New PL-TCM (Pickling and Tandem Cold Strip Mill) in Vietnam

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Introduction

Commercial operation of the captioned PL-TCM which JP Steel Plantech Co. (SPCO) applied SPEOS™ technology to all stands has started up in November 2013 .

Since Vietnam is one of the most rapid growing countries in the world, a number of major steel producers in the world have planed or actually started construction work to build new steel mill plants in this country.

In such circumference, China Steel Sumikin Vietnam Joint Stock Company (CSVC), a joint venture company of China Steel Corporation (CSC) in Taiwan and Sumitomo Metal Industries (now Nippon Steel Sumitomo Metal Corporation) in Japan, placed an order of PL-TCM with SPCO in 2010.

The descriptions as shown below are the outline and technical high-lights of PL-TCM constructed and started up by SPCO in 2013.

Specification of Major Equipment

Main Specification of the line :

Entry thickness	: 1.4 - 6.5 mm
Delivery thickness	: 0.2 - 2.4 mm
Width	: 1600 mm Max.
Coil Weight	: 30 tons Max.
Rolling Speed	: 1250 mpm Max. at No.5 stand exit

Figure 1. shows General Layout of the line

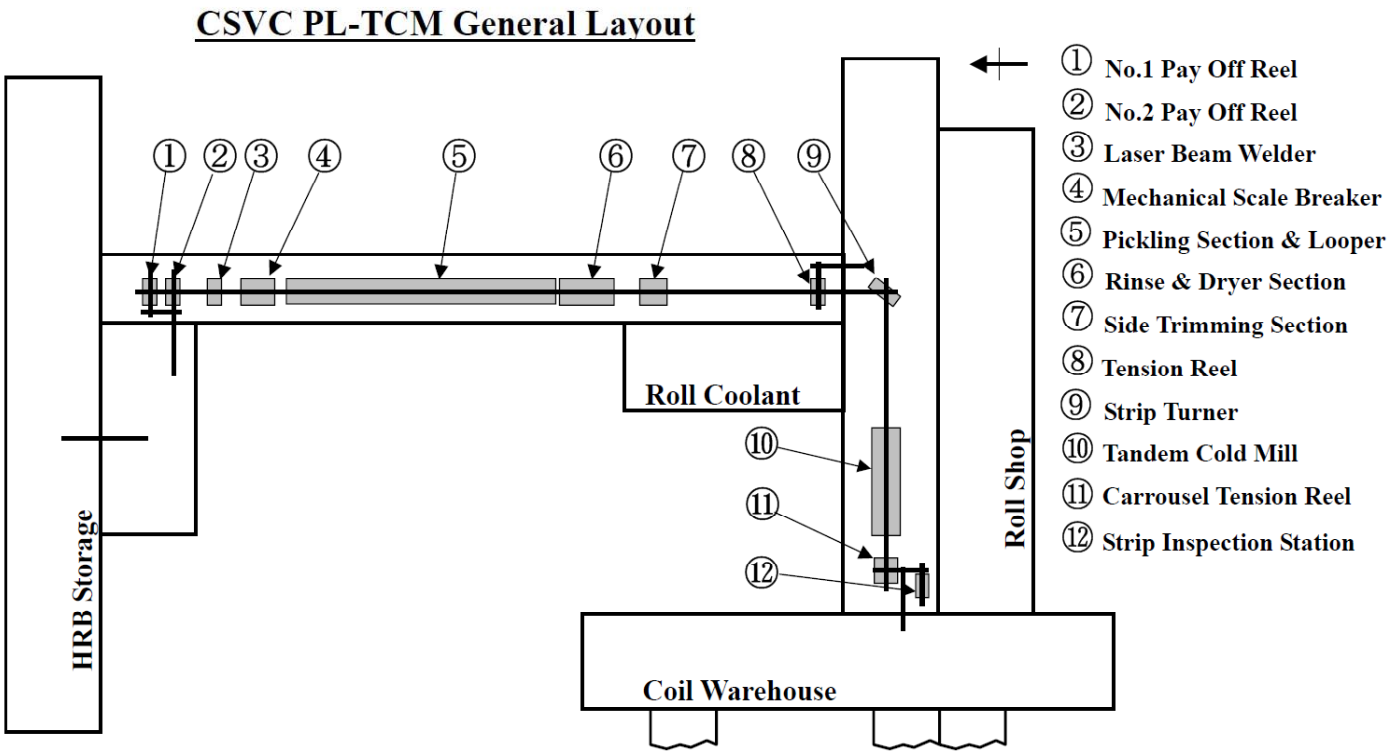

Figure 1 General Layout of the line

Double Pay-off Reel

To minimize downtime of switching coils to be paid off at entry section, Double Pay-off Reel arrangement is adopted. This allows strip head-end feeding operation of following coil up to the waiting position of Welder during the preceding coil is being paid off.

Laser Welder

Performance of Welder is very important for continuous operation of PL-TCM of this kind. Laser beam type fully automatic welder is provided for higher quality of strip welding. Welding time necessary for 4ft wide strip of 3.2 mm thick is 22 seconds.

Entry, Center and Delivery Looper

Strip loopers are provided for strip accumulating function, consist of entry, center and delivery sections in order to keep continuous operation in each section respectively.

When switching coils at Pay-off reels, and strip stops for welding, Entry Looper takes the strip length commensurate with the downtime. When strip width change or knife change at Trimmer, Center Looper stores the strip, while Delivery Looper pays out accumulated strip to keep TCM running. Delivery Looper also functions to absorb handling time of pickled and oiled coils, and strip cutting time at mill delivery Shear. And at the time of mill roll changing, Center Looper and Delivery Looper stores the strip to keep PL running.

Scale Breaker

A tension leveler type scale breaker is provided at the entry side of Pickling tank to break the iron oxide on the strip surface mechanically in order to enrich pickling performance. This scale breaker is dry leveling type with hydraulic quick open function.

