



THE NEW GLOBAL COMPETENCE IN HOT ROLLING

INTRODUCTION

THE GLOBAL COMPETENCE IN HOT ROLLING

Primetals Technologies represents a new global plant building competence with a wide portfolio, innovative technology and customized services for the metals industry. This competence becomes visible especially in the area of conventional hot rolling mills.

The demands related to the capabilities of a conventional hot rolling mill have changed in the last years. In addition to the high level of output and productivity, the demand for quality improvement is still growing up. Safety and energy saving become a very important aspect. Today there is a clear trend in developing new steel grades like AHSS grades (Advanced High Strength Steel), dual-phase and multi-phase grades. This trend challenges the conventional hot mill technology because it requires new technologies which provide more flexibility in metallurgical treatment during the rolling process. In parallel, the high level of productivity and quality has to be maintained.

In order to follow these trends Primetals Technologies is continuously investing in R&D. Highly skilled researchers cooperate with universities and other R&D institutes. Beside the application of an impressive number of patents, Primetals Technologies offers advanced equipment and technologies for rolling mills. Examples are: slab sizing press, PairCross and SmartCrown® technology for profile and flatness control, looper shape meter (LSM) for strip tension measuring within mill stands or power coiler for coiling of thick and hard material. In the area of strip cooling technology Primetals Technologies is in the role of a trend setter with its

Power Cooling technology for hot strip mills and Mulpic for plate mills which open the door for many metallurgical treatments in a conventional hot rolling mill such as transfer bar cooling, interstand cooling, runout table cooling or in plate production as well as reduction of expensive alloying elements.

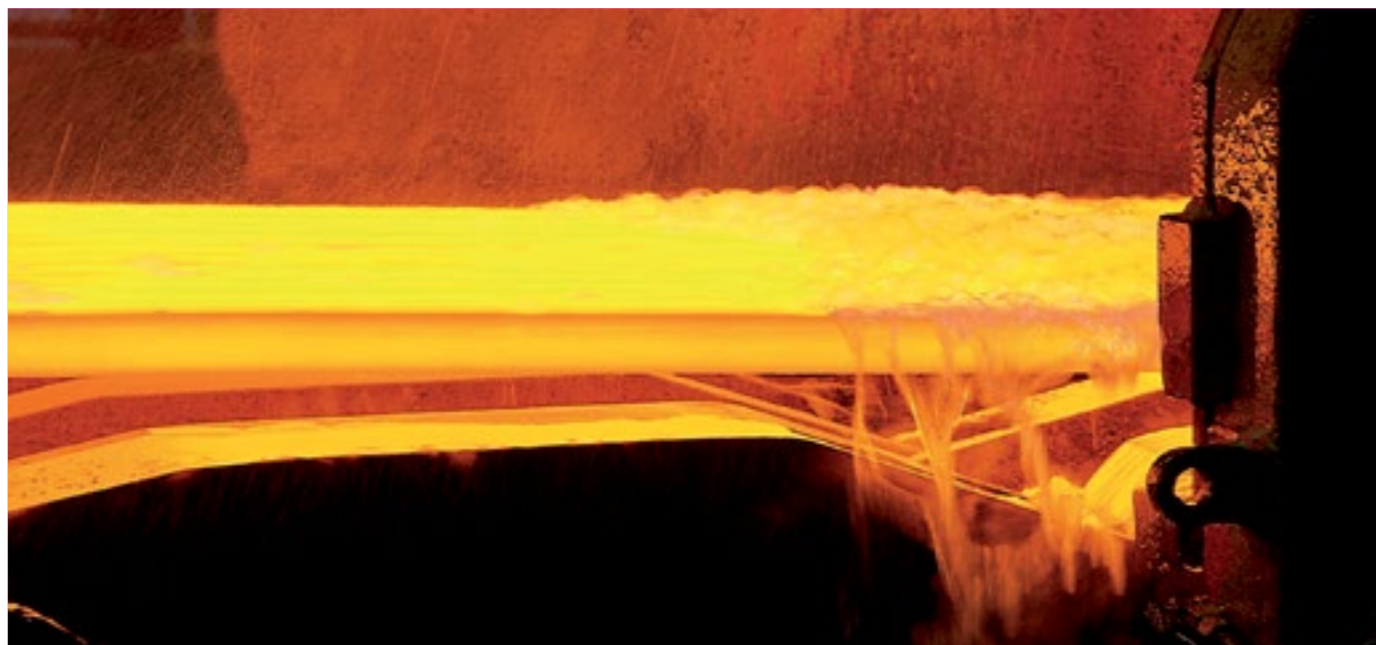
The number of references (new mills and modernization projects) proves the capability of project management of Primetals Technologies. The installation of new mills requires different project management skills in comparison to modernization projects where the precise shut down planning and execution becomes one of the most critical topics. Primetals Technologies employs an extremely experienced team of project managers and commissioning managers with specific know-how in rolling mills in order to provide the best services to the customer.

The hot rolling technology of Primetals Technologies comprises a wide range of advanced equipment and technologies together with studies, services and consultancy in the area of rolling process and quality improvement as well as metallurgical know-how. Testing facilities to check new designs are available to secure the innovative advantage e.g. in roll cooling, work roll lubrication or strip cooling technology.



HOT STRIP MILLS

NEW INSTALLATIONS



Primetals Technologies supplied seventeen (17) new conventional hot strip mills in the last 15 years. This number of mills corresponds to a yearly production of hot rolled coils of approximately 55 million tons.

The table on the next page gives an overview of these installations. The mills are located all over the world, from USA and Brazil over Turkey, Europe, India, Korea, Taiwan, Vietnam to Japan which proves the high and worldwide acceptance of Primetals Technologies hot rolling technology and the trust of our customers into Primetals Technologies capabilities in engineering and project management.

The individual mills feature a wide range of dimensions and steel grades. Whereas the hot strip mills for JSL (India) and Fujian-Fuxin Special Steel (China) are dedicated for the production of stainless steel, the hot mill for Allegheny Ludlum (USA) is capable of rolling Titanium and Zirconium ingots and slabs in addition to carbon steels. The thickness range varies from 1.2 mm to 25.4 mm and the width range is from 700 mm to 2100 mm.

The process layout of some of the mills allows production of more than 5 million tons per year; an example is the mill for Formosa Ha Tinh Steel (Vietnam) or the hot strip mill for Tata Steel Kalinganagar (India). Many layouts have already the provision for future extension of production and product mix.

The different requirements of production and product mix require individual planning of the process layout and the selection of the related rolling mill equipment. The portfolio of Primetals Technologies hot strip mill technology covers all these demands.

The hot strip mill for ArcelorMittal in Krakow (Poland) and the hot strip mill for SAIL RSP in Rourkela (India) are two examples of full turn-key projects. In these projects the scope of Primetals Technologies includes civil works, bays, steel structures and cranes, water treatment plant, roll shop, slab and coil yards. The hot strip mill for ArcelorMittal Poland was installed within 24 months from contract signature to first coil. Currently the construction and commissioning of 4 new hot strip mill projects is ongoing.

NEW HOT STRIP MILLS

REFERENCES

CUSTOMER COUNTRY	START UP	STEEL GRADES	PRODUCTION [Mt/y]	STRIP THICKNESS [mm]	STRIP WIDTH [mm]
Undisclosed Company Mexico	2020				
Undisclosed Company Mexico	2020				
JSW Dolvi India	2020	CS, API, DP	5.0	1.5 - 16.0	900 - 1650
SAIL RSP India	2019	CS, API, DP	3.0	1.2 - 25.4	725 - 2150
FORMOSA Ha Tinh Steel Vietnam	2015	CS, API, DP	5.3	1.2 - 25.4	900 - 1880
TATA Kalinganagar India	2015	CS, API, DP	5.5	1.2 - 25.0	800 - 2050
Allegheny Ludlum USA	2014	SS, CS, API, DP, Si, Ni-alloys, Ti-alloys	3.0 (4.0 future)	1.78 - 25.4	660 - 2083
Fujian-Fuxin Special Steel China	2013	SS, CS, API	2.5	1.2 - 18	830 - 1630
USIMINAS Cubatao No 2 HSM Brazil	2012	CS, API, DP	2.3 (4.8 future)	1.5 - 20	750 - 2050
JSL India	2011	SS, CS	1.6 SS (3.2 incl. CS future)	1.5 - 12.7	1000 - 1650
Hyundai C-HSM Korea	2010	CS, API, DP	5.5	1.2 - 25.4	800 - 2000
Dragon Steel Taiwan	2010	SS, CS, API, DP, Si	3.8	1.2 - 25.4	700 - 1880
JSW Vijayanagar India	2010	CS, API, DP	5.0	1.2 - 25.4	900 - 2150
Tokyo Steel Tahara Japan	2009	CS	2.4	1.2 - 22	740 - 1600
Isdemir Turkey	2008	CS, HSLA, API, DP	3.5 (4.5 future)	1.2 - 22	700 - 2050
ArcelorMittal Poland	2007	CS, API, DP, Si	2.4 (4.5 future)	1.2 - 25.4	750 - 2100
Bao Steel No 3 HSM China	2007	CS, API, DP, Si	3.7	1.2 - 19	700 - 1730

