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DEVELOPMENT AND APPLICATION OF NEW GENERATION NO-BELL TOP CHARGING SYSTEM FOR LARGE-SCALE BLAST FURNACE[1]

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Abstract

In recent decades, blast furnace has been developing towards large-scale trend with top pressure and top temperature increasing. With varies of intensified smelting method, the top charging system is challenged by more high-standard and more strict demands. CISDI were constantly striving to develop a new no-bell top charging system, which features high control accuracy, high reliability, good temperature adaptability and convenient maintenance, is well satisfied for large blast furnace manipulation demands.

Key words: No-bell top; Hydraulic transmission distributor; Top testing.

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1 INTRODUCTION

In the early 1970s, the blast furnace no-bell top charging technology emerged. The system is flexible in distributing and good performance in sealing, even less equipment investment, low running costs, easy maintenance, much more efficient and environmentally friendly, etc. It is gradually adopted by the majority of the world blast furnaces(especially large and medium-sized blast furnace).Until now，No-bell top has become the mainstream technology of the blast furnace top charging system[1,2].
As an international engineering company, CISDI has undertaken more than 160 blast furnaces designing and overhauling work with bell or no-bell top, and even a number of top revamping projects from bell top into no-bell top.
In 1989, the no-bell top equipment designed by CISDI have been applied in Panzhihua steel No.4 BF(1350m^3) and Chongqing steel No.5 BF(1200m^3) in China. In recent years, CISDI has been closely following the large-scale development trend of blast furnace technology[3], with continuous innovation to develop a new generation of large no-bell top system technology which has been applied into engineering projects and achieved good effects.

2 DEVELOPMENT

2.1 Top Feature

For a long time, CISDI has always been committing to the development of no-bell top system technology. After nearly three decades of innovative researching, CISDI owns a full set no-bell top patents and know-how with independent intellectual property rights. CISDI can undertake various levels of new building and revamping no-bell top projects, as well as design and equipment supply of various forms of top charging equipment and top hydraulic, lubrication, cooling, electrical control system, etc.
CISDI's No-bell top equipment system features:

- Layout compact, suitable for various levels of blast furnace top new building and revamping.
- Uniform distribution and less segregation.
- High precision in device control.
- Able to withstand high top temperature.
- Simple structure, light in weight, easy for maintenance.
- Less investment.

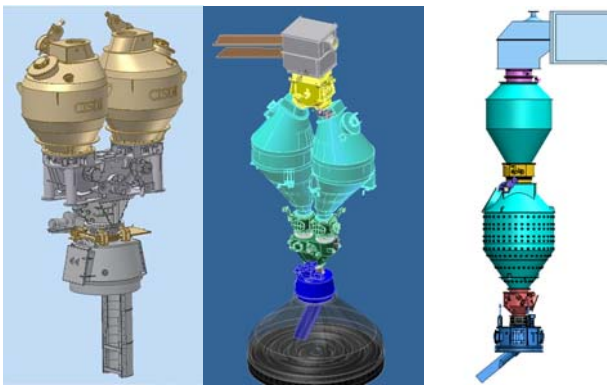

Figure 1. CISDI's no-bell top products range.

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2.2 Technology Development

In recent years, CISDI has developed a whole new generation of large scale no-bell top technology and equipment with independent property rights, the main technical indicators reached to the international first-class level.

2.2.1 Distributor

In the 1980's, the hydraulic distributor which based on the vertical level dynamic bearing structure was invented by Quansong Seng,etc in China[4]. Nearly 30 years, hundreds of this kind of distributor have been applied on small scale blast furnaces in China, but none in large-scale blast furnace. In recent years, CISDI cooperated with Baosteel and Qinye to carry out lots of revolutionary improvements and innovations about hydraulic system, water cooling structure, sealing structure etc based on the original distributor system. Finally research and develop a new generation of high precision and reliability BCQ distributor which are suitable for large-scale blast furnace successfully. And the key features of BCQ distributor are:

- Chute tilt action driven by hydraulic cylinders, rotation and tilting acts are separate.
- To use industrial water (not soft water) to cool directly, with high cooling efficiency.
- Adjustable chute tilt speed (0-3 °/s) is beneficial to shorten the spiral length when switches, to improve distributing uniformity.
- Adaptable for high top temperature, uneasy to be stuck, be able to run normally for a long time under the top temperature of 500 °C.
- Simple structure, large interior space, convenient for repairing and maintenance.
- Easy erection and dismantlement for distribution chute.

