University of Michigan

College of Engineering

MECHANICAL ENGINEERING ANNUAL REPORT

2002

MichiganEngineering

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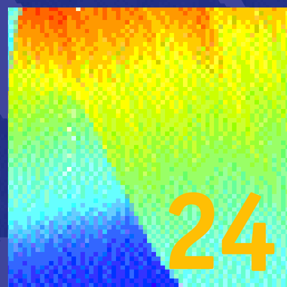

sustaining excellence

fostering innovation

tents

Mechanical Engineering Annual Report • 2001-2002

ME Faculty and Staff Continue to Make News

Students Maintain Tradition of Excellence

Our Distinguished Alumni and Supporters

Message from the Chair

As the new Chair of the Department of Mechanical Engineering, I am delighted to share with you our Department's impressive annual report for 2001-2002. In January 2002, when I succeeded Galip Ulsoy who is continuing his research and teaching in ME, I have found a Department in excellent shape. We have the strongest faculty we've ever had, the best students, and *US News and World Report* has ranked our undergraduate program fourth and our graduate program second in the nation — the highest we have ever been ranked in our history. By renewing our commitment to excellence and by fostering innovation, we are positioning our Department to be among the leaders for years to come.

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Dennis N. Assanis

Our Department is continuing to build on our indisputable strengths in manufacturing and automotive engineering. Our world class centers, which include the NSF sponsored Engineering Research Center for Reconfigurable Manufacturing Systems, the S. M. Wu Manufacturing Research Center, the DOD-funded Automotive Research Center, and the GM-UM Collaborative Research Laboratory on Vehicle Systems, have continued to flourish. In parallel, during 2001-2002, we have attacked new grand challenges that are re-inventing the traditional fields and extend our leadership position. International attention has been drawn to the UM-led Multi-University Consortium on Homogeneous Charge Compression Ignition Engine Research, founded in partnership with M.I.T., Stanford, Berkeley, and Texas A&M. Furthermore, our Dual Use Science and Technology consortia, focused on simulation-based design and manufacturing of next generation powertrains, exemplify successful government-industry-academia partnerships.

At the same time, we are launching major new initiatives in the rapidly emerging areas of mechanical engineering. In bio-systems research, our Department spans an impressive bandwidth ranging from the molecular and cellular level to the tissue and organism level. For instance, major projects funded by DARPA are creating "living-based actuators" whose applications include the building of micro-chemical sorters, chemical weapon

message from the chair

detectors, and micro-actuators that restore function if someone is injured. Similarly, our faculty and their students are carrying-out groundbreaking work in micro and nano-systems, such as using flames to generate nano-particles and creating new engineered materials and structures by mimicking self-assembling bio-structures. In this process, we are discovering new truths and discarding old prejudices about the atomic and continuum description of matter. The ME researchers are also exploring new clean forms of energy conversion using fossil and renewable fuels in devices ranging from large- to micro-scales. In linking engineering design and manufacturing decisions with their environmental impact and economics, we are improving quality of life.

During 2001-2002, we have added to our ranks five new faculty members — Edgar Meyhofer, Bob Dennis, Charlie Hasselbrink, Wei Lu, and Bogdan Epureanu. Our dynamic and diverse faculty body has continued to excel in curriculum innovation and reform. Examples include our new courses on bio- and nano-systems, our award winning global product realization class, our interdisciplinary projects showcased at the Design Expo and our X50 Studio — a unique instructional facility in which students can rapidly prototype and integrate mechanical systems into working pieces of modern machinery. The ME Department has also opened its doors to the world and to the future. We have systematically exchanged courses, faculty, and students with strategically selected global partners, notably with the Shanghai Jiao Tong University in China and KAIST in Korea. In addition, many of our faculty members have vigorously pursued K-12 programs intended to spark the interest of the brightest youngsters — including women and traditionally underrepresented groups — in math, science and engineering.

It is indeed gratifying to see that the accomplishments of our faculty, students, alumni, and staff have been recognized again with major national and international awards and distinctions during the past year. Among them, Professor Christophe Pierre has been named as the Stephen P. Timoshenko Collegiate Professor of Mechanical Engineering, thus honoring Christophe's professional contributions and paying tribute to the father of engineering mechanics. We are also especially proud of the legendary accomplishments of Professors Vedat Arpaci and Wen Jei Yang, who have retired — but not slowed down — after their more than 40 year distinguished career in ME.

This past year has been full of success stories for our ME community...I wish to take this opportunity to thank you for your interest and support.

In summary, this past year has been full of success stories for our ME community. As you read this report, you will get a taste of the exciting developments and innovative efforts that make the Department of Mechanical Engineering at The University of Michigan unique. I wish to take this opportunity to thank you for your interest and support.

Dennis N. Assanis
Chair, Mechanical Engineering
Jon R. and Beverly S. Holt Professor of Engineering

ME Builds Partnerships, Reputation Around the World

China Connection

Since August 2000, Shanghai Jiao Tong University (SJTU) in Shanghai, China, and ME have been collaborating on a series of programs based on a sharing of knowledge and information between the distant locations.

"Jiao Tong is restructuring their curriculum based on the Michigan model," says Professor Jun Ni, who is coordinating the SJTU efforts.

Professor Debasish Dutta travelled to China last summer to teach ME250 (Design & Manufacturing I) along with Professor Michael Thouless, who taught ME211 (Introduction to Solid Mechanics). Attending these classes was a select group of 60 students who will be following the U-M mechanical engineering curriculum, with at least a third of them coming to Michigan to study in their senior year.

This summer, four ME faculty are teaching at SJTU as a new group of students comes on board and the original group moves forward in their program: Professor Michael Chen (ME230, Thermal & Fluid Sciences), Dutta (again teaching ME250), Professor Elijah Kannatey-Asibu (ME350, Design & Manufacturing II), and Associate Professor Huei Peng (ME360, Modeling, Analysis and Control of Dynamic Systems).

Professor Deba Dutta introducing his ME 250 project and student groups at Shanghai Jiao Tong University on June 14. Shanghai Vice Mayor Dr. Yan is third from left (seated).

During the Winter 2002 term, four SJTU faculty came to Michigan to observe ME faculty in action — attending classes and labs, meeting students, and seeing projects.

The Chinese university is not the only beneficiary of the exchange. SJTU has offered new educational opportunities to U.S. students working or studying in China. In addition, Ni and Jack Hu have collaborated with SJTU counterparts on a research program that led to the establishment of a GM Satellite Research Lab on Automotive Body Design and Manufacturing at SJTU.

Award-Winning Global Products

Beginning in the Fall 2000 term, the innovative Global Product Development course conceived by Dutta has brought engineering students from England, Korea, and the University of Michigan together to develop "culturally sustainable" products.

Dutta's Global Product Development course has made great strides and received much recognition since 2000. It recently received the prestigious 2002 Computerworld Honors — an award the Computerworld selection committee (comprised of top executives from among 100 leading information technology companies around the world) gives to those "whose use of information technology has been especially noteworthy for the originality of its conception, the breadth of its vision, and the significance of its benefit to society."

Dutta developed this course after spending 18 months studying global industrial product development. "This is a reflection of the world outside," he says. "When you produce a product that is culturally sustainable, it's much more likely to succeed."

During the 2001 fall term, teams were formed with students from each of the three participating countries meeting in Oxford for one week at the beginning and at the end of the term. In between, they relied on video-

global initiatives

Mechanical Engineering has in the past several years commenced a series of initiatives that have been bringing University of Michigan students and faculty closer to their peers around the globe.

conferencing and other collaboration technologies commonly used in industry for the same purposes. The class was taught in Oxford by Dr. Janet Efsthathiou, in Seoul by Dr. Jongwon Kim, and in Ann Arbor by Dutta. Guest lecturers from the Law School, Business School, Psychology, International Institute, and Anthropology informed students on such issues as culturally appropriate innovation, global branding, and global products liability.

Among the products conceived and developed by students were a plant-care system accessible over the internet for vacationing houseplant owners, a pharmaceutical dispenser with a remote ordering system, and an electronic learning toy that can be reprogrammed as the child's skills develop. For the Fall 2002 course, Dutta hopes to attract investors willing to have product ideas marketed directly by his students.

This innovative class has required students to put their cultural differences aside while battling the more obvious barriers of language, time zone, and technological differences. "We're all engineers and the technology knowledge level is the same, but the approach to product development is different," says Dutta. When he asked in an end-of-the-term course survey, "Has this course changed the way that you view the world?" every single one of his students answered, "Yes."

"When they get into leadership positions," says Dutta, "I hope the experience they gained here will help them make decisions that have a much broader impact on society."

Information Sharing in Distant Lands

The latest global partnership was formed in February 2001 between ME and the ME department of the Korea Advanced Institute of Science and Technology (KAIST) to exchange students and faculty for research and academic purposes of common interest.

Though ME of KAIST is the major counterpart of the program, Kwang-Ju Institute of Science (KJIST) is partially involved as well. The primary thrusts of the collaboration are in the areas of automotive engineering, manufacturing, and noise/vibration control.

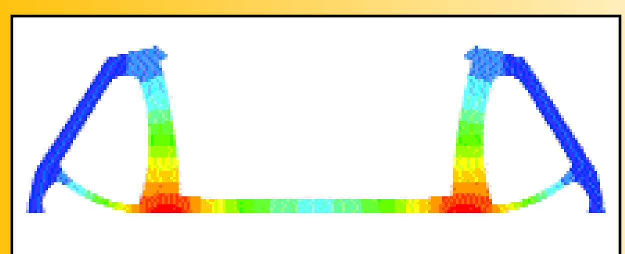
Assistant Professor Hong G. Im, a native of Korea and one of ME's major organizers of the program, says that one of the highlights of this global collaboration was having six graduate students from KAIST visit the Ann Arbor campus during the 2001-2002 academic year to participate in research activities. Among the students, Chunghwan Kim finished his Ph.D. in July — with ME Professor Noel Perkins attending his defense as a committee member — and Sang-Hun Kang, whom Im continues to advise, is in his third year of the Ph.D. program.

Last year, Assistant Professor Kazu Saitou was invited to present a seminar at KAIST, and two KAIST faculty members began or will begin their U-M sabbatical trips in 2002 — Professor Yang-Hahn Kim has been hosted by Associate Professor Karl Grosh since July, and in September Professor Sang Yong Lee will visit Professor Arvind Atreya.

This past July was a very busy time at KAIST. A large group of ME faculty were there to participate in the general steering meeting for the future direction of the program and to attend a technical workshop and collaboration organized by Im on reacting flow systems. The workshop was attended by Professors Assanis, Atreya, Im, and Wooldridge, and by Drs. Zoran Filipi and Dohoy Jung. Those attending the general meeting included the following ME faculty, present to discuss their own research agendas: Jyoti Mazumder (Manufacturing); Noel Perkins and Karl Grosh (Noise/Vibration Control); and Katsuo Kurabayashi (MEMS).

Also during the visit to Korea — as a follow-up to the previous visit of the Dean of Engineering at Seoul National University — Assanis visited with his colleagues at Seoul National University to discuss future collaborations in mechanical and automotive engineering.

research



Assistant Professor Kazuhiro Saitou has applied this topology optimization technique to design a new class of reversible integral attachments, where disengagement can be activated by local heating. This feature fulfills the concept of product-embedded disassembly.

pre-college

Pre-College Programs Open Windows to the Future

Raising awareness about engineering among pre-teens is part of the objective of several education and outreach programs within the Department of Mechanical Engineering and the College of Engineering. Sparking youngsters' interest in math, science, and engineering in the crucial pre-college years has proven to be instrumental in encouraging them to pursue careers in engineering.


Elijah Kannatey-Asibu Jr.

"Most youngsters have a misconception of what engineering is all about," says Professor Elijah Kannatey-Asibu Jr., associate director for education for the Engineering Research Center for Reconfigurable Manufacturing Systems (ERC/RMS). "These programs change that image for the kids who get involved."

The Detroit Area Pre-College Engineering Program (DAPCEP) is at the forefront of the programs. Since 1999, the ERC/RMS has participated in the pre-college program, offering middle school students the opportunity to learn about and use mechanical engineering concepts. When they leave the program, students have a better understanding of what role engineering plays in their everyday lives — from how products are made to how automobile safety is dependent on factors such as force and momentum.

University of Michigan junior Michele Goe is a perfect example of the outreach success. Goe was first introduced to engineering concepts as a Southfield, Michigan, eighth-grader — through the hands-on DAPCEP program that brings middle-schoolers to campus for a series of Saturday morning sessions.

Goe, who participated in DAPCEP for three years, learned through DAPCEP what she could do with her math and science skills. After her third year of DAPCEP, Goe took part in a four-week summer engineering program. Goe, who now is pursuing a degree in mechanical engineering, was an intern this summer at Texas Instruments in Attleboro, Massachusetts.

"When I was in middle school and high school it changed me by showing me there were other students who were focused on what I was focused on — that I wasn't a geek," says Goe, who now works in the ERC/RMS and participated in the spring 2002 DAPCEP program as a mentor and instructor. As a mentor, Goe taught students about impact, momentum, and force, helped them use a computer program to calculate those factors and their effects when a car hits a wall at different speeds, and watched as the students built their own model cars and crashed them.

The mission of DAPCEP, says Kannatey-Asibu Jr., is to increase the number of under-represented minority students who are motivated and prepared academically to pursue careers in engineering, science, and mathematics-related fields. "The biggest obstacle for minority kids is the lack of role models, and the perception created by the media. Sparking interest at a young age makes a world of difference," Kannatey-Asibu says.

In addition to DAPCEP, ME is involved in several other outreach efforts. ME Associate Professor Ann Marie Sastry was one of a few award-winning scientists and engineers asked to help kick off the National Science Foundation's "Scientists and Engineers in the Schools Program," which began with a week of events in which the team visited middle schools with the aim of promoting careers in science and engineering. Sastry continues to conduct regular school visits, and she also chairs a College of Engineering committee that is reviewing outreach efforts college-wide.


ME graduate student James K. Santosa works with 7th- and 8th-grade DAPCEP students.

ERC/RMS also goes into middle schools and high schools with its portable manufacturing program. With a computer, a robot, and a portable milling machine, ME provides younger students with the opportunity to design and then engrave their own blocks. The center also is developing an interactive display for the Ann Arbor Hands-On Museum that will be shared with other museums. At the computer in the display, youngsters will be able to alter the design of a product — a pen, for example — and see how those alterations affect the cost of production.

"DAPCEP has shown me what a huge impact you can make early on," says Goe. After seeing the effects of such a program, Goe says, "I have a grand idea, after I graduate, to help set up community centers to teach kids about engineering, advanced math — all the things they wouldn't have the chance to see otherwise."

Automotive Engineering Program Rolls On

The Mechanical Engineering Department's Automotive Engineering Program was initiated in 1995 — founded and developed by current ME Chair Dennis Assanis in response to what many in the department understood was the need to take greater advantage of the opportunities available within the auto industry, whose close proximity to the University of Michigan made closer connections a natural development.

"We offered some automotive classes as part of the mechanical engineering profile of courses," says Assanis, "but we did not have a dedicated Master's Degree in Automotive Engineering."

What a difference seven years can make. Working closely with industry partners, most notably Ford, ME's first curriculum in automotive systems engineering was soon developed. It paralleled — and continues to track — what is actually happening in the automotive world. It responded to the need to produce technical leaders in the automotive environment who have depth in their own disciplines, breadth across disciplines, a solid grasp of management issues, and the ability to lead project teams. Assanis calls it "the engineer's answer to an MBA degree."

Growth of the program has been phenomenal. In 1996, it consisted of six students. Enrollment doubled or tripled each year, and now stands at about 120 students. Since fall 1999, Automotive Engineering (AUTO) has become a College-wide interdisciplinary program administered by InterPro. While AUTO courses are drawn from a number of departments, ME continues to provide the critical backbone of the automotive curriculum. Students who enter the program are required to have a minimum of two years work experience before they join the program. Some are working toward their degrees full-time on the Ann Arbor campus, while others take advantage of various distance delivery options, including internet-based video-streamed lectures and taped programs offered at dedicated industry facilities, to pursue their degrees part-time.

Assanis is most impressed with the caliber of the students attracted to the program. "They bring as much to the program as they take out of it," he says. Many are poised to take their careers to a new level, but they require additional knowledge, or upgraded skills, or exposure to a new area, before they can do so, and nearly every student who enrolls in the program completes its requirements. Graduates do "phenomenally well" in the job market, says Assanis.

"Building this program is probably the most gratifying experience I have had," Assanis says. "With great help from my colleagues, the members of the Automotive Council and industry, we have managed to create a world-class master's program that others are trying to emulate. And I'm sure that will continue to flourish under the able leadership of the new AUTO Program Director, Associate Professor Huei Peng."


Huei Peng

Peng — whose primary areas of research and interest include vehicle dynamics and adaptive and optimal control systems, hybrid electric and fuel cell vehicles, and vehicle simulation models development — was named the program's new director in April 2002.

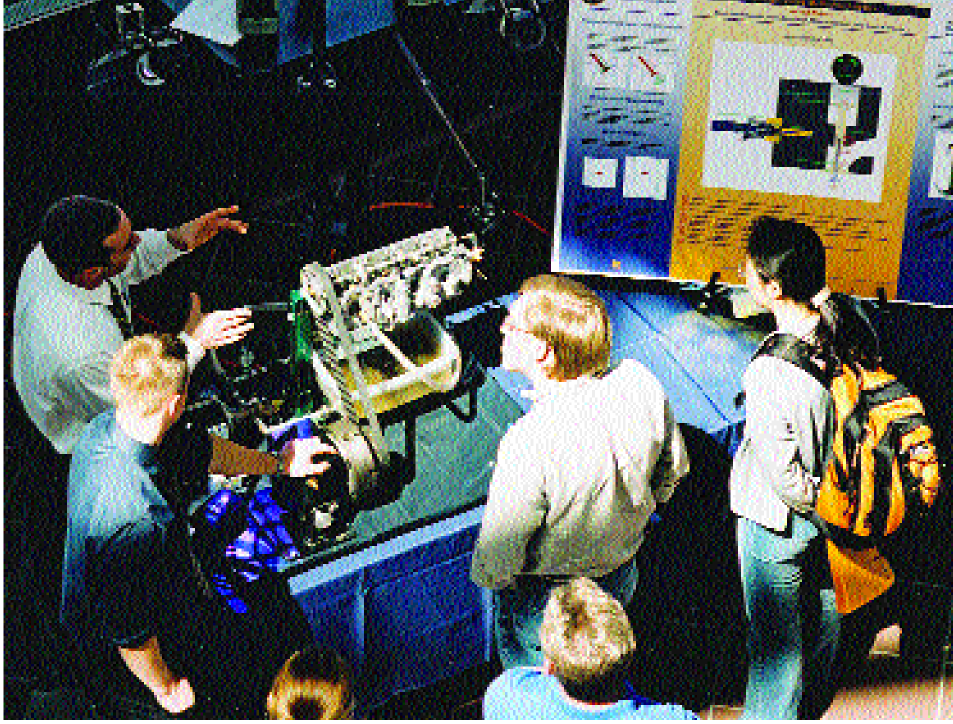
"It is my distinct honor and pleasure to have assumed the stewardship of the Automotive Engineering Program, following the very successful six-year tenure of Professor Dennis Assanis," Peng says. "This program is in excellent condition."

Paralleling Assanis' vision for the future, Peng says one of his primary goals is to "establish leadership in global automotive education by initiating international collaboration programs." Other future goals include improving the quantity and quality of distance learning courses, and further exploring the potential of the program by tapping into the resources of smaller companies.

automotive

"This program is in excellent condition."