LEGEND

CS	Carbon Steel
SS	Stainless Steel
HSLA	High Strength Low Alloyed
DP	Dual Phase
API	Pipe Grades
Si	Silicon Steel

PLATE AND STECKEL MILLS

NEW INSTALLATIONS



Plate-Steckel mill at AHMSA, Monclova, Mexico

Primetals Technologies supplied twelve (12) new Plate and Steckel mills in the last 15 years. This number of mills corresponds to a yearly production of approximately 13.6 million tons flat rolled plate and 1.15 million tons hot rolled coils.

The table on the next page gives an overview of these installations. The mills are located all over the world, from Brazil to Mexico, over India, China, Korea and Indonesia which proves the high regard and worldwide acceptance of Primetals Technologies hot rolling technology and the trust of our customers into Primetals Technologies capabilities in engineering and project management.

Nearly all the plate mills are dedicated for the production of carbon steels of varying parameters used in the oil and gas, bridge, pressure vessels, yellow goods, construction and shipbuilding industries and thickness varies from 4.5mm to 150 mm thick plate rolled from Ingots at 360mm.

The process layout of these mills allows production of around 1.5 to 2 million tons per year, an example is the mill for Xiangtan Iron & Steel (China). Many layouts already have the provision for future extension of production and product mix.

The concept of Plate/Steckel mills provides a middle ground in plate rolling by producing discrete plate (up to 50mm) and coil plate (4.5 to 25mm) in one line. Pure Steckel Mills are also beginning to emerge as major contenders where a low cost start in the market is sought by an investor. These produce both carbon steel, stainless steel and special steels

The different requirements of production and product mix require individual planning of the process layout and the selection of the related rolling mill equipment. The portfolio of Primetals Technologies hot mill technology covers all these demands.

NEW PLATE AND STECKEL MILLS

REFERENCES

CUSTOMER COUNTRY	TYPE	START UP	MILL STAND [mm]	STEEL GRADES	PRODUCTION [Mt/y]	THICKNESS x WIDTH [mm]
Carpenter Technology USA	Steckel Mill	2020	625	Super alloy, SS	0.056 coil	1.9-7.6 x 483
Gerdau Acominas SA/BR Brazil	Plate Mill	2015	3800	L-CS, M-CS, H-CS, API	1.1 plate	4,5-150 x 900-3600
Gerdau Acominas SA/BR Brazil	Steckel Mill	2013	2200	L-CS, M-CS, API	0.83 coil	2-20 x 900-2100
PT Krakatau Indonesia	Plate Mill	2013	4700	L-CS, M-CS, H-CS, API	1.5 plate	6-120 x 1200-4650
AHMSA Mexico	Plate/Steckel	2012	3300	L-CS, M-CS, H-CS, API	0.75 plate, 0.25 coil	4.5-50 x 1500-3200
Jindal Steel & Power India	Plate Mill	2011	5000	L-CS, M-CS, H-CS, API	1.2 plate	5-50 x 900-4800
Jinan I&S Group China	Plate Mill	2010	4300	L-CS, M-CS, H-CS, API	1.8 plate	6-120 x 1500-4100
Jiangsu Shagang Group Co. Ltd. China	Plate Mill	2009	5000	L-CS, M-CS, H-CS, API	1.5 plate	5-50 x 900-4800
Dongkuk Iron & Steel Korea	Plate Mill	2009	5000	L-CS, M-CS, H-CS, API	1.5 plate	4.5-150 x 900-4800
Xiangtan Iron & Steel China	Plate Mill	2008	5000	L-CS, M-CS, H-CS, API	2.0 plate	5-150 x 900-4800
WUHAN IRON & STEEL China	Plate Mill	2008	4300	L-CS, M-CS, H-CS, API	1.2 plate	5-150 x 1050-4100
Tokyo Steel Kyusyu Japan	Plate Mill	2007	2650	L-CS, M-CS, H-CS	1.0 plate	9-60 x 1500-2500

LEGEND L-CS Low Carbon Steel
M-CS Middle Carbon Steel
H-CS High Carbon Steel
API Pipe Grades
SS Stainless Steel

