ChE department

DELFT UNIVERSITY OF TECHNOLOGY

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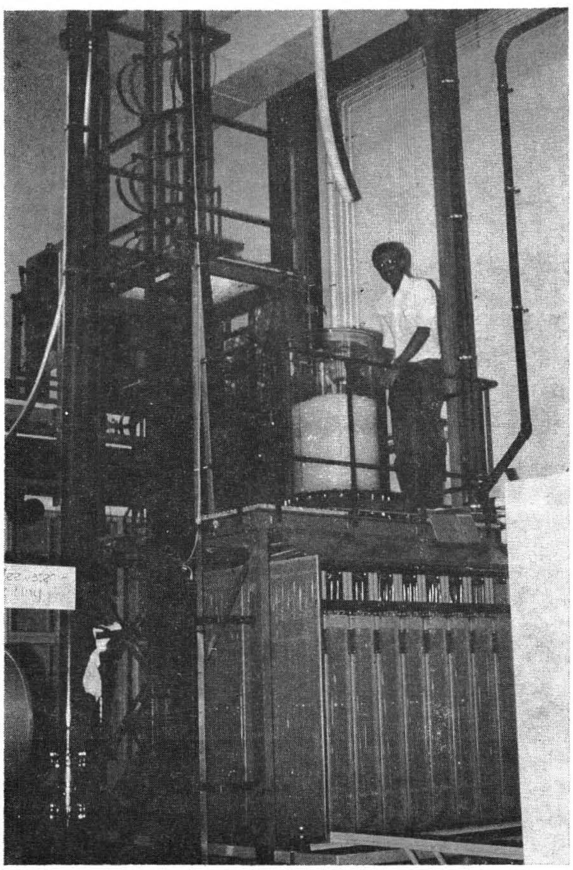
ARE YOU TRYING TO locate lecture room 123? This may be relatively easy at an American university, where all you need do is differentiate the many classrooms by their room numbers. But at the Delft University of Technology in Delft, The Netherlands, your predicted easy search for room 123 will instead lead to your wandering about the Scheikundige Technologie (Chemical Engineering) building. You will observe laboratory upon laboratory, but not many classrooms with desks and blackboards. You may not realize it at the time, but you are seeing classrooms, because at Delft, the laboratory itself is a classroom.



A large reactor located in the Physical Technology laboratory, one of the required laboratories for 3rd and 4th years.

I had the unique opportunity to discover the organization and activities of the Delft Chemical Engineering and Chemistry Department as an exchange student participating in the International Association for the Exchange of Students for Technical Experience (IAESTE) program. Through my discussions with twelve members of the department—professors, graduate students, laboratory technical staff, and a program coordinator—I was able to translate departmental documents and catalogues, compiling an informational report on the educational experience at the Delft University of Technology.

Chemical engineering and chemistry are combined into a single department at Delft, so there are no "pure" chemistry majors or chemical engineering students. The department is sub-divided into the following ten workgroups:

- **Chemical Engineering**
- **Organic Chemistry**
- **Analytical Chemistry and Laboratory Automation**
- **Inorganic and Physical Chemistry**
- **General Chemistry**
- **Biochemistry**
- **General and Applied Microbiology**
- **Biochemical Reactors**
- **General and Technical Biology**
- **Technical and Macromolecular Systems**

This particular combination of so many fields has a historical basis in the Delft fermentation industry and in the production of rubber, tea, and coffee in the former Dutch colonies.

The department currently has 430 employees

16 full professors
6 associate professors
120 academically-degreed professionals, of which 80 are tenured research associates
40 non-permanent graduate students
290 technicians, secretaries, and service employees

Each of the sixteen professors typically has two staff members, several graduate students, and a varying number of fourth- and fifth-year stu-

In addition to the six different required laboratories, two research projects initiated by current research being performed by a professor, or by some aspect of a Ph.D. project, are required.

dents working with him. Professors are highly respected and highly paid ($50,000 per year) for conducting research, teaching, and representing the department through international travel, seminars, and industrial contacts.

