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Cand. Tech. Sc., Prof. M. N. Chaltsev

SOME HYDRAUMECHANIC LAWS ANALOGIES OF HYDRAULIC AND PNEUMATIC CONVEYING SYSTEMS

The conclusion of pneumatic and hydraulic conveying flows analogy and the possibility of developing the strategy of defining main conveying parameters, considering the features of every flow has been made on the basis of the comparative analysis of the experimental characteristics of hydrodynamic processes of pneumatic and hydraulic conveying flows

The characteristic feature of bulk materials hydraulic and pneumatic conveying is characterized as of high complexity degree. The complexity is caused by the necessity of dealing with two phase heterogeneous mixtures, one of which is a discrete set of various solids and the other one forms the continuous fluid or gas medium surrounding the inclusions. Motion of such a mixture in a horizontal pipe is uneven in time and space, two phase flow components interaction does not obey any of the known laws of continuous medium mechanics.

In the world practice sufficiently reliable models and methods of hydraulic design have not been developed yet. The available methods are of empiric nature therefore their scope is often limited by unacceptably low accuracy and the conditions of the experiment.

One of the general disadvantages of the existing design methods is that they do not take into account the connection of the hydraulic resistance with the flow kinematic structure. Transverse averaged velocities and tensions profiling along flow is a necessary condition for hydraulic design accuracy improvement.

Recently in two phase flows simulating process significant progress, based on the results of previous experiments, has been made. Primarily it deals with hydraulic conveying [1, 2, 3, 4, 5, 6, 7].

In the monograph [2] the hydraulic mixture motion is studied in terms of statistical hydromechanics fundamental provisions and kinematic structure experimental data, turbulence characteristics and flow averaged parameters. The obtained designed dependences for determination of averaged velocities and the flow concentration, specific hydraulic resistances and the critical velocity were tested with the use of a large amount of experimental material and are characterized as of sufficiently high accuracy degree and used in the hydraulic conveying system engineering practice. Other publications confirming the achievements in the sphere of hydraulic conveying theory development are presented in the national and foreign scientific literature.

In the sphere of pneumatic conveying no breakthrough achievements have been observed. Therefore the question about the generalization of achievements in the sphere of pulp pipelines designs for the pneumatic conveying system raises.

From the hydromechanics point of view the peculiarities of hydraulic and pneumatic conveying are mostly conditioned by different physical properties of the carrier medium, first of all by its thickness, viscosity and the fluid compressibility in comparison with the gas (air). Thickness and viscosity of the carrier medium determine the optimum motion velocity; the compressibility causes the pulsation of the velocity, pressure and the mixture concentration.

Despite the disagreements of this kind, hydraulic and pneumatic conveying systems have a range of significant similarities. Particularly the asymmetry of concentration spread, particles fineness and the mixture velocity in the pipeline cross section are characteristic for the both flow types. The dependences character is practically identical for hydraulic- and pneumatic conveying as shown in figure 1.

