ISSN 1068-364X, Coke and Chemistry, 2018, Vol. 61, No. 6, pp. 209–212. © Allerton Press, Inc., 2018.
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Modification of Refractory Components in Russian Coke-Oven Linings

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Received April 28, 2018

Abstract—To date, Giprokoks designs have been used for all Russian coke batteries. The condition of these coke batteries has been deteriorating from year to year. The mean life of Russian coke batteries is 32 years, with values of 35 years for OAO EVRAZ ZSMK, 40 years for OAO MMK, 33 years for OAO Altai Koks, and 30 years for PAO Severstal'. The condition of the coke ovens determines the stability of steel output. The Russian coke industry faces the challenge of renewing (modernizing) its worn-out coke batteries. Changes are proposed here in some refractory components used in coke-battery linings. These proposals may be of interest to coke-battery designers and to contractors preparing for the reconstruction (or construction) of coke batteries.

Keywords: fireclay linings, silica linings, expansion joints, burners, ceramics, inspection

DOI: 10.3103/S1068364X18060029

Our proposals for modifying the design of coke-oven linings are as follows.

1. INCREASE THE PROPORTION OF FIRECLAY COMPONENTS AND DECREASE THE PROPORTION OF SILICA COMPONENTS

In Giprokoks designs, the *lower boundary* between fireclay and silica (Dinas) elements in the coke-oven lining is the expansion seam between the dividing walls of the roof channels (fireclay) and the regenerators (silica). That design is convenient in terms of grating placement but does not correspond to the operating temperatures of the boundary zones. The lower rows of the silica lining are not at high temperatures, so as to ensure regeneration of the silica brick and hence to ensure the required dimensions after heating and switching to temperature maintenance. Serious problems are caused by mismatch of the vertical gas channels in the fireclay and silica lining. It is difficult to ensure sealing of their joints.

For purposes of sealing, refractory solutions are poured into the gas channels and metal cuffs are installed. However, with increase in operating time, this problem becomes more severe. Constant efforts, which are not always successful, are required to seal the vertical gas channels.

Operational experience with coke batteries in which the boundary between the fireclay and silica linings is above the gratings confirms that there is no need to introduce refractory solutions or install metal cuffs.

In Giprokoks designs, the *upper boundary* between fireclay and silica coke-oven linings runs along the top of the furnace-roof components (silica brick) and the lining of the furnace roof (fireclay). The silica components do not withstand great heat transfer in exceptional circumstances (jamming of the coke in the furnaces, repairs). The formation of cracks in the silica roof components over time is associated with collapse at the center.

For fireclay roof components, the temperature at which deformation begins under load is sufficient for use in this zone, on the one hand. On the other, they are able to withstand repeated heat transfer. The seal between the fireclay roof components is also replaced by fireclay. The upper boundary between the silica and fireclay components is lower than in the Giprokoks designs.

Successful operation of free fireclay furnace roofs at batteries in China and at some Russian plants confirms the effectiveness of this approach. The fireclay components are made with a junction section. The size of the junction varies over the furnace length so as to ensure equal gaps between the heating walls and the projection of the roof components, taking account of furnace taper.

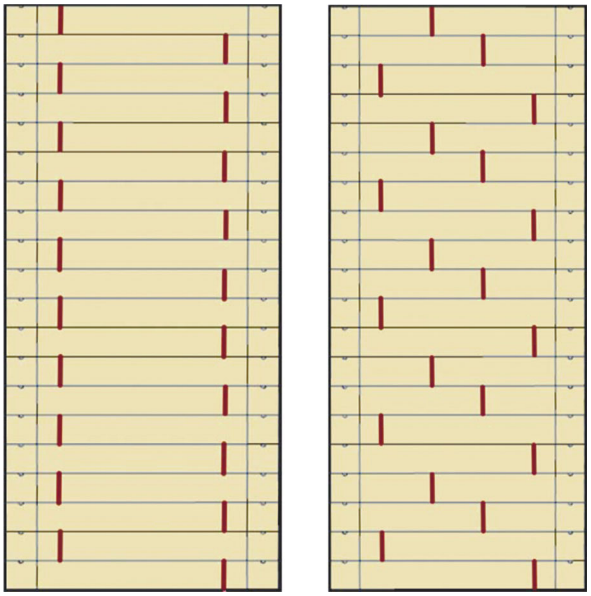

Fig. 1. Configuration of vertical expansion joints in the binder barrier: (a) Giprokoks design; (b) proposed configuration.

The fireclay roof components are of moderately dense or (at slightly greater cost) dense blast-furnace grade.

