of the underlying stage, there occurs a substantial influx of the liquid from the overlying stage. With such a location of the overflow channel the pipe height (Fig. 1) will depend only on the height $H$ of the swirler plates.

LITERATURE CITED


HYDRAULIC RESISTANCE TO EMULSION FLOW

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Water-in-oil type emulsion is formed in oil exploitation and desalination processes as well as in polymer synthesis when the polymer and its solution is washed off the catalyst residues with water. When viscous liquids are processed, emulsions of air in the liquid are formed which are distinguished by a high stability on account of a low rate of rise of gas bubbles to the viscous liquid surface. Emulsions are also formed in the process of drying of liquid polymers.

When emulsion viscosity is used as the key hydrodynamic characteristic, it is not always possible to adequately describe the properties of the emulsion as a pseudohomogeneous system. Differences in the hydraulic parameters of the emulsion flow can be explained by the fact that during its flow the emulsion undergoes layering into zones with different contents of the disperse phase.

There is a series of relationships for calculating the viscosity of emulsions of a gas in a liquid. In this case the emulsion viscosity is always higher than the viscosity of the pure liquid and may even exceed the liquid viscosity by an order [1]. The properties of the emulsions of the oil-in-water type can be described well by a well-known equation [2, 3] obtained theoretically and validated experimentally.

There is no such relationship for describing the viscosity properties of the water-in-oil type emulsions. Therefore, in the experimental study the viscosity was determined on a Höffpler viscosimeter. It was shown that the emulsion viscosity depends on the size of the particles in the disperse phase. Therefore, the experimental results were evaluated only at the viscosity values obtained for the test emulsion specimen on the viscosimeter.

For processing the experimental data on the emulsion flow in straight tubes we used the equation [4, 5]

$$\Delta \rho = \lambda \frac{l}{d} \frac{\rho v^2}{2} ,$$

which, in its criterial form, has the form

$$Eu = \left( \frac{A}{Re + B} \right) \frac{l}{d} ,$$

where $\lambda$ is the coefficient of friction; $l$ and $d$ are respectively the length and diameter of the tube; $v$ is the emulsion velocity; $Eu = \Delta \rho / \rho v^2$ is the Euler criterion; $Re = \rho d / \nu$ is the Reynolds criterion; $A$ and $B$ are constants; $\rho$ and $\nu$ are respectively the emulsion density and viscosity; $\Delta \rho$ is the hydraulic resistance.

Fig. 1. Variation of coefficient of friction \( \lambda \) during flow through a straight tube, of:

\[ \begin{align*}
0 & \quad \text{pure polybutadiene;} \\
- & \quad \text{30\% water emulsion in polybutadiene;}
\end{align*} \]

emulsion; \( d = 20 \) (1), 4 (2), 6 (3), and 8 mm (4).

Fig. 2. Hydraulic resistance of a tube during the flow of an emulsion of air in an aqueous methyl cellulose solution: \( d = 10 \) (a) and 24 mm (b); \( \varphi = 0 \) (1), 0.1 (2), and 0.3 (3).

The emulsions for the experiments were prepared by saturating the liquid in an apparatus with a stirrer by a gas or a second liquid (water) acting as the disperse phase. The hydraulic resistance in emulsion flow through straight tubes was determined by measuring the pressure differential in a 1-m-long tube section in a circulation type apparatus by using tubes of different diameters.

The experimental data obtained for water-in-liquid polybutadiene emulsions with a viscosity of 13.2 Pa \cdot sec are presented in Fig. 1. Similar relationships were obtained at an emulsion water content \( W = 5-40\% \). From the experimental data it follows that the coefficient of friction in emulsion flow may have a value both higher and lower than the coefficient of friction during the flow of a pure liquid. The curve passes through the origin of the coordinates only for tubes with a diameter \( d \geq 20 \) mm.

The results of an investigation of the hydraulic resistance of straight tubes during the flow of an aqueous methyl cellulose solution containing dispersed air showed (Fig. 2) that for liquid-gas type emulsions the difference in the hydraulic resistance is very wide only for narrow tubes. For a diameter of straight tubes \( d \geq 20 \) mm the resistance can be calculated from a pseudohomogeneous model. The data of Fig. 2 were obtained by using Newtonian liquids having the following rheological constants:

\[
\begin{align*}
\varphi = 0, & \quad \mu_1 = 3.5 \text{ Pa} \cdot \text{sec}^n (n=0.5); \\
\varphi = 0.1, & \quad \mu_1 = 4.8 \text{ Pa} \cdot \text{sec}^n (n=0.64); \\
\varphi = 0.3, & \quad \mu_1 = 2 \text{ Pa} \cdot \text{sec}^n (n=0.75),
\end{align*}
\]

where \( \varphi \) is the gas constant; \( \mu_1 \) is the consistency index; \( n \) is the flow index.

In this case the Reynolds criterion was calculated by the equation

\[
\text{Re} = \left( \frac{4n}{n+1} \right) \left( \frac{3n+1}{n} \right)^{1-n} \frac{Rc^2}{\mu_1} \frac{\rho^2}{\rho},
\]