UNIVERSITY OF DELAWARE

NEWS mechanical engineering

FALL 1997

Edited by
Diane Kukich,
Robert Veazey, &
Anthony S. Wexler

The Chair's Corner

by Dr. Andras Z. Szeri

This year the Mechanical Engineering Department welcomed 62 freshmen, including 12 women, three Hispanic Americans, and one Native American. The freshman class has an average SAT score of 1255 and is the first to experience Curriculum 2000.

Professor Dick Wilkins is teaching the first course of the new curriculum, MEEG 101, "Introduction to ME." Designed to satisfy many of the requirements of the ABET Engineering Criteria 2000, the course was developed by benchmarking exciting new freshman courses throughout the country. The department particularly focused on the programs offered at Maryland, Penn State, Rose-Hulman, Rowan, NC State, and Arizona State. After scrutinizing all of these programs, the "Introduction to Engineering Design" course at Arizona State was chosen as a model for our "Introduction to ME." The course focuses on three major topics: the ME profession, engineering design projects, and modeling skills. Our goal in teaching MEEG 101 is to excite students about mechanical engineering. The enthusiasm will aid them to master the knowledge and skills needed to become successful.

As you may be aware, seven new faculty joined the Department within the last three years; these new faculty are already contributing significantly to the Department's research effort. During 1996–97, the Mechanical Engineering Department had a total of 51 active grants and contracts. In addition, members of our faculty served as principal investigators on 12 grants that were located in other UD departments. Among the 63 grants, 31 were from federal sources. During the same period, we submitted new grant proposals totaling $9,778,109.

To demonstrate the broad base of our research and inform you of our research activities, I will, from time to time, highlight selected research projects in this column.

Hip Prosthesis by Injection Molding of Short Fiber Composites (Whitaker Foundation)—S. G. Advani and M. H. Santare
Conventional prostheses tend to shield the surrounding bone from physiological loads, leading to bone resorption and eventually loosening. The goal is to design a hip prosthesis that minimizes shielding and therefore has the potential to stay fixed for a longer period of time.

Soot Particulate Characterization—from Laboratory to Industrial/Residential Sources (UDRF)—H. Wang and A. S. Wexler
Rapid single-particle mass spectrometry is used to study a major combustion-generated pollutant, smoke particles, from laboratory flames to practical combustors such as diesel engines. The study will provide essential data for future regulatory developments and for designing combustors of low-particulate emission.

Layered Manufacturing: An Intelligent CAD Based System (ONR)—T-W. Chou
Initiated at Rutgers University, this program aims for the design, fabrication, and optimization of electromechanical components, such as smart actuators and transducers for vibration control and sonar.

Advanced Magnetic Materials (AFOSR)—A. P. Majidi
Initiatives to develop an electric airplane/vehicle call for advanced magnetic materials capable of operating at temperatures far exceeding those of present-generation magnets. Magnets with improved mechanical and magnetic properties are being developed in a collaborative effort with researchers in the Department of Physics and Astronomy and the Bartol Research Institute.

Advanced Materials Intelligent Processing Center (ONR)—S. G. Advani and K. V. Steiner
This program focuses on intelligent control of liquid molding processes such as resin transfer molding (RTM) and vacuum-assisted RTM. The program combines virtual manufacturing (simulation) with intelligent process control based on on-line sensor input towards prototype development of composites components. The University of Delaware has teamed with industry for this program.

Analytical and Experimental Study of Crack-Interface Interactions (NSF)—J. Lambros and M. H. Santare
Many naturally occurring (e.g., bone and plant structures) and man-made materials (e.g., composites) are inherently inhomogeneous and involve continuously varying elastic properties. This research deals with how such materials fracture under various loading conditions.

Development of High Oleic Soybean Oil Lubricants (industry)—M. Keefe, J. Glancy, and A. Szeri
The goal is to determine additives that will render a genetically engineered soybean oil-based hydraulic fluid a good performer, for use in environmentally sensitive areas. Our research focuses on defining and quantifying the time dependence of the degradation of the oil.