Design Exposition Reaches Out



Among projects exhibited in the Winter 2002 Design Expo was this through-valve methanol fuel injector, which is designed to route methanol directly through the valve center, causing minimal obstruction to cooling-passages. This injection method improves the pre-combustion fuel-air mixing.

The ME Winter Design Exposition 2002, held April 11 in the North Campus Media Union, was by all accounts a huge success.

Each semester, students in the ME design and manufacturing courses are challenged to seek both creative and practical solutions to real-world design problems. Teams of students labor over working prototypes, and at the end of the term, their work is exhibited at the Design Expo — a hands-on design experience, with the student inventors on hand to conduct demonstrations.

"This is where we get to show off the design and manufacturing curriculum to the public," says Assistant Professor Steven J. Skerlos. "It was perhaps a bit more eclectic and avant garde than it might have been in the past. There were traditional and off-the-wall projects that were crowd pleasing and excellent educational experiences."

The sophomore and junior courses each held one exhibit, showing multiple approaches to solve the same design problem. Sophomore level ME 250 students presented prototypes for a "variable-grip" computer mouse designed to fit comfortably within the hand of a toddler as well as an adult. Juniors in ME 350 demonstrated prototypes of a material transfer system based on a power-screw machine that can lift a total of 24 kilograms, in multiple trips, as quickly as possible.

Thirty-three different ME 450 projects were on display. Many of the projects developed this semester reflected the interdisciplinary nature of this year's ME 450 course.

In fact, two of the five sections of ME 450 were exclusively dedicated to "Interdisciplinary Mechanical Engineering Projects." Among these was a set of kinetic sculpture projects that were collaborative endeavors between a group of U-M art and design students and a team of ME 450 students supervised by Professor Noel Perkins. Their shared challenge was to incorporate at least two fundamental mechanical engineering principles into a work of art. Another team of students developed a microbial detector that could not only quantify bacteria in drinking water and other aqueous fluids but that could also be used to identify the particular type of bacteria present. A fuel cell project was also showcased — a working model of a miniaturized fuel cell bus.

Another special feature of this year's Design Expo was the Second Bi-Annual Mechanical Engineering BattleBots Cyber Smackdown. This event was held the day before the Exposition as a kind of warm-up in front of a large crowd assembled inside the G.G. Brown Laboratory.

Mirroring the popular television show "Battlebots," the contest featured one battlebot designed by the project advisor Assistant Professor Robert Dennis and another by a team of ME 450 design students. The first round of the Smackdown was a hazards competition in which the bots battled to accumulate points through various obstacles designed by yet another ME 450 team. And in the head-to-head second round, each team tried to get its bot to knock the other over and out.

Skerlos said student design activities are enhanced by the use of the ME 450 Design Portal, a collaborative online environment and workspace for students and faculty alike. The Design Portal has been used for successful collaborations not just among ME 450 students but also between ME 450 teams and groups of students at the U-M School of Art and Design as well as with the renowned Parsons School of Design in New York.

design expo

This surgical biosafety helmet air system acts as a protective barrier, drawing in filtered air for the surgeon while maintaining sterility for the patient. The helmet, filter, fan and gown interface have been completely redesigned to reduce noise, weight and vibration.

This pneumatic hip-knee-ankle-foot orthosis is designed to assist in gait rehabilitation. The team's goal was to "minimize the weight and size of the brace, optimize the location of the four muscles on each leg, maximize the joint range of motion and size of the muscles, design a system that mimics the patella, and simplify the use of the orthosis."

pim director

Professor S. Jack Hu:

New PIM Director

Following a four-month sabbatical in Sweden and Germany during the Fall 2001 term, Professor S. Jack Hu returned to the University of Michigan and accepted a new assignment as Director of the Program in Manufacturing (PIM) in January 2002.

The interdisciplinary PIM is designed to provide engineers with not only advanced skills within their engineering discipline but also greater breadth across engineering disciplines, and a comprehensive understanding of the entire product development, manufacturing process and business/management practices. PIM is one of several programs of the Interdisciplinary Professional Programs (InterPro) in the College of Engineering, which was created in 1999 to coordinate all administrative and financial matters related to the college's interdisciplinary programs.

"The program is in very good shape, thanks to the outstanding leadership of past directors, Professors A. Galip Ulsoy and Deba Dutta," Hu says of PIM. "One of the things we need to do is to continue our enrollment growth," which Hu notes has increased to about 130 students since the program's inception in 1995.

Hu, who received his B.S. degree from Tianjin University, China, in 1983 and his M.S. and Ph.D. degrees from the University of Michigan in 1986 and 1990, says he also wants to further promote distance learning opportunities with universities in China, an initiative that was developed by Professors Dutta and Jun Ni during the past two years, as well as in other parts of the world.

S. Jack Hu

Since most PIM students are distance or part-time students, Hu says that global distance learning is a natural fit for the program.

Another of Hu's goals is to further strengthen the Doctor of Engineering in Manufacturing Program. Designed to be different from the Ph.D. — which focuses on academic research — the Doctor of Engineering Program is geared toward students with an interest in industrial leadership.

Since joining the ME faculty in 1995, Hu has gained extensive experience in graduate education administration as the ME Graduate Program Chair from 1999 to 2001 and as a three-year member of the ME Graduate Study Committee. He currently serves as the University co-director for General Motors Collaborative Research Laboratory, the director of the National Science Foundation Industry/University Cooperative Research Center for Dimensional Measurement and Control in Manufacturing, and is the deputy director of the S.M. Wu Manufacturing Research Center. He will continue to teach as well as pursue his research in manufacturing.

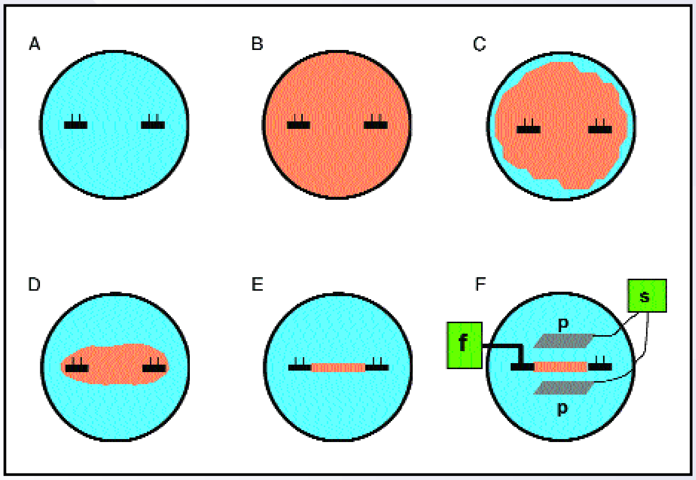
Bio-Systems on the Rise in Mechanical Engineering

Mechanical Engineering has committed to becoming a leader in the biotechnology field by further incorporating bio-systems research and an enhanced educational curriculum into its portfolio of activities. Associate Professor Edgar Meyhöfer and Assistant Professor Robert Dennis — both bringing strong biological research and education backgrounds — have recently been added to the ME faculty to build a stronger bridge between engineering and biology.

"Nearly half of our faculty — 24 of 54 of us — have significant interest in biological systems," says Dennis, who adds that he and Meyhöfer joined the ME faculty last summer primarily because, as Dennis says, "the rest of the faculty is so supportive of this new thrust area that we call Bio-Systems."

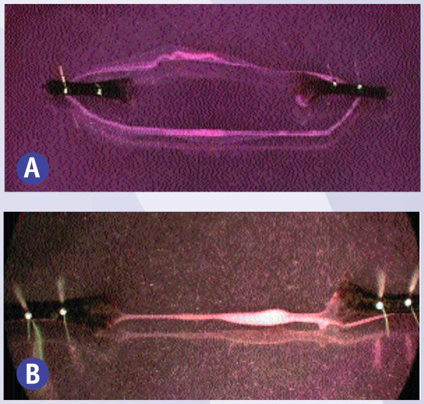
As Dennis explains, the term "bio-systems" generally refers to a broadly defined area that ranges from the molecular and cellular level to the tissue and organismal levels that are either inherently mechanical in nature, or that may be advantageously addressed by classical mechanical engineering disciplines, such as thermal and fluid sciences, dynamics, and controls or materials.

In addition to his ME appointment, Dennis retains appointments as assistant in Biomedical Engineering and as assistant research scientist at the U-M Institute of Gerontology. The graduate level class he developed — Biomechatronics: Tissue Interfaces — is "a very new area," Dennis says. "There are not very many people in the world who are doing it."



Process of self-organization of cardiac muscle constructs in culture.

Biomechatronics is the interdisciplinary study of biology, mechanics, and electronics, with particular focus on the interactivity of biological organs with electromechanical devices and systems. "This involves the integration of living tissues, cells, or other living components," Dennis explains, "with some mechatronic device, which contains electro-mechanical components, an embedded controller with software."



Self-organizing cardiac muscle tissue in culture. (A) Partial delamination of the monolayer of cells at ~180 hours in culture. Note that the cell monolayer remains attached to the anchors while progressively detaching from the PDMS substrate. (B) After complete delamination, the cells reorganize into a 3-dimensional cardiac muscle organ.

Biomechatronics holds one of the keys to the potential development of advanced medical devices and life-support systems. This includes "anything from a hearing aid to an artificial heart, where the artificial heart actually includes the important biological component," says Dennis.

But the crux of Dennis' research at U-M concerns tissue engineering of skeletal and cardiac muscle. "What I really work on is self-organizing skeletal and cardiac muscle tissue in culture," he explains. "I start with cells, and I give them mechanical and chemical signals to encourage or promote them to form into functional muscle organs, such as a little functional piece of a heart muscle or a skeletal muscle."

And as Dennis points out, ME has hired faculty members to do this kind of work at all structural levels.

"Edgar (Meyhöfer) does this with molecules that are from living organisms; I do it with cells and tissues; others, such as Art Kuo and James Ashton-Miller, do it with whole organisms," Dennis says. "Art and James don't actually engineer the organism, but they measure the dynamics. Edgar tears apart cells and investigates single molecules. My objective is to actually start with living cells and build them up into functional tissues. So the spectrum goes from molecules all the way up into living organisms."

Dennis and Meyhöfer recently received almost $6 million in research funding between them from the Defense Advanced Research & Projects Agency (DARPA), which conducts advanced research for the bio-systems

Department of Defense. They are working on creating "living-based actuators" — Meyhöfer at the molecular level, Dennis at the cellular level — whose applications include, according to Dennis, "the building of micro-chemical sorters, chemical weapons detectors, micro-actuators that might be used to restore function if someone is injured."


Robert Dennis


Edgar Meyhöfer

Meyhöfer, who taught mostly medical students during his tenure in the department for Molecular and Cellular Physiology at a Medical School in Hannover, Germany, received his Ph.D. in Zoology at the University of Washington in Seattle, and he did post-doctoral work in biophysics in Seattle before heading to Germany. Meyhöfer's major research interests are in molecular motors, which he describes as "little machines in our bodies that use chemical energy from the cell to drive all kinds of mechanical processes as diverse as muscular contraction, the beating of our hearts cell division or intracellular transport."

There are three different families of motors, he explains further: dyneins, which if not working properly may result in immotile sperm; myosins, which allow muscles to contract; and kinesins, which belongs to a largest family of motor molecules that are, among many other functions, responsible for intercellular transports, bringing vesicles with neurotransmitters to the synapse to allow chemical communications with the neurons.

With this basic understanding, says Meyhöfer, you begin to see the "bigger picture: anything that can't be done by diffusion, which basically only works efficiently over a micrometer distance or so — or anything where you need some asymmetric distribution of things; where you need to get something to a specific location —needs to be done by the cell expending energy; by having the molecular machinery actually transport things around."

"So we have some idea of what these molecules do," Meyhöfer concludes. "We're trying to figure out exactly how… Our strategy is to look at single molecules, using laser trapping or micro-needle devices — some technique that allows us to directly track their mechanical signature," explains Meyhöfer. With laser trapping, a near infrared laser beam is focused to a diffraction-limited spot, so that a micrometer-sized bead is trapped with a light.

"You optically trap this particle, which makes it very powerful because, in a light microscope, where you need a slide and a cover glass and it's very hard to go in with any mechanical device and manipulate things around, [with laser trapping] you can do this with a light through the glass. So in a way it's contact-less, and you can exert minute mechanical forces and measure sub-nanometer displacements."

Using this technique, many new things can be discovered, including what steps the molecule takes, how much force it generates — and how often — and how it interacts with the tract along which it moves. And then, says Meyhöfer, "we can go in and use modern genetic engineering techniques to change the molecules."

The purpose of Meyhöfer's course in Biomechanics is to expose senior undergraduate students to the idea of developing this interface between biology and engineering — and to the value of learning from nature about finding optimal solutions to various problems ranging from the nano world to the level of entire organisms.

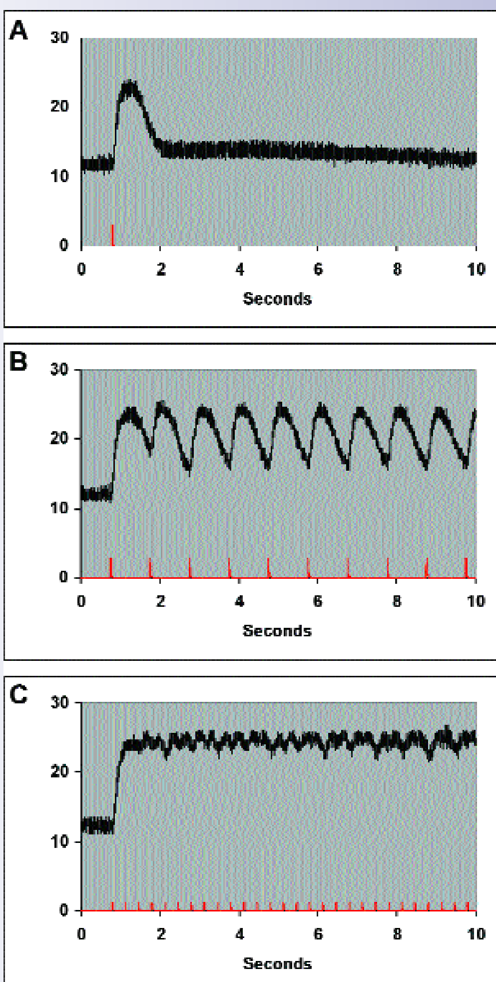
"Look at a cell," says Meyhöfer. "It's actually a very complex nano-machine. It has about 10,000 different proteins, it's size is of a few micrometers, yet it's capable of organizing all reactions, and having everything happen at the same time. In a way, it's the ideal study system for learning how we as engineers can develop nano-technology. It's at least one example of a perfect solution."

Meyhöfer notes that we as humans may have different objectives than a single cell, and thus while it may not offer any complete answers, it does suggest the use of "hybrid designs that incorporate both small

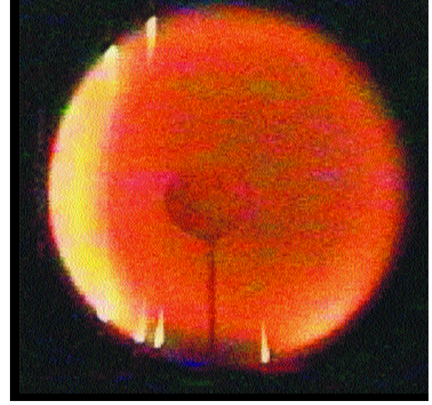
continued ▸

features — like the MEMS type devices that we are engineering now — and combining them in a clever way with biological systems."

And this is in fact the nature of one of Meyhöfer's new research projects — a collaborative effort involving faculty from ME, Biomedical and Electrical Engineering. This project aims at taking the motors studied at the single molecule level and integrating them into man-made micro- and nano-sized artificial structures to generate devices with completely new functionality.



Isometric contractility of a cardiac muscle construct. After attachment to a force transducer, electrical stimulation pulses are applied via parallel electrodes. In all graphs, the black trace is force (in micro Newtons) as a function of time. The red spikes indicate the time of application of each 10 ms wide electrical pulse. (A) A single electrical stimulus pulse (40 V) is applied. (B) A series of 40 V stimulation pulses is applied at a frequency of 1 Hz. (C) A series of 20 V stimulation pulses is applied at a frequency of 3 Hz. In each graph, the baseline force is ~12.5 mN, with a peak active force of ~ 13 mN superimposed upon the baseline force.



Professor Arvind Atreya studies the behavior of flames in microgravity. This photo shows a methane flame formed around a porous sphere at very small gravity.

Arvind Atreya: Clean Combustion

Our economy is driven by fossil fuel combustion, says ME Professor Arvind Atreya.

Arvind Atreya

"Most power plants (excluding nuclear), IC engines, airplane turbines and other transportation systems burn fossil fuels and their combustion causes serious environmental problems…. If you cleanly burn hydrocarbons, you make carbon dioxide—a greenhouse gas, which causes global warming. But clean combustion is not always possible. Consequently, combustion products such as SOx, NOx and unburned hydrocarbons result in acid rain, stratospheric ozone depletion, and ground level smog. From the environmental point-of-view, even clean combustion is not a panacea, we must reduce our usage of energy or begin to use fuels such as hydrogen that produce water upon burning. There is a large effort, currently underway in ME, CoE, U-M and the State of Michigan to utilize hydrogen as the next fuel."

Atreya has been intent on adding an environmental thread into the mainstream undergraduate curriculum, and especially in the early introductory courses, to make students understand how combustion products interact with the solar radiation, and how these gases are transported around the globe.

"Most of the time we don't care so much because we don't really understand. However, we need to bring this understanding to future engineers, who will be responsible for solving these problems — especially here at a place like Michigan, where we should be leading the way."

The graduate course Atreya designed — Management of Sustainable Manufacturing — delves into these problems in greater detail, and ties in management and economics with the search for environmental solutions. Large amounts of pollutants are formed in the manufacturing processes. Industries won't voluntarily reduce pollution unless the solution is economically feasible. This course seeks environmentally friendly solutions that are financially feasible.

Atreya says solutions can be found through research and education. Atreya and his students have for several years been

Engineering for the Environment: Two Eco-Solutions

studying the problem of NOx — the gas that produces smog in the presence of hydrocarbons — and soot. All furnaces and boilers produce NOx, as well as carbon dioxide, but Atreya and his team of student researchers recently received funding to develop a new industrial furnace that utilizes energy more efficiently, without producing NOx and other pollutants. Carbon dioxide cannot be eradicated unless fossil fuels usage is eliminated.

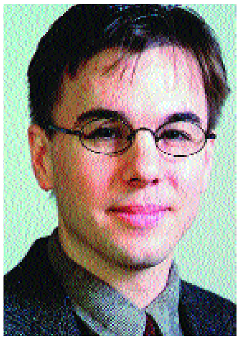
And Atreya is part of a group of fellow scholars and researchers at the U-M as well as other premier universities studying the homogeneous charge compression ignition (HCCI) engine — which also aims at a low-polluting, high-efficiency solution. (See related story on page 20.)

The ME Department, under Atreya's guidance, also operates the Center for Industrial Energy and Environmental Analysis. Over the past seven years, the center has helped more than 200 companies by suggesting economically feasible energy-saving solutions for their manufacturing processes, saving them a combined total of approximately $9 million per year.

Steve Skerlos: Interdisciplinary Approaches

Whereas Atreya's work is atmospheric or gas-based, Assistant Professor Steven J. Skerlos focuses on the conservation of natural resources, particularly water, and the links between engineering decisions and environmental sustainability.

