

The Design for 3000 m³ Blast Furnace

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Abstract. This design mainly includes the design of blast furnace type, the design of furnace lining, the selection of blast furnace cooling equipment and the design of tuyere and iron outlet. The main body of blast furnace is divided into five parts: throat, body, waist, chamber and chamber. The cross section of the blast furnace is the circular ironmaking shaft furnace, the steel plate is used as the furnace shell, and the furnace shell lining is firebrick lining. At the same time, the design of blast furnace with small environmental pollution, the furnace body structure and auxiliary system must meet high temperature resistance, high pressure resistance, corrosion resistance, good sealing performance, reliable work and long service life to achieve high quality, low cost, high output, long life of furnace life. Good quality, high output, low consumption and other requirements. In the design of blast furnace body, the size of blast furnace body is calculated according to technical and economic indexes, and the furnace shape is determined. Reasonable allocation of firebrick, reasonable choice of blast furnace cooling equipment, reasonable design of tuyere and iron outlet.

1. Introduction

Blast furnace ironmaking is the process of smelting iron ore (including natural ore and artificial enrichment) into pig iron. Blast furnace ironmaking plant is an important part of iron and steel enterprise and an independent factory of ironmaking production. The main products are steel making and cast iron. The blast furnace ironworks of steel mills are mainly engaged in the production of pig iron, while independent ironworks usually produce iron according to actual needs^[1].

The development model of China's large blast furnace is similar to that of foreign countries. It mainly adopts the new large blast furnace and combines some old and small blast furnaces into large blast furnaces to expand the capacity of blast furnaces and promote the large-scale development of blast furnaces. According to incomplete statistics, since 2000, China has built and put into operation 15 seats in the 3,200 m³ class, 8 seats in the 4,000 m³ class and 3 seats in the 5,000 m³ class. Hebei mobile steel and Shandong Jinan steel are also building 4,000 m³ blast furnaces. Recently, Baosteel Zhanjiang and Wuhan iron & steel Fangchenggang projects are also planning to build 5,500 m³ of extra-large blast furnaces^[2-10].



2. BF profile design

This design is a five-stage blast furnace type, and a simplified internal model is shown in Fig 1. h_1 : height of hearth; h_2 : height of furnace abdomen; h_3 : height of furnace waist ; h_4 : height of furnace body; h_5 : height of furnace throat.

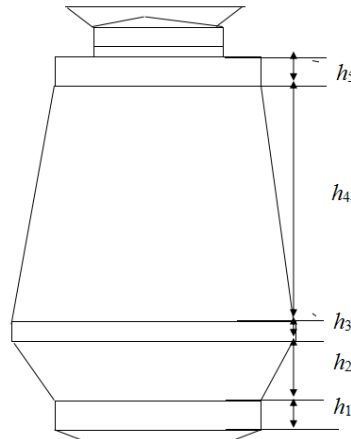


Fig. 1 Schematic diagram of furnace profile

2.1. Furnace design requirements

The design principle of furnace type is to set the proportion of each area size. The type of blast furnace should meet certain smelting strength, reduce the coke ratio reasonably, can extend the service life of blast furnace. With the improvement of smelting conditions, equipment level and operation level, the inside of the blast furnace gradually develops into a dumpy shape^[11].

2.2. Furnace design method

The furnace type design is to reasonably determine the size of each area between the scale. This is because the ratio between the dimensions of the furnace components affects and limits each other. Unilateral overemphasis on enlarging or reducing the size of a part will adversely affect the production of blast furnace, and the appropriate proportion of these will vary with the effective volume of furnace, lining structure, fuel and operation^[12].

2.3. Calculation of blast furnace effective volume

(1) Determining the annual pig iron task of blast furnace

It is known that the annual output of this design is 5 million tons of steelmaking pig iron, i.e., the annual pig iron task is: $P=5000000$ t/a

(2) The daily output P of blast furnace is caculated: $P=p/(m \times 355)$, Where, m is the number of BF, and which is 2 in the design; 355 is the working day of blast furnace year, then, The daily output of blast furnace is: $P=7333$ t

(3) One can calculate the effective volume of blast furnace V_u , $V_u=p/n=p \times K/I$, where, K is the coke ratio of each ton of pig iron, and which is 0.45 in this design; I is the smelting strength, and which is 1.1, then , the effective volume of blast furnace is 3000 m^3 .

