# Chemical Engineering at Kansas State University


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Kansas State University is located in Manhattan, Kansas, 110 miles west of Kansas City in the northeast corner of Kansas in the Flint Hills, a region of beautiful prairie hills and wooded river valleys. The Department of Chemical Engineering has a long history of success in education and research, with the first BS awarded in 1924, the first MS in 1932, and the first PhD in 1964. Located in the breadbasket of the nation at the northern end of the great oil fields of the south-central United States, the Department has long been closely linked with the petroleum and agricultural industries, but the research activities of the faculty and employment options for graduates have become much broader over the past decade.

## MANHATTAN

In 1855, Manhattan's founders left Cincinnati by boat and traveled west, down the Ohio and Mississippi Rivers to St. Louis, and then up the Missouri and Kansas rivers until they ran aground near the spot where the Big Blue River joins the Kansas. They named the city Manhattan in hopes that it would become the Midwestern equivalent of Manhattan, New York. Although the population has yet to catch up to its namesake, the "Little Apple" has grown steadily over the years into a vibrant Midwestern city of nearly 50,000 people. It is a regional trade center, providing shopping, health care, entertainment, and the arts for nearly 200,000 people in the surrounding counties.

Manhattan is also a center of outdoor recreation. Belying the Wizard-of-Oz stereotype of Kansas as flat and dry, it is located near large lakes in a uniquely picturesque region known as the Flint Hills. The rocky soil of the Flint Hills made the area unsuitable for agriculture, and as a result it contains the largest stands of virgin tallgrass prairie left in the U.S. Five miles south of Manhattan lies the Konza Prairie Biological Station, an 8,616-acre preserve of untouched prairie. Bison herds can be observed grazing on the section of the preserve used for ecological research by the Division of Biology at Kansas State University.

While the Flint Hills lend themselves to a wide variety of terrestrial activities such as hiking, biking, and camping, the rivers and reservoirs ringing Manhattan yield ample opportunities for aquatic recreation such as fishing, swimming, canoeing, power boating, water skiing, and sailing. Just five miles north of campus is the 13,000-acre Tuttle Creek reservoir on the Blue River, with beaches, marinas, campsites, and hiking trails along its 104 miles of shoreline. Outdoor recreational opportunities in town include biking and walking trails, thirteen parks, numerous athletic fields, and four golf courses, including the PGA Tour licensed course Colbert Hills, rated among the top ten collegiate courses nationwide.

## KANSAS STATE UNIVERSITY

Kansas State University (K-State) was established as a land-grant college under the Morrill Act in Manhattan, Kansas, on February 16, 1863, only six years after the city was incorporated. Architecturally, the campus has a consistent look, with all of the buildings sheathed in the gleaming white of Kansas limestone. As a land-grant university, K-State has a broad mission in teaching, research, and service, with an emphasis on the applied sciences, engineering, and agriculture. The University is organized into nine colleges: Agriculture; Architecture, Planning, and Design; Arts and Sciences; Business Administration; Education; Engineering; Human Ecology; Veterinary Medicine; and Technology (in Salina).

K-State has had 150 years of accomplishment in education and research, yet over the last fifteen years alone, the University has advanced substantially in all areas of its mission in its goal of becoming recognized as one of the top ten land-grant universities in the nation. Student enrollment has surged from 15,000 to over 22,000 during this time, and annual research expenditures grew from $18 M to over $100 M. The *Kaplan/Newsweek College Catalog 2001* ranked K-State as one of the ten most popular universities in the U.S. and the "trendiest" overall, and *Yahoo! Internet Life* magazine has rated K-State thirty-first out of 1300 colleges and universities in its 2001 "Most Wired Colleges" ranking. The students at K-State rank first in the nation among public universities, and sixth in the nation among all universities in the number of Rhodes, Marshall, Truman, and Goldwater Scholars awarded in the past fifteen years.

