UNIVERSITY OF FLORIDA

FALL 2003

MECHANICAL & AEROSPACE ENGINEERING

Morphing Aircraft A Reality

Imagine airplanes whose wing shape can change in flight helping it to maneuver …… sound like a fantasy? Not to today's aerospace engineers.

"The idea is, you can have an aircraft that flies similarly to birds," said MAE Professor Rick Lind, one of the UF researchers investigating the morphing concept. "When a bird flies you think of it as flapping its wings, but it also takes on a lot of complicated shape shifting in response to the air to fly better," he explained.

Mujahid Abdulrahim test flying his morphing aircraft.

The 33-year-old professor is part of a research team which includes MAE professor Peter Ifju and students Mujahid Abdulrahim and Helen Garcia. The larger scale vision-based autonomous project includes MAE's Andy Kurdila and Mike Nechyba from Electrical Engineering. The team has three main projects – a 6-foot wing span craft with a segmented trailing wing edge, a 24-inch, and a 10-inch vehicle.

A traditional airplane has only one wing shape. Morphing allows the wing's shape to change during flight, optimizing it for different flight conditions and maneuvers, according to Lind.

Morphing the wing of both micro-scale as well as full-scale aircraft is a hot research area for aerospace engineers. UF's MAE recently received a $5M/5 year grant plus additional funds from federal sources to delve deeply into the science aiming at creative, practical solutions. Some of the funding comes from the National Aeronautics and Space Administration (NASA), and the Air Force Office of Scientific Research (AFOSR). Eglin Air Force Base has also contributed to the project.

"This is a very hot topic for aircraft design because today's technology is now making this aircraft possible," Lind explained. "This includes the materials that can morph in this fashion along with electronics which enable us to fly these small vehicles – 10 years ago we couldn't have done any of this," he added.

Interestingly, NASA has had a very large morphing project in place for more than five years, but they have yet to fly anything – simply because they are looking at large aircraft which are very difficult to morph. "Compared to a 6-inch airplane anything is very large," Lind chuckled.

Morphing is particularly appealing for twisting the wing and enabling roll control. Essentially, the wing deforms under loading in flight helping to smooth the flight path. This concept can be extended to allow greater twists that are actively commanded to generate large roll moments.

Morphing wing science is continually evolving, and is seen as a way around the ineffective elevator and rudder assembly which often make small and agile remote-controlled micro air vehicles (MAV) difficult to fly. The concept of the morphing wing presents several ways for controlling a MAV.

This innovative field is under intense research at the UF's MAE, which is focusing on designing MAVs with wing spans of less than 6 inches to operate at airspeeds less than 25 mph. They are typically envisioned for use as expendable military surveillance devices in dangerous or confined spaces.

But this isn't the scenario that Lind foresees for the use of MAVs. For instance, they could be an integral part of a biological response team should a toxic substance be released, or used for search and rescue operations.

"Imagine that every police car has several MAVs in the trunk," Lind theorized. "The police are called out on a dangerous situation with the potential for a biological threat, and they deploy the MAVs. Right away the police get an idea if there is a biological hazard with only minimal risk to human life," he said.

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GATOR Engineering

MAE students Helen Garcia and Mujahid Abdulrahim work on one of the fleet of morphing aircraft under intense research investigation.

"Morphing MAVs also could be used for people hiking in difficult terrain," Lind continued. "The MAV could be deployed by hikers to get a real view of the terrain, something they can't get just by looking at a topographic map, and be able to find water or find their way out of a predicament," he explained.

Active morphing is reasonable for full-size aircraft, but the power and size needed for the actuators precludes their use on a MAV. The morphing wing concept is being adopted for the "active aeroelastic wing" to provide roll control of the F/A18 military jet. This aircraft has just flown this spring. Aerodynamics causes the leading edge of this airplane's wing to actuate generating a "twisting moment." This differs from the MAV in that controllers are directly changing the wing shape rather than air conditions, Lind explained.

This wing twist is currently used by the MAE's award winning MAV competition team. Since 1999 MAE has won various challenges within the Micro Aerial Vehicle Competition (MAVC) sponsored by the International Society of Structural and Multidisciplinary Optimization (ISSMO), with unique designs ranging from 2-foot, to 4-inch wing spans. The aircraft are remotely piloted using vision feedback to a ground station.

