Oklahoma Section

Central Oklahoma Section
Mid-Continent Section

AIAA/ASME Oklahoma Symposium XXXIV

Saturday, March 29, 2014

Prince Engineering Center
Oklahoma Christian University
Oklahoma City, OK

Sponsored by

Oklahoma Section, American Institute of Aeronautics and Astronautics
Central Oklahoma Section, American Society of Mechanical Engineers
Mid-Continent Section, American Society of Mechanical Engineers

Hosted By

The Department of Mechanical Engineering
Oklahoma Christian University

Oklahoma Christian University
School of Engineering

Welcome to the **XXXIV Oklahoma AIAA/ASME Symposium** sponsored by the Oklahoma Section of the American Institute of Aeronautics and Astronautics (AIAA) and the Central Oklahoma and Mid-Continent Sections of the American Society of Mechanical Engineers (ASME).

Symposium Committee:	Dr. Bill Ryan, Chair Dr. David Cassel, Abstract Coordinator
Luncheon Keynote Speaker:	Geoff Rodman Lead Manufacturing Engineer F-35 JSF Mate Lockheed Martin

Geoff Rodman

Keynote Speaker

Geof Rodman is an Oklahoma Christian University alum with a B.S. degree in Biochemistry. His son, Josh, is a junior Mechanical Engineering major here at OC.

He worked at General Dynamics as a Manufacturing Engineer, working on the F16 Modification Programs. He was responsible for developing the tooling required to support Falcon Up, which was the multi-million dollar F16 Service Life Extension Program.

At West Coast Industries, he worked as a Project Engineer, developing tooling to extend service life of multiple aircraft hardware systems, including published research at NASA's Aging Aircraft Symposium.

As the Owner and Project Engineer for Rodman Aerospace Products, he developed a government supplier of machined products supporting multiple military hardware systems (specifically machining of Inconel and Titanium parts as well as other challenging products.)

He is currently the Lead Manufacturing Engineer for F35 EMAS at Lockheed Martin. In this capacity, he has led a major affordability initiative, resulting in cost savings of $1.6 billion over the life of the program. As culture change leader, he has developed a collaborative teaming approach between functional teams which ultimately helped reduce the Scrap, Rework, and Repair (SRR) costs by 80% over a three year span.

He is also a licensed pilot and single/multi engine A&P mechanic.

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Oklahoma City, OK 73136

Schedule

8:15-9:00	**Registration**, Coffee & Donuts		PEC Atrium
9:00-9:10	**Welcome** *Dr. Byron Newberry, Chair of Graduate Engineering / Professor of Mechanical Engineering* *Oklahoma Christian University* **Introduction** *Dr. Bill Ryan, Professor of Mechanical Engineering* *Oklahoma Christian University*		PEC 229
9:15-10:45	**Session 1**	Mechanical Design	HSH 211
	Session 2	Nanotechnology	PEC 228
	Session 3	Fluids I	HSH 212
	Session 4	Material: Properties & Testing	PEC 233
10:45-11:00	**Coffee Break**		PEC Atrium
11:00-12:30	**Session 5**	Aero-Design	HSH 211
	Session 6	Bio – Engineering	PEC 228
	Session 7	Fluids II	HSH 212
	Session 8	Materials: Manufacturing & Corrosion	PEC 233
12:30-2:00	**Luncheon** (*cost included in registration f*ee)		PEC Atrium/PEC 229

Keynote Speaker: Geof Rodman, *Lockheed Martin*

"Required Skills for the 21st Century"

Session 1 Mechanical Design – *Chair: Kevin Plumlee, OC* HSH 211

9:15 Smith, J.D., and Miller, D.P. University of Oklahoma. “Design And Modeling Of A Martian Rover Leg To Assist Sandy Slope Traverse”

9:30 Schroeder, K., Beams, M., Pease, S., & Wilson, M. Oral Roberts University - Engineering "Caseco outrigger"

9:45 Dachowicz, D. P., Sussman, A. M., Hill, J. C., Goh, C., Allen, J. K., & Mistree, F. " The Integrated Multiscale Robust Design of Materials and Products in Automobile Gears"

10:00 Leake, C., Miller, M., Whitesell, N., Winter, D., & Ryan, W. Oklahoma Christian University. "Hydro-holics senior design project."

10:15 Rodriguez, A. D., Carlile, C. M., Khosrojerdi, A., Allen, J. K., & Mistree, F. University of Oklahoma. "Developing a sustainable electric charging station for plug-in hybrid electric vehicles"

Session 2 Nanotechnology – *Chair: Fred Striz, OU* PEC 228

9:15 Webster, J., Barua, B., & Saha, M. C. University of Oklahoma. "Ultrasound synthesis of zinc oxide nanoparticles. "

9:30 Bandla, S., & Hanan, J. C. Oklahoma State University. "Dispersion Of Graphene In Polyethylene Terephthalate – Effect On Mechanical Properties"

9:45 Shabafrooz, V., Bandla, S., & Hanan, J. C. Oklahoma State University. "Forcespinning Of Polymer Nanofibers "

10:00 Cannon, N., & Hawa, T. University of Oklahoma. "Molecular Dynamics Study Of Ion And Water Permeability For Imogolite And Methyl-Functionalized Imogolite Nanotubes"

10:15 Telang, C. M., & Otanicar, T. P. The University of Tulsa. "Spectral Optical Properties Of Core Shell Spherical Nanoparticles"

10:30 Barua, B., & Saha, M. C. University of Oklahoma. "Effect Of Relative Humidity On Morphology And Mechanical Properties Of Electrospun Pan Nanofiber Yarn"

Session 3 Fluids I – *Chair: Brian Elbing, OSU* HSH 212

9:15 Zhabagina, G., Kochick, J., Mohan, R. S., & Shoham, O. University of Tulsa. "Experimental Investigation Of Dilute Crude Oil-Water Dispersions"

9:30 Najmi, K., Delavan, M., McLaury, B. S., Shirazi, S. A., Cremaschi, S. University of Tulsa. "Low Concentration Sand Transport In Single Phase (Liquid) Horizontal Pipes With Emphasis On Viscosity Effect"

9:45 Adebayo, A.E., Sallam, K.A., Oklahoma State University. "Secondary Breakup Effects On Fuel Atomization In Crossflow"

