

TESTING THE PRESSURE TRANSIENT FLOW-FORCE FOR SPOOL-TYPE TWO-WAY VALVES

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ABSTRACT

An analysis is presented of the flow force acting on a two-way valve using the equilibrium condition of the piston and the equilibrium condition of fluid in the control volume. Three types of flow forces are identified: pressure-difference-induced flow force, viscous-shear-induced flow force, and momentum-induced flow force. Nondimensional analysis shows that among all steady flow force the pressure-difference-induced flow force is largest with viscous-shear-induced flow force the second and momentum-induced flow force the smallest. However, the fluid inertial-induced flow force, which is a momentum-induced flow force, is very important while the pressure transient effect caused by the slight compressibility of the fluid is negligible. A trial test on the steady state flow force shows that the sound-wave phenomenon is strong and additional pressure gradient in the vertical direction needs to be taken into consideration. To enable further experiment 100-points average and pressure profile factor are introduced. Using a novel square-wave generator it is proved experimentally that the pressure transient effect is true and its magnitude is underestimated by the proposed theory. In addition, geometry characteristic such as leakage, valve length and damping length can change the direction of the pressure transient flow force.