The purpose of straightening is to prepare the material after unwinding to allow it to pass freely through the die and produce an acceptable part. The requirements vary depending on the material defects present, the design of the die and the finished part requirements. Straightening is accomplished by bending the strip around sets of rollers to alternately stretch and compress the upper and lower surfaces, exceeding its yield point so that both surfaces end up the same length after spring back which results in flat material.

Straightening machines today fall into two basic categories, the most common of which are known as "straighteners" or "flatteners". This arrangement is generally available in models with between 5 and 11 work rolls. The roll diameters and center distances vary depending on material thickness and width but straighteners and flatteners are generally distinguished by fairly large diameter, widely spaced rollers, usually not backed up. This kind of straightening machine is only capable of removing coil set from the material, thus allowing it to pass unrestricted through the die, which satisfies most applications.

Power straighteners or levelers on the other hand can be configured as part of the unwinder as in the case of coil cradles, or for "pull off" operation with coil reels. They can also be free standing with a second slack loop between the straightener and unwinder as with pallet decoilers or in cases where delicate material would be damaged by pulling off of a large coil. In most cases, powered models are generally followed by a slack loop, which allows continuous operation without starting and stopping. This reduces the power requirements relative to combination feeder/straighteners, which straighten material as it is fed and are required to start and stop with each feed progression demanding far more power than with continuous payoff.

An understanding of the basic principles of straightening is necessary to obtain effective and consistent results in the set-up and production of a straightening machine. A solid understanding of these guidelines is also helpful for the initial specification of your straightening equipment. Knowing the fundamental capability and capacity of your coil processing equipment will position you to raise production efficiencies and improve product quality.

In simple theory, three staggered rollers should be sufficient to straighten most materials. This basic approach can be applied to an application if the amount of coil set present in the material remains or non-powered. Non-powered straighteners are known as “pull through” straighteners. As the name suggests, the feed provides the power to pull the strip through the straightener. The advantages of this style is low cost and the fact that straightening is done after the loop, allowing the loop length to be condensed without the worry that set will be re-induced in the material, which can be a problem if straightening is done prior to the loop. With pull through straighteners the horsepower to straighten must be drawn from the feeder. This can either reduce its speed capability or greatly increase its cost. Additional disadvantages to pull through straighteners include marking due to the non-powered straightening rolls slipping on the material upon starting and stopping and inaccuracy as a result of feed slippage because of the additional load.
constant throughout the coil. Depending on the material composition, thickness, and yield strength the amount of coil set in the material can dramatically increase as the coil is depleted. In most cases coil set is induced in the material during a previous process such as slitting, edge conditioning, or finishing. The outer wraps of the coil are placed under the tension and compression required to bend the material around the outside diameter of the coil. This diameter is typically 54” - 72”. The inner wraps of the coil are placed under the tension and compression required to bend the material around the inside diameter of the coil. This diameter is typically 16” - 24”.

The potential wide range between the inside and outside diameters of a coil can result in a dramatic change in the amount of coil set in the material. With only three staggered rollers, the operator would have to constantly adjust the machine to obtain an acceptable level of flatness. Power straighteners are built with multiple work rolls to effectively address the issue of varying coil set. As more work rolls are employed in a straightener, the range of coil set that can be effectively removed becomes greater.

Another basic principle of straightening is that thicker materials require relatively larger diameter rollers. The center distance spacing of these rollers can be relatively larger and still do an effective job of back bending the material. Thicker materials will typically require fewer straightener rollers. As the material thickness specification increases, the roller diameters and support journal diameters must increase. The work rolls must be capable of withstanding the forces required to back bend the material without excessive deflection across their width.

Thinner materials will require relatively smaller diameter rollers. The center distance spacing of these rollers will have to be relatively shorter to effectively stretch and compress the material. Thinner materials will typically require a greater number of rollers to effectively remove the varying amount of coil set present in the material. Consideration must still be given to the support journal diameters of the work rolls on light gauge applications. As the material and machine widths increase, the tendency for the smaller diameter rollers to flex and deflect will also increase.

Today’s metalstamper faces the dual challenge of high flexibility with his coil processing and stamping operations, coupled with continuously increasing targets for output yields and efficiencies. The vast majority of companies are not afforded the luxury of building their capital equipment to meet the needs of a dedicated and long-term product line. The modern metalstamper must build capacity and flexibility into his coil processing and stamping machinery to meet the long term challenges presented by changing product lines, changing customers, and often changing markets. This overlying challenge is a substantial obstacle in the path of proper straightener specification. Some fundamental decisions must be made early in the game related to the level of flexibility of the straightener and the breadth of the application demands that it must meet. For most metalstampers there is an acceptable range of these capabilities within the standard product line of a machine manufacturer. Working within this range will position the buyer to be most cost effective in his capital equipment procurement.

