

THE DIFFUSION-ELECTRIC PROCESS IN WATER-SATURATED CERAMIC MIX

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A method based on measuring the concentration profile in a diffusion pair with an inner electric heat source was worked out for determining the diffusion-electric coefficient in a water-saturated porcelain mix. The diffusion-electric process, due to the concentration gradient of soluble salts in the saturated ceramic body, decreases the density of alternating electric current. The ceramic mix containing a concentration gradient of the soluble salts, behaves as an inhomogeneous conductor and if it holds that $\text{grad } c = 0$, it behaves as a homogeneous conductor.

INTRODUCTION

If the transmission of electric current in a water-saturated ceramic mix is regarded as a diffusion process involving relative movement of ions with respect to neutral particles, the following relationship holds for the electric current flux \mathbf{j} :

$$\mathbf{j} = -\sigma \text{grad } \varphi - L_1 \text{grad } c - L_2 \text{grad } T, \quad (1)$$

where σ is the specific electric conductivity, $\text{grad } \varphi$ is the electric field potential, c is the concentration, T is temperature and L_1 , L_2 are the diffusion-electric and the thermo-electric coefficients respectively.

To describe the electrical properties of an inhomogeneous conductor, it is necessary to determine the significance of the individual terms in equation (1) for electric current transmission. In studies [1—3] it was found that in water-saturated porcelain mix with a constant content of soluble salts, distributed homogeneously throughout the body volume, the specific electric conductivity σ does not depend on the moisture content of the mix, and that its dependence on the concentration of soluble salts and temperature has the following form:

$$\sigma = ((0.01678c + 0.0044) T - 4.21c - 1.109) \text{ Sm}^{-1}, \quad (2)$$

where c is the concentration of soluble salts in wt. %. It was likewise found that the effect of the temperature gradient, i. e. that of the thermoelectric process on the transmission of alternating electric current in a water-saturated porcelain mix, can be neglected.

To describe completely the electric properties of a water-saturated porcelain mix, it is therefore necessary to express the effect of the diffusion-electric process in equation (1) on the transmission of electric current.

The present paper had the aim to work out a method for reliable determination of the diffusion electric coefficient in a water-saturated porcelain mix and to determine the significance of the effect of the diffusion-electric process on the flux of electric current.

METHOD FOR THE DETERMINATION OF THE DIFFUSION-ELECTRIC COEFFICIENT

During unidirectional passage of electric current through a prism-shaped body L in length there arises an electric field potential, a concentration gradient and a temperature gradient. If the effect of the temperature gradient in the body on the electric current transmission is negligible, the following relationship holds for the electric current flux:

$$\mathbf{j} = -\sigma(T, c) \nabla\varphi/\partial x - L_1(T, c) \partial c/\partial x. \quad (3)$$

At the same time, it holds for \mathbf{j} that

$$\mathbf{j} = -\sigma_{\text{eff}} \nabla\varphi/\partial x, \quad (4)$$

where σ_{eff} has the significance of effective specific electric conductivity, also involving the effect of the concentration gradient. By joining equations (3) and (4), one obtains the following equation for the calculation of the diffusion-electric coefficient L_1 at time t and temperature T :

$$L_1 = (\sigma_{\text{eff}} - \sigma) (\nabla\varphi/\partial x) (\partial c/\partial x)^{-1}. \quad (5)$$

For the calculation of L_1 one has therefore to know the values of σ_{eff} , σ , the electric field potential $\nabla\varphi/\partial x$ and the concentration gradient $\partial c/\partial x$.

To express $\partial c/\partial x$, one can use the concentration profile obtained by solving the weight balance for diffusion coefficient D independent of concentration, in the form:

$$\partial_t c = -D \partial_x^2 c, \quad (6)$$

where ∂_t and ∂_x are derivatives in terms of time and the ordinate respectively.

