The RETRAN Newsletter

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Development of a GUI-Based RETRAN Running Environment

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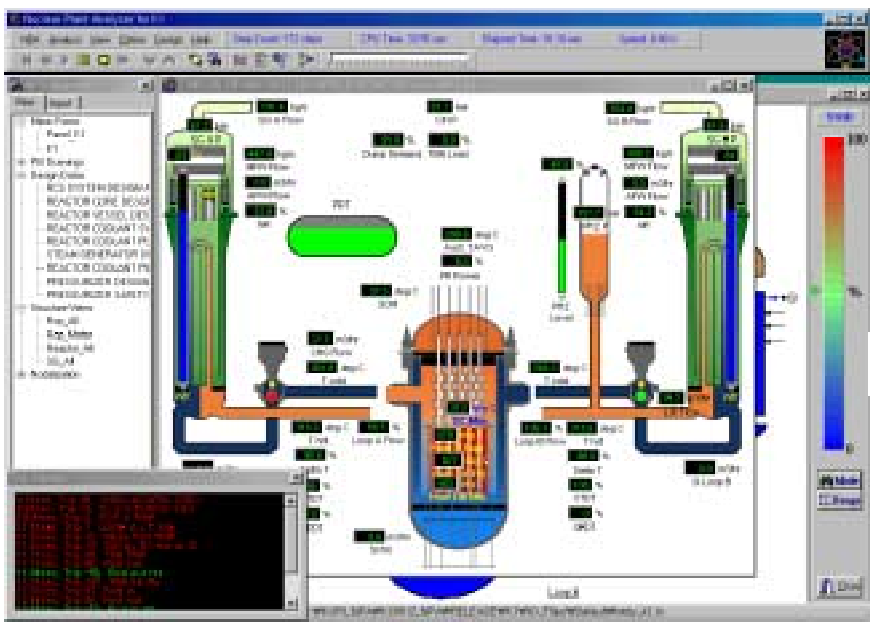


Fig. 1. An Example of the Plant Mimic

RETRAN can be used in various plant support activities such as licensing calculations for plant design changes, EOP validation, and training. Its utilization, however, has been limited to only a few groups of RETRAN specialists because of its complexity. In order to assist ordinary users in their input preparation, code execution, and output interpretation, KAERI and KEPCO have jointly developed a graphic user interface (GUI) based code running environment for RETRAN named RRE (RETRAN Running Environment).

The RRE was developed using Delphi 4.0 and Visual Fortran 6.0 and it runs on personal computers (Windows 95, 98, 2000, and NT). It loads RETRAN-3D at the time of execution that was generated as a dynamic link library (DLL).

The RRE provides dialog boxes for input data preparation and for graphical representation of the RETRAN results (Fig. 1). It also provides a replay function, on-line help, etc. The RRE takes two sets of basic input data: a normal RETRAN input deck and a graphic file containing plant mimics and/or a nodalization diagram.

Interactive Input Preparation Features

- <u>Control system edit window</u> - graphically shows the functional diagram of the control system cards in the base input, allows the user to modify the existing control system cards (Fig. 2), and also enables to add a new control system by a drag-and-drop of the equipped control functions (Fig. 3).

(continued on page 4)

Analysis of the OECD/NEA Power Rod Ejection Benchmark with CORETRAN and RETRAN-3D

H. Ferroukhi, P. Coddington, Paul Scherrer Institute

At PSI, the 3-D kinetic codes, CORETRAN and RETRAN-3D, are used to perform transient analyses of the Swiss LWRs. CORETRAN is used for full-core model applications, while RETRAN-3D is used for plant system analyses requiring 3-D kinetics. The boundary conditions for the RETRAN-3D analyses, e.g., the 3-D cross-sections, are generated using a steady-state CORETRAN depletion calculation.

3-D Kinetic Assessment

The first phase in the implementation of the 3-D kinetic codes was to set-up and to verify CORETRAN static models for the Swiss nuclear power plants. This work showed, in general, good agreement between CORETRAN plant data and other industry standard codes [1].

The second phase is to verify and assess the 3-D transient solutions of both codes. As a first step in this direction, the OECD/NEA LWR core transient benchmark problems [2] were chosen in order to compare the CORETRAN and RETRAN-3D results, for a given transient, with other 3-D solutions. Selected results from the full model, single control rod ejection cases at Hot-Zero-Power (HZP) and Full-Power (FP) are presented here. A more complete set is given in Reference 3.

