

The problem of liberation of one of the components of a chemically reacting gas mixture as a result of its selective diffusion through a semipermeable membrane is formulated; a numerical example is examined for the solution of the problem for a dissociation reaction.

Selective diffusion through semipermeable metallic and polymer membranes permits realization of important technological processes of gas mixture enhancement in the direction desired and in the liberation of pure gases therefrom [1, 2]. Obtaining especially pure hydrogen by such a method for the needs of modern metallurgy, power, etc., is of special applied interest [3, 4].

Independently of the structural details, apparatus for the diffusion separation of gas mixtures can be represented as sets of elementary cells consisting of delivery and discharge channels separated by a thin membrane whose permeability is not the same for different mixture components. The initial gas mixture is pumped into the delivery channels, the mixture that is obtained after diffusion through the membrane goes into the discharge channels, from which it is directed to the collector. There is a very large number of experiments on the separation of mixtures of different composition by using diffusion of the most different nature through a membrane; numerous attempts at a theoretical analysis of the diffusion separation and the creation of appropriate computational methods are also known (see [5, 6] for recent examples).

Unfortunately, theoretical investigations are performed under quite strong assumptions that significantly delimit the applicability of the results obtained to the description and optimization of real processes. Most substantial are assumptions on ideal mixing in the delivery channels and on ideal displacement in the discharge channels, as well as neglecting chemical reactions in the gas mixture. Mixture inhomogeneity in the delivery channels and the presence of hydraulic drag in the discharge channels and lines connecting them to the collector are capable of substantial influence on the operating characteristics and the efficiency of the diffusion separation apparatus. If the gas to be liberated is obtained as a result of a reaction proceeding in the initial mixture, then its intensive discharge from the system should lead to a shift in the chemical equilibrium towards further progress of the reaction. This latter affords the possibility, in principle, of obtaining even more liberatable gas by diffusion separation that is contained in the initial equilibrium mixture in pure form, and therefore, of intensifying the operation of the appropriate apparatus.

A stationary process is considered below for separation in an elementary cell with one delivery channel with cross-sectional area S and length L and one discharge channel of the same length; the working perimeter of the semipermeable wall assuring the diffusion connection between channels is P . The separation rate depends on the mixing rate in the delivery channel and the transport to the wall surface, the gas adsorption and dissolution in the wall material, the gas diffusion in the solid solution, its desorption in the discharge channel and its efflux therefrom. Ordinarily gas penetration through the wall, which we also assume later, is the main limiting factor. Interaction of the sorption-desorption, dissolution, and diffusion rates can be described strictly by using a model of the type proposed in [7]; for simplification we here characterize the rate of penetration through the wall by using a unique coefficient of effective permeability that reflects the influence of all the elementary processes mentioned. We neglect longitudinal mixing in the delivery channels as well as their hydraulic drag, which indicates the general tendency to construct real apparatus in which it is desirable to assure high mixture flow rates and its high pressure for a minimum of hydraulic

losses. We therefore arrive at a model of ideal mixing in each section of the delivery channel under the condition of ideal displacement along its length. Moreover, neglecting the hydraulic drag permits considering the mixture pressure homogeneous for a stationary flow in the delivery channel [8].

For definiteness, we assume the mixture to contain the reagents A_i , the reaction products B_i , and the ballast gas C that does not participate in the reactions, where a single reversible reaction holds that proceeds according to the stoichiometric equation



where the summation is over all reagent or over all reaction products. We consider that just one gas (B_1) to diffuse through the wall, and the whole process to occur under isothermal conditions.