In order to determine L_1 , the authors developed the method of a diffusion pair with an inner three-dimensional heat source, ensuring unidirectional transmission of electric current and heat as well as unidirectional transfer of salts. The method was therefore based on creating and determining the electric field potential, the temperature and concentration profile in the body at time t . The apparatus, whose schematic diagram is shown in Fig. 1, consists of electrodes — 1, between which there is a body insulated thermally — 2, and with a moisture barrier — 3; the body consists of two bodies — 4, 5 of water-saturated porcelain mix with different

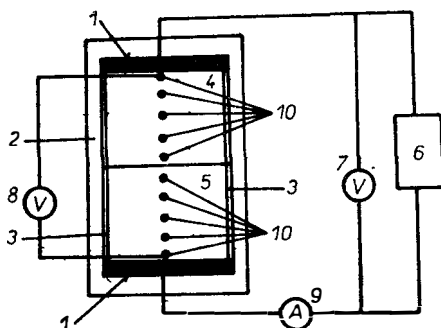


Fig. 1. Schematic diagram of the diffusion pair method with an inner three-dimensional heat source 1 — electrodes, 2 — thermal insulation, 3 — moisture barrier, 4, 5 — bodies with soluble salt concentrations c_1 and c_2 respectively, 6 — transformer, 7, 8 — voltmeter, 9 — ammeter, 10 — thermocouples

initial concentrations of salts c_1 and c_2 . The body is supplied with an adjustable constant alternating voltage from transformer — 6, the voltage being indicated by voltmeter — 7. The voltage on the body is measured by voltmeter — 8, and the electric current by ammeter — 9. The system of insulations, electrodes and the bodies is loaded by force 6 N. The temperature field in the body is measured by copper-constantan thermocouples — 10.

Resolving of balance (6) for the boundary conditions:

$$\begin{aligned} t = 0, & \quad x \in \langle 0, \infty \rangle, & c = c_0, \\ t > 0, & \quad x = 0, & c = c_s, \\ & \quad x \rightarrow \infty, & c = c_0, \end{aligned} \quad (7)$$

one obtains the following equation for the concentration profile:

$$(c - c_s)/(c_0 - c_s) = \operatorname{erf} (x/2\sqrt{Dt}), \quad (8)$$

where c_0 is the initial concentration and c_s is the final concentration on the surface $x = 0$.

The bodies for the measurements were prepared from a water-saturated porcelain mix by adding Na_2SO_4 [2] in the respective amounts of 0 wt. %, 0.3 wt. %, and 0.6 wt. %. The moisture content was 26 %. The bodies with a cross section of 30 mm \times 30 mm and length $L = 60$ mm or $L = 27.5$ mm were prepared by forming in a vacuum auger. The waterproofed bodies were allowed to mature for 48 hours in a water-saturated medium to attain a homogeneous distribution of the electrolyte throughout the body volume. The homogeneity of Na_2SO_4 distribution at all the concentrations was checked by comparing that in the entire body with one section 10 mm in length, obtained by cutting the original body. Identical values of σ were established. At all the concentrations, the electric field potential was measured by the procedure described in [1]. The results indicated that the electric field potential was established in the bodies immediately following the switching on of the electric current and that the dependence $U = U(x)$ was linear in all the instances. As was already found [3], the temperature gradient in the body does not affect the passage of electric current. In spite of this, voltages of $U < 10$ V were applied on the bodies, because at such voltages the individual time developments of temperature in bodies with different contents of soluble salts, i.e. different σ , do not show any great mutual differences, and the arising temperature gradient in the diffusion pair is small.

The temperature profiles measured in the diffusion pairs were used in the calculations in substituting the corresponding values of σ , calculated from equation (2).

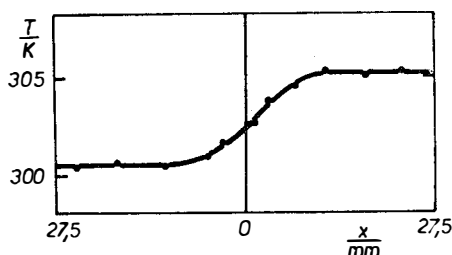


Fig. 2. Temperature profile in a diffusion pair

A typical temperature profile in a diffusion pair, e.g. that for a pair composed of bodies with concentrations of 0 wt. % and 0.6 wt. % of Na_2SO_4 respectively, is shown in Fig. 2 at a voltage of $U = 8$ V.

In view of the small temperature gradients involved, the mean temperatures in the diffusion pairs, T , are specified.

