

FORMATION OF CONVECTIVE FLOW IN GLASS MELTS DUE TO VAPORIZATION OF A SURFACE ACTIVE COMPONENT

Part II: Discussion of results and the vaporization model

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The results of experiments dealing with identification and rate of cell flow, resulting from the vaporization of surface active components from some glass melts, allow a corresponding model of vaporization to be suggested. In the given instance, the model derived from fluoride glass melt corresponded to the process of mass transfer in which resistance of the liquid phase and that of the phase boundary are involved. In the later stages of vaporization the two resistances show roughly identical effects. According to the experimental conditions, the fluorides being vaporized were hydrolyzed to an extent from 10 to 75 %.

INTRODUCTION

The first part of the present study [1] was concerned with the question whether the vaporization of surface active components of the glass melt leads to the formation of the so-called cell flow, which had been earlier found and studied on other systems. High temperature behaviour of fluoride glasses (opal), borosilicate glasses (Neutral) and lead glasses (crystal with 24 wt. % PbO) were studied at melting temperatures; vaporization of components from these glasses has always significant technological consequences. The high-temperature motion-picture technique was used to provide the experimental evidence; using fine bubbles as indicators of the direction of flow, the method proved explicitly the existence of cell flow in fluoride and borosilicate glass melts, whereas no firm evidence was found with the lead glass melt. The motion-picture experiments and density measurements showed that neither thermic nor density convection take part in the formation of the flow, so that this has to be attributed to surface forces. Evaluation of films and specimens of coloured glasses showed the most frequent shapes of the flow cells in the measuring cell, and provided the mean as well as the surface rates of flow. The time dependence of these rates of flow on temperature was established, as well as that on the rate of flow of moist and dry nitrogen above the glass melt surface. The loss of fluorides and Na₂O from the opal glass in the course of measurement was determined analytically. The experimental conditions were chosen so as to correspond roughly to those of free-surface melting furnaces. The data obtained for fluoride glass melts were satisfactory for suggesting a qualitative mechanism of the vaporization of a surface-active substance, for proposing a mathematical model of vaporization and for determining the controlling process of vaporization.

QUALITATIVE MECHANISM OF THE VAPORIZATION OF FLUORIDES

a) The degree of volatilization and the degree of hydrolysis of the fluorides being vaporized

The results of analyses of fluorides and Na_2O plotted partially in Fig. 13 [1] indicate that the system suffers great losses of fluorides. The degree of hydrolysis of the fluorides being vaporized (the portion of the total amount of vaporized fluorine volatilized in the form of HF) was calculated from the difference between the molar concentration of the fluorine volatilized and that of sodium (or potassium). As the glass melt was not analyzed for K_2O , it was only possible to calculate the bottom and the top limit of hydrolysis corresponding to the total or zero amount of volatilized potassium [2]. Fig. 1 shows the degree of hydrolysis of the fluorides

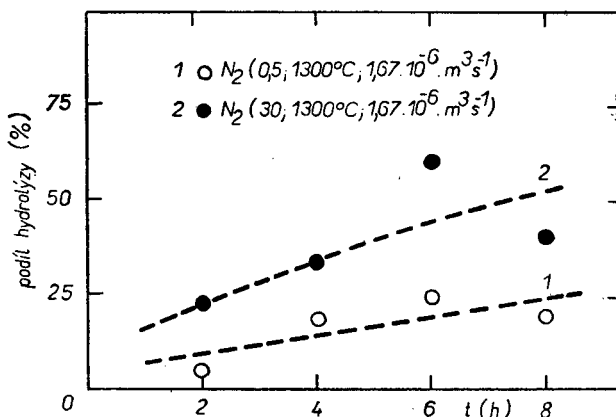


Fig. 1. The time dependence of the degree of hydrolysis of volatilizing fluorides in % on the assumption that one half of the potassium present is volatilized. The temperature is 1300 °C.

being volatilized for half the amount of volatilized potassium. The results indicate that the degree of hydrolysis increases in terms of time (because the $\text{F} : \text{H}_2\text{O}$ ratio decreases) as well as in terms of the moisture content of nitrogen. The degree of hydrolysis is relatively high even for "dry" nitrogen. However, determination of the moisture content in this nitrogen indicated that at the given rate of flow, the amount of water determined, i.e. $7.33 \times 10^{-4} \text{ kg H}_2\text{O}/\text{m}^3 \text{ N}_2$ under normal conditions, would be enough to hydrolyze all the volatilizing fluorides. In the case of dried nitrogen, the mean hydrolysis degree was around 16%. The hydrolysis can be probably attributed to the existence of OH groups in glass melt. The temperature dependence of hydrolysis is indistinct in view of the lack of the respective data for 1250 °C; however, the hydrolysis degree increased between 1300 and 1350 °C (for partial water vapour pressure in nitrogen of 0.5 kPa it amounted to about 38% at 1350 °C after 8 hours, for $p_{\text{H}_2\text{O}} = 30 \text{ kPa}$ it amounted to about 68% after 6.5 hours). The dependence of the hydrolysis degree on the rate of flow was not studied.

