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Drying and Heating of the Insulating Walls of Coke-Battery Buttresses

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Abstract—The reconstruction of coke battery 1 at Isfahan Steel Works is considered. The structure of the Dinas component in the insulating walls at coke battery 1 with a PVR-51 system is described; this battery has bottom supply of the heating gas; the useful volume of a single oven is 27.3 m^3. The research shows that drying and heating of the Dinas component by a burner with a protective casing protects the refractory surface of the insulating wall from an open flame during heating from 20 to 500°C.

Keywords: coke battery, refractory lining, drying and heating, buttress, coke-oven gas, insulating wall, burner

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Coke battery 1 at Isfahan Steel Works is based on a Giprokoks design with bottom supply of coke-oven gas and with a PVR-51 coke-discharge system. The battery (characterized by paired heating channels and recirculation of the combustion products) consists of 58 furnace chambers (two sets of 29 furnaces) [1].

The battery was reconstructed by TRL (Tata Refractories Limited), which supplied the refractory materials and produced the lining. The mechanical equipment was installed and debugged by staff members of Isfahan Steel Works. Specialists from Tyazhpromeksport (Russia) oversaw the installation, drying, and heating of the coke battery.

In coke-battery operation, the extreme heating walls experience large technological loads, associated with deformation of the walls and aging of the refractory lining, with the possibility of displacement of the fireclay furnace cover in the region of the inspection shafts at the extreme heating channels. Therefore, in drying and heating of the coke battery, attention must be paid to correct heating of the Dinas (silica) insulating walls. In other words, the temperature rise in the insulating walls must be synchronous with the temperature rise in the heating system of the whole coke battery.

In heating the Dinas component of the insulating walls at coke battery 1, the following difficulties may be noted.

1. The design of the insulating walls does not include connectors for the heating channels in the extreme walls. Therefore, discharge of the combustion products is a problem.

2. The design includes a 5-mm expansion gap between the insulating wall and the extreme heating walls, with cardboard lining.

3. For organizational and financial reasons, the drying and heating of the walls was repeatedly postponed. The heating of coke battery 1 began on December 1, 2013. The coke plant is at an altitude of 1757.500 m above sea level, with a sharply continental climate. In winter, the atmospheric pressure is low, and there are sharp fluctuations in temperature during the day. During the reconstruction project, the temperature rose from –7°C at night to +12°C in the day. Therefore, in the initial stages of drying and heating, maintaining constant temperature over the whole of the insulating walls was a problem, because of the considerable mass of the refractories and the hindrance to motion of the heating gas.

4. The use of burners with an open flame for drying and heating of the Dinas lining in heating the insulating walls by coke-oven gas led to destruction of the refractory casing and to nonuniform temperature distribution over the length of the walls [2]. Incorrect expansion of the refractory was also observed.

Adoption of the recommendations in [2] regarding temperature maintenance and the introduction of hydraulic drying and heating of the coke battery by gaseous fuel [3] proved unhelpful.

The design calls for 12 vertical channels of square cross section in the insulating wall, six on the machine side and six on the coke side. Two horizontal channels are present: a rectangular channel (179 × 279 mm) in the lower part of the wall, through which the hot gas is