Pickling Tank Section

This section consists of three (3) tanks of jet flow type, Rinse section and Dryer section. Edge Blower is provided between Rinse section and Dryer section.

Adoption of Polypropylene (P.P.) Tanks contributes to maintenance free operation. P.P. tanks do not require periodical replacement of bricks, which is inevitable for traditional brick lining tanks.

Figure 2 Pickling Tank Section

Double Steering Rolls at Trimmer Entry (Two (2) rolls + three (3) rolls)

At the entry side of Trimmer, two sets of Steering Rolls are equipped. The roles of each steering rolls are, coarse centering by the front two rolls and fine centering by the back three rolls. Those two separate functions realize stable and accurate strip centering.

Side Trimmer and Scrap Chopper

A pair of non-driven turret type Side Trimmer is provided. This design allows easy and quick changing of knives. Stabilizer rolls located just in front of Trimmer, Hold Down Roll at the center of the line contributes stable side trimming work.

For continuous side scrap cutting stably, a pair of Rotary Scrap Choppers is closely arranged at delivery side of the Trimmer.

Tension Reel for pickled and oiled coils (P.O. coils)

One (1) set of Tension Reel is provided for production of pickled and oiled coils.

Gripper on the mandrel of Tension Reel catches the leading end of P.O. coil. The series of processing P.O. coil, from shear cutting to deliver the coil by coil car, including grip and un-grip operation, is fully automated.

Strip Turner

Due to effective utilization of the plant site, this PL-TCM must be so designed to have one rectangular corner in the entire line. To meet this requirement, one set of helical Strip Turner is provided with touch rollers.

Double Steering Rolls at Mill Entry (Two (2) rolls + two (2) rolls)

At the entry side of TCM, two sets of Steering Rolls are equipped. Coarse centering by the front two rolls and fine centering by the back two rolls are realized. Those two separate functions make strip centering stably and accurately at the entry side of the mill.

5-stand Tandem Cold Mill

Most modern Tandem Cold Mill of five (5) stands with all 6-high mill is provided.

Positive and negative Roll Benders for Work Rolls and Intermediate Rolls, Roll Shift Device for Intermediate Rolls are provided for all stands. Intermediate Rolls are designed to have SPEOS curves for wider range of strip crown and flatness control. In addition, Work Roll Shift Devices are equipped on No. 1 and No. 2 stands for the purpose of reducing edge drop by shifting work rolls with special contour for this purpose. Back-up Roll eccentricity compensation function is provided for No. 1 stand as well.

