



General view of Quadrangle 2 of Syracuse University with domed stadium for 50,000 people on the left.

**ChE** department

## ***SYRACUSE UNIVERSITY***

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**O**UR CHEMICAL ENGINEERING department is an important part of the L. C. Smith College of Engineering, which is named after the famous Smith of typewriter fame who was born and raised in the area of Syracuse. The college is one of eleven at Syracuse University which has 11,000 undergraduate and 4,000 graduate students from all fifty states and ninety-four foreign countries. A mosque, a synagogue, and several churches (orthodox, catholic and protestant) are all within a short walking distance of the S.U. campus.

The university began its first academic year in 1871 and was established as a residential uni-

versity by the Methodist Church, but it has since become nonsectarian. There are enough residential facilities (dormitories, fraternities, sororities, and individual apartments) on or near campus to house the entire student body (and their families, in the case of graduate students).

We take pride in our university as well as our department. In 1966 the university was elected to the prestigious American Association of Universities (AAU), to which belong only fifty-two of the better known universities in the nation, including all the Ivy League institutions.

The department and Syracuse University as a whole are currently engaged in a new enterprise: the Center for Advanced Technology in Computer Applications and Software Engineering (CASE Center). Formally designated by the governor in February, 1984, the CASE Center is one of seven New York State Centers for Advanced Technology. It is a particularly promising example of the current national trend toward increased interaction between universities and industry. Building upon Syracuse University's longstanding ties with industry, the Center is helping to improve the University's research facilities, to strengthen academic programs, and to support economic growth in New York. Current projects conducted

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through the Center by chemical engineering faculty members include investigation of electromigration in thin film microconductors, development of knowledge-base on properties of materials, and work on computer software for finite-element analysis in chemical separation theory.

Our campus of two hundred acres is well maintained and has the only domed stadium in the state of New York. A recent visitor to our department (a seminar speaker) said, "This campus looks just like a university campus ought to look!" The campus is adjacent to the State University of New York (SUNY) College of Environmental Science and Forestry, which has a first-class chemistry department. All S.U. students may take courses there.

Syracuse University has always emphasized the sports of football and basketball, and some of us professors used to view this practice with disdain. But right after 1959, when S.U. won the national championship in football, we got the largest and best crop of chemical engineers we had ever seen. Since then we don't disdain our superiority (some years) in sports.

The city of Syracuse was named after the Greek city-state of the same name, now in Sicily. It was in the old Syracuse that Archimedes shouted in his bathtub, "Eureka!" when he discovered the principle of buoyancy 2200 years ago. We always mention this in Transport I (fluid mechanics). The mayors of Syracuse, New York, and Syracuse, Sicily, frequently visit each other in current times.

Syracuse is in the center of New York state and has excellent air transportation since it is served by four major airlines and six feeder lines. The city is near the beautiful and largest state park in the nation, Adirondack State Park. It is an industrial city that is host to many diversified industries which include Allied Corporation (Chemical Sector), important divisions of General Electric, General Motors and Bristol-Myers; Millers and Matts Breweries, and a host of other companies making ball bearings, electroplated items, specialty steels, etc. Syracuse is also the headquarters of the Carrier Corp., the first and original air-conditioning company in the world, and of Crouse-Hinds the manufacturer of electrical components and of the first commercial red and green traffic signals in about 1920.

## THE DEPARTMENT

Our department was originally a part of the Chemistry Department and we awarded our first

BS in chemical engineering in 1917, our first MS in 1922, and our first PhD in 1949. We separated from chemistry and became part of the Engineering College as the Department of Chemical Engineering and Metallurgy in 1914, but our title was changed in 1973 to Chemical Engineering and Materials Science.

Our department chairman before 1954 was Charles D. Luke, who left to take a job with the government. The next chairman was James A. Luker, and when he became Dean of Engineering we began looking for another chairman. Then some wag suggested we look for a chairman named



**Hinds Hall, home of chemical engineering and civil engineering.**

Lukest so that we would have the procession of Luke, Luker, Lukest!

Some notable BS graduates have been Andreas Acrivos (1950), now teaching at Stanford, the late Leon Lapidus (1945), formerly a professor and department head at Princeton, and Donald G. Stevens, former Vice President of SOHIO.

