CACHE News

Volume 50 **Spring, 2000**

TABLE OF CONTENTS

CACHE in the 21st Century

James F. Davis, , President, CACHE Corporation

Welcome to the Year 2000 edition of the CACHE Newsletter. It is fitting both because of the start of the new millennium and because CACHE is approaching the age of 30 that I use this issue of the newsletter to tell you about a new CACHE.

Times have certainly changed. When CACHE began, computing was in its infancy, there was virtually no such thing as computing in chemical engineering let alone in education and there was no advocacy for computing and the role it might play in chemical engineering in general. In those days, we praised the capacity of our computers for a 12 hour turn-around on a batch job and we were excited with 300 bps transfer rates. This is in such stark contrast to today where computing and information technology are the norm, computing in Chemical Engineering education is a requirement and the chemical process industry is highly dependent on the technology. We now expect sub second responses with models of exceptional fidelity, transfer rates are at gigabit levels and the pace of impact of computation and information technology is unprecedented. There is certainly no longer a need to advocate for computation in chemical engineering.

Like changing technology, CACHE has significantly shifted its emphasis over the past several years recognizing its strength in the collective opinion of its twenty-eight academic and industrial trustees. The 28 trustees currently bring together a wide spectrum of computing and information technology expertise and application across the US and Canada. The current range of expertise is remarkable covering large-scale, linear systems optimization, and programming, process design and synthesis, data analysis, process control, molecular modeling, reactor kinetics, fluids and transport, and computation theory and computer laboratories. It is indeed a unique blend of expertise that comes together twice a year to consider the implications of computing technologies in Chemical Engineering.

It is in this context that CACHE has been expanding beyond its traditional design, operations, and control focus allowing the organization to reconfigure itself for facilitating the technological and educational potential for new frontiers in computing. The approach is dynamic and CACHE has redesigned its approach to systematically consider strategic and emerging directions for computing technologies and then reorganize to take action.

A key component of this approach is the Industrial Affiliates program started three years ago and which has grown into a vital entity. The Industrial Affiliates program provides a broader industrial network to complement the longstanding network of university member departments. The program has strengthened our capacity for important industrial input and for bringing academic and industrial concerns together.

CACHE is very pleased with its recently established efforts in molecular modeling and its building capability in computational fluid dynamics. Other frontier areas can be expected soon. While the areas of application change, many mainstay mechanisms for impacting the chemical engineering community, however, remain quite viable. These include conferences, sponsored projects and collaborations, case studies and the distribution of application software of general interest. You can expect these to increasingly reflect the newer areas of computational application.

CACHE is particularly proud to kickoff the new millennium with the first Foundations on Molecular Modeling (FOMMs) conference scheduled for July 2000 and is looking forward to a continuing tradition of high value, high impact conferences. To be sure, CACHE will continue its Foundation Conferences on computing in process operations and design and the American Computing and Control conferences. While computing in design, operations and control is mainstream, continued advances with computing in these areas have justified experts gathering from around the world every three years to examine implications and to establish new areas of pursuit. Additionally CACHE will continue its strong working relationship with the AIChE and in particular the CAST division.

In closing, I urge you to bookmark and visit the CACHE website (www.cache.org). It is redesigned to provide you important information on all of the CACHE activities, initiatives, and products, the links to the conferences, and a vehicle to provide input to us.

CACHE Webpage

Thomas F. Edgar, University of Texas at Austin

CACHE has recently redesigned its website to give it the modern look and feel of a modern portal, serving learning community made up of chemical engineering faculty and students. During the past year www.cache.org has been continually adding new features. There are 10 top level URLs on the CACHE home page.

1. Information Center – basic information about CACHE and its trustees
2. Newsstand – previous CACHE newsletters
3. Teaching Resource Center – compilation of educational materials, course descriptions, software and simulations
4. Convention Center – information on CACHE-sponsored conferences, including the ability to register on-line
5. Industry Hall of Fame – description of industrial affiliates and supporting departments
6. Library – digital resources, data bases, on-line journals
7. CACHE University – distance education site for web-based or web-enhanced courses
8. Superstore – list of CACHE products (software, books) that can be ordered from the CACHE office
9. Post office – how to send communications to CACHE
10. Council Headquarters – list of officers and trustees.

People are able to register for the 2000 PSE (Process Systems Engineering) conference through an online registration form, and all future conferences will permit registration over the web using credit card number via a secure transaction. With the increasing popularity of the Internet, CACHE is focusing on providing extensive material from faculty at different universities/colleges, links to online journals, books, software, chemical products, as well as other features related to chemical engineering. The links that the CACHE provides are selected and reviewed rather than randomly picked from search engines like Yahoo, Altavista, and Metacrawler. The educational materials have been divided into three areas, namely, CACHE University, Teaching Resource Center, and Library.

CACHE University provides self-contained Chemical Engineering courses (or parts of courses) for students interested in learning over the web, in a distance learning mode. Each course will have a brief description, links to related course material, overheads, and eventually audio-video sites. As of now, the courses which the CACHE University will be offering have been sketched out, and some of them already have links. This web site is currently under development, and we are trying to identify the best possible material for each course. Selected faculty are being contacted for such web-based courses.

The Teaching Resource Center would provide educational materials from faculty, such as syllabi for different courses, software, simulation, and text material. There also is an online directory of all chemical engineering faculty. E-mails have been sent to selected professors requesting them to put links to their materials on the CACHE web page, since search engines are often unable to identify relevant information. This section will have links to textbooks, software, and will also allow reviews of the materials (in the spirit of amazon.com). The first prototype is being developed by Tom Edgar in the area of process control. Other areas to be covered include:

Introduction to Chemical Engineering
Material and Energy Balances
Mass Transfer
Heat Transfer
Fluid Mechanics
Thermodynamics
Transport Phenomena
Separation Processes
Unit Operations
Kinetics and Reaction Engineering
Process Control
Numerical Methods
Process Design
Material Science
Catalysis
Pollution Control
Hazardous Waste Management
Polymer Science
Molecular Simulation
Technical Communication

We will be identifying area editors for the above curriculum topics to moderate each area. Faculty who would like to volunteer to moderate a given area should contact Tom Edgar at edgar@mail.utexas.edu.

The library site, as the name suggests, will have a guide to ChE resources on the web, databases, and career information. Some of the features of the library include items such as online journals.

POLYMATH 5.0 For Windows™

Mordechai Shacham, Ben-Gurion University of the Negev
Michael B. Cutlip, University of Connecticut
Michael Elly, Ben-Gurion University of the Negev

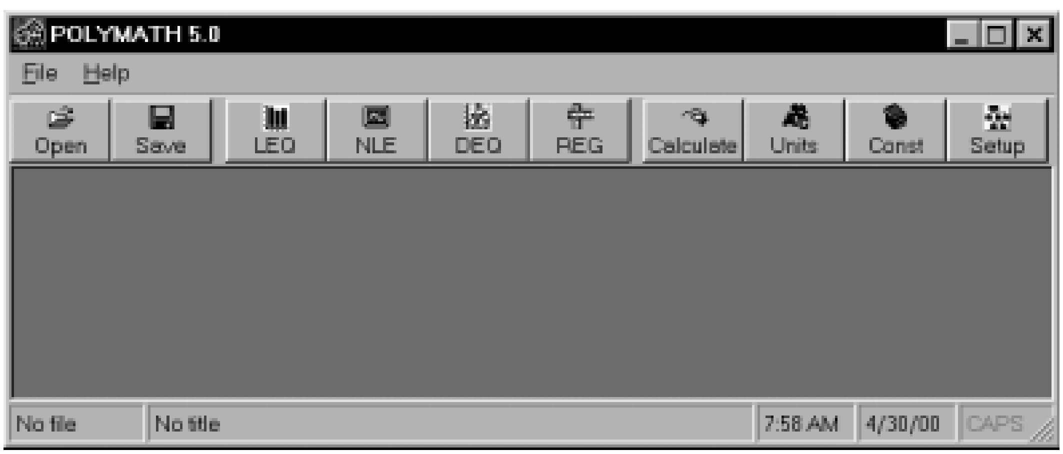
A completely reprogrammed POLYMATH Numerical Analysis Software Package for all 32-bit Windows™ operating systems is now available as a site license from the CACHE Office and the CACHE web site. All users who have a continuing site license should be receiving this latest version. Please contact the CACHE office if you have not. If you would like to consider POLYMATH, there is also a special offer of a trial period for four months for an academic department before a site license needs to be purchased. Details can be obtained from CACHE. Individual student and professional copies can be ordered from www.polymath-software.com.

This product has resulted from over two years of programming efforts and testing to bring all the latest Windows features to POLYMATH while enhancing the user friendliness and intuitive aspects of the previous versions. Polymath programs continue to include capabilities for:

1. **Simultaneous Ordinary Differential Equations - DEQ**
2. **Simultaneous Nonlinear Equations - NLE**
3. **Simultaneous Linear Equations - LEQ**
4. **Polynomial, Linear and Nonlinear Regressions - REG**

Perhaps the greatest improvement for this version is the standard Windows™ organization and editing that is provided. All attached printers are automatically supported by Windows™. The simple solution of a set of ordinary differential equations will be used to indicate some of the features of the new POLYMATH.

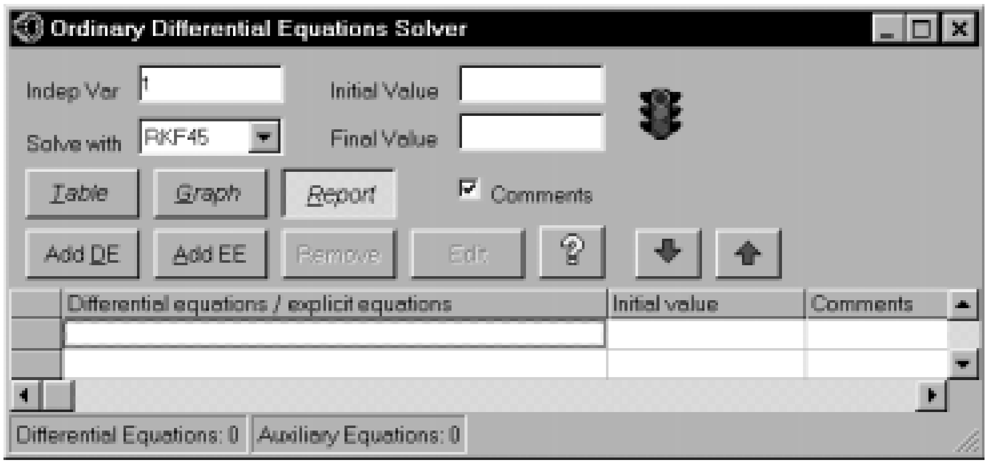
The main menu screen for POLYMATH gives the selection buttons for the particular programs with the shorthand abbreviations indicated above.



The four selection buttons on the right provide access to:

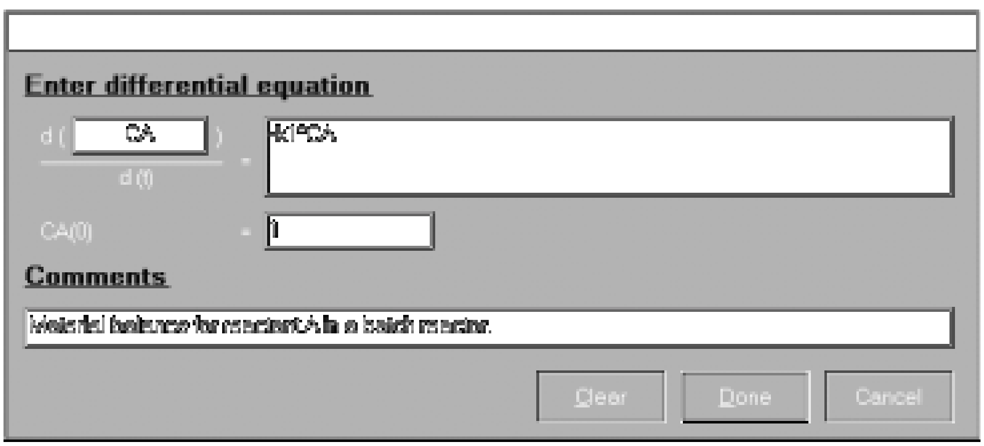
1. **A very sophisticated calculator – Calculate**
2. **A powerful unit converter – Units**
3. **A convenient library of conversion factors and constants – Const**
4. **A setup file for the programs and numerical methods – Setup**

Lets continue with the Ordinary Differential Equations Program - DEQ. The equation entry window allows easy input of both differential equations (DE), explicit algebraic equations (EE), and optional user comments on each equation.

