MODERNIZATION OF THE KROMAN WIRE ROD MILL TO INCREASE PRODUCTIVITY, UTILIZATION AND PRODUCT QUALITY*

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Abstract

A modernization project was undertaken by Kroman Celik Sanayii A.S. in order to improve their product quality, consistency and shape of the coil package, reduce maintenance and delays in rod mill, thereby increasing utilization and productivity. The project involved installation of a new Morgan Intelligent Pinch Roll and High Speed Laying Head, modifications to the existing controlled cooling conveyor, plus replacing the coil reforming station. The new pinch roll and laying head were to provide better control of the ring formation and consistency of the coil on the conveyor, while reducing delays on the conveyor. Changes to the controlled cooling conveyor included installation of new nozzle decks and Optimesh air distribution system along with re-arrangement of existing fans in order to improve both cooling rates and uniformity of cooling. This paper explains details and features of the newly-installed equipment technology. Resulting product and process improvements are presented, including increased tensile strength and uniformity, reduction in delays on the conveyor and reform tub, plus improvements in coil quality.

Keywords: Rod; Modernization; Quality; Productivity.

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1 INTRODUCTION

Kroman Celik is a combination bar and wire rod mill located in Darica, Turkey. In the wire rod mill, the reheat furnace accommodates 150mm to 180 mm square billets for rolling up to 120 t/h in the mill. Products from 5.5 to 20.0 mm plain round and 6.0 to 16.0 mm rebar are finished in a 10-stand finishing block. Finished coil weights range from 1,500 to 3,300 kg and have dimensions 1250/850mm OD/ID. The mill was commissioned in 2006. Kroman primarily produces for the construction industry, but wants to move into higher quality markets such as supplying cold heading and high carbon grades. In order to roll these value added products, Kroman had to address several continual quality and production problems plaguing them since commissioning. In 2014 Kroman contracted Primetals Technologies to replace and modify various equipment in the wire rod mill to position themselves for supplying higher quality markets in Turkey and abroad.

2 MATERIAL AND METHODS

2.1 Need for Improvement

One of the most significant problems was the ring pattern from the existing laying head, which was very poor and caused inconsistent cooling around the ring and therefore large variations in tensile strength. The poor ring pattern was the largely caused by the absence of a bottom center tripper assembly combined with the use of the side trippers with wobble to try to centralize the rings on the conveyor. This resulted in a very erratic ring pattern as shown Fig. 1. This combined use of wobble and side trippers also resulted in interlocking rings on the conveyor, causing significant delays at the reform station.

In addition, the laying head did not have any tail end control capability nor was the pinch roll operating properly for tail end slowdown, resulting in large out of control tail end rings on small diameter products. Limitations on the pinch roll capabilities caused other problems, such as marking of the bar and slipping of the rolls on the bar.

The existing conveyor at Kroman had not been supplied with nozzle decks below the rollers, resulting in relatively low air velocity, which further diffused prior to reaching the rod. In addition, there is no air distribution system to direct more air flow to the edges of the conveyor where the rings are most densely packed. The poor ring pattern from the laying head resulted in uneven ring spacing, i.e. clumping of the rings as well as scattering of the rings. These combined factors resulted in uneven cooling, yielding poor tensile uniformity, which is critical for fast cooled or hybrid cooled products, especially high carbons. Fig. 2 shows an example of hot edges on the coil pack as a result of the uneven cooling.

Another limitation of the existing cooling conveyor was that there were insufficient drops at the conveyor exit to allow for speed to be decreased for reforming. Preferably, the speed through the conveyor should be steadily increased in order to change the ring contact points and therefore increase the ring spacing for improved cooling efficiency. Those speed increases would make it necessary to decrease speed for proper reforming. As a result of not having the speed decrease capability with drops, the speed increases must be limited to achieve the ideal entry speed into the reform station for optimum coil formation.

Figure 1. Example of poor laying pattern from old laying head.

Figure 2. Non-uniform cooling on the conveyor.

Another main issue in the mill was the poor coil shape resulting in poor compaction, loose ties and damage to the inner and out diameter rings during transportation.

These problems were caused by the extremely deep reform tub (approx. 2 m) with only one set of iris fingers located at the bottom of the tub. As a result, the coil formed low in the tub, such that the ring distribution system at the top of the tub has no effect on the coil formation. This limitation of the reform tub, coupled with the bad ring pattern on the cooling conveyor resulted in a poor compacted coil package, like those shown in Fig. 3.

Figure 3. Examples of poor coil package.

2.2 Modifications

2.2.1 Pinch Roll and Laying Head

To address the problems of controlling the ring formation at the entry to the conveyor the existing pinch roll and laying head were replace with a new Morgan Intelligent Pinch Roll and new Morgan High Speed Laying Head.

The pinch roll arrangement consists of the latest generation design with a patented system for automatic servo motor pinch force control. With the intelligent pinch roll there is no need to manually adjust the roll gap in order to set the pinch force. Instead, the roll gap is automatically set to induce the correct amount of pulling force for tension regulation without slipping on the rod or marking the rod when closed. The system also allows for faster response for tail end slowdown on small diameter, high speed products, thereby improving the tail end ring control.

