

Advances in Cold Rolling Technology

Sendzimir Z-High® Cold Rolling Mills in the 1980s

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Introduction

At the beginning of 1985, the steel and non-ferrous industries found themselves in a bind -- they were faced with low consumption, shrinking markets, higher costs, increased quality demands, and lower prices. This was not an enviable position, particularly as it followed three decades of relatively good prosperity.

The customer of the mid-1980s has had to accept smaller cars; higher interest rates, and greater costs for owning his home. He has experienced inflation and a bigger food budget, higher taxes, and a spouse who has a second job and shares in decisions of how to make ends meet. What does that mean? It means that the customer is more choosy and more difficult to satisfy.

Since the oil crisis of 1974 and its aftereffects, which led to the reduction in demand for all types of fuel, we have put constraints on the use of metal, and substituted quality for quantity. The industry has had to produce new and more sophisticated products. There have been significant developments in the electronics field, including computers, television, VCR's, microwave ovens, and other "gadgets". To this end, the non-ferrous producer had to produce thinner and extremely accurate brass and copper strip. Stainless and high carbon producers followed in step.

In the automotive field, thinner gauges of steel were used throughout the car, not only in the outer body panels but in doorposts, frames, wheels, undercarriages, and so on. To compensate for the reduction in gauge, we used low-alloy high-strength steels, and in order to make work for the presses easier, new limits on gauge tolerances were established.

In the food industry, beverage cans had to meet competition from aluminum, plastics, and paper containers. The result was a thinner can with less expensive coatings. But a big revolution took place on precoated steels. Several lines have been built in Europe, the United States, and Japan that precoat the material so that it can be formed and used directly in the finished product.

The above describes some of the changes that have occurred. But this revolution has not yet run its course, and I believe that many other changes will take place before the end of this decade. Indeed, I foresee the possibility that low-carbon steel, as such, will disappear, and all steels will have alloying elements and exact specifications for each job.

In the flat products market, a very substantial investment has been made in cold rolling equipment and not all of it has been fully amortized. Construction costs for new equipment are today almost prohibitive. Moreover, the investment has to be calculated at higher interest rates, and its return on investment has to be fulfilled in a shorter period of time.

Z-High® Rational

Several years ago, Sendzimir considered the possibility of combining the advantages of the Sendzimir cluster-type rolling mill with those of the 4-High. After several attempts, the Z-High® configuration, and the concept of retrofitting the 4-High mill with a Z-High® insert, were born.

The Z-High® concept permits the revamping of a classical mill with a system that uses a much smaller work roll. This new configuration allows the operator to take heavier reductions per pass and achieve thinner gauges. Harder materials can be rolled without intermediate anneals, and a better surface can be produced. Moreover, intermediate rolls are equipped with axial displacement and, when they are ground with parabolic tapers at their ends, the mill can change "effective flat" and provide excellent shape control possibilities.

Normally, the conversion of a 4-High to a Z-High® requires no other changes, except to reverse the leads to the main mill motor so that it will rotate in the opposite sense. However, other improvements can be incorporated, including screwdown, winder mandrel upgrades, higher tension, and if necessary, a change in mill lubrication and wiping.

Z-High® Description

There are several versions of the Z-High®, each incorporating a different number of rolls in the mill. Let us first look at the classical ZR-60 series (18-roll mill), converted from a 4-High mill.

To retrofit the 4-High mill, its work rolls are spread vertically apart in order to accommodate small-diameter work rolls. The new work roll diameter can vary in the ratio of approximately 1 to 2. The new small-diameter work rolls have no necks and no bearings. They are free to float axially and are restrained in their axial movement by thrust bearings located in the doors of the mill. These work rolls are laterally retained by a side support intermediate set of slightly smaller diameter rolls (side intermediate rolls), each of which, in turn, is nestled by two shafts containing bearings. There are no saddles in these shafts. Any force vector generated by the work roll is transmitted to the backing beam, which is attached to the housing.

