Fall

UNIVERSITY OF FLORIDA

2007

MECHANICAL & AEROSPACE ENGINEERING

Scott Banks does ground-breaking research in biomechanics of human motion, design of joint replacements, injury mechanisms in sports and image-based motion measurement as part of dynamics, systems and control research activities. For the past ten years, he has hosted international orthopaedic surgeons and health professionals in his Orthopaedic Biomechanics Laboratory.

UF | UNIVERSITY of FLORIDA

chairman's column

The Department of Mechanical & Aerospace Engineering

Welcome to another edition of the MAE newsletter. As you can see, the look and feel of the newsletter is continuing to evolve, as we continue to experiment with our publications. We have tried to stay focused and concise and not fill page after page with text (If you are interested, you can always get more information on any of the stories covered by contacting the department). Also, the philosophy in covering the stories has been to primarily focus on the human side as opposed to technical details.

We want the newsletter to be accessible and interesting to all our friends and alumni, all of whom are pursuing diverse professions. For those who are interested in the more intricate details of all the top-notch research that goes on in the department, we now have the Mechanical and Aerospace Engineering Research Summary. Our 2006 issue presented a detailed snapshot of the impressive array of funded research in the department. We plan to continue this tradition each year, and if you are interested in getting a copy of the Research Summary, please let me know.

It is with great pleasure that I announce the selection of professors James Klausner and Greg Sawyer as our new Ebaugh Professors and professors Ghatu Subhash and David Hahn as our Millsaps Professors. They have distinguished themselves through outstanding contributions to teaching, research and service, and the professorship is our token of appreciation for their excellence and international reputations. This brings the number of endowed

and distinguished chairs and professorships in the Department to nine. A quick survey of other leading mechanical and aerospace departments in the country shows that we need to more than double this number to stay competitive. Needless to say, we have our work cut out for us in the Florida Tomorrow campaign.

For the past few years we have been the largest department in the College. Our undergraduate enrollment has been quite high; this year our undergraduate enrollment is 1,350. Last year we enacted our Graduate Admissions and Awards Policy and streamlined our recruitment and admissions process. Our hard work is paying huge dividends. The number of incoming graduate students has increased by 26 percent and our current graduate enrollment is 341, which is an all-time high. Students are our customers. They are the reason for our existence, and in this sense, our department is in an excellent position of strength.

I look at this newsletter and I see that it is deficient in one main area. There is not nearly as much Alumni News as I would like to see. I am sure there are many interesting things happening in your life, big or small – a recent award, a trip around the world, winning the lottery, etc. I issue a challenge: we will supply the faculty news for the next issue, you need to supply the alumni news. Finally, we will see which is more interesting! Check the back cover of this edition for ways to contact us. Please send in your updates and stay connected with the Gator Nation.

The final point I want to emphasize is that we have a call for nominations for the MAE Outstanding Alumnus Award. We envision several Outstanding Alumnus Awards in both young and senior categories. The award is established to recognize the budding accomplishments of young alumni under the age of 40 and the significant accomplishments of senior alumni. The deadline for nominations is January 31, 2008 and the awards will be handed out at the departmental award ceremony to be held in April. Nominations can be made on the Web at www.mae.ufl.edu/MAE-OAA.

HAPPY HOLIDAYS, AND GO GATORS,

feature article

Distinguished Guest: Dr. Julien Chouteau

For the past ten years, professor Scott Banks has hosted international orthopaedic surgeons and other health professionals, as well as research fellows, in his Orthopaedic Biomechanics Laboratory. The focus of Banks' research is "the human body in motion." While biomechanical engineering and orthopaedic surgery may seem to be unrelated, when it comes to cutting-edge research, these fields work together to solve big problems.

Dr. Julien Chouteau, a knee surgeon from Lyon, France, was a recent fellow who lived in Gainesville and worked in Banks' lab for the past year. Chouteau came to UF with the X-rays of 107 patients who had received Innex knee prostheses over the past five to 10 years. He had hoped to study the 3-D kinetics using a CAD 3-D model of the prosthesis. While at UF, Chouteau's successful research has already been published in the Journal of Biomedical Feasibility, and he has four papers already accepted for publication elsewhere.

Banks explained that different cultures have different expectations for advancement. For example, in Japan, to advance one's career as a surgeon, one is expected to complete self-supported international collaboration. A sponsoring institution or company generally supports the visiting fellows. For Banks and his UF lab, the benefit of having such a high level of collaboration with no financial burden is simply invaluable. For visiting doctors like Chouteau, the benefits of being able to perform research at a top-level university, which also happens to have a top-level university hospital only a few blocks away, are just as invaluable.