A straightener that is designed with seven work rolls that are 4.0” diameter and located on 7.0” centers will effectively straighten .250” thick MCRS, given that the machine has been adequately powered and geared. The same machine will have minimal effect on .050” thick MCRS. Likewise, a straightener that is designed with seven work rolls that are 3.0” diameter and located in 5.0” centers will effectively straighten the .050” thick MCRS, but is unlikely to have the horsepower and roll strength to process the .250” thick MCRS. If an application calls for this type of variation in materials, a fundamental decision must be made in regards to the cost effectiveness of building a special machine to meet the full spectrum of needs, versus building a standard machine that will provide optimum straightening at either the light gauge end or the heavy gauge end.

When determining the level of flexibility and range of materials that a straightener will process, the maximum width of the material and machine must be considered in parallel with the range of material thickness. As the width of a given model of straightener increases, the ability of that machine to process a material with a defined thickness and width is compromised. The tendency of work rolls and end journals to deflect becomes greater as the machine width increases. A 12” wide straightener with work rolls that are 3.0” diameter and located on 5.0” centers will effectively process 6” wide and .187” thick MCRS. The same straightener configuration built at 36” wide will not effectively process this material due to the potential roll deflection. Excessive roll deflection results in a loss of contact surface area, decreased straightening efficiency, slippage of the material through the straightener, and in the worst case, broken work rolls.

When an application dictates that a straightener must work effectively across a wide range of material thickness and widths, the machine builder will specify “back-up” rollers for the work rolls. Depending on the maximum
width of the material and machine, the back-up rollers may be positioned in one, two, or three places across the width of the work roll. The back-up roller assembly usually consists of precision cam followers mounted on a heavy-duty weldment and supported on a precision adjustment mechanism like a jack or screw. The proper placement of back-ups minimizes the stress and potential deflection of the work roll.

A common mistake in the specification of straighteners is to request a machine that is capable of processing wide coil material without giving consideration to the effect that narrower material will have on the machine. A machine rated to straighten 48” wide x .125” thick MCRS may have difficulty processing 12” wide x .187” thick MCRS. The cross section and strength of the 12” wide material is substantially less than the 48” wide material, but the straightener rollers will most likely experience a greater amount of deflection when running the narrower material. The forces and stresses are now concentrated at the center of the rollers. This area is furthest from the end journals and bearings that support the rollers. Placement of a single row of back-up rollers will give this machine the capacity to efficiently straighten the narrower material.

The horsepower required to drive a straightener is often a misunderstood part of the straightening equation. Obviously the maximum material thickness and width of material are fundamental in determining the horsepower requirement. There are many other factors, some of them not as obvious. The maximum yield strength of the materials must be defined. Most straighteners are rated by their capacity to process mild steel, less than 50,000 PSI yield strength. Materials with higher yield strengths will have a greater tendency to keep their coil set, and therefore will demand greater horsepower to straighten to an acceptable level of flatness. The combination of work roll diameter and center distance spacing can drastically affect the horsepower demands. If two straighteners both have 3.0” diameter work rolls, with the first machine having 5.0” center distance spacing, and the second machine having 6.0” center spacing, the first machine will require more horsepower to process material with the same thickness and width.

In a pull-off application the coil size and weight are critical variables in the horsepower determination. The maximum coil weight must be defined since the straightener motor must provide the torque and horsepower to accelerate this mass to line speed. The minimum and maximum coil outside diameter must also be defined. Though a coil has its greatest mass when at maximum outside diameter, this is not always the worst case condition related to horsepower demands. As the coil is depleted the straightener loses the mechanical fulcrum provided by the greater outside diameter. Its ability to overcome the drag brake tension placed on the reel decreases as the coil is depleted.

The process requirements for throughput in feet per minute (FPM) are necessary to accurately calculate the horsepower requirements for the straightener. This is obtained by multiplying the maximum speed of the press by the maximum progression length. For example, if the maximum speed of the press is 40 SPM, and the maximum progression length is defined as 18” (1.5 feet), the throughput for the application is 60 FPM. Care should be taken to not be short sighted when determining this variable. Most often, the throughput parameter is established based on past or current production limitations, rather than on the potential of the equipment and tooling in the manufacturing process.

With such a wide potential variation in material types, thickness, and widths, no single straightener will effectively meet the demands of every application. There is no such thing as a “universal” straightener. A legitimate question at this point would be, how does the machine builder address the potential variations in application demands? At the equipment specification process, careful consideration must be given to all variables associated with the straightening process. The variables related to the material include the ranges for thickness, width, yield strength, and surface finish. In a “pull off” operation the variables related to the coil must be defined. These include inside diameter, outside diameter, coil width, and maximum coil weight. For all straightener applications the maximum line speed must be defined. Attention to detail in defining all of the variables for a given application will give the machine supplier a solid understanding of the process requirements, and assure that the correct machine is selected for the job.