The airframe of MAE's MAV is constructed of composite carbon-fiber, and the wing skeleton is covered with a membrane skin of latex rubber. The resulting craft can be grossly deformed by mechanical means yet is still capable of carrying a payload. The flexible nature of the wing permits small changes in wing shape in response to gusty wind conditions. (While both wings can be morphed, currently one wing at a time is morphed.) The aircraft is still in its infancy with increased flight stability as a goal, as well as automation to help control yaw, pitch, and roll.

"Using carbon fiber for the frame ensures the MAVs' strength, and yet it is very light keeping the weight of the aircraft low," Lind explained. The wing needs surface area but not much strength, so latex provides enough lift for this size aircraft he said.

All of this work is part of a much larger project for doing vision-based autonomous flight. The MAE research team envisions MAVs being able to navigate amidst the buildings of a city, avoiding cars and pedestrians on its own -- rather than the current method of control which entails a human "pilot" using video feedback at a ground station.

Lind has been working on this concept for years and feels passionate about the research. "It's the intellectual challenge of an unexplored flight system, and some of it is the ability to do things with airplanes that we couldn't do before," he reflected.

The MAE morphing research team is earning international recognition for its innovative and groundbreaking research, and intends on furthering the work by looking at changing the area/camber, overall shape, and much larger, much more complicated changes.

"The goal is to develop many more advances in morphing science – the work we've done currently is relatively simple in that we are changing twist and span," Lind reflected.

Mujahid Abdulrahim with his prototype morphing aircraft. This 6-foot wingspan aircraft has a segmented morphing trailing edge surface.

Mujahid Abdulrahim Wins AIAA Best Paper Award on Morphing Aircraft

MAE student Mujahid Abdulrahim won the 2003 Best Paper Award from the American Institute of Aeronautics and Astronautics (AIAA) for his senior undergraduate paper at the recent AIAA Southeast Regional Student Conference. Abdulrahim won a $500 honorarium and a chance to compete in the national level at the AIAA Annual Aerospace Sciences Meeting to be held in Reno, Nevada in January 2004.

The winning paper's title is "Flight Dynamics and Control of an Aircraft with Segmented Control Surfaces." Abdulrahim is working on developing design and control strategies for morphing aircraft – these are aircraft whose wings change their shape during flight.

Abdulrahim is a member of the micro air vehicles (MAV) team, working with professors Pete Ifju, Rick Lind, and Andy Kurdila, doing characterization of flight mechanics and control design. The work he presented resulted from the independent study course he is taking from Dr. Lind this year to study control surface shaping for controlling a tailless model.

Student Awards

MAE Wins at Human Powered Vehicle Competition

MAE's Human Powered Vehicle (HPV) team came home from the ASME's East Coast 2003 Competition with four first place trophies along with a $500 check from the ASME. UF won first place in the final Tandem Event, Multi-Rider Sprint Standings, Multi-Rider Endurance Standings, and the Utility Endurance Event.

The UF's two-seater consisted of thick-walled steel tubing, the stuff used for race car roll cages. "Our HPV weighed about 150 lbs. -- tough riding uphill," team member Suzanne Atyeo recalled. "We were lucky the only problem we had was a broken fairing during the last competition. The front rider not only had to maneuver the course, but also held the fairing out of the way," she described.

Front row -- Philippe Simon; Standing (L-R) Ryan Mackey, William Joseph Bacawat, Jared M. Greenberg, Karin Cole, Suzanne M. Atyeo, Manson Gup, and Jason Barber.

A tight budget prevented the team from building a new vehicle, so instead they adapted last year's car. "We modified the roll bar and frontal fairing to make the car lighter," explained team member Jared Greenberg. "And we put on wheel covers to make it more aerodynamic," he added.

Human Powered Vehicles are aerodynamic, highly engineered vehicles for use on land, water, or air. The point of the competition is in the ingenuity of the design and presentation, practicality, and safety. There are three different vehicle classes - single rider, multi-person, and practical. The practical vehicle emphasizes its usefulness for daily activities like shopping, transportation, or recreation. These must negotiate a slalom course while carrying packages, going over bumps or potholes, stopping at signs, and obeying the rules of the road. The single and tandem vehicles compete in sprint and endurance events.

'Tailgator' Wins Intelligent Ground Vehicle Trials

UF MAE's 'Tailgator' took first place in the navigation and follow-the leader trials at the Intelligent Ground Vehicle Competition, sponsored by the Association for Unmanned Vehicle Systems International. The competition was held in early June on the campus of Oakland University, in Rochester, Michigan. Twenty-six teams registered for the competition.