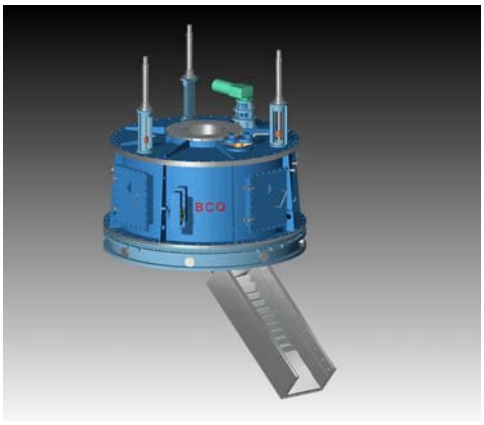

Figure 2. BCQ distributor.

Figure 3. Interior structure of BCQ distributor.

In order to improve the control precision and meet requirements of the large-scale blast furnace, CISDI has invented a unique hydraulic composite controlling system for distributor. In this controlling system, each driving cylinder of distributor configured one proportional valve separately, which instead the original mechanical synchronization method with hydraulic and electrical synchronization method. By this way to solve the synchronization problem of the original structure and improve the accuracy of the chute tilt angle control, while driving more stable and reliable.

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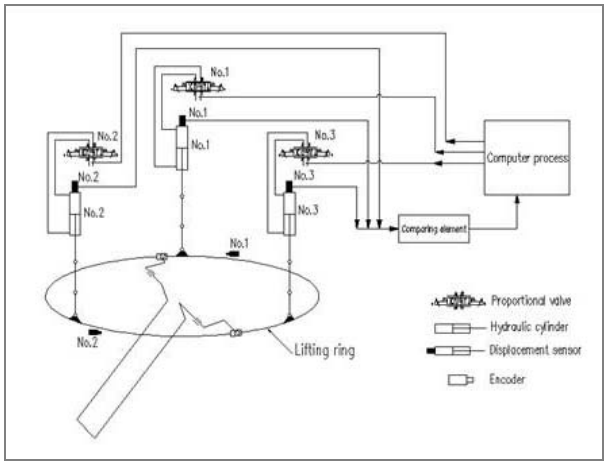

Figure 4. Principle of hydraulic composite synchronization control.

2.2.2 Material control gate

CISDI has developed a new generation material control valve for large-scale blast furnace, which is driven by hydraulic cylinders and transmitted by parallel shafts and connecting rods. It features simple structure and easy to manufacture, maintenance, and also accurate material flow control, γ-angle controlling accuracy up to ± 0.1°.

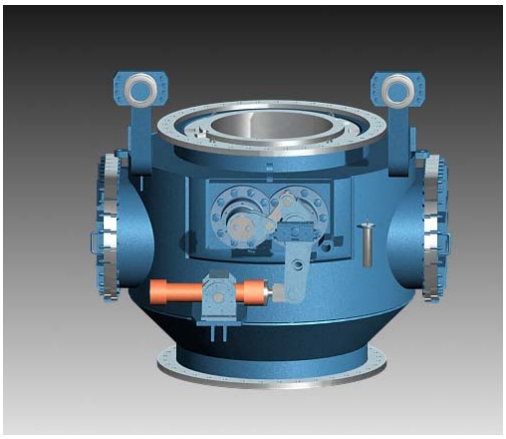

Figure 5. Material control gate.

2.2.3 Top Control System and Distribution Model

CISDI has developed top charging system and distribution model which are integrated with CISDI blast furnace expert system. By this system, we can track the trajectory of materials dynamically and monitor materials on line and simulate the surface deformation as well as check the ore coke ratio on line. These ways could give full play to the blast furnace upper part regulation, ensure the reasonable distribution structure effectively, supply good air permeability, materials decreased stability, improve blast furnace smelting conditions, and reduce the coke rate. This can provide high-quality, low consumption, longevity, stability in production ways.