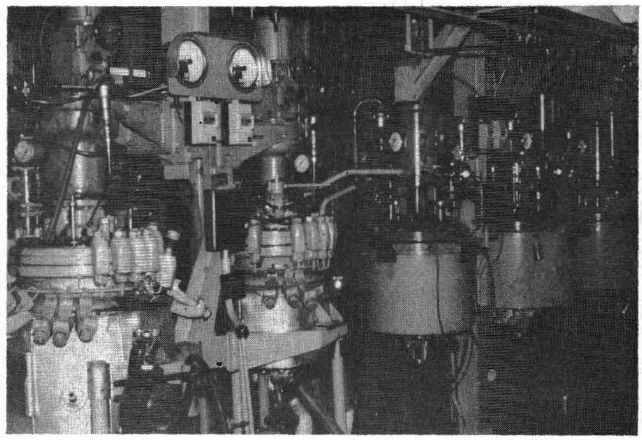
Approximately 130 new students enter the department each year. Because forty percent of these students do not pass the Propaedeutic Examination after the first year, only approximately 55 students graduate per year. Considering only the full professors, the student-to-faculty ratio is 31:1. However, because of the academically-degreed professionals, the tenured research associates, and the graduate students, who also teach courses and instruct laboratories, the student-to-teacher ratio is closer to three students per "teacher." There is sufficient space for all: the professors, staff, and students in the ten workgroups have their laboratories located in four large chemical engineering and chemistry buildings.

The state government completely finances the Delft University of Technology with the exception of some research money from the research foundation Z.W.O. and less than one percent from industry. The students pay very little for their university education: only f900, or $360, per year. In addition, for many students cost of living expenses are provided by the government in the form of interest free loans. Because of the huge sums of money invested in Delft by the government during the past fifteen to twenty years, the university is a showcase of technology for The Netherlands.

In the Chemical Engineering and Chemistry Department, a lump sum from the government pays wages, equipment costs, travelling expenses, and other operation expenses. During the 1980 fiscal year, this sum amounted to approximately 2.25 million dollars. This figure does not include salaries, however, because the state pays the staff as civil servants directly. Salary costs were approximately $12.5 million in 1980. The chemical engineering workgroup received 24% of all the funds that were divided between the ten different work groups during the 1980 fiscal year.

Because of government reluctance to continue increasing its expenditures for higher technical education, more pressure is now being placed on researchers to obtain research funds from industry. For the 1982 fiscal year the department will receive approximately fifty percent of that received in the past to finance equipment costs, and expectations for future years are not very good. Also, the government has required a reduction in the duration of study programs from five years to four years starting in September 1982. Students will have "student" status only for six years.

The present five-year study program leads to the title Chemical Engineer for a student who passes the Propaedeutic examination, the Candidate's examination, and the Final Engineer's ex-



Small scale production and control of a process forming catalyst consisting of an alloy on a carrier, located in the Process Technology laboratory.

amination. The first two years are identical for all students, whereas the last three years are referred to as the "free study", during which time a student specializes in one major field and one minor field. Because the study program lasts for five years—with the fifth year devoted to research—the degree obtained from Delft is more similar to the M.S. chemical engineering degree from an American university.

The new four-year study program—begun September 1982—is very similar to the present five-year program. The only fundamental changes are a reduction in the credits associated with the research project, design project, and literature study, and the inclusion of such work in the fourth year. Table 1 gives the proposed curriculum, which can now be directly compared with the four-year chemical engineering programs in the United States. Note that semesters at Delft last for thirteen weeks, and that course credits are designated as "c.p. units", where 1 c.p. unit equals approximately 40 hours.

From my observations, Dutch students work very hard in high school, and enter the university at a higher level than do students in the United States (perhaps with the equivalent of a year of college in the U.S.). Once they enter the university, the question of student attitudes and motivation can be raised. Many students take it easy, typically completing the five-year chemical engineering program in six to seven years, for example.