OECD/NEA Benchmark

The benchmark core was derived from a realistic 2775 MW PWR reactor and consists of 157 fuel assemblies of 17x17 type. For all assemblies, the same geometrical and thermo-physical properties are defined. The axial representation consists of 16 nonhomogenous active fuel layers and two reflectors.

One objective with the CORETRAN/RETRAN-3D analyses was to follow as closely as possible the NEA specifications. Therefore, several code modifications were necessary. However, it was not possible during the framework of these analyses to modify the codes to take into account the cross-section dependency on moderator temperature specified by the benchmark. It is important to observe that because such dependency is lacking, the reference moderator temperature used in the preparation of the cross-section library will introduce a bias in the evaluated actual cross sections during a reactor calculation.

Because the X-S model in CORETRAN and RETRAN-3D could not be modified with regard to this dependency, two analyses were performed using two distinct X-S libraries. In the first (LIB-I), the core inlet temperature of 286 °C was used as the reference temperature, while in the second (LIB-II) the benchmark reference temperature of 306.6 °C was used.

Modeling

A 2x2 neutronic mesh was used to make the model as close as possible to that of the benchmark reference solution. In CORETRAN, each fuel assembly is modeled as an individual thermal-hydraulic channel while for RETRAN-3D the 157 assemblies are compacted (lumped) into 38 RETRAN hydraulic channel components.

The ARROTTA numerical solution was used because in both codes, the Purdue solution option would only work in the steady-state mode.

Steady-State Results

The steady-state results at both HZP and FP conditions are shown in Table 1. These results show that both codes are in close agreement with the reference solution (PANTHERS 2x2) and lie well within the range of the other benchmark codes (as indicated by the standard deviation in Table 1).

At HZP, a larger reference temperature than the core uniform temperature (LIB-II) gives a negative reactivity bias reflected by the lower critical boron concentration.

(continued on page 6)

RETRAN/VIPRE/CORETRAN User Group Meeting

G. C. Gose, CSA

RETRAN, VIPRE, and CORETRAN users gathered in Dallas to discuss the latest news and results during the October 2000 User Group Meeting. Hosted by TXU Energy in their main floor conference complex, the meeting allowed engineers and scientists to exchange ideas, trade recent technical information, and renew old friendships during the two-day event.

The Dallas meeting continued the tradition of strong international participation with representatives from Spain, Korea, and Taiwan attending. Eighteen representatives from U.S. Nuclear Analysis groups were present and two individuals that discussed the latest Westinghouse RETRAN and VIPRE activities were also at the meeting.

The first day was begun by a very positive and forward-looking presentation by Mr. James Kelley, Vice President of Nuclear Engineering and Support at TXU Energy. The remainder of the day was devoted to RETRAN maintenance and modeling issues and several detailed technical papers given. The RETRAN-3D code continues to provide expanded analysis capability beyond previous codes and several papers were presented to illustrate the new kinetics, air-water models and the five-equation methods.

During the second day, topics included the use of the VIPRE code to investigate the trends and problems associated with the axial offset anomaly problem. This issue deals with a complex interaction of water chemistry and core physics phenomena that ultimately result in a power distribution prediction problem and operational issues. The verification and validation of the CORETRAN fuel management options was discussed in detail.

From the Editor

Sitting in the back row of the recent RETRAN user group meeting, there seemed to be something different even from the first few minutes of the introductory session. First, there were the encouraging words from TXU's Vice President of Nuclear Engineering and Support, James Kelley, for his group and the rest of the RETRAN/VIPRE folks. It's been a while since we have heard encouragement about the things we are trying to accomplish. But there was more. It really didn't hit me until the flight home that there was a real sense of cooperation; people were helping each other out. This was especially true during the Q&A sessions after the presentations and during the breaks. A lot of useful information was exchanged.

