MODULAR MODELING SYSTEM
MMS
B&W
Babcock & Wilcox

# B&W/MMS User Group Newsletter

**MMS: A COMPUTER PROGRAM DEVELOPED BY THE ELECTRIC POWER RESEARCH INSTITUTE**

September 1985 Vol. 1 No. 2

## The President's Corner

I have been pleased with the development of the B&W/MMS User Group over these first six months. It has been successful from both the support given by B&W to the users and the contributions made by the users in the form of suggestions for improvements.

Based on the concerns that we users expressed at the first User Group meeting, B&W will propose some modifications to the membership agreement. Phil Bartells will be reporting on these at our September meeting.

Another area where users have made a worthwhile suggestion is a User Group electronic bulletin board. Hemmat Safwat of Bechtel wrote a letter to B&W with some suggestions for several improvements including the use of the electronic bulletin board. B&W has now set up such a bulletin board and Phil will show us how to use it at the September meeting.

In July I represented the B&W/MMS User Group at a meeting between EPRI and B&W in Palo Alto. The purpose of this meeting was to review where B&W stood on the list of tasks they were required to do as part of their license agreement with EPRI. It appeared that B&W had accomplished all of the major tasks for EPRI with only a little more documentation to be done. It should be remembered that the EPRI list of tasks differs from the prioritized list we users put together at the past User Group meeting. We will be holding B&W responsible to our list.

The membership in the B&W/MMS User Group is growing. I would like to formally welcome the following organizations which have joined since the March User Group meeting:

- Cleveland Electric Illuminating
- Utah Power and Light
- Arizona Public Service
- Empresarios Agrupados, S.A.

As I see it, the more members we have in the User Group, the more interchange of MMS experience we can have and the more improvements to MMS can be made by B&W.

Charles Sayles
President

*August 29, 1985*

# EPRI Completes Development of Air/Gas Dynamics

The EPRI project to develop enhanced variations of the MMS fossil modules to simulate the pressure/flow dynamics on the air/gas side of the boiler modules is due to be completed in the early Fall of this year. These modules are intended to provide users the capability to simulate startup, shutdown, and operation of the draft and firing systems in fossil fired units. This capability is not available in the present version of MMS.

Module formation is firmly based on rigorous application of mass and energy conservation. Combustion analysis is based on the results of the EPRI DUCSYS code and 150 years of B&W boiler design experience. These modules will add the capability to analyze the draft and combustion control systems to the existing capability to analyze the feedwater system, steam system, and control loops to provide the capability for analysis of the entire plant system.

The new modules may be invoked instead of current modules AIRHX, DRUMFC, DRUMNC, ECON, OTBLR, PULV, REGHX, and SPRHTR. The new versions of these modules, AIRHXA, DRUMFA, DRUMNA, ECONA, OTBLRA, PULVA, REGHXA, and SPRHTA, will be supplemented by modules representing the combustion components (BURNER), connective modules (CONNA), dampers (DAMPER), dividers (DIVA), ducts (DUCTR, DUCTRS, and DUCTSR), axial fans (FANASR), centrifugal fans (FANCSR), junctions (JUNCA). These new modules, and the modifications of the existing modules, follow the same Resistive-Storage methodology upon which MMS is based. Upward compatability is assured by retention of the current, quasi-steady-state fossil modules without change.

**- LANCE SMITH**

# Steady-State Finder Evaluation Continues

Evaluation of alternatives to the current ACSL TRIM steady-state finder routine continue. Reports of problems with the TRIM routine are a familiar litany to experienced MMS users. Difficulties are particularly encountered as the size of the model approaches 50 states or more. Response to these problems has resulted in several analyses by EPRI, Mitchell & Gauthier, B&W, and Argonne National Laboratory (ANL) to identify the cause and provide a fix. Recent studies by B&W have analyzed the current TRIM routine and a developmental Mitchell & Gauthier routine. In a separate study, Dr. David Hetrick at the University of Arizona is applying another technique to steady-state finding for MMS models.

The current ACSL TRIM routine uses a Newton-Raphson technique to iteratively update the states in an attempt to reduce the square root of the sum of the squares of the derivatives below a threshold value. In order to apply the TRIM routine, which is based on solution of linear problems, to the highly non-linear MMS problems, the user is required to manually adjust a parameter which controls the fraction of the linear step taken at each iteration.

Under EPRI funding, Dr. Howard Geyer of ANL developed a hybrid technique which utilizes a combination of a Newton-Raphson and a Steepest Descent method. The Steepest Descent method calculates the direction and distance to update the states to minimize the square root of the sum of the squares of the derivatives. It is this calculation of the distance, which relieves the user of any manual adjustment of parameters, which present the major advantage of the technique. B&W tests of the hybrid technique suggest that it is no poorer than the current ACSL TRIM routine for large models and requires fewer User inputs for smaller models.