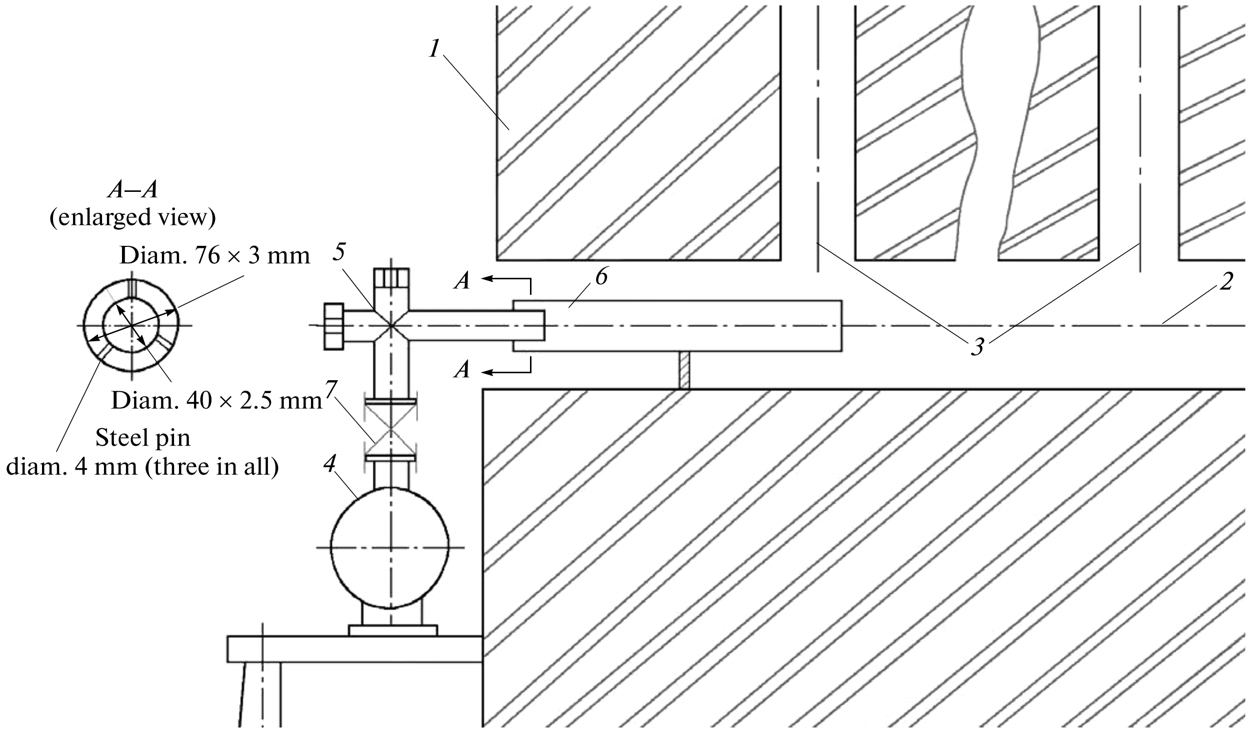

Fig. 1. Burner with an enclosed flame for heating the insulating Dinas section of the buttress: (*1*) insulating wall; (*2*) horizontal channel in buttress wall; (*3*) vertical channel in buttress wall; (*4*) temporary gas line for heating; (*5*) burner crosspiece; (*6*) protective casing of adjustable length; (*7*) shutoff system (valve).

supplied in drying and heating; and a rectangular channel (179 × 279 mm) in the upper fireclay part of the wall. The vertical and horizontal channels are connected. During drying and heating, the other upper horizontal channel is closed at both ends to reduce heat losses.

To monitor the temperature in the insulating walls, Chromel–Copel thermocouples (length 2.5 m) are installed in channels 2, 4, and 5 on the machine side and channels 8, 9, and 11 on the coke side. The temperature over the whole lining of the insulating walls is measured at 2-min intervals in real time, with display of the results on a monitor.

To create sufficient draught during drying and heating, temporary chimneys (height 2.5 m) were installed at vertical channels 7 and 8; metal gates regulated the draught in the wall. The pipes were made of Sh-6 fireclay refractory. Beyond 300°C, when the flow rate of hot gas increased, it was necessary to use additional chimneys in channels 3 and 10. Thus, during drying and heating of the coke battery, the supply of the heating gas to the Dinas refractory and its subsequent dispersal were successfully organized.

At the beginning of drying and heating, burners with an open flame were employed [2]. However, the surface of the Dinas refractory was damaged, on account of the sharp temperature rise and the instantaneous expansion at the contact of the open flame with the refractory.

Accordingly, a burner of adjustable length with an enclosed flame was proposed (Fig. 1).

BURNER WITH AN ENCLOSED FLAME

Vertical pipes (with shutoff valves) supplying coke-oven gas to the temporary heaters and the horizontal channels in the Dinas component of the insulating walls are mounted on the temperature coke-oven gas lines in the working areas of the coke battery, on both sides. Between the vertical and horizontal sections of the pipe there are crosspieces; in the horizontal section, there are flanges for calibration diaphragms, which are used to dose the gas supply to both the furnaces and the horizontal channels in the Dinas refractory [1]. A casing (diam. 76 × 2.5 mm) is soldered to the horizontal tube (diam. 40 × 2.5 mm). The length of the casing is initially 3.0 m but is reduced to 1 m after reaching more than 300°C in the hot section.

In the table and in Fig. 2, we show the temperature rise over the coke battery. The temperature in the upper zone is monitored in heating channels 7 and 24. The buttress temperatures are measured at six points. The table presents the mean values for four buttress walls.

