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Research on Welding Process of Cross Wedge Rolling Molds

Li Chenglong

Rizhao Polytechnic, Rizhao 276826, China

ABSTRACT. *Cross wedge rolling molds are very complicated and bulky. It takes a lot of time and energy to process. And the cost of the materials and the processing of the molds is expensive. If the mold is discarded, large waste will be generated. Since the center distance of the rolling mill is adjustable, the old mold can be repaired and renovated to reach a reusable state. This kind of renovation plays a pivotal and practical role in saving the cost of the mold, and it also meets the requirements of energy saving, low carbon, and environmental protection in advanced manufacturing in China.*

KEYWORDS: *Cross wedge rolling molds; Repair welding; Renovation*

1. Introduction

In modern industry, stepped shafts are power transmission mechanisms commonly utilized in production and living areas. Cross wedge rolling technology gradually wins a decisive spot in the manufacturing industry with its advantages such as high material utilization, energy saving, continuous forming and high efficiency.

Cross wedge rolling process refers to the process in which wedge-shaped rollers on the upper and lower mold surfaces rotate in the same direction and drive the intermediate cylindrical billet to rotate. Under the action of radial pressure and a certain speed, the rolled product is forced to compress and roll radially. The material flows axially and finally various shaft products are obtained[1].

The cross wedge rolling mold is very complex, with a large volume, a 1,000 mm inner hole, a 1,230 mm outer circle, and an average weight of 2 tons for each set. So it takes much time and effort to produce the molds, and the cost of materials and the processing adds up to about ￥100,000 on average. However, due to the complexity of the cross wedge rolling mold structure, processing and adjusting process, the mold wears quickly, which results in the reduction of the mold dimensional accuracy and increases the reject rate of the rolled product until the mold is completely scrapped and normal production cannot be performed.

In general, the molds need to be repaired after rolling a batch of 3 million pieces, and scrapped after 8-12 thousand pieces. After the mold is worn, the rolled product will also have quality defects such as loose center and cracks. The service life of each set of molds at the production site is between 30,000 and 50,000 pieces. If the molds are scrapped, large waste will be generated. Since the center distance of the rolling mill is adjustable, the old mold can be repaired and renovated to reach a reusable state. This kind of renovation plays a pivotal and practical role in saving the cost of the mold, and it also meets the requirements of energy saving, low carbon, and environmental protection in advanced manufacturing in China.

2. Reasons for the Effectiveness of the Molds

The life of molds is a comprehensive technical issue. Abrasion is a key factor affecting the life of the mold during the course of processing. The failure rate of the mold can exceed 70% due to the abrasion in continuous rolling under high temperature. The abrasion of the mold is not an inherent characteristic of the material, but related to many complicated factors such as working conditions, mold materials, blank materials, surface morphology, contacting methods and so on. Cross wedge rolling molds cannot be used if it goes through prolonged abrasion or sudden damage. We call it “mold invalidation” which includes early invalidation and normal invalidation. People call molds that cannot be used in the form of severe abrasion, cracking, severe formation, etc. before reaching the service life recognized by industry standards as early failure. Normal invalidation means that after a long period of normal use (when the total time reaches the expected use time), the mold cannot be repaired and eventually scrapped due to creep, slow abrasion, gradual plastic deformation, or

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fatigue failure of the material[2].

Severe deformation: The surface material of the mold softens due to high temperature, high pressure, extrusion, and friction. At the same time, serious deformation of the mold takes place due to external alternating load such as mold elliptical bending, frame, cantilever beam bending and so on.

Fracture: Cracks are mainly caused by stress concentration due to the chilling and heating of the mold. Under the action of cyclic stress, the cracks rapidly expand till the mold breaks, which manifests in the form of cracks on the work roll surface.

Abrasion: Abrasion is the loss caused by the friction due to the intense extrusion of the mold and the heat transfer during the processing. The forms of the failure of the mold due to wear are abrasion, pits, dimensional errors, and so on.

3. Repair Welding and Renovation of Molds

By welding and renovating, the old mold can be used again. The most critical factor is the determination of the technology or process of mold repair welding.

