

Interdisciplinary Curriculum and Laboratory Development for Chemical Process Operator Technology Education

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Abstract

Delaware's chemical industries are critical to the state's economic viability and require technicians entering their workforces to have greater academic knowledge and laboratory-based experiences related to current and future job responsibilities. To meet this community need Delaware Tech has initiated a new Associate Degree in Chemical Process Operator Technology. Delaware's major chemical companies have played a key role in designing the new curriculum, which includes broad preparation in mathematics, chemistry, physics, and a range of courses with direct application to the operation of several different types of chemical plants. The Chemistry Department is developing the program in cooperation with faculty in other A.A.S. disciplines, including mechanical engineering technology, industrial plant maintenance technology, and process instrumentation technology. A July 1999 National Science Foundation award is enabling the College to implement its new Chemical Process Operator Technology curriculum that is adapted from the American Chemical Society's *National Voluntary Industry Standards for Chemical Process Industries Technical Workers*. The adaptation involves consideration of local industry needs. The NSF grant is also helping to equip four state-of-the-art laboratories for integrated use in Chemical Process Operator Technology, Mechanical Engineering Technology, Industrial Plant Maintenance Technology, and Process Instrumentation Technology. Laboratory equipment that is planned for the new computer simulation, mechanical systems, process instrument, and unit operations laboratories will be highlighted. Overall program goals are to implement an A.A.S. Degree in Chemical Process Operator Technology, to enhance related A.A.S. Degree courses, and to work with an Industry Advisory Committee of local chemical industry representatives to ensure that the associate degree curriculum and new laboratories meet industry, American Chemical Society, and TAC-ABET standards.

I. Introduction

The State of Delaware has a critical need for high quality advanced education in chemical engineering technology. The chemical industry, which is a major part of the state's economy, is very diverse with businesses ranging from pharmaceuticals, to specialty and commodity chemicals, to large scale processing of plastics and petroleum products. With the rapid modernization of the chemical industry, these companies require technicians entering their workforces to have greater academic knowledge and laboratory-based experiences related to current and future job responsibilities. In addition, these firms will need trained candidates to replace expected retirees estimated at 50% of current workforces over the next three to five years.

To meet this community need, Delaware Tech initiated a new Associate Degree in Chemical Process Operator Technology in 1999.. The program was developed after in-depth needs assessments were conducted through surveys and meeting with local chemical industry representatives. An Industry Advisory Committee has provided key input in the design of the new curriculum, which includes broad preparation in mathematics, chemistry, physics and a range of courses with direct application to the operation of several different types of chemical plants.

Industry Advisory Committee

Ciba Specialty Chemicals
DuPont
FMC
Metachem Products
Noramco
Oxychem
Rodel
Uniqema

A July 1999 National Science Foundation award¹ is enabling the College to implement its new Chemical Process Operator Technology curriculum. In addition, the NSF grant is helping to equip four state-of-the-art laboratories for integrated use by other associate degree disciplines, including mechanical engineering technology, industrial plant maintenance technology, and process instrumentation technology.

II. Interdisciplinary Partnership

The Chemistry Department in cooperation with the Industrial Training Division, the Mechanical Engineering Technology Department, and the Electronics/Electrical Engineering Technology Department is directing the curriculum and laboratory development effort. The new Chemical Process Operator Technology program is being developed concurrently with improvements in these other associate degree programs, which are sharing the use of the state-of-the-art laboratory equipment and facilities. Sharing of laboratories is relevant to the design of the Chemical Process Operator Technology program since the three other technology disciplines are integral parts of the Chemical Process Operator curriculum. The new laboratories will give all four cooperating technology programs new opportunities for hands-on, industry-based, problem-solving experiences.

III. Curriculum Development

The new Chemical Process Operator Technology curriculum is industry focused and job relevant. It is based on the American Chemical Society's *National Voluntary Industry Standards for Chemical Process Industries Technical Workers*² and is consistent with the Standards of the Technology Accreditation Commission of the Accreditation Board for Engineering and

Technology (TAC-ABET)³. The curriculum⁴ includes ten existing courses plus nine new courses that are under development for a total of 65 credit hours.

