CHEMICAL ENGINEERING PLANT DESIGN

COURSE AT FLORIDA TECH

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Chemical Engineering Plant Design is a course commonly taught to senior students. Today there are textbooks, problem sets and so forth. At Florida Institute of Technology (Melbourne, Fl.), prior to the fall of 1991, this course had been handled primarily as an exercise in the use of design simulators. Other schools have taught the course on a project basis, and this was the method adopted at Florida Tech after a curriculum revision.

This course has a dual objective. It must first naturally bring together all the material previously covered by the student. However, besides this review, it should provide a transition from the academic surrounding to an actual work-place environment. After three years, the student is expert at solving textbook problems. In actuality, most engineering work begins with defining the problem, an area that until the senior year is rarely addressed

Two customer sets are addressed by chemical engineering education. The student wants to become a well paid, valuable employee and the employer wants a person who can do productive work as quickly as possible.

These objectives can best be met by making the course project-based. Projects force integration of knowledge and skills and move away from textbook type problems. Functions that require judgment are automatically added and projects usually start with definition. A typical three credit-hour two-semester or three-quarter course allows a group of several students to complete an overall "expense level" design. This can be rigorous even though it does not have the detail of a "capital" funded design.

Going to projects using groups requires a different approach to grading. Some fraction of the grade is common to each member of the group because it reflects the quality of the project work. The remainder of the grade can then be applied to individual performance. By scheduling team meetings and rotating team leadership one can evaluate in an approximation of an employment situation. Schedule integrity, problem solving skills, and so forth are evaluated in the same manner as in an employment situation.

There are also some general skills which need reinforcement. Today very few chemical engineers seem to do much work without computers, yet almost none write programs. Some true experience with simulation and design packages is most essential. Report writing and oral presentation skills must also be practiced.

Chemical Engineering is changing to meet different challenges. Many of us are involved in environmental impact. Energy is a constantly rising problem. New materials may be considered. Safety emphasis is in current focus. None of these are new and economics is still the bottom line. It is necessary that the projects chosen reflect these areas.

Six class projects carried out at Florida Tech in the last two years are: a methyl tertiary-butyl ether plant, a pressurized fluidized bed coal combustor, vanadium recovery from oil fly ash, co-generation in a citrus plant, clean coal for gas-turbine cogeneration, and newsprint from bagasse.

There are multiple sources of projects. Some authors have built sets of packaged projects. There are nationally circulated contests. Ideally, industrial sponsorship with sponsor involvement is most certain to nominate projects that are valid and worthy of the truly significant effort on the part of the student.

Our specific purpose in presenting this paper is to attract projects and sponsors. Many chemical engineering departments are trying to refocus and are building committees of outside active chemical engineers to help them plan for the future. Projects for a plant design class is one advantageous method of establishing communication. The school receives good current focus and the company gets an outside view of a problem.

The rest of this paper represents the students view of the chronological sequence of problems that arose during the effort, with an emphasis on how they were eventually overcome and what skills were polished or gained. The sample project that will serve as the platform for this discussion is cogeneration in a citrus juice processing plant, the project of John Fessenden and Daniel Rocha, and the rest of this paper will break away from the traditional format and take the form of a first person view of these two students.

The first "problem" we encountered was to choose and define the project to be attempted. Here the biggest flaw in our education surfaced - we could solve many packaged problems, but our background knowledge of any given chemical engineering process was likely no better than a non-engineers. It was suggested that we look into energy consumption at a citrus processing plant, and, in our admittedly ignorant optimism, we initially decided to perform a complete energy balance and optimization for a citrus plant. Dr. Shaffer was kind enough to allow us to puncture our own delusion, which came rather rapidly as we began to understand the enormity of the task we had set before us. Remember that a three credit hour course theoretically represents three hours per week of actual class time, and a targeted six hours per week of out-of -class time. Even for a class which demands significantly more than this, as plant design certainly does, time is limited by the other classes one is taking. For two students, even twelve hours per week each, over thirty weeks, represents only 660 total man-hours, in which to essentially gain a thorough working knowledge of the subject and produce an "expense level" design for either a new operation or a significant improvement on an existing one. For the first few weeks of the class our project scope seemed to dwindle daily, until we decided to propose the installation of a pair of gas turbines for purposes of cogeneration at an invented citrus processing plant. Much of our more realistic project scope was conceptualized through making industrial contacts, which is described in more detail later.

The next step was to perform a thorough literature search. Certainly almost 100% of all college students are at least reasonably familiar with the campus library.

