

## **WIDE PLATE MILLS<sup>1</sup>**

### **NEW WIDE PLATE MILL COMPLEX FOR MIDDLE EAST REGION - TECHNOLOGICAL EQUIPMENTS AND ACHIEVEMENTS**

*Francesco Stella<sup>2</sup>*

#### **Abstract**

The new wide plate mills has been designed to fulfill the requirements for high productivity, yield, tight dimensional tolerances, enhanced mechanical properties and improved surface quality that are a must for the modern plant. The main target of this paper is to present a complete solution of a wide plate mill complex composed not only by technological mechanical, automation and electrical equipments but also by heat treatment lines (normalizing, quenching and tempering) and auxiliary items as roll shop, water treatment plant, compressed air system, laboratories, cranes etc. Other particular subject to show on this paper is the special condition of the site location, located at middle east region with bad soil condition and the plant installed on a platform at + 7,5 m from ground level.

**Key words:** Plate mill; Hot rolling mill; Plates production.

## **NOVO LAMINADOR DE CHAPA GROSSA PARA ORIENTE MÉDIO - EQUIPAMENTOS TECNOLÓGICOS E RESULTADOS**

#### **Resumo**

Os novos laminadores de chapas grossas vêm sendo desenvolvidos de forma a preencher todos os requisitos de uma planta mais moderna como alta produtividade, rendimento, tolerâncias dimensionais mais apertadas, produtos com melhores propriedades mecânicas e qualidade superficial. O objetivo principal deste trabalho é apresentar uma solução completa de uma planta de laminação de chapa grossa que é composta não só dos equipamentos mecânicos, elétricos e de automação assim como de uma linha de tratamento térmico (normalização, têmpera...) e outros itens auxiliares como oficina de cilindros, planta de tratamento de água, planta de ar comprimido, laboratórios e pontes rolantes. Uma particularidade a ser mostrada neste trabalho é a condição especial do local da planta, instalada no Oriente Médio com uma condição de solo muito ruim e a linha instalada numa plataforma a 7,5 m de altura do nível zero.

**Palavras-chave:** Laminador de chapas grossas; Laminação a quente; Produção de chapas grossas.

<sup>1</sup> *Technical contribution to the 47<sup>th</sup> Rolling Seminar – Processes, Rolled and Coated Products, October, 26<sup>th</sup>-29<sup>th</sup>, 2010, Belo Horizonte, MG, Brazil.*

<sup>2</sup> *Sales Manager, Danieli Wean United, Italy*

## 1 INTRODUCTION

The modern plate mills must fulfill the requirements for high productivity and yield, tight dimensional tolerances, enhanced mechanical properties and improved surface quality.

The feedstock is a thick slab (up to 400 mm) that can be charged either cold or hot into the reheating furnace.

Reliable equipment and advanced technology coupled with in-house developed mathematical models guarantee plate producers the competitiveness needed for the challenge of producing new steel grades, such as API X100 and beyond.

Wide plate mills allow the achievement of excellent performances in terms of mechanical characteristics for finished products, enabling cross rolling with sizing, broadside and reduction stages, conventional rolling, temperature-controlled rolling, thermo-mechanical rolling, accelerated cooling/direct quenching.

Steel grades that nowadays are produced in the conventional route cover all the needs of the construction industry, shipbuilding industry, oil and sour gas transportation industry.

The most advanced references of this technological process and equipment for wide plate production is Khouzestan Steel Co (KSC) in IRAN.

## 2 METHODS AND MATERIALS

### Production and equipment

The typical production capacity of hot rolled plates for wide plate mills is up to 1.4 mtpy for single-stand plants and up to 2.0 mtpy for double-stand configuration.

Plates are produced through conventional and thermo-mechanical rolling with accelerated cooling.

In addition to the rolling and plate finishing lines, heat treatment facilities are provided for plate normalizing as well as for hardening and tempering.

### Rolling Line

In general the rolling area includes:

- Double ramp descaler box for primary scale removal;
- 4-high reversing roughing mill stand (*in case of double stand configuration*);
- 4-high reversing finishing mill stand;
- Direct quenching device;
- Accelerated cooling device;
- Hot plate leveler.

### Descaling unit

Slabs coming from the discharge area of the reheat furnace proceed to the 4-high reversing plate mill through a high pressure (220 bar) descaling box.

The main purpose of the descaling unit is the removal of primary scale due to reheating process in the furnace. High pressure water sprays are used to this purpose. To allow a constant impact pressure on the slab surface a screw jack system is used to adapt the top header position to the entry thickness of the slab.