b) The rate of flow of the glass melt

The rates of flow are plotted in Figs. 8 through 12 in Part I [1]. The mean rates of flow in the individual flow cells were measured. These data have the disadvantage of involving an error of about 30 %, of providing no data from the actual beginning of the measurement, and of yielding the rates of surface flow not from the surface proper, but from its close proximity. All the diagrams indicate a rapid decrease of the rate of flow in terms of time and a subsequent equalization at a roughly constant value. The surface rate of flow values are higher at the beginning of the measurements ($1-3 \times 10^{-4} \text{ m s}^{-1}$) than those of the mean rates ($0.5-2 \times 10^{-4} \text{ m s}^{-1}$). The initial decrease of the rates related to the decrease of the volatilization rate of fluorides is indicative of the non-stationary character of volatilization during this period; after roughly 3 to 6 hours and up to 24 hours, the mass transfer in the liquid can be approximated by the steady state. The comparison implies that the mean rates of flow are always higher when using dry nitrogen starting from times of about 0.5 hour, and roughly the same applies to surface rates of flow; the only exception was at very low rates of flow of the gas, when the result was opposite. In these instances, the faster flow at the surface corresponds to a faster loss of fluorine from the melt, which was proved analytically for measurements at 1300 °C. Both the mean and the surface rates of flow increase with temperature, this being the result of accelerated volatilization.

An increase in the rate of flow of nitrogen, according to Figs. 8 through 12 [1], leads to increased both surface and mean rates of flow for dry nitrogen; there is obviously no correlation with moist nitrogen. The effect of the rate of flow of gases on that of the melt is probably related with the concentration of fluorides in the gaseous phase, which is higher in the case of dry nitrogen (a lower hydrolysis degree) and therefore more influenced by the rate of flow of the gas. The values of the rates of flow established may serve to estimate the shares of diffusion and convective transfer in glass melt. On considering a 5 % concentration of NaF in glass melt, the value $\rho_{\text{NaF}} = 2.5 \times 10^3 \text{ kg m}^{-3}$ [2] and the surface rate of flow about 10^{-4} m s^{-1} , the flow of fluoride ions by weight is then about $5.6 \times 10^{-3} \text{ m}^{-2} \text{ s}^{-1}$. On estimating the maximum concentration gradient at the surface $dw/dx \approx 10^2 \text{ m}^{-1}$, then, on assuming the existence of this gradient for the diffusion coefficient of fluoride ions, $2.6 \times 10^{-10} \text{ m}^2 \text{ s}^{-1}$ [2], the diffusion flow should have the value of about $2.9 \times 10^{-5} \text{ kg m}^{-2} \text{ s}^{-1}$. This diffusion flow is lower by at least two orders of magnitude than the convective flow. The diffusion flow will be actually still smaller, because the electron microanalysis failed to determine any concentration gradient of sodium ions at the phase boundary. It may therefore be assumed that the diffusion flow is negligible all over the entire measurement range (0—24 h, 5.3—1.25 % F). Further information on the shares of convective and diffusion mass transfer may be provided by the values of the mass transfer coefficients.

APPROXIMATE MODEL OF THE FLUORIDES VOLATILIZATION MECHANISM

Let us consider the transfer of a volatile substance from the liquid phase into the gaseous phase, in which the resistance of the liquid phase, that of the phase boundary as well as that of the gaseous phase can be involved. On assuming that $w_L \ll 1$ and that the volume of the diffusion layer is small with respect to the total

volume of the liquid, the following equation may be written for the mass flow N of the volatilizing substance at the liquid-gas phase boundary:

$$N = K_L \rho_L (w_L - w_{L0}) = - \frac{dw_L}{d\tau} \rho_L \frac{V_L}{S}. \quad (1)$$

