Over the past 50 years, Mitsubishi Heavy Industries and Hitachi have individually worked with the world steel industry supplying advanced technologies, increasing production and improving quality. In the face of increased global competition, the steel industry divisions of Mitsubishi Heavy Industries and Hitachi joined on October 22nd, 2000 and established a joint venture to provide superior service and products.

Mitsubishi-Hitachi Metals Machinery (MHI) has developed new key technologies for the hot strip mill and has massive experiences not only in the conventional rolling line but also in the endless rolling line of the hot strip mill. MHI can supply top-notch rolling technologies as a power full partner for you.
LEADING-EDGE TECHNOLOGIES FOR HOT STRIP MILL
(MH can supply top-notch rolling technologies as a powerful partner for you!)

Endless Rolling Technology
Main Equipment
- Bar-joining machine
- Dynamic bar cross mill
- High-speed flying shear
- Advanced downcoiler with Switch-over function
- Carousel coil
Features
- Endless rolling technologies proved through many experiences in actual plants

Down Coiler
Main Equipment
- Hydraulic pinch roll
- Hydraulic side guide
- Roller for pinch roll
- Advanced downcooler
Features
- Non-stop expanding mandrel
- Quick-open control (QDC)
- Excellent coil shape and surface
- Long-life mandrel

Strip Cooling System
Main Equipment
- Intermediate bar cooling system between FM and DC
- Strip cooling system between FM and DC
Features
- Intensive strip cooling
- Wide range temperature control
- High-speed temperature control

Finishing Mill
Main Equipment
- Advanced bar cross mill (PC mill)
- MH stabilizing device (MSS)
- Online roll profile (ORP)
- Looper shape meter (LSM)
- CRM shift mill
- Hydraulic AGC system
Features
- High reduction rolling
- Powerful and accurate strip crown & flatness controllability
- Schedule free rolling
- Extension of coil change interval
- Guide roll change

Semi-Endless Rolling
Tunnel Furnace
Slab/Continuous Casting Machine

Endless Rolling
Re-heat Furnace

Conventional Rolling
Re-heat Furnace

1. Slab Sizing Press
Features
- Higher slab width reduction up to 350mm
- Various pressing patterns for decrease of croissant
- Short shutdown for installation to existing plant

2. Roughing Mill
Main Equipment
- Mill
- Roughing mill
- Hydraulic AGC system
- Hydraulic AHC system
Features
- Higher reduction of width and thickness
- Higher width and thickness accuracy
- Passline adjustment device for stable rolling operation
- Guide roll change

3. Advanced Coil Box
Features
- Automatic slitting system with side heat shields
- Prevention of temperature drop at coil inner wrap and coil edge
- Buffer function especially for endless rolling

4. Crop Shear
Features
- Differential speed rotary crop shear
- Quick knife changing

5. Descaler
Main Equipment
- Roughing scale breaker
- Finishing scale breaker
Features
- High pressure descaler up to 400 MPa
- Easy maintenance

6. Finishing Mill
Main Equipment
- Advanced bar cross mill (PC mill)
- MH stabilizing device (MSS)
- Online roll profile (ORP)
- Looper shape meter (LSM)
- CRM shift mill
- Hydraulic AGC system
Features
- High reduction rolling
- Powerful and accurate strip crown & flatness controllability
- Schedule free rolling
- Extension of coil change interval
- Guide roll change
Slab Sizing Press

MH 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 MH has been continuously improving the technology.

- **Features**

  1. **Construction**
     - Main equipment installed on foundation
     - Optimized screw arrangement → two screws per side
     - Application of roller bearing for rotating and reciprocating parts
     - Optimized anti-buckling roller arrangement
     - Stop-and-go press to reduce the risk for production of a cambered slab

  2. **Pressing pattern**
     - Pre-forming press: top and tail end → decrease cropping loss
     - Stop press: top and tail position → decrease top and tail width shrinkage
     - These features are assured by accurate slab positioning by pinch roller and anvil shifting device.

  3. **Short shutdown time for installation in existing plant**
     - Reference construction schedule for adding SSP (slab sizing press) to existing plant:
       - 1st shut down: Approximately 10 days for foundation work preparation
       - 2nd shut down: Approximately 15 days for installation work
       - *Period between 1st and 2nd shut down is at least 6 months.
       - **MH adopts the following method for installation work to reduce shutdown time.
         1) Assembling SSP beside mill line (1 month)
         2) During 2nd shutdown, the SSP is moved into the mill line by means of hydraulic cylinders and rails and is lowered onto the shoe plate by hydraulic cylinders. (approx. 10 days)
         3) Electrical adjustment for transferring slab without pressing.
         After 2nd shut down, 1 month of on-line and off-line adjustment is carried out.

  4. **Other features**
     - Reduces inventory of slab yard
     - Increases productivity of slab caster

- **Technical Data**

  - Press force: 24,500kN
  - Width reduction: up to 350mm depending on material
  - Main drive motor: 3,300kW
  - Processing speed: 38.65mm/press x 52 press/min = 20m/min
  - Slab width: Min 600mm to Maximum 2,300mm
  - Slab length before press: Minimum 4.2 m

- **Option**

  - Automated anvil changing equipment

- **Recent Supply Record**

  - Hyundai Steel C-HOT, Korea: 2010
  - JFE Steel Karihin, Japan: 2008
  - Baosteel No.3 HSM, China: 2007
  - POSCO Pohang No.2 HSM, Korea: 2002
  - POSCO Pohang No.1 HSM, Korea: 2001
  - Nippon Steel Kimitai Works, Japan: 1999
  - JFE Steel Chiba, Japan: 1995
  - JFE Steel Kurashiki, Japan: 1986
Hydraulic AWC and AGC systems for Hot Rolling Mill

Hydraulic AWC system for Hot Rolling Mill

Excellent width accuracy can be achieved by providing the hydraulic AWC system on the vertical edger(s), from top end to tail end of the production.

