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Development and Application of Remote Centralized Control Model For Constant Weight System of Billet Caster

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ABSTRACT

In view of the disadvantages of the traditional billet caster in the production process, the operating environment and the steel yield, the remote centralized control system based on the C/S architecture is developed for the remote centralized control model of the constant weight system of a billet caster in E'cheng Iron& Steel Corp. Through the design and development of operation functions such as steel type, mold steel throughput, pure scale/weight mode switching, weight qualification rate statistics, steel rolling data feedback, etc., the real-time monitoring and control of on-site production is realized, and the production efficiency is greatly improved. According to the internal statistics of E Steel, since the remote centralized control model of this continuous casting machine weight fixing system was developed and applied online, the qualification rate of aerosol cooling has increased by about 10%, the sizing rate has increased by 1%, the finished product rate has increased by 0.2%-0.35%, and the economic efficiency has been improved.

Keywords: *billet; fixed weight; fixed ruler; continuous casting; remote centralized control development; C/S framework.*

INTRODUCTION

Steel plays an extremely important role in our economic development and is a symbol of our economic strength [1]. Whether it is the construction industry or fine equipment, steel is in great demand [2]. As the traditional technical requirements for the production of steel are not high, making some small steel mills without technical costs develop rapidly and the competitiveness of the steel industry is gradually fierce [3]. In order to increase the revenue of steel mills, while expanding the market externally, the internal production costs and the rate of finished steel are also big issues that need to be taken into account [4]. From the current domestic market, it seems that many small enterprises are backwardly equipped and have low production levels, and it is already a trend for backward enterprises to be eliminated in an era of rapid technological development [5]. Relative to foreign enterprises, China's production of steel technology still needs to be continuously improved, in expanding foreign markets to occupy a position in the need for technological progress [6]. This paper focuses on exploring the technological improvements brought about by the development of a remote fixed-weight system in the continuous casting process, which to a certain extent solves the losses caused by the billet cutting process and generates an efficiency of about 13 million yuan in 11 months of operation from February 2021, as measured internally by ESSCO.

The technology of fixed-weight and fixed-measure is still only used by many small enterprises for fixed-measure cutting [7]. However, due to the difference in the quality of small billets [8], the fixed-weight cutting alone cannot meet the increase in the production rate, and a fixed-weight system needs to be developed [9]. The foreign weighing system has been developed in comparison with the domestic one [10], but the actual situation of each steel mill is different [11].

Through the remote centralized control development of the weight setting model system, Baowu Group Yicheng Iron and Steel Co., Ltd. ECSTEEL） developed the existing weight setting model and updated it to the server side, and developed the large centralized control client and installed it to the large centralized control industrial computer. The main working principle is shown in Figure 1: the weight model system collects data in real time, then the server analyses the real time data and predicts the quality of the billet during the drawing and casting process in real time. After checking the quality, the cutting system issues instructions and cuts the billets. After cutting, the billets are weighed again and the positioning system sends the inspection data to the weight model server. The weighting model server learns from the data received each time, and the accuracy of the weighing is improved by analyzing the data several times through big data analysis in the computer and by the system learning itself.

During the development process, the system is constantly updated and improved, and the remote large set control has been equipped with complete real-time online continuous casting billet weighing and cutting operation, and real-time monitoring of remote production cutting screen, monitoring, retrieving production information such as weighing pass rate, and realizing remote integration of weighing system. ECSTEEL 1 # billet continuous casting machine original hook weighing qualified rate of only 50%, the original sizing rate of 98.50%, and from this system in E steel since 2 online system response time ≦ 1s, the system remote delay time ≦ 0.5s, the system weighing accuracy ± 0.2%, weighing qualified rate ≧ 80%, rolling steel sizing rate of 99.5%.

