MASTER ROLL Mfg's

The straightening or leveling process involves the bending of flat-rolled material up and down, between sets of offset rolls. This alternately stretches the top and bottom fibers of the material past the yield point until a permanent and, hopefully, improved change of shape has occured. Increasingly, equipment builders and their customers see leveling equipment as being designed for shape control and not just to make flat-rolled stock flatter. The question is: Should the stamper or rollformer straighten or level material in coil, sheet or blank form before the press or mill or after it's in the form of semi-finished parts? The obvious response would be that if some of the stamped or formed parts were out of flatness tolerance, then those parts could be run through a straightener or leveler. The issue is not that simple. In Europe, the custom has been to level off-tolerance parts after stamping or forming. In North America, most manufacturers level the material beforehand, usually in its coil form.

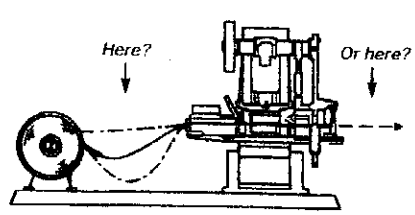
Equipment and Terminology

In exploring the issue, terminology and equipment design should be reviewed. There are three different equipment configurations.

1. Nonbacked up, spread-center straightener (Fig 1 next page).

2. Backed-up, close-center straightener (Fig 2 next page).

3. Precision corrective leveler (Fig 3 next page).



Where should the leveler or straightener be placed?

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It is helpful, too, to distinguish between straighteners and levelers. In the European context, builders and manufacturers us the term "levelers" to describe straighteners and leveler configurations. Quite often European machines will have smaller roll diameters and, thus, smaller roll centers than their American counterparts. With smaller roll centers for a given material and thickness, the clamping or separating loads between upper and lower work-roll banks are much higher. These loads are accommodated by use of double-hung backup rollers (Fig 4). This design does not have the capability for roll-bend alignment and thus should not be compared to what we as Americans call a "leveler."

In the American context, the primary difference between a backed-up, close-center straightener and a leveler is that the leveler has controllable roll bend. Levelers have a mechanism for controlled bending of the work rolls so that some portions of the material can be worked harder than others. The roll-end journal bearings and backup rollers must have a built-in tolerance for angular misalignment due to this variable roll bend (Fig 5).

Dimensional Limitations

There are maximum and minimum thickness limits for any given machine configuration and material yield strength. Maximum thickness is based on machine deflection. Minimum thickness is the point at which so little yielding of the outer fibers occurs that no permanent change in shape can be made.

With the double-hung backup roller design, smaller work rolls can be employed, giving a lower minimum thickness capability when used as a close-center, backed-up straightener. Smaller roll centers do not imply that a better job of straightening can be done at the upper capacity limit. Little practical increase in penetration of the surface-fiber yielding occurs past four yield strains.

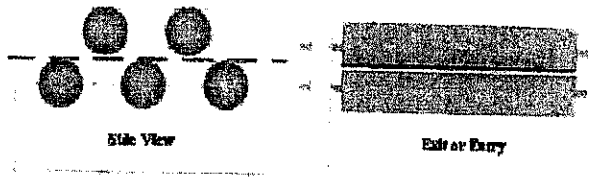

Fig. 1—A nonbacked-up, spread-center straightener.

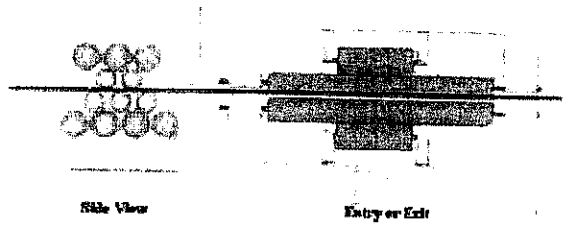

Fig. 2—A backed-up, close-center straightener.

