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University of Cincinnati
Dept. of Chemical and Nuclear Engineering

Quarterly Progress Report
Period Ending June 30, 1973

"Investigation of Pressure Drops and
Heat Transfer Coefficients For
Loss of Coolant Evaluation"

Report No. COO-2152-8

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Contract AT(11-1)2152
"Investigation of Pressure Drops and
Heat Transfer Coefficients For Loss
of Coolant Evaluation"

Quarterly Report for Period
April 1 to June 30, 1973

The objective of this contract is the study of pressure drop and heat transfer phenomena of importance during a loss of coolant accident. The study is divided into three experiments: a) Transient Pressure Drop Investigation b) Two Phase Pressure Drop and Flow Pattern Study c) Transition Boiling and Reflooding Heat Transfer Tests.

I Transient Pressure Drop Investigation

The transient pressure drop apparatus functions by discharging Freon 113 from a large storage accumulator. The Freon flashes across a needle valve and a 3-way valve directs a portion of the 2 phase mixture to a storage accumulator and the remainder through the test section. By varying the position of the 3-way valve, a time varying flow is obtained.

Single-phase transient tests were run during the last quarter and were previously reported. During this quarter, the experimental techniques were adapted to two-phase transient studies. Several difficulties were encountered. It was found that there was significant temperature stratification in the source accumulator. This was largely eliminated by relocation of the band heaters on the accumulator and changing the technique used to return the Freon to the source accumulator.

The lack of thermodynamic equilibrium poses a more serious difficulty. By visual observation through the sight glass it was determined that the Freon had to be heated by as much as 20-30°F above the saturation temperature before any flashing would occur. It is thus not possible to use the quality calculated on the basis of thermodynamic equilibrium. The quality was estimated by assuming homogeneous flow and obtaining the mass flow rate from the weigh cell and the volumetric flow from the turbine meter. The qualities so obtained are substantially below what would be obtained assuming thermodynamic equilibrium.

Steady state pressure drop measurements were made over a range of conditions. Using the above procedure for estimating quality and void fraction, values of the overall pressure loss coefficient, K , were computed. At low values of α , the overall K was essentially identical with single phase values.

After a number of exploratory runs, conditions at which transient pressure drops could be determined were established. Successful measurements of contraction resistances were made for α ranging from 0-15%. The K_c values computed showed appreciable scatter but no trend with α . However, all appeared lower than the steady state values previously obtained. The reason for this discrepancy is under study.

Useful transient measurements across the expansion were not obtained. The overall expansion K is very nearly zero and small amounts of flashing caused large changes in computed value of K_e . To avoid this difficulty, the differential pressure cell connections have been revised. Instead of measuring the expansion Δp directly, the combined pressure drop across the expansion and contraction will be determined.

II Two-Phase Pressure Drop and Flow Pattern Study

These experiments are being conducted in a recirculating loop using Freon-113. During this quarter, a new contraction-expansion test section constructed of glass was installed in conjunction with a straight pipe test section. When the equipment was operated, it was discovered that the high loop pressure drop prevented operation at the desired conditions. A satisfactory loop resistance was obtained by removing the straight pipe test section. The equipment has been operated extensively and data has been acquired at a wide variety of mass flow rates, void fractions and system pressures. Because of the high pressure drop in this test section, significant flashing occurred in some runs. The data analysis, which is underway, considers this effect.

Visual observations of the flow pattern at the area changes were made. Considerable mixing was observed at both the expansion and contractions.

III Transition Boiling and Reflooding Heat Transfer Tests

Experimental Work

These experiments are conducted in a heat transfer loop using hot mercury as the heat source. Boiling of water takes place in a vertical glass annulus around the mercury pipe.

Preliminary runs were carried out and transition boiling data was obtained at low flow rates ($\sim 3 \times 10^4 \frac{\text{lbm}}{\text{ft}^2 \text{hr}}$) and ΔT s ($\leq 100^\circ \text{F}$). However, during the tests, failure of a seal in the test section led to leakage of mercury into the water. The water side has been completely repiped

and the seal in the test section has been replaced by a weld. A new flow meter was also added on the mercury side. Difficulties were also encountered with a sliding seal which allowed for the differential expansion between the steel and glass. The seal is now being replaced.

Analyses of Transition Boiling Data

The transition boiling correlation for flow conditions, reported in the last quarterly report, assumed that the transition boiling h contained a boiling and convection component. Fig. 1 shows a plot of this convective component versus $(\Delta T - \Delta T_m)^*$. In Fig. 2, the line correlating this data is compared with the available pool boiling data^{1,2,3}. It is seen that there is a substantial difference between these quantities. This may indicate a fundamental difference between the flow and pool boiling situations. However, the fact that the pool boiling data was obtained with horizontal cylinders and the flow boiling data from vertical cylinders could also account for the difference observed.

In Fig. 3, the proposed transition boiling correlation has been compared with data from two FLECHT runs^{4,5}. A direct comparison is not possible since the fluid quality in the FLECHT tests is unknown. A range of reasonable qualities was therefore assumed and a prediction band determined. As seen from Fig. 3, the experimental data fall in the vicinity of the prediction bands.

*See report COO-2182-7 for definition of symbols

References

1. Farber, E.A. and R.L. Scoria, "Heat Transition to Water Boiling Under Pressure," Trans. ASME, 70, 369 (1948).
2. Stock, B.J., "Observations on transition boiling heat transfer phenomena," ANL-6175 (June 1960).
3. Braunlich, R.H., M.S. Thesis in Chemical Engrg., M.I.T. (1941)
4. PWR FLECHT Group I Test Report, WCAP-7435.
5. L. Hochreiter, Westinghouse Nuclear Energy Systems, personal communication.

FIG. 1. POOL BOILING COMPONENT FROM FLOW TRANSITION BOILING DATA
 (h_{pool}/h_m) VS $(\Delta T - \Delta T_m)$

FIG. 3. CORRELATION FIT OF FLECHT DATA