In order to realize various modes of automatic gauge control, laser type speed-meter is equipped on every X-ray thickness gauge.

Strip tension detectors are provided at the entry side of No.1 stand and delivery side of each stand for automatic tension control. One flatness detector at delivery side of No.5 stand has also strip flatness detecting function to feed back to flatness control loop.

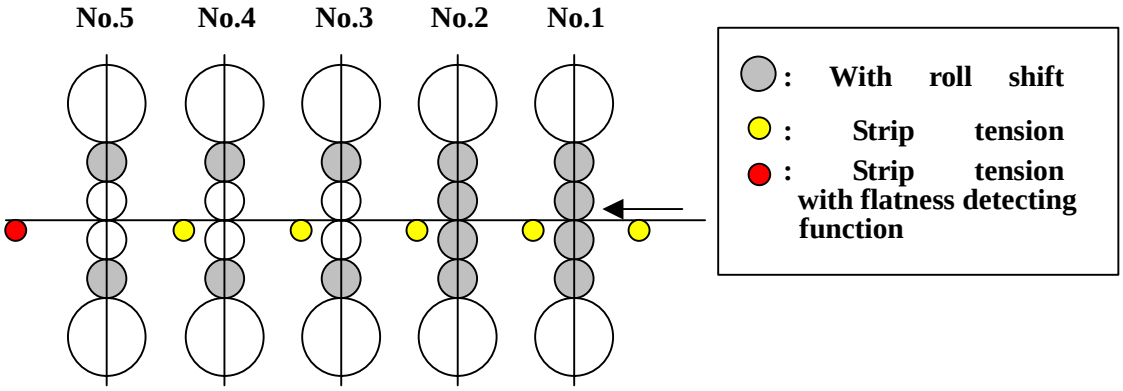

Figure 3 Five (5) stand Tandem Cold Mill

Figure 4 Tandem Cold Mill

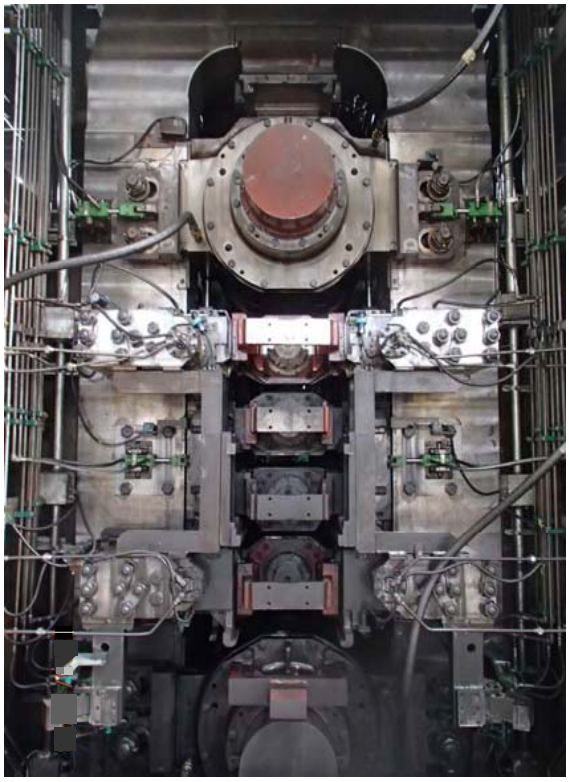

Figure 5 Mill Window (No.3 Stand)

Automatic Roll Changing System

Work rolls, intermediate rolls and back-up rolls can be changed while strip is in the mill. Work Rolls and Intermediate Rolls are to be changed by full automatic mode. Rolls of all stands can be changed simultaneously, when roll diameters are larger than certain figure, without decreasing strip speed in the pickling section, thanking to large capacity of strip accumulation in the Center Looper and Delivery Looper.

Actually measured roll changing time for all stands (WR + IMR together) is approximately 4 minutes.