The department presently consists of fourteen full time faculty, including three professors of materials science and eleven professors of chemical engineering. A fifteenth has full time administrative duties as Vice President for Research and Graduate Affairs of S.U. There are 104 undergraduate students, 43 graduate students, 9 post doctoral research associates, and 3 visiting scholars. The department presently occupies 27,000 square feet of space in Hinds Hall and Link Hall, exclusive of classrooms.

## THE UNDERGRADUATE PROGRAM

One of the outstanding features of our undergraduate program is the individual attention we give our students. The present (1984) student-to-

faculty ratio is less than fifteen. This structure gives us the opportunity to interact closely with the students so that we can instill a sense of pride in their engineering and scientific accomplishments and a high level of confidence in their background. All of the eleven faculty members in chemical engineering are involved in undergraduate teaching.

Another characteristic of our program is the participation of undergraduate students in research projects. This year over twenty percent of the seniors and some juniors are performing research under the guidance of the faculty. Some seniors have had articles accepted for publication in technical journals prior to graduation and have given presentations at national AIChE meetings.

The undergraduate curriculum is a typical blend of mathematics, physical sciences, and engineering courses. Most of our students follow the General Chemical Engineering Option which covers the traditional program terminating in the senior courses in process design and control. By replacing certain upper level courses in the general option, students can tailor their program of study to the options in environmental systems or materials science. For the former option, courses in biology, air pollution, and waste treatment are added, while courses in the structure and properties of materials, polymer science and processing, and metallurgy can be added in the latter option.

A few years ago, a freshman chemical engineering computing course was instituted, and this year it is being taught in our new microcomputer laboratory. All of the courses (especially those in design and control) are being updated to reflect the growing importance of computers in the engineering profession. It is also useful to get the freshman students into chemical engineering courses before their sophomore year. We are pleased to report that renovation of the undergraduate laboratory will begin this summer. In addition to moving to a new location with more space, modern instrumentation (including microcomputers for data acquisition and analysis) and new experiments in materials properties and processing are being installed, with funds provided by the IBM Foundation.

## GRADUATE EDUCATION AND RESEARCH

The Department of Chemical Engineering and Materials Science offers a MS and a PhD in chemical engineering. Masters candidates may pursue the thesis or non-thesis option, although all

students on research or teaching assistantships must complete a master's thesis. The thesis is 6 semester hours of the 30 semester hour total. The PhD requires 90 semester hours beyond the BS of which up to 39 hours may be doctoral dissertation. Presently there are 43 full-time Chemical Engineering and Materials Science graduate students in the department, 40 percent of whom are PhD candidates.

Considering the size of the department, research covers a broad spectrum that includes biomedical, catalysis, surface science, materials science, polymers, electrochemistry, process simulation and control, separation and transport processes.

For the twenty-three years prior to 1980, **Allen J. Barduhn** did a lot of research on desalting sea water by freezing and by gas hydrate formation and became an expert on the growth rates of ice crystals and the thermodynamics of many gas hydrate systems. In 1964 Barduhn invented the eutectic freezing process for treating waste waters.

**John C. Heydweiller** is investigating the optimal design of entire processes by using the Rayleigh-Ritz approach to incorporate distributed models. This project involves the investigation of various approximating functions and search procedures to find an efficient and robust combination. Another topic of interest to Heydweiller is the numerical solution of partial differential equations, particularly those involving steep fronts.

**Vasilios A. Karagounis** is interested in the photolithographic fabrication of dissolved oxygen and pH sensors on silicon chips. Theory is developed for unsteady state measurements of oxygen concentration using cyclic voltometry at high scan rates. He is also investigating the adhesion of metals on polymer substrates. This study concentrates on the development of plasma treatments of substrates which will increase the number of covalent chemical bonds at the metal-polymer interface. The scanning electron microscope (SEM), electron spectroscopy for chemical analysis (ESCA), and Auger spectroscopy are used to examine the interface.

Mathematical models for insulin and glucose metabolism in humans are also being developed by Karagounis. Simulation studies, using the Advanced Continuous Simulation Language (ACSL), explore the effectiveness of different control schemes (feedback, feedforward, adaptive and inferential) in controlling glucose in diabetic patients with an artificial pancreas.