The competition offers a design experience that is multidisciplinary, theory-based, hands-on, team implemented, outcome assessed, and based on product realization. The event consisted of four competitions, navigation, follow-the-leader, automony, and design, each posing a different challenge for the 'Tailgator.'

In the navigation trial each team was given the latitude and longitude of nine goal points located on an 80x80 meter field. Several highway construction barrels were scattered throughout the field. "The objective of this competition is for the vehicle to autonomously navigate to within two meters of each goal point without colliding with any of the construction barrels," said the team's faculty advisor Professor Carl Crane. "We were the only team to reach all nine goal points," he said.

During the follow-the-leader trial, the team's vehicle autonomously followed a lawn tractor driven along an obstacle-strewn course. "The course consisted of highway construction barrels, a tunnel, a bridge, and a duplicate stationary lawn tractor," Crane recalled. "The UF team finished first in this competition and was the only team to complete the entire course," he said.

In the autonomous challenge trial, vehicles moved autonomously through an obstacle-strewn course. "The course was made up of two white stripes that are painted on the grass, numerous highway construction barrels, a bridge, a sand pit, and several simulated potholes," Crane described. "The vehicle must travel between the stripes and across the bridge while avoiding the construction barrels and the potholes," he said. The UF team finished third in this competition.

(L-R) Dr. Carl Crane, Tom Galluzzo, Duk Sun Yun, David Armstrong, Donald MacArthur, Erica Zawodny, Roberto Montane, and Danny Kent.

Student Awards

MAE Team Wins Pinckney Award for Helicopter Parts Machining

A UF team of MAE scientists won the Robert L. Pinckney Award for 2003 from AHS International (formerly the American Helicopter Society) for their research on high-speed machining of titanium alloys. The research has been implemented commercially to significantly drive down the cost of machining titanium parts for helicopters and tilt rotors. Their research integrated advanced concepts in structural dynamics, machine tool design, cutting tool materials, cutting tool design, and fixturing and cooling to cut difficult titanium alloys at unprecedented rates.

The UF team members included Professors John K. Schueller and (the late) Jiri Tlusty, and graduate students Christopher Martin and Anthony Kakiel (M.S. MAE 1999). The team also was comprised of UF alumni K. Scott Smith, and Tom Delio, both of whom earned their M.S./Ph.D.'s from MAE.

High-Speed Machining of Titanium Team 2003 Pinckney Award winners at May ceremony. Pictured (L-R) are K. Scott Smith, MAE Prof. John K. Schueller, and Tom Delio. Smith is now a professor at the University of North Carolina/ Charlotte, and Delio is the Vice President of MSG Labs, Inc.

MAE student and Pinckney Award winner Christopher Martin has moved on to his Ph.D. work, and is seen here inspecting an expander of a power-refrigeration cycle.

Nicoleta Apetre Wins Amelia Earhart Award for Aerospace Materials

MAE doctoral student Nicoleta Apetre won the Amelia Earhart Award from the Zonta International Foundation, which aims to advance women worldwide. The annual award is granted to women pursuing graduate degrees in aerospace-related sciences engineering.

"I am really happy about winning this award," Apetre said. "By getting this award I feel I am on the right track," she reflected.

Apetre is a 27-year-old Romanian in her third year of doctoral studies. Her research focuses on analytical models for functionally graded materials in aerospace engineering. She received her bachelor's and master's degrees in mathematics from the University of Bucharest.

Nicoleta Apetre focusing in on her research on analytical models for functionally graded materials.

Samantha Mirabal Wins Yellott Award for Renewable Hydrogen Production

MAE master's student Samantha Mirabal won the 2003 John and Barbara Yellott Award from the American Solar Energy Society (ASES) for her continuing research on renewable hydrogen production and for developing cost projections showing its cost effectiveness in the future.

"I am quite excited about the award," Mirabal exclaimed. She is a 23-year-old in her first year of graduate school. "I found out that I'd won the award on my birthday, May 20," she recalled. Mirabal particularly enjoys researching topics within the thermal sciences. "I really like small-scale heat transfer," she said.

MAE master's student Samantha Mirabal intently researching renewable hydrogen production.