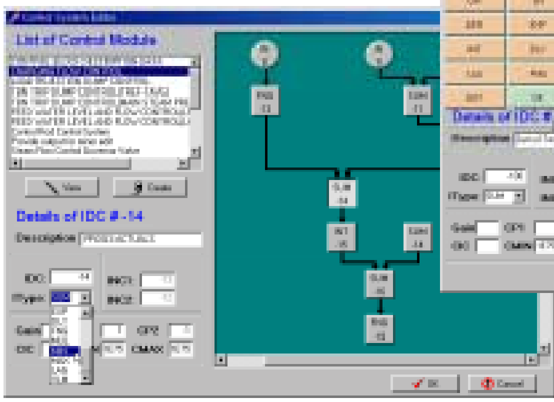
Nice job everybody and thanks to TXU for hosting the meeting.

This issue of the Newsletter features two great technical articles from our international colleagues. The combined efforts of KEPRI and KEPCO have resulted in a very interesting user interface for RETRAN. The application looks quite powerful and in the future may take RETRAN into the simulation area.

On another RETRAN-3D front, PSI has reported good comparisons between RETRAN-3D and CORETRAN for a PWR rod ejection benchmark case. This work adds to the overall code validation base. PSI has proven to be a leader in the application of CORETRAN to transient problems and their experience will prove to be valuable for all of us.

Thank you for your efforts.

Development of a GUI-Based RETRAN Running Environment (Cont'd)



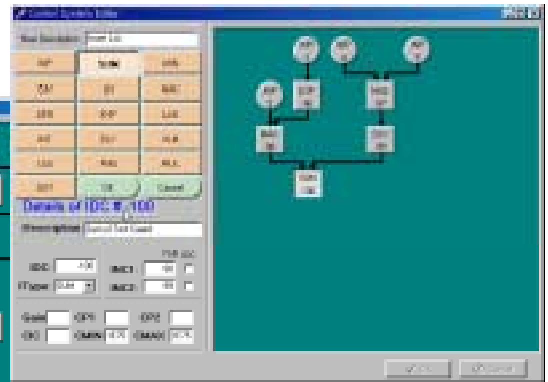


Fig. 3. Control System Creation

Fig. 2. Control System Modification

- **<u>Dialog box for trip cards</u>** - shows the list of trip cards existing in the base input deck and enables to modify the selected trip card information (Fig. 4).

- **<u>Input data for volume and junction cards</u>** - can be modified using the dialog boxes. Input cards for the component to be modified can be selected by just clicking the appropriate location in the nodalization drawing.

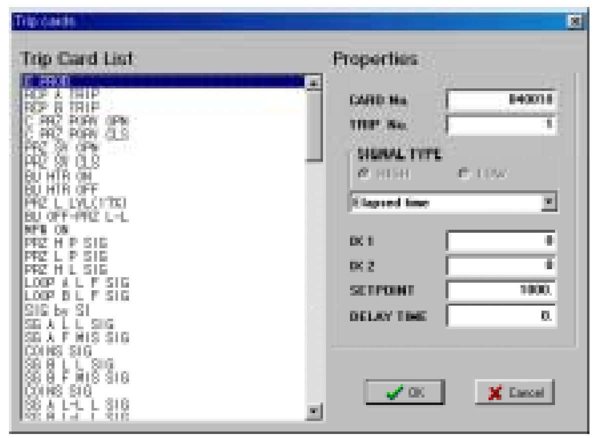


Fig. 4. Dialog Box for Trip Card Editing

Graphical Representation of the Output

- **<u>Plant mimic</u>** - shows major parameters through some selected indicators (Fig. 1). The RRE provides various types of indicators (Figs. 5 and 6), such as digital meters, level gauges, dial meters, LED indicator, and etc., which can be added into the plant mimic by drag-and-drop operations. The added indicators can be mapped with the specific output using the dialog box.

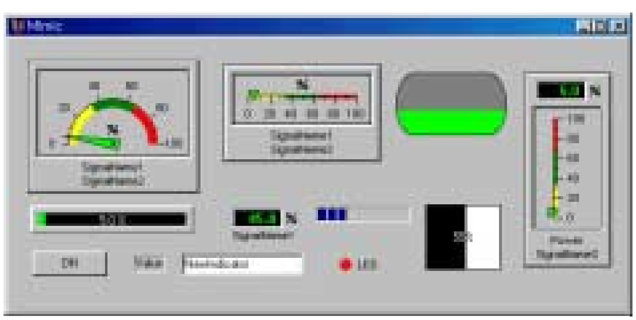


Fig. 5. Indicators Available in the RRA

Fig. 6. Dialog Box for Indicator Editing

Development of a GUI-Based RETRAN Running Environment (Cont'd)

