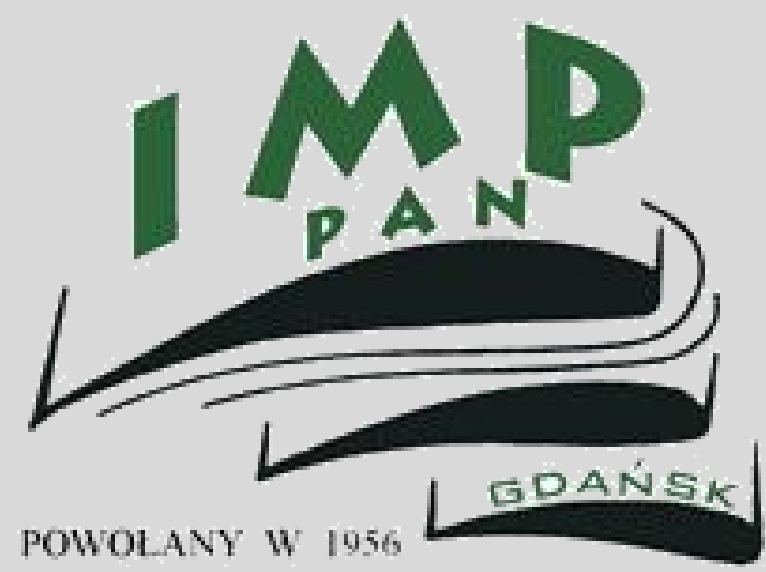


THE SZEWALSKI INSTITUTE OF FLUID-FLOW MACHINERY, PAS (IMP PAN)

CENTRE FOR MECHANICS OF LIQUIDS

DEPARTMENT OF HYDRAULIC MACHINERY



MATHEMATICAL MODELING OF THE LIQUID COLUMN SEPARATION PHENOMENON ACCOMPANYING TRANSIENT FLOW IN PIPELINES

The original model for numerical simulation of the column separation phenomenon accompanying hydraulic transients in pipelines has been developed in the Szwalski Institute of Fluid-Flow Machinery. This model, the New DVCM, belongs to a group of discrete-vapour-cavity models which are based on one-dimensional description taking vaporous cavitation into consideration. This model is an improvement over other models from this group known from the literature and commonly used in engineering practice (such as the Classic DVCM or the Single-Vapour Zone (SVZ) Model). In this model, the pipeline with the cavity zones discretely distributed in its cross-sections is replaced with the pipeline with only one cavity zone in such a way as it is equivalent in terms of mass and energy conservation laws. This assumption requires a procedure for choosing the main cross section where all volumes of cavity zones will be shifted during calculation process (loop). It also leads to the appropriate averaging of flow velocities in the rest of the pipeline cross-sections where the pressure falls to the vapour pressure level. In consequence, the New DVCM helps to avoid generation of unreal pressure oscillations or excessive numerical damping of the pressure wave – features which characterized the Classic and SVZ models.

