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Design on the furnace for heat treatment of welding

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Abstract
In some industries, the application of welding bonding between two different metal plates is increasingly concerned. The recrystallization phenomenon is proved with the second welding at the thermal influence zone and indicates equal particle size after the second welding turn. The δ - ferrite content is found with the highest value of all cases in the first welding in the melting zone. Moreover, the recrystallization method of the melting zone changes from course to δ - ferrite needle to fine and bone-shaped structure in one to three turns. Obviously, their occurrence is the cause of the formation of internal grain formation and significantly creates limited SCC of the weld. In addition, the disruption of the structure at the phase of the phase also increases the SCC sensitivity of sample weld phase molasses. Welded heat treatment equipment in the world is usually controlled completely automatically with the existing heat treatment process (cost of process is often very expensive). Normally, the price of welding heat treatment equipment usually costs around $ 10,000 per device and is required to buy some heat treatment processes at quite expensive prices. Therefore, it is difficult for domestic enterprises to access these devices.

Keywords: weld, maritime industry, heat treatment, furnace

1. Introduction

In the marine economic development strategy, the maritime industry plays an important role, in which seaports are the development nucleus, the focal point for receiving and transporting import and export goods and circulation to all parts of the country. Shipping is currently responsible for up to 90% of import and export goods and a part of goods to regions, is the main artery in the transport and distribution system of the economy. Currently, Vietnam shipbuilding industry is still facing many difficulties and limitations. First of all, according to the information shared by Mr. Dam Dinh Vinh, expert of International Ship Brokerage Company Maersk Broker, the shipbuilding market around the world is currently very fierce as demand for shipbuilding is declining. Prices in all ship segments are relatively low and shipyards in general are competing fiercely in all areas such as ship type, pricing, financial and service issues. Regarding internal limitations, the construction capacity of Vietnam's shipbuilding industry currently only reaches 30-40% of design capacity. Supporting industry is very important for shipbuilding industry, but the progress of supporting industry development is slow, investment is spread, the localization rate is not reached. In terms of human resources, shipbuilders with international certificates are very few compared to the requirements. In terms of design, according to experts, the technical design stage currently only meets the requirements for small and popular vessels. Vietnam does not have a model test tank of international standards to develop new designs, all technical designs of export vessels still buy from foreign countries. This is the weakest point of Vietnam's shipbuilding industry today and will be a weakness in the coming time if there is no policy to prioritize investment and train design engineers. Metal is a material that has beneficial properties for construction: high strength, ductility and high fatigue resistance. As a result, metal is widely used in construction and other engineering industries. In its pure form, due to its low strength and hardness, high ductility, metal has a very limited use range. They are mainly used in the form of alloys with other metals and metals, such as carbon. Iron and its alloys (steel and cast iron) are called ferrous metals; the remaining metals (Be Mg, Al, Ti, Cr, Mn, Ni, Cu, Zn, etc.) and their alloys are called non-ferrous metals. Depending on the use and condition of

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the use of metal structures, the importance of houses and buildings people use different types of steel to withstand different temperatures of outdoor air. 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 60-65 HRC, which increases the abrasion resistance. The base content of the components does not change so they retain their toughness.

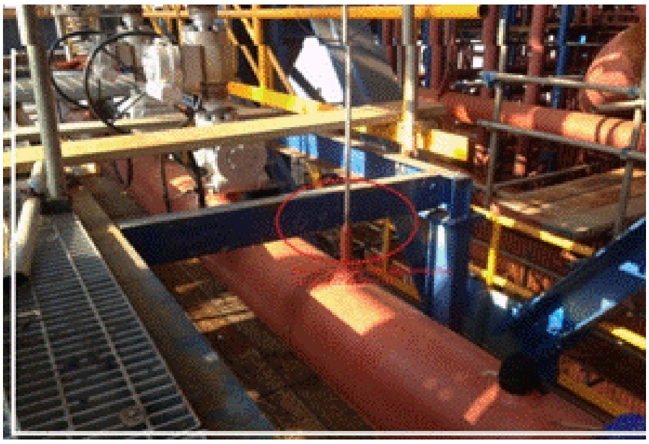

Fig. 1: Welding dust shields of the boiler roof section between 304L austenitic stainless steel and carbon steel

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.