MATERIAL BALANCE IN THE GAS MIXTURE

Let the rate constants of the forward and reverse reactions (1) be K^+ and K^- , respectively, and the molar flux of the gas B_1 through the wall be q . The material balance equations for molar reagent and reaction product fluxes in the delivery channels have the form

$$\frac{dj_{ai}}{dl} = -\nu_i F, \quad \frac{dj_{bi}}{dl} = \mu_i F - \frac{P}{S} q \delta_{i1}, \quad (2)$$

$$F = K^+ \prod_m n_{am}^{\nu_m} - K^- \prod_m n_{bm}^{\mu_m}.$$

The molar flux of the ballast gas is $j_c = n_c v = \text{const}$; consequently, the rate v which is identical for all the mixture gases can be expressed as $j_c/n_c = j_c/x_c n$, where n is the total molar concentration defined uniquely by the constant mixture pressure. Hence

$$j_{ai} = n_{ai} v = \frac{x_{ai}}{x_c} j_c, \quad j_{bi} = n_{bi} v = \frac{x_{bi}}{x_c} j_c,$$

$$\frac{dj_{ai}}{dl} = \frac{j_c}{x_c} \left(\frac{dx_{ai}}{dl} - \frac{x_{ai}}{x_c} \frac{dx_c}{dl} \right),$$

$$\frac{dj_{bi}}{dl} = \frac{j_c}{x_c} \left(\frac{dx_{bi}}{dl} - \frac{x_{bi}}{x_c} \frac{dx_c}{dl} \right).$$

Taking into account that the sum of the molar fractions of all the mixture gases equals one identically, we have

$$\sum_i \frac{dj_{ai}}{dl} + \sum_i \frac{dj_{bi}}{dl} = -\frac{j_c}{x_c} \left(\frac{dx_c}{dl} + \frac{1-x_c}{x_c} \frac{dx_c}{dl} \right) = -\frac{j_c}{x_c^2} \frac{dx_c}{dl}.$$

On the other hand, we obtain from (2)

$$\sum_i \frac{dj_{ai}}{dl} + \sum_i \frac{dj_{bi}}{dl} = (\mu - \nu) F - \frac{P}{S} q,$$

where μ and ν are the sums of all the stoichiometric coefficients μ_i and ν_i . We therefore obtain the equation

$$\frac{dx_c}{dl} = \frac{x_c^2}{j_c} \left[(\nu - \mu) F + \frac{P}{S} q \right], \quad (3)$$

governing the change in the molar fraction of the ballast gas along the channel.

By using (3) we have from the definitions presented above for dj_{ai}/dl and dj_{bi}/dl

$$\frac{dj_{ai}}{dl} = \frac{j_c}{x_c} \frac{dx_{ai}}{dl} - x_{ai} \left[(\nu - \mu) F + \frac{P}{S} q \right], \quad (4)$$

$$\frac{dj_{bi}}{dl} = \frac{j_c}{x_c} \frac{dx_{bi}}{dl} - x_{bi} \left[(\nu - \mu) F + \frac{P}{S} q \right].$$

Relationships (4) permit rewriting the equation in (2) thus:

$$\begin{aligned} \frac{dx_{ai}}{dl} &= \frac{x_c}{j_c} \left\{ x_{ai} \left[(v - \mu)F + \frac{P}{S} q \right] - v_i F \right\}, \\ \frac{dx_{bi}}{dl} &= \frac{x_c}{j_c} \left\{ x_{bi} \left[(v - \mu)F + \frac{P}{S} q \right] + \mu_i F - \frac{P}{S} q \delta_{ii} \right\}. \end{aligned} \quad (5)$$

Under the assumptions made relative to penetration of the gas being liberated through the wall, we write

$$q = k(p'_{b1} - p'), \quad (6)$$

where k is the effective coefficient of permeability, which can be defined as the product of the traditionally inducible gas solubility in the wall material by the coefficient of its diffusion therein divided by the wall thickness. The exponent r permits taking account of the necessity for gas dissociation during its adsorption and dissolution (if the gas does not generally dissociate, $r = 1$; for a dissociating diatomic gas in conformity with Sievert's law $r = 1/2$, etc.).