UNIQUE ON THE PLANET

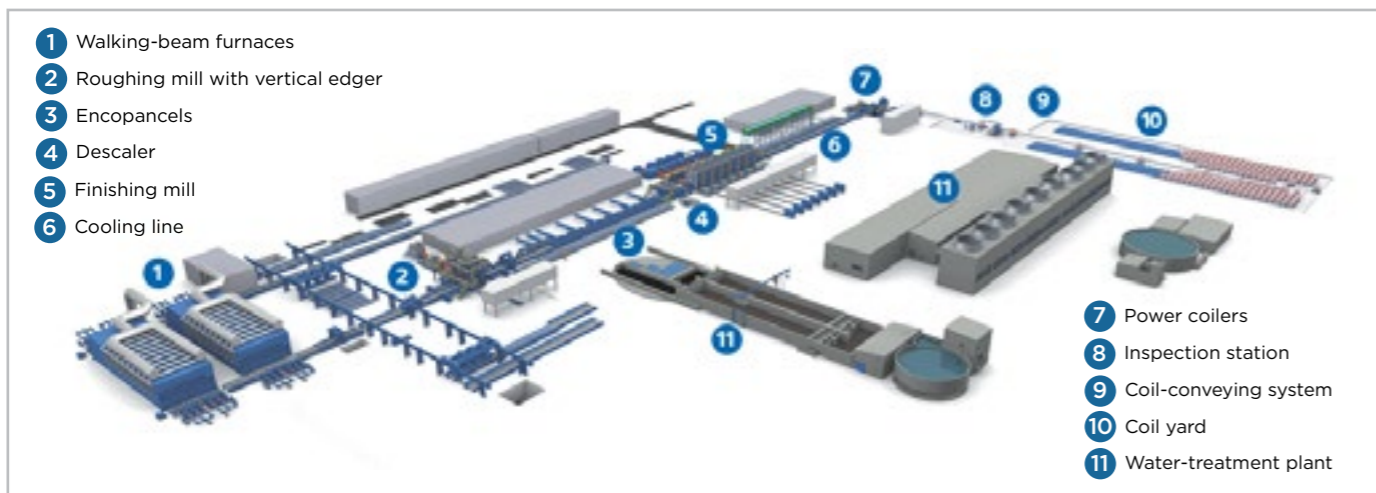
THE WORLD'S MOST POWERFUL HOT-ROLLING MILL



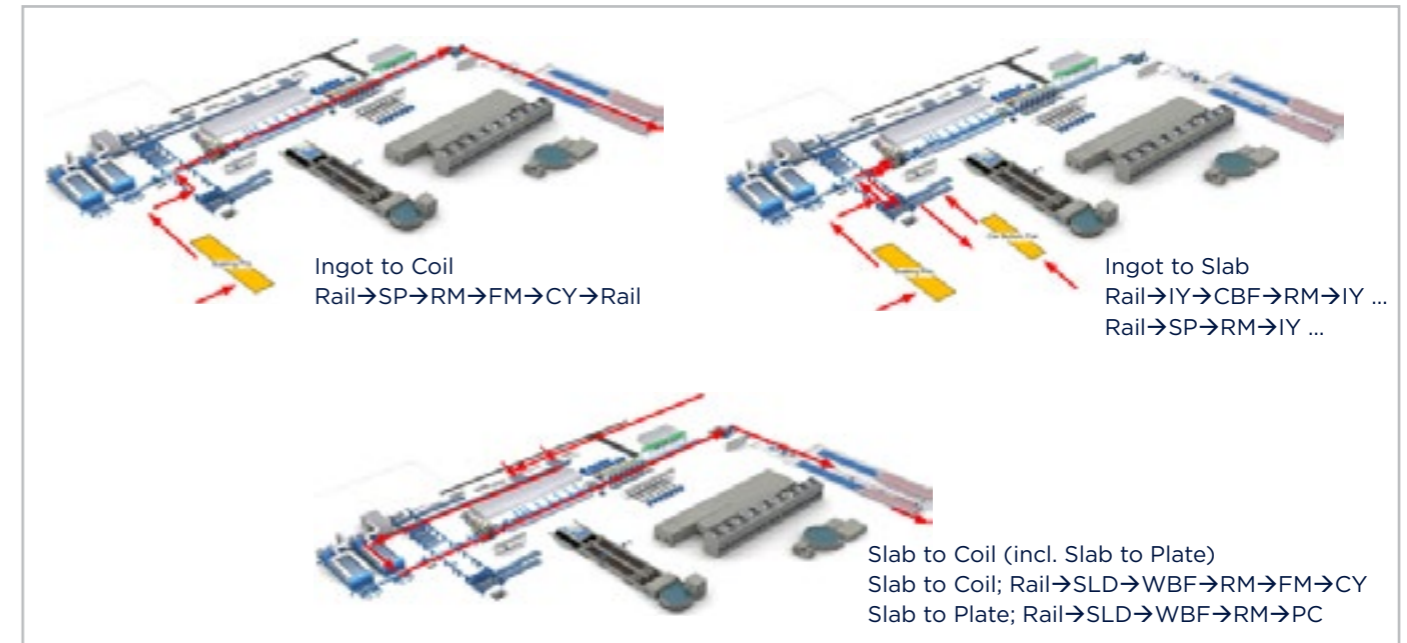
View of ATI's hot-rolling processing facility, Brackenridge, Pennsylvania, U.S.A.

Primetals Technologies supplied the new fully integrated hot rolling and processing facility on a turnkey basis at the Brackenridge facility of Allegheny Technologies Incorporated (ATI) in Pennsylvania, U.S.A. The mill is capable to roll up to 3.5 million tons per year of a broad range of highly diversified stainless and carbon steels, specialty metals and electrical steel grades. The material is applied to the aerospace, automotive, defense, petroleum, chemical, construction, mining and power industries, as well as in various medical, food-equipment, machine and cutting-tool applications. The rolling forces are the highest ever to be applied in a hot rolling mill. The project scope included engineering, supply, installation and commissioning of mechanical equipment as well

as electrical and automation systems. Leading-edge technologies are built into the mill to ensure top-class performance and to control key parameters such as thickness, cooling and coiling temperatures through the use of built-in process models and the associated automation-controlled actuators. This project represents an outstanding example of a successful cooperation between a market-leading supplier of specialty metals and a metallurgical plant builder. The installed power, size and advanced technology of the mill, combined with decades of operational expertise, allow ATI to utilize this unparalleled capability to fully meet the most demanding customer requirements in a highly efficient and productive manner.



PROCESS ROUTES



Basically three main process routes are in place based on a product master plan

HOT-ROLLING AND PROCESSING FACILITY EQUIPMENT

ROUGHING MILL

Following reheating and descaling, the slabs or ingots are initially rolled in the roughing mill which is equipped with an edger and state of the art twin drives each with a motor power of 9.5 MW (maximum load of 60MN) each. The roughing mill stand is capable of exerting a maximum load of 60 MN. This immense power gives the hot rolling and processing facility the capability and versatility to process and roll the broadest ranges of specialty metals in the industry.

FINISHING MILL

The finishing mill is designed with seven 4-high mill stands, each equipped with 10 MW drives and a mill-stand load of up to 55 MN. All stands feature dynamic work-roll cooling. Additional systems include interstand cooling, work-roll lubrication, a fume-suppression system, strip cross sprays, entry-guide cooling as well as looper cooling as the basis for optimum process parameters and equipment conditions.

SmartCrown® rolls are installed in the finishing stands, which operate in conjunction with L-type bending blocks and the work-roll shifting system as the decisive factor for assuring excellent strip profile and flatness.

LAMINAR COOLING SECTION

The laminar cooling section comprises 54 top headers and 162 bottom headers that allow a maximum water-flow rate of 20,000 m³/h. The cooling headers are flow-controlled on the basis of calculations from a microstructure target-cooling model. Laminar cooling is split into a fast cooling

and a normal cooling zone. Each top header with the associated group of bottom headers is separately regulated by a flow-control valve.

DOWNCOILER SECTION

Two power coilers are installed in the coiling section, which are dimensioned that they are capable of coiling API X100 pipe-grade material at a thickness of 21.2 mm and a width of 1,956 mm, or API X80 pipe-grade material with a thickness of 25.4mm and a width of 2,083 mm. The power coilers are equipped with servohydraulically controlled side guides, pinch-roll units and four wrapper arms. They are also outfitted with pinch-roll polishers and quick-exchange pinch-roll units.

AUTOMATION AND LOGISTICS

A complete suite of Level 1 automation systems and sophisticated Level 2 process-optimization systems with integrated tailored process models ensure that nothing is left to chance. Level 2 rolling systems include models for the precise control of rolling parameters; profile and flatness control, roll bending, roll thermal crown and roll wear, material flow, roll flattening and roll shifting. The cooling section control includes models for parameters; cooling section model includes temperature monitoring and control, heat-transfer and phase transformations. The coil transport is carried out with the newly developed Modular Coil Shuttle system (MCS).

NEW HOT STRIP MILL

FORMOSA HA TINH STEEL CORPORATION (HA TINH, VIETNAM)



FM area at Formosa Ha Tinh Steel Corporation, Vietnam

The 2,050mm semi-continuous hot strip mill supplied by Primetals Technologies in Vietnam started up in 2015.

Formosa Ha Tinh Steel Corporation, a member of the Formosa Plastic Group, is one of the largest integrated steel manufacturer in Southeast Asia. Primetals Technologies provided the hot strip mill for production of strip up to 1,880mm wide utilizing state of the art technologies.

Primetals Technologies was responsible for the design, engineering and supply of the mechanical equipment and also supervised the erection and commissioning of the plant, and conducted the staff training.

PRODUCTION DATA

Production capacity	5.3 million tons/year
Steel grade	Carbon steel, Pipe steel DP Steel, TRIP steel HSLA, etc.
Slab thickness	230 mm to 250 mm
Slab width	950 mm to 1,880 mm
Slab length	max. 11 m
Strip thickness	1.2 mm to 25.4 mm
Strip width	900 mm to 1,880 mm
Coil weight	max. 40,000 kg

PRIMETALS HAS SUPPLIED THE FOLLOWING EQUIPMENT

- Slab sizing press
- Vertical edger (E1) with automatic width control (AWC)
- 2-high roughing mill (R1)
- Vertical edger (E2) with automatic width control (AWC)
- 4-high roughing mill (R2) with quick roll changing device
- Heat retention cover
- Drum-type crop shear
- Descaling facilities
- Vertical edger (F1E) attached to F1 with automatic width control (AWC)
- Seven 4-high finishing stands with:
 - Pair cross (F1-F4)
 - Mill stabilizing device (F1-F4)
 - Work roll shift (F5-F7)
 - Work roll bending (F1-F7)
 - Hydraulic automatic gauge control (AGC)
 - Hydraulic looper
 - Quick roll changing
 - Work roll lubrication
 - Interstand cooling
- Three down coilers with:
 - Hydraulic automatic jumping control (AJC)
 - Non-step expanding mandrel
- Coil conveyor

NO. 2 HOT STRIP MILL

USIMINAS (CUBATAO, BRAZIL)



FM area at USIMINAS Cubatao No.2 HSM, Brazil

The No. 2 hot strip mill at USIMINAS Cubatao started operation in 2012. To cover the wide range in production sizes and steel grades, many modern technologies were applied. Primetals Technologies was involved in this project as a mechanical equipment supplier for the following equipment:

- Furnace entry and delivery tables
- Roughing mill
- Finishing mill
- Down coiler
- Coil conveyor

In addition to the above main line equipment, Primetals Technologies also supplied foundation design, auxiliary equipment such as roll shop equipment, water treatment system, compressed air plant, cranes, ventilation air condition system, fire detection and extinguishing system, etc.

The production capacity of the mill is 2.3 million tons per year in the initial phase, with a maximum of 4.8 million tons per year in future expansion. The product mix includes low, middle and high carbon steel, API pipe steel (up to X80), DP, TRIP, HSLA, IF steel and electrical steel. The hot run tests and performance tests were successfully completed within 6 months after hot run start. During these tests, low carbon steel of 1.5mm thickness, API X70 of 6 mm to 19 mm thickness, HSLA of 2.0 mm thickness with a tensile strength of 590 MPa, DP, IF, as well as electrical steel were all produced successfully.