10:00 Padsalgikar, A., Mohan, R., & Shoham, O. University of Tulsa. "Interfacial Wave Characteristics And Interaction In High Density Gas And Liquid Stratified Flow"

10:15 Wilson, J., & Gramoll, K., University of Oklahoma. "Viscous Fluid Dynamics Simulator for Mobile Devices Using a Remote High Performance Cluster"

10:30 Nguyen, H., Wang, S., Mohan, R., & Shoham, O. University of Tulsa "Mechanistic Modeling of Droplet Deposition and Coalescence in Long Elbow Bend"

Session 4 **Material: Properties & Testing – *Chair: Kashif Nawaz, OU*** **PEC 233**

9:15 Whetsell, J., Liang, J., Saha, M., & Altan, M. University of Oklahoma. "Effects Of Sizing On Thermal Conductivity Of Individual Carbon Fiber In Longitudinal And Radial Directions"

9:30 Jayakumar, B., & Hanan, J. Oklahoma State University. "Novel Honeycombs With Higher Axial Compressive Strength"

9:45 Brunner, J., Dixon, A., Estabrook, K., & Plumlee, K. Oklahoma Christian University. "Dual-Axis Tribometer Design And Assembly"

~~10:00 Zhao, T., University of Tulsa. "Studies on Incremental Step Test"~~

10:15 Liang, J., Saha, M., & Altan, M., University of Oklahoma. "Application Of 3ω Method On The Measurement Of Transverse Thermal Conductivity Of Individual Carbon Fiber"

Session 5 Aero-Design – *Chair: Arvind Santhanakrishnan, OSU* HSH 211

11:00 Hekiri, H., Emanuel, G., & Striz, A. University of Oklahoma. "Scramjet Diffuser Analysis"

11:15 Santhanakrishnan, A. Oklahoma State University. "Aerodynamics Of Wing-Wing Interaction In The Flight Of Tiny Insects"

11:30 Erickson, C. & Striz, A. University of Oklahoma "Analysis Of Klein-Fogleman Airfoil"

11:45 Timoshenko, D., Olsson, A., Wheeler, J., & Sugiyama, J. Oral Roberts University. "Remote Operated Quadrotor Uav"

12:00 Erickson, C. & Striz, A. University of Oklahoma. "Design Of Modular Unmanned Aerial System (M-Uas) For Wildfire Reconnaissance And Post-Fire Damage Assessment"

12:15 Nevrekar, A., Striz, A., & Vedula, P. University of Oklahoma "Optimal Climb Performance Of A Supersonic Aircraft"

Session 6 Bio-Engineering – *Chair: Curtis Vickery* PEC 228

11:00 Wood, D. & Plumlee, K. Oklahoma Christian University "Ripple Formation And Wear In Ultra-High Molecular Weight Polyethylene, A Finite Element And Experimental Approach"

11:15 Buck, T., Mayo, J., Bastola, K., & Vaidyanathan, R. Oklahoma State University. "Polymerization of Polymers for Reusable Health Products"

11:30 Frias, J., Marshall, A., Fabrie, C., O'Hara, C. & Ryan, W. Oklahoma Christian University. "The Edisons"

11:45 Kreis, R., Krause, J., & Tryon, T. Oral Roberts University. "Ares For Leg Enhancement"

12:00 Fitzgerald, J., Swokolo, C. & Valderrama, E. Oral Roberts University. "Synthesis And Utilization Of Nanoparticles For Use In The Medical Field"

Session 7 Fluids II – *Chair: Ed Reynolds* HSH 212

11:00 Nawaz, K. & Jacobi, A. University of Illinois. "Pressure drop through pororus media (Metal foams, carbon foams, wire meshes)-A comparative study"

11:15 Nababan, A., Mohan, R., & Shoham, O. University of Tulsa. "Foam Break-Up In Cfc/Glcc© System"

11:30 Daniel, L. & Elbing, B. Oklahoma State University. "Development Of A High-Reynolds Experimental Fluid Mechanics Laboratory"

11:45 Subramaniam, J., Shoham, O., & Mohan, R. University of Tulsa. "Scale-Up Study Of Gas-Liquid Two-Phase Flow In Downcomers"

12:00 Molayari, A., Mohan, R., & Shoham, O. University of Tulsa. "Design And Performance Of

Balanced Feed Manifold (Bfm)"

12:15 Ogunsola, O. & Song, L. University of Oklahoma. "Investigation Of Building Passive Thermal Storage For Optimal Heating System Design"

Session 8 Materials: Manufacturing & Corrosion – *Chair: Sudheer Bandla, OSU* PEC 233

11:00 Baghernejad, L., Iski, E., Appathurai, S., & Odeuyungbo, S. University of Tulsa. "Production Of Electrospun, Cellulosic Nano-Materials And Their Applications In Oil Industry"

11:15 Dunagan, D., Cruz, A., & Seigel, A. Oral Roberts University. "Improving The Manufacturing Process Of A Heat Induction Tube Bending Machine"

11:30 Meduri, C., Jayakumar, B., & Hanan, J. Oklahoma State University. "Effect Of Corrosion On Mechanical Properties Of Amorphous Fe45Ni45Mo7B3 Ribbons"

11:45 Hall, A., Roberts, K., Shirazi, S., Keller, M., Rybicki, E., & Shadley, J. University of Tulsa. "Validation of New Test Facility for Erosion-Corrosion Inhibition Prediction"

12:00 Arabnejad, H., Shirazi, S., & McLaury, B. University of Tulsa. "Effect of Particle Hardness on the Erosion of Stainless Steel"

Lunch and Keynote Address

12:30 – 2:00 **Mr. Geof Rodman, *Lockheed-Martin***

Geof Rodman is Oklahoma Christian University alum with a B.S. degree in Biochemistry. His son, Josh, is a junior Mechanical Engineering major here at OC.

He worked at General Dynamics as a Manufacturing Engineer, working on the F16 Modification Programs. He was responsible for developing the tooling required to support Falcon Up, which was the multi-million dollar F16 Service Life Extension Program.