### 4-high rolling mill

One or two rolling stands are provided, based on the total production the plants aims to.

In the two-stand configurations the first stand works as roughing mill and the second stand as finishing mill. If one stand only is provided, the complete rolling process from entry thickness/width to final thickness/width is achieved within the same mill.

In either the cases the rolling mills are reversing type and the rolling line is design in such a way that the stand(s) is(are) completely disengaged from the upstream and downstream facilities. The distances between the equipment are, thus, carefully studied based on the rolling process requirements.

The 4-high stand is the used configuration, and features the most modern design concepts and technological advances available to the industry today.

For housing manufacturing three different technologies are available:

- 1) Casting the complete housing;
- 2) Welding of four pieces in workshop
- 3) Bolting of four pieces on site.

According to the requirement of the customer, mill size, delivery condition, Danieli is in the position to supply the housing using the most suitable technology for the project.

### **Accelerated cooling device**

At the exit side of the rolling stand are positioned the cooling banks.

The plate temperature and the cooling rate under cooling system are defined to assure the proper metallurgic characteristics of the end products.

Two cooling strategy are available: plate can pass through the cooling section in one pass, or plate oscillates under the cooling zone. The use of the cooling device in combination with thermomechanical rolling also permits to obtain higher strength steel plates to be provided with simpler chemical composition and/or with increased mechanical properties. The cooling process is automatically controlled on the basis of mathematical models, which determine the cooling rates and cooling patterns. Temperature inputs, to control this system, are taken from the pyrometers, and are transferred via computer to determine the actual plate temperature at the exit of the rolling stand and the number of headers and sprays required to achieve the desired cooling temperature.

### **Direct quenching**

In those cases where high cooling rates are required by the process, a dedicated section of cooling system is activated. This section typically includes six benches of multiple-nozzle top and bottom headers, spraying on the plate surface pressurized water (up to 5 bar).

This system allows a fast cooling of the material that results in a treatment known as direct quenching.

### **Hot plate levelers**

The hot leveler is designed for treating hot plates coming from the rolling line.

The leveler can correct any deviation from the flat or straight shape of the plate through alternating plastic bending performed by the leveling rolls and ensures excellent flatness and minimum residual stresses of the leveled plate. A plastic penetration of 60-80 % is normally achieved. The leveling range goes from 3 mm to 100 mm in thickness and exceeds 5,000 mm in width.

The number, diameter and spacing of the rolls depend on thickness and yield strength. The top roll set is actuated via four servo-controlled hydraulic cylinders to generate the gap (vertical positioning), the tilting (operator side-drive side tilting), and

the skewing (entry-exit tilting). Overload protection is provided by a quick opening function.

The deflection of the machine is compensated by a roll bending system that is also able to correct shape defects of the plate. Different types of bending can be provided, depending on the product mix to be leveled:

- V-type bending, applied to the split top frame by a hydraulic cylinder.
- Individual roll bending, applied to top rolls only, or to top and bottom rolls.
- Tilting beam bending, applied to bottom rolls.

Via the tilting and skewing function it is possible to differentiate the plate deformation within its section from the entry to the exit side and across the width of the plate. Automation models are used for pre-setting the machine and for in-bar dynamic control. For the most demanding applications, closed loop control with a flatness gauge can be provided. In-house developed mathematical model is used to predict the load and torque distribution for a defined plastic fraction and plate geometry, steel grade, and temperature.

### **Cooling beds**

Between the rolling area and the finishing area the plates undergo an air-cooling process achieved by keeping them laying on the cooling beds. One or more cooling beds are typically present.

The selection is made between two designs: walking beam-type and disc-type.

When more than one cooling bed is installed a good option is having one disc-type cooling bed specialised for light gauges and a walking beam-type specialised for heavy gauges.

Although the cooling process is quite a simple and static one, maximum precaution is taken in the cooling bed design in order to avoid skid mark effects which will result in out-of-flatness in the cold plate.

### **Plate finishing line**

The final plate dimensions are obtained in the plate shearing line installed downstream the cooling beds.

The shearing line is treating cold plates and is provided to give to the final plates the proper geometry before they are delivered to the shipping yards. For this purpose, side trimming and dividing shears are typically present. In some cases a slitting shear is also installed to work in conjunction with the rocking side trimmer.

### **Marking and piling**

Once the final geometry is achieved the plates are marked and plate piles are created through plate pilers.

### **Cold leveler**

To complete the plate finishing line a cold plate leveler is installed. The cold leveler can be either installed directly at the end of the shearing line or off-line in a separate bay. The thickness range covered by the cold leveler is normally from 3 to 30 mm. The purpose of the cold leveler is to remove residual internal stresses which, in the case of light gauges, can result in flatness problems. The functions envisaged in the cold leveler are same as the hot leveler, whereas smaller roll diameters are normally used due to the lower plate thickness.

