A Course in

PROCESS AND PLANT DESIGN PROJECT

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THE CHEMICAL ENGINEERING Department at Manhattan College has had in effect for the past five years a "design-oriented" master's degree program geared toward those students who wish to pursue career objectives in the process industries. This is a cooperative program with industry encompassing one complete calendar year. An initial internship is provided in the form of summer employment of the students by the participating companies* involved in the program. The subsequent two-semester academic phase entails an intensive effort in applying fundamental engineering principles to the solution of industrial problems.

A total of thirty credits are necessary for the Master of Engineering (ChE) degree, eighteen of which are in required courses in mass transfer, fluid mechanics and heat transfer, kinetics and reactor design, and process evaluation and plant design. A prime requirement for the completion of the program is the submission of a Project Evaluation Report summarizing a comprehensive process and plant design project. The course, Process and Plant Design Project, serves as the vehicle for guiding the student through the many phases of the project including initiation, assessment of processing alternatives, design and specification of equipment, and economic evaluation.

OBJECTIVES

THE OVERALL OBJECTIVE of the project is to unify and build upon a diversity of scientific and engineering principles by application to a comprehensive, open-ended problem. Specific objectives of the course are to develop the capabilities of the student in the area of process synthesis, technical and economic evaluation of alternatives, process optimization and communication skills.

The comprehensive nature of the project requires that a diversity of subjects be employed. Integration of these subjects to solve a single problem requires a thorough understanding not only of a specific area but also of its interrelationship with many other areas. Being open-ended, emphasis is placed on organizational ability to formulate a plan of attack prior to execution of any specific project detail.

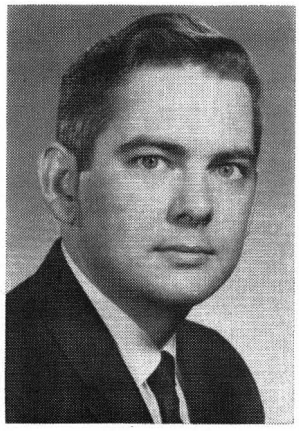
The development of an overall process flowsheet based on information available in the literature or on an innovative idea involves the conceptualization of the overall problem and technical and economic evaluation of alternatives at many points in the process. Once a scheme has been developed, optimization of the entire process as a unit would be most desirable, but is usually limited to segments of the process to facilitate completion of the project during the academic phase of the program.

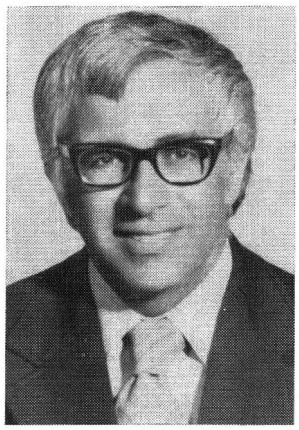
A salient objective of the project is the improvement of communication skills. The Project Evaluation Report is treated in the same manner as a thesis, that is, it must be both technically correct and well presented. In addition, each student must present his project orally and defend it.

ORGANIZATION

PROCESS AND PLANT Design Project is offered as a three- credit course during the spring semester. However, the projects are actually selected during the fall semester. Since it is a required course, this presents no particular difficulty with regard to who will be enrolled, etc. The students normally work in teams of two; partners are selected by lot; each team works on a different project. The team approach applies only to the technical phases of process and equipment design; each individual is responsible for his or her own Project Evaluation Report. Projects can be concerned with any appropriate type of industrial design problem, but have typically involved the preparation of an organic or inorganic chemical. Some of the recent projects

* Presently participating in the program are Celanese Plastics Co., Esso Research & Engineering Co., FMC Corp., Mobil Oil Corp., Pfizer, Inc., Stauffer Chemical Co., and Texaco, Inc.





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Edward G. Kelleher received his BChE from Manhattan College and MS and EngScD degrees from Columbia University. He has worked with Celanese Plastics Company and American Cyanamid Company, and is currently associated with Ecolotrol, Inc. in process design for environmental control. His teaching interests include mass transfer, process and plant design, and numerical methods. He is a member of AIChE, ACS, Sigma Xi, and ASEE. (left photo)

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were process designs for the synthesis of urea, terephthalic acid, isoprene, vinyl chloride, and vinyl acetate from basic raw materials.

Early selection of the project enables the students to complete their literature search during the first semester. During this period, teams usually complete a preliminary process flowsheet, preliminary material balance, and a set of processing alternatives to be evaluated. Although no formal classes are held, groups meet informally with their project advisor to discuss progress.

