Proceedings of the Korean Nuclear Society Spring Meeting
Cheju, Korea, May 1996

Analysis of Locked Rotor Event Using TASS Code

Byung Il Lee, Jong Jin Kim, Seung Su Baek, *Kil Sub Um, Hee Cheol Kim
Korea Atomic Energy Research Institute

Abstract

When locked rotor event occurs, instantaneously affected loop and core flow were quickly reduced, which resulted in an increase in coolant temperature and system pressure. Analysis method of this event was that constant core inlet temperature and system pressure as well as change in core flow calculated from COAST code were statically used as an input variable to HERMITE code, because of no tools to simulate NSSS behavior and 1-D core neutronics transient coincidently. With employing TASS code revised with 1-D neutronics model, this event was analyzed in point of DNBR. By doing so, analysis procedure could be simplified and unreasonable conservatism might be removed in DNBR calculation by consideration of pressure increase.

1. Introduction

A single reactor coolant pump locked rotor can be caused by seizure of the upper or lower thrust-journal bearings. Flow through the affected loop is rapidly reduced, leading to a reactor and turbine trip. A sudden decrease in core coolant flow which the reactor is at power results in an increase in pressure and a degradation of core heat transfer which could result in fuel damage.

The specific criteria necessary to meet the relevant requirement of GDC 27, 28, and 31, and 10 CFR Part 100 for this event are roughly divided into three point of view, pressure in the reactor coolant and main steam system, the potential for core damage, and any activity release at site boundary [1]. In this paper, the second item was mainly treated in analysis methodology.

2. CE Analysis Method at Present

Locked rotor event was terminated by hot leg low flow rate trip signal [2]. Not only the change in hot leg flow used for trip time calculation but also core flow used as a static input to HERMITE would be calculated with COAST code [3], in which main input data was homologous curve [4]. This event was sensitive to the core flow and axial power distribution. In order to conservatively calculate DNBR, COAST code and 1-D HERMITE code were employed for flow change and 1-dimensional core transient calculation, respectively. The change in core flow on locked rotor was used as a static input to 1-D HERMITE code. HERMITE performs steady state or space-time coarse mesh neutronics and thermal hydraulic calculations. This event analysis starts at POL, which means that the initial core should retain the margin to be required for COLSS/CPC operation. The results of HERMITE, normalized node heat flux, was used to calculate DNBR with CETOP-D code [5].

3. Code Replacement

In using HERMITE code, there is a limiting point in simulation of change in core inlet temperature and pressure. HERMITE could not simulate the change in core inlet temperature and pressure. In other words, constant values for core inlet temperature and core pressure must be used as a constant during a transient because HERMITE is core space-time kinetics and thermal hydraulics codes. HERMITE code was licensed under the condition that this code could be applied for the only event that the change in core inlet temperature is negligible during the transient and that pressure increases or doesn't change.

At this point, it is necessary to understand the sequence of locked rotor event. After locked rotor, the affected loop flow rate is quickly reduced, which results in reactor and turbine trip. Coincidently, core flow was decreased, too. [These changes in hot leg and core flow would be calculated with COAST code.] Decrease in core flow results in a degradation of core heat transfer which results in an increase in coolant temperature and system pressure. After trip breaker opening due to hot leg low flow trip signal, turbine trip would occur, which enable the system pressure to increase far more. The predicted pressure could and would not used in calculating DNBR during the transient with HERMITE and CETOP-D. Because there has been no tools to calculate pressure change and 1-D core transient including NSSS behavior. [On the point of peak pressure, CESEC code was used where constant k-factor was used as a flow resistance instead of homologous curve.]

But, TASS code [6] has the capability to simulate locked rotor NSSS behavior based on homologous curve and 1-D core transient. Before using 1-D TASS code, it is required to initialize core parameters such as fuel temp., coolant temp., and moderator density for 1-D neutronics calculation. This procedure would be verified and automatized [7].

