This column provides examples of cases in which students have gained knowledge, insight, and experience in the practice of chemical engineering while in an industrial setting. Summer interns and co-op assignments typify such experiences; however, reports of more unusual cases are also welcome. Description of analytical tools used and the skills developed during the project should be emphasized. These examples should stimulate innovative approaches to bring real world tools and experiences back to campus for integration into the curriculum. Please submit manuscripts to Professor W. J Koros, Chemical Engineering Department, University of Texas, Austin, Texas 78712.

EXPERIENCE—THE EASTMAN WAY

A Wealth of Cooperative Chemical Engineering Under One Roof

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A cooperative educational experience at Eastman Chemical Company's large integrated headquarters facility offers special opportunities not available at smaller, less diverse sites. An overview of the Eastman program and the types of assignments available are the subjects of this paper. We will also summarize the makeup of our co-op work force by discipline and cooperating university location and will illustrate the specific educational growth and development opportunities within this special environment with two examples involving chemical engineering co-op students.

HISTORY AND PHILOSOPHY

Eastman Chemical Company, recently spun off from Eastman Kodak Company to form an independent company, has its headquarters located in the foothills of the Appalachian Mountains in eastern Tennessee. The location of a chemical company is usually determined by some economic advantage, and Eastman is no exception. The abundance of hardwood trees in the Appalachian Mountains provided a rich feedstock for Eastman's production of methyl alcohol in the 1920s by a then-new process of wood distillation. At that time, methyl alcohol was important to Eastman Kodak Company in the manufacture of photographic film. More recently, coal from nearby locations, which is gasified to form syngas, has become a rich source of chemicals for Eastman.

Cooperative education is now widely accepted as a desirable complement to a traditional chemical engineering education. Universities have the unenviable task of equipping a chemical engineering student with a huge amount of theory and basic concepts in a relatively short period of time. It is tempting but inappropriate for those of us in industry to assess the practical skills learned from experience and chastise universities for not providing those skills up front. Cooperative chemical engineering is the solution—it allows students to gain practical experience from an industrial setting while allowing universities to focus on continually upgrading their curriculum to include new tools and technologies.

So what is unique about cooperative chemical engineering at Eastman? Diverse industrial experience can be provided by dozens of large chemical companies. What sets Eastman apart, however, is the fact that in Kingsport, Tennessee,* there are hundreds of manufacturing processes, including

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* *Eastman also has manufacturing facilities in Texas, Arkansas, New York, and South Carolina.*

management, administration, engineering, marketing, and research facilities. This enables both cooperative education interns[1] and regular employees to share in a common culture while experiencing diverse job opportunities. Common culture is a subtle advantage which is difficult, if not impossible, for a company with many manufacturing sites and a separate head office location to maintain. It allows an Eastman intern to quickly learn how to succeed in the industrial setting by making personal contacts, familiarizing himself/herself[2] with technical tools, working on processes, and focusing on safety by using procedures and resources which will not change throughout his entire cooperative engineering tenure.

Included in the following paragraphs is a summary of the cooperative engineering program, including types of general assignments an engineering intern is likely to encounter at Eastman as he becomes more experienced in his classwork and industrial experience. Following the job summaries are two case studies which will illustrate some of the unique skills an Eastman intern can acquire apart from the classroom.

TYPICAL PATH OF CO-OP INTERNS

Cooperative engineering at Eastman operates similarly to other companies: after a complete freshman year, the student begins alternating work with school every other semester or quarter. Students are interviewed on campus for cooperative intern positions and once selected, serve at least three work sessions (typically four to five work sessions). Eastman generally enrolls between fifty and a hundred interns at a given time, including those at work and in school. Historically, after graduating from college a high percentage of cooperative interns later become full-time employees with Eastman. Figure 1 illustrates the variety of universities represented in Eastman's co-op program, and Figure 2 shows the breakdown of engineering disciplines represented in the cooperative engineering program.