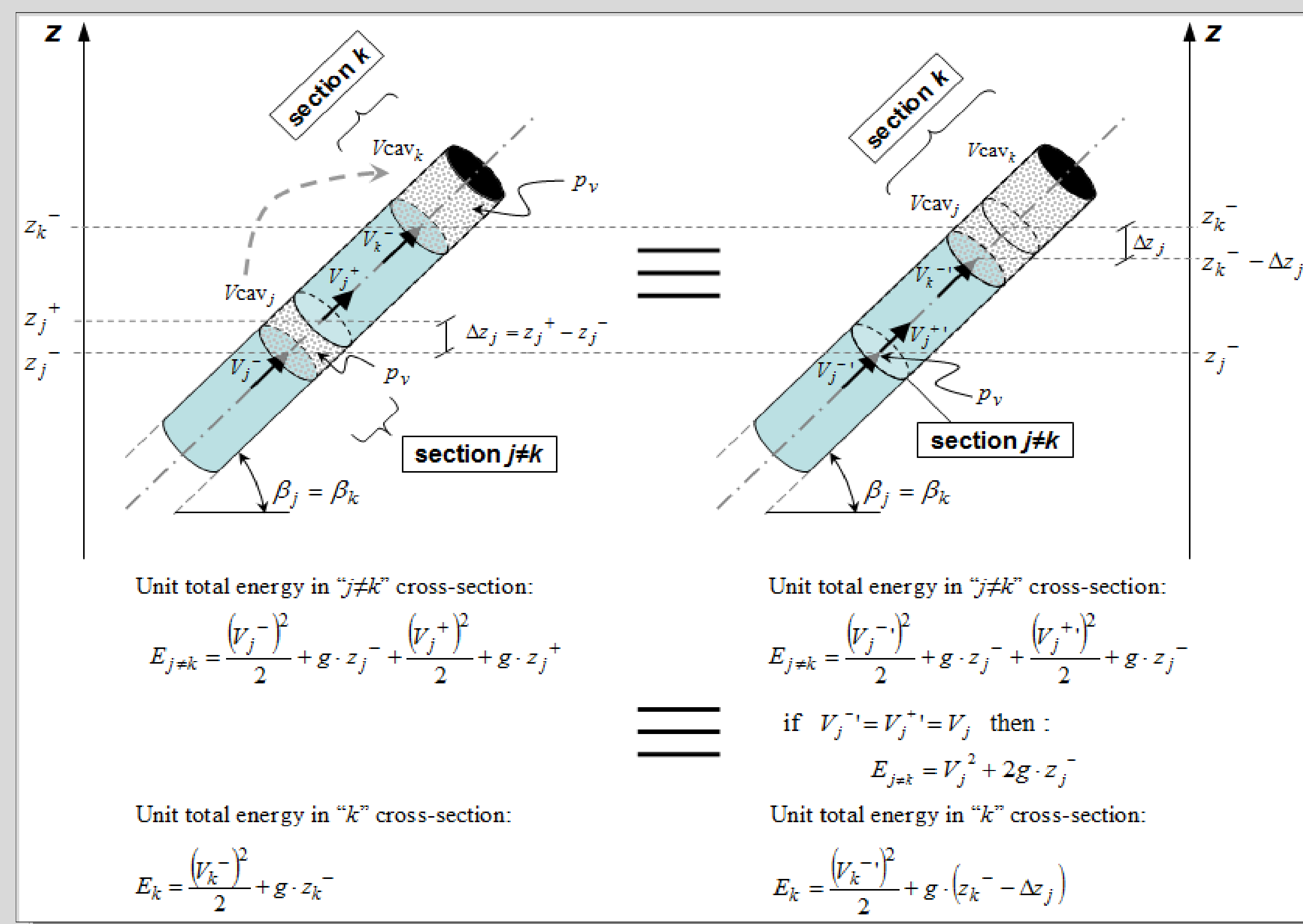


Fig. 1. The basis of the New DVCM – the liquid flow with the idealized cavity zones in the pipe segments equivalent to each other in terms of the mass and energy conservation laws.

This model has been implemented in the computer program designed for simulation of transient flows in closed conduits considering different unsteady friction models. The program was verified basing on experimental tests conducted in the special laboratory test rig (RPV system) in a broad range of changes of the initial conditions (Reynolds numbers and pressures in the pipeline). The comparative analysis, showing good agreement between the results of calculations and measurements (especially in comparison to other analyzed models), confirms the validity of the assumptions underlying the proposed New DVC Model.

