Session 3147

Introduction of System Simulation Techniques into the Mechanical Engineering Technology Programs

Digendra K. Das
Associate Professor
Department of Mechanical Engineering Technology
SUNY Institute of Technology at Utica/Rome
P.O. Box 3050, Utica, NY 13504-3050
Phone: (315) 792-7421
e-mail: das@sunyit.edu

Abstract

The paper addresses the various aspects of the introduction of Simulation Techniques into the Mechanical Engineering Technology programs at the undergraduate and graduate levels. The topics presented in the paper include the development of the simulation laboratory, the curriculum, students' response and future plans.

Introduction

The Department of Mechanical Engineering Technology at SUNY Institute of Technology at Utica/Rome, N.Y., has established a successful baccalaureate degree program over the past two decades. The department offers B. S. and B. Tech. degrees in Mechanical Engineering Technology and the program is accredited by TAC/ABET. Recently a new Master of Science in Advanced Technology (MSAT) degree program has been initiated. All of these programs are supported by fifteen well equipped laboratories as a consequence of the fact that the department emphasizes the concept of offering mostly laboratory-based courses in Engineering Technology.

The rapid advancement of computer technology, both hardware and software, in the past few years, has made it possible to use simulation techniques in the study of a variety of systems in engineering technology. The department introduced simulation applications in both undergraduate and graduate degree programs in the fall of the 1998/1999 academic year. The various aspects of that endeavor have been addressed in the following sections.

The Development of the Simulation Laboratory

A new simulation lab, named The Advanced Environments Lab, was developed in summer 1998. The lab consists of twenty-four (24) Pentium computers connected to two file servers by NT Network. Each station is a Pentium Pro 200 equipped with 64MB of RAM, a 3.2GB hard drive, a 17 inch monitor at 1024 x 768 resolution, a 4MB graphics card and a sound card with the headphone adapter located below each monitor.

The two file servers are Dual Pentium Pro 200's, each with 256KB cache, 128MB RAM and a 9GB hard drive. The file servers are named "Post" and "Turing".

a) All profile information and user directories are stored in Post, which is the Backup Domain Controller.

b) Turing is the Primary Domain Controller.

The lab is also supported by a HP LaserJet 5Si printer and the print server is an Intel Netport Express PRO/100. Further details about the lab can be obtained from the website www.humboldt.sunyit.edu/ntlab.

The software selected for simulation application were the professional versions of MATLAB and SIMULINK.   The professional version of SIMULINK consists of nineteen (19) Tool Boxes. The following tool boxes were identified to be relevant to the MSAT program: Control System, Fuzzy Logic, Image Processing, Optimization and Signal Processing.

Integration of Simulation into the Curriculum

As indicated earlier, simulation was introduced into both undergraduate and graduate degree programs. In the MSAT program, a graduate level course entitled "System Simulation" was developed and offered to a cohort of twenty (20) graduate students. The students completed approximately twenty simulation assignments in this course.

In the undergraduate level, simulation was introduced in such courses as Fluid Mechanics, Heat Transfer, and Thermodynamics. Students were required to complete two or three simulation assignments in addition to their usual hands-on laboratory assignments. A couple of typical Heat Transfer and Fluid Mechanics models assigned to the students are briefly described below.

Model 1:

The objective of this model was to convert a ramp type input temperature distribution from the Fahrenheit scale to the Celsius scale using the relationship:

$$T_C = (T_F - 32)(5/9) \quad \text{--------------(1)}$$

The simulation model was developed using the software SIMULINK and is shown in Fig. 1. The following data were used in the model.

Initial Temperature = 60^oF
Final Temperature = 212^oF
Slope dT/dt = 1.52
Simulation time range = 0 - 100 sec.

