SASSYS PRETEST ANALYSIS OF THE THORS-SHRS EXPERIMENTS*

by

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The THORS Facility at ORNL was recently modified to allow the testing of two parallel 19-pin simulated fueled subassemblies under natural circulation conditions similar to those that might occur during a partial failure of the shutdown heat removal system (SHRS) of a liquid-metal fast breeder reactor. The planned experimental program included a series of tests at various inlet plenum temperatures to determine boiling threshold power levels and the power range for stable boiling during natural circulation operation.

Pretest calculations were performed at ANL, which supplement those carried out at ORNL [1,2], for the purposes of validating the SASSYS model in the natural circulation regime and of providing data which would be useful in planning the experiments.

A discrepancy was found between the preliminary SASSYS predictions of boiling thresholds and the ORNL pretest predictions. Discussions with ORNL staff to compare modeling assumptions indicated that the problem was due primarily to the use of different friction correlations which agreed fairly well under normal flow conditions but differed significantly in the lower Reynolds number regime encountered in natural circulation. To test this hypothesis, the THORAX friction factor formula, Eq. (1), used in the ORNL pretest analyses, was programmed into the SASSYS model and the boiling threshold was reevaluated. The comparison of results in Table I show that the SASSYS threshold computed by this formula falls in the range of the various ORNL pretest calculations, thus substantiating the hypothesis

$$f = 100/R + 0.3164/R^{0.25}. \qquad (1)$$

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Table I

Comparison of Boiling Threshold Power Predictions

Inlet Temperature °C	Bundle Power, kw/pin: SASSYS THORAX Friction Eqn.	SASSYS Best Estimate	ORNL Pretest[1,2]	LIMBO[3]
354	4.43	5.55	3.5-4.7	6.22
538	2.38	3.05	1.9-2.6	3.41

The "best estimate" case was recomputed using a new set of friction correlations. The selected turbulent friction factor formula, Eq. (2), is based on Novendstern's [4] correlation with the THORS bundle geometry factored in. Similarly, the laminar friction formula, Eq. (3), was derived from the correlation of Engle et al. [5]. The transition Reynolds number was taken to be that at the intersection of the two equations.

$$f = 0.334/R^{0.25}, \quad R > 1336 \tag{2}$$

$$f = 73.8/R, \quad R < 1336 . \tag{3}$$

The "best estimate" boiling thresholds given in Table I are seen to be in fair agreement with LIMBO [3] predictions but appreciably exceed ORNL predictions. The boiling threshold at the nominal inlet temperature of 354°C, for example, is around 20% of the nominal bundle power (28 kw/pin). This is appreciably in excess of decay heat levels, which are roughly of the order of 5% or less. Even the higher temperature case, corresponding to a degraded SHRS, gives a boiling threshold exceeding decay heat levels.

An indicator of the stability of boiling is the power range for stable boiling which we define to be the difference between the pin power at pin burnout and that at the boiling threshold. The SASSYS code runs to determine this range used a simulated experiment in which the pin power was incremented in steps of 0.05 kw (in the near-boiling and boiling ranges) with power plateaus of 200 s duration before boiling and 50 s after.

The SASSYS predictions (best estimate case) for the power range for stable boiling are compared with those for ORNL and LIMBO in Table II. The SASSYS predictions fall in the range of those obtained at ORNL using various models. The differences between the SASSYS and LIMBO results are believed to be due to differences in their boiling models: one is a Lagrangian, bubble model and the other an Eulerian, distributed-void model. All models predict a larger stable power range at 538°C, which is the lower power case.

Table II
Comparison of Predicted Power Ranges for Stable Boiling

Inlet Temperature °C	Stable Power Range, kw/pin		
	SASSYS	ORNL pretest [1,2]	LIMBO [3]
354	0.10	0.05-0.20	0.33
538	0.30	0.30-0.40	0.71

The main conclusions of the present study are:

(1) the predicted boiling threshold powers exceed decay heat levels for the cases considered;

(2) the disagreement in boiling threshold powers is mainly due to differences in the friction correlations in the natural circulation flow regime;

(3) all models predicted relatively small power ranges for stable boiling for the cases considered.

References

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