LINE SPECIFICATION

PRODUCTION DATA

Production capacity	2.3 million tons/year (4.8 million tons/year in future)
Steel grade	Carbon steel, Pipe steel, HSLA, DP steel, TRIP steel, Electrical steel, etc.
Slab thickness	210-260 mm
Slab width	750-2,050 mm
Slab length	max. 11,500 mm
Strip thickness	1.5-20 mm (1.2-20 mm in future)
Strip width	750-2,050 mm
Coil weight	max 35,000 kg

COMBINED STECKEL / PLATE MILL

GERDAU ACOMINAS (MINAS GERAIS, BRAZIL)



Steckel mill stand at Gerdau Acominas, Brazil

The new fully integrated hot rolling facility supplied by Primetals Technologies on a process turnkey basis started up at the Gerdau Acominas', Ouro Branco facility, in Minas Gerais, Brazil in 2013 and 2015.

The mill complex is capable of rolling up to 1.9 million tons per year in a broad range of highly diversified carbon steels grades of both discrete plate and coiled products that find use in the local industries of Brazil and its surrounding countries. This project represents an entry into the flat products market by a key player in the long products sector. The installed power, size and advanced technology of the mill, combined with expertise of Primetals Technologies, allowed Gerdau Acominas to enter a mature market with products that could compete both on a quality and commercial basis, both as discrete plate and rolled coil.

COMMON FACILITIES FOR PLATE AND COIL PRODUCTION

- Transfer and handling equipment for slabs
- Heating/reheating furnaces

PLATE PRODUCTION PROCESS

- Primary descaler
- (Provision for future roughing stand)
- 4-high reversing plate mill stand pre-leveller (Plate mill in the first phase)
- MULPIC cooling machine
- Hot leveller
- Cooling bed

- Future crop shear
- Double side trim shear
- Divide shear
- Transfer and inspection beds
- Cold leveller
- Inspection and transfer equipment

COIL PRODUCTION PROCESS

- Primary descaler
- (Provision for future roughing mill stand)
- Rotary crop shear
- Steckel furnaces
- 4-high roughing and finishing stand
- (Provision for a future 3 stand finishing train)
- Laminar strip cooling section
- 1 Down coiler (with provision for a second)
- Walking beam coil handling
- Integrated sampling, inspection, marking and strapping machines



Plate mill stand at Gerdau Acominas, Brazil

PLATE PRODUCTION PROCESS

PLATE MILL STAND

Following reheating and descaling, the slab is rolled in the plate mill which is equipped with state-of-the-art twin drives each with a motor power of 8.5 MW. The mill stand is capable of exerting a maximum load of 84 MN.

Thickness	4.5 ~ 150 mm
Width	900 ~ 3,600 mm
Length	3,000 ~ 18,000 mm

MULPIC COOLING SECTION

The cooling section comprises a MULPIC machine designed to produce a phase transformation in the metal after rolling and this is where the final microstructure of the plate is controlled for final mechanical properties

SHEAR LINE SECTION

The plant line has provision for a future crop shear which is used to increase productivity, a double side trim shear used to trim as rolled plate to final width, and a divide shear used to cut mother plates into final plate lengths.

AUTOMATION AND LOGISTICS

The entire facility is controlled from strategically positioned control pulpits, designed to meet today's exacting standards whilst keeping labour costs to a minimum. A complete suite of Level 1 automation systems and sophisticated Level 2 process-optimization systems with integrated tailored process models ensure that nothing is left to chance.



Steckel mill stand at Gerdau Acominas, Brazil

COIL PRODUCTION PROCESS

STECKEL MILL STAND

Following reheating and descaling, the slab is rolled in the 4-high Steckel mill (roughing and finishing stand) which is equipped with state of the art twin drives each with a motor power of 7.0 MW. The mill stand is capable of exerting a maximum load of 54 MN.

Thickness	2 ~ 20 mm
Width	900 ~ 2,100 mm
Weight	Max. 45 ton

LAMINAR COOLING SECTION

The laminar cooling section comprises 32 top headers and 96 bottom headers that allow a maximum water-flow rate of 11,500 m³/h. Laminar cooling is split into a fast cooling zone and a normal cooling zone.

DOWN COILER SECTION

The down coiler is installed in the coiling section at the end of the line and is dimensioned capable of coiling 20mm, X70 material at full width.

HOT STRIP MILL TECHNOLOGIES



Slab sizing press at POSCO, Pohang No.1 HSM, South Korea



Heavy edger at ArcelorMittal Poland S.A. Kraków, Poland

SLAB SIZING PRESS

Primetals Technologies is the pioneer developer of the slab sizing press, and the first slab sizing press in the world was supplied to JFE Steel Kurashiki in 1988. The slab sizing press has shown excellent performance, and Primetals Technologies has been continuously improving the technology. Because the slab sizing press can reduce the kind of casting slab width for the HSM, the productivity of the caster can be increased. It can achieve the large economical advantage for total production of the steel plant. Because of the large width reduction achieved by the slab sizing press, the ratio of hot charged slabs can be increased which contributes to significant energy savings.

HEAVY EDGER

Fully hydraulic vertical edgers feature long-stroke cylinders with integrated system control, a position transducer for absolute width measurement as well as advanced automatic width-control functions. Heavy edging with high width reduction capability introduces the benefit of adjusting to various rolled strip widths from standard slab sizes.

AUTOMATIC WIDTH CONTROL (AWC)

The automatic width control comprises roll gap adjustment during rolling to compensate width and temperature deviations. Furthermore, the short stroke functionality enables compensation of narrow head and fish tail effect. This concept is especially beneficial for upgrades due to limited additional investment cost and low extra maintenance requirements.

ROUGHING MILL

Primetals Technologies has supplied many roughing mills with the following functions:

- Electrical screw down for high speed gap adjustment
- Hydraulic gap adjusting cylinder
- Twin drive for top and bottom work rolls.

The hydraulic gap adjusting cylinder features the following functions:

- Fine levelling and zeroing calibration with higher zeroing and levelling force (compared with only electrical screw down)
- Excellent thickness accuracy including top and tail ends of the transfer bar

The hydraulic gap adjusting cylinders are located under the bottom backup roll chocks or above the top of the backup roll chocks.

In the case where the hydraulic gap adjusting cylinders are installed at the bottom side, the cylinder can also enable the proper pass-line adjustment functions.

By means of the pass-line adjustment, the bottom hydraulic cylinder can also be used to reduce the turn-up and turn-down of the ends of the transfer bar especially for hard materials such as stainless steel along with independent speed control between top and bottom work rolls.



Roughing mill at USIMINAS, Cubatao No.2 HSM, Brazil



Coil box at Baosteel Stainless Steel Co., Ltd. Shanghai, China

TRANSFER BAR COOLING

The Primetals Technologies Power Cooling technology is especially designed reach the highest cooling rates. This technology can be implemented as intensive cooling between the roughing and the finishing mill area. This leads to improved strip temperature control to increase productivity. Furthermore transfer bar cooling enables advanced "in-line" metallurgical treatment of the strips.

ENCOPANELS® AND HEAT HOLDING COVER

The Encopanel heat-retention system or Heat holding cover is installed after the roughing mill to conserve the heat of the transfer bars as well as to enable a more accurate control of the strip temperature, especially for thin-gauge strip. As a special feature of Encopanel, bottom scale-clearing panels discharge scale from the system to ensure a scale-free Encopanel surface for the transfer bar.

COILBOX

The coilbox design is characterized by modern design features such as coil transfer without the use of a mandrel. Advantages of this equipment include reduced power rating and lower energy consumption in the mill train, as well as a shorter distance between the roughing mill and the finishing mill in a new plant. It is capable of handling a wide range of transfer bar dimensions (20 - 55 mm transfer bar thickness and up to 2,050 mm width as in reference plants) and can be used with carbon and stainless steel grades.



Transfer bar cooling unit installed at TATA Steel, Port Talbot

HOT STRIP MILL TECHNOLOGIES



Crop shear and Primary descaler at ArcelorMittal Poland S.A. Kraków, Poland



Pair Cross finishing stand at USIMINAS, Cubatao No.2 HSM, Brazil

PRIMARY AND SECONDARY DESCALER

Primetals Technologies descalers feature low-maintenance design and optional height adjustment and are designed for minimum water and energy consumption.

