Experimental investigation of slugging as initiating water hammer phenomenon through indirect contact steam condensing in a horizontal pipe heat exchanger

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Slugging as a water hammer initiator is a fascinating topic because it has a strategic impact on equipment safety in industrial systems, i.e. pressurized water reactors (PWR), heat exchangers, etc. The present research’s objective was to investigate slugging as initiating the water hammer phenomenon through indirect contact steam condensing in a horizontal pipe heat exchanger. The experiment apparatus used in the present experimental study consisted of an inner annulus pipe made of copper (din = 17.2 mm, do = 19 mm) with a length of 1.8 m and an outer annulus pipe of galvanized iron (din = 108.3 mm, do = 114. 3 mm) with a length of 1.6 m. The tested liquid was water. The experiments were conducted at a static pressure of Ps = 108.825 kPa and the temperature of T = 119.7°C. The obtained experimental data of temperature and differential pressure fluctuations were analyzed using statistical analysis. The results were as follows: 1) the flow pattern area of non-slugging (stratified and wavy flow), transition (wavy-slug flow), and slugging (slug and large-slug) were determined, with the transition flow pattern of slug and large-slug defined as initiating water hammer; 2) transition area ranges for the wavy-slug flow pattern are from ?co=1´10-1 kg/s to ?co=6´10-1 kg/s for ?st=6´10-3 kg/s to ?st=7.5´10-3 kg/s, and ?co< 3´10-1 kg/s for ?st=8´10-3 kg/s to ?st=9´10-3 kg/s. These obtained data are very important in order to develop a database for the input of an early warning system design in a safe, two-phase flow installation piping system during steam condensation.