SIMULATION OF GENERATION AND PROPAGATION OF SHOCK/COMPRESSION WAVES IN BUBBLY MEDIA

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Abstract: A model and a numerical method are proposed for calculating the propagation of shock/compression waves in a bubbly medium in extended pipeline systems. The model considers the process in a one-dimensional approximation within the assumption of the mechanical, thermal, velocity, and phase equilibrium in the "vapor bubbles – liquid" system. The proposed model was implemented numerically using the Godunov's approach. The model reproduces with good accuracy the available experimental data on the structure and parameters of circulating waves in a liquid and bubbly media. The possibility of generation of shock waves in pipelines with variable altitudes in the case of cavitation and subsequent collapse of cavitation zones is demonstrated. Contrary to the case of the conventional water hammer when the flow slows down due to valve closing, this effect can be considered as a localized water hammer; in the case of a "classic" water hammer, the flow is slowed down on closed valves. It has been shown by calculation that the collapse of the cavitation zones with the generation of pressure waves leads to an increase in the loads on the pipeline: the arising pressures are a factor of 1.5 higher as compared to the conventional water hammer.

Keywords: shock waves; compression waves; bubbly medium; water hammer; cavitation; Godunov type method

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Figure Captions

Figure 1 Calculated dependences of pressure on time in the pipeline in front of the valve at the end of the pipeline (*a*) and in the middle of the pipeline (*b*): *1* — without cavitation; and *2* — with cavitation

Figure 2 Calculated dependences of velocity on time in the pipeline in front of the valve at the end of the pipeline (*a*) and in the middle of the pipeline (*b*): *1* — without cavitation; and *2* — with cavitation

Figure 3 Calculated (*1*, with cavitation) and measured (*2*) dependences of pressure histories in the pipeline in front of the valve at the end of the pipeline (*a*) and in the middle of the pipeline (*b*)

Figure 4 Height profile of the pipeline

Figure 5 Pressure profile at normal pipeline operation

Figure 6 Pressure profile at 3.029 (*1*), 3.05 (*2*), 3.07 (*3*), and 3.133 s (*4*) after the start of valve closing

Figure 7 Pressure profile at 3.238 (*1*), 3.2672 (*2*), and 3.3299 s (*3*) after the start of valve closing

Figure 8 Pressure in the pipeline with (*1*) and without (*2*) taking the possible oil cavitation into account

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