Int. J. Heat Mass Transfer. Vol. 16, pp. 1339–1346. Pergamon Press 1973. Printed in Great Britain

MASS TRANSFER PECULIARITIES OF A DISC ROTATING IN NON-NEWTONIAN FLUID

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(*Received* 24 *March* 1971)

Abstract—Results are reported on analytical investigation of mass transfer and relaxation process of a diffusive flux at a disc rotating in non-linear pure viscous liquids. Data are presented on experimental investigation performed using the electrochemical method for different solutions with Na-CMC additive. The paper shows good agreement between experimental and predicted data.

NOMENCLATURE

r, z,	cylindrical coordinates;
n, k,	rheological parameters;
N,	k/ρ;
ρ,	density;
R_0,	radius of "lacquered" disc section;
R,	disc radius;
j,	local value of diffusion flux on electrode surface of disc;
ΔR,	width of annulus;
$j(R)$,	mean flux density on disc;
j_ρ,	local value of diffusion flux on electrode surface of annulus;
c,	concentration of active agent;
c_0,	bulk concentration of active agent;
D,	active agent diffusivity;
τ, ξ,	similarity variable;
ω,	angular speed of disc revolution;
ψ,	stream function;
F, H, G,	additional functions;
a,	dimensionless velocity gradient $= F'(0)$.

Subscripts

lim,	limit value;
0,	referred to bulk phase outside the boundary layer.

THE PROBLEM on developed convective mass transfer of a disc rotating in rheologically complex fluids is of particular interest because of specific application of a rotating disc as a model for investigation of chemical and physicochemical processes in Newtonian fluids.

Work [1] deals with a case when a reacting surface is that of the whole disc, rotating in nonlinear viscous i.e. "power-law" fluid. Concentration has been assumed dependent only on distance along the normal towards the disc surface.

As is known [2], this assumption is not generally valid for non-Newtonian media by virtue of the disc surface not being equally accessible. For clarification of the mechanism of the convective diffusion process at a rotating disc, of considerable theoretical and practical importance are also those problems on diffusion when individual sections of the reacting surface possess different properties, in particular, diffusion non-homogeneity.

A boundary-value problem on convective mass transfer of a disc rotating in nonlinear pure viscous fluid with the power-law rheological equation of state is analytically investigated for the case when the inner disc section of the radius R_0 is "lacquered", i.e. passive with respect to diffusion, and an annulus of width ΔR is the reacting surface.

Paper [2] gives a numerical solution of the appropriate dynamic problem based on Karman's assumption of similarity of velocity profiles. Similarity variables are defined as

$$\zeta = z\left(\frac{\omega^{2-n}r^{1-n}}{N}\right)^{1/(1+n)} \quad (1)$$

$$V_r = \omega r F(\zeta)$$

$$V_\varphi = \omega r G(\zeta)$$

$$V_z = (r^{n-1}\omega^{2n-1}N)^{1/(1+n)}H(\zeta). \quad (2)$$

Substitution of the functions F, G and H transforms the original system to a system of general differential equations and the continuity equation takes the form

$$2F + H' + \frac{1-n}{1+n}\zeta F' = 0. \quad (3)$$

Here the primes denote derivatives with respect to ζ.

The convective diffusion equation in cylindrical coordinates is of the form

$$V_r\frac{\partial c}{\partial r} + \frac{V_\varphi}{r}\frac{\partial c}{\partial \varphi} + V_z\frac{\partial c}{\partial z} = D\left(\frac{\partial^2 c}{\partial z^2} + \frac{\partial^2 c}{\partial r^2} + \frac{1}{r}\frac{\partial c}{\partial r} + \frac{1}{r^2}\frac{\partial^2 c}{\partial \varphi^2}\right). \quad (4)$$

For the case of a "limit" diffusive flux the boundary conditions are

$$c = c_0 \text{ at } z \to \infty$$

$$c = 0 \text{ at } z = 0. \quad (5)$$

By axial symmetry and problem stability the concentration is independent of the azimuth φ. Here end effects of the annulus are assumed negligible (for details see [3]). Then with the boundary layer approximation, equation (4) is written as

$$V_r\frac{\partial c}{\partial r} + V_z\frac{\partial c}{\partial z} = D\frac{\partial^2 c}{\partial z^2}. \quad (6)$$

Absence of mass transfer on the inner central "lacquered" disc section is described by the following boundary condition

$$\frac{\partial c}{\partial z} = 0 \quad r < R_0. \quad (7)$$

In [2] dimensionless auxiliary functions $H(\zeta)$ and $F(\zeta)$ are tabulated for different values of n. With the help of these tables equation (6) can be numerically integrated.