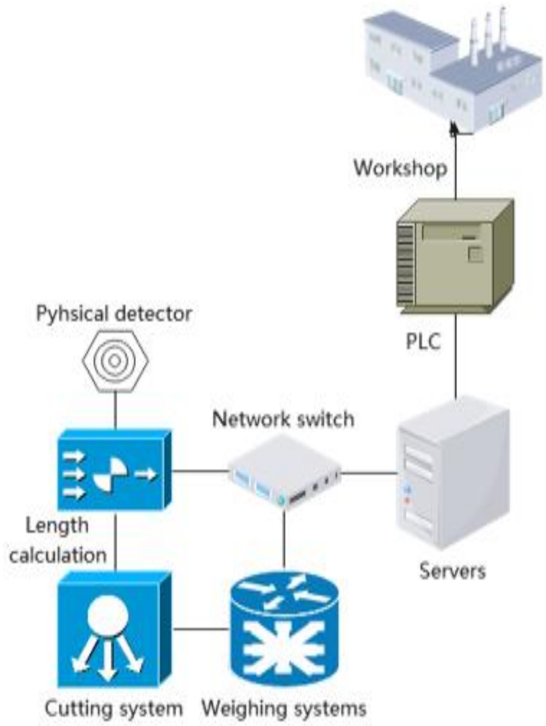

Figure1. *Flowchart of the remote centralized control model of the weighing system*

Analysis of the Current Situation of ECSTEEL Billet Continuous Casting Machine Cutting

In order to improve the efficiency of steel production, continuous cost reduction has become one of the ways pursued by various steel companies [12]. Continuous casting is one of the most critical steps in the steelmaking process and is a process that is constantly being researched and improved by Chinese steel companies [13]. The stability and qualification rate of billets cut by the 1# and 4# billet continuous casting machines of ECSTEEL need to be strengthened, with the main problems being: different weighing quality of billets of the same production specification; the original sizing model system cannot be fed back to the client in time during the billet sizing cutting process, resulting in errors in the reception of cutting production information, while the communication of data in the original sizing model system Security is not guaranteed.

The accuracy of the measurement of the control object by the remote control development system plays a crucial role in the whole central control development system [14], and at present the domestic enterprises are more concerned with the production costs [15], and the process of producing billets in the continuous casting machine is the most critical step for the costs [16]. The factors affecting the quality of the billet production process are divided into the following: crystalliser wear conditions, pulling speed, equipment factors, and process [17]. In the process of producing steel, ECSTEEL pays particular attention to the cutting of constant weight and scale in the process of producing cast billets. The secondary development in the original remote centralised control development system has greatly improved the qualification rate of billet production and reduced costs.

Architecture of the Remote Centralized Control System for the Fixed Weight Cutting of Continuous Casting Billets

The remote centralised control development system for billet cutting consists of four main components: length detection of the continuous casting billet, weight detection of the continuous casting billet, cut-to-length of the continuous casting billet and automatic computer control, as shown in Figure 2.

The continuous casting machine has always produced billets cut to a fixed length as the main standard, but the weight could not be well controlled, and today major companies have largely changed to a fixed weight and fixed length cutting process. In the steel casting segment, the fixed-weight and fixed-measure cutting process mainly involves making the cast billet with weight as the control indicator, then converting the weight into a billet size specification as the control target and then cutting it to size. The cut-to-length step requires manual input of specific values for the cut-to-length dimensions into the computer, and then the billet is inspected by the billet cut-to-length tracking system, which transmits the results of the inspection to the server at the other end. Based on the instructions from the client, the cutting control system works in real time, weighing the freshly cut billets online after cutting and making minor corrections according to the specification dimensions.