## THE COLLEGE OF ENGINEERING

Engineering has been included in the mission of K-State since the founding of the University, with formal courses in applied mechanics first taught in 1884. In 1908, the first dean of mechanic arts was named, leading to the formal establishment of the Division of Engineering in 1913. Since then, the College has grown into the most comprehensive college of engineering in the region. It ranks among the top 10% of engineering colleges in the U.S. in terms of enrollment, with 2800 undergraduate students and 500 graduate students. It is comprised of eight departments: Architectural Engineering and Construction Science, Biological and Agricultural Engineering, Chemical Engineering, Civil Engineering, Electrical and Computer Engineering, Computing and Information Sciences, Industrial and Manufacturing Systems Engineering, and Mechanical and Nuclear Engineering. The College is housed primarily in a modern, integrated complex of three interconnected buildings: Durland Hall (opened in 1976), Rathbone Hall (opened in 1983), and Fiedler Hall (opened in 2000).

***The [ChE] Department at Kansas State University has been producing successful graduates and high-quality research for over 75 years. It maintains strong connections with the chemical process and petroleum industries, but has broadened its teaching, research, and student employment base into microelectronics and bio-based industries as well.***

In the spirit of the land-grant mission of the University, the College aspires to be recognized as the best comprehensive college of engineering in the U.S.—that is, the one that most effectively integrates all aspects of its mission in teaching, research, and service into a unified whole. As one example of this integration, the College's Advanced Manufacturing Institute (AMI) is a world-class facility supported by state, federal, and industrial funds that uses the College's expertise in research and education to meet the needs of Kansas' manufacturers. AMI has worked with over three hundred companies in recent years on a wide variety of projects involving staff engineers, faculty members, and undergraduate and graduate engineering, computer science, and business students.

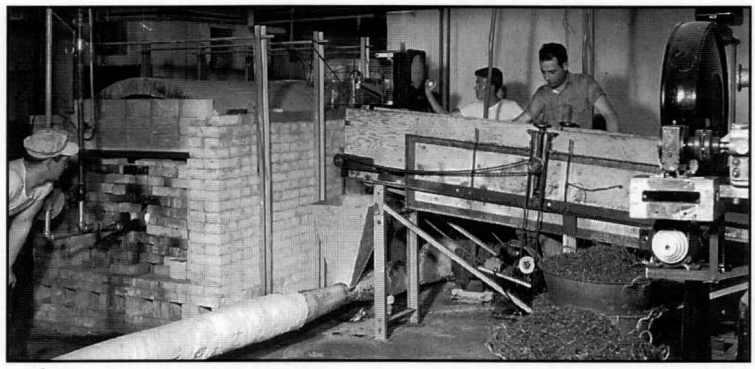
## HISTORY OF THE DEPARTMENT

Chemical engineering at K-State began in 1924 when a curriculum proposed by the Department of Chemistry was approved by the faculty; the first BS degree in chemical engineering was subsequently awarded in 1926, but the curriculum was composed of courses already offered at the university. In 1927, the first professor of chemical engineering, Dr. W.F. Brown, joined the faculty, and by 1928 two new courses in chemical engineering were offered. By 1940, the course offerings had increased to nineteen, including unit operations, industrial stoichiometry, thermodynamics, and chemical technology, and a Department of Chemical Engineering (with four staff members) was formed in the School of Engineering.

Despite the small size of the department, a Master's degree

in chemical engineering was offered for the first time in 1938. Both fundamental and applied research was carried out in the early years of the Department. Projects included the production of starch by wet-milling of grain sorghum, catalytic oxidation of organic chemicals, suspension of pulverized coal in oil, extraction of soluble material from granular solids, and the application of kinetics to reactor design. These research themes persist to the present day, reflecting the continuing importance of both value-added agricultural products and the petrochemical industry in Kansas.

Under the leadership of Dr. Henry Ward, who became department head in 1948, the Department's activities expanded significantly in the 1950s. Ward established a program in nuclear engineering in 1954, which was later spun off as a separate department. He also placed greater emphasis on research, expanding the graduate program and obtaining authorization for a PhD degree in 1958.



