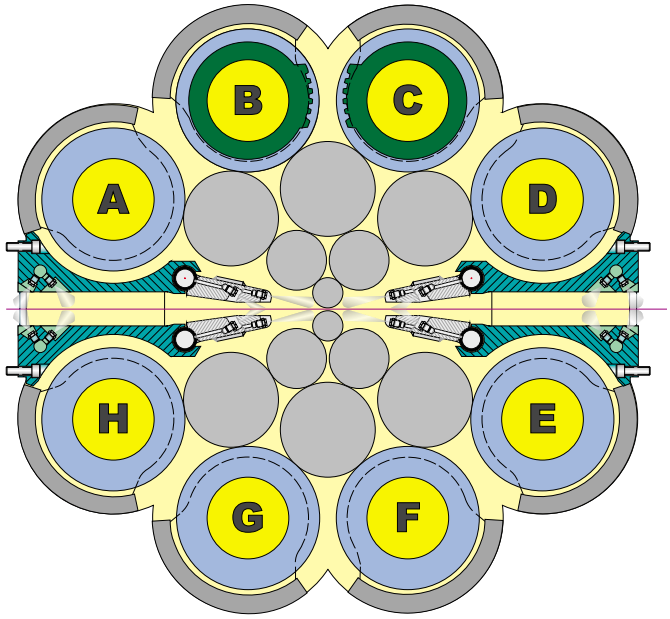
Sendzimir's 20-High Mills

Sendzimir's 20-high mills are unique in that they have a small, chockless work roll and a cluster configuration for the back-up rolls. The cluster configuration transmits the roll separating force from the work rolls to the mill housing. The small size of the work roll permits superior reductions on very hard materials, such as stainless steel.

Advantages

Sendzimir mills are known worldwide for their ability to roll extremely hard materials to very thin gauges with few, if any, intermediate anneals. They consistently maintain quality aspects that are difficult, if not impossible, to duplicate on conventional mills. They are capable of consistently holding extremely close gauge tolerances on very wide strip as well as on metals ranging from soft aluminum alloys to stellite and molybdenum.

The pyramid configuration of the back-up rolls transmits the roll separating force along the length of the work rolls, through the intermediate rolls, to the back-up assemblies, and finally to the rigid monoblock housing. Since the work rolls are supported throughout their length, any uncontrolled deflection is minimal, and extremely close gauge tolerances can be maintained across the full width of the material being rolled.



The layout of a typical Sendzimir 20-high cluster mill

By way of comparison, the rigidity of conventional mills is governed by the relatively large size of their work rolls and back-up rolls, which are supported by their necks in two separate housings connected by columns that elongate under load. Under rolling pressures, this design results in roll deflection and flattening, and therefore thickness variation, especially near the center of the strip. Gauge variation of incoming strip is difficult to correct.

The size of Sendzimir's work rolls, being small, offers additional very important advantages: quality of surface, speed of replacement, and control of deflection. They can be manufactured of die steel, high-speed steel, or even tungsten carbide. The work roll material can therefore enable extremely high quality strip surface finishes. This is particularly important for bright stainless steels, for example. Additionally, tungsten carbide work rolls are much harder (85 Rc) and have a higher modulus of elasticity. This results in fewer passes, especially on the thinnest gauges.

The small, chockless work rolls are very easy to remove and install. Gauge-to-gauge times of under a minute are becoming standard on modern designs. The size of the work rolls also permits greater responsiveness to shape control mechanisms, whether they be tapered 1st intermediate rolls, As-U-Roll crown control, or Flexible Segmented Backing Assemblies.

Nomenclature

Sendzimir 20-high cluster mills commonly carry the prefix ZR, which stands for “zimna,” the Polish word for “cold,” and “reversing.” This prefix was used the first time to describe Silesia's first reduction mill. The numbers, and sometimes letters, following this prefix describe the mill’s geometry, the relative size of its work roll, and the widest strip that the mill can roll.

The number immediately following the “ZR” indicates the vertical (as seen from the front of the housing) size of the backing bearings, the work rolls, and so on. For example, a ZR23 has backing bearings with a diameter of 8.858 inches (225 mm) and work rolls with a diameter of 1.578 inches (40 mm). A ZR32, on the other hand, has backing bearings of 1.875 inches in diameter and work rolls of 0.250 inches in diameter. The significance of the difference is that a ZR23 can roll ferrous and nonferrous materials down to a minimum gauge of 0.002 inches, while a ZR32 can roll ultrathin nonferrous foil down to 0.0001 inches, which is 20 times thinner!