Since the main rolls are in the vertical line of the mill, statically there should be no side component at all if we are on a perfect dead center. However, once rolling torque is imparted to the rolls, this torque will generate a lateral force that will have to be absorbed by the bearings and thence by the side beams. This side force, in normal operation, is a small fraction of the vertical roll-separating force. It is important that, whenever the roll diameters are changed, the realignment of the mill is made to its vertical line. It is also important that the entire cluster be firmly closed together. It should be obvious that the rotation of the main mill motor will have to be reversed.

For axial displacement of the intermediate rolls, there are several concepts, including a hydraulic motor actuated system or a hydraulic cylinder. The amount of axial adjustment will depend upon the width of the mill, but for a 1-meter mill, approximately 200mm might be the correct movement.

Should the Z-High® be required to transmit more torque than the previous 4-High arrangement - in other words, should the mill motor power have to be increased -- then we would modify the mill to "exclude" the intermediate roll chocks and to utilize two more backing shafts to nestle each intermediate roll (the 22-High version). Conversely, for micromills, a 14-High version exists.

All of what has been said above has referred to the revamping of existing mills into Z-High® mills. However, should we design a Z-High® mill right from the beginning, we can make such a mill considerably smaller in size. This would be made under the assumption that each pass would take the same amount of reduction as an equivalent 4-High. The Z-High®, nevertheless, would have the ability to continue making more passes and reducing the metal, where roll flattening on a standard 4-High would prohibit further reduction. On the Z-High®, due to the smaller-diameter work roll, the roll separating force is smaller and, consequently, the diameter of the backing roll and its bearings can be substantially reduced in size. With a smaller-diameter backup roll, the housing can be scaled down in weight to approximately half the size of an equivalent 4-High housing. In effect, we would then produce a rolling mill that could be substantially lighter, more efficient, and less expensive.

Having explained what the Z-High® looks like and some of the different modes in which it can be transformed, let us examine some practical applications:

Stainless

In stainless steel, 20-High Cluster Mills have dominated the market. However, some works have older 4-High mills that have been built with high torque in order to prereduce heavy-gauge hot-rolled strip. By converting these mills to Z-High® mills, not only would they retain their breakdown capability, but they could also serve as finishing mills. In stainless steel, there are also some ultrawide applications in the 2-meter width and wider where the Z-High® mill could give new reduction possibilities. Elimination of intermediate anneals, better gauge accuracy, and improved surface finish are additional benefits. In this category, I would also put wide stainless plate mills and stainless clad steels.

Non-Ferrous

In the non-ferrous field, there is demand for thinner-gauge brass and copper. Mills for such materials, in order to keep good production volume, have to go to high speeds. Consequently, heat extraction is an important factor. The Z-High® mill has proven itself superior in this respect, having operated with speeds of up to 7,000 RPM at the work roll.

Tandem Mills

Another way to approach this thin-gauge market is to use two or even three mills in tandem. One such installation in Canada reduces strip from 0.0045" all the way down to 0.00075" in only two passes. This is a reduction of over 80% and, with bigger-size coils, generates miles and miles of strip every hour.

Carbon Steel

Coming to carbon steels, advantages similar to stainless steel could take place in high-carbon and medium-carbon applications. An interesting application would be to calibrate thick, medium-carbon strip in one pass to narrow tolerances, which subsequently would be required for press applications.

For low-carbon installations, a Z-High® in four and five-stand tandem mills would give those mills completely new parameters for rolling new products to thinner gauges or in low-alloy high-strength steels. Another interesting application would be in the skinpass mill, where shape control is important and the axial displacement of intermediate rolls is advantageous.

Aluminum Mills

There might also be interest in using the Z-High® mill for rolling aluminum. The Z-High® would be the only practical mill capable of using work rolls of a small enough diameter that a tungsten carbide composition is possible, thereby giving the aluminum strip unsurpassed surface finish.

The Z-High® is a new concept and, be it a retrofit or a new mill, it has yet to make its mark in the rolling mill field. However, the initial results of operation on over a dozen mills indicate that it has very interesting potential, and the incoming inquiries and the studies that have been made on pre-engineered mills show that multiple advantages can be obtained for a very modest investment.