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WASHINGTON, D. C. 20555

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MEMORANDUM FOR: Harold R. Denton, Director
Office of Nuclear Reactor Regulation

FROM: Saul Levine, Director
Office of Nuclear Regulatory Research

SUBJECT: RESEARCH INFORMATION LETTER NO. 43: THE SUPER SYSTEM CODE, A COMPUTER PROGRAM FOR DYNAMIC SIMULATION OF LMFBR POWER PLANTS

43

This Research Information Letter transmits information on the availability and use of the loop version of the Super Systems Code (SSC-L) that has been completed at Brookhaven National Laboratory. The code is specifically directed to the analysis of the adequacy of natural circulation in sodium-cooled reactors to prevent clad melting. The code also has the capability to analyze normal operating transients and less severe accidents that do not breach the integrity of the system or fuel.

Introduction

Development of the Super Systems Code was initiated at Brookhaven National Laboratory in FY 1976. The initial objective of the program was to develop an independent analytical tool to assess the consequences of malfunctions in the heat transport systems of a loop type LMFBR. The methods were required to have the capabilities to analyze (1) the pipe rupture accident and (2) loss of forced circulation. Other potential accidents can also be addressed with the codes. For example, the temperature of a component or a pipe could be determined under an assumed operating mode as input to a creep-stress analysis. The simulation can be run without the plant protection and control system or with various assumptions concerning the behavior of the protection and control systems.

Results

The code is operational on the BNL-CDC-7600 computer and can be operated through the NRC terminals at the Phillips and Willste Buildings. A workshop on model description and usage instructions for the SSC-L code was held at the BNL on April 5-6, 1978. The workshop was attended by 33 representatives from reactor vendors, National Laboratories, DOE and NRC. The NRC Fast Reactor Systems Code Review Group was well represented.

Several calculations of interest have been run with the code. A calculation of the effect of a 10¢ step reactivity on the CRBR plant was made with SSC-L and is compared with a similar calculation made by the University of Arizona in the enclosed report, "A Comparison Between SSC-L and BRENDA Systems Codes," K. E. St. John, et. al. BNL-NUREG-25099, October 1978. There is a slight offset between the response curves from the two codes caused by differences in initial conditions, but in general the agreement is good.

Another set of results is given in the enclosed report "SSC-L Simulation of System Transient in CRBRP," by J. G. Guppy and A. K. Agrawal, November 1978. In addition to giving results for the loss of forced cooling accident, this report, which is an expansion of a paper given at the International Meeting on Nuclear Power Reactor Safety at Brussels, Belgium, October 16-19, 1978, gives a good description of the SSC-L code and its modeling. Two models were used in the calculations. One used 4 core channels and one set of plant loops. The other used 12 core channels and two sets of plant loops. Cases were run with and without redistribution of flow between channels in the multichannel core models. The conclusions of the study are summarized on page 34 of the report. The most significant conclusion is that without redistribution boiling would occur in the hot blanket channel. With redistribution, the margin to boiling is 50°K. A total of 5 channels (including a hot blanket and a hot core channel) gives an adequate representation of the core. Computer time required for the 12 channel/2-loop model is about twice that for a 4 channel/one-loop model. At BNL the time for the latter problem was 300 seconds CPU time for 300 seconds of real time.

Discussion

The SSC-L code has been written to allow the user to model any loop-type LMFBR power plant with the degree of detail that the user's computer and budget allow. The code is modular in structure so that the modeling of any of the plant components can be independently modified. All dimensioning is variable so that the problem can be structured to fit the computer available to the user. A self-initialization routine automatically establishes a steady-state plant condition to comply with an arbitrary input parameter configuration before insertion of the transient to be analyzed. The numerical time integrations are accomplished with a multi-step scheme whereby different time steps are used for the various components in the system. Slow moving component models can be integrated using relatively long time steps (0.5 sec) while other components may require short (millisecond) time steps. With the usual common time step integration method all components of the calculation would be advanced with a timestep dictated by the smallest allowed step size in the system. The use of the multi-step scheme reduces computing time by a factor of about five.

The limitations of SSC-L derive largely from the assumption that one dimensional flow paths are adequate for the description of the system. The code does allow for a multichannel treatment in the core which allows flow redistribution. This resolves a serious problem with some of the vendor codes. There are three-dimensional flow effects that cannot be handled properly with SSC-L without empirical corrections. Examples of these are: flow stratification and flow reversal in long horizontal pipe runs during coastdown, and flow stratification in plena or mixing tees. As part of the validation program, these problems will be investigated either experimentally or with the ANL COMMIX code and empirical corrections made.

The physical models for various processes and components in the code are described in an enclosed report "An Advanced Thermohydraulic Simulation Code for Transients in LMFBRs (SSC-L Code)," by A. K. Agrawal, et. al., BNL-NUREG-50773, February 1978. A complete description of the code structure and the details of input preparation are given in the enclosed report "User's Manual for the SSC-L Code," by A. K. Agrawal, et. al., NUREG/CR-0452.

Future Work

A matrix of test cases which cover the range of operational transients to be expected in an LMFBR plant, and the accidents identified in the CRBR and FFTF Safety Analysis reports has been prepared. During FY 1979, this test matrix will be calculated. The test cases will be calculated with the Plant Protection and Control System (PCS) and with assumed malfunction of the PCS.

A version of the code to model pool-type reactors (SSC-P) is being developed. A working version should be completed in FY 1979. The EPRI Prototype Breeder Reactor will be the reference design for the code. A special version of the code (SSC-S) is being developed to handle long-term decay heat removal problems. The FY 1979 effort will be limited to code structure and numerics.

An input deck to model the FFTF reactor is being developed for SSC-L in FY 1979. As part of the validation program, the FFTF preoperational tests will be precalculated.

Users desiring to access the code on the BNL-CDC-7600 computer through terminals should contact Phillip M. Wood of the RES staff for copies of the users manual and necessary input decks and computer information. Users desiring to operate the code on other computers can obtain copies of the code and users manual from Dr. J. G. Guppy at BNL.

Saul Levine

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Office of Nuclear Regulatory Research

Enclosures:

1. K. E. St. John, A. K. Agrawal, and J. G. Guppy, "A Comparison Between SSC-L and BRENDA System Codes," BNL-NUREG-25099.

2. J. G. Guppy and A. K. Agrawal, "SSC-L Simulation of System Transients in CRBRP," BNL-NUREG-25100, November 1978.

3. A. K. Agrawal, et., al., "An Advanced Thermo-hydraulic Simulation Code for Transients in LMFBRs (SSC-L Code)," BNL-NUREG-50773, February 1978.

4. A. K. Agrawal, et. al., "Users Manual for the SSC-L Code," NUREG/CR-0452, November 1978.

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Original Signed by
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Saul Levine, Director
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1. K. E. St. John, A. K. Agrawal, and J. G. Guppy, "A Comparison Between SSC-L and BRENDA System Codes," BNL-NUREG-25099.

2. J. G. Guppy and A. K. Agrawal, "SSC-L Simulation of System Transients in CRBRP," BNL-NUREG-25100, November 1978.

3. A. K. Agrawal, et., al., "An Advanced Thermo-hydraulic Simulation Code for Transients in LMFBRs (SSC-L Code)," BNL-NUREG-50773, February 1978.

4. A. K. Agrawal, et. al., "Users Manual for the SSC-L Code," NUREG/CR-0452, November 1978.

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