This relationship can be modified for particular applications. A letter indicates modifications to the mill, and in particular a nonstandard work roll size. The letter combination “AA” indicates a work roll that is much smaller than standard, while the letter “N” indicates the largest possible work roll. In between these two extremes, the letters progress, from small to large: “A,” “B,” “BB,” “D,” “M,” and “MB.”

Sometimes a letter is used to indicate still another characteristic of the mill. For example, a “C” after the mill type — for example, ZR23C — indicates the addition of As-U-Roll crown adjustment to shafts B and C. The letter “C” before the mill type — for example, CZR23 — indicates that the mill has been designed to fit as a cartridge inside another mill stand’s housing.

Other letters that are used include “T” before the mill type to indicate a tandem configuration, “S” after the mill type to indicate slightly larger rolls for multiple applications, and “W” after the mill type to indicate As-U-Roll crown control for severe wedge shape.

With regard to the suffix in the Sendzimir 20-high cluster mill terminology — the number representing maximum strip width — it should be noted that the mill can easily roll strip widths smaller than the maximum.

Materials Rolled and Thicknesses Obtained

Sendzimir’s 20-high cluster mills can roll any metal, especially very hard metals. They roll:

* autobody sheet
* deep and extra-deep drawing, low-carbon steels
* feed stock for the manufacture of tinplate
* austenitic, martensitic, and ferritic stainless steels
* non-oriented as well as grain-oriented silicon steels
* high-carbon steels for items such as razor blades and saws
* nonferrous metals such as brass and special alloys of brass, copper, bronze, berylium copper, and bimetals
* metals such as aluminum, zirconium, molybdenum, silver, gold, tantalum, titanium, cobalt, and nickel, and their alloys, such as aluchrom

The various mill types, the materials for which they are best suited, and the gauges they can obtain

Sendzimir 20-high cluster mills: materials rolled and gauges attained (inches)

mill section	ZR32	ZR34	ZR24	ZR33	ZZR23	ZR23M	ZR22	ZR22B	ZR21B
maximum strip width, narrowest mill	4.25	7.50	7.50	13.00	19.00	19.00	26.00	26.00	33.00
maximum strip width, widest mill	8.75	17.50	17.50	48.00	62.00	62.00	120.00	120.00	209.00
minimum strip gauge	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
materials rolled	ultrathin nonferrous foil	electrical alloys, stainless steels, tantalum, zirconium, and super alloys	low carbon, high carbon, and stainless steels; nonferrous alloys	low and high carbon steel; nonferrous alloys	ferrous and nonferrous	heavy reductions on softer materials	ferrous	ferrous	low carbon, silicon, and stainless steels

Sendzimir 20-high cluster mills: materials rolled and gauges attained (millimeters)

mill section	ZR32	ZR34	ZR24	ZR33	ZZR23	ZR23M	ZR22	ZR22B	ZR21B
maximum strip width, narrowest mill	108	191	191	330	483	483	660	660	838
maximum strip width, widest mill	222	445	445	1219	1575	1575	3048	3048	5309
minimum strip gauge	0.0025	0.0102	0.0203	0.0254	0.0508	0.0635	0.0762	0.0889	0.0889
materials rolled	ultrathin nonferrous foil	electrical alloys, stainless steels, tantalum, zirconium, and super alloys	low carbon, high carbon, and stainless steels; nonferrous alloys	low and high carbon steel; nonferrous alloys	ferrous and nonferrous	heavy reductions on softer materials	ferrous	ferrous	low carbon, silicon, and stainless steels

Experience List

More than 400 Sendzimir mill installations have been built in over 40 countries.

Figure 1 shows the popularity of the 20-high cluster mills that have been built since the 1940s: the ZR22 series is by far the most common. Of these particular mills, most are in the 50 to 52-inch maximum strip width range.

