B&W/MMS User Group Newsletter

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

September 1986 Vol. 2 No. 2

The President's Corner

Phil Bartells reports to me that we now have another international member in our B&W/MMS User Group. The new member is Chubu Electric Power Company. Chubu Electric is a Japanese electric utility headquartered in Nagoya. According to Phil, Chubu plans to use MMS in control system studies of their fossil plants.

With the membership of Chubu Electric, MMS can be considered to circle the globe with members in Europe (Spain), Asia (Japan) as well as the U.S. B&W has been conducting a concerted international marketing effort and we will be looking forward to more international members.

It appears to me that over the last few years the use of MMS for fossil plant analysis has increased. When Ron Dixon and others first developed the forerunner of MMS they did so for the transient and control system analysis of B&W fossil plants. Of course, it was B&W that successfully proposed to EPRI to develop the MMS code for both nuclear and fossil applications. EPRI developed MMS with joint funding from the nuclear division and the fossil division. And, when MMS was released it had been successfully used for both nuclear and fossil applications. Since then it appears to me to have been applied more to fossil problems than for nuclear. I see two reasons for this. First there are more fossil plants than nuclear plants. The second is that I see more competition in the nuclear area. The other reactor vendors are now making their transient and control system analysis computer codes available for utility use. Frequently they have a PC version of the code. Also, some small firms are offering PC based codes for nuclear transient analysis. Often these firms have individuals who previously worked for a nuclear reactor vendor doing transient and controls analysis. While these competing codes do not have the flexibility of MMS, they are often sufficient for some utility needs. These competing codes tend to describe the overall nuclear plant. It is this competition that tends to reduce the number of utilities using MMS for nuclear applications.

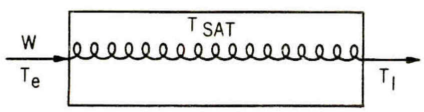
The advantage of MMS for nuclear plants is its flexibility and capability to model in detail a smaller portion of the overall plant. An example would be an MMS model that would allow proper settings for the feedwater control system. To date most of those procuring transient analysis codes for nuclear applications have focused on the overall plant and have not been concerned with detailed subsystem modeling.

CHARLES SAYLES
PRESIDENT
July 30, 1986

B&W Investigates Improved Heat Transfer Formulations

Work at the B&W Research & Development Division over the last two years has resulted in some further understanding of heat transfer formulations, which promise to improve the ability of MMS to model low flow situations in which rapid temperature excursions are encountered.

Consider a simple heat exchanger heating water from a temperature of T_e to T_l by condensing steam at a constant temperature of T_{sat}, as depicted below:



A simple uniform flow model of this system illustrates the problem. Assuming a linear average temperature profile, and heat transfer at the average temperature, the differential equation for the derivative of the leaving temperature is:

$$\frac{dT_l}{dt} = \frac{w\,c_p\,(T_e - T_l) + q}{M\,c_p}$$

$$= \frac{w\,c_p\,(T_e - T_l) + UA\,[T_{sat} - (T_e + T_l)/2]}{M\,c_p}$$

Consider the response of this system to a rapid increase in the entering temperature. If the heat transfer conductance term, UA/ 2, is larger than the mass flux term, wc_p, the outlet temperature will decrease. There are no circumstances under which this response is correct. In fact, this analysis allows us to define the minimum number of control volumes which we must use in order to achieve a physically realistic response:

$$\frac{UA}{2} < w\,c_p$$

This suggests that with this formulation the number of control volumes, N, must be given by:

$$N > \frac{UA}{2wc_p}$$

As the flowrate falls off, the number of control volumes necessary to avoid this non-physical response increases. And, this is only for a physically correct response, not an accurate response, which requires an increase by a factor of perhaps three. Of course, none of the current MMS modules use a heat transfer formulation this simplistic.

Most MMS modules use a log mean temperature formulation which determines an effective temperature difference using the entering and leaving temperatures. This method does provide an exact solution for the heat transfer at steady-state but it also suffers from the same response characteristics as the heat transfer at the mean which is described here. The problem inherent in this situation is that those modules which use the LMTD formulation can be expected to exhibit non-physical responses at some low flowrate.

With a great deal of experimentation, Lance Smith and Ron Dixon have found a formulation which retains the accurate steady-state characteristics of the log mean but will not move in the wrong direction regardless of the flowrate and does not increase the computational burden associated with increasing the number of control volumes.