Existing Courses

College Math & Statistics
Computer Applications
Conceptual Physics
Composition
Industrial Psychology

General Chemistry
SPC Overview
Process Instrumentation
Technical Writing & Communications
Social Science Elective

New Courses

Intro to Chem. Proc. Tech.
Safety, Health, & Environment
Chemical Process Technology I
Mechanical Systems
Electricity & Instrumentation
Chemical Process Technology II
Basic Organic Chemistry
Chemical Process Technology III
Internship

Schedule

Fall 1999
Fall 1999
Spring 2000
Fall 2000
Fall 2000
Spring 2001
Spring 2001
Fall 2001
Spring 2002

Most of these courses have laboratory requirements to provide hands-on experiences for the students. To provide the needed facilities, four new laboratories are being built and outfitted with state-of-art equipment. Construction of the new laboratory building is scheduled for completion in the Fall 2001.

New Laboratories

Computer Process Simulation Laboratory
Mechanical Systems Laboratory
Process Instrument Laboratory
Unit Operations Laboratory

Courses in Mechanical Engineering Technology, Industrial Plant Maintenance Technology, and Process Instrumentation Technology are also being updated to utilize the capabilities of these new laboratory facilities.

IV. Computer Process Simulation Laboratory

The Computer Process Simulation software⁵ is an interactive, dynamic, real-time process simulator that runs on a standard personal computer network. The dynamic simulator emulate a Distributed Control System used by modern chemical plants to electronically run processes. We have procured seven sets each of 23 standard process models that simulate many of the basic

unit operations found in chemical plants and petroleum refineries. A partial listing of the modules include pumps, mix tank, heat exchanger, flash tank, distillation, instrumentation, steam boiler, pH control, and batch reactor. The simulators will permit the students to start-up, shutdown, and troubleshoot operating problems with the realism of an actual process unit. Primary benefits of the simulator-based training include increased knowledge retention, improved troubleshooting skills, faster response time, and better understanding of plant standard operating procedures. Further, the simulators are a proven method of transferring knowledge and skills that should enable the students to safely operate complex chemical processes.

V. Mechanical Systems Laboratory

The following trainers⁶ were purchased for the Mechanical Systems Laboratory in the Spring 2000:

- Centrifugal pump cutaway
- Pump cavitation demonstrator
- Reciprocating compressor cutaway
- Steam trap cutaway assortment
- Valve cutaway assortment

Centrifugal Pump Cutaway

This sectioned industrial centrifugal pump allows training in the operation, construction, and maintenance of this common piece of process equipment. Internal configuration of the pump is highlighted by cutaway areas and color-coding.

Pump Cavitation Demonstrator

This device allows for the demonstration of pump cavitation and the effect of the variation of static head and piping configuration on flow and pressure.

Reciprocating Compressor Cutaway

This demonstrator depicts a typical double-acting, reciprocating, crosshead-type compressor. The unit includes simulated motion and can be completely disassembled.

Steam Trap Cutaway Assortment

This four-piece cutaway assortment allows for training in maintenance, use, and selection of common steam traps. Through cutaways and color-coding the complex internal configurations are more easily understood.

Valve Cutaway Assortment

Cutaways of eight types of valves commonly used in chemical plants permit training in operation, construction, and maintenance. Seal features and hardware locations allow for hands-on exercises.

VI. Process Instrument Laboratory

The following trainers⁶ were procured for the Process Instrument Laboratory in the Spring 2000:

- Flow, level, and pressure process control trainer
- Temperature process control trainer
- PID trainer

Flow, Level, and Pressure Process Control Trainer

This trainer is used to teach process measurement and control fundamentals relating to flow, level, and pressure applications. It is a realistic, working fluid process system designed for hands-on training. In addition, the trainer allows control loops to be configured employing feedback, feed forward, and cascade control methods. Variable demand and supply disturbances can be inserted using solenoid valves in combination with metered ball valves.