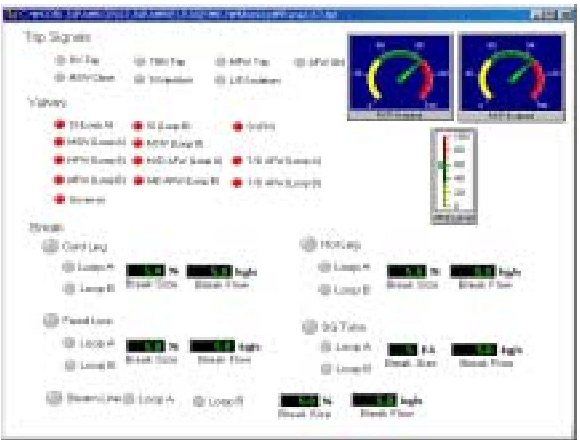


Fig. 7. Panel Window

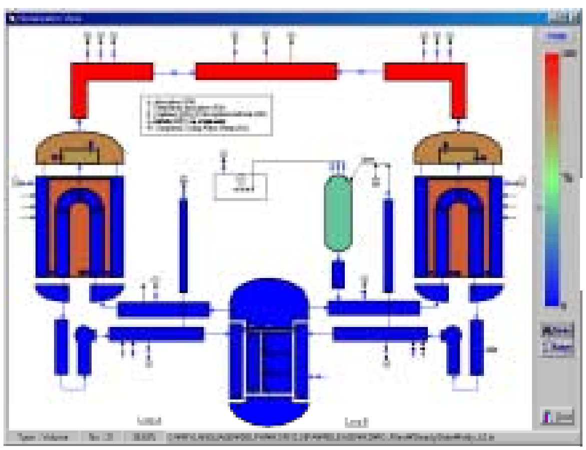


Fig. 8. Nodalization Window

- **Panel mimic** - shows the trip information, valve positions using LED indicators, and break flows and sizes through digital meters (Fig. 7). The panel mimic is established by drag-and-drop operations of menu items. The user can also create an additional mimic.

- **Trip window** - shows trip times and descriptions for each trip occurrence (the left bottom of Fig. 1). The scroll bar makes it possible to examine the previous trip occurrences during the transient.

- **Nodalization window** - shows void and temperature distributions in a color spectrum (Fig. 8). Users can see the exact value from the status bar by selecting the location. Each volume and junction can be interactively mapped using the base input.

- **Trend windows** - show on-line X-Y graphs for user-selected variables. The user can select major volume and junction properties and minor edit variables through the dialog box (Figs. 9 and 10).

Other Features

- RETRAN execution, pause, restart, and termination.
- Integrated information database: scanned P&I drawings, plant design data, structural views.
- Replay using pre-calculated results in fast/slow/real time modes.
- Target plant selection (RETRAN input, mimics, and other data base by changing the target plant through main menu).