***Value-added agriculture has been on the department's research agenda since its founding. Here, an experiment on the drying of alfalfa is monitored by several students in the 1940s.***

This was also a year of two pivotal hires for the department. L.T. Fan (who had received his MS degree at K-State and was completing his PhD at West Virginia) wrote to Dr. Ward and asked if he would be a job-search reference. Ward responded with a postcard offering Fan a faculty position at K-State; he accepted. Dr. Fan is now in his forty-third year on the faculty, including thirty years as its head. Ward also hired Benjamin Kyle in 1958, who spent almost forty years on the faculty. To the profession, Kyle is best known as the author of a successful textbook, *Chemical and Process Thermodynamics,* currently in its third edition with Prentice-Hall.

The curriculum had largely reached its modern form by 1960. Process dynamics and control, along with chemical reaction engineering, had been added in the early 1950s. L.T. Fan and his close friend, the late C.Y. Wen, made a bus trip to the University of Wisconsin in the summer of 1959 to secure a copy of the prepublication notes for the paradigm-shifting book *Transport Phenomena* by Bird, Stewart, and Lightfoot. Thus, transport phenomena was taught at K-State even before publication of the book in 1960. In the 1960s, Fan and Larry Erickson expanded the research emphasis into biochemical engineering and added the first formal course on this subject to the curriculum in 1969. The first chemical engineering computer course was also added in the 1960s.

After Ward's untimely demise in a train accident in 1960, William H. Honstead took over as the Head. Honstead was a 1939 BS graduate of the Department, with a PhD from Iowa State and several years of industrial experience. He oversaw the successful launch of the PhD program, with Larry Erickson receiving the program's first doctorate in 1964. Erickson returned to K-State as an assistant professor after a stint as a post-doctoral fellow with Art Humphrey at the University of Pennsylvania. Honstead also hired two other faculty members, Richard Akins and John Matthews, who were each to spend over thirty years with the Department.

In 1968, Honstead moved into other leadership and administrative roles at K-State, and L.T. Fan took over as Head, remaining in this position for the next thirty years. Under his guidance, the Department's research programs and reputation grew substantially. He was also instrumental in securing funding for the construction of Durland Hall, which enabled the Department to move out of a building that had been built as a dairy in 1902 and into space designed to the faculty's specifications.

During the energy crisis of the 1970s, many of the Department's faculty were involved in research on alternate energy sources, especially biomass. Fan also established K-State as a leading center for research in process synthesis and design. In 1985, Fan and Erickson established the Hazardous Substances Research Center at K-State, with Erickson as its director—thus adding environmental engineering to the Department's research portfolio. In 1989, this Center was significantly expanded with EPA support, and the current research activities of the Great Plains/Rocky Mountain Hazardous Substance Research Center include bioremediation, phytoremediation, and related activities designed to address problems associated with contaminated soil and groundwater.

With the hiring of Walter Walawender in 1969, the core faculty members who were to guide the department over the next generation were largely in place. Professors Akins, Erickson, Fan, Kyle, Matthews, and Walawender provided a heart to the Department that remained intact for almost thirty years. A key addition to the faculty in 1978 was Larry Glasgow, who replaced retiring professor Herbert Bates in 1978. Glasgow became widely recognized as one of the best instructors at K-State, winning numerous teaching awards at all levels. In the mid-1980s, Drs. John Schlup and James Edgar were hired into new faculty lines to teach courses in materials science, while also supporting the Department's mission

in chemical engineering. They developed materials science and engineering as an important component of the Department's research program.

By the late 1990s, some of these faculty began to retire. In 1998, Stevin Gehrke was hired from the faculty of the University of Cincinnati to take over from Fan as Head of the Department. Drs. Matthews and Kyle had also retired by 1998. Keith Hohn was hired from the University of Minnesota to replace Matthews' expertise in catalysis and reaction engineering. In 2002, Mary Rezac and Peter Pfromm will join the faculty as associate professors, coming to K-State from the faculties of the Georgia Institute of Technology and the Institute of Paper Science and Technology, respectively. Terry King also came to the department in 1997 from Iowa State University, although his attention is primarily devoted to leading the College of Engineering as its Dean. Information on the current faculty members of the Department and their research interests is summarized in Table 1.

