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Application of Automation and Intellectualization Technology in Steelmaking Plant

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Abstract: Steelmaking plant of Fujian San Gang min Guang Co., Ltd. is keeping pace with the trend of the times. Under the new situation that the labor cost is rising day by day . Constantly introducing intelligent technology to improve the level of automation operation and reducing labor intensity of staff and workers. Especially under the support of MES information system. Advanced and practical technology is adopted in converter, refining and continuous casting process. In recent years, production management and control, energy management and control , material tracking, cost control and equipment operation and maintenance and reducing personnel to new achievements in reducing personnel.

Keywords: Intellectual technology; Automtic level; Converter; continuous casting; Refining

Introduction

With the rise of the "Industry 4.0" trend internationally, the steelmaking plant of Fujian Sansteel Minguang Co., Ltd. keeps up with the trend of technology, continuously introduces intelligent technology, improves automation level, and makes positive progress in production planning, quality control, energy management, material preparation, cost control, and equipment operation and maintenance [1].

1 The role of intelligent technology in steelmaking process

With the advancement of automation basic detection technology, such as the application of furnace lining thickness gauge, oxygen analyzer, continuous casting inverted taper measuring instrument, roller spacing measuring instrument, etc., the control ability of converter and continuous casting process has been effectively improved [2]. In addition, with the development of programmable controller technology, fuzzy logic control technology, intelligent control technology, industrial network technology, expert systems, computer-aided production technology, etc., the level of intelligence in steelmaking has also been promoted. The core of "intelligence" in steelmaking is the comprehensive application of operations research, expert systems, and process simulation technologies, under the premise of improving basic automation, to coordinate the operations of various processes on the production line, and to carry out full line logistics tracking, quality tracking control, cost online control, equipment prediction and maintenance. The specific technologies include the static model, dynamic model, blowing automation model, main raw material calculation model, alloy model, etc. of the converter. Continuous casting includes automatic pouring, automatic addition of protective slag, etc. Currently, the sulfur content in the molten iron of Minguang Iron and Steel Co., Ltd. is 0.020%~0.040%, which can meet the requirements of variety production. Therefore, the pretreatment process of molten iron is basically not put into use [3].

2 Automatic control functions and key technologies of converter

2.1 Static and dynamic model control technology for converter smelting

The automation control technology of converter steelmak-

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ing is based on the weight and temperature of the steel type and molten iron [4]. Before the converter is mixed with iron, the secondary computer analyzes the static data of the entire process, such as the oxygen gun blowing height, flux addition amount, oxygen blowing amount, and bottom blowing amount. At the same time, the composition and temperature of the molten steel are detected in the later stage of blowing, and the dynamic model adjustment data is analyzed through the secondary computer system to achieve automatic control of steelmaking, Ensure the ultimate goal is achieved.

2.2 Automatic control of oxygen flow rate in converter oxygen gun

During smelting, a set of oxygen flow rate models that vary with smelting time are analyzed and calculated based on the characteristics of the composition changes of the generated flue gas [5]. The oxygen flow rate in the oxygen gun is automatically controlled in stages according to the model during smelting, and dual PID control is applied to the oxygen flow rate to improve the stability of oxygen control. Currently, the flow rate can be controlled within ± 500m^3/h of the set value.

2.3 Automatic feeding system for converter

The computer can automatically perform vibration, batching, and feeding operations into the furnace based on the feeding model, completing the feeding and slagging of a furnace of steel, achieving automatic feeding control during the converter smelting process, which is conducive to stable production and smelting, and facilitating the establishment of smelting control models under different conditions [6]. The feeding system will automatically feed according to the oxygen step, and the upper and lower silos will be interlocked to ensure that there is no situation where the material weight is inaccurate due to the simultaneous opening of the upper and lower silos. At present, the automatic feeding system is being put into routine use in the converter, and each model has basically met production needs.

2.4 Automatic control of bottom argon blowing in converter

The automatic control of bottom argon blowing in the converter is fully automatic. After establishing the model and confirming the same steel grade, no operation is required [7]. The system will automatically perform phased fully automatic control based on parameters such as smelting oxygen supply and converter inclination angle. Establish an oxygen step model based on the oxygen supply in the smelting process. The supply of argon or nitrogen to the bottom blowing pipe is determined by the set values in the model table, and the valve automatically switches. The main screen of the upper computer displays lights indicating faults in argon, nitrogen, and gas supply.