Interning with Eastman offers a wide variety of work experience, and as a student progresses in his education, job assignments become more challenging. Typical beginning-level assignments include maintenance, research and development (R&D), and technical services.

In maintenance jobs the intern works with a skilled maintenance crew and is exposed to many different areas in the chemical plant. For many, this will be the first time inside a processing facility, and this job familiarizes them with equipment, layout, terminology, and basic repair. In R&D and technical service jobs, the student intern works as a lab technician, learning basic research procedures and lab work documentation. Typically, the student becomes familiar with business software such as word processors, spreadsheets, and graphics packages which will likely be used throughout his career.

Representative intermediate-level assignments include marketing, power and services, and some manufacturing assignments. By this time a cooperative engineering student should be into his sophomore or possibly his junior-level classes.

Jobs in marketing expose students to business and sales aspects of the chemical industry. These jobs demonstrate other opportunities for engineers outside of typical engineering assignments. Power and service jobs include work in wastewater treatment, powerhouses, and refrigeration services. These jobs impress upon the student the role of utilities in a chemical plant and how utilities are managed. This opportunity also gives a chemical engineering student a chance to work on an assignment that is not typical chemical

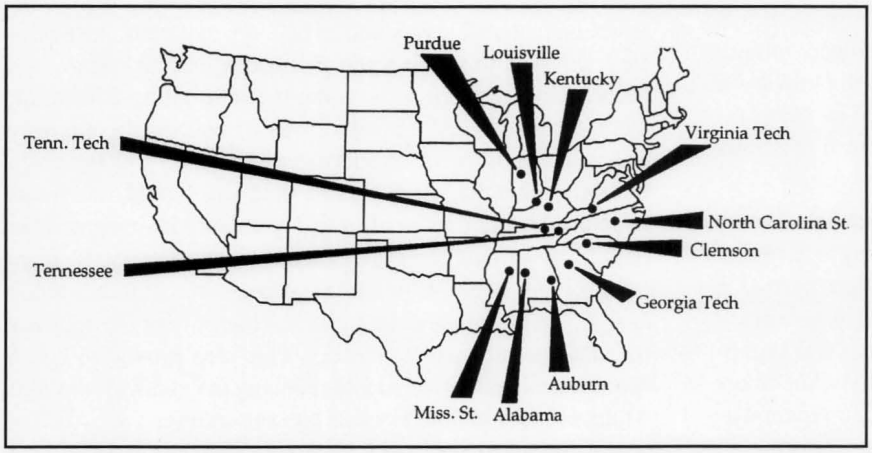

Figure 1. *Eastman co-op engineering students attend a variety of universities.*

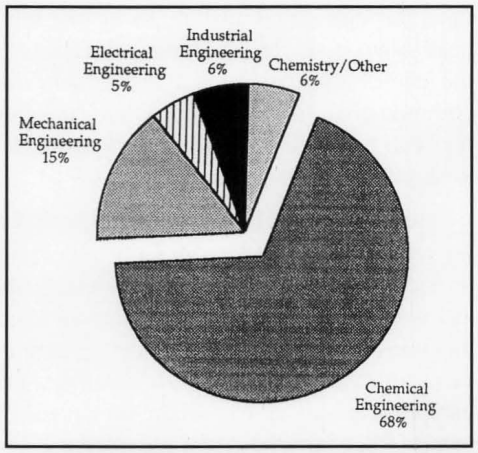

Figure 2. *Breakdown of cooperative education disciplines at Eastman.*

[1] *A difference exists at Eastman between cooperative engineering students and interns. For this paper, both groups will be referred to as "Cooperative Engineering interns" or more simply, "interns."*

[2] *For simplicity, the masculine pronoun will be used to describe the "typical" intern.*

engineering work, giving the student an understanding of other engineering disciplines.

Intermediate manufacturing assignments are relatively flexible and can be tailored to the individual, depending on his interest and progress in school. Manufacturing assignments include Eastman Chemical divisions such as Polymers, Cellulose Esters, and Acid. In these assignments, the student is a member of the engineering process improvement group for the area and is given responsibility for his own engineering projects.