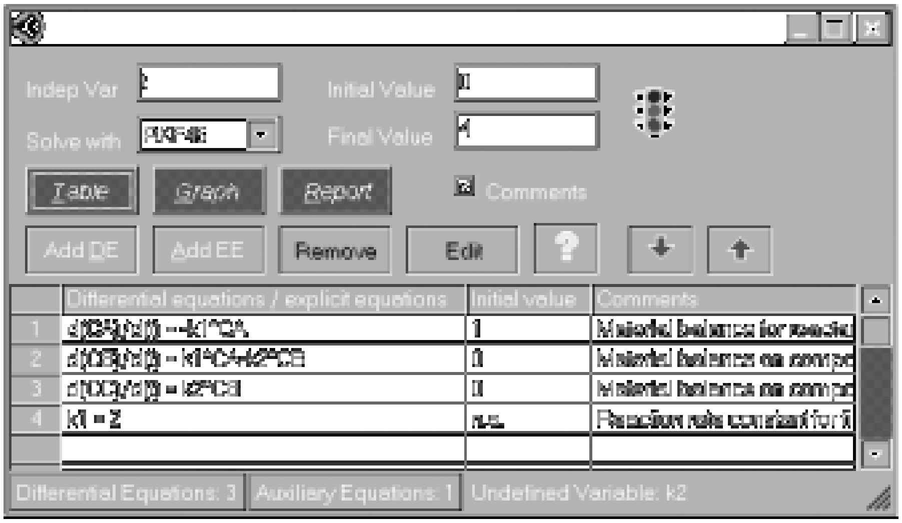


Note that all the controls are on this screen for the user to specify the problem and the various output that is desired. The output include a complete summary of the problem and solution (Report), a versatile graphic of some or all of the variables (Graph), and a spreadsheet-like summary for all variables (Table). The pull-down menu associated with "Solve with" allows the selection of the desired numerical algorithm with the most useful as the default.

A mouse click on the "Add DE" button brings up a small window for the entry of a differential equation. Lets consider a simple batch reactor where A reacts in a series of first order reactions to B and then to C. The differential equation for A is easily entered into the correct format, and the syntax is checked before this equation is accepted.



The "Comments" line allows a description of the entry as a user selected option. The complete system of three differential equations one of the two needed explicit algebraic equations and necessary integration input are summarized on the main program display.



Note that the above problem is not complete as the bottom right of the window indicates that the variable k2 is not defined. This indicates one of the extremely useful features of POLYMATH, which is the identification of "Undefined Variables" during problem entry. When the value for variable k2 is entered and the solution is requested, the "Report" output gives a summary of the problem solution.

Differential Equations Solution #1

POLYMATH 5.0 Results

04-30-2000

Calculated values of the DEQ variables

Variable	initial value	minimal value	maximal value	final value
t	0	0	4	4
CA	1	3.355E-04	1	3.355E-04
CB	0	0	0.295797	6.586E-04
CC	0	0	0.9990059	0.9990059
k1	2	2	2	2
k2	3	3	3	3

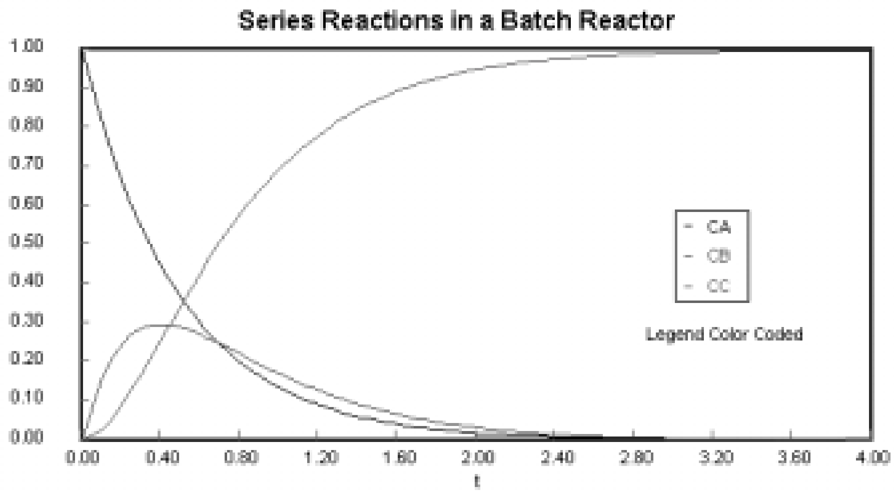
ODE Report (RKF45)

Differential equations as entered by the user
[1] d(CA)/d(t) = -k1*CA
[2] d(CB)/d(t) = k1*CA-k2*CB
[3] d(CC)/d(t) = k2*CB

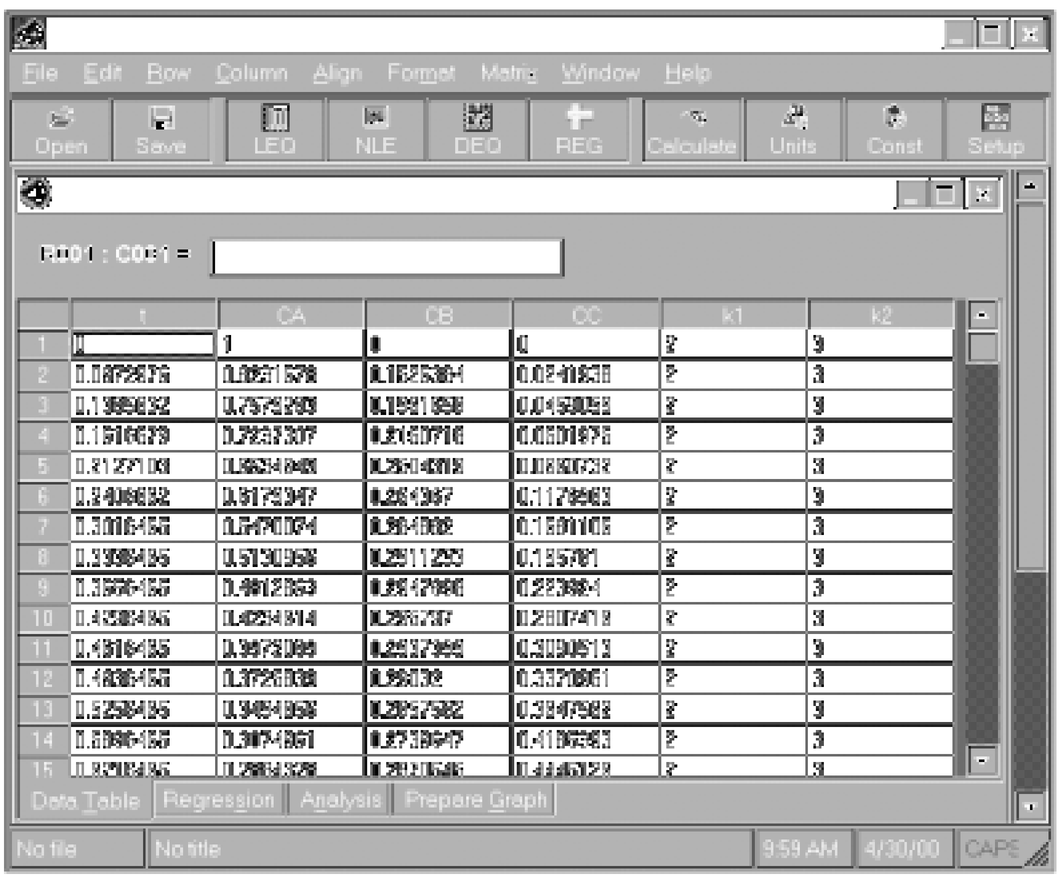
Explicit equations as entered by the user
[1] k1 = 2
[2] k2 = 3

Comments
[1] d(CA)/d(t) = -k1*CA
Material balance for reactant A in a batch reactor.
[2] d(CB)/d(t) = k1*CA-k2*CB
Material balance on component B in the batch reactor.
[3] d(CC)/d(t) = k2*CB
Material balance on component C in the batch reactor.
[4] k1 = 2
Reaction rate constant for first irreversible reaction.
[5] k2 = 3
Reaction rate constant for second irreversible reaction.

The "Graph" button yields a default graph that shows all differential equations variables automatically scaled. The graphics can then be saved and/or copied directly into documents and presentation software. A host of options regarding the graphics are available in this new version.



The "Table" button gives all of the data for all of the variables in a spreadsheet-like table which enables additional plotting, data manipulation, and data regression.



Selected columns of this "Table" can be highlighted and copied to spreadsheet or graphics programs for further manipulation and output.

An important enhancement in POLYMATH 5.0 is the option to “copy” the Report and the graphical and tabular results and paste them into Word, Excel, or other type of documents.

The new POLYMATH 5.0 program for ordinary differential equations is currently limited to problem with up to 200 simultaneous variables. There are six different integration algorithms that can be used. The default method is Runge-Kutta-Fehlberg (RKF45), and the recommended stiff algorithm is the semi-implicit midpoint rule of Bader and Deufhand (STIFFBS).

This new version retains all of the capabilities of the previous versions including the use of logical variables. The problem files can be used by this new version with only some minor modifications regarding exponentiation where X**2 is replaced by X^2.

Space limitation in this newsletter prohibit more detailed discussion of POLYMATH here, but much more information is available on the Internet from the POLYMATH site:

www.polymath-software.com

The CACHE web site gives more information on examination copies for educational use and for inexpensive site licenses for educational purposes.

www.cache.org

We would like to take this opportunity to thank the many students and faculty who have been helping with the reviews of the beta versions of POLYMATH 5.0. It should be mentioned that they have been giving rave reviews for this completely reprogrammed version. The bottom line is that this software allows students and faculty to solve most numerical analysis problems easily and interactively on personal computers.

The prices for Polymath 5.0 have not yet been established. Please contact CACHE office for prices and more information.

REACT!™ - The Reactor Flow-Sheet Analysis Program

Jamal M. Saleh and Jack R. Hopper, Lamar University

The REACT program is used to perform an analysis for plug flow (PFR), continuously stirred tank (CSTR) and batch reactors. It can handle multiple reaction systems, up to 30 reactions and 36 components. In addition, various types of energy models such as isothermal, non-isothermal, and adiabatic can be handled. Constant and variable densities (Liquid and gas) options are available. The program runs under two modes: (1) Flow-sheeting mode; reactors may be connected in series or parallel along with other generic process units such as heat exchangers, mixers or splitters and (2) Unit Reactor mode which is used to perform analyses of an individual reactor. In each mode, the reactant concentration, conversion, temperature and pressure will be calculated as a function of reactor length, volume, or time. REACT may also be used as a simulation tool for reactor design course at the undergraduate level.

