B&W/MMS User Group Newsletter

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

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INTRODUCTORY COURSE HELD IN ENGLAND

A three day, introductory MMS course was held May 26-28 at Sussex University in Brighton, England. The course was organized by Rapid Data Limited (B&W's Western Europe sales representative for MMS) and the course instructor was "yours truly".

The eight course participants (see picture below) were from Belgium, Finland, France(2), Holland(2), Scotland, and Sweden. They represented one university, one utility, one simulator manufacturer, one research organization, and four suppliers of engineering services to the European utility community.

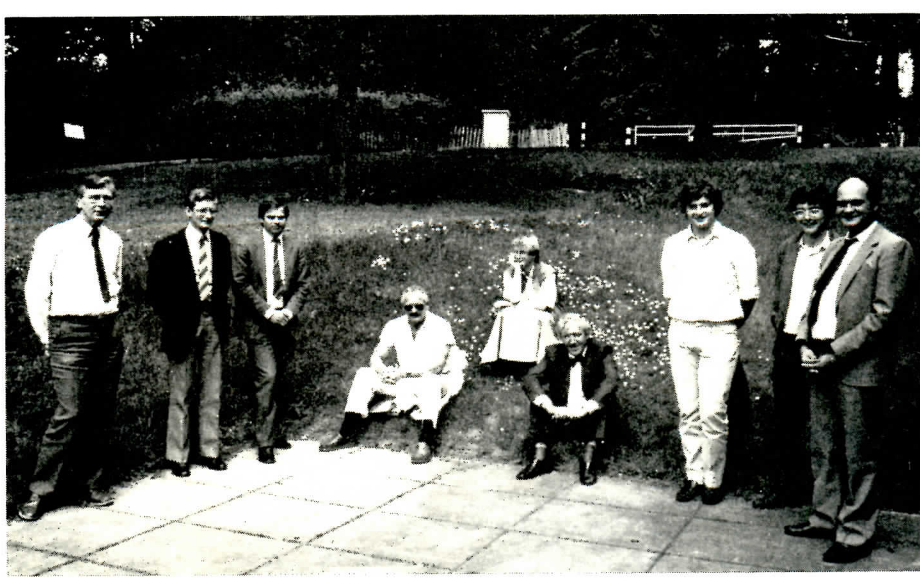
The course was structured to provide a comprehensive working level overview of the MMS, encompasing the methodology, the tools available for use, and practical examples of MMS applications. Both fossil and nuclear models were included in the instructions. Use was made of the MMS/PC Workstation for teaching, demonstration, and development (by the class) of a small MMS model.

To date, five of the participating organizations have requested a proposal for MMS trial evaluation. One of the five has already begun the evaluation process. The need for an SI-based version of MMS was stressed by the participants if the MMS is to be successfully utilized by the European energy supply community. As a result, B&W will develop a plan and present it at the September User Group meeting in Detroit.

The classroom facilities and equipment were donated by Sussex University and this was very much appreciated. The actual course went very well and the attendees kept the instructor "on his toes" with their excellent questions. All the attendees spoke English and were able to understand this Yankee-turned-Southerner.

All in all, the course was judged to be a success and we hope that it will lead, eventually, to a European MMS User Group being formed.

Phil Bartells
Babcock & Wilcox



PENN STATE DEVELOPING A REAL-TIME NUCLEAR POWER PLANT SIMULATOR USING MMS AND THE IBM ACS

The Advanced Control System (ACS) is a commercial product offered by IBM for process control and plant management in a medium to large scale process or industrial plant. The ACS uses a mainframe computer, such as a 4341 coupled with an IBM Series 1, for Input/Output processing and a software package for facilitating real-time plant process control. In university environments, the ACS software has become an effective means for implementing real-time simulations of a variety of chemical and industrial process plants. The Chemical Engineering departments at Purdue and the University of Waterloo (Canada) have pioneered the use of such ACS simulations in undergraduate education of process control since 1982.

