Project Highlights

for

March 1983

PROGRAM: A. SSC Development, Validation and Application (FIN No. A-3015)
B. CRBR Balance of Plant Modeling (FIN No. A-3041)

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This is the monthly highlights letter for (A), the Super System Code (SSC) Development, Validation and Application Program and (B) the CRBR Balance of Plant (BOP) Modeling Program for the month of March 1983. These programs are covered under the budget activity number 60-19-03-01.

A. SSC DEVELOPMENT, VALIDATION AND APPLICATION (J.G. Guppy)

The prime activity of this program is to provide independent licensing tools to simulate plant-wide transients in liquid metal fast breeder reactors (LMFBRs). A series of computer codes, denoted by the prefix SSC (Super System Code), is being developed. Versions of SSC presently under development include: 1) SSC-L for the simulation of transients in loop-type LMFBRs, 2) SSC-P for pool-type LMFBRs and 3) SSC-S for the simulation of long-term shutdown transients. The SSC Development, Validation and Application Program is currently focused to provide direct support to the on-going CRBRP licensing activities within NRC.

I. SSC-L Code (M. Khatib-Rahbar)

1. CRBRP Accident Analysis

- Natural Circulation Transient (J.G. Guppy)

The emphasis on this event has now shifted to assessing the conservatisms (and their sensitivities) used by the project. A series of computer runs is now being developed based on a proposed work plan to address these issues.

- Pipe Break Analysis (J.G. Guppy)

The new pipe break data decks, which incorporate additional information obtained from the CRBR Project, are being developed for SSC. The Project's case 3 (break at the top of the downcomer at the IHX inlet) is currently being focused on.

2. Intra-Assembly Flow Redistribution (M. Khatib-Rahbar, E. G. Cazzoli)

Calculations for intra-assembly heat conduction effects on flow redistribution in a subassembly are now under consideration.

II. SSC-P Code (E.G. Cazzoli)

1. Code Maintenance (E.G. Cazzoli)

The pool version of SSC is under review and is being modified to the latest cycle of the program library, in order to take advantage of recent improvements in SSC-L. In order to establish that the revision is performed consistently, we plan to analyze plant test transients for the Phenix reactor, simulated previously, and compare results.

III. SSC-S Code (B. C. Chan)

1. Improved Upper Plenum Modeling (B.C. Chan)

We are now in the process of testing the limited scope, improved model of the upper plenum representation to be incorporated into SSC. Cases are being conducted on the stand-alone version of this model using straightforward problems for which the solutions are known "a priori", either through an analytical solution or through results obtained using other computer codes. Our current focus is on the momentum equation, and we are looking at the flow fields in isothermic problems.

In one such test case, a viscous fluid in a driven square cavity was represented using a 5 x 5 constant cell spacing (Cartesian coordinates). The fluid motion is driven by one of the bounding walls, which is placed in motion, parallel to its initial position (it effectively has infinite length). Calculations began with the fluid at rest, and converged to a steady state in 0.076 seconds of CDC-7600 CPU time. The calculated flow field agrees well with a flow field solution from the SOLA code, reported by Los Alamos (LA-5852).

In another test case, the flow field for an inviscid fluid flowing around a cylindrical can was calculated. Cylindrical coordinates were used for this calculation, with the can occupying 5 x 10 cells of the total 20 x 40 representation. The initial flow field was assumed to be uniform in the axial direction of the can. Approximately 6 seconds of CDC-7600 CPU time were needed for convergence on the flow field, with the increased computational requirement resulting largely from the increased nodalization. In this case, the SOLA calculations were reported with limited detail. However, the flow patterns from the two calculations were clearly similar, including a recirculation flow region generated downstream of the can.

At this stage, it appears that our upper plenum model is correctly simulating flow fields for isothermic conditions. We plan to begin testing the model for non-isothermic problems shortly. It should be noted that these studies on simpler problems are necessary to validate the model for future use in our simulations of system wide transient behavior.

IV. SSC Validation (W.C. Horak)

1. EBR-II Data Deck (W.C. Horak, R.J. Kennett)

Information was obtained during this month on a proposed generic core power and flow map to be used for pre-test predictions of the upcoming natural circulation tests. This information has been reworked into a data deck, which contains information on assembly type, location, power, and flow on an assembly by assembly basis. A computer program is now being prepared that will automatically process this data, returning information on the hot and average channel for each assembly type which will be used in the SSC analysis.

Detailed drawings of the assembly types used in EBR-II were also obtained from the Project. These drawings have been extremely useful in preparing input data for SSC, but several crucial parameters are still unknown. Therefore, additional contacts with the Project will be necessary.