MP will apply complete hydraulic cylinder operated width control system which will work as the Short Stroke Control (SS) for the top end and tail end parts, and also work as Automatic Width Control System (AWC) for body part. The electro-mechanical servo valves precisely control the hydraulic cylinder position.

Hydraulic AGC system for Hot Rolling Mill

Excellent thickness accuracy can be achieved, from top end to tail end of the production, by providing hydraulic gap adjusting cylinders with the AGC system on mill stands.

The hydraulic gap adjusting cylinders are located under bottom back-up roll chocks or on top back-up roll chocks. The cylinders installed under bottom back-up roll chocks will also work for the pass-line adjustment and the skin-head control especially for the roughing mill.

The electro-mechanical servo valves precisely control the hydraulic cylinder position.

Main parameter
- Strip thickness: 0.8 to 25.4 mm
- Strip width: 650 to 2,200 mm
- Rolling force: up to 50,000 kN

Recent Supply Record

<table>
<thead>
<tr>
<th>Year</th>
<th>Customer</th>
<th>AWC</th>
<th>RM HGD*</th>
<th>RM AGC</th>
</tr>
</thead>
<tbody>
<tr>
<td>2012</td>
<td>Fujin Special Steel, China</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>2011</td>
<td>USINNAS Cubatao No.3 HSM, Brazil</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>2010</td>
<td>Hyundai Steel C-HOT, Korea</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>2010</td>
<td>Dragon Steel, Taiwan</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>2009</td>
<td>Dongbu Steel, Korea</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>2009</td>
<td>jW Steel, India</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>2008</td>
<td>ISDEMIR, Turkey</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>2007</td>
<td>Baosteel No.3 HSM, China</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>2006</td>
<td>Tonghua Iron &amp; Steel, China</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>2006</td>
<td>Barsei Iron &amp; Steel, China</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>2003</td>
<td>Baosteel Stainless Steel Branch, China</td>
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</tr>
<tr>
<td>2000</td>
<td>Corus DSP, The Netherlands</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
</tbody>
</table>

* Hydraulic Gap Control

Roughing mill attached vertical edger with hydraulic AWC system
Advanced Coil Box (Mandrelless Coil Box)

The coil box is located between the roughing mill and finishing mill to coil the transfer bars after roughing passes. The coil box enables a shorter distance between the roughing mill and the finishing mill in a new plant as well as minimizes the temperature drop of the transfer bar entering the finishing mill.

The mandrelless coil box contributes further to reducing the temperature drop at the coil inner wraps in comparison with the mandrel-type coil box. The mandrelless coil box also makes space to install the side heat shields which contribute to reducing the temperature drop at the coil edge.

Comparison of mandrelless coil box and mandrel type coil box

- Mandrel Type Coil Box
  - Coiling Position
  - Uncoiling Position
  - Temperature Drop at Inner Wrap due to Heat Transfer to the Mandrel

- Mandrelless Coil Box
  - Coiling Position
  - Uncoiling Position
  - Prevention of Temperature Drop at Inner Wrap (Strip Tail End)

- Features
  - Prevention of temperature drop at the coil inner wrap through mandrel less coil transfer
  - Prevention of temperature drop at the coil edge through adjustable side heat shields
  - Short-pitch coiling operation through higher coil speed operation (up to 5 m/s) and the forced coil transfer operation from coiling position to uncoiling position to enable the higher productivity
  - Stable operation of the finishing mill through higher temperature and uniform temperature over the whole length of the transfer bar. Due to this feature zoom rolling in the finishing mill is not required.
  - Passing through the coil box without cooling is selectable according to the required production and operation methods
  - Large coil capacity for a wide range of transfer bar sizes (20mm to 55mm thickness, over 2,000mm width maximum in reference plant) to enable a wide range of carbon steel production, as well as stainless steel production

Forced Coil Transfer Operation

MN’s designed mandrelless coil box has two selectable coil transfer operations. One is passive coil transfer without any positive mechanical actions as a simple operation method. The other is forced coil transfer. The forced coil transfer system ensures smooth and quick coil transfer and enables higher productivity.

Recent Supply Record

- Fuxin Special Steel, China 2012
- ISDEMIR, Turkey 2008
- POSCO, Pohang No.2 HSM, Korea 2006
- Baosteel Stainless Steel Branch, China 2003
- G-Steel, Thailand 1999
Differential-speed Rotary Crop Shear

Transfer bars rolled at a roughing mill have shapes out of square, so-called tongue and fishtail, on their head and tail ends. The crop shear is located in front of the finishing train to cut off such unsteady parts of the transfer bar as crops for stable threading into the finishing train. The differential-speed rotary crop shear is a unique product of Mitsubishi Hitachi Metals Machinery (MH). The design incorporates top and bottom drums with different diameters and peripheral speeds. During operating turn, the knife gap is transitionally changed from plus-zero, which ensures several operational and economical advantages to customers (Fig. 1).

The differential-speed type rotary crop shear of MH has adopted the following features through long-standing experience over 30 years.

- **Features**
  - Since the differential speed rotary crop shear is insensitive to the knife wear and extended knife gap (Fig. 2), sharp cutting performance is assured, and the knife changing cycle is also extended (lasting typically twice as long).
  - MH maintains a line-up of several sizes of crop shears from which an optimum configuration can be proposed to each customer with optional items.
  - The MH rotary crop shear is able to cut the end crops in very short pieces, from a minimum of 20mm, and with a crop optimization system, so that a remarkable improvement in the crop loss is achievable.
  - Robust design and high torsional rigidity with the application of synchronizing gears on the drum shaft ends between top and bottom.
  - Quick knife changing with hydraulic unclamping system.

