BNL-NUREG-32858
Conf-830853--2

MINET: Transient Analysis of Fluid-Flow and Heat-Transfer Networks.

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BNL-NUREG--32858
DE83 011622

ABSTRACT

MINET, a computer code developed for the steady-state and transient analysis of fluid-flow and heat-transfer networks, is described. The code is based on a momentum integral network method, which offers significant computational advantages in the analysis of large systems, such as the balance of plant in a power-generating facility. MINET currently contains component models for pipes, pumps, valves, heat exchangers, and tanks or flow junctions, and is designed so as to facilitate coupling with another computer code.

An application is discussed in which MINET is coupled to the Super System Code (SSC), an advanced generic code for the transient analysis of loop-or pool-type LMFBR systems. In this application, the ability of the Clinch River Breeder Reactor Plant to operate in a natural circulation mode following an assumed loss of all electric power, was assessed. Results from the MINET portion of the calculations are compared against those generated independently by the Clinch River Project, using the DEMO code.

INTRODUCTION

MINET (Momentum Integral NETwork) is a computer code developed for the transient analysis of intricate fluid flow and heat transfer networks, such as those found in the balance of plant in power generating facilities. It can be utilized as a stand-alone code, or interfaced to another computer code for concurrent analysis. Through such coupling, a computer code currently limited by either the lack of required component models or poor computational speed can be extended to more fully represent the thermal hydraulic system, thereby reducing the need for estimating essential transient boundary conditions.

The MINET code, and the underlying numerical methods and models will be presented in this paper. A comparison of MINET analysis against results generated by the Clinch River Breeder Reactor Plant (CRBRP) Project [1] is provided. In this application MINET was used in conjunction with another systems code, the Super System Code (SSC) [2].

MOMENTUM INTEGRAL NETWORK METHOD

The method employed in the MINET code is a major extension of a momentum integral method developed by Meyer [3]. Meyer integrated the momentum equation over several linked nodes, called a segment, and used a segment average pressure, evaluated from the pressures at both ends. Nodal mass and energy conservation determined nodal flows and enthalpies, accounting for fluid compression and thermal expansion.

In MINET, a network structure was built around Meyer's momentum integral model for the flow segment. In this extended method, a system is represented using one or more flow networks, connected to one another only through heat exchangers. Each network is composed of segments, accumulators, and boundaries. Segments contain one or more pipes, pumps, heat exchangers and valves, each of which is represented using one or more nodes. Accumulators represent voluminous components and significant flow junctions. Accumulators and boundaries are connected by segments.

In systems which can be represented by MINET, heat exchangers are frequently shared by segments in two networks, with the flow from one segment passing through the tubes and the flow from the other passing on the outside. In order to decouple these segments during a transient time step, the tube temperatures are treated explicitly in the heat transfer calculations, and are not advanced until the end of the step.

With the segments and networks thus decoupled, MINET transient calculations proceed in a three step

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*Work performed under the auspices of the Nuclear Regulatory Commission.

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DISTRIBUTION OF THIS DOCUMENT IS UNLIMITED process, repeated for each network. The initial step is to march through the network segments, loading the segment matrix equation

$$\underline{A}_s \underline{x}_s = \underline{B}_s \underline{y}_s \quad , \qquad (1)$$

and solving for the segment response matrix, $\underline{B}_s'$ ($=\underline{A}_s^{-1} \underline{B}_s$). For a segment s with N_s nodes, $2N_s+2$ linearized equations are loaded, including N_s nodal mass conservation equations, a segment momentum equation, and a total of N_s+1 donor-cell differenced nodal energy equations and segment inlet enthalpy boundary conditions. Vector $\underline{x}_s$ contains nodal interface enthalpies and flows, and vector $\underline{y}_s$ includes changes in enthalpy and pressure in the modules the segment ends.

The second step is to march through the network accumulators, loading the network matrix equation

$$\underline{C}_n \underline{v}_n = \underline{D}_n \quad , \qquad (2)$$

and solving to advance accumulator enthalpies and pressures. For a network n with N_n accumulators, N_n conservation of mass and N_n conservation of energy equations are loaded. The terms for the mass and energy entering and exiting the accumulators are evaluated using the segment response matrices, $\underline{B}_s'$, thereby linking the accumulators.

The final step is to march through the network segments, using the solution from Eq. 2 to determine vector $\underline{y}_s$. The segment response matrix, $\underline{B}_s'$, is then multiplied by $\underline{y}_s$, and the nodal interface enthalpies and flows are advanced. After segment conditions are advanced in all networks, the heat exchanger tube temperatures are advanced.

Two features of the method account for the flexibility and speed of MINET. First, segment nodes connect only to immediately adjacent nodes, causing matrix $\underline{A}_s$ to be banded, except for the momentum equation. This allows the storage of matrix $\underline{A}_s$, and the solution of Eq. 1, in close-packed form, i.e., with large blocks of zeroes suppressed. Thus, the complexity of the flow network is absorbed entirely in Eq. 2, where the matrices are lower order. Second, because a segment average pressure is used, saturation properties are evaluated once per segment per step.

COMPONENT MODELS

While the momentum integral network method forms the basis for the MINET code, several component models, called "modules", are used to determine key parameters in the basic conservation equations. These parameters include the heating term in the energy equation and the pressure loss term in the momentum equation.