## THE UNDERGRADUATE PROGRAM

The success of the undergraduate program has been the result of three key factors: high student quality, faculty dedication, and excellent facilities. First and foremost, students entering the program have always been of very high quality, combining intellectual ability (class average ACT scores are consistently over 28, the 93rd percentile) with a strong work ethic. Historically, most of the Department's students came from small-town and rural Kansas, where hard work was expected and "can-do" problem-solving mindsets were developed. Although student demographics have broadened over the last twenty years (a substantial percentage of students now come from metropolitan Kansas City, Wichita, and Topeka), these traits continue to prevail among the student body.

The second key reason for the success of the Department's graduates lies in faculty dedication to the undergraduate program. The faculty have long emphasized development of a strong foundation in the fundamentals of the chemical engineering discipline, grounded with emphasis on the laboratory sequence.

Finally, throughout its history, the Department has had its graduate and undergraduate programs largely consolidated in a single building. Durland Hall, the three-story home of the Department since 1976, was designed to encourage spontaneous interaction among faculty and students. Most of the undergraduate courses are taught in a single classroom in the

**TABLE 1**
**Chemical Engineering Faculty and Research Interests**

***Richard G. Akins • Professor***
*BS and MS, University of Louisville; PhD, Northwestern University*
Natural convection in heat transfer; undergraduate computational technology; laboratory instruction

***James H. Edgar • Professor***
*BS, University of Kansas; MS and PhD, University of Florida*
Semiconductor processing; light-emitting diodes; chemical vapor deposition

***Larry E. Erickson • Professor***
*Director, Hazardous Substance Research Center; AIChE Fellow*
*BS and PhD, Kansas State University*
Biological waste treatment process design and synthesis; phytoremediation; environmental air quality; biochemical engineering

***L.T. Fan • University Distinguished Professor***
*Mark H. and Margaret H. Hulings Chair in Engineering, AIChE Fellow*
*BS, National Taiwan Univ.; MS, Kansas State Univ.; MS (Mathematics) and PhD, West Virginia University*
Process synthesis and control, biomass hydrolysis and gasification; particle technology, including fludization and solids mixing; environmental pollution control

***Stevin H. Gehrke • Professor and Head***
*Tom H. Barrett University Faculty Chair*
*BS, Kansas State University; MS and PhD, University of Minnesota*
Synthesis, properties and applications of polymer gels and networks; controlled drug delivery; protein-based biomaterials

***Larry A. Glasgow • Professor***
*William H. Honstead Professor of Chemical Engineering*
*BS, MS, and PhD, University of Missouri*
Behavior of dispersed-phase entities (bubbles, droplets, and particles) in turbulent flows

***Keith L. Hohn • Assistant Professor***
*BS, University of Kansas; PhD, University of Minnesota*
Catalysis and reaction engineering; natural gas conversion; oxidative dehydrogenation of light hydrocarbons; millisecond contact time reactors

***Terry S. King • Dean, College of Engineering***
*BS, Iowa State University; PhD, Massachusetts Institute of Technology*
Catalysis and surface science; surface thermodynamics; reaction engineering

***Benjamin G. Kyle • Professor Emeritus***
*BS, Georgia Institute of Technology; MS and PhD, University of Florida*
Thermodynamics; phase equilibria

***John C. Matthews • Professor Emeritus***
*BS, Washington University; ScD, Washington University*
Catalysis

***Peter H. Pfromm • Associate Professor***
*MS, University of Stuttgart; PhD, University of Texas*
Membrane science and technology; electrodialysis; environmentally benign manufacturing; glassy polymer physics

***Mary E. Rezac • Associate Professor***
*BS, Kansas State University; MS and PhD, University of Texas*
Membrane science and technology; novel polymeric membrane materials; enzymatic membrane reactors; nanoporous organic/inorganic hybrid materials

***John R. Schlup • Professor***
*BS and BS (Chemistry), Kansas State University; PhD, California Institute of Technology*
Bio-based industrial products; intelligent processing of materials; polymerization kinetics; applied spectroscopy and thermal analysis