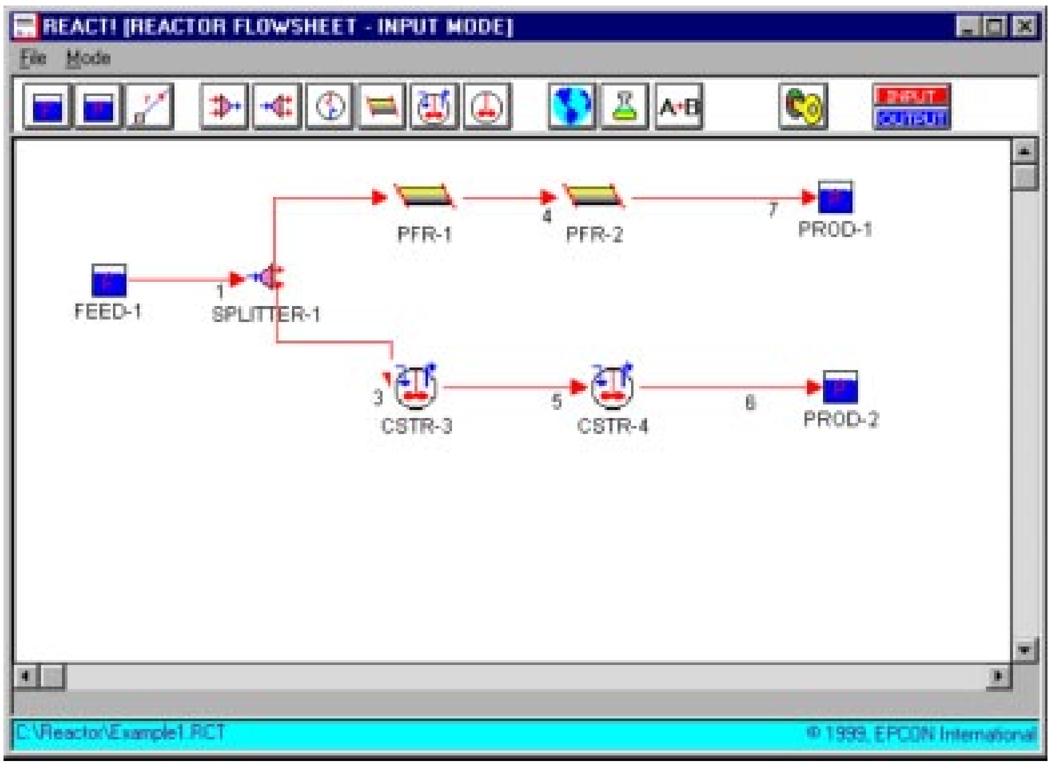


Figure 1: Reactor Network for Example 1

Program Options

Two options are available for the user in the REACT analysis program. The "Mode" menu allows the user to choose between the Flow-sheeting mode and the Unit Reactor mode. The data input requirement and procedure will change accordingly.

The selection of mode depends on the requirements of the user. If it is desired to simulate a network of reactors with multiple series or parallel configurations, the Flow-sheeting mode is the appropriate choice. Any combination of (continuous) reactors of different types can be simulated in this mode. In addition the streams can be heated or cooled by means of external generic heat exchangers (set heat duty) in the network. Mixers and splitters can also be used to split (based on a user input volume fraction) or mix two or more process streams. All the process units are connected using pipes. Program calculates the pressure drop in a pipe using pipe specifications. If the user wishes to consider the temperature gradient across the pipe, he can do so by providing additional data such as ambient temperature and overall heat transfer coefficients. In this mode, input for an intermediate process unit is automatically derived from the output of other connected units.

The second option in the Mode menu is "Reactor Unit" which is useful for simulating a stand-alone reactor. The user can select a reactor such as a Batch, CSTR or a Plug Flow Reactor.

Flow-Sheeting Mode

The following units are available when the flow-sheeting mode is selected:

Feed Tank, Pipe, Mixer, Splitter, Plug Flow Reactor, Continuous Stirred Tank Reactor, Generic Heat Exchanger, and Product Tank.

Feed Tank: The tank composition, temperature, elevation and pressure are required data input. The elevation and pressure are used to calculate the system pressure for the connected pipes and units.

Pipe: The input data is the pipe diameter, length, and roughness factor. If pipe is connected to a Feed Tank, the user needs also to set the mass or volume flow. To estimate the temperature change, an overall heat transfer coefficient is required.

Splitter: One inlet pipe and two outlet pipes should be specified. The user will set the volume-split fraction for the exit pipes. Two or more splitters must be used when there is a need to split the inlet stream into three or more streams.

Mixers: Used to mix two inlet streams to produce one outlet stream. Energy and mass will be ideally mixed to produce an outlet stream with new composition, temperature and pressure. More than one mixer should be used to mix three or more streams.

Heat Exchanger: The user needs to set the heat duty, BTU/Hr, to heat or cool one inlet stream. No phase change is assumed.

Plug Flow Reactor: Reactor length and diameter are required data input. A heat transfer area and an overall heat transfer coefficient is required for none-isothermal models. Inlet reactor conditions will be assumed as the reactor inlet stream conditions.

Continuos Stirred Tank Reactor: Reactor volume is required while an overall heat transfer area and coefficent are required for none-isothermal models. Inlet reactor conditions will be assumed as the reactor inlet stream condition

Calculation Bases:

Pipes

Pressure drop in pipes is calculated using the Darcy equation. The Colebrook equation is used to predict the friction factor. Gas density is calculated using the ideal gas law, while liquid density is assumed to be constant. Heat transfer is found by (with consistent units):

Cp.M. DT= U A (Tinlet – Tambient)

Cp	**Heat capacity**
M	**Molar or mass flow**
DT	**Fluid Temperature change**
U	**Overall heat transfer Coefficient based on outside surface area**
A	**Outside pipe surface area**

Plug flow, Batch, and Continuos Stirred Tank Reactors:

The Multiple reaction approach suggested by Fogler in "Elements of Chemical Reaction Engineering", 2nd Ed., is applied with the Newton-Raphson and Euler numerical methods to solve for the reactor design equations. The reader is referred to the reference for a full coverage.

Mixers

Streams are mixed ideally; no heat of solution or phase change is assumed. Outlet stream pressure is set to equal to the lowest of the inlet streams pressure.

Splitters

An inlet stream is split into two streams with the same composition, temperature, and pressure. The flow rate of each stream is set by the user as a volume fraction of the inlet stream.

Heat Exchanger

Reactor inlet or effluent streams may be cooled or heated by means of a generic heat exchanger. This feature provides a way to provide reactor stage cooling/heating. The user has to specify a heat duty (BTU/Hr) for each heat exchanger. Stream temperature change is predicted using the following equation with consistent units:

Cp M DT = Q

Cp	**Heat capacity**
M	**Molar or mass flow**
DT	**Fluid Temperature change**
Q	**Heat Duty**

Example

The following example is used to illustrate the different features available for the flow-sheeting mode:
Consider a reactor network consisting of one feed tank, a splitter, two PFR in series, two CSTR's in series and two product tanks, See Figure 1. To draw the reactor network,

the mouse is used to click and drag units (feed tanks, reactors etc) to the workspace. Pipes and steams may be drawn similarly Data input for each pipe and unit is displayed with a mouse double click. (A user manual is available).The following data input is required for the reactor network flow sheet example:

Global Data: Includes the physical properties, kinetic data, and other global options which are valid for the entire network such as pipe roughness factors, outside temperature etc. Figure 2 shows the global data input screen. Figure 3 shows the reaction stoichiometry input screen, Figure 4 shows the reaction rate input screen, and Figure 5 shows the Arhenius-type reaction constants input screen for the reaction to be used in the example.

Specific Data: Includes specific data for process units such as reactor dimensions, pipe diameter, feed tank composition and flow rate, etc.

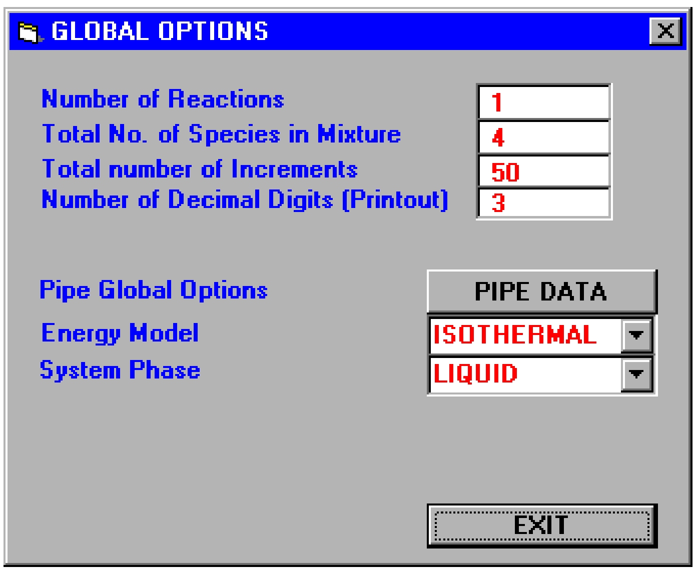
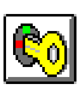


Figure 2. Global Options Data Input Screen



Running the Simulator

When all the required data input is complete, the analysis may be performed by clicking on the "key" icon on the toolbar (shown above). All the process units are executed in sequence. A message indicating the completion of calculations is displayed at the end of calculation process. The color for all the piping changes from red to blue to indicate the output mode. Messages will be prompted for incomplete data.

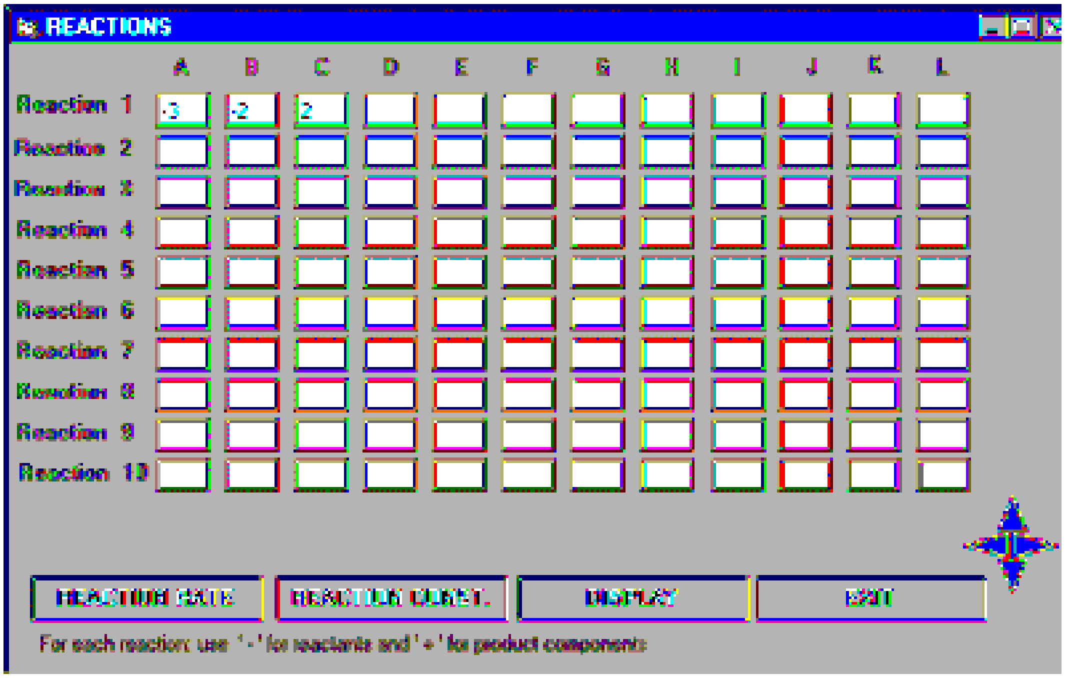


Figure 3. Stoichiometry Input Screen For 3A + 2 B —> 2C

Figure 4. Reaction Rate Input Screen, Example 1, $(-r_{1A}) = K_1\ C_A^{1.5}$

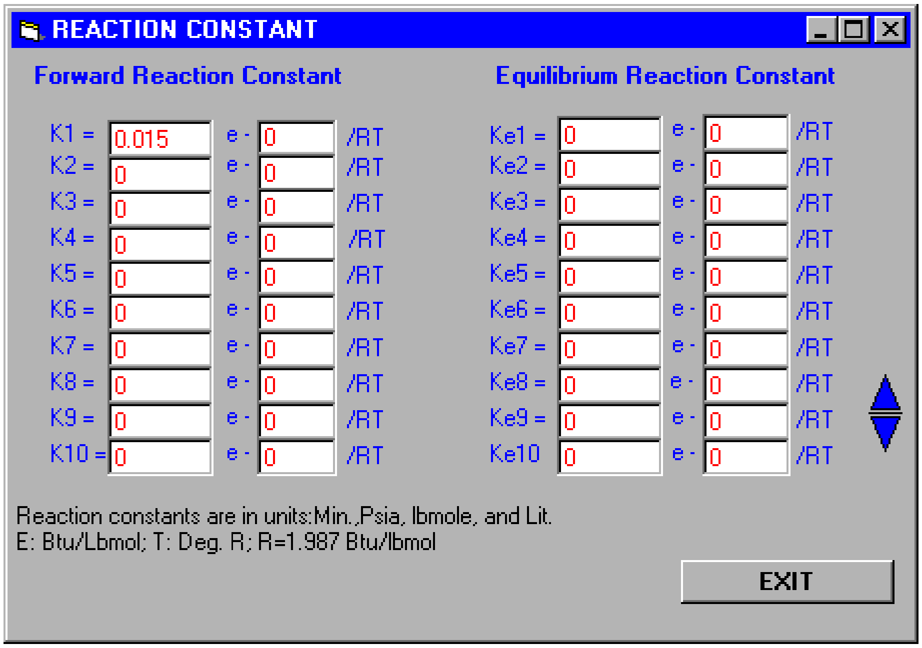


Figure 5. Input Screen for the Reaction Rate Constant, k = 0.015

Displaying the Results

In REACT!™, the output of any process unit or pipe may be viewed by double clicking the ikon on the Reactor Flowsheet screen. It is important to note that the program has to be in the "RESULTS" mode otherwise the input specification screen will be displayed. The net product information can be obtained by clicking at the product tank which is the last unit in any reactor network. The output screen for the product tank PROD-1 is shown in Figure 6 below. This provides the net concentrations of all the components at the end of the process.

