Locked Rotor Analysis of UCN 3/4 Using RETRAN

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1. Introduction

A locked rotor (LR) event could be caused by seizure of the upper or lower thrust-journal bearings of a reactor coolant pump (RCP). Following the seizing of a shaft, the core coolant flow rate rapidly decreases to its value corresponding to an 'N-1' RCPs operating. This coolant flow rate reduction causes an increase in the average core coolant temperature and results in some fuel pins experiencing a departure from nucleate boiling (DNB).

The objectives of this analysis are, during a LR event, assure that the peak primary and secondary pressures do not exceed 110% (respectively 2750 psia, 1397 psia) of their design limits during the transient, determine the amount of fuel failure and calculate mass release from secondary side used for doses calculation.

2. Analysis of Effects and Consequences

2.1 Input Parameters and Initial Conditions

The RETRAN computer code was used to calculate the maximum primary and secondary pressures. The results are compared with those from CESEC-III. For the fuel failure calculation in LR, the conservative inputs and assumptions were determined using UniCoRN-TM, coupled code of RETRAN, MASTER and TORC, computer codes. The UniCoRN-TM has been developed to implement the multi-dimensional kinetics model into the system and thermal hydraulic analysis code. In fact, in the case of vendor's method, the HERMITE-1D is used to estimate the DNBR and fuel failure due to the limitations of point kinetics model code, such as CESEC-III. So, the 1-D kinetics feature of UniCoRN-TM was applied to this study for the comparison with HERMITE-1D. The analysis was based on the Power Operating Limit (POL) conditions generated within an assumed 15% Required Over-Power Margin (ROPM). POL conditions were generated with a CETOP-D model.

The major parameter of concern of this study is the minimum hot channel DNBR. This parameter establishes whether a fuel design limit has been violated and thus whether fuel damage could be anticipated. Those factors which cause a decrease in local DNBR are:

a. Increasing coolant temperature
b. Decreasing coolant pressure
c. Increasing local heat flux (including radial and axial power distribution effects)
d. Decreasing coolant flow.

Table 1 presents initial conditions for this analysis. Initial core flow is 95% of nominal core flow and the initial core power is 102% of 2815 MWt in this analysis.

Table 1. Initial Conditions

POWER	2871.3 MWt
Tin	560 °F
Pressure	2325 psia
Core flow	112.7×10^6 lbm/hr

Trip time used in this analysis is the time at which hot leg flow rate decreases under the 80% of initial value. The hot leg flow fraction of 0.80 is reached at 0.14 sec. And the 1.2 sec of response time was also considered. It is assumed that at least 3 seconds delay exists from the time that reactor trip breakers open until the time that a Loss of Offsite Power occurs resulting in the coastdown of the remaining 3 pumps. The coastdown of the 3 remaining pump does not cause the DNBR to go below the already determined minimum DNBR.

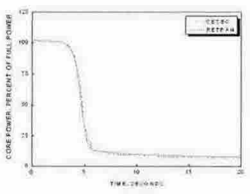
2.2 Results

The results of analysis performed to maximize primary and secondary pressure show that the peak pressures reach 2517.23 and 1290.4 psia, respectively. These values are less than 110% of design pressures, 2750 and 1397 psia., respectively. Figure 1 presents the comparison of results. The results using RETRAN are similar to those from CESEC-III. Table 2 shows the peak pressure comparison of the results using RETAN with CESEC-III.

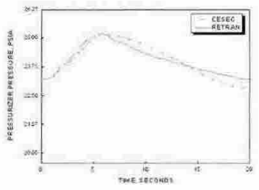
Table 2. RETRAN / CESEC-III Comparison of Peak Pressure

	RETRAN	CESEC-III
RCS Pressure	2517.23 psia	2519.08 psia
S/G Pressure	1290.41 psia	1315.67 psia

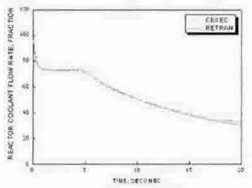
For the calculation of the minimum DNBRs during the transient, the CETOP-D code was used to guarantee the comparison.Figure 2. presents core power during transient. The core power from UniCoRN-TM is similar to the result from HERMITE-1D. However, in the case of DNBR, there were some differences in the values despite of the similar trends.



(a) Core Power

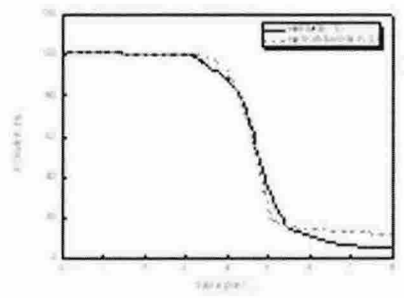


(b) RCS Pressure



(c) Core Flow

Figure 1. The Results of System Analysis for LR with RETRAN & CESEC-III



(a) Core Power

Figure 2. Core Power for LR with UniCoRN-TM and HERMITE

3. Conclusion

The results using RETRAN are similar to those from CESEC-III. The peak pressures of the primary and secondary systems during the transient are below the limiting criteria. And on the viewpoint of one-dimensional kinetics analysis, the results of UniCoRN-TM show the similar trends to those of HERMITE. So, it is concluded that the UniCoRN-TM would be used for further analysis hereafter.

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