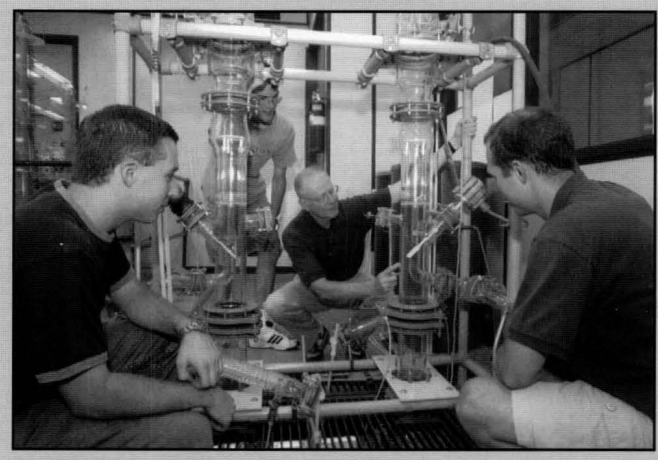
***Walter P. Walawender • Professor***
*BS, MS, and PhD, Syracuse University*
Activated carbon; pyrolysis; biomass energy production; fluid-particle systems

center of the building. This classroom, known simply as "129" to all graduates of the program over the last 25 years, along with the adjacent undergraduate computer and study rooms, provides a "home away from home" for ChE students during their years on campus. The departmental office and all of the faculty offices surround this classroom, thus promoting regular interaction between students, faculty, and staff. The bottom level of the building holds the undergraduate laboratories and the shop, while the top floor holds the research laboratories and graduate student offices. As a result, alumni loyalty to the Department is very strong (this is true across campus, with K-State having the highest level of participation in its alumni association among all Big-12 schools).

Chemical engineering students at K-State have been successful in national competitions of all kinds and include winners of Goldwater, Marshall, and Udall scholarships. Over the last nine years, eight students have received AIChE National Scholarship Awards (only fifteen are awarded nationwide annually). Students are encouraged to take the Fundamentals of Engineering (FE) Exam, and the passing rate of graduates is 91%, well over the national average of 81%. The AIChE Student Chapter has received recognition as a National Outstanding Student Chapter for the past seven years, and the chapter advisor, Walter Walawender, received the National AIChE Student Chapter Outstanding Advisor Award in 1999.

The Department has over 1700 living alumni, many of whom hold or have held top executive positions in internationally recognized companies. For example, Tom Barrett was Chief Executive Officer of the Goodyear Tire and Rubber Company, Joe Downey was Vice President of the Dow Chemical Company, Gary Draper was President of Vista Chemical Company, Wayne Harms is Executive Director of ExxonMobil, R.E. Mistler is Senior Vice President of Paine Webber, Inc., Hal Siegele was President and CEO of Esso Norway/Exxon, and Susan Tholstrup is Vice President of Shell Chemical. About two dozen graduates have gone on to successful careers in academia.

About 20% of the Department's alumni currently work for just five companies: Conoco, Dow Chemical, ExxonMobil, Phillips Petroleum, and Procter & Gamble. Together with Koch Industries, Black & Veatch, Cargill, Archer Daniels Midland, and Motorola, these companies have hired about half of all the Department's graduates since 1993. Since that time, more than eighty different companies have hired K-State chemical engineers, with half of the graduates going into the traditional employment sectors (fuels, chemicals, design, and construction), a third joining biologically oriented sectors (food and consumer products, environmental engineering, and biotechnology), and most of the remainder going into electronics, advanced materials, or aerospace, while 13% of




***Top Photo:*** *Some intricacies of the condenser section of a pilot scale distillation column are being explained by Dick Akins to seniors Justin Coulter, Ryan Lonard, and Kerry Campbell*

***Middle Photo:*** *Each spring there is an Open House for residents of the state to tour the College and learn about engineering. The festivities are kicked off with a skit by seniors in front of Seaton Hall, the historic home of the College.*

***Bottom Photo:*** *Undergraduate honors student Justin Weatherford (right) and Professor John Schlup prepare the dynamic mechanical analyzer for low temperature characterization of polymeric composites derived from biomass.*

the graduates went directly into graduate degree programs. Approximately one-third of the graduates in this time frame have been women.