Reactor Unit: The output for a reactor unit (CSTR, PFR, and Batch) can be viewed by double clicking on the reactor unit icon in the flow sheet. The first output screen consists of a graph showing concentration profiles of all the components with respect to reactor length, volume or time (depending on the reactor type) (See Figure 7). User can view variation of various parameters such as pressure, temperature or conversion by selecting the appropriate option at the bottom of the screen. The data can also be viewed in tabular format by selecting the "Data" option. In addition, a brief summary listing the inlet and outlet conditions is also available which can be seen obtained by clicking the "Summary" button.

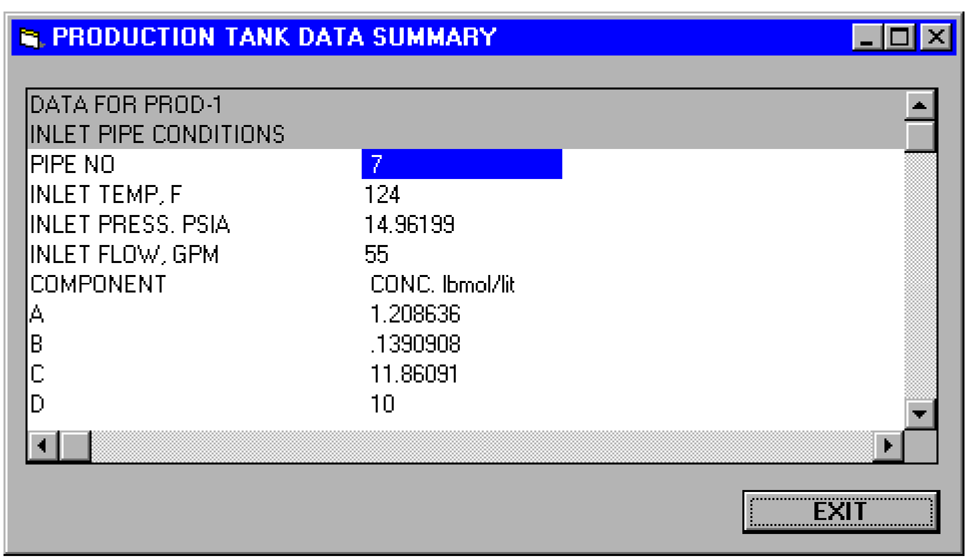


Figure 6. Output Screen for Product Tank

Figure 7. Reactor Unit Output Screen

Summary

Performance of reactor network flow-sheeting with simple mass split/mix and heat transfer may be predicted using the REACTprogram.This tool provides a simulation aide to understand and solve reactor networks.

An Academic version of the program is available for free. Contact email is lsaleh@epcon.com

Nitrogen from Air:
A Web-based Tutorial on Air Separation

L.T. Biegler, Carnegie Mellon University

Over the past 15 years, the CACHE design case studies have been a very successful teaching tool for a number of chemical engineering courses. Moreover, with the widespread use of web-based tools, the traditional mode of case studies can now be augmented with a number of additional resources. Here we describe such a vehicle for design case studies along with web-based tutorial material for air separation. The resulting web site is distributed by CACHE (Computer Aids for Chemical Engineers) as a learning tool for the general public, engineering students, and professional chemical engineers. It can be accessed through the CACHE web page:

http://www.cache.org

or directly from

http://www.cheme.cmu.edu/course/06302/airsep2

This site provides information about air separation processes, why we need them, and details on how they can be evaluated. Specifically it deals with the purification of nitrogen and describes three competing technologies: cryogenic distillation, membrane separation and pressure swing adsorption.

The planning for this tutorial web site began in the fall of 1998 when Dr. Rakesh Agrawal, from Air Products and Chemicals, Inc., and I put together a class project on nitrogen generation for the senior process design course at Carnegie Mellon University. The project dealt with the design and evaluation of nitrogen separation processes based on three competing technologies. The class was distributed into several teams so that these technologies could be evaluated in terms of ability to meet specifications, profitability and sensitivity to external inputs. The design class produced an excellent set of design reports that led to material for a CACHE case study.

Moreover, a subsequent interdisciplinary project course, run by Prof. Art Westerberg in 1999, afforded me with a unique opportunity to work with a group of students, from the entire engineering college, to turn this design project into a web-based tool. Resources for supporting this project were graciously provided by Air Products and Chemicals. A short description of the tutorial, in terms of air separation technologies as well as the web site itself, follows next.

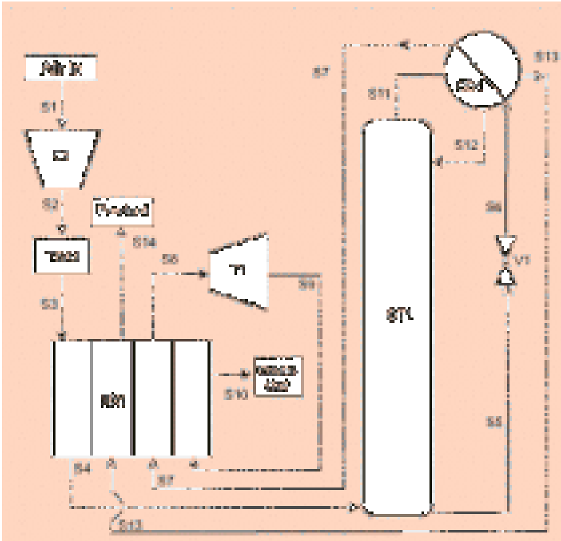
Description of Air Separation Processes

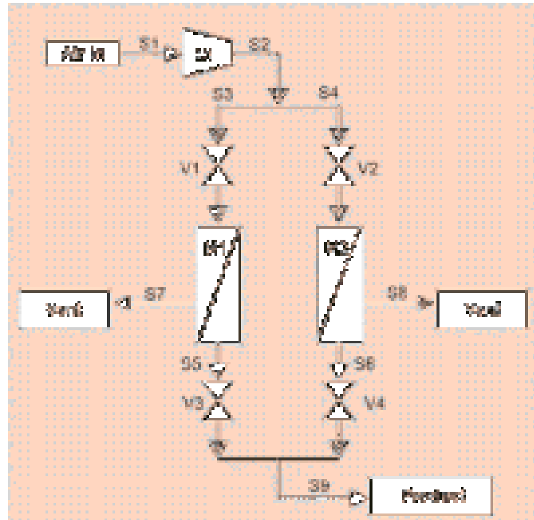
Dry air is composed of 78% nitrogen, 20% oxygen, 1% argon, and a remaining 1% that includes carbon dioxide, and many trace gases. Air separation processes take air input and isolate one or more of these components to within 95-99.99+% purity. Usually, either pure nitrogen or oxygen is produced. This web site focuses on processes that generate nitrogen; processes to generate oxygen are similar and are often combined with nitrogen processes. Although you may not know it, nitrogen is one of the most widely used gases in industry. Due to its inability to support combustion and its low oxygen and moisture content, nitrogen has a wide variety of uses in processes where safety and quality are an issue, including blanketing and freezing. For instance, even potato chip bags contain nitrogen instead of air because nitrogen avoids oxidation and acts as a natural preservative.

Historically, nitrogen has been generated by cryogenic distillation plants. One either had a distillation plant onsite, was part of a local pipeline delivery service, or received periodic shipments of nitrogen, usually in the form of liquid nitrogen. However, developments in the past twenty or so years have allowed for new methods of nitrogen supply, namely pressure swing adsorption (PSA) or membrane separation.

Cryogenic separation is a distillation process that occurs at temperatures around –170 C and a pressure of 8-10 atmospheres is required for this process. At this temperature, air exists in liquid and vapor phases. Before separation can occur, specific operating conditions that must be achieved. These conditions are achieved via compression and heat exchange; cold air exiting the column is used to cool air entering it. Nitrogen is more volatile than oxygen and comes off as the distillate product.

A cryogenic air separation plant is expensive and accommodates large feed and product flows; the distillation column is several stories high and must be well-insulated. Consequently, it only becomes economically feasible to separate air this way when a large amount is needed. Cryogenic separation is also capable of producing much purer nitrogen than either of the other two processes. A typical flow sheet for cryogenic distillation is given below.





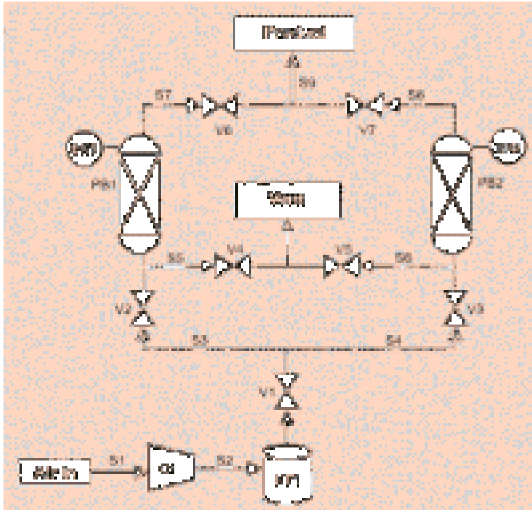
In contrast, membrane separation of air does not require a phase change. Based upon specific characteristics of each molecule, such as size and permeation rate, the molecules in air can be separated to form mostly pure forms of nitrogen, oxygen, or both. In a membrane system, there is a hollow tube filled with thousands of very thin membrane fibers. Each membrane fiber is another hollow tube through which air flows. The walls of the membrane fiber are porous and are specially made so oxygen molecules can permeate through the wall at a faster rate than nitrogen, allowing a nitrogen-rich stream to flow out the other end of the fiber. Meanwhile, the air outside the fiber, in the hollow tube, is now oxygen-rich and can be collected in the vent stream.

The purity of the nitrogen generated depends primarily on two factors: the flow rate and air pressure. At high pressure, oxygen molecules have greater incentive to permeate through the fiber wall. If our flow rate is slower, then oxygen has more time to permeate through the fiber wall. We can easily adjust both of these factors to allow a system operator to vary the amount and purity of the nitrogen generated in a very short amount of time.

Membrane processes are simple to install and operate but are limited to applications which do not require high purity nitrogen. A typical flow sheet for membrane processes is given above.

