Journal of Engineering and Applied Sciences 3 (6): 440-442, 2008
ISSN: 1816-949X

Design and Application of Medium Frequency Coreless Induction Melting Furnace for Aluminum

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Abstract: In recent years, the MF and its technology are developing rapidly. MF Melting Furnace progressive development, but still there are many technical difficulties. In this study, the present status and future development trend of the captioned furnace are briefly described while the features of the furnace and the technical problems and relevant solutions in the designing, manufacturing and using of the furnace are discussed in detail.

Key words: Medium frequency induction furnace, features, technical problems

INTRODUCTION

In recent years, the capital cost of coreless melting furnaces has been significantly reduced in real-money terms, for a given melting rate. This has been due to the development of high power-density furnaces fed at medium frequency via the solid-state inverter, the output power frequency to alter to maintain tuning to the natural frequency of the coil system. Thus, capacitor switching is eliminated and the power applied to the furnace is dependent solely on the limits of current and voltage within the inverter, these being chosen to allow substantially constant power input to be achieved throughout the melting of a cold charge, the load conditions of which will change during the total melt cycle (Eddgerley, 1977; Stefano, 1975; Rowan, 1971; Meir and Schmidt, 1999b; Meyer *et al*., 1984; Moffatt, 1965; Saluja *et al*., 1990).

It is precisely because of aluminum melting furnace MF these advantages, It widely used. In the past, domestic MF relatively backward technology, MF Melting Furnace less and have less power and tonnage, most of aluminum melting furnace using the frequency coreless furnace or resistance furnace, but the frequency and resistance furnace melting furnace by the aluminum power, loss, efficiency and pollution factors affected seriously impeded its development process.

In light of these problems, this study MF coreless Melting Furnace the main features and based on this, the technical difficulties are further solutions are needed.

MF CORELESS INDUCTION FURNACE MELTING ALUMINUM CHARACTERISTICS

The small Burning Aluminum is a lively metal, heated to its casting, the temperature is about 700°C (the melting point of aluminum 660°C). Aluminum very easy at the moment with oxygen in the air to form a combustion phenomena that Al_2O_3, as a generation of Al_2O_3 powder Slag to be removed and this is the depletion of aluminum. The role of the electromagnetic force, the gas-liquid will eventually be tossed. Al extent of the burning and that the level of oxidation of the aluminum roller degree. Tossed more intense, aluminum liquid contact area and the greater the air, oxidizing more serious, that is burning is, the smaller the contrary.

In order to be able to clearly articulate the problem, given type 1 and Fig. 1.

$$\Delta h = 0.3165\sqrt{\frac{1}{\rho_2 f}} \times \frac{P_2}{S} \times \frac{10^3}{\gamma} \quad (1)$$

Where:

Δh = Said mixing high (also become highly Hump)/cm.
ρ_2 = Said that the resistivity of molten aluminum/Ωcm; f MF frequency/Hz.
P_2 = That the power consumption in Charge/kW;
S = Sensor that was surrounded by the burden surface cm^{-2}.

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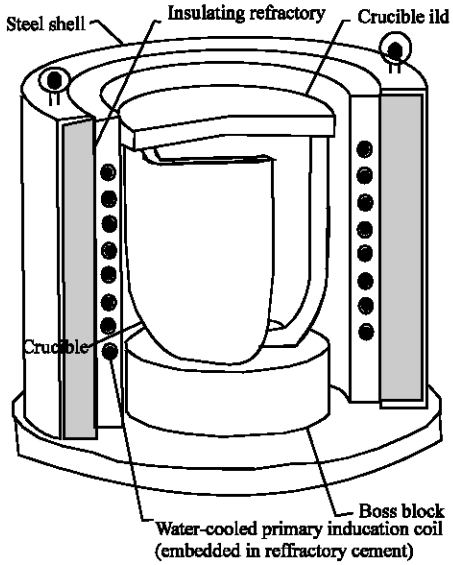

Fig. 1: MF Melting Furnace

γ = said that the proportion of liquid molten aluminum kg cm^{-2}.

Figure 1, we can see the power in the same circumstances, the higher the frequency of power supply and a high degree of mixing of molten aluminum, the lower liquid metal tossed will become weak contrary is stronger, therefore, is to reduce the loss of molten aluminum, increased frequency is a very good channel. IF furnace frequency than the high-frequency furnace. Therefore, IF furnace can be used to reduce the depletion of aluminum components to reduce the degree of oxidation. However, the high frequency furnace manufacturers will increase the difficulty (easy because MFL) and prone to leaking furnace phenomenon, lining will substantially reduce the life span of a short, it should choose an appropriate frequency to achieve optimal results.

The fluctuating axial magnetic field linking the charge within the crucible causes I^2R heating within it. The power induced in the charge depends on the physical properties of the material, the flux linking it and its geometrical shape. For efficient energy transfer to the load, the cross-section of the current paths must be greater than three times the penetration depth of the electromagnetic wave in the material.