2 Material and dimensions of the infiltration furnace

For austenitic stainless steels, the temperature of stress reduction annealing is usually between (550 - 1100)^{0}C depending on the purpose of the heat treatment process (stress reduction or microorganism adjustment). When you want to remove part of stress without affecting welding area organization, the temperature is usually in the range (550 - 650)^{0}C. To significantly reduce residual stress or change microstructure to improve weld quality, annealing temperature is in the range (650 - 900)^{0}C.

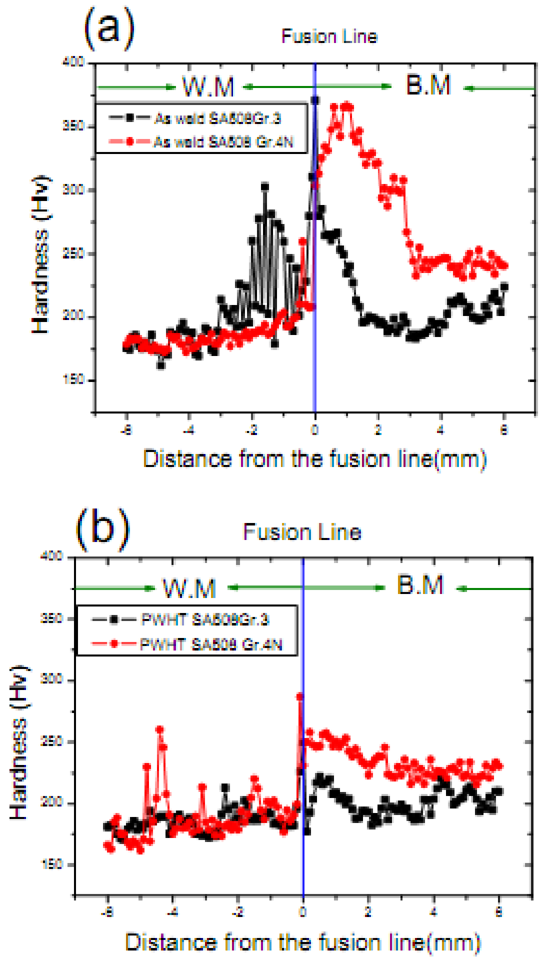

Fig. 2: Micro hardness of weld before and after heat treatment.

At this time, both the M23C6 carbide and the sigma phase will be formed very quickly. This case is often applied when weld metal is completely austenitic or metal electrode is low carbon steel. In other cases, when you want to completely eliminate residual stress, change the microstructure of the weld without the formation of carbide, the annealing temperature can reach (950 – 1100^{0}C). Technological processes as well as technological parameters in the heat treatment process before and after welding greatly affect the quality of the weld. The choice of appropriate process design depends on the nature of the material, the previous welding mode as well as the working condition of the weld. There are a lot of researches around the world, especially when welding two different materials. There were many studies have condicted about the effect of heat treatment after welding on welds between two different materials SA508 Gr.4N and SA508 Gr.3 with electrode is 308L and 309L, welding method is SAW. With a heating temperature of 610K for 30 hours, the highest hardness obtained in the weld metal area, the lowest hardness in the region near the melting line for both types of steel. In addition, by using EPMA by road scanning, the author also concluded that the hard area is a carbon-rich region and that more bits of carbide are released and the soft area is at a low carbon position and the content of carbide is less.

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

So the outside diameter of the furnace is: D_{out} = 1.276m

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

$$H_{out} = 1.485\text{m}$$

c) Dimension of the lid

The lid size does not include the propeller shaft and lifting system. Dimensions are as follows: The lid is 0.45m in diameter

δ_1 : the corresponding thickness of the Samot heat-resistant layer is 0.115m

δ_2 : the thermodynamic brick is 0.115m

δ_3 : ceramic insulating cotton is 0.065m

δ_4 : the thickness of the sheet is 0.0055m

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)

It can be calculated by the following formula:

Brick samot A: (γ = 1800kg/m^3)

$$\lambda_1 = 0.407 + 0.000349 * t_{tb}$$

Brick diatomite (γ = 500kg/m^3)

$$\lambda_2 = 0.279 + 0.000233 * t_{tb}$$

Cotton insulation (γ = 200kg/m^3)

$$\lambda_3 = 0.0756 + 0.000233 * t_{tb}$$

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°C). Heat conduction of steel shell is 35 W/m.K.