While working at UF, Chouteau was able to attend surgeries at Shands as well as the weekly MAE seminar series, featuring visiting lecturers in mechanical and aerospace engineering. He was also able to collaborate with engineering faculty and other visiting fellows (including a Belgian physical therapist, two

Japanese orthopaedic surgeons and one Japanese shoulder surgeon) to use UF's tools to develop the technical capabilities needed to complete his study and further the research of all involved.

In addition to his work, Chouteau was also pleased with his stay in Gainesville and his extracurricular travels while here in the U.S. He calls the Florida winter "perfect," and praised his host nation.

"Everything is possible in America," Chouteau said. While living in the U.S., Chouteau was able to travel to Tampa, West Palm Beach and even to Chicago to visit some colleagues. His family was also able to come from France to take in a little slice of American life.

"In one year, I had it all: quality of life and quality of work at the highest level," Chouteau said.

He also says he would highly recommend that other surgeons consider coming to UF. Banks says that this sort of "marriage" of "surgeons with problems" and "engineers with ideas for solutions" is "ground-breaking, and could literally change the world." It is the sort of collaboration that could alter the future of orthopaedics and the many people, in the U.S. and internationally, that stand to benefit from advancements in the field.

Scott Banks can be reached at banks@ufl.edu.

Julien Choueau

news

faculty

An article by professor Ghatu Subhash, "Local heating and viscosity drop during shear band evolution in bulk metallic glasses under quasistatic loading," originally published in the Journal of Applied Physics 102, 043519 (2007), was selected for the September 10, 2007 issue of the Virtual Journal of Nanoscale Science & Technology. The Virtual Journal, which is published by the American Institute of Physics and the American Physical Society in cooperation with numerous other societies and publishers, is an edited compilation of links to articles from participating publishers, covering a focused area of frontier research. The Virtual Journal can be found at www.vjnano.org

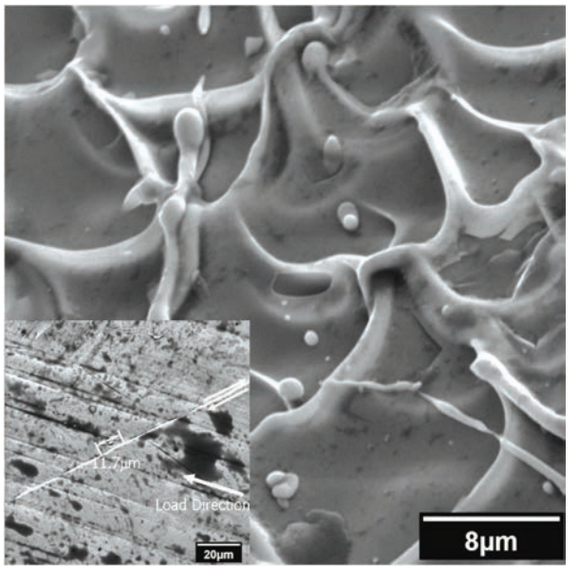


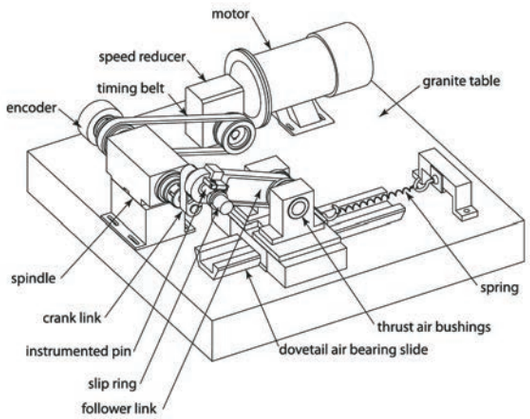
Figure 1. Formation of vein pattern and liquid-like droplets on the fracture surface of Zr57Cu15.4Ni12.6Al10Nb5. Inset displays the representative shear displacement accommodated by a shear band formed under uniaxial compression.

students

Nate Mauntler, a doctoral student supervised by W.G. Sawyer and T. Schmitz, was awarded the American Society for Precision Engineering 2007 Student Scholarship. His award included a $1,000 stipend and acknowledgement at the Society's annual meeting. Mauntler also presented a paper describing the crank-slider tribometer he designed and constructed in conjunction with professors Sawyer and Schmitz to validate the Combined Element Wear Model developed by N. H. Kim and his student Saad Mukras.