2. EMPLOY FEWER VERTICAL EXPANSION JOINTS

The position of the vertical expansion joints in the heating walls of Giprokoks coke batteries is a problem. The vertical expansion joints are stress concentrators. For each row, they are placed one above the other in the binder barriers and in the channel walls within the heating sections.

The binder barriers undergo stresses associated with the transverse forces that arise in coke discharge. Repeated coke discharge over the operating life with a simple distribution of the vertical expansion joints leads to crack formation at the joints. Cracks in the binder barriers disrupt the overall wall and furnace geometry. In most cases, cracks of the heating walls may be mended. In the binder barriers, however, access is limited. Crack development in the binder barriers entails relining over the whole length of the heating walls. Consequently, cracks in the binder barriers are more dangerous than those in the channel walls.

If the vertical expansion joints between the swivel and binder beams in the binder barriers (Fig. 1) and those between the swivel and ladle components of the channel wall (Fig. 2) are not aligned, the risk of cracking along the vertical expansion joints is diminished. After introducing the proposed changes, the vertical expansion joints will be distributed along the same axis, but in three rows rather than one. In this configuration, crack development is difficult.

The vertical expansion joints in the channel wall may be redistributed by introducing swivel units with different dimensions of the slotted regions:

– 50% of the swivel units with increase in the slotted region from 296 to 396 mm;

– 50% of the swivel units with decrease in the slotted region from 296 to 216 mm.

The expansion joints in the binder barriers may be redistributed by introducing swivel units with different dimensions of the straight regions:

– 50% of the swivel units without change in the straight region (160 mm), corresponding to swivel units with increase in the slotted region;

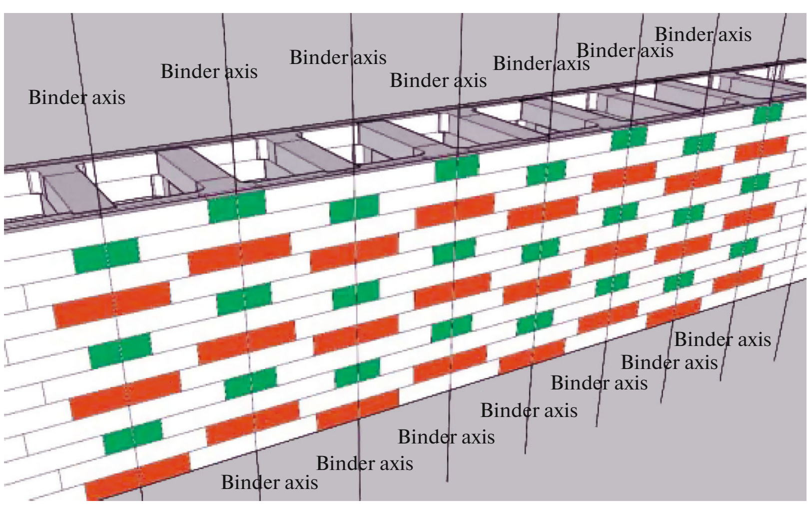

Fig. 2. Proposed configuration of vertical expansion joints in the channel wall.

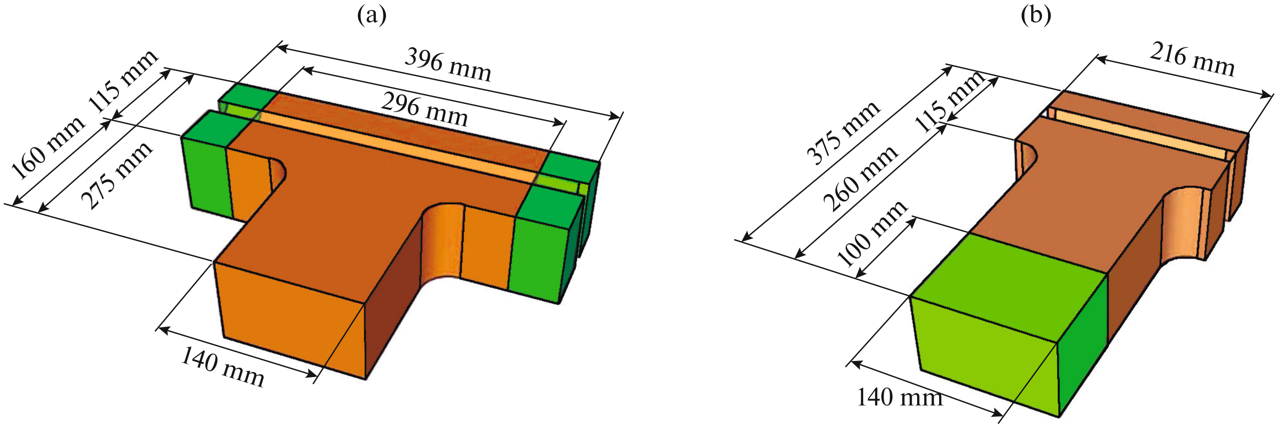

Fig. 3. Modification of swivel-unit structure: (a) with increase in the slotted region; (b) with increase in the straight region.

