The Technological Institute, home of the Department of Chemical Engineering.

ChE department

NORTHWESTERN UNIVERSITY

... THE NORTHWESTERN PHILOSOPHY

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IF YOU READ NO further than this first paragraph, I would like you to leave with the impression that we take pride in our teaching, that we strive to be on the forefront in our research, and that we are committed to meaningful contact with our students. Those priorities provide the guiding philosophy for the department.

This philosophy has been tested by time. This year marks the 40th anniversary of the first class graduating in chemical engineering from the Technological Institute. We awarded our first master's degree in 1945 and our first PhD in 1948.

Our department now includes 18 faculty, 250 undergraduate and 100 graduate students, six visiting scholars, and three postdoctoral fellows. Since modern chemical engineering research is increasingly interdisciplinary in nature, a number of the faculty hold joint appointments with other departments: biomedical engineering, chemistry, materials science and engineering, mechanical and nuclear engineering, and neurobiology/physiology.

As we have become convinced of the synergism, we have chosen to emphasize several broad areas of research rather than 18 individual activities.

No scale for the comparison of chemical engineering graduate programs exists. It is clear that, while top departments all offer excellent faculty and facilities, there are differences in educational philosophy and in the research interests of their faculties. Our department strives to maintain a balanced commitment to teaching and research. The training of graduate and undergraduate students is taken seriously by all of us.

The prerequisites for admission to graduate work include a bachelor's degree in chemical engineering from a university or college of recognized standing. Graduates of a curriculum in science or in other fields of engineering whose programs have included sufficient courses in chemistry, mathematics, and physics will also be accepted for graduate work in chemical engineering. However, they may be required to take selected undergraduate courses without credit, in addition to the normal graduate program.

An individual plan of study is arranged for each student after consultation between the student, his or her adviser, and the graduate committee of the department. Every effort is made to design a program covering the fundamentals of modern chemical engineering science and technology while allowing for individual specialization in particular fields of interest.

For the MS degree, we require a minimum of nine (quarter) courses. Research and the preparation of an acceptable thesis may be an alternative to three extra courses.

For the PhD, a minimum of 18 (quarter) courses are required beyond the BS degree or nine (quarter) courses beyond the MS. Students are guided towards this program based on their classroom performances. The formal qualifying exam is oral and focused on the research topic proposed for the thesis. We have no language requirements.

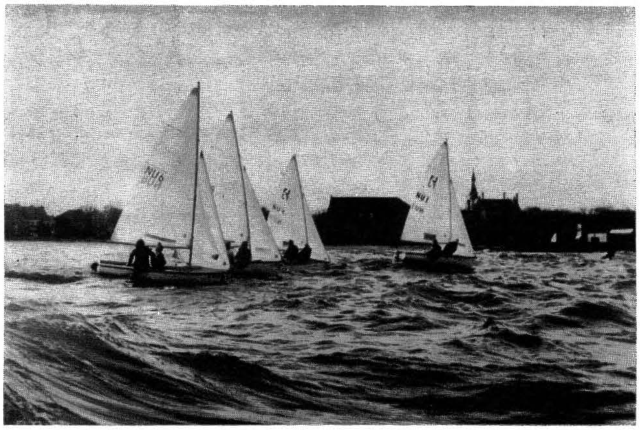
As we have become convinced of the synergism, we have chosen to emphasize several broad areas of research rather than 18 individual activities. In the descriptions that follow, observe that we have encouraged for the same reason interactions between faculty which cross department boundaries. The single paragraphs devoted to individual faculty are meant to give an impression of their activities rather than to summarize their multifaceted research programs.

RESEARCH

Chemical Reaction Engineering. The largest single area is chemical reaction engineering: kinetics, catalysis, chemical reactor design, and combustion. There are five faculty active in this area: John B. Butt, Joshua S. Dranoff, Harold H. Kung (who has a joint appointment with chemistry), Chung K. Law (who has a joint appointment with mechanical and nuclear engineering), and Wolfgang M. H. Sachtler (who has a joint appointment with chemistry). This group features extraordinary interactions with faculty in materials science and engineering, chemistry, and physics through the Catalysis Research Center, which will soon have its own building adjacent to the Technological Institute.