To determine the concentration profile of water soluble salts in a diffusion pair consisting of two bodies with the same moisture content, with lengths $L_1 = L_2 = 27.5$ mm and having roughly the same temperature but a different initial concentration of salts, the following procedure was used: Having joined the bodies into a diffusion pair with a length of $L = 55$ mm and connected it to an electric circuit with a constant voltage, the relationships $I = I(t)$ and $T = T(x, t)$ were measured. After time t , the diffusion pair was cut into slices about 10 mm in thickness in the direction of diffusion. Following their waterproofing, the slices were cooled down to 293 K and kept for 48 hours to equalize the salt concentration throughout the volume. The dependence $I = I(t)$ and $T = T(t)$ under constant voltage was then measured on the individual slices.

These relationships were used for expressing the relationship $\sigma = \sigma(T)$ in the individual slices, and these in turn served in the calculation of the mean concentration of soluble salts in the slices from the known dependence $\sigma = \sigma(c, T)$ according to equation (2). This procedure yielded dependence $c = c(x)$ in the diffusion pair.

DETERMINATION OF THE DIFFUSION-ELECTRIC COEFFICIENT BY THE DIFFUSION PAIR METHOD WITH AN INTERNAL THREE-DIMENSIONAL SOURCE OF HEAT

The effect of the concentration gradient on the transmission of electric current in water-saturated porcelain mix with a constant moisture content at a constant temperature was measured at a voltage of 8 V or 9.7 V on the diffusion pair. Experimental measurements were carried out on diffusion pairs composed of bodies with concentrations of $c = 0$ wt. % and $c = 0.6$ wt. %, or $c = 0$ wt. % and $c = 0.3$ wt. % of Na_2SO_4 at a mean temperature of $T = 303$ K. The established current values expressed as a specific electric conductivity of the diffusion pair at three temperatures are listed in Table I.

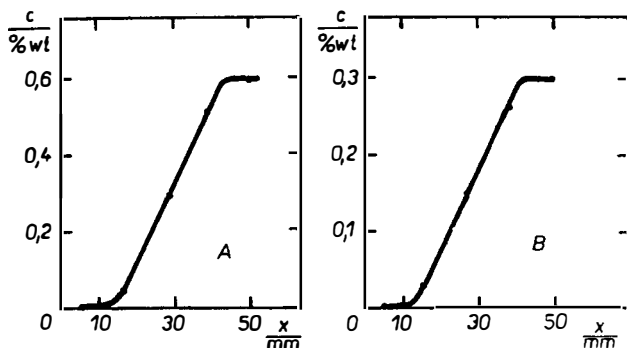


Fig. 3. Concentration profile in a diffusion pair at $T = 303$ K. A — 0—0.6 wt. %; B — 0—0.3 wt. %

Table I
Values measured on diffusion pairs

Diffusion pair	$\frac{U}{V}$	$\frac{I}{mA}$	$\frac{T}{K}$	$\frac{\sigma_{eff}}{Sm^{-1}}$
0—0.6 wt. %	8	37.5	295	0.29
		41.0	298	0.31
		46.5	303	0.36
0—0.3 wt. %	9.7	41.3	295	0.26
		44.0	298	0.28
		48.5	303	0.31

The results of measuring the slices obtained by cutting the diffusion pairs are listed in Table II. The concentration profiles $c = c(x)$ in the diffusion pairs are plotted in Fig. 3.

DISCUSSION AND CONCLUSION

Let us first verify the concentration profiles measured in the diffusion pairs. In the diffusion pair prepared from a water-saturated porcelain mix of equal moisture content, the only difference was in the Na_2SO_4 concentration. Knowledge of the concentration profile allows the diffusion coefficient of Na^+ or SO_4^{2-} ions to be calculated. On the basis of equation (8), c_s is the concentration at the interface of the diffusion pair, and c_0 is the initial concentration in the body of the diffusion pair having the higher concentration. On carrying out the indicated calculation, one finds from the diffusion pair of 0—0.6 wt. % the value of the diffusion coefficient, $D = 3 \times 10^{-9} m^2 s^{-1}$ at $T = 303$ K. For the diffusion pair of 0—0.3 wt. %, the diffusion coefficient value of $D = 4 \times 10^{-9} m^2 s^{-1}$ is obtained.