The Nuclear Engineering department at the Pennsylvania State University has recently begun a program that will develop a real-time simulation of commercial nuclear power electrical generation stations, using an IBM 4341 with the ACS software. It is expected that successful implementation of such a simulator will herald a new era in university research of new nuclear plant concepts and study of advanced control systems including artificial intelligence and expert systems applications.

The ACS software is structured to permit an interface to a real-time data base from a user written FORTRAN program or external simulation language. Since the MMS provides modules of all major power plant components and runs within the ACSL simulation language, the combination is ideally suited for use with the ACS. Penn State will use B&W supplied MMS models of typical nuclear plant systems for use as a starting point in the development.

Recently, I attended the IBM Advanced Control System (ACS) User Group (ACSESS) meeting at Purdue University, in order to obtain a better understanding of requirements for bringing up MMS simulations in real time on the IBM ACS in the PSU Engineering Computer Lab (ECL). Prior to the meeting, our ECL ACS was exercised using the laboratory workbook for the Purdue Undergraduate Process Control course. The operational familiarity gained by following their workbook, in conjunction with the user group meeting, was very beneficial in understanding the next step in implementing our simulations in ACS. The meeting was attended by about 30 university personnel from 15 universities and about 15 IBM personnel. Penn State was the only Nuclear Engineering department represented and we are, undoubtedly, the only ones looking into using ACS for nuclear power plant simulations at present. An IBM representative mentioned ACS installations currently going forward at Kentucky, Notre Dame, Tulane, and Arizona. In order to get ACS installed, study agreements with IBM are the current approach being employed. For Arizona to get ACS, they are looking into non-chemical engineering applications (note: non-chemical includes Nuclear applications). At Notre Dame, they are going to look into Expert System applications using ACS. Kentucky is looking to provide industry support. At Penn State, our Chemical Engineering Department acquired ACS last fall and we are using that installation in our ECL without any specific study agreement with IBM. Our study of the ACS is sponsored by our FERMI (industry) affiliates group for the next year.

The most encouranging user presentation, that directly influences the speed at which we will be able to implement MMS simulations, was by a group from the Imperial College in London. They presented a new feature that allows FORTRAN simulations, such as our MMS, to be able to run in their native VM/CMS environment and communicate in real-time with the ACS software running under a different operating system (OSV1) on the same host computer. Their development interfaces their SPEEDUP simulation language through a software enhancement that they developed and named the Data Base Server. SPEEDUP seems quite similar to the ACSL based MMS system. Their Data Base Server software, or equivalent, will be required to efficiently interface our MMS to ACS. The purpose of the ACSESS User group is to share developments, and they stated their willingness to provide this software to other users. I requested that a copy be provided to Penn State. SPEEDUP was installed and demonstrated at Purdue during the few days before the meeting. During an hour demonstration on the last day of the meeting, they took a SPEEDUP simulation from translation to compilation to real-time interactive execution.

Another interesting application, being pursued at Imperial College, is to have on-line simulations running in parallel with the process plant. The goal is to be able to give plant operators the capability to ask "what-if" type questions of the simulator in order to help guide them in decision support of operations. With ACS operating the plant and the simulator, there is a direct means to initialize the simulator to plant data as well as having an exact duplication of the control system for the plant in the simulation. There is also a possibility of using the on-line simulation as a fault diagnostic tool in order to track expected performance versus actual performance, an anomaly detector. They discussed the possibility of both open loop feedback corrections passed through the operator and closed loop corrections using the on-line simulation.