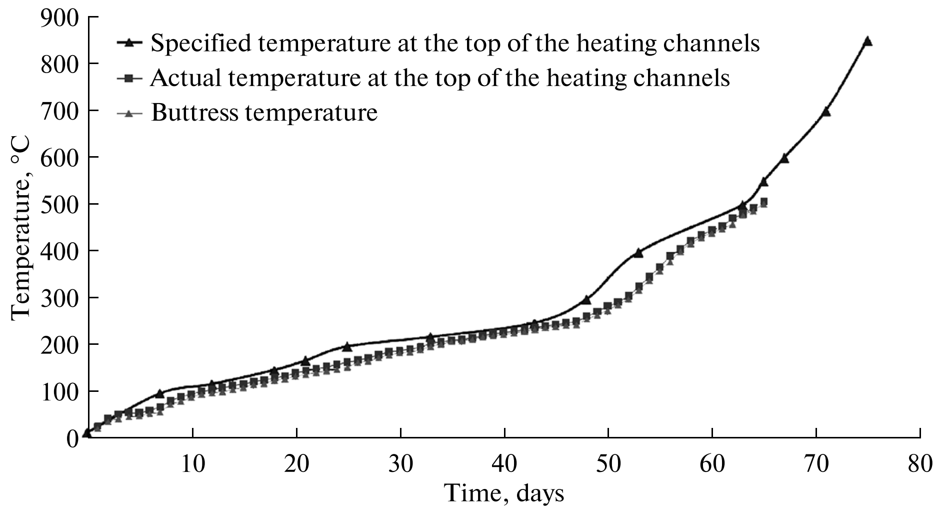

Fig. 2. Heating of coke battery 1.

Heating of insulating walls

Day	Temperature, °C		Day	Temperature, °C	
	top of heating channels	but-tresses		top of heating channels	but-tresses
0	17.0	15.0	33	205.7	199.3
1	30.0	25.5	34	209.1	204.3
2	46.0	40.0	35	212.2	209.7
3	55.5	46.0	36	214.2	211.7
4	58.0	50.0	37	217.7	214.9
5	57.5	52.0	38	222.3	219.4
6	63.6	57.0	39	226.5	222.5
7	70.75	60.0	40	228.8	224.8
8	83.0	76.2	41	232.1	228.3
9	92.3	82.6	42	235.3	232.05
10	97.3	91.3	43	239.8	235.9
11	103.7	98.2	44	243.1	240.0
12	107.3	100.67	45	246.0	242.05
13	111.6	103.7	46	249.0	244.54
14	115.8	108.2	47	252.9	246.0
15	119.6	112.5	48	262.5	256.5
16	124.5	118.8	49	273.5	266.0
17	128.0	121.0	50	284.5	276.0
18	132.3	127.8	51	293.6	287.5
19	136.7	130.75	52	306.7	300.1
20	142.2	136.1	53	326.6	319.0
21	147.8	139.9	54	346.6	339.2
22	151.0	143.8	55	368.1	359.9
23	155.85	147.7	56	389.9	378.8
24	160.8	150.2	57	407.1	401.5
25	165.7	155.2	58	423.8	418.2
26	170.0	165.6	59	435.6	429.8
27	175.0	168.0	60	445.8	440.1
28	181.2	175.7	61	453.8	448.5
29	187.8	180.8	62	470.6	458.8
30	190.5	185.8	63	480.4	478.2
31	193.9	188.0	64	493.5	486.5
32	197.9	192.5	65	506.2	501.8

Measurements of the heating of coke battery 1 to 500°C.

Analysis of the results in the table and in Fig. 2 indicates that the use of burners with an enclosed flame has the following benefits.

1. The refractory surface may be protected from an open flame on heating from 20 to 500°C.

2. By adjusting the burner length, the consumption of heating gas may be uniformly distributed over the whole of the insulating wall and the delay in the temperature rise in the insulating walls relative to the heating channels at the top of the battery may be reduced.

CONCLUSIONS

(1) The use of a burner with an enclosed flame protects the refractory surface from an open flame on heating from 20 to 500°C.

(2) The use of a burner with an enclosed flame to heat the Dinas insulating component of the buttress permits uniform regulation of the temperature rise over the whole of the insulating walls in parallel with the temperature rise over the whole battery. That ensures uniform expansion of the Dinas component in the walls.

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