# Energy Studies

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The Center for Energy Studies is a multidisciplinary research center, the central liaison for energy research, education, and public service at The University of Texas at Austin. Dr. John R. Howell is director.

Editor: Jennifer Evans

## Better methods to separate liquids

### Researchers are learning to predict the performance of an extraction tower, a difficult task

Extraction is a technology for separating liquids that often works when distillation won't. Certain mixtures of liquids are too heat sensitive for distillation, such as proteins used in pharmaceuticals. Other mixtures, like that of benzene and dimethyl pentane, have similar boiling points and so would boil off together rather than separately in the distillation process.

Extraction is the method of choice to separate mixtures of these kinds. In general, extraction processes involve contacting a liquid mixture with another liquid or a gas that acts as a solvent. The right solvent will dissolve or attract one component of the mixture but not the others, thus separating it out.

The solvent and the feed must be immiscible, like oil and water. A later step is required to separate the solvent from the solute.

Extraction is an industrial process widely used yet poorly understood. Occasionally, multimillion-dollar extraction towers around the world have been designed, constructed—and then have failed to achieve their expected performance.

Why? Industry and academia lack a fundamental understanding of the

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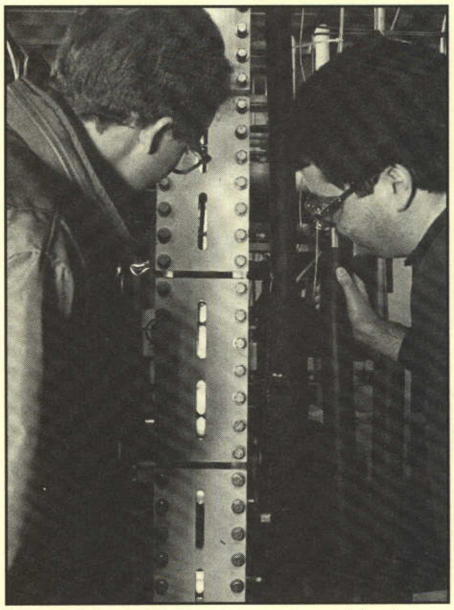


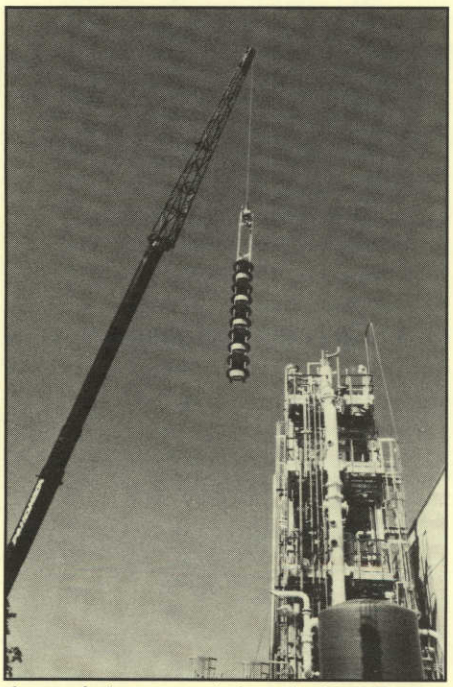
*Separations researchers use a 4-inch-diameter supercritical extraction column with windows for viewing the interior.*

*A view of a carbon dioxide droplet rising in water, inside the supercritical extractor column, left.*

factors that affect the extraction process, according to Frank Seibert, an engineer who has studied extraction for seven years within the center's Separations Research Program. Too often a system that performs well on an experimental scale later performs not so well on the plant scale.

Dr. Seibert and other UT researchers such as James R. Fair and Jose Luis Bravo, the head and the manager of the Separations Research Program, study how to make extraction scale up reliably. They say the key lies in creating accurate mathematical models of extraction and the factors that affect it.