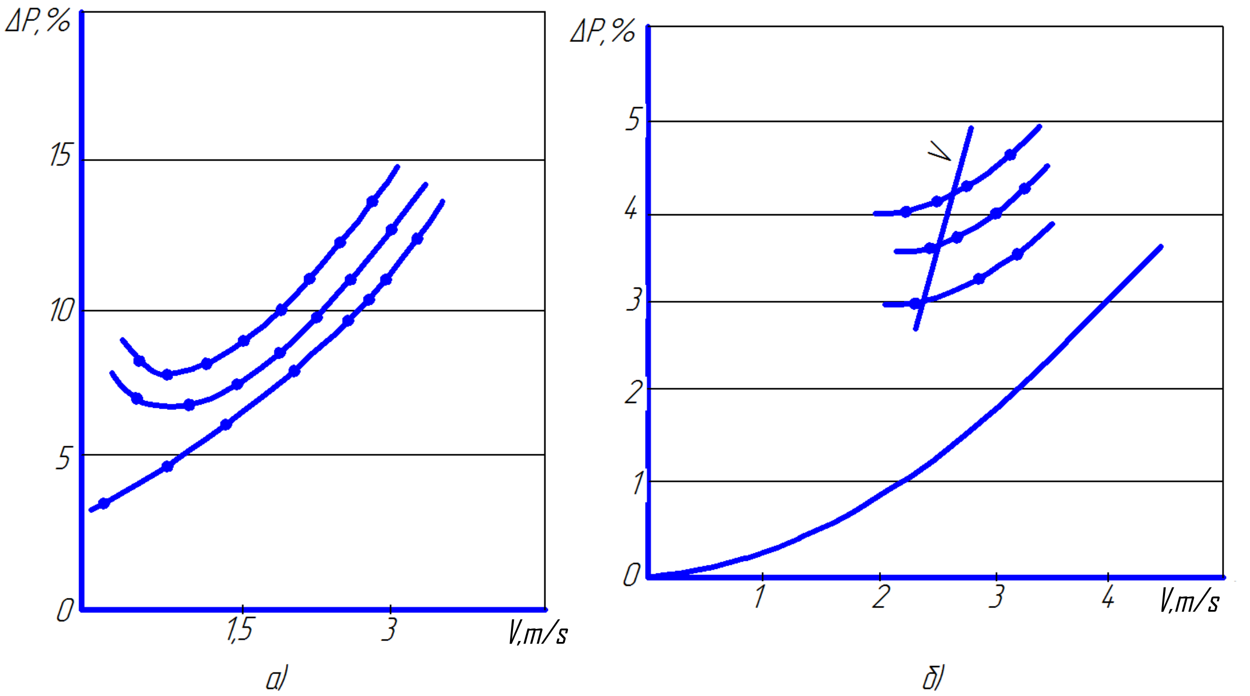

Figure 1 – Velocity dependence of hydraulic resistance at hydraulic- and pneumatic conveying: a) pneumatic conveying of asbestos of class 1-2mm, D = 0.32 m; Qs = 0; 0,17; 0,34 kg/sec.; b) hydraulic conveying of coal of class 0-70 mm; D = 0,307 m, m = 0; 0,1; 0.2; 0,28

Hydraulic resistances and critical velocities also have a similar characteristic. As an example, general view of hydraulic resistance dependences while hydraulic- and pneumatic conveying is given in figure 2.

According to figures 1 and 2 hydro- and gas mixtures kinematics and dynamics are almost identical. Concerning the two flow types dynamics and kinematics quality analogy it is possible to assume that the approach to the basic parameters determination will be general.

The assumption was checked by the example of the suspended matter critical velocity calculation on the basis of the equations derived for the hydraulic conveying conditions. Particularly in the study [2] the following is suggested:

$$\frac{\rho^o_{cr}}{\rho_g}\cdot\frac{\lambda_{cr}}{(1-a_{cr})\cdot w}\cdot\frac{v^2_{cr}}{2gD}=\frac{k(\Delta_S-1)2S_g h_{cr}}{(1+a_{cr})}, \qquad (1)$$

where a_{cr}, w_{cr}, ρ^o_{cr} – parameterscharacterizingthevelocityfieldaxialasymmetryinthecriticalmode;

– hydraulic resistance coefficient in the critical velocities mode;

– solids dry sliding friction coefficient;

– suspended matter limit possible concentration;

– settled layer relative thickness.

