Study and Practice on Direction Blasting Techniques of Heat Metallic Slag

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Abstract: According to the difficult point of direction blasting of heat metallic slag, this paper designs the scheme of blasting on the four aspects: perforation of blasting, schemes of temperature reduction, forms of structure of charge and ways of ignition. It discusses the construction management plan and safe guarding, proposes the experience of these blasting. It can provide utilizations and references for the similar engineering.

1. Project Profile
The project involves a large submerged arc furnace of Haitong Special Steel Co., Ltd. in Jiawang District Industrial Park, Xuzhou City, with the height of 12m, internal diameter of 15m and power of 27000VA (kVA). The submerged arc furnace is a rotary furnace for refining fine ferronickel using laterite nickel ore. More than 1~2m of slag has accumulated in the furnace after more than one year’s operation. If the traditional mechanical construction method is adopted to remove the slag, it will take about half a year, with a high labor cost, long period and low efficiency. Therefore, the owner decided to use blasting technology to remove the slag. It is required to achieve disintegration of the slag by blasting, without damaging the two electrodes in the furnace wall and the electric furnace; and the size of slag block shall be effectively controlled for convenient manual and mechanical cleaning and transport.

2. Engineering Difficulties
(1) High-temperature condensate is a kind of agglomerate of metal and slag, with a high hardness and toughness, and mostly it has only one free surface, so ordinary alloy drill bits cannot achieve perforation on it and the blasting conditions are poor as well.
(2) The temperature inside the high-temperature condensate is generally 800°C~1000°C, and sometimes reaches approximately 2000°C[1]. Therefore, special thermal insulation and cooling treatment must be implemented for the materials to be blasted, to ensure blasting safety, otherwise self-blasting or early-blasting will occur.
(3) The shape of high-temperature condensate has no fixed characteristics, the thickness is within the range of 1.0 to 2.0 m, and it is difficult to observe as located inside the furnace. Therefore, the blasting construction is of high difficulty and repeatability, and the operation needs to take a long time.
(4) The two electrodes in the furnace shall be protected, to ensure that they will not be damaged by the flying chips generated during blasting.

3. Design of Blasting Scheme

3.1. Technical Scheme for Perforation

It is not easy to form a blasthole in the furnace accretion because the hardness of such scale is similar to that of the cemented carbide drill bit, and even the pneumatic drill is difficult to drill holes in the furnace accretion. To form a blasthole in the furnace accretion, the characteristics of the high-temperature molten metal can be fully utilized. Through practical exploration, the hole is pierced from the outside to the inside by means of blowing oxygen. The blastholes are horizontally arranged and raised by about 5° to facilitate the molten metal flows out along the holes to prevent the fluid from forming scale and blocking the holes [2].

3.2. Cooling Scheme

For the case that the temperature in the furnace is too high, the first step is to implement uninterrupted cooling using cooling water in the hole. The furnace accretion still has a temperature as high as 200°C even after the oxygen is blown for cooling through the oxygen blowing tube. To this end, local cooling measures may be taken. Before charging the blasting charge each time, a water pipe is inserted into the blasthole, and the cold water is continuously poured to the furnace accretion, so that the hole wall is rapidly cooled down [2]-[3].

The water tube shall not be taken not for charging until the temperature in the hole is lowered below 80°C as indicated by the automatic thermometer. The second step is to use thermal insulation materials to cool the blasting charge. In this method, the heat-resistant asbestos cloth, asbestos rope and other heat-resistant materials are used wrap the charge, so that the temperature rise speed of the explosive in the high temperature blasthole is slowed down.

3.3. Forms of Structure of Blasting Charge

According to the characteristics of the high-temperature furnace, it is required to deliver the charge quickly and take reliable thermal insulation measures on the charge to prevent any accident. Therefore, the blasting cartridges with sizes from 60mm to 100mm shall be processed according to the hole size. The outer shell of the blasting cartridges is made with cylinder shape by using iron sheet, and the peripheral part shall be wrapped with heat-resistant asbestos cloth. The end of the charge near the bottom of the hole is filled with loess for 20cm, then filled with powdered ammonium nitrate explosive. The middle section of the blasting cartridge adopts 200g military TNT block as the blasting body. Besides, the electric detonator foot line is lengthened at the head end of the blasting cartridge, and wrapped with electrical tape by two layers for protection, to prevent the high temperature from melting the conductive wire and resulting in short circuit. In addition, the head end is pulled by a No. 8 wire to prevent the cartridge from being blocked during charging of the cartridge or the conductive wire from being pulled back upon short circuit. Figure 1 shows the forms of structure of blasting charge.

