4.3m wide plate mill at Jiang Yin Xing Cheng Special Steel Works

The 4.3m wide mill at Jiang Yin Xin Cheng Special Steel Works Co Ltd has been designed to produce an extensive range of plates, both in terms of steel grade and thickness, by making extensive use of ingots for thick plate production and thermo-mechanical processing for high strength.

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Danieli Wean United

In 2008 Danieli received an order from Jiang Yin Xin Cheng Special Steel Works Co Ltd (JYXC) for the supply of a new wide plate mill to be installed on a greenfield site near their existing bar mill facilities. It was commissioned in 2011. Production capacity is 1.65Mt/yr of discrete plates and was designed for the production of a wide range of steel grades: structural, high strength, low alloy (HSLA), anti-corrosion, bridge, offshore, pipeline, shipbuilding, mechanical construction, vessel and boiler. Thermo-mechanical rolled products, some for further heat treatment in the quench and tempering line, account for 78% of the produced mix.

Of the specific features, one is the capability of the mill to roll both slabs up to 350mm thick and ingots up to 1,000mm thick, for the production of high-quality plates in the thickness range 6-300mm thick and 900-4,100mm wide. The plant can handle up to 300,000t/yr of ingots, and it is particularly suitable for the thickest plates for shipbuilding, HSLA, mechanical construction, boiler and container steels.

The main equipment includes three slab reheating furnaces, a battery of soaking pits for ingots, high pressure water descaler, vertical edger, reversing roughing stand, reversing finishing stand, pre-leveller, direct quenching and accelerated cooling units, hot plate leveller, cooling beds, crop shear, double sided trimming shear and dividing shear.

A number of the Danieli group’s organisations were involved in the project:
- Danieli Wean United (DWU) for the hot technological area and design and manufacture of the core equipment of the main machine.
- Danieli Metallurgical Equipment (DME) located in Beijing, and Danieli Changshu (DCS) located close to Shanghai and plant site for the finishing and shearing equipment in terms of design and local manufacturing.
- Danieli Automation (DA) for the complete Level 1 and Level 2 automation system for the rolling area and the control of individual equipment for the finishing and shearing line.

The validity of Danieli’s strategy in creating two strong local companies in China under the direct control of Danieli headquarters has been confirmed, with optimum results reached in terms of quality and customer satisfaction. One of the main aspects of this was the rapid response to customer requests during project execution.

STEEL GRADE SUPPLY DEFINITIONS

As-rolled AR
Controlled rolled CR
Thermo-mechanical controlled processing TMCP
Normalised N
Quench and tempered QT

KEY FEATURES

Ingots and slabs There are three ingot sizes:

\[
\frac{1,770 \times 850}{1,665 \times 700} \times 2,630 - 2,830 \text{ (mm)} \sim 22 \text{ t}
\]

\[
\frac{2,017 \times 880}{1,968 \times 730} \times 2,800 - 2,980 \text{ (mm)} \sim 29 \text{ t}
\]

\[
\frac{2,140 \times 960}{2,090 \times 780} \times 3,015 \text{ (mm)} \sim 35 \text{ t}
\]

Slab sizes are:
- Thickness: 150-350mm
- Width: 1,200-2,600mm
- Length: 1,500-4,100mm
- Max. slab weight: 22.5 t
Discrete plate size range
Thickness: 6-300mm
Width: 900-4,100mm
Length: 3,000-25,000mm

ROLLING MILL EQUIPMENT

Rolling stands

Both 4-high rolling stands (see Figure 1) have a 9,000t rolling force and are equipped with hydraulic automatic gauge control (HAGC), electromechanical screwdown and load cells. High pressure water scalers are installed on both rolling stands at entry and exit side in order to achieve optimal surface quality. Each mill is directly driven by 2 AC motors: 2 x 7,000kW at 35rpm on the rougher and 2 x 9,000kW at 50rpm on the finisher. The finishing mill also includes double jack heavy bending and hydraulic work roll shifting for the complete control of plate geometrical characteristics.

Pre leveller and hot leveller
These are of hydraulic, 4-high, 9-roll design with interchangeable cassettes. Each leveller is driven by 2 x 750kW AC motors and has a levelling capability in excess of 3,360t. Roll pass design is

Fig 1 4-high rolling stands

Fig 2 Cooling section

Fig 3 Finishing line

Reheating

The incoming slabs from the slab yard are charged by cranes on a charging bench and reheated through three walking beam furnaces. Each furnace is equipped with a charging and discharging device. A mathematical model is used to control the burners to achieve the optimum reheating curve for each steel grade. The ingots are heated in three pit type furnaces and charged and discharged by a crane.

At the exit-side of the furnace, the slabs proceed to the 4-high reversing plate mill through a high pressure descaling box.