The existing turndown pipe after the pinch roll was replaced with a new turndown guide arrangement that utilizes a new patented design with special high wear resistant materials on the guide surfaces. This improved guide provides extended life and improves stability of the rod entering the laying head, further improving the consistency in the ring pattern on the cooling conveyor.

The current generation of Morgan High Speed Laying Head arrangement (Fig. 4) improves upon earlier generations by altering the basic design of pipe support from two pieces to a single integrated piece, shrinking the total weight by 28 percent. The new design shifted the center of gravity for the pipe support back toward the gearbox, resulting in a slightly longer pipe curve and lower vibration levels. The new design also lowered the maximum stress level concentration in the laying head by 70 percent. Pipe life is dramatically increased with a new optimized pipe path and the use of the patent SR Series® pipe.

Figure 4. Morgan High Speed Laying Head.

The SR Series technology is a proven pipe design concept, wherein new material replaces worn sections of laying head pipe through a slow “self regenerating” process during rolling, controlled by managed thermal cycling, tolerances and friction [1]. The regeneration shifts the wear zone up to 150 mm (six inches) without affecting the laying head dynamic balance. The resulting dramatic improvement in pipe life can be further enhanced with pipes made with proprietary materials.

2.2.2 Conveyor
The existing conveyor sections from the entry section up to the curved conveyor section were modernized with new roller nozzle decks, covers, plenum chambers with Optimesh air distribution system using the existing blowers.

A new entry tilt section was supplied to provide the correct interface between the laying head bottom tripper assembly and the conveyor rollers, so that the optimum ring pattern onto the conveyor. The entry section also uses close-centered rollers to prevent small diameter head or tail ends from getting caught between the rollers. Front end positioning is provided with the new automation system to ensure the correct presentation of the head end rings on to the conveyor to further prevent this from occurring. Ductile iron side wall deflectors at the exit of the laying head also prevents turbulence in front of the laying head eliminating the deformation of the small diameter product rings as well as scratch on large sizes when utilizing wobble.

New roller decks were provided for zones 1 to 6. Each zone is 9.25 m in length and utilizes three of the existing blowers. Positioned just below the rollers the rollers are nozzle decks with angled nozzles extending up between the rollers, generating a high velocity air flow for maximum contact time with the rod for fast cooled products. Below the nozzle deck is the patented Optimesh air distribution system that gradually provides more air at the edges that than the center. This gradual change in air flow provides added improvements with respect to tensile uniformity around the ring. Fig. 5 shows the new conveyor sections.

To improve the tensile uniformity throughout the coil for fast cooled products, the speed between each zone is adjustable using VVVF drives. Between each half zone a fixed speed increase is provided through the sprocket drives on the rollers. By gradually increasing the speed along the conveyor the contact points on the overlapping rings are continuously changed and the spacing between the rings increased to help with higher cooling rates.

As mentioned above. with the increase in conveyor speed the product must be slowed prior to entering the reform tub otherwise the rings will bounce off the upstream wall of the reform tub. Therefore, drop zones are provided prior to the exit section to allow the product speed to be reduced. Prior to the drop section, centering rollers are provided to push the rings to the center of the conveyor. Bullet rollers are provided at the exit of the drop section to ensure the ring fall squarely onto the next section. Close-centered rollers on the succeeding roller module prevent the rings from getting caught between the rollers when they drop.

The existing exit section was replaced with a new traversing section, including another set of side wall deflectors to preserve coil centering for presentation to the reform tub. . The exit section traverse position will be set based on the speed of the product entering the reform tub. The position of the exit section ensures that the rings drop squarely over the nose cone and do not dive into the reform tub, which could result in sloped or slanted coils. The presentation of the rings into the reform tub is the starting point for a good coil package. Fig. 6 shows the new exit section and top of the reform tub.

Figure 5. New conveyor section with angled nozzles and Optimesh system.

2.2.3 Reform

To ensure the optimum coil package the coil must be formed in an orderly manner and also completely formed inside the upper portion of the reform tub. The ordering of the rings coming off the exit section is achieved with a ring distributor, which is a proven design of rotating blade within the upper portion of the tub that directs how the rings fall onto the forming coil. Furthermore, the tub depth must be kept as short as possible to prevent large drops from the iris fingers to the coil plate and to maintain a fixed distance between the top of the coil and the underside of the ring distributor, so that they benefit of the ring distributor is preserved [2]. A new reform tub was supplied, and the existing descending coil plate was modified to minimize the length of the drop from the iris fingers to the coil plate. A mechatronic package controls the reform cycle, using a series of laser sensors to measure the coil height in the reform tub to adjust the coil plate rate of descent maintaining a constant collection height.

Figure 6. New exit section and reform tub.

By producing a stable ring pattern from the laying head onto the conveyor and controlling the rings entering the reform tub with the ring distributor and automatic coil plate descent, the coil formed will be densely packed with a thick wall and constant O.D. and I.D. Fig. 7 shows the bottom side of the reform tub with the coil plate in the top position and vertical stem positioned to receive a coil.