The boundary layer theory says that if there is no chemical reaction, the ratio of the thickness of the diffusion and the hydrodynamic limit layer is constant, and that [3]

$$\delta_L = K_{\delta L} v_{L0}^{-1/2}. \quad (2)$$

The following empirical equation was suggested for the time dependence of the surface rate of flow on the basis of photographic measurements:

$$v_{L0} = v_{L00} \exp(-K_{FT}\tau). \quad (3)$$

The mass transfer coefficient, K_L , can then be interpreted as follows:

$$K_L = \frac{D_L v_{L0}^{1/2}}{K_{\delta L}} = \frac{D_L v_{L00}^{1/2}}{K_{\delta L} \exp(K_{FT}\tau/2)}. \quad (4)$$

For the mass flow at the phase boundary it holds that:

$$N = K_I \rho_G (H^{-1} w_{L0} - w_{G0}). \quad (5)$$

For the mass flow in the gaseous phase it holds that:

$$N = K_G \rho_G (w_{G0} - w_G). \quad (6)$$

On combining equations (1), (4), (5), (6) and rearrangement, one obtains the following equation for the mass flow through a liquid:

$$- \frac{dw_L}{d\tau} \frac{V_L}{S} = \frac{K_L K_I \rho_G^2 K_G}{K_I \rho_G^2 K_G H^{-1} + K_L \rho_L K_G \rho_G + K_L \rho_L K_I \rho_G}, \quad (7)$$

where the first term on the right side represents the value of the overall mass transfer coefficient K .

The total resistance is then given by the sum of the respective resistances of the liquid phase, the phase boundary and the gaseous phase:

$$\frac{1}{K} = \frac{1}{HK_L} + \frac{\rho_L}{K_I \rho_G} + \frac{\rho_L}{K_G \rho_G}. \quad (8)$$

If the volume of the diffusion layer in the gaseous phase is small compared to the total volume of the liquid, the following equation holds for the mass balance in the gaseous phase:

$$\frac{dw_G}{d\tau} \rho_G V_G = \rho_L SK (H^{-1} w_L - w_G) - \dot{V} w_G \rho_G. \quad (9)$$

The system of equations (7), (9) and (4) then describes the suggested model.

On the assumption of existence of a boundary layer even in the gaseous phase, the mass transfer coefficient K_G depends as follows on the rate of flow of the gaseous phase:

$$K_G = \frac{D_G \dot{V}^{1/2}}{K_{\delta G} S_G^{1/2}}. \quad (10)$$

The following instances can arise when this simplified case is applied from the standpoint of the controlling process:

a) The resistance of the liquid phase is the only one involved. The total mass transfer coefficient K decreases in terms of time and its decrease is proportional to the decrease of the rate of flow at the surface according to the equation:

$$\frac{K_1}{K_2} = \left(\frac{v_{L01}}{v_{L02}} \right)^{1/2} \quad (11)$$

b) The resistance of the liquid phase and that of the phase boundary are effective. The total mass transfer coefficient decreases in terms of time, but this decrease is slower than would correspond to equation (11). The total mass transfer coefficient is independent of the rate of flow of the gaseous phase for the case when $w_G \rightarrow 0$.

c) The resistances involved are those of the liquid and gaseous phases and that of the phase boundary, or the resistance of the liquid and of the gaseous phases. The total mass transfer coefficient decreases in terms of time and its decrease is slower than would correspond to equation (11). Its value depends on the rate of flow of the gaseous phase even for $w_G \rightarrow 0$.

d) The resistances involved are that of the phase boundary and that of the gaseous phase, or only one of these resistances. The total mass transfer coefficient is constant in terms of time.

The values of the total mass transfer coefficient can be established from equation (7):

$$K = \frac{\frac{dw_L}{d\tau} \cdot \frac{V_L}{S}}{H^{-1}w_L - w_G} \quad (7a)$$

On using the values $V_L/S = 1.21 \times 10^{-2}$ m, $H = 17.54$ [2] (from the pressure of saturated NaF vapours above the NaF melt on the assumption of ideal behaviour) and on setting $w_G = 0$, it is possible to obtain the K values from our measurements. The assumption that $w_G = 0$ will introduce a larger error of the measurements with the lower partial water vapour pressure ($p_{H_2O} = 0.5$ kPa) which involves a lower degree of hydrolysis and thus $w_G \neq 0$.

The values of the total mass transfer coefficients are listed in Table I. The time dependence of the K values was obtained for 1300 °C and a flow rate of 1.67×10^{-6} m³ s⁻¹ of nitrogen with a partial pressure of water vapour of 0.5 and 30 kPa respectively. Only the mean values of K from the entire measurements were calculated for the other experiments, because just the initial and the final concentrations of fluorides in the glass melts were known.