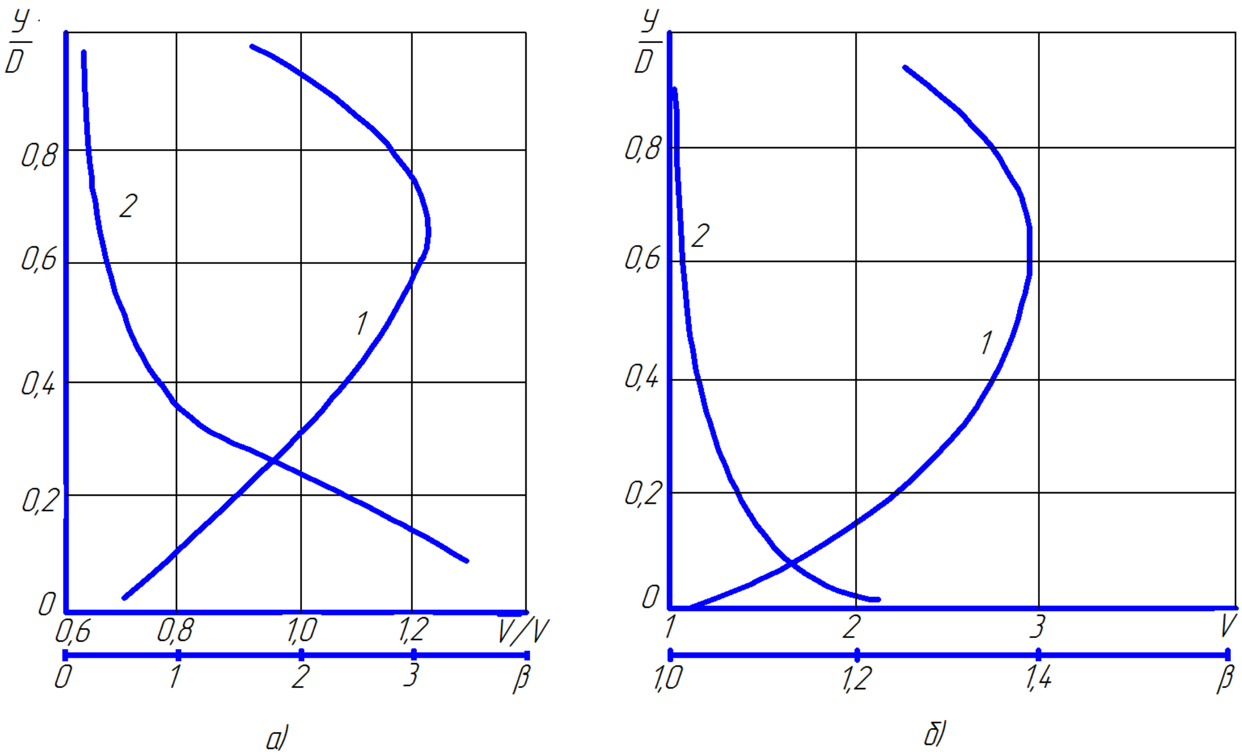

Figure 2 – Velocity (1) and thickness (2) distribution along the pipeline vertical diameter while hydraulic- and pneumatic conveying:

a) wheat pneumatic conveying D = 0,061 m; V = 26 m/sec; QS = 0,59 kg/s; b) coal hydraulic conveying D = 0,206 m; V = 2,44 m/s; S = 0,08

The equation (1) describing the critical transportation mode can be solved if the values and are determined. The values are available from suspended material flow experimental researches result reports. Particularly in the present case fine grained coal was chosen as a dispersed material: = 1500 kg/m3 and = 0,85 • 10-4 m.

The examples of the suggested analogies check carried out by different methods are given in figure. 3a – for hydraulic conveying and 3b – for pneumatic conveying of coal.

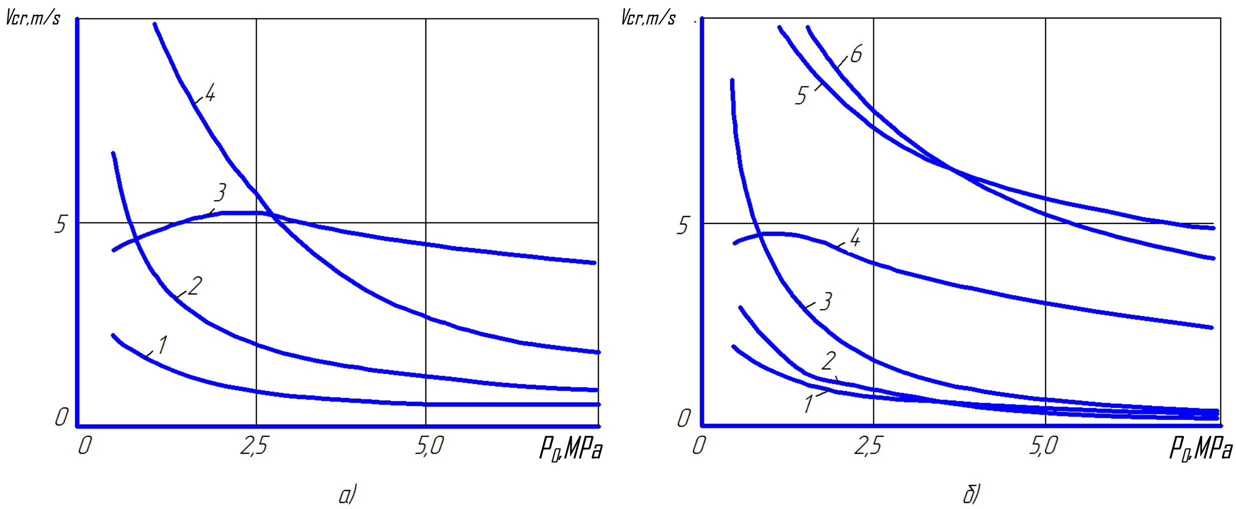

Figure 3 – Initial pressure dependence of hydraulic – (a) and pneumatic conveying (b) critical velocity: a) 1 – evaluation according to [4]; 2 – according to [7]; 3 – by formula (1); 4 – according to [6]; b) 1 – evaluation according to [4]; 2 – according to [7]; 3 – by formula (1); 5 – according to [5]; 6 – according to [1]

The results of the carried out check comparison confirms the authorized use of innovative methods of hydraulic conveying system various parameters design for pneumatic conveying conditions, concerning the particularities of the carrier medium.

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