Manufacturing assignments and process engineering jobs are final-level job assignments. The process engineering assignment includes traditional chemical process design and capital project work. By this time an intern has completed most of his junior-year classes and work given the student is similar to that of a newly hired engineer.

HELP WANTED: HERCULEAN CHEMICAL OPERATOR

A profile of one of Eastman's summer interns can illustrate more clearly the types of skills one can obtain by working in a practical industrial setting. Projects in industry often require a broad focus—a variety of resources must be used to reach an effective solution. Eastman interns have the advantage that company experts are close by to help them immediately solve problems in the field, office, or laboratory.

Greg Dickerson is a chemical engineering graduate from the University of Alabama. He currently works in the Advanced Process Technology group for Eastman's Engineering Division. As a former summer intern, Greg acknowledges the intern program as a valuable learning experience that not only translates into marketable technical skills, but also facilitates classroom learning. In particular, Greg recognizes teamwork as one of the most beneficial skills developed through an internship. As he see it, "No project falls neatly into a single [academic] discipline. Projects require the contribution of several individuals working toward a common goal. In industry, problems are solved by networking with people from various backgrounds—from operators to technical specialists."

During his internship with the Organic Chemicals Development and Control Group, Greg was assigned to a capital project start-up team which was established as part of a process feasibility study. The start-up team had bi-weekly meetings to discuss safety issues, ergonomics, and equipment limitations. During these meetings, the team members had process walk-downs where each piece of equipment was inspected and evaluated for intended use and operability.

One such walk-down revealed a possible problem. The team identified an unsafe situation where production operators would have to lift a 250-pound manway (which sealed the entry port on a carbon treatment tank) at least five times a day as part of the processing. As a result of the field evaluation, the team established an action item to address this concern. Greg was assigned to champion an effort that required an engineering evaluation, a design proposal, and a recommended course of action.

In proceeding with his evaluation, Greg wanted to determine how difficult it would be for operators to lift the manway. To do this he employed the assistance of two operators who helped him perform the task of unbolting and removing the manway. This gave Greg a hands-on appreciation of the task's difficulty as well as an understanding of the operability constraints faced by the workers. Since the engineering evaluation was intended to determine the most effective way of mitigating the difficulties of using the tank as a processing unit, Greg had to determine the best solution that addressed the operability, materials compatibility, structural integrity, and economic feasibility constraints.

First, Greg considered having the manway constructed of a lighter material. He determined what types of chemicals would be processed in the carbon treatment tank and presented this information to Eastman's materials engineers. They in turn provided him with a list of available materials that would be compatible with the process chemicals. After consulting the pressure vessel specialists, however, Greg found that only a few of the materials could be fabricated in a way that would make the manway lighter while also safely maintaining the vessel's pressure rating. In addition, a cost analysis indicated that specialty alloys were not economically feasible for the application. Eastman Chemical's plant site has a high degree of integration which simplified this preliminary evaluation since obtaining the assistance of these specialists required only a short walk to Engineering Division's on-site offices.

As is often the case in industry, Greg returned to the drawing board to consider another alternative. Since construction material was found to be a set constraint, he evaluated ways of improving the manway's current design. As before, Greg was faced with the pressure rating constraint; therefore, he needed a creative way of making the manway easier to handle without sacrificing its structural integrity. Realizing that the existing flat manway would not be as structurally sound as an elliptical one, Greg investigated the possibility of designing a domed manway fabricated from light gauge steel. With the assistance of computer-aided design, Greg evaluated the structural integrity of the manway for various thicknesses of steel. This idea proved to be an economically effective way of reducing the manway's weight while maintaining the vessel's pressure rating.

Once Greg had decided on the design he would recommend, he used a graphics software package and a word processor to generate a technical presentation to be delivered to the start-up team and his supervisor. Greg received pointers from colleagues about different types of presenta-

tion media that help make technical presentations effective. He presented his methods of evaluation and his basis for design. Upon reviewing Greg's proposal, the team concurred with his recommendations and decided to implement the design. Greg then followed up the presentation with an in-house archived technical report that detailed his finding and recommendations.

