THE CHE DESIGN LABORATORY

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A new design program for senior-undergraduate chemical engineers was initiated at Stevens Institute of Technology in the 1968-69 academic year. One important feature of the program is the use of the ChE laboratory as a vehicle for teaching design. Because of the emphasis on design, this laboratory is called the ChE design laboratory. This paper discusses the philosophy and organization of the laboratory.

PHILOSOPHY AND OBJECTIVES

A recent report* gives the distribution of chemical engineers according to areas of specialization. As one would expect, no one category predominates. For this reason it does not seem reasonable to place the emphasis in design education entirely on process design. In order to obtain a broader and more flexible program in design we have added the ChE design laboratory to our course to complement process design. Besides giving a student who is interested in process design a broader view, the design laboratory also gives the student experience in project engineering and the design of experimental systems for research and development. Furthermore, one of the most valuable experiences any young engineer can obtain is to follow a project from its conception through it design stages and finally reduction to practice. The design laboratory gives the student this opportunity.

The importance of design in research and development needs further discussion. An engineer working in this area must frequently design his own apparatus, and he must usually show results within a year to justify the continuation of a research project. A considerable amount of valuable research time may be wasted due to errors in the design of apparatus. There are many unpredictable factors in a research project that one cannot afford to be held back by errors in design. Probably, some of the recent disenchantment with research productivity can be traced back to avoidable delays caused by poor equipment design. At any rate, the one way a research engineer can increase his productivity is by becoming a skilled designer of equipment. The importance of design in research and development is generally overlooked.

ANATOMY OF A PROJECT

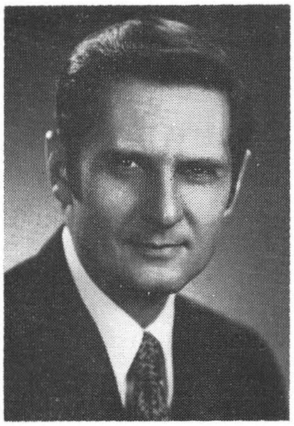
Each student is interviewed and assigned a project according to his interest and ability. The process begins by having each student make up a resume of his experience, skills and career objectives. After the interview the students are formed into teams which consists of a maximum of three students. Teams of two students are optimum, but economics requires that many three-man teams be formed.

We are willing to undertake many types of projects. Our only requirements are that the project is useful; that someone can be found who is knowledgeable in the area to act as an advisor for the project; and that the project can be completed at a reasonable cost. A project may involve designing a completely new apparatus or designing an improvement or addition to an existing system. It should be emphasized that an important objective of the design laboratory is that the students develop the skills required to reduce his design calculations to practice. It is one thing to make design computations and another thing to translate these computations into a working system. A typical project involves a) definition of the problem b) design calculations c) evaluation and purchasing of equipment d) assembling the apparatus e) testing and trouble shooting f) collecting correlating data g) and writing the final report.

The student is usually given the objectives of his project in a general way. To help define the problem students are required to search the literature and read several articles to become familiar with the theory and experimental details.

Since the design laboratory involves many different projects, much of the information must be conveyed through personal contact. Thus, the student is urged to seek information from faculty members, graduate students and industry. There are, however, many aspects of apparatus design

*Roethel, D. A. H., Counts, C. R., Realignments in the Chemical Profession Continue, p. 90, Nov. 15, 1971.



Harry Silla obtained his BS degree from City University of New York and his MS and PhD ('70) degrees from Stevens Institute of Technology. His research interests include combustion and transport properties of flame plasmas.

that appear frequently enough to warrant discussing them in lectures; for example the design of flow systems. In the design laboratory there is no need to withhold information from the student, that is, the instructor knows the answer to a particular problem but withholds the answer to see if the student can arrive at the same answer. There are enough real problems to be solved without creating artificial ones.

After making their design calculations the students are ready to select standard parts such as heat exchangers, pumps, valves and instruments to produce a working system. In some cases special parts must be designed and fabricated. This requires a knowledge of materials, equipment and fabrication techniques. Since the students do not have the necessary experience to fabricate equipment, they discuss their designs with the departmental machinist and graduate students who are working on experimental theses. At this point the reliability of their design is also considered. Will the apparatus withstand the temperatures and pressures? Is thermal expansion considered? Are corrosion-resistant materials selected? Is the apparatus safe?

If the necessary equipment is not available in the department's stockroom, students are given equipment catalogs, and they are urged to contact sales engineers to discuss their problems. This aspect of the design forces the students to consider not only equipment costs but also the importance of time as a factor in construction of equipment.

The students are held responsible for the accuracy of their work. It is not possible to check all the detailed calculations for the many projects that are being carried out. The laboratory instructors and graduate-student advisors, however, because of their greater experience will be able to tell if a number or design is reasonable and thus will prevent the student from making any serious errors. It goes without saying that when the students construct and test their equipment their oversights, errors in calculations and planning are emphasized. When a student obtains 90% on an examination, he walks away pleased, but in the design laboratory this frequently is not enough. To extricate himself from his miscalculations forces him to be very inventive.