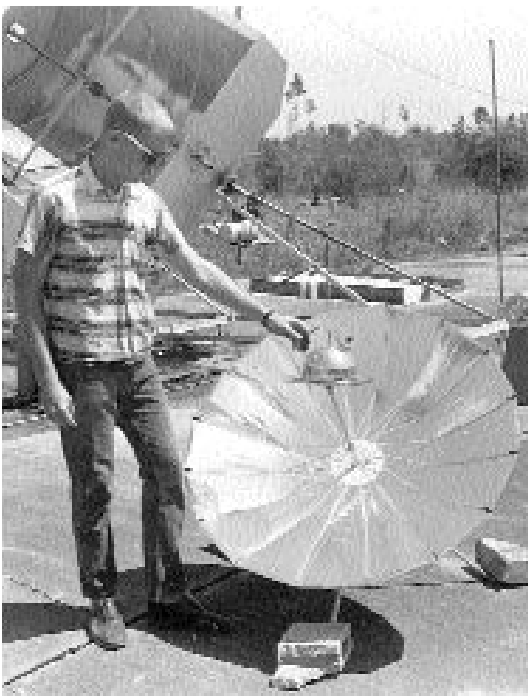
Ben Andrew Griffin in a lighthearted moment.

Ben Griffin Wins NSF Graduate Student Fellowship

Benjamin A. Griffin won the National Science Foundation (NSF) Graduate Fellowship Award for spring 2003. NSF graduate fellowships offer recognition and three years of support for advanced study to approximately 900 outstanding graduate students in the mathematical, physical, biological, engineering, and behavioral and social sciences, including the history and philosophy of science, and to research-based Ph.D. degree students in science education.

The 22-year-old first year graduate student will receive three years of tuition and a stipend. Griffin, who is studying acoustics, enjoys solving everyday problems that come up when doing experimental research as well as the overall applications.

NewsWire



(TOP) Early SEECL student demonstrates solar cooking on a collapsible umbrella cooker. The concentrated solar radiation heated the teapot water quite effectively – and the collapsing umbrella made storage easy (mid 1950s).

(RIGHT) Prof. Erich Farber (L) demonstrates historical solar energy devices inside the "Solar House" at the UF's SEECL (2003).

Solar Energy Lab Named Heritage Site by ASME

The University of Florida's Solar Energy and Energy Conversion Laboratory (SEECL) was named a Heritage Site by the History and Heritage Program of the American Society of Mechanical Engineers-International (ASME), in 2002. A ceremony commemorating the designation was held January 31, 2003 at the SEECL in Gainesville, Florida. A bronze plaque was awarded to the SEECL from ASME.

Founded in 1954, this highly diverse research and teaching laboratory pioneered solar energy applications worldwide. Long before solar energy was considered a serious energy alternative, the laboratory was unique in developing practical solar energy devices based on established principles of thermodynamics, heat transfer, and fluid mechanics. Among its many significant technological accomplishments are advanced solar collector designs, solar-assisted HVAC systems, space power systems, breakthroughs in solar-based housing, and development of advanced materials including glazings and highly selective surfaces. Both the U.S. Department of State and the United Nations have recognized this facility for its global accomplishments in training and innovation.

Student Awards

MAE's Flexible Wing Micro Air Vehicle Wins Competition 5th Year Running

The UF MAE's flexible wing micro air vehicle team took first place for the fifith year in a row at the 6th International Micro Air Vehicle Competition and Exposition hosted by the University of Florida the weekend of March 3. This was the largest contest to date with 11 schools worldwide competing.

The UF team won the overall by placing first in the endurance competition, second in the surveillance competition, and second in the design report competition.

MAE's winning MAV team. Top row (L-R) Kyu-Ho Lee, Peter Ifju, Alex Sierra, Mark Skowronski, Carlo Francis, James Clifton, Shawn Mitryk, Scott Bowman, Lucian Speriatu, Joe Estrada. Bottom row -- Frank Boria, John Jung, Jos Cocquyt, Dan Claxton, Aaron Crespo, Mike Williams, Mujahid Abdulrahim, Roberto

Purdue Honors MAE Emeritus Professor Charles Taylor

Charles E. Taylor, MAE professor emeritus, earned an honorary doctorate and recognition for his contributions as a pioneering researcher in photoelasticity and holography, from Purdue University Saturday May 17, in West Lafayette, Indiana.