Heat Transfer Analysis of Cooling Systems for Thermophotovoltaic Generators (industry)—A. K. Prasad and S. G. Advani
Organic fuels are burned inside the core of a thermophotovoltaic (TPV) generator, where a ytterbium mantle radiates light of a specific wavelength to a shroud of TPV material. A portion of the incident light is directly converted by the TPV to electricity; the remainder must be rejected as heat to the ambient. We are designing and evaluating novel TPV cooling systems. The generator, designed primarily for the U.S. Army, will also be targeted towards the boating and camping sector.

High-Performance Simulations of Complex Turbulent Flows (industry)—L. P. Wang
Large-scale computer simulations are used to study multi-dimensional, time-dependent processes in turbulence and multiphase flow systems. Specifically, our simulation results reveal a new mechanism for slow settling of aerosols in the lower atmosphere and point to a predictive model of this non-diffusive turbulent transport.

High-Strain-Rate Properties of Fiber-Reinforced Thermosetting and Thermoplastic Polymer Matrix Composites (ONR)—J. R. Vinson and J. Lambros
High-strain-rate tensile/compressive mechanical properties are being obtained for graphite, Kevlar®, and glass fiber composites, which can differ significantly from available static properties. A predictive capability is being developed that will deduce dynamic material properties from known static property values mathematically, thus saving much effort and expense.

Gas-Particle Transport Limitations in Atmospheric Aerosols (NSF)—A. S. Wexler and M. Johnston (Chemistry)—
This research investigates the impact of atmospheric particles on climate and urban smog. Particle chemical composition governs their impact. The research group has developed the first instrument to efficiently size, count, and analyze in real time individual atmospheric particles down to 10 nm.

Congratulations to Associate Professor Michael Keefe, President Elect of the University Faculty Senate.

Pathfinder Cocooned Inside Airbags Designed by UD Engineers

by Diane S. Kukich, 73BA, 84MA

On the 4th of July, 1997, NASA's Mars Pathfinder ended its 309-million mile journey from Earth by landing on the rocky surface of Mars. The success of that landing was made possible by the efforts of an engineering team from ILC Dover that included three UD ME grads and a colleague with a degree from UD's chemical engineering department.

Unlike the typical landing employing a "retrorocket"—a rocket that produces thrust in the opposite direction for deceleration—the Pathfinder landing was cushioned by an airbag subsystem. Chuck Sandy, 78BME, Jim Stein, 91BME, Brad Walters, 83BME, and Bob Munion, 86ChE, were core members of the team that designed the four six-lobe airbags enabling the lander to survive Mars' inhospitable surface.

NASA's Jet Propulsion Laboratory (JPL) initiated the airbag concept as a means of reducing costs, avoiding contamination of the landing site, and optimizing the scientific mission objectives. "It was trial and error and intuition," JPL airbag designer Tommasso P. Rivellini is quoted as saying in *Aviation Week and Space Technology*. "Sandia and Rockwell tried to analyze it with nonlinear finite element codes, but that was not sufficient. We got lucky with the ILC guys. They are a crack team of designers and technicians."

Best known for producing space suits for the Apollo and subsequent missions, ILC Dover is a division of ILC Industries, Inc., Bohemia, N.Y. University of Delaware graduates make up approximately 20 percent of the company's staff; in addition to Sandy, Stein, and Walters, MEs include Alan George, 80BME; Joseph Welch, 86BME; Brian Remington, 87BME; Jim Smoker, 89BME; Robert Lingo, 91BME; and Jonathon Day, 95BME. ILC Dover president Homer Reihm (ENG 60) is a member of the University's Board of Trustees.

Mars Pathfinder airbags undergo vertical drop tests against an angled, simulated rocky Martian terrain in NASA/Lewis Research Center's vacuum chamber.

Class Notes

U.S. Patent No. 5,626,472, "Adjustable Hot Gas Torch Nozzle," was issued on May 6, 1997, to I**an Howie**, 92BME; **Roderic C. Don**, 90BME; **John W. Gillespie Jr**. 76BME, 79MMAE, 85PhDMAE; and **Scott T. Holmes**, 90BME, 95MME. The device enables rapid temperature changes to be effected in any application that uses a gas stream to melt a material, such as automated thermoplastic composite tow placement.