DESIGN PROJECTS

A total of twenty projects are currently under way. These projects are listed in Table 1. Some of these projects have been continued from the previous year. For these latter projects, the students begin by reading final reports of last year's graduates, evaluating their recommendations, and outlining a program. This feature of continuing projects adds considerable flexibility to the course, because all projects are eventually completed.

Many of our projects are directed toward expanding our laboratory facilities. Examples of this type of project is the design of a Karr solvent extraction column and a batch reactor facility. These projects will improve our capabilities to handle more complex problems in the future.

Other projects are to design equipment to collect engineering or physical property data required for design: for example, measuring heat transfer coefficients in falling film evaporator or obtaining vapor-liquid equilibrium data. Admittedly, designing apparatus for measuring physical property data does not have much glamour, but this can be just as challenging as designing a distillation column.

One of our more novel projects is the development of a process to extract potential antibiotics from sea sponges. The objective in this project is to extract sufficient material for an organic chemist to determine the structure of biologically active compounds. These compounds will then be synthesized by an organic chemist. A similar project is to determine the sex attractant dispersed by a female lobster. The interest in studying the lobster is for aquaculture and commercial trapping. The students in this group are designing a Karr*

*We are grateful to T. C. Lo of the Hoffman-LaRoche Co. for his help in the design of the extractor.

TABLE 1—DESIGN LABORATORY PROJECTS

Project and Faculty Advisors
Separations
Extraction of Antibiotics from Sponges, A. K. Bose, J. Kryschuk, H. Silla
Extraction of Sex Attractant of Lobsters from Sea Water, A. K. Bose, R. L. Spraggins,[b] H. Silla
Controlled Cycling Solvent Extraction, H. Silla
Countercurrent Distribution Solvent Extraction, H. Silla
Fluid Bed Drying, H. Silla
Filtration, H. Silla
Polymers
Design of a Stress Relaxometer, C. G. Gogos
Effects of Porosity on the Physical Properties of Polymers, K. C. Valanis
Development of a Hydrophilic Gel for a Gel-Permeation Chromatograph, J. A. Biesenberger, I. Duvdevani
Instrumentation
Design of a Gel-Permeation Chromatograph, J. A. Biesenberger, I. Duvdevani
Reaction Engineering
Internal Recirculation Catalytic Reactor, G. B. DeLancey, H. Silla
Catalytic Plasma Jet Reactor, M. J. McIntosh
Fluid Bed Combustion for Waste Treatment, H. Silla
Biomedical Engineering
Diagnosis of Lung Damage by Measuring Weight Shifts in the Upper Body, J. R. Kaim[c], H. Silla
Ultrasonic Generation of Monodispersed Submicron Particles for Lung Studies, M. Lippmann[d], H. Silla
Engineering Properties
Heat Transfer in a Fluid Bed, M. Sacks[a], H. Silla
Flow in a Fluid Bed, M. Sacks[a], H. Silla
Heat Transfer in a Falling Film Exaporator, H. Silla
Plate Efficiencies of a Sieve Plate Distillation Column, H. Silla
Transport Phenomena in a Flame Plasma, H. Silla

a. Doctoral student
b. Post-Doctoral Research Associate
c. M.D., College of Medicine and Dentistry of New Jersey at Newark
d. Ph.D., New York University Medical Center

extraction colum to remove the sex attractant from sea water.

Each year there are a few students who are interested in biomedical engineering or who intend to go to medical school. To satisfy this group of students we have established a working relationship with a local hospital to generate medical projects. Last year two students designed and built an automatic blood sampler which is now being used by the hospital.** There is a need for rapidly locating which lung is damaged because of accidents or diseases. This is not as simple as it may appear. The student involved in this project is investigating the possibility of measuring the shift in the center of gravity of the individual during his breathing cycle. During inspiration the heart shifts in the direction of the damaged lung, thus causing a shift in the individual's center of gravity.

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The design of instrumentation is a rich source of projects and an area where many principles of chemical engineering can be applied on a miniature scale. Gel-permeation chromatography is an example of a project of this type. In this project the students were assigned the problem of redesigning an existing chromatograph with the objective of making a more reliable compact instrument.

CONCLUSIONS

The design laboratory has been enthusiastically accepted by the students, who have christened the design laboratory, "The Super Lab." Even students who have had no prior interest in design or who have chosen other areas of specialization have been challenged by the projects. The design laboratory not only is a challenge to the student, but to the instructor as well because of the variety of projects that must be managed, and because the projects are constantly changing.

The design laboratory is still in the process of evolving, and many problems will have to be solved before the laboratory reaches maturity, nevertheless, the results to date have been gratifying. One can see a student arrive in the Fall in "rough form" and then leave in the Spring as a much improved engineer. We have reached the point in the design laboratory where we feel that many of the design projects are equivalent to industrial experience. The design laboratory should play an important role in the undergraduate chemical engineering curriculum.

**We are grateful to Dr. W. Perl of the College of Medicine and Dentistry of New Jersey at Newark for his help in the design of the sampler.