for a model of ideal mixing

\[ u_{m}^{\text{fin}} = \frac{U_{0}}{1 + 0.61 + k_{II}} \]  

(5)

for a combination model

\[ u_{\text{comb}}^{\text{fin}} = \frac{U_{0} e^{-0.00573k_{II}}}{2.61 (1 - e^{-0.01574k_{II}}) + 1 + 0.565k_{II}} \]  

(6)

If the rate constant is small, the calculation can be made using Eq. (5) for ideal mixing, since there is almost no divergence in the results of the determination of the final moisture content. However, if \( k_{II} \) is sufficiently great, the divergence in the calculation is already considerable and the calculation must be made using Eq. (6). Thus with

\[ k_{II} = 10^{2} h^{-1} \frac{u_{m}^{\text{fin}}}{u_{\text{comb}}^{\text{fin}}} = 1.7 \]

In the equations given the following notation is used, not considering that given earlier: \( z \) is the instantaneous length of the displacement zones; \( c_{i} \) is the concentration; \( v \) is the volumetric mass flow rate of the material; \( r \) is the recirculating volumetric flow; \( R = r/v \) is the recycle; \( i = 1, 2, \text{tot} \) denote different zones; \( V_{i} \) are the volumes; \( \tau_{i} \), \( \tau \) is the instantaneous mean residence time of the tracer in the dryer; \( K, K_{i} \) are the ratios of the volumes of the displacement zones; \( \alpha_{2}, \alpha_{1} \) are the dimensionless dispersions, respectively, of \( K \) and \( K_{i} \); \( g \) is the amount of tracer; \( U_{i} \) is the moisture content of the material; \( k_{I} \) and \( k_{II} \) are the rate constants of the drying in periods I and II; \( \delta(\tau) \) is an impulse function.

LITERATURE CITED


NOT-FULLY-ESTABLISHED PROCESSES IN PIPELINES OF CRYOGENIC SYSTEMS

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The use of cryogenic liquids on an industrial scale is bound up with an increase in the reliability of cryogenic systems, through whose branching pipelines large masses of product are transported.

A statistical analysis of failures in a number of industrial systems shows that the principal damages are connected with dynamic loads arising under transitional conditions.

The classical theory of not-fully-established processes, developed for high-boiling liquids, does not explain the phenomena characteristic for cryogenic liquids observed in the operation of industrial systems. The specific special properties of cryogenic liquids, i.e., a low temperature and a narrow range of conditions for the existence of the product in liquid form, small heats of vapor formation and condensation, and others, bring about special reasons for the appearance of intense dynamic loads during the course of the technological operations, differing by their great instability. A common physical special characteristic of not fully established processes in the pipelines of cryogenic systems is the fact that, although the work is effected in a single-phase, usually underheated, product in the individual sections, in stagnant zones there is the possibility of the formation of vapor cavities with an interface over the whole cross section of the pipeline. Under transitional conditions there is filling of given cavities, accompanied by heat- and mass-transfer processes at the phase interface.

Investigations have made it possible to bring out the following phenomena characteristic for cryogenic liquids: Acceleration and deceleration of the liquid with the opening of a shutoff device after a long-term

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shutdown of the circulation; throwing of the liquid into blind outlets filled with vapor; a geyser effect; throwing of liquid with the freezing of a pipeline of considerable extension, with a large heat effect.

A calculating scheme for determining the parameters of transitional processes is shown in Fig. 1.

The movement of a cryogenic liquid over pipelines of considerable length (which makes possible a one-dimensional statement of the problem) is described by a system of the equations of motion, continuity, and energy:

\[ w \frac{\partial (\rho w)}{\partial x} + \frac{\partial \rho}{\partial t} + \rho \frac{\partial \rho}{\partial x} = 0; \]  

\[ \frac{\partial (\rho w)}{\partial x} + \rho \frac{\partial \rho}{\partial x} = 0; \]  

\[ \frac{\partial i}{\partial x} + \rho \frac{\partial i}{\partial x} = 0. \]

where \( w \) is the velocity; \( \rho \) is the pressure; \( q_w \) is the specific heat flux; \( \rho \) is the density; \( x \) is a coordinate; \( \tau \) is the time; \( i \) is the enthalpy; \( \delta \) is the fraction of the longitudinal gradient \( \partial \rho/\partial x \) expended for friction and deformation of the velocity profile; \( D \) is the diameter of the pipeline.

Equations (1)-(3) constitute a system of nonlinear differential equations in partial derivatives. Their solution is very complex and demands the development of special methods and improved computers.

In practice there are generally cases for which a simplification of the starting system is possible.

The parameters of the flow change slowly, i.e., their change in the flight time of an acoustical wave with a length double that of the column of liquid is small:

\[ \frac{dp}{d\tau} \ll \frac{2L}{c}, \]

where \( c \) is the velocity of sound in the liquid in a pipeline with elastic walls. This makes it possible to bring Eqs. (1) and (2) to the equation

\[ \rho \frac{dw}{d\tau} + (1 - \delta) \frac{dp}{dx} = 0. \]

The equation of energy with the transport of a single-phase liquid along a pipeline can be represented in the form

\[ \frac{Q}{w} \frac{\partial T}{\partial \tau} + \frac{G}{w} \frac{\partial T}{\partial x} = \Pi q_w, \]

where \( q_w = 0.023/D \lambda \text{Re}^{0.8} \rho^{0.4} (T_w - T_L) \) from [1]; \( \text{Re} = \rho w D/\mu \) is the Reynolds number; \( G \) is the mass flow rate; \( \Pi = c \rho \mu/\lambda \) is the Prandtl number; \( \Pi \) is the perimeter of the pipeline; \( \lambda \) is the thermal conductivity; \( \mu \) is