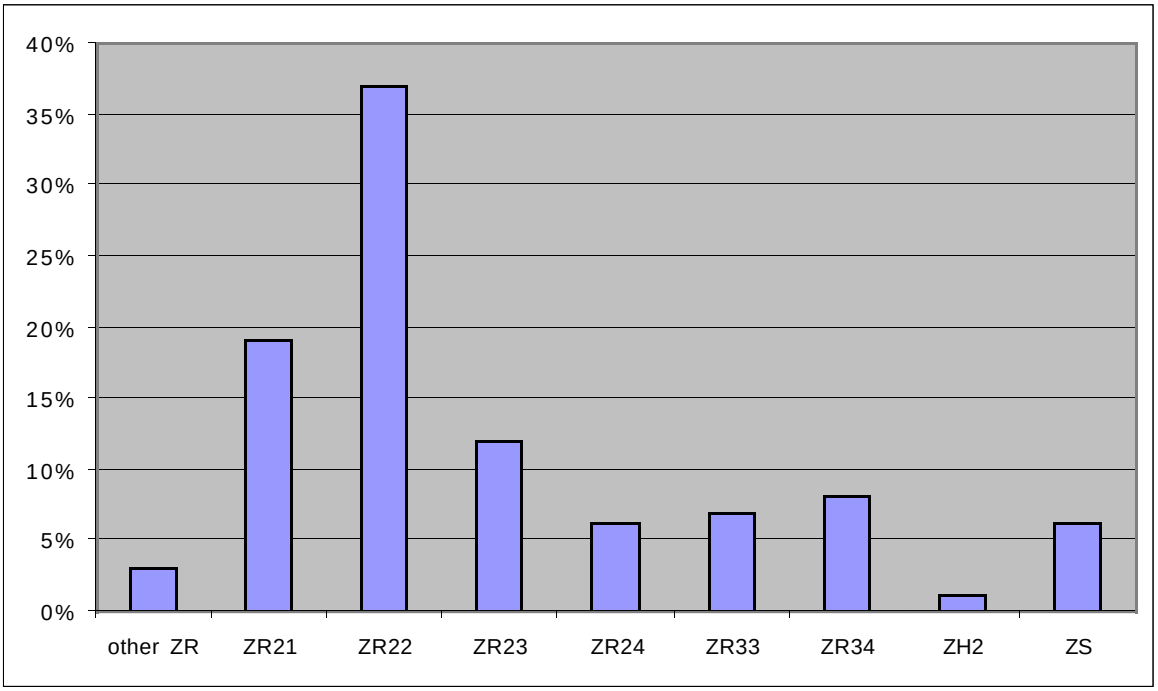


Figure 1

Figure 2 shows the regions in which Sendzimir cluster mills are to be found: Europe and Asia are most heavily populated, with France and Japan being the preferred countries.

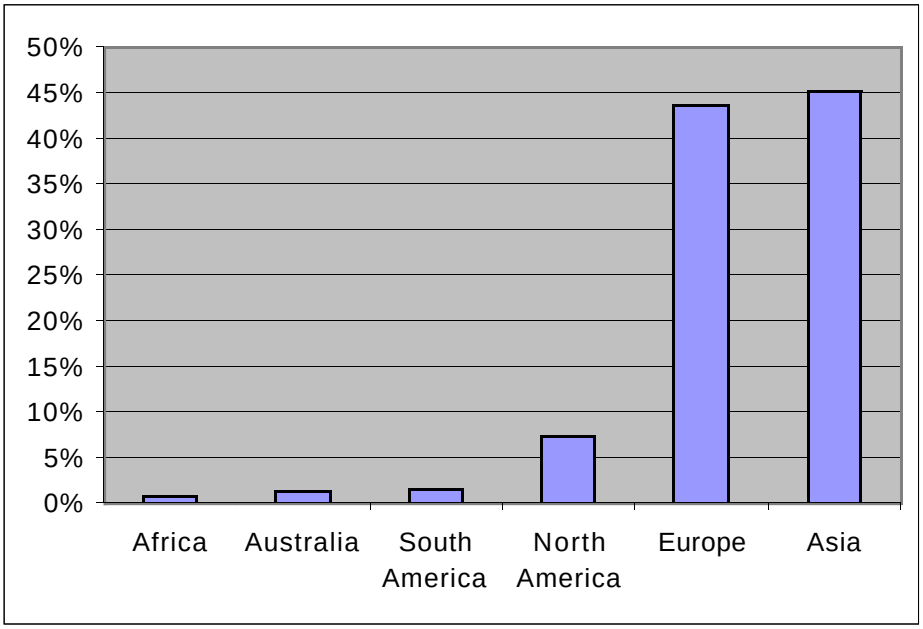


Figure 2

Redesigned ZR 24 1st intermediate thrust couplings

A Sendzimir improvement to its 20-high cluster mills redesigned the 1st intermediate thrust couplings. This improvement applies only to the ZR24 mill series. However, it almost doubles the life of the 1st intermediate rolls.

The range of the diameter of the 1st intermediate roll, which customarily ranges from 1.515 inches (38.5 mm) to 1.625 inches (41.3 mm), has been increased to 1.378 inches (35 mm) to 1.625 inches (41.3 mm). This new design uses symmetrical rolls with removable roll necks on both ends of the 1st intermediate rolls. The roll can easily be reversed or used in multiple locations.

