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Carburizing Furnace: Calculation of Heat Transfer

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Abstract: Carburizing is a chemical-heat method where steel parts are put into the environment (solid, liquid or gas) with the capable of dissociating the active atom of the diffused atom, then heating it up to suitable heat. The processes occur in three successive stages: segregation, absorption and diffusion. Furnace is used to improve the mechanical properties of the machine parts. However, the calculation of tonal design of the furnace is quite complex. The article presents the method of thermal calculation and design of the furnace.
Keywords: carburizing furnace, heat transfer, thermal calculation

1. Introduction

In the market economy, the quality determines the competitiveness of the product. For mechanical products, one of the most important, if not the most important, determines the quality of the product is the thermal process. Training. In equipment used in all industries there are many components that require a hard surface and abrasion resistance, high strength and durability on the entire base, typically shaft type, gear type, clam type. The heat treatment is the method of effective processing to meet the requirements of the work of that. Heat treatment is a technology that increases the content of one or more elements on the surface to increase hardness, reaching 60-65HRC, which increases the abrasion resistance. The base content of the components does not change so they retain their toughness.

The requirement of multifunctional furnace is to create a positive pressure to ensure the permeability. In addition, with the infiltration equipment, the air inlet system and in the infiltration equipment required by the Hanoi Department of Science and Technology, automatic control of the infiltration process is required. When developing technological processes for each product, the most basic parameters of the permeability process such as temperature, time, hardness and thickness of the permeability layer are required in advance to meet that requirement. The most important factor is the device. Good equipment will promote the advantages of the infiltration layer and avoid the disadvantages of infiltration technology. Therefore, the subject goes into calculating the design of the multifunctional infiltration furnace in which the heat exchanger calculation calculates the furnace. Permeability is the most important issue.

About permeability equipment: Currently, Vietnam mainly uses the equipment of the Soviet Union (old) with backward process, the current process is still incomplete. There are many institutes and enterprises in the country started the fabrication. However, domestic production equipment has not been studied properly. The parameters of the blast furnace are not controlled automatically. Also several major mechanical units imported some permeability equipment of Korea or some other countries. However, these devices can only be applied to a specific infiltration technology (not suitable for small and medium enterprises). Moreover, these devices can not actively source imported gas materials. This leads to poor product quality. Some modern equipment (plasma nitrogen absorption) is very expensive. Maintenance mode is extremely complicated. The source of gas is completely imported from abroad so not active gas.

2. Material and dimensions of the infiltration furnace

Carbon monoxide is a heating process in which iron or steel is heated with the presence of other material (below the melting point of iron) that can be released into the carbon as it decomposes. The outside surface will have a higher carbon content than the original. When iron or steel is cooled rapidly by me, the outer surface with high carbon content becomes hard, while the core retains its softness and toughness. It is possible to recognize this production process according to the following key features: for low carbon components; Contact details for gaseous, liquid or solid substances that are high in carbon; Produces a hard surface; The detail core almost retains toughness and flexibility; And the depth of the hard surface is up to 6.4 mm

Carbon permeability to steel involves the metal surface heating using solid, liquid, gaseous or plasma carbon sources. Previously, carbon sinks were made by direct exposure to coal on the metal, but modern techniques use carbon-producing gases or gasses (such as carbon dioxide or methane). The process depends mainly on the composition of the surrounding gas and the furnace temperature. These factors need to be carefully monitored as heat can affect the microstructure of the material. When required to control the composition of the gas, carbon permeability can be realized at low pressure in the vacuum chamber.

Plasma carbon dioxide is being increasingly used in the industry to improve the surface properties of some metals, especially stainless steel, as it is environmentally friendly (compared with the use of gases or substances Liquid) and can work evenly on a complex shape (plasma can penetrate holes and narrow slits).

The carbon-based process is based on the transfer of carbon atoms to the surface of a metal. Metal consists of metal atoms bonded tightly to each other in a metal lattice, carbon atoms embedded in the lattice can be integrated into a solid solution (low temperature) or reflective Corresponds to the metal base forming the ceramic carbide (high temperature). Both of these mechanisms increase the durability of the metal surface but have different effects: The first mechanism, known as solid-state hardening, improves metal corrosion resistance. No significant increase in hardness; The second mechanism, called precipitation, increases the hardness, but often affects the corrosion resistance of the metal. The choice of mechanism is up to the request.

A major requirement for carbon sequestration is to ensure maximum contact between carbon details and sources. When using gas or liquid, the details are held on a basket or wire mesh. When solid, particulate and carbon sources are applied to a container to ensure contact occurs at the maximum possible surface area, this container is typically of aluminum or aluminum alloy steel. Nickel-chrome and covered with clay.

2.1. Furnace materials

Refractory bricks include Samot A, Samot B. Insulated brick including diatomite, ceramic insulating cotton. In addition to the standard size brick, we also put some malleable tiles to support the resistor wire
Calculate the oven dimensions
a) Dimension of stem body:
Diameter of furnace: $D_{out} = D_{furnace} + 2 * (\delta_1 + \delta_2 + \delta_3 + \delta_4 + \delta_5)$
δ_1 : corresponding thickness of the heat-resistant layer Samot
δ_2 : dielectric insulating bricks
δ_3 : ceramic insulating cotton
δ_4 : thickness of sheet metal
δ_5 : distance between the stove and the first wall
b) Height of the furnace body:

$$H_{out} = H_{furnace} + (\delta_1 + \delta_2 + \delta_3 + \delta_4 + \delta_5)$$