Let $p_{b1} = x_{b1}p$, and let the molar concentrations of the mixture components be expressed in terms of the corresponding molar fractions and the total molar concentration, while the latter is expressed in terms of the total mixture pressure p . This permits all the quantities in (5) to be expressed in terms of x_{ai} , x_{bi} and constant parameters. Taking account of the expression for F from (2) and the relationships (6), we obtain

$$\begin{aligned} F &= K^+ \left(\frac{p}{RT} \right)^v \prod_m x_{am}^{v_m} - K^- \left(\frac{p}{RT} \right)^\mu \prod_m x_{bm}^{\mu_m}, \\ \frac{P}{S} q &= \frac{Pkp'}{S} (x'_{b1} - y'), \quad y = \frac{p'}{p}, \quad x_c = 1 - \sum_m x_{am} - \sum_m x_{bm}. \end{aligned} \quad (7)$$

Therefore, to close the system (5) it is necessary to formulate just an equation for the relative pressure y of the gas being liberated in the discharge channel.

The mass and momentum conservation equations in the discharge channel have the form

$$\frac{dj'}{dl'} = \frac{P}{S} q, \quad \frac{dp'}{dl'} = -\alpha \rho' v', \quad dl' = \pm dl.$$

Taking into account that the molar flux therein is $j' = \rho' v' / M$, we hence obtain

$$\frac{d^2 y}{dl'^2} = - \frac{\alpha PM kp'}{Sp} (x'_{b1} - y'), \quad (8)$$

which closes the system (5).

SYSTEM OF DIMENSIONLESS EQUATIONS AND BOUNDARY CONDITIONS

It is convenient to introduce the dimensionless coordinate z and the dimensionless functions

$$\begin{aligned} z &= \frac{Pkp'}{Sj_c} l, \quad \beta = \frac{\alpha SM j_c^2}{Pkp^{1+r}}, \quad N = (v - \mu)G + x'_{b1} - y', \\ G &= \frac{S}{Pkp'} \left[K^+ \left(\frac{p}{RT} \right)^v \prod_m x_{am}^{v_m} - K^- \left(\frac{p}{RT} \right)^\mu \prod_m x_{bm}^{\mu_m} \right]. \end{aligned} \quad (9)$$

Then taking account of (6) and (7), we write (5) and (8) in the following dimensionless form

$$\frac{dx_{ai}}{dz} = x_c (Nx_{ai} - v_i G), \quad (10)$$

$$\frac{dx_{bi}}{dz} = x_c [N x_{bi} + \mu_i G - (x'_{b1} - y') \delta_{i1}],$$

$$\frac{d^2 y}{dz^2} = -\beta (x'_{b1} - y'), \quad x_c = 1 - \sum_m x_{am} - \sum_m x_{bm}. \quad (10)$$

The boundary conditions at the input to the delivery channel can be given in the form

$$x_{ai}|_{z=0} = x_{ai}^{\circ}, \quad x_{bi}|_{z=0} = x_{bi}^{\circ}, \quad (11)$$

where the sum of the quantities on the right sides of these equalities should be less than one; the mentioned quantities are otherwise generally arbitrary.

The boundary conditions for the discharge channel depend on the specific flow organization therein. We here examine the versions corresponding to the forward and back flow; in the former case the section $z = 0$ of the discharge channel is choked and gas sampling is through the section $z = Z$, while in the latter, the reverse holds [the dimensionless channel length Z is expressed in terms of L in conformity with the first relationship in (9)]. The boundary conditions

$$dy/dz|_{z=0} = 0, \quad y|_{z=Z} = y_*; \quad y|_{z=0} = y_*, \quad dy/dz|_{z=Z} = 0. \quad (12)$$

correspond to the versions mentioned.

For a large dimensionless hydraulic drag coefficient β and high relative pressure y_* characterizing the condition at the exit from the discharge channel, the difference in the operation of the forward and reverse apparatus ($d\bar{z}' = d\bar{z}$ and $d\bar{z}' = -d\bar{z}$, respectively) determined in the boundary conditions (12) turns out to be quite substantial. As follows from an analysis of the separation of gas mixtures without chemical reactions, the backflow apparatus have serious advantages as compared with the forward flow, thereby assuring higher productivity, other conditions being equal.