2. FFTF Natural Circulation Transients (W.C. Horak, R.J. Kennett)

Efforts this month continued to center on resolving discrepancies between DEMO analysis, FFTF results, and SSC analysis. Careful examination of the input data showed some small differences in the fluid temperatures which are now being changed to obtain a better match.

B. CRBR BALANCE OF PLANT MODELING (J.G. Guppy)

The CRBR Balance of Plant (BOP) Modeling Program deals with the development of safety analysis tools for system simulation of nuclear power plants. It provides for the development and validation of models to represent and link together BOP components (e.g., steam generator components, feedwater heaters, turbine/generator, condensers) that are of direct application for the CRBRP, but at the same time are also generic to all types of nuclear power plants. This system transient analysis package is designated MINET to reflect the generality of the models and methods, which are based on a momentum integral network method.

1. Balance of Plant Modeling (G.J. Van Tuyle)

The fundamental improvements needed to represent the condensers and feedwater heaters are now in the stand-alone version of MINET, and await the completion of the input processor revisions before full scale testing can begin. We plan to begin incorporating the turbine model soon.

While there are a limited number of basic components in the balance of plant, there are quite a number of variations in individual component design, particularly for the heat exchangers. We will be adding a number of options to allow us to better represent U-tube heat exchangers, cross flow heat exchangers, and other common heat exchanger designs.

2. MINET Code Improvements (G.J. Van Tuyle, T.C. Nepsee)

The improvement in the pump head model, recently incorporated in the stand-alone MINET, has undergone limited testing. We are currently minimizing further code modifications until the revisions to the input processor can be completed and tested.

Input processor code revisions continued during this month. The major effort has been to develop an enhanced network representation method to handle multiple flow networks in generalized form. The following considerations were identified relevant to the design goals:

- CORRECTNESS - The method must correctly process all networks belonging to the generalized class for which it is to be applied. This implies that the class must be characterized in exact terms rather than just listing ad hoc examples of known network configurations.

- ERROR RECOVERY - In order to be of any practical use, the method must provide for identification of and recovery from user-generated input data errors at the global level. Incomplete, inconsistent, and inappropriate specifications must be identified when they occur and informative diagnostic messages must be issued to facilitate correction of the errors.

- EFFICIENCY - Code and data size efficiency is somewhat more important than execution time efficiency. Due to limited main memory size afforded by major classes of target computers, compactness of design is indicated.

An abstract design has been completed for the above. Overall implementation design and detailed code design have been started. Implementation and testing have been divided into three phases:

1. input data reading
2. network processing
3. computational data loading

Work is now progressing on the second phase.

3. MINET Standard Decks (G.J. Van Tuyle)

MINET standard decks C4 and C5 are the current standard decks for one- and two-loop analysis of CRBRP, using CY-41 of SSC/MINET. There are no standard decks for stand-alone MINET, as it continues to be in a developmental phase.

Standard deck E1, for the EBR-II steam generator system is under development, and will be documented in the near future. This deck is to be used in our effort to simulate test transient 8A, a coastdown to natural circulation from 36.3% power, performed in 1980.

4. MINET Applications (G.J. Van Tuyle)

The effort to simulate EBR-II test transient 8A is now in progress, using cycle 41 of SSC/MINET. A standard one-loop deck for CRBRP was used as a starting point, and portions of the input relevant to MINET were revised to represent the EBR-II steam generator system and part of the intermediate loop. A steady state was achieved in the MINET calculations, with the calculated conditions closely approximating the initial conditions for test 8A. Currently, the remaining portions of the input deck are being converted from representing Clinch River to a representation of EBR-II.

There are features in the design of the EBR-II steam generator system that make correct estimation of some of the transient boundary conditions somewhat difficult, particularly for the pre-test predictions. The problem is that there is little attempt to isolate the balance of plant during a transient (save for the turbine), which means the system really should be represented all the way to the condenser. To analyze such an extended representation requires the new models in the stand-alone version of MINET, which still need to be tested. Using the version of MINET currently interfaced with SSC, we will have to use the behavior from the test 8A transient to estimate the BOP influence at the boundaries of our representation, so that we can proceed with the pre-test predictions.

5. <u>User Support</u> (G.J. Van Tuyle, B. Schubert)

MINET is being used (with SSC) to represent a steam generator, in the German KNK II plant, that has a change in tube diameter approximately in the middle, i.e., half way along the flow path. As this novel design feature was not considered in designing the MINET heat exchanger model, this heat exchanger currently has to be represented by two adjoining heat exchangers. To make this approach acceptable for part load studies, we plan to force the area correction factors for the two units to be equal. In the longer term, we may incorporate an option allowing such a change in tube size through user input, depending on whether there will be further uses for such an option.

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