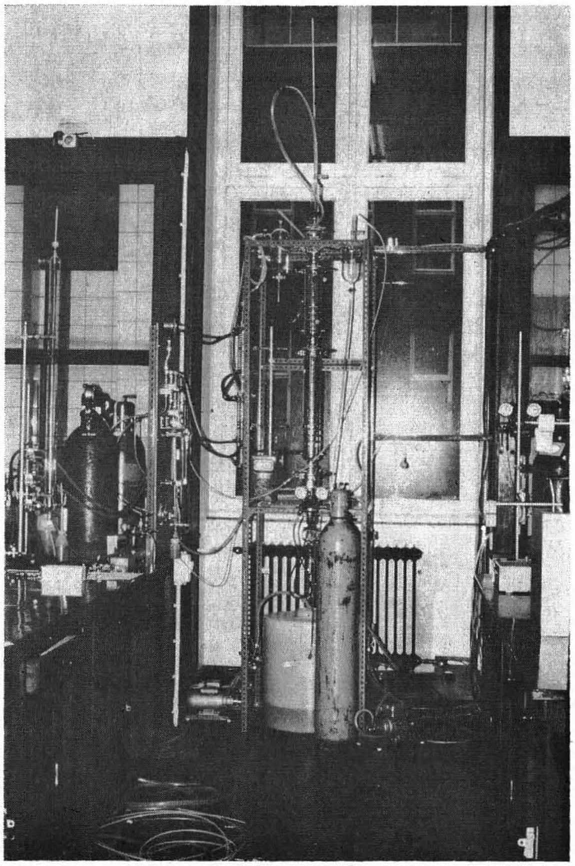
One reason why the chemical engineering study program requires more time is the number of required laboratories. A more important reason is that students take their final examinations only twice a year, and not necessarily immediately following the end of class lectures. This delayed examination schedule lends itself to class cutting and the postponement of studying until several weeks before the yearly exams. But the chemical engineering students are not an exception. While the average chemical engineering student completes his five-year program in six to seven years, the average student at Delft finishes his five-year program in seven to eight years, with architecture students finishing typically in nine years.

The most outstanding quality I encountered in all of the students that I met was their realization of the importance of research, both to gaining new knowledge and applying this knowledge to current problems. The students are thinkers and innovators, mainly because of Delft's emphasis on open-ended research, challenging student projects, and laboratory experience.

Because Delft considers laboratory experience and research to be such an important part of a complete chemical engineering education, attention should be drawn to the outstanding facilities and

TABLE 1

	c.p. units
FIRST YEAR	
1st Semester	
Mathematics I	3
Mechanics of Solids and Fluids	3
Inorganic Chemistry	3
Organic Chemistry	3
Quantum Chemistry	2
Technical Writing	1
	15
2nd Semester	
Mathematics II	3
Computer Programming	2.5
Transport Phenomena	2.5
Thermodynamics	4
Bioscience I	3
	15
First Year Laboratories (divided over both semesters)	
Chemistry (IR, UV, AAS, GLC)	8
Physics	2
Chemistry and Society	1
Excursions to Industry	1
	12
SECOND YEAR	
1st Semester	
Mathematics III	4
Phase Equilibria	3
Kinetics	2
Separation Processes	3
Physical Chemistry	3
	15
2nd Semester	
Statistics	4
Particle Technology	2.5
Reactor Design	3.5
Organic Chemistry II	2.5
Bioscience II	2.5
	15
THIRD YEAR	
1st Semester	
Automation	2.5
Process Design	2.5
Analytical Chemistry	2.5
Environmental Studies	2
System Modeling	2.5
Elective	2.5
	14.5
2nd Semester	
Polymers	3.5
Industrial Chemistry	2.5
Process Equipment	2.5
Product Technology	2.5
The Chemical Plant	2
Elective	2.5
	15.5
Second and Third Year Laboratories	
Physics	2
Methodology	.5
Basic skills in:	
Organic Chemistry	3
Inorganic & Physical Chemistry	3
Biosciences	3
Automation	3
Physical Technology	3
Process Technology	3
Research Project	2x 3
	24.5
FOURTH YEAR	
Electives (3)	3x 3
Industrial work	7
Literature study & report	6
Design Project	6
Research Project & paper	20
	43.5



Absorption apparatus for second year project #47, Removal of CO_2 from process gases.

program the department has developed.

First year laboratories stress development of good experimental and research techniques, thoroughness, and report writing ability. One laboratory located in the Propaedeutic Chemistry building is devoted solely to gas-liquid chromatography and infrared equipment for first-year students. An assistant specialized in analytical techniques is responsible for this GLC/IR laboratory. During the first week, the chemistry laboratory reviews high school techniques. Twelve to fourteen inorganic and physical chemistry laboratory experiments follow during the next twenty-three weeks, scheduled during Thursday and Friday mornings (9 a.m. to 12:30 p.m.) and afternoons (1:30 p.m. to 5:15 p.m.). During the second semester, six or seven organic laboratory experiments are completed. Thus, during the first year a total of eighteen to twenty experiments in organic, inorganic, and physical chemistry are conducted, with each experiment having a duration of approximately six to ten hours.

The typical laboratory experience is much more than one of just following, step by step, a standard university experiment handbook. To perform an experiment, a student, working individually, must get an outline from one of the two laboratory assistants (there is one laboratory assistant for every ten students). The student must first review the cited literature, then speak to the lab assistant privately and answer preliminary questions that he may raise. If the student is adequately prepared, he is allowed to set up his apparatus. This process of setting up usually takes an entire morning, or at most, an entire day. The laboratory assistant must then approve the apparatus before the student can begin the experiment. The data, results, and theoretical post-experiment questions are handed in for grading in very concise form. Longer reports are written only three or four times per year.