Conditions corresponding to the initial equilibrium mixture of stoichiometric composition are an important particular case of the boundary conditions at the input to the delivery channel. In this case, by assumption

$$x_{ai}^{\circ} = \frac{\nu_i}{\nu_1} x_{a1}^{\circ}, \quad x_{bi}^{\circ} = \frac{\mu_i}{\mu_1} x_{b1}^{\circ} \quad (i > 1), \quad (13)$$

$$K^+ \left(\frac{p}{RT} \right)^{\nu} \prod_i (x_{ai}^{\circ})^{\nu_i} = K^- \left(\frac{p}{RT} \right)^{\mu} \prod_i (x_{bi}^{\circ})^{\mu_i},$$

i.e., the input values of all the molar fractions can be expressed in terms of any one of them (for instance, in terms of x_{b1}° , which characterizes the fraction of gas being liberated in the unbound state). The input molar fraction of the ballast gas is here also a function of x_{b1}° and can be determined from the relationship

$$1 - x_c^{\circ} = (\nu/\nu_1) x_{a1}^{\circ} + (\mu/\mu_1) x_{b1}^{\circ}, \quad x_{a1}^{\circ} = f(x_{b1}^{\circ}). \quad (14)$$

It is convenient to introduce a relative productivity function, which is the ratio between the total quantity of gas being liberated in the cell per unit time and the consumption of this gas contained in the initial mixture in free form, or its total consumption is both the free and the bound state. Taking account of (6) and (9) we have for the first relative productivity

$$\varphi = (Sf_{b1}^{\circ})^{-1} P \int_0^L q dl = \frac{x_c^{\circ}}{x_{b1}^{\circ}} \int_0^Z (x'_{b1} - y') dz. \quad (15)$$

In connection with the fact that the removal of the gas being liberated through the wall results in a shift in the equilibrium in a chemically reacting mixture, the quantity φ can exceed one.

If one mole of the reagent A_1 contains σ_1 moles of the gas being liberated B_1 , then the second relative productivity can be written in the form

$$\psi = x_c^{\circ} (x_{b1}^{\circ}) + \sum_i \sigma_i x_{ai}^{\circ} \int_0^Z (x'_{b1} - y') dz. \quad (16)$$

In contrast to (15) this quantity is less than one in any case.

In the particular case of an inert gas mixture (without chemical reactions), it is sufficient to distinguish just the molar fraction x of the gas being liberated and the fraction $1 - x$ of the ballast gas mixture. In this case, in place of the system of equations for x_{a1} and x_{b1} we have the single equation

$$\frac{dx}{dz} = -(1-x)^2(x' - y'). \quad (17)$$

The system (10) is also simplified somewhat when the pressure in the collector and in the discharge channels is much less than p . It can here be assumed $y = 0$ and neither the equation of motion in the discharge channel nor its boundary conditions need generally be considered. Let us note that the difference between the forward and the return flow elementary cells or apparatus vanishes here.

NUMERICAL EXAMPLE: DISSOCIATION REACTION

As a simple illustration we consider the dissociation reaction which is stoichiometrically similar to the reaction $2\text{H}_2\text{O} \rightleftharpoons 2\text{H}_2 + \text{O}_2$. In this case the coefficients $\nu_1 = 2$, $\mu_1 = 2$, $\mu_2 = 1$ differ from zero. For simplicity we consider $y = 0$ and we take $r = 1/2$. We then have from (10)

$$\begin{aligned} \frac{dx_{a1}}{dz} &= x_c [x_{a1} \sqrt{x_{b1}} - G(2 + x_{a1})], \\ \frac{dx_{b1}}{dz} &= x_c [-(1 - x_{b1}) \sqrt{x_{b1}} + G(2 - x_{b1})], \\ \frac{dx_{b2}}{dz} &= x_c [x_{b2} \sqrt{x_{b1}} + G(1 - x_{b2})], \end{aligned}$$

where

$$\begin{aligned} x_c &= 1 - x_{a1} - x_{b1} - x_{b2}; \quad G = g(\gamma x_{a1}^2 - x_{b1}^2 x_{b2}); \\ g &= \frac{SK^-}{Pk\sqrt{p}} \left(\frac{p}{RT}\right)^3; \quad \gamma = \frac{K^+}{K^-} \left(\frac{p}{RT}\right)^{-1}. \end{aligned}$$

