

The First Sendzimir Tandem Mill

Nisshin Steel Co. placed the world's first Sendzimir tandem mill into operation at its Shunan works in 1969. Located in Nanyo, Japan, the plant occupies a site of approximately one-third square mile. Occupying about 18 percent of the 315-ft total installation length are four Sendzimir stands: one ZR 22N-50 and three ZR 21B-50. Once up and running, the mill's maximum finished monthly production capacity totaled 18,300 net tons -- 35 percent 400 series; 65 percent 300 series stainless steel.

Nisshin's tandem installation is the first one designed to continuously cold roll stainless coils up to 50 inches wide and weighing a maximum of 24 net tons. Most of the hot band (either 300 or 400 series stainless ranging in thickness from 0.255 to 0.063 in) comes from the reversing hot mill at Nisshin's Shunan works. Some hot band is supplied by the Kure works. Strip from the tandem ranges from 0.158 in to a minimum of 0.012 in. The maximum rolling speed is 1969 fpm.

The Nisshin installation is a fully continuous rolling facility. Incoming coils are fed from payoff reels through a welder that joins the head and tail of consecutive coils, thereby eliminating tail-out and the necessity to rethread.

Eleven years before installing the tandem mills, Nisshin commissioned Japan's first wide (50-in) high-production Sendzimir mill. A ZR 22-50 (at that time the largest and most powerful Sendzimir reversing mill ever built) was installed in the Hanshin works near Osaka. This mill was equipped with twin drives -- the first time such a drive arrangement had been incorporated in a mill of this type and size -- with a 5000-hp main motor taking the mill up to a 2800-fpm top speed. The Hanshin plant was dedicated to the production of low-carbon steel.

In 1964, a second ZR 22-50 mill with solid winders was put into operation, thereby increasing Nisshin's wide stainless strip capacity to 56,000 net tons per year.

In 1969, the BOF process successfully produced stainless; in 1970 Nisshin installed two 40-ton converters. In September 1969, the Sendzimir cold tandem installation, built exclusively for production of stainless strip, began operation. This installation made it possible to more than triple production.

Installation of the tandem mill started in the middle of March 1969 and was completed by the middle of August.

A no-load test of each piece of equipment was made between the middle and end of August 1969.

Adjustments of the control systems for the winding reel control, accumulator control, speed matching control, strip guiding control, and so on were made by rolling on both 2-high mills while letting the ZR mills run idle. This cold-run period lasted from September 1 to 7 and was followed by live rolling of low-carbon strip on September 8. The trial rolling produced strip with good shape and no breakage. The first strip rolled was of 43-in-wide, 0.126-in hot band reduced to 0.040 in. The test run with low-carbon steel strip was continued until September 20, 1969, in order to adjust tension and speed control.

On September 21, rolling of AISI 430 stainless steel strip commenced with 0.140-in strip reduced to 0.071 inch in one pass. A total of 550 tons of low-carbon steel and 300 tons of stainless were produced during the 15 days following mill startup on September 8.

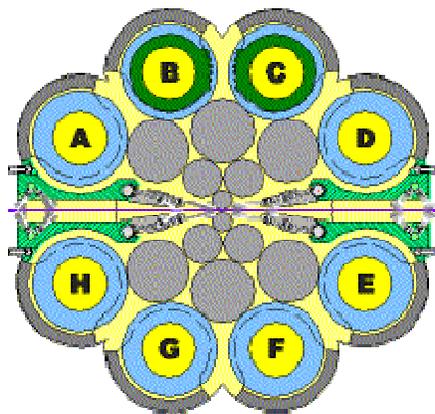
Chatter marks were observed following the no. 1 stand. This was eliminated by changing the amount of tension on both sides of the mill.

Difficulties were experienced with centering the strip at the entry of the 2-high mill. This problem was solved by adding another EPC device to the deflector roll at the exit of the accumulator.

The Sendzimir Cluster Design

Before Nisshin Steel's tandem mill was even considered, only a few Sendzimir mills in the world were being used to reduce or skinpass strip on a once-through basis. Most Sendzimir cluster mills were being used in a series of reversing operations.

Sendzimir has developed several mill arrangements, but the dominant layout is the 1-2-3-4 configuration. This design permits the smallest possible roll diameter for any given backing bearing diameter.



In the classical 1-2-3-4 arrangement, there are eight backing shafts, numbered A to H in the clockwise direction. Shafts B and C are the main screwdown shafts and are equipped with large hydraulic cylinders on the top of the mill. These shafts have roller bearings in the saddle rings and can be easily rotated under heavy screwdown pressure. All the other shafts have plain bearings in the saddle rings and can be rotated only under no-load conditions. These shafts are also self-locking, i.e., in order to open or close the mill, the shafts have to positively moved.

Shafts A and H are moved by an electric motor located in the back of the mill. Shafts D and E are also moved by an electric motor. These shafts are brought closer together or further apart, depending on the size of the rolls in the mill.

Shafts F and G, the two bottom shafts, are moved by hydraulic cylinders located in the front of the mill. These shafts are opened or closed in order to change the work rolls in the mill. The movement of these shafts in the conventional Sendzimir installation serves two purposes: First, it brings the bottom work roll to the passline of the mill, therefore providing the even bearing of the work roll end surfaces against the thrust bearings located in the front and back of the mill. Second, the closing of the bottom rolls removes the slack between the rolls and enables the full travel of the top screwdown of the mill. This permits the operator to reduce heavy hot-rolled gauge down to the thinnest gauges without changing the work rolls.