U. S. Patent No. 5643390, "Bonding Techniques for High-Performance Thermoplastic Compositions," was issued on July 1, 1997, to **Roderic C. Don**, 90BME; **John W. Gillespie Jr**. 76BME, 79MMAE, 85PhDMAE; and **Steven H. McKnight** (96PhD MSE). The invention, commonly referred to as Diffusion-Enhanced Adhesion (DEA), is a new process to promote adhesion between thermoplastic polymers and thermosetting resin adhesives.

Robert C. Wetherhold, 84PhDMAE, 76MMAE, Associate Professor of Mechanical and Aerospace Engineering at the University at Buffalo, has been awarded a Fulbright fellowship to do research and teach in Germany during the 1997–98 academic year. He is studying fracture and fatigue properties of composites, as well as tribology—the friction and wear—of composites. In addition to his research, Wetherhold will teach courses in composite materials at the University of Darmstadt.

Robert J. Stratton, 89BME, received the Small Disadvantaged Business (SBD) Advocate award from Lockheed Martin Aeronautical Systems. Stratton was honored for his commitment to developing minority-owned businesses as suppliers for the aerospace company. A member of Aeronautical Systems' Engineering branch, Stratton is program manager for F-22 resin transfer molding, where he oversees four subcontractors who build more than 250 parts.

Terry S. Creasy, 97PhDME, is the M. C. Gill Postdoctoral Fellow at the University of Southern California (USC).

Mechanical Engineering Department 1997 Honors Day Awards

SENIOR YEAR AWARDS

Faculty Award to the Distinguished Senior in Mechanical Engineering
For the extraordinary senior mechanical engineering student who has demonstrated creativity, academic accomplishment, and achievement as determined by the faculty of the department (award made from faculty contributions).
Christian Fermani

Mary and George Nowinski Award for Excellence in Undergraduate Research
For demonstration of originality in a stimulating senior research project as judged by the mechanical engineering faculty (this year's award from Dr. Chou in place of Dr. Nowinski).
Eric D. Ramos

JUNIOR YEAR AWARDS

W. Francis Lindell Mechanical Engineering Achievement Award
For junior mechanical engineering students in recognition of scholarship and creativity in engineering as recommended by the students and faculty of the department (awards made from the Lindell Foundation).
Thomas C. Koehler
Robert B. Gifford Jr.
Brian P. Givens
Joseph J. Salvia II

OTHER DEPARTMENT AWARDS

Delaware Section of The American Society of Mechanical Engineers Outstanding Student
To the outstanding student in the Delaware section of ASME.
Jeffrey M. Lawrence

Delaware Section of the American Society of Mechanical Engineers Senior Design Project Award
"Athletic Field Hardness Tester"
Team members: **James Cermak, Christian Fermani, Donald Longo, and Jerome Posatko**

American Society of Mechanical Engineers Student Section
A certificate to an outstanding member of the ASME Student Section for good academic standing and valuable contributions to the chapter.
Shawn P. Riley

Robert T. Bosworth Scholarship
To a student majoring in mechanical engineering with both outstanding academic achievement and financial need.
Thomas C. Koehler

Redden Scholarship
To a student majoring in mechanical engineering with both outstanding academic achievement and financial need.
Jason L. Firko

Boeing Scholarship
Two $2,000 scholarships available to minority and female students majoring in mechanical or electrical engineering.
Prathana Vannarath

CENTER FOR COMPOSITE MATERIALS

Scholar's Award
Simon Bickerton

Outstanding Senior Award
Mark L. Scott

COLLEGE AWARDS
(paid by College or University)

The Delmarva Power & Light Company Scholarship
Two $500 scholarships for mechanical and electrical engineering majors. Selection is based upon academic excellence and promise in the field of engineering. Two candidates from the Delmarva area are selected.
Scott Quirico

Bangalore T. Lakshman Scholarship
Scholarship awarded to a student who reflects the personal characteristics important to Mr. Lakshman. (Hard-working, ethical, generous. Mr. Lakshman is extremely active in Rotary, to benefit those less fortunate than he.) For returning minorities.
Nikhil Vithal Bhate

Rise Corporate Friends Award
Scholarship to returning undergraduate minority student with outstanding scholarship and promise for success.
Ricardo Blackett

UNIVERSITY AWARDS

Alumni Honors Day Book Award
Joseph J. Salvia II

George A. Johnson Award
Ricardo Blackett

Boeing Company Scholarship
Prathana Vannarath

Liston A. Houston Scholarship
Brian B. Gifford Jr.
Brian P. Givens
Thomas C. Koehler
Joseph J. Salvia II

