EFFECT OF THE DESIGN ELEMENTS OF THE PORT
ON THE WORKING OF A GLASS MELTING FURNACE

S. I. Pechenkin, N. I. Kokarev,
A. A. Tsukanov, M. A. Gromkova,
and L. G. Geroimenkova

An intensification of the thermal working of a glass-melting furnace depends primarily on the design of
the fuel-combustion unit. Transfer of heat is improved significantly where the flame of burning gas comes
close to the surface of the molten glass. Therefore one tries to direct the flame on to the clear surface of
the melt and to retain for as long as possible the levelness of the flame so long as there is no contraindication
from the production requirements relating to the interaction between the gas medium and the glass.

The levelness of the flame is affected by the angle of slope of the crown and paving of the ports and also
by the direction in which the natural gas is supplied. Keeping the level of the flame constant over a significant
portion of its length depends on the rate at which the gas-air mixture is supplied from the port drum or on
the angle of incidence with the clear surface of the glass. Increasing the angle of incidence from 10 to 40° cor-
responds to a 9% increase in the thermal flow [1].

From the data provided by a cold model we have developed a port design [2] which has its crown and
paving sloped towards the surface of the glass (Fig. 1). The distance from the port drum at which the slope
of the crown begins is determined from the ratio,

\[ \frac{l_1}{h} = 1.75 - 2.5, \]

where \( l_1 \) is the distance at which the slope of the port crown begins, m; and \( h \) is the height of the port crown, m.

The distance at which the slope of the paving begins is determined as follows:

\[ \frac{l_2}{h} = 1 - 2, \]

where \( l_2 \) is the distance from the port drum at which the slope of the paving begins, m.

If \( l \) is made less than the lower limit, then the gas-air flow cannot become stabilized in the port and
eddies arise at the outlet from the drum thus worsening the aerodynamic characteristics of the flame. If \( l \)
is made greater than the upper limit, the height of the vertical channel is increased and, consequently, the
consumption of refractories is increased.

Fig. 1. Port: 1) crown of drum; 2) paving; 3) water-cooled gas nozzle.

Fig. 2. The change in the temperature of the flame across the furnace.
Four years ago at the Tuimazinsk Medical-Glass Plant an industrial prototype of a port uptake was installed in the No. 3 furnace with a transverse flame direction. This shaft made an angle of 18° with the crown and of 7° with the paving; the angle made by the water-cooled gas nozzles with the surface of the glass was 7° (Fig. 1) [3].

### Characteristics of Tank Furnace No. 3

<table>
<thead>
<tr>
<th>Area</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>melting end</td>
<td>58.33 m²</td>
</tr>
<tr>
<td>working end</td>
<td>6.77 m²</td>
</tr>
<tr>
<td>Average productivity</td>
<td>24.9 tons/day</td>
</tr>
<tr>
<td>Number of uptake ports</td>
<td>3 pairs</td>
</tr>
<tr>
<td>Consumption:</td>
<td></td>
</tr>
<tr>
<td>natural gas</td>
<td>583 m³/h</td>
</tr>
<tr>
<td>air</td>
<td>6830 m³/h</td>
</tr>
<tr>
<td>Heat loading of furnace</td>
<td>89,000 kcal/(h·m²)</td>
</tr>
<tr>
<td>Temperature:</td>
<td></td>
</tr>
<tr>
<td>melting</td>
<td>1470°C</td>
</tr>
<tr>
<td>auxiliary heating of air</td>
<td>960-1000°C</td>
</tr>
<tr>
<td>exhaust gases in vertical</td>
<td></td>
</tr>
<tr>
<td>channel of port</td>
<td>1360°C</td>
</tr>
<tr>
<td>flue gases in subchequerwork channel</td>
<td>630°C</td>
</tr>
</tbody>
</table>

This furnace is used to melt NS-1 glass.

During the furnace campaign we studied the flame of the uptake port of the new design and carried out a general observation over the furnace. Using an optical pyrometer of the OPPIR type with windows mounted on the back wall to the right and left of the doghouse, we measured the temperatures of the flame at a distance of 1 m from the drum of the working port and at the same distance from the drum of the opposite port. At the same time, the temperature of the flame space along the length of the furnace was measured by sighting the pyrometer on to the flame through the windows beyond the first and third ports. Moreover, we also made observations on all the heat-engineering parameters of the furnace using the appropriate instrumentation. We studied the operation of the water-cooled nozzles of the burners which were installed in place of the ceramic port blocks.

The changes in the temperature across the width of the furnace are shown in Fig. 2. For comparison Fig. 2 also shows the change in the temperature of the flame in the No. 4 furnace, analogous to No. 3, but working with the old port design and without the water-cooled nozzles.

It is clear that the temperature of the flame in the No. 3 furnace at the outlet to the flame space is between 1650 and 1690°C while in the No. 4 furnace, the temperature is slightly lower (1610-1630°C). The temperature of the flame at the drum of the outgoing port of the No. 3 furnace changes from 1535 to 1555°C and in the No. 4 furnace the "tail" of the flame has a temperature of 1535-1550°C. As we can see, the flame in the No. 3 furnace leaves more heat in the flame space than the flame of the No. 4 furnace since the difference in temperature at the entrance and outlet of the flame space is greater in the experimental furnace.

This can be explained by the fact that in furnace No. 3, the method of burning the fuel has been improved. The water-cooling of the outlet nozzles makes it possible to use the optimum design of the nozzle for the output of gas in each port. The combustion of fuel in the furnace occurs by a diffusion process. This made it possible to slightly increase the luminosity of the flame as a result of the self-carburation of the natural gas in the jet [4].

The consumption of fuel was distributed as follows among the three pairs of ports: first, 32%; second, 45%; third, 25% of the total fuel requirement in the melting end of the furnace. The diameters of the fuel nozzles, were 18, 21, and 16 mm, respectively.

Ceramic port blocks were installed in the No. 4 furnace. These rapidly burned out and, as a result, the levelness and luminosity of the flame deteriorated since the low density between the port blocks and the gas supply lines creates the conditions for an inflow of air. The natural gas injects cold air, in part becomes mixed with it in the cavity in the port block, and rapidly burns up forming a short flame with low luminosity and this reduces the heat transfer from the flame to the melt and thus increases the fuel consumption.