Throughout this project Greg developed several essential skills and used a diversity of resources to prepare him for his professional career. The experience of managing a small project allowed him to work with a variety of people with diverse backgrounds, which improved his interpersonal skills. In addition, the project gave him an opportunity to refine his communication skills since he had to prepare and present technical information to his peers and supervisor for their approval. Finally, in the process of completing his assignment and preparing his findings, Greg gained valuable experience with high-level analysis and presentation software, which further developed key computer skills. All these developmental opportunities were certainly beneficial, but perhaps the most valuable aspect of Greg's experience was the teamwork setting in which he completed his project.

ASH TO ASH

Other cooperative engineering assignments require analysis similar to a classroom example but with more significant implications than a letter grade. Wayne Chastain, a graduate of Clemson University, is now an Eastman chemical engineer specializing in safety engineering. He works for the Engineering Division, helping to ensure that processes from all divisions are designed, operated, and maintained safely.

When he was a co-op student, Wayne had a chance to work in the Coal Gasification Department. He was to evaluate a new type of coal in the gasification process. The high-priced coal could potentially pay for itself through lower by-product disposal costs, but many other factors needed to be considered before a decision could be made.

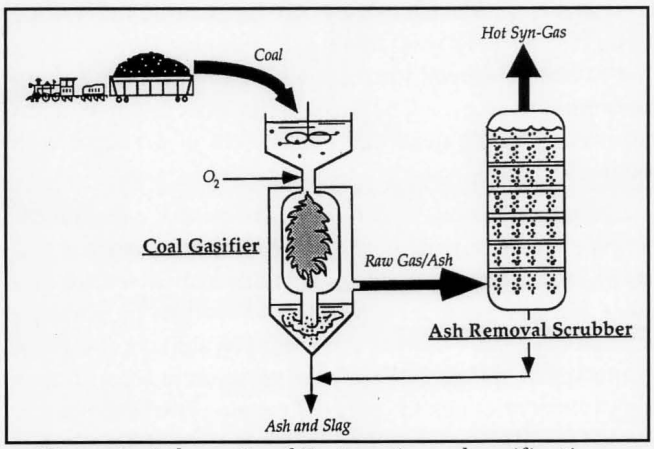

Figure 3. *Schematic of Eastman's coal gasification process*

In the coal gasification plant at the Kingsport site, coal from nearby mines is gasified at high temperatures and pressures to produce synthesis gas. This syn-gas can subsequently be converted into more valuable chemicals like methanol, acetic acid, and acetic anhydride. Figure 3 shows a simplified schematic of the front-end process. A by-product of the gasification is ash and other unburnable solids known as slag, which must be isolated and disposed of (at some cost). Wayne was asked to evaluate a new coal which was lower in ash content that typical coal but which was priced higher.

He began by writing a proposal detailing the scope of his evaluation, how it would affect operation of the gasifier, and what the potential benefits were. After this proposal was approved, Wayne had the responsibility of executing it and analyzing the results. Some of the challenges included gaining cooperation from other Eastman personnel. Wayne worked with production operators—they knew how to set conditions of the gasifier to insure that syn-gas made from low-ash coal was of a high quality. Wayne acquired coal through the Purchasing Department, and other process improvement engineers provided him with process consultation.

The scope of the project was simple: conduct a two-week run of the gasifier using low-ash coal; evaluate the effect on the gasifier, syn-gas production, solids removal, and decreased solids load; and finally, put together an economic comparison of the trade-offs. Wayne had to access on-line analyzers and a plant-wide database to compile data he needed to perform the analysis. Some manipulation of the data using a mainframe computer was needed to determine which results were statistically significant and which were not.