**Acceptance by industry.** Dr. Seibert and his coworkers have developed a pair of closely related models for liquid-liquid and supercritical extraction. The Separations Research Program makes these models available to the companies that are its sponsors.



*A set of sieve trays is installed in UT's 30-foot liquid-liquid extraction column.*

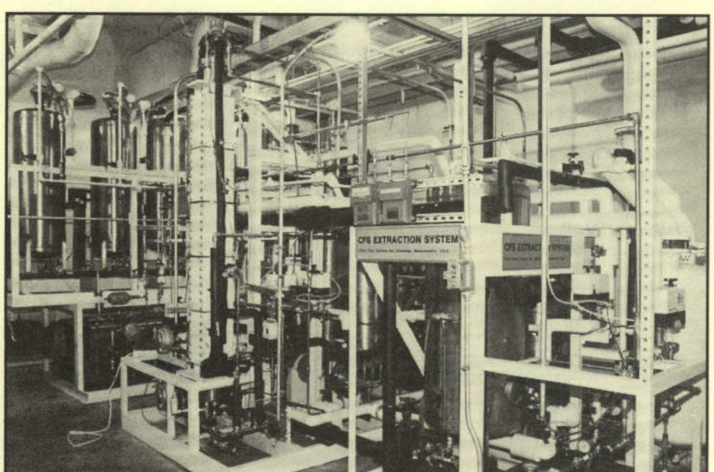
"The models are fairly new, so there's a little hesitation, but industry is starting to use them," Dr. Seibert said. "The models seem to fit their wide range of data a lot better than the past models. They report good agreement with their own data."

Other researchers working on extraction are Chester Little, graduate student in chemical engineering, and Diane Bauer, undergraduate in chemical engineering. Other faculty members perform research in related areas, such as Keith Johnston, associate professor of chemical engineering, in supercritical fluid technology.

Extraction is used mainly in the chemical, petrochemical, food, and pharmaceutical industries. In liquid-liquid extraction, a liquid mixture and a liquid solvent are flowed past each other in a tower. Trays (see photo, left), packings, agitators, and other devices are placed inside the column to increase contacting.

Supercritical extraction involves adding heat and pressure so that supercritical conditions are achieved. The solvent, originally either a gas or a liquid, turns into a supercritical fluid and has better solvent properties.

**Breaking up droplets.** The models developed by the UT researchers apply to both liquid-liquid and supercritical extraction, a feature that industrial sponsors prefer and one that makes the model more fundamentally correct.




*Supercritical extraction involves using heat and pressure to turn a solvent into a supercritical fluid and enhance its ability to dissolve.*

Dr. Seibert said a main reason for the increased accuracy of the UT models is that they are more fundamental in nature and were validated with data taken from UT's pilot-scale supercritical extraction column 4 inches in diameter and its pilot-scale liquid-liquid extraction column 16.75 inches in diameter and 30 feet high.

These are large experimental systems, and results from them seem to have good agreement with industrial-scale results from columns of 30 or more inches in diameter, Dr. Seibert said. The liquid-liquid tests were done on a standard test separation, using toluene to separate acetone from water.

Likewise, the supercritical tests were made extracting isopropanol, and later ethanol, from water using carbon dioxide. These components were chosen because their physical properties are well known.

The researchers recently tested saddle-shaped random packings and a structured packing of corrugated sheet metal to see how they enhance the efficiency of the process.

The extraction research is supported by industrial sponsors and two state programs, the Energy Research in Applications Program and the Advanced Research Program.

Testing and modeling are now focusing on the effects of phase redistribution. Performance in packed extractors improves whenever drops of one of the liquids coalesce and then reform. To redistribute these drops into fine droplets, a perforated tray is often installed. The researchers found that one redistribution point halfway through a 40-foot, packed-bed column can increase the separation efficiency by 60 percent. A modeling effort is under way to better understand the efficiency gains possible with redistribution.

**Outlook for extraction.** In supercritical extraction, the group is now studying how to apply the process to extract hydrocarbon impurities from oilfield brine in order to clean it for reinjection underground.