Segment Components

Segment components include pipes, pumps, heat exchangers, and valves. Each representative module contributes pressure "losses" to the segment momentum equation.

Pipes. Pipes are the simplest component to represent. Pressure losses due to friction, gravity, acceleration, and form (i.e., obstructions) are calculated. Module heating or cooling is user-input as a function of time.

Pumps. Pumps are essentially one node pipes with an additional pressure "loss" term due to the pump head. Coefficients for the pump head as a fourth order polynomial fitted function of the pump flow rate, at a reference pump speed, are input by the user. A family of curves is implied for all pump speeds, based on the assumption that the head varies with the square of the pump speed. The pump speed is presently determined in one of three ways: 1) a user-input value vs. time table, 2) a simple coastdown model, or 3) a control system calculation.

Valves. Valves are basically one node pipes, with an additional pressure loss term due to the drop across the valve opening. The user has the option of ignoring the possibility of critical flow at the valve orifice, or using critical flow models by Henry-Fauske or Moody to place an upper bound on the flow passing through the valve. If critical flow is anticipated, the valve must be isolated in a segment by itself, as the imposition of a local choked flow limit is in conflict with the segment integral momentum equation. The valve position can be: 1) user-input as a function of time, 2) calculated in response to pressure (safety/relief) or flow (check), or 3) determined by a control system calculation.

Heat Exchangers. Heat exchangers are treated as two pipes linked via heat transfer through the tube wall. The heat transfer from the tube to the fluid is calculated at each time step and used in the nodal energy equations. A fixed mesh nodalization is used, with any change in heat transfer regime within nodes factored into the nodal heat flux calculation, i.e., heat flux is piecewise averaged.

There are several heat exchanger designs in use, particularly if one includes the experimental units, which provide much of the transient data needed for code validation. A number of options are available in MINET, including co- and counter-flow; straight and helical tubes; and co-axial, square, and hex (triangular pitch) tube configurations. Another important design, the U-tube is being studied, and improvements will be incorporated to allow representation of these units.

Accumulators. Accumulator computational modules are used to represent voluminous system components, as well as locations in a network where pressure must be accurately monitored, e.g., significant flow junctions. For example, one would use one or more accumulators (connected by short, wide pipes) to represent a pressurizer or steam drum, or for a header between flow paths of unequal resistance. Currently, one can specify the geometry as a box shape, a vertical or horizontal drum, or a partial box or drum, as well as the operating conditions, i.e., whether the contents are distributed homogeneously or, if saturated, divided into liquid and vapor regions.

Boundaries. External interfaces to the MINET system representation are provided through the boundary modules. At each boundary, two conditions are required: 1) pressure or flow, and 2) temperature, enthalpy, or quality (if saturated). These are supplied by the user or by another computer code. Generally, the temperature parameter will be used in the MINET calculations only when flow is entering the system. The exception to this rule is that the user can fix the temperature at an outlet boundary during the steady state, provided that some heating source is available for adjustment by MINET. MINET will always calculate the unspecified flow/pressure parameter and the temperature of the flow exiting the system, save for the one exception where the temperature is fixed by the user. With regard to pressure and flow, the user must provide the pressure at outlet boundaries and the flow at inlet boundaries for the steady state calculations. There is no restriction as to which parameter is specified for the transient calculations. The steady state restriction may be relaxed in future versions of MINET.

Turbines. There is no turbine model currently in MINET, but one is planned for incorporation in the near future. It will be a static representation, and will link boundary modules, so that the flow conditions coming from the turbine can be updated using the flow conditions entering it.

CONSTITUTIVE RELATIONS

In addition to the basic MINET method and the supporting component models, various constitutive relations are needed for fluid properties and heat transfer. Currently MINET contains properties and correlations for water/steam, air, sodium, and eutectic NaK.

Because of the complexity introduced by phase changes, the package of functions for water and steam is the most extensive. The property functions are based on polynomial fits of the 1967 ASME steam tables. The heat transfer correlations include those for subcooled convection, subcooled nucleate boiling, forced convection vaporization, film boiling, superheated convection, and filmwise condensation.

Air is treated as an ideal gas, but the property functions are programmed to parallel the functions for water/steam. A heat transfer correlation for air crossing heated tubes is available in MINET, and other correlations can easily be added as they are needed.

Sodium and NaK are assumed to be subcooled, and in that state they are essentially incompressible. Both are treated as thermally expandable, i.e., the density changes with temperature. The property functions are programmed to parallel those for water/steam and air. Heat transfer correlations are available for both fluids, whether passing inside or outside of tubes. In principle, MINET could analyze boiling or superheating in either fluid, once appropriate properties and correlations have been added.

THE MINET CODE

The MINET code is relatively small and fast running, due to modular programming, careful data structuring, and an underlying numerical method that allows a large problem to be broken down into several small ones. In addition, steps have been taken to maximize the range of problems that can be analyzed, as well as the potential for concurrent analysis, i.e., with another computer code.

Data Structure

MINET is variably dimensioned, with nearly all of the principal data residing in a large "container" array. Pointers are defined for each variable, which indicate the position in the container array where the values for the variable are located. The contents of, and pointers for, the container array are carefully preserved throughout the calculations.