CROP SHEARS

In order to meet the requirements of high-strength steels, Primetals Technologies has developed several shear types for different applications.

The differential speed rotary crop shear is a unique portfolio of Primetals Technologies. Sharp cutting performance is assured, and the knife change interval can be extended because the strict management of knife gap clearance is not necessary. An innovative switchable gear design minimizes motor power demand. The full integration of the crop optimization system into the overall automation system ensures minimal crop-losses.

ADVANCED PAIR CROSS MILL

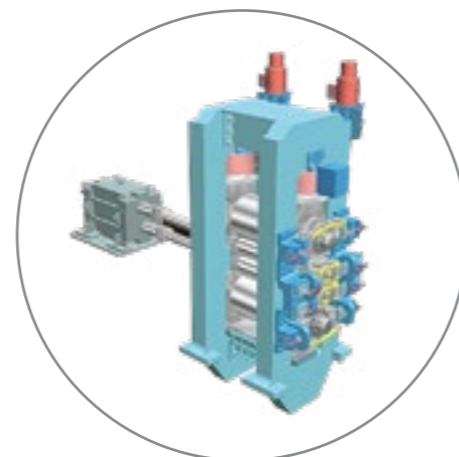
The Pair Cross (PC) mill was developed in the 1980's and has contributed to the achievement of high accuracy and quality of the strip crown and flatness through its superior strip crown and flatness control. Primetals Technologies has enhanced the PC mill and is now supplying a 3rd generation PC mill with a mill stabilizing device, the so-called advanced PC mill.

The number of the mechanical component required for roll crossing in the advanced PC mill is reduced to less than a quarter of those of the 1st generation PC mill.

The mill stabilizing device is installed on the entry side housing and eliminates the clearance between the chocks and housing during operation, which reduce the task of maintaining the entry-side housing liner to approximately one-third of a conventional mill.

The main features of the advanced PC mill are as follows:

- Stable operation with the elimination of clearance between roll chocks and housing and symmetrical roll crown control to reduce camber and pinching problems
- Powerful strip crown and flatness control with the simple principle of axial roll crossing
- Higher reduction rolling without mill vibration through the combination of PC mill and mill stabilizing device even in severe rolling condition such as thinner and harder products, because mill stabilizing device increase the dynamic rigidity of the mill stands



SmartCrown finishing stand at ArcelorMittal Poland S.A., Kraków, Poland

SMARTCROWN®

SmartCrown enables significantly enhanced profile and flatness control by means of the combination of curved roll contours and roll shifting.

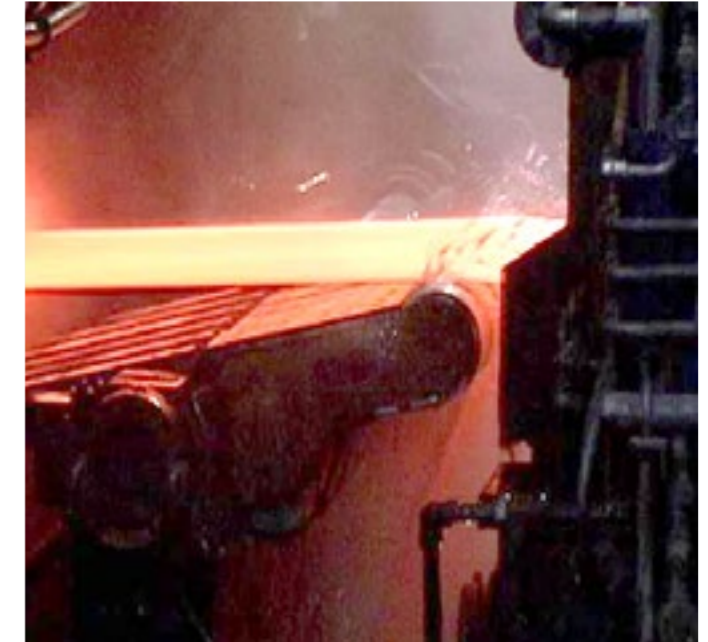
SmartCrown work rolls feature a modified, sine-shaped contour. By selecting the correct contour coefficients and shifting the work rolls by the same amount in opposite directions, the resultant unloaded roll gap is always cosine-shaped, regardless of the actual shifting position of the rolls.

By means of optimum work roll contours of the SmartCrown rolls, a wider range of roll gap profile adjustment, especially in the high order range such as fourth-order, can be achieved. SmartCrown also enables strip flatness control of high-order to avoid e.g. quarter buckles defects.

SmartCrown is suitable for new installations as well as for revamping of existing mills.

THICKNESS CONTROL

Gap adjustment is actuated by hydraulic automatic gauge control (HAGC) systems consisting of hydraulic gap control cylinders with integrated system control and the adjacent hydraulics. Integrated load cells in the mill housings guarantee correct set-values. This system enables precise control of strip thickness and provides faster roll change times and increased flexibility in setting up the mill.



Looper Shape Meter at Tata Steel Europe, IJmuiden BV, Direct Sheet Plant, IJmuiden, Netherlands

LOOPER SHAPE METER (LSM)

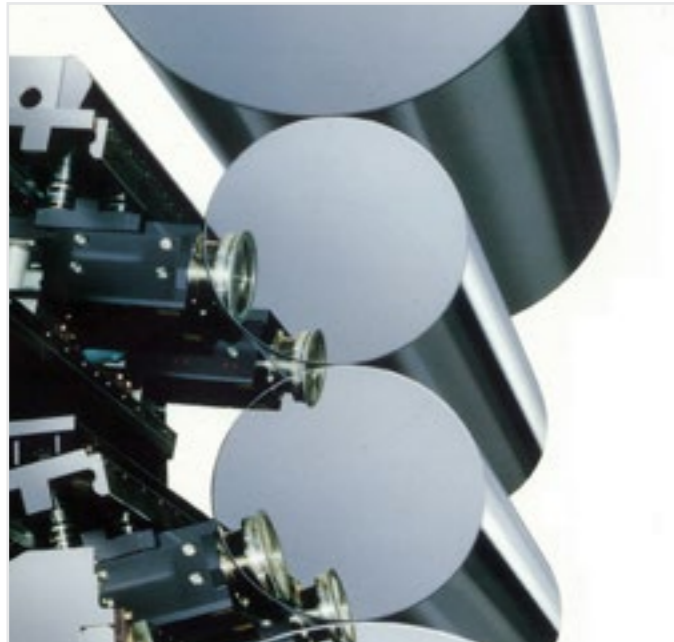
The measurement of strip shape between mill stands on a hot strip mill has previously been rather difficult and unreliable. Primetals Technologies has developed a looper shape meter (LSM) to continuously and accurately measure interstand shape.

LSM measures the tension distribution across the strip width through individually detected contact loads on segmented rolls, and then converts the distribution of tension into the strip shape.

LSM features the following advantages:

- The load on the segment roll is measured by a torque meter without any influences of hysteresis of the mechanism, unlike a load cell. Measuring by torque meter enables higher accuracy and increased measuring reliability without any influences caused by changing mechanical condition.
- Easily interchangeable with existing loopers and LSM because the moment of inertia is small
- Easy replacement of segment roll for maintenance

HOT STRIP MILL TECHNOLOGIES



Online roll profiler



Interstand Equipment

WORK ROLL LUBRICATION (WRL)

The work roll lubrication system is designed with patented mixing nozzle units that apply the water oil emulsion directly on the entry side of the work roll. A lower coefficient of friction between the work rolls and the strip is achieved, which leads to a significant reduction in rolling force and improvement of the work roll surface quality, and thus to better strip quality. Due to the position of the nozzles the normal work roll cooling can be kept in operation during strip lubrication. Special wiper material is installed to keep the strip surface dry and ensure optimal lubrication. Quick couplings for faster maintenance of the newly developed nozzle beam are installed in the most recent WRL references.

ONLINE ROLL PROFILER (ORP)

The online roll profiler (ORP) is a compact roll grinder which is installed in the mill stands and used to grind work rolls during rolling to maintain the work roll surface quality. The disc-type grinding wheel is composed of a cubic boron nitride material mounted on higher damping mechanism. The design has improved service life highly damped greater grinding capacity and more reliable operation. The driving components to rotate the grinding wheel, to press the grinding heads onto the roll and for oscillation along the roll axis are mounted in a compact box that keeps the components clean for higher reliability and lower maintenance.