Millar Memorial Scholarship of the Delaware Contractors Association
Brian P. Givens

Around the Laboratories: University of Delaware

By Dr. Jack R. Vinson, H. Fletcher Brown Professor of Mechanical and Aerospace Engineering Fellow, ASME and AIAA
adapted from an article in *Newsletter of the Society for Sandwich Construction*

ME has a distinguished history of research in sandwich construction under the direction of Dr. J. R. Vinson. Since his first publication in 1966, Vinson has developed analytical methods providing exact solutions for the determination of face thickness and core depth; cell size and wall thickness for honeycomb cores; values of core shear modulus for foam and solid cores; and the dimensions for truss-core and web-core sandwich panels, in order to obtain absolute minimum weight in flat and cylindrical panels with in-plane compression and shear loads. Twenty-two papers summarize this work to date. The following summarizes some of the recent research done by Vinson and his students.

Piezoelectric ceramic actuators/sensors can be attached to sandwich structures to control deflection and suppress or initiate vibration. Recently completed studies by Moti M. Leibowitz, 94PhD, on beams and flat panels and Phillip H. Larson, 96PhD, on shells and rings have yielded interesting results. Piezoelectric ceramic patches and their electrical leads can be bonded to the inner surfaces of sandwich faces, where they are protected by being "potted" in the foam core. Leibowitz showed that active piezoelectric actuators can significantly enhance the performance of passive constrained layer damping in structures. The work of James F. Newill, 95PhD, focused on enhancing the effects of viscoelastic damping through the use of intelligent materials.

Cylindrical shell sandwich components with various circumferential angles may be integral parts of structural cross-sections of truck tank bodies, train and subway cars, boat hulls, and fuselages for advanced aircraft. Solutions for these structures have been developed by Kessavan Potty, 96PhD.

Very low-cost composite sandwich structures are promising materials for emergency housing and storage. This construction uses a sandwich with a double-truss core and a triple face of treated Kraft paper for the primary structure, sealed in a protective external layer of non-woven glass mat.

Eyassu Woldesenbet, a current PhD student, is conducting a structural analytical/optimization study of this form of construction. The result is a 400 ft^2 structure, easily assembled in a few hours by two men with staple guns and rollers. It can easily be transported, even in a station wagon or pick-up truck, and it meets all existing building codes. It is earthquake-proof and resistant to rodents and fire.

Ballistic impact on composite material panels (including the faces of sandwich panels) is the subject of analytical procedures developed by Jeffrey Walker, 94BME. From only two penetration experiments for any composite construction, the procedures provide the means to study any other ballistic impact and tell whether that impact will penetrate the target or not and, if it does, what the residual velocity will be. They also provide the ballistic limit for any impactor. The result is a great saving in time and expense, as well as a practical way to select materials and stacking sequences in order to maximize ballistic impact resistance.

Brian Powers, 96MME, used the UD Split Hopkinson Pressure Bar facility to study the high-strain-rate mechanical properties of various thermosetting and thermoplastic composite materials. The work was sponsored by the Office of Naval Research. Experimental data was analyzed and the failure process modeled in order to characterize materials often used for sandwich construction. Properties at strain rates of $1000s^{-1}$ can differ from static properties by factors of 2 (for strength) and 2 to 3 (for elastic moduli). High strain rates can cause failure to change from ductile to brittle.

Recently, Dr. Vinson has taught courses on sandwich construction and the use of piezoelectric materials to create adaptive sandwich structures as well as one on sandwich structures to coincide with the publication of his new textbook, *The Behavior of Sandwich Structures Composed of Isotropic and Composite Materials*.

Did you know that…

- the average annual salary for a full professor in 1891 was $1,750?
- Mechanical Hall cost just over $7,000 to build in 1898, Evans Hall was $360,000 in 1930, and Spencer Lab cost $9.7 million in 1983?
- the average starting salary for a mechanical engineer with a bachelor's degree was $2700 in 1947 and $5100 less than 10 years later?
- the father and son for whom Evans Hall was named served a total of 87 years on the boards of trustees of Delaware College and the University of Delaware?
- when the department of mechanical and electrical engineering was established in 1891, one professor was assigned to the program; while in 1997, close to 30 full-time, visiting, and adjunct faculty are affiliated with the ME department?
- out of the 154 bachelor's degrees awarded by Delaware College between 1909 and 1914, 120 were in engineering, leading President Harter to say, "The College is now becoming an Engineering School largely"?
- electrical and mechanical engineering were part of a single department until 1911 and, even after they separated, their curricula remained the same except for the fourth-year requirements?