As has already been assumed, the K values for dry nitrogen are mostly lower, because they involve a larger error ($w_G \neq 0$). A comparison of the K values for both time dependences indicates that values for dry nitrogen are lower by a factor of about 1.4. In the 1300 to 1350 °C region, the K values increase with temperature; the corresponding value for 1250 °C was not available. The comparison of the mean values of K for 1300 °C after 6.5 h and at 30 kPa of water vapour at various rates of flow indicates that within the limits of errors, there is no increase in K with an increase in the flow rate ($K = 6.5 \times 10^{-6}$ m s⁻¹ at a flow rate of 1.67×10^{-6} m³ s⁻¹ and 5.6×10^{-6} m s⁻¹ at 8.33×10^{-6} m³ s⁻¹). The K value increases with dry nitrogen under otherwise identical conditions ($K = 4.75$ and 5.60×10^{-6} m s⁻¹ at a flow rate of 1.67×10^{-6} m³ s⁻¹ and 7.8×10^{-6} m s⁻¹ at a flow rate of

$8.3 \times 10^{-6} \text{ m}^3 \text{ s}^{-1}$); however, at a lower rate of flow, the K values involve a larger error and are lower by a factor of about 1.4 than what corresponds to the actual value. Also in view of the fact that the gaseous phase was observed to be subject to very extensive mixing (it looked like smoke) the K value may be assumed not to be affected by the rate of flow.

Table I
The rate of fluoride losses from opal glass melt and the total mass transfer coefficients

Specimen	τ (h)	w_L	$dw_L(d\tau) \text{ s}^{-1}$	\bar{w}_L	$K \text{ (m s}^{-1}\text{)}$
1250, 1.67×10^{-6} , 0.5	24	0.014	-4.51×10^{-7}	0.0335	2.86×10^{-6}
1250, 1.67×10^{-6} , 30	23	0.014	-4.61×10^{-7}	0.0335	2.93×10^{-6}
1350, 1.67×10^{-6} , 0.5	8.2	0.022	-1.05×10^{-6}	0.0375	5.96×10^{-6}
1350, 1.67×10^{-6} , 30	6.5	0.018	-1.47×10^{-6}	0.0357	8.74×10^{-6}
1300, 3.33×10^{-6} , 0.5	16	0.012	-7.03×10^{-7}	0.0327	4.56×10^{-6}
1300, 1.67×10^{-6} , 0	6.5	0.028	-1.06×10^{-6}	0.0405	5.60×10^{-6}
1300, 8.33×10^{-6} , 0.5	6.5	0.021	-1.37×10^{-6}	0.0370	7.84×10^{-6}
1300, 8.33×10^{-6} , 30	6.5	0.028	-1.06×10^{-6}	0.0405	5.60×10^{-6}
1300, 1.67×10^{-6} , 0.5	6.5	0.031	-9.40×10^{-7}	0.042	4.75×10^{-6}
1300, 1.67×10^{-6} , 30	6.5	0.025	-1.20×10^{-6}	0.039	6.50×10^{-6}
1300, 1.67×10^{-6} , 0.5	0	0.053	-1.86×10^{-6}	—	5.59×10^{-6}
1300, 1.67×10^{-6} , 0.5	2	0.043	-9.70×10^{-7}	—	4.77×10^{-6}
1300, 1.67×10^{-6} , 0.5	4	0.037	-6.90×10^{-7}	—	3.96×10^{-6}
1300, 1.67×10^{-6} , 0.5	6	0.032	-5.00×10^{-7}	—	3.32×10^{-6}
1300, 1.67×10^{-6} , 0.5	8	0.030	-4.40×10^{-7}	—	3.10×10^{-6}
1300, 1.67×10^{-6} , 30	0	0.053	-2.08×10^{-6}	—	8.26×10^{-6}
1300, 1.67×10^{-6} , 30	2	0.040	-1.20×10^{-6}	—	6.37×10^{-6}
1300, 1.67×10^{-6} , 30	4	0.0315	-7.80×10^{-7}	—	5.26×10^{-6}
1300, 1.67×10^{-6} , 30	6	0.0255	-5.50×10^{-7}	—	4.58×10^{-6}
1300, 1.67×10^{-6} , 30	8	0.0235	-5.00×10^{-7}	—	4.51×10^{-6}

Explanation notes to the "specimen" column: the first number is temperature in $^{\circ}\text{C}$, the second number is the rate of flow of gas in $\text{m}^3 \text{ s}^{-1}$ under normal conditions, the third number is the partial pressure of water vapour in kPa.