Most of the storage space used for calculations is accessed through data abstractions. The data abstraction package of functions manages a container array and the accessing of the array, through pointers similar to those used in the principal container. Through the data abstractions, MINET can create storage for a matrix equation, perform the matrix calculations, and de-allocate the storage space, so that it is available for other calculations. Thus, the data abstractions facilitate the efficient use and re-use of storage space, while masking the details of container management from high level MINET subroutines.

Input Processor

The MINET input processor reads in a deck of free-format input records, and temporarily stores the data using data abstractions. It then processes the data, linking the various components into segments and networks. The data is then organized according to computational module number, segment number, and network number, and loaded into the principal container.

Steady State Calculations

At the beginning of the steady state calculations, the system configuration, and component geometries and performance are known, as are the flow rates and temperatures at inlet boundaries and the pressures at outlet boundaries. The temperature at an outlet boundary is also known when it has been "fixed" by the user. In addition, the form loss factors for each segment component, the valve positions, the pump speeds, and the initial level in any accumulator with separated (saturated) contents are all known. The user's estimates of the energy transferred into or across (heat exchangers) components are treated as "known" if possible, but are subject to change if they contradict the boundary conditions. The user's estimates of the initial flows out of the accumulator ports and the network pressures are used only to initialize the iterative process.

The steady state calculation is a four step iterative process. First, energy transfer rates throughout the system are checked against boundary conditions, and any required changes will be made through energy adjustment factors. Second, the adjusted energy transfer rates will be used to determine segment, accumulator, and boundary enthalpies in each network. Third, pressure losses will be evaluated for every segment in each network, for current flows and enthalpies. During this step, the heat exchangers must be initialized, with an area correction factor used to resolve any discrepancies between the required energy transfer rate and that indicated by the heat transfer correlations. Fourth, the segment flow rates and accumulator and inlet boundary pressures are adjusted. At this point, if all the system enthalpies are not converged (from Step 2), the process is repeated, starting again at the first step.

Any adjustment factors for energy or heat transfer will be printed as part of the steady state calculations. Should any of these factors be significantly different than 1.0, the user is expected to review the input data for inconsistencies.

MINET Transient Calculations

The transient calculations are based on the momentum integral network method described earlier. Adjustment factors determined during the steady state calculations are applied consistently in the transient computations. Transients are driven by changes at the boundaries, via the pump speeds or valve positions, and through the heat sink term in non-heat exchanger modules. All of these parameters can be controlled through user-input value vs. time tables. Alternately, pumps can be tripped and coasted down and valves can be tripped open and closed in response to pressure (safety/relief) or flow (check). A compatible generic control system is planned, although not currently available.

MINET has consistently exhibited excellent computational speed. The MINET calculations for the complex 85 node network shown in Figure 1 required 357 seconds of CDC 7600 CPU time to simulate the first 600 seconds of the loss of electric power transient. Approximately 3500 words of storage were required for the principal container array, and somewhat less storage was required for the containers accessed through the data abstractions.

APPLICATION TO CRBRP TRANSIENT

The response of the Clinch River Breeder Reactor Plant (CRBRP) to a loss of electric power (LOEP) event, resulting in decay heat removal under natural circulation, is a major concern in the licensing process, as it bounds the severity of many other postulated events. The CRBRP Project has analyzed this event using the DEMO code, and reported their results for the first ten minutes of the transient [1]. The Super System Code (SSC) and MINET were used to analyze the event and assess the DEMO analysis, through a direct comparison of predicted results [5].

The DEMO code was developed by the CRBRP Project for the transient analysis of the Clinch River Plant. It is a code which utilizes several "conservative" assumptions in order to limit code size and complexity, and minimize execution time. In a past comparison of SSC/MINET vs. DEMO, the effects of some of these assumptions were identified and explored [6].