The literature [4] specifies diffusion coefficients $D_{Na^+} = 1.27 \times 10^{-9} m^2 s^{-1}$ and $D_{SO_4^{2-}} = 0.83 \times 10^{-9} m^2 s^{-1}$ at $T = 298$ K. On taking into account the temperature difference of 5 K, one finds a satisfactory agreement between the measured diffusion coefficients and those given in the literature. The method suggested for measuring the concentration profile on the basis of determining the specific electric conductivity of the mix gives reliable results. This finding allows us to analyze the electric behaviour of a porcelain mix with a concentration gradient of soluble salts.

Let us assume that the diffusion pair behaves as a resistor composed of partial resistors connected in series. In the given case the following equation holds for the total resistance:

$$R_c = \sum_{i=1}^n R_i = \sum_{i=1}^n (L_i / \sigma_i S) \tag{9}$$

and for the total specific electric conductivity it holds that:

$$\sigma_c = L_c / R_{cS}, \tag{10}$$

where L_c is the length of the diffusion pair. Let us first consider the initial state when the diffusion pair is composed of two bodies with a homogeneously distributed but different contents of salts. It is therefore composed of two resistors with conductivities σ_1 and σ_2 . This situation is described by the values measured at

Table II

The measured and calculated values for the slices

Diffusion pair 0–0.6 wt. %	I mA	U V	T K	σ Sm ⁻¹	C wt. %	\bar{C} wt. %
$L_1 = 1.08 \times 10^{-2}$ m	42.5	2.7	295	0.19	0	0
	103.3	6.2	298	0.20	0	0
	117.3	6.4	303	0.22	0	0
$L_2 = 1.18 \times 10^{-2}$ m	89.9	5.5	295	0.22	0.04	0.043
	103.4	5.8	298	0.23	0.04	
	109.8	5.6	303	0.26	0.05	
$L_3 = 1.10 \times 10^{-2}$ m	178.2	5.3	295	0.41	0.30	0.303
	197.5	5.4	298	0.45	0.31	
	206.8	5.2	303	0.49	0.30	
$L_4 = 0.98 \times 10^{-2}$ m	184.2	3.5	295	0.57	0.52	0.520
	208.3	3.7	298	0.61	0.52	
	235.0	3.8	303	0.68	0.52	
$L_5 = 1.16 \times 10^{-2}$ m	205.3	4.2	295	0.63	0.60	0.6
	230.8	4.4	298	0.68	0.6	
	238.0	4.1	303	0.75	0.6	
0–0.3 wt. %						
$L_1 = 1.04 \times 10^{-2}$ m	86.7	5.3	295	0.19	0	0
	97.9	5.6	298	0.20	0	
	112.4	5.8	303	0.22	0	
$L_2 = 1.08 \times 10^{-2}$ m	167.0	9.5	295	0.21	0.03	0.033
	180.8	9.6	298	0.23	0.03	
	211.5	9.8	303	0.26	0.04	
$L_3 = 1.13 \times 10^{-2}$ m	116.7	5.0	295	0.29	0.14	0.147
	130.4	5.1	298	0.32	0.15	
	135.7	4.8	303	0.36	0.15	
$L_4 = 1.05 \times 10^{-2}$ m	133.4	4.0	295	0.39	0.27	0.267
	150.4	4.3	298	0.41	0.26	
	169.5	4.3	303	0.46	0.27	
$L_5 = 1.20 \times 10^{-2}$ m	123.3	4.0	295	0.41	0.3	0.3
	148.2	4.5	298	0.44	0.3	
	149.8	4.1	303	0.49	0.3	

$T = 295$ K (cf. Table I). The σ_c of the system calculated from equation (10) for $n = 2$, where the σ_1 and σ_2 for $T = 295$ K are given by equation (2), is in a good agreement with the σ_{eff} obtained experimentally for both diffusion pairs, as follows from Table III. This means that if the system is composed of two bodies

Table III

Calculated and experimental values of specific electric conductivity of diffusion pairs