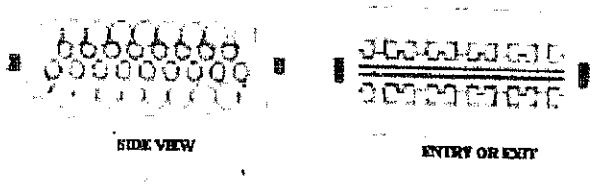

Fig. 3—A precision corrective leveler with individually adjustable backup rolls for work-roll bend control.

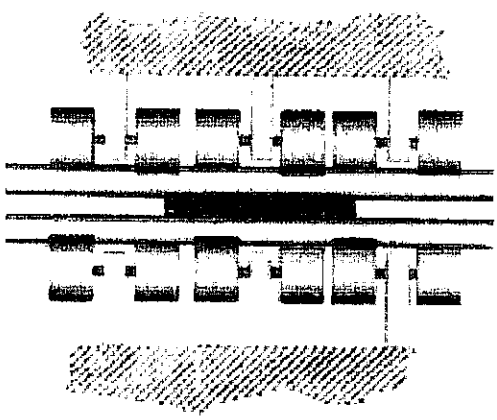

Fig. 5—Cantilever-hung backup rollers can be designed to accommodate work-roll bend.

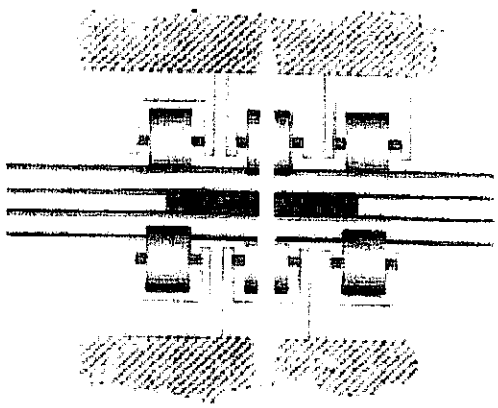

Fig. 4—Double-hung backup rollers support high loads, but cannot tolerate roll bend required for precision leveling.

There is a minimum length issue with all straighteners or levelers. Any material that does not span at least three work rolls, one on one surface and two on the other, will not be worked at all (Fig 6). For example, an 8 inch part running through a machine with 2 inch roll centers will not be worked on the first 2 inches or the last 2 inches. Only the center 4 inches or one half of the area will be worked. Smaller roll centers may help, but not much.

A second pass, at 90 degrees from the first pass is sometimes recommended, but probably won't make a significant difference if the shape problem is more than simple coil-set or crossbow. A second pass results in either double handling or two machines with feeding conveyors, double-feed protection (Fig 7) and other complications placed between them.

In the example above, if the material were straightened in the coil form before stamping, all of it would have been worked except the inconsequential head-and-tail 2 inches of the master coil.

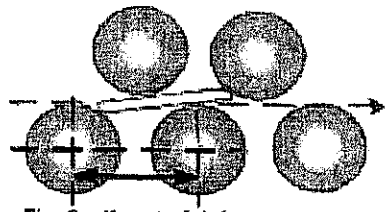

Fig. 6—If material does not span at least three work-roll centers, it will not be worked.

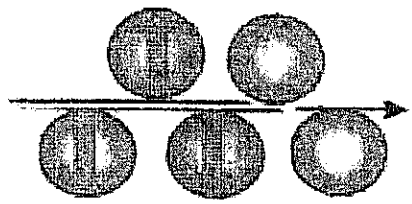

Fig. 7—Double-fed blanks or parts will overload the machine.

Process Limits

Straightening or leveling in coil form is easy to automate, works the entire strip and clearly is the more effective option for longer runs. In the coil form, we work almost the entire length and width of the material and, thus, 100 percent of the final part. In part or blank form, we work only part of it. For short runs, working in the blank form may reduce setup time and head and tail losses. Materials purchasing also may be more economical in sheet and blank form than in coil. Working or straightening parts after forming has few advantages. It may not even be possible if the part has inconsistent or weak cross-sections or if it has been formed in any way.