With $Sc \gg 1$ (this is the very case considered in the paper) an approximate asymptotic solution of the problem stated is possible based on a linear profile of a radial velocity component within the diffusional boundary layer i.e.

$$F = a\xi \quad (8)$$

where $a = F'(0)$ is the dimensionless gradient of radial velocity at the disc surface. Then

$$V_r = \omega r a\xi = aN^{-1/(1+n)}\omega^{3/(1+n)}r^{2/(1+n)}z. \quad (9)$$

Let us introduce as usual the stream function

$$V_r = \frac{1}{r}\frac{\partial\psi}{\partial z} \qquad V_z = -\frac{1}{r}\frac{\partial\psi}{\partial r}. \quad (10)$$

The type of stream function is defined with the help of the expression

$$\frac{\partial\psi}{\partial z} = aN^{-1/(1+n)}\omega^{(3+n)/(1+n)}r^{3/(1+n)}z. \quad (11)$$

Since the variable ψ is introduced by means of differential relationships (10), then it is defined apart from an arbitrary constant. The latter is chosen so that at the disc surface, i.e. at $z = 0$, $\psi = 0$. Then from (11) we obtain

$$\psi = 2^{-1}a(N^{-1}\omega^3 r^{3+n})^{1/(1+n)}z^2. \quad (12)$$

Next we take ψ as a new variable in equation (6) making substitution of variables in it

$$r, z \to r, \psi.$$

Then

$$\frac{\partial c}{\partial r} = \left(\frac{\partial c}{\partial r}\right)_4 + \frac{\partial c}{\partial \psi}\frac{\partial \psi}{\partial r} = \frac{\partial c}{\partial r} - rV_z\frac{\partial c}{\partial \psi} \quad (13)$$

$$\frac{\partial c}{\partial z} = \frac{\partial c}{\partial \psi}\frac{\partial \psi}{\partial z} = rV_r\frac{\partial c}{\partial \psi} \tag{14}$$

$$\frac{\partial^2 c}{\partial z^2} = rV_r\frac{\partial c}{\partial \psi}\left(rV_r\frac{\partial c}{\partial \psi}\right). \tag{15}$$

Substituting expressions (13)–(15) into equation (6), we arrive at

$$\frac{\partial c}{\partial r} = rD\frac{\partial}{\partial \psi}\left[rV_r\frac{\partial c}{\partial \psi}\right]. \tag{16}$$

In equation (16) the concentration and radial velocity component are presented as a function of the coordinate r along the disc radius and the stream function ψ.

The boundary conditions for equation (16) are

$$\begin{aligned} c &= c_0 && \text{at} \quad \psi \to \infty \\ c &= 0 && \text{at} \quad \psi = 0 \quad r \geqslant R_0 \\ \frac{\partial c}{\partial \psi} &= 0 && \text{at} \quad \psi = 0 \quad r < R_0. \end{aligned} \tag{17}$$

By substituting the expression in terms of ψ for the velocity V_r we get from (16)

$$r^{-\frac{3n+5}{2(n+1)}}\frac{\partial c}{\partial r} = \gamma\frac{\partial}{\partial \psi}\left[\sqrt{\psi}\frac{\partial c}{\partial \psi}\right]. \tag{18}$$

Here

$$\gamma = (2a)^{\frac{1}{2}}DN^{-\frac{1}{2(n+1)}}\omega^{\frac{3}{2(n+1)}}. \tag{19}$$