Mitchell & Gauthier are committed to incorporate a modified version of this steady-state finder in the next release of ACSL. B&W has also tested this version of the algorithm and made recommendations for its use. With these, it should be possible for MMS Users to utilize the hybrid technique or to fall back on an algorithm which is essentially identical to the current routine.

The B&W analysis indicates that many of the previous problems which have been assigned to the steady-state finder are, in fact, more accurately attributable to either the model or to peculiar characteristics of some MMS modules. B&W has been able to TRIM the 100+ state TMI turbine trip model to a steady-state with the current routine by essentially eliminating the pressurizer module states. An analysis suggests that the high non-linearities associated with the equilibrium/non-equilibrium transition present almost insurmountable obstacles to the steady-state finder. This analysis also suggests that even small model definition problems can completely incapacitate the steady-state finder. In the course of the study, B&W inadvertently applied the new ACSL technique to a 26-th order model which included a string of components with flowrate boundary conditions at both the upstream and downstream ends with non-identical flowrates as boundary conditions. The steady-state finder self destructed with few indications of the fundamental problem. A short integration of the model resulted in rapidly decreasing pressures in a specific portion of the model which resulted in the identification of the problem. Together with previous experience with models with small parameterization errors which prevented the

model from conserving mass or energy, this suggests that no steady-state finder is a good tool to use to bring an un-debugged model to steady-state. B&W's conclusion is that this is the cause of many of the previously reported problems with the TRIM function. This result is consistent with the limited success that some of the user community have had with the current routine.

Additionally, application of a still different routine is currently being analyzed at the University of Arizona. Under contract to B&W, Dr. David Hetrick is applying a pattern search routine to two MMS models supplied by B&W. Work to date is inconclusive, but has demonstrated that the technique, called INCON, can be applied to MMS models.

The search continues, but results now suggest that many of the problems reported previously may not have been completely attributable to the ACSL TRIM routine, but to inherent model problems resulting from either parameterization errors, inconsistent boundary conditions, or module formulation. It is clear that no steady-state finder can reasonably be expected to find a steady-state for a model which has no steady state. The best that can be asked of this routine is that it die gracefully and in a manner that suggests where the fundamental problem lies.

**- LANCE SMITH**

# Extended Range Features Implemented

The Extended Range Features consist of a set of modules which have been modified to provide additional capabilities. These modifications allow the modules to calculate system dynamics during conditions of:

- Low flow
- Reverse flow
- Two-phase flow

In implementing these capabilities, *the modeling approach* has been to provide a calculation mechanism that works simply and reliably rather than to provide a high degree of detail in the modeling. The primary objective was to permit calculation through a short, relatively unimportant excursion by a model into these regions.

The following lists the modules which have been modified to include the Extended Range Capabilities:

| | | |
|---|---|---|
| PIPER | CONN1 | AIRHX |
| PIPERS | CONNC | ECON |
| PIPERSR | RX1 | DRUMFC |
| PUMP | UTSGA | DRUMNC |
| VALVEC | UTSGE | OTBLR |
| VALVED | OTSGEM | FWHTR |
| VALVE1 | PUMP4Q | FLASH |
| JUNC | PZRB | CONDEN |
| DIV | SURJNC | SPRHTR |

The status of this development is that all modules have been modified and tested. Testing has included both single module tests and system tests. For the system tests, a fossil boiler model and a B&W nuclear system primary model were converted to use the modified modules. These models were tested to see that the modules produced the same results as the conventional modules in normal operation as well as testing the new features. The extended range modules are expected to be released as additional modules in the MMS library. Names will be modified for the new modules so that users may use both old and new versions of the modules. Interface modules are also being developed to connect conventional and extended range modules in the same model.

**- TOM WILSON**

# MMS-EASE+ Version 0.91 Released to Users

Version 0.91 of the MMS-EASE+ pre- and post-processor package was delivered to eight member organizations during July and August. This version has pre-processing for all the BOP modules, all the Fossil modules, and the following nuclear modules: MSRHT, PZRB, RX1, SURJNC, UTSGA and UTSGE. Pre-processing activities include model building using interactive graphics, on-screen forms for data entry and display, automated parameterization calculations, automated water property look-ups and automatic preparation of model files and command files. The model files may contain user-defined macros and/or FORTRAN subroutines, along with user-specified inline ACSL coding. The command file contains a user-customized PREPAR list that is generated as the modules are parameterized. Without exiting from MMS-EASE+, the user may call up any communications program for sending the model and command files to a mainframe. Post-processing activities involve extracting plot data from ACSL output files and generating plots using interactive graphics.