If blank or part feeding is to be done, a throated machine should be specified. On feeding a closed-entry machine, the leading edge may not rise over the third roll, causing it to jam (Fig 8). Some builders employ a quick opening procedure for blank or parts feed up but this is difficult and time consuming. It is much simpler to build a throated machine with the first entry roll dropped. Machines designed for coil feed usually do not have this feature. A precision leveler with roll bend can eliminate or control problems other than coil set or crossbow, such as oil canning, buckle or wave (Fig 9). In this case the part or material, theoretically, must be wide enough to span at least three flights of adjustable backup rollers. I've seen some cases where coil width was less than this and the process still worked. If the shape problem involves length differentials such as oil canning or waves, it probably will not be effective to work in blank or part form because the machine may not be able to grip the metal. Straightening after stamping, in part form, also may distort critical dimensions, angles, holes or hole positions. When considering straightening parts after stamping or forming, the workpiece can not have flanges, stiffeners, etc. It also must have a fairly strong and consistent cross-section. The side of a computer tape-drive take-up reel, for example, has three very large openings at 120 degree intervals. No matter which way we turn it, the weak section, including the large holes, will get all the bending.

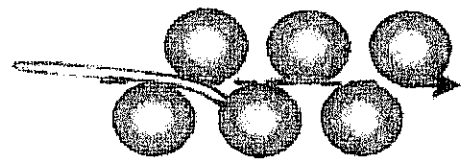

Fig. 8—The leading edge of a blank or part, when fed into a closed-entry, or nonthroated, machine may not rise over the third roll, causing a jam.

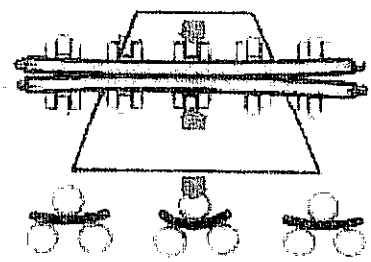

Fig. 9—A precision leveler has individually adjustable backup roller flights for work-roll bend control.

Shape Compensation

Consider a ship's anchor chain. It doesn't matter in which sequence the links are joined, as long as each performs it's function. Likewise, a straightener or leveler can control the shape of finished parts whether it is before or after the press or rollformer but there are some other issues to consider.

The stamping or forming process and variations in the incoming material may cause an undesired dishing or wave in the finished part. A leveler can induce a compensating shape, buckle or wave in the incoming coil or blank while the material is still in the flat condition. The operator adjusts the material shape before stamping based on inspection of the parts exiting the press.

On the other hand, blanks to be laser-cut or stamped in a high-speed turret punch press, for example, may need to be flat to begin with. In cases such as this, straightening or leveling after stamping may be necessary but hole tolerance, roundness and location will be altered in the process.

Straighteners are called that because they straighten. Levelers are so named because they level. This equipment can also be set to "unlevel" the material for shape control, to compensate for some of the things that are happening in the dies, as described above.

Stability

By working the material very hard, either with a close-center backed-up straightener or with a leveler, we effectively can reduce the effect of the random trapped stresses from the rolling-mill process.

When materials are stretched or compressed past their yield points they take on a new shape and, in general, the previous shape and internal stresses are forgotten.

It would be incorrect to imply that this process eliminates trapped stresses. It doesn't. It does replace random rolling-mill induced stresses with consistent and more predictable stresses, providing more stable material, especially where the part is to be subsequently heat-treated or welded. This process must be done in a manner to work the entire cross-section, in coil form, before stamping. Electrical laminations are a perfect example of this. Leveling after stamping is not usually practical. The slit coils are worked hard before stamping so that the parts stay flat in the heat-treat process immediately following.

In Summary

In most cases, except for low production quantities, logic suggests controlling material shape before stamping or forming. Sometimes material cost issues dictate material purchase in blank form. Otherwise, shape control in coil form, after the uncoiler and before the press or roll-former, is preferable.

We at Master Roll Manufacturer's hope you find this article informative and useful for future reference. Call, fax or e-mail us with any of your leveling questions. We are here to assist you with any of your leveling needs.

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