If the initial mixture is an equilibrium mixture and has a stoichiometric composition, then in conformity with (13) and (14), we obtain

$$\begin{aligned} x_{a1}^\circ &= \frac{1}{\sqrt{2\gamma}} (x_{b1}^\circ)^{3/2}, \quad x_{b2}^\circ = \frac{1}{2} x_{b1}^\circ, \\ \gamma &= \frac{1}{2} (x_{b1}^\circ)^3 (1 - x_c^\circ - \frac{3}{2} x_{b1}^\circ)^{-2}, \end{aligned}$$

which permits considering x_{b1}° and x_c° as independent characteristics of the mixture at the input to the delivery channel. Assignment of these quantities defines the state of the initial mixture completely (including the ratio p/T also).

The dependences of x_{a1}/x_{a1}° , x_{b1}/x_{b1}° , and x_{b2}/x_{b2}° , obtained numerically, on z for $g = 1$ and the different x_{b1}° with $x_c^\circ = 0.5$ are shown in Fig. 1. The molar content of the gas being liberated decreases monotonically along the channel, and the contents of the reaction and the second product of the direct reaction grow as a whole. In the general case when the initial mixture is nonequilibrium these dependences can have quite definite minimum and maximums whose appearance would be due to the competition between production of the gas being liberated because of the reaction and its discharge because of selective diffusion through the wall.

The relative productivities (15) and (16) are written as follows in the case under consideration ($r = 1/2$, $y = 0$, $x_c^\circ = 0.5$)

$$\varphi = \frac{1}{2x_{b1}^\circ} \int_0^z \sqrt{x_{b1}} dz, \quad \psi = \frac{1}{1 - x_{b1}^\circ} \int_0^z \sqrt{x_{b1}} dz.$$

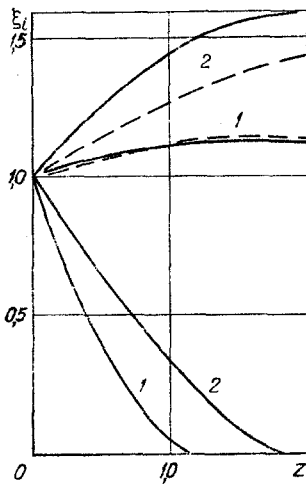


Fig. 1

Fig. 1. Dependences of the quantities $\xi_1 = x_{b1}/x^o_{b1}$ (lower half of the figure), $\xi_2 = x_{b2}/x^o_{b2}$ and $\xi_3 = x_{a1}/x^o_{a1}$ (dashed and solid curved in the upper half) on z for the dissociation reaction with $x^o_{b1} = 0.1$ and 0.3 (1 and 2, respectively); $g = 1$, $x^o_c = 0.5$.

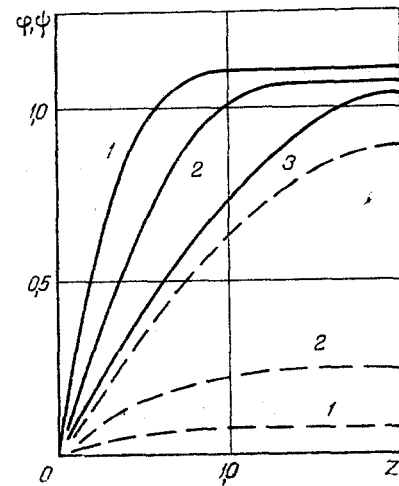


Fig. 2

Fig. 2. Dependence of the relative productivities φ and ψ (solid and dashed curves) on the dimensionless length Z for apparatus with the dissociation reaction for $x^o_{b1} = 0.03$, 0.1 , and 0.3 (1, 2, 3, respectively); $g = 1$, $x^o_c = 0.5$.