$\frac{T}{K}$	Diff. pair 0–0.6 wt. %				Diff. pair 0–0.3 wt. %			
	$\frac{\sigma_{eff}}{Sm^{-1}}$	σ_c/Sm^{-1}			$\frac{\sigma_{eff}}{Sm^{-1}}$	σ_c/Sm^{-1}		
		n = 2	n = 3	n = 5		n = 2	n = 3	n = 5
295	0.29	0.29	—	—	0.26	0.26	—	—
298	0.31	0.31	—	—	0.28	0.28	—	—
303	0.36	0.34	0.36	0.38	0.31	0.30	0.31	0.34

with different but homogeneous contents of soluble salts, this system in an electric field can be regarded as two resistors connected in series.

In the case when $T = 303$ K, the concentration profiles in the diffusion pairs are plotted in Fig. 3. The difference between σ_c and σ_{eff} indicates (cf. Table III, $n = 2$, $T = 303$ K) that the approximation carried out does not describe the electrical properties of the system at this temperature. To assess this difference between σ_c and σ_{eff} at $T = 303$ K, it is possible to use precisioning of the calculation of σ_c by replacing the two resistors by five resistors, which would be obtained by determining the concentration profile $c = c(x)$ in both diffusion pairs. The values of σ_i corresponding to L_i at $T = 303$ K listed in Table II were measured on slices with homogeneous distribution of salts throughout their volume. The σ_c calculated for these values from equation (10) for $n = 5$ at $T = 303$ K, both diffusion pairs are listed in Table III. A comparison of these values of σ_c with those of σ_{eff} gives evidence of the difference between the two quantities. This means that if a concentration gradient of soluble salts is present in a body, the behaviour of the body in an electric field does not correspond to that of resistors in series with different homogeneous contents of soluble salts. The precisioned calculation for $n = 5$ also leads to the finding that a system composed of several homogeneous resistors connected in series has a higher specific electric conductivity than a system with a concentration gradient of soluble salts.

Let us utilize the findings and carry out the division of a diffusion pair into resistors arranged in series according to Fig. 4, on the basis of the established dependences $c = c(x)$ (cf. Fig. 3). In the given case, the diffusion pair consist of two bodies with a homogeneous content of salts c_1 and c_2 , and specific electric conductivities σ_1 and σ_2 , and one body with a concentration gradient of soluble salts $c = c(x)$ with effective specific electric conductivity σ_{effp} . The values of the corresponding quantities at $T = 303$ K for both diffusion pairs are listed in Table IV, and the values of σ_1 and σ_2 are given by equation (2). The calculated σ_c of this system from equation 10 for $n = 2$ and $T = 303$ K is given for both diffusion pairs in Table III. The agreement between the values of σ_c and σ_{eff} means that the system composed of bodies with homogeneously distributed content of salts, and bodies with a concentration gradient in an electric field can be described as resistors connected in series in the case where the bodies with the concentration gradient are expressed by effective quantities.

To establish the significance of the diffusion electric process on electric current transmission in a water-saturated porcelain mix containing soluble salts, let

us determine the concentration profile according to Figs. 3 and 4. For the sake of simplification, the entire concentration profile is approximated by a linear dependence, as illustrated by Fig. 3. The electric voltage profile is also considered to be linear. In the given case, equation (5) acquires the form

$$L_1 = (\sigma_{effp} - \sigma_c^-) (\Delta\varphi/\Delta x) (\Delta c/\Delta x)^{-1}, \tag{11}$$

where σ_c^- is the specific electric conductivity of a body with homogeneously distributed mean concentration of salts, \bar{c} in the diffusion pair $\Delta x = x_p$. For the diffusion pair part x_p according to Fig. 4, Table IV and Fig. 3 indicate the values of quantities listed for $T = 303$ K in Table V. The diffusion-electric coefficients L_1 calculated according to (1) are given in Table V.