– 50% of the swivel units with increase in the straight region from 160 to 260 mm, corresponding to swivel units with decrease in the slotted region.

The length of the broad section of the ladle component is modified accordingly (Fig. 3). The binder components change in length in accordance with the relations between the swivel and ladle units.

Such redistribution of the vertical expansion joints was adopted at Giprokoks coke battery 5 in Cherepovets in 1993, but has not undergone further development.

3. USE FIXED BURNERS FOR COKE BATTERIES WITH BOTTOM SUPPLY OF COKE-OVEN GAS

In such coke batteries, the supply of coke oven gas to each vertical heating channel may be corrected by adjusting the cross section of the attached nozzle. In that case, the burners in the base of the heating channels do not help distribute the heating gas supplied.

The proposed burner for coke batteries with bottom supply of coke-oven gas (Fig. 4) has a projection for positioning in the lining of the channel base. At present, such burners are used at coke plants in China and at some Russian plants.

Fig. 4. Proposed burner design.

4. MOVE THE SLOTTED STRUCTURE AT THE ROOF OF THE VERTICAL HEATING CHANNEL AWAY FROM THE HEATING-CHANNEL WALLS

Experience in the repair of the heating-channel roof under the gas hatches indicates the need to shift the slotted structure at the roof of the vertical heating channel away from the heating-channel walls. Research on the blistering of the lining below the gas hatches indicates that it may be attributed to graphite accumulating in the vertical crack along the slotted region. By moving the slotted structure away from the heating-channel walls (Fig. 5), we may decrease the likelihood of such defects, which interfere with coke discharge.

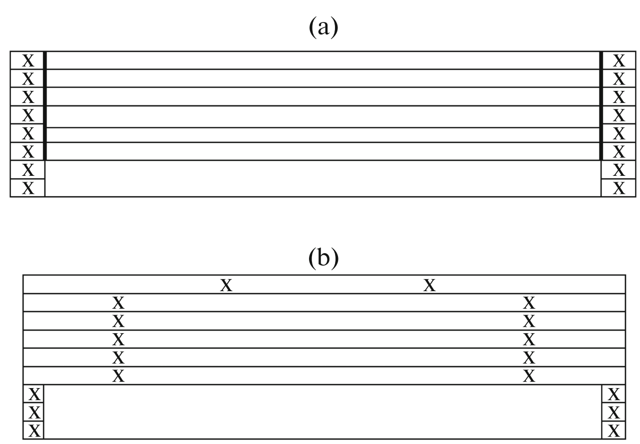

Fig. 5. Current (a) and proposed (b) position of ridges and slots in the roof of the heating channels.

5. INCREASE THE THICKNESS OF THE LADLE COMPONENTS IN THE LAST FEW HEATING CHANNELS OF THE HEATING WALLS

The temperature distribution over the length of the heating walls indicates that there is scope for temperature rise at the extremes of the heating channels. Utilization of this reserve is hindered by the likelihood of coke spillage at discharge. Increase in the thickness of the ladle-type components in the last few heating channels protects the extreme sections of the lining from premature wear on account of the increased local temperature, without coke spillage at discharge. This is better than previous approaches to the problem.

At coke battery 3 of Makeevsk coke plant (built in 1975), the thickness of the ladle-type ceramics in the extreme heating section is 130 mm, as against 105 mm elsewhere.

6. INCREASE THE HEIGHT OF THE INSPECTION-SHAFT CORNICES

Design flaws of the current inspection-shaft cornices include the following: they are not attached to the crosspiece lining and they are not sufficiently strong. During most of the heating period, with low pressure in the coke battery, it is difficult to ensure sealing under the inspection-shaft cornices when they are not attached to the crosspiece lining. In most cases, up to 15% of the cornices must be replaced, on account of cracking.

If the height of the inspection-shaft cornices is increased without changing their other dimensions, they will be attached in the course of heating. The fracture area in cracking will be increased, but the probability of cracking will be decreased. This will entail adjusting a series of local hooks. When increasing the height of the cornices, the inspection shaft itself will be lower by one row of bricks.

Translated by Bernard Gilbert