Their dependence on the dimensionless length Z of the apparatus is illustrated in Fig. 2. It is seen that the quantity φ can actually exceed unity even for an equilibrium initial mixture. This effect is magnified significantly if the initial mixture is nonequilibrium, and contains the dissociating gas in excess quantities (for a given temperature and pressure).

Computations analogous to that presented can easily be executed even for more complex situations when the reaction includes a greater number of reagents and reaction products, while the initial mixture is not stoichiometric in composition and is not in equilibrium. Means to generalize the problem considered to situations when several interrelated or unrelated reactions proceed in the mixture are moreover evident, even for situations when the semipermeable walls separating the delivery and discharge channels are permeable for several gases at once. It is expedient to conduct such an analysis in application to specific mixtures and membranes, accompanied by confirming experiments. Examples of such an investigation will be proposed later.

APPENDIX

INACCURACIES IN THE TRADITIONAL DESCRIPTION OF MASS-TRANSFER PROCESSES

An analysis of mass-transfer processes of the most diverse nature and a computation of the appropriate apparatus extended to chemical technology, power, and other branches are based substantially on examination of the same material balance requirements as were used above. For simplification of the engineering computations here, and to make them more graphic, the concepts of the number of transport units, the number of so-called degrees of transport (theoretical plates), etc. are introduced. Unfortunately, elementary errors are quite often admitted here and the concepts mentioned either do not generally have meaning or are incorrectly introduced. Because such errors are even in textbooks, and the question is itself extremely important, we reproduce reasoning here with commentary relative to the simplest mass-transfer process, vapor condensation from a mixture with an inert gas in a one-dimensional channel [8].

Let x be the molar fraction of vapor, n and n_c the molar vapor and gas concentrations, and j and j_c their molar fluxes. The relationship

$$dn/n = dx/x = Pqdl/Sj \quad (A1)$$

is taken as fundamental balance relationship in [8].

Using the identity $(1-x)j = xj_c$ and the constancy of j_c , we obtain

$$\frac{dx}{dl} = -x \frac{Pq}{Sj} = -(1-x) \frac{Pq}{Sj_c} \quad (A2)$$

Now, if the Stefan formula is used for the flux to the walls, we obtain [8]

$$q \sim \ln \frac{p-p_*}{p-p_v}, \quad \frac{dx}{dl} \sim \frac{P}{Sj_c} (1-x) \ln \frac{1-x}{1-x_*} \quad (A3)$$

where p is the total mixture pressure, p_v and p_* is the vapor pressure far from and on the condensation surface (where it equals the saturated vapor pressure), and x and x_* are the molar fractions of vapor corresponding to the pressures p_v and p_* . Equation (A3) is easily integrated, consequently, we obtain an expression for the standardly induced number of transport units E [8]

$$E = \ln \ln \frac{1-x_L}{1-x_0} \sim \frac{P}{Sj_c} L \quad (A4)$$

Here x_0 and x_L are values of x at the input and output from the channel, and L is the length of the channel.

In reality, relationship (A1) which does not follow from anywhere but is nevertheless often postulated is untrue. It should be replaced by the requirement of vapor flux continuity $Sdj = -Pqdl$, from which we obtain in place of (A2)

$$\frac{dj}{dl} = j_c \frac{d}{dl} \left(\frac{x}{1-x} \right) = -\frac{P}{S} q, \quad \frac{dx}{dl} = -(1-x)^2 \frac{Pq}{Sj_c}$$

and later in place of (A3)

$$\frac{dx}{dl} \sim \frac{P}{Sj_c} (1-x)^2 \ln \frac{1-x}{1-x_*},$$

which actually corresponds to (17). In contrast to (A3), this equation is not integrated as simply, and it is clear in every case that (A4) and the number E it defines have no relation to the mass-transfer process being considered. The origination of inaccuracies is associated with the utilization of the false equality $dn/n = dx/x$. Actually, $dn/n = (n + n_c)n_c^{-1} dx/x$ or $dx/x = (1-x)dn/n$ follow from the definition $x = n(n + n_c)^{-1}$, which in the long run will result in the need to insert the additional factor $1-x$ into (A2) and (A3).