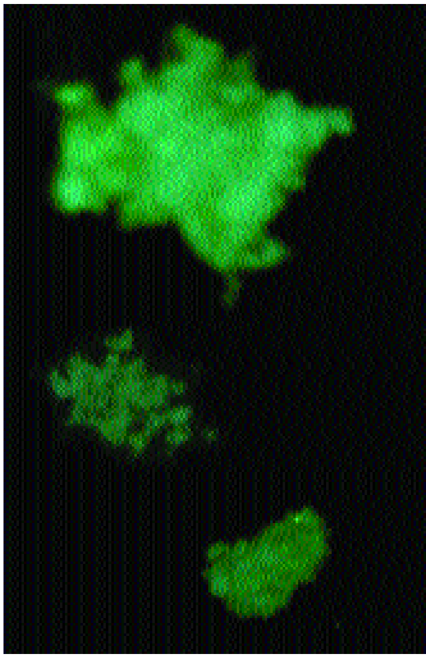
"Most environmental problems such as global warming, resource scarcity, and air/water pollution, arise directly from engineering decisions, whether intended or not," Skerlos says.



Steven J. Skerlos

Skerlos dedicates his research and education program at U-M toward developing an interdisciplinary approach to eco-design and manufacturing. This approach is facilitated by his interdisciplinary background. Skerlos received his B.S. in Electrical Engineering from the University of Illinois at Urbana-Champaign in 1994. After studying environmentally conscious technologies for the semiconductor industry for his undergraduate thesis, he went on to develop environmentally conscious technologies for the metals manufacturing industry during his Ph.D. Along the way, he built a strong background in design, manufacturing, environmental science, and specific technology systems related to sensors and control systems that can function in water-based environments.

These technology systems, originally developed for recycling and protecting human health in manufacturing, have recently gained attention for their potential role in countering bio-terrorism initiatives. One such technology, membrane-based microfiltration, has been extensively researched by Skerlos for its ability to remove microorganisms from industrial fluids where they cause spoilage and create health hazards for workers. He is also developing a microsensor that can detect, quantify, and identify microorganisms.



This photo illustrates the fluorescence of ribonucleic acids in Mycobacteria parafortuitum that is produced via in situ hybridization of peptide nucleic acid molecular beacons designed by Assistant Professor Steve Skerlos specifically for that bacteria. This fluorescence can be detected photographically under a microscope, or by using the MicroIntegrated Flow Cytometer, which is under development by U-M faculty, including Skerlos. While the probe is specific for one species of bacteria, the probe design approach is general for any bacteria and can be used as a tool to detect bioterrorism agents (e.g., anthrax), disease agents (e.g., tuberculosis) waterborne pathogens (e.g., ryptosporidium), and many others.

"It is not enough to have technology available to remove microbial threats. From an economic efficiency standpoint, it is imperative to know where and when such threats may exist and to remove the microbes at their source," he says.

Toward this end, Skerlos and ME Assistant Professor Katsuo Kurabayashi have worked together over the past two years to develop a prototype of a low cost and miniaturized microbial sensor called the MicroIntegrated Flow Cytometer, which can be used for detecting and identifying microbial species.

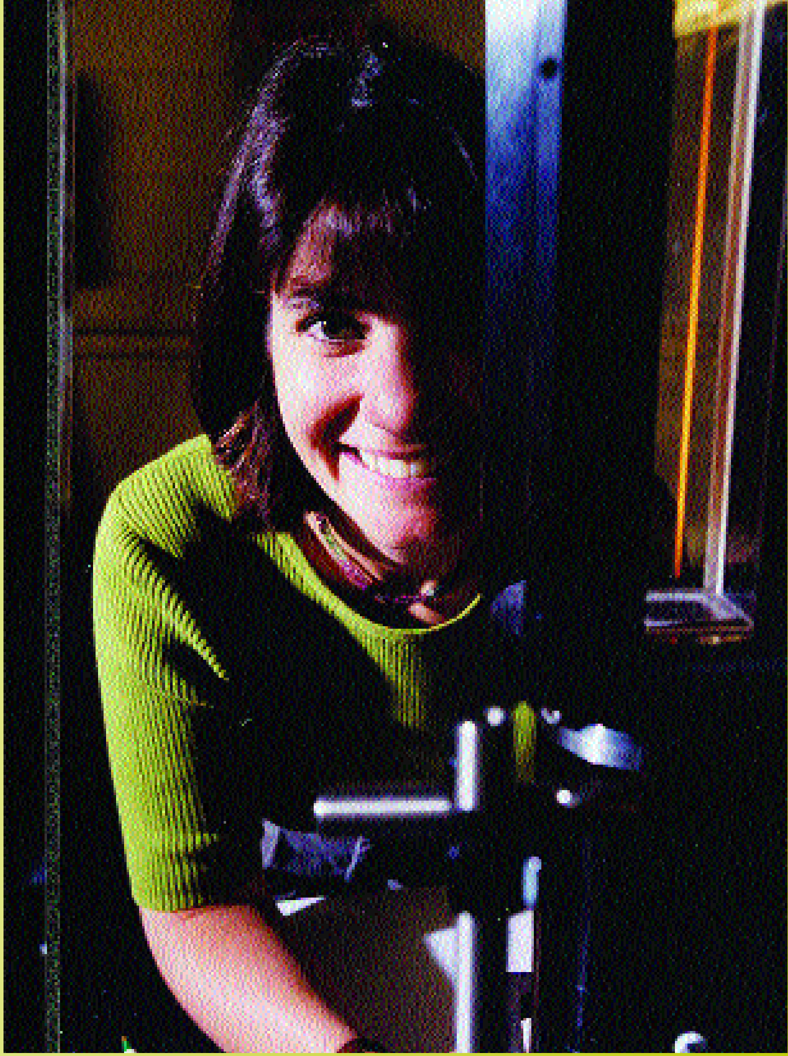
Skerlos also has dedicated a significant amount of his research toward linking design decisions with environmental impact. He has worked on projects involving eco-product design, design for recycling, and life cycle assessment for cell phones, consumer appliances, and automobiles. Skerlos' graduate-level course, Eco-Design and Manufacturing, takes up these same topics. After considering the science behind topics such as global warming, ozone depletion, and acid rain, the class investigates the sources and solutions to pollution rooted in mechanical engineering design and manufacturing decisions.

Big Advancements at the Micro- and Nano-Level

Numerous ME faculty members and their students are making large strides in many "small" ways with groundbreaking work in micro- and nano-systems.

Associate Professor Margaret S. Wooldridge works primarily at the nano-level. "It's actually difficult for us to create anything with micron proportions," she says.

Whereas a MEMS device, for instance, is typically built from the top down — larger to smaller — Wooldridge builds from the bottom, or molecular, level up "until we reach the nano dimension we want. There are only a handful of general techniques that can be used to create nanoparticles. We use flames. We essentially burn reactant precursor materials to break them up into their molecular components and then rebuild them into the shape and structure we want. We use the flame as a chemical reactor."


Margaret Wooldridge

Her group is developing a technique to make nano-composites, which involves having multiple condensed phased species in the flame, and one of the systems under investigation is gold/silica.

"We'll have gold nano-islands distributed on nano-sized silica particles as the substrate. One of the advantages of gold is that it is an extremely active catalyst; however, the activity is strongly affected by the support material and the morphology of the gold particles and the substrate. So if you can make the nanocomposite in one step and control the respective morphology, composition, particle size, etc. of the two materials, you can essentially design and create catalysts with highly enhanced activities and hopefully enhanced stabilities."

Wooldridge and her students are also involved in making thin films, with applications as sensors. Tin oxide, for instance, is a primary component in many gas sensors; if the chemical process of making nanoparticles is interrupted, instead of manufacturing tin oxide particles, a film can be made. Nanocomposites also have considerable potential for improving the properties of thin films as well.


Wei Lu

Assistant Professor Wei Lu and his students also have made important progress in nano-level research in the simulation of nano-scale self-assembly. According to Lu, "advanced technologies demand solid structures of decreasing length scales" — and structures in nanometer dimensions exhibit characteristics that offer potential for significant and unique technical improvements in the transport and carrier fields. While the ability to successfully "pattern nano-scale structures" is crucial to the miniaturization and development of novel functional devices, the main challenge has been to produce them economically.

"So when nano-structures self-assemble — which they sometimes can — a low-cost, high-throughput fabrication method becomes a promising possibility," says Lu. Lu is involved in two investigations into the phenomenon of self-assembly. One concerns a Pb (lead) and Cu (copper) monolayer mixture on a Cu substrate, which can form two phases: a Pb overlayer and a Pb-Cu surface alloy. The two phases in the monolayer may self-organize into ordered, nano-scale patterns, such as a triangular lattice of dots and serpentine stripes with the pattern type, feature size, and degree of long-range order varying with surface composition and temperature.

Lu's research reflects a growing interest in understanding, modeling, and simulating phenomena and processes in nano-scale structures, which significantly contribute to nano-structure engineering. His work extends the continuum theory to incorporate processes in small scale, revealing the interaction of various thermodynamic forces in nano-structure evolution.

nano technology

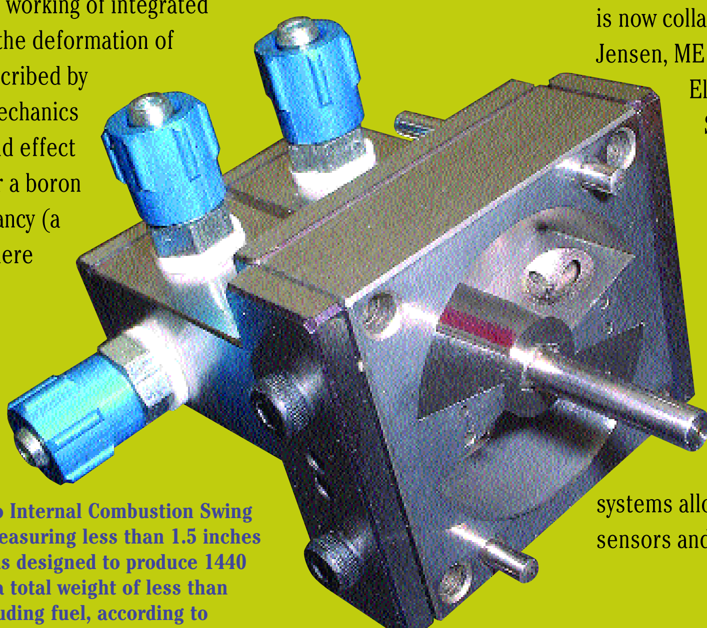
Krishna Garikipati

Similarly, the focus of the research conducted by Assistant Professor Krishna Garikipati is in the realm of continuum mechanics, and in the accurate and efficient descriptions of the physics of nano-systems when material is modeled not by accounting for distinct atoms, but by considering the mechanics of large numbers of atoms, where the material is viewed as an unbroken medium. Garikipati applies these ideas to the deformation of nanostructures.

"The models applied to cars, bridges, and galaxies do an astoundingly good job at the nano-scale, if some additional effects are incorporated," says Garikipati. "These are referred to as 'strain gradient effects.' Roughly speaking, a nano-scale glob of matter responds to the amount we stretch it, and to how much we stretch a neighboring glob."

Garikipati's research group works with the atomic and continuum descriptions, using them to infuse and inform each other. They systematically construct continuum theories by starting with distinct atoms. Once the continuum description is obtained, the atomic description can be forgotten. These theories are then used to probe the deformation of nano-structures.

These ideas find application in solid state physics. The distribution of "dopant" atoms (boron, arsenic, indium, etc.) in silicon, for instance, is central to the working of integrated circuits. And the deformation of silicon as described by continuum mechanics has a profound effect upon whether a boron atom or a vacancy (a vacant site where an atom ought to be) is found at a given position in the silicon lattice.



This Micro Internal Combustion Swing Engine, measuring less than 1.5 inches across, was designed to produce 1440 Whr with a total weight of less than 815g, including fuel, according to Professor Jun Ni.

"We have forged a combination of molecular dynamics and continuum elasticity to understand and model this behavior," Garikipati explains. "In the process, we are discovering new truths and discarding old prejudices about the atomic and continuum descriptions of matter." This study is being conducted in close collaboration with Assistant Professor Michael Falk of the Material Sciences & Engineering Department, as well as the semiconductor industry.

Katsuo Kurabayashi

Assistant Professor Katsuo Kurabayashi is involved in four different small-scale projects — including a recently funded endeavor concerning nanoscale material processing work with near-field optics lasers with ME Assistant Professor Suman Das — but he and his students still find a lot of work to do at the "larger" micro-level as well. As an extension of his ongoing research with MEMS actuators, Kurabayashi is now collaborating with ME Ph.D. student Brian Jensen, ME Assistant Professor Kazuhiro Saitou, and Electrical Engineering and Computer Science Professor John Volakis on the development of reliable Radio Frequency (RF) MEMS switches for reconfigurable antennae to be used in wireless communication devices.

The future of wireless communications, Kurabayashi explains, requires lower weight, volume, power consumption, and cost — with increased functionality. Since September 11, miniaturized RF systems allowing for wireless data transmission from sensors and communication devices have been in

continued ▸

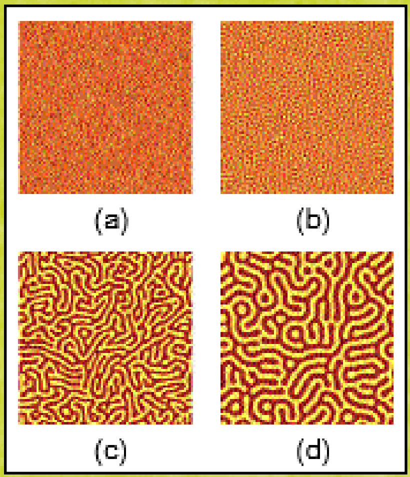


Figure 1

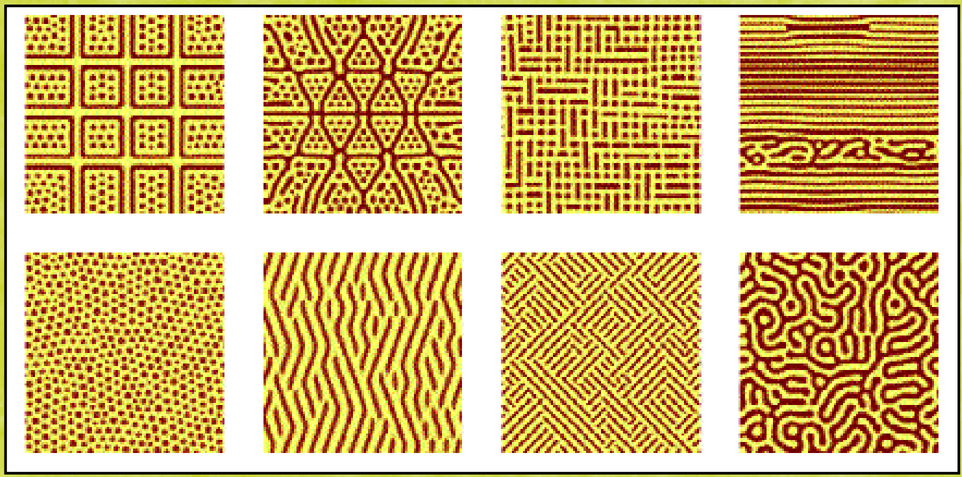


Figure 2

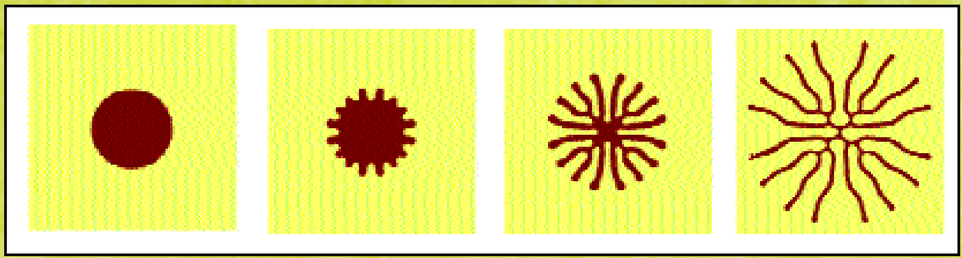


Figure 3

One of the main challenges in nano-scale technology is to develop economic production methods. According to Assistant Professor Wei Lu, sometimes nanostructures can self-assemble, indicating a promising low-cost, high-throughput method. Figure 1 is a simulation of evolution sequence demonstrating the self-assembly of a binary epilayer. By adjusting the material properties, various patterns can be obtained (Figure 2). Figure 3 demonstrates how an interface may lose stability and self-assemble into patterns. The self-assembled patterns may directly satisfy technical needs, or can be used as templates.

greater demand, since such systems can help monitor bridges, nuclear plants, and military facilities, and transmit and receive information and electronic data from a remote area.

"It's easy to create that kind of contact," says Kurabayashi, referring to the electro-static actuation that creates the physical contact that switches on a device. "It's such a short distance, typically two microns. But the problem is that because it is so small it can easily get stuck, which creates the reliability problems."

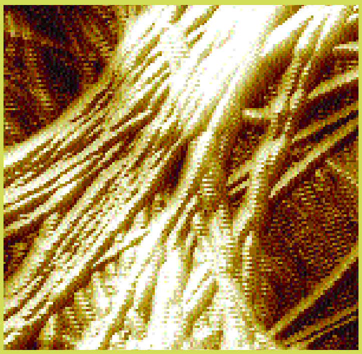
Kurabayashi's research entails the use of computer-generated design techniques and a "clean room" facility to manufacture integrated circuitry. "This kind of research involves extremely small devices — maybe less than a human hair in diameter, or 200 microns or less — yet they're mechanical in nature," says Kurabayashi. "You cannot see them with your naked eye. You have to look at them using optical microscopes only."

"We are focusing on only one particular component of the entire system," he emphasizes — the RF MEMS switches, which he describes as "micro-bridges; they have the shape of a suspended bridge, and they're sitting — in fact they're moving — on a silicon chip." Quite simply, he concludes, "we're trying to come up with some mechanism which prevents adhesion of the micro-bridge to the substrate."

"But eventually, if we succeed in further miniaturization of the entire device — integrating all of the mechanical devices on a single chip — including the antenna, we may be able to develop a wrist-watch type of transceiver, James Bond, or Dick Tracy style. And research of this nature requires us to work as a team with other people in different technical backgrounds as we do."

Ann Marie Sastry

Associate Professor Ann Marie Sastry's research spans engineered and biological nanostructures. "Self-assembling biological structures, which have evolved over millions of years, give us a wonderful 'database' to explore and exploit in creating new engineered materials," Sastry explains. "The connections among molecules, their synthesis — these are probabilistic phenomena, and so our simulations reflect this, the 'messiness' of real systems." Simulations in her group proceed after careful imaging of nanostructures via AFM and TEM; these allow both an understanding of the likelihood of achieving high-efficiency structures and also their ultimate properties. Her group's work also includes fundamental modeling (theoretical and computational) of percolation phenomena, or the study of formation of continuous paths of phases in a material. This work has great significance in understanding how much of a particular material must be present in order to appreciably affect properties.



Supercomputing allows simulation of real molecular processes, with use of nanoscale imaging techniques. Percolation simulations predict interactions and assembly behavior of complex, three-dimensional arrays at the molecular scale (above). Atomic force microscopy informs the simulations by quantifying protein structure and placement of molecules (as left, with collagens of the peripheral nervous system).

In biological materials, Sastry and her students are working to understand the effects of diabetes on collagens at the nanoscale, and how these changes might contribute to the permanence of symptoms of diabetic neuropathy. Their collaborators at U-M include Dr. Kelli Sullivan in Internal Medicine, Dr. Eva Feldman in Neurology, and Dr. Martin Philbert in Toxicology.