The work roll changing interval can be extended by a factor of 2 - 3 times compared with conventional mill (without work roll shifting).

INTERSTAND COOLING AND DYNAMIC WORK ROLL COOLING

Strip temperature during the rolling process strongly influences the steel properties. Thus, to increase productivity and still meet target temperatures and properties, it is necessary to employ interstand cooling. In combination with model predictive control, interstand cooling ensures increased throughput with constantly high steel quality.

Dynamic work roll cooling provides control of thermal crown through the combination of three different spray patterns. The system is integrated into the level 1 and 2 automation systems. The work roll cooling spray headers are separately actuated by valves.

STRIP COOLING

The solution includes mechanical components such as cooling headers for a wide range of applications as well as an online cooling model. In addition to standard laminar cooling headers, Primetals Technologies supplies turbo laminar headers with higher cooling rates and Power Cooling systems that enable the dissipation of more heat. The combination of high cooling rates and a wide adjustment range enables the production of high quality steel grades even in hot rolling mills with short cooling sections.

The cooling rates of each systems are as follows:

- Standard headers : up to 1.5 MW/m²
- Turbo laminar headers : up to 2 MW/m²
- Power cooling system: more than 4.5 MW/m²



Strip Cooling Line



Coil Inspection

COILING TECHNOLOGY

Perfect coiling is an important requirement for strip producers. Primetals Technologies standard coiler design has three wrapper rolls and is applied for soft grades as well as high-strength steel from 1.2 up to 25.4 mm thick. A special down coiler design is applied for endless strip mills (Arvedi ESP) to coil the thin strips from 0.8 up to thicker gauge. For high-strength steel strip up to 25.4 mm thickness, the heavy duty coiler design can be used.

COIL TRANSPORT

The most important requirements of coil transport system are safe and gentle coil handling, high reliability, maximum coil collection frequency and minimum maintenance costs. For this purpose Primetals Technologies offers numerous different coil transport systems. The latest solution is the modular coil shuttle (MCS) car system. The shuttle cars are driving autonomously on the rail system from the down coiler to the coil storage area. They are fed by current collectors via conductor rails and controlled by an industrial wireless LAN system. Implementing the modular components such as shifting, turning or lifting, the coil transport route can be designed highly flexible. The transport capacity can be easily adapted by varying the number of shuttle cars in operation.

COIL INSPECTION AND SAMPLING

The ratio of sampled coils is increasing especially for high strength steel grades. Primetals Technologies offers in line sampling and inspection directly implemented in the coil transport line as well as offline stations. Surface inspection typically for strips up to 6 mm thick can also be done

without cutting the sheet of the coil and recoiling it after inspection for minimized scrap. High strength steels with thickness of up to 25.4 mm strip thickness (e.g. X80) can be handled by Primetals Technologies heavy gauge plasma cutting unit.



Coil shuttle car

PLATE AND STECKEL MILL TECHNOLOGIES



Plate Steckel mill at AHMSA, Monclova, Mexico

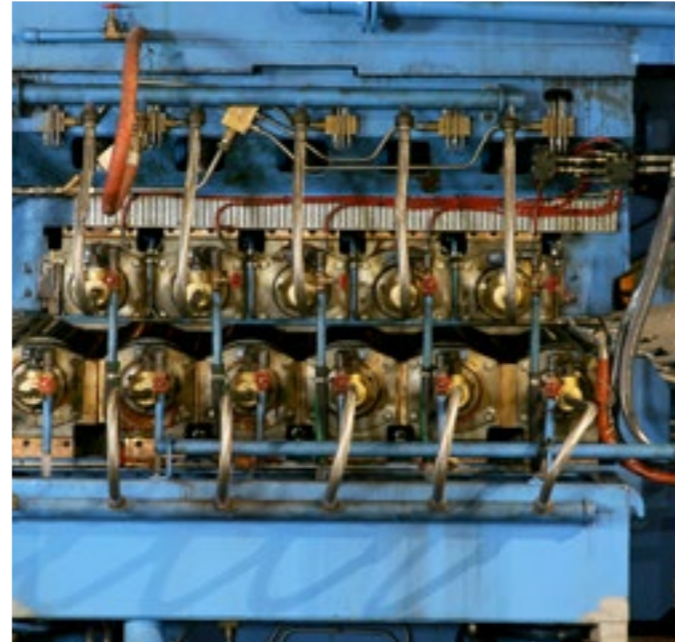


Plate leveler at Dongkuk Steel, Dangjin, South Korea

PLATE STECKEL MILL

Our plate Steckel mills combine the asset utilization of the strip rolling process with the grade and width range of the reversing plate mill, allowing to deliver a broad range of steel products at low cost. Primetals Technologies' long experience and innovative engineering assures industry-benchmark levels of dimensional control performance and yield. High productivity comes with the concept, but Primetals Technologies' standards of metallurgical precision, maintainability and reliability are designed into this exceptional product as well.

MILL STAND

The rolling stand is capable of flexible rolling of coil and plate products. Intermediate products can be Steckel rolled to increase productivity, using the Steckel Furnaces. The mill stand is equipped with SmartCrown® Work Roll Shifting and Heavy Work Roll Bending to ensure optimal flatness and crown performance. A vertical Edger can be incorporated while maintaining a compact layout.

STECKEL FURNACES

Our references feature patented Steckel furnaces technology including the two-part flap system for guiding and closing the furnace. Our installed Steckel Furnaces can coil products up to 3,250 mm wide with a weight of up to 67 tonnes.

ROTARY CROP SHEAR

A rotary crop shear is installed after the mill stand to divide long-rolled lengths into shorter discrete plate length.

ACCELERATED COOLING SYSTEM

Accurate strip and plate cooling is accomplished by Primetals Technologies' solution from MULPIC®.

DOWNCOILER AND UP COILER

A coiler allows for the fast coiling of strip product, generating accurate coils.

LEVELLERS FOR PLATE MILL

Flatness becoming a more challenging target as products are evolving towards harder materials along with increasing thickness ranges.

This evolution is also driven by new metallurgical routes such as inline direct quench downstream of the mill stand using MULPIC® traditional offline heat treatment, which leads to significant changes within operations. Primetals Technologies Heavy Plate Levellers are designed for high strength products. Our levelling control ensures the best possible roll gap at all periods of the process based on torques and speed measurements. Using the actual torques and speeds, an intelligent algorithm generates commands for the entry and exit gaps and for each motor individually.

We provide a complete levelling solution throughout plate production - Pre-Leveller, Hot Leveller, Warm Leveller, Cold Leveller.

FEATURES

Single cassette changeable between 7 and 11 rolls configurations.

MECHATRONIC SOLUTION MAXIMISING MILL PERFORMANCE AND CAPABILITY



Divide shear at Dongkuk Steel, Dangjin, South Korea



Double side trim shear at Dongkuk Steel, Dangjin, South Korea

CROP AND DIVIDE SHEARS FOR PLATE MILL

Primetals Technologies' Crop and Divide Shears have a rolling blade action, with a small blade vertical overlap, so minimising any plate distortion caused by the cutting action.

Prior to dividing the plate is pushed to a set of vertical datum rollers, in the entry roller table. This ensures that the divide cut is perpendicular to the plate edge.

The Divide Shear incorporates a scrap pusher therefore can also cut over length material into manageable pieces to be disposed of along the scrap conveyor.

FEATURES

Two Crank Rolling Cur Mechanical Shear.

DOUBLE SIDE TRIM SHEAR SLITTING SHEAR FOR PLATE MILL

Primetals Technologies' Shear has a rolling blade action, requiring the plate to be stationary during the cut. The plate is fed during the time the blades are open, by pinch rolls.

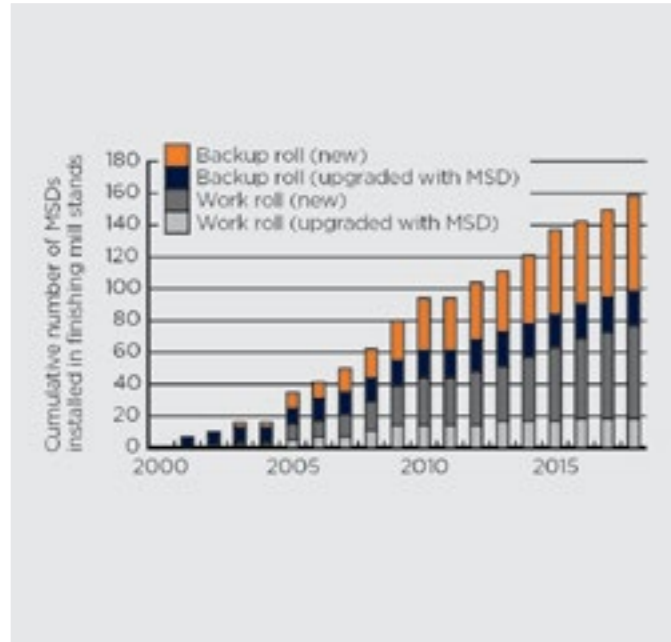
The integral Scrap Shear cuts the scrap into manageable lengths to fall onto a scrap conveyor, which transports the scrap to bins. Prior to trimming the plate is aligned to laser lines, set to the trimmed width.