The main factors were the high initial price of the coal versus reduced landfill cost. Complications included the following considerations:

- *How would syn-gas quality change?*
- *Would the gasifier need to operate at a higher temperature that would compromise its mechanical design?*
- *How would the solids removal process be affected by different ash composition?*
- *How does one quantify long-term environmental benefits from reduced ash and therefore reduced heavy metals in the landfill?*

Wayne used a complex model to evaluate benefits and costs associated with these factors for the two different coal types.

In his presentation to management, Wayne showed that low-ash coal was only marginally economically attractive. Management chose to go with the low-ash coal on a long-

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Experience: The Eastman Way

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term basis, perhaps more from a positive environmental standpoint than a driving economic advantage. Wayne followed up his project by documenting his planning, execution, and final analysis in a technical report.

One of the benefits of Wayne's assignments was that it exposed him to "the big picture" of solving real-world chemical engineering problems. As Wayne puts it, "Using a broad range of engineering resources to complete my study not only gave me an appreciation for my [undergraduate] chemical engineering courses, but also helped prepare me for my current assignment as a process engineer." By managing a variety of resources, Wayne learned how to plan and coordinate a project in which he required assistance and interaction from operators, purchasing, other process improvement engineers, and even management.

The "hands-on" nature of Wayne's project clearly differentiates it from a classroom setup. More than just compiling data from a variety of sources, Wayne worked side-by-side with operators during actual operation of the gasifier; additionally, he was required to gather cost and other data for a variety of operating scenarios. When too much information was available, Wayne determined which data were applicable for his investigation. When information was scarce, he ascertained the best method to generate or estimate required data.

A FINAL WORD

The true value of cooperative chemical engineering does not lie solely in acquisition of technical skills, but rather is the variety of job-related experiences. From safety issues and analysis to interpersonal skills and project management, an industrial setting is an efficient means of gaining practical skills that are not easily attained through classroom experience.

In the professional environment, interns develop teamwork skills and learn how to solve problems where scope must be quantified, the basis determined, and constraints identified. These assignments cultivate industrial experience by interaction with diverse groups including technical specialists, financial analysts, production operators, supervision, and peers. A recent study's finding specifically point to benefits of cooperative learning and the type of education gained through a cooperative engineering program. Frequency of group work has a positive correlation with most areas of self-reported satisfaction and education growth.[1] Furthermore, solving real-world problems allows students to see "the big picture" by requiring them to use a variety of engineering resources. This view of the overall picture can enable students to gain an appreciation of their chemical engineering courses by showing how key concepts are interrelated.

Although universities could emphasize some of these concepts within their curricula, many of the skills are more effectively acquired through the hands-on experiences of cooperative internships. Additionally, Eastman's highly integrated site provides a common culture and broad scope of resources to accomplish challenging technical assignments. It is apparent that cooperative education is an effective way to acquire practical industrial skills through diverse assignments within a common culture—this is the essence of experience, the Eastman Way.

ACKNOWLEDGMENTS

We wish to express our gratitude for the contributions provided by two current Eastman cooperative engineering students: Catherine Flanders, who attends Auburn University, and Susanne Smith from Mississippi State University. We would also like to thank Greg and Wayne for allowing us to showcase their practical and beneficial experiences.

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ChE book review

HANDBOOK OF HEALTH HAZARD CONTROL IN THE CHEMICAL PROCESS INDUSTRY

by Sidney Lipton and Jeremiah Lynch
Wiley Interscience, New York, NY; 1003 pages, $89.95 (1994)

Reviewed by
Daniel A. Crowl
Michigan Technological University

When I was originally asked to review this book, the title strongly indicated to me that I would be reviewing another industrial hygiene book. I was pleasantly surprised to find that I was wrong! This 1003-page tome contains a wealth of detailed information in a new area (at least to me) of "health hazard control." This area relates to exposure control from both fugitive emission sources and process hazards for both workers and the community. The main emphasis of the book is clearly on traditional industrial hygiene-type exposures, *i.e.,* chemical exposures which occur mostly on a continuous basis during routine chemical operations and handling. A few short sections toward the back of the book are devoted to episodic releases which occur during an accident scenario.

The book also contains a wealth of practical process infor-

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