"Changes at the molecular level can be directly accounted for when the variation in real tissues is measured," says Sastry, "AFM, in combination with immunohistochemistry, gives us the structural and the material composition information we need to develop meaningful computational models." Sastry's group has also studied the extracellular matrix of marine eggs, to explore the effects of nanoarchitectured polysaccharides on the eggs' resistance to mechanical loads. "At this point, we are moving away from continuum modeling to solve the realistic, though computationally more intensive, biochemical problems," Sastry says, "so, we may be good mechanical engineers, but now we have to become capable biochemists, in order to do the right simulations."

She continues, "This is probably the future of the engineering sciences, this push to explore nanoscale problems in lock-step with the latest advances in biochemistry and biophysics—the interdisciplinarity of our work will hopefully affect more than just engineering practice, by coupling what we can measure directly, and meaningfully, with what we can model and make at the atomic scale."

Mars Rover 2009 is Underway

Senior Research Scientist Johann Borenstein received a $500K grant from NASA/JPL to develop a position estimation system suitable for mobile robots that navigate without the benefit of a GPS system. The Mobile Robotics Laboratory, under Borenstein's direction, is developing a special navigation system called Fuzzy Logic Expert navigation (FLEXnav) that provides such a capability.

Borenstein writes, "NASA is interested in adding our system to its so-called Mars Rovers — vehicles destined to move around on Mars in future missions. One such Mars Rover mission filled the headlines of the media when it beamed back to Earth pictures from the Mars surface during the Sojourner mission in 1997. Our FLEXnav system is being developed for the Mars Rover mission planned for the year 2009. Why so far ahead? Because NASA requires four years to implement and test novel software and hardware before it is used on expensive missions. It also takes 7-8 months for the Rover to be flown to Mars, so the 2009 mission actually lifts off in 2008."

The X50 Studio: Rapid Prototyping Turns Ideas Into Machines

Not much more than a year ago, ME Professors Diann Brei, Suman Das, R. Brent Gillespie, Katsuo Kurabayashi, and Jonathan Luntz wrote a funding proposal for the creation of a unique instructional facility in which students can rapidly prototype and integrate mechanical systems into working pieces of modern machinery.

Now, as the Fall 2002 term begins, that vision is being realized — and students and faculty alike are already beginning to reap the benefits of such a tool, which has tentatively been renamed "X50 Studio." The name refers to the three ME undergraduate design courses (250, 350, and 450) intended to make the most use of the opportunities these new prototyping tools present. The facility was made possible by generous funding from the College of Engineering and ME Department.

"Realizing a physical model of a device or process [that you're trying to develop] that you can test by traditional means — meaning hold it in your hands, put it into operation, test it in its normal operating environment — that's usually expensive and time-consuming," says Assistant Professor R. Brent Gillespie. Rapid prototyping involves investing more money up front in tools that make it easier to fabricate a testable prototype — and thus more efficient and cost-effective overall.

The "X50 Studio" tools include a laser cutter, a rapid control system prototyping tool, a printed circuit board prototyping machine, and a basic stamp.

Gillespie says the laser cutter is fun and easy to use. Using this machine, students are able to convert their CAD virtual models into physical, functional prototypes in a matter of hours. There is no tooling or fixturing (as in conventional machine tools), and thus substantially reduced setup. "It's almost like printing it on a piece of paper but it comes out as a piece of Plexiglas," says Gillespie.

The rapid control system prototyping tool, implemented at state-of-the-art workstations, provides a complete control system development and testing environment using Simulink, which is an extension of MATLAB, a commonly used piece of mathematical software. Then there's the break-out board — 50 or more electrical connections, each with a particular function, that either send out or take in a signal. By looking up numbers and appropriately hooking up motors and sensors, students can use the motors to act on incoming sensor signals to achieve the behaviors they're seeking — such as getting a robot to move a certain way.

The custom printed circuit board prototyping machine is capable of machining a computer-generated circuit layout diagram onto a circuit board blank (rather than connecting chips with wires pin to pin), creating the necessary pathways for electrical connectivity. After students fabricate and assemble a mechanical prototype, and design and test its control system, the control logic can be implemented into the physical hardware.

Assistant Professor Suman Das' research is in the field of solid freeform fabrication (SFF) which involves building objects layer by layer using materials of choice. His research focuses on using SFF for rapid prototyping physical objects using a selective laser sintering technique, and on developing new and advanced methods of multiple material deposition for rapid prototyping objects of heterogeneous composition.

Using the laser cutter, students are able to convert their CAD virtual models into physical, functional prototypes in a matter of hours.

Das and his students are presently at work in his SFF laboratory making progress on four distinct projects. One is an NSF-funded collaborative project with ME Professor Sridhar Kota that involves developing multi-material optimized representations of compliant system assemblies, and fabricating these systems using selective laser sintering of multiple materials — such as polymers, metals, and ceramics — where the location of the material composition within the component has been optimized according to function and properties.

"Most fabrication processes involve material removal from a bulk preform and are subtractive, whereas our SFF process is additive. Materials are added layer by layer, and only where you need them, to define the shape being fabricated," says Das.

A second project involves the development of a laser processing technique to rebuild damaged single-crystal aircraft engine turbine blades made of nickel superalloys. Das has designed and constructed a machine specifically to perform a scanning laser-based process for repairing these blades to their "pristine condition." Experimental trials

X50 Studio

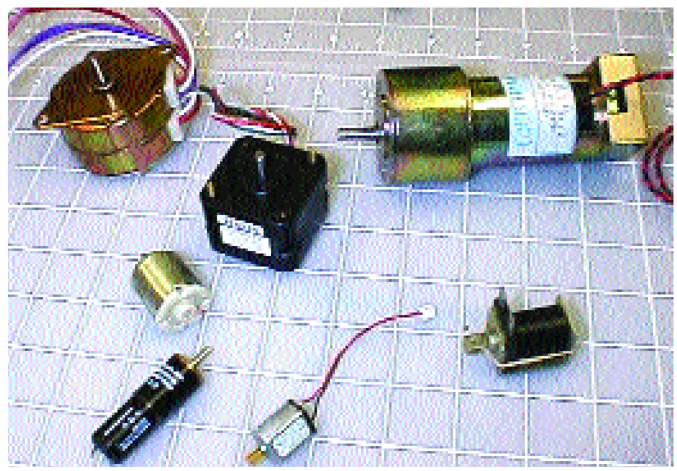
will soon commence using this new equipment. According to Das, there are an enormous number of used blades stored in warehouses around the world that are awaiting the arrival of the appropriate repair process.

Another research endeavor that has important surgical applications is the development of an SFF process for fabricating functionally tailored tissue engineering scaffolds using biopolymers and bioceramics. The project's long-term goals include gaining the knowledge and ability to build an entire replacement knee joint using this process.

Finally, Das is involved in a technological development that involves designing and constructing a SFF machine that is capable of depositing multiple powders with particle sizes only approximately 100 microns and smaller. Once the powders are deposited in designed patterns, they are consolidated to full density by laser processing, layer by layer.

Applications for this fabrication process include multifunctional and smart components, and tailored composites.

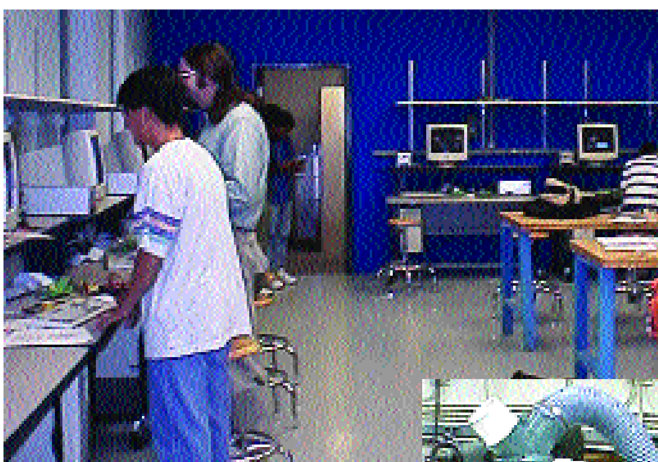
The objective of a new course introduced by Das during the Winter 2001, Solid Freeform Fabrication, is to introduce students to various state-of-the-art solid freeform fabrication technologies and to increase their understanding of the fundamental physics driving these technologies.



Above, a selection of available electromechanical components in the X50 Design Studio.

At left, real-time workstations line the walls in the primary room of the X50 Design Studio.

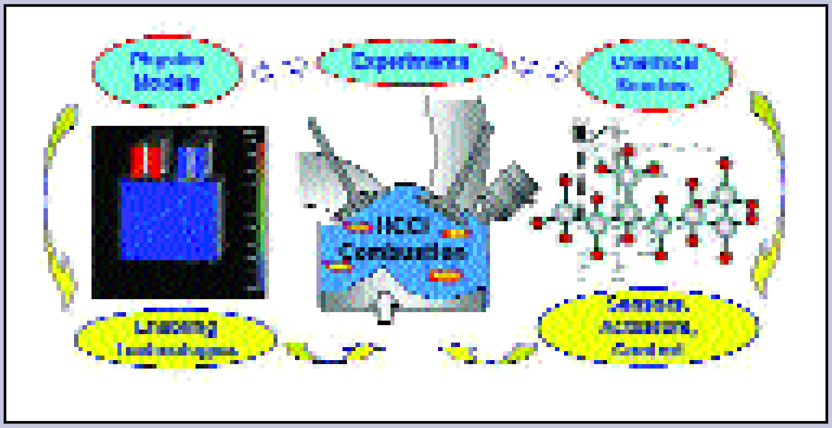
Below, is a laser cutting machine, part of the X50 Design Studio.



Reinventing the Internal Combustion Engine

Though gasoline-electric hybrids and fuel-cell powered vehicles are garnering most of the mainstream media headlines, there is a lesser known but perhaps more promising alternative to the traditional gasoline engine powered vehicle that could be the vehicle of choice in the near future.

Certainly, that's the goal of the U-M-led Multi-University Consortium on Homogeneous Charge Compression Ignition (HCCI) Engine Research, which capitalizes on the indisputable strengths of five of the nation's premier engineering schools — U-M, Massachusetts Institute of Technology, Stanford University, University of California at Berkeley, and Texas A&M University. A three-year, $4 million endeavor is funded mostly by the Department of Energy and partly by major automotive industry partners. The consortium brings together internationally recognized leaders in the areas of engine processes and controls, fundamental combustion and chemical kinetics, engine modeling and optical diagnostics, and engine system optimization. Their collective efforts aim to advance the understanding of the fundamental chemical and physical processes involved in HCCI combustion and use this understanding to optimally design and control HCCI engines.



U-M-led HCCI consortium is addressing challenges related to this innovative new technology through a balanced approach between fundamentals and application.

HCCI Consortium Director Professor Dennis Assanis explains: "The spark ignition engine internal combustion engine has impressive power density, attractive specific cost, and effective emission control, but leaves a lot to be desired in terms of efficiency. The diesel engine, as a traditional alternative, has high efficiency, but struggles with reducing emissions of NOx and particulate matter. This provides the impetus for accelerated investigations into whether an alternative engine based on a novel mode of clean combustion can become commercially viable."

The HCCI engine uses lean, premixed charge, much like the spark ignition engine, but relies on high temperature in the combustion chamber at the end of compression to provide nearly spontaneous ignition. Operating without the throttle and with a high compression ratio, the HCCI concept holds a promise of delivering diesel-like fuel economy, while virtually eliminating emissions due to homogeneous, low temperature burning. However, having no means for direct control of ignition close to the start of heat release creates a great new challenge: how to control the "seemingly uncontrollable."

The consortium, which commenced work in October 2001, hopes to answer scientific questions critical to progress in developing the HCCI technology. Investigators will study the chemical kinetics of real gasoline and diesel fuels, using both theoretical and experimental methodologies. Validated kinetic schemes will be implemented in high fidelity HCCI engine system simulations that are being developed to guide engine experiments and optimize engine control strategies. Associate Professor Margaret S. Wooldridge, who is a co-principal investigator in the consortium, says it presents a "wonderful opportunity to synergize multiple research efforts…We get a great deal more done than we would if we were each working on our own. We have chemists working together with engine modelers and experimentalists…and it gives a level of perspective that you wouldn't otherwise have." Other UM faculty involved in the HCCI Consortium include Professors Arvind Atreya, Hong Im, and Volker Sick, Dr. Zoran Filipi, and Dr. George Lavoie.

Assanis speculates that a vehicle using a dual-mode HCCI engine, which at high engine loads would switch from the auto-igniting HCCI mode to spark-ignition operation, could be in use within a five-year period. "It is a much nearer alternative than the fuel cell. The HCCI engine can burn all fuels, including hydrogen. So when hydrogen comes around for fuel cells, it will also be available for HCCI. We are delighted to lead the consortium efforts and work closely with our distinguished colleagues from other premier universities" Assanis says.

hcci engine

ARC Continues to Excel and Looks Ahead

The Automotive Research Center (ARC) is a unique research partnership founded in 1994 to advance state-of-the-art modeling and simulation of military and civilian vehicles, while providing both educational opportunities and a cooperative link among the military, academia and the automotive industry. Over the past eight years, the ARC has been funded and supported by the Department of Defense and the U.S. Army in particular, through its National Automotive Center at TACOM in Warren, Michigan. In its first phase (1994-1998), the ARC was initially established with five University partners, led by the U-M, and a $2.5 million annual budget. In the renewal Phase II (1998-2003), the ARC was expanded to eight universities and a $5 million annual budget. Current academic partners are Clemson University, Oakland University, the University of Alaska-Fairbanks, the University of Iowa, the University of Tennessee, the University of Wisconsin, and Wayne State University.

Within U-M, faculty participate in the ARC from the mechanical, electrical, computer science, industrial, and naval engineering departments. Professor Panos Papalambros has served as the center's founding director from 1994 to 2000, when directorship was transferred to Professor Dennis Assanis. Papalambros continues to serve the ARC as an executive director with overall strategic management. Professors Jeff Stein, Christophe Pierre, Greg Hulbert, and Naeim Henein (Wayne State University) have been serving the ARC as associate directors since its inception, while Professor Don Chaffin (IOE) has been an associate director since September 2001. Dr. Zoran Filipi joined the ARC's management team as an assistant director in March 2002.

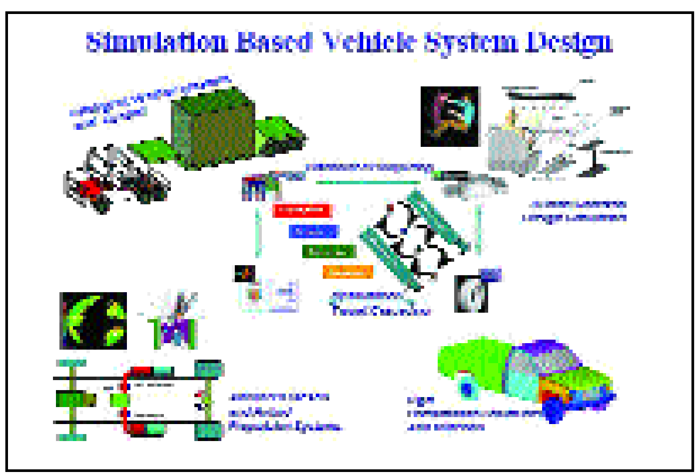
The first phase of the ARC was focused on modeling and simulation of the body, the chassis, and the engine of the vehicle, and how to devise integrated computer simulation techniques for evaluating new concepts early on in the development, thus making design and procurement processes more cost effective. The second phase of the ARC added the human interface, and increased emphasis on controls and hybrid propulsion systems. Planning for the next five-year phase of the ARC is now underway. As Assanis said, "ARC participants intend to continue to do what they do best — engage in the development of ground-breaking modeling and simulation processes, while implementing a systems-within-systems approach by considering effects on the national and global economy, public policy issues, and energy and fuel questions — thereby increasing the scope and influence of the center."

The ground-breaking research work of the ARC is highlighted at the ARC's Annual Conference which showcases both collective research efforts, through integrated vehicle case studies, as well as contributions of individual researchers in parallel technical sessions focusing on intelligent vehicle dynamics and controls, digital human modeling, high performance structures and materials, advanced and hybrid powertrains, and integrated system design and simulation. To restate the center's renewed commitment to its dual purpose role of serving both government and industry needs, the ARC's Annual Conference has been co-hosted by industry, government and academia since 2001, when the first day of the event was held at Ford Motor Company.

Most recently, the *Eighth Annual ARC Conference on Modeling and Simulation of Ground Vehicles* took place in mid-May at the GM Tech Center in Warren, Michigan, and at U-M North campus facilities in front of a record number of participants. Four-star General Paul J. Kern, Commanding Officer of the U.S. Army Materiel Command, a distinguished ME alumnus and member of the EAB, spoke with great conviction concerning the growing importance of developing methodologies that will redesign future combat systems in order to make our armed forces more agile over the next several decades. Dr. Larry Burns, vice-president for research, development, and planning for GM, described challenges in vehicle product development and innovation and emphasized the need for enhanced global thinking as the 21st century begins.

Other keynote speakers included General Ross Thompson, Commanding General of US Army TACOM; Dan Ustian, president, International Truck and Engine Corporation; and Dr. Hazzem Ezzat, co-director of the GM-UM GM Collaborative Research Laboratory.

More information on ARC research and upcoming events can be found at http://www.arc.engin.umich.edu.



The ARC provides a collaborative research environment allowing integration of areas critical for simulation-based vehicle design.

Engineering Research Center Looks at Next Generation of Manufacturing Technology

Over the next few months, there'll be a couple of public glimpses into one of the University of Michigan's best-kept secrets.

In August 2002, walls of an engineering laboratory will literally be moved to allow a space-age-looking RMT — reconfigurable machining tool — to be transported to the International Manufacturing Technology Show in Chicago. The giant machine, designed by faculty and research scientists at U-M, detailed by Lamb Technicon, and built by Masco Machine, Inc. was installed in the spring of 2002. The RMT is capable of drilling and milling non-orthogonal surfaces with only three axes. The arch-type machine has a range of motion from 45-degrees to minus 15 degrees from the horizontal and can be reconfigured in threw minutes.


Yoram Koren


A. Galip Ulsoy

In another project that seems unrelated, young visitors to the Ann Arbor Hands-On Museum soon will be able to use an interactive display to create their own customized product — a writing pen, for instance — and in the process see how changes in the design and production of that pen affect the final product.

Both of these efforts are made possible through the National Science Foundation (NSF) Engineering Research Center for Reconfigurable Manufacturing Systems (ERC/RMS) at U-M, and represent just a fraction of the over 34 projects currently underway at the center, where cutting-edge manufacturing technology is being tested and developed under the directorship of ME Professors Yoram Koren and A. Galip Ulsoy.

The ERC/RMS, founded in 1996 with funding from the NSF, has an annual budget of $5 million to $6 million and recently underwent a critical sixth year review. "The recent NSF site review went well," says Ulsoy, who serves as deputy director. "Contingent upon final approval of a research plan in early fall, the annual NSF funding will be renewed through 2007." The remainder of the funding comes from industry (30%), the university (15%), and the state of Michigan (5%).

The work being conducted at the ERC/RMS focuses on the next generation of manufacturing technologies, where machines are designed to be rapidly changed in response to product demand. This approach is in contrast to dedicated transfer lines, which produce large volumes of specific parts, and so-called "flexible" systems, which are computer-controlled and highly flexible but more costly and slower to finish products. RMS provides a cost effective hybrid solution, drawing from the most desirable characteristics of both dedicated and flexible systems. The result is an RMS that can be switched quickly to produce different parts within a feature-based family of products, and which can be easily expanded should the need for higher volume arise.

