Optimization of Heat Treatment Furnace Based on Automatic Control System

Xiuqi Wu¹, Jie-tao Dai²a*, Ju Yan², Liejun Li³

¹Guangdong Songshan Vocational and Technical College, Shaoguan, Guangdong, 512100, China
²School of mechanical and electrical engineering, Guangzhou University, Guangzhou, 510006, China
³South China University of Technology School of Mechanical & Automotive Engineering, Guangzhou 510641, China

*Corresponding author: aemail:daijietao@gzhu.edu.cn

Abstract: This paper takes the steel mill heat treatment furnace with the supporting control system as the carrier. On the basis of utilizing the existing hardware, Using the latest control ideas and control concepts, further research and optimization and improvement of the control system software, improve automation control. Strive to maximize the capabilities of the existing hardware, improve the utilization rate of the effective heating space in the furnace and accelerate the production rhythm of the heat treatment furnace, to help enterprises to improve the product heat treatment quality, improve productivity, further save energy, reduce consumption, and increase efficiency.

1. Introduction

Special rolling mill 3450mm production line is a professional medium thick plate production line, a new heat treatment production line was added in 2008, Realize the production of positive and tempering delivery steel plate. After the upgrading of the sheet process heat treatment furnace in July 2017,[1]automatic control of the combustion model, however, the combustion control model has limited functional accuracy, difficult to support mass, high-speed production, heating accuracy requires further improvement. After 2018, with the increase of heat treatment steel plate production year by year and the development of various steel products represented by 1.2311 and 1.2738, Problems such as low heating precision, low production efficiency[2], and substantial fluctuation of steel plate performance after heat treatment have seriously restricted the stability of heat treatment products and the delivery of heat treatment steel plate orders on schedule.

2. Technical route

2.1. Optimization of furnace temperature model control

Automatic upgrade of the heat treatment furnace, With functions such as combustion model control, And added the temperature tracking calculation function module, The different parts of all steel plates in real time and accurately in the furnace³.

According to the product development needs, Considering the factors of furnace type, radiation heat transfer and steel species, According to the effective heating area of heat treatment furnace, To
make the steel plate quickly reach the thermal insulation temperature section, With full consideration of the heat treatment supply heat load, Improve production efficiency and improve process. By studying the temperature setting values of the different heating sections of the heat treatment furnace, Subdividing the 20 heating furnace areas of the heat treatment furnace and dividing the following physical areas: Preheating section 1-4, Heating a section of Zone 5-8, Heating Section 9-14, Zone 15-20, Set the preheating section respectively according to the steel number (as shown in table 1). Heating a single section, Target temperature of heating the second section and the average heat section, Maximum and minimum temperatures, For Level L2 to calculate a reasonable furnace temperature control heating curve according to the temperature setting range, Class L1 conducts automatic combustion control according to the setting situation of the furnace temperature curve.

Tab.1 Temperature control table for temperature treatment furnace

| Steel grade                  | Brand  | Soaking section temperature | Furnace area         |
|------------------------------|--------|----------------------------|----------------------|
|                              |        |                            | I、II、IIIⅥⅤⅣⅢ      | IV、V、VIⅨⅧⅦⅥⅤⅣⅢⅡ  |
|                              |        |                            | Temperature range, ℃ |                      |
| Ordinary ship plate          | NO1    | 900±10                     |                      | 820-850 850-890 820-850 850-890 |
| High strength ship plate     | NO2    | 900±10                     | 830-860 840-870 830-860 840-870  |
|                              | NO3    | 900±10                     |                      | 830-860 840-870 830-860 840-870  |
|                              | NO4    | 900±10                     |                      | 830-860 840-870 830-860 840-870  |
|                              | NO5    | 900±10                     |                      | 830-860 840-870 830-860 840-870  |
| Steel plate of high-rise building | NO6  | 880±10                     |                      | 830-860 840-870 830-860 840-870  |
|                              | NO7    | 880±10                     |                      | 830-860 840-870 830-860 840-870  |
| Carbon structural steel plate| NO8    | 880±10                     |                      | 830-860 840-870 830-860 840-870  |
| Low alloy structural steel plate | NO9  | 880±10                     |                      | 830-860 840-870 830-860 840-870  |
| Steel plates for pressure vessels | NO1 0| 880±10                     |                      | 830-860 840-870 830-860 840-870  |
|                              | NO1 1  | 890±10                     |                      | 830-860 840-870 830-860 840-870  |
|                              | NO1 2  | 900±10                     |                      | 830-860 840-870 830-860 840-870  |
|                              | NO1 3  | 920±10                     |                      | 830-860 840-870 830-860 840-870  |

2.2. Increase manual adjustment to ensure heating accuracy
Level L1 performs Class L2 setting process temperature, To meet the ± 10 ℃ range for the temperature of the heat treatment furnace in the effective heating area, The project team has optimized the furnace temperature control mode, Adjust manual intervention, Optimization, according to the actual temperature control situation, Real-time dynamic adjustment of the furnace temperature, Ensure that the heating accuracy meets the heat treatment production requirements, As shown in Figure 1.
2.3. **New heat processing and heating data record and query function**

To realize the data recording and query function after heat processing production, Record the furnace temperature control of the heat treatment steel plate. Developed the L2 process data query function newly, Check the process execution of the released steel plate offline, Optimize the heat treatment production process combined with the performance situation, The fault condition of the burner or other combustion equipment can also be reported through the temperature control situation.