### Technical Data
- **Transfer Bar Thickness:** 13 - 60 mm (Design max 80 mm)
- **Transfer Bar Width:** 550 - 2300 mm
- **Shearing Force:** 5000 - 17200 kN
- **Speed:** 0.35 - 4.1 m/sec

### Optional Items
- Cassette type drum retraction
- Quick drum changing system (cassette type only)
- Customized crop disposal system
- Double-knife type drums
- Hydraulic unclamping system
- Crop optimization system
- Knife contours
- Retractable exit roller

### Recent Supply Record
- Fuxin Special Steel, China 2012
- USIMINAS Cubatão No.2 HSM, Brazil 2011
- Hyundai Steel C-HOT, Korea 2010
- Dragon Steel, Taiwan 2010
- Dongbu Steel, Korea 2009
- JSW Steel, India 2009
- SDEMIR, Turkey 2008
- Baosteel No.3 HSM, China 2007
- Zhangjiapang Pohang Stainless Steel, China 2006
- Tonghua Iron & Steel, China 2005
- Benxi Iron & Steel, China 2005
- Baosteel Stainless Steel Branch, China 2003
- Tangshan Iron&Steel, China 2002
- Anshan Iron & Steel, China 2000
- G-Steel, Thailand 1999
- Harbo Steel, Korea 1997
- Nucor (Trico Steel), USA 1996
- POSCO Kwangyang, Korea 1996
- Baosteel No.2 HSM, China 1996
- JFE Steel Chiba, Japan 1995
Advanced Pair Cross Mill
(Pair Cross Mill with Mill Stabilizer)

The pair cross mill (PC mill) was developed in 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 controllability. MHI has enhanced the PC mill and is now supplying a 3rd generation PC mill with a mill stabilizer, the so-called Advanced Pair Cross Mill.

The advanced PC mill is simpler to operate and easier to maintain. The number of the roll cross devices is reduced to less than one-fourth of those of the 1st generation PC mill. The advanced PC mill has the capability for higher reduction thru the use of a mill stabilizer to reduce mill vibration. The mill stabilizer is installed on the entry side housing and eliminates the clearance between the chocks and housing during operation. This feature will reduce the task of maintaining the entry-side housing liner to approx. one-third that of a conventional mill.

- **Features**
  - Higher reduction rolling without mill vibration through the combination of PC mill and mill stabilizer
  - Powerful strip crown and flatness controllability with the simple principle of roll cross (see below)
  - Stable operation with the elimination of clearance between roll chocks and housing and symmetrical roll crown control to reduce camber and the pinching problems.
  - Reduction of impact force at the roll bite through the mill stabilizer, resulting in the reduction of the damage and wear on equipment.
  - Higher reliability of equipment
  - Very few maintenance parts with long replacement interval
  - Possible to install the mill stabilizer to any type mills (conventional mill, shift mill, PC mill, etc.) as a modification.

- **Recent Supply Record**

<table>
<thead>
<tr>
<th>Company</th>
<th>Year</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fuxin Special Steel, China</td>
<td>2012</td>
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<tr>
<td>USMINAS Cubatao No.2 HSM, Brazil</td>
<td>2011</td>
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<tr>
<td>Hyundai Steel C-HOT, Korea</td>
<td>2010</td>
</tr>
<tr>
<td>Dragon Steel, Taiwan</td>
<td>2010</td>
</tr>
<tr>
<td>Dongbu Steel, Korea</td>
<td>2009</td>
</tr>
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<td>JSW Steel, India</td>
<td>2009</td>
</tr>
<tr>
<td>ISDEMR, Turkey</td>
<td>2008</td>
</tr>
<tr>
<td>Roosteel, No.3 HSM, China</td>
<td>2007</td>
</tr>
<tr>
<td>Tonghua Iron &amp; Steel, China</td>
<td>2005</td>
</tr>
<tr>
<td>Benxi Iron &amp; Steel, China</td>
<td>2005</td>
</tr>
<tr>
<td>Baosteel Stainless Steel Branch, China</td>
<td>2003</td>
</tr>
</tbody>
</table>

**Principle of roll cross**

\[
\Delta C = \frac{b^2}{2Dw} \times \theta^2
\]

- \( \Delta C = \text{Se-Sc: Equivalent Roll Crown} \)
- \( \theta : \text{Roll cross angle} \)
- \( b : \text{width of material to be rolled} \)

Note: \( Sc=\text{Constant (Independent of cross angle)} \)

**Control of strip crown by roll cross**

- **0 degree**
  - Positive

- **Middle**
  - Flat

- **Large**
  - Negative
On-line Roll Profiler (ORP)

On-line roll profiler (ORP) is installed in the mill stands and used to grind work rolls during rolling operation to maintain the work roll surface quality. The disc-type grinding wheel is composed of a cubic boron nitride (CBN) material mounted on higher damping mechanism.

The design has improved service life, greater grinding capacity and more reliable operation. The driving components for the grinding wheel rotation, for pressing to 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 grinding wheel position against the roll is adjusted according to the various roll diameters and roll position by the tilting mechanism.