4. Analysis Results

Locked rotor event was analyzed with TASS code. The purpose of this paper was to demonstrate that TASS code could be used for calculation of locked rotor NSSS response for DNBR calculation. So, any kind of sensitivity study [axial power distribution, initial flow, and pump inertia] would not be done. Normal conditions were used as initial one.

The initiating event was locked rotor at time=0.0. Reactor trip signal was generated in hot leg low flow rate trip function in Reactor Protection System [80% of full power steady state hot leg flow]. Total response time for this trip function and rod coil decay time were 1.2 and 0.5 seconds, respectively. However assumed that loss of offsite power (LOOP) is to occur at 3 seconds after reactor trip, MDNBR would be occurred before LOOP.

Figure 1 through 5 show the changes in core power , pressurizer pressure, each cold leg flows, core flow, and core inlet temperature. Figure 6 shows two DNBR curves, one is the case with increase in pressure and the other is without one. The former was simulated under the condition pressurizer pressure control system was not working. This just demonstrate that DNB SAFDL margin could be increased by credit of pressure increase.

5. Summary & Recommendation

It was found that TASS could be utilized to calculate NSSS behavior of locked rotor for DNBR calculation. By using TASS, COAST used for core and loop flows could be removed from the present analysis procedure and the unnecessary conservatism in DNBR calculation could be cut off by considering the pressure increase.

In analyzing locked rotor event, the most important thing to be considered was the change in core flow and pressure. Because they could directly affect the actual heat transfer and critical heat flux, respectively. Therefore, it is necessary to conservatively calculate the core flow and pressure. In this analysis, however so, any conservatism was not applied in flow calculation.

Whereas core T/H model of TASS code has only average channel, HERMITE code has two types of flow channels, average and hot channel. T/H model of TASS core is to be revised in order to consider the change in Fr (integrated radial peak). Analysis results with TASS are to be compared with HERMITE results under the same initial condition.

6. *Reference*

1. USNRC Standard Review Plan. Rev.2, July 1981
2. R.O.Allen, 'Design Data for the Safety Analysis for YGN 3/4', Rev.1, Jan. 25, 1991
3. K.S.Min, 'YGN 3/4 Homologous Pump Parameters for RCPs', April 12, 1990
4. Y.M.Kim, 'Results of the RCP Coastdown Analysis for YGN 3/4 FSAR', March 6, 1991
5. C.E., 'CETOP-D Code Structure and Modeling for Arkansas Nuclear One-Unit2', July 1982
6. H.Y.Yoon et al., 'Development of TASS Code for Non-LOCA Analysis Licensing Application', 1995
7. 심석구외, '원전계통 분석코드 TASS 개발', 한국원자력연구소, KAERI/RR-1468/94, 1995