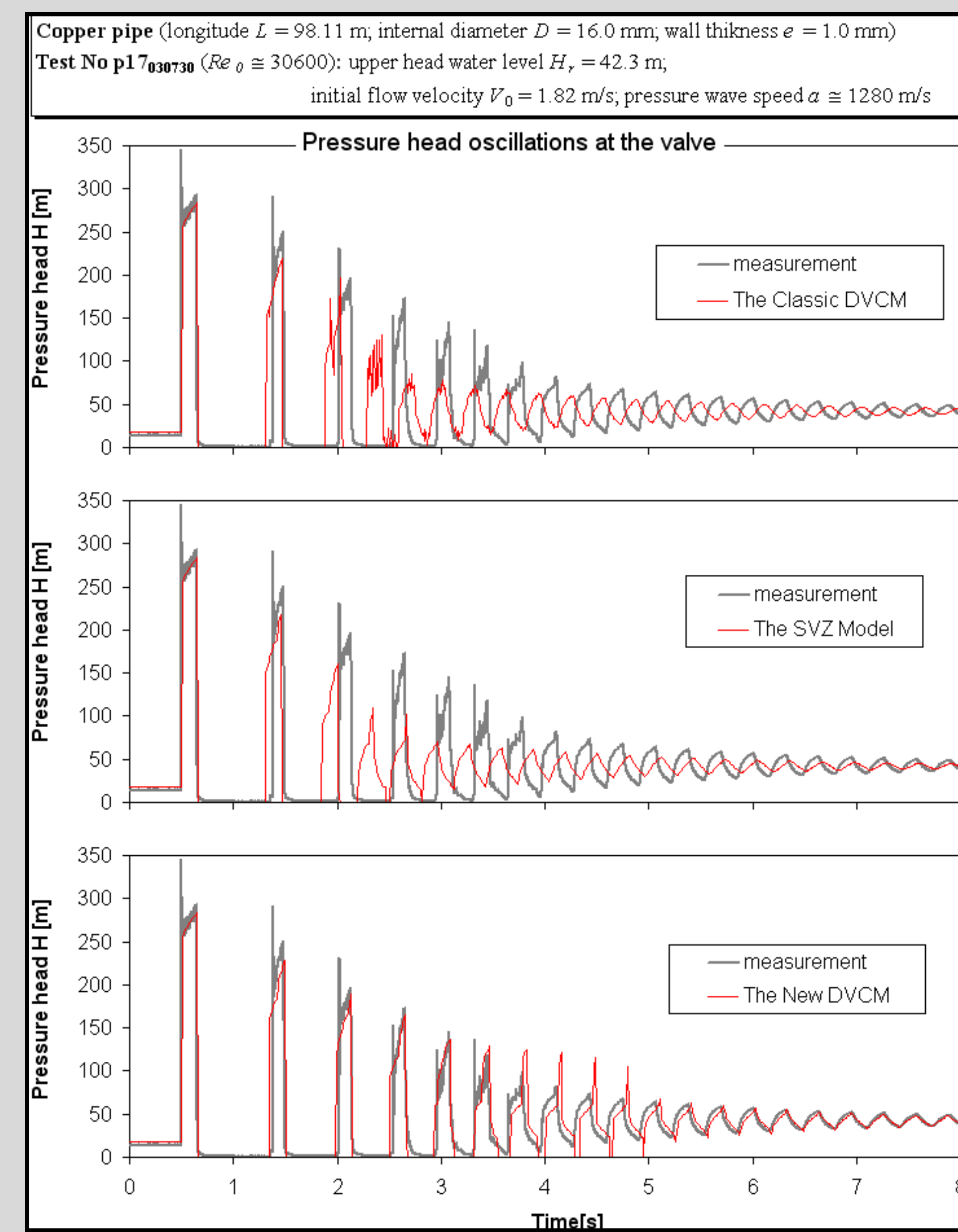


Fig. 2. An example of qualitative analysis of conformity between the measured and calculated results used to assess the selected Discrete-Vapor-Cavity Models together with the New DVCM. Calculations were made using the Vardy&Brown unsteady friction model.