b) Specific heat capacity kcal/kg.K

The specific heat capacity of the brick depends very little on the temperature, which can be taken for the type is 0.22kcal/kg.K. The average specific heat capacity of the steel shaft at 20oC is 0.11kcal / kg. Also at 900 to 1000°C is 0.17 kcal/kg.K. The average specific heat capacity of the heat-resistant shell is 0.14 kcal/kg.K

c) Heat loss

Heat through the wall; pass the gate. Through walling for three parts: bottom, side walls and top. Through the side walls of three layers. The surface area in the furnace wall is:

$$F_{in} = \pi * 0.655 * 1.055 = 2.171\text{m}^2$$

Surface contact area between layer 1 (Samot) and layer 2 (diatomite) is:

$$F_2 = \pi * 0.77 * 1.208 = 2.922\text{m}^2$$

Surface contact area between layer 2 (diatomite) and layer 3 (cotton insulation) is:$F_3 = \pi * 0.885 * 1.362 = 3.787\text{m}^2$

$$F_{out} = \pi * 1.276 * 1.485 = 5.953\text{m}^2$$

Average square

$$F_{1\,average} = \sqrt{F_{trong} * F_2} = 2.512\text{m}^2$$

$$F_{2\,average} = \sqrt{F_2 * F_3} = 3.327\text{m}^2$$

$$F_{3\,average} = \sqrt{F_3 * F_{ngoài}} = 4.748\text{m}^2$$

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} = 830^{0}C
- Contact temperature between the emitter layer and the insulating layer (layer 3): t_{23} = 440°C
- The contact temperature between cotton and sheet is: 65°C
- Iron and outer shell temperature is 60°C

Average temperature:

$$t_1 = \frac{t_{in} + t_{12}}{2} = 915^0\text{C}$$

$$t_2 = \frac{t_{12} + t_{23}}{2} = 620^0\text{C}$$

$$t_3 = \frac{t_{23} + t_{out}}{2} = 235^0\text{C}$$

Brick samot A: (γ = 1800kg/m^3)

$$\lambda_1 = 0.726[\frac{W}{m.K}]$$

Brick diatomite (γ = 500kg/m^3)

$$\lambda_2 = 0.261(\frac{W}{m.K})$$

Cotton insulation (γ = 200kg/m^3)

$$\lambda_3 = 0.130(\frac{W}{m.K})$$

Heating coefficient α_2 = 9.1kcal/m.h.K = 11.154W/m.K; Heat flow through the furnace wall:

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

R - thermal resistance: R = R_{in} + R_1 + R_2 + R_3 + 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 1100°C, Rin does not count. The actual heat transfer through the wall is:

$$P_{wall} = 2.96073[\text{kW}]$$

Check the temperature of the layers

$$t_{12} = t_{in} - P * R_1 = 813.47^0C$$
$$t_{23} = t_{12} - P * R_2 = 422.65^0C$$
$$t_{34} = t_{23} - P * R_3 = 63^0C$$
$$t_{out} = t_0 + P * R_{out} = 62^0C$$

The calculated temperature is consistent with the initial hypothesis temperature.

So the chosen temperature is correct and the heat loss through the wall is P = 2960.73W

2.3. Heat lost through the bottom.

Wall materials like the material of the vertical layer:

$$F_{in} = \pi r^2 = \pi * (0.3275)^2 = 0.337m^2$$
$$F_2 = \pi r^2 = \pi * (0.4075)^2 = 0.522m^2$$
$$F_3 = \pi r^2 = \pi * (0.5245)^2 = 0.778m^2$$
$$F_{out} = \pi r^2 = \pi * (0.6875)^2 = 1.325m^2$$

Average square

$$F_{1\ average} = \sqrt{F_{trong} * F_2} = 0.419m^2$$
$$F_{2\ average} = \sqrt{F_2 * F_3} = 0.637m^2$$
$$F_{3\ average} = \sqrt{F_3 * F_{ngoài}} = 1.015m^2$$

Assume temperature classes are as follows:

The surface temperature in the furnace wall is 1000°C

Temperature between layers: t_{12} = 830°C; t_{23} = 440°C; t_{34} = 60°C

Shell temperature: t_{max} = 50°C

The average temperature between classes will be:

$$t_1 = \frac{t_{in} + t_{12}}{2} = 915^0C$$
$$t_2 = \frac{t_{12} + t_{23}}{2} = 635^0C$$
$$t_3 = \frac{t_{23} + t_{out}}{2} = 230^0C$$

Heat conduction coefficient for each layer:

