Engineering design highlights of high-efficiency slab casters relocated at Baosteel Zhanjiang

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Abstract. Baosteel Group decided in 2013 to relocate the main segment equipment of the 2 single-strand 2,300 mm slab casters which were shut down at its Luojing Plant to the Zhanjiang Plant and transform them into an upgraded two-strand slab caster. CISDI was contracted to supply the overall design and the main equipment packages. CISDI employed a couple of advanced technologies including online mould width adjustment, top-inserted dummy bar, dual strand tracking and casting at constant speeds to enhance the production capacity of the caster; for sake of Opex saving CISDI also optimized the arrangements of the independent mechanical maintenance shop, utilities of compact design, cooling water valve stations and hydraulic valve stations of compact designs, and open-air cooling water pump station, etc.

1. Introduction

The two single-strand 2,300 mm continuous slab casters at Baosteel Luojing which were completed and put into operation in 2007 and 2009 respectively were shut down in 2012. In 2013, Baosteel Group decided to relocate the main segment equipment of the two casters at its Luojing Plant to the Zhanjiang Plant, and transform them into a two-strand slab caster. Main technical data of the slab caster as transformed are shown in table 1. CISDI was contracted to supply the overall design and the main equipment packages. At present, the steel industry of China has been facing a severe overcapacity of common steel products. Meanwhile, the supply of upmarket products is relatively insufficient. In the current scenario when supply-side structural reforms are being continuously implemented nationwide, it will put any late-comers at a disadvantage, if a high-efficiency operation for new slab casters are designed with a differentiated and boutique product portfolio [1-5]. The relocation project was planned adjustment to transform the continuous casters into one caster that could perform high-efficiency, low-cost casting of high-quality products. In May 2013, the project was launched. After three years of engineering design, equipment demolition, transformation, installation and commissioning, the desired slab caster underwent the load test successfully in one go on May 15, 2016.

2. Technologies for high-efficiency operation

2.1. Online mould width adjustment
Provided the casting speed is stable, the most effective way to increase the capacity of a caster is to increase the number of continuous casting heats. However, in the traditional continuous casting production, when the slab width size is changed, the casting has to be interrupted in order to replace the mould, or the caster has to be shut down in order to allow mould width adjustment, then perform restranding, resume casting, which result in low production efficiency, high workload, and considerable metal loss.

Table 1. Main technical data of the 2,300 mm slab caster at Baosteel Zhanjiang.

| No. | Designation                | Unit   | Specification/Value                                      |
|-----|----------------------------|--------|---------------------------------------------------------|
| 1   | No. of strands             |        | 2-2                                                      |
| 2   | Caster design              |        | Vertical curved, with continuous bending, straightening  |
| 3   | Products                   |        | Line pipe steel, pressure vessel steel, structural steel, ship-building steel, steels for special purposes, etc. |
| 4   | Dummy bar insertion        | -      | Top-inserted                                             |
| 5   | Slab sizes                 | mm     | 200/230/250 × (1,200~2,300)                             |
| 6   | Production capacity         | tpa    | 2,750,000                                               |

After many years of R & D activities, CISDI has successfully developed the on-line mould width adjustment technology [6]. It allows quick adjustments to the mold widths even when casting at full speed, meets the requirements for the production of slabs with different width sizes in an uninterrupted way, thus increases the metal yield and operating rate, and improve the caster productivity.

CISDI has conducted in-depth studies on the mechanism of strain and air gap generation in the strand shell during the mould width adjustment process and established an online mould width adjustment process model with wedge slab envelop as a core, paving the way theoretically for the performance of quick, safe and stable online width adjustments. On this basis CISDI has developed high-precision mould width adjustment device successfully, incorporating the driving device for width adjustment with high control accuracy and self-locking capability, the soft clamping device on the wide face which can ensure the safety of casting operation and the mould body which meets the width adjustment requirements. The width adjustment is performed with electric servo drives. The two narrow faces of the mould are driven by the four sets of worm servo motor transmissions to move in the same or opposite direction at the same speed so as to achieve the width and taper as required by the width adjustment operation [7]. Featuring width adjustment with high precision and good stability, etc., it can effectively suppress the narrow face width and taper drift during the production process.

The 2,300 mm slab caster at Baosteel Zhanjiang equipped with the online mould width adjustment technology developed by CISDI has been running stably since it was put into production. It performs width adjustments more than 2 times a day on average, with width and taper adjustment within ±0.2 mm.

2.2. Two-strand tracking

The production capacity of a caster can be effectively increased by reducing the restranding time, provided that the casting speed is stable and the number of continuous casting heats is fixed.

If a bottom-inserted dummy bar is used, it cannot be inserted for the casting of the next heat before the last strand is transported out of the dummy bar storage area, which means the restranding time is as long as 80 minutes or so.

Use of a top-inserted dummy bar is an effective measure to reduce the restranding time. When the last strand comes out of the segment, the dummy bar can be inserted for casting of the next heat. And the restranding time is shortened to about 50 minutes.

