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AEC-NASA TECH BRIEF

Self-Sustained Hydrodynamic Oscillations in a Natural-Circulation Two-Phase-Flow Boiling Loop

An experimental and theoretical study is reported (ref.) that attempted to determine factors affecting self-sustaining hydrodynamic oscillations in boiling-water loops; it yielded a wide range of pertinent and consistent data on flow variables for this type of system. The literature on past work is reviewed, and theoretical and experimental results are compared.

Proper design of many systems of technological importance requires understanding of the behavior of heat-transfer systems in which the circulation is provided by the density difference caused by boiling in the heated section. The effects of geometry, subcooling, and pressure on the inception and development of oscillatory behavior in a natural-circulation boiling-water loop were studied. The following ranges of parameters were covered by the experimental study:

Heat flux, Btu/hr-ft^2	$0.2–3.1 \times 10^5$
Pressure, psia	200–1500
Inlet subcooling temperature, °F	0–62
Test section, lengths, in.	48, 72, 96
Internal diameters, in.	0.364, 0.625, 0.8125
Riser, lengths, in.	48, 60
Internal diameters, in.	0.3125, 0.625, 1.049

The critical power density was determined by an arbitrary criterion, since the steady-oscillation amplitude increases continuously with power. For large oscillations, periodic inlet-flow reversals were found, which could be compared to the steady inlet-flow velocities. These phenomena are emphasized by lower system pressure and small-diameter test section and riser. Other parameters did not affect these phenomena in a distinct fashion. The frequencies of the oscillations varied from 0.24 to 0.76 Hz and generally increased with increase in power, as did the flow amplitudes.

Two theoretical models were investigated: one linear and one nonlinear. The linear analysis in frequency domain showed good ability to predict the oscillation threshold and the frequency associated with the initial oscillations. The predictions of the threshold power were correct within 5% for over 60% of the tested cases, and within 10% for over 80%.

The nonlinear model had to be modified for satisfactory prediction of the steady inlet-flow velocities. However, this modification and the original model failed to give reasonable predictions of the oscillation thresholds and frequencies. Neither form of the model satisfactorily predicted the amplitudes. It is thought that the one-dimensional formulation fails to take into account vaporization, which acts as a periodic forcing function, of superheated liquid near the leading edge of the two-phase region. The introduction of such a forcing function allows the computation of periodic bounded oscillations similar to those observed experimentally, and also explains qualitatively the observed trends with parameter variations.

Reference:

1. Jain, K. C.: Self-Sustained Hydrodynamic Oscillations in a Natural-Circulation Two-Phase-Flow Boiling Loop. ANL-703, Argonne National Laboratory, Aug. 1965.

Notes:

1. This information may interest workers with systems involving natural cycles of boiling water, such as specific power, water-purification, and desalinization systems.

(continued overleaf)

2. Inquiries concerning this information may be directed to:

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Patent status:

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