Its validation process are as follows:

MF aluminum melting furnace, efficiency:

$$\eta_d = \frac{P^2 r_2}{R} \quad (2)$$

Where:

P_2 = Transform coefficients

$$P_2 = \frac{x_m^{\ 2}}{r_2^{\ 2} + x_2^{\ 2}} \quad (3)$$

r_2 = BURDEN resistance

$$r_2 = \rho_2 \frac{\pi d_2}{h_2 \Delta_2} \quad (4)$$

R = Equivalent resistance system

$$R = r_1 + P^2 r_2 \quad (5)$$

ρ_2 = BURDEN resistivity (liquid aluminium)

Furnace and the noise pollution indicators by the mixing of the F parameter to study,

$$F = \frac{0.3162 P_2}{\sqrt{\rho_2 f.S}} \quad (6)$$

Where:

F molten aluminum that the agitation by electromagnetic force/kg Cm^{-2}, the remaining units and the meaning and parameters of Eq. (1) the same.

By type Eq. (6) can be seen, the higher the frequency *f*, F value of mixing smaller mixing of the smaller, the smaller the vibration of molten aluminum, which makes the noise also furnace smaller and the dust and powder Breathing is the less.

THE TECHNICAL DIFFICULTIES OF MF MELTING FURNACE

Sensor layout and material selection: Layout sensors should be divided into 5 parts, namely short-circuit the upper part of the upper water-cooled coils, the coils, cooling coil and the lower bottom short circuit loop, as shown in Fig. 2. Magnetic yoke arranged in the upper and lower short circuit loop between the magnetic field to show in Fig. 2. Coil should not be too much work, partial layout for the good work of the brass coils should not be less than 4 mm thickness, because aluminum furnace natural low power factor, brass large current density.

MFL: In the whole process of melting, magnetic field vulnerable divergence and the magnetic yoke layout to be reasonable.

First, the magnetic yoke area must be large enough, as long as possible, to ensure sensors axial and radial

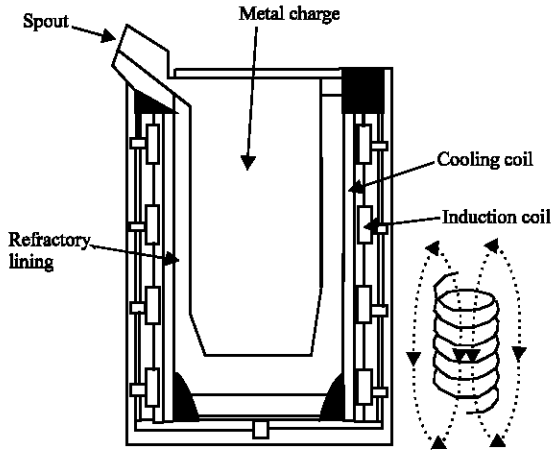

Fig. 2: The 5t MF Melting Furnace

magnetic field sufficient-edge. If the sensor coil is two (parallel anti-around), the Department would consider the middle joints of the magnetic flux leakage problems. Secondly, the distance between the sensors turn hard, to 8 ~ 12 mm suitable.

Lining: MF aluminum furnace vibration because of high frequency of aluminum molten and the aluminum's own characteristics. Aluminum furnace should be used for lining, the lining general good furnace can be used more than 300 times.

Power stability: Initially, the rules without charge distribution, power supply caused by powerful blows, it is easy to burn SCR, production power, it is necessary to step up its consideration of the impact resistance.

DESIGN MF MELTING FURNACE

The 5t aluminum furnace parameters, the size of the design in Fig. 2. d_2' = Charge calculation diameter (124.2 cm); h_2' = Burden of height (172 cm); Δ_2 = penetration depth charge (1.74 cm); r_1 = sensor resistance (1.43×10^{-4} Ω); x_m = 2 Charge System sensors mutual inductance (7.1×10^{-4} Ω); x_2 = furnace Expected inductance (8.4×10-4 Ω), $\rho^2 = 0.24\times10^{-4}$ Ω cm.

Will be all of the above parameters and Eq. (3-5)-can now be designed by the UOT Aluminium 5t aluminum furnace design parameters for example, the size of the design in Fig. 2.

$$\eta_d = \frac{0.7134\times 0.31}{0.364} = 0.608$$

The thermal efficiency of the furnace η_r = 0.96, the total efficiency $\eta = \eta_d \cdot \eta_r$ about 0.58 ~ 0.59. And the resistance of aluminum furnace using thermal radiation heat transfer, design calculation based on past results, the general efficiency of 0.15-0.30.

By type Eq. (1) also can be introduced, according to a certain increase in the proportion of P_2 and f, can $\triangle h$ remain unchanged. In other words, increase power at the same time increasing frequency, high hump can guarantee the same or trace changes. Once, the power increase, aluminum heating rate will be increased, thus enhancing the rate of melting aluminum and aluminum does not add to the degree of oxidation. The resistance furnace heating aluminum resistance wire heating is the use of aluminum will be melted and its efficiency is only 0.15-0.3.

CONCLUSION

Currently, MF coreless induction furnace melting aluminum industry in the application more widely. First, aluminum melting furnace MF frequency less losses than the aluminum melting furnace; Secondly, the electric furnace melting aluminum resistivity high efficiency furnace; third, MF aluminum melting furnace can increase power rates to increase melting section. Fourth, under the same power aluminum melting furnace MF frequency furnace noise and dust pollution less. Along with the further development of intermediate frequency technology and matures, the development of new materials and manufacturing technologies improve, MF Melting Furnace of various technical difficulties will gradually be overcome, MF aluminum melting furnace will also be better application and development.

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