Carrousel Tension Reel

For this project, SPCO adopted Carrousel type Tension Reels. Comparing with two-reel-type, necessary distance between deflector roll and the reel at entry side can be designed shorter. Normal coiling speed is 1250 mpm Max. Wheel revolution is 4 rpm Max. Belt Wrapper is located beneath the entry side reel position. One (1) set of Coil Car is provided at the delivery side reel to take out finished coil to the next process.

Figure 6 Carrousel Tension Reel

Independent Strip Inspection Line

Inspection Pay-off Reel is arranged at the end of stroke of Coil Car confronting to Carrousel Tension Reel delivery position.

Coils not required for inspection are lifted up by Walking Beam Conveyor located between Carrousel Tension Reel and Inspection Pay Off Reel and transferred to coil storage yard.

In order to inspect strip bottom surface as well visually, an elevator type Lifting Table is arranged to provide necessary space for

inspector.

Roll Coolant System

For recirculation of roll coolant, three (3) independent main tanks are provided. Two (2) of them are for all five stands and the third tank is for No.5 stand only. Two large tanks contain different density coolant respectively, to be switched properly suitable for steel grade to be rolled. The third tank contains ultra-low density coolant for dull work rolls to be set in No.5 stand.

For the purpose of making up coolant, to compensate carried over or evaporation, two (2) different base oil charging systems are provided.

Technical Features

In this chapter, principal technologies adopted for this project are introduced.

SPEOS™ :

SPEOS™, an acronym based on the name “Superior Profile with Edge Oriented Shifting”, is advanced crown control technology involving shifting of special curved rolls to the axial direction[1].

Different from prevailing roll curve of cubic function, SPEOS curve consists from three curves of independent functions continuously. Steeper curve is given to the zone from the peak to edge, while gentler curve is given to the zone from the bottom to the other edge, comparing to the center zone.

Figure 7. indicates typical SPEOS curve concept.

A pair of SPEOS curved rolls creates “Gap Expanding Transitional Zone” (GETZ) at both side of strip edge zone, for any width of strip to be rolled. When proper roll shift position is selected, strip thickness out side of GETZ becomes thicker than center naturally as shown on Figure 8.

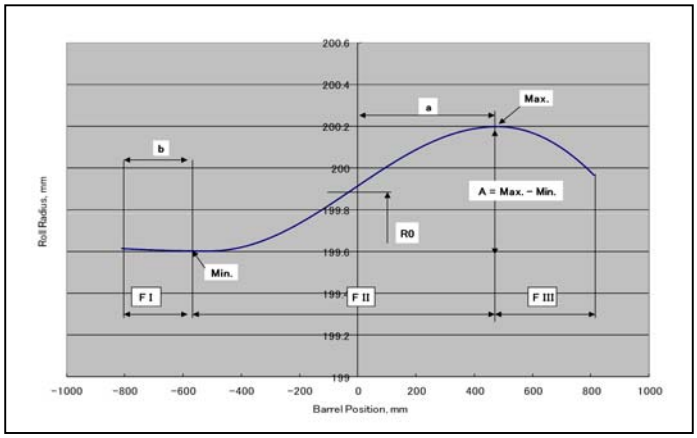

Figure 7. Typical SPEOS Curve

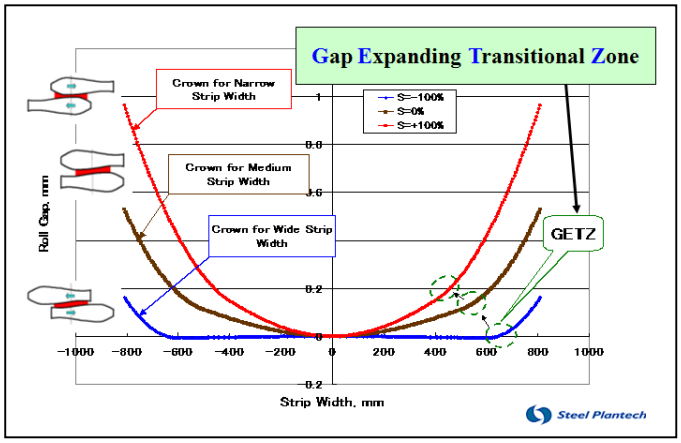

Figure 8. Roll Gap at each position of SPEOS Rolls

The following illustrations, Figure9 to 11, show conceptual schematics of each roll gap for rolling wide, middle and narrow strip.

