bottom wedge back and forth so the entry and exit ends of the backup flight move up and down equally. This

Leveler Thickness Capacity for Mild Steel at 45,000 PSI Yield Strength			
Work Roll Dia.	Min. Thickness	Max. Thickness	Range
1.250	0.017	0.055	3.24X
1.500	0.019	0.075	3.95X
1.750	0.028	0.127	4.54X
2.000	0.037	0.150	4.05X
2.500	0.043	0.187	4.35X
3.000	0.060	0.264	4.40X
3.500	0.078	0.300	3.85X
4.000	0.086	0.350	4.07X
4.500	0.093	0.400	4.30X
5.500	0.142	0.601	4.23X
6.500	0.193	0.745	3.86X

▲**FIGURE 3** Work roll diameter and center distance in a roller leveler determine the machine's thickness capacity.

means that the smile or frown the operator sets will be the same at the entry and exit ends of the machine. For feathering the nesting from entry to exit, the leveler top frame is mounted on pivot pins and is tipped by four large jacks.

A hydraulic leveler has two cylinders under each backup flight. These cylinders are independent of each other, allowing the entry and exit ends of the backup flight to move independently. The operator can set a smile or frown at the entry end and independently set a flat feathering profile at the exit end of the machine.

Since feathering is accomplished with the cylinders, the top frame does not need to tip, which eliminates the pivot pins and large jacks. This design allows very aggressive roll bending and nesting at the entry end of the machine for maximum shape correction while maintaining flat feathering at the exit end.

Increasing Roller Leveler Capacity

For flat-rolled process lines that handle a variety of thicknesses or products, more than one leveler might be required. One approach uses one leveling machine frame with two separate leveling cassettes. These cassettes are stored on a shuttle tray in front of the leveler frame, which positions the cassette and then inserts it into the frame. No tools are required, and the cassettes can be swapped in less than five minutes.

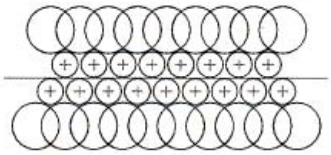
Each cassette can have different roll sizes for varying thickness capacities, as well as different intermediate roll arrangements for varying material types. In addition, cassette levelers allow offline cleaning and maintenance. The line can continue to run while one cassette is being serviced, so downtime is reduced significantly.

Computers and Roller Leveling

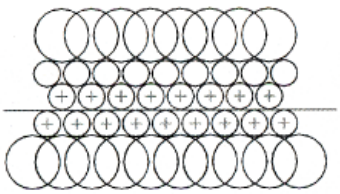
Operating a leveler requires training and skill, but computers are making the task much easier. A computer can quickly set the machine to a good starting point and allow very fine adjustment of the backups. Once the leveler is delivering good results on a particular coil, the settings can be saved and called up later. That saves setup time when coils are partially run and then sent back to stock.

Sometimes flatness requirements cause those who process or use flat-rolled strip to purchase a more expensive grade of material or a machine that allows them to flatten it in-house. Understanding why flat-rolled strip needs to be leveled in the first place, and what methods are available for making it flat, should help with that decision. ■

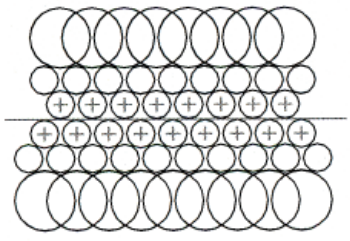
Ken Shoop is southeast regional manager with Braner USA Inc., 9301 W. Bernice St., Schiller Park, IL 60176, 847-671-6210, kshoop@braner.com, www.braner.com.



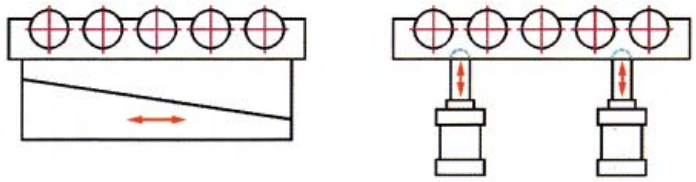
▲**FIGURE 4** A four-high leveler has no intermediate rolls, so the backup rolls act directly on the work rolls, simplifying roll bending and shape correction.



▲**FIGURE 5** A five-high leveler has one row of full-length intermediate rolls on the top of the strip.



▲**FIGURE 6** Six-high levelers have two rows of full-face intermediate rolls located above and below the strip.



▲**FIGURE 7** Roller levelers use multiple flights of backups to adjust roll bending and nesting. However, mechanical levelers use wedges, and hydraulic levelers use cylinders to move the backups.