On going over in (18) to the new variables η and φ, connected with r and ψ by the relationships

$$\eta = \frac{n+1}{2(5n+7)}\gamma r^{\frac{5n+7}{2(n+1)}} \qquad \varphi = \sqrt{\psi} \tag{20}$$

we obtain, after simple transformations,

$$\frac{\partial c}{\partial \eta} = \frac{1}{\varphi}\frac{\partial^2 c}{\partial \varphi^2} \tag{21}$$

and the boundary conditions (17) acquire the form

$$c = c_0 \quad \text{at} \quad \varphi \to \infty$$

$$C = 0 \quad \text{at} \quad \varphi = 0 \quad \eta \geqslant \frac{n+1}{2(5n+7)}\gamma R_0^{\frac{5n+7}{2(n+1)}}$$

$$\frac{\partial c}{\partial \varphi} = 0 \quad \text{at} \quad \varphi = 0 \quad \eta < \frac{n+1}{2(5n+7)}\gamma R_0^{\frac{5n+7}{2(n+1)}}.$$

The boundary-value problem formulated has a single solution [3]. It may be found by solving a similar problem on limiting conditions over the whole disc surface. Following Meiman [3] we build up a solution of the boundary-value problem in terms of η and φ variables.

The boundary conditions here are

$$\begin{aligned} c &= c_0 && \text{at} \quad \varphi \to \infty \\ c &= 0 && \text{at} \quad \varphi = 0. \end{aligned} \tag{23}$$

However, these conditions are insufficient for a complete solution of equation (21) since it comprises the second derivative of $c(\eta\ \varphi)$ with respect to the variable φ and the first derivative with respect to φ. As an additional condition one can use the requirement that at the point $\eta = 0$, $\varphi = 0$, the expression for concentration has no singularities and is a single-valued coordination function i.e.

$$c = c_0 \quad \text{at} \quad \eta = 0 \quad \varphi = 0. \tag{24}$$

Introduction of the similarity variable

$$\tau = \varphi(9\eta)^{-\frac{1}{3}} \tag{25}$$

transforms equation (21) into

$$\frac{d^2 c}{d\tau^2} + 3\tau^2\frac{dc}{d\tau} = 0. \tag{26}$$

In its solution

$$c_{\text{lim}} = c_0[\tfrac{1}{3}\Gamma(\tfrac{1}{3})]^{-1}\int_0^\tau \exp(-\lambda^3)d\lambda \tag{27}$$

subscript "lim" denotes the condition of a limit diffusive flux on the whole disc surface. Then the limit local diffusive flux towards the disc surface is determined as

$$j_{\text{lim}} = D\left(\frac{\partial c}{\partial z}\right)_{z=0} = c_0[\tfrac{1}{3}\Gamma(\tfrac{1}{3})]^{-1}\left(\frac{5n+7}{18n+18}\right)^{\frac{1}{3}}a^{\frac{1}{3}}D^{\frac{2}{3}}N^{-\frac{1}{3(n+1)}}\omega^{\frac{1}{1+n}}r^{\frac{1}{3}\left(\frac{1-n}{1+n}\right)}. \tag{28}$$

On account of the invariance of expression (27) regarding substitution of η + const. for η, the function

$$c = c_0[\tfrac{1}{3}\Gamma(\tfrac{1}{3})]^{-1}\int_0^{\varphi[\Theta(\eta+\text{const})]^{-\frac{1}{3}}} \exp(-\lambda^3)\,d\lambda \qquad (29)$$

as well as equation (27) is a solution of equation (26) satisfying, however, other boundary conditions.

Choosing

$$\text{const.} = -\frac{n+1}{2(5n+7)}\gamma R_0^{\frac{5n+7}{2(n+1)}}$$

we get

$$c = c_0[\tfrac{1}{3}\Gamma(\tfrac{1}{3})]^{-1}\int_0^{\varphi\left[\Theta\left(\eta-\frac{n+1}{2(5n+7)}\gamma R_0^{\frac{5n+7}{2(n+1)}}\right)\right]^{-\frac{1}{3}}} \exp(-\lambda^3)\,d\lambda). \qquad (30)$$