Finally, Pressure Swing Adsorption (PSA) units separate air using a special sieve that adsorbs oxygen preferably to nitrogen. When high-pressure air flows through the sieve, oxygen molecules are caught while nitrogen molecules pass on. The sieve continues to adsorb oxygen until a saturation point is reached. After that, the entering air stream is cut off and the oxygen is able to leave the tank at low pressure. In a PSA unit, several connected tanks, containing sieves, work together to produce a near continuous stream of nitrogen. When one tank becomes saturated and starts to release adsorbed oxygen, the entering air stream is switched to the other tank for oxygen adsorption.

PSA units are best used to produce nitrogen in low-volume situations. They have a very long lifetime, even in cold temperatures; the sieve is simply replaced a number of times a year. The units are also easy to install on-site for operations that need nitrogen on demand. However, PSA's main disadvantage occurs when large flow rates of nitrogen are needed and nitrogen becomes significantly cheaper to buy from a cryogenic source. A typical flow sheet for membrane processes is given below.



Description of Web Site

The air separation web site is divided into three modes. The most interesting web-based mode is an *interactive* one that uses a shockwave plug-in and contains a number of animations, calculators and downloadable files. This contains all of the material needed to explain basic processes for air separation, and also to develop a project for a capstone design course. In contrast, the simplest mode is a set of *html* documents that contain all of the text and most of the figures from the interactive version, but can be viewed quickly with basic browsing tools. Finally, a *guided tour* is provided that provides an overview of the interactive version and allows the user to discover the resources contained in the web site in a sequential manner.

In each of these modes, the web tool contains the following components:

- a qualitative description that allows the generalist to learn about air separation methods through text, pictures of actual plants and, for the interactive mode, shockwave animations,
- a detailed technical description of air separation processes that includes calculators and downloadable files for process modeling and simulation in the interactive mode,
- a systematic approach to design and evaluate processes for air separation. These include descriptions on selecting alternative flowsheets, mass and energy balances, sizing and costing, economic evaluation and also downloadable design reports in the interactive mode.

All sections contain a general overview and links to more detailed technical descriptions. In particular, the flowsheets include guides that trace the flowsheet and 'rollovers' that describe all of the major unit operations. Further information of all of these units is provided through further technical descriptions and interactive unit calculators. Moreover, the overall flowsheets can be evaluated using:

- ASPEN and Pro/II process simulation input files for cryogenic plants
- an Excel spreadsheet for membrane processes (based on a FORTRAN program from Dr. S. Auvil at Air Products)
- a calculator for PSA units based on correlated data (also from Dr. S. Auvil at Air Products)

In the design component, process features of the three technologies are contrasted and quantitative descriptions allow the user to choose a given technology for a particular set of specifications. Finally links are provided to major air separation suppliers for further information.

Acknowledgements

This tutorial would not be possible without the sponsorship and guidance of Dr. R. Agrawal of Air Products, Inc and Prof. A. Westerberg, design course advisor. I am especially grateful to the student teams who designed the web site: Michelle Armitage, Link Brown, Anne Devine, Trisha Dolsky, Debraj Ghosh, Paulien Herder, Mimi Huang, Ed Knittel, M. Scott Shell, Han Slootweg, Mike Slowik, Yoshiki Torii, Adam Turk and Alice Wu. It was a real pleasure to work with them. Finally, Anne Devine, Tim Drews, David Dunsavage, Heidi Eash, Michael Fenwick and Jennifer Moore are gratefully acknowledged for providing their senior design reports as downloads for the web site.

Enhancing the Process Control Laboratory with Generic, Multivendor Hardware, Software, and a Network

Peter Rony, Robert Rice and Jim Robertello, Virginia Tech University
and Karl Rony, Invensys Corporation

Introduction

Keeping a computer-based undergraduate laboratory up to date during the 1990s has seemed like an exercise in futility. Escalating software bloat requires larger hard drives, faster processors, and more robust operating systems. State-of-the-art, DOS-based, vintage-1991 controls hardware and software became obsolete by 1997, the replacement for which in turn will become obsolete by 2003. As an example of operating system (OS) software bloat, "In 1995, I could easily run a Window OS on a laptop with a meager 16 MB of RAM and a 500 MB hard drive (with room to spare). . . . Now, with Windows 2000, we have an OS that takes more than 60 MB of RAM and 700 MB of hard drive space just to install and run. It's full of wonderful things that 90 percent or more of users will never need or use." [1]

Our objectives here are (a) to introduce you to the advantages of Wonderware InControl and InTouch software and (b) to offer assistance to you (once you obtain Wonderware educational license) with examples of our InControl and InTouch programs and several Powerpoint student presentations that illustrate how our students communicated their laboratory results during our recent spring 2000 ChE 3016 laboratory course.

Evolution from Single-Vendor to Multivendor Control Systems

Table I illustrates the evolution from proprietary, single-vendor hardware and software components during the 1970s to generic, multivendor components during the 1990s. Even National Instruments' Labview, which is popular in academic laboratories, is characterized by proprietary — and quite expensive — I/O interface boards and associated I/O drivers. For the chemical process industries, an attractive solution to at least one obsolescence problem is the concept of software packages that are coupled via I/O software drivers to a variety of industry-standard I/O backplanes. Thus, the updating of computer-based process controls — whether in an industrial process or in an academic laboratory — with faster and more effective computer hardware and software no longer requires the replacement of a legacy I/O backplane and the re-wiring of hundreds of I/O connections.

Why Industrial Hardware/Software for Undergraduate Controls Labs?

A process controls laboratory is a useful respite from the mathematics -- Laplace transforms, block diagram algebra, equation linearization, and matrix manipulation — that characterize an introductory process controls course. Industrial process controls hardware and software are becoming simpler to install and configure. Students can,

- test process control skills by engaging in data acquisition;
- determine the operating curve, operating range, and operating point;
- obtain model parameters for an open-loop response curve;
- calculate and test an initial set of IMC tuning parameters;
- analyze a closed-loop response curve;
- "tweak" an initial set of tuning parameters to improve closed-loop performance; and
- make a higher-order system behave unstably during closed-loop operation.

Why Wonderware Instead of Labview?

An important comparison between Wonderware and Labview is illustrated Tables II and III. The key difference is simple: the availability of software drivers for (1) industrial automation systems versus (2) laboratory instrumentation. Wonderware software drivers are exclusively oriented to category (1), whereas Labview drivers are primarily oriented to category (2). Table II enumerates the variety of I/O backplanes for which software drivers are available from Wonderware; Over 600 software drivers are available from all vendors, including third parties. The problem facing the designer of a control system is the variety of I/O backplanes, even for a single vendor such as Allen-Bradley, GE Fanuc, or Siemens. Table III, which lists only Hewlett-Packard instrument drivers for Labview, contrasts with Table II.

Wonderware applications exist at more than 80,000 installations worldwide — the largest installed customer base in the industrial automation marketplace, representing a 35% share of the human-machine interface (HMI) market. FactorySuite ™ 2000 is a fully integrated suite of software for factory automation.

The Network is the Message

The Ethernet-networked laboratory experiment is an idea whose implementation during the 1990s has become quick, effective, and economical. SMC 10/100 BaseT Fast Ethernet adapter boards, Ethernet adapter cards for PCMCIA slots, and multiport 10/100 standalone hubs are all relatively inexpensive. Vendors of I/O backplanes, such as AutomationDirect.com — which we use — provide Ethernet modules to facilitate networking. To quote John McGilvreay [2], "Many industry experts believe Ethernet is poised to become the foundation for the next generation of industrial control networks."

In the Virginia Tech controls lab, with its local laboratory Ethernet network, we now have the ability to run any experiment from any of six Pentium workstations. We believe that Ethernet-based laboratory networks will become commonplace in both ChE research and undergraduate laboratories during the current decade. To paraphrase Marshall McLuhan, "the network is the message".

Ordering Wonderware Factory Suite 2000

The ordering information for the academic version of the Wonderware Factory Suite 2000 is straightforward: (a) Order part numbers 25-707D, 25-717D, and 10-510 as a combination (all three part numbers must be ordered); (b) The system will have a 12-month timeout; License files will need to be renewed annually but will incur no additional charge; (c) <u>You must be sponsored by a Wonderware distributor</u>; (d) The Comprehensive Support contract will cover all 21 systems at the university; (e) When renewing Comprehensive Support for Educational Systems, all 21 serial numbers must be listed on your purchase order; use part number 10-510R for renewal. Item 25-707D, $400 net, contains one FactorySuite 2000 Development system, including IndustrialSQL and MSSQL. Item 25-717D, $0 , contains 20 FactorySuite 2000 Development systems without MSSQL; students can utilize the SQL database on the Instructor's Consignment system. Item 10-510, $0, provides comprehensive support for the 25-707D and 25-717D systems, and must be renewed annually

Table IV summarizes the many CD-ROM discs that are included in the November 1999 update. The number of discs seems intimidating, but it should be kept in mind that only three discs are immediately useful for an undergraduate process controls laboratory: InTouch 7.1, InControl 7.1, and I/O Servers. InControl 7.1 is the key disc, namely, personal-computer-based real-time control software. InTouch 7.1 is a versatile process visualization package that allows one to create a human-machine interface (HMI). I/O Servers is a disc that contains the software drivers summarized in Table II. At Virginia Tech, we have not yet tested InBatch 7.1, IndustrialSQL Server 7.1, or the Web Server for Internet Visualization. Nor have we depended upon the Introduction and Pre-Course Tutorial discs to learn how to program the Wonderware software.

Installing Wonderware Factory Suite 2000

Installation of both InControl and InTouch is straightforward. The installation of version 7.1 is slower than earlier versions on Windows NT 4.0. As of March 2000, Windows 2000 is not yet supported with a marketed version of the Wonderware software. InTouch is first installed followed by the installation of InControl. The order of these two program installations is important. Windows NT 4.0 with Service Pack 5.0 is a requirement for Wonderware version 7.1. An InTouch HMI is not necessary to run a lab experiment; the HMI is simply "frosting on the cake" that provides an intuitive, animated, and colorful, user interface for students. From our experience during the Spring 2000 semester, an effective human interface greatly facilitates student lab performance.

An InControl program is called a "project", which contains a group of files that are executed together. An example group of project files, for project OPAMP-1, is shown in Figure 1. A variety of programming capabilities are provided to a user, including relay ladder-logic (RLLs) programs, sequential function charts (SFCs), structured-text language programs (STLs) that resemble Pascal programming, symbol files, watch windows (WCH), and preprogrammed factory object files (FOE) such as the PID Control object. Even text files (TXT) are allowed in order to provide local documentation.

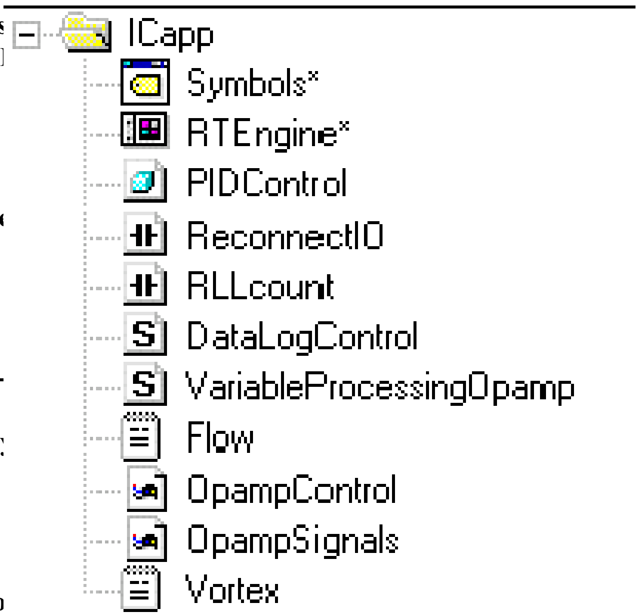


Figure 1. Files associated with the project, OPAMP-1 .