"I think supercritical will have its biggest application in the food and pharmaceutical industries because it does not leave a toxic residue," said Dr. Seibert.

"Liquid-liquid extraction will stay in the bulk processing industries, petrochemical and chemical, and will go toward use of structured packings, but we'll always have mechanically agitated columns as well." ■

# CES Update

## Office of Director

**A monitored retrievable storage (MRS) facility** for managing the country's nuclear wastes would have substantial benefits although at a higher cost than storage at individual utility sites, according to a study by faculty and students at UT's LBJ School of Public Affairs.

At an MRS facility, high-level nuclear wastes would be shipped in from civilian nuclear reactors across the country. The wastes—spent fuel—would be possibly repackaged, and then held in a safe way until permanent disposal. About 20,000 metric tons of high-level nuclear waste has accumulated at about 70 sites nationwide, and about 2,000 tons a year is added.

The US Congress created a commission in 1988 to conduct hearings and recommend whether or not to build an MRS facility. The commission's findings are due in November.

The LBJ School group, led by Marlan Blissett, professor of public affairs, attended hearings and analyzed the issues and arguments related to monitored retrievable storage. (Prof. Blissett passed away June 12, when the MRS study was nearly completed. The faculty and staff of the Center for Energy Studies mourn his death.)

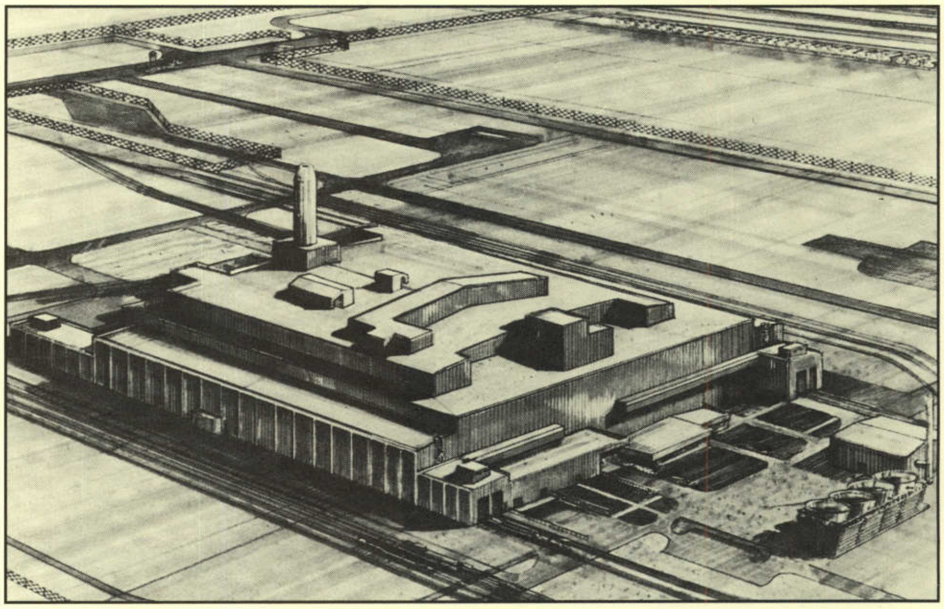
Graduate students who participated in the project are Karen Bock, Helen M. Dey, Tasos Georgiou, Sung-Deuk Hahm, John D. Merrill, Jing Shiang, Stephen D. Trainer, Zichuan Ye, and Chih-Chen Yi. The study was sponsored by the center.

The group wrote in their final conclusions:

"An MRS built and operated at the federal level . . . . removes the pressure on developing a final [nuclear waste disposal] site, allowing exploration and testing of all options before the selection and construction of a permanent facility. Emphasis on final solutions is presently motivated by the desire to relieve political pressure, not [on] sound judgment.