As indicated by Fig. 2 and Table I, the K values decrease distinctly with time, so that there is an effective resistance of the liquid phase. Even though relatively extensive convection in the liquid phase was established photographically, it should be taken into account that the K values are higher by up to three orders of magnitude than those for volatilization from lead glass or from soda-silicate glass [4]; even smaller resistances are therefore effective. Fig. 2 also indicates that the square root of the surface rate of flow decreases faster than K , so that the equation (11) does not hold. These facts imply that the resistance of the phase boundary is involved together with that of the liquid phase in the vaporization process. For the case that $K_G \gg K_L$ and $K_G \gg K_I$, equation (7) then acquires the form:

$$\frac{dw_L}{d\tau} = -\frac{S}{V_L} \frac{K_L K_{I\varrho} G}{K_{I\varrho} G H^{-1} + K_{L\varrho} L} (H^{-1} w_L - w_G), \quad (12)$$

where the second term on the right-hand side is again the value of the total mass transfer coefficient K . If the w_L value can be regarded as constant and at the same

time $w_G \rightarrow 0$, the rate of the loss of the volatile substance is constant in terms of time (for constant K):

$$\frac{dm}{d\tau} = S \rho_L K H^{-1} w_L \quad (13)$$

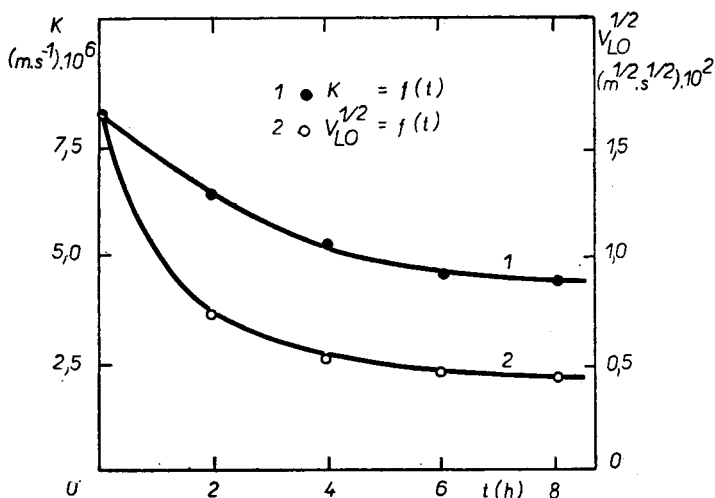


Fig. 2. The time dependence of the total mass transfer coefficient K and the dependence of the surface rate of flow on time, 1300 °C, rate of flow $1.67 \times 10^{-6} \text{ m}^3 \text{ s}^{-1}$ under normal conditions, $p_{\text{H}_2\text{O}} = 30 \text{ kPa}$.

To be able to determine at least approximately the share of resistance to mass transfer in the liquid phase and the resistance of the phase boundary, let us express the total resistance as a sum of resistances in the liquid phase and at the phase boundary by means of equations (12) and (4). For the two time levels 1 and 2 one thus obtains:

$$\frac{1}{K_1} = \frac{\text{const}}{v_{L01}} + \frac{\rho_L}{K_{I\rho G}}, \quad (14a, b)$$

$$\frac{1}{K_2} = \frac{\text{const}}{v_{L02}} + \frac{L}{K_{I\rho G}}.$$

By subtracting the equations, it was possible to obtain the value of the constant and to calculate the resistance of the liquid phase ($\text{const}/v_{L0}^{1/2}$) and the resistance of the phase boundary ($\rho_L/K_{I\rho G}$). The mean value of the constant for various time intervals amounted to $559 \text{ m}^{-1/2} \text{ s}^{1/2}$ with a maximum relative error of 29%. The comparatively large dispersion should be attributed to the inaccurate v_{L0} values and to the neglecting of the w_G values. The calculated portions of the liquid phase resistance and the phase boundary resistance are plotted in Fig. 3. For the value of $\rho_L = 1.13 \times 10^3 \text{ kg m}^{-3}$ and $\rho_G = 1.47 \times 10^{-1} \text{ kg m}^{-3}$ [2], the mean value of K_I was calculated for the given conditions and amounted to $9.02 \times 10^{-2} \text{ m s}^{-1}$, and the maximum relative error amounted to 22%. Knowledge of H allows the K_L values to be calculated; they are also plotted in Fig. 3. This

figure indicates that the portion of the liquid phase resistance increases in terms of time, and after roughly 4 to 6 hours is equalized at about one half of the total resistance. The constant values of both resistances in this time period support the assumption that even this region involves convective transport only.