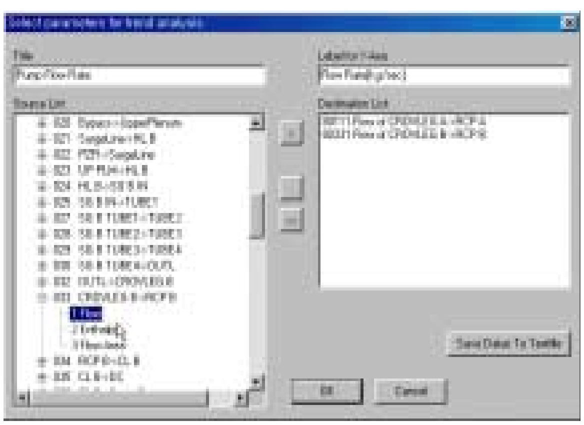


Fig. 9. Dialog Box for Graph Selection

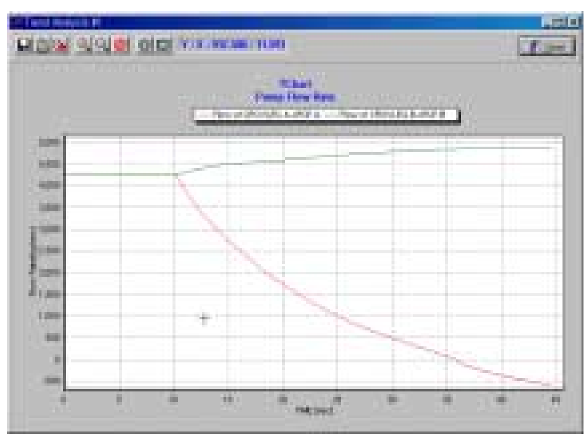


Fig. 10. Trend Graph

Analysis of the OECD/NEA Power Rod Ejection Benchmark with CORETRAN and RETRAN-3D (Cont'd)

Table 1	Critical Boron Concentration (ppm)		Max. Nodal Peaking Factor (-)		Static Rod Worth (pcm)	
	HZP	FP	HZP	FP	HZP	FP
Reference Solution ± Standard Deviation	1135.3 ± 17.02	1160.6 ± 27.9	2.187 ± 0.10	2.221 ± 0.18	958.0 ± 3.5	78.0 ± 1.6
CORETRAN (LIB-I/LIB-II)	1134.8/1128.4	1164.8/1159.4	2.188/2.189	2.230/2.230	956.9/967.9	80.0/80.6
RETRAN-3D (LIB-I/LIB-II)	1135.0/1128.6	1154.9/1149.6	2.188/2.189	2.230/2.232	957.3/968.1	79.2/79.6

At FP on the other hand, the LIB-II results are slightly better which is expected because of the increased core average temperature.

The 3-D power distributions were also compared with the benchmark reference solution and showed excellent agreement in both codes although slightly better with CORETRAN, which may be expected because of the more detailed core hydraulic representation.

Transient Results

The calculated power excursions for HZP/LIB-I are shown in Fig. 1, and the maximum pellet centerline temperature in Fig. 2.

As can be seen in Fig. 1, the power peak predicted by CORETRAN and RETRAN-3D is in excellent agreement with the reference solution. However, in both codes, it is noticed that the peak occurs earlier.

Fig. 2 shows that the energy released during the first second of the transient is very similar in CORETRAN, RETRAN-3D, and to that of the reference solution. After the first second, the energy release becomes slightly larger in CORETRAN.

Sensitivity Analyses

Along with this benchmark, several calculations were performed to investigate the