Descaler unit
This removes primary scale using high pressure water jets. To allow 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. Lateral sprays are used to descale the ingot sides.

Vertical edger
The vertical edger is specifically designed to roll the ingots. Its rolling force is in excess of 700t, and each roll, 1,200mm high, is bottom driven by a 1,600kW AC motor. The electromechanical screw-in and the hydraulic automatic width control (HAWC) system carries out the force and position control, with each screw and each HAWC cylinder equipped with an internal position transducer. The design of this edger takes into consideration ease of maintenance and the visibility of the operator in front of the roughing stand. The total maximum reduction in width is 75mm. They are then tilted through 90° and rolled in 4-high stands as per slabs.

Fig 4 Cooling section
focused on the rolling of plates from 6 to 60mm thickness, but in flattening mode the range is extended to 100mm.

Cooling section The ExStream cooling section is designed to achieve plate cooling rates up to 80°C/s, necessary for such grades as API grade X100, hull and high strength structural steel such as FH40, Q550, Q690 and WelTen 950 (see Figure 2). It is separated into two zones for either DQ or AC. The DQ system consists of four, high pressure 5-bar headers placed on the top and bottom of the roller table and separated by pinch rolls. The cooling rate ranges from 80 to 3°C/s. The AC system consists of 16 U-Tube headers at the plate top and spray headers for the underside. The cooling rate ranges from 40 to 2°C/s. The plate temperature and the proper cooling rate under cooling system are defined to ensure the metallurgic characteristics of the end products.

Shearing and finishing line The shearing line is designed to side trim and cut to length plates up to 50mm thick. All shears are of the rocking type and guarantee optimal final dimension tolerances and superior edge quality. The finishing line (see Figure 3) also includes four cooling beds, ultrasonic inspection station, surface inspection beds, plate turning device, marking and stamping, plate piling and handling facilities.

Electrics and automation This includes all basic and technological Level 1 and Level 2 systems, along with state-of-the-art mathematical models for superior profile and flatness control, thus providing the customer with a highly integrated and optimised automation system that ensures accurate and reproducible results in terms of product quality and improved plant efficiency (see Figure 4). Along with standard plate production, the automation system is able to process ingot rolling, longitudinal plate rolling for special building and shipbuilding applications, and DQ and AC capabilities for API grades.

PRODUCTION RESULTS
Plant test data have confirmed results for the following:
- API X65 15mm and 25mm thick and up to 3,600mm wide
- API X70 15mm and 20mm thick and up to 3,200mm wide
- API X80 15mm and 25mm thick and up to 4,000mm wide

Figure 5 shows typical X65 and X80 microstructures from the thermo-mechanical process.

The API X80 plates have been cooled at up to 20°C/s in the ExStream cooling system, achieving mechanical properties as illustrated in Table 1. X100 properties are also illustrated.

HULL STRUCTURAL STEELS
Grade FH40 details are shown in Table 2. The steel grade delivery conditions are AR, CR, TMCP, N and QT.

The seaborne container transportation and the significant growth in the container carrier size requires thicker plate with high strength material and good resistance to corrosion, weldability and low temperature resistance at severe temperatures down to -60°C. For the high strength grade, TMPC with AC is used to obtain a fine grain microstructure, as illustrated in Figure 6.
FORMING PROCESSES

are low alloy grades (Q550) and some are precipitation strengthened grades (Q690). In these cases, the end rolling temperature will be ~800°C and pre-leveller and hot leveller are used to obtain good flatness and uniform cooling over the width at the end before the cooling beds. Typical results are shown in Tables 3-5.

At the time of writing, JYXC had developed the following steel grades:

- Pipeline steels
- Hull structural steels
- High strength structural steels
- Boiler and pressure vessel steels
- Special purpose steels

DEVELOPMENT OF NEW PRODUCTS & TECHNOLOGIES

Plans are in place for further product development:

- Boiler and pressure vessel steels for low temperature service: 16MnDR, 15MnNiDR and 09MnNiDR
- Abrasion resistant steel plates: Hardox 500, 550 and 600
- Pipeline steels with high deformation resistance: X80, X100 and X120

Also being developed is a new quenching technique for ASTM A514 extra-heavy gauge plates (>150mm) as used for racks in jack-up rigs.

CONCLUSIONS

Hot rolled plate is recognised as a very traditional and well-established product in the steel industry, however, new production strategies are being conceived in modern plate mills. Generally speaking, the main goal is to enhance the mechanical properties of the plates in such a way that thinner plates can be used, so saving on weight, transportation and welding time. Modern rolling strategies make use of DQ and AC systems to maximise potential benefits.

The Danieli Wean United, designed and built, 4,300m wide mill at Jiang Yin Xin Cheng Special Steel Works Co Ltd, demonstrates the capabilities of modern mills. MS

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