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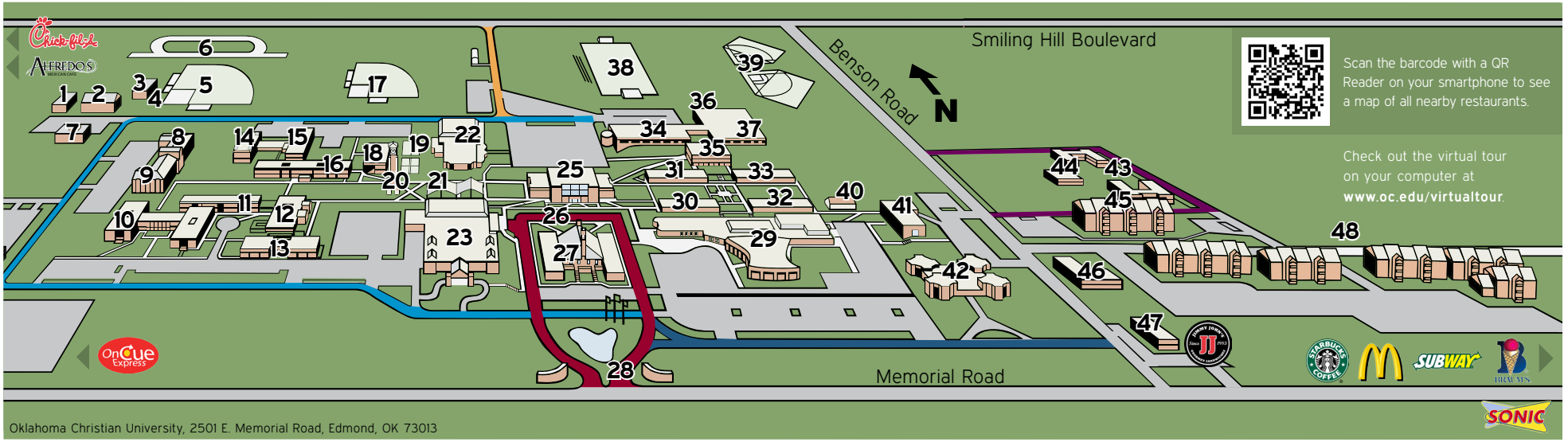
He is also a licensed pilot and single/multi engine A&P mechanic.

CAMPUS MAP

OKLAHOMA CHRISTIAN UNIVERSITY



ACADEMICS

35 Davisson American Heritage Building
- Dept. of History & Political Science
- Dept. of Psychology & Family Studies
- School of Education

40 Dept. of Nursing

29 Garvey Center
- Dept. of Art & Design
- Dept. of Communication
- Dept. of Music

41 Harvey Business Center
- Graduate School of Business
- School of Business Administration

37 Herold Science Hall
- Dept. of Biology
- Dept. of Chemistry & Physics

25 Mabee Learning Center

First Floor
- Beam Library
- Honors Program

Second Floor
- Archives
- College of Arts & Sciences
- Dept. of Language & Literature

Third Floor
- Children's Library
- Library Research
- North Institute

36 Noble Science Wing
- Kim Gaither Center for Biology

34 Prince Engineering Center
- Graduate School of Engineering
- School of Engineering

33 Vose Hall / Mabee Laboratories

27 Williams-Branch Center for Biblical Studies
- College of Biblical Studies
- Center for Global Missions
- Graduate School of Theology
- Intergenerational Faith Center
- Scott Chapel

ADMINISTRATION / OFFICES

30 Benson Hall / Johnson Executive Suites
- President & Executive Offices

32 Cogswell-Alexander Hall
- Bridge Program
- Help Desk
- Information Technology Services
- Registrar

42 Enterprise Square
- Advancement
- Alumni
- Church Relations

29 Garvey Center
- Box Office
- Events Management
- Phillips Welcome Center

31 Gaylord Hall
- Admissions (2nd Floor)
- Student Financial Services (1st Floor)
- Telecounseling (2nd Floor)

46 Heritage Plaza
- Business Office
- Human Resources
- International Programs

47 Heritage Village
- Campus Police
- The Christian Chronicle
- Residence Life
- University Services

25 Mabee Learning Center

Second Floor
- Career Services
- Disability Services
- Marketing & Communications
- Spiritual Life
- Student Success

ATHLETICS

3 Bobby Murcer Indoor Training Facility
2 David Smith Athletic Center (The Barn)
5 Dobson Baseball Field
39 Jackson Family Intramural Fields
4 MidFirst Plaza
22 Payne Athletic Center / Eagles' Nest
- Dept. of Athletics
- Dept. of Physical Education
- Fitness Center / Swimming Pool

38 Soccer Field
19 Tennis Courts - Sand Volleyball
17 Lawson Softball Complex / Heath Field
6 Vaughn Track

STUDENT SERVICES & HANGOUTS

23 Gaylord University Center
- Bookstore
- Counseling Center
- Mail Center
- Student Government Association
- Student Life
- University Dining
- Wellness Center / Team OC

44 Nowlin Center

LIVING QUARTERS

14 Fails Hall
10 Gunn-Henderson Hall
13 Honors House at Davisson Hall
45 McNally House Phase 5
12 Tinius Hall East
11 Tinius Hall West
8 University House North
9 University House South
43 University Village Phases 3, 4
48 University Village Phase 6
15 Warlick Hall
18 Wilson Hall East
16 Wilson Hall West

UNIVERSITY VENUES & LANDMARKS

20 Freede Centennial Tower
29 Garvey Center
- Hardeman Auditorium
- Judd Theatre / Adams Recital Hall
- McIntosh Conservatory / Box Office

23 Gaylord University Center
- Gaylord Dining Room
- Gotcher Dining Room

21 Lawson Commons / McGraw Pavilion
26 Thelma Gaylord Forum
27 Williams-Branch Center for Biblical Studies
- Scott Chapel