2.5 Automatic slag detection during converter steelmaking

The automatic slag detection device for converter steelmaking is composed of a camera, an industrial computer, etc., which realizes automatic slag blocking control for converter steelmaking, reduces slag amount, and improves steel quality.

2.6 Automatic control of argon blowing at the argon station after the furnace

A model table is established based on the position of the ladle and the inclination angle of the converter, and the argon blowing flow rate of the ladle is supplied in stages according to the model. The automatic control of the argon station after the converter further realizes the direction of unmanned operation [8].

2.7 Fully automatic control technology for dry dust removal

The automatic control technology of the dry process dust removal system includes automatic temperature control of the dry process EC (evaporative cooler), automatic speed control of the ID fan, automatic switching of recovery or release stations, and automatic ignition of the release chimney, which can reduce labor intensity; Automatically control the speed of the ID fan to save electricity, automatically ignite the exhaust chimney to save coke oven gas, and improve the alarm system.

2.8 Automatic driving navigation system

The system accurately calculates the current position of the crane, the position of the trolley, the position of the main hook, and the position of the steel ladle by installing positioning equipment on the auxiliary span steel liquid crane operating vehicle [9]. It automatically navigates according to the predetermined route of the steel liquid, providing real-time prompts and guidance for the operation of the crane operator to avoid collisions between the lifted object and fixed buildings on the ground. Further functions are still under development.

3 Refining automatic control technology

3.1 Model control

It includes two parts: a composition model and a temperature model. The composition model refers to the calculation model of the amount of alloy iron input when reaching and predicting the composition, while the temperature model refers to the calculation model of temperature loss per minute during the process of reaching the predetermined temperature.

3.2 Production planning and scheduling

This includes receiving L3 production plans and instruction information, preparing and adjusting L2 job plans, requesting new work plans and instruction information, and managing refined essential information [10].

3.3 Raw material feeding management

Including manual feeding, automatic wire feeding (aluminum wire, calcium wire, carbon wire and other core wires), and management of feeding auxiliary materials and alloy materials in the silo.

3.4 Automation technology for refining wire feeding

system

This technology has been put into use in the refining process, with an automatic wire feeding ratio greater than 98%. The automatic wire feeding process is stably implemented, effectively reducing the content of inclusions in steel, stabilizing composition control, and improving the internal quality of products [11].

3.5 VD vacuum degassing model

The automatic control technology for the vacuum pumping process of the VD furnace has transformed manual pumping and adjusting steam pressure into a one click vacuum pumping, improving the qualification rate of the vacuum degree of the VD furnace.

4 Introduction to intelligent automatic technology for continuous casting

4.1 Automatic detection of slag in ladle

Realizing automatic and accurate detection of slag in the ladle, automatically closing the ladle slide, reducing the labor intensity of workers, and reducing the amount of slag in the ladle, can help improve and enhance the quality of steel billets.

4.2 Continuous temperature measurement of intermediate ladle

Realize continuous and automatic detection of molten steel temperature in the intermediate ladle during continuous casting production, and transmit real-time temperature values.

4.3 Automatic control of crystallizer liquid level

According to production needs, by continuously and real-time detecting the liquid level of the crystallizer and automatically controlling the stopper mechanism, the crystallizer liquid level is stably controlled within a certain range, reducing the labor intensity of employees on the job and improving the stability of the crystallizer liquid level.

4.4 Robot automatic addition of protective slag

The technology is currently in the installation stage and will be put into use this year to achieve automatic addition of crystallizer protective slag by robots in a "frequent, uniform, and minimal" slag adding mode, reducing the labor intensity of workers and improving the on-site working environment. It can also stabilize the three-layer structure of protective slag in the crystallizer and improve the quality of steel billets.

4.5 Expert system for slab bonding alarm

By using an inserted thermocouple to detect temperature changes in the copper plate, and through expert system judgment, when a bonding alarm occurs in the crystallizer, the casting machine's pulling speed immediately automatically returns to zero, in order to reduce the reaction time and operation time during manual operation.

