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

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COMPACT WATER HAMMER TEST RIG

Water hammer is a physical phenomenon connecting with unsteady liquid flow in closed conduits, especially in pipelines. It is caused by sudden change of flow rate in a pipeline and it is observed as pressure waves propagating along the pipeline. This phenomenon occurs very often in practice, in different hydraulic flow systems. Violent pressure variations, accompanying with its appearance, can cause very destructive effects and are often reasons of dangerous failures in different flow systems. As an example it can be pipeline shell rupture. Therefore, it is very important to get the knowledge about the water hammer, its causes and courses, and also about the method of its reduction. The experimental stand (rig) proposed can be a good place for getting such practical knowledge. It can be used both for education and research purposes.

Main Technical Description

The experimental set-up for the investigation of water hammer phenomenon in a pipe is built in a compact form. For this reason, the long pipe (about 70 m) is of a spiral design. Using a quick-closing valve, an immediate change in the flow rate in the pipe is induced, and this initiates a water hammer pressure waves that propagate along the pipeline length axis. The standard medium used for the experiments is water, however it is possible to use another kind of liquid, oil for instance.

The cooper pipe of $D_{\text{pipe-external}} = 0.012$ m external diameter ($D_{\text{pipe-inner}} = 0.01$ m internal diameter) is spirally coiled on a metal cylinder with diameter of about $D_{\text{cylinder}} = 0.6$ m and is rigidly mounted to the cylinder coating in order to minimize its vibrations. Because of the high ratio $D_{\text{cylinder}}/D_{\text{pipe-inner}} = 60$ the pipe can be considered as a straight line. The inclination angle of the pipeline is less than 1°.

The cut-off valve no. 3 is installed at the beginning of the pipeline, just before the air chamber. Two valves, no. 4 and 5, are installed at the end of the pipeline. The valve no. 4 is a quick closing flow device which allows fast stopping the flow in the pipeline and inducing water hammer phenomenon. It is possibility to realize manual closure of this valve, with different speed. The special spring drive of this valve is an additional option which allows, after its mounting, an almost stepwise complete flow shut-down. The valve no. 5 is flow regulating device that gives possibility to adjust the pipe flow rate (or average flow velocity in the pipe) under steady flow conditions.

A pressure vessel with a cushion of air simulates an open ended pipe such that there is a clear reflection of the water hammer pressure wave. The pressure in the cushion can be regulated using a hand pump. The allowable pressure is 1.0 MPa.

Two special absolute pressure transducers are mounted; the one is mounted at the end cross-section of the pipe, close to the quick - closing valve, and the second one – at the middle cross-section of the pipeline. The measuring range of these transducers is (0-4) MPa with broad transmitted frequency band (0-5) kHz and linearity of 0.1 %. An electromagnetic flowmeter with the range of V_a = (0.5-5) m/s and precision class of 1% is used for measurement of flow mean velocity in the pipeline under steady flow conditions.

In order to enable to perform experiments, the test rig has to be connected to a source of water, for instance, to the drinking water connection greater than 400 l/h.

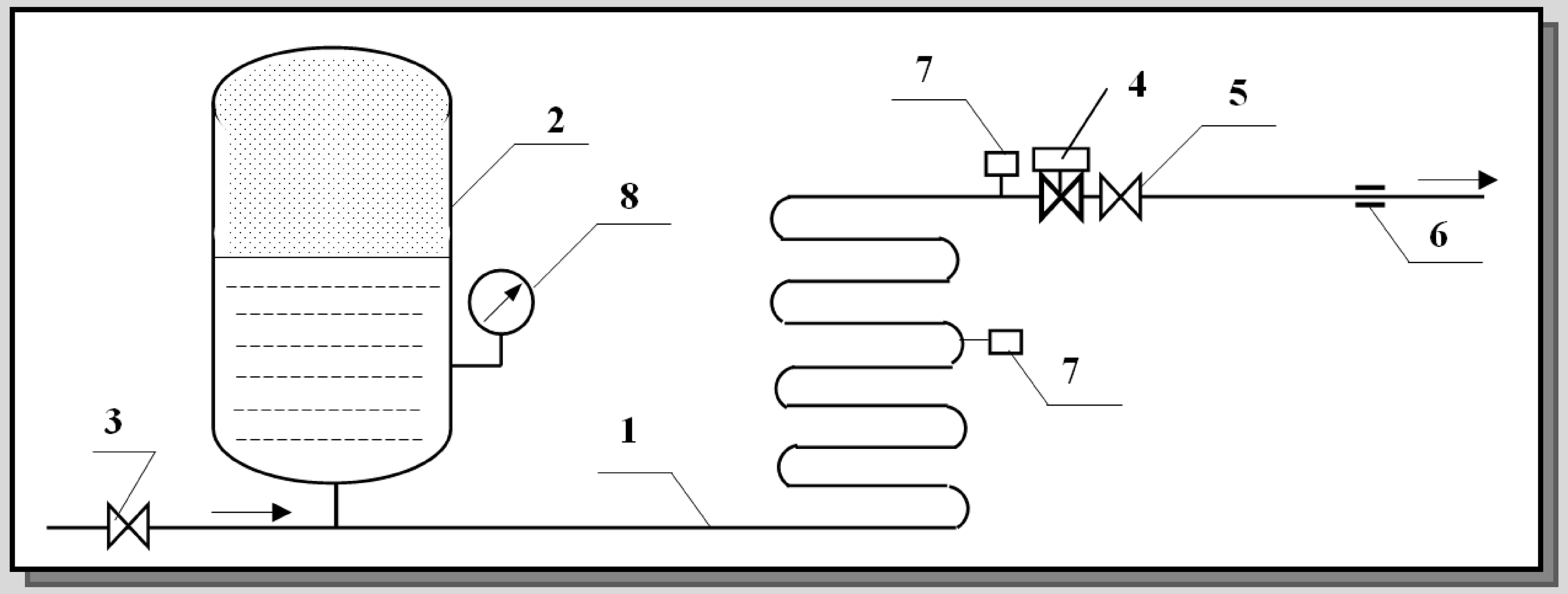

Fig. 1. Layout of the test rig for water hammer investigation.

Specification: 1. Copper pipe spirally coiled, 2. Pressure vessel with cushion of air, 3. Cut-off valve, 4. Quick closing ball valve, 5. Regulating valve, 6. Electromagnetic flowmeter, 7. Absolute pressure transducer, 8. Relative pressure transducer with display.

Fig. 2. Front view of the water hammer test rig.

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