"Numerous geologies have been examined, but none [has] exhibited all the qualities necessary for a successful permanent solution to date. Storage, on the other hand, is a proven technology with a good track record within the utility industry.

"An early MRS would impose some form of standardization on waste packaging, benefiting all future



*A UT study concludes that a Monitored Retrievable Storage (MRS) facility for holding high-level nuclear waste would solve interim storage problems. Congress will consider the idea in November (Photo: US Department of Energy).*

aspects of waste disposal (transportation, site construction, emplacement, and monitoring). . . . This opportunity [for standardization] may be lost if utilities are forced to maintain storage facilities until the predicted repository opening in 2003 [a delay of a decade or more is likely, according to an MRS Commission source], as they will seek the lowest cost storage methods available to their particular plants.

"Removal of wastes from the electric plants is also desirable. While some public utilities advocate on-site storage for the life of the plant in dry casks, they fail to address the effects of potential plant closings. . . . Who maintains those sites at that point? Furthermore, are [dozens of ] waste sites dotted around the country more desirable or controllable than one or two central locations?

"The establishment of a storage-only MRS will force the antinuclear coalitions to reevaluate their present intractable position on nuclear waste, which may lead to a possible realignment to support the development of a permanent repository. . . . The potential for an MRS becoming permanent would be slim, as former opponents would align themselves to support a final solution to avoid that. . . .

"This does not mean that all concerns raised by the antinuclear groups are insignificant or smokescreens for obstructing all nuclear waste sites. Standards and confidence in the team operating the system are prerequisites for success. . . .

"To force the issue of an MRS and waste disposal, the Executive branch, with the support of Congress, will need to assert a more aggressive leadership role. . . . To do so, they will need to redefine the rules for developing and controlling the program. . . . It is not a question of jurisdiction or authority, but rather a failure of will and the neglect of responsibility . . . that has stalled all progress on a high-level waste management system."

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**The director general of Taiwan's** Industrial Development Bureau visited the center July 10. Shih-Chien Yang toured the center's research

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facilities and met with program leaders.

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**John R. Howell,** director of the center, along with Alan Kraus of the Naval Postgraduate School, taught a short course August 5–6 on "Spacecraft Thermal Design." The course was part of the National Heat Transfer Conference in Philadelphia.

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**Steven P. Nichols,** deputy director of the center, has been appointed chairman of the American Bar Association's Committee on Physical Sciences.

# Building Energy Systems

**The Conservation and Solar Energy Program** of the center has changed its name to the Building Energy Systems Program.

Bruce D. Hunn, program manager, said that the new name better reflects the focus of the program on topics such as improving the energy efficiency, peak electrical demands, and environmental and comfort conditions in residential and commercial buildings. The program will remain active in solar and other renewable energy research also.

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The largest North American **conference on solar energy** in recent years will be held in Austin March 19–22, 1990.

The conference, SOLAR 90, is actually two events: the Annual Conference of the American Solar Energy Society and the 15th National Passive Solar Conference. A third conference, SOLTECH 90, which includes an industrial exhibition, will also occur in Austin the same week.

Those who wish to submit papers to SOLAR 90 must mail in 200- to 400-word abstracts by October 31. For information, contact the American Solar Energy Society, 2400 Central Ave., Suite B-1, Boulder, Colorado 80301 (303/443-3130).

Dr. Hunn is chairman of the national organizing committee of the conference, and the center is a cosponsor.

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The Sixth Annual Symposium on **Improving Building Systems in Hot and Humid Climates** will be held October 3–4 in Dallas at the Holiday Inn Crowne Plaza Hotel.

The Energy Systems Laboratory of Texas A&M University is the principal organizer of the conference, and the Center for Energy Studies and ten other organizations are cosponsors.

Topics to be included at the conference include insulation, radiant barriers, economizer systems, air-conditioning technologies, lighting technologies, humidity control, governmental programs, whole building performance, and thermal storage.