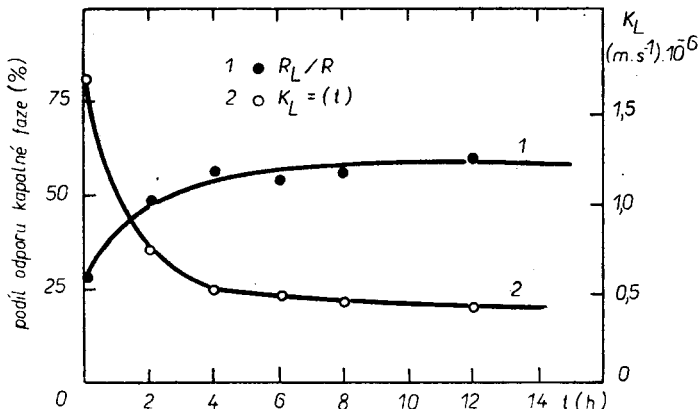


Fig. 3. The time dependence of the liquid phase resistance in % and the mass transfer coefficient in liquid, K_L ; 1300 °C, rate of flow $1.67 \times 10^{-6} \text{ m}^3 \text{ s}^{-1}$, $p_{\text{H}_2\text{O}} = 30 \text{ kPa}$.

The equations (12), (9) and (4), together with the data obtained, allow the vaporization process to be described quantitatively under the given conditions. The conditions in actual glassmaking furnaces with a free glass melt surface and extensive mixing of combustion gases, are similar to the experimental ones. However, in view of the large amounts of combustion gases it is possible to take $w_G = 0$, so that equation (9) is eliminated, similarly to w_G in equation (12). If the changes in the concentration of fluorides in the glass melt are small, the vaporization is described by equation (13). Under real conditions the volatilization rate can only be affected by decreasing the melting temperatures, by decreasing the concentration of fluorides in the glass melts or by covering the melt surface (change in the way of heating). For small rates of flow of gases above the melt surface it is suitable to use the lowest possible partial pressure of water vapour in the gas.

The formation of cell flow has unfavourable consequences on the elimination of microscopic seed. This problem can be resolved by brief heating of the melt to the refining temperature where the bubbles increase their volume and rise to the surface.

CONCLUSION

Evaluation of the experiments yielded a comparatively satisfactory correlation between the rate of flow in the cells and intensity of vaporization of fluorides; the degree of hydrolysis of the fluorides was found to be in the range of 10 to 45 % for dry nitrogen and 41 to 75 % for moist nitrogen. The information on the existence of cell flow allowed a mathematical model of the vaporization of fluorides to be suggested for opal glass melts on the basis of effective liquid phase and phase boundary resistances. The numerical values indicate that in the later stages the

portions of the liquid phase resistance and phase boundary resistance are roughly the same, while in the beginning the phase boundary resistance prevails. The high values of the total mass transfer coefficient (of the order of 10^{-6} to 10^{-5} m s⁻¹) are indicative of extensive vaporization of fluorides. The experimental results are qualitatively applicable to industrial melting furnaces with free glass melt surfaces. The small number of experimental data did not allow a suitable model to be suggested for borosilicate glasses. Such a work would be very useful in view of the industrial significance of borosilicate glasses.

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List of symbols

- m — weight
- v_{L0} — rate of flow at the phase boundary
- v_{L00} — rate of flow at the phase boundary at time $\tau = 0$
- w_G — weight fraction of the volatile substance in the gaseous phase
- w_{G0} — weight fraction of the volatile substance in gaseous phase at the phase boundary
- w_L — weight fraction of the volatile substance in the liquid phase
- w_{L0} — weight fraction of the volatile substance in the liquid phase at the phase boundary
- D_L — diffusion coefficient of the volatile substance in liquid phase
- H — Henry's constant
- K — total mass transfer coefficient
- K_F — an empirical constant
- K_G — mass transfer coefficient in the gaseous phase
- K_L — mass transfer coefficient in the liquid
- N — rate of flow by weight
- $K_{\delta G}$ — a constant characterizing the thickness of the diffusion layer in gaseous phase
- $K_{\delta L}$ — a constant characterizing the diffusion layer thickness in liquid phase
- K_I — a rate constant of mass transfer from liquid to gaseous phase
- S — phase boundary surface
- S_G — cross section perpendicular to the surface through which the gas flows
- \dot{V} — rate of flow of gas by volume
- V_L — the volume of the liquid
- δ_L — thickness of the diffusion layer in liquid phase
- ρ_G — density of the volatile substance in gaseous phase
- ρ_L — density of the volatile substance in liquid phase
- τ — time
- R — total resistance
- R_L — resistance of the liquid phase
- V_G — gaseous phase resistance