A Notre Dame representative discussed

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their expected usage of the ACS involving Expert Systems applications. Their initial studies are concerned with "reasoning in time" for discreet event control methods. For example, turn on a pump until a tank is full and then turn it off. This control method is non-linear (on-off) and does not lend itself easily to evaluation of stability and operability by linear analysis methods, although they are manipulating the mathematics in that direction. He mentioned 3 approaches for evaluation of discreet event systems: temporal logic, event calculus, and minimax algebra. In temporal logic, they are adding new logic symbols to the traditional AND, OR, NOT and IMPLICATION logical operations that include a time element. They are adding HENCEFORTH, EVENTUALLY, AT NEXT INSTANT, and UNTIL. For example, HENCEFORTH starts(motor) implies that AT NEXT INSTANT high-(pressure). Another example: HENCEFORTH NOT (start(motor) AND open-(valve)). They are looking to use PROLOG to provide automated reasoning using these new logic operations. He also mentioned this area as involving DEEP REASONING and SYSTEM THEORETIC. He went on to discuss event calculus and minimax algebra. With minimax algebra, they manipulate the nonlinear discreet event system into something which can be evaluated with classical linear systems theory.

The father of university usage of ACS, Lowell Koppel, presented his current application area which he has developed since leaving Purdue a couple of years ago. He is still into ACS, but at a higher level than his work at the university. While at Purdue, he dealt with ACS applications at the process plant level. In industry, he is applying ACS at a higher level, involving the entire oil supply network, including pipelines, tanker shipments, and overall economics. There must be an analogy using ACS at higher levels in power plant operations where the analogous concerns are over the electrical distribution grid, pump storage, fuel supply, and economics. He also mentioned that the University of Florida is looking into using ACS for power utilization concerns at the campus level.

While waiting for our copy of the Data Base Server, some small simulations will be tried at the ECL in order to gain familarity with creating simulations in ACS. Simulations can be entered directly into ACS using the ACS general algorithm. Small MMS and ACSL simulations should be operable from the FORTRAN Slave partition of ACS; however, they will apparently be inefficient because the SLAVE partition program can only be directed to execute at a fixed frequency, which presently requires reloading from disk and resetting initial conditions and saving end results to disk files. However, it is understood that, between the reset of initial conditions and resaving to disk, real-time interaction with an operator can take place. Progress will be reported in future Newsletters. If anyone wants additional information, please contact me at (814) 865-1341 or leave a message on the MMS bulletin board.

Bob Edwards
Penn State

MMS USED TO SOLVE STEAM TEMPERATURE PROBLEM

INTRODUCTION - Niagara Mohawk Power Corporation (NMPC) contracted Stone & Webster Engineering Corporation (SWEC) to perform an engineering study of the superheater outlet steam temperature control for Oswego Steam Station, Units 5 and 6. NMPC identified the *problem* as being the steep temperature gradient in the finishing superheater outlet coupled with a high peak temperature occuring in the 0-100 MW range during start-up. SWEC evaluated the start-up data, provided by NMPC, to identify the problem; the unit was then simulated using the Modular Modeling System (MMS). From the Base Case simulation, operating parameters (combustion air flow, firing rate, burner level, etc.) were varied to identify their impact on the superheater outlet steam temperature. Operator guidelines were prepared and then tested on the Oswego 5/6 plant simulator.

SUMMARY - The study was performed by specific tasks. Task 1 was Problem Identification; Task 2 was the development of the MMS model; Task 3 was the Analysis of Operational Changes using MMS; Task 4 was Analysis of Hardware Changes; and Task 5 was the Final Report.

In Task 1, SWEC investigated the design requirements of Foster Wheeler Engineering Company (FWEC) and Westinghouse Electric Corporation for main steam temperature ramp rate and maximum steam temperature reached during normal unit operations and a unit start-up.

Comparison of start-up data, submitted by NMPC for March, May, and June 1986, indicated that the steam temperature ramp rate exceeded FWEC limitations in only the June start-up. Comparison of temperature ramps to Westinghouse recommendations indicated that first stage rotor cyclic life was being used at a faster rate than recommended.

Comparison of maximum superheater temperature reached for each start-up indicated that FWEC recommendations were not being exceeded; however

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Westinghouse recommendations for the turbine were exceeded. When this occurs, the time and duration should be recorded.