Nisshin's Tandem Installation

In Nisshin's tandem installation, the design of the lower F and G shaft assembly differed from the classical Sendzimir reversing mill in that these shafts were equipped with roller bearings in the saddle rings as in the upper B and C screwdown shafts. This special feature was incorporated to provide as much flexibility as possible into the stands to reduce the occurrence of strip

breakage at the welds. The lower screwdown, depending on the weld condition, could be operated to provide either constant roll pressure or constant roll gap in addition to the conventional fixed-position locked system. To accomplish the first two operational modes, two large hydraulic cylinders substantially the same as the upper screwdown system were utilized on each stand, replacing the single small cylinder used in the conventional arrangement.

Shape Control on Sendzimir Mills

Most modern Sendzimir mills utilize "As-U-Roll" adjustment, activated through small hydraulic motors that can be controlled from the operating pulpit during rolling. This adjustment is provided on shafts B and C acting simultaneously through a very small secondary eccentric gear train. The adjustment can be made under load so that the operator can change the shape of the strip while the mill is rolling.

The first intermediate rolls can be axially adjusted from the front of the mill, and on bigger mills this adjustment is motorized, necessitating only pushbutton control. This mechanism shifts the rolls to the front or the back of the mill, which is very important for the operation of the mill since these rolls are ground with a taper. The top rolls have a taper from the front side, and the bottom rolls from the rear side. In this way, with an independent movement of the top and the bottom rolls, it is possible to control the shape of the edges of the strip to an extremely fine degree. The combination of crown control and axial shift of the intermediate rolls gives an operator a means of controlling shape and producing extremely flat strip.

The roll separating force on the 1-2-3-4 mill is distributed from the work rolls to the intermediate rolls and then to the backup shafts in such a fashion that the outer shaft takes a heavier force component, i.e., absorbs more load than the center shafts. The driven rolls in the mill are the outer second intermediate rolls. The choice of driving these rolls enables the designers to incorporate larger pinions. Therefore, the mill can transmit more torque.

The Sendzimir mills in Nisshin's tandem installation have all the modern features listed above.

The Exit Section at Nisshin

The single 20-in-diameter collapsible-block winder has an outboard bearing for additional support during operation. The mandrel is driven through a gear unit by two 1350-hp armatures providing a maximum tension of 22 tons up to the maximum installation exit speed of 1969 fpm.

To overcome the pressure on the winder block due to the buildup of large coils of thin strip, Nisshin selected the collapsible mandrel design. This mandrel differs from conventional designs in that the drum in its expanded position is filled with solid heat-treated alloy steel as the strip is being coiled.

Because the mill was designed for continuous operation, a hydraulically operated horizontal-type two-strand belt wrapper initiates coiling.

A single coil transfer car similar in design to those at the entry side payoffs moves the completed coils from the mandrel to the coil conveyor.

The chain-type coil conveyor is equipped with coil supporting saddles and has an overall length of approximately 52 feet.

Nisshin's Lubrication and Hydraulic Systems

Two soluble-oil roll coolant and backing-bearing spray systems were installed: one services the entry 2-high mill along with the first and second Sendzimir stands; the other services the third and fourth Sendzimir stands. The no. 1 system has a 50,000-gal receiving tank and 41,000-gal clean tank; system no. 2 has capacities of 40,000 and 33,000 gal, respectively. Filtration of the oil is by flat bed filters with system capacities of 23,000 and 29,000 gpm for systems no. 1 and 2, respectively. In total, the entire system consists of two receiving tanks, two clean tanks, six filtering pumps, six spray pumps, six bearing pumps and two flat-bed filters.

Lubrication of the backup bearings in the Sendzimir stands is supplied by three oil mist lubrication units servicing each stand.

Summary

When the first wide Sendzimir mill went into operation in 1955, the idea of putting ZR stands in tandem became apparent. Two accomplishments made it possible to realize the idea: suitable welding of the ends of each strip and the adoption of accumulators, and improvement of the electrical controls.

In order to use small work rolls most effectively, especially on materials that are difficult to roll, great tension is required. Under normal circumstances, the tension provided by a tension reel is limited by the strength of the reel. Greater tension can be obtained by using entry and exit 2-high mills. Moreover, by installing a 2-high mill at the entry side, it is not necessary to use pressure pads for back tension. This not only improves the surface condition of the strip but eliminates time lost during the exchange of pressure boards linings.

The second advantage is the improvement of production capacity, which can be shown by comparing the installation cost of a reversing mill with that of a 4-stand tandem. If one assumes that the installation cost of a reversing mill is 1, then for a 4-stand tandem it is 2.4. However, the production capacity of a 4-stand tandem mill is four times greater, i.e., the production ratio is 4:1. Combining these ratios provides an increase in production capacity, as compared with the initial cost of the equipment, of 1.67:1. The tandem mill needs only one winder for several mill stands, while a reversing mill needs two sets of winders and motors for each stand.

Labor saving costs are also important. Instead of using three full-time workers, which is required for a single reversing mill, the 4-stand tandem requires seven full-time workers per shift. Considering the auxiliary equipment, such as roll grinding, etc., the resulting actual labor productivity will be 2:1.

The most remarkable merit of the continuous mill is its production capacity. In order to take advantage of this high capacity, it is very important that as many as possible mill stops be eliminated. In this way, the change in gauge produced by the mill will be reduced. Second, single coils of 50 tons or more, without welds, would be desirable.