Returning from variables η, φ to the original physical variables r, z we find

$$c(r,z) = c_0[\tfrac{1}{3}\Gamma(\tfrac{1}{3})]^{-1}\int_0^{\left(\frac{5n+7}{18n+18}\right)^{\frac{1}{3}} a^{\frac{1}{3}} D^{-\frac{1}{3}} N^{-\frac{1}{3(n+1)}} \omega^{\frac{1}{1+n}} z r^{\frac{1}{3}\left(\frac{1-n}{1+n}\right)}\left[1-\left(\frac{R_0}{r}\right)^{\frac{5n+7}{2(n+1)}}\right]^{-\frac{1}{3}}} \exp(-\lambda^3)\,d\lambda \quad \text{at} \quad r > R_0 \qquad (31)$$

$$c(r,z) = c_0 \quad \text{at} \quad r \leqslant R_0. \qquad (31')$$

By differentiating equation (31) with respect to z we obtain a relationship for the local mass flux at $r > R_0$

$$j(r,0) = -D\left(\frac{\partial c}{\partial z}\right)_{z=0} = c_0[\tfrac{1}{3}\Gamma(\tfrac{1}{3})]^{-1}\left(\frac{5n+7}{18n+18}\right)^{\frac{1}{3}} a^{\frac{1}{3}} D^{\frac{2}{3}} N^{-\frac{1}{3(n+1)}} \omega^{\frac{1}{1+n}} r^{\frac{1}{3}\left(\frac{1-n}{1+n}\right)} \times \left[1-\left(\frac{R_0}{r}\right)^{\frac{5n+7}{2(n+1)}}\right]^{-\frac{1}{3}}. \qquad (32)$$

$$\Phi(n) = \left(\frac{5n+7}{18n+18}a\right)^{\frac{1}{3}} \qquad \tfrac{1}{3}\Gamma(\tfrac{1}{3}) = 0{\cdot}89. \qquad (37)$$

Accordingly, a dimensionless expression may be obtained for the limiting case of the whole reacting surface

$$Sh = \frac{\Phi(n)}{0{\cdot}89} Sc^{\frac{1}{3}} Re^{\frac{1}{3}\left(\frac{n+2}{n+1}\right)}. \qquad (38)$$

At $n = 1$ expression (38) turns into the well-known equation given in [3] for the case of a disc rotating in a Newtonian fluid.

In a dimensionless form expression (32) is written as

$$Sh = \frac{\Phi(n)}{0{\cdot}89} Sc^{\frac{1}{3}} Re^{\frac{1}{3}\left(\frac{n+2}{n+1}\right)}\left[1-\left(\frac{R_0}{r}\right)^{\frac{5n+7}{2(n+1)}}\right]^{-\frac{1}{3}} \qquad (33)$$

wherein

$$Sh = \frac{jr}{c_0 D} \quad \text{is the Sherwood number} \qquad (34)$$

$$Sc = \frac{N\omega^{n-1}}{D} \quad \text{is the Schmidt number} \qquad (35)$$

$$Re = \frac{\omega^{2-n} r^2}{N} \quad \text{is the Reynolds number} \qquad (36)$$

Now we compose a ratio of the real flow to the limit diffusive flow

$$\frac{j}{j_{\text{lim}}} = \left[1-\left(\frac{R_0}{r}\right)^{\frac{5n+7}{2(n+1)}}\right]^{-\frac{1}{3}}. \qquad (39)$$

The ratio j/j_{lim} depends not only on R_0/r but on the rheological property n as well. To achieve the condition j_{lim} pseudoplastic fluids require less "transition" length of the radius r compared to Newtonian fluids. The picture is quite reverse with dilatant systems. The exponent of the ratio R_0 ranges from 3·5 (limit pseudoplasticity, $n = 0$), to 2·5 (limitʳ dilatancy, $n \to \infty$). For the case of j and j_{lim} differing, say, by 5 per cent, at a fixed R_0, the value of r for limit pseudoplastic fluid $r_{5\%} \approx 3R_0$, for Newtonian one $r_{5\%} \approx 4R_0$ and for dilatant $r_{5\%} \approx 6R_0$ i.e. the relaxation region of a diffusive flux towards its limit value is of an order of the radius of the "lacquered" disc section. This result can be explained as follows: at the regions adjacent to the "lacquered" R_0 section the flow takes place past the disc with no mass transfer. Since radial mass transfer is of importance, the flow density here considerably exceeds that of a limit flux i.e. the highest possible flux with mass transfer normal to the surface. And at a considerable distance from the "lacquered" section, say of an order of R, the solution concentration becomes decreased so that the main transfer proceeds in the direction normal to the surface, and flow density decreases to j_{lim}. Disregard for radial transfer and substitution of real conditions by assumption of equal attainability may lead to considerable errors.