NOTATION

A_i, B_i, C , reagents, reaction products, and ballast gas; E , number of transport units; F, G , functions inserted in (2) and (9); j , molar flux; K^+, K^- , rate constants of the forward and reverse reactions; k , effective permeability coefficient; L , channel length; l, l' , coordinates along the delivery and discharge channels; M , molecular weight of the gas being liberated; N , function introduced in (9); n , molar concentration; P , channel working perimeter; q , flux through the wall; R , universal gas constant; r , exponent in (6); S , cross-sectional area of the delivery channel; T , temperature; v , gas mixture velocity; x , molar fraction; y, y_* , dimensionless pressures in the removal channel and its output; z, Z , dimensionless coordinate and length of the channels; α, β , dimensional and dimensionless hydraulic drag coefficients; μ_i, ν_i , stoichiometric coefficients; μ, ν , sums of μ_i, ν_i ; ρ , is the density; σ_i , quantity of moles of liberated gas bound to the reagent A_i , φ, ψ , relative productivities. Subscripts: a_i, b_i, c refer to the gases A_i, B_i, C ; degree to conditions at the input to the delivery channel; prime to the discharge channel.

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KINETICS OF DISSOLUTION OF THE FACES OF A SLOT CHANNEL IN A SEAM

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The mathematical model for slot channel wall dissolving at a constant liquid velocity under continuous pumping through of the fresh dissolvent and circulation of its fraction is developed. The treatment of the experimental data suggests the values of mass transfer coefficients for kerosene dissolving of sulfur at different temperatures. Estimate is made of liquid front concentration during hydrobreak of the salt layer.

In the geotechnological processes of subterranean sulfur extraction and recovery of NaCl, KCl, and other salts, the solvent is kept in motion between wells by hydraulic fracturing of the bed or seam at a constant rate of $1.6 \cdot 10^{-3}$ to $3.5 \cdot 10^{-3}$ m/sec with a solvent mass flow rate of $8.3 \cdot 10^{-5}$ m³/sec [1]. In many cases the drift or "slot channel" collapses under the action of rock pressure after hydraulic fracturing. It is advisable to dissolve the top and bottom faces of the channel in order to stabilize it and allow continued removal of the ore.

The objective of the present study is to investigate analytically and experimentally the kinetics of dissolution of the faces of a slot channel at a constant fluid velocity in two working regimes; the continuous once-through pumping of fresh solvent and the circulation of a predetermined volume of solvent. The problem of the kinetics of dissolution of the surface of a horizontal seam with a continuous incoming supply of fresh solvent has been solved by Aksel'rud [2]. Using the latter's method, we solve the stated problems of dissolving the walls of a slot channel.

A diagram of the process is shown in Fig. 1. The solvent moves along a channel of length L, width b, and height H from left to right at a velocity w. The dissolution concentration is reduced from C_s at the solid surface to C_1 in flow. Such a process can be described from the system of equations [2]:

$$\frac{\partial C_1}{\partial x} = \frac{K\sigma}{w} (C_s - C_1); \quad (1)$$

$$\frac{\partial h}{\partial t} = \frac{K}{\rho_T} (C_s - C_1). \quad (2)$$

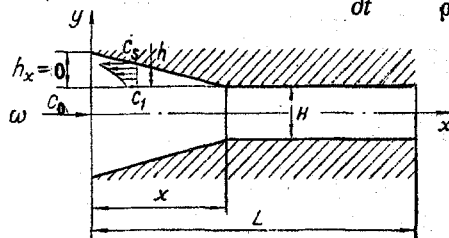


Fig. 1. Diagram of dissolution of the slot channel.