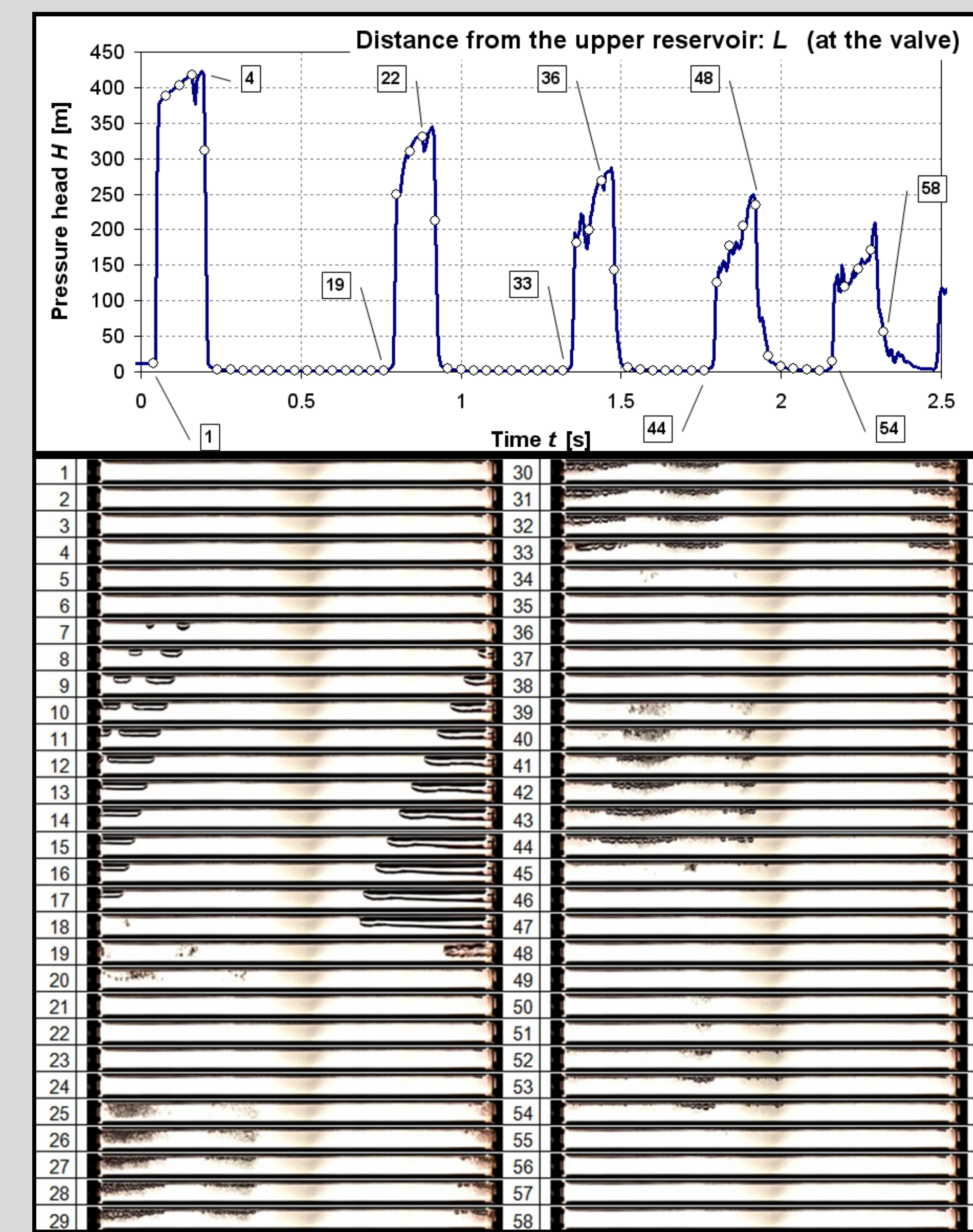


Fig. 3. An example of pressure time-traces measured at the quick-closing valve with the film frames of cavity zones made using visualization sections during special laboratory tests of water-hammer with column separation in the simple RPV hydraulic system.

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