Let us determine mean flux density on a disc of R_0 radius for the limiting case of the whole reacting surface. For this purpose we integrate the expression (28) over the disc radius. In this case the expression for the flux density is of the form

$$j(R) = \frac{c_0 D^{\frac{2}{3}}}{0{\cdot}89}\left(\frac{a}{3}\right)^{\frac{1}{3}}\left(\frac{6n+6}{5n+7}\right)^{\frac{2}{3}} N^{-\frac{1}{3(n-1)}}$$
$$^{-\frac{1}{3(n+1)}} \times \omega^{\frac{1}{1+n}} R^{\frac{1}{3}\left(\frac{1-n}{1+n}\right)}. \tag{40}$$

If an annulus with an inner radius R_0 and outer one R serves as a reacting surface then a mean flux density on the surface of the annulus would be expressed by the equation

$$j(\Delta R) = \frac{c_0 D^{\frac{2}{3}}}{0{\cdot}89}\left(\frac{a}{3}\right)^{\frac{1}{3}}\left(\frac{5n+7}{6n+6}\right)^{\frac{1}{3}}$$
$$\times N^{-\frac{1}{3(n+1)}} \omega^{\frac{1}{1+n}} \frac{2}{R^2 - R_0^2}$$
$$\times \int_{R_0}^{R} \frac{r^{\frac{2}{3}\left(\frac{n+2}{n-1}\right)}\,\mathrm{d}r}{\sqrt[3]{\left[1 - \left(\frac{R_0}{}\right) r^{\frac{5n+7}{2(n+1)}}\right]}}. \tag{41}$$

Let us take the ratio of the mean flux density at the annulus to the mean flux density when the whole disc surface takes part in the reaction. Then

$$\frac{j(\Delta R)}{j(R)} = \frac{5n+7}{3(n+1)}(R^2 - R_0^2)^{-1} R^{\frac{1}{3}\left(\frac{1-n}{1+n}\right)}$$
$$\times \int_{R_0}^{R} \frac{\tau^{\frac{2}{3}\left(\frac{n+2}{n+1}\right)}\,\mathrm{d}r}{\sqrt[3]{\left[1 - \left(\frac{R_0}{r}\right)^{\frac{5n+7}{2(n+1)}}\right]}}. \tag{42}$$

EXPERIMENTAL

Experimental investigation of convective mass transfer of a disc was carried out on an apparatus according to the procedure described in [4]. The electrochemical method applied permits the verification of theoretical relationships as well as registering instantaneous values of mass flow at different conditions of mass transfer. This circumstance is of importance while investigating transfer processes in non-Newtonian fluids since, due to the anomalous behaviour of the latter, different secondary effects are possible in a shear flow leading to an anomalous behaviour of convective mass transfer.

Works [4, 5] depict analogous investigations on the applicability of the electrochemical method based on the diffusion-controlled reversible oxidation–reduction reaction $Fe(CN)_6^{3-} \rightleftarrows Fe(CN)_6^{2-}$ for measurements of j-flows in aqueous solutions of polymers. The investigations proved the high reliability and precision of the method and revealed some peculiarities which should be accounted for during experiments. It primarily refers to the necessity of careful electrochemical refining of electrodes and performance of test measurements by a certain procedure.

Diffusion coefficients of active agents $Fe(CN)_6^{3-}$ were also determined with the help of the electrochemical method, by the procedure presented in [6]. Data on the diffusion coefficients of $Fe(CN)_6^{3-}$ ions in aqueous solutions of the polymer Na-CMC are listed in Table 1. The same table gives values of power-law

Table 1

Composition of solution 2×10^{-3} M$K_3Fe(CN)_6$ + 0·2 $K_4Fe(CN)_6$ + Na-CMC %	$\rho \times 10^{-3}$ kg/m^3	$k \times 10^3$ kg $\times$ s^{n-2}/m	n	$D \times 10^9$ m^2/s
0	1·015	1·16	1·00	0·625
0·5	1·023	37	0·78	0·550
0·75	1·028	78	0·74	0·536
1·00	1·032	264	0·65	0·510
1·50	1·040	950	0·57	0·484

parameters n and k obtained by means of a capillary viscometer.