### Technical Data

<table>
<thead>
<tr>
<th>Description</th>
<th>Specification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grinding wheel speed</td>
<td>2,000 rpm</td>
</tr>
<tr>
<td>Grinding wheel size</td>
<td>210 mm dia x 15 mm thickness</td>
</tr>
<tr>
<td>Grinding wheel material</td>
<td>Cubic boron nitride</td>
</tr>
<tr>
<td>Drive system</td>
<td>Electric motor</td>
</tr>
</tbody>
</table>

### Features

<table>
<thead>
<tr>
<th>Cause of coil surface trouble</th>
<th>Solution</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rough surface</td>
<td>-</td>
</tr>
<tr>
<td>Pinching mark</td>
<td>-</td>
</tr>
<tr>
<td>Roll banding</td>
<td>-</td>
</tr>
</tbody>
</table>

### Effect

- Elimination of strip surface defects caused by roll surface defects
- Extension of roll campaign
- Extension of roll length with same width rolling
- Realistic width-reverse rolling (change of width from narrow to wide)

### Recent Supply Record

- **Nippon Steel Nagoya Works, Japan**: 2011
- **Hyundai Steel C-HDT, Korea**: 2010
- **Nippon Steel Hino Works, Japan**: 2008
- **Hyundai Steel B-HDT, Korea**: 2007
- **Baosteel No.3 HSM, China**: 2007
- **POSCo Pohang No.2 HSM, Korea**: 2006
- **JFE Steel Chiba, Japan**: 2006
- **Baosteel Stainless Steel Branch, China**: 2003
- **Tangshan Iron&Steel, China**: 2002
- **Nippon Steel Oita Works, Japan**: 2002
- **Nippon Steel Yawata Works, Japan**: 2002
- **POSCo Pohang No.1 HSM, Korea**: 2001
- **POSCo Kwangyang No.1-3 HSM, Korea**: 2002
- **Arishan Steel, China**: 2000
Looper Shape Meter (Tension meter)

The measurement of strip shape between mill stands on a Hot strip mill has previously been rather difficult and unreliable. MHI has developed a looper shape meter (LSM) to continuously and accurately measure interstand shape as well as strip off-centering.

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

LSM also detects off-centering through the distribution of the loads on segment rolls. LSM has superior advantages as follows:

- The load on the segment roll is measured by a torque meter without any influences of hysteresis of mechanism, unlike a load cell. Measurement by torque meter enables higher accuracy and increased measurement reliability without any influences caused by changing mechanical condition.
- The strip shape and off-centering can be measured at the same time.
- Easily interchangeable with existing loopers and LSM because the moment of inertia is small.
- Easy replacement of segment roll for maintenance.

**Features**

- Higher accuracy continuous measurement of strip shape (center buckle, edge wave, side wave, etc.) and off-centering between mill stands during rolling operation.
- Strip shape feedback control to roll cross angle in PC mill and work roll bending force for whole length of strip during rolling operations to enable higher strip shape quality and mill productivity.
- Reduction of pinching problems at strip tail end to enable higher productivity and stable rolling, especially thin-gauge rolling.
- The synchronized measurements of strip shape and off-centering to enable control of off-centering

### Example of measurement in actual operation

1. Total shape is calculated from the torque measurement value.
2. The calculated total shape can be divided into 0th, 1st, 2nd and 4th order strip shape.
3. Strip shape can be controlled according to the results of each order calculation.

### Technical Data

<table>
<thead>
<tr>
<th>Sensor type</th>
<th>Torque meter</th>
</tr>
</thead>
<tbody>
<tr>
<td>Roller dimension</td>
<td>185mm dia x 194mm body length</td>
</tr>
<tr>
<td>Strip thickness</td>
<td>0.7-20mm</td>
</tr>
<tr>
<td>Strip width</td>
<td>≥ 1000 mm</td>
</tr>
<tr>
<td>Segment</td>
<td>7 (For example of width 1560mm) depending on strip width</td>
</tr>
<tr>
<td>Applicable scope</td>
<td>Conventional mill, Mini mill, Stackel mill, Strip caster</td>
</tr>
</tbody>
</table>

### Recent Supply Record

Corus DSP, The Netherlands 2006
Intensive Strip Cooling System

The strip cooling system cools the strip rolled by the finishing mill, and it is mounted on the run-out table between the finishing mill delivery side and the down coiler. The cooling system is designed as a laminar flow system on both top and bottom, incorporating a line-side head tank system. The cooling zone is divided into the required cooling banks, which will consist of intensive cooling banks for faster cooling, normal cooling banks for regular cooling, and fine cooling banks for fine temperature control in order to achieve the desired cooling patterns and cooling temperatures for dual-phase (DP) and trip steel, etc. For easy maintenance of the roller table, the top header is designed to swing up by means of the hydraulic cylinder.

**Features**
- Head tank along cooling line
  - A major factor in strip cooling systems involves the obtainment of a stable supply water head for all spray headers without incurring pressure changes in each cooling unit that normally result from the rapid on-off control of each unit. In this regard, a head tank type water supply system provides excellent means for ensuring a stable water supply and also performs high repeatability of cooling increments in view of rapid on-off control.
- Wide range (from rapid cooling to mild cooling) temperature control suitable for dual-phase, trip steels and also mild steels.
- High response control valves
- For easy maintenance, top headers can swing-up.

**Recent Supply Record**
- Fuxin Special Steel, China 2012
- USIMINAS Cubatao No.2 HSM, Brazil 2011
- Hyundai Steel CHDT, Korea 2010
- Dragon Steel, Taiwan 2010
- Dongbu Steel, Korea 2009
- JSW Steel, India 2009
- ISDEMR, Turkey 2008
- Basteel No.3 HSM, China 2007
- China Steel No.1 HSM, Taiwan 2004
- Basteel Stainless Steel Branch, China 2003
- Anshan Iron & Steel, China 2000
- Hanbo Steel, Korea 1997
- Basteel No.2 HSM, China 1996
Advanced Down Coiler

To make excellent coil profiles MH proposes a high-rigidity frame coiler fixed on the foundation. To properly coil high-strength material, such as X80 or thicker strip up to 25.4 mm, coiler will be a three-unit roller type, and to coil strip ranging from thin to thick properly, a speed-change gear set will be applied. An outboard bearing is mounted at the mandrel and to firmly support the mandrel.