4.6 Dynamic secondary cooling water distribution

Based on the casting machine speed, steel grade, and preset parameters of the secondary cooling water meter during the production process, the pouring process system automatically controls the amount of secondary cooling water in each area.

4.7 Dynamic light pressing of slab

On the basis of roll gap shrinkage, slight pressure is applied to the solidified end of the billet to improve the internal quality of the billet. The use of light pressing can prevent the formation of shrinkage voids, compensate for the shrinkage at the final solidification end, alleviate center looseness, reduce internal cracks, and improve center segregation.

4.8 Automatic cutting of casting billet with fixed length plan

By automatically collecting information on the length of the casting billet in the MES system, issuing instructions for cutting the length of the casting billet, and automatically detecting the real-time length of the casting billet, controlling the fire cutting machine to automatically cut the casting billet, improving the cutting accuracy and length accuracy of the casting billet, reducing the labor intensity of employees on the job, and improving the working environment of employees.

4.9 Automatic detection of surface quality of castings

The automatic detection system for surface defects in castings based on image processing technology effectively identifies and classifies common types of defects in castings. Reduce the labor intensity of quality inspectors and ensure that qualified products are input into the next process.

4.10 Robot automatic number spraying

The robot can automatically provide data information corresponding to the spray number and identification of the casting billet, mark and code the hot billet, prevent mixing, and ensure the quality and smelting tracking of the casting billet.

4.11 Automatic deburring of castings

Remove the adhesive steel slag (burrs) remaining on the cutting edge of the steel billet to avoid burrs affecting the surface quality of the rolled steel product.

4.12 Integrated control system for hot delivery operations in casting production

This system originally merged four positions on the long span hot delivery line for casting production, including P4, 1 # turntable, 3 # turntable, and one pit operation, into one operation position. The equipment and parameters that required manual operation and monitoring for the original three positions were centralized and integrated into P4 automatic operation control, achieving the goal of energy conservation, consumption reduction, and efficiency reduction.

5 Effect

The improvement of automation and intelligence has provided strong guarantees for the production, quality, and equipment management of steelmaking plants, promoting the overall level of steelmaking.

5.1 Production and order plan completion rate

The arrangement of steel grades and maintenance has been further scientific, making production more stable and smooth. The completion rate of production plans has increased from 92.23% in 2015 to 94.79% in 2017, and the order completion rate has increased from 95.81% to 98.12% in 2017.

5.2 Energy management

Establish a secondary energy management system for steelmaking, deeply tap into the energy-saving potential of each process, promote innovation in energy-saving technology, vigorously carry out research on the recovery of converter gas, improve gas utilization efficiency, and save 14.69 million yuan in electricity and energy in 2017 compared to 2015.

5.3 Material tracking

We have established daily reports on iron consumption before and after production, monitored steel material consumption and metal yield, tracked the weighing and weighing of casting billets, and coordinated the timely recovery of scrap steel. We have also developed a daily report on iron containing materials, reducing the iron loss rate from 0.06% in 2015 to 0.03% in 2017; The qualification rate of single weight of cast billets has increased from 93.6% in 2015 to 94.21% in 2017.

5.4 Cost control

Due to the improvement of material consumption tracking and inventory system, a daily cost accounting system and a monthly cost system have been established. In the current production of 188 steel grades, a cost analysis system by steel grade has been established to provide a basis for benchmarking and product sales pricing.

5.5 Equipment operation and maintenance

Through equipment repair and maintenance records and queries, as well as online monitoring of equipment status, accidents that affect production and quality have decreased. As of April and May 2018, there was only one equipment malfunction that affected production for two consecutive months.

5.6 Personnel reduction

In the new era of increasingly high labor costs, intelligent technology has been continuously introduced to improve automation levels and reduce employee labor intensity. With the increase in production, some positions have been merged, and operators have been moderately reduced. The production has increased from 5.18 million tons in 2012 to 6.53 million tons in 2017, but the number of personnel has decreased from 2386 to 1815, with intelligence and automation playing a key role.

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