δ_1 : corresponding thickness of the heat-resistant layer Samot
δ_2 : dielectric insulating bricks
δ_3 : ceramic insulating cotton
δ_4 : thickness of sheet metal
δ_5 : distance between the stove and the first wall
c) Dimension of the lid: The lid size does not include the propeller shaft and lifting system. Dimensions are as follows:
δ_1 : the corresponding thickness of the Samot heat-resistant layer
δ_2 : the thermodynamic brick
δ_3 : ceramic insulating cotton
δ_4 : the thickness of the sheet

2.2. Calculation of the thermal equilibrium process and the kiln capacity

To determine the capacity of the furnace, it is necessary to know the thermal conductivity, the specific heat of the furnace materials and the details.
a) The thermal conductivity coefficient λ (W/m.K) can be calculated by the following formula:
Brick samot A: (γ = 1800kg/m^3)

$$\lambda_1 = 0.400 + 0.000350 * t_{tb}$$

Brick diatomite (γ = 500kg/m^3)

$$\lambda_2 = 0.280 + 0.00023 * t_{tb}$$

Cotton insulation (γ = 200kg/m^3)

$$\lambda_3 = 0.0755 + 0.00023 * t_{tb}$$

Where ttb is the average temperature of the corresponding brick. For this calculation we calculate the maximum temperature in the oven (at the resistor 1000^{o}C).

b) Heat loss includes: Heat through the wall; pass the gate. Through walling for three parts: bottom, side walls and top. Through the side walls of three layers. To calculate the average temperature of each tile, it is necessary to know the temperature at each surface of each layer. The contact temperature between the layers must be preset for calculation and then check again if the test value Approximate to the hypothetical value, accept the calculated value is true. We can assume the class temperatures as follows:

- The contact temperature between the samot brick (layer 1) and the ditodermite layer (layer 2): t_{12}
- Contact temperature between the emitter layer and the insulating layer (layer 3): t_{23}
- The contact temperature between cotton and sheet
- Iron and outer shell temperature

Average temperature :

$$t_1 = \frac{t_{in} + t_{12}}{2}$$

$$t_2 = \frac{t_{12} + t_{23}}{2}$$

$$t_3 = \frac{t_{23} + t_{out}}{2}$$

$$\lambda_1$$

Heat flow through the furnace wall:

$$P_{wall} = \frac{t_{in} - t_o}{R}$$

R - thermal resistance: R = Rin + R1 + R2 + R3 + R_{out}
λ - heat transfer coefficient of the laminated material;
F - average area between classes;
δ - thickness of layers

$$R_{in} = \frac{1}{\alpha_1 * F_{in}}$$

$$R_{out} = \frac{1}{\alpha_2 * F_{out}}$$

α_2 is heat transfer coefficient from outside wall to air environment. Because the furnace surface temperature is more 1100^{o}C, R_{in} does not count. Re-check the temperature of the layers by the equations

$$t_{12} = t_{in} - P * R_1$$
$$t_{23} = t_{12} - P * R_2$$
$$t_{34} = t_{23} - P * R_3$$
$$t_{out} = t_0 + P * R_{out}$$

The calculated temperature is consistent with the initial hypothesis temperature.

2.3. Heat lost through the bottom.

Wall materials like the material of the vertical layer: F_{in}, F_2, F_3, F_{out},
Average square

$$F_{1\ average} = \sqrt{F_{in} * F_2}$$
$$F_{2\ average} = \sqrt{F_2 * F_3}$$
$$F_{3\ average} = \sqrt{F_3 * F_{ngo\ ài}}$$

2.4. Heat through the door of lid

Radiation through the furnace door according to the Stefan - Boltzman formula

$$Q_{radiation} = C * \left[\left(\frac{T_{furnace}}{100}\right)^4 - \left(\frac{T_o}{100}\right)^4\right] * F * 10^{-3} kW$$

C – The radiation coefficient, hole in the wall can be calculated as the absolute black body and equal to 5.67 kW/m^2.K^4;
$T_{furnace}$ – Absolute temperature of the working range of the furnace
To – The absolute temperature of the environment around the furnace
F – Effective radiation area of the hole, F = F_0*Φ
The open coefficient Φ depends on the size ratio of the furnace, ie the width and height for the wall thickness can be taken 0.76.
The total heat loss of the furnace is:

$$Q_{total} = Q_{wll,lid,bottom} + Q_{open}$$

Determination of furnace capacity and heating capacity details:
Suppose it is absorbed with a maximum weight of 200kg.
Heat function of steel is

$$I = C * (t_{ct\ end} - t_{begin})$$

3. Conclusion

The paper presents the method of calculating and infiltration furnace. Determine the maximum capacity of the blast furnace; Provide specific design drawings of multifunctional furnace. Besides, there are many elements or materials that can be used to carry out this process, most of which are high in carbon. Some common types are carbon monoxide (CO), sodium cyanide (NaCN) and barium chloride (BaCl) or charcoal. When using gas, CO is produced from propane or natural gas. When using liquids, CO is produced from molten salts with predominantly NaCN and BaCl content. When using solids, carbon is produced from charcoal or coke.

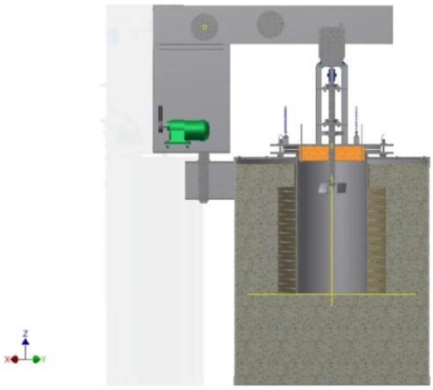

Figure 2: Cross section of multifunctional furnace

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