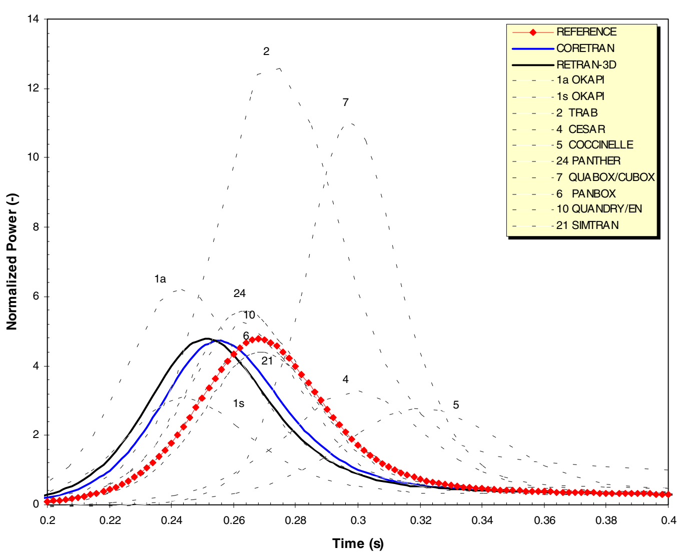


Fig. 1. HZP - Reactor Power

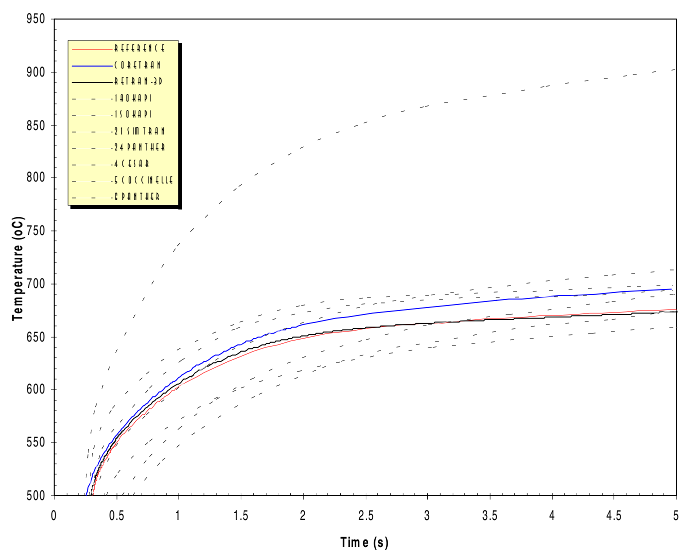


Fig. 2. HZP - Maximum Pellet Centerline Temperature

Analysis of the OECD/NEA Power Rod Ejection Benchmark with CORETRAN and RETRAN-3D (Cont'd)

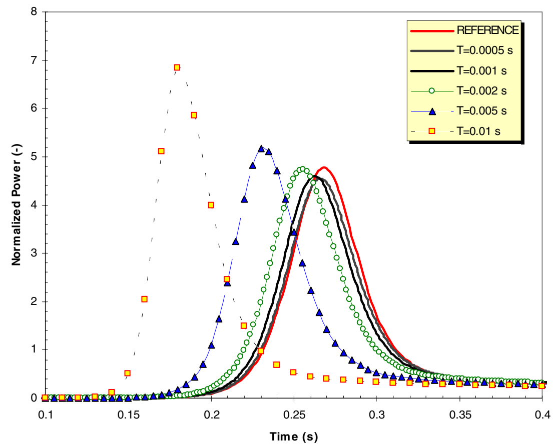


Fig. 3. Sensitivity Upon Time-Step Size at HZP (CORETRAN Results)

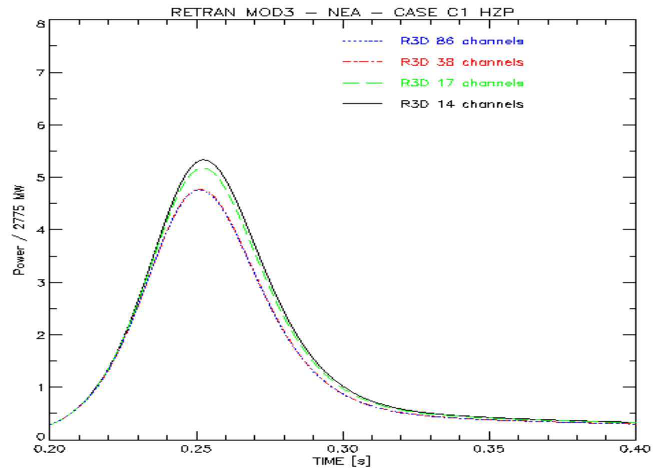


Fig. 4. RETRAN-3D Channel Lumping Sensitivity

sensitivity of both the steady-state and transient results to various modeling options.

A time-step sensitivity is shown in Fig. 3 for CORETRAN. In each calculation, a constant time-step was used. As can be seen, the sensitivity eventually disappears if a sufficiently small time step is selected.

Finally, the RETRAN-3D thermal-hydraulic channel lumping impact on the HZP results is shown in Fig. 4. The results are shown for 86, 38, 17, and 14 RETRAN-3D hydraulic channels. The 86-channel model makes use of the benchmark core symmetry and is therefore equivalent to a full-core model.

The results show no difference in the peak power for the full-core and the "standard" 38-channel model. The peak power increases by about 15% when the number of channels is reduced to 14.

Conclusions

The overall conclusion is that both codes give steady-state and transient results that lie well within the range of the benchmark solutions, with the CORETRAN and RETRAN-3D results being among the closest to the reference solution.

However, the lack of a moderator temperature dependency in the current X-S model of both codes represents a significant source of uncertainty. The choice of time-step is also found to be a major factor influencing the results.

The channel lumping in RETRAN-3D is found to have only a minor impact on the results if a sufficiently large number of thermal-hydraulic channels are selected around the ejected rod.

Finally, the good agreement between CORETRAN and RETRAN-3D provides confidence in using CORETRAN as a static interface code for RETRAN-3D and provides confidence in using RETRAN-3D (even with a lumped core model) for plant system transients.

