Design of 120t converter furnace body

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Abstract. At present, the oxygen converter steelmaking equipment of large-scale, production of continuous and high-speed, which has achieved a high productivity, and this requires matching equipment to complete together. The process about the layout of these equipment and the workshop of various materials must be reasonable in order to enable the production to proceed smoothly. The furnace body for 120t converter is designed in the paper. The results are as follows. The converter raw data has been used, the experimental step of the design has been listed to determine the data required for the furnace size design, including the steel yield, scrap ratio, furnace type, etc. The size of the data has been obtained by the calculation, and, check the results to determine the design of the furnace for the specific data according to the empirical formula of the size of the calibration, the data can be used for practical production. Through the rigorous calculation of the design, the converter furnace capacity ratio, aspect ratio, pool diameter and depth of experimental data have been determine. The results show that the design is reasonable. The design data of the converter and the corresponding furnace can meet the equipment of the effective volume of 120t converter design. That can ensure the smooth production process of the converter, while achieve the requirements of lining longevity.

1. Introduction

Starting from the industrial age, the iron and steel has been the main application of structural materials, which is also the largest and the most common functional materials production in human society, and it plays an important role in the economic development, known as "the backbone of industry". Although in recent years the iron and steel is faced with ceramic materials, polymer materials, non- ferrous metal materials (such as aluminum) in the competition, but it has some significant advantages, such as ore reserves, the cost of production, recycling utilization, and comprehensive performance. In the foreseeable future, compared with other kinds of materials iron and steel in the industrial production has the superiority and important position still won't change [1-5].

Bessemer converter steelmaking process with a bottom blowing on appeared Britain in 1856. French Martin used heat storage principle, and founded that pure oxygen top-blown converter in Austria in 1952. In the mid and late 1980s, Western Europe, Japan and the United States developed the process of remaking and remaking of oxygen converter. The advantage is good slag and the amount of steel used in converter steelmaking in the bottom and back converter steelmaking, at the same time, it also has the advantage of a mixture of oxygen bottom blown converter steelmaking melting pool, iron and manganese oxidation loss, and less metal spraying, etc. Therefore, most of the world's large-capacity converters are used in the process of steelmaking [6-15].

2. Parameters and dimensions of converter

2.1 Determine the original parameters

(1) The nominal capacity (T) is the name of the size of the converter, the tonnage of converter. It is the main symbol of the converter production ability and the important basis of furnace design.

(2) The average amount of steel in the furnace is 120t, the rate of steel is 90%, the maximum scrap is 10%, and the quantity of oxygen is 51.65 (m^3/t), which is cooled by scrap steel.

(3) Volume ratio (V/T): the ratio of the effective volume (V) to the nominal capacity (T) of the furnace in the new furnace（m^3/T）. In domestic 100-200t converter capacity ratio between 0.90-1.0. At the same time, according to the stove, the greater the furnace capacity and the smaller the experience rule, in the design of the furnace capacity of 0.92m^3/t is used

(4) Cap Angle (θ) referred to the angle between the furnace cap and the furnace body, the furnace cap and the horizontal line of the furnace. The recommended value of Θ = 60-68º, the big stove takes the lower limit, the small furnace takes the upper limit. According to domestic production experience, the number is 64º。

2.2 The size of the converter is determined

(1) Molten pool diameter *D*

The most common formula is recommended by the Beijing steel design institute：

$$D = K\sqrt{\frac{G}{t}}$$

Type: *D*-melt diameter, m; G-new furnace metal load, T; t-oxygen blowing time, min; *K*-proportional coefficient, *K* of 120t converter is 1.79.

According to the formula：

$$G = \eta 2T / (2 + B) = 121\text{t}$$

Oxygen blowing time (t) =2.83m^3/ (t·min)

So D_{molten} =4.64m

(2) The depth of molten pool h

The calculation formula of depth h of molten pool is:

$$V_{\text{molten}}=0.79D^2\text{h-}0.046D^3$$

Determine the diameter of the molten pool is 4.64 m, h=1.32m

Check: the depth diameter ratio of molten pool (*h*/D) is 0.23-0.54. This is *h*/D =1.32/4.64=0.284,which meets the requirements.

Determination of furnace cap size

Glory hole diameter d_0=0.51D=0.51×5.393=2.37m；

Furnace cap height H_{cap}： H_{cap}＝H_{mouth}+H_{cone};

The design of the furnace mouth is 400mm.

$$H_{\text{core}} = 1/2(D_0 - d_0)\tan\theta = 1/2(4.64 - 2.37)\tan 64 = 2.33\text{m};$$

$$H_{\text{cap}} = H_{\text{mouth}} + H_{\text{core}} = 2.33 + 0.4 = 2.73$$

The furnace volume cap V_{cap}:

$$V_{\text{cap}}=\pi/12H_{\text{core}}(D^2+Dd_{02}+\pi/4d_{02})+d_{02}H_{mouth}=\pi/12*2.33(4.642+4.64*2.37+2.372)+\pi/4*2.372*0.4=25.03\text{m}^3$$

Determination of body size

According to the selected furnace ratio of 0.92, the total capacity of the furnace has been calculated.

$$V_{\text{total}}=0.92\times120=110.4\text{m}^3$$

As V_{total} was known, the body product of the converter was calculated, thus the height of the furnace has been obtained.

$$H_{\text{body}} = 4V_{\text{body}} / \pi D^2 = 4\text{m}$$

3. Furnace lining and furnace shell

3.1 Furnace lining

The design of 120t converter furnace was completed by referring to relevant literature on the design of converter furnace. This design aims at the design of 120t converter furnace body, and follows the design idea of modern furnace with practical, advanced, high quality, low consumption, long life and environmental protection. Through this design, the conclusion is as follows:

(1) The development status and furnace structure of the converter are studied. The original conditions include: the nominal capacity T takes 120t, the rate of steel is 90%, the maximum scrap ratio is 10%,and the oxygen time is 18min.