Once a machine is properly specified and built for an application. Effective results are contingent on correct and consistent set-up. The combinations for pinch roll pressures, drag brake strength, and work roll depth settings will determine the level of effectiveness for the straightening operation. Pinch roll pressures are typically established by an air pressure regulator and gauge combination. All straighteners have a set of entrance side pinch rolls as the primary means of gripping and pulling the material. Some machine models are also provided with exit side pinch rolls to further improve the gripping and pulling capability of the machine. The amount of pinch roll force required for a specific material is based on the material width, thickness, and surface condition. Heavy gauge materials will generally require greater pinch...
roll forces. Thin materials will have a tendency to wrinkle under excessive pinch roll forces. Too much pinch roll force will not only damage the material, but it can also result in pinch roll deflection. Any deflection of the pinch rolls results in a loss of effective contact surface area on the material and promotes slippage.

The optimum amount of drag brake strength will vary with the coil weight and outside diameter. The purpose of the drag brake is to maintain adequate tension on the strip between the reel and the entrance pinch rolls of the straightener. Here are some common set-up problems related to the drag brake. When the coil is at maximum O.D. and there is not enough drag brake strength applied, the coil will exhibit a tendency to overspin and develop slack material between the reel and straightener. Eventually the reel will decelerate and lose RPM due to the loss of tension in the strip. As the straightener continues to run the slack is consumed and the strip will be snapped tight. The material may be stretched or damaged when this occurs. Too much drag brake strength applied at any O.D. of the coil may cause material slippage through the straightener or apply excessive tension on the material. As mentioned previously, as the coil is depleted the straightener loses the mechanical advantage of the larger outside diameter and the drag brake strength should be decreased. There is often an acceptable range of drag brake strength that will maintain proper tension on the strip, and not cause material slippage or damage.

Straighteners are provided with a method of calibration for the upper work roll depth setting. The amount of work roll penetration required to back bend the material to an acceptable level of flatness depends on the combination of material thickness, material type, roller diameter, and roller center distance spacing. Once the optimum depth setting is established for a specific material it is critical that the work rolls are consistently returned to this position each time the job is run. As standard, most straighteners are provided with a simple calibrated scale and pointer combination to establish the roller position. When more accurate positioning is required, alternative methods of positioning are utilized. These methods include mechanical indicators, dial height indicators, and L.E.D. readouts. The upper work rolls of most straighteners are contained in precision guiding slide block assemblies. The alternative methods for raising and lowering the rollers within the slide block assemblies include fine threaded screw and nut combinations, worm gear and screw mechanisms, and precision screw jacks.

Stock straighteners are typically equipped with an odd number of work rolls. The extra work roll is in the lower "fixed" bank of rolls. Most coils are unwound by the material being uncoiled from the top of the coil. The induced coil set naturally gives the material a downward bend. With proper set-up, this configuration of the work rolls allows a slight upward bend to be placed in the material as it leaves the straightener. Such a curvature will help the material slide across the die surface with a lower amount of friction.

All straighteners have a “zero” or “home” position for the work roll depth setting. This is the point at which the upper work roll is tangent to the corresponding lower work roll. It is also referred to as the point at which there is zero daylight between the upper and lower rollers. Simply put, if all the upper work rolls are placed in the “zero” position, you could run a line that is .000” thick through the straightener without bending that line.

The guidelines for establishing proper work roll depth settings tend to vary as much as the potential variations in material types, thickness, and width. For the purpose of these examples we will assume the use of a seven roll straightener with three adjustable upper work rolls. The recommended roll depth setting is also referred to as amount of penetration relative to the nominal material thickness. For example, if the material is .125” thick, 100% penetration is at the zero position of the work roll, 50% penetration is at .063” above the zero position of the work roll, and 0% penetration is at .125” above the zero position. As a guideline, the first work roll should do the most straightening work, with each successive roll set to a declining amount of penetration. Regardless of the number of upper work rolls, you should be able to draw a straight line through the center of each upper work roll when the machine is initially set-up. This guideline is demonstrated in Figure 3.

Following are some recommended starting points for straightening MCRS. Some trial and error may be required to obtain an acceptable level of flatness for your specific material. Once again, the variables of material type, thickness, and yield strength combined with the work roll diameter and center distance spacing create a wide range of potential settings.
It is important to use the minimum roll penetration which will produce an acceptable level of flatness. Excessive roll penetration will cause poor straightener efficiency, cause material to slip across the straightener, and place unnecessary strain on the machine drive components.

A quick visual check of the flatness can be done before the material is run into the loop area. Use the threading table or similar device to support the leading edge of the material as it exits the straightener. Fine tune the work roll settings to the minimum depth required to give the leading edge a slight upward bend. Document these settings for reference and correct set-up the next time the material is processed.