John Butt's work in catalysis has been largely in the area of supported metal catalysts. His group's current research is devoted to the study of hydrogenolysis and hydrogenation reactions on supported Pt group metals and to synthesis reactions on supported iron alloys. Particular emphasis is given to the relationship between the morphology of the supported metal crystallites and their activity and selectivity properties. More generally, John Butt is concerned with the interrelation between catalyst deactivation and chemical process dynamics.

The work of Josh Dranoff and his students in photochemical reaction engineering has previously involved gas and liquid phase photochlorination reactions as well as solution photopolymerization.



A practice race in view of the campus.

Current emphasis is focused on the study of novel photoreactor designs in which the photoinitiation and subsequent thermal reaction steps common to many photoreactions of interest are carried out in spatially segregated zones.

Harold Kung is pursuing the reasons for high selectivities in oxide catalysis. Using modern surface science and catalyst characterization techniques, his group has prepared and characterized both model single crystal oxide catalysts that have high concentrations of a particular type of surface defect, such as anion or cation vacancies, as well as microcrystalline oxide catalysts smaller than 10 nm that possess unusually high selectivities.

A viable approach to enhance combustion efficiency and reduce pollutant formation is through lean combustion. Since lean mixtures are hard to ignite and easy to extinguish, the use of heterogeneous catalysts can significantly extend the lower flammability limits of these mixtures. Ed

Law's group is working to identify the dominant catalytic mechanisms and to determine the associated overall kinetic constants for hydrocarbon/air mixtures flowing over different catalysts.

Wolfgang Sachtler and Harold Kung are studying stereospecific catalysts with the objective of understanding the relationship between the geometry of the active site and catalytic selectivity. On the basis of Wolfgang Sachtler's previous work, it has been proposed that many such reactions involve a dual site mechanism. Their research is aimed towards checking this model and evaluating the prospects of dual site hydrogenation catalysts in general.

Interfacial and Multiphase Transport Phenomena. We have three faculty working in the general area of interfacial and multiphase transport phenomena: S. George Bankoff (who has a joint appointment with mechanical and nuclear engineering), Gregory Ryskin, and me. All three of us find complementary interests in the activities of Stephen H. Davis (who has joint appointments in engineering science and applied mathematics and in mechanical and nuclear engineering). We are involved in such diverse activities as dynamic interfacial phenomena, coalescence, two-phase flows with heat transfer, flows in porous media, flows of suspensions, and structural models for the stress-deformation behavior of polymer solutions.

George Bankoff has been directing a broad program of experimental and theoretical studies on two-phase flow and heat transfer. His particular motivation has been problems associated with nuclear reactor accidents. Rather than studying these complicated problems directly, he and his students have chosen to examine more fundamental problems that can shed light on particular aspects of the overall process.

Gregory Ryskin's current research interests focus on the numerical solution of fluid mechanics problems. He is considering both flows with free boundaries as well as the motions of polymer solutions, the stress-deformation behavior of which is determined by the local microstructure.

My students and I have directed our attention to a series of fundamental problems concerned with dynamic interfacial behavior and multiphase flows arising in the context of oil production. For example, we have been investigating the influence of the interfacial viscosities upon displacement and the stability of displacement of residual oil from old oil fields.

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Polymer Science. Our three faculty whose primary interests are in the area of polymers have joint appointments with materials science and engineering: Stephen H. Carr, Buckley Crist Jr., and John M. Torkelson.

Plastic films that possess either permanent electrical polarizations or electrical conductivity are currently being used as the active elements in such devices as microphones, infrared detectors or batteries. Steve Carr and some of his students are seeking to understand the origins of the persistent polarization that can be established in some polymer solids. They are studying other polymers that are electronic conductors and act as organic metals.

Using model crystallizable hydrogenated polybutadiene (HPB), Buck Crist's group is making significant advances in understanding the important effects of molecular weight, molecular weight distribution, short chain branching and long chain branching on the structure and properties of semicrystalline polymers. These studies utilize light scattering, x-ray scattering and diffraction, small-angle neutron scattering, calorimetry and density measurements on HPB having extremely well-defined molecular microstructures.