References

1. H. Ferroukhi, P. Coddington, "Towards a Best-Estimate Steady-State and Transient Analysis Using the CORETRAN Code", ANS Best-Estimate Conf., Nov. 12-16, 2000, Washington, DC.

2. H. Finnemann, A. Galati, "NEACRP 3-D LWR Core Transient Benchmark – Final Specifications", OECD/NEACRP-L-335, Rev. 1.

3. H. Ferroukhi, P. Coddington, "Analysis of the OECD/NEA PWR Rod Ejection Benchmark with CORETRAN and RETRAN-3D", PSI Internal Report, October 2000.

Summary of RETRAN-02 Trouble Reports

The following is a summary of RETRAN-02 Trouble Report/Code Maintenance Activity as of October 31, 2000. There are five outstanding trouble reports. A list of trouble reports and the status can be obtained directly from the EPSC (1-800-763-3772). Additional information is available from the RETRAN-02 Trouble Report Page at http://www.csai.com/retran/r02trpt/index.html.

NO.	TROUBLE REPORT TYPE OF PROBLEM	CORRECTION NO.	IDENT	COMMENTS
354	Large Step Change in PHIR	***	*******	
376	Control Reactivity, No Motion	***	*******	
394	Anomalous Heat Trans. Behavior	***	*******	
408	OTSG Heat Transfer Problems	***	*******	
439	Decay Heat Input	408	MOD005P3	
440	Kinetic Energy/Time Dep Area	414	MOD005P3	
442	Poor Diagnostics	***	*******	
443	Liquid Region Work Term	411	MOD005P3	TH Manual Modification
444	Positive Slip Velocity	412	MOD005P3	
445	Boron Transport Inconsistency	409	MOD005P3	TH Manual Modification
446	Theory Manual Problem in Bubble Rise	---	-------	TH Manual Modification.
447	Smoothing Algorithm in SVOID	---	-------	Update Available
450	Momentum Flux Error Non Right Angles	410	MOD005P3	
451	Incorrect Condensation Switch	413	MOD005P3	

Generating Static Rod Worth Data

G. C. Gose, CSA

One of the more difficult things to determine when generating one-dimensional kinetics data is how good the model captures the correct physics behavior. An important figure of merit is the static rod worth curve. The one-dimensional model in RETRAN can capture the correct control rod effect in most cases, but how does one know?

A one-dimensional static rod worth curve can be generated in the following way. A series of RETRAN steady-state initialization runs can be made for different values of the control rod insertion depths. The steady-state eigenvalue will represent the conditions of the core, including the presence of control rods. Even though the RETRAN cross-section model is not affected by the initial thermal-hydraulic conditions in the RETRAN core, it is dependent on the initial control fractions as supplied by the RETRAN control system. So by changing the control block card (specified on the 315000 card) initial conditions to the desired insertion or withdrawal distance, a rod worth curve can be generated.

The accuracy of the rod curve is a function of the number of control states that are on the TAPE40 cross-section file. The current model allows five withdraw positions and five insert positions relative to the base case so one could have up to 11 distinct control states captured on the cross-section file.

Correction

The Tech Tip for May 2000, "Simulating a Second-Order Control System in RETRAN-02", contained an incorrect statement. In the example given it was stated that the unitary step occurred at four seconds. This should read that the unitary step occurred at one second. Thanks to Lou Frasson of Detroit Edison for helping out on this one.

Summary of RETRAN-3D Code Trouble Reports

A total of 226 trouble reports had been filed as of October 31, 2000. Of these, 188 reports have been resolved, while 38 remain unresolved. A summary of the unresolved trouble reports is shown below. Additional information for RETRAN-3D trouble reports is available at http://www.csai.com/retran/r3dtrpt/index.html.