**Hao-wen Liu**, in materials science, is studying cyclic loading at elevated temperatures which reduces service lives of engineering structures and engineering components. Oxidation, particularly grain boundary oxidation, is being investigated as the damaging mechanism for the reduced service lives. Also, the slip systems associated with crack growth and the applied stresses on these slip systems are being studied. The characteristics of crack tip deformation in large scale yielding and in general yielding are being analyzed and the results of the crack tip field analyses are being used to study elastic-plastic fracture mechanics and crack growth in strain controlled fatigue.

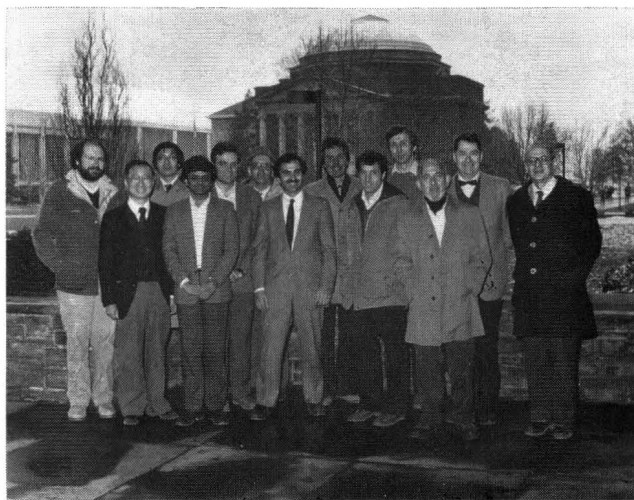
Using a cyclic mechanical load, cyclic slip will take place in crystalline materials. Fatigue damage is closely related to the changes in dislocation structure caused by cyclic slip and the resulting crystal distortion, which is measured with x-ray diffraction. The results of this study enable us to monitor fatigue damage in materials and engineering structures.

The relationship between the molecular structure of the polymer chain and the physical behavior and performance of the material is being investigated by **George C. Martin**. His primary interest is in the physical properties and applications of polymers. He is investigating the use of polymer elastomers as integral components in micro-electronic and micro-optical devices. He is interested in the rheology and characterization of polymer composites, especially with respect to the nature of the curing process, the glass transition temperature, and the mechanical performance and processing of the materials.

**P. A. Rice** recently completed an investigation of the stripping of emulsified refrigerant from water in a vacuum spray chamber. This work shows that the major mechanism for the removal of emulsified refrigerant is the flashing of the droplets as they are exposed to the chamber atmosphere when the surface of the disintegrating liquid sheet expands. Rice is also pursuing an interesting joint project with Upstate Medical Center on the effect of ethanol on the rate of amino acid transport in the human placenta.

**Ashok S. Sangani** is studying the fluid mechanics and stability of magnetic fluids or suspensions of magnetized solids. Such phenomena are important in leakproof seals and magnetic ink jet printers. The development of theoretical models for prediction of the effective transport properties of two phase media is another research interest of Sangani.

**Klaus Schröder** is presently interested in magnetic properties of fine particles and thin films. He is studying the effect of ultrasonic stress waves on magnetization changes. The materials used in these investigations are BiMn alloys with small



**Faculty of Chemical Engineering and Materials Science. Front Row left to right: Liu, Sangani, Tavlarides, Heydweiller, Barduhn, Stern. Second Row left to right: Martin, Tien, Karagounis, Schroder, Schwarz, Rice, Vook. Missing are C-S Wang (on leave) and V. Weiss, who is a Vice President of S.U.**

ferromagnetic BiMn precipitates, and MgO with magnesioferrite precipitates. Schröder is also measuring the effect of a non-magnetic overlayer on the magnetization of thin iron and nickel films.

**James A. Schwarz** is our specialist in catalysis and is investigating adsorption-desorption kinetics of reactive gases important in the production of synthetic fuels and is developing novel methods of analyzing surface reactions using cyclic operations. He has recently extended his interests in surface chemistry to the area of micro-electronic device-fabrication and reliability.