In the case of the system discussed here, we can solve the log mean temperature relation simultaneously with the energy conservation relation, eliminating T_l, and resulting in:

$$q = wc_p\,[1 - \exp\,(\frac{-UA}{wc_p})]\,(T_{sat} - T_e)$$

As surprising as it seems, the solution in terms of only the entering temperature can be shown not to exhibit the non-physical response of the other possible formulations. Other formulations have been developed for counterflow and parallel flow exchangers.

As an illustration, a simple counterflow heat exchanger model is depicted in Figure 1. The model has the following operating conditions:

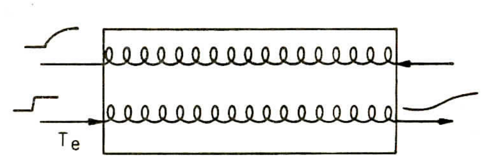
M	2780 lbm
w	200000 lbm/hr
c_p	1 Btu/lbm
UA	1×10^6 Btu/hr-F

with:

$$\frac{UA}{2wc_p} = 2.5$$

Suggesting that at least three nodes are required to avoid the inaccurate response. This is typical of low flow situations.

Figure 1: Heat Exchanger Model



The transient imposed on this model is a step increase in the entering cold temperature from 100F to 200F. Figures 2 and 3 show the true response of the cold and hot outlet temperatures. Figure 2 illustrates the response expected. The residence time for the system is 50 sec., and there is very little response for the cold outlet temperature until requires the fluid has passed to the outlet. The hot outlet temperature responds immediately since it sees the change in the cold inlet immediately. The true response was obtained by using 100 nodes for the model.

Figure 2: Cold Fluid Outlet Exact Solution

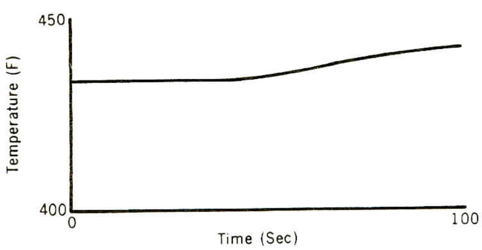
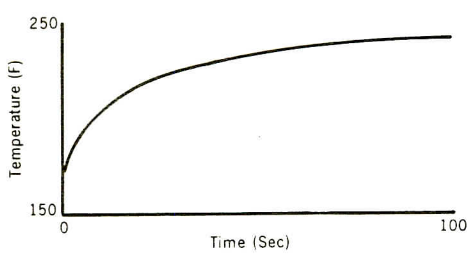


Figure 3: Hot Fluid Outlet Exact Solution



Figures 4 and 5 show the temperature response of the heat exchanger model for three different heat transfer formulations. The first formulation uses a simple linear average heat transfer at the mean formulation (HX at Mean). The second formulation uses the standard log-mean temperature difference (LMTD) which is most widely used in current MMS modules. The third formulation uses the log-mean at the entering temperature formulation, similar to that which was described above.

Figure 4: Hot Fluid Outlet

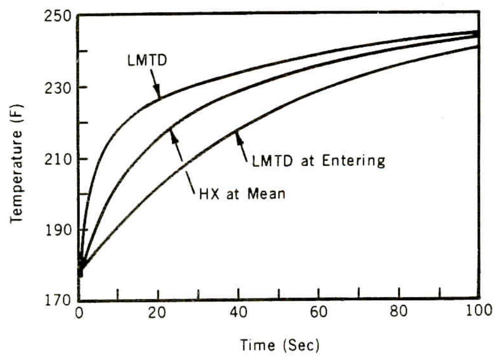
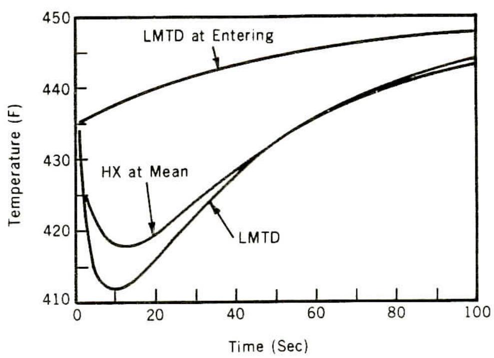


Figure 5: Cold Fluid Outlet



Examination of Figure 4 demonstrates that the hot fluid outlet temperature response is similar for all three formulations. Interestingly, the HX at Mean formulation is closest to the true solution depicted in Figure 3. Figure 5 depicts some rather startling results for this simple case. For the HX at Mean and LMTD formulations, the cold fluid outlet temperature decreases significantly, which is physically unrealizable. The LMTD at the entering temperature formulation exhibits a physically realizable response very similar to that shown in Figure 2. The time delay is not present since a single node representation cannot represent transport phenomena.