However, previous classes that had required use of the library took the approach that it was only necessary to find enough knowledge on any given topic to produce whatever assignment was required. Indeed, the approach was often in the reverse direction of what it should be: the student would perform a cursory search of readily present library materials, and decide (for example) upon the subject of a paper by surveying what materials had already been found. Clearly this approach would not work in this case. Rather, a complete subject search was required, including for most students, their first use of on-line databases and inter-library loans. The plant design class spent two days in the library, with library personnel providing samples of available information-gathering techniques. Not an introductory-level use of the card catalog or where the reference section is, but how to perform computer searches, how to request copies of information via inter-library-network, and how to perform patent searches. Essentially, it was a crash course in technical search skills, which frankly opened many eyes to the actual abundance of knowledge available. Rather than, as previously, feeling limited by the amount of accessible information, many now felt daunted by suddenly being given four hundred page weekend reading assignments as new information arrived. "Take it home and become an expert in the subject by Monday" became an only half-joking catchphrase.

The next problem was to conceptualize what a finished project might look like. Except for a single chemical engineering lab, and some departmental plant tours, most student chemical engineers think a heat exchanger looks like this: ; a pump: ; and a valve: . Again, this is only half joking. Frankly, much of the "hand on" experience of the undergraduate chemical engineering curriculum has been lost as the emphasis has shifted towards computers and theory. We were faced with a fundamental gap in our knowledge: What does a gas turbine cogeneration unit look like? Beyond the very stylized simplistic flowsheet produced, what is the appearance of the equipment? It is rather unwieldy to design a piece of equipment when your best description of it begins with " Well, its bigger than a breadbox....". Furthermore, Dr. Shaffer loves to regale us with tales who moral is usually something like: "If you don't know what you are talking about, the operators will eat you alive". Four weeks into the design of the system, neither of us had a better idea of what a turbine would look like than "something like a jet engine, only bolted to the floor". The solution to this problem was clearly targeted plant tours, which we made as soon as humanly possible, and which, in addition to providing a mental picture of the finished product, yielded the added benefit of providing two industrial experts to whom we could turn when stumped. These two gentlemen engineers are Jack Webb of Tropicana, and Dick Kennedy of Citrus World, and we owe them a major debt of gratitude for providing their time and expertise.

A major part of engineering design includes being able to communicate the design to potential clients. To this end, as part of the course requirements, each group was required to write a formal proposal for the project. This was done on the basis that we are independent (engineering contractors, consultants, etc.) and that the audience (Dr. Shaffer) is made up of upper level management and engineers of "Porticola" Inc., a fictionalized citrus processing concern.

In addition to the written proposal we had several opportunities to present our project: twice to the other members of our class and once to the local student A.I.Ch.E. chapter. At each presentation we were critiqued on speaking style, content, persuasiveness, visuals, and overall effectiveness.

After our proposal was "approved" by Porticola, the next step was to do a complete mass and energy balance on the cogeneration system. To aid in this, and to broaden our experience, we used ChemCad II© from Chemstations, Inc. The advantages of using this system, besides the time saved in extensive calculations, is that we developed a general working knowledge of how to use a process simulator, what can be done on a simulator and what you need to know before even turning the computer on.

The primary disadvantage of this simulator is that for the most part, it is product independent and completely process dependent. That is, it is similar to those text book problems that we have gotten so good at solving.

As an example, one specific problem that we had with this particular simulation was that there was no predefined unit operation for a gas turbine. After brainstorming this dilemma, we decided to connect a compressor, a mixer, a Gibbs reactor, and an expander in series, to create a "simulation of a simulation" of a gas turbine.

Next, it was necessary to compile a list of the major equipment and to contact vendors to get prices, with the goal to produce a detailed economic analysis. Unfortunately, without the backing of an actual company, we were perfunctorily dismissed by many of the vendors. We were told that they " don't have time for students". Needless to say, without their cooperation, the leaning experience becomes much more difficult. Some students have taken the approach of "creating" a company for whom they say they are working, others have enlisted the aid of our professors and even the dean of engineering. Finally, some have chosen to simply contact a large number of vendors, until finally finding one who is willing to give of their time. Hopefully, students who would operate under the auspices of an industrial sponsor would be able to use that company's name as leverage, or perhaps to use that company's connections to aid in this process.

As of the deadline for this paper, this step we are currently working on. Still to be completed are: a final economic analysis (+/-10%), a complete control system and a P&I diagram, and the project final report. More of this can be discussed during the presentation.

The Senior Plant Design course at Florida Tech brings together all the material previously learned by the student and puts it to use not in the traditional academic surroundings, but in a simulated work place setting. By drawing on all their resources, discovering some new ones, and perhaps even creating a few, each group of students is able to nurture their project from the infancy of problem definition to the adolescence of a completed final report. Each student was confronted with most of the phases of design work with the expectation that they will be better able to handle many of the "surprise" situations that occur in a real world environment.

However, essential to this process is industrial participation, even at the low-activity level of acting as advisors. If the curriculum at Florida Tech is to be successful, industrial "sponsors" will be required to give of their time and expertise. Once again, we ask you to become involved in shaping the education received by the next generation of engineers.