FEATURES

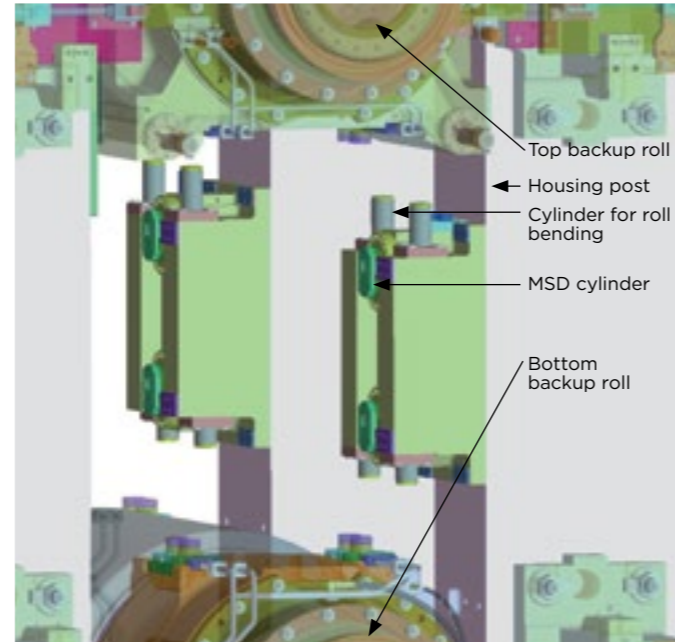
Three Crank Rolling Cur Mechanical Shear.

MILL STABILIZING DEVICE FOR PC MILLS

HIGHER REDUCTION AND STABLE OPERATION IN HOT STRIP MILLS



Cumulative number of Mill Stabilizing Devices installed since 2000



3D CAD view of the Mill Stabilizing Device

MILL STABILIZING DEVICE

Primetals Technologies Mill Stabilizing Device (MSD) can satisfy the today's market demands for superior strip quality and high-strength steels rolled to thinner gauges. The MSD can increase the dynamic rigidity of mill stand and reduce the mill vibration which happens at upstream stands under very severe rolling condition such as thinner and harder products of faster speed. It enables to make the best out of the rolling performance of the mill stand.

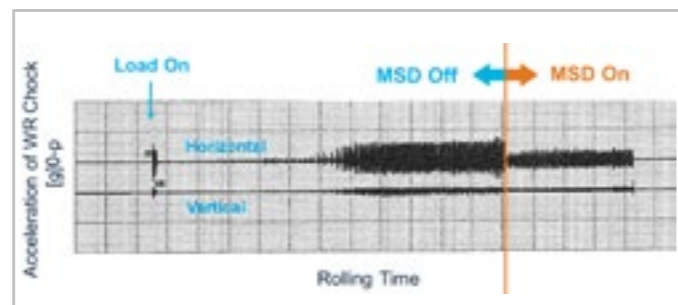
The MSD eliminate the clearance between roll chocks and housings, which maintains better alignment between the backup and work rolls. Thus, the thrust force in the axial roll direction is reduced, which decreases the differential rolling force between the drive side and work side. As a result, an improvement of strip steering stability can also be achieved.

The MSD can easily be installed as a retrofit as well as in new mills. As the results, the MSD has been utilized by many customers (over 30) in all over the world for various type of mill such as

- Advanced PC mill
- WR shift mill
- Conventional mill

APPLICATION OF THE MSD LEADS TO THE FOLLOWING BENEFITS

- Reduced mill vibrations even in severe rolling condition, which allow greater strip reduction during rolling
- Increased operating stability of the mill during rolling
- Stabilized strip steering during threading and tailing out
- Lower impact forces during threading of the strip front end into the mill stands and thus reduced wear and maintenance costs
- Easily installed in various mill types, also as a retrofit in existing mills



Acceleration of work roll chock with MSD & without MSD

MULPIC®

FOR RAPID COOLING OF PLATE PRODUCTS



MULPIC at Baosteel Zhanjiang Iron & Steel, Zhanjiang, China



MULPIC at Xiangtan Iron & Steel, Xiangtan, China

MULPIC® MULTI PURPOSE INTERRUPTED COOLING

The majority of the phase transformation occurs during in-line cooling after rolling and this is where the final microstructure of the plate is controlled. To achieve the required microstructure and mechanical properties, the cooling rates and cooling stop temperatures must be precisely controlled. Primetals Technologies MULPIC is the most advanced and matured inline cooling machine that is proven to achieve required cooling accuracy.

A standard MULPIC comprised of 24 top and 24 bottom headers with individual flow control and zone separation spray in between group of headers. The precise flow control along with speed control enables accurate temperature accuracy and uniformity across the length.

MULPIC® FEATURES

- Flexible Cooling Modes - DQ, ACC, Oscillation, Soft Cooling, Intermediate Cooling, Interrupted Cooling: 4 to 100 °C/sec
- Cooling Accuracy - better than 15°C
- Uniform Cooling

CUSTOMER BENEFIT

- Increased product range - added value products
- Reduced alloying, improved weldability - cost saving
- Uniform mechanical properties
- Process Compression - minimise heat treatment processes

HYBRID COOLING

Primetals Technologies has introduced the concept of hybrid cooling for existing Plate Mills that combines an existing cooling machine with new MULPIC® headers.

FEATURES

- MULPIC® only mode - standard features
- Hybrid mode - MULPIC® + Lamina integrated

CUSTOMER BENEFIT

- A flexible upgrade path
- Utilisation of existing assets
- Increased product range

POWER COOLING FOR RAPID COOLING OF COIL PRODUCTS



Power Cooling Unit

POWER COOLING

Hot strip mills often reach their limits in terms of power and flexibility for production of advanced high strength steel grades (AHSS) like API X80/X100, dual-phase, martensitic and complex-phase grades.

For cooling and advanced “in-line” metallurgical treatment of new materials, Primetals Technologies developed “Power Cooling” technologies. This combines the advantages of normal laminar cooling or “low pressure cooling” and “high power cooling” with the highest cooling rates for flexible operation.

EQUIPMENT - POWER COOLING TECHNOLOGY

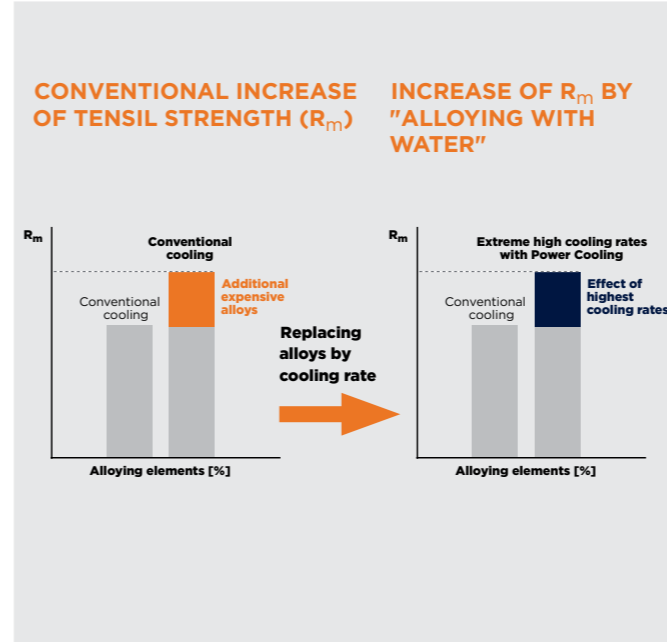
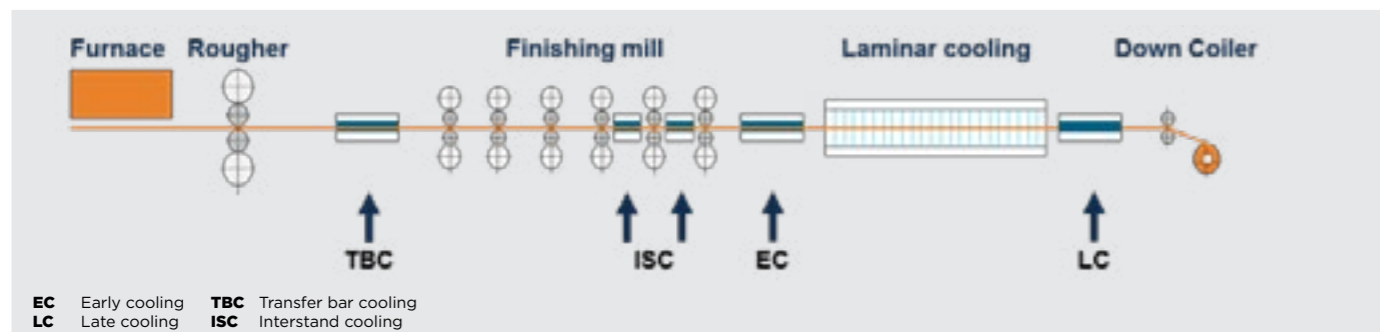
In addition to applying Power Cooling Technology to the early stages of cooling it can also be applied between the roughing mill and the finishing mill, between the finishing mill stands and in the late part of the cooling area. This is necessary to make different production strategies possible as they are shown in the diagram below.