The down coiler mandrel is a link & wedge and step-less expanding type. All sliding surfaces, such as wedge, etc. inside the mandrel are positioned at the mandrel center, and each slide way is securely and automatically lubricated with grease by a distribution valve. No internal water cooling is required.

To realize quick changes, the mandrel has a plug-in connector between the mandrel and the rotary cylinder. The mandrel can be pulled out from the down coiler without disassembling the mandrel drive unit.

- **Other Essential Features**
  1. **Sideguides**
     - High-response hydraulic side guides will be installed in front of each down coiler. To realize quick guide liner changing, MH applies a cassette plate with guide liner.
  2. **Pinch roll**
     - The pinch roll is mounted on the coiler frame. The pinch roll has enough rigidity and the roll gap or pinching force is applied by hydraulic cylinders controlled by servo valves.
     - A roll polisher (as an option) can be provided for the top and bottom pinch roll to smooth up the roll surface.
  3. **Quick opening control**
     - All down coilers will be equipped with a QOC (Quick open control) function whereby each unit roll avoids the shock load from the step formed by the top end of the strip and prevents top-marks on the coil.
     - In advanced QOC, the jump up control is executed in the combination with the mandrel non-step expansion.

- **Recent Supply Record**
  - Fuxin Special Steel, China 2012
  - USIMINAS Cubatao NO.2 HSM, Brazil 2011
  - Hyundai Steel C-HDT, Korea 2010
  - Dragon Steel, Taiwan 2010
  - Dongbu Steel, Korea 2009
  - JFE Steel Fukuyama, Japan 2009
  - JSW Steel, India 2008
  - ISBEMR, Turkey 2008
  - Baosteel No.3 HSM, China 2007
  - Zhangjiagang, Pohang Stainless Steel Co., Ltd., China 2006
  - Tonghua Iron & Steel Co., Ltd., China 2005
  - Benxi Iron & Steel Co., Ltd., China 2005
  - China Steel No.1 HSM, Taiwan 2004
  - Panthhua Iron & Steel, China 2002
  - POSCO Kwangyang No.2 HSM, Korea 2002
  - Corus DSP, The Netherlands 2001
### 1 Sheet Bar Joining Machine

The concept of the endless hot rolling was introduced to meet demands for diverse products of hot rolled steel sheets using a cost-effective process compared to the conventional batch-type process. Endless rolling involves joining of the tail end of a preceding bar and the head end of a following bar after rough rolling. The repetitively joined hot bars are subsequently finish-rolled, which results in the endless rolling. This process has the following advantages over the conventional batch-type process:

1. **Expansion of product lineup:** Production of thinner, wider and harder steel sheets. Stable rolling of thin and hard-to-roll materials.
2. **Increase in productivity:** Great reduction in mill idle time, and constant rolling speed with reduction of mill acceleration and deceleration time.
3. **Improvement of product quality:** Improvement in accuracy and uniformity of strip thickness, crown, and width.
4. **Energy savings:** Reduction of the mill acceleration and deceleration frequencies.
5. **Increase of yield:** Minimization of miss-rolling of thin and hard-to-roll materials. Application of tension at head and tail parts of bar.

#### [a] Induction Heating Joining (IHJ)

JFE Steel Chiba No.3 HSM is the first HSM in the world to realize endless hot strip rolling. The key to Endless Rolling is the Induction Heating Joining Machine that was developed by Mitsubishi-Hitachi Metals Machinery, Inc. jointly with JFE Steel.

**Joining Method**

<table>
<thead>
<tr>
<th>Joining Process</th>
<th>Power source</th>
<th>Joining area</th>
</tr>
</thead>
<tbody>
<tr>
<td>Induction Heating, Joining (IHJ)</td>
<td>Induction heater</td>
<td>Clamp</td>
</tr>
<tr>
<td>Joining : Semi-solid (Solid fraction 70%)</td>
<td>Joining area</td>
<td>Joinder</td>
</tr>
<tr>
<td>Super Deformation Joining (SDJ)</td>
<td>Press</td>
<td>Crop</td>
</tr>
<tr>
<td>Joining : Super Deformation and Frictional Upsert</td>
<td>Knife</td>
<td></td>
</tr>
</tbody>
</table>

**Joining Temperature**

- **Joining : Semi-solid (Solid fraction 70%)**
  - About 1000°C (Material temp.)
  - Within 1 (sec)

**Characteristics of Equipment**

- Running stroke : Long
- Large up-down mechanism of joining table
- Debur
- Running stroke : Short
- Crop disposal is necessary with this method.

#### [b] Super Deformation Joining (SDJ)

The Super Deformation Joining Machine that was developed by Mitsubishi-Hitachi Metals Machinery, Inc. jointly with POSCO was installed in 2006 and is now in operation at No.2 Hot Strip Mill in Pohang Works, POSCO.

**Joining Sequence and Mechanism**

The procedure consists of four steps: partial descaling, overlapping, joining, and crop disposal.

1. **Partial descaling:** High-pressure water is first performed on the area to be joined before overlapping.
2. **Overlapping:** The head of the following bar is partially overlapped on the tail of the preceding bar by increasing the speed of the following bar.
3. **Joining:** Both bars are joined by shearing action of the stationary pendulum type-joining machine.
4. **Crop disposal:** Crops on both sides are pushed off from the joint and disposed.

**Recent Supply Record**

- POSCO Pohang No.2 HSM, Korea (SDJ) 2006
- JFE Steel Chiba No.3 HSM, Japan (IHJ) 1996

**Design of Super Deformation Joining Machine**

**Super Deformation Joining Machine in Operation**
Endless Rolling Technology

2 | Key Technologies for Endless Rolling

In addition to the transfer bar joining technology, the following items are key technologies to implement for successful endless rolling.