Table I. Evolution from Single-Vendor to Multivendor Control Systems

CATEGORY	1980	1990 Texas Instrument TI545	2000 Labview	2000 Wonderware
Processor	Single-Vendor	Generic	Generic	Generic
Processor Instruction Set	Single-Vendor	Generic	Generic	Generic
Processor Assembly Language	Single-Vendor	Generic	Generic	Generic
Mathematical Co-Processor	Not Available?	Generic	Generic	Generic
Operating System	Single-Vendor	Single-Vendor	Generic	Generic
Algorithm Computation Software	Single-Vendor	Single-Vendor	Single-Vendor	Multi-Vendor
Human/Machine Interface (HMI)	Single-Vendor	Single-Vendor	Single-Vendor	Multi-Vendor
I/O Backplane	Single-Vendor	Generic	Generic	Multi-Vendor
I/O Interface Boards	Single-Vendor	Single-Vendor	Single-Vendor	Multi-Vendor
I/O Software Drivers	Single-Vendor	Single-Vendor	Single-Vendor	Multi-Vendor
Network Interface Board	Not Available?	Single-Vendor	Generic	Multi-Vendor
Network Software	Not Available?	Single-Vendor	Generic	Multi-Vendor
Network Software Drivers	Not Available?	Single-Vendor	Multi-Vendor	Multi-Vendor
Computer Housing	Single-Vendor	Single-Vendor	Multi-Vendor	Multi-Vendor
Other Application Software	Single-Vendor	Single-Vendor	Single-Vendor	Multi-Vendor

Table II. Wonderware I/O software drivers for industrial automation systems.

Allen-Bradley KTX	PCDIO
Allen-Bradley 1784-KT V5.5	Profibus
Allen-Bradley Ethernet Direct V7.1.0.3	Reliance AutoMate Serial V7.0.0.5
Allen-Bradley Serial V7.0.0.6	Reliance AutoMax PC Link V7.1.0.0
Aquatrol 1500 MODBUS V4.5	Reliance AutoMate R-Net Direct Link V7.0.0.4
AutomationDirect.COM	Serial I/O
DeviceNet	Siemens/Texas Instruments 305/405 CCM V4.5
Fisher ROC V5.5	Siemens/Texas Instruments 405 MODBUS V4.5
GE Fanuc CCM2 V7.0.0.2	Siemens 3964R V5.5
GE Fanuc Genius V5.5	Siemens SIMATIC NET S7 V7.0.0.3
GE Fanuc Host Communications (HCS) V7.0.0.2	Siemens SIMATIC TI CVU TIWAY V7.0.0.3
GE Fanuc Series 90 Protocol V7.0.0.3	Siemens SIMATIC TI Direct V7.0.0.4
GE 90/30	Siemens SIMATIC TI TIWAY V7.0.0.2
GE Genius	Siemens SINEC H1 V5.5
Interbus-S	Siemens SINEC H1 CP 1413 V7.1.0.1.
JBUS V5.5	Siemens SINEC L2 FDL V5.5a
Mitsubishi A-Series V7.1.0.8	Siemens SINEC L2 FDLA2 V5.5
Modicon Ethernet V7.0.0.15	Squard D SY/LINK V7.1.0.1
Modicon MODBUS V7.0.0.12	Square D SY/MAX Point-to-Point V7.1.0.0
Modicon MODBUS Plus V5.6	S-S Technologies 5136-SD V5.5
OMRON Host Link V7.1.0.2	Telemecanique Xway V5.5
OMRON SYSMAC NET V7.0.0.3	
Opto22	

Industrial Contributors to CACHE

AEA/Hyprotech	Fluent Inc.
Air Products and Chemicals	Merck & Company
Aspen Technology	Mobil Technology Company
Dupont	Parke-Davis
Eastman Chemical Company	Union Carbide

Table III. Labview Instrument Drivers for Hewlett-Packard Instruments

Driver	Instrument	Filename
E1326A	5.5-Digit Multimeter	hpe1326a.llb
E1328A	4-Ch. D/A Converter	hpe1328a.llb
E1330A/B	Quad 8-bit Digital I/O	hpe1330.llb
E1333A	3-Ch. Universal Counter/Timer	hpe1333a.llb
E1340A	Arbitrary Function Generator	hpe1340a.llb
E1345A	16-Ch. Relay MUX	hpe1345a.llb
E1346A	48-Ch. Single Ended Relay Matrix	hpe1346a.llb
E1347A	16-Ch. Thermocouple Relay MUX	hpe1347a.llb
E1352A	32-Ch. Single Ended FET MUX	hpe1352a.llb
E1355A	8-Ch. 120 Ohm Strain Gauge Relay MUX	hpe1355a.llb
E1356A	8-Ch. 350 Ohm Strain Gauge Relay MUX	hpe1356a.llb
E1410A	6.5-Digit Multimeter	hpe1410a.llb
E1411A	5.5-Digit Multimeter	hpe1411a.llb
E1416A	Power Meter	hpe1416a.llb
E1420A/B	Universal Counter	hpe1420a.llb
E1426A	500 MHz Digitizing Oscilloscope	hpe1426a.llb
E1428A	1 GSa/s Digitizing Oscilloscope	hpe1428a.llb
E1429A/B	20 MSa/s 2-Ch. Digitizer	hpe1429.llb
E1440A	21 MHz Function/Sweep Generator	hpe1440a.llb
E1445A	Arbitrary Function Generator	hpe1445a.llb
E1446A	Summing Amplifier/DAC	hpe1446a.llb
E1460A	64-Ch. Relay MUX	hpe1460a.llb
E1463A	32-Ch. 5-Amp Switch	hpe1463a.llb
E1465A	16 by 16 Relay Matrix	hpe146xa.llb
E1466A	4 by 64 Relay Matrix	hpe146xa.llb
E1467A	8 by 32 Relay Matrix	hpe146xa.llb
E1468A	8 by 8 Matrix Switch	hpe1468a.llb
E1469A	4 by 16 Matrix Switch	hpe1469a.llb
E1472A	50 Ohm RF MUX	hpe1472a.llb
E1473A	50 Ohm RF MUX Expander	hpe1472a.llb
E1474A	75 Ohm RF MUX	hpe1474a.llb
E1475A	75 Ohm RF MUX Expander	hpe1474a.llb
E1476A	64 Channel Thermocouple Relay MUX	hpe1476a.llb hpe1476s.llb
E1740A	150 MHz Time Interval Analyzer Card	hpe1740a.llb

Table IV. Wonderware FactorySuite 2000 CD-ROM Discs, Version 7.1.

Version 7.1 Introduction

InTouch 7.1 Process Visualization

InControl 7.1 PC-Based Real-Time Open Control

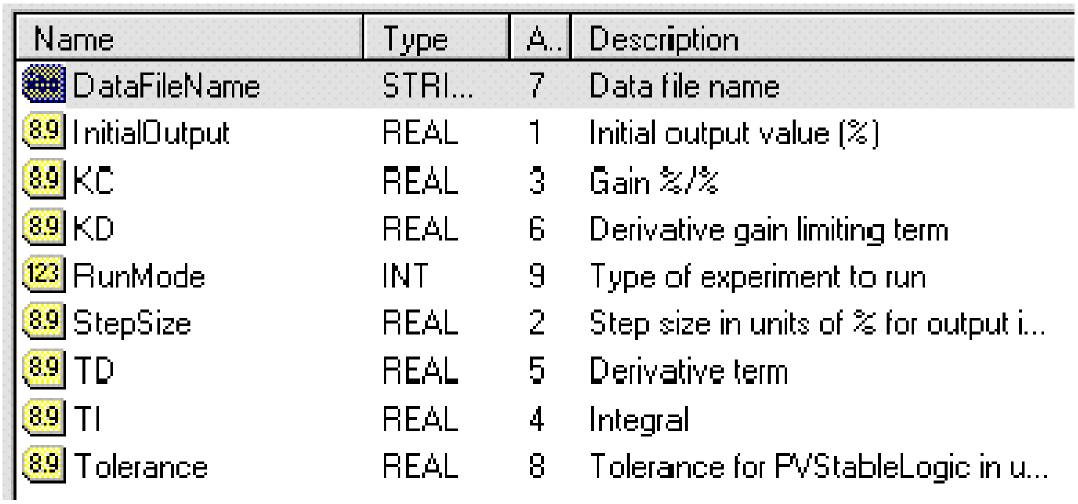
Pre-Course Tutorials

InBatch 7.1 Flexible Batch Management

IndustrialSQL Server 7.1 Real-Time Plant Data Management

I/O Servers

FactorySuite Web Server Internet Visualization



Name	Type	A...	Description
DataFileName	STRI...	7	Data file name
InitialOutput	REAL	1	Initial output value (%)
KC	REAL	3	Gain %/%
KD	REAL	6	Derivative gain limiting term
RunMode	INT	9	Type of experiment to run
StepSize	REAL	2	Step size in units of % for output i...
TD	REAL	5	Derivative term
TI	REAL	4	Integral
Tolerance	REAL	8	Tolerance for PVStableLogic in u...

Figure 2. Experimental Parameter Symbols file.

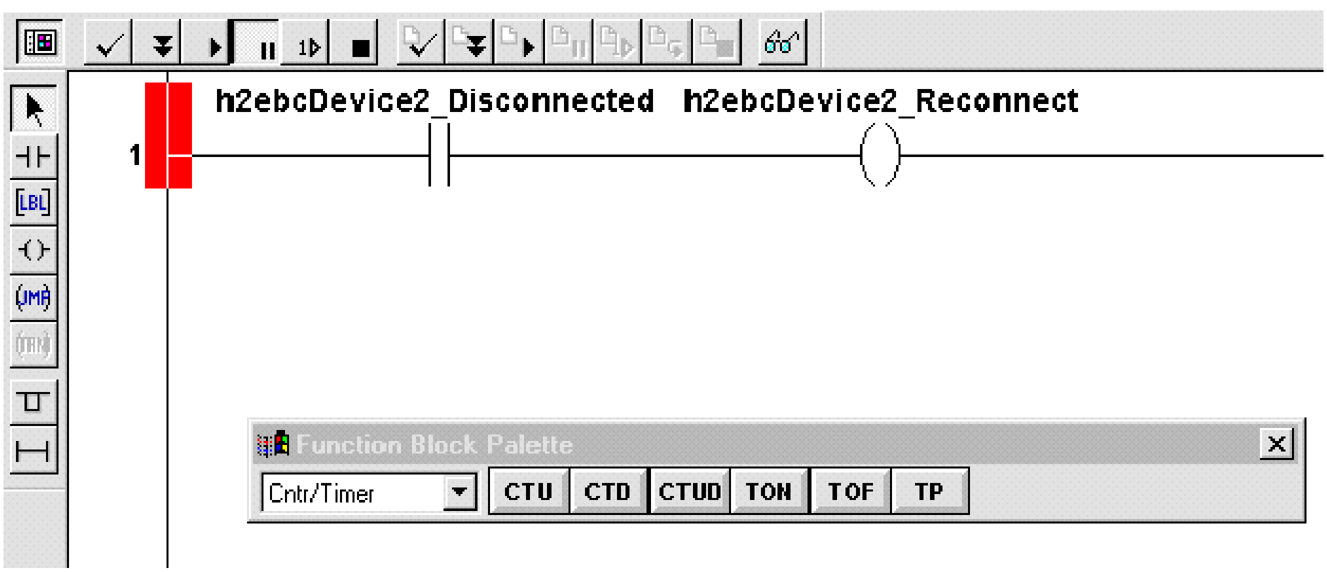


Figure 3. The Reconnect RLL file.

```
(* Store data to a file using the simple file operations of InControl. *)

(* Initialization *)
DataLogTimer.EN := TRUE;
DataLogTimer.PT := LogInterval;

(* Set Logging control presidence of StartLogging/Logging/StopLogging *)
If ( StopLogging ) then
    Logging := FALSE;
    StartLogging := FALSE;
END_IF;
If ( Logging ) then
    StartLogging := FALSE;
END_IF;

(* Start logging to the file defined in the global symbol DataFileName. *)
If ( StartLogging and not( DataLogFCB.open )) then
    (* Create a new file *)
    NEWFILE( DataLogFCB, ExperimentParameters.DataFileName );

    (* If the file couldn't be created *)
    IF ( DataLogFCB.EFLAG ) THEN
        MSGWND( "Unable to create the data file", "New File Error" );
```

Figure 4. Top portion of the Data Log Control STL file.