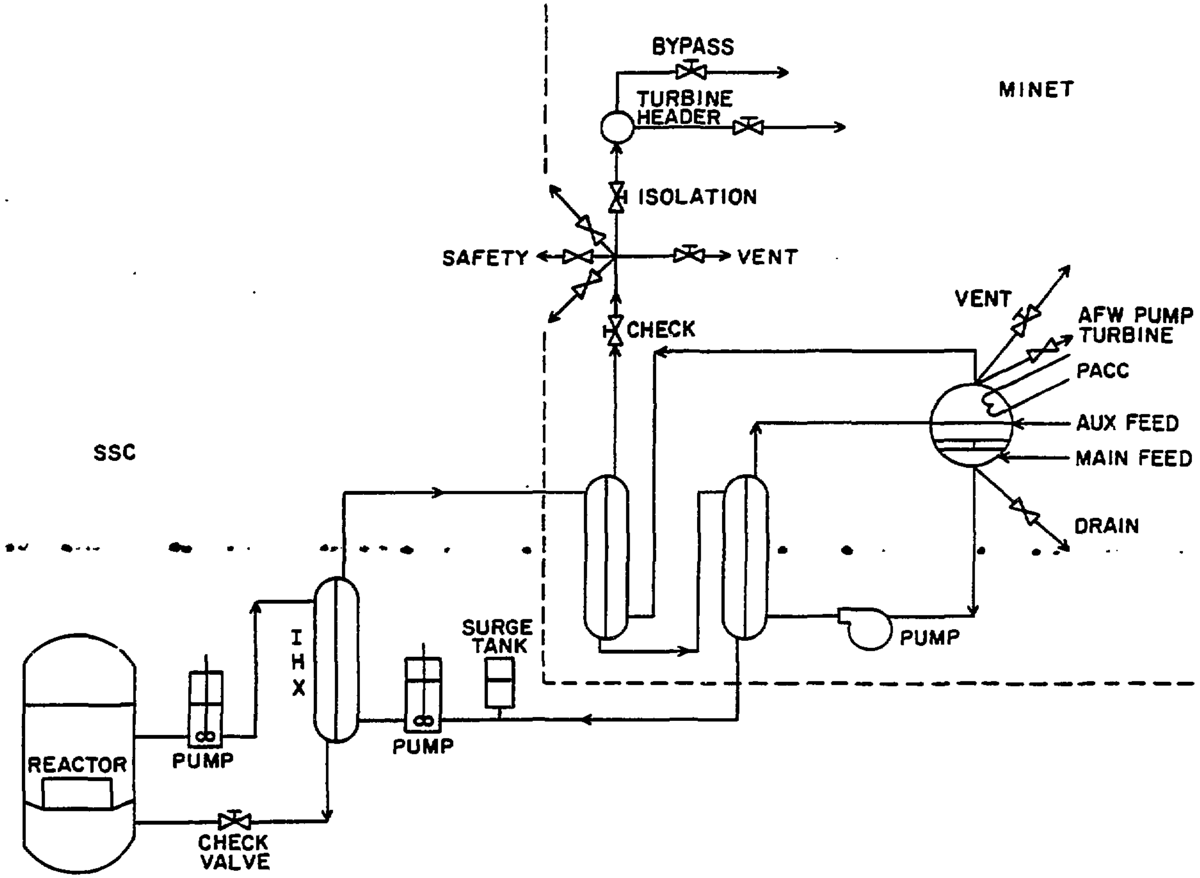

Fig. 1 Clinch River Breeder Reactor Plant (CRBRP) Representation Using SSC/MINET

SSC is an advanced, generic code for the transient analysis of loop- or pool-type LMFBR systems. It has been tested against plant transient data [7] and other computer codes [8,9], and is being used in the analysis of CRBRP, FFTF, EBR-II, the German SNR-300 plant, and the Japanese MONJU plant. The SSC portion of the representation extends well into the intermediate loop of an LMFBR, where it interfaces with the MINET code (see Figure 1), exchanging boundary conditions on the sodium side of the steam generators.

CRBRP Representation

The representation of CRBRP used for the SSC/MINET analysis is shown in Figure 1. SSC is used to represent the reactor, the primary loop, the intermediate heat exchanger (IHX), and much of the intermediate loop. During the steady state and throughout the transient, SSC provides MINET with the mass flow rate and temperature of the sodium approaching the superheater, and the sodium pressure near the evaporator outlet. MINET returns (to SSC) the calculated sodium flow and temperature near the evaporator outlet and sodium pressure near the superheater inlet.

MINET was used to analyze the remainder of the CRBRP system representation, i.e., the steam generator system and the portion of the intermediate loop near the steam generators. The steam drum was represented using two "volumes" and a short wide, connecting "pipe". The upper volume was divided into saturated liquid and vapor regions, reflecting the work of the steam separators. The smaller, lower volume contains a mixture of the main feedwater (normally subcooled) and the saturated fluid dropping down from the lower region of the upper volume. The auxiliary feedwater is added to the upper volume. Thus, when the main feedwater is shut off and the auxiliary feedwater is on, the contents of the lower volume will trend toward saturation conditions.

Several lines connect at or close to the steam drum. These include the entrance and exit of the Protected Air Cooled Condenser (PACC) loop, the piping to the steam generator auxiliary heat removal system (SGAHRS) steam drum vent valve, the steam drum drain line, and the line to the small turbine that drives one of the auxiliary feedwater pumps. The heat sink due to PACC loop operation is incorporated directly in the steam drum (upper volume) energy calculation, rather than explicitly as a loop. Lines to the vent valve, the AFW pump turbine, and the steam drum drain are represented as pipes with valves and outlet boundary conditions.

In addition to the steam drum, the representation includes the evaporators, the superheaters, the recirculation loop pumps, the main steam isolation valves, and the SGAHRS vent valves at the superheater outlet. Nodalization for the evaporator was selected at 15 nodes in order to adequately represent the considerable heat transfer that takes place in the uppermost part of the evaporator during the course of the transient. Six nodes were used in the superheater. The recirculation pump was represented using a simple pump-head relationship. Valves were represented using form loss pressure drop calculations, unless they vent to atmosphere, in which case, the choke flow limit was checked and the lower of the two resulting flow rates was used.

Plant Initial Conditions

Since one of the objectives was to conduct a direct inter-code comparison, initial conditions for the SSC/MINET calculations were set to match those from the DEMO analysis, even though these conditions were somewhat hotter than the expected plant conditions. Initial values from the SSC/MINET and DEMO analyses are given in Table 1.