OTHER

7 Central Plant
28 Main Entrance
1 Physical Plant Services

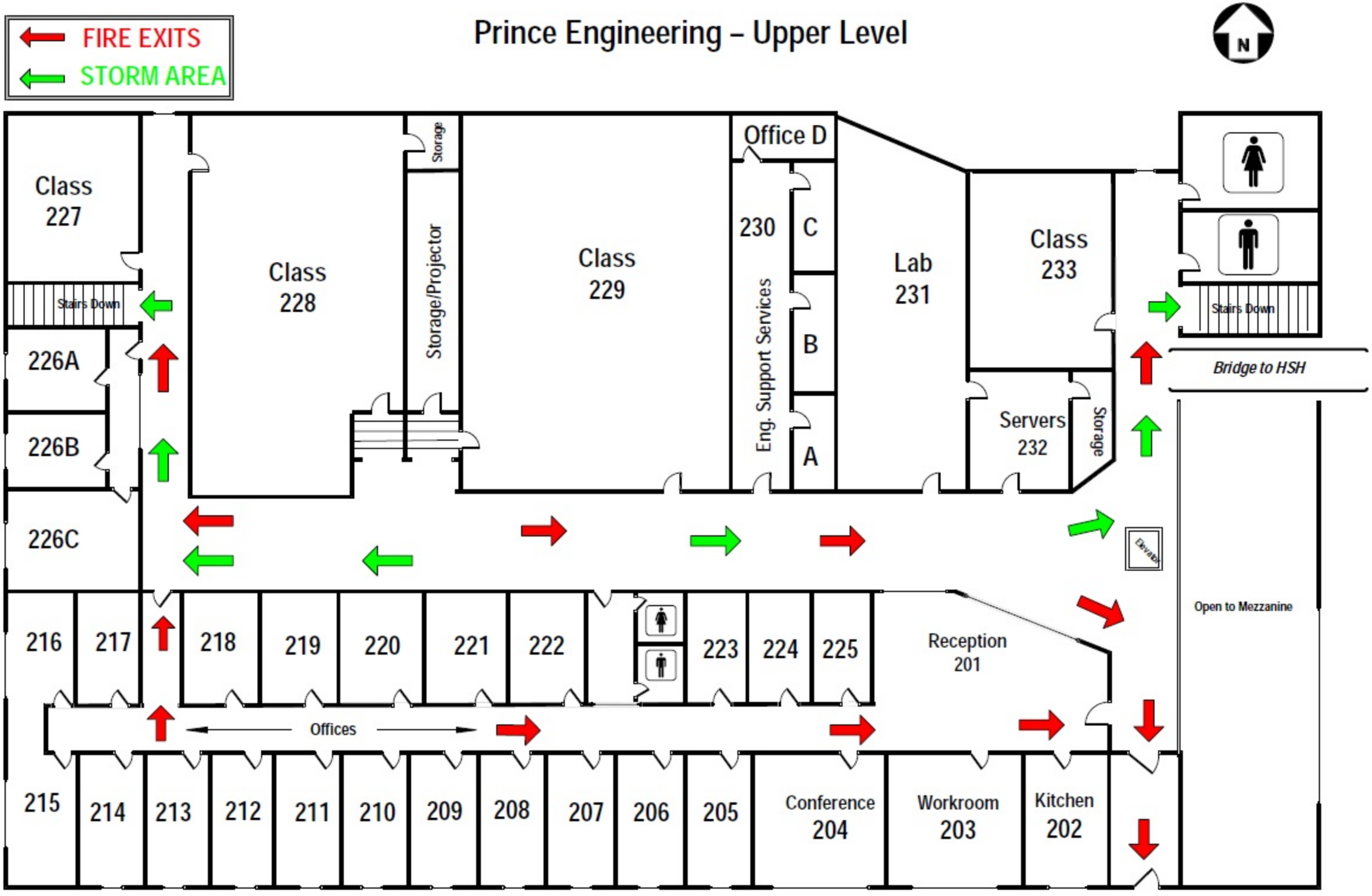
STREET NAMES

LR Wilson Way	
Baird Loop	
Johnson Lane	
Jacobs Court	
O'Neal Avenue	

'EAGLE BUCKS' ACCEPTED AT THE LOCATIONS HIGHLIGHTED ABOVE

Alfredo's Mexican Cafe
Chick-fil-a
Jimmy John's
OnCue Express

Prince Engineering – Upper Level



July 2013

Session 1

Mechanical Design

Chair: Kevin Plumlee, OC

HSH 211

DESIGN AND MODELING OF A MARTIAN ROVER LEG TO ASSIST SANDY SLOPE TRAVERSE

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ABSTRACT

Mars rover Solar Rover 2 is designed to perform on mission similar to the now hibernating Spirit rover. The Spirit rover is currently stuck in Martian regolith and is not receiving enough sun irradiation to its solar panels for communication with earth. Stuck at 12 degree angle, Spirit also has broken wheel. An articulating leg will provide a means by which it can move itself from the current position. This project recommends a hybrid mobility system that utilizes both legged and wheeled locomotion. The four wheels of the rover provide the primary method of locomotion, while the leg acts as an assistive device in overcoming sandy inclined slopes. We address the modeling and analysis of the rover's hybrid mobility system with focus on the action of a two-degree-of-freedom assistive leg. The leg utilizes active actuation in its axial direction, but is otherwise passive. The leg has two degrees of freedom, and twelve inches of actuation. The actuator may assist traverse in two methods: either in motion at a rate similar to the wheel locomotive rate, or to elevate the lower portion of the rover to change the free-body force values for traction. The actuator selection criteria is stated and evaluated. Model and simulation results for the prototype are presented for demonstration and evaluation.

* This work has been under the tutelage of Dr. David Miller
** Member, AIAA and ASME

CASECO OUTRIGGER

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ABSTRACT

The purpose of this project is to design a heavy-duty outrigger for the CASECO Truck Company*. The current outrigger that CASECO is using is failing when technicians lift over the maximum load with the crane, bending the support. This creates two problems, including a safety hazard and after the outrigger is bent it cannot be stored properly into the casing on the truck. The outrigger will fit within our space restraints, width-96" and ground clearance 11", and tie into our body support structure. The outrigger will be deployable. The outrigger will support a specified load with a reasonable safety factor. The outrigger will provide the truck with stability when in use and withstand total weight approx. 20,000 lbs. The outrigger that will be designed will also be manufactured and sold on the current CASECO bodies.

The design that we have worked on is a hydraulically operated outrigger that will lower and deploy itself to the ground at several different angles. The outrigger will also be able to retract and store itself when the job is complete. Another factor of the outrigger is it will be able to hold a 12000 lb. load directly on the outrigger with a factor of safety of 2.