Additional features and modules will be added to the MMS-EASE+ system in future versions. Some of the additional features currently planned are:

- Capability for larger models by linking together multiple model "pages."
- Display of results on the model diagram. This function will display initial conditions and perhaps eventually be capable of displaying transient results (pressures, temperatures, etc.) on the appropriate flow stream.
- Linking with MMS/PC. See the article on MMS/PC for more details.
- A MMS-EASE+ report generator, which will provide the documentation for MMS-EASE+ developed models with minimal user action.
- A more user-friendly plotting package.
- Extended capability for pre-processing of controls-type modules.
- Optional high resolution color graphics capability.

**- ROSS SCHAACK**

# MMS/PC — A New Way to Run MMS

With the advent of the MMS-EASE+ pre- and post-processor and ACSL/PC, it is time to bring MMS to the PC. MMS/PC uses the same ACSL macros as the mainframe version, and (functionally) the same water properties routines. It requires the ACSL/PC translator, available from Mitchell and Gauthier Associates (MGA), and the Microsoft version 3.2 FORTRAN compiler. The current version of MMS/PC is limited to very small models (less than 20 states, unless only a few modules are used, then as many as 30 states), and it is not as accurate in its calculations as mainframe MMS. However, for small models, MMS/PC is probably a more efficient tool than mainframe MMS.

MMS/PC has a different sort of library from the mainframe MMS library. The macro coding is used as the MMS library, and a program supplied with the MMS/PC package is run to insert the required MMS modules into a copy of the model file. The library was handled in this way so that the limited amount of table space currently available in ACSL/PC could all be used for the user's model, rather than for modules that are not called.

MMS/PC can be linked to the MMS-EASE+ pre-processor so that the user does not have to exit from MMS-EASE+ to run his model. The translation and compilation process is fairly time-consuming (20 minutes for the deaerator level control study model), but the entire process can be done without user attention, so the user can be accomplishing other tasks while the PC is doing its processing.

ACSL/PC has all the commands and capabilities of mainframe ACSL, so the MMS user will be right at home with MMS/PC. Command files can be swapped between machines without modifications. Also, ACSL/PC can produce plots, giving the MMS/PC user another option for post-processing activities.

B&W has recently obtained the source code for ACSL/PC under a confidential arrangement with MGA. The next step is to attempt to modify ACSL/PC so that it can utilize all available memory in the PC for table space, thereby dramatically increasing the model size that can be translated. If all goes well, it is planned to offer this improved version of MMS/PC by the end of 1985.

**- ROSS SCHAACK**

# Gasification Combined Cycle Analysis May Improve MMS

EPRI has awarded Stone & Webster Engineering Corp. (SWEC) and B&W a contract to develop a modeling system for gasification/combined cycle processes.

In general, the GCC modeling approach will follow the MMS formats and technical approach. However, the wide range GCC applications impose some special requirements that the MMS approach does not easily accommodate:

1) The GCC models will be run on small computers in realtime for some applications as well as the traditional mainframe computer applications. MMS is not currently designed to run on small computers in realtime because of the numerical integration methods used.
2) GCC models are likely to be larger than typical MMS models thereby requiring substantial memory and table space for compilation. The MMS approach currently uses a large amount of table space. Therefore, the GCC approach must avoid unnecessary use of table space to allow substantial size models.
3) MMS was designed primarily for steam/water systems. The GCC models will contain over 15 chemical species which requires a modification to the MMS nomenclature.

To alleviate these limitations, the following modifications to the MMS approach are planned for the GCC modeling system:

1) The use of connective nodes for linking two resistive type modules in series will be eliminated. This will reduce the number of variable names in a given model and alleviate the numerical integration problem caused by connective nodes. This will be replaced by a "netnode" that will calculate an equivalent resistance of the resistive modules in series automatically.
2) Pressure calculations at flow splits and merges will be formulated to allow an integration step size of 1 second rather than the very small step size currently imposed by connective nodes.
3) The GCC module coding will use subroutines more extensively than currently used in MMS. This will substantially reduce computer memory requirements, and translation time required.
4) The MMS nomenclature will be modified to accommodate any number of chemical constituents. This will be done by using array variables instead of scalar variables. This approach also helps to reduce the table space requirements of the final model.

If successful, the above changes could be expected to be incorporated into the MMS-B&W at some later date. This would require approval by EPRI in order to take place.

**- LANCE SMITH**

**MMS User Group Newsletter**
**Editors: Phil Bartells (804) 385-2637**
**Paul Henningson (804) 385-2209**

Published quarterly by Babcock & Wilcox for the MMS User Group to report on current MMS developments and User Group activities.