Hansford and Litt [1] investigated convective mass transfer of a disc rotating in various polymer solutions by the method of dissolution of the working body, which was made of benzoic acid. This method is laborious as well as characterized by low precision and impossibility of registering local and instantaneous characteristics of mass flux. The experiments were qualitative since no data were available on diffusion coefficients of benzoic acid in the polymer solutions tested. In the range of revolutions to 1000 rpm a large scatter of experimental points was observed which the authors attributed to the anomalies resultant from the manifestation of viscoelastic properties exhibited by aqueous solutions of Na-CMC.

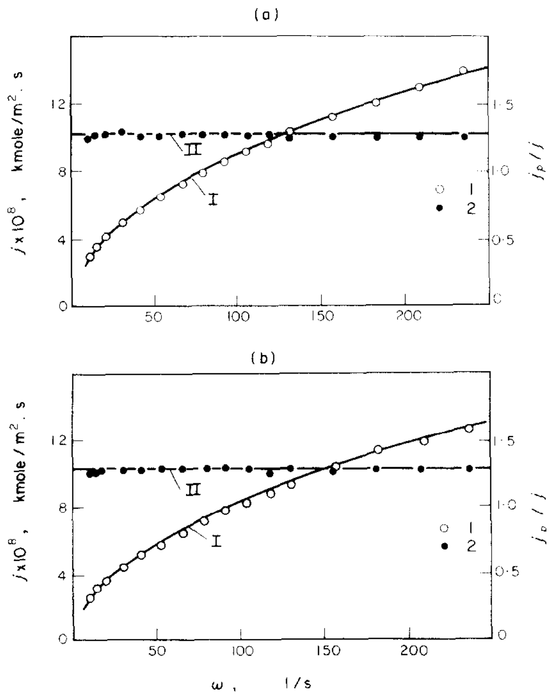

FIG. 1. Developed convective mass transfer at a disc: (a) 0% Na-CMC; (b) 0·1% Na-CMC; I—solid disc (theory); II—annulus (theory); 1—solid disc 20 mm dia; 2—annulus, $\Delta R = 3·5$ mm.

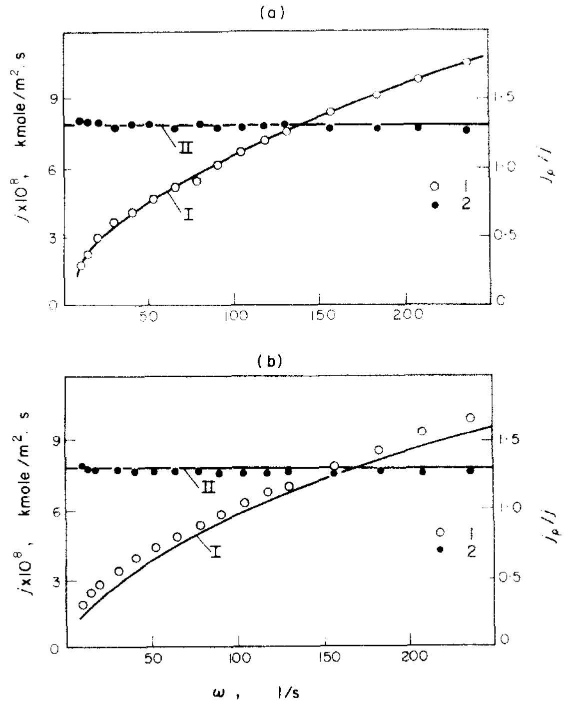

FIG. 2. Developed convective mass transfer at a disc: (a) 0·5% Na-CMC; (b) 0·75% Na-CMC; 1—solid disc 20 mm dia; 2—annulus, $\Delta R = 3·5$ mm.

In the experiments, the results of which are discussed below, convective mass transfer was investigated to the whole surface of a 20 mm dia disc and to an annular surface with 13 mm i.d. and 20 mm o.d. In the latter case the radius of the "lacquered" disc surface was 6·5 mm.

Figures 1–3 present experimental data on convective mass transfer at the disc and theoretical results predicted by equation (40) (solid lines). With an increase of polymer concentration in a solution, a decrease of mass transfer rate is observed. A good agreement between experimental data and those predicted by the theory is seen in the case of the 0·5 and 0·75 per cent Na-CMC concentration. For the Na-CMC concentration being 1 and 1·5 per cent, some deviation of experimental points from the theoretical curves appear within 5–17 per cent and tend to be higher at higher rotating speeds.