Coordination among the graduate faculty provides the students with the background necessary to make marked progress during the fall semester. In particular, the Kinetics and Reactor Design and Process Evaluation and Plant Design courses are organized so as to provide direct input to the development of the project. The latter part of the Kinetics and Reactor Design course, which is given in the first semester, includes several case studies in reactor design. At least one of these is extended to include the development of a down-stream processing scheme and the effects thereon of varying reaction conditions. The two-semester course in Process Evaluation and Plant Design emphasizes the integrative case study approach to develop in the students the concepts of process synthesis, evaluation of alternatives, economic evaluation, and optimization. Typical case studies covered in depth in this sequence include hydrogen reforming, ammonia synthesis, nylon-6 synthesis, power recovery cycles, and hydrocarbon separation schemes.

In addition to the supplementary material given in the aforementioned courses, the background of the students is further reinforced by a seminar series that is an integral part of the overall program. The companies participating in the program provide the speakers for these seminars on topics of industrial importance. Recent seminar titles illustrating their contributive role include:

Selection and Design of Commercial Fractionation Equipment,
Non-Linear Matrix Algebra and Engineering Application,
Profitability and Engineering Projects,
Implementation of a First Level Process Computer,
Process Modeling in Chemical Engineering,
Catalytic Reforming,
Materials Engineering in the Petroleum Industry.

The project course itself is offered as a two lecture hour course with a two hour discussion period. The lecture period topics are selected to augment the material presented in basic courses, providing the student with a fundamental understanding of several areas which are important considerations for any overall industrial problem. These include:

1. Equipment design and specification
2. Safety
3. Control
4. Plant layout
5. Offsites
6. Process economics
7. Technical writing

Equipment design is limited to major specifications and does not include detailed mechanical design. Safety is considered from the viewpoint of safety in equipment design and safety in an overall processing scheme. Control schemes, rather than instrumentation, are discussed for individual units and overall segments of a process. Process economics includes estimation techniques for total capital investment, total product cost, profitability parameters, and evaluation of alternatives. Several lectures are devoted to the basic principles of improved technical writing

skills.

The discussion period has no fixed format, but is usually devoted to a discussion of common technical problems among the groups or to discussion with the individual groups. In addition to these formal meetings, groups meet regularly on an informal basis with their project advisor to discuss problems, review progress, and plan. These informal discussions are not limited to their project advisor. The groups are free to and do consult with all members of the faculty who have a diversity of backgrounds, experience, and interests.

It is difficult to illustrate the depth to which the various phases of the project are carried, but the Table of Contents from one of last year's Project Evaluation Reports is given in Table I as a general guide. The process flowsheet includes all equipment, a complete material balance, and all major controls. The cost estimates are all based on the cost of the equipment. All equipment must be sized and reasonable details given, but without mechanical details. Specifications include all materials of construction and costs for each item.

TABLE I. Table of Contents

I. Summary
II. Introduction
III. Presentation
  A. Description of Process
    a. Chemistry of Process
    b. Special Features and Innovations
    c. Process Description
    d. Process Flowsheet
  B. Description of Major Equipment
  C. Plant Layout and Location
  D. Economics of Process
    a. Cost of Equipment
    b. Estimated Capital Investment
    c. Total Product Cost and Profit
    d. Depreciation
    e. Profitability
  E. Conclusions and Recommendations
IV. Discussion
V. Nomenclature
VI. Bibliography
VII. Appendix
  A. Properties of Materials
  B. Design Data
  C. Sample Calculations
  D. Long Tables and Computer Programs
  E. Equipment Specifications

DISCUSSION

THE PRESENT ROLE of the overall program seems particularly important in enabling students to make the transition from the classroom to an industrial environment. Judging by the input from industrial representatives, it has been particularly effective in improving the competence of young engineers by affording them an intensive, guided experience in developing their capabilities in handling industrial problems.

The students have found that the comprehensive nature of the process and plant design project has been effective in giving them a broader perspective of chemical engineering. They have learned to think more effectively in terms of the overall result of changing a single problem variable. They are better prepared to evaluate alternatives on both technical and economic bases. They are more aware of the total implication of a single engineering decision.

The lecture material of the course contributes to this broader view of engineering. Although many of the topics are in actuality the domain of specialists in their respective fields, the students develop at least a basic working knowledge of these areas and an appreciation of their role in the overall engineering picture.

The continual interaction of the students with the faculty is conducive to the meaningful cross fertilization of ideas. Reinforced by the summer internship in industry and continued contact with practicing engineers during the seminar program, this manifests itself in realistic approaches to the solution of a given problem. Needless to say, this does require a considerable commitment in time and effort on the part of the faculty and the participating companies.

The emphasis placed on teamwork in the project has many obvious benefits. It does make the workload more reasonable and allows time for creative effort. It also leads to discussions of tremendous mutual benefit to the students as well as to some innovative ideas in processing techniques. At the same time, individual effort is required to prepare the final Project Evaluation Report. Improved communication skills result from the emphasis placed on the written presentation of the report and from the oral presentation of the project in a seminar.

Overall, student reaction to the project has been extremely favorable. Students have found it to be the unifying agent within their graduate education. This is not as much due to the fact that the project represents the culmination of the program as it is that it serves to interlace much of the knowledge previously held to be unique and isolated. □