VZNIK KONVEKTIVNÍHO PROUDĚNÍ VE SKLOVINÁCH
PŘI VYPAŘOVÁNÍ POVRCHOVĚ AKTIVNÍ SLOŽKY
II. DISKUSE VÝSLEDKŮ A MODEL VYPAŘOVÁNÍ

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Rychlosti proudění vzniklého při vypařování povrchové aktivní složky z fluoridové skloviny (opál) a borité skloviny (Neutral) činily řádově 10^{-5} — 10^{-4} m \cdot s $^{-1}$ a byly zhruba v korelaci s intenzitou odpařování fluoridů. Z analýz fluoridů ve sklovině byl vypočten přibližný podíl hydrolyzovaných odpařených fluoridů, který činil 10—45 % pro sklovinu s atmosférou „suchého“ dusíku ($p_{\text{H}_2\text{O}} = 0,5$ kPa) a 41—75 % pro sklovinu s atmosférou vlhkého dusíku ($p_{\text{H}_2\text{O}} = 30$ kPa). Na základě experimentálních výsledků byl navržen model vypařování fluoridů, předpokládající uplatnění odporu kapalně fáze a fázového rozhraní, a vypočteny podíly odporu kapalně fáze a fázového rozhraní, které se v pozdějších stadiích ustálí na zhruba stejných hodnotách. Navržený model kvalitativně odpovídá podmínkám v provozním zařízení s volnou hladinou. Ukazuje se, že snížení tékání lze dosáhnout pouze snížením teploty, koncentrace fluoridů a snížením parciálního tlaku vodní páry v atmosféře při nízkém průtoku plynů. Provozně se osvědčí tavení se zakrytou hladinou.

Obr. 1. Závislost podílu hydrolyzy těkajících fluoridů v % na čase za předpokladu, že vytěká polovina přítomného draslíku, teplota 1300 °C.

Obr. 2. Závislost celkového koeficientu přenosu hmoty, K , na čase a závislost hladinové rychlosti proudění na čase, teplota 1300 °C, průtok $1,67 \cdot 10^{-6}$ m 3 \cdot s $^{-1}$ za normálních podmínek, $p_{\text{H}_2\text{O}} = 30$ kPa.

Obr. 3. Závislost podílu odporu kapalně fáze v % a koeficientu přenosu hmoty v kapalně K_L na čase, teplota 1300 °C, průtok $1,67 \cdot 10^{-6}$ m 3 \cdot s $^{-1}$, $p_{\text{H}_2\text{O}} = 30$ kPa.

ВОЗНИКНОВЕНИЕ КОНВЕКЦИОННОГО ТЕЧЕНИЯ
В СТЕКЛОМАССАХ ПРИ ИСПАРЕНИИ
ПОВЕРХНОСТНО-АКТИВНОГО КОМПОНЕНТА
II. РАССМОТРЕНИЕ РЕЗУЛЬТАТОВ И МОДЕЛЬ ИСПАРЕНИЯ

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Скорости течения, возникающего при испарении поверхностно-активного компонента из фторидной стекломассы (опал) и боратной стекломассы (нейтрал) составляют величины порядка 10^{-5} — 10^{-4} м с $^{-1}$ и в общем находятся в корреляции с интенсивностью испарения фторидов. На основании анализа фторидов в стекломассе рассчитывается приблизительная доля гидролизированных испаряемых фторидов, которая в случае стекломассы с атмосферой „сухого“ азота ($p_{\text{H}_2\text{O}} = 0,5$ кПа) составляет 10—45 % и в случае стекломассы с атмосферой влажного азота ($p_{\text{H}_2\text{O}} = 30$ кПа) 41—75 %. На основании экспериментальных результатов предлагается модель испарения фторидов с предположением использования сопротивления жидкой фазы и раздела фаз, который в последующих стадиях устанавливается в общем на одинаковых величинах. Предложенная модель количественно отвечает условиям в промышленной установке с открытым уровнем. Она показывает, что понижение улетучивания можно достичь только понижением температуры, концентрации фторидов и понижением парциального давления водяного пара в атмосфере при низком притоке газов. В промышленном масштабе рекомендуется использовать плавление со закрытым уровнем.

Рис. 1. Зависимость доли гидролиза улетучивающихся фторидов в % от времени при предположении, что улетучивается половина присутствующего калия, температура 1300 °С.

Рис. 2. Зависимость общего коэффициента массопередачи K от времени и зависимость уровневой скорости течения от времени, температура 1300 °С, проток $1,67 \times 10^{-6} \text{ м}^3 \text{ с}^{-1}$ при нормальных условиях $p_{\text{H}_2\text{O}} = 30 \text{ кПа}$.

