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Interface of RETRAN/MASTER Code System for APR1400

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1. Introduction

MASTER(Multi-purpose Analyzer for Static and Transient Effects of Reactors), which was developed by KAERI, is a nuclear analysis and design code which can simulate the pressurized water reactor core or boiling water reactor core in 3-dimensional geometry.

RETRAN is a best-estimate code for transient analysis of Non-LOCA. RETRAN code generates neutron number density in core using point kinetics model which includes feedback reactivities and converts the neutron number density into reactor power. It is conventional that RETRAN code for power generation is roughly to extrapolate feedback reactivities which are provided by MASTER code only one time before transient analysis.

The purpose of this paper is to interface RETRAN code with MASTER code by real-time processing and to supply adequate feedback reactivities to RETRAN code. So, we develop interface code called MATRAN for real-time feedback reactivity processing. And for the application of MATRAN code, we compare the results of real-time MATRAN code with those of conventional RETRAN/MASTER code.

2. System Interface

2.1 Power Generation Model

The power generation model of RETRAN code[1,2] uses point kinetics and is shown below.

$$\frac{dN(t)}{dt} = \left(\frac{R(t)-1}{l^*}\right)N(t) + \sum_i \lambda_i C_i(t)(t)$$

$$\frac{dC_i(t)}{dt} = \frac{\beta_i N(t)}{\beta l^*} - \lambda_i C_i(t) \qquad \text{(Eq. 2-1)}$$

$$R(t) = R_0 + [R(t) - R(0)]_{explicit} + \sum_i [R_i(t) - R_i(0)] \qquad \text{(Eq. 2-2)}$$

Let

R_0 = initial reactivi
$R_{explicit}$ = explicit reactivity
R_i = feedback reactiv .

Neutron number density in Eq. 2-1 is affected by parameters related with delayed neutron and R(t). R(t) is composed of explicit reactivity function and feedback reactivity function in Eq. 2-2. The former includes effects from control system and the latter includes feedback reactivity effects from fuel and moderator change. In paper, moderator density reactivity among feedback effects is selected for real-time processing parameter supplied by reactor analysis code, MASTER code[2].

2.2 Interface RETRAN code with MASTER code

The system interface procedure between RETRAN code and MASTER code is below.

First, RETRAN code analyzes the system status until target time and generates reactor power and thermal-hydraulic parameters such as reactor inlet/outlet temperatures and flow rates. And MASTER code generates reactivity according to reactor power change using them. Then, RETRAN code using restart option replaces moderator density reactivity with new one and analyzes the transient system status for a time step. Last the same procedure is iterated for the next step.

Standard C language is used to interface RETRAN code with MASTER code and this interface program is called MATRAN. It has the ability of interfacing two codes and initiating and simulating a rod drop event during given time.

3. Results

The single rod drop test for APR1400 is performed using MATRAN. The results of MATRAN code are compared with those of conventional RETRAN code for system transient analysis. APR1400 core initial condition for simulation is shown in Table 3-1[4] and Table 3-2 shows moderator density coefficients from 104 second to 110 second. During a single rod drop test, MATRAN code runs 3 seconds later, because single rod is not inserted within 2.01 seconds and restart option of RETRAN code is not to reflect this control logic.

Table 3-1: Core Initial Condition for APR1400

Power	3983MWth
Reactor Inlet Temp.	291.11℃
Reactor Outlet Temp.	325.97℃
Single Rod Drop Time	101 (sec)
Start up Time for MATRAN	104 (sec)

Table 3-2: Density Reactivity coefficients of RETRAN code and MATRAN code

Time (sec)	RETRAN ($/(lb/ft3))	MATRAN ($/(lb/ft3))
104	2.2965	2.2965
105	2.2965	2.1832
106	2.2965	2.1933
107	2.2965	2.1991
108	2.2965	2.2007

109	2.2965	2.2014
110	2.2965	2.2024

Comparing the results of RETRAN code with those of MATRAN code in Fig. 3-1, the powers of MATRAN code is slightly greater than those of RETRAN code.