2.4. Calculation of mold size in blast furnace

(1) The diameter of furnace cylinder is the parameter to determine the burning amount of coke and the iron output capacity of large blast furnace. $d=0.4087V_u^{0.4205}=0.4087 \times 3000^{0.4205}=11.677$ m, then the value of d can be used as 11.7 m.

(2) Diameter of furnace waist.

It is determined by the diameter of furnace cylinder, the Angle of furnace waist blast furnace and furnace waist, etc., and the permeability of slag is proportional to the diameter of furnace waist. The empirical formula is: $D=0.5684 Vu^{0.3942}=0.5684 \times 3000^{0.3942}=12.981$ m, then the value of D can be used as 13.0 m.

(3) Diameter of furnace throat. $d_1=0.431 Vu^{0.377}=0.4317 \times 3000^{0.377}=8.769$ m, then the value of d_1 can be used as 8.8 m.

(4) Height of hearth. It is required to be able to store the amount of primary iron and primary slag.

$h_1=1.4206 Vu^{0.159}-34.8707 Vu^{0.841}=5.004$ m, then the value of h_1 can be used as 5.0 m.

(5) Belly height

The furnace burden in the furnace decreased slowly, and the unrestored ore was completely restored and entered into the furnace abdomen. The furnace abdomen was slightly higher during pig iron smelting, making the ore more responsive.

$h_2=(1.6818 Vu+63.5879)(Vu^{0.7848}+0.719 Vu^{0.8129}+0.517 Vu^{0.841})^{-1}=3.497$ m, then the value of h_2 can be used as 3.5 m.

(6) Height of furnace body

It is affected by factors such as the size of furnace particles and the strength of coke.

$h_4=(6.3008 Vu^{-47.7323})(Vu^{0.7848}+0.7833 Vu^{0.7701}+0.5769 Vu^{0.7554})^{-1}=16.23$ m, then the value of h_4 can be used as 16.2 m.

(7) Height of furnace throat

The furnace throat plays an important role in controlling the material running and air flow distribution. The higher the height of the furnace throat, the higher the working burden of the furnace throat will be $h_5=0.3527 Vu^{0.2446}+28.3805 Vu^{-0.7554}=2.548$ m, then the value of h_5 can be used as 2.5 m.

(8) Waist height

In the position of the furnace abdomen, the load of the furnace abdomen decreases slowly, and the non-reductive ore is reduced completely before entering the furnace waist. Therefore, the height of furnace waist should be suitable to the capacity of furnace abdomen. If the furnace abdomen is too large, the material may not work before entering the furnace waist.

$h_3=0.3586 Vu^{0.2152}-6.3278 Vu^{-0.7848}=1.982$ m, then the value of h_4 can be used as 2.0 m.

(9) Effective height

The effective height of blast furnace affects the heat exchange capacity and reduction capacity of blast furnace and affects the air permeability.

$$h_1+h_2+h_3+h_4+h_5=29.2 \text{ m}$$

(10) Number of vents

The central distance between adjacent vents is used to calculate the number of vents. $n=3.14 \times d/1.3=28.23$, then the value of n can be used as 28.

(11) Furnace waist Angle is 79.5° .

(12) The furnace body Angle is 82.6° .

(13) Checking the furnace capacity

Furnace cylinder volume: $V_1=656.33 \text{ m}^3$; Furnace volume: $V_2=419.44 \text{ m}^3$; Furnace waist volume: $V_3=265.33 \text{ m}^3$; Furnace volume: $V_4=1429.60 \text{ m}^3$; Furnace volume: $V_5=151.97 \text{ m}^3$.

3. Conclusion

This design is aimed at 3000 m^3 and the following conclusions are obtained.

(1) Diameter of hearth is 11.7 m; Furnace waist diameter is 13.0 m; Diameter of furnace throat is 8.8m; Height of hearth is 5.0 m; Furnace abdomen height is 3.5 m; Height of furnace body is 16.2 m; Furnace throat height is 2.5 m; Effective height is 29.2 m.

(2) The height of dead iron layer is 2.0 m; The number of tuyere is 28; Bosh Angle is 79.5° , shaft Angle is 82.6° .

(3) Finally, the furnace capacity was checked.

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