* This work has been supported by CASECO Truck Company.
** Member of ASME

AIAA/ASME Symposium 2014

The Integrated Multiscale Robust Design of Materials and Products in Automobile Gears

Adam P. Dachowicz, Marli M. Sussmann, James C. Hill, Chung-Hyun Goh, Janet K. Allen, and Farrokh Mistree

Abstract

In a conventional design approach, system designer inductively achieved the performance of the system requirements by selecting existing materials. However, it is not easy to find suitable materials from the material database. The system designer cannot come up with this difficulty from the material selection. On the other hand, the material scientist has focused on developing new materials to improve mechanical strength regardless of the customer's aspirations. It is shown that there is an interface between the products design and the materials design. Therefore, the integrated design of materials and products has been introduced to overcome this gap interface between system designers and material scientists.

In this presentation, the integrated design of materials and products is applied to automotive gears as a demonstration problem. A transmission gear is generally produced by a sequence of several processes from steelmaking to final machining and surface treatment. The manufacturing processes play a significant role in determining the mechanical properties and fatigue strength of gears. Therefore, these manufacturing processes should be carefully considered in determining the performance and property of the end product.

The integrated multiscale robust design approach using the Inductive Design Exploration Method (IDEM) is implemented to improve robustness by determining the tradeoff between performance and quality in gear design and manufacturing. The four pass roll design, which consists of oval and round grooves, is used to simulate the hot bar rolling process. The microstructure evolution, flow stress, and wear prediction models are implemented in the analysis model to account for the process-structure relationship in each roll pass. Using the relationship of processing-structure-property-performance, the concurrent design of material and product can be accomplished over multiple length scales.

Key Words: Integrated Design, Inductive Design Exploration Method, Processing-Structure-Property-Performance

HYDRO-HOLICS SENIOR DESIGN PROJECT

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ABSTRACT

A donated hydraulic press was refurbished from a non-functional state, in order to prepare it for an automation process. This automation process was programed using LABview, and it will take data from three sensors, a Linear Variable Differential Transformer (LVDT), a digital pressure gage, and a load cell. Three programs were created from LABview that will perform tensile, and compression testing, as well as stamping. Calibration was done according to each sensors manuals, and then by using $1/4$" diameter tensile testing pieces, 10 in the hydraulic press, and 10 in a professionally calibrated tensile test machine. Compression testing was done on concrete specimens using Fast-Setting Quickrete®. The specimens were 4” in diameter by 8.8” in length, and were cured for 2hrs, 24hrs, and 7 days. Finally, A design of stamping was tested to form an aluminum cup measuring 1.5” in diameter by 1.5” in height. The completed project will be integrated into Manufacturing Processes, an Oklahoma Christian University undergraduate class, that teaches Mechanical Engineering students how to work with machines and tools that one might encounter in a professional manufacturing environment.

AIAA/ASME Symposium 2014

DEVELOPING A SUSTAINABLE ELECTRIC CHARGING STATION FOR PLUG-IN HYBRID ELECTRIC VEHICLES

Alexander D. Rodriguez, Casey M. Carlile, Amirhossein Khosrojerdi, Janet K. Allen, Farrokh Mistree

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ABSTRACT

Studies suggest that a structural transformation like the shift from oil based vehicles to electric is, with today's technology, the most feasible step for decreasing greenhouse gas emissions and for the independence from oil. A main deterrent for the massification of plug-in hybrid electric vehicles (PHEVs) is the lack of infrastructure for a quality service of charging. Some solutions have been developed for this problem, however, few address all aspects of sustainability: social, economic and environmental. For designing a sustainable charging station, we are considering three objectives named as maximizing service level (social acpect), minimizing developmenet cost (economic aspect) and minimizing gass emision (environmental spect). Our proposed model consists of a simulation model to project different charging behaviors by PHEV drivers at stations and a surrogate model to project the service level model. The simulatin model is developed based on discrete event simulation modeling for different design alternatives. The surrogate model is developed based on Multivariate Adaptive Regression Splines (MARS) which is used to estimate the level of service at charging stations for different design scenarios based on the results of the simulation model. Focus is given in justification of the approach, a recommendable procedure to create, validate and choose the model, and results. The results of the metamodel are significantly important for exploring the design space using Ternary Plots.

Keywords: Sustainable design, simulation model, surrogate model, plug-in hybrid electric vehicle.

Session 2

Nanotechnology

Chair: Fred Striz, OU

PEC 228

ULTRASOUND SYNTHESIS OF ZINC OXIDE NANOPARTICLES

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ABSTRACT

Nanoparticle research has become a popular field as some consider the potential of nanotechnology to be the next great breakthrough in materials science. This great potential for nanoparticles research comes from their high surface area and morphologies that influence their unique properties such as improved optical characteristics and electrical properties. Zinc Oxide (ZnO) nanoparticles have various applications in a wide variety of fields such as hydrogen fuel cell technology, cancer treatment, antibacterial treatment, and energy storage applications. The use of ultrasonic energy has a lot of potential in the synthesis of nanoparticles as it may allow control of particle nucleation, a decrease in particle growth, and possibly lead to synthesis of preferred morphologies resulting in particles with higher surface area.

This study highlights two types of ultrasound synthesis method such as tip sonication and ultrasonic atomization for ZnO nanoparticles. Both synthesis processes use a chemical reaction between Potassium Hydroxide and Zinc Chloride solutions to synthesize ZnO nanoparticles. The tip sonication synthesis method involves the injection of the individual precursor solutions into deionized water in a controlled reaction environment where the ultrasonic energy is applied. Whereas, the ultrasonic atomization synthesis process involves introduction of ultrasonic energy to the precursor solutions as they travel through an atomizer probe which produces a mist of the two reacting solutions that settle on a substrate below. It is expected that the nucleation and growth rates will be affected differently due to the application of ultrasonic energy. The investigation focuses on the application of ultrasonic energy and the relationships of particle size and morphology of ZnO nanoparticles with respect to process variables such as reaction temperature, ultrasonic energy input, reaction concentration, reactant injection method, and atomization conditions.