The oscillogram of instantaneous values of j-flows revealed (see Fig. 4) an unexpected result for nonseparated laminar flows i.e. a presence of intense low-frequency fluctuations, whose level reached 5 per cent from the mean value of a diffusive flux at the rotating disc. Such fluctuations may provide an increase of mass transfer rate compared with that predicted by the "power-law" model. A nature of such anomaly is probably connected with the manifestation of elastic properties by the solution [4].

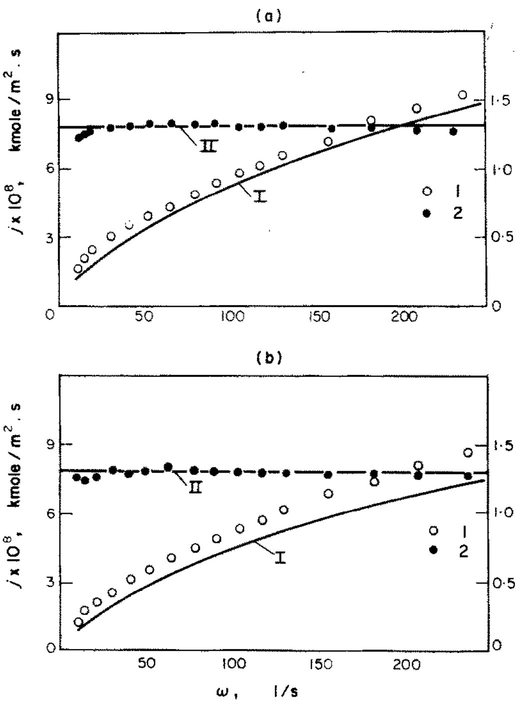

FIG. 3. Developed convective mass transfer at a disc: (a) 1%—Na-CMC; (b) 1·5% Na-CMC; 1—solid disc, 20 mm dia; 2—annulus, ΔR = 3·5 mm.

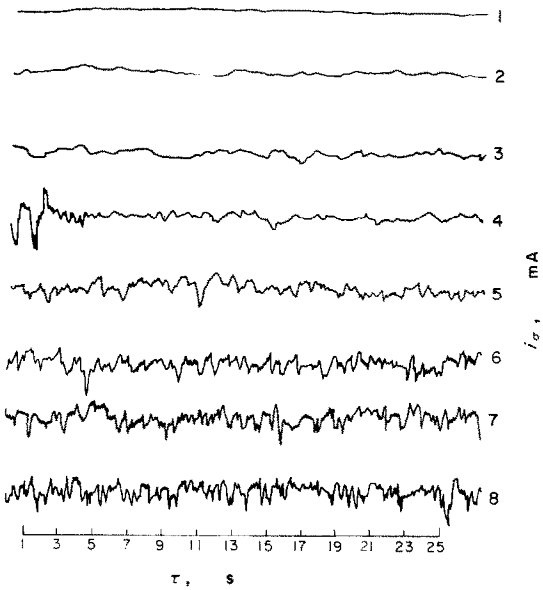

FIG. 4. Graph of mass flux fluctuations at a disc rotating in 1·5% Na-CMC solution: 1—200 rpm; 2—400 rpm; 3—500 rpm; 4—750 rpm; 5—1000 rpm; 6—1500 rpm; 7—2000 rpm; 8—2500 rpm.

Experimental data on relaxation of diffusion process are also presented in Figs. 1–3. Here a mean density of a diffusive flux at the annulus is referred to that of a flux at the whole disc. In this case the mass flux intensity at the annulus is considerably higher than that of the mass flux at the whole disc which agrees with the results predicted by theory.

In the experiments described experimental data fall on one curve in contrast to the considerable scatter of points in the experiments of Hansford and Litt [1]. On one hand, this fact is evidently related to the difference in rheological properties of the polymer solutions tested—and on the other hand it may be attributed to errors in experiments [1] caused by distortion of the originally flat disc surface because of dissolution, appearance of roughness, formation of hollows along the lines of flow of current and finally surface distortion. The latter is due to the fact that for liquids tested the rotating disc surface is not equally accessible with respect to diffusion.