For Task 2, dynamic simulation of the Unit using a MMS Model was performed. A Base Case was prepared to sumulate the behavior of primary, furnace, and finishing superheater temperatures based on test data submitted.

For Task 3, operational changes were investigated to determine their potential for minimizing or eliminating the identified problem. Boiler setpoints and operating parameters, which could be controlled by unit operators, were identified. The parameters which were determined to affect main steam temperature characteristics were:

- Fuel Flow
- Turbine Ramp Rate
- Auxiliary Steam Flow and Source
- Reheat Damper Position
- Combustion Air Flow
- Burner Level

Each selected parameter was individually varied to quantify its effect on the superheater outlet temperature during start-up.

From the results, it was concluded that the superheater outlet steam temperature could be controlled by operation of the unit and that hardware modifications (Task 4) were not recommended . For the analysis, it was assumed that the existing hardware was operating as designed.

<u>CONCLUSIONS</u> - It was concluded, in Task 1, that for the data submitted, FWEC design recommendataions were not exceeded. However, it was determined that the turbine cyclic life was being expended at a much faster rate than Westinghouse's recommendation of 10,000 cycles. The options available to reduce the rate of cyclic life comsumption are to maintain the total change in main steam temperature but reduce the rate of temperature increase, reduce the change in total steam temperature but maintain the present rate of temperature change, or to reduce both the change in steam temperature and the rate of change.

From this analysis, it was concluded that the unit can be loaded without exceeding the temperature limits recommended by the boiler and turbine manufacturer. The May start-up tended to support this conclusion. Based on this conclusion, the following operating guidelines were recommended to allow start-up of the unit without exceeding the temperature limits.

- The lowest burner level should be used during initial firing, Hot Restart System operation, and initial turbine loading.
- Do not use drum steam for an auxiliary steam source.
- The Hot Restart System should provide auxiliary steam during the bypass mode and until turbine synchronization.
- Following synchronization, <u>reduce</u> air flow to the minimum value consistent with operational and safety limits (typically 25 percent) and shutdown the Hot Restart System. Maintain this air flow until fuel flow is aligned.
- Open the reheat dampers after synchronization to increase reheater outlet temperatures and to decrease superheater outlet temperatures.
- Ramp the firing rate to maintain an acceptable temperature gradient, based on turbine cyclic life and FWEC guidelines.
- Ramp the turbine at a rate which maintains steam pressures nearly constant for the above firing rate. At a throttle temperature of approximately 850 degrees F, initiate transfer from full arc to partial arc admission.
- As steam temperatures approach 950 degrees F, quickly increase the fuel flow to the point of alignment with air. Open the governor valves rapidly to achieve at least 80 MW. At this load, peak superheat steam temperatures can be regulated through the use of spray flows or through a fast load increase to minimum load.

These guidelines were evaluated on the plant training simulator at Oswego Station. The results indicated that the peak steam temperature should be controlled by aligning air, fuel, and steam flows. Also, the simulator steam temperature gradients were controlled by fuel flow.

Other results of the simulator testing were the prediction of severe drum level variations and rapid load increase. These variations follow the increase of fuel flow to alignment and the quick opening of the governor valves. Based on these results, operator action should be taken to prevent drum level trip. This includes start-up of the turbine driven boiler feed pump prior to fuel alignment. Attentive manual regulation of the feedwater control valves is required because single element control cannot be sufficiently responsive. Above 80 MW, the steam temperature can be slowed through the use of sprays instead of further opening of the governor valves.

Ted Kulczycky
Niagara Mohawk Power Co.

Tips on Specifying Communication Interval for ACSL

The following is provided as a guideline in the use of CINT and NSTP in ACSL, all versions:

CINT - CINT is the communication interval that ACSL uses for OUTPUT'ing and PRINT'ing values. As such, it needs to store all the PREPAR'd variables at each CINT interval. CINT should be set as high as possible to avoid storing excess data. The LARGEST time step that the Gear integrator can take is controlled by the value of CINT. Since it has to store data, the integrator cannot take a step past the CINT interval. For most MMS applications, set CINT to a value of at least 1.0, even higher if you are running a slow transient.