The model under investigation combines finite element techniques with a traditional wear model to iteratively update contact geometry and pressure profiles. In this case, the model is applied to an oscillating contact between a pin and bushing in the crank-slider tribometer.

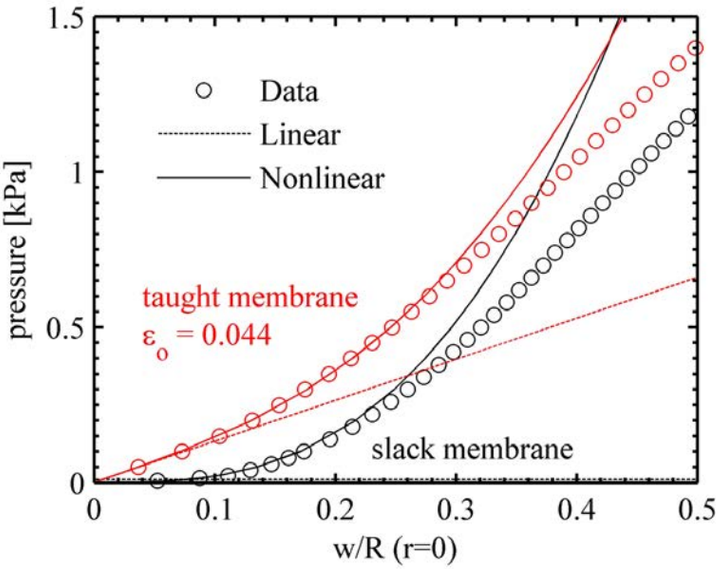
Since the model focuses on a single joint, every effort was made to limit friction, wear, and error motions in the pin-bushing joint between the crank and follower arms. This is accomplished primarily through the use of porous carbon air-bearing joints.



Additionally, the joint of interest is instrumented in order to measure the coupled evolution of wear and contact forces. The joint pin is configured with strain gauges to monitor the time dependent forces. Simultaneously, two capacitance probes track wear by measuring the position of the pin with respect to fixed points on the follower arm. The evolution of force and displacement signals are recorded during crank-slider motion and compared to the model predictions.

students

Bret Stanford, a doctoral candidate working with professor Peter Ifju, won second place in the student paper competition at the Society for Experimental Mechanics (SEM) International Conference, June 2007, in Springfield Mass. The title of the paper was "The Validity Range of Pressurized Membrane Models with Varying Fidelity".



The figure shows the out-of-plane deformation at the center of a circular latex rubber membrane sheet. The membrane is being inflated with a hydrostatic pressure. Experimental data is given, as well as the predictions from two models. Results are given for both a slack membrane and a taught membrane.

The University of Florida Human Powered Submarine (UF HPS) team is developing its second-generation submarine, Swamp Thing II, to compete in the International Submarine Races at the David Taylor Model Basin in Bethesda, Md. and the West Coast Invitational at the Offshore Model Basin in Escondido, Calif. In 2006, Swamp Thing I completed four successful runs at the 9th International Submarine Race with a top speed of 2.262 knots. This performance earned an eighth place finish in the single-person propeller-driven submarine category.

The UF HPS is an undergraduate organization comprised of students from various departments within the UF College of Engineering and the UF Warrington College of Business Administration. It is also aligned with the UF Chapter of the American Society of Mechanical Engineers. The team is guided by William Lear with the assistance of Peter Ifju and Subrata Roy.

Swamp Thing

A team of undergraduates from the student chapter of the American Institute of Aeronautics and Astronautics (AIAA) placed first at the 43rd AIAA Joint Propulsion Conference Student Design Challenge held in Dayton, Ohio. This competition was co-sponsored by the U.S. Air Force and AIAA. It involved the integration of propulsion and power systems that would enable video surveillance of a ground target while optimizing available power to both the engine and avionics. The UF team was awarded $7,000 by the organizers to fabricate their design after submitting a proposal for a formal review.

In June, the team traveled to Wright-Patterson Air Force Base to compete against other schools in both flight performance of their design, nicknamed 'Agent Orange,' and submission of a written report. The top-placing UF team and two other teams were invited to present their projects at the 43rd AIAA Joint Propulsion Conference in July. The team (shown in a photo taken at Wright-Patterson Air Force Base) was led by Patricia Miller, a senior in Mechanical and Aerospace Engineering, and included Baron Johnson, Rebecca Browning, Barry Solomon and Stephen Gildea of MAE, and Nick Karlovich and Joshua Childs of Electrical Engineering.