In the ERC/RMS, about 80 students — half undergraduate, half graduate — work alongside industry members, research scientists, and faculty members in creating software and prototype machines, testing theories and methodologies, and obtaining critical hands-on experience. The 26 member companies are vertically integrated along the machine supply chain and include the Big Three, automotive suppliers, system integrators, machine tool builders, controls vendors, and software providers. These companies contribute both financial and in-kind support to the center. In return, regular members are entitled to royalty free use of the software and other intellectual property developed in the ERC/RMS.

The center's impact on the students is measurable. According to Dr. John Cristiano, industry liaison to the center, students hired by member companies after working in the center are lauded for their real-world readiness. "Through the experience they get as being a part of the center, by the time they graduate they are very well prepared both technologically and interpersonally," Cristiano says. "Entering the work force with the set of experiences provided by the ERC gives a student a competitive advantage, especially in difficult economic times."

A prototype of a reconfigurable inspection machine (RIM) has been developed by the ERC/RMS that uses rapid, non-contact electro-optical measurements for the testing of parts. This new approach has the potential to replace coordinate measuring machines currently used for the inspection of machined parts (e.g. cylinder heads). The RIM offers significant potential benefits both in terms of speed (minutes versus hours) and ease (in-line versus off-line).

manufacturing

The center is also involved in education and outreach efforts. In addition to the exhibit planned for the Hands-On Museum, the ERC/RMS participates in the Detroit Area Pre-College Engineering Program, bringing in middle school students for a series of hands-on sessions each spring to introduce them to the options of engineering. In addition, the ERC/RMS provides experience through the Research Experiences for Undergraduates program and conducts distance learning and workshops. “The objective of the education component is to both create an awareness of manufacturing as a career, and to develop and train next generation manufacturing leaders,” says Koren.

The professional sector is also taking notice of the center’s work. A recent article in *American Society of Mechanical Engineers’ Mechanical Engineering* magazine featured an ERC study that compared the efficiencies of RMS to CNC (computer numerical control)-based systems. The research showed that reconfigurable systems produce significant savings over the CNC systems. An RMS is being used by a small company to produce a variety of different connecting-rod designs for their customers with only a 30 minute reconfiguration time.

There is further evidence that the ERC/RMS is impacting industry. The center has inventions for five U.S. patents, three of which form the cornerstone of the RMS design. In the recent annual review of the center’s progress, member companies expressed a strong belief that being involved in the center has significantly changed the way they do manufacturing. Companies are using the center’s life-cycle modeling software — which allows them to assess their manufacturing system investment decisions (e.g. dedicated, reconfigurable, flexible, or a mixture) under specific scenarios — to plan and select system design by feature-based part families, using the concepts and methodologies developed at the ERC/RMS.

“Machining is a slow-moving industry,” Cristiano says. “It’s a mature industry that is reticent to accept changes. The fact that our industry members acknowledge that the ERC has created an environment of open-thinking, allowing them to consider a new manufacturing paradigm is a significant accomplishment of the center.”

Professor Yoram Koren, director of the Engineering Research Center for Reconfigurable Manufacturing Systems at U-M, inspects the indexing mechanism of the new 'Arch-type' reconfigurable machine tool in the ERC/RMS testbed.

The U-M - General Motors Collaboration: A Continuing Success

When U-M and General Motors entered a collaborative relationship nearly five years ago, the idea was to take advantage of the collective interests and strengths of the university and the automaker. This joint venture has been highly successful and the GM and U-M researchers are currently engaged in defining a second five-year program for the GM Collaborative Research Laboratory (GMCRL).

Graduate students Orgun Guralp (left) and Junseok Chang (right) installing the single-cylinder DISI engine instrumentation prior to testing.

GM has used the U-M laboratory as a model for five others across the country and the world, with plans for two additional labs to open soon. The laboratory at the University of Michigan remains the largest; it is expected to continue to receive $1 million annually.

ME Professor Panos Y. Papalambros, who has co-directed the lab since its inception in 1998 together with GM's Dr. Hazem Ezzat, points out that the GMCRL is an outgrowth of the automotive and manufacturing research activities at the U-M. "The value is that we are working on research projects that the faculty think are intellectually important, and GM is supporting them because they relate to GM's core technology," says Papalambros. As a result, three areas of interest were identified:

- Body design and manufacturing, directed by Professor Jack Hu
- Powertrains, directed by Professor and ME Chair Dennis Assanis
- Systems engineering, directed by Professor Panos Papalambros

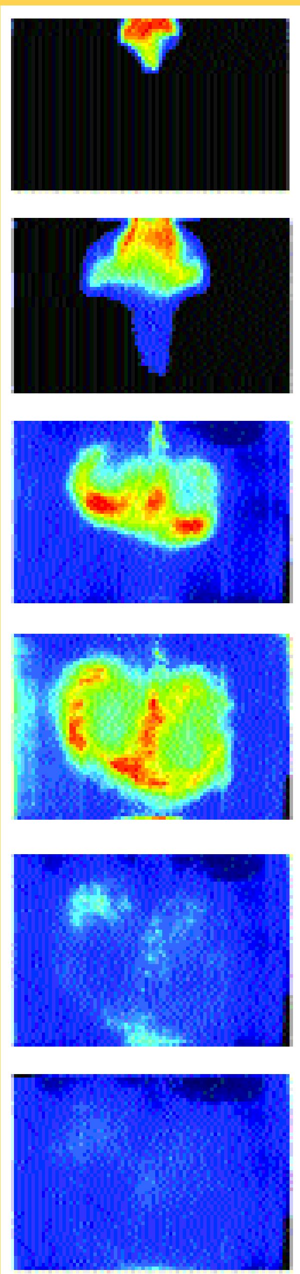
Part of the measure of the lab's success is that the GMCRL has sustained interest through a succession of GM research leaders. The lab was started under Baker, but has been vigorously supported by succeeding Vice President Larry Burns and the R&D Executive Director Alan Taub. "The long-term relationship gives us opportunity to do more fundamental research," says Hu, who was recently appointed GMCRL co-director to succeed Papalambros. GM is being particularly supportive of the graduate students. The consistency of support allows the Ph.D. students to concentrate on their thesis work.

In body design, Hu and his graduate students are using mathematical models and software to evaluate body shop design. Work continues on the development of new lightweight body structures, such as those made from aluminum, which is increasingly used in manufacturing vehicle bodies. Modeling the welding process allows researchers to find the best and most efficient methods for joining steel and aluminum alloys, thus improving quality of vehicle structures.

In the powertrain area, researchers are using a combination of various diagnostic techniques to study issues related to direct injection engines. Associate Professor Volker Sick and his students are developing advanced laser-imaging techniques and applying them to study in-cylinder processes in an optical engine. The analysis of fuel, nitric oxide, flow, and temperature distributions in the engine provide direct information on details of advanced engine concepts. In a parallel effort, Assanis, Dr. Zoran Filipi, and a team of students use special pistons instrumented with fast-response thermocouples in a single-cylinder engine to characterize the thermal environment and its effect on mixing and emissions. A multi-cylinder diesel engine set-up has just been upgraded for studies of novel modes of combustion, after completing an extensive investigation of lubricant formulations for improved fuel economy and emissions of high-speed diesels.

In systems engineering, Papalambros and his team use decision-making models and mathematical optimization techniques. These techniques were used extensively in completed projects involving diesel and hybrid electric propulsion systems. Currently, the team is focusing on optimizing product platform design. Component sharing among vehicle variants reduces development time and manufacturing costs but may compromise individual performance and product differentiation, so careful tradeoffs are necessary.

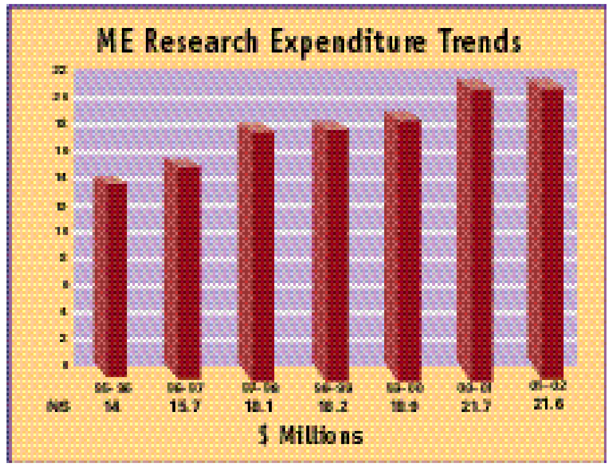
As the laboratory embarks on its second five years, GM and the U-M are in the process of establishing the research agenda, which should be decided by December. “It’s a complementary process, and a negotiating process,” says Papalambros. “The value is in matching resident expertise with the projects GM has an interest in.”

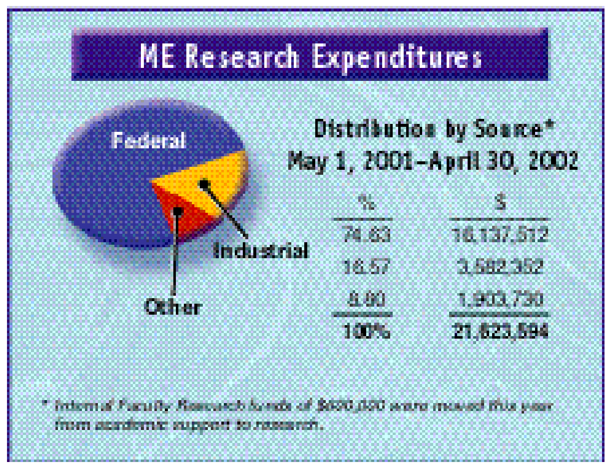


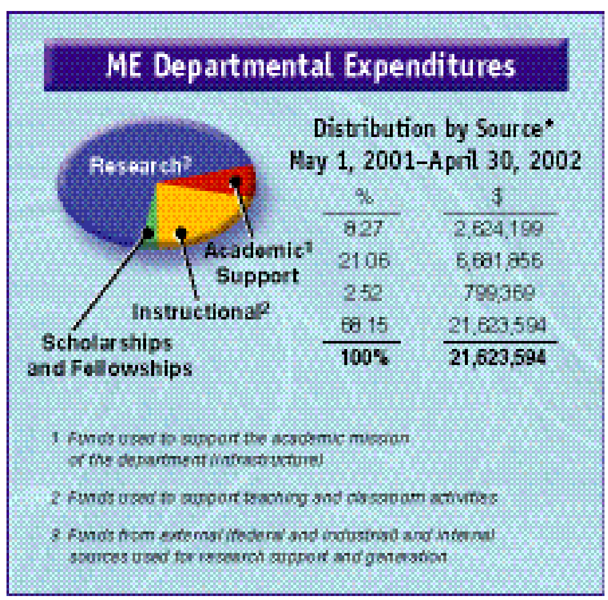
These planar laser-induced fluorescence images of a fuel spray show how the fuel gets mixed with air inside the engine. (The color scale reflects the amount of fuel with red showing high and blue low amounts). As time proceeds (shown left to right), the fuel gets more and more evenly distributed in the cylinder.

collaboration

trends & expenditures







Innovative Dual Use Science and Technology Partnerships

In an effort to address complex, system-level problems that seem to dominate the agenda of many industry leaders, ME is developing collaborative academia-industry-government research consortia and solidifying its world-class reputation in the automotive engineering and related manufacturing. These partnerships are leveraging the success of ongoing activities in centers, as well as direct partnerships with industry, in a very innovative way. In particular, ME is leading two Department of Defense's Dual Use Science and Technology (DUST) programs that intend to benefit not only the military but that also foster national competitiveness in the automotive industry. Both of them are multi-disciplinary in nature, building on ME's strength in many areas. The GM-DUST Program studies trade-offs between manufacturing processes and powertrain performance, while the Ford-DUST Program focuses on advancing technologies for future clean diesels.

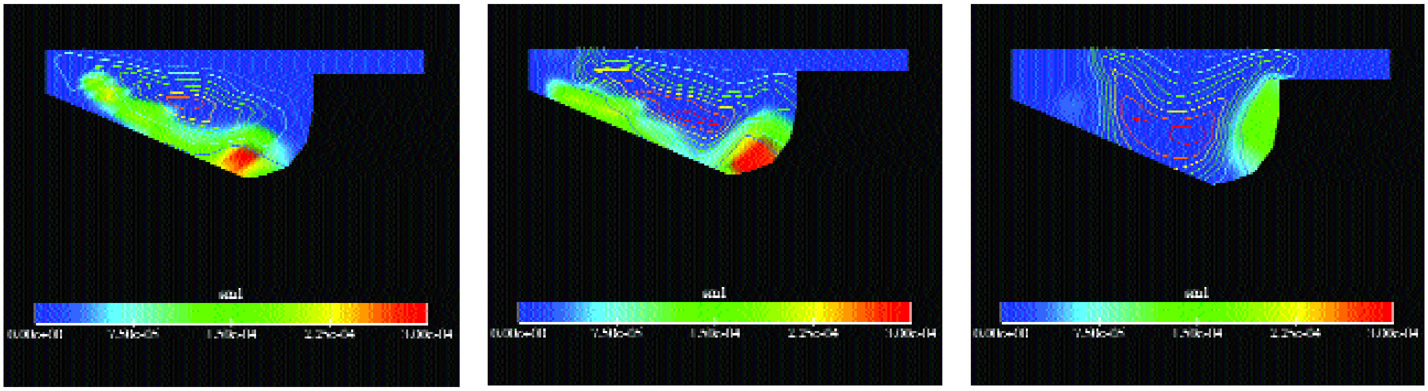
The GM-DUST Program on "Simulation Based Design and Manufacturing of Next Generation Powertrains" is a two-year, $6 million partnership among the DOD, GM, and the U-M. The objective of GM-DUST is to develop and use a scientific simulation-based framework to assess and optimize the effect of manufacturing processes on engine performance and emissions. Professor Panos Y. Papalambros, director of GM-DUST, explains that this research program is in large part an extension of the scope of the work performed by the GM Collaborative Research Laboratory (GMCRL) on vehicle systems. In its effort to pursue dual use science and technology projects, the U.S. government awarded the GM-DUST project to the U-M on the strength of its visible and successful relationship with GM. The core group of ME professors involved in the GMCRL — including Co-Director Jack Hu and ME Chair Dennis Assanis — are also involved in GM-DUST, as are ME Professors Kazuhiro Saitou, Steven Skerlos, Zoran Filipi, Nestor Michelena, Kaushik Iyer, and Jan Shi from IOE.

"The particular emphasis of the GM-DUST Program," says Papalambros, "is to explore how the manufacturing processes that are used to produce advanced engines and their components can be linked with the performance and emissions of the engine." The key component, however, is the ability to make these links based completely on mathematical models, so that they can be used in conjunction with optimization algorithms to explore associated cost trade-offs involved in decision making. One example concerns the effect that surface roughness of cylinder liners can have on both performance and emissions. "If you have very, very smooth surfaces," explains Papalambros, "you will have reduced friction, but you may actually have a detrimental effect on oil consumption and blowby. The question is, how much is the right amount?" Once the link is established, researchers will turn their attention toward strategic decision-making and cost-benefit analyses: i.e., how much should be invested in improving or replacing a manufacturing process in order to achieve a certain higher level of performance or reduced emissions?

DUST-GM Program uses a multi-disciplinary approach to assess and optimize the effect of manufacturing processes on engine performance and emissions.

The $6 million FORD-DUST Program on the "Simulation Based Design and Demonstration of Next-generation, Near-zero Emission Diesel Technology" is responding to urgent research questions related to continued expansion of the light-truck market: how to keep in check the rapid increase in total fuel consumption of light trucks, while minimizing the environmental impact of their exhaust emissions. In this case, U-M is partnering with DOD, Ford Motor Co., and International Truck and Engine Corporation to provide an ideal "vehicle" for realization of the dual-use vision: benefit the competitiveness of U.S. manufacturers, but also support development of new technologies that will allow the Army to procure and use better products in future.

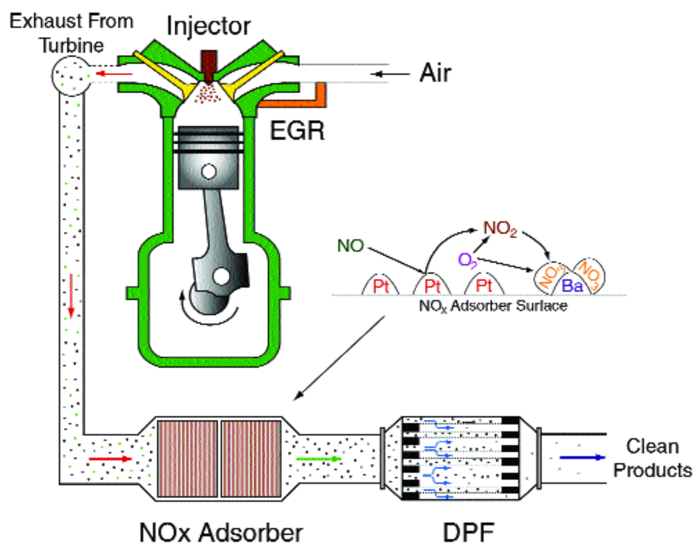
This is what Assanis, FORD DUST Program Director, says about the initial idea: "Ford is buying International engines



3-D engine soot formation model, including transport, coupled to a turbulent combustion model, can resolve the species and soot concentrations inside a combustion chamber. Picture shows a sequence of three images calculated during a combustion process in a direct injection engine, where colors indicate soot concentration, and NO concentration contours are superimposed on top. Simulation studies using 3-D CFD tools can be used to optimize injection characteristics as well as combustion chamber shape for reduced emissions.

for their medium duty trucks, and they were looking into expanding the use of diesel engines into the light-duty segment. At the same time, EPA announced new emission regulations for 2007 and 2010, intended to really clean up diesel exhaust, much like we have already done with passenger car gasoline engines. Given our past and ongoing direct collaboration with International, as well as our extensive efforts within the Automotive Research Center on modeling and simulation of diesel engines and vehicle systems, we were ideally positioned to address research issues related to development of advanced diesel technologies and their integration in the Ford vehicle."

The main objective of the FORD-DUST Program is to create a concurrent simulation-based engine design environment that will allow rational, quantitative decisions regarding component and sub-system design, optimization, and vehicle integration. "Diesel engines are known to be the most efficient users of fossil fuels for vehicle propulsion," says Assanis. "In recent years, they have evolved from being rough, noisy, and polluting engines to a high-tech propulsion system." However, making them more environmentally friendly will require a two-prong approach: first, improve fundamental processes, such as fuel injection, mixing, and combustion; and, second, integrate advanced components and subsystems, such as exhaust aftertreatment, to manage system operation and purify the exhaust. The U-M team involves a number of other faculty with diverse backgrounds — Professors Margaret Wooldridge and Hong Im, and Dr. Zoran Filipi, among others. A highly-dynamic test cell in the W. E. Lay Automotive Laboratory is being configured to allow model validation, as well as demonstration of technologies on a real engine coupled to a virtual vehicle via a software interface.



Meeting future EPA regulation for diesels requires simultaneous advances in injection, mixing and combustion strategies, as well as optimization of external sub-systems, such as the Exhaust Gas Recirculation and Aftertreatment, and their control considering in-vehicle operating conditions.

innovative partnerships

Assanis Heads New Administrative Team

In January 2002, Professor Dennis Assanis was named as the new chair of the Department of Mechanical Engineering, succeeding A. Galip Ulsoy, who is continuing his teaching and research in ME. Assanis has appointed a new administrative team committed to building upon ME's exceptional achievements under its previous leadership.