For examples of such files, please see Figures 1 through 6. The Symbol files are the most important since the "strongly-typed" InControl programming environment requires all symbol types to be explicitly defined before they are used in STL programs, RLL and SFC programs, and Watch Windows during execution.

```
(* Normalize PV, SP, and Output *)
NormalizedPv := (( PIDControl.Pv - PIDControl.PvEuLo ) / ( PIDControl.PvEuHi - PIDCo
NormalizedSp := (( PIDControl.Sp - PIDControl.SpLo ) / ( PIDControl.SpHi - PIDContro
NormalizedOut := PIDControl.Out / 100.0;
NormalizedPvPercent :=  NormalizedPv * 100.0;
NormalizedSpPercent :=  NormalizedSp * 100.0;
NormalizedOutPercent := PIDControl.Out;
ProportionalGain := PIDControl.Kc;
IntegralTime := PIDControl.Ti;
```

Figure 5. Variable Processing Opamp STL file.

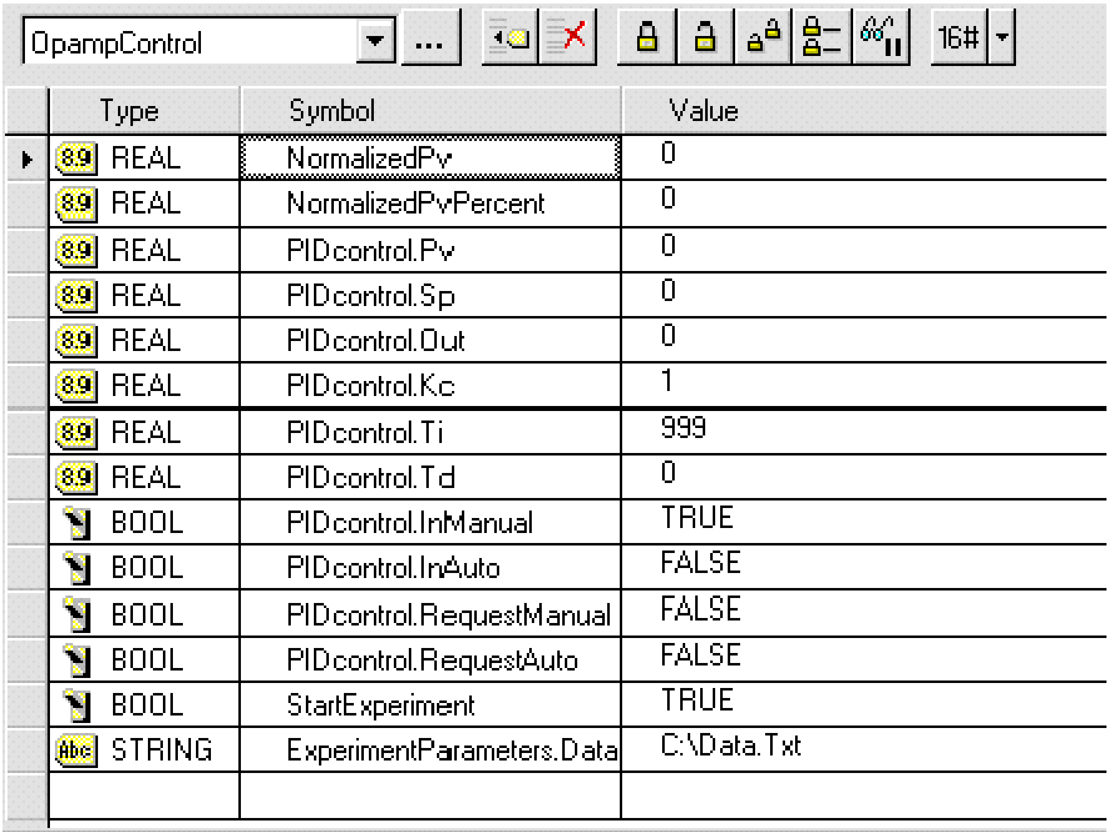


Figure 6. OpampControl Watch Window file.

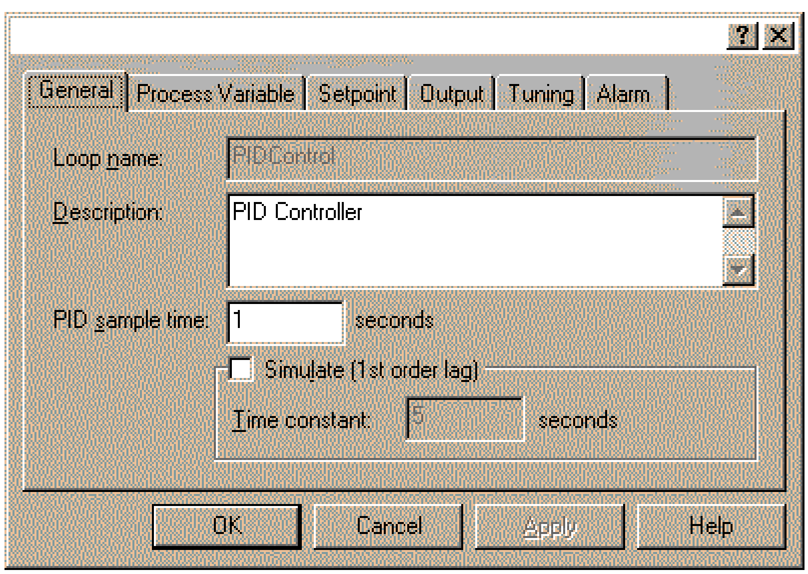


Figure 7. Preprogrammed PID Control factory object (*.foe) file.

Wonderware InTouch offers two capabilities: (1) WindowMaker, which permits you to configure a human-machine interface (HMI), complete with colors and animation; and (2) WindowViewer, which permits an operator to use the HMI for the control of a plant. InTouch is a mature product that has been extremely successful in industry; its commercial use preceded InControl by at least 8 years.

Figure 8 illustrates the animated, colored experimental apparatus for the OPAMP-1 experiment, which contains four cascaded, first-order operational amplifiers (and thus is a robust fourth-order system that readily exhibits closed-loop instability). Figure 10 demonstrates how we have adapted OPAMP-1 to another experiment, VORTEX. Observe in Figures 8 through 10, (a) the data logging section, which permits filename and path identification, the viewing of file data, the ability to start and stop data logging, and animation (not shown) of the data logging process in action; (b) the hidden PID controller window {Figure 9), which permits the setting of PID tuning parameters, the value of the setpoint, and the mode (Auto or Manual) of controller operation; (c) the trend chart section, which permits the display of the PV, SP, and MV as a function of time, and the setting the limits for the signal and time axes; and (d) the process animation section, which includes the ability to set or monitor the SP, MV, and PV.

It is important to emphasize that, during the spring 2000 semester, we have standardized both the InControl and InTouch programs among six different experimental systems in the junior-ChE controls laboratory. The significant differences between the experiments are (a) the input I/O module (either Voltage or thermocouple inputs); (b) the process variable and setpoint engineering units and ranges; (c) the symbol names for the input PV signal; and (d) the depicted experimental apparatus on the user interface. Standardization provides significant benefits to the conduct of experiments in the laboratory: students develop skills in using the interface, and are able to complete data acquisition and analysis tasks during a lab afternoon more quickly as the semester progresses, even if the nature of the experiment changes from week to week.

All of our six experiments are oriented toward "short" time constants (< 10 seconds), which permits rapid data acquisition. Our junior ChE students must make repeated runs and both successfully acquire and partially analyze laboratory data within a period of three hours during a weekday afternoon. With the exception of the PYRO experiment, which we purchased for $2000 from Dow Chemical Co., the remaining experiments were developed from scratch by students. Some of our experiments have proven their robustness and fast data acquisition rates throughout many years of use, during a period of time that has witnessed successive technology transitions from (1) microcomputer trainers and chart recorders; to (b) early IBM PCs; to (c) Leeds & Northrup, Robertshaw, and YEW single-loop microprocessor-based controllers; to (d) Metrabyte Corporation data acquisition boards, Tutsim real-time software, and the DOS operating system; to (e) Texas Instruments TI545 programmable logic controllers, Application Productivity Tool (APT) software, the DOS operating system, and IBM 486DX computers, and finally to (f) AutomationDirect.com I/O backplanes, Wonderware InControl and InTouch software, the Windows NT4.0 operating system, and Pentium computers.

PowerPoint-based files — converted to Adobe Acrobat PDF files — are available for downloading on the web site www.chemeng.com [3]. These files include both tutorials concerning how to use Wonderware software and also examples of student work (Powerpoint-based oral presentations).

The interesting fact is that, during the transition from 1970s-vintage chart recorders to Wonderware data file recording, the communication emphasis in the lab has changed from a situation where data was scarce and analyzed in crude ways to a situation today where data is abundant and is analyzed by sophisticated software tools such as Doug Cooper's (University of Connecticut) Control Station Design Tools [4] as well as Microsoft Excel. As a consequence, the quality of the group laboratory reports has improved substantially between 1978 and 2000.

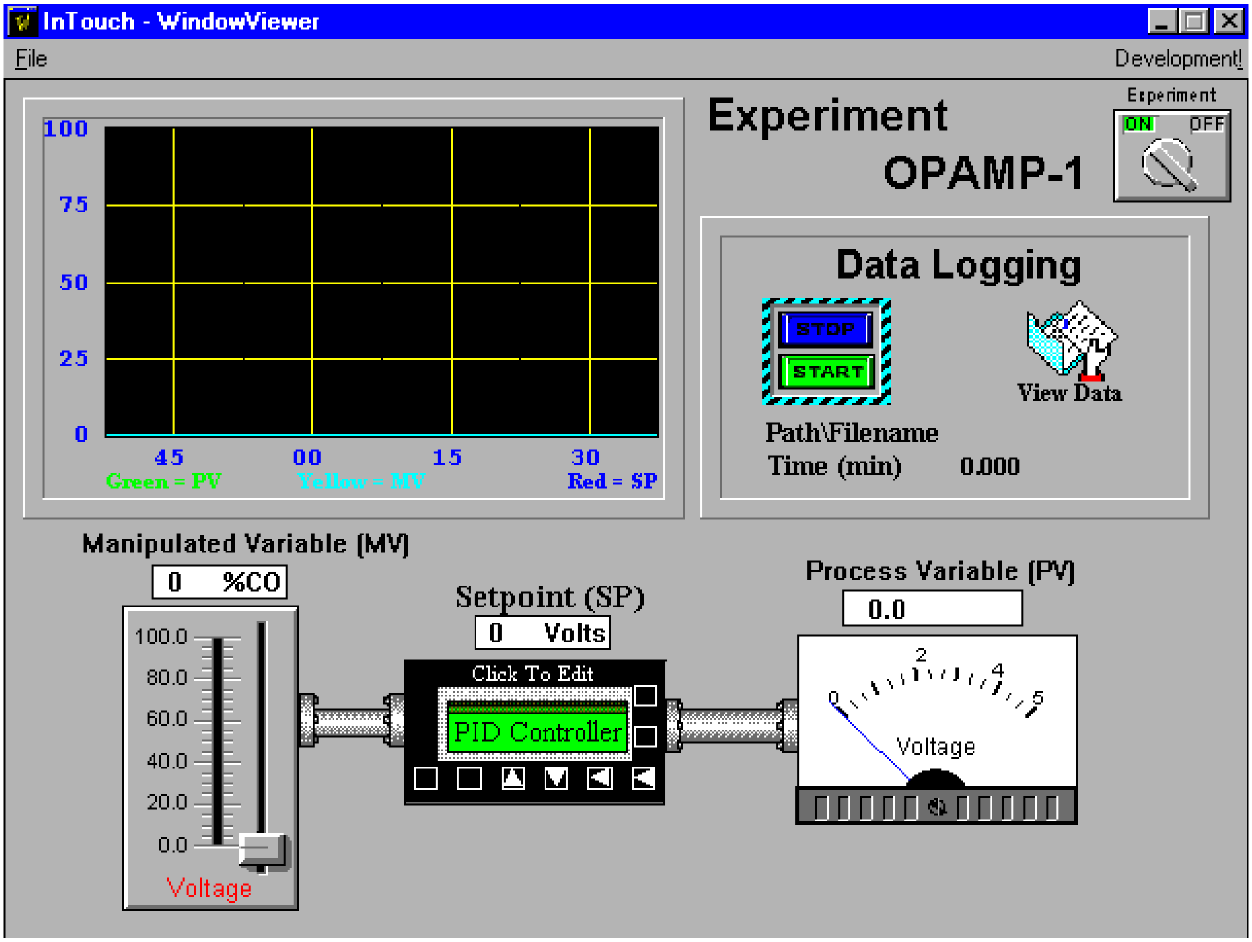


Figure 8. Animated InTouch human/machine interface (HMI) for project OPAMP-1, which is based upon a quad operational-amplifier integrated circuit with four, cascaded adjustable first-order time constants.