While the first-year and most of the second-year laboratories are located in the Propaedeutic Chemistry building, some of the second- and all of the third-year physics and methodology laboratories and the basic skill laboratories in organic chemistry, inorganic and physical chemistry, bioscience, automation, physical technology, and process technology are located in different workgroup laboratories.

In addition to the six different required laboratories, two research projects initiated by current research being performed by a professor, or by some aspect of a Ph.D. project, are required. The general reasons for having these projects are to have students learn to cooperate and to distribute work among themselves, to stimulate research interest, and to combine several different study

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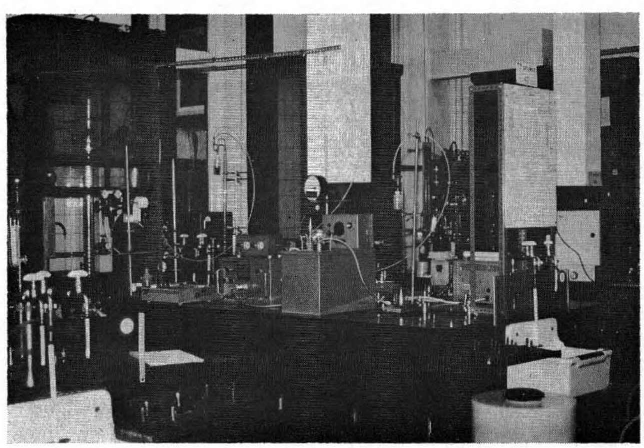

Following the absorption of CO_2, shown above, the CO_2 is desorbed. Recovery concentrations and measurements are made with the analysis equipment shown.

situations where it is a cause of operating problems. □

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areas. Specifically, the department requires the project to consist of six students who work five to ten days as a team, to integrate at least two of the six different laboratory areas, and to be scientifically relevant or practical, remaining open-ended and constantly requiring new research ideas from the student group. Some of the research projects from a recent 27-project list include:

- **Heterogeneous catalytic decomposition of acids**
- **Water purification**
- **Removal of carbon dioxide from process gases**

During the experiment work, each of the students in the group is required to keep data, graphs, and analyses. One of the students is then designated to write the group's report. The project assistant grades each student based upon the report, upon the individual reports written after each day of experiments, and upon the skills the student shows during his work.

The equipment used in these laboratories is quite extensive, and well maintained. It is usually associated with a professor's current research or has been obtained after a research project has been completed. Equipment is also available for new projects when an old project is phased out after three or four years. Thus, the research remains open-ended, and ten-year-old equipment and projects do not exist.

By the fourth year of study, a student has chosen major and minor fields of specialization, and has a specific research aspect of the research project of a professor or graduate student. Now the student truly has access to the showcase of technology and equipment available at Delft. For example, in the reaction kinetics laboratory a student may work with any of the following equipment:

- **thermal analysis (TA)**
- **differential thermal analysis (DTA)**
- **differential scanning calorimetry (DSC)**
- **evolved gas analysis (EGA)**
- **advanced impregnation apparatus**
- **high-temperature drying apparatus**
- **variety of furnaces**

There is a great variety of research to choose from at Delft, and a student can review the directory that summarizes all research being conducted in chemical engineering and chemistry before he selects a professor. Some of the specific research topics available, from a recent list of thirty-two different research areas, include:

- **Inhibition of crystal growth in industrial processes.**
- **Separation of hydrous and anhydrous calcium sulfate in the production of phosphoric acid.**
- **The influence of flow behavior on the separation of solids from aluminum melts.**
- **Automation of kinetic experiments involving the hydrogenation of carbon monoxide.**
- **Desalination of sea water.**
- **Recovery of metals from waste water.**
- **Removal of hydrogen sulfide from process gases.**
- **Production of manganese oxide for batteries.**
- **Pressurized fluidized bed combustion of coal.**
- **Process development on the hydroformylation of olefins using immobilized catalysts.**

Because of Delft chemical engineering's strong emphasis on applying theory directly to research and practical industrial process problems, a Delft chemical engineer is valued highly by industry. The Delft graduate has no difficulty in adapting to "real world" chemical plants, since he has been working with small scale reactors and processes since his second year at the Delft University of Technology. □