* This work has been partly supported by the CoE SEED Program
** Member, ASME

DISPERSION OF GRAPHENE IN POLYETHYLENE TEREPHTHALATE – EFFECT ON MECHANICAL PROPERTIES

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ABSTRACT

Polymer nanocomposites are known for their superior properties compared to conventional composites. Nanoscale reinforcements are advantageous over micro-reinforcements because of their higher aspect ratios and fewer defects. Graphene is a single layer of carbon atoms with a two-dimensional honeycomb lattice. With several unique characteristics, it is the most sought out reinforcement for preparing nanocomposites. With high surface energy, graphene tends to agglomerate and form aggregates in the polymer matrix, making it difficult to realize its advantage. Recognizing the importance of achieving a dispersed state for success of graphene nanocomposites, dispersion of graphene into polyethylene terephthalate (PET) matrix was investigated. Graphene nanoplatelets (GNP) of 5 μm diameter and 15 nm thickness were used in this work. Acoustic mixing, Twin-screw mixing, Ultrasonic assisted twin-screw mixing, and Forcespinning were used for dispersing GNP into PET. Microscopy and X-Ray techniques were used to study dispersion. PET-GNP nanocomposites obtained from injection molding of the compounded material showed an improvement in the Young's modulus, tensile strength, and toughness. Forcespinning approach showed better dispersion.

[*]Student member of ASME
[#]Member of ASME
This work has been supported by Niagara Bottling LLC.

FORCESPINNING OF POLYMER NANOFIBERS

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ABSTRACT

Recently, there has been a remarkable increase in the research on polymeric nanofibers which are promising candidates for various applications such as tissue engineering applications, drug delivery, wound healing, technical textiles and protective clothing, filtration, bio sensors, and energy storage materials. Over the years, several techniques such as electrospinning (solution and melt), self-assembly, phase-separation, template synthesis, and Forcespinning (solution and melt) were investigated for nanofiber production. In the current research, Forcespinning was adapted for making polymer nanofibers. Forcespinning provides advantages like high throughput, choice of materials and simple operation, over conventional techniques for making nanofibers. Using Forcespinning, nanofiber formation for polyethylene terephthalate (PET) along with the process scalability was studied. With the fiber formation based on centrifugal action, material temperature (or concentration) and spinneret rotational speed were found to be the primary process parameters for melt (or solution) spinning. Fiber diameters achieved through Forcespinning were compared with PET fibers made using different processes. Also fiber diameters and throughput using Forcespinning for different polymers was compared. Overall, processing of nanofibers through Forcespinning has the potential to become a promising candidate for various applications.

[*] Student member of ASME
[†] Member of ASME

Molecular Dynamics Study of Ion and Water Permeability for Imogolite and Methyl-Functionalized Imogolite Nanotubes

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Nanotubes have been considered as possible water filters. Their small size means that they can be very selective, but furthermore, it has been found that the amount of energy that would be required to force water through them would be much less than conventional methods. The imogolite nanotube is small enough to be used as a water filter and is the object of this study. The investigation was performed using molecular dynamics simulations with the LAMMPS package. A model of the nanotube was made using the CLAYFF energy potential. A different model was made to mimic the properties of the carbon nanotube. In this model the hydroxyl groups that line the inner surface of the imogolite nanotube were replaced by methyl groups. To model this modified imogolite nanotube the CLAYFF energy potential was combined with the CVFF energy potential.

The focus of this study was the interaction of nanotubes with water and dissolved ions in the water. The model of water that was used was the SPC\e model, and all ions were simulated as point charges with Van der Waals interactions. Water flow was achieved in the simulations by applying an external acceleration directly to water atoms. The average velocity of the water inside a nanotube was measured over a 9ns simulation. The ratio of this to the velocity expected from the no-slip assumption in continuum mechanics theory gives the enhancement factor. The unmodified imogolite nanotube was measured to have an enhancement factor of 0.9; while the methyl functionalized imogolite nanotube had an enhancement factor of 4.5.

To study the ion filtering effectiveness of the nanotubes, the potential of mean force acting on an ion was determined. For the natural imogolite nanotube, the potential of mean force acting on a chlorine ion and a sodium ion was collected. The potential of mean force indicates that the negatively charged chlorine ion would be selected against whereas the sodium ion would be freely able to pass through the nanotube. Further simulations remain to be done for the methyl functionalized imogolite nanotube as well as other types of ions.

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SPECTRAL OPTICAL PROPERTIES OF CORE SHELL SPHERICAL NANOPARTICLES

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ABSTRACT

Core-shell nanoparticles are widely studied due to the unique optical properties that arise due to surface Plasmon resonance and have been proposed for use in various applications from solar energy harvesting, to bio sensing to photo thermal tumor therapy. While chemical synthesis Methods have resulted in shells with full coverage, it is possible during the shell growth process to create shells with only partial coverage.

The primary objective of this paper is to analyze how partial coverage of gold nanoparticles used to grow a gold shell affect the optical properties of the overall particle. This is accomplished by Modeling the geometry comprising gold nanoparticles used to build the shell and the dielectric Polymer core, and solving the FEM model on COMSOL. A variety of partial coverage geometries are considered including different size cores, shell seed growth particle size, area coverage ratio, non-uniform and uniform partial coverage. This study shall help us design particles that would exhibit better optical properties and thereby accomplish model with enhanced heat transfer. The applications can be found in a number of areas ranging from Photo votaic systems to phase changing materials and biomedical applications.

This work has been supported by NSF
Member, ASME.

EFFECT OF RELATIVE HUMIDITY ON MORPHOLOGY AND MECHANICAL PROPERTIES OF ELECTROSPUN PAN NANOFIBER YARN

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ABSTRACT

Electrospinning is a straight forward and cost effective technique to produce long, well aligned and random oriented polymeric nanofibers. Electrospun polyacrylonitrile (PAN) nanofibers can be converted to carbon nanofibers (CNFs) by subsequent heat treatment. CNFs are currently being explored as potential candidate materials in many applications including thermal management, composite reinforcements, rechargeable batteries, and supercapacitors. A few important characteristics of CNFs in these applications include surface area, morphology and mechanical properties. In this study, we investigate how humidity during electrospinning influences these specific properties of PAN nanofiber yarn.

PAN nanofiber yarns are made by electrospinning of 10% PAN in N,N-Dimethylformamide (DMF) solution in a closed chamber, at 18±1°C, by applying 15kV across 18cm gap between the needle and a rotating drum collector. The relative humidity (RH) is varied from 12% to 60%. SEM images show that increasing the RH causes increase in diameter of the nanofibers. The surfaces of the nanofibers are found to be very smooth at low humidity (12% and 22% RH). Rough surfaces are evident at higher humidity (30% RH) and the surface roughness increases with increasing RH. These morphologies are caused by complex interactions among moisture, DMF, and PAN polymer. The tensile tests reveal that the PAN nanofiber yarns made at 22% RH exhibits the highest tensile strength and fracture toughness. The nanofiber yarns exhibit the lowest tensile properties at 60% RH due to excessive surface defects present on the nanofiber surface.

