

Flow visualization of bubble behavior under two-phase natural circulation flow conditions using a high-speed digital camera

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The present work aims at identifying flow patterns and measuring interfacial parameters in the two-phase Natural Circulation Circuit (CCN) installed at the Nuclear Engineering Institute/CNEN, by using a visualization technique. The CCN comprises heater, heat exchanger, expansion tank, the pressure relief valve and pipes to interconnect the components. A glass tube is installed at the midpoint of the riser connected to the heater outlet. The circuit is complemented by a control and a data acquisition system. The instrumentation is composed by 12 thermocouples, an electromagnetic flowmeter, 2 rotameters and a high-speed digital camera. The analysis of the experiments could be divided into three stages, as shown in Fig.2. The first stage corresponds to the region of the graph with the evolution of temperature in hot and cold legs, occurring in a linear way, characterizing the single-phase flow. The second stage corresponds to the development of both the nucleate boiling regime and dispersed micro-bubbles, characterizing the single-phase to two-phase transition. The third stage of the two-phase flow starts as the slug and churn regimes appear. The bubbles in the finely dispersed flow were small spherical types whereas in the slug flow they were spherical cap types. The visualization system was able to determine the bubble size as well as the bubble velocity. Most bubbles were located in the region where the velocity was within an interval of 0.30 m/s to 1.60 m/s. Based on the results of the flow rate measurements and the frames recorded by the high-speed digital camera it was possible to achieve an explanation for the flow oscillations, according to the phenomenon called "natural circulation oscillation" in literature. The visualization system with a high-speed digital camera allowed characterizing the flow regimes. It was observed two regimes: finely dispersed bubble, slug flow and churn flow, Fig. 3.

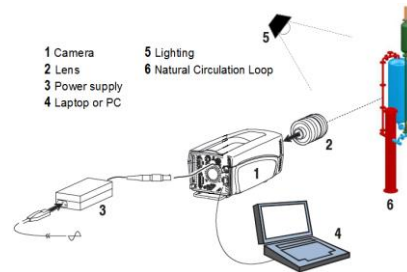


Figure 1: Schematic of natural circulation circuit and visualization system.

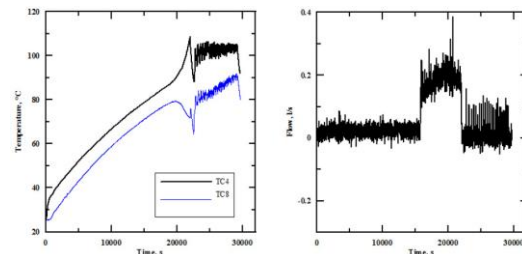


Figure 2: (a) Temperature measurements between TC4 and TC8, (b) Natural circulation flow measurements.

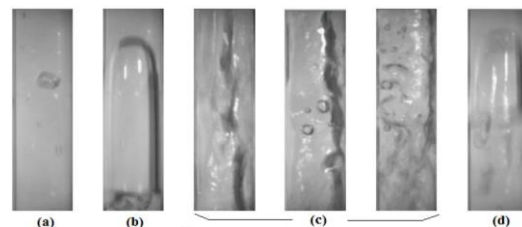


Figure 3: Two-phase flow regimes in natural circulation.

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Reference

- [1] LEMOS, W. F.; FACCINI, J. L. H.; SU, J. Flow visualization of bubble behavior under two-phase natural circulation flow conditions using high speed digital camera. In: INTERNATIONAL NUCLEAR ATLANTIC CONFERENCE, 2013, Recife. **Proceedings...** Recife: ABEN, 2013.