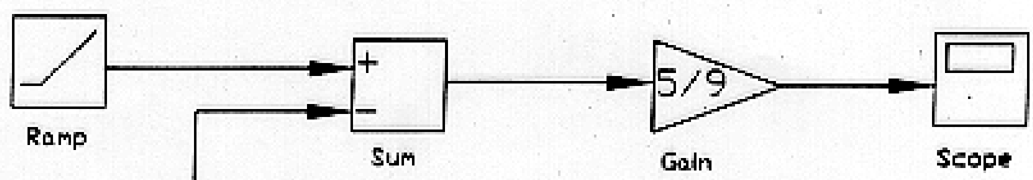

Fig. 1 Model 1

Model 2:

A single, completely mixed chemical reactor with an inflow and an outflow was modeled. The reactor is shown in Fig. 2.

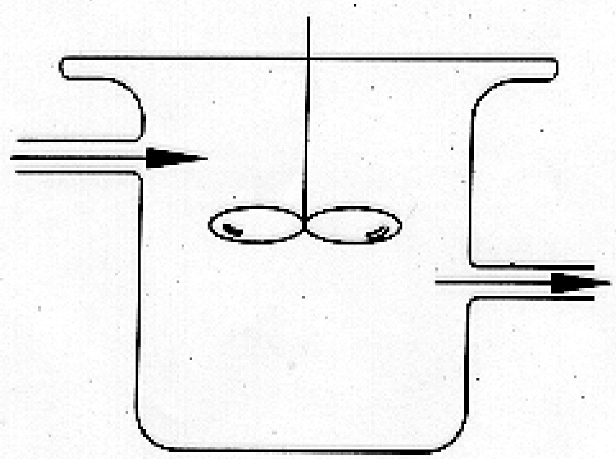

Fig. 2

A single, completely mixed reactor with an inflow and an outflow.

The mass balance equation for the reactor can be written as:

$$V\,dC/dt = QC_{in} - QC \qquad \text{----------- (2)}$$

where V = Volume
Q = Flow rate
C = Concentration
t = time

The analytical solution of the model can be written in the following form:

$$C = C_{in}(1 - e^{-(Q/V)t}) + C_0 e^{-(Q/V)t} \quad \text{------------ (3)}$$

where $C = C_0$ at $t = 0$

The following data were used for the model:

$C_{in} = 50\ mg/m^3$
$Q = 5\ m^3/min$
$V = 100\ m^3$
$C_0 = 10\ mg/m^3$

Hence, equations (2) and (3) can be written as follows:

$$\dot{C} = dC/dt = 2.5 - 0.05C \quad \text{---------------- (4)}$$

$$C = 50(1 - e^{-0.05t}) + 10\, e^{-0.05t} \quad \text{--------- (5)}$$

The SIMULINK models for equations (4) and (5) are shown in figures 3 and 4 respectively. Fig. 3 shows the numerical simulation model which uses the fourth and fifth order Runge-Kutta methods for the solution of the differential equation.