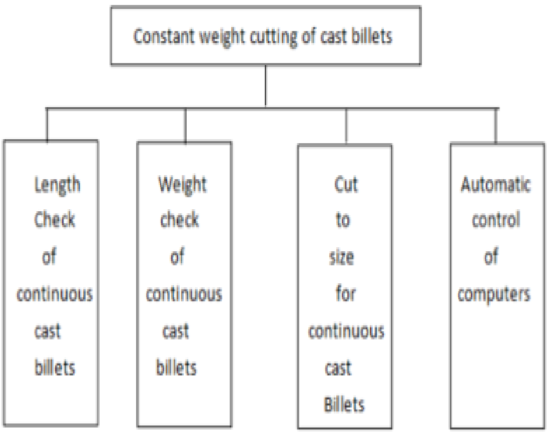

Figure2. *Composition of the continuous casting billet weight cutting module.*

Software Development For Continuous Billet Weighing/Sizing Systems

Software Development of the Continuous Billet Weighing System

The continuous casting billet sizing system uses a C/S architecture to control the user console remotely through the model, which is updated on the server side through the secondary development of the existing sizing model. The actual principle of this system architecture is that the client of the system sends an SQL request to the data server of the system, and then the server of this system returns the calculated results to the client. The client side encapsulates part of the application logic while providing user interface functionality. The database server on the server side can provide some of the application logic through triggers and stored procedures and also has the ability to store data.

The fixed-weight model can only be operated by 1 end user at any one time. The operation mode of the fixed-weight system is multi-user exclusive, i.e. it can be monitored by multiple users in both the remote central control and the local small central control. However, it can only be operated by 1 user at any one time: the remote central control or the local small central control. The remote central control and the local small central control are mutually exclusive in their control operations and require a secret key for log-in operations to avoid leakage of information and to ensure the security of the data transmission process back and forth.

Figure3. *Main screen for monitoring from the remote central control of the fixed weight model.*

The hardware architecture of the remote central control system of the fixed weight model: each casting machine is an independent system, with two existing model servers as the server side and two additional industrial computers as the client side of the big central control, which control the two casting machines respectively. At the same time, the client can have a rich user interface, so that the operator has a better operating experience, the main screen for monitoring the remote central control of the fixed weight model is shown in Figure 3.

Software Development of Continuous Casting Billet Sizing System

The continuous casting billet sizing system uses a special machine as the server side, and a special machine for sizing is added to the large central control as the client side. The special machine for sizing on site, i.e. the server side, is already connected to the first level network of ECSTEEL, and the large central control has the first level network condition, so the client side of the sizing machine is connected to the first level network to realize data communication. Through transformation and secondary development of the existing sizing system's stand-alone version into C/S architecture version, new development of remote operation end. The site is the server side, the remote large set control is the client side, in the first-level network to achieve the transmission of communication data. While remote monitoring, when the amount of information transmitted is large, timely and accurate communication is possible. Using it for cutting can satisfy data transmission and interface functions, with relatively good scalability and cross-platform, and achieves higher precision automatic cutting on the basis of the original system.

The sizing system can only be operated by 1 end of the user at the same time, and the operation mode is multi-user exclusive operation, that is, it can be monitored by multiple users in both remote central control and local small central control, but it can only be operated by 1 end at the same time: the remote central control end or the local small central control end. The two control operations are mutually exclusive and the operation is carried out by means of a secret key for login. The sizing machine and the sizing machine communicate within a dedicated network, and the remote centralised sizing console can carry out sizing length modification, sizing fine adjustment, sizing/sizing switching, sizing camera exposure index fine adjustment, etc. During the sizing process, ECSTEEL uses high-definition infra-red cameras to collect the light signal, which ensures night vision even in poor light conditions. The hardware structure is mainly 2 new monitors for the large central control, which are used for the remote transmission of the sizing images of 2 casters respectively; 2 sets of new sizing special machines are used for the remote operation of the large central control client of 2 casters respectively.

The sizing system can realize the remote transmission of high-definition images instantly, and the sizing images are transmitted in real time through high-definition video encoders and decoders for remote centralized control and local small centralized control to guarantee the immediacy and ensure the cutting production. The remote central control of the remote transmission system is linked to the local small central control by a dedicated fibre optic network, with one new client computer for each casting machine. The new development of the C/S architecture of the fixed-size model remote centralised control user control side, using the advantages of the hardware at both ends, the operator input instructions reasonably allocated to the client and the server, can be divided to play a client processing data capacity, greatly reducing the communication costs of the system.