2.2.4 Other Top Equipment

CISDI has also developed other types of proprietary equipment and technology for the Serial and Parallel hopper top system. During the design process, CISDI focus on researching about control accuracy, long campaign, reliability of equipment, especially applying a variety of technique ways and know-how to prevent distribution segregation and achieves better results.

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3 TOP TEST AND APPLICATIONS

3.1 Top 1:1 Test

For proving no-bell top equipment, a 1:1 test platform which meets the needs of 1000m^3 to 6000m^3 blast furnace top tests is set up. This test platform integrates the key equipment of top system including hopper (100m^3), material control gate, distributor, distribution chute, as well as charging, weighing, hydraulic, electrical control, lubrication, cooling, heating, dust, monitoring and other related systems.

Figure 6. Top System test platform.

The top system tests were carried out on this 1:1 platform, including:

- top cold state function test;
- top hot state test;
- top distributing test;
- distributor synchronization control test.

These tests indicate that top equipment runs well and can achieve multi-loop, single-loop, sector, spiral and pot distribution, the average tilting speed is 2-3°/s. The hydraulic composite synchronization system developed for distributor plays successfully with the high titling angle control accuracy of ±0.1°.

During the top hot state test, the heating device is used to produce high-temperature air to model the actual situation in blast furnace throat. The test results show that only 10~15t/h cooling water is able to meet with normal working conditions. Also the distributor could ensure normal operation, indicators and control accuracy as under cold state for working at the top temperature of 500°C. Even at 800°C, the distributor can still keep normal work for a long period of time, no jamming and other abnormal phenomena occur, that certificates good adaptability for high top temperature. In addition, without cooing water, distributor is able to maintain normal production more than one hour.

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Figure 7. Hot test for distributor.

During distributing test，the MCG curve, material trajectory under different tilting angle, surface shape, particle distribution, etc. have been tested, which will supply valuable references for large-scale blast furnace operation. The test platform with the parallel hopper and the testing furnace throat diameter is 11.3m, due to advantageous of top device system anti-segregation design, the actual difference of the distribution radius is only less than 200mm.

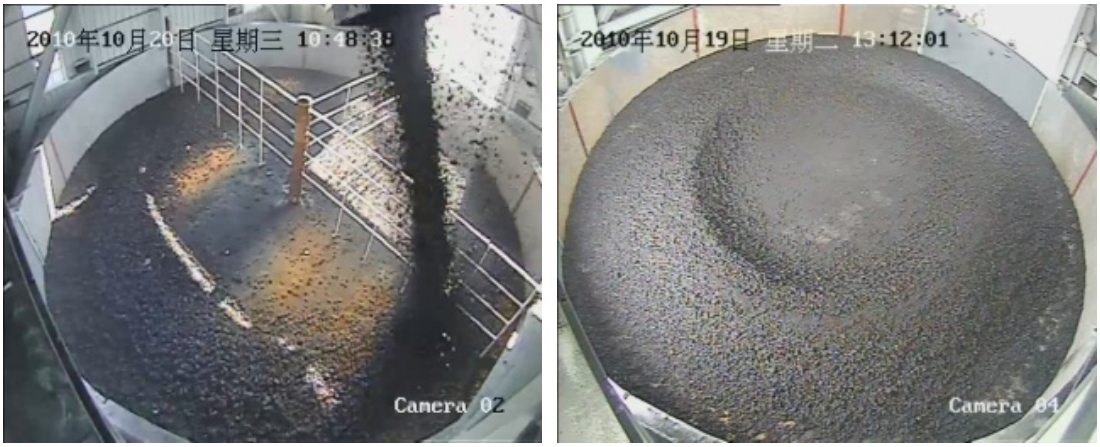

Figure 8. Distribution test and results.

3.2 Engineering Applications

CISDI large-scale no-bell top equipment system has been supplied in Baosteel No.1 BF (3rd generation, 4966m^3, 2009) and Shuicheng steel No.4 BF (2500m^3,2011) successfully. In 2011, CISDI and Qinye cooperated to won the bid in POCSO Indonesia BF project (3800m^3).

Baosteel No.1 BF (1st and 2nd generation) top system used bell top, in the end of 2008 the BF quick overhaul finished, and the project cycle was only 78 days. After the overhaul, the blast furnace capacity expanded from 4063m^3 to 4966m^3 which is the first 5000m^3 level blast furnace in China.