Brick samot A: (γ = 1800kg/m^3)

$$\lambda_1 = 0.726[\frac{W}{m.K}]$$

Brick diatomite (γ = 500kg/m^3)

$$\lambda_2 = 0.262(\frac{W}{m.K})$$

Cotton insulation (γ = 200kg/m^3)

$$\lambda_3 = 0.129(\frac{W}{m.K})$$

Heating coefficient α_2 = 9.1kcal/m.h.K = 11.154W/m.K. The actual heat transfer through the wall is:

$$P_{bottom} = 0.3769kW$$

Check the temperature of the layers

$$t_{12} = 857^0C$$
$$t_{23} = 563^0C$$
$$t_{34} = 48^0C$$
$$t_{out} = t_0 + P * R_{out} = 45^0C$$

The calculated temperature is in line with the given assumption. So the heat flowing through the bottom is:

P_{bottom} = 376.9 W = 0.3769 kW

2.4. Heat lost through the lid

The lid is divided into three layers (like the bottom):

P_{lid} = 165.39W=0.16539kW

2.5. 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

T_o – 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 0.75.

Hence: $Q_{open} = 0.97kW$

The total heat loss of the furnace is:

$Q_{total} = Q_{wll,lid,bottom} + Q_{open}$ = 4.473 kW

Determination of furnace capacity and heating capacity details:

Suppose it is absorbed with a maximum weight of 200kg.

Heat function of steel at 950°C is

$$I = C * (t_{ct\ end} - t_{begin}) = 158.1kcal/kg$$

Heat needed to heat the metal:

$$Q_{metal} = G * I = 31620kcal$$

Table 1: The table combines the capacity and heat of the furnace

Factors	Results (kW)
Mechanical part firing	18.39
Basket firing	7.57
Air firing	1.5
Bricks firing	5.37
Qtotal	32.83

Heat loss due to power cables accounted for 2% so

$$Q = 1.02 * Q_{total} = 1.02 * 28233.8 = 28798.476kcal/h$$

Determination of oven capacity:

$$P = K * Q = 1.2 * \frac{28798.476}{860} = 40.18\ kW$$

K = 1.2 – Reserve factor. So kiln capacity is 40.18 kW

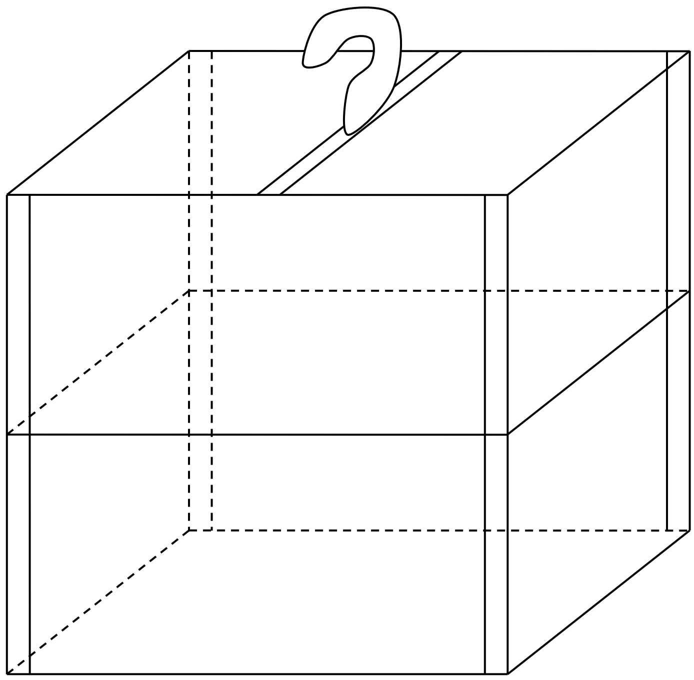

Fig. 3: Heat treatmet furnace

3. Conclusions

The Vietnamese and world maritime industry is now developing and developing both in terms of quality, quality and modernity. Special welds, which are welds between different types of materials, exist many problems that need to be addressed in order to improve the welding quality and life of the equipment. Welds before heat treatment appear welding stress; unevenly organized organization of many natural castings. With such an organization, it affects the quality of the work, especially the working details in special conditions: long-term, heavy-load, constantly changing load ... Therefore, the research Rescue weld structure especially welding two different materials from which to search for weld treatment is essential. The paper presents the method of calculating and calculating the specific design for a 450mm*650mm infiltration furnace. Determine the maximum capacity of the blast furnace; provide specific design drawings of multifunctional furnace.

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