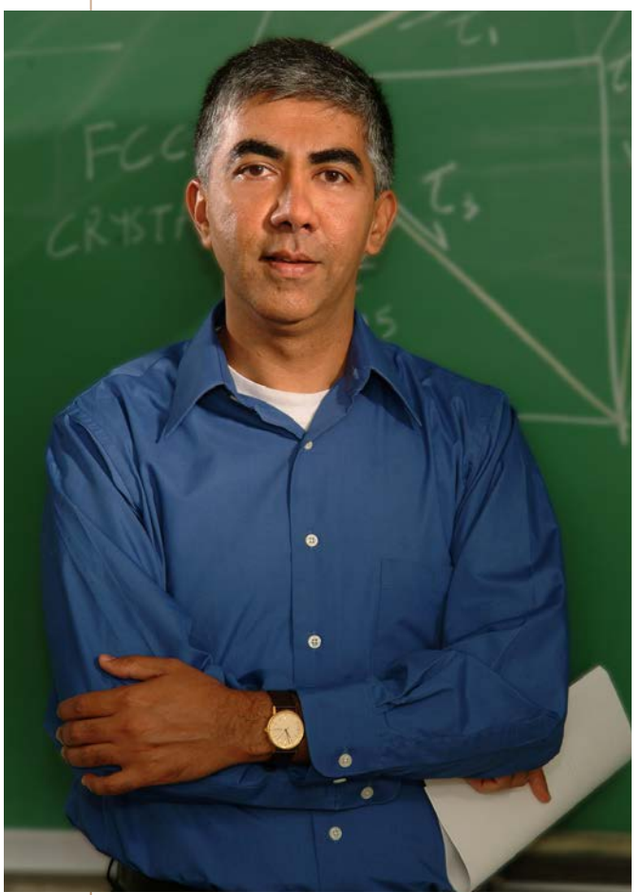
Shawn English, a doctoral student and MAE Alumni Fellow, was recently awarded the NASA Graduate Student Research Program (GSRP) fellowship by the NASA Marshall Space Flight Center. In his dissertation research, he will study failure mechanisms of metal liners in composite pressure vessels under the direction of Nagaraj Arakere.

A composite overwrapped pressure vessel (COPV) consists of a thin metallic (usually aluminum, titanium or stainless steel) inner liner wrapped with a comparatively thick composite shell, made from Kevlar or, more recently, a carbon/epoxy composite. The shell/wrap serves as the primary structural component, with the liner supporting very little load. The fracture, buckling resistance and wrap adherence of the liner become important when considering leak characteristics of the vessel. Due to safety concerns, past COPVs have been designed to support the leak before burst failure mode. Recent concern has developed due to the catastrophic effects of even a small leak in a vessel employed on a space craft in long-term, pressurized service, such as the International Space Station or future moon and Mars missions. In his studies, English will test sub-scale articles and material coupons and complete numerical analyses of these specimens. He will also explore full-scale fracture models and non-destructive evaluation techniques.

English spent this past summer at the NASA Marshall Space Flight Center where he initiated his research into the elastic-plastic fracture of surface cracks for the inner liner in COPVs slated to be used on the upper stage of the Ares I crew launch vehicle (part of NASA's constellation program). The goal of this research is the development of proof test logic and safe life evaluation for COPVs.

A rendering of the Ares I crew launch vehicle. This spacecraft, which is open for public use from NASA, is the vehicle on which English will conduct his study.

Focus on Research



NAGARAJ ARAKERE and his doctoral students, George Levesque and Nathan Branch (both UF Alumni Fellows), spent the summer at the Air Force Research Labs (AFRL), in Dayton, Ohio, addressing issues associated with hybrid ball bearing failures in the turbine engine used in the advanced F-35 Joint Strike Fighter (Figure 1).