2.4. **Improve the utilization rate of effective space in the heat treatment furnace**

Total length of sheet heat treatment furnace of special rolling mill is about 69.2m, Generally produced heat treatment plates are approximately 6-15 m long, After the 2017 heat treatment Class L1, L2 upgrade, The heat treatment furnace provides accurate position and information tracking, But the original safety distance of 3 meters can not meet the heat treatment production demand, Therefore, the heat treatment furnace internal control is deeply studied and improved, The effective safety distance between the steel plates in the heat treatment furnace will be shortened from 3 m to 1.1 m. Take a board of 8 meters in length, Originally, only 5 panels in the furnace, Now 6 pieces, The improvement greatly improves the effective space utilization rate in the heat treatment furnace, Fig. 2 shows each parameter setting and safety distance setting screen inside and outside the furnace.
2.5. Optimized rear-furnace automatic cooling system

1. A set of collectors is designed and installed after the heat treatment furnace. Connect the header inlet to the line, install the manual gate valve at the connection point, Flow-flow meter, and Flow control valve, Realize accurate flow control.

2. Install two sets of compressed air purges between the roller lanes adjacent to the catchment pipe, Connect to the line compressed air line, Install the manual gate valve and the pneumatic switch valve at the connection, Ensure no water on the plate surface.

3. Steel plate reciprocates for cooling under the header, Add the automatic cooling function to the operating console, Set cooling process parameters such as spray cooling channel and opening degree of cooling valve, Accurate control of the cooling process, Fig.3.

3. Conclusion

Through optimization of heat treatment furnace, Without the full capacity production of the heat treatment furnace, Heat treatment production efficiency has been improved, The qualified rate of hot products in 2020 is 100%; Production efficiency reaches an average of 109.2 tons / class, Production efficiency of tempering heat treatment reaches an average of 69.3 t / class, Improve the performance and stability of the heat-treated steel plate, Reduce the product fill mill rate, Shorten the delivery period, Ensure a smooth production organization, Indirect, reduced production costs, With the good economic benefits, There is a very high application value.

Acknowledgments

The authors gratefully acknowledge Key scientific research platforms and projects of colleges and universities in Guangdong Province[grant number: 2018GkQNCX110];And The financial support of Guangzhou Science and Technology Project [grant number: 202007020007]; And Shaoguan Science and Technology Planning Project [grant number: 2018CD11803];And Guangdong Science and Technology Project[grant number: 2017B090907015].

References

[1] Li Hai sheng and Li Rongxuan and Wu Feng. A New Control Performance Evaluation Based on LQG Benchmark for the Heating Furnace Temperature Control System[J]. Processes, 2020, 8(11) : 1428-1428.

[2] Kostur K. Optimal control of heating in a reheating furnace[J]. Metalurgija, 2020, 59(4) : 473-476.

[3] Feilong Zheng, Yundan Lu and Shuguang Fu. RESEARCH ON TEMPERATURE CONTROL OF HEATING FURNACE WITH INTELLIGENT PROPORTIONAL INTEGRAL DERIVATIVE CONTROL ALGORITHM[J]. Thermal Science, 2020, 24(5B) : 3069 - 3077.

[4] D. Ya. Vishnyakov; G. N. Rostovtsev; A.A. Neustroev; S. L. Rustem.Equipment mechanization, and automation of heat treatment departments [J].Metal Science and Heat Treatment Volume 8, Issue 1. 1966. PP 87-88.

[5] WANG Qing-hua, HUANG Wei-quan, GAO Ping. Automatic Design and Application of
Medium Plate Heat Treatment Furnace[J]. Journal of Iron and Steel Research Vol.23, Supplement 1 Oct.

[6] A. P. Mironov. Mechanization and automation of heat treatment at the lyuberets agricultural machinery works[J]Metal Science and Heat Treatment Volume 3, Issue 3-4. 1961. PP 142-145.

[7] Zheng Li; Qianlin Wu; Zhonghua Zhang; Hongshuang Di. Corrosion Behavior of Seamless Pipeline C–Mn Steel by On-line Controlled Cooling Technique[J]ISIJ International Volume 58, Issue 4. 2018. PP 734-741.

[8] Lihui Song; Xiu Zheng; Jiayi Fu; Zhenguojri. Controlled cooling process for efficient hydrogenation[J]Journal of Alloys and Compounds Volume 698, 2017. PP 892-897.