**S. Alexander Stern** is studying the separation of gaseous and liquid mixtures by selective permeation through polymer membranes. In the area of gas separation, the studies are concerned with the mathematical modelling of new concepts of membrane process design, such as recycle and multimembrane permeators. The results of these studies are being tested experimentally. The separation of azeotropic mixtures by pervaporation, osmotic distillation, and osmotic phase separation is also being studied theoretically and experimentally. The main research effort is being de-

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so integration gives

$$r = 0.05 \text{ cm} - 0.034 \text{ kt} \quad (\text{A-17})$$

Inserting the numerical values given, we find

$$\begin{aligned} 0.027 \text{ cm} &= 0.05 \text{ cm} - 0.034 \text{ k}(420 \text{ sec}) \\ &= 1.6 \cdot 10^{-3} \text{ cm/sec} \end{aligned} \quad (\text{A-18})$$

Remember that this coefficient is defined in terms of the concentration in the liquid, and would be numerically different if it were defined in terms of the gas phase concentration.  $\square$

## DEPARTMENT: Syracuse University

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voted to an investigation of transport mechanisms of small molecules in rubbery and glassy polymers, and to some important applications of these mechanisms. The applications include the development of high-selectivity, high-flux membranes for fluid separation processes, the design of controlled drug delivery systems, and the improvement of adhesion of integrated circuits.

**Lawrence L. Tavlarides** is conducting research on chemically reactive turbulent liquid dispersion and chemical reaction kinetics. The objective of the research in liquid dispersions is to provide a fundamental basis for the design and scale up of extractors and reactors. The microscopic droplet rate processes of coalescence and breakup are analyzed with population balance equations and Monte Carlo simulation techniques. Hydrodynamic turbulent flow models are also developed to predict the local turbulent kinetic energy and energy dissipation in mechanically agitated turbulent dispersions. Hydrometallurgical solvent extraction in Tavlarides' group is focussed on multiple metal chelation reactions and chemical equilibria. Intrinsic chemical kinetic models are developed for reactions occurring at or near the liquid-liquid interface using the novel liquid jet recycle reactor. Thermodynamic based heterogeneous equilibrium models are also developed. The above simulation models are employed with the kinetic and equilibrium models to predict conversion and selectivity. Other studies by this group include catalyst deactivation by surface carbon to determine kinetic rate models for synthesis reactions.

**Chi Tien's** major research activities are in three areas: fluid-particle technology, liquid phase adsorption, and biochemical engineering. The fluid-particle technology research covers a broad spectrum of topics including deep bed filtration of liquid suspensions, aerosol filtration in granular

and fibrous media, and in fluidized beds with or without magnetic stabilization, and stratification and segregation of particles in sedimentation and liquid fluidized beds. In filtration research a theoretical framework which incorporates all the important aspects of filtration process has been developed to quantitatively describe the dynamic behavior of the process.

In liquid phase adsorption studies, efficient algorithms are developed for exact and detailed adsorption calculations in various process configurations involving systems with arbitrarily large number of adsorbates, formulation of the species-grouping procedure for simplifying multicomponent adsorption calculations and establishment of a characterization procedure which describes gas solution with unknown adsorbates as solution with a fixed number of pseudo-species of adsorbates.

In biochemical engineering research, Tien's group is studying the interaction between adsorption and bacterial growth when granular activated carbon is used to treat liquid waste containing both adsorbable and biodegradable organic substrates. The work is applied to fluidized bed biofilm reactor design.

**Professor Vook** is studying various properties of current carrying and sliding electrical contacts. The work is carried out in an ultra high vacuum system where electrical contact resistance, friction coefficient, and the chemical composition of the slip ring surface (by Auger electron spectroscopy) are measured in situ as a function of contact force, current through the contact, and gaseous lubricating environment. The goal of this work is to understand the physical and chemical forces that limit the current-carrying capacity of the moving (rotating) electrical contact. Vook is also developing thin film coatings and surface pretreatments for preventing the out-of-core radioactive buildup that occurs on austenitic stainless steels used in boiling water nuclear reactors.

**Chiu-Sen Wang** is on leave for a few years and working at CalTech in the area of particle deposition in branched airways (e.g. the lungs), and in aerosols.

These projects illustrate the breadth and depth of the research interests of the faculty at Syracuse. There is breadth in the number and variety of research interests and depth in that several faculty members work in the key areas of separation and transport processes, chemical reaction engineering, fluid-particle technology, and materials science.  $\square$