The result is caused by moderator density coefficients. RETRAN code, that is, uses constant moderator density coefficient between 3860 and 4000MWth. But MATRAN code uses variable moderator density coefficients every time step(1 second). In Table 3-2, the moderator coefficients used by MATRAN code is less than those of RETRAN code about 4~5%. This causes less negative reactivity to MATRAN code when power increases and moderator density decreases simultaneously. Therefore the power of MATRAN code is a little bigger than the that of RETRAN code. Fig. 3-2 shows reactor power in detail from 104 second to 120 second.

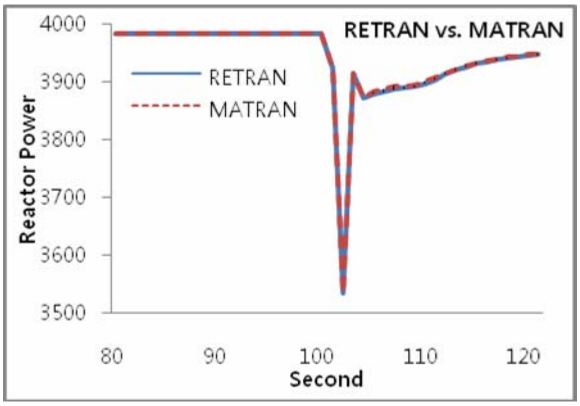

Fig. 3-1. Power change of single rod drop test for APR1400 from 80 second to 120 second.

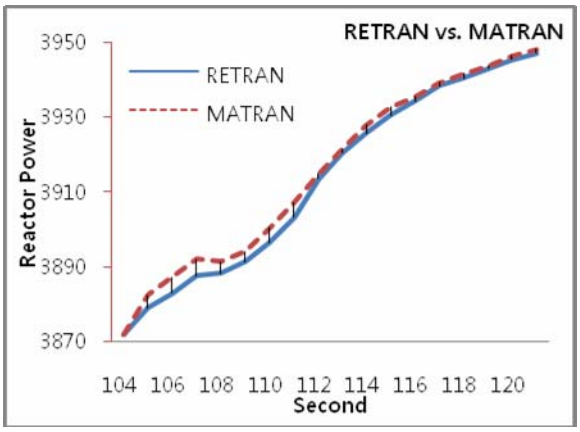

Fig. 3-2. Detail power change of single rod drop test for APR1400 from 104 second to 120 second.

4. Conclusions and Further Studies

The method of conventional power generation by RETRAN code which is composed of point kinetics model uses moderator density reactivities which are produced by extrapolating between rough moderator density bands. MATRAN code is developed to increase the accuracy of extrapolated moderator density data according to power change. From the comparison of the results of RETRAN code with those of MATRAN code, the difference of reactor power of RETRAN code and MATRAN code is within 0.2%. So, MATRAN code is suitable for interface RETRAN code with MASTER code. Using MATRAN code which is real-time feedback reactivity processing code, we get more optimum results such as reactor power.

The aim of this paper is to conduct a feasibility study for the application of MATRAN code. The final objective of ours is to calculate and review axial power distributions of variable power changes according to APR1400 RPCS(Reactor Power Cutback System) actuation using MATRAN code. So, in the near future, all feedback reactivity effects such as fuel temperature reactivity including moderator density reactivity are going to be compared by MATRAN code and the application of MATRAN code will be finally confirmed. Then, the evaluation of axial power distribution will be performed using inherent RPCS logic for APR1400.

REFERENCE

[1] "RETRAN-3D : User's Manual", COMPUTER SIMULATION & ANALYSIS, INC, July 2001.
[2] "RETRAN-3D : Theory and Numerics", COMPUTER SIMULATION & ANALYSIS, INC, July 2001.
[3] "MASTER3.0 USER'S MANUAL", KAERI, March 2004.
[4] "APR1400 SSAR", KHNP.