Baosteel No.1 BF (3rd generation) adopted CISDI new generation parallel hopper no-bell top charging equipment which were all manufactured in China, and CISDI was responsible for independent integration and technical support for total top system.

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Figure 9. Top system(3rd generation) of Baosteel No.1 BF.

In February 15 2009, Baosteel No.1 BF (3rd generation) restarted production. After that, the BF condition is stable and production increased, the operating parameters were significantly improved, the average utilization factor of BF increased by nearly 10% and daily output amount exceeded 11,500 tons. In recent years, with the BF coke quality decrease and the productivity increases, the BF fuel ratio is no increase but even decreased, the average gas utilization is also maintained at a high level.

More than three years, CISDI's new generation parallel hopper top charging equipment applied on Baosteel No.1 BF operated well. The system has low failure rate, equipment service life extends and top system maintenance costs significantly reduce. Because of reasonable top system structure layout and device structure design, this top system achieves quick and easy equipment replacement, such as replacement time of both material control gate and lower valve box is less than 6 hours, distribution chute replacement time is less than 4 hours. That brings great effectively convenience to blast furnace top equipment operation and maintenance which is beneficial to reduce the blast furnace shut-down time.

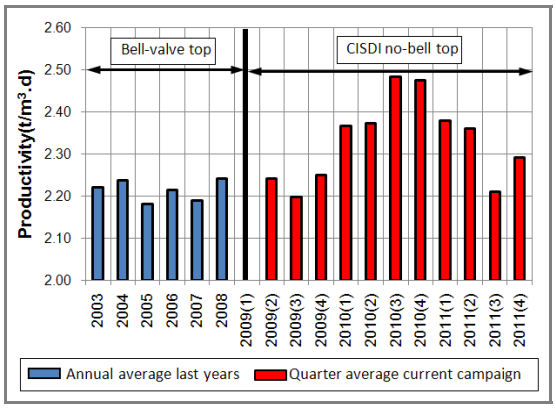

Figure 10. Average productivity.

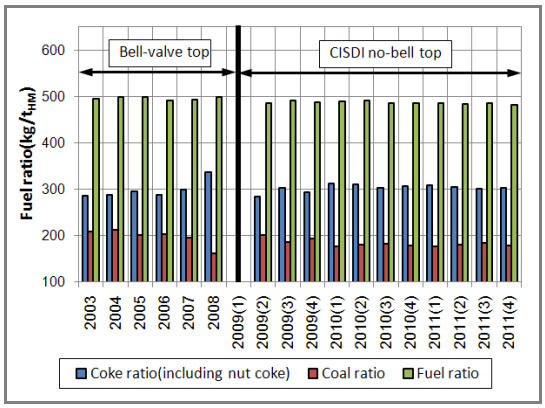

Figure 11. Average fuel ratio.

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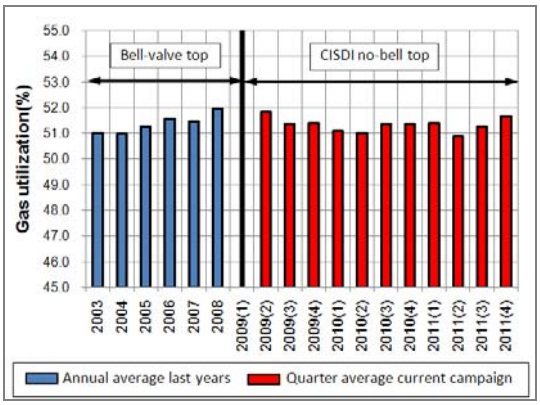

Figure 12. Average gas utilization.

4 CONCLUSION

With more than 160 blast furnaces design and overhaul experience, as well as more than 20 years' no-bell top design and research history, CISDI developed the 'state of art' no-bell top technology and products which suitable for the large-scale blast furnaces. After 1:1 top test and engineering application verification, CISDI's large-scale blast furnace no-bell top system can provide with advanced technology, more reliable performance, more convenient operation and maintenance, the main technology indicators has reached international advanced level, some key indicators (as α angel control precision, control response property, high temperature of adaptability, etc.) especially has unique advantage compared to other similar products, it provides customers with a new and worthy to be trusted of no-bell top product selection.

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