TEACHING PLANT DESIGN TO CHEMICAL ENGINEERS

E. CLARENCE ODEN
Mississippi State University
State College, Mississippi 39762

FOR THE PAST TWELVE years, the Department of Chemical Engineering at Mississippi State University has taught plant design in an atmosphere similar to that which a process engineer encounters in industry. The professor utilizes his twenty years or more of industrial experience (a large percentage of which was directly involved with plant design, expansion and bottleneck removal programs in large industrial plants and petroleum refineries) to teach this course in a practical manner. The principal handicap has been the three credit hours of time allotted in the curriculum for such an important course, a disadvantage experienced by most schools due to so much material being squeezed into a four year program.

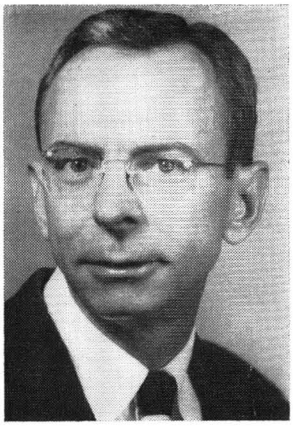
OBJECTIVE AND TEACHING METHOD

The principal objective of the course is to train engineering students to apply the materials presented in other college courses to the practical solution of one large plant design problem. A problem in design must be selected from a large list of possible chemical plants that will require a great deal of thinking and application of graphics, mathematical and chemical knowledge, mass and energy balances, thermodynamics, unit operations, and kinetics in the solution of the problem. In addition, the students are required to consider the instrumentation and the practical application of economics by having to make an economic appraisal of the proposed investment when the plant is assumed to operate at 80, 100 and 120% of design capacity.

Another objective is to aid the students in the transition from college courses to industrial work. It is believed to do their best, the students must be exposed to conditions similar to those they generally encounter in industry. The three credit-hour course at this institution is divided into a one hour lecture and a six hour continuous design period. The objective of this long design period, consisting mostly of desk and library work, is to permit the students to adjust to a longer period of concentration as experienced in industry. This longer period is better also, because it allows them to spread their design instruments and data out onto a drawing board. And it reduces the percentage of time utilized in getting settled down to work and of getting ready to leave which takes place when equal time is distributed over two design periods.

The students are encouraged to visit the professor in his nearby office when they need help or they may be permitted to visit some other professors on the staff that may have some specific experience or data that would be helpful in the solution of some particular phase of their problem. Students have the same degree of freedom of visiting other areas of the campus as the need arrives by simply signing out as to when they left and where they may be located. They are highly discouraged from returning to their living quarters for more than enough time to pick up something they may have left behind. They are to remove their name from the register when they return to the building. This record is normally kept in one corner of the blackboard where it can easily be seen by all. This serves about the same as leaving word with an office secretary or group leader in industry. The students are given a list of chemical plants from which they may choose one to design. Each group of three students works on a separate problem. A group of three was chosen for advantages in training in human relations; and because there is plenty of work assigned to keep three people

We teach plant design in an atmosphere similar to that which a process engineer encounters in industry.



E. C. Oden is a graduate of the University of Alabama and Brooklyn Polytechnic (M.S. '38) and has done graduate work at Cornell and the University of Michigan. He has many years experience in the chemical and petroleum industries and is presently teaching plant design.

busy. A group of four generally does not work out well because they often work too much in pairs and create disciplinary problems with each set competing or griping about the other two's work or the like; or one student acting like an outcast and going his own way—most commonly goofing off and not doing his share of the work.

The one hour lecture is devoted to informing the students of the general information they need to know to follow the next progress stepwise procedure as outlined in the "Plant Design Instruction Manual," a book of approximately 215 pages written by the professor. The course is divided into six steps and each step is terminated by a progress report. The six major progress reports are divided-up into progress steps as follows:

PROGRESS REPORT 1—

Selection of Process Route

A literature survey is conducted of the possible routes that could be selected to produce some chemical or group of chemicals that are used in industry on a large scale. A list of about 50 or more are given to the students to choose from, or they may select something based on knowledge they have learned in summer work or in the co-operative program. Students often have made a literature survey and know what they wish to work on when they register for the course.

The students are expected to make block flow diagrams of all the routes that have been used on a commercial basis as revealed by the literature search and describe the process in a general manner. Then they select one of the routes and give their reasons for selecting that particular route over the other ones.