** Member, ASME

Session 3

Fluids I

Chair: Brian Elbing, OSU

HSH 212

EXPERIMENTAL INVESTIGATION OF DILUTE CRUDE OIL-WATER DISPERSIONS[1]

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ABSTRACT

Dilute crude oil-water dispersions (dispersed phase fractions < 25%) created at different operating parameters such as water-cuts, mixture velocities, salinity (NaCl concentrations), orifice plate β-ratios and choke pressures are investigated using a state-of-art Dispersion Characterization Rig (DCR). While there is considerable data on how each of this parameter separately affects emulsion stability, there is few data on the contrasting effects of parameters collectively. The study showed that water-cut has the most significant impact on emulsion separation, namely, higher water-cut promotes faster emulsion separation. For oil-continuous emulsions (up to 25% WC), formation of mousse emulsion was observed with no free-water separation even after 24 hours of aging. Water-continuous emulsions (with 85% WC and up) did not show any sign of mousse emulsion formation and separated very efficiently. Addition of NaCl highly improves emulsion separation, decreasing the effects of increased shear rate (higher choke pressure differential and smaller orifice plate β-ratio).

Fundamental study on how salinity and droplet size affect the coalescence time of an oil droplet is conducted with a Coalescence Time Measurement facility. Coalescence time of a droplet is determined from the moment the droplet touches the interface to the moment it coalesces. Distilled water, sodium chloride of Grade A and crude oil, "Dubie" were also used in these experiments. The results showed that the larger diameter droplets have longer lifetime at oil-water/brine interface. Addition of salt impacted droplet lifetime by significantly reducing it. Interfacial tensions (IFT) of crude oils ("Masala" and "Dubie") were examined with the pendant drop tensiometer and were analyzed in terms of molecular adsorption on the oil-water interface with addition of NaCl. The increase of NaCl concentration promotes higher adsorption decreasing IFT.

[1] These activities are supported by Chevron Tulsa University Center of Research Excellence (TU-CoRE)
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LOW CONCENTRATION SAND TRANSPORT IN SINGLE PHASE (LIQUID) HORIZONTAL PIPES WITH EMPHASIS ON VISCOSITY EFFECT

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ABSTRACT

Particle transportation has been an area of much research for many years. Different industries are interested in transporting particles through or out of their respective flow lines. The particles may be a vital component of the process or an unwanted by-product. In either case, care should be taken for proper transport. On the other hand, in real applications especially in the oil and gas industry, particles may be in flows with high viscosity components. In many industrial applications such as oil and gas, pharmaceutical, food, chemical and painting, geology etc. it is very common to have solid particles flowing in the presence of a viscous fluid. So finding a minimum velocity for such systems is crucial. In spite of the industrial importance, there is a limited number of studies considering particle transport in viscous systems. A reason for this limited number of studies may be the complexity of the phenomena. Increasing viscosity on one hand promotes particle transport by increasing drag force which is applied on the particles. On the other hand, it resists particle transport by damping turbulent eddies and increasing viscous sub-layer thickness. Maybe that's why contradictory conclusions have been reported in the literature considering the effect of viscosity on particle transport. The velocity that is needed to transport particles is referred to by most researchers as the critical velocity. However, this velocity has been defined in different ways. In this study, critical velocity is the minimum velocity to keep particles moving continuously in the pipe. The main objective of this study is to experimentally investigate the effect of different physical parameters such as particle concentration, particle size, particle shape and carrier fluid viscosity on particle transport in liquid flow. The obtained data is compared with some available data in the literature and finally the effect of viscous sub-layer thickness on critical velocity is investigated.

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SECONDARY BREAKUP EFFECTS ON FUEL ATOMIZATION IN CROSSFLOW

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ABSTRACT

An investigation of the spray characteristics of an aerated fuel injector in subsonic crossflow is described. Test conditions include injector diameter of 0.04 inch, momentum flux ratio of 5, crossflow Mach numbers of 0.3, and Gas-to-liquid ratio of 8%. Double-pulsed digital holography was used to investigate the spray characteristics. The holograms are analyzed using image-processing algorithms to yield information about the drop sizes and numbers at downstream distances of 50, and 100 jet diameters. Different drop size distributions are tested and compared including Rosin-Rammler distribution, log-normal distribution, and Simmons' universal root-normal distribution. The results show that log-normal distribution and Simmons' universal root-normal distributions performed better than the others. The drop number densities are analyzed to yield information about the effects of secondary breakup processes on the spray characteristics in the spray far field.

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INTERFACIAL WAVE CHARACTERISTICS AND INTERACTION IN HIGH DENSITY GAS AND LIQUID STRATIFIED FLOW[1]

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ABSTRACT

Prediction of the fluid flow behavior based on easily measurable parameters like pressure drop is essential for oil and gas pipeline design. Initial work was done by Sanchis et al. (2011) on an air water system. The current work extends this to a higher pressure system by introducing SF6 gas to increase the density and extending the fluid viscosity from 33 cP to 120 cP. Experiments were conducted to study the waves formed at the interface in a stratified flow pattern. This work investigates the effect of gas density and fluid viscosity on structures at the gas liquid interface in a stratified wavy flow. The effect of both these parameters on wave height, length and celerity were experimentally studied and the results will be discussed and compared with the previous air - water study.

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Viscous Fluid Dynamics Simulator for Mobile Devices Using a Remote High Performance Cluster

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ABSTRACT

With the increase use of tablets and smartphones as the primary internet access method, there is a need to move engineering content and simulation tools to mobile devices, particularly for education. These tasks range from watching recorded lectures, reading online notes, or looking up supplementary information such as data or relevant charts. To address this situation, an effort has been under taken to enhance the average engineering student's access to information, and second to provide it freely and reliably. This was partially accomplished by developing an online, interactive engineering tool which models fluid flow around any two-dimensional cross-section. This allows students to interactively experience many different aspects of fundamental fluid dynamics, including viscid and inviscid flows, instantaneous drag and lift coefficients, and a visualization of velocity vectors and the pressure distribution. The simulation tool is available as a web-based applet and as an 'app' for Android mobile devices (Apple-based mobile app is also planned).