1) Dynamic APFC (crown and flatness control)
2) Shear to split long strip before cooling
3) Dynamic switching over of coilers during high-speed rolling and coiling

MH is the only supplier in the world that can supply a complete endless rolling system, and five hot strip mills are under operation with MH’s endless rolling technology, with remarkable accomplishments.

MH offers, in connection with the above, the following proven technologies for the customer.

1) Advanced dynamic PC Mill
2) High-speed shear
3) Advanced down coilers with switch-over function (Optional: Carousel coiler)

- **Advanced Dynamic PC Mill**
  - Dynamic PC Mill is designed to provide to dynamic APFC, which produces high-quality products in combination with a high-response work roll bending system at the above-mentioned 5 hot strip mills.
  - Application and number of Dynamic PC stands are customized in accordance with product range and other requirements.
  - Dynamic PC Mill can also be effective for normal batch rolling for compensation of thermal expansion of work rolls and changes in other rolling conditions in bar.
  - Main specification:
    - Max PC angle : 1.2 degrees
    - Max speed : 0.04 deg/sec (in-bar)

- **High Speed Shear (HSS)**
  - Rotary-type shear with single knife.
  - Equipped with eccentric mechanism, with which the drums approach each other at shearing.
  - Long-life design knives.

- **Advanced DC with switch-over function**
  - Four-unit roll type hydraulic down coiler.
  - Equipped with:
    - Hydraulic pinch roll with offset adjustment mechanism.
    - Swinging gate
    - Pneumatic strip feeding system
  - Main Specifications:
    - Strip thickness : 0.8 to 12.7 mm
    - Strip width : 750-1,750 mm (2,200mm)
    - Threading speed : Max. 20m/sec
REFERENCE

Baosteel No.3 Hot Strip Mill Project (Shanghai, China)

1,880mm deluxe hot strip mill with short delivery time

On March 30, 2007, Baoshan Iron & Steel, Ltd., the leading company in China for iron and steel manufacturing, successfully produced the first coil from its No.3 Hot Strip Mill with just 255.5 months after the contract. The No.3 Hot Strip Mill is being commissioned in due course to produce high grade grain oriented silicon steel products.

- **UNIQUE FEATURES**
  - Start-up Phase
    - Slab sizing press
    - 2-high roughing stand (R1) and 4-high roughing stand (R2)
      - with quick roll changing system
    - R2 attached vertical edger with automatic width control (AWC)
    - Edge heater and bar heater
    - Drum type crop shear
    - Descaling facilities
    - F1 attached vertical edger
    - Seven 4-high finishing stands with:
      - Pair cross system (F1-F4)
      - Mill stabilizer device (F1-F4)
      - Work-roll shift device (F5-F7)
      - Online roll profiler (F5-F7)
      - Work-roll bending system (F1-F7)
      - Hydraulic automatic gauge control system (AGC)
      - Hydraulic looper
      - Quick roll changing device
      - Hot-rolling oil system
      - Interstand cooling system
      - Laminar cooling system
      - Two down coilers with hydraulic quick opening control system (QOC)
    - Non-stop expanding mandrel
    - Down conveyor system
  
  - Future Phase
    - One additional down coiler

- **LINE SPECIFICATION**
  
  **Production Data**
  
  **Production Capacity**: 3.7 million tons/year
  
  **Steel Grade**: Carbon steel, Low alloy steel, Non-grain-oriented Si steel, Grain oriented Si steel, IF steel, DP & TRIP steel

  | Slab Thickness | 230 (210 & 250) mm |
  | Slab Width | 900 mm to 1,750 mm |
  | Slab Length | Max. 11 m |
  | Strip Thickness | 1.2 mm to 19 mm |
  | Strip Width | 700 mm to 1,730 mm |
  | Coi Weight | Max. 34,500 kg |

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Baosteel Stainless Steel Branch HSM (Shanghai, China)

Stainless steel branch HSM for Baoshan Iron & Steel Co., Ltd.

The new HSM started production in December 2003 at the stainless steel branch of Baosteel. The HSM has been designed considering stainless steel rolling with a cooperation of a Japanese steel mill. Additionally, the HSM was equipped with the latest in technology by MH, such as advanced mandrel coil box, 3rd-generation PC mill (advanced PC mill) and on-line roll profiler (ORP). Based on the great facilities and the enthusiasm of the company’s staff, the HSM has extended the production of stainless steel very smoothly and reliably.

- **UNIQUE FEATURES**
  - HSB ( HEADER height is adjustable)
  - Vertical edger with automatic width control (AWC)
  - One heavy-duty 4-high roughing stand with quick roll changing system
  - Mandrelless coil box
  - Drum-type crop shear
  - FSIB (No water leakage during stainless steel rolling)
  - F1 attached vertical edger
  - Seven 4-high finishing stands with:
    - Advanced pair cross system
      - (PC mill with mill stabilizer device) (F1-F4)
      - Online roll profiler (F5-F7)
    - Work roll bending system (F1-F7)
    - Hydraulic automatic gauge control system (AGC)
    - Quick roll changing device
    - Hot rolling oil system
    - Laminar cooling system
    - Two down coilers

- **LINE SPECIFICATION**
  
  **Production Data**
  
  **Production Capacity**: 2 million tons/year for carbon steel, 1 million tons/year for stainless steel
  
  **Steel Grade**: Carbon steel, Low-alloy steel, Stainless steel

  | Strip Thickness | 1.2 mm to 12.7 mm for carbon steel |
  | Strip Width | 50 mm to 1,630 mm for stainless steel |
  | Coil Weight | Max. 30,000 kg |

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**LINE CONFIGURATION**

![Diagram of production line with labels and descriptions]
### ISDEMIR Hot Strip Mill Project (İskenderun, Turkey)

**2,180mm first hot strip mill in Turkey supplied by MH**

ISDEMIR (İskenderun Iron & Steel Works Co.), a member of ERDEMİR Group, has been a manufacturer of long steel products in Turkey. It promotes modernization and expansion projects in the factory. In 2005, ISDEMIR decided to construct a hot strip mill producing flat steel products as a core project.