Bearing failure is the leading cause of engine-related Class A mishaps (defined as $1 million or greater in damage or loss of life) for the Department of Defense and the second leading cause for the U.S. Air Force. During the past five years, the total cost to the Department of Defense for engine-bearing-related Class A failures was approximately $350 million. Attempts to reduce these failures have led to the development of hybrid bearings with silicon nitride balls and metal raceways made of the stainless case hardened material Pyrowear 675 (P675) with high hot hardness. Past and current bearing material programs only addressed life issues, or the time until initiation of failure due to rolling contact fatigue as shown in Figure 2. However, in military fighter aircraft engine applications, the initial raceway spall cannot be reliably detected during operation, and the time from initiation to spall propagation leading to catastrophic bearing failure can be less than 10 hours. Extending spall propagation life is especially important for single-engine military fighter aircraft such as the F-35. Data suggests that Hertzian (contact) stress, material properties and microstructure, residual compressive stress and the selection of oil additives affect the rate of failure. A bearing program to specifically

address the material and lubrication technologies for extending the time from initiation until catastrophic failure has not been previously established.

In this research project, supported by AFRL and Timken Bearings, Arakere and his students are using fracture mechanics principles and elastic-plastic finite element modeling to improve understanding of the failure of silicon nitride balls and bearing raceways due to rolling contact fatigue.

Figure 1. F-35 Joint Strike Fighter Aircraft (JSF)

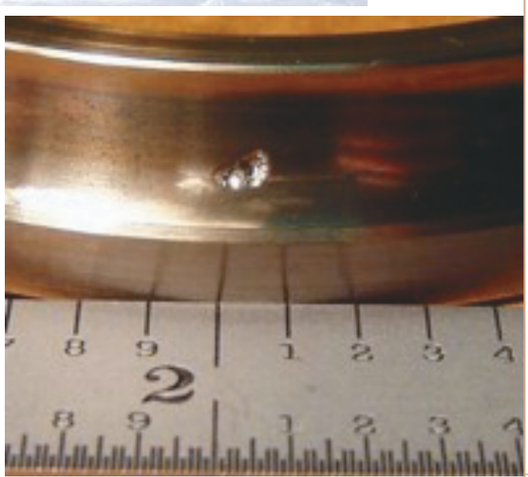


Figure 2. Initiation of fatigue in a ball bearing raceway due to RCF

Fall

Acknowledgements

2007

Department of Mechanical & Aerospace Engineering
S. Balachandar, Professor & Chair
P.O. Box 116250
Gainesville, FL 32611-6250
352.392.0961
www.mae.ufl.edu

Managing Editor	*Christine Schmitz*
Copy Editor	*Dan Treat*
Copy Editor	*Melissa Garcia*
Design	*Linda Corsair*
Photographer	*David Blankenship*

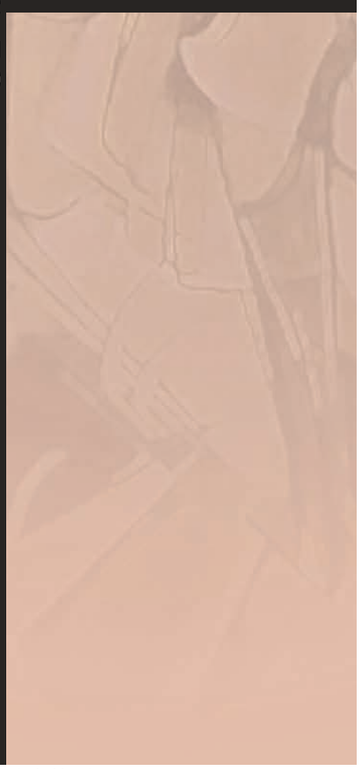
UF UNIVERSITY of FLORIDA

MAE Department Newsletter
231 MAE-A
P.O. Box 116250
Gainesville, FL 32611-6250

Non-Profit Org
US Postage
P A I D
Panama City, FL
Permit No. 230

UF UNIVERSITY of FLORIDA

MAE Department Newsletter
231 MAE-A
P.O. Box 116250
Gainesville, FL 32611-6250



Our newly designed MAE Alumni Newsletter has everything . . . except Alumni News! Please let us know where you are and what you have been doing since leaving Gainesville. Simply email us at **mae-newsletter@mae.ufl.edu** with your personal and professional updates or clip and return this form to so we can make sure to include bi-annual features and updates of our former classmates and faculty.

NAME IN FULL (INCLUDING MAIDEN NAME)

RESIDENCE ADDRESS

CITY **STATE** **ZIP** **PHONE (AREA CODE)**

YEAR OF GRADUATION **DEGREE** **MAJOR**

NEWS OF INTEREST ABOUT YOUR ACTIVITIES, RECOGNITIONS, ETC.

JOB TITLE **EMPLOYER**

BUSINESS ADDRESS

Yes, I would like to make a charitable donation to the department. Enclosed

❑ $25 ❑ $50 ❑ $100 ❑ OTHER