TEMPERATURE RISE IN THE WALLS AND CROWN OF BLAST FURNACE STOVES

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The reliability of the operation of blast furnace stoves to some extent depends on the proper calculation of the temperature expansion of the structure. The temperature expansion of refractory structures is affected by many factors, including the properties of the refractories, the temperature of the brickwork, etc. It is possible by calculation to determine only the approximate value of the thermal expansion.

The thermal expansion ΔH of the structure has been calculated from the equation

$$\Delta H = \beta H t_{mean},$$

where β is the coefficient of linear expansion of the structure; H is the height of the stated section of the structure; and t_{mean} is the mean temperature over the height of the section of the structure.

Figure 1 shows the results of calculating the temperature expansion of the internal layer of the structure of the walls and housing across the height of the stoves of a blast furnace with a volume of 2000 m^3. The calculations were made for the following conditions:

The temperature of the structure over the height alters rectilinearly from 300 to 1400°C.

The temperature of the internal surface of the structure was used for the calculations.

The after-contraction of the refractories during warming up of the structure was ignored.

The temperature of the housing was uniform over the height, and equal to 100°C.

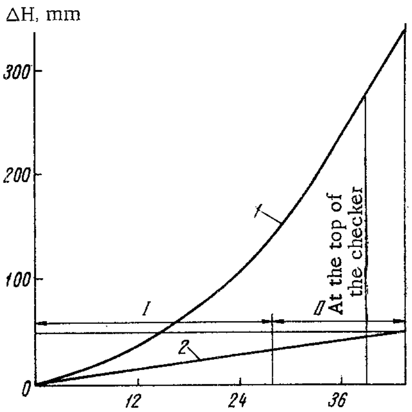

Fig. 1. Thermal expansion of the structure of the walls (1) and housing (2) over the height of the stove. I) Firebrick; II) high-alumina VGO-62; temperature at the bottom of the checkers 300°C, at the top 1400°C.

The coefficient of linear expansion of the housing [1] was $11.7 \cdot 10^{-6}$, firebrick structure in the range 20-900°C $7 \cdot 10^{-6}$, and high-alumina material in the range 900-1400°C $10 \cdot 10^{-6}$ deg^{-1}. As we see from Fig. 1 the temperature expansion of the structure relative to the housing over the height of the stove reaches 300 mm.

TABLE 1

Date of measurement (February)	Time of measurement, h	Temperature of cupola, °C	Temperature of combustion products at exit from the checkers, °C	ΔR, mm	Δh, mm	ΔH, mm
15	9	500	35	0	0	0
16	9	500	35	4	0	0
19	9	720	125	5	8	10
20	9	880	110	6	15	35
21	14	1000	240	6	16	46
22	9	1060	340	6	20	52
23	10	1130	390	7	24	56

Novo-Lipetsk Metallurgical Factory. Translated from Ogneupory, No. 5, pp. 33-35, May, 1971.

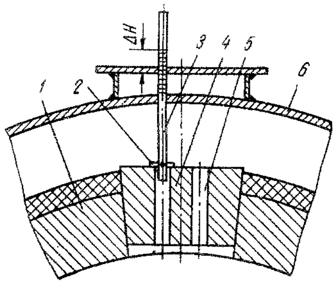

Fig. 2

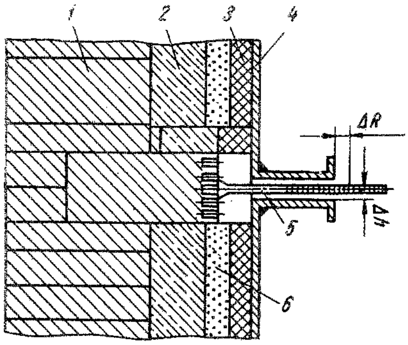

Fig. 3

Fig. 2. Change in the thermal expansion of the structure of the cupola relative to the housing of the stove. 1) Lining of the cupola; 2) metallic supports; 3) metallic pipe diameter 50 mm with scale; 4) refractory plug; 5) apertures for the thermocouples; 6) housing of the stove.

Fig. 3. Measuring the thermal expansion of the structure of the hot-blast stove relative to the height and radius at +25 m; 1) VGO-62 high-alumina brick; 2) light-weight diatomite; 3) diatomite brick; 4) hot-blast stove housing; 5) 6 mm diameter metal shim (scale); 6) friable diatomite.

In comparison to the calculations, experiments were made to determine the thermal expansion of the structure of the walls and the cupola (crown) of the stoves relative to the housing.

Figure 2 shows the scheme for measuring the thermal expansion of the structure of the cupola ΔH relative to the housing, and Fig. 3 the scheme for measuring the thermal expansion of the structure of the walls over the height Δh and radius ΔR relative to the housing of the stove at the mark +25 m. Measurements were made during drying and warming up of the stove. The drying and warming up of the stove commenced on February 3. The results of the measurements are given in Table 1.

Calculations for the temperature at the bottom of the checker indicated 390°C and the cupola 1130°C giving: $\Delta H = 210$ mm, $\Delta h = 60$ mm, and $\Delta R = 23$ mm.

The noncorrespondence between the actual expansion of the refractories and the calculated values can be partially explained by the shrinkage of the structure made with refractory mortar. Thus, chamotte and high-alumina plasticized mortars with a mositure content of up to 4% give a shrinkage of up to 4%. Considering that the moisture content of the mortar is several times higher, it can be expected that its shrinkage will also be greater, and the more so the higher the temperature.

After completion of drying and warming up during operation of the stoves in a period of one month, at a cupola temperature of 1300°C repeat measurements were carried out on these values. The values ΔH, Δh, and ΔR were practically unaltered despite the increase in the cupola temperature from 1130°C to 1300°C. This can be explained by the fact that with a further rise in the temperature of the cupola, the expansion of the structure was compensated by the shrinkage of the refractories. The measurements at the commencement and termination of the heating period gave the same results. With a cupola temperature of 1300°C the calculated values of the factors under investigation equaled: $\Delta H = 250$ mm, $\Delta h = 75$ mm, and $\Delta R = 28$ mm.

The temperature expansion of the structure across the radius, if no compensation is specified, causes additional stresses in the housing, and may be the cause of its rupture.

CONCLUSIONS

During the heating of blast furnace stoves the structure shows an expansion. The actual magnitude of the thermal expansion of the refractory structure in the stoves relative to its housing across the height and radius is less than the calculated value.

The discrepancy between the calculated and experimental data in terms of thermal expansion of these structures requires the carrying out of wider experiments.

LITERATURE CITED

1. M.A. Lifshits, Refractories in the Iron and Steel Industry [in Russian], Metallurgizdat (1960), p. 210.