Provided that rolling force per unit width is constant, appropriate roll shift position, compensating roll deformation by rolling force, moves toward increasing mechanical crown as strip becomes narrower.

Aforesaid GETZ (Gap Expanding Transitional Zone) automatically appears around strip edge, when the rolls with proper crown are shifted each other to appropriate position according to each strip width with unit rolling load.

At this situation, since contact pressure between WR and BUR out side GETZ is reduced, smaller edge drop and higher roll bending effect can be performed.

In case of smaller edge drop oriented rolling, the roll shift position can be so set up as to meet edge drop minimum position and strip crown can be controlled by work roll bender with relatively small bending force. Thus, easy set up of mill becomes available aiming strip crown and edge drop control at the same time.

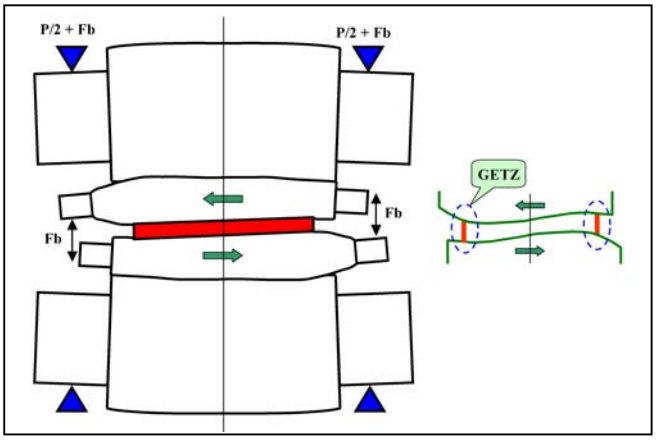

Figure 9. Roll Gap Schematic for wide strip

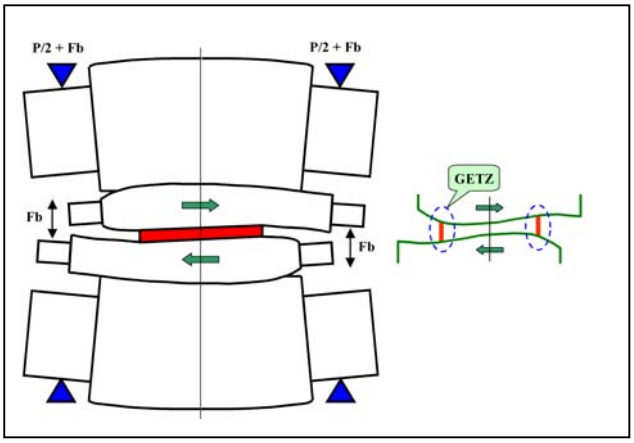

Figure 10. Roll Gap Schematic for medium width strip

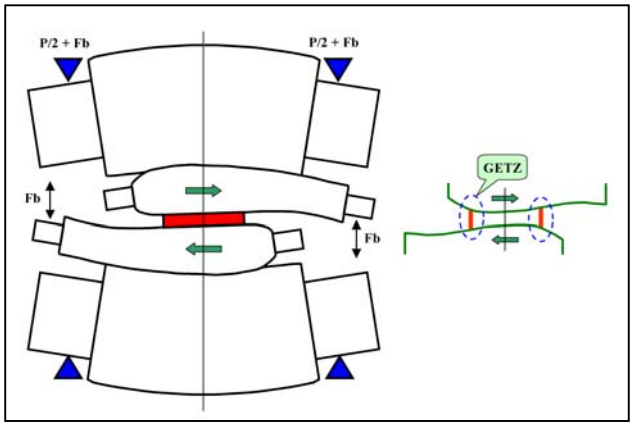

Figure 11. Roll Gap Schematic for narrow strip

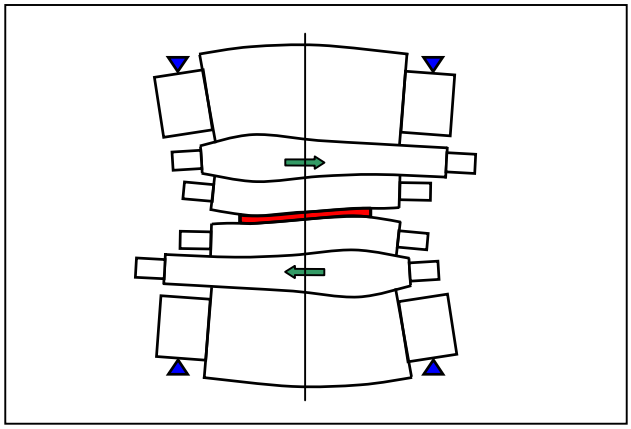

Figure 12. 6Hi SPEOS™ Mill

For this project, since five (5) stand tandem 6-high mill configuration is adopted, only one kind of SPEOS curve is provided for all intermediate rolls of five stands. Shifting position of intermediate rolls for SPEOS 6-high mill is set depending on strip width and estimated unit roll force so as to keep WR bending and IMR bending around zero force. Thus full scale of WR bending and IMR bending can be employed in each rolling conditions. When a weld point of next coil is entering, high response WR bending works to meet required crown of the next coil while IMRs are shifted under higher rolling speed prior to the weld point or after the weld point passes. As a result, off-gauge of shape and flatness can be minimized. In addition, aforesaid GETZ is located on gap between BUR–IMR and gap between IMR-WR in each strip edge region, therefore bending effect of IMR and WR is increased compared to ordinary shift mill with ordinary roll contour.