A top-inserted dummy bar and two-strand tracking technology, as shown in figure 1 have been applied to the 2,300 mm slab caster at Baosteel Zhanjiang. They have enabled the slab caster to cast the last strand and insert the dummy bar at the same time: Once the last strand leaves the segment 3,
the dummy bar can immediately be inserted for casting of the next heat [8], further reducing the restranding time to about 35 minutes. So, the slab caster is more flexible in production and its production capacity can be increased effectively.

![Figure 1. Sketch of strand dual-tracking.](image)

### 2.3. Casting at constant speeds
In the traditional continuous casting production, the continuously cast steel grades, section sizes frequently change due to the restrictions imposed by the composition, temperature of the molten steel and the tempo of the molten steel supply from the upstream (steelmaking) process. It frequently changes also due to the influence of the changes in the slab section sizes and the demand for steel grades by the downstream (rolling mill) process. In order to allow the slab caster to keep up with the tempo of the basic oxygen furnace(s), the casting speed often has to fluctuate greatly, making the casting tempo and the slab quality cannot be stable.

Based on the process of hot rolling with constant width and edge reduction, the continuous slab caster at Baosteel Zhanjiang has been designed to produce slabs of a few typical widths. The hot rolling mill can perform heavy edge reduction to meet the requirements for all the width sizes, so the continuous caster does not need to frequently change the slab widths, allowing for operation with a larger number of continuous casting heats for a single slab width size. Moreover, sufficient secondary metallurgy facilities have been installed upstream to provide qualified molten steel with stable composition and temperature of molten steel at the tempo required by the slab caster, truly conducive to realizing production scheduling with continuous casting as the core. Continuous casting is performed at constant speeds. Stable molten steel flow field distribution in the tundish, stable mould level and stable equipment status [9] have contributed to the high-efficiency operation of the slab caster and high-quality slabs by the slab caster.

### 3. Technologies for low-cost operation

#### 3.1. Independent mechanical maintenance shop and utilities of compact design
In the traditional design, the mechanical maintenance facilities for continuous casters are arranged in the main building of the continuous casting plant, and the utilities such as high-voltage electrical rooms, water treatment plant, and air compressor stations have to be placed in an area far away from the continuous caster itself. However, at Baosteel Zhanjiang, all the mechanical maintenance facilities for the continuous caster have been concentrated, and an independent light-duty Mechanical Maintenance Center has been constructed outside the main building of the Continuous Casting Plant [10]. The capital expenditure (Capex) and operating expenditure (Opex) of the mechanical maintenance facilities are reduced, and on the other hand, as the mechanical maintenance facilities are not in the main building, the spiral-flow settling tank and other water treatment equipment, the secondary cooling zone air compressor station and the high-voltage electrical rooms, etc. can be close to the continuous caster itself. Arrangements like this have not only reduced the length of pipes and cables, but also increased the response speed and sensitivity of the continuous caster itself to the changes in the demand for energy & media, thus helpful to reduce the Capex, Opex and improve the slab quality as well.

#### 3.2. Cooling water valve stations and hydraulic valve stations of compact design
For a slab caster of the traditional design, the cooling water valve stations and the hydraulic valve
stations are respectively arranged on multiple-floor platforms including pipe tunnels. In the Continuous Casting Plant at Baosteel Zhanjiang all the cooling water valve stations have been installed on the ground floor on both sides of the slab caster, and all the hydraulic valve stations have been arranged on the second floor on both sides of the slab caster. This has not only greatly reduced the length of the pipes, shortened the distance between the regulating valves to the end-user, but also increased the response speed and sensitivity of the equipment to the changes in the demand for cooling water and hydraulic media, thus helpful to reduce the Capex, Opex and improve the slab quality as well.

3.3. Open-air cooling water pump houses
The cooling water pump station for continuous casters in the traditional design are mainly installed indoors. However, the cooling water pump station for the slab caster at Baosteel Zhanjiang all have been installed open air. The production practice in the past two years has proved the success in the open-air arrangement of the pump station. It has not only reduced the Capex, but also decreased the Opex of the ventilation and lighting facilities for the plant building.

4. Conclusions
The 2,300 mm slab caster at Baosteel Zhanjiang, equipped with the technologies of online mould width adjustment, top-inserted dummy bar, two-strand tracking and casting at constant speeds, etc. has achieved the desired high-efficiency casting operation. The production of one year since its start-up has proven that the production capacity of the two-strand slab caster reaches 2.8 million tonnes of slabs per annum, with qualified slabs accounting for over 99%.

The arrangements of independent mechanical maintenance shop, utilities of compact design, cooling water valve stations and hydraulic valve stations of compact design, and open-air cooling pump station have benefited the slab caster by reducing production cost. The production of one year since its start-up has proven that the energy consumption by the continuous casting process at Baosteel Zhanjiang is about 30% lower if compared with a similar continuous caster.

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