On expressing, on the basis of the L_1 established, the effect of the electric field potential, i.e. $(-\sigma) d\varphi/dx$ and that of the diffusion-electric process, i.e. $L_1 dc/dx$ on the electric current density j according to equation (3) one finds that the flux through a conductor with the concentration gradient $dc/dx = 21.8$ wt. % m^{-1}

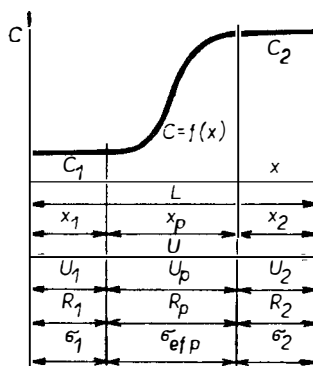


Fig. 4. Schematic diagram of the division of a diffusion pair into resistors connected in series according to the dependence $c = c(x)$

Table IV

Survey of values for the series connection of resistors according to Fig. 4

Diffusion pair	$\frac{x_1}{\text{mm}}$	$\frac{x_2}{\text{mm}}$	$\frac{x_p}{\text{mm}}$	$\frac{U_1}{\text{V}}$	$\frac{U_2}{\text{V}}$	$\frac{U_p}{\text{V}}$
0–0.6 wt. %	14	13.5	27.5	3.23	0.93	3.84
0–0.3 wt. %	13	14	28	3.13	1.55	5.02

diffusion pair	$\frac{\sigma_{effp}}{\text{Sm}^{-1}}$	$\frac{c_1}{\text{wt. \%}}$	$\frac{c_2}{\text{wt. \%}}$	$\frac{I}{\text{mA}}$
0–0.6 wt. %	0.37	0	0.6	46.5
0–0.3 wt. %	0.30	0	0.3	48.5

Table V

Values of quantities for the calculation of the diffusion-electric coefficient

Diffusion pair	$\frac{\sigma_{effp}}{\text{Sm}^{-1}}$	$\frac{\bar{c}}{\text{wt. \%}}$	$\frac{\sigma_c^-}{\text{Sm}^{-1}}$	$\frac{\Delta\varphi/\Delta x}{\text{Vm}^{-1}}$	$\frac{\Delta c/\Delta x}{\text{wt. \% m}^{-1}}$	$\frac{L_1}{\text{wt. \% VSm}^{-3}}$
0-0.6 wt. %	0.37	0.3	0.487	139.8	21.8	-0.75
0-0.3 wt. %	0.30	0.15	0.355	179.3	10.7	-0.92

is smaller by 24 % than that in a conductor without any concentration gradient. In the case of $dc/dx = 10.7 \text{ wt. \% m}^{-1}$, this flux is lower by 15 %.

On the basis of the results obtained it may be concluded that the electric process due to the concentration gradient of soluble salts decreases the passage of alternating electric current through the water-saturated ceramic mix. The negative effect of the diffusion-electric process on the transmission of electric current decreases with decreasing concentration of salts in the mix. In an alternating electric field, a water saturated ceramic mix with a concentration gradient of soluble salts behaves as an inhomogeneous conductor. In the case of $\text{grad } c = 0$, its behaviour is described by a homogeneous electric conductor.

References

- [1] Havrda J., Gregorová E., Oujíř F.: *Silikáty* 33, 367 (1989).
- [2] Havrda J., Gregorová E., Oujíř F.: *Silikáty* 33, 291 (1989).
- [3] Havrda J., Gregorová E., Oujíř F.: *Silikáty* (1989) in press
- [4] Landolt-Börnstein: *Zahlenwerte und Funktionen*, II. Band, 5. Teil, Bandteil a, Viskosität und Diffusion. Springer, Berlin 1969.

DIFÚZNĚ ELEKTRICKÝ PROCES VE VODOU NASYCENÉ KERAMICKÉ SMĚSI

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Difúzně elektrický proces ve vodou nasycené keramické směsi je studován metodou difúzního páru s vnitřním objemovým zdrojem tepla, při níž je směr přenosu elektrického proudu rozpustných solí a tepla stejný. Metoda je založena na měření koncentračního profilu v tělese na základě stanovení specifické elektrické vodivosti směsi. Je proveden rozbor elektrického chování nasycené keramické směsi s vnitřním zdrojem tepla a koncentračním gradientem rozpustných solí. Difúzně elektrický proces, vyvolaný gradientem koncentrace rozpustných solí, snižuje tok střídavého elektrického proudu ve vodou nasycené keramické směsi. Vodou nasycená keramická směs, obsahující gradient koncentrace rozpustných solí, se ve střídavém elektrickém poli chová jako nehomogenní elektrický vodič, je-li tento gradient roven nule, popisuje její chování homogenní elektrický vodič.

