similar reduction in ωc.s. due to a decrease in the difference in velocities between the drops and the gas being cleaned. This conclusion is consistent with the findings in [1, 2].

In conclusion, we should note that the above-described effects are manifest to a greater degree in the co-current movement of the gas and drops in the direction opposite to that of gravity.

NOTATION

η, cleaning efficiency; P, (ΔP), pressure, pressure drop; z, longitudinal coordinate; ξ, friction coefficient; d, diameter; W, velocity; ρ, density; σ, surface tension; Ψ, volumetric vapor content; N, number of drops per unit volume; β, angle of inclination of generatrix of cone; G, flow rate; ω, removal coefficient; g, gravitational acceleration; We, Weber criterional number. Indices: \(^{\prime}\), gas, liquid; E, total value; d, s, drop, solid particle; m, maximum value; fr, friction; wa, wall; a, acceleration; g, weight component; 0, quantity referred to the inlet section; n, most probable value.

LITERATURE CITED


ELECTRODIFFUSIVE DIAGNOSIS OF THE VISCOELASTIC PROPERTIES OF POLYMER SOLUTIONS ON A ROTATING SPHERICAL ELECTRODE

Z. P. Shul'man, N. A. Pokryvailo, O. Vain, and I. I. Gol'bina

UDC 532.135:53.082.75

This article examines the feasibility of measuring normal stresses from data from electrochemical diagnosis over the surface of a rotating sphere.

The rotation of a sphere in a liquid causes a secondary meridional flow as well as the main circular flow. Such flow is centrifugal for Newtonian fluids, with flow toward a pole and flow back to the region of the equator. In rotational shear flow of viscoelastic liquids, nonisotropic normal stresses are created. These stresses either lower the rate of the centrifugal flow or convert it into centripetal flow. In the last case, the liquid flows over the sphere in the equator region and flows back from the pole region. These effects were first examined by Giesekus [1]. Quantitative calculations of the flow of a viscoelastic second-order fluid about a rotating sphere [1, 2] make it possible to determine the normal stresses on the basis of study of the kinematics of the secondary meridional flows. Such experiments are usually performed by visualization of the flow about a rotating sphere [3]. Since the intensity of the meridional flow decreases very rapidly with increasing distance...
from the surface of the sphere, the results of these experiments are qualitative. Consequently, the use of visualization is limited to strongly elastic and viscoelastic fluids. More reliable for quantitative study of the kinematics of meridional flows are methods of indirectly determining the wall gradient of meridional velocity on the basis of measurements of the rate of convective heat and mass transfer. The electrochemical method [4] may be the most advantageous of these methods from the point of view of sensitivity and constancy of the initial properties of the fluid. It should be noted that instrumental methods of measuring the difference in normal stresses (such as with a Weissenberg rheogoniometer) are inapplicable in weak polymer solutions at shear rates less than \(10^3 \text{ sec}^{-1}\). We will examine the possibility of measuring the difference in normal stresses from data from electrochemical diagnosis of the secondary meridional flow about the surface of a rotating sphere. The rheodynamic theory of such flows was developed for fluids for which the following differences in normal stresses occur in simple shear flow along with the shear stresses \(\tau_{12}\):

\[
\tau_{12} = \eta \dot{\gamma}, \quad \tau_{11} - \tau_{22} = \nu_1 \dot{\gamma}^2, \quad \tau_{22} - \tau_{33} = \nu_2 \dot{\gamma}^2.
\]  

(1)

In contrast to more realistic models of viscoelastic media, here we assume that the material coefficients \(\eta, \nu_1, \) and \(\nu_2\) are constant, i.e., are independent of the shear rate. The approximate solution of the equations of motion is based on the following representations [5]. With sufficiently slow rotation of the sphere in an infinite fluid having a constant viscosity, primary circular flow with the following distribution of angular velocities is established

\[
\dot{\omega} = \Omega (R/r)^3 \sin \Theta.
\]  

(2)

Such a flow is isoviscous and in a viscoelastic fluid is accompanied by the creation of a difference in the normal stresses

\[
\tau_{\theta\theta} - \tau_{\phi\phi} = (\nu_1 + \nu_2) \dot{\gamma}^2, \quad \tau_{rr} - \tau_{\theta\theta} = \nu_2 \dot{\gamma}^2.
\]  

(3)

The shear rate field \(\gamma(r, \Theta)\), with allowance for (2), is expressed by the relation

\[
\dot{\gamma} = -\sin \Theta r \partial_r \dot{\omega} = 3\Omega \sin \Theta (R/r)^3.
\]  

(4)

Due to the action of the elastic stresses (3) and inertia \(\rho V_0^2\), secondary meridional flows with corresponding viscous drag are created in the fluid. As a result, the equations of motion for the stream function \(\chi\)

\[
V_\theta = \sin^{-1} \Theta r^{-1} \partial_r \chi, \quad V_r = -\sin^{-1} \Theta r^{-1} \partial_\theta \chi.
\]  

(5)

can be represented in the form

\[
\eta \sin^{-1} \Theta \left(\partial_r^2 + r^{-2} \sin \Theta \partial_\theta \sin^{-1} \Theta \partial_\theta \right) \chi = P_c - P_N,
\]  

(6)

where

\[
P_c = -\rho \left(\cot \Theta \partial_r - r^{-1} \partial_\theta\right) V_0^2 = 6\rho \Omega^2 (R/r)^5 \sin \Theta \cos \Theta;
\]  

(7)

\[
P_N = -\left(\cot \Theta \partial_r - r^{-1} \partial_\theta\right) \tau_{\phi\phi} - \tau_{\theta\theta} - r^{-2} \partial_r \partial_\theta (\tau_{rr} - \tau_{\theta\theta}) = 72\nu_N \Omega^2 R^{-1} (R/r)^7 \sin \Theta \cos \Theta;
\]  

(8)

\[
\nu_N = \nu_1 + 2\nu_2
\]  

(9)

(usually, \(\nu_N = \nu_1\), since \(|\nu_2| \ll |\nu_1|\)).

The solution of biharmonic equation (6) with the corresponding boundary conditions can be reduced to the following simple form [6]

\[
\chi = \frac{\rho \Omega^2 R^5}{8\eta} \left(1 - \frac{R}{r}\right)^2 \left(1 - Ab \left(2 + 4 \frac{R}{r}\right)\right) \sin^2 \Theta \cos \Theta,
\]  

(10)

where

\[
Ab = \frac{\nu_N}{\rho R^2}.
\]  

(11)

The corresponding profile of the gradient of meridional velocities over the surface of the sphere can be expressed as

\[
\dot{\gamma}_m(\Theta) = \partial_r V_\theta|_{r=R} = \frac{1}{4} \Omega \Re (1 - 6Ab) \sin^2 \Theta \cos \Theta,
\]  

(12)

1271