NSTP - NSTP is the initial number of integration steps in a communication interval. The first step the Gear integrator will take is H = CINT/NSTP. Then it will adjust the time step, H, to take as large a step as it can and still stay within the error criterion.

A rule of practice is to set NSTP to a value that will result in a minimum step of .001 or less. See section 4.77 of the ACSL manual for guidelines on specifying NSTP. A guideline to follow in calculating an initial step size, H, is to find the state that, when divided by its derivative (and after taking the absolute value of the ratio), results in the smallest value for all the states in the model. Divide this value by 100 to get an idea of a reasonable value for H. Then NSTP=CINT/H+1.

Note the smallest value for NSTP is 1 since it is an integer. We generally start a model with a value of 1.0 for CINT and a value for NSTP of 100,000 or 1,000,000, if the model is not at a good steady-state, to avoid taking too large a time step and having the model fail on a water properties call. You should experiment to find the optimum combination and then use the technique in section 4.77 of the ACSL manual to take care of it if you change CINT in future runs. If you use fixed step integration algorithms, read section 4.74 which discusses MAXT and MINT. If you want to see the time step that the Gear integrator is using, you can OUTPUT CSSITG and it will be reported at each communication interval.

I think that, if you try a few combinations, you will be pleasantly surprised at the improvement in model run-times. If you use too small a value for CINT, the Gear integrator cannot do its basic function, which is to take large time steps when things are not changing much. If the range of the eigenvalues in your model (use the ANALYZ 'EIGEN' command) are not too great, you might be better off using IALG=1 (Adams-Moulton).

Phil Bartells
Babcock & Wilcox

THE PRESIDENT'S CORNER

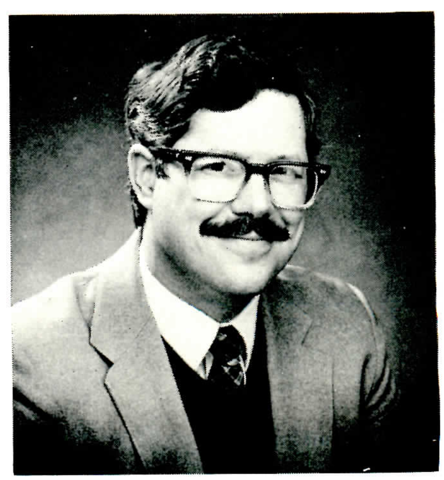
I would like to welcome you back from your summer vacations and bring you up to date on what's been happening.

The plans for the next User's Group meeting are firming up. Detriot Edison is hosting this meeting, currently scheduled for September 15 and 16 at Detriot Edison. Details of the meeting will be mailed out to each member. It's not too early to organize your thoughts on what you want to report on at the meeting. Also, think about areas you would like improved, expanded, or changed with respect to the code, documentation, etc. One idea I have been tossing around is inviting guest speakers to give half day seminars on specific topics in the areas of modeling & simulation, controls, and process design. These half day seminars would be part of the User Group meeting. I haven't worked out the details with B&W on this but if you like this idea, let me or Phil know and we'll pursue it.

A recent letter from Phil indicated that Toledo Edison has joined the User Group and that the Mechanical Engineering Department at Cornell University also has decided to use MMS in their curriculum. On behalf of the User Group, I extend a warm welcome to Toledo Edison and Cornell University.

I would like to thank Chuck Arndt of Detriot Edison for his outstanding work as secretary of the User Group. As a result of the last elections, Chuck has moved up to the vice-president slot with Al Sudduth of Duke Power Company taking over as secretary.

As a final note, Phil needs your input in the way of short articles, helpful tips on using MMS, or any other notes of interest. Dave Dion of Pacific Gas & Electric contributed a technical note on finding steady state for large models. Thank you Dave!



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