TABLE 1

Initial Conditions In CRBRP LOEP Analysis,

SSC/MINET & DEMO

	SSC/MINET	DEMO
Intermediate Loop		
Mass Flow Rate (1 of 3 loops)	1610.25 kg/s	1610.25 kg/s
Superheater Inlet Temp*	787.3 K	783.76 K
Steam Generator System		
Steam Drum Pressure	12.61 MPa	12.68 MPa
Superheater Outlet Pressure	10.58 MPa	10.57 MPa
Superheater Outlet Temp	766.2 K	765.8 K
Steam Flow to Turbine	405 kg/s	404.5 kg/s
Re-Circ Loop Flow (per loop)	280 kg/s/	279.7 kg/s

*The difference in temperature traces to inconsistencies in DEMO initial conditions, as DEMO does not perform a true steady state calculation.

It should be pointed out that the conditions shown in Table 1 do not completely define the steady state, principally because the flow out the steam drum drain line is not stated in Ref. 1. By extrapolating from the 100% load conditions, the feedwater flow and temperature were set at 444 kg/sec and 492°K, respectively. While these feedwater conditions are not unique, they are probably representative of the ones used in the Project's analysis.

The initial level in the steam drum was not indicated in Ref. 1. Since the SGAHRS system initiates on a low steam drum level at 8 inches below the normal water level, i.e., 7 inches below drum centerline, the drum level was initialized at relative level 0.4028 (drum diameter = 6 feet), corresponding to this trip level.

Control System Actions

Of the various plant protection and control systems, only the steam generator auxiliary heat removal system (SGAHRS) controllers directly impact the MINET calculations during the first 10 minutes of the LOEP event. In the DEMO analysis, this system was activated almost immediately due to a low level in the drum. Therefore, in the MINET calculations, the SGAHRS system was also activated very quickly. The SGAHRS system rapidly closed the main steam isolation valves and the drum drain line valves. It opened the valve to the auxiliary feedwater (AFW) pump turbine, which is required to provide auxiliary feedwater. Vent valves, located off the steam drum and superheater outlet, were opened. Louvers were opened on the Protected Air Cooled Condensers (PACCs), increasing the heat removal capacity. Throughout the 10 minute period, the auxiliary feedwater flow, the vent valve positions, and the PACC heat removal capacity were controlled to keep the steam generator system pressure slightly under 10 MPa and the relative liquid level in the drum near a normalized setpoint value of 0.264, i.e., 17 inches below center line in the 6 foot diameter drum.

Transient Boundary Conditions

The transient begins with a loss of power to the pumps in the primary, intermediate, feedwater, and re-circulation loop (evaporator) pumps. The ensuing scram and other actions in the primary and intermediate loop are reflected in three parameters entering MINET at the SSC/MINET interfaces in the intermediate loop. The intermediate loop flow, shown in Figure 2, coasts down to natural circulation conditions at 2 minutes, and maintains a value near 80 kg/sec/loop for the rest of the ten minute interval. The temperature of the sodium entering the superheater holds constant for 5 minutes, then drifts upward (slightly). Because subcooled sodium is essentially incompressible, the pressure in the intermediate loop is of little significance to the MINET calculations.

Transient boundary conditions in the steam generator system are shown in Table 2. In this transient, the turbine throttle, turbine bypass, safety, and check valves have no real impact after the isolation valves are closed. The principal factors influencing the ultimate response for this transient are the vent valves, the auxiliary feedwater, and the steam used to drive the auxiliary feedwater pump turbine.

Table 2 Steam Generator System Transient Boundary Conditions

t	Event
0-1s	Turbine Throttle Valve Closes
0-1s	SGAHRS Vent Valves Open
0-3s	Main Feedwater Flow Drops to Zero
0-4s	Re-Circ Pump Speed Ramped Down to 0.0
2-5s	Steam Drum Drain Line Valves Closes
2-5s	Main Steam Isolation Valves Close
2-30s	Valves in Line to AFW Pump Turbine Opens
2-30s	Flow to AFW Pump Turbine Increases to 12.6 kg/sec
30-35s	Available AFW Flow Increases to 104.78 kg/sec
0-300s	Maximum PACC Capacity Raised from 6.75 MWt to 13.5 MWt