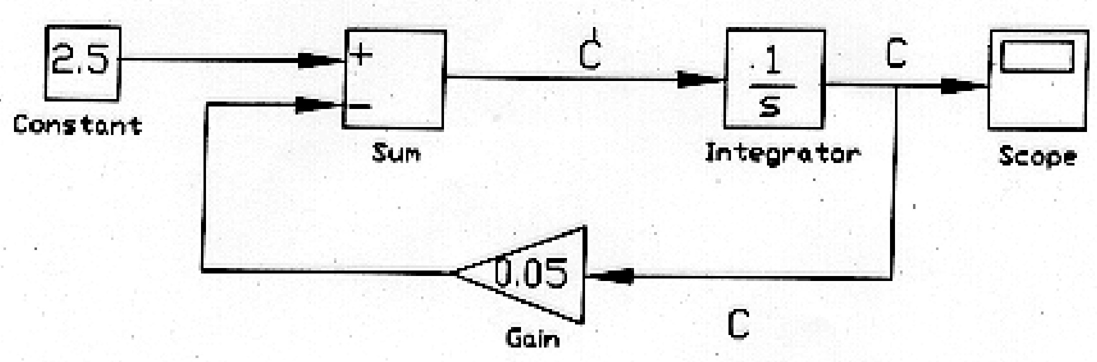

Fig. 3 Model 2

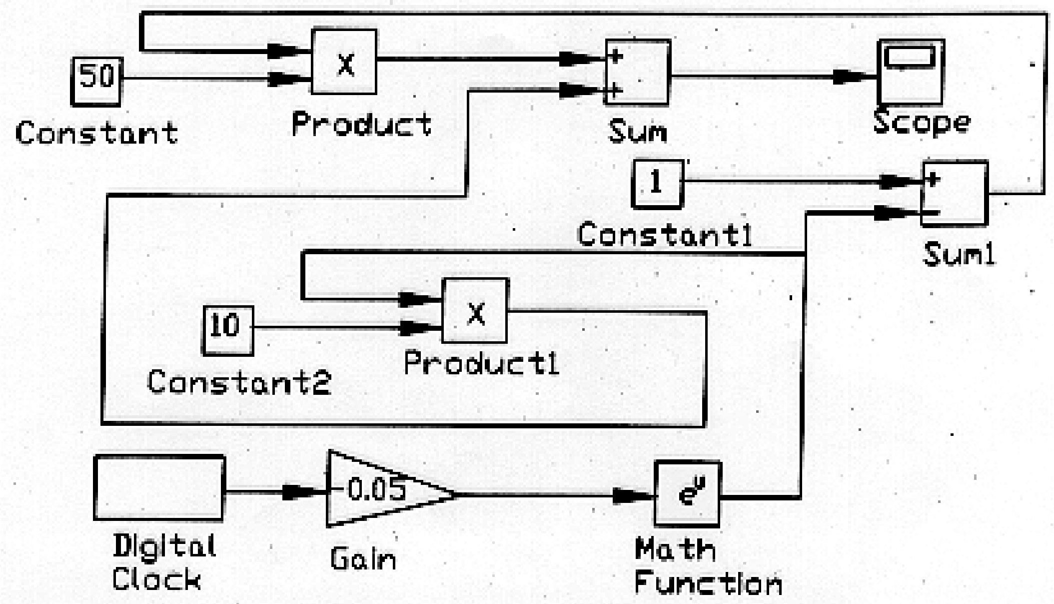

Fig. 4 Model 3

Response of the Students

The response of the students to the introduction of simulation techniques into the curriculum was overwhelming in both the undergraduate and graduate levels. Particularly in the undergraduate level, most of the students indicated that the techniques should be introduced into as many courses as possible. The next section outlines the future plans of the department in this respect.

Future Plans

In response to the overwhelmingly positive reaction of the students to the introduction of Simulation into the Engineering Technology programs, the department has decided to take the same measure in other higher level courses such as Heat Transfer II, Turbomachinery and Space Technology.

In the graduate level, a number of students have selected the application of simulation techniques for their final projects. Contractual agreements have been made with the Air Force Research Laboratory (AFRL) at Rome, N.Y., for SUNYIT students to participate in some of the simulation projects in their state-of-the-art laboratories. The area of interest is MEMS (Micro Electro-Mechanical Systems) and the software selected for use are MEMCAD 4.0 and IDEAS.

Conclusions

The simulation techniques have been successfully introduced into the Mechanical Engineering Technology programs, both in the undergraduate and graduate levels. Students' response in both levels being very positive, the application of these techniques in other higher level undergraduate courses, as well as graduate projects, has been deemed to be justified.

References

1. S. C. Chapra and R. P. Canale; *Numerical Methods for Engineers*; McGraw-Hill Book Company
2. *SIMULINK: A Dynamic System Simulation Software; User's Guide*, The Math Works, Inc.
3. *MATLAB: The Ultimate Computing Environment for Technical Education; User's Guide*, The Math Works, Inc.