Where is ME on the UD Campus?

by Diane S. Kukich, 73BA, 84MA

From wooden shops that were consumed by fire in 1898 to the modern Spencer Lab, completed in 1983, ME has had several homes on the UD campus over the past century.

Although courses were actually taught in the "mechanic arts" as early as the 1850s, ME did not achieve departmental status until 1891, when a department of mechanical and electrical engineering was established at what was then the male-only Delaware College. In 1892, during the tenure of Mr. F. A. Weihe, the first professor in the four-year program, a one-story 30' x 50' frame workshop was built to house all of the equipment available at the time—three engine lathes, a small planer, a milling machine, and a drill press, operated by an 8-horsepower gasoline engine.

THEN

NOW

The department moved into a real home in 1898, when Mechanical Hall was built to house the entire Engineering School. By 1919, the new facility had been outgrown, so three one-story wooden buildings were erected to house civil and electrical engineering, while ME remained, appropriately enough, in Mechanical Hall.

By the late 1920s, with the post–War wooden structures falling into disrepair, the Delaware General Assembly appropriated funds to build a new facility dedicated to engineering. With additional support from benefactor Pierre S. du Pont, Evans Hall was completed and dedicated in 1930. Named after George Gillespie Evans and his son Charles Black Evans (both long-time members of the institution's Board of Trustees), the building housed all of the engineering programs except chemical engineering, which was located in Wolf Hall. (Mechanical Hall then became a dormitory for varsity athletes and was renamed the Training House.)

While Evans was under construction, a new dean of engineering, Robert L. Spencer, was appointed. He served as dean until shortly before his death in 1945 and is credited with contributing substantially to the development of the physical facilities needed to support engineering science and technology at the University of Delaware. According to a 1945 issue of the *University of Delaware News*, "Money provided to equip the building [Evans] was inadequate. Teachers and students had to make and install what they could. Dean Spencer himself built all the classroom desks and bulletin boards in the new building."

It is thus fitting that ME's next home was named after him: the Robert L. Spencer Laboratory was completed and dedicated in 1983. Completion of the new facility not only provided a new, permanent home for ME but also enabled Evans Hall to be renovated for the Department of Electrical Engineering.

The dedication program for Spencer Lab lists "specialized laboratories for a wide range of teaching and research functions"—from computer-aided design, electron microscopy, and composite materials processing to heat transfer, fluid mechanics, and impact physics. The department had come a long way from "the old shop engine and boiler [that] comprised practically the whole experimental setup," as described by Professor Merrill Van Giesen Smith in the *Delaware College Review* in 1912.

Yet despite tremendous growth in engineering programs at UD and radical changes in technology since the turn of the century, it is sometimes true, as the cliché alleges, that "the more things change, the more they stay the same." In his 1912 article, Smith wrote about the need to reduce the cost of manufacturing and develop new processes and equipment—issues that are still at the forefront of engineering as we near the turn of another century.

NOW

THEN

The author gratefully acknowledges the assistance of Betty Dunn, University Archives, in compiling information for this article. Dr. John A. Munroe's book, The University of Delaware: A History *(University of Delaware, 1986) was also very informative.*

Race Car Team Returns with Valuable Experience

by Ed Okonowicz
(reprinted with permission from
UD *Update, May 22, 1997*)

A team of UD students in Pontiac, Mich., in May for the annual Formula SAE 97 race car competition didn't bring home any trophies, but they did nab a spot on CNN and learned some valuable lessons for next year's event.

UD project team leader Suhas Malghan was interviewed May 16 on CNN during a news feature about the annual competition.

The UD chapter of the Society of Automotive Engineers started building UD's car during spring break of 1996. According to Malghan, "Our concept was quite ambitious for a first-year car. We decided to construct a composite structure because it would result in a very light, strong, rigid, and safe structure."