Weighing/Sizing System Communication Interface Table With the Casting Machine

The communication equipment of the sizing/ sizing system needs to communicate with the PLC of the continuous casting machine on a first level network with a total of two computers, i.e.: one for the sizing and positioning system IPC and one for the sizing model server; each needs to be assigned a first level network IP address.

Communication Between the Sizing System and the PLC

The positioning system sends the clamping signal to the PLC of the flame cutting machine in each stream of the casting machine by means of two communication methods: hard contact connection and switching communication. The sizing and positioning system writes the rollerway start/stop signal of each stream weighing section to the DB block of the PLC by means of TCP/IP Ethernet communication, and the PLC of each stream rollerway controls the start and stop of the rollerway motor of the electronic weighing section according to the information read from the DB block. The specific interface variables are as follows.

Table1. *Table of variables for sizing interfaces*

Physical significance	Type & Address	Notes
Communication detection signals	DBX0.1	Alternating 0/1 every second
Weighing rollerway stop	DBX0.2	Valid along the rise
Weighing rollerway start-up	DBX0.3	Valid along the rise

Casting machine manufacturers need to write the clamping signals for each stream of the cast billet cutter, to the DB block of the PLC of each stream, and the sizing and positioning system calibrates the sizing system by reading the information from the DB block of each stream.

The single-stream interfaces are as follows.

Physical significance	Type & Address	Notes
Clamping of cast billet cutters	DBX0.0	0：Loose 1：Clamped
Output length (m)	REAL2	
Pull speed	REAL6	

Communication Between the Fixed-Weight Model Server and the PLC

The fixed-weight model server communicates with the PLC via TCP/IP Ethernet communica-tion. The following real-time values of the variables for each stream of the casting machine manufacturer are written into the DB block of the PLC for each stream, and the fixed-weight model server reads the DB block information for each stream, with the following main variable names.

Table2. *Table of variables collected for the fixed weight model*

Name 1	Name 2	Name 3	Name 4
1-stream pulling speed	1-stream crystallizer specific water volume	1-stream crystalliser inlet and outlet water temperature difference	1-stream second-cooling section specific water volume
2-stream pulling speed	2-stream crystallizer specific water volume	2-stream crystalliser inlet and outlet water temperature difference	2-stream second-cooling section specific water volume
3-stream pulling speed	3-stream crystallizer specific water volume	3-stream crystalliser inlet and outlet water temperature difference	3-stream second-cooling section specific water volume
4-stream pulling speed	4-stream crystallizer specific water volume	4-stream crystalliser inlet and outlet water temperature difference	4-stream second-cooling section specific water volume
5-stream pulling speed	5-stream crystallizer specific water volume	5-stream crystalliser inlet and outlet water temperature difference	5-stream second-cooling section specific water volume
6-stream pulling speed	6-stream crystallizer specific water volume	6-stream crystalliser inlet and outlet water temperature difference	6-stream second-cooling section specific water volume
7-stream pulling speed	7-stream crystallizer specific water volume	7-stream crystalliser inlet and outlet water temperature difference	7-stream second-cooling section specific water volume

Continuous Billet Weighing/Sizing System Functional Applications

The continuous casting billet sizing model can be operated remotely for all main functions. The remote interface can be monitored in real time through a dedicated network, and the remote sizing model machine can be logged in and operated to set the sizing steel grade, update the standard, maintain the crystalliser throughput, switch between pure sizing/ sizing mode, sizing pass rate statistics, mill data feedback, sizing standard acceptance and update, etc. The main remote screen of the sizing system is shown in Figure 4. The sizing machine and the sizing machine communicate within a dedicated network, and the remote centralized control sizing console can carry out sizing length modification, sizing fine-tuning, sizing/sizing switching, sizing camera exposure index fine-tuning and other functions.