Assanis Sees Challenge and Opportunity

"This is a time of great challenge. It is also a time of great opportunity to build on the strengths of the Mechanical Engineering Department."

It is these words that reflect the philosophy of Dennis Assanis, who originally joined the ME faculty in 1994 and was named the Jon R. and Beverly S. Holt Professor of Engineering last year. He holds a BSc MarineE ('80) from University of Newcastle-upon-Tyne, U.K., and SM ME ('82), SM NAME ('82), Ph.D. Power & Prop ('85), and SM Mgmt ('86) degrees from the Massachusetts Institute of Technology.

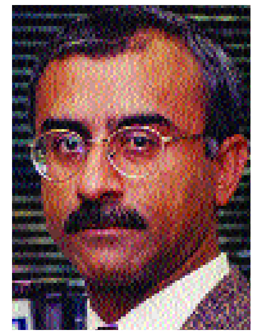
"The Department is in very good shape, in fact, I believe it's the best it's ever been, thanks to the work of everyone who came before me, and especially the previous two chairs, Professors Panos Papalambros and Galip Ulsoy. We have the strongest faculty we've ever had, the best students, and the highest national ranking in our history. Now, our challenge is to make it even better. I wholeheartedly intend to do everything possible to see our Department continue to excel in research, teaching and citizenship. In parallel, we need to plant the seeds to make it the world's best. With all due respect to our competition, I think we can do it."

As the world is rapidly changing, Assanis sees great new opportunities for ME. "I expect the level of innovative thought, creativity, and interdisciplinary thinking to rise noticeably. As educators, we'll reaffirm our mission: to teach, to inspire and to guide. As researchers, we'll investigate sciences, systems, and technologies with a new vigor. I believe mechanical engineers will be key contributors to the world that's coming."

Coming into the office at a time when the economic situation is not as strong as it might have been even a few years ago hasn't dampened Assanis' enthusiasm for the responsibilities he faces. Rather, he sees this time as one in which valuable preparation can be accomplished for the better times to come. "The current economic climate is actually one of my biggest challenges," he said. "But it's also a great opportunity. It's a good time to do our homework and planning, so when the turnaround comes, we'll be poised to take a leadership role."

One of the new chair's strategies is to raise the international profile of ME, including plans to host more international conferences to attract more of the world's best minds. There will also be increased use of the technology already in place to develop even more sophisticated distance learning capabilities. "We have a wonderful faculty here," said Assanis, "and we need to make them available to others beyond our campus."

Debasish Dutta, Associate Chair


Debasish Dutta

Professor Debasish Dutta began his two-year term as Associate Chair in January. He was founding director of the College of Engineering's Interdisciplinary Professional Programs (InterPro), former director of the interdisciplinary Program in Manufacturing within InterPro, and former director of the Design Laboratory. He also has served as a member of the ME Advisory Committee and in various service roles in the college.

Dutta, who came to the U-M after receiving his Ph.D. in 1989 from Purdue University, will be working with both the graduate and the undergraduate program directors. In that role, he will be looking at how to restructure graduate programs and develop concentrations — such as a master of science in energy systems — to prepare students for leadership roles in emerging technologies.

Dutta also will be involved with the Center for Professional Development (CPD), the unit of the College of Engineering that delivers professional degree and certificate programs by distance learning and through short courses on campus. As ME embarks on such programs for industry, Dutta will work closely with the CPD to understand those unique needs and to develop programs to meet them.

challenges

Arvind Atreya, Director of Laboratories


Arvind Atreya

Since having ample and appropriate room to conduct research is a prominent concern for ME faculty members, Assanis created the new position of Director of Laboratories, and appointed Professor Arvind Atreya as the first director, serving a two-year term.

Atreya will be responsible for coordinating the usage and allocation of the instructional and research laboratories, overseeing all laboratory safety issues, and supervising all technical staff personnel. In his new position, Atreya also becomes chair of the safety committee. Safety requirements are determined by the Occupational Safety & Health Administration, but monitored by the new director.

Atreya joined the U-M faculty as an associate professor in 1992 and was named a full professor of ME in 1996. His research interests are in the area of thermo-fluid sciences, with an emphasis on combustion, fire, energy and combustion-generated pollutants. He continues his regular teaching and research responsibilities.

Jun Ni, Graduate Program Director


Jun Ni

Professor Jin Ni, also currently a member of the ME Graduate Study Committee, was appointed to a two-year term as Graduate Program Director.
An ME faculty member since 1987, Ni is also director of the S.M. Wu Manufacturing Research Center, a position he has held since 1992. The holder of several patents, Ni has been an exhaustive researcher during his tenure at U-M. His research has included the modeling and control of manufacturing equipment and processes, micro/meso-scale manufacturing and intelligent maintenance systems.

Ni has been steadfast in establishing collaborative programs with major universities in China, including Shanghai Jiao Tong University (SJTU). The collaboration with SJTU offers the UM ME program an opportunity to enhance its worldwide visibility and promote distance learning. Ni has served as an advisory and guest professor at numerous universities in China and continues to serve as an advisory professor at his alma mater, Shanghai Jiao Tong University. Ni received his B.S. degree from Shanghai Jiao Tong University and his M.S. and Ph.D. degrees from the University of Wisconsin-Madison.

Gregory M. Hulbert, Undergraduate Program Director


Gregory M. Hulbert

Professor Gregory M. Hulbert has been appointed to a two-year term as Undergraduate Program Director.

Hulbert has been a member of the College Curriculum Committee for the past four years. With the largest number of students in the college currently working on dual or joint degrees (more than 60, which is nearly 10 percent of its student body), effective assessment of the undergraduate curriculum will be crucial to ensuring that the program maintains its challenging standards while remaining supportive of such ambitious and motivated students.

Curriculum assessment will also be critical for the program in the next few years as the department prepares for an ABET accreditation evaluation in 2005. The department undergoes an accreditation evaluation every six years, and Hulbert is currently training to become an evaluator for ABET.

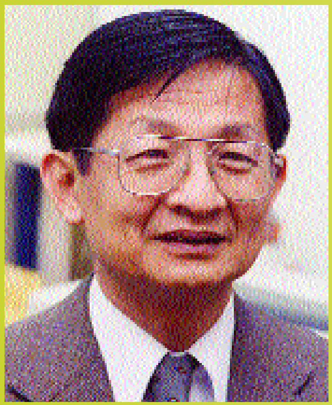
opportunities

Two Heat Transfer Legends Retire

Two professors internationally known for their contributions to heat transfer research retired in 2002 after 40-year careers at the U-M Department of Mechanical Engineering. Vedat Arpaci joined ME in 1959, and Wen-Jei Yang began teaching in the department in 1961. Since then, each has graduated more than 40 Ph.D. students, has been recognized with awards inside and outside the university, and has established himself as a legend in the field of thermal science.

Wen-Jei Yang: No slowing down — yet

Professor Wen-Jei Yang may have retired January 1, but he isn't living a life of leisure just yet. Yang, president and founder of the Pacific Center of Thermal-Fluids Engineering, continues to edit three of the center's journals. Over the summer he took part in a NATO-sponsored Advanced Study Institute in Turkey, was a visiting scholar at Kansai University in Osaka, Japan, and attended an ASME meeting in Montreal. Yang continues to direct doctoral students as well.



Wen-Jei Yang

Born in Taiwan, Yang graduated in 1954 from National Taiwan University, and came to the University of Michigan, earning his master's degree in 1956 and Ph.D. in 1960. Since then, he's written several books and has published more than 700 articles. In 1997, he added the title of professor of biomedical engineering to professor of mechanical engineering.

His greatest accomplishment since he began his career at the U-M? Fulfilling the mission of educating young minds, he says.

"I enjoyed teaching and supervising students' research," Yang says. "I also enjoy being respected internationally." Indeed, recognition of Yang's work spans the globe, from academies and societies in Italy, Germany, Japan, Taiwan, China, and the United States. He was awarded the American Society of Mechanical Engineers Heat Transfer Memorial Award, the Japan Society of Mechanical Engineers Thermal Engineering Award, and a Fullbright Lectureship Award.

Several of the 41 doctoral students Yang has worked with have gone on to great things, including one high-level NASA engineer, several important leaders in industry, and two politicians.

"Engineering students are good at solving problems," Yang says, and this applies in areas outside engineering as well.

In addition to watching his former students succeed professionally, Yang has watched society and the university atmosphere change around him. When he came to the U-M, Yang was one of only a couple foreign-born professors in ME. Now the majority of professors and a great number of students are foreign-born, reflecting a greater diversity.

In his four decades at the U-M, Yang says he's most proud of the work he did in the 1970s with heat transfer applications in biomedical engineering. Using microwave and ultrasound, he investigated how body temperature is regulated under normal conditions, as well as in a heated bath or sauna. He also did research using microwave and ultrasound to attack malignant tumors, which are more sensitive to heat than are healthy cells.

Yang was a pioneer in flow visualization and microscopic description of transport phenomena, from biological to high-technology systems. He also made original and high-impact contributions to fluid flow and heat transfer of rotating machineries. His research efforts in bio-heat and mass transfer include original visualization of transport phenomena in plants and hyperthermia, pulmonary, and cardiovascular biomechanics.

His greatest accomplishment since he began his career at the U-M? Fulfilling the mission of educating young minds, Yang says.

two legends

Vedat Arpaci: Educator, researcher, scholar

Forty-three years after first stepping into the classroom, Professor Vedat S. Arpaci, a shy man, still finds himself tongue-tied in front of a room. But after a five-minute warm-up, the longtime educator has always been able to forget his nervousness and breathe life into the subjects of heat transfer, microscales and internal combustion engines, helping students to understand underlying foundations of science. His ability to do so has cemented his reputation as that professor — the one that students never forget.


Vedat Arpaci

Arpaci retired in May, after teaching an estimated 5,000 students and mentoring 45 Ph.D. students, about half of whom have gone on to positions at universities around the world. Most point to their mentor as the reason, and most keep in touch with Arpaci to this day. Among them: Chuck Vest, president of Massachusetts Institute of Technology, as well as several department heads and top professors at other schools.

Arpaci says the difference — what made him memorable to his students — was that "I gave my heart to it. Rather than just trying to give them a formula and plug some numbers into it, I went to the foundation, and slowly developed an idea." Students appreciated that approach; Arpaci received the Michigan Student Assembly teaching award three times, meaningful to him because it was awarded solely on student evaluations.

It was his own first higher education experience that molded Arpaci's teaching method. "The first day, I knew I was going to be a teacher," Arpaci says of his first class at Istanbul Technical University in Turkey. "I was listening to the professor teaching, and I said, 'That's not the way to do it.' "

Later, when he started teaching at the U-M, Arpaci would arrive about 7 a.m., about an hour before his first class. He would walk around campus, looking for real-world examples he could bring into the classroom — ways to make things understandable to his students. He wrote four textbooks himself, including one recently published, *Introduction to Heat Transfer.* He was responsible for instituting six graduate-level courses that grew out of and led into new areas of research.

"The first day, I knew I was going to be a teacher...I gave my heart to it. "

— Vedat Arpaci

In addition to his reputation as a top-notch educator, Arpaci was a renowned researcher during his four decades at the U-M. In 2000, he was awarded the prestigious Max Jakob Memorial Award, in recognition of distinguished service in the area of heat transfer, bestowed jointly by the American Society of Mechanical Engineers and the American Institute Chemical Engineers. In 1996, Arpaci was named a fellow of the ASME.

Arpaci, who received his master's degree in 1952 from Istanbul Technical University and his Ph.D. in 1958 from Massachusetts Institute of Technology, made important discoveries during his four decades at the U-M, including:

- The optical dependence of radiating gas instability,
- Two radiating gas constitutions,
- The photon-vibration interaction in radiating plasma kinetics,
- The splitting of heat flux in terms of entropy flux which led to new concepts such as thermal displacement and deformation,
- The microscales of complex turbulent flows,
- The discovery of the microscale foundations of what are usually assumed to be empirical heat and mass transfer correlations, and
- The discovery of a dimensionless number for natural convection involving a combination of both Rayleigh and Prandtl numbers.

"Dr. Stefanopoulou is an exceptionally talented and creative researcher with an enthusiasm for engineering that she imparts to her students and colleagues." — Jeffrey Cook

Stefanopoulou Named Top Innovator and Educator

innovation

Associate ME Professor Anna Stefanopoulou gained national attention this year by winning a prestigious Society of Automotive Engineers (SAE) award and by being named one of the Top 100 Young Innovators by *Technology Review.*

Stefanopoulou, a member of the ME faculty since 2000, received the top innovators award in May in Cambridge, Massachusetts, along with 99 other individuals under age 35 whose contributions have had a profound effect on today's world. Stefanopoulou's current research interests are centered in the automotive control area. She is focusing on the control of breathing through valves, vanes, and membranes, control of advanced internal combustion engines, fuel cell power systems, fuel processing, and hydrogen reforming.

Stefanopoulou's work has earned her respect in industry as well as academic circles. Jeffrey Cook, a staff technical specialist at the Ford Research Laboratory in Dearborn, Michigan, has worked with Stefanopoulou since 1992, when she was a U-M graduate student and a Ford intern. "Anna Stefanopoulou is a leader in the field of control systems for automotive powertrains," Cook says. "She has made particular contributions in the control of variable cam timing engines and electro-mechanical 'camless' valvetrains." Her graduate students work as Ford researchers and interns, contributing with her to the development of advanced powertrain controls and systems.

"Dr. Stefanopoulou is an exceptionally talented and creative researcher with an enthusiasm for engineering that she imparts to her students and colleagues," Cook says.

Stefanopoulou, who has received four Ford Innovation awards based on patents and publications originating from her work, says of the Technology Review recognition: "I saw it as validation for the work I've done." Her objective is to build an internationally recognized research group in the automotive control area, hoping to "make the U-M the obvious source of knowledge and training in the interdisciplinary area of advanced powertrain control."

"Anna is working on the fundamental science aspects of important engineering problems," says U-M Electrical Engineering and Computer Science Professor Jessy Grizzle, who along with Cook nominated Stefanopoulou for the Top Innovators award. Grizzle points to Stefanopoulou's work in the area of fuel cells, where he says she is "leading the way" in finding the clues to better performance for this important alternative energy source.

Anna Stefanopoulou

Another of Stefanopoulou's professional goals, in fact, is to develop better capabilities in low-temperature fuel cell power systems. In a Fuel Cell Control Laboratory scheduled to open this fall, she will conduct design, testing, and integration of fuel cell research. Her goal, she says, is to "actually have a better design based on microprocessor control, adaptation, and monitoring integrated in the area of energy-efficient devices."

Stefanopoulou also has gained attention as an educator. She was one of nine engineering educators to receive the 2002 SAE Ralph R. Teetor Educational Award. The award, named for the former SAE president, is based on contributions to teaching, research, and professional activities, and is awarded by a board of judges from both academia and industry.

Stefanopoulou, a native of Greece, graduated from the National Technical University of Athens in 1991 with a diploma degree in naval architecture and marine engineering. She received two master's degrees from U-M, in naval architecture and marine engineering in 1992, and in electrical engineering and computer science in 1994. In 1996, she earned her Ph.D. from the U-M in electrical engineering and computer science. She began work in the automotive control area in 1996 as an assistant professor at the University of California, Santa Barbara, before transferring her work back to the University of Michigan in 2000.

Laura Elgas a Fine Recruit

Laura Elgas graduated from the University of Michigan's College of Literature, Science & the Arts in 1999 with a bachelor degree in psychology, and she didn't have to travel very far or wait very long to put her education to good use in her first job in student services U-M College of Literatures, Sciences & the Arts. In September 2001, she moved to North Campus, where her highly energetic and friendly approach to her new job as an ME graduate recruiter has had a major impact on the department.

"Laura has helped to completely revise the way applications…are being processed," says former Graduate Chair Volker Sick. "Her engaged organization and activity in all of our recruiting events certainly contributed to the success of this year's recruiting period."

Elgas says that perhaps the biggest change in going from counseling undergraduates to recruiting graduate students is that graduates have a "different mind set," particularly graduate engineering students, whom she characterizes as "organized, smart, and focused. Graduate students are so directed. They're here because they want to be here."

But the main aspect of her work that has not changed a bit is the pride she takes in making a connection with all students — trying to determine specific needs, and helping students become comfortable and acclimated to their environment when they first arrive on campus.

"I really like getting to know them; they're such a nice group of students," Elgas says. And with a diverse international representation, she has enjoyed getting to know more about the geography and cultures of many other countries as well. "So many make an extra effort to try to teach me about their countries; they seem to enjoy that, and so do I."

Elgas says that she has a special interest in the recruitment of women and other minorities who have been traditionally under-represented at engineering schools.

Bogdan Epureanu Joins Faculty

Bogdan Epureanu joined the ME faculty in January 2002 as an assistant professor teaching Dynamics and Vibrations (ME 240). In Fall 2002, he will teach Nonlinear Oscillations and Stability of Mechanical Systems (ME 648).

Bogdan Epureanu

Epureanu received his Ph.D. in Mechanical Engineering from Duke University, North Carolina, in 1999 and shortly after, he took up a teaching position and moved to Canada. He previously taught at McGill University in Montreal, where his research interests focused mainly on nonlinear dynamics and nonlinear mechanical phenomena, including fluid-structure interaction (aeroelasticity, unsteady aero-dynamics), manufacturing and robotics.

Epureanu works in the field of nonlinear and chaotic dynamics and is especially interested in reduced order modeling and control schemes for nonlinear systems, such as aeroelastic, manufacturing, robotics and other complex systems. In particular, he develops chaos suppression methodologies and system identification techniques for fluid-structural systems which exhibit spatio-temporal chaos.

Together with Professor Earl H. Dowell (Duke) and Professor Felipe Montoya (Valladolid, Spain), Epureanu received the A. M. Strickland Prize awarded by the Division of Manufacturing Industries of the Institution of Mechanical Engineers for the best paper published in the Proceedings of IMechE as a significant contribution to the field of manufacturing (London, May 1998). He is also the winner of the 1998 Eaton Mechanism Design Contest, recipient of the 2001 Petro-Canada Young Innovator Award and the 2001 Best Paper Finalist Award presented by the Society of Manufacturing Engineers.

Over the past years, Epureanu taught several courses, including Dynamics, Linear Feedback Control Systems, Mechanical Vibrations (lab), Computer Methods in Engineering (lab), and Robot Calibration.

faculty

Faculty Promotions

The following faculty were promoted during the 2001-2002 reporting year:

Shixin Jack Hu (ME), Associate Professor with tenure to Professor with tenure
Gregory M. Hulbert (ME), Associate Professor with tenure to Professor with tenure
Volker Sick (ME), Associate Professor without tenure to Associate Professor with tenure
Margaret S. Wooldridge (ME), Assistant Professor to Associate Professor with tenure

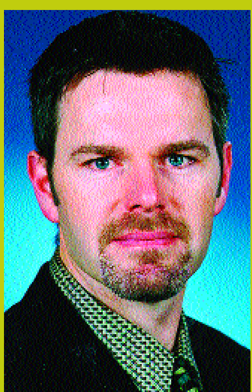
nsf

Gillespie, Im
Continue NSF Awards Tradition

Assistant Professors Brent Gillespie and Hong Im are the latest among the ME faculty to be recognized by the National Science Foundation (NSF) for superior research.

PECASE awarded to Brent Gillespie

For Assistant Professor Brent Gillespie, the Presidential Early Career Award for Scientists and Engineers (PECASE) he received from the NSF recognizes his two greatest passions: music and mechanical engineering.



