BRIGHT ANNEALING OF WIRE IN SHAFT FURNACES

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At the Lepse plant *Brown-Bovery* shaft furnaces are used for annealing low-carbon wire. Three to four heat-resistant kettles are placed at each furnace which can be set into the furnace in turns. The kettles are provided with lined lids which fit tightly to the casing and which have rubber, water-cooled annular seals (Fig. 1). The lid is fastened onto the kettle by four to six bolts located around the periphery. The charge in the form of layers of coils is suspended from the lid on auxiliary rods.

The protective gas is fed through a pipe bent into an annulus which is fastened to the inner side of the lid. Gas comes out of the pipe and after having enveloped the charge descends and exits through a central pipe welded to the lid of the kettle and terminating on the outer side of the lid in a connecting pipe with a calibrated aperture of 3-4 mm.

There is a shut-off valve below the connecting pipe. There is a unit of control thermocouples in the central pipe. The protective atmosphere comes from the gas preparation station to a distributing box set up on the working platform of the furnaces. Gas is fed to each kettle through a flexible hose. A constant pressure (50-60 mm HgO) of the protective gas is maintained in the collector attached to the box which permits a given gas imput to be maintained for a particular opening in the connecting pipe.

After the charge has been loaded and the lid placed on and tightly sealed, protective gas for scavenging (the shut-off valve below the pipe is open) is fed into the cold kettle located in a cooling well. Without interrupting the supply of protective gas, the kettle is transferred to the electric furnace which has been heated to the working temperature. There is a constant flow of protective gas in and out during the entire time that the charge is heated and held in the furnace. Before removing the kettle from the furnace the outflow of gas is shut off. The charge is cooled to 50°C in the protective atmosphere.

During the time of annealing the gas medium in the kettle is enriched with considerable quantities of moisture. Moreover, as the result of pyrolysis of an emulsion held in the form of a film on the surface of the wire, the medium becomes contaminated with CO, CO₂, and CH₄. In order that a bright surface of the wire be obtained, it is necessary that at the end of heating the medium in the kettle be purged of admixtures. It has been established that this is achieved by feeding into the ladle during heating a quantity of protective gas which corresponds to 0.035-0.040 m³ per 1 m² of surface of the wire being annealed.

Before heating the charge the kettle is purged with protective gas. Purging time is determined according to the empirical formula:

\[ \tau = 4,5 \frac{V}{Q} \text{ h}, \]  

Fig. 1. *Brown-Bovery* shaft furnace: 1) casing of the electric furnace; 2) kettle; 3) rods for suspending the charge; 4) pipe for removal of protective gas; 5) connecting pipe with calibrated opening; 6) lid of the kettle.

* Direct transliteration of Russian — publisher's note.
Fig. 2. Kinematics of variation of the moisture content of the gas medium in the ladle (1) and heating curve of a charge of CB0.8 wire 0.5 mm in diameter (2). The dew point of the protective gas initially is -40°C.

As investigations have indicated, the rate of oxidation in media of the type H₂-N₂ with a low partial pressure of oxygen below 500°C is low and can be neglected.

Thus, heating U9 and Kh05 steels in an H₂-N₂ atmosphere (with 5% H₂) to 500°C, holding at this temperature for a period of 2 h, and cooling (with the furnace) to 50°C provides a bright surface already with a ratio $\frac{P_{H_2}}{P_{H_2O}} = 4$.

Increasing the temperature to 600°C (with $\frac{P_{H_2}}{P_{H_2O}} \leq 6$) occasions intense coloring of the surface with temper colors.

The moisture content of the medium at 500°C is identified with a dew point of 4°C, and at the end of heating with a dew point of -16°C (Fig. 2). Hence, the average moisture content $v_{av}$ amounts to about 0.5%, and the necessary minimum amount of hydrogen to 3.25%. The maximum variation in the concentration of hydrogen in the protective gas with automatic regulation is ±1%. The class of accuracy of the conductometric pickup used in the automatic regulation system amounts to 5% of the maximum value; this constitutes an error in measurement of about 1% H₂.

On the basis of estimates made, the protective gas has the following optimum composition: 5% H₂, remainder N₂, and dew point -40°C.

Annealing stainless wire from Kh18N9T steel which is conducted in furnaces "in passing" without protective gas occasions the necessity of subsequent pickling. Wire production according to the scheme "drawing-annealing-pickling" is permissible only for wire of large and medium dimensions.

The electric through furnaces for annealing stainless wire 0.2-0.5 mm in diameter were designed and manufactured by the Lepse Plant. The wire passes through a pipe 12 mm in diameter made of KhN78T alloy heated from above and below by carborundum heaters. A tubular cooler is installed beyond the furnace. Each muffle is joined with the corresponding tube in the cooler by means of a special collar unit. Protective gas is fed into this unit.