PROGRESS REPORT 2—

Process Flowsheet

This involves the layout of a detailed process flowsheet using typical symbols for the equipment for the battery unit. Each stream in numbered with all major equipment, such as pumps, condensers, exchangers, reboilers, etc., shown. A heat and material balance is required over the overall plant as well as the individual pieces of equipment. The size range, feed, and product series qualities for the plant are set by the professor and differ from any other previously designed plant, but are comparable in sizes to those being quoted in the construction box score reported in the literature. Utilities are generally assumed to be available in the complex operated by the mother company. The unit cost figures placed on these utilities are selected for the region of the country where the plant is to be located (usually the Gulf Coastal region, in our case).

PROGRESS REPORT 3—

Site Selection, Plot Plan

This involves the selection of a plant site, assuming the selection has been narrowed down to one area in each of three states. Then students make a plot plan layout of an assumed plant complex using blocks for office buildings and battery limit units other than the battery limit plant under design. The specific plant being designed has a plot layout of all the major equipment that is shown on the process flowsheet. The students are shown aerial views of chemical plants and refinery layouts. Layouts in the department of model units are discussed. A general discussion of how to go about selecting a plant site on the basis of tangible and intangible items takes place before students begin this progress report.

PROGRESS REPORT 4—

Equipment Specification Details

The students submit detailed specifications for each major piece of equipment shown on the flowsheet as if the specifications were being sent to equipment manufacturers for bids. The students survey equipment manufacturing catalogs and list three manufacturing companies that they would like to have bid on the various classes of equipment such as exchangers, pumps, etc. They also select three overall contractors from the literature reviews that they would prefer to build the plant (of course, without ever actually contacting any of these companies). A sample calculation of the size, etc., of each general type of equipment is required, such as, that of an exchanger, a fractionating tower, etc.

PROGRESS REPORT 5—

Instrumentation Flowsheet, Detailed Reactor Design

A proposed instrumentation flowsheet for the equipment shown on the process flowsheet is required. A detailed drawing of one major piece of equipment, generally a reactor which most plants will have, is required.

Students are required to consider the instrumentation and practical application of economics by having to make an economic appraisal.

PROGRESS REPORT 6—

Economic Appraisal

An economic evaluation of the proposed plant showing the payout on a net profit and cash flow basis at assumed rates of 80, 100 and 120% of design capacity is required.

FINAL REPORT

The final report must be typed and assembled (including a cover letter) as if it were being submitted to the Board of Directors of a company for their consideration as a capital investment.

This course is required of all chemical engineering students that have completed or are enrolled in all their basic chemical engineering courses. Students that enter our graduate school who have not had a comparable course in plant design are highly encouraged to take this course as an elective and all foreign students are especially urged to take the course. Foreign students from the same country are prohibited from working together in the same group in design to facilitate their learning to communicate in the English language.

The students are encouraged to take pride in the reports they submit. It is not difficult to get their cooperation, perhaps, because they are influenced by the knowledge that their report is kept in the files in the department indefinitely, and may be reviewed by students succeeding them. Each class that follows is encouraged to improve upon former students reports. No plants proposed for design ever have the same specifications as a previous report. They will generally be different in feed, product quality and annual capacity along with other variations. The prices on equipment, utilities, etc., are generally in keeping with inflation, and the size of plants in general have continuously shown a general increase in size over a twelve year period. There have been about 30 to 50 different varieties or types of plants theoretically built and evaluated on paper. These range from inorganic chemicals, such as caustic, chlorine, nitric acid and sulfuric acid, to the various types of alkylates, esters, organic acids, isoparaffins, cumene, paraxylene, etc. In general, the plants show cash flow payouts varying from about 3 to 10 years, depending on the size, type products, and feedstocks selected, when using current market prices for raw materials and product sales prices known to be realistic prices;—that companies are actually paying and receiving for the materials involved.

The use of progress reports was selected by the instructor because inexperienced students and engineers make many mistakes that would carry all the way through a design unless a careful progress check is made by an experienced engineer. By a system of checks by an experienced engineer, the big mistakes can easily be detected and the progress report returned to the group for correction. Progress report 3 has been placed between 2 and 4 to allow the instructor time to review the process flowsheet, the students are assigned the site selection and Plot Plan as a progress report. By this time the process flowsheet has been corrected and approved for the students to write out detailed specifications for all the major equipment. Since detailed specifications will be vital to the cost estimates, these need approval of the instructor. To allow him time for this, the students are asked to specify the instrumentation flowsheet and detailed reactor design in order to give them training in this aspect of communication. Any mistakes in progress reports 3 and 5 will not have any bearing on the economic appraisal performed in progress report 6. Pictures, scale model plants, and layouts of other plants on paper are used as aids in presenting data on how to complete progress reports 3 and 5, in particular.□