Experimental study of two-phase flow oscillations in a natural circulation loop

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This work aims to investigate experimentally the oscillations during the operation of a natural circulation loop, designed to meet the single and two-phase flow similarity criteria to a typical Passive Residual Heat Removal (PRHR) system of an Advanced Pressurized Water Nuclear Reactor (APWR), [1].

The loop was one-tenth scale in height and operated at atmospheric pressure. It was comprised of a cylindrical vessel with descending tube, a core barrel housing electrically heated rods, and upper and lower plena interconnected to a seven-tube shell heat exchanger by hot and cold pipe legs. A data acquisition and control system was provided, including a power control and instrumentation, in order to permit variations of the power to the electrically heated rods, as well as to acquire flow rate, pressure and temperature data in a timely manner. The main components and instrumentation are shown in Figure 1.

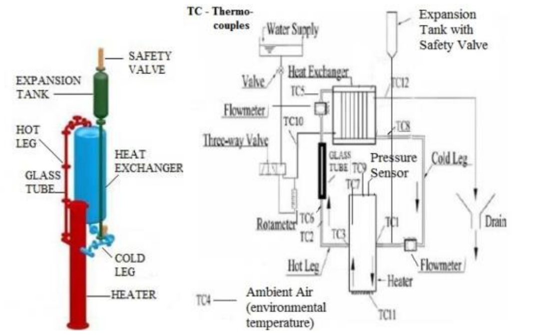

Figure 1. Natural Circulation Loop: main components (out of scale) and instrumentation.

The results obtained, especially in terms of temperature and flow rate oscillations, indicated that the loop was subject to a condition of cyclic two-phase flow instability. It was characterized by the periodic repetition of the same pattern of changing in the temperature, flow rate and other important flow characteristics, like the sequence of two-phase flow patterns during the instability period, [2].

Figure 2 shows the temporal evolution of the highest loop temperature, at the heater exit, as well as the temperature in the hot leg middle part. It also shows the detailed evolution of those temperatures during the two-phase flow.

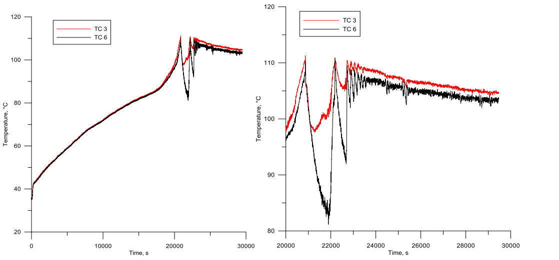

Figure 2. Evolution of the temperatures at the heater exit, TC3, and in the hot leg middle part, TC6, with the cooling rate of 6 l/h during single and two-phase flow on the left; and during two-phase flow only on the right.

Figure 3 shows the temporal evolution of the gauge pressure below the heater upper cover in the beginning of two phase operation at the cooling rate of 3 l/h, together with the temperature in the heater exit.

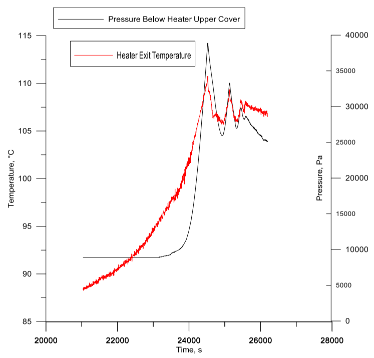

Figure 3. Temporal evolution, in the beginning of two-phase flow, of the gauge pressure below the heater upper cover and the heater exit temperature, with the cooling rate of 3 l/h.

References

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