The theoretical analysis and experiments carried out on convective mass transfer of a disc rotating in non-linear pure viscous fluid by means of the electrochemical method allowed the conclusion to be made that rotating disc and annular electrodes may be successfully applied not only to the case of Newtonian solutions but to physico-chemical investigations in polymer solutions provided that rheological behaviour of the latter may be described by the Oswald de Wael equation.

ACKNOWLEDGEMENT

The authors wish to express their acknowledgement to V. D. Lyashkevich for his assistance in the present work.

REFERENCES

1. G. S. HANSFORD and M. LITT, Mass transfer from a rotating disc into power-law liquids, *Chem. Engng Sci.* **23**, 849 (1968).
2. P. MITSCHKA and I. ULBRECHT, Strömung nicht-newtonsscher Flüssigkeiten Oswals-de-Waeleschen Typs in der Umgebung rotierender Drehkegel und Scheiben, *Coll. Czech. Chem. Comm.* **30**, 2511 (1965).
3. V. G. IEVICH, *Physico-Chemical Hydrodynamics*. Fizmatgiz, Moscow (1959).
4. A. V. LUIKOV, Z. P. SHULMAN *et al.*, Convective mass transfer of a disc rotating in non-Newtonian fluids, *Inzh-Fiz. Zh.* **18**, 1010 (1970).
4. Z. P. SHULMAN, N. A. POKRYVAILO, W. I. KORDONSKY and E. B. KABERDINA, Rheodynamics and mass transfer in rotating flow of anomalous-viscous fluids, International Seminar, Herceg-Novi (1970).
6. A. M. YAKUBOVSKY and N. A. FEDOTOV, Electrochemical method for determination of dissolution and diffusivity of electrochemically active gases in electrolytes, *Zh. Elektrokhimiya* **5**, 312 (1969).
7. T. KOTAKA, M. KURATA and M. TAMURA, Normal stress solutions, *J. Appl. Phys.* **30**, 1705 (1959).
8. A. V. LUIKOV, Z. P. SHULMAN and B. I. PURIS, External convective mass transfer in non-Newtonian fluid, *Proceedings of the 3rd All-Union Heat and Mass Transfer Conference*, Vol. 3, pp. 24–44. Minsk (1968).

PARTICULARITES DU TRANSFERT MASSIQUE D'UN DISQUE TOURNANT DANS UN FLUIDE NON-NEWTONIEN

Résumé—On présente les résultats d'une recherche théorique sur le processus de transfert massique et de relaxation sur un disque tournant dans un liquide pur visqueux non-linéaire. On présente les résultats de l'étude expérimentale menée à l'aide de la méthode électrochimique pour différentes solutions avec addition de NaCl. L'article montre un bon accord entre les résultats expérimentaux et théoriques.

BESONDERHEITEN BEIM STOFFÜBERGANG AN EINER SCHEIBE, DIE IN EINER NICHT-NEWTON'SCHEN FLÜSSIGKEIT ROTIERT

Zusammenfassung—Es wird über die Ergebnisse einer analytischen Untersuchung des Stoffübergangs und des Relaxationsvorgangs im Diffusionsstrom an einer Scheibe berichtet, die in einer reinen, nichtlinearen viskosen Flüssigkeit rotiert. Die Daten der durchgeführten experimentellen Untersuchungen werden angegeben, bei denen eine elektrochemische Methode für verschiedene Lösungen mit Na-CMC-Additiven benutzt wurde. Es zeigt sich gute Übereinstimmung zwischen experimentellen und berechneten Werten.

ОСОБЕННОСТИ МАССООБМЕНА ДИСКА, ВРАЩАЮЩЕГОСЯ В НЕНЬЮТОНОВСКОЙ ЖИДКОСТИ

Аннотация—Сообщаются результаты аналитического исследования массопереноса и процесса релаксации диффузионного потока на диске, вращающемся в нелинейной чисто вязкой жидкости. Приводятся результаты экспериментального исследования, выполненного с помощью электрохимического метода для различных растворов с добавками $N\alpha$-КМЦ. Отмечается хорошее совпадение экспериментальных данных с результатами аналитического решения.