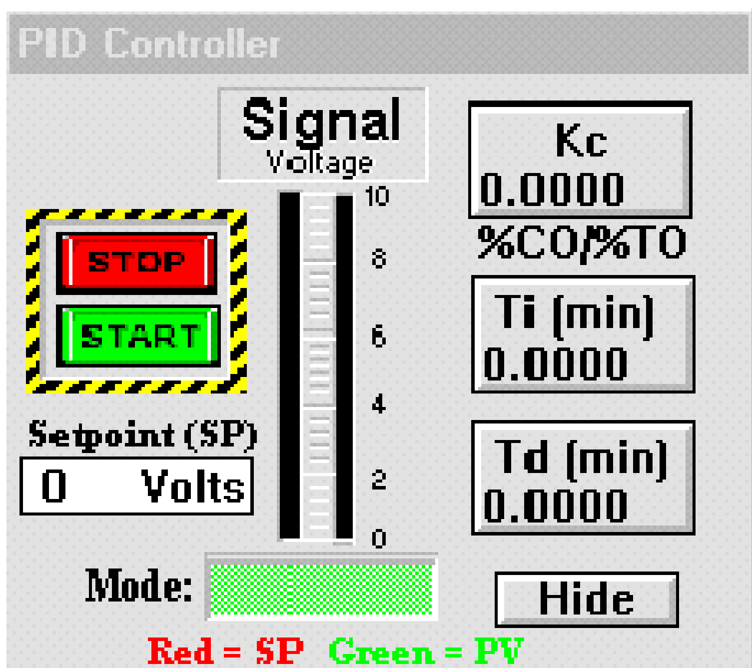


Figure 9. InTouch PID Controller pop-up window for project OPAMP-1.

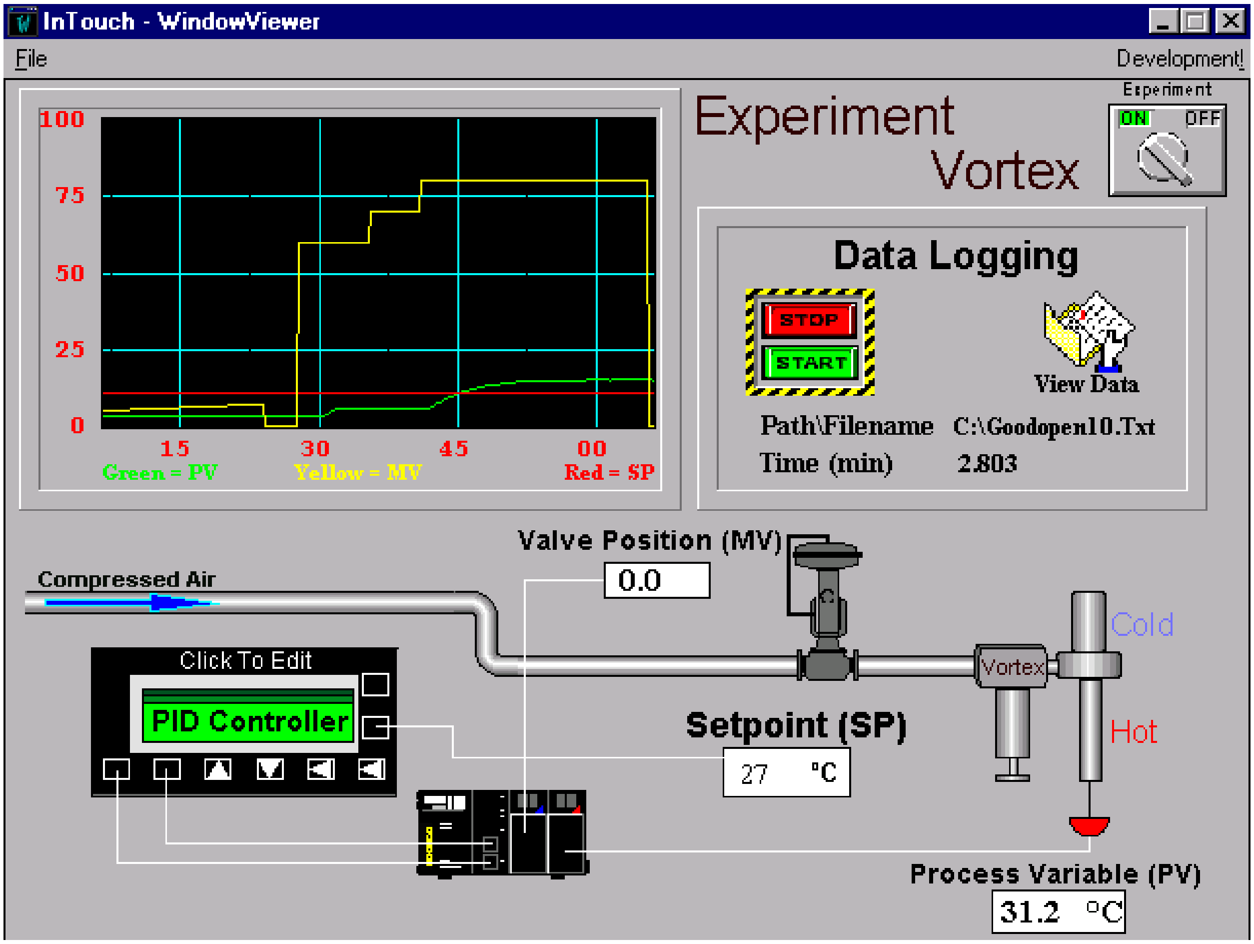


Figure 10. Animated InTouch human/machine interface (HMI) for project VORTEX, an experiment based upon the use of a small vortex tube.

References

1. Professor Alan Hedge [Director, Human Factors and Ergonomics Laboratory, Cornell University, Dept. of Design & Environmental Analysis, Ithaca, NY], Letter to the Editor, PC Week 17 (11), March 13, 2000, p. 60.

2. John McGilvreay [2] "The Ethernet Decision", Industrial Computing, February 2000, pp. 16-18.

3. The domain name, chemeng.com , was registered by Peter Rony in December 1995 as a possible site for archiving and distributing chemical engineering related information.

See Doug Cooper's web site at http://www.engr.uconn.edu/control/workbook.html .

Glossary

I/O — Input/Output.
I/O Backplane —The set of metallic interconnections that allow input/output modules or boards to communicate digital signals among each other
Bus — A path over which digital information is transferred, from any of several sources to any of several destinations. Only one transfer of information can take place at any one time. While such a transfer is taking place, all other sources that are tied to the bus must be disabled.
OS — Operating system.
Generic — Standardized in the computer or controls industry; commercial products provided by multiple manufacturers.
Multivendor — Several different manufacturers provide the indicated hardware or software, or both.
Single-Vendor — Only a single manufacturer provides the indicated hardware or software, or both.

FIRST ANNOUNCEMENT

Sixth Conference on Chemical Process Control (CPC-6)

Westward Look Resort
Tucson, Arizona

January 7-12, 2001

Chemical Process Control 6 (CPC-6), sponsored by the CAST Division of AIChE and CACHE Corporation, is the sixth in a series of international conferences held every five years to address the current and future directions of chemical process control research and practice. The conference is intended to provide a forum for the interaction between engineers and scientists from academia, industry, and government to assess promising new research directions, technology development, and application of chemical process control.

Sessions

The following is a tentative sessions list. Titles may change before the final announcement.

- Controller performance monitoring
- New and emerging tools from control theory
- Process modeling and identification
- Hybrid discrete and continuous systems
- Chemical reactors and separators
- Applications in the life sciences
- Poster session for contributed papers
- Summary session: issues in the emerging researcher, manufacturer, vendor triangle

Intended Audience

The CPC conference is an international conference attracting participants from North and South America, Europe and the Pacific Rim. In order to achieve the meeting goals, the number of attendants will be limited to approximately 150. Based on previous CPC meetings, we expect 50-75% industrial attendees and the remaining attendees from universities.

Format

In the tradition of CPC conferences, speakers will be selected and all oral presentations will be invited. A poster session will be available for submitted contributions.

Number of Participants

100-150 attendees expected (approximately 130 people attended CPC 5).

Goals

The goals of the CPC conference series are to:

1. Gain an appreciation of the state of process control practice in industries currently or potentially employing and supported by process control engineers and chemical engineers with systems backgrounds.

2. Present tutorial overviews for nonspecialists in each of the important areas of systems and control theory, particularly emerging and new areas.

3. Provide a forum for in-depth discussions between university researchers, industrial practitioners and commercial control technology vendors.

4. Provide practitioners and vendors with a current understanding of the new and significant tools emerging from the research community in order to stimulate wider implementation.

5. Provide a forum for assessing promising research directions for the next decade. Assess needs and challenges in the process industries, as well as evaluate opportunities for increased activity and application in non-traditional industries.

Latest details: http://www.che.wisc.edu/cpc-6/

Co-Chairs

James B. Rawlings
Department of Chemical Engineering
University of Wisconsin
Madison, Wisconsin

Babatunde A. Ogunnaike
DuPont Company
Wilmington, Delaware

Organizing Committee

Frank Allgower	Derrick Kozub
B. Wayne Bequette	Jay H. Lee
Lorenz T. Biegler	Jorge Mandler
Francis J. Doyle	Wolfgang Marquardt
James J. Downs	Thomas J. McAvoy
Thomas F. Edgar	Manfred Morari
J. Brian Froisy	Kenneth R. Muske
Christos Georgakis	Ahmet N. Palazoglu
Vince Grassi	Stephen Piche
Iori Hashimoto	Sigurd Skogestad
Rob Hawkins	Robert E. Young

Conference registration information will be provided in a second accouncement.

Contributed Papers

Contributed papers are invited that discuss novel contributions to chemical process control emerging from both the academic and industrial communities, opportunities for research and application in non-traditional industries, and the state of chemical process control technology and practice. All contributed papers will be presented at the conference during a poster session and published in the conference proceedings.

To submit a contributed paper to the conference, send four copies of the complete manuscript along with corresponding author contact information (postal address, phone, fax, and email) by postal mail to the poster session chair. Submissions should be received by July 31, 2000. Note that all contributed papers will be allotted 5 pages in the conference proceedings. Submissions that exceed this limit may not be considered. To facilitate manuscript preparation, typesetting instructions and a LaTeX style file are available from the conference web site: (http://www.che.wisc.edu/cpc-6/).

Contributed papers will be selected for inclusion in the poster session and the conference proceedings by a review panel based on reviews of the submitted manuscripts. Notification of selection will be made by October 15, 2000. The manuscript deadline for the conference preprints is December 1, 2000.

Schedule Summary

Jul 31, 2000	Contributed paper manuscript submissions due
Oct 15, 2000	Author notification
Dec 1, 2000	Manuscript deadline for conference preprints
Jan 7-12, 2001	CPC-6 Conference
Mar 1, 2001	Manuscript deadline for final conference proceedings

Chair

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