3.1 Mold Repair Welding

3.1.1 Selection of Welding Material Model

The complete set of cross wedge rolling molds is formed by splicing multiple arc-shaped blocks. The arc-shaped blocks do not bond well after repair welding, and the later rolling is easy to fall off, resulting in blank scrap. The optimization of the mold welding materials is necessary. The substrate is fused firmly, and the hardness of the mold after welding must be guaranteed to facilitate subsequent processing. The mold material is 5CrMnMo. After repeated tests, it is determined that the welding material meets the mold requirements. After welding, the welding material has good bonding performance with the mold, and the hardness is about HRC36, which can meet the machining requirements.

3. 1.2 Design of Mold Preheating and Repair Welding Fixture

During the repair welding of the mold, the arc block is prone to large deformation. In order to ensure better bonding between the welding material and the mold, the mold needs to be preheated to 300 ℃ before repair welding. To reduce the deformation caused by heating and repair welding, it is necessary to design a special fixture to ensure that the outer circle of the fixture fits the inner hole of the mold. When entering the furnace and doing repair welding, the mold can be fixed by T-slots with screws. After the mold is cooled, it can be disassembled, which can effectively reduce the deformation of the mold and achieve the expected effect.

3.1.3 Formulation of Mold Repair Welding Process

According to the experimental requirements, the following repair welding processes were formulated.

(1)The molds which need to be repaired will be sent to the repair area of the mold workshop. First, the original repair layer, fatigue corrosion layer, and cracks of the mold are removed by carbon arc planer. Residues, such as scale, top carbon will be removed by shaking the brushes.

(2)Detection: Before welding, measure the dimensions of both sides of the outer arc surface of each mold and make a record.

(3)Preheating before welding:

The mold will be placed on a preheating fixture and then put in a box furnace to be incubated at 300 ℃ for 2 hours.

3.1.4 Welding:

(1) After preheating, the mold should be taken out immediately, cover it with insulation cotton and expose the part to be welded.

(2) The mold material is 5CrMnMo. It is welded with electrode RMD535. After selecting and baking of the electrode. The electrode will be baked in the furnace at 250-350℃ for 1 hour before using. Weld the wedge

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surface, wedge tip and side of the step according to the mold drawing. The thickness is required to be visible during mold processing.

Hardness HRC35-38 is expected after the welding. Blocking and intermittent repair welding sequence is used to prevent welding deformation. The repair welding layer is required to be dense and uniform, and 2-3mm machining allowance is left in each part after welding.

(3) Two or three pieces can be welded alternately at the same time. Remove the slag with a slag gun soon after welding one layer. Finally, do the welding inspection. Check whether the mold is missing with a mold template (used to measure the forming angle and groove size).

4.1.5 Tempering:

Temper in time after welding. Pad the middle of the mold with a refractory brick and suspend both ends in the furnace. Heat to 400 ° C and keep the heat for 2 hours. After coming out of the oven, stand on the ground, cover the mold tightly with insulation cotton, and air-cool to room temperature.

4.1.6 Review:

Measure the dimensions of both sides of the outer arc surface of the mold. Compared with the dimensions before welding, the welding deformation is required to be less than 0.5mm. After passing the test, transfer it to the falling surface process.

4.2 Renovation of Mold Surface

4.2.1 Preparation

Before the mold is installed, clean the arc surface that is in contact with the roll. Use a dial indicator to straighten the mold and control it within the range of ± 0.2mm.

4.2.2 Processing:

The renovation should be in strict accordance with the tooling drawings, generally 2-3mm each time. If one of the landing does not meet the requirements, another attempt should be made.

4.2.3 Review:

Measure the dimensions of the two sides of the outer arc surface of the mold. Compared with the dimensions before welding, the welding deformation is required to be less than 0.5mm. If the requirements cannot be met, notify the technician. When passing the inspection, transfer it to the processing procedure.

5. Conclusion

If the mold is worn, the rolled product will have quality defects such as loose center and cracks. The service life of each set of molds at the production site is between 30,000 and 50,000 pieces. The scrapping of the molds produces large waste. Since the center distance of the rolling mill is adjustable, the old mold can be repaired and renovated to reach a reusable state. This kind of renovation plays a pivotal and practical role in saving the cost of the mold, and it also meets the requirements of energy saving, low carbon, and environmental protection in advanced manufacturing in China.

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