### ***Danieli Leveler special features and description***

The machine is conceived with a roll cassette design, so that roll cassettes are interchangeable for different application.

According to the application the cassette that is split in top e bottom part has different characteristics and the main parameters to be considered as the basic of design are:

- Number of top and bottom leveling rolls;
- Diameter of leveling rolls;
- Roll spacing;
- Back up roll diameter and arrangements;
- Roll material and cooling system.

The choice of these parameters depends on thickness and yield strength.

For very wide product range, design solutions with a twin cassette are also possible.

The performances are influenced not only by the cassette configuration by also by the way to control the cassette positioning, deformation and drive system of the machine.

Special features have been developed by Danieli to optimize the leveler capability.

First of all the cassette positioning control is of primary importance:

The top roll set is actuated via four servo- controlled hydraulic cylinders to generate the gap vertical positioning for the cassette tilting (operator side-drive side tilting) and the skewing (entry – exit tilting).

Tilting and skewing positioning is the core of the machine to achieve the performance and the hydraulic cylinder with multiplier high pressure system and related position and pressure transducer are designed to reach the best response time a positioning accuracy. Via the tilting and the skewing function it is possible to differentiate the plate deformation within its section from the entry side to the exit side and across the width of the plate. Automation models are used for pre-setting the machine and for in-bar dynamic control. For the most demanding applications, closed loop control with flatness gauge can be provided. In house developed mathematical model is used to predict the load and torque distribution, for a defined plastic fraction and plate geometry, steel grade and temperature.

Beside this, an overload machine protection is provided by a quick opening function.

Another important point is the control of the deflection of the machine during leveling process It must be fully compensated by a roll bending system that is also able to correct shape defects of the plate. For bending system different kind of design can be provided, depending on the product mix to be leveled:

V-type bending applied to the split top frame by and hydraulic cylinder;

Individual or full roll bending applied ton top rolls only or to both top and bottom rolls;

Tilting beam bending, applied to bottom rolls.

With individual adjustment or with titling beams it is possible to differentiate the bending action from entry to exit side and across the plate width.

Special attention must be considered for drive system.

Each leveling roll is driven via a dedicated spindle. For normal application the spindles are connected to a pinion stand where the torque coming from one motor, through a gearbox is distributed to a maximum of six rolls. Special safety coupling are provided for spindle overload protection. Two or three motors are normally provided to drive the whole set of rolls.

Recent customer requirement in terms of special grades and high torque demand, typical of leveler installed on the heat treatment line for high strength steel material, has pushed to the limit the selection of main driving spindles and requires more sophisticated solution for the drive line by installing a single driven roll design.

Based on this extreme requirements Danieli has developed and patented a MULTIMOTOR system. In these cases leveling rolls are driven by independent motors to guarantee the possibility of adjusting speed as well as the torque supplied to each single roll, thereby optimizing the leveling process and protecting the mechanical component.

The driving group is studied as to have top reliable and lasting components and even the space is compacted.

Each roll is driven by a cinematic chain formed by:

- Electrical motor
- Extended gear coupling equipped with locking brake and safety joint for overload protection;
- Compact planetary reduction group, with parallel axes and helicoids tothing cylindrical gears pre-reduction.
- Distribution group which, on one side supports the planetary reducers, on the other allows the grouping of exit shafts through idle cylindrical gears disaxling groups in order to limit the working angle of spindles;
- Gear type spindle.

The advantage of this system is the possibility to use a very compact drive system with independent roll speed control with reduced working angle allowing the utilization of gear type spindle with superior torque transmission that is essential for machine for high quality and high strength steel.

### **3 CONCLUSION**

There is a strong signal from the market that demand of this kind of steel will increase in near future.

Mainly because the steel produced at plate mills are being used to attend the shipbuilding, pipelines, oil & gas markets, which are prosperous markets in terms of consumption and weight.

The consolidation and continuation of this kind of markets in Brasil, and with local production must push the Brazilian steel plants to invest in this kind of equipment to avoid the need of importation of this product from worldwide, actually only one steel plant in Brasil is able to supply this kind of product and we know that other Brazilian steel plant will also becomes a player in this market in near future, in the next 3 years only 2 Brazilian steel plants will be able to supply this kind of product to the market.

Looking for the potential future, especially in Brazil, we believe that the acknowledgement on this kind of technology becomes useful and interesting to share in this seminar.