"I never expected to get this, but it was a pleasant surprise," Taylor said. "I guess I got it for my work in photoeleasticity – and my good looks," he chuckled. Taylor's wife, Nikki, recalled that "He was shocked. He thought he was going to walk up there and receive some kind of certificate, but instead it was receptions and parties, and really a royal treatment."

At both Illinois and Florida, Dr. Taylor actively researched photoelasticity, holography, and experimental mechanics, for which he received several awards. His love of academic life was contagious -- almost all of his former Ph.D. students are now professors at prestigious universities around the world, including Purdue. He has often said the greatest satisfaction in his career came from the success of his graduate students.

Dr. Taylor has been active in, and honored by, several organizations. He served as president of three of those, the Society of Experimental Mechanics, the Society of Engineering Science, and the American Academy of Mechanics and has been an associate editor for the American Society of Mechanical Engineers' journal.

In 1979, Dr. Taylor was elected to the National Academy of Engineering for his pioneering developments in three-dimensional photoelasticity and in the use of lasers and holography.

In Memoriam

'Minus 40 – Neff' Dies at 93

Long retired but fondly remembered, Professor Thomas O. Neff, Sr. died June 18, 2003. He was 93. Neff became a professor of the department of Mechanical Engineering in 1946, and was widely known to his students as "Minus 40 – Neff" for his tough grading policy. The title, Neff claimed in 1975, came from the "badmouthing" of his students who claimed he deducted 40 points from each assignment before he started to grade it.

Colleague and MAE Emeritus Professor Vernon Roan remembers Neff as a hard-working, honest guy with a big smile. "His students considered him tough but really good," Roan recalled.

Neff retired in 1975 after 30 years of teaching engineering mechanics, structures, and statics. During his tenure he taught nearly 9,000 students, sometimes finding that he'd taught two generations of engineers. "One generation isn't bad," Neff said in 1975. "It's even something of a compliment, but two generations!"

Neff continued to do consulting work in structural analysis and accident reconstruction during his retirement years. He received his bachelor's and master's degrees in Engineering at UF and began teaching there in 1946. He took over as head of mechanical graphics in 1968.

Tony Schmitz Wins Navy Grant for Precision Machining

MAE professor Tony Schmitz was awarded the 2003 Office of Naval Research (ONR) Young Investigator grant for his work in collaborating with an existing Navy project in manufacturing technology (MANTECH). Schmitz was awarded a $100,000 three-year grant to fund his continuing research project to produce a dedicated software module that Navy machinists can use.

The MANTECH project uses high speed machining to make submarine propellers, Schmitz said. "These are really big work pieces, like 6 meters in diameter, and they weigh in the order of 100,000 lbs. Right now it takes 12 months to machine one of these things, and the Navy can't make the propellers fast enough to meet its production schedule," Schmitz explained.

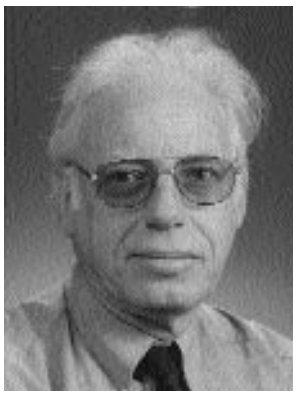
Schmitz's project involves developing a method to predict machine dynamics. The software which he will develop for this project will be used by the machinists at the Naval Foundary and Propeller Center in Philadelphia, Pennsylvania.

"What I am particularly excited about is being able to contribute to the military efforts. Right now it seems particularly relevant in today's world," Schmitz said.

Tony Schmitz attaching accelerometer to cutting tool (mounted in high-speed spindle) in preparation for frequency response measurements.

Esteemed "Old Guard" Retire

With fondness and respect the Department of MAE bid farewell to seven of our longtime faculty and staff at a retirement party April 29, 2003. A wine and cheese reception and buffet dinner honored the retirees. Their broad experience and zest for engineering provided an exciting milieu for research and education for decades. We will miss their presence and hope their retirement years are happy.



Martin A. Eisenberg
Professor Emeritus, 1966-2003
Mechanics of solids, theory of plasticity, inelastic wave propagation, computer methods of structural analysis.

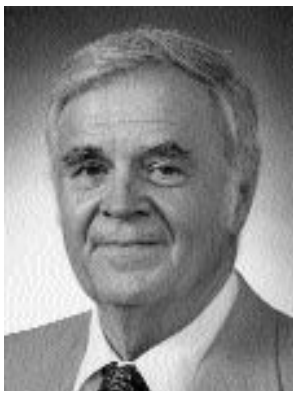
Alex E. Green
Graduate Research Professor Emeritus, 1963-2003
Radiological, atmospheric, nuclear and atomic physics, clean combustion technologies.