(2) According to the previous experience and the original conditions of the person, of the tube ball type furnace type was selected, and the ratio of the furnace volume of 0.92 m^3/t was determined, and the high ratio of the check height of 1.59m. The diameter of the molten pool D = 4.64 m was determined, the depth of the molten pool is 1.32 m, the furnace cap h_{cap} =2.73 m, and the furnace body h_{body} = 4m.

(3) The high quality furnace lining and furnace shell is selected to ensure the normal working of the converter, and maintain the service life of the converter and the safety of the staff regularly.

The design determines the parameters of the 120t converter furnace, and the corresponding furnace structure is obtained. The design can meet the design requirements of the effective volume for the operation of the 120t converter.

Converter lining life reflects an enterprise's management and technical level, and directly affects the productivity of the converter, which can not be ignored in the design of furnace lining life, and it is also a type of a problem. To improve the life of lining, from the technical aspect, it is to insist on reasonable operating system, from the design point of view:

(1) The high quality refractory for furnace lining should be chose;

(2) The best lining thickness should be selected.

3.2 The furnace shell

The furnace shell: the converter shell is similar to a container bearing high temperature and high pressure. It has the following forces in its use:

(1) Stress caused by static load;

(2) The stress generated by the dynamic load;

(3) The expansion stress of the lining;

(4) The thermal stress.

According to the use characteristics of the shell, the material of the furnace shell is required to withstand the time of high temperature resistance, creep resistance and good forming and welding property. Generally small converter with carbon structural steel, large converter with low structural steel, such as Q235, 16Mn, 15MnTi, 14MnNb, etc.

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References

[1] Omran M, Fabritius T. Effect of steelmaking dust characteristics on suitable recycling process determining: Ferrochrome converter (CRC) and electric arc furnace (EAF) dusts [J]. Powder Technology, 2016, 308 (2017): 47-60.
[2] Bodor M, Santos R M, Cristea G, et al. Laboratory investigation of carbonated BOF slag used as partial replacement of natural aggregate in cement mortars[J]. Cement & Concrete Composites, 2016, 65:55-66.
[3] Brezny B. The Microstructures and Properties of Magnesia-Carbon Refractories [J]. Key Engineering Materials, 1993, 88: 21-40.
[4] Cunha A P, Pacianotto T A, Fileti A M F. Steelmaking process: Neural models improve end-point predictions [J].Computer Aided Chemical Engineering, 2004, 18(04):631-636.
[5] Omran M,Fabritius T.Effect of steelmaking dust characteristics on suitable recycling process determining: Ferrochrome converter (CRC) and electric arc furnace (EAF) dusts[J].Powder Technology,2016,308 (2017):47-60.
[6] Bodor M, Santos R M, Cristea G, et al. Laboratory investigation of carbonated BOF slag used as partial replacement of natural aggregate in cement mortars[J].Cement & Concrete Composites,2016,65:55-66.
[7] Brezny B. The Microstructures and Properties of Magnesia-Carbon Refractories [J]. Key Engineering Materials, 1993, 88: 21-40.
[8] Cunha A P, Pacianotto T A, Fileti A M F. Steelmaking process: Neural models improve end-point predictions[J]. Computer Aided Chemical Engineering, 2004, 18(04):631-636.
[9] Almeida S M,Lage J, Fernández B, et al. Chemical characterization of atmospheric particles and source apportionment in the vicinity of a steelmaking industry[J]. Science of the Total Environment,2015, 521–522:411-420.
[10] Hleis D, Fernándezolmo I, Ledoux F,et al. Chemical Profile Identification of Fugitive and Confined Particle Emissions from an Integrated Iron and Steelmaking Plant[J]. Journal of Hazardous Materials, 2013, 250–251(2):246-255.
[11] Cullen J M, Allwood J M, Bambach M D. Mapping the Global Flow of Steel: from Steelmaking to end-use goods[J]. Environmental Science & Technology, 2012, 46(24): 48-55.
[12] Singh R K, Murty H R, Gupta S K, et al. Development of Composite Sustainability Performance Index for Steel Industry[J]. Ecological Indicators, 2007, 7(3): 565-588.
[13] Draney C T. Converter Furnace,US2288272[P]. 1942. US2288272.
[14] Jiang H. Design and Practice of Converter Lining Protection Technology by Slag Splashing [J].Steelmaking, 2000.
[15] Wang L. New Technology on a 300t-Converter Shell Replacement at Baosteel[J].Metallurgical Equipment, 2002.