The utility of photophysics in studying macromolecular diffusion-controlled reactions has been demonstrated by studies of intermolecular reactions between labelled polystyrene chains as well as by studies of intramolecular cyclization dynamics of a single polystyrene chain. By a combination of carefully selected fluorescence and phosphorescence studies, John Torkelson is investigating the Rouse dynamics of polymer chains.

Process Engineering. The area of computer-aided process planning, design, analysis, and control is the interest of Richard S .H. Mah and William F. Stevens.

The research of Dick Mah and his students is directed towards the development of comprehensive theories and techniques for operating processes. One focus of their research is their work on process data reconciliation and rectification, which has already led to new techniques of gross error detection and identification, a rigorous theory of observability and redundancy, and efficient variable and measurement classification algorithms. Another thrust is in the design and scheduling of batch chemical processes.

Process optimization and process control are beginning to depend significantly upon the utilization of equipment and procedures for "real-time" computing. Bill Stevens' current research activities emphasize the development of programs and procedures for the implementation of various "real-time" applications utilizing minicomputers and microcomputers.

Separation Processes. There is currently a developing interest in the department in separation processes.

Josh Dranoff has had a long-term interest in separations based on sorption in zeolites and similar adsorbents. Currently his students are investigating the kinetics of sorption of binary gas mixtures by zeolite adsorbents using a differential bed-chromatographic type apparatus.

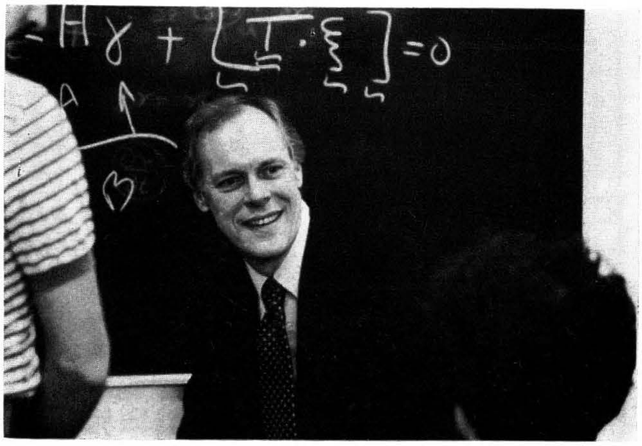
Dick Mah's group has proposed and is investigating a new class of distillation schemes designed to enhance overall thermal efficiency. This is accomplished through heat exchange between the rectifying and stripping sections of a distillation apparatus in what is known as secondary reflux and vaporization (SRV) distillation.

George Thodos and his students are studying the removal of SO_2 from flue gases using regenerable sorbents such as Nahcolite ($NaHCO_3$), which may offer the possibility of closed loop systems for clean-up of power station stack gases. Separately, he is testing supercritical extraction as a separation tool.

Individual Activities. Naturally, not all of the research in the department is done in the context of group activities.

Thomas K. Goldstick (who has joint appointments with biomedical engineering and neurobiology/physiology) is well known for his long-term interests in biomedical engineering. His current research centers around the dynamics of oxygen transport in the retina of the eye.

Studies of vapor-liquid equilibria and critical state phenomena continue to occupy the interests of George Thodos and some of his students, while with another group he extends his investigation of solar energy collection and storage.



Chairman John Slattery in an informal discussion with students.

FUTURE DIRECTIONS

Chemical engineering is an evolving discipline, the one continuous thread being that we are all concerned with applications of chemistry, broadly interpreted. The emphasis given to particular areas of research shifts as the needs of society change, the current faculty matures in its outlook, and we add new faculty.

Looking to the future, we are anxious to expand our activities in the area of computer-aided process planning, design, analysis, and control, when we are presented with the right opportunity. Both the students and faculty agree that this will be a field of increasing importance to the profession.

We would also like to move into biochemical technology. This is not only an area of considerable promise, but also it is one in which, by our judgment, the primary impact of chemical engineers is still developing.

But as we continue to look in new directions, basic priorities will remain unchanged: our pride in our teaching, our eagerness to be on the forefront in our research, and our commitment to meaningful contact with our students. □