Obr. 1. Schéma metody difúzního páru s vnitřním objemovým zdrojem tepla; 1 — elektrody, 2 — tepelná izolace, 3 — vlhkostní izolace, 4, 5 — tělesa s koncentrací rozpustných solí c_1, c_2 , 6 — transformátor, 7, 8 — voltmetr, 9 — ampérmetr, 10 — termočlánky.

Obr. 2. Teplotní profil v difúzním páru.

Obr. 3. Koncentrační profil v difúzním páru při $T = 303 \text{ K}$. A — (0 — 0,6) % hm.; B — (0 — 0,3) % hm.

Obr. 4. Schéma rozdělení difúzního páru na sériově řazené odpory podle závislosti $c = c(x)$.

О ДИФФУЗИОННО ЭЛЕКТРИЧЕСКИЙ ПРОЦЕСС
В НАСЫЩЕННОЙ ВОДОЙ КЕРАМИЧЕСКОЙ СМЕСИ

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Диффузионно электрический процесс в насыщенной водой керамической смеси исследовали с помощью метода диффузионной пары с внутренним объемным источником тепла, при котором направление переноса электрического тока растворимых солей и тепла одинаковы. Метод основывается на измерении концентрационного профиля в теле на основании определения удельной электрической проводимости смеси. Приводится анализ электрического поведения насыщенной керамической смеси с внутренним источником тепла и градиентом концентрации растворимых солей. Диффузионно электрический процесс, вызванный градиентом концентрации растворимых солей, понижает проток переменного тока в насыщенной водой керамической смеси. Насыщенная водой керамическая смесь, содержащая градиент концентрации растворимых солей, в переменном электрическом поле ведет себя как неоднородный электропроводник, и если данный градиент равен нулю, то описывает ее поведение однородный электропроводник.

Рис. 1. Схема метода диффузионной пары с внутренним объемным источником тепла; 1 — электроды, 2 — теплоизоляция, 3 — влажностная изоляция, 4, 5 — тела с концентрацией растворимых солей c_1 , c_2 , 6 — трансформатор, 7, 8 — вольтметр, 9 — амперметр, 10 — термоэлементы.

Рис. 2. Температурный профиль в диффузионной паре.

Рис. 3. Концентрационный профиль в диффузионной паре при $T = 303$ K; A — (0—0,3) % по весу; B — (0 — 0,3) % по весу.

Рис. 4. Схема разделения диффузионной пары на каскадно упрядоченные сопротивления согласно зависимости $c = c(x)$.

OPRACOVÁNÍ ULTRAZVUKEM představuje velký pokrok v oblasti technologie konečné úpravy různých materiálů. Metoda využívá ultrazvukem indukované vibrace. Při kombinaci s abrasivní hmotou umožňuje přesné vrtání otvorů jakéhokoliv tvaru. Jedná se o ne-teplný, neelektrický a nechemický postup, který nemá negativní vliv na chemické a fyzikální vlastnosti opracovaného materiálu. Mezi materiály opracovatelné ultrazvukem patří Al_2O_3 , karbid a nitrid křemíku, piezokeramika, tavený křemen, sklo, boritokřemičité sklo, jedno- a polykrytalický Si, safír, karbidy a různé kovy. Mezi nejběžněji používaná obrusiva se řadí karbid B a Si a oxid Al. Pro opracování skelných materiálů a taveného křemene je nejvhodnější karbid Si. Tento postup je možné využívat v různých oblastech — od výroby keramických motorů v automobilovém průmyslu až po přípravu Al_2O_3 podložek používaných při automatizované výrobě diod. Výhody opracování ultrazvukem spočívají v dosažení vysoké kvality opracovaných výrobků bez vzniku napětí při nižších cenách. Metoda umožňuje opracování i výrobků s reflexní nebo pokovenou vrstvou bez narušení těchto vrstev.

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