Рис. 3. Зависимость доли сопротивления жидкой фазы в % и коэффициента массопередачи в жидкости K_L от времени, температура 1300 °С, проток $1,67 \cdot 10^{-6} \text{ м}^3 \text{ с}^{-1}$, $p_{\text{H}_2\text{O}} = 30 \text{ кПа}$.

V. CHVALOVSKÝ: BANKY DAT. Druhé přepracované vydání, 210 str. SNTL, Praha 1984. Cena 33 Kčs.

První vydání knihy z r. 1976 zachytilo první pokusy konstruovat banku dat a vycházelo z tehdejších možností výpočetní techniky u nás. Druhé, podstatně přepracované vydání vychází z původní publikace, ale shrnuje a vyhodnocuje dosud nashromážděné zkušenosti a poznatky z teorie i praxe. Zabývá se komplexně technickým řešením, provozním a programovým zabezpečením a využitím banky dat při automatizaci v různých oblastech. Navrhuje progresivní využití výpočetní techniky a zvyšování efektivity sběru, vyhodnocování a využívání dat.

Obsah knihy vyplývá z názvů jednotlivých kapitol: 1. Teoretická východiska a základní pojmy; 2. Postavení banky dat v procesu automatizace; 3. Uspořádání banky dat; 4. Technicko-programové a provozní zabezpečení banky dat; 5. Stručný popis vybraných standardních systémů bank dat; 6. Problémy spojené se zaváděním a využíváním banky dat.

Knihla je určena pracovníkům v oboru automatizace a zpracování dat, studujícím na školách technického a ekonomického směru a účastníkům odborných kursů.

J. Hlaváč

SBORNÍK GEOLOGICKÝCH VĚD, řada TG-technologie, geochemie, sv. 19. Vydal Ústřední ústav geologický v Akademii, nakladatelství ČSAV, Praha 1984, I. vyd., 215 str., 56 obr., 24 křídových příloh, cena brož. výt. Kčs 24,—.

Nejnovější Sborník geologických věd obsahuje v řadě TG — technologie, geochemie — osm původních prací českých a slovenských autorů z ÚNS v Kutné Hoře, ÚÚG v Praze, VŠT v Košicích a Geologického průzkumu ve Spišské Nové Vsi, vypracovaných v letech 1979 až 1982.

Úvodní příspěvek A. Grenara a K. Klementa je věnován problematice možnosti výroby belitického cementu z vápnitých slínovec s nižším obsahem uhličitánu vápenatého. Slínovce s dostatečně vysokým obsahem CaCO_3 se již delší dobu používají jako přirozená surovinná směs s minimální korekcí vápencem pro výrobu portlandského slínku. Převládající složkou v tomto slínku je trikalciumpilikát — C_3S (alit), vedlejší dikalciumpilikát — C_2S (belit). Bylo však prokázáno, že na výrobu cementářského slínku je možno využívat vedle slínovec s vysokým obsahem vápence i slínovce s nižším obsahem této látky. V práci je uvedena jedna z možností — využití slínovec s obsahem CaCO_3 kolem 70 % pro výrobu belitického slínku. Z maltovinářského hlediska jde o reálné průmyslové využití aktivních hornin, ze kterých je možno získat vhodným výpalem slínky s převládajícím obsahem belitu a semletím tohoto slínku se sádrovcem cement belitického charakteru.

V práci J. Vtělenského, P. Šeby, O. Lubiny a M. Gabriela je podán přehled o minerální, chemické a fyzikálně technologické charakteristice kaolínových rezidíí na ložiskách v okolí Znojma, která jsou nejnadějnější pro průmyslové využití v keramice. Jsou vytyčeny korelace mezi obsahy $\text{FeO}_3 + \text{Na}_2\text{O}$ a zbarvením výpalku, mezi obsahem alkálií a stupněm slinutí a další vztahy mezi minerálním složením a technologickými vlastnostmi. Z těchto podkladů a na základě početných technologických zkoušek jsou naznačeny možnosti využití studovaných surovin v keramických výrobcích a způsob optimální úpravy.

Práce Z. Skokanové, J. Kročana, V. Hronského, J. Murína, D. Olčáka, M. Rákošihho a Š. Richtera obsahuje výsledky studia magnetických vlastností přírodního azbestu. Je zaměřena na určení magnetické susceptibilitity, zjištění feromagnetických příměsí statickou metodou a identifikaci paramagnetických iontů metodou elektronové paramagnetické rezonance (EPR) v tomto materiálu. Tyto vlastnosti byly zjišťovány u práškových vzorků v teplotním