The remote centralised control has a complete real-time online operation of the sizing and cutting of continuous cast billets, and monitors the remote production cutting screen in real time, monitors and retrieves the production information of the sizing and passing rate, realising the remote integration of the sizing system. The billet sizing model system and the sizing system for cast billets meet the requirements for billet metering data management information [18], realising automation and intelligence in billet management and improving production organization and management [19]. The production cost of the continuous casting machine has been significantly reduced, which has greatly improved the efficiency of the enterprise [20]. Although some problems were encountered during the application process: the operation could not be carried out in time due to the delay of the system, resulting in a low qualification rate and low sizing rate of the cast billets. However, these problems were solved in time by subsequent model optimization algorithms.

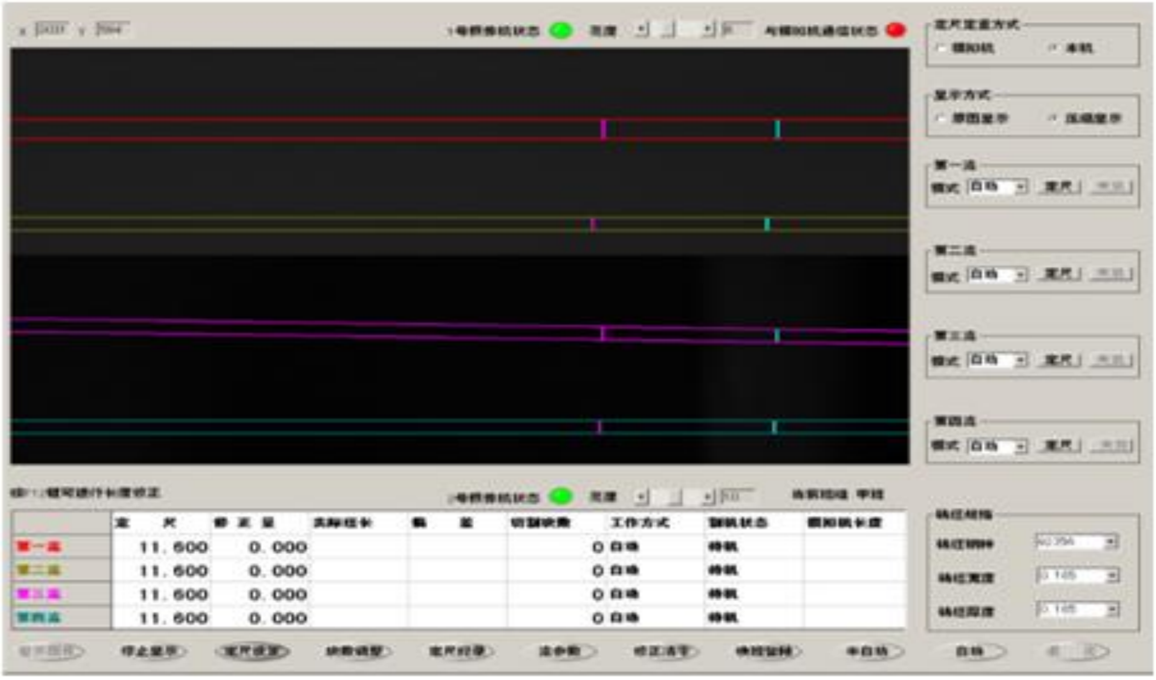

Figure3. *Telemetry main screen of the sizing system*

Conclusion

This study is based on the remote centralized control system of C/S architecture to develop the remote centralized control model of a square billet continuous caster weighing system of ECSTEEL, through the design and development of steel type, crystallizer steel throughput, pure sizing/weighing mode switching, weighing pass rate statistics, rolling steel data feedback and other operational functions, realizing real-time monitoring and control of on-site production and greatly improving production efficiency. Its advantages are：

- ECSTEEL's secondary development of the weight setting / sizing system ensures the accuracy of billets produced during continuous casting with standard specification billets on the basis of the original equipment is not affected.
- The application of remote central control reduces the waste of time and cost. Through the remote central control operation, the technician only needs to send instructions to the server through the client, and the specific situation on site can be fed back to the client by the server in a timely manner, which to a certain extent reduces the cost of a manual round trip to the plant and ensures the immediacy of production.
- The billet weighing/sizing system is a further step forward in the automation of billet production in the continuous casting machine, helping to produce billets accurately in large batches and providing reference value for subsequent production studies.
- However, there are still deficiencies in the remote centralised control model of this billet continuous caster weighing system, and the information interaction rate between client and client can be improved by using the chord algorithm on the original communication between client and server in the follow-up.