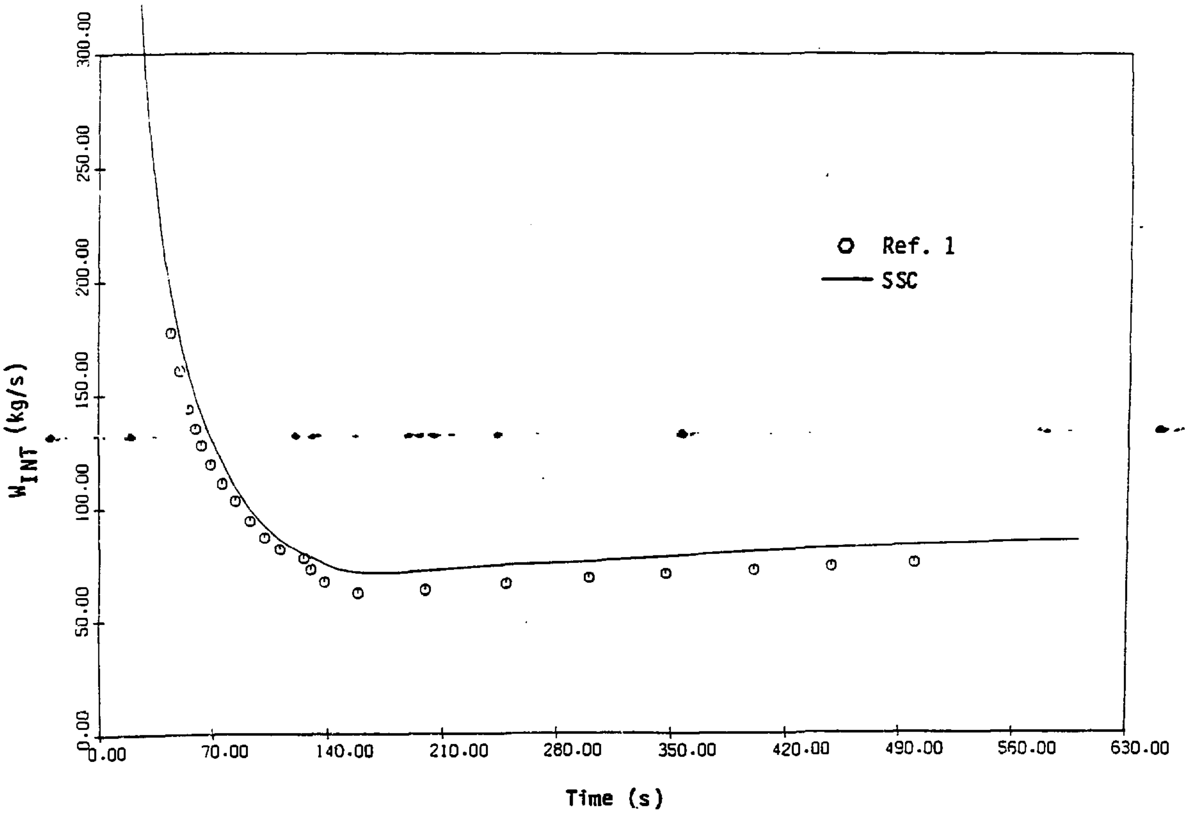

Fig. 2 Intermediate Loop Flow Rate

Transient Results

Results from the MINET portion of the transient calculations are shown in Figures 3 - 5. These plots are for the steam drum pressure, the auxiliary feedwater flow rate, and the temperature of the sodium exiting the evaporators. In all three plots, MINET results are compared with the DEMO results, taken from Ref. 1.

During the first minute of the transient, steam is vented through SGAHRS vent valves at the steam drum and superheater outlets, and is supplied to the AFW pump turbine. This venting of steam, without adding feedwater, reduces the drum pressure and relative liquid level. Because the recirculation flow rate increases relative to the intermediate loop flow, the thermal center moves upward in the evaporator, and the sodium outlet temperature decreases.

Near the end of the first minute, the drum liquid level drops to the point where auxiliary feedwater comes on. The drum pressure subsequently drops to levels where the vent valves at the steam drum and, later, the superheater outlets close.

During the 1 to 4 minute time period, cold auxiliary feedwater enters the steam drum, and steam is provided to the AFW pump turbine, but is not vented due to the low system pressure. During this period, the thermal front of saturated water, resulting from the cutoff of main feedwater, has been moving toward the evaporator and eventually begins to heat up the bottom of the evaporator, raising the evaporator outlet sodium temperature. Soon after the saturated water reaches the evaporator and begins changing phase, the system pressure starts to rise.

Approximately 4.5 minutes into the transient, the system pressure rises to the point where the vent valve at the superheater outlet opens once again. The evaporator is now receiving a steady stream of saturated water, and the evaporator outlet sodium temperature levels out.

During the final 5 minutes of the analysis, the steam generator system operates at a near equilibrium. Flow from the auxiliary feedwater system is regulated so as to maintain the drum level, and essentially makes up the inventory that is lost through the vent valves and the AFW pump turbine. The vent valve positions are controlled so as to maintain the system pressure. There is little change in the evaporator outlet sodium temperature.

In general, the agreement between the MINET and DEMO calculations is good. There are two areas of disagreement, one due to a modeling difference and another due to a different boundary condition.

The DEMO model of the re-circulation loop effectively suppresses the transport delay between the steam drum and evaporator (Ref. 6). Thus, when the main feedwater is cut off at the start of the transient, saturated water is transported immediately to the evaporator inlet. This effectively reduces the drop in the sodium outlet temperature, as shown in Figure 5. By contrast, in the MINET calculations, a time span of 220 seconds was required for the saturated conditions to prevail in the lower drum volume, and to move through the re-circulation loop to the evaporator inlet. Shortly thereafter the codes converge on the evaporator outlet sodium temperature.

The area of disagreement regarding a boundary condition concerns the flow to the AFW pump turbine, which was neglected in the DEMO calculations. Because the 12.6 kg/sec was correctly compensated for in the MINET calculations, the AFW flow is generally higher and the vent valve flow is lower. This also accounts for differences in drum pressure in the 1 to 4 minute period, during which DEMO models a nearly closed system while MINET correctly models the steam flow to the AFW pump turbine.