For more information contact Frances Hunley, Department of Mechanical Engineering, Texas A&M University, College Station, Texas 77843 (409/845-1500).

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**Three Soviet visitors** and former Austin Mayor Frank Cooksey toured the solar measurement facility on top of the UT Engineering Teaching Center July 14. Grigory Noghin, Alexander Baronowsky, and Larisa Vasiljevna Kuprijanova are Yalta city officials. The group was hosted by Dr. Hunn.

# Electric Power

Texas Utilities Company (TU) spends $1 billion a year on fuel, and a UT professor has been asked to help shave a little off that bill by investigating a **new technique for short-term load forecasting.**

W. Mack Grady, associate professor of electrical and computer engineering, said he is exploring whether adaptive algorithms can be applied to TU's short-term load forecasts. An adaptive algorithm is a computer code that learns as it goes. The short-term forecasts are used to predict demand on the system one hour to several days in advance.

In load forecasting, an adaptive algorithm may be able to react quickly and more accurately to weather changes.

Dr. Grady is also helping TU integrate a computer model into the utility's operating program. The HARMFLO model will allow the company to better deal with troublesome third-harmonic interference in the power network.

For another utility company, Bonneville Power, Dr Grady is working on improvements to reduce harmonic distortion in single-phase mountaintop repeater stations that affects large industrial electricity users.

# Process Energetics

Radio-frequency heating may attract the interest of the food industry as a way to dry food products more quickly and evenly.

Process Energetics researchers recently completed a preliminary study of **radio-frequency drying of dog food**. In a typical arrangement, a bed of dog-food pellets is dried by passing it through a convective dryer. The researchers found that adding 1 kilowatt of absorbed radio-frequency power per square foot of a 7-inch-thick bed would allow throughput to be increased 87 percent.

The dog food dried more evenly also, improving its quality.

Conventional heating relies on heat moving from the surface to the center of the object by convection and conduction. Radio-frequency energy, on the other hand, generates heat inside the object, heating it throughout.

The dielectric properties and geometry of the material, the frequency of the applied energy, the geometry of the oven's applicator, and several other factors have an influence on the radio-frequency heating process. Radio-frequency heating and drying technology is still relatively new compared with convective drying.

A report, *Radio-Frequency Drying of Grain-Based Pet Food: Preliminary Feasibility Study,* by center researchers James Hitzfelder and Vince Torres, is available from Carlene Wooley, Center for Energy Studies, The University of Texas at Austin, 10100 Burnet Road, Austin, Texas 78758. The cost is $15.

The research was supported by the Electric Power Research Institute.

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Materials vary widely in how they respond when placed in a dielectric