With a densely formed coil on the vertical pallet the coil shape and integrity is maintained through further cooling of the coil. As a result, the coil shape is maintained during compacting and the compacted coil does not relax during shipping and therefore the ties do not become loose.

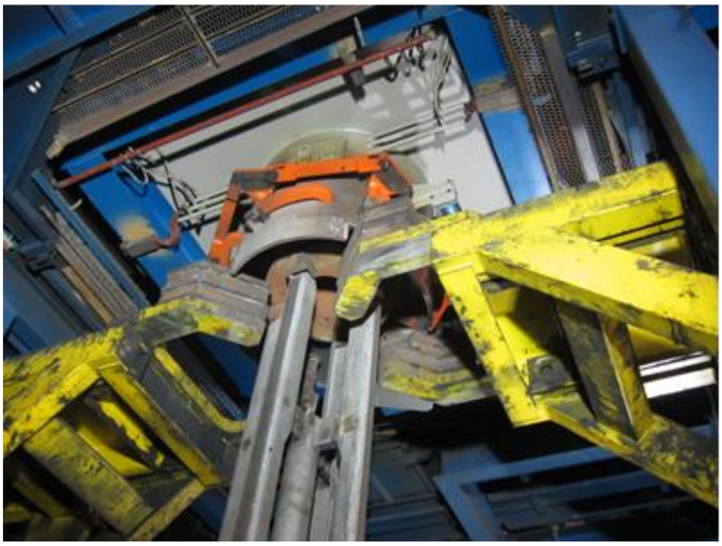

Figure 7. New reform tub and interface with existing descending coil plate.

3 RESULTS AND DISCUSSION

Three sizes (5.5, 8.0 and 13.0 mm) of 1080 grade were rolled and processed for fast cooling on the conveyor. The billets were produced from BOF route. The uniform laying pattern and well distributed forced air flow resulted in a uniform cooling rate around the ring. This was tested by cutting a ring into eight samples to be tensile tested. If the edges are cooling slower than the center positions, there will be significant differences in tensile results between center and edge samples.

Kroman sampled three consecutive rings from three different billets to determine the around-the-ring tensile uniformity. The results are given in Table 1. The smallest diameter is the most influenced by cooling rate and usually has the largest deviation of tensile strength. The results show that two billets of 5.5 mm had excellent uniformity, <40 MPa in the coil and <30 MPa in most rings. Using one standard deviation of tensile strength as a percentage of average tensile as a measure uniformity ("percent standard deviation"), most coils and rings were <0.90%. Only one ring of the nine had a higher value than the norm.

As diameter increases, the uniformity becomes tighter. For 8.0 mm, all rings had a range <35 MPa or 1.0 percent standard deviation. Coils were less than 37 MPa and 0.91% percent standard deviation. Nearly identical results were obtained for the 13.0 mm.

Cooling rate was fast enough on the 13.0 mm to produce small amounts of resolvable pearlite with no grain boundary cementite.

All rolling speed tests were achieved within the capability of the rolling line for the pinch roll and laying head. The head, tail and overall coil package on the conveyor was acceptable on all sizes.

Table 1. Table 1. Tensile test results for three product sizes

Size (mm)	Ring (MPa) (%SD)	Coil (MPa) (%SD)	Avg. (MPa)
5.5	20, 35, 30 0.62, 0.99, 0.86	36 0.83	1165
5.5	70, 25, 18 1.98, 0.82, 0.53	70 1.23	1157
5.5	16, 21, 28 0.48, 0.56, 0.84	30 0.68	1158
8.0	17, 20, 21 0.60, 0.74, 0.64	29 0.69	1120
8.0	17, 10, 16 0.52, 0.33, 0.45	21 0.42	1112
8.0	30, 33, 35 0.97, 0.84, 1.0	37 0.91	1129
13.0	10, 22, 38 0.28, 0.68, 1.11	39 0.77	1093
13.0	14, 22, 22 0.41, 0.67, 0.59	27 0.57	1090
13.0	22, 29, 30 0.61, 0.94, 0.85	34 0.78	1095

The properly laid rod is successfully reformed (see Fig. 8) and compacted (see Fig 9) into dense, well-formed coils that are able to be shipped and paid off downstream without snarls, tangles and delays. All sizes and processing routes (fast cool to slow cool) are reformed without issue.

54º Seminário de Laminação e Conformação
Anais do Seminário de Laminação e Conformação ISSN 2594-5297 vol. 54, num. 1 (2017)

Figure 8. Well-formed coil on vertical stem pallet.


Figure 9. Compacted coils at the coil unloading station.

4 CONCLUSION

The rod outlet at Kroman was updated in 2015 to solve many of the production and quality problems that have plagued the mill. Primetals installed new pinch roll, laying head, updated the cooling conveyor to properly fast cool high carbon, improved the conveyor exit end with speed decreases, and revamped the reform. Along with the improvements to the mechanical equipment, Primetals Automation was able to integrate the new Mechatronic packages with the existing system. Kroman can now consistently produce well-formed coils easily paid off by their customers. Kroman is now also positioned to supply high carbon that can be processed at a world-class level with their updated cooling conveyor.

ISSN 2594-5297 vol. 54, num. 1 (2017)

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