References

[1] Zhou Congrui, Xiong Liangyou, Wu Jianjun, Kang Xinlei, Zhang Liqiang. Application of fixed weight cutting technology on small billet continuous casting machine [J]. Metal World, 2022 (06):75-79.

[2] Pei Xiaojiao. Improvement and research on the full-length counting system of square billet continuous casting machine [D]. (Master's thesis). Liaoning University of Science and Technology,2014-06-07

[3] Zuo Kangjun. Li Zhiyong. Wang Z T. Zhu Tongfeng. Improvement of precision control of square billet fixed weight cutting. China Instrumentation, 2011, 27(06)

[4] Zou Chunlong. Application of billet fixed-weight shearing technology in the continuous

casting machine of XISCO. Heilongjiang metallurgy, 2015, 35(04)

[5] Chen Shichao. Research on fixed-weight optimized cutting system for continuous casting machine based on fixed-weight. Shandong Industrial Technology,2015 (18): 240

[6] Wang Bo. Mi Chunxia. Hu M. Modification and application of automatic billet cutting control system for continuous casting machine. Automation Expo, 2010, 27(07)

[7] Lu Zhen. Research on the application of fixed-weight and fixed-measure cutting technology in continuous casting billet cutting. Mechanical Engineering and Automation, 2014(1):202

[8] Hao Xiaofeng. Research on SQL database technology based on C/S architecture [J]. Computer programming skills and maintenance, 2021(02):104-106.

[9] He Bin. Research and development of wire cutting system based on C/S architecture [D]. Guangdong University of Technology, 2021.

[10] Xu G, He YL, Hu YQ, Yu LIChao. Design of a networked serial debugging system based on C/S architecture [J]. China New Communication, 2019, 21(19):60-61.

[11] Liu Yuan, Zhang Wei, Wang Zhixue. Embedded remote monitoring system based on B/S and C/S architecture [J]. Instrument Technology and Sensors, 2008(10):39-41.

[12] Bian Lu. Research on data prioritization technology of mobile terminal communication system based on big data in C/S architecture [J]. Information and Computer (Theory Edition), 2019, 31 (18):190-192.

[13] Liu Zhenwei. C/S architecture-based system monitoring software design and implementation [J]. Computer programming skills and maintenance, 2021(06):43-45.

[14] Tian Zunchao, Xiaotao Qi, Linlin Li, Liang Zhao. Application of visual recogni-tion system in shear line sizing measurement [J]. Shandong Metallurgy, 2022, 44(04):57-58.

[15] Pu Chao. Design and implementation of nuclear waste management system based on C/S architecture [D]. Southwest University of Science and Technology, 2019.

[16] Hua Xuehui. Design and implementation of an intelligent traffic signal system based on C/S architecture for area coordination control [J]. Automation Technology and Applications, 2018, 37(07):114-117.

[17] Li W,Huang Dajun,Wu Shuai,Xia Jinkui,Lin Qian,Zhang Liqiang. Online fixed-weight cutting technology for continuous casting billets in process practice [J]. Continuous Casting, 2022 (05):101-107.

[18] Li ZG. Development and application of continuous casting single-branch fixed-weight cutting system [D]. University of Science and Technology of Liaoning, 2016.

[19] Jiang N. Li K. Kang Fengmei. Zhang Q. Liu Zheng. Application of fixed-weight cutting technology in billet fixed-weight system [J]. Shandong Metallurgy, 2009, 31(02):34

[20] Wang Lin, Li Genwen, Wang Song, Huang Desheng. Online fixed-weight cutting technology process practice for continuous casting billets [J]. Sichuan Metallurgy, 2014, 36(04):24-27.

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