NO.	TROUBLE REPORT TYPE OF PROBLEM	CORRECTION NO.	IDENT	COMMENTS
22	Problem using Wilson bubble rise model &	***	*******	
	error when using low power initialization		MOD001	(partial fix)
30	2-loop Oconee w/5-eq. fails in steady state	***	*******	
40	Results do not agree with data	***	*******	
48	Steady state fails after 6 iterations	***	*******	
		006	MOD001g	(partial fix)
52	MOC does not return to the initial temp.	***	*******	
54	MOC solution; no null transient for two-phase	***	*******	
60	Anomalous countercurrent flooding	***	*******	
70	Fails in subroutine DERIVS	***	*******	
81	Steady-state failure at iteration #6	***	*******	
116	Fails in steady-state initialization	***	*******	
122	Problems with EOS convergence	***	*******	(water packing)
142	Timestep selection causes 3-D kin to fail	***	*******	
144	TAUGL model doesn't apply for horiz. flow	***	*******	
145	SS fails to converge for low press. and flow	***	*******	
150	SS solution void fraction oscillation	***	*******	
152	Junct pressure lags vol pressure 1 time step	***	*******	Model limitation
164	3-D kinetics causes floating point exceptions	***	*******	
165	3-D kinetics unable to specify profile fit for subcooled boiling model	***	*******	
168	Incorrect null trans w/3d Kin. mod ht & 5eq	***	*******	
170	PARCS numerics will not hold a null transient	***	*******	
174	5-EQ error in steam lines	***	*******	
182	Kinetics problem type is fixed at 3	***	*******	Model limitation 3D kinetics
190	Error when reversing from/to junc. w/ angle	***	*******	
197	>1 geometry data set is supplied on the CDI	***	*******	
198	Momentum flux error – if junction angles are not 0, 90, 180, 270	***	*******	
200	SS failure for NCG (WAT0 error maybe WAT17)	***	*******	
201	SS failure when flow split option used	***	*******	
202	Error when pcrit reached during tran – 5-Eq	***	*******	
203	Pressurizer time step selectn when Przr solid	***	*******	
205	Channel model doesn’t allow dyn gap cond mdl	***	*******	
209	SLB sample problem using direct mod. heating	***	*******	
211	PC version of MOD003 gives different results	***	*******	
212	Possible errors in dynamic flow regime model	***	*******	
214	Freeze option freezes all feedback	***	*******	
222	Error in gen transport with iterative soln	***	*******	
223	Liquid mass & level not defined for time=0	***	*******	
224	Mom Eqn error when multiple jun connect to a volume	***	*******	
226	MOC error when flow reverses	***	*******	

About This Newsletter

RETRAN Maintenance Program

The RETRAN Maintenance Program is part of a program undertaken by EPRI to provide for the support of the software developed in the Nuclear Power Division. The main features of the Subscription Service include:

- the code maintenance activities for reporting and resolving possible code errors,
- providing information to users through the User Group Meetings and this newsletter, and
- preparing new versions of RETRAN.

The RETRAN Maintenance Program now has 26 organizations participating in the program, including 22 U.S. utilities and 4 organizations from outside of the U.S. A Steering Committee, composed of representatives from the participating organizations, advises EPRI on various activities including possible enhancements for the code and the scheduling of future code releases. Information regarding the Maintenance Program can be obtained from

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Palo Alto, CA 94303
lagee@epri.com or (650) 855-2106

Newsletter Contributions

The RETRAN Newsletter is published for members of the Subscription Service program. We want to use the newsletter as a means of communication, not only from EPRI to the code users, but also between code users. If this concept is to be successful, contributions are needed from the code users. The next newsletter is scheduled for February 2001 and we would like to include a brief summary of your RETRAN activities. Please provide your contribution to CSA, P. O. Box 51596, Idaho Falls, ID 83405, or to the E-mail addresses below by February 9, 2001. ***Contributors of a feature article will receive a RETRAN polo shirt.*** We are looking forward to hearing from all RETRAN licensees.

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The RETRAN Web Page is located at http://www.csai.com/retran/index.html.

Previous issues of the RETRAN Newsletter are available from the RETRAN Web Pages at http://www.csai.com/retran.

EPSC Contacts

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To Order EPSC Software: (800) 313-3774
EPSC Fax: (650) 855-1026
To Order RETRAN Products contact Colette Handy via email chandy@epri.com

Calendar of Events

October 7-10, 2001

10th International RETRAN Meeting
Jackson, Wyoming

Please supply us with technical tips for our Tech Tips section and you will receive a RETRAN mouse pad.

Your contributions are greatly appreciated. We, EPRI and CSA, encourage everyone to participate in this newsletter.