The limitations in the DEMO representation of the CRBRP steam generator system do not appear to have caused any serious misrepresentation of the plant response to the postulated LOEP event, at least during the first ten minutes of the transient. However, in evaluating the steam generator system response under varying postulated situations and events, the use of MINET has two clear advantages. First, MINET can represent the system in as little or much detail as is necessary for a given event. Second, a generic code such as MINET is fundamentally easier to validate than a system dependent code, particularly when the system has not yet been built.

Summary and Conclusions

The MINET code currently includes the network framework and many of the component models required to perform thermal hydraulic transient analysis of flow networks such as the balance of plant. Many fluid properties and heat transfer correlations are in place, and others can easily be added as they are needed. MINET can be utilized as a stand-alone code, or interfaced to another computer code for concurrent analysis. In this paper, the specific interfacing of MINET to the Super System Code (SSC), for LMFBR analysis, is discussed.

In a recent application, MINET, coupled to SSC, was used to analyze the steam generator system of the Clinch River Breeder Reactor Plant. Results were compared against those generated by the Clinch River Project, using the DEMO code. Disagreements in the generated results were traced to limiting assumptions in the DEMO representation of the postulated event.

The two principal advantages of the MINET code are its generic methods and models, and its run characteristics. Because of the computational advantages of the momentum integral network method, and the flexibility of the component models, a wide variety of systems can be represented by MINET. The excellent computational speed and limited storage space requirements facilitate concurrent analysis with other computer codes.

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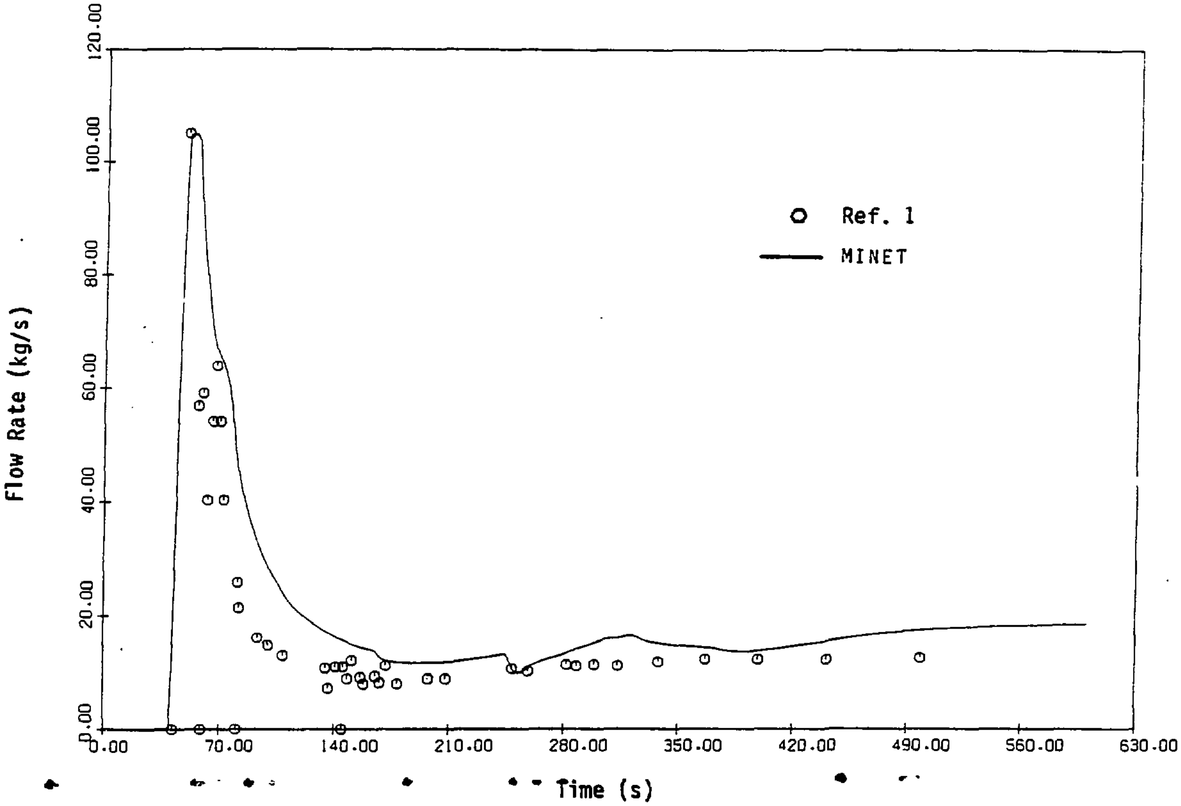