In Turkey, MH was proud to have a share in such a core project and provides the hot strip mill for production of strip up to 2,050mm wide by utilizing the state of the art technologies.

#### UNIQUE FEATURES

- **Start-up Phase**
  - Vertical edger with automatic width control (AWC)
  - 4-high roughing mill
  - Mandrelless type coil box
  - Drum type crop shear with quick drum changing device
  - Descaling facilities
  - Six 4-high finishing mills with:
    - Pair cross system (F1-F4)
    - Mill stabilizer device (F1-F4)
    - Work roll shift device (FS-F6)
    - Work roll bending device (F1-F6)
    - Hydraulic automatic gauge control system (AGC)
    - Hydraulic looper
    - Quick roll changing device
    - Hot rolling oil system
    - Interstand cooling system
    - Laminar cooling system
    - Two down coolers with hydraulic quick opening control system (QOC)
    - Non-step expanding mandrel
    - Down coil conveyor system

- **Future Phase**
  - One additional roughing mill
  - One additional finishing mill
  - One additional down cooler

#### LINE SPECIFICATION

<table>
<thead>
<tr>
<th>Production Data</th>
</tr>
</thead>
<tbody>
<tr>
<td>Production Capacity</td>
</tr>
<tr>
<td>(4.5 million tons/year in future)</td>
</tr>
<tr>
<td>Steel Grade</td>
</tr>
<tr>
<td>Slab Thickness</td>
</tr>
<tr>
<td>Slab Width</td>
</tr>
<tr>
<td>Slab Length</td>
</tr>
<tr>
<td>Strip Thickness</td>
</tr>
<tr>
<td>Coil Weight</td>
</tr>
</tbody>
</table>

### Hot Strip Mill Project for JSW Steel Limited (Toranagallu, India)

**2,250mm hot strip mill supplied by MH in India will start up in 2009**

JSW Steel Limited, a leading private company in India, has been a major manufacturer of flat steel products in India and promotes modernization and expansion of production capacity. In 2006, JSW decided to construct the new advanced hot strip mill producing high quality and high grade of strip.

In India, MH will supply the first hot strip mill for production of strip up to 2,150mm wide by utilizing the state of the art technologies such as advanced pair-cross mill.

#### UNIQUE FEATURES

- **Start-up Phase**
  - Vertical edger (E2) with automatic width control (AWC)
  - 4-high roughing mill (R2) with quick roll changing device
  - Drum-type crop shear
  - Descaling facilities
  - Six 4-high finishing mills with:
    - Pair cross system (F1-F4)
    - Mill stabilizer device (F1-F4)
    - Work roll shift device (FS-F6)
    - Work roll bending system (F1-F6)
    - Hydraulic automatic gauge control system (AGC)
    - Hydraulic looper
    - Quick roll changing device
    - Hot rolling oil system
    - Interstand cooling system
    - Laminar cooling system
    - Two down coolers with hydraulic quick opening control system (QOC)
    - Non-step expanding mandrel
    - Down coil conveyor system

- **Future Phase**
  - One additional slab sizing press (SSP)
  - One additional roughing mill (E1/R1)
  - One additional finishing mill (F7)
  - One additional down coil (No.3 DC)

#### LINE SPECIFICATION

<table>
<thead>
<tr>
<th>Production Data</th>
</tr>
</thead>
<tbody>
<tr>
<td>Production Capacity</td>
</tr>
<tr>
<td>(5.0 million tons/year in future)</td>
</tr>
<tr>
<td>Steel Grade</td>
</tr>
<tr>
<td>Slab Thickness</td>
</tr>
<tr>
<td>Slab Width</td>
</tr>
<tr>
<td>Slab Length</td>
</tr>
<tr>
<td>Strip Thickness</td>
</tr>
<tr>
<td>Coil Weight</td>
</tr>
</tbody>
</table>

### LINE CONFIGURATION

[Diagram of ISDEMIR Hot Strip Mill Project]

[Diagram of Hot Strip Mill Project for JSW Steel Limited]
Tata Steel Europe Direct Sheet Plant (IJmuiden, The Netherlands)

Semi-endless rolling process on compact hot strip mill

The Direct Sheet Plant of Tata Steel Europe (formerly Corus) in Ijmuiden, The Netherlands, started production in April 2000. The basic concept of the plant is to produce thin gauge hot rolled coils by the semi-endless rolling process on the compact hot strip mill, featuring the latest MH developed technologies. In this process, a very long slab is rolled and the strip is cut to suitable length, according to the desired coil weight, just before the carousel coiler. This process realizes stable rolling and uniform strip quality even for the production of thin gauge, because non-steady rolling at the head and tail end of each strip can be largely reduced.