Brent Gillespie

A former concerto soloist with the UC Davis Symphony Orchestra, Gillespie eventually steered toward another of his interests—engineering. Fortunately, the focus of his research has allowed him to stay in touch with music. His application for the NSF PECASE combined his work on mechanized haptic exploration and automated modeling with the thesis work he conducted at Stanford University on virtual piano action.

"It was kind of a funky, artsy application," Gillespie admits. The thrust of Gillespie's research on virtual piano action is centered on making a synthesizing keyboard feel more like a real piano.

"You can make a synthesizer sound like a piano, but it needs to feel like a piano," Gillespie says. In his work at Stanford, where he first worked on the virtual piano concept, Gillespie proposed designing a keyboard action simulator (software) and a haptic display device (hardware) that emulates the feel of various keyboard instruments such as a grand piano, harpsichord, or forte piano. Gillespie says the concept would also have application as a practice keyboard for a carillon as well as other historical instruments.

The iTouch motor is a low-budget, single axis, voice-coil based haptic device intended for use in a laboratory setting to teach system dynamics fundamentals to undergraduate students in mechanical engineering. Students build this motor from scratch, including hand-winding the coils, then use electronic feedback control to realize virtual springs and dampers which can be recognized haptically (by feel).

A haptic display device is a motorized key which under computer control makes it possible to interact with virtual objects through touch. Noting the integral relationship between an instrument's acoustic response and its touch response, Gillespie says a synthesizer with the ability to emulate an instrument's touch as well as its sound would provide musicians with a much greater degree of expressive control. Gillespie, who received both his M.S. and Ph.D. degrees in mechanical engineering from Stanford University, came to U-M as an assistant professor in 1999. He took his B.S. degree in mechanical engineering from the University of California at Davis and earned a master's degree in music from the San Francisco Conservatory of Music.

Each year NSF selects nominees for this prestigious award from among the most meritorious new NSF CAREER awardees. The PECASE program recognizes outstanding scientists and engineers who show exceptional potential for leadership at the frontiers of knowledge early in their careers. The Presidential Award is the highest honor bestowed by the U.S. government on scientists and engineers beginning independent careers.

Gillespie traveled to Washington, D.C., July 11-12, for an NSF award celebration and a second ceremony at the White House recognizing the PECASE awardees.

Hong Im Receives NSF CAREER Award

While the possibilities for combustion as a future alternative energy source in micro-engines are endless, the challenge for Assistant Professor Hong G. Im is to develop a combuster that works effectively in devices that are as small as a fraction of a millimeter.

Im's research in the area of micro-combustors — which could have application in items ranging from batteries for portable electronics to small-scale aerospace propulsion systems — is of such import that he was recently recognized by the NSF with its prestigious CAREER Award. Im was selected in 2001 to receive the five-year, $375,000 award for his proposal "Steady and Transient Dynamics of Catalyst-Assisted Combustion in Micro-Scale Power Generators."

"Combustion can be much more efficient as a power source than batteries," explains Im, and to illustrate his point, he notes that even at a conversion efficiency of just 10 percent, hydrocarbon combustion can provide higher energy density than a battery. Operation costs are also less expensive in fuel than in batteries, and the combustor is not prone to technical difficulties involving the memory effect, or long recharging times.

awards

Im also sees tremendous promise for micro-combustors as an important component in the fuel processor for fuel cells. But the biggest challenge in any of these areas is also the smallest: integrating combustion into the tiniest devices.

Hong Im

"As you shrink down the scale," says Im, "the effect of the surface material on combustion becomes more and more dominant." It is anticipated that an appropriate choice of catalytic materials will allow stable combustion and power generation in the small dimension which would otherwise be impossible to achieve.

With the NSF CAREER Award, Im says he will continue to explore alternative designs in the development of micro-combustors with the hope of moving the technology from the concept to the application stage.

NSF Awardees, Past and Present

PECASE AWARD WINNERS

Ann Marie Sastry	1997
Brent Gillespie	2002

NSF CAREER AWARDEES

Ellen Arruda	1997
William Endres	1998
R. Brent Gillespie	2001
Karl Grosh	1999
Jack Hu	1996
Hong Im	2002
Katsuo Kurabayashi	2001
Jonathan Luntz	2001
Huei Peng	1998
Kazuhiro Saitou	2000
Steven J. Skerlos	2001
Anna Stefanopoulou	1998
Michael Thouless	1995
Dawn M. Tilbury	1999
Margaret Woodridge	1998

Marcy Brighton Honored with CoE Excellence in Staff Service Award

In May 2002, Marcy Brighton was among six College of Engineering employees — and the only ME representative — to receive the CoE Staff Excellence Award. 2002 was the tenth anniversary of this Award Program, which was established as part of a comprehensive initiative to recognize the vital contributions made by staff members to the College's success and national prominence. Recipients are nominated and ultimately chosen by a selection committee (comprised of previous award winners and at least one non-College member) on the basis of their exemplary work and special achievements. Department Chair Dennis Assanis nominated Brighton, and Dean Stephen W. Director presented the award to her:

"Marcy has done an outstanding job in managing administrative tasks for the Mechanical Engineering department, one of our largest departments," Director said. "In addition to sound fiscal management of the department, Marcy has been instrumental in creating a productive and pleasant work environment for her staff… She is very committed to staff professional development and encourages her team to learn new skills and expand their professional interests."

Nominations must be supported by at least four but by no more than nine other anonymous co-workers, and among her nine supporters, one faculty member wrote, "[Marcy] has hired excellent people and…fostered an environment in which [they] enjoy their jobs."

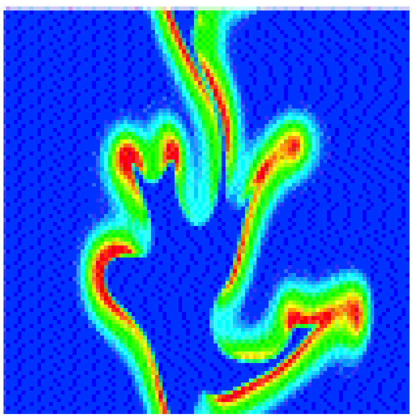
Another simply said, "Marcy Brighton has been a 'godsend' to the ME department." And one of her colleagues echoed those sentiments: "Marcy is the best thing that has happened to our department. I am proud to be a member of her team."

Brighton's team introduced collocated staff service offices, where staff and faculty are physically closer together to enhance both camaraderie and communications, and to foster enhanced cross-training opportunities. ME has also vastly improved its financial structures under Brighton's stewardship, with more accurate and timely reporting leading to improvements in the department's planning and budgeting processes.

Brighton says, "It was overwhelming to hear some of the things being said about our accomplishments, and to think — did we really get all of those things done in less than two years? And you know what? We did!"

Im and Colleagues Receive New Department of Energy Award

Assistant Professor Hong G. Im and two colleagues received one of the first awards under the new Scientific Discovery through Advanced Computing (SciDAC) program sponsored by the Department of Energy (DOE). The project, "Terascale High-Fidelity Simulations of Turbulent Combustion with Detailed Chemistry," received funding for three years, totaling $1.124 million.



Pictured is an instantaneous snapshot of heat release rate iso-contour during the interaction of turbulent hydrogen-air premixed flame, using the high-fidelity direct simulation tools developed under the SciDAC program. The flame wrinkles are generated by the turbulence action, resulting in non-uniform heat release rate distribution along the flame.

Joining Im as principal investigators in the project are Professor Arnaud Trouve, University of Maryland, and Professor Christopher J. Rutland, University of Wisconsin.

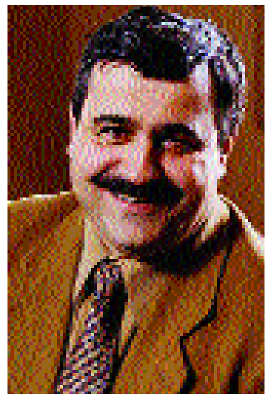
One of the goals of the project is "to use terascale technology to overcome many of the current direct numerical simulation limitations. Because of its high demand for computational power, current (gigascale) state-of-the-art DNS remains limited to small computational domains (i.e., small Reynolds numbers) and to simplified problems corresponding to adiabatic, non-sooting, gaseous flames in simple geometries."

As Im observed, "The parallel computing technology has now reached a teraflops speed computation power, which can calculate trillions of mathematical operations in a second by running thousands of processors simultaneously. Since a realistic simulation of turbulent reacting flows demands extremely large computer resources, these high-speed computers can be applied to achieve the goal."

kudos

Christophe Pierre Named to Timoshenko Chair

Professor Christophe Pierre conducts his research with an added incentive since he was named the Stephen P. Timoshenko Collegiate Professor of Mechanical Engineering. "The name of Timoshenko is so powerful in the research community," Pierre says. That creates a challenge, he says, to have his own research be on par with the reputation of the man many consider to have been the father of engineering mechanics.



Christophe Pierre

Pierre, whose research focuses on vibrations and dynamic behavior of complex structures, says of the Timoshenko chair, which he will hold through February 28, 2007: "It's a great honor for me and for my research group. It really brings distinguished recognition…I feel very fortunate, and also somewhat humbled. It gives me something to live up to."

Timoshenko made some of his biggest breakthroughs and published several of his most famous books while he was a professor of engineering mechanics at the U-M from 1927 to 1936. "Before Timoshenko, the subject of mechanical engineering was somewhat empirical," says Pierre. "He made the whole field rigorous by building a mathematical foundation. Because of him the teaching of mechanics was changed forever."

During his tenure as the Timoshenko chair, Pierre said his research, which takes place primarily in the Structural Dynamics Laboratory, will be focused in the area of the dynamic behavior of complex structures. Pierre and his team will be looking at the vibratory response of large-scale systems, such as aerospace and automotive structures, across a broad frequency range. With the help of mathematical techniques, vibratory responses can be modeled, predicted, and understood, so that these structures can be designed for reduced vibration response.

Pierre also is associate director of the Automotive Research Center, and he is beginning a second three-year term as associate dean for academic programs and initiatives at the Rackham School of Graduate Studies. Pierre came to the University of Michigan in 1985 after earning an engineering degree from Ecole Centrale de Paris in France in 1982, a master's degree from Princeton University in 1984, and a Ph.D. from Duke University in 1985. He has been recognized with Excellence in Research and Excellence in Service awards from the U-M College of Engineering, and has been an American Society of Mechanical Engineers Fellow since 1996.

awards & honors

Faculty & Research Staff

Vedat Arpaci
- Winner of 2000 Max Jacob Award, which is bestowed in recognition of eminent achievement in the area of heat transfer by the American Society of Mechanical Engineers' Heat Transfer Division in conjunction with the AIChE.

Dennis Assanis
- Fellow, Society of Automotive Engineers, 2001.

Arvind Atreya
- Fellow, American Society of Mechanical Engineers, 2002.
- Service Award, Department of Energy.

Diann Brei
- ME Award for Outstanding Accomplisment, 2002.
- Ruth & Joel Spira Outstanding Teaching Award.

David Dowling
- Best Paper Award in Underwater Acoustics, 141st Meeting of the Acoustical Society of America, Chicago, IL, 2001.

Debasish Dutta
- 2001 ComputerWorld Honors for Global Product Realization course.

Bogdan Epureanu
- Petro-Canada Young Innovator Award, Montreal, 2001-2002.

Zoran Filipi
- Society of Automotive Engineers Outstanding Speaker Award.

R. Brent Gillespie
- 2002 National Science Foundation Presidential Early Career Award for Scientists and Engineers.

Jack Hu
- American Society of Mechanical Engineers Best Paper Award.

Hong G. Im
- National Science Foundation CAREER Award, 2002.
- 2001 Scientific Discovery through Advanced Computing award, Department of Energy.

Elijah Kannatey-Asibu, Jr.
- Fellow, Society of Manufacturing Engineers.

Bruce H. Karnopp
- Pi Tau Sigma Teacher of the Term, 2001.

Massoud Kaviany
- Heat Transfer Memorial Award.

Sridhar Kota
- American Institute of Aeronautics and Astronautics Best Paper Award.

Jyoti Mazumder
- Inventor Recognition.

Jun Ni
- Distinguished Visiting Chair Professor, Hong Kong Polytechnic University, 2001-2002.
- Best Paper Award, 2001 North American Manufacturing Research Conference, NAMRI/SME.
- 2001-02 Research Excellence Award, U-M College of Engineering.

Zbigniew Pasek
- 2001-2002 Outstanding Research Scientist Award, U-M College of Engineering.

Noel C. Perkins
- Named Arthur F. Thurnau Professor, July 2001.
- GM Technical Education Program Outstanding Distance Learning Instructor.

Christophe Pierre
- Named Stephen P. Timoshenko Collegiate Professor of Mechanical Engineering.

Anna G. Stefanopoulou
- Named as one of World's Top 100 Young Innovators in technology and business by *Technology Review* magazine, 2002.
- 2002 SAE Teetor Educational Award.
- Ford Innovation Awards (based on patents issued and publications), 1998, 1999, 2000, 2001.

Dawn Tilbury
- ME Award for Outstanding Accomplishment, 2002.
- Donald Eckman Award for outstanding accomplishments by a young engineer in the field of automatic control, American Automatic Control Council, 2001.
- Best Paper Award, 2002 Network, Operations, and Management Symposium (NOMS) International Conference.

Alan Stuart Wineman
- American Society of Engineering Education A. Higdon Award, for outstanding accomplishments as a mechanics educator throughout his distinguished career, 2002.

The 2002 MRacing team poses with their award-winning formula car. The teams start from scratch building their vehicle each year, but they actually begin with the previous year's design and improve upon it.

MRacing Finishes 4th at FormulaSAE Competition

The U-M student racecar team, MRacing, finished in fourth place out of 140 competing teams at the annual international FormulaSAE collegiate design competition held May 15-19 at the Pontiac Silverdome.

The FormulaSAE (Society of Automotive Engineers) competition, regarded as the premier and largest engineering student competition in the world, pits student teams against each other to conceive, design, manufacture, test, and race with small formula-style cars.

Michigan's leadership included the following ME students: May graduates Ben Brady (Team Leader), Keith De Maggio, Clint Vigus, and Greg Pearce; December graduates Jason Kline and Jeff Mosher, who are enrolled for graduate studies; Ph.D. candidate Bruno Vanzieleghem, and senior Bob Riley. The team advisor is Department Chair Dennis Assanis, director of the Automotive Research Center and Walter E. Lay Automotive Laboratory.

Besides its overall fourth-place finish, the Michigan team also won $600 for the Spirit of Excellence Award; $250 for placing third in the Mechanical Dynamics Functional Digital Formula Car Award, which rewards the best use of computer software for design; and a set of Goodyear tires for the Best Performance Award in the endurance competition. The endurance is the toughest of the events, with only 30 percent of participants actually finishing the race.

Undergraduate Student Scholarships and Awards

Fall 2001 and Winter 2002

3M Scholarship
Kirsten Thomson

A. D. Moore Award
Kiran D'Souza

ASME Foundation Scholarship
Kiran D'Souza

BP Award - Foundation Scholarship
Crystal Kornak
Kirsten Thomson

Caddell Memorial Award for 2001-2002
Jessica Connor
Brock Partee
Brian Walby

Cooley Writing Prize
Jeffrey Sitko

Distinguished Achievement Award for 2002
Brian Walby

Distinguished Leadership Award
Benjamin Brady
Janet Pien

Dow Chemical Scholarship for 2001-2002
Brent Fiedler
Vernon Newhouse
Kevin Toller

Frank William and Dorothy Given Miller Scholarship from the ASME
Crystal Kornak

Graebel
Charles Vogel

Harry B. Benford Award
Robert Eaton

Hugh G. Rumler Prize
Elena Marin

J. A. Bursley Prize
Colleen Doyle

Lubrizol
Kiran D'Souza

R & B Tool Scholar
Jessica Connor
Charles Vogel

Roger M. Jones Fellowship
John Decker Ringo

Graduate Student Fellowships and Awards

Fall 2001 and Winter 2002

Departmental

Graduate Student Symposium Awards:

- **Design & Manufacturing —**
  1st place oral presentation: Brian Trease
  2nd place oral presentation: Panayiotis Georgiopoulous
  1st place poster presentation: Felicia Brittman

- **Dynamics, Systems, and Controls —**
  1st place oral presentation: Robert White
  2nd place oral presentation: Caroline Gatti
  3rd place oral presentation: Hakan Yilmaz
  1st place poster presentation: Polat Sendur

- **Fluid Mechanics, Heat Transfer, and Combustion —**
  1st place oral presentation: Ronald Grover
  2nd place oral presentation: Bruno Vanzieleghem
  1st place poster presentation: Bin Wu

- **Solid Mechanics and Materials —**
  1st place oral presentation: Mahmoud Hussein
  2nd place oral presentation: Kristen Mills
  1st place poster presentation: Bradley Layton

Departmental Fellowship:
Shiyao Bian
Janet Blumenfeld
Parag Dixit
Tulga Ersal
Christophe Gibaud
Basilios Hamosfakidis
Karim Hamza
Xin He
Ilkin Hossoy
Dejun Jing
Sang-Wook Lee
Yong Lei
Zhijun Li
Jia Li
Jiayin Li
Keivan Mohammadia
Fabrice Ponti
Andrew Stansel
Ardalan Vahidi
Wei Xi
Victor Yu
Jianpeng Yue
Rui Zhang

Robert Caddell Memorial Award:
Fu Zhao

William Mirsky Memorial Award:
Neha Gandhi
Katherine Peterson

Rackham Graduate School

Predoctoral Fellowship:
Caroline Gatti

Recruitment Fellowship:
Aaron Hula
Alan Tkaczyk

Engineering Award Fellowship:
Ibrahim Badiru
Kimberly Cook
Cavin Daniel
Elizabeth Ivy
Angela LaFleur

Sneha Madhavan-Reese
Brian McMillion
Melody Papke
Brett Thompson

Outstanding Graduate Student Instructor Award:
Paul Alexander
Michael Sasena

Committee on Institutional Cooperation/General Electric Predoctoral Fellowship:
Elizabeth Ivy

College of Engineering

Distinguished Achievement Award:
Mahmoud Hussein

Distinguished Leadership Award:
Ronald Grover

McIvor, Ivor Memorial Award:
Wei-Yi Chien

Dean's Fellowship:
Deniz Akcabay
Selahattin Baslamisli
Carrie Boles
Joseph Dougherty
Jonathan Hagena

Regents' Fellowship:
Jesse Kirchner
Laura Schilling
Peggy Meinhart
Constance Pagedas

Corlett Fellowship:
Matthew Leustek

Other

U-M Outstanding Student Leadership Award:
Tershia Pinder

SAE Doctoral Scholars Program Fellowship:
Michael Sasena

Michigan Teaching Fellow Award:
Michael Sasena

The National Consortium for Graduate Degrees for Minorities in Engineering and Science Fellowship:
Ibrahim Badiru
Cavin Daniel
Nia Harrison
Elizabeth Ivy

National Science Foundation Fellowship:
Peggy Meinhart
Constance Pagedas
Alan Tkaczyk

National Defense Science and Engineering Graduate Fellowship:
Tiffany Miller

Eastman Kodak Fellowship:
Nia Harrison

Ford Motor Company Graduate Fellowship:
Laura Schilling

awards

Doctoral Degrees Conferred

August 2001

Cem Mehmet Baydar
Off-Line Error Prediction and Recovery Logic Synthesis Using Virtual Assembly Systems.
Chair: K. Saitou

Jeffery Edward Bischoff
Constitutive Modeling and Testing of Soft Tissue.
Co-Chairs: E. Arruda, K. Grosh

Bryan Joseph Cannon
Piezoceramic Hollow Fiber Active Composites.
Chair: D. Brei

Supavut Chantranuwathana
Adaptive Robust Force Control for Vehicle Active Suspensions.
Chair: H. Peng