He explained that the shell and covering used in the UD auto employed techniques used in aircraft construction, and the team received assistance from staff at Hardcore-DuPont and the Center for Composite Materials.

According to Malghan, the UD entry was the third lightest vehicle at 470 pounds, and, he added, the team believes it can do better in the future, since there were a number of places where additional weight could be cut.

"Many people were impressed by our efforts as a first-year team," Malghan said. "In fact, actually making competition the year you plan to go is an achievement itself, and by some stroke of luck we managed to get on CNN."

Unfortunately, the UD vehicle experienced mechanical problems and was unable to compete in several of the events. Malghan said he was impressed with the assistance offered by other teams and the determination and positive attitude demonstrated throughout by the UD team members.

"Instead of dwelling on the current dismal situation, we kept looking forward," he said. "Though we weren't happy with our performance, and things certainly didn't go the way we planned, we're only more determined to apply everything we've learned to make next year's car a winner. I did Formula SAE before I transferred here from the University of Texas at Austin, and I can tell you that teams that work this well together are few and far between. All the seniors regret that they can't do this next year."

Team member Scott Suhmann said the group is seeking additional members for next year's effort. Individuals with a variety of talents and from different majors are needed.

He said business majors could be involved on cost reports and time charts; electrical engineers are needed to work on the electrical systems that run the engine and other components; public relations majors can provide assistance with publicity; computer science majors could promote the project on the web; and other engineers are needed to do research and work on the car itself.

The student car was spray painted by Ed Dennie, Facilities Management Structural Shop, with paint donated by that unit. The entire exterior of the car was designed by Keith Heckert, Media Services, Information Technologies.

Start your engines! *The UD chapter of the Society of Automotive Engineers entered this race car in the May 1997 Formula SAE 97 competition. More than a dozen students were involved in the project. Shown with their vehicle are (standing, from left) Andy Parre, Mike Lentz, and Brian Davison, (front row) Keith Heckert, media services, Stefan Vapaa, Mark Scott and David Ameen. At the wheel is Jeremy Freeman. Not pictured are Suhas Malghan, Sam Lee, Jason Firko, Scott Suhmann, Greg Martin, and Ed Dennie.*

Alumni E-mail Addresses

Many of our local alumni have e-mail accounts on the ME department computer (me.udel.edu). These accounts are available free to all alumni. Please contact **info@me.udel.edu** if you would like an account. Below we list our alumni's me.udel.edu e-mail accounts so you can contact your friends. Let us know your e-mail address at work or home so we can add it to our alumni e-mail directory. Send address information to donna@me.udel.edu.

All addresses are **alumxxx@me.udel.edu**, where the xxx represents the person's initials. Usernames for the alumni listed below appear in parentheses:

Dominick Anthony Azeglio (alumdaa)
James Michael Byrnes (alumjmb)
Jeffrey Scott Burmeister (alumjsb)
James Joseph Crescenzo (alumjjc)
John Edward Daly (alumjed)
Edward Lewis Danfelt (alumeld)
Shawn Renee Doebling (alumsrd)
Megan Mary Donofrio (alummmd)
Jason Todd Iceman (alumjti)
Brian Carl Klinetob (alumbck)
Regina Michelle Knotts (alumrmk)
Malcolm Walter Kroeber (alummwk)
Kurt I. Kuhn (alumkik)
John David Lamiet (alumjdl)
Charles Joseph Litz (alumcjl)
Matt George Mcbride (alummgm)
David Marc Mcelwee (alumdmc)
George Greer Macmasters (alumggm)
Angela M. Miller (alumamm)
Edward A. Milligan (alumeam)
Donald Francis Olsen (alumdfo)
Charles William Pell (alumcwp)
Robert Bryant Pigford (alumrbp)
Robert H. Pigford (alumrhp)
Tzy Ken Shih (alumtks)
Kevin Michael Stolfo (alumkms)
Alicia Marie Walsh (alumamw)
Clint Alfred Weslager (alumcaw)
Michael Paul Wolynetz (alummpw)

UNIVERSITY OF DELAWARE

NEWS
mechanical engineering

Department of Mechanical Engineering
University of Delaware
Newark, DE 19716-3140

NONPROFIT
ORGANIZATION
U.S. POSTAGE
PAID
NEWARK, DE
PERMIT NO. 26