Temperature Process Control Trainer

This trainer is used to teach process measurement and control fundamentals relating to temperature applications. It is a working fluid process utilizing a shell-and-tube heat exchanger to vary process variables. The device allows control loops to be configured employing feedback and feed forward control methods, using thermocouple inputs.

PID Trainer

This trainer provide basic control training using a simulated level control application and a generic process controller. It permits training of technicians in the use of controllers in both manual and automatic mode. The controller display illustrates the major sections of a common controller, including the proportional, integral, and derivative amplifiers and the manual output. Indicators permit the student to see the affect that a change in controller output has on the process variable being controlled.

VI. Unit Operations Laboratory

The following trainers⁷ will be acquired for the Unit Operations Laboratory during 2001:

- Batch Distillation Unit
- Fluid Flow Unit
- Liquid/Liquid Extraction Unit
- Heat Transfer
- Absorption

Batch Distillation Unit

The distillation unit comprised an 80 mm diameter by 1500 mm long packed column, 20 liter reboiler, reflux ratio controller, and distillate receiver. All components are manufactured from borosilicate glass to permit students to observe the internal functions of the batch rectifier. A methanol/water mixture will be used in experiments to provide hands-on training in process and quality control.

Fluid Flow Unit

The fluid flow unit is designed to study the operation of valves and flow meters and the pressure loss characteristics of pipeline fittings. The equipment consists of three test circuits. Circuit one contains lengths of smooth and rough pipe and several pipeline fittings to allow determination of pressure loss at various flow rates. Circuit two contains four valves and permits pressure drop and valve characteristics to be evaluated. Circuit three contains venturi and orifice meters that demonstrate the relationship between pressure and velocity through a flowmeter.

Liquid/Liquid Extraction Unit

The liquid/liquid extraction unit consists of two 50 mm diameter by 1000 mm long packed columns, 50 liter light and heavy phase feed and storage vessels, and duplex metering pump. All components are manufactured from borosilicate glass to permit observation of internal functions by the students. The unit is designed to study hydrodynamics and mass transfer in liquid/liquid extraction systems.

Heat Transfer Unit

The heat transfer unit contains shell-and-tube and coil heat exchangers made from borosilicate glass. The unit permits investigation of material and energy balances as well as the influence of flow rate on heat transfer coefficients.

Absorption Unit

The absorption unit consists of two 80 mm diameter by 1500 mm long borosilicate glass columns that are filled with glass rasching rings and ceramic saddles, respectively. The unit will allow studies of the effect of pressure drop for different packings and the gas absorption of different gas/liquid mixtures.

VII. Summary

Delaware Tech initiated a new Associate Degree in Chemical Process Operator Technology in 1999 to provide trained technicians for the local chemical industry. An Industry Advisory Committee has played a key role in designing the curriculum which includes broad preparation in mathematics, chemistry, physics, and a range of new courses with direct application to chemical plant operations. The Chemistry Department in partnership with faculty from three other Associate Degree disciplines is developing the curriculum and equipping four state-of-the-art laboratories. A July 1999 National Science Foundation award is assisting the College in implementing the new curriculum and equipping new computer process simulation, mechanical systems, process instrument, and unit operations laboratories.

References

1. This material is based upon work supported by the National Science Foundation Grant No.9950887, *Interdisciplinary Curriculum and Laboratory Development for Chemical Process Operator Technology Education*, Helen S. Hauer (1999).
2. American Chemical Society, *Foundations for Excellence in Chemical Process Industries: Voluntary Industry Standards for Chemical Process Industries Technical Workers*", Robert Hofstader and Kenneth Chapman (1997).
3. Standards of the Technology Accreditation Commission of the Accreditation Board for Engineering and Technology -- *Criteria for Accrediting Programs in Engineering Technology: Program Criteria for Chemical Engineering Technology and Similarly Named Programs* (1998)
4. URL:[http:// www.dtcc.edu/stanton/appsci/CurricCpo](http://www.dtcc.edu/stanton/appsci/CurricCpo)
5. Simtronics Corporation, Little Silver, NJ (2000)
6. Design Assistance Corporation, Swedesboro, NJ (2000)
7. Sentinel Process Systems, Inc., Hatboro, PA (2001)

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