Han-Wen Chen
Application of Binary Interaction Theory to Linear and Nonlinear Rheology of Star- Branched Polymers.
Chair: R. Larson, W.J. Yang

Ian M. Darnell
An Efficient Three Dimensional Tire Model for Predicting Spindle Loads.
Chair: G. Hulbert

George J. Delagrammatikas
A Design Optimization Methodology for Advanced and Hybrid, Diesel-Based, Automotive Powertrains.
Co-Chairs: D. Assanis, P. Papalambros

Yu Ding
Modeling and Analysis of Stream-of-Variation in Multistage Manufacturing Processes.
Co-Chairs: D. Ceglarek, J. Shi

David Mark Douglass
Spectroscopic Investigation of the Vapor Plume During Laser Processing of AISI 52100 Steel Using a High Brightness Diode-Pumped Nd:YAG Laser
Chair: J. Mazumder

Sang Jin Hong
3-D CFD Modeling of In-Cylinder Ignition, Combustion and Pollutant Formation Processes with Detailed Chemistry and Mixing Effects.
Co-Chairs: D. Assanis, M. Wooldridge

Daphne Joachim
Selective Deposition of Polycrystalline Silicon for Tuning Micro-Electro- Mechanical Resonators: Experiment and Simulation.
Co-Chairs: L. Lin, R. Scott

Jin-Yong Joo
Nonlinear Synthesis of Compliant Mechanisms: Topology and Size and Shape Design.
Chair: S. Kota

Jinhyuk Jung
Optimal Drill Point Design and Grinding for High Throughput and Deep Hole Making.
Chair: J. Ni

Hyungson Ki
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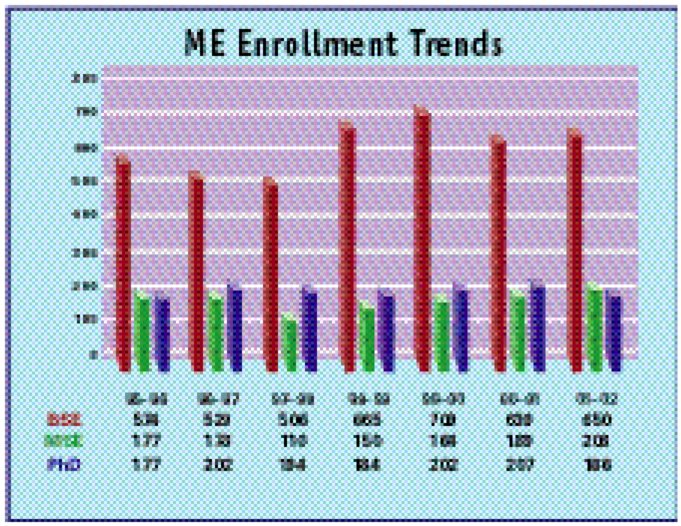
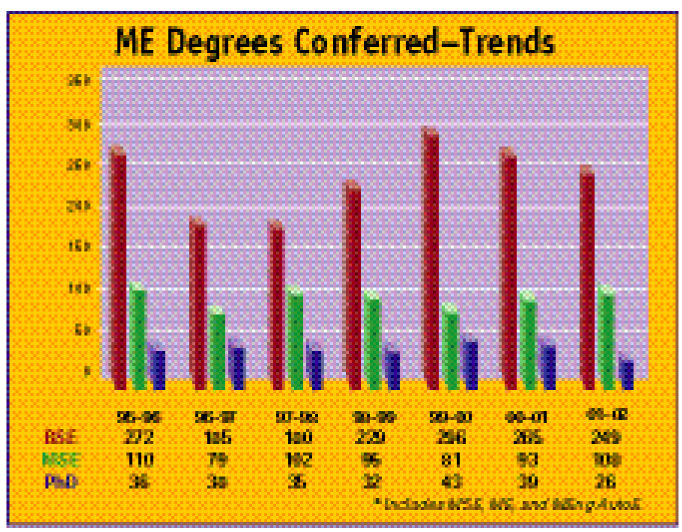
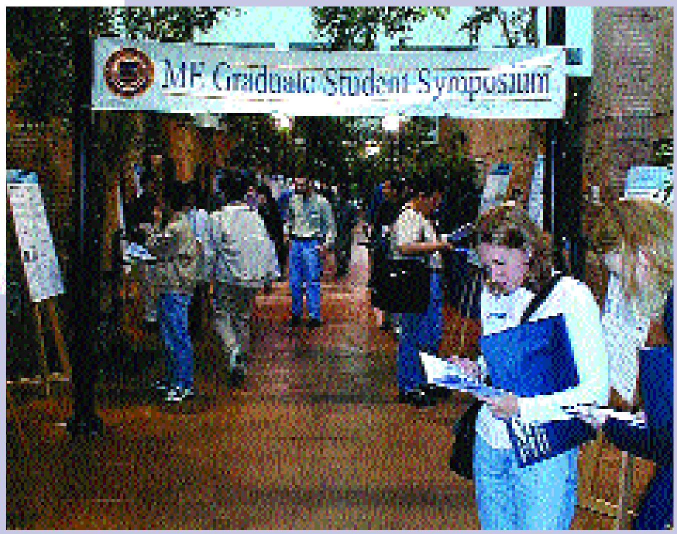
trends





graduate student symposium

The second annual ME Graduate Student Symposium was held in October 2001. The symposium gives current graduate students an opportunity to present their research in a relaxed environment, and it offers new graduate students and those looking to do research with a chance to learn about what is going on in the department.



Mechanical Engineering Student Leader Board

meslb

The Mechanical Engineering Student Leader Board was established to enhance the overall educational experience of Mechanical Engineering students by improving communication and fostering a greater sense of community and cooperation among various student groups. Pictured, left to right are (back row) Kirsten Thomson, Kiran D'Souza, Mark Christian, Rahul Sathe; (front row) Tiffany Miller, Kristina Schmitt, and Michele Goe. Not pictured are board members Mike Kelly and Vinay D'Souza.

Marshall Jones Receives 2001 Coolidge Award

Marshall G. Jones

In what can readily be described as a stellar career, Dr. Marshall G. Jones, who earned his B.S. in Mechanical Engineering from the U-M and is a member of the ME External Advisory Board, has earned another feather in his cap with the 2001 Coolidge Award, General Electric's Global Research Center's highest honor.

The award is named after William Coolidge, a pioneer in ductile tungsten and one of GE's greatest contributors. Honorees are granted a six-month leave to pursue individual projects and research interests of their choosing either within the company, at a university or research institution, or anywhere else worldwide, at company expense.

Jones, one of the foremost authorities in the field of fiber-optic laser beam technology, said he will pursue research in that subject area but has not yet decided where he will go.

"I'm leaning toward spending half of my time at one of the institutions in Europe and the other half somewhere in the U.S. I may even come back to my alma mater for part of it," he says.

Jones' numerous contributions in the field include invention, development, and demonstration of a technique for injecting high-power laser energy into single-core fiber optic cables. This technique has been put to practical use for welding lead wires in automobile headlamps and joining electrodes in metal halide lamps, among other applications.

Dr. Jones has also conducted pioneering research in laser material processing — using lasers to heat-treat and otherwise enhance the properties of materials — and he initiated an ongoing program to adapt GE's high-brightness military laser technology for industrial applications. His recent work includes the invention of a laser fiber optic-based cladding process designed for repairing nuclear reactor structures in their hostile underwater environments and, most recently, he developed a novel laser hot wire method that is being used for joining difficult-to-weld super alloys in advanced GE gas turbines.

Jones has received 43 patents for his work and authored or co-authored some 35 technical publications.

"The reason I've been at the Global Research Center so long," Jones says of his 28-year tenure with GE, "is that GE is one of the most diversified companies in the world. I've worked in aircraft, lighting, medical, fiberoptic, even network TV. I've been fortunate to have worked for almost all of GE's businesses."

In addition to his professional contributions, Jones is active in education and community affairs. He mentors kindergarten through 12th grade students through GE's Corporate Mentoring Program at Capital Regional Schools, and has been an adjunct professor at Schenectady County Community College for 25 years.

Jones says his community service work stems from his desire to "give back," and to try to inspire young children. As a result of presentations he's made at elementary schools, Jones was encouraged to write a book about his life. Two years ago he self-published, *Never Give Up: The Marshall Jones Story,* designed for young readers.

"When I was growing up, I really didn't have a role model to inspire me," he says. "My passion for the field of engineering is what inspired me."

"My passion for the field of engineering is what inspired me."

Jones is a native of Aquebogue, N.Y., and is an alumnus of Mohawk Valley Community College. He earned his master's degree and Ph.D. in mechanical engineering from the University of Massachusetts.

For his achievements, Jones has been recognized in many quarters. Honors include election to the National Academy of Engineering, induction into the Mohawk Valley Community College Hall of Fame, the Pioneer of the Year Golden Torch Award of the National Society of Black Engineers, the Dr. Rene Wasserman Memorial Award of the American Welding Society, and GE Global Research Center's Willis R. Whitney Technical Achievement Awards in 1988, 1994, and 1997. The University of Massachusetts presented him with its Chancellor's Medal, Distinguished Achievement Award for Professional and Community Service, and Alumnus of the Year Award by the College of Engineering in 1987, 1995, and 2001.

alumni

External Advisory Board

The ME External Advisory Board consists of distinguished ME friends and alumni who visit campus twice per year to advise the ME chair. At the group's first meeting with newly-appointed Chair Dennis Assanis, held March 22, 2002, the board discussed several issues, including:

- Assanis' vision for the department's future;
- updates on student enrollment, the increasing interests of faculty and students in biosystems, and the department's interdisciplinary structure;
- Associate Professor Ann Marie Sastry's activities on the College of Engineering's K-12 outreach committee; and
- applications of biosystems in ME, presented by Professors Ellen Arruda, Robert Dennis, Karl Grosh, and Edgar Meyhöfer.

Pictured, left to right, are EAB members attending the March 2002 meeting: (seated) ME Chair Dennis Assanis, Roberta Zald, Roger McCarthy, Marshall Jones, and Ashok Nayak (Executive Director of Development and Applied Engineering at ALCOA), who attended the meeting in place of board member John Collins; (standing) Richard Heglin, Ward O. Winer, General Paul Kern, and Mike Korybalski.

eab

ME Alumni Society Awards

2001-2002
Wen-Ying Tsai BSEME 1953
Sculptor

2000-2001
Charles M. Vest MSE 1964, PhD 1967
President, MIT

1999-2000
Robert Transou, Jr. MSE 1967
Retired Group Vice resident of Manufacturing, Ford Motor Company

1998-1999
Ward O. Winer BSEME 1958, MSE 1959, PhD 1962
Regent's Professor & Director, Woodruff School of Mechanical Engineering, Georgia Institute of Technology

1997-1998
William Sommers BSEME 1955, MSE 1956, PhD 1961
Retired President & CEO, SRI International

1996-1997
Charles Hutchins BSEME 1957
Chairman & Co-Founder, Manufacturing Data Systems, Inc.

1995-1996
Carroll J. Haas, Senior BSEME 1947
Chairman of the Board, Colonial Engineering, Inc.

1994-1995
Roger McCarthy BSEME 1972
Chairman of the Board, Exponent Inc. & Exponent Failure Analysis Assoc., Inc.

1993-1994
Robert J. Buckler BSEME 1971
President & COO, DTE Energy

1992-1993
D. Roger Heimbuch MSE 1967, PhD 1970
Executive Engineer of Power Train Systems, General Motors, GM Tech Center

Entrepreneurial Korybalski Named Alumni Society Merit Award Winner

For Michael (Mike) E. Korybalski, co-founder and former Chief Executive Officer of Mechanical Dynamics, Inc. (MDI), the recent sale of the company he founded 25 years ago culminated a lifetime of dedication, commitment, and achievement.

Only months after selling the company he founded in 1977, Korybalski was honored for that same dedication, commitment, and achievement by the Department of Mechanical Engineering when he was named Alumni Society Merit Award Winner.

"This really came as a huge surprise," Korybalski notes of the award. "I am very honored and proud."

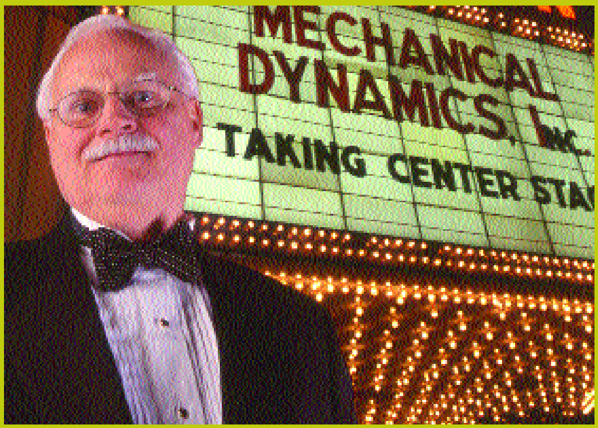
Yet this is not the first time that Korybalski has been recognized for his entrepreneurial spirit. In January 1994, Korybalski received the Entrepreneur of the Year Award from the New Enterprise Forum, a Michigan-based organization dedicated to encouraging the spirit and success of entrepreneurs. And in May 1994, he was a finalist for *Inc.* magazine's Entrepreneur of the Year Award in the State of Michigan.

Korybalski, who earned his BSME in 1969, MSEME in 1972, and MBA in 1980 — all from U-M — has been an active alumnus. He currently is third chair of ME's External Advisory Board and is a member of the National Advisory Council for the College of Engineering.

A former product engineer for Ford Motor Company, Korybalski explains that the decision to forge ahead to develop his own company was first formed during his U-M days. A student of former ME professor Milt Chace, Korybalski says that at the time he was working on his bachelor's degree Chace was heading up research on how computers could be used in the engineering design and development process.

Using that research, in June 1977, Korybalski, Chace, and U-M research associate John Angell co-founded MDI. Korybalski served as vice president and general manager in 1977 and became president and chief executive officer in 1984. In February 1997, he became chairman of the board of directors and chief executive officer.

Mechanical Dynamics, Inc., which employed almost 400 people in 22 offices throughout the world, was known as a leader in virtual prototyping. On April 18, 2002, MDI was purchased by MSC Software Corp. of Santa Ana, California.



Mike Korybalski poses in front of the Michigan Theater during Mechanical Dynamics' January 1999 company kickoff event. Each January, the company held a week-long event in Ann Arbor for employees from offices around the world to hear from management about the company's goals and objectives for the new year, as well as to participate in training on new products and sales. The week always included one fun day for employees. The 1999 event was a show at the Michigan Theatre, complete with tuxedoes, video commercials produced by different departments, and awards.

"I am very honored and proud."

Korybalski explains that the company's founders were not the only ones with U-M ME backgrounds. "We had many U-M grads working at MDI and hired many U-M students during the summer months," he notes. "It was beneficial both ways."

With the sale of the company, Korybalski says he has taken a lesser role — at his request — acting as an advisor to the CEO. He says he is looking forward to dedicating his time to serving on boards and advising younger companies.

He also notes that serving the university that has been an integral part of his personal and professional life will continue to be a priority. Korybalski has been a speaker at the U-M School of Business Administration and College of Engineering, and is active in many professional organizations.

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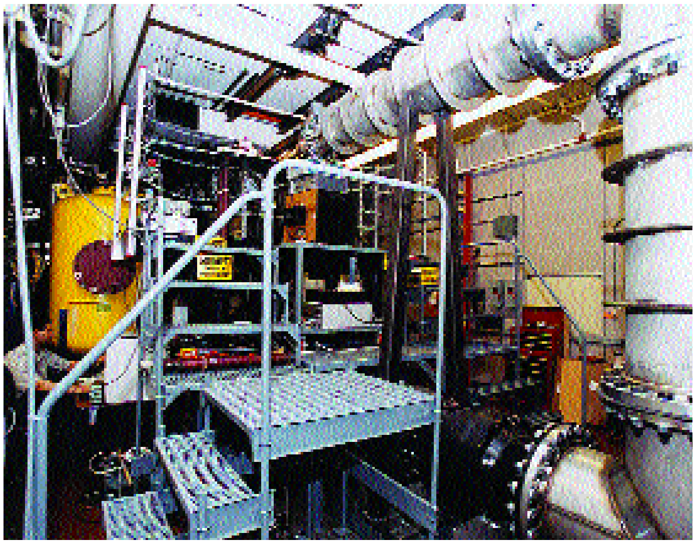
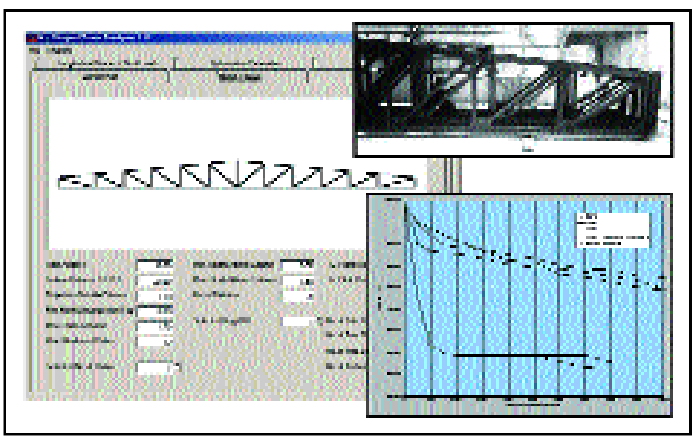
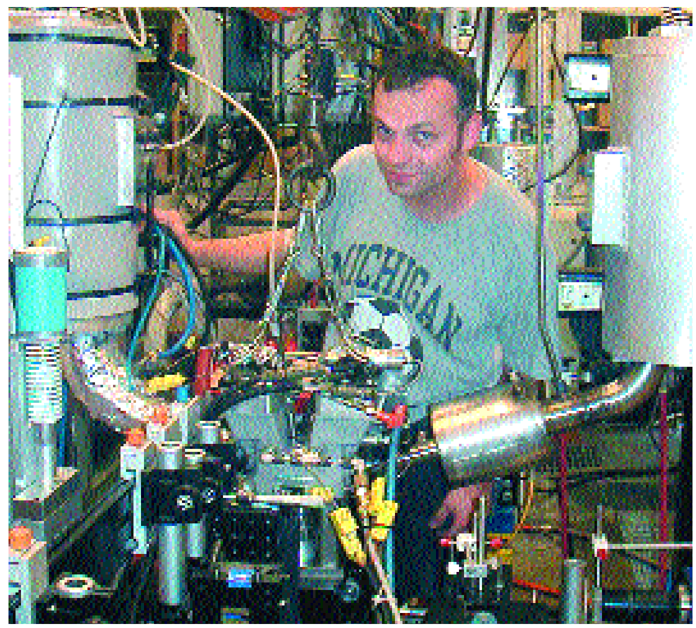
research views



ME recently completed the construction of a recirculating water tunnel for the study of hydrodynamics. The facility was designed and built by Associate Professor Steven Ceccio, his students, and the technical staff of ME, including Bill Kirkpatrick, Warren Eaton, Lynn Buege, Kent Pruss and John Mears. The test section has a 23 cm (9 inch) diameter, and the tunnel can operate with test section flow velocities up to 18 m/s (59 ft/s). The tunnel can be pressurized or held under vacuum to facilitate the study of cavitating flows. Support for the project is provided by the Office of Naval Research.



Implementation of Genetic Algorithm and Reactive Taboo Search in an Interactive Design Program succeeded in Decreasing the Weight of an Actual N-Shaped Truss by approximately 30 percent.



Graduate student Udo Fissenewert at the optical engine that he built for the Quantitative Laser Diagnostics Laboratory.

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