Fig. 3 Auxiliary Feedwater Flow Rate

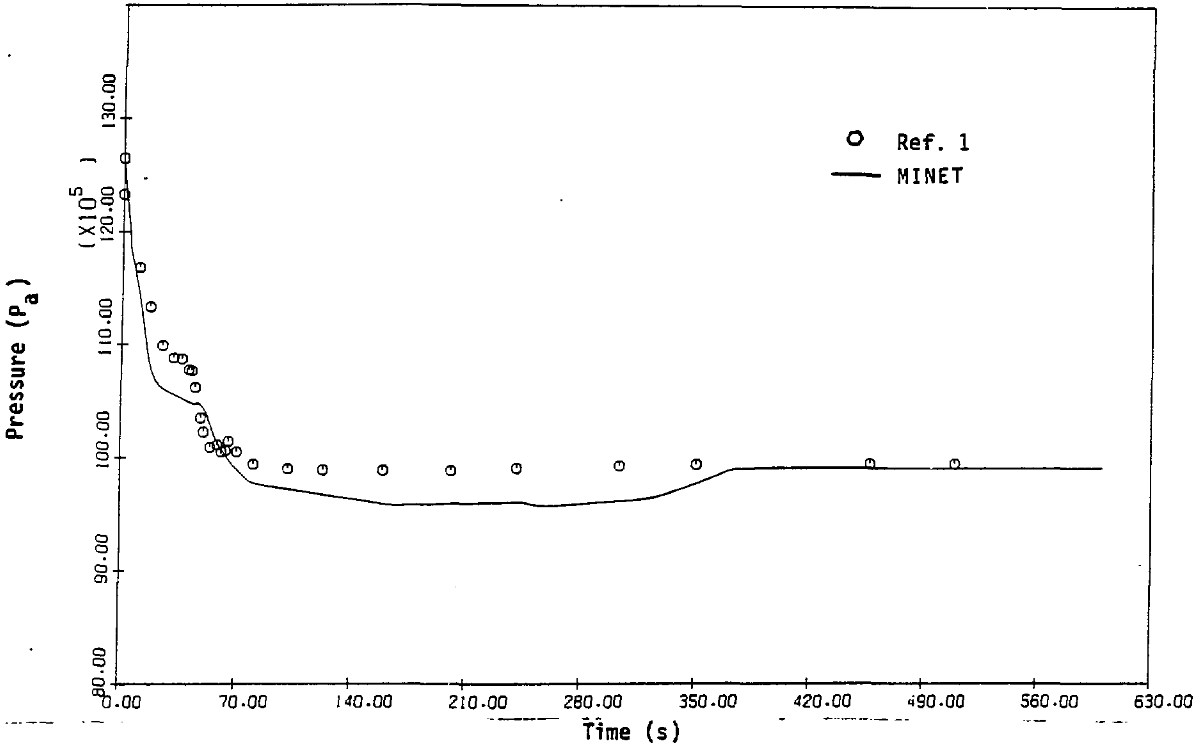

Fig. 4 Steam Drum Pressure

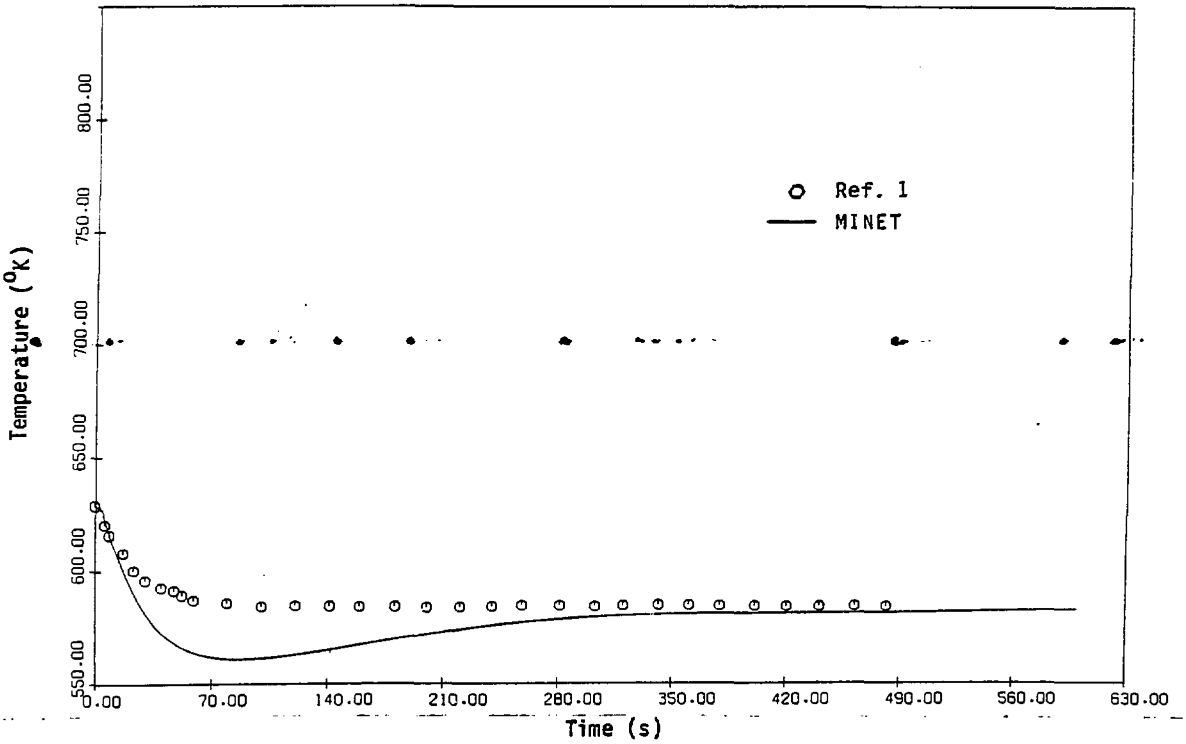

Fig. 5 Temperature of Sodium Exiting the Evaporators