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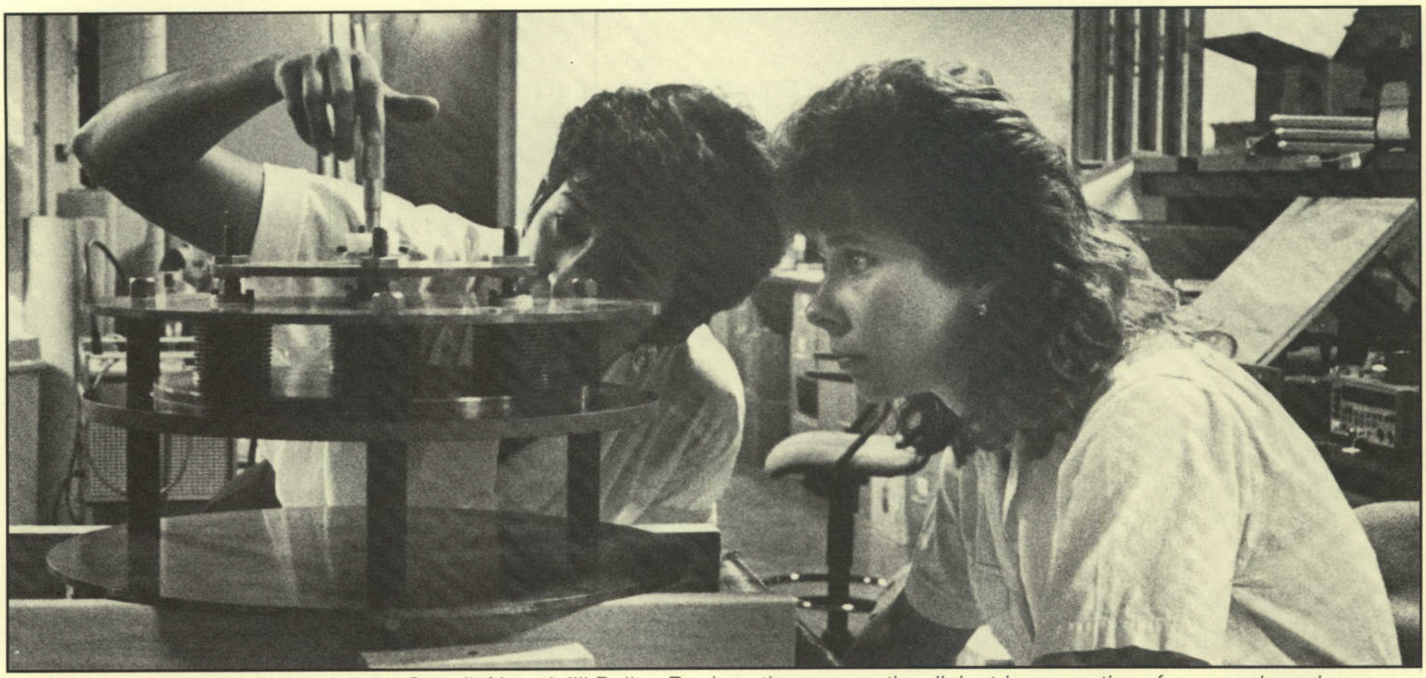

*Engineering graduate students Anita Ortiz (left) and Jill Bailey-Duckworth measure the dielectric properties of gypsum board.*

field for heating, drying, or curing. Process Energetics researchers have designed and assembled an instrumentation system for measuring a crucial **physical property of materials that affects dielectric heating**.

In order to model a process such as microwave drying or radio-frequency heating, a measure called the *complex dielectric constant* must be determined for each material, according to John A. Pearce, Process Energetics researcher and associate professor of electrical and computer engineering.

The complex dielectric constant indicates how readily a material is heated by a high-frequency electric field. Dielectric constants for most common industrial materials are not reported in the open literature.

Under Dr. Pearce's supervision, graduate students Anita Ortiz, Dwight Munk, and Sung Yang have created a probe apparatus to measure the real and imaginary components of the complex dielectric constant. Slabs, pellets, and liquids can be tested with the device (see photo).

The group calibrated the instrument by applying it to organic liquids with known dielectric values. Two kinds of industrial materials have gone through the measuring process: gypsum wallboard and dry dog-food pellets.

Program manager Vince Torres said that the new dielectric properties apparatus, like other Process Energetics research systems, is used by the program in heating and drying design studies in collaboration with industry.

# Rotating Machines and Power Electronics

Rotating Machines researchers are developing **a reluctance motor** that may some day outperform the induction motor.

Nine out of ten motors today are the induction type, in large part because induction motors have higher power factors and torque capacity, according to John S. Hsu, head of the center's Rotating Machines and Power Electronics Program.

Reluctance motors, on the other hand, often achieve only about half the torque of comparable induction motors. They have the advantage of being able to be synchronized and are often used by industry where two or more motors must work in concert.

Herbert H. Woodson, dean of the UT College of Engineering and former director of the center, and Dr. Hsu applied July 7 for a patent on a new type of reluctance motor. Shy-Shenq P. Liou, a Rotating Machines researcher, participated in the research.

