DETERMINING PRESSING CURVES FOR INDUSTRIAL REFRACTORY BODIES

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During the exploitation and development of projects for new types of presses operating the semidry pressing technique it is necessary to know the relationships between the shrinkage of the body, the compression coefficient, the porosity, and the apparent density of the articles, and the specific fabrication pressure.

The literature contains several formulas showing the relationship between the shrinkage of the body and other factors and static pressure.

The formula of Balandin [1, 2] is

\[ \delta = \frac{H}{\eta} (1 - e^{-a \sigma_0 e}) \]

where \( \delta \) is the full shrinkage of the body, mm; \( H \) is the depth of filling, mm; \( e \) is the natural logarithm base; \( \sigma_0 \) is the pressure under the moving stamp; \( a, \eta, \) and \( n \) are constants for the body.

The formula of Kazakevich [3] is

\[ k_c = a \rho^n \]

where \( a \) and \( n \) are the equation parameters; \( k_c \) is the compression coefficient, and \( \rho \) is the specific fabrication pressure, kg/cm\(^2\).

The formula of Berezhnoi [4] is

\[ \varepsilon = a - b \log \rho \]

where \( \varepsilon \) is the true porosity, \( \% \); \( \rho \) is the fabrication pressure, kg/cm\(^2\); and \( a \) and \( b \) are equation parameters.

These equations have certain drawbacks which hinder their use. In Eq. (1) there is no value for the apparent density of the filling, although with certain values for \( H \) the shrinkage \( \delta \) will vary as a function of this factor. The physical concept of the asymptote of the equation (when \( \sigma_0 \to \infty \)) is not covered.

Equation (2) does not satisfy the limiting conditions \( \rho = 0 \) and \( k_c = 0 \), \( \rho = \infty \) and \( k_c = \infty \). In fact \( k_c \) can vary from 1 to some finite value.

Equation (3) also does not satisfy the limiting condition: when \( \rho \to \infty \), \( \varepsilon \to -\infty \), and in fact \( \varepsilon \geq 0 \).

Equations (2) and (3) are close to experimental data only in certain \( \rho \) change limits. The literature contains very little information about real values for equation coefficients for semidry refractory bodies.

Fig. 1. Limiting conditions for the pressing curves.

All-Union Institute of Refractories. Translated from Ogneupory, No. 11, pp. 22-28, November, 1969.

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Fig. 2. Graph $e^{-ap^n} = f(p)$. Figures on the curve indicate the numbers of the bodies.

Fig. 3. Relationship between the porosity of the wet $P_m$ and dry $P$ green brick and the specific pressing pressure. Numbers on the curve indicate the numbers of the bodies.

In connection with this, studies were made to obtain more general and suitable formulas for practical use. The work was done in two directions: a graphic record of the actual relationships between the shrinkage of the bodies in the press molds and the specific fabrication pressure, and the establishment of a mathematical relationship between the pressing parameters and the specific pressure.

The graphic record was made by pressing the commonest semidry bodies used in the refractories industry and selected at the Chasov Yar Combine, the Semiluks Factory and the Magnezit Factory. In all 24 bodies were studied.

The samples of bodies (6–7 kg) taken from the factory mixers, were stored in polythene bags to retain the moisture content and delivered to the All-Union Institute of Refractories. At the factory a certificate was drawn up for each sample giving the results of analyses made by the departmental laboratories.

The record on the diagram for the pressing pattern was made in the Institute on a press with a force of 120 tons. Gravimetric batching of the bodies was used.

Depending on the density (specific gravity) of the powders, the weight of the specimens amounted to 500 g for chamotte, 600 g for high-alumina, and 700 g for magnesia refractories.

The internal dimensions of the molds in plan were 95.0 $\times$ 59.5 mm. The height of the specimens was from 38 to 46 mm. The volume of the article equalled about one eighth of the volume of a standard brick. Each body was used to press seven specimens and from these we recorded the pressing curves. The average rate of pressing was about 0.3 mm/sec. After ejection of the article from the mold we measured the dimensions with sliding calipers, calculated the apparent density, the coefficient of compression, and other factors.

From the seven pressing curves we determined the average which was included in the album. From each seven specimens three were taken for determining the compressive strength of the green brick. The album of pressing curves included diagrams for the shrinkage of the body and tables of values for the shrinkage of the body $l$, relative deformation $\varepsilon=l/h_0$, the height of the specimen $h$, and the apparent density for specific fabrication pressures of from 0 to 1500 kg/cm² with a pressing range of 100 kg/cm² for each one of 24 bodies.

The semidry refractory body consists of a three phase system: solid, liquid, and gaseous phases.

The quantitative relationship between the three phases in the pressed body and in the green brick is characterized by the following independent parameters: $\delta_Y$ is the density (specific gravity) of the solid phase, g/cm³; $\delta_L$ is the density of the liquid phase (g/cm³); $W_0$ is the relative moisture content of the body, %, and also of the following parameters: $\delta$ is the apparent density of the green brick, g/cm³ or $P_m$ – the porosity of the moist green brick, %, consisting of the ratio of the volume of gaseous phase to the total volume of the green brick.

Using another terminology [5] the porosity of the system, that is, ceramic powder on pressing, is always understood as the ratio of the volume of space unoccupied by the solid phase (that is, the total volumes