There are several advantages to this redesign: To start, this reconfigured roll will work in all four 1st intermediate roll positions. Furthermore, the roll neck is bolted on and can be replaced in case of breakage. Finally, the common size allows the grinding of several rolls at once instead of having to grind the two upper intermediate rolls in one set and then the two lower intermediates in another.

Flexible Shaft Backing Assemblies and Segmented Idler Rolls

Sendzimir's Flexible Shaft Backing Assemblies can effect far more shape control than conventional solid-shaft backing assemblies. This proven improvement thus retains the rigid, "die-like" capability of the Zero-crown monoblock housing while granting much more shape control.

For example, quarter-buckle or center buckle elimination can be entered as a goal. Alternatively, the mill can be set for either an "M" or a "W" shape. Moreover, variable wave amplitude and mill period can be set, and the Shaft design allows for a combination of wedge offset, 2nd order, 3rd order, and 4th order shape control.

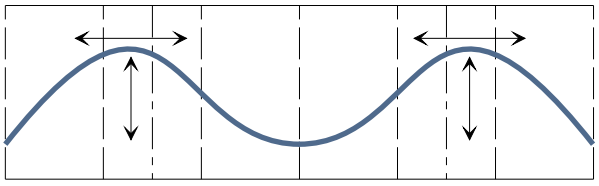


Figure 3

Figure 3 demonstrates the maximum and minimum parabolic shape adjustment achieved through Sendzimir's Flexible Shaft Backing Assemblies. This is also known as 2nd-order shape control. Classic backing assemblies, being solid, cannot bend in any shape other than the simple parabola.

Figure 4 demonstrates the dramatic bending that these backing assemblies can achieve at each saddle position. Thus, the mill crown control can be set for a 4th-order (quarter buckle) shape control, and the wave shape is infinitely adjustable in terms of amplitude and phase.

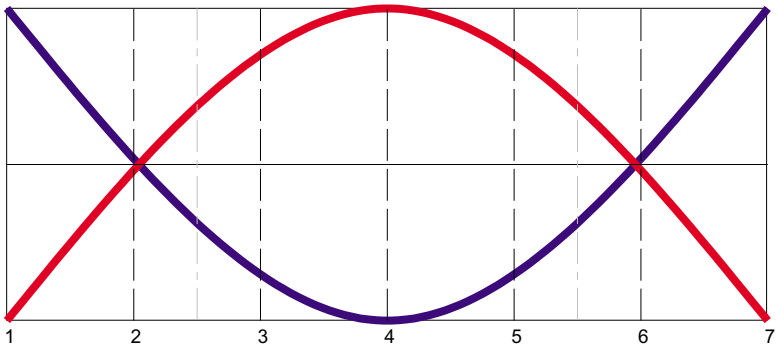


Figure 4

Zero-Crown Housing

Sendzimir's Zero-crown housing was invented more than 20 years ago, yet its strong side frames and tapered top and bottom have withstood the test of time.

This design, as shown in Figure 5, does not eliminate stretch under load. Rather, it forces the housing to stretch uniformly under load. The unique combination of side frame deflection and transverse slab deflection maintain uniform forces along the full length of the work rolls, thus assuring a "zero-crown" contour across the entire strip width.

More than 40 zero-crown housings have been built worldwide since 1975.

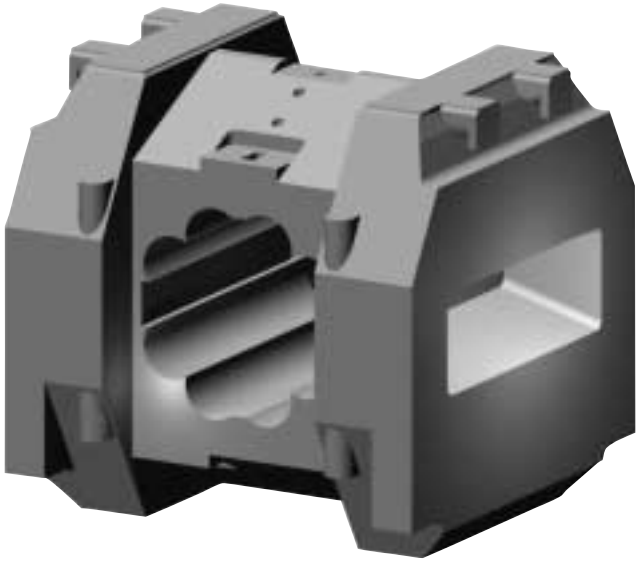


Figure 5