The device is called a peaked-mmf smooth-torque reluctance motor. The approach of the group is to increase the torque of a reluctance motor by changing the shape of its magnetomotive force (mmf) wave.

The investigators discovered that when the wave form representing the magnetomotive force peaked higher, the flux per pole was reduced and the torque capacity was increased.

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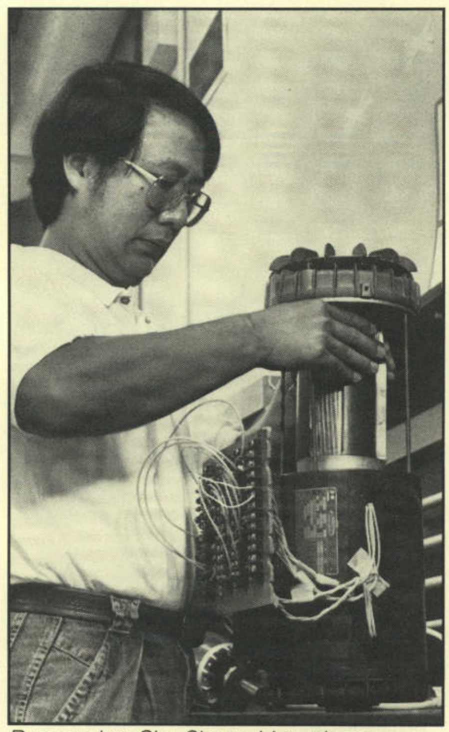

*Researcher Shy-Shenq Liou places a rotor inside a prototype reluctance motor. In testing, the new motor showed approximately double the normal torque capacity.*

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The higher peak in the magnetomotive force was brought about by adding a third-harmonic magnetomotive force to the fundamental force.

Overall, in a one-horsepower, two-pole prototype motor, the torque capacity was approximately doubled, Dr. Hsu said.

## Separations

**The manager of the Separations Research Program** has been invited to conduct research at the University of Essen in West Germany this fall.

Jose L. Bravo will be a visiting researcher at the German university from the end of September through December. His investigations will focus on gas-liquid contacting devices. Mr. Bravo will also visit European companies that are Separations Research Program sponsors.

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**"Separations of Fluids Mixtures,"** a 5-day short course, will be taught February 5–9 in Austin by the center's separations experts.

The course is designed for engineers and others seeking a better understanding of the technology and economics of state-of-the-art separations processes in distillation, membranes, adsorption, liquid-liquid extraction, and supercritical extraction.

Faculty for the course are James R. Fair, head of the Separations Research Program; Mr. Bravo; and chemical engineering faculty members Keith P. Johnston, William J. Koros, Donald R. Paul, and Gary T. Rochelle.

For information about registering, contact Continuing Engineering Studies, College of Engineering, The University of Texas at Austin, Austin, Texas 78712 (512/471-3506).

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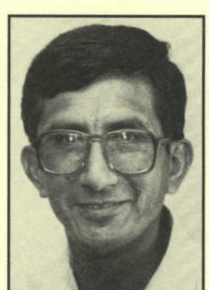
**Antonio Rocha,** a faculty member from the Instituto Tecnologico de Celaya, Celaya, Guanajuato, Mexico, has joined the Separations Research Program as a visiting researcher for 15 months. His areas of investigation are distillation and extraction. Dr. Rocha coordinates joint research between the two universities.



*Antonio Rocha*

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**Thomas F. Edgar** is the 1989 winner of the UT College of Engineering's highest honor, the Joe J. King Award. Dr. Edgar is chairman of the Department of Chemical Engineering.

## Thermal Analysis

**Dale E. Klein** was appointed director of UT's Center for Technology Development and Transfer, beginning August 1. The former director, Stephen A. Szygenda, professor of electrical and computer engineering, returned to full-time teaching and research.

*Dale E. Klein*

Dr. Klein is head of the center's thermal analysis area, associate professor of mechanical engineering, and associate dean for research in the College of Engineering.■