FAST MODELS FOR TRANSIENT ANALYSIS OF PIPE NETWORKS

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The problems of calculation of parameters of unsteady flows (transients) in piping systems belong to a category of important and widespread problems arising in practice. The systems of water supply, thermal networks, gas and oil pipelines, hydro drives of machines and mechanisms are the examples of such systems.

Traditional approach uses the models with the distributed parameters for pipeline mode simulation, applying the equations of water hammer for the description of unsteady flows, and the systems of the algebraic equations and/or the ordinary differential equations describing functioning of nodes. The solution of such global system of the equations is rather complicated and demands the significant computing resources.

The approach is offered in this paper, based on the models with the lumped parameters which uses for the description of liquid currents in pipelines only by systems of the ordinary differential equations. This allows perform calculations on base of such model with much smaller expenses of computing resources. Use of such fast models is rather effectively for execution of fast preliminary and evaluating calculations, quick-and-dirty prediction, etc.

The second order model with lumped parameters is suggested for the description of liquid flow in the pipe, which based on non-classic quadrature rule:

$$\frac{L\omega}{K_e}\frac{d}{dt}\left(\frac{p_0+p_L}{2}\right)-\frac{L^2}{a^2}\frac{d^2}{dt^2}\left(\frac{Q_0-Q_L}{12}\right)+\frac{L^2}{a^2}\frac{\omega}{\rho L}\left(\frac{df_0}{dQ_0}\frac{dQ_0}{dt}-\frac{df_L}{dQ_L}\frac{dQ_L}{dt}\right)=Q_0-Q_L,$$

$$\frac{\rho L}{\omega}\frac{d}{dt}\left(\frac{Q_0+Q_L}{2}\right)-\frac{L^2}{a^2}\frac{d^2}{dt^2}\left(\frac{p_0-p_L}{12}\right)=p_0-p_L+\rho g(z_0-z_L)-\frac{\rho L}{2d\omega}\frac{\lambda_0|V_0|Q_0+\lambda_L|V_L|Q_L}{2},$$

where p is pressure, Q is discharge, z is ordinate of pipe, L is the pipe length, d is diameter and ω is cross-section of pipe, ρ is density, a is water hammer wave velocity, λ is hydraulic friction factor; $K_e = \rho a^2, f = \lambda|Q|Q/2d\omega$. This model operates with the values at the beginning of pipe (index 0) and the end of pipe (index L) only. Comparison this model with the first order models with lumped parameters (Atavin & Tarasevich, 2001) is presented. It was shown that this suggested model allow to make rather accuracy calculation for the not high intensive transients.

The using of combined models based on both distributed parameters and lumped parameters models seems the rather promising way for enhancement of calculation efficiency.

The examples of such approach's application for water distributing system and the hydraulic drive and comparison with experimental data are represented.

The important sphere of application of such models may serve operational management and on-line control of water supply network. It is necessary to be able to estimate consequences of those or other control actions on work of the system for quick selection of optimum control strategy of such system's work. Application of the above-mentioned models will allow obtain such estimations in real-time operation mode that will allow correct and/or make a choice of the best control sufficiently promptly.

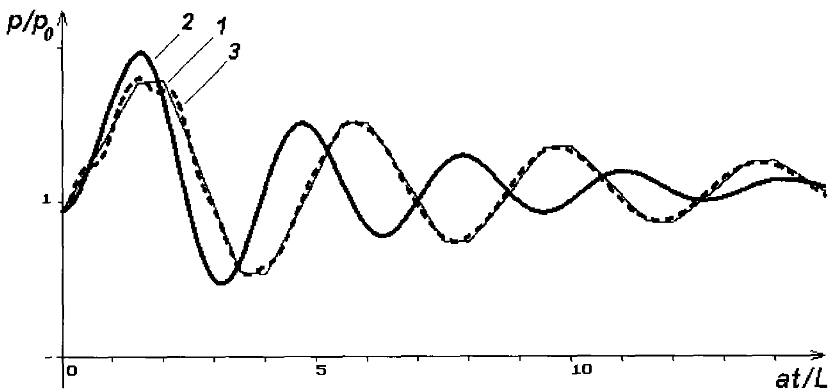

Fig. 1 Transient in pipeline supplying by centrifugal pump under sufficiently slowly valve closing ($t_{cl} < 2L/a$, where t_{cl} is time of valve closure). Here *1* is "exact" solution; *2* – the first order model with lumped parameters; *3* – the second order model with lumped parameters.

REFERENCES

Atavin, A.A. and Tarasevich, V.V. (2001). "Simulation of Unsteady Processes in piping systems by the systems with lumped parameters", *Proc. XXIX IAHR Congress*, Theme D, vol.II., Beijing, China, pp. 499 – 504.