**UNIQUE FEATURES**

Start-up Phase
- Dynamic pair-cross system equipped on the roughing mill (R2) and all finishing mills (F1-F5), which can achieve powerful crown control even during rolling and is highly effective for flying gauge change function necessary for semi-endless rolling
- Small work roll diameters (450-500 mm) on the later stands (F3-F5) to reduce rolling force at higher reduction
- Ultra-fast cooling system installed on the run-out table for cooling the strip rapidly to the target cooling temperature in a shorter cooling zone
- High-speed strip shear for cutting the strip to suitable length using two knife drums and a carousel coiler, enabling continuous and stable cooling with two mandrels

Innovation Phase
- Looper shape meter (LSM) for measurement of strip shape and off-centering, leading to more stable rolling operation
- Mill stabilizer device for prevention of mill vibration

**LINE SPECIFICATION**

<table>
<thead>
<tr>
<th>Production Data</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Production Capacity</td>
<td>1.3 million tons/year</td>
</tr>
<tr>
<td>Steel Grade</td>
<td>Low-carbon steel, High-strength steel</td>
</tr>
<tr>
<td>Slab Thickness</td>
<td>70 mm</td>
</tr>
<tr>
<td>Slab Length</td>
<td>Max. 300 m</td>
</tr>
<tr>
<td>Strip Thickness</td>
<td>0.8 mm to 2.5 mm</td>
</tr>
<tr>
<td>Strip Width</td>
<td>750 mm to 1,560 mm</td>
</tr>
<tr>
<td>Coil Weight</td>
<td>Max. 33,000 kg</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Line Data</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>No. of Mill Stands</td>
<td>7 stands (2-RM and 5-FM)</td>
</tr>
<tr>
<td>Type of Mill</td>
<td>Dynamic pair cross (R2, F1-F5), Mill stabilizer device (F1-F2)</td>
</tr>
<tr>
<td>Looper</td>
<td>Looper with shape meter (#4 looper)</td>
</tr>
<tr>
<td>Strip Cooling</td>
<td>Ultra-fast cooling type</td>
</tr>
<tr>
<td>Strip Shear</td>
<td>Flying out-type with rotary drums</td>
</tr>
<tr>
<td>Coiler</td>
<td>Carousel reel and wrapper roll type</td>
</tr>
<tr>
<td>Line Speed</td>
<td>Max. 1,200 m/min</td>
</tr>
</tbody>
</table>
Hot Strip Mill Project for Dragon Steel Corporation (Taichung, Taiwan)

2,080mm Semi-Continuous hot strip mill supplied by MH in Taiwan has started up in 2010

Doragon Steel Corporation, a member of CSC Group, has been a manufacturer of long product in Taiwan. It promotes modernization and expansion project in the factory. Dragon Steel Corporation, decided to construct a hot strip mill producing flat steel products as a core project. MH provided the hot strip mill for production of strip up to 1,880mm wide by utilizing the state of the art technologies.

**UNIQUE FEATURES**

*Start-up Phase*
- 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 (PS2) with quick roll changing device
- Heat Holding Cover
- Drum-type crop shear
- Descaling facilities
- Seven 4-high finishing mills with:
  - Pair cross system (F1-F4)
  - Mill stabilizer device (F1-F4)
  - Work roll shift device (F5-F7)
  - Work roll bending system (F1-F7)
  - Hydraulic automatic gauge control system (AGC)
  - Hydraulic looper
  - Quick roll changing device
  - Hot rolling oil system
  - Interstand cooling system
  - Laminar cooling system
- Two down coilers with hydraulic quick opening control system (QOC)
- Non-stop expanding mandrel
- Coil conveyor system

*Future Phase*
- One additional slab sizing press (SSP)
- One additional down coiler (No.3 DC)

**LINE SPECIFICATION**

<table>
<thead>
<tr>
<th><strong>Production Data</strong></th>
<th>3.0 million tons/year (3.8 million tons/year in future)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Steel Grade</strong></td>
<td>Low-carbon steel</td>
</tr>
<tr>
<td><strong>Slab Thickness</strong></td>
<td>250 mm - 3000 (stainless steel)</td>
</tr>
<tr>
<td><strong>Slab Width</strong></td>
<td>780 mm to 1,880 mm (900—1550 : SUS)</td>
</tr>
<tr>
<td><strong>Slab Length</strong></td>
<td>Max. 10 m</td>
</tr>
<tr>
<td><strong>Strip Thickness</strong></td>
<td>1.2 mm to 25.4 mm</td>
</tr>
<tr>
<td><strong>Strip Width</strong></td>
<td>700 mm to 1,880 mm (900—1524 : SUS)</td>
</tr>
<tr>
<td><strong>Coil Weight</strong></td>
<td>Max. 35,500 kg</td>
</tr>
</tbody>
</table>

G Steel Public Company Limited (Rayong, Thailand)

G Steel (formerly Siam Strip Mill Public Co., Ltd.) plant in Thailand is the largest integrated hot rolled coil products manufacturer in Southeast Asia. It comprises the three basic production processes of steelmaking, continuous casting and hot rolling mill integrated into a close-coupled production line so called “Mini Mill.”

MH supplied not only the hot rolling equipment and its auxiliaries, such as water treatment plant, cranes, sub-station, etc. but also the civil and building construction and installation for whole the production process equipment, on turn-key basis.

**UNIQUE FEATURES**

- Tandem operation of two roughing mills independently to finishing mill operation
- Mandrelless coil box
- Six finishing mills with:
  - Hydraulic automatic gauge control (AGC) in all stands
  - Pair-cross mill (PC Mill) for F2 and F3
  - Online roll profiler for F5 & F6
  - Work roll bending system in all stands
  - Hot rolling oil system in all stands

**LINE SPECIFICATION**

<table>
<thead>
<tr>
<th><strong>Production Data</strong></th>
<th>1.5 million tons/year (Start-up phase)</th>
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</thead>
<tbody>
<tr>
<td><strong>Steel Grade</strong></td>
<td>Low-carbon, Peritectic, Medium-carbon, High-carbon</td>
</tr>
<tr>
<td><strong>Strip Thickness</strong></td>
<td>1.0 mm to 12 mm</td>
</tr>
<tr>
<td><strong>Strip Width</strong></td>
<td>900 mm to 1500 mm</td>
</tr>
</tbody>
</table>

Mandrel-Less Coil Box

Overview of Plant