The simple example outlined here demonstrates the need for improved heat transfer formulations to model low flow situations in which rapid temperature variations occur. The example used, a 100F step change, is not likely to be encountered in reality, but was used to demonstrate the different response which can result from the choice of the heat transfer formulation. Work is continuing on investigation of this revised formulation by actual application to some MMS modules. If results are as expected, it is anticipated that modifications will be made to all affected modules and released in the next MMS update.

LANCE SMITH

Current Membership at 17

After two years, the B&W/MMS User Group membership includes eleven EPRI members, two domestic non-EPRI members, two international organizations and two universities. The current list is:

EPRI Member Utilities

Cleveland Electric Illuminating
Detroit Edison
Duke Power
Niagara Mohawk Power
Pacific Gas & Electric
Philadelphia Electric
Public Service Electric & Gas
San Diego Gas & Electric
Southern California Edison
Tennessee Valley Authority
Utah Power & Light

Other Domestic

Bechtel Power Corp.
Oak Ridge National Laboratory

International

Empresarios Agrupados, Spain
Chubu Electric, Japan

Educational Institutions

Pennsylvania State University
Tennessee Technological University

PHIL BARTELLS

Chubu Electric Joins User Group

Chubu Electric Power Company joined the User Group in August. Chubu supplies electricity to about 7.6 million customers in a 39,131 square-kilometer area in Central Japan. About 15 million people live and work in the service area. Industries in the territory served by Chubu include automotive and automotive-related parts, iron and steel, chemicals, and a diversified group of other industries.

Chubu Electric is one of the nine-investor-owned utility companies presently operating in the four main islands of the Japanese archipelago. Installed generating capacity was 18,817 thousand kilowatts, as of March 31, 1985.

MMS will be used to study contol systems and possible design changes in approximately 30 operating fossil plants in Chubu's system. Mr. Matsumura of Chubu Electric will be the primary investigator and he was first introduced to the MMS when Lance Smith and Phil Bartells conducted an MMS seminar in Tokyo in February, 1985 (see Newsletter Vol. 1, No. 1, June 1985).

Nuclear Data Corporation (NDC) played a major part in encouraging Chubu to join. NDC has also been actively promoting MMS to other organizations in Japan (see Chiyoda article, this issue). NDC is located in Tokyo, Japan and is B&W's sales representative for MMS in Japan. NDC supplies computer services, software development, and technical analysis consulting services to various Japanese industries including electric power, governmental research, shipbuilding, and aerospace. NDC employs over 200 in its Tokyo, Osaka and Tokai offices.

PHIL BARTELLS

B&W Conducts Seminar For Chiyoda Chemical

B&W conducted a four day MMS seminar for Chiyoda Chemical Engineering & Construction Co., Ltd., of Yokohama, Japan in July. The seminar was held from July 1 to July 4 at the Tokyo offices of Nuclear Data Corporation and was conducted by Lance Smith. Seven engineers and managers from Chiyoda participated in an intensive MMS overview and demonstration.

Chiyoda is one of the world's leading engineering and construction companies and is involved in the design and construction of process and power plants worldwide. They are primarily interested in MMS as a tool for fossil plant analysis and design. Chiyoda intends to use MMS to study responses to anticipated transients like loss of load and as a tool to evaluate design alternatives like turbine bypasses.

The seminar featured an MMS overview, an introduction to ACSL, the Deaerator Example, a presentation on MMS-EASE+, and a description of the fossil and BOP modules and validation. MMS operation on the PC and the Power Computing Co. mainframe in Dallas were demonstrated using the new MMS Workstation as a frontend. Two days were spent in a hands-on demonstration with Chiyoda engineers building their own MMS model using MMS-EASE+. The Chiyoda engineers were able, with a little coaching, to construct, parameterize, translate, and execute a 39-th order model of a boiler, with four superheater banks, two reheat banks, an economizer, an HP turbine, and LP turbine, and associated piping and controls, in two days. This included time spent to convert their physical and operating point data from SI units to English units. They made very positive expressions of interest in MMS and EASE and have recommended to their management that Chiyoda join the User Group.

Following the Chiyoda seminar, Lance conducted a shorter two day seminar for Nuclear Data Corporation. During this session, NDC engineers were able to construct a 15-th order model of a U-tube steam generator in a day. Again, this included a good deal of time in unit conversion.

Overall, the two seminars were very successful. Both groups were exposed to a thorough background in MMS and both were able to develop reasonably complex MMS in a very short period of time. In fact, models when asked how long a comparable RELAP model of the U-tube steam generator model might have required, the senior NDC engineer, with a good deal of RELAP experience, indicated that three months, rather than one day, would have been needed.

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