OPTIMUM CHANNEL DESIGN FOR WORKING GLASS TUBES

K. K. Vilnis, V. M. Terent'ev, A. A. Shecherbakov, and V. I. Korenev

In domestic glass melting furnaces for working tubes by the Danner method the glass melt was fed to the mouthpiece machines along a comparatively wide (to 1000 mm) and deep (to 500 mm) channel. In furnaces with six drawing lines only four could operate simultaneously. Using a fifth line resulted in an increase in production waste. The factory specialists attributed this to exceeding the melting capacity of the furnace.

Observation on the state of the mirror of the glass melt in the melting tank showed that the appearance of flaws on the drawn tube when the fifth line was being operated could not result from exceeding the melting capacity of the furnace. Such defects should appear only because of an unsatisfactory design of the feeding channel.

The service life of the channels did not exceed two years. The greatest wear was observed in the bottom refractory: The residual thickness of the chamotte bottom blocks was not more than 50 mm. Covering the bottom with Bakor tiles was of little effect: The chamotte bottom broke up at practically the same rate; the Bakor tiles were greatly damaged. This indicated that an intensive convection of the glass mass occurred in the channel.

Experiments on models showed that with a decrease in total height of the glass melt layer, first of all the thickness of the lower flow is reduced and despite the lowering of the force of the convective exchange the gradient of the flow rate at the bottom increases as a result of which increased failure of the bottom refractories can be expected [1]. However, convection exchange practically does not occur through the neck [2] and the fracture products of refractories remain in the glass melt channel. It is possible, some portion of them are sent out and are dropped into the stagnant zones and during a change in the production flow are drawn into the work. This is substantiated by the deterioration in the quality of the tubes at the end of the furnace campaign; there is an increase in such flaws as cords, stones, and capillaries.

In the development of the improved channel design (done at the All-Union Scientific-Research Institute for Illumination Engineering) the task was proposed to eliminate the convection exchange of the glass mass due to the decrease in its cross-sectional area. Moreover, modeling data and positive service experience with channels were utilized.

During the reconstruction of furnace No. 2 of the Tomsk Electric Lamp Factory the working tank was replaced by channels 350 mm deep and 400 mm wide. To heat the channels special injection burners were constructed. A propane-butane mixture supplied under 5-6 kPa (500-700 mm water col.) pressure served as the fuel.

Operation of these channels showed that at constant gas pressure, a stable glass melt temperature in front of the overflow at the mouthpiece is assured and the productivity of the GVT lines can be raised. Thus, already on the first run it was increased on the average by 19% [3]. However, a 350-mm deep layer does not permit the complete elimination of the convective exchange of the glass mass: It appears during the pause of the working flow (controlled by letting in the coloring material into the tap of the channel with the nonworking line). In this case a poor quality refractory located in one of the taps of the channel (if working is stopped in it) can cause flaws in the glass mass in the working lines.

The experimental channel tap on one of the GVT lines of the furnace in the Smolensk Electric Lamp Factory had a 250 x 400-mm cross section and 4-m length. It was built on to the channel of typical design and was heated by three type B-37 injection burners of the Steel plan design instead of the two conducting ones used before. The channel was made from high alumina refractory.

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Experimental operation of the channel for two years showed that the shallow channel was more sensitive to the temperature fluctuations and the level of the glass melt. This demanded stricter maintenance of the technological regime in the melting tank which resulted in improving the quality of the molten glass. The injection burners facilitate and simplify the maintenance of a stable temperature regime in the channel. After selecting the optimum gas consumption for each of the burners it was not necessary to regulate them during the operation of the line.

As a result of these studies it was established that after stopping the furnace, the high alumina refractory at the bottom and the side walls in the experimental channel was less than 5% broken up and the chamotte bottom of the remaining portion of the channels was more than 60% disturbed.

In the reconstruction of the furnace, new channels were laid in all the lines. The actual depth of the glass melt in the channels was 200 mm. Because there was not a sufficient amount of high alumina refractory the bottom of the channels was made from chamotte bottom block. Decreasing the width of the channels permitted the duplex lines to be separated and in this way to decrease their effect on each other (Fig. 1). Simultaneously during the reconstruction the glass mass level was increased in the furnace over the floor of the mill to create a reserve of drawing speed.

Starting the reconstructed furnace substantiated the original assumptions: All six lines could operate simultaneously; the total glass melt production from the furnace increased by two; the annual tube production grew from 65 to 75%.

During the operation several weak units of the drawing line which hindered raising the speed were modernized. Thus, the rotational frequency of the mouthpiece was increased; a new variable-ratio transformer was set up in the drive mechanism of the machine; an electromagnetic drive mechanism of the chip unit was replaced by a mechanical one; the kinematic assembly scheme for turning the tube was reconstructed, giving a smoother rotation. This made it possible to increase the tube drawing rate from 25 to 38-40 m/min on the machines with a mouthpiece 800 mm long and 195 mm in diameter. The productivity of the line for drawn glass melt increased from 8 to 11-12 tons/day.

Formerly at the factory three furnaces were operated simultaneously for the working of tubes for luminous lamps: two furnaces with a 40 tons/day productivity with four operating lines out of the six set up at each furnace; and one furnace with a 12 tons/day productivity with two operating lines out of the four that were set up. The adoption of the new channel system permitted tubes to be put out only in one furnace with six lines operating simultaneously.

Observations showed that after the first ten months of the furnace run the chamotte bottom of the channels was dissociated for 30-40 mm and in 22 months, maximally for 130 mm. This is two times less than the disturbance of the bottom of the 500 mm deep channels. If you assume to the first approximation that the break-up rate of the refractory is proportional to the gradient of the flow rate of the glass mass at the bottom, then this gradient from the convection flow of the glass mass is two times higher than the gradient created by the production flow in the channel which has one fourth the cross section. The elimination of the glass mass convection exchange in the working channels makes it possible not only to decrease the dimensions of the channels and to lessen the consumption of refractories, but also to facilitate the service conditions, to lengthen the run, and to decrease the contamination of the glass mass.

Thus, as a result of utilizing narrow and shallow channels at the Smolensk Factory the following was established: The 250 x 400 mm channel dimensions are close to optimum; conversion to the new system of locating the channels decreases the consumption of the refractories by approximately two times; the high alumina