Gene W. Hemp *Professor Emeritus, 1967-2003*
Non-linear oscillations, applied mathematics, biomechanics, dynamic material properties.

Ulrich H. Kurzweg
Professor Emeritus, 1968-2003
Fluid mechanics, magneto-hydrodynamics, applied mathematics, heat transfer by high frequency oscillations.

Gale E. Nevill, Jr. *Professor Emeritus, 1964-2003*
Internet based design, conflict resolution in design, expert systems for conceptual design.

Howard J. Purdy
Laboratory Machinist Specialist, 1974-2003
Hands-on machine shop milling, assisting students in machining experimental devices and parts.



Vernon P. Roan, Jr.
Professor Emeritus, 1964-2003 **Fluid mechanics, gas dynamics, propulsion systems, transportation.**

Promoted Faculty

- **Lou Cattafesta** – Promoted to Associate Professor with tenure. His research interests include microelectro-mechanical systems (MEMS) for fluid mechanics, acoustic and flow control applications. The 38-year-old father of two particularly enjoys working with the graduate students. "I enjoy the educational process and seeing the students grow. When they first come they're really very timid, and then their confidence raises by the time they leave having learned a thing or two," he reflected.

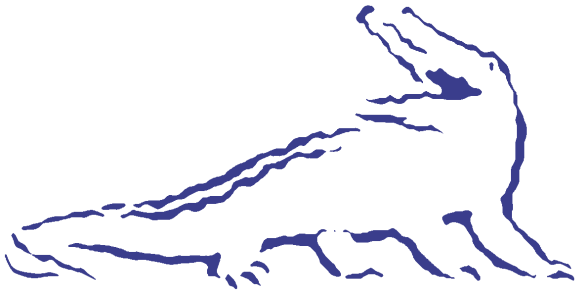
- **David W. Hahn** – Promoted to Associate Professor with tenure. He applies his expertise in laser diagnostics to emerging biomedical applications as well as traditional thermal engineering problems. The 39-year-old father of three enjoys his research into corneal ablation. "I'm really curious about learning and understanding how laser beams truly interact with tissue," he said.

- **Mark Sheplak** – Promoted to Associate Professor with tenure. His current research focuses on the design, fabrication, and characterization of high-performance, instrumentation-grade, MEMS-based sensors and actuators that enable the measurement, modeling, and control of various physical properties. The 36-year-old father of two enjoys problem solving with his students. "I really enjoy working with the students and watching them grow," he said.

Notes of Interest – Conferences MAE Has Held

- January 2003 saw MAE hosting the successful Winter 2003 American Society for Precision Engineering (ASPE) Topical Meeting, focusing on "Machines and Processes for Micro-scale and Meso-scale Fabrication, Metrology, and Assembly." Some 98 attendees from all over the world attended, including the keynote speaker Dr. Jan van Eijk of the Phillips Center for Technology in the Netherlands.

- In February 2003, MAE hosted the International Conference on Co-utilization of Domestic Fuels. The conference examined various types of energy technologies and their environmental and economic benefits. Particular attention was given to the co-use of coal with biomass in eco-friendly thermo-chemical reactors for electrical generation and waste disposal, and for production of gaseous fuels, liquid fuels, and chemicals. About 70 attendees from academia, government, and non-governmental organizations attended.



Faculty Honors

- **Carl Crane** – Elected to Fellow of the American Society of Mechanical Engineers (ASME).
- **Erich A. Farber** – Awarded the 2003 Medal of Honor from the American Biographical Institute (ABI), Raleigh, NC.
- **D. Yogi Goswami** – Elected President of the International Solar Energy Society (ISES) for 2004-2005.
- **Alex E. Green** – Appointed Chair of the Coal Biomass and Alternative Fuel Committee of the International Gas Turbine Institute of the American Society of Mechanical Engineering (IGTI/ASME).
- **S.A. Sherif** – Awarded Kuwait Prize in Applied Sciences by the State of Kuwait, as well as the Distinguished Service Award from the American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE).
- **Wei Shyy** – Awarded Pendray Aerospace Literature Award for 2003 from the American Institute of Aeronautics and Astronautics (AIAA).

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