## DEPARTMENTAL RESEARCH

The faculty have long had an exceptionally strong emphasis on scholarly activity and research, despite being a small department by the profession's standards. In fact, in the last ranking of PhD. chemical engineerig programs by the National Research Council, K-State ranked ninth among the 42 programs with ten or fewer faculty. The research programs emphasize transport phenomena, reaction engineering, and materials science. Many of the research projects have biological or agricultural themes, reflecting K-State's strengths in these areas.

In transport phenomena, Dick Akins' research into natural convection in heat transfer is quite fundamental in nature, as is Larry Glasgow's research into the behavior of dispersed phase entities (bubbles, cells, droplets, and particles) in turbulent flows, including floc formation and breaking in coagulation processes. Larry Erickson's research has biology at its heart, whether the problems are reaction engineering in closed systems (bioreactors) or transport phenomena in open systems (phytoremediation). L.T. Fan's extraordinarily productive career has included pioneering work in most areas of modern chemical engineering, as documented in over 700 publications. He has generated an exceptional body of work in process synthesis, and his work in reaction engineering includes many areas of biological application, such as production of energy from biomass, value-added agricultural products, and production of activated carbons by pyrolysis of grains. In the latter case, Walter Walawender collaborates. Walawender focuses on reaction engineering of particulates such as metal oxide nanoparticles and activated carbons, as well as biomass energy production.

Stevin Gehrke, Peter Pfromm, Mary Rezac, and John Schlup form a research nucleus around structure-property relationships in polymeric materials. Gehrke's research centers around the synthesis, characterization, and applications of crosslinked, water-swellable materials known as hydrogels, especially in medical and pharmaceutical applications. Mary Rezac has focused on development of materials and methods for membrane separators, integrated membrane-reactor systems, and barrier packaging. Peter Pfromm's interests are also in the engineering and materials science of polymers, particularly polymeric membranes in electrodialysis and bioprocessing; the use of these membranes to achieve environmentally benign processes and materials is often a key goal. John Schlup's interest in materials processing includes studies of polymerization cure kinetics and the development of novel bio-based composite materials.

The nucleus of faculty whose research is at the interface of inorganic materials science and reaction engineering are Keith Hohn, Terry King, and Jim Edgar. Hohn and King support the Department's broadly based activities in reaction engineering; they emphasize use of inorganic catalysts in hydrocarbon conversion, continuing the Department's long-standing history of research in this area. Hohn's research is focused on the study of novel reactor configurations, such as short contact time reactors, and novel catalyst forms such as nanoparticles. King's work examines fundamental catalysis and surface science, surface thermodynamics, and reaction engineering. Edgar applies chemical engineering principles to semiconductor processing; his current emphasis is growth of semiconductor crystals such as silicon carbide and aluminum nitride from the vapor phase.

The graduate program includes interdisciplinary research programs in food science, environmental engineering, and bio-based industrial products. The latter is a new program established in 2001 with support from the Department of Energy. This program is led by John Schlup and leads to an interdisciplinary graduate certificate in bio-based materials science and engineering. Another new interdisciplinary research and technology transfer program is the National Environmental Evaluation and Remediation Consortium (NEER), coordinated by Larry Erickson. NEER addresses complex environmental issues that affect the health and safety of the nation's air, water, and land.

## CONCLUDING REMARKS

The Department of Chemical Engineering at Kansas State University has been producing successful graduates and high-quality research for over 75 years. It maintains strong connections with the chemical process and petroleum industries, but its teaching, research, and student employment includes microelectronics and bio-based industries as well. The Department has benefited from an exceptional level of stability among its faculty, which has created and reinforced a strong sense of loyalty and shared mission among its constituents. The current faculty look forward to continuing this tradition of excellence, and to the challenges of educating the next generation of students while generating research that contributes to the ongoing development of the profession of chemical engineering. ❐

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