IMPLEMENTATION INTO NEW OR EXISTING PLANTS

The Power Cooling unit can be retrofitted into existing plants using the existing water treatment plant, tank and piping infrastructure. The Power Cooling units are supplied with water via a booster pump generating the required operation pressure. Alternatively the pump can be bypassed to supply the Power Cooling headers directly from the overhead tank for operation in laminar cooling mode. Thus, the full operation spectrum which requires laminar cooling on the total cooling length can be kept after installation of Power Cooling.

APPLICATION

The working area of Power Cooling is not only dedicated to thick strips (> 18mm) with high cooling rates. Due to the extended control of water flow and therefore control of heat flux it is also used for strips with a critical combination of thickness-speed ratio and required cooling rates and for standard steel grades, e.g. using the Power Cooling in laminar mode.



Alloying with water = saving money

The combination of Power Cooling with laminar cooling is a perfect solution for cooling lines which offers a wide range of applications as well as for optimizing the current product mix and future metallurgical requirements.

TYPICAL PHYSICAL CHARACTERISTICS OF POWER COOLING

- Significantly increased cooling rates compared to laminar / turbo laminar cooling
- High heat flux rates up to 5 MW/m²
- Wide flow-rate control range for maximum metallurgical flexibility

ALLOYING

Power Cooling opens the door for reduction of alloying costs by substitution of hardening elements with hardening effects of higher cooling rates.

REFERENCE INSTALLATIONS

- Power Cooling at ThyssenKrupp AG, Beeckerwerth, Germany (2010)
- Power Cooling and transferbar cooling at ThyssenKrupp AG, Bruckhausen, Germany (2011)
- Power Cooling at Wuhan Iron and Steel Co., Ltd., China (2013)
- Further upgrade Power Cooling at ThyssenKrupp AG, Beeckerwerth, Germany (2014)
- Power Cooling for transferbar cooling at TATA Steel Port Talbot, UK (2017)
- Power Cooling at ArcelorMittal Dofasco, Canada (2019)

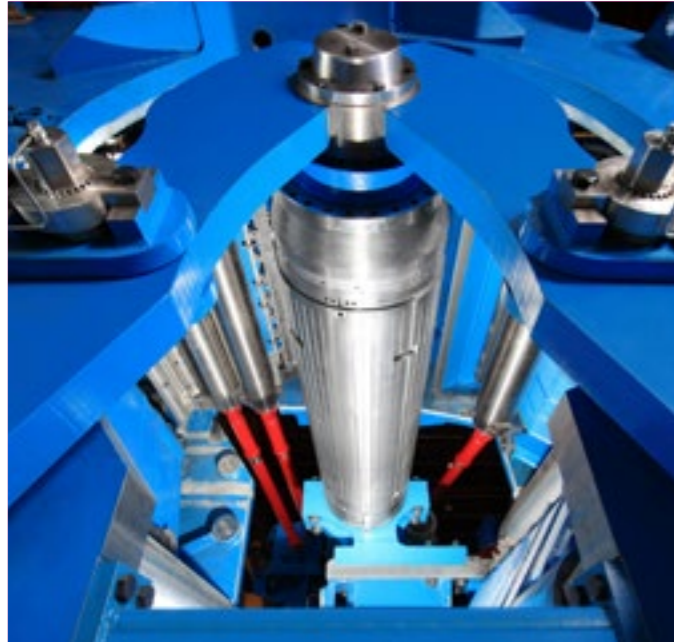
BENEFITS

Primetals Power Cooling is an advanced strip cooling technology

- Providing extreme high cooling rates (up to 40K/s @ 25.4mm)
- Providing extreme flexibility with an adjustment range from 10% to 100%
- Used for the complete product mix by operating in 2 modes, laminar and Power Cooling.
- Installed in running mills and new mills in combination with laminar cooling or as transfer bar cooling or as interstand cooling
- Perfect solution for 2 step cooling patterns e.g. needed for DP-grades
- Perfect for de-bottlenecking of short cooling lines



CONTINUOUS MODERNIZATION CONTINUOUS BENEFIT



Pre-assembled down coiler



Crop shear

A new hot strip mill has a lifetime of several decades. During this time, the mill must be able to meet market demands for a wide range of steel grades especially for high-strength steel and advanced steel grades with superior strip quality. Additional important factors in hot strip rolling are high yield, mill availability and production throughput. Continuous modernization of the existing equipment is the most effective way to continuously meet market requirements and to achieve the competitive level of conversion cost during the lifecycle of the mill.

Also, when taking a hot strip mill out of operation after a number of decades, the mill still has the potential of being employed as a second hand mill and may be refurbished and relocated for a new "lifecycle", as examples have shown.

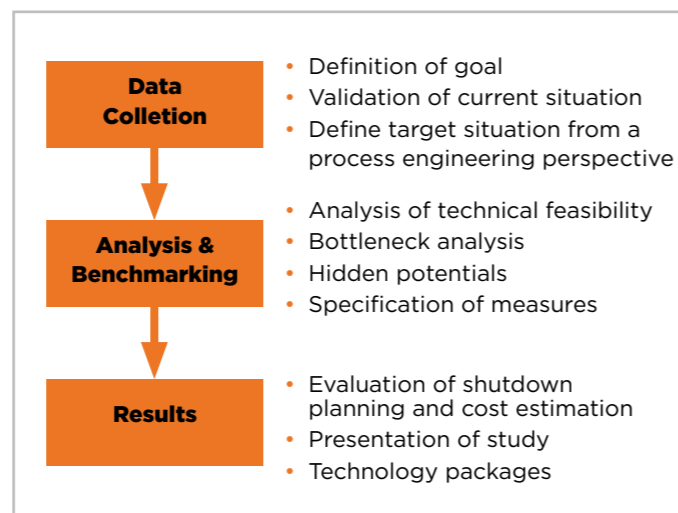
Primetals Technologies has vast experience in upgrading and modernizing hot strip mills. Using a systematic approach, we work closely with our customers to develop a tailored modernization concept according to the particular requirements and constraints of the project. Each solution may be purely mechanical, purely electrical, purely automation, or a combination of these. Based on the selected concept, the modernization can be carried out in several steps or during a single mill shutdown.

Prior to modernization Primetals Technologies may offer specific investigations (studies) in order to e.g. check technical feasibilities, to identify bottlenecks or justify investment estimations.

Primetals plant building experience, feedback from installed references and application of dimensioning and simulation tools guarantees that the results of such studies are of the highest standard of technical elaborations.

Beside high-tech equipment and skilled employees a comprehensive process know-how and metallurgical know-how is necessary for the successful operation of a hot rolling mill. Primetals Technologies support customers with metallurgical simulations for further development of steel grades or introduction of new grades.

TYPICAL MILL STUDY PROCEDURE



COMPLEX MODERNIZATIONS AT US GARY, HSM, INDIANA, USA



Upgrades to the USS Gary HSM to allow the existing assets to be able to extend the existing product range into thicker / harder API products as well as wider AHSS products. In addition the improvement of shape & profile for the existing products.

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