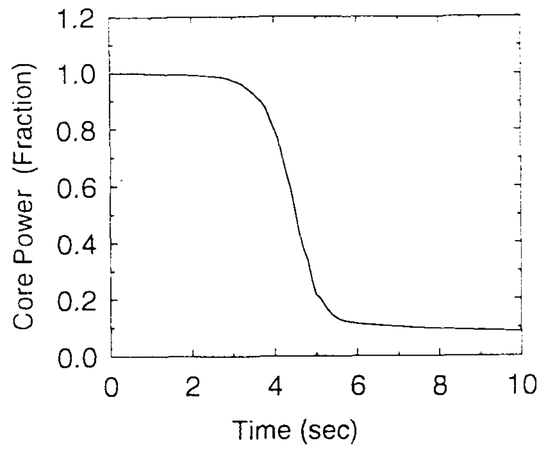

Figure 1. CORE POWER

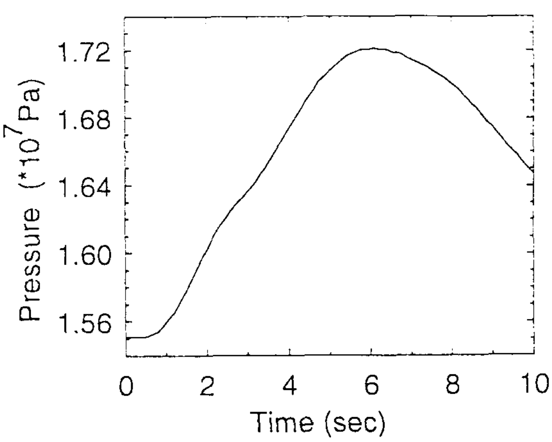

Figure 2. Pressurizer Pressure

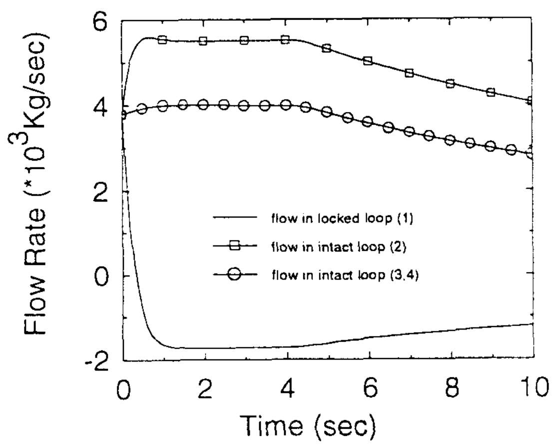

Figure 3. Cold Leg Flows

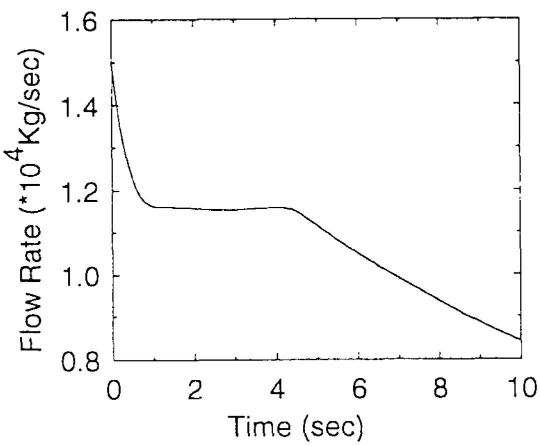

Figure 4. Core Flow

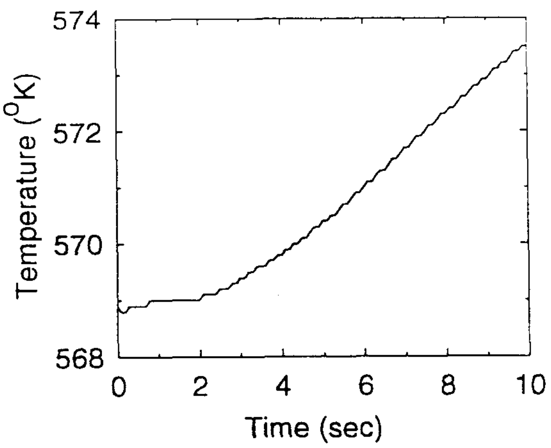

Figure 5. Core Inlet Temp.

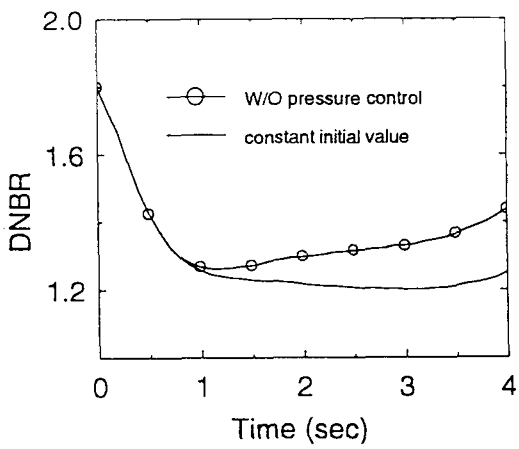

Figure 6. DNBR Change