Features of SPEOS 6-high mill are summarized as follows.

(1) Excellent crown and flatness control leads higher yield especially on weld point region.
(2) Bending effect is superior due to GETZ compared to ordinary shift mill with ordinary roll contour.
(3) Flexible and stable operation compared to ordinary 6-high mill with long stroke shifting of straight intermediate roll.

Edge Drop Control :

For edge drop control, single tapered work rolls are employed for No.1 and No.2 stands with work roll shift mechanism.

Creating edge up shape by No.1 and No.2 stands, by shifting taper portion to appropriate position towards the strip edge, strip with near rectangular section can be obtained at delivery of No.5 stand.

For the purpose of rolling particular steel grade such as electric steel of narrower width up to 1300 mm, tapered work rolls for edge

drop control are set in the front two stands. Work roll shifting stroke is ±150 mm.

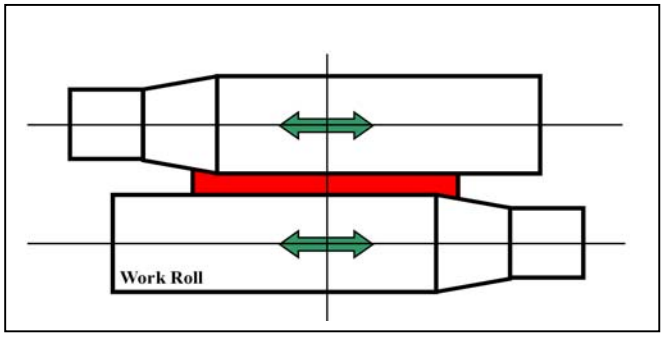

Figure 13. Tapered-crown work rolls

Conclusions

Given in the above is the outline of PL-TCM for CSVC constructed and started-up by SPCO.

As committed by SPCO at the early stage of the project, this new PL-TCM line is producing high quality cold rolled coils to the market.

Encouraged by the fact that the first PL-TCM – a project contains many challenges as SPEOS in tandem mill, first Carousel Tension Reel, etc. – is finally concluded in commercial operation, SPCO is prepared for a new attempt to produce better PL-TCM by making good use of valuable experiences obtained through this project.

Acknowledgements

In closing this paper, we at SPCO would like to express our sincere gratitude to everyone at CSVC, all other companies and individuals involved for their efforts and cooperation in bringing this project to an expected goal.

References

1) T.Kikkawa : Superior Profile Control Technology with Edge-oriented Shifting : AISTech2012