CONF-851115--5

MASTER

THE IMPORTANCE OF MOMENTUM DYNAMICS IN BWR NEUTRONIC STABILITY:EXPERIMENTAL EVIDENCE

CONF-851115--5

DE85 013996

José March-Leuba

The University of Tennessee
Knoxville, TN 37996

Pedro J. Otaduy

Oak Ridge National Laboratory*
Oak Ridge, TN 37831

Submitted to the American Nuclear Society Winter Meeting
San Francisco, California. November 10-14, 1985

---

*Operated by Martin Marietta Energy Systems, Inc., for the U.S. Department of Energy under Contract NO. DE-AC05-84R21400.

Momentum dynamics affect the boiling water reactor (BWR) neutronic stability by coupling steam void perturbations and core-inlet coolant flow. Computer simulations[1,2] have shown that proper modeling of the recirculation loop, which shares the upper and lower plena pressures with the reactor core, is essential for accurate stability calculations. The purpose of the present work is to show experimental evidence, obtained from a recent series of stability tests performed at the Browns Ferry-1 BWR,[3,4] demonstrating the important role of momentum dynamics in BWR neutronic stability.

The results of the Browns Ferry stability tests[3,4] confirmed the stability of this reactor and showed that the sensitivity of the decay ratio (DR) to variations in power and flow followed the same trends during two-loop and single-loop operation (SLO). SLO measurements, however, exhibited a significant noise increase (300%) in most process signals. The source of this higher noise level was determined to be related to increased turbulence in the downcomer due to crossflow between active and inactive pump loops. This determination was made by comparing the reactor transfer functions (obtained from noise measurements without external perturbations) to the results of computer simulations. Figure 1 presents the transfer function (TF) between active-loop flow and average reactor-power for test BFTP3. The remarkable agreement observed between the calculated and measured TFs implied that the noise source was external to the core and was included in the flow signal.[3,4]

Given the relative simplicity and low cost with which noise measurements can be performed, this well-known technique might be used in the future to obtain reactor TFs which can, in turn, be used to quantify the reactor stability in terms of indices such as the DR. Contrary to TFs from perturbative tests, the correctness of noise TFs relies on assumptions of the location and characteristics of the driving noise source, which, in general, cannot be measured directly. The TFs calculated from the Browns Ferry noise tests data (for instance, the TF presented in Fig. 1a) were computed from the measured power and flow signals; therefore, they are open-loop TFs. Computation of the closed-loop TFs would have required a direct measurement of the noise source, which was not possible. The open-loop TF does not account for the recirculation loop momentum dynamics; as a result, its DR is expected to be smaller (i.e., more stable) than the closed-loop DR.[1] Thus, it does not yield a conservative estimate of the reactor's stability.

The closed-loop DR can be estimated from noise measurements by analyzing only the power noise. This technique, which has been described and validated in refs. 5 and 6, allowed us to calculate noise-based, closed-loop DRs that can be compared to the open-loop DRs calculated by functionally fitting the measured TFs. This comparison (see Table I) shows that the open-loop DRs are about 50% smaller than the closed-loop DRs for these test conditions. Table I also contains open-loop and closed-loop DRs calculated by a numerical stability code[2] to permit comparisons and confirm noised-based DR trends. Note that, although the calculated DR values agree satisfactorily with the measured ones, the intention of this comparison is to show that the observed experimental trends agree with analytical predictions. The lack of test-specific cross-section and flow data[3,4] for the numerical calculations precluded other possible conclusions from this comparison.

In essence, the present work has shown experimental evidence that momentum dynamics play an important role in BWR dynamic behavior. Proper modeling of the recirculation loop is, thus, essential for accurate stability calculations; otherwise, nonconservative errors of as high as 50% could result. In addition, we have shown that noise analysis can be used to estimate DRs in BWRs, but obtaining a conservative DR from this technique requires extreme care in the identification of the noise source location to determine whether the DR represents the open-loop or the closed-loop reactor stability.