![Fig.1 Forms of Structure of Blasting Charge](image-url)
3.4. Blasting Method

The temperature in the high temperature furnace is too high, so the explosive charging time is required as short as possible. Therefore, the blasting of charge is achieved in the form of single-hole blasting, one charge hole is blasted each time, based on the electric blasting method.

4. Blasting Parameters

4.1. Layout of Charge Holes

The charge holes are arranged from the outside to the inside of the submerged arc furnace. Considering that if the charge mass dose per linear meter of single hole is small and it is difficult to ensure the blasting effect, the diameter of the blasthole should be slightly larger for the sake of safety, to ensure the charge mass dose meets the unit consumption requirement. Therefore, the blasthole diameter \( d \) is \( 60~100\text{mm} \); the depth of the blasthole is taken as \( 1.5~2.0\text{m} \) according to the burning conditions; and the spacing is \( 1.0~2\text{m} \) depending on the slag shape.

4.2. Charge Mass dose Calculation

According to Literature [4] the charge mass dose calculation formula:

\[
Q = c \left( \frac{2a}{3} - 0.1 \right)^3
\]

Where:
- \( Q \) is the charge weight of a single hole, in kg;
- \( a \) is the thickness of furnace accretion, in m;
- \( c \) is the coefficient, generally taken as \( 1.5 \sim 3.2 \) according to the blasting experience. Usually, a smaller value is taken first, and it may be gradually increased if the blasting effect is not satisfying. When \( c \) is taken as 3.0 according to calculation, \( Q \) shall be taken as 0.55~5.6kg according to the thickness of the slag. From the blasting effect, the calculation result for the charge hole with shallow depth is too small, and the charge mass dose for the hole with depth of about \( 2.0\text{m} \) can basically meet the requirement. Therefore, the minimum charge mass dose for actual blasting is 3.0kg, and the maximum is 6.0kg after the adjustment of charge mass dose.

5. Construction Organization and Safety Protection

5.1. Construction Sequence

The construction sequence for the controlled blasting of high-temperature metal slag is: shut down the equipment after clearing the furnace accretion and workload according to the relevant requirements, evacuate the unrelated personnel off the site outside the furnace prepare for construction. The blasting construction sequence is shown in Figure 2. It should be noted here that the construction sequence of controlled blasting of high-temperature metal slag is different from the general controlled blasting. It not only includes the additional links of water injection for cooling and measurement of temperature inside the hole, but also involves the connection of the lengthened and wrapped detonator foot line with the conductive wire before charging in order to shorten the charging time. Besides, only one hole is charged for each shot. Two operators shall be allocated, one of them is responsible for delivering the charge that was insulated and bundled on the wooden pole to the bottom of the hole as quickly as possible, and the other person is responsible for filling the stem, and then the two operators shall quickly evacuate to a safe place. The interval from the charge to the blasting during each shot shall not exceed lmin.

Fig.2 Construction Sequences
5.2. Safety Protection

In addition to the high temperature protection of the charge, the main hazard of blasting of the accretion is from the flying chips generated from blasting, so the following safety protection measures should be taken.

1. Cover two layers of protective cover on the surface of the blasting body, namely, a thick layer of wet straw, and then cover the straw with a layer of waste belt to prevent the flying chips from damaging the suspension electrodes in the furnace.

2. Outside the slag-removing gate cut on the south side of the furnace body, arrange four iron cabinets right in front of the gate for shielding to prevent damage to the equipment and facilities in the workshop.

6. Effects and Experience

1. The use of the controlled blasting technology has achieved the expected effect on the blasting of high temperature metal slag. After blasting, mechanical and artificial cleaning, the blasting task was completed within 20 days, which has brought benefits for the enterprise.

2. High-temperature metal slag blasting is different from the controlled blasting under general conditions, and it involves many unpredictable factors. Several dangerous situations appeared in this blasting process. Practice has proved that scientific management, solid technical quality and correct operation are important factors to ensure the success of blasting.

3. The calculation formula for the charge mass dose for the blasting of metal slag is mainly determined based on empirical calculation. The blasting medium is very complicated and there is a certain gap to the actual blasting charge dose, further exploration is needed.

References

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