REFERENCES

1. P.J. OTADUY and M.J. OHANIAN, "The Importance of Momentum Dynamics in BWR Neutronic Stability," proceedings of the Topical Meeting on Advances in Reactor Physics and Core Thermal Hydraulics, Kiamesa Lake, N.Y., Sepember 22-24, 1982. NUREG/CP-0034

2. P.J. OTADUY, "Modeling of the Dynamic Behavior of Large Boiling Water Reactor Cores," Ph.D. Dissertation, University of Florida (1979).

3. J. MARCH-LEUBA, R.T. WOOD, C.O. McNEW, and P.J. OTADUY, "Browns Ferry-1 Single-Loop Operation Tests." Oak Ridge National Laboratory, ORNL/TM-9601 (1985).

4. J. MARCH-LEUBA, R.T. WOOD, C.O. McNEW, and P.J. OTADUY, "Stability Tests at Browns Ferry-1 Under Single Loop Operating Conditions," to be published in Nuclear Technology.

5. J. MARCH-LEUBA, "Dynamic Behavior of Boiling Water Reactors," Ph.D. Dissertation, The University of Tennessee, Knoxville, (1984).

6. J. MARCH-LEUBA and C.M. SMITH, "Development of an Automated Diagnostic System for Boiling Water Reactor Stability Measurements." Reactor Noise - SMORN IV, Proceeding of the Specialists Meeting, Dijon, France, October 15-19, 1984, to be published by Pergamon Press.

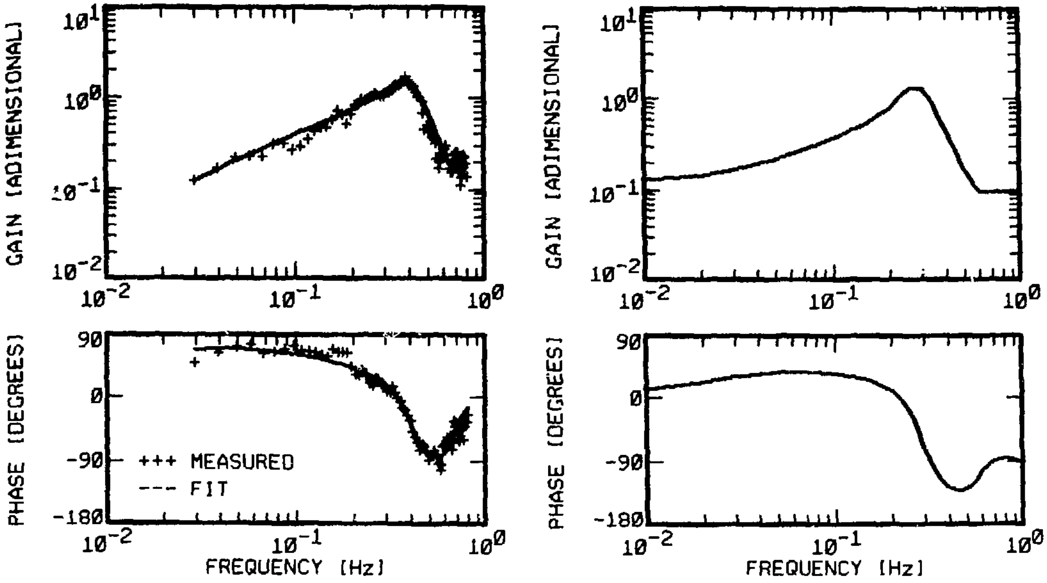
Table I. Comparison of open-loop versus closed-loop decay ratios

Test	Power	Flow	Experimental decay ratio		Calculated decay ratio	
	(%)	(%)	open-loop	closed-loop	open-loop	closed-loop
BFTP1[a]	66	56	0.21	0.34	0.15	0.26
BFTP2[a]	54	38	0.30	0.45	0.26	0.47
BFTP3[b]	47	32	0.33	0.53	0.30	0.56
BFTP4[b]	54	45	0.26	0.39	0.20	0.34
BFTP6[b]	59	52	0.28	0.34	0.16	0.25

[a] Two-loop operation
[b] Single-loop operation

Fig. 1. Open-loop flow-to-power transfer function for test case BFTP3.

ORNL DWG-85-13016



(a) Experimental (b) Computer calculation