By taking advantage of a remote high performance cluster (HPC), computational power and time are alleviated from the student. Educationally, this allows the student access to a finite element fluid flow package outside of the class and without any additional cost. Essentially, this opens the door for anyone who has internet access to solve intensive engineering problems on a smartphone or tablet at their convenience. Since the solution is done at a remote cluster with hundreds of CPUs (thousands of cores), the local client CPU is not relevant other than drawing results.

The tool approximates the Navier-Stokes equation's solution governing fluid flow in the primitive variable. A Galerkin finite element formulation using Taylor-Hood triangular elements was implemented and solved for the unknowns simultaneously. By using Intel MKL PARDISO solver on a high-performance cluster, the drag coefficients of two dimensional objects were obtained within a reasonable range of fluid viscosities by using Simpson's rule to approximate the area under the curve according to the integrated drag coefficient equation.

MECHANISTIC MODELING OF DROPLET DEPOSITION AND COALESCENCE IN LONG ELBOW BEND[1]

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ABSTRACT

Even though there have been several studies conducted by the industry on the use of different inlet devices for gas-liquid separation, there have been limited laboratory and field evaluations on the use of external piping configurations as flow conditioning devices upstream of a separator inlet. The aim of this work is to provide some guidelines for piping layout immediately upstream of conventional separators, particularly for offshore platforms.

A research has been conducted to investigate the performance of a number of curved pipe bends as a droplet coalescer including: short elbow bend, long elbow bend, 180° pipe bend, cushion tee bend and target tee bend, along with straight pipe. It is found that all curved pipe bends have higher Droplet Deposition Fraction (DDF) but perform differently. Long elbow bend and 180° pipe bend have similar performance at the top with 10-20% DDF higher, whereas the other bends offer between 10-15% DDF better than that in straight pipe. Long elbow bend is recommended for field application over 180° pipe bend given its easier fabrication and installation. A mechanistic model has been developed for prediction of droplet deposition and coalescence in long elbow bend.

[1] This research is supported by Chevron Tulsa University Center of Research Excellence (TU-CoRE) and Tulsa University Separation Technology Projects (TUSTP)
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Session 4

Materials: Properties and Testing

Chair: Kashif Nawaz, OU

PEC 233

EFFECTS OF SIZING ON THERMAL CONDUCTIVITY OF INDIVIDUAL CARBON FIBER IN LONGITUDINAL AND RADIAL DIRECTIONS

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ABSTRACT

Commercial carbon fibers are treated with sizing to improve the surface defects and the adhesion at the fiber-matrix interface. With increasing demand of high performance composites, the utilization of carbon fibers is growing, particularly in the area of thermal management applications. However, carbon fibers are highly anisotropic in thermal conductivity due to the orientation of carbon atomic structure. It is reported that the thermal conductivity of carbon fiber in the longitudinal direction is one to two orders of magnitude higher than the radial direction. Having a sizing layer further influences the anisotropic behavior of the fiber. Moreover, additional surface treatments can have significant influences on the thermal properties of single carbon fibers.

In this paper, a wire-based 3ω method is utilized to investigate the effect of sizing and additional surface treatments on the longitudinal and radial thermal conductivities of individual carbon fibers. By applying an ac current of frequency ω through the fiber, the secondary harmonic 3ω response can be recorded, and an appropriate heat conduction model can be used to determine the thermal conductivity. For longitudinal thermal conductivity, the one-dimensional heat conduction model proposed by Lu et al. [1] is used, whereas for radial thermal conductivity a two-phase heat conduction model is developed. Validation of the experimental technique is done by using platinum and tungsten fibers, which shows excellent agreement with the published data. The thermal conductivities of different types of carbon fibers are measured with sizing, without sizing, after de-sizing, and after grafting a multifunctional molecular sizing.

** Member, ASME

[1] L. Lu, W. Yi, and D. L. Zhang, "3 omega method for specific heat and thermal conductivity measurements," Review of Scientific Instruments, vol. 72, pp. 2996-3003, Jul 2001.

NOVEL HONEYCOMBS WITH HIGHER AXIAL COMPRESSIVE STRENGTH

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ABSTRACT

Honeycombs are cellular structures used as cores in sandwich structures. They are used in applications ranging from packaging to aerospace. Their high specific strength and specific stiffness have enabled a high user volume especially in aircraft structures. With an increasing need to minimize operational cost and improve overall efficiency, there is a demand for higher performance materials in weight sensitive applications. Amorphous metals, also known as metallic glasses are excellent candidates for making honeycombs, owing to their exceptional mechanical properties. However, their high elastic limits and tendency to form shear bands upon plastic deformation have limited the use of conventional (expansion and corrugation) methods of honeycomb manufacturing. Recently, we proposed a novel manufacturing approach, used for making Amorphous $Fe_{45}Ni_{45}Mo_7B_3$ honeycombs with a teardrop cellular structure. An analytical model was proposed for the "teardrop" honeycomb, predicting their relative density and compression strength in the out-of-plane direction. Densities of amorphous $Fe_{45}Ni_{45}Mo_7B_3$ honeycombs ranging from 0.3 – 0.6 g/cc were demonstrated and tested for their mechanical properties in the out-of-plane direction. Results validate the analytical model, and show that higher specific strengths can be achieved with Amorphous Metal Honeycombs. In comparison with existing analytical models and highest performing metallic honeycombs currently used in the industry, amorphous metal honeycombs show an unprecedented specific strength.

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DUAL-AXIS TRIBOMETER DESIGN AND ASSEMBLY

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ABSTRACT

Wear and friction account for millions of dollars of loss every year thanks to the inefficiencies due to energy loss, and the machinery downtime and expense needed to replace worn parts. Tribology is the study of interacting surfaces in motion, and a tribometer is a device used to measure friction and wear in materials. One interesting application of tribology is the simulation of wear seen in artificial joints. Artificial joints are typically comprised on metal components articulating against a polymer bearing surface, with both materials being inert in the body while in their bulk form. However, over years of use, wearing down of the polymer releases microscopic particles into the body, which triggers an immune system response, and leads to a failure of the implant. In an effort to quickly explore this wear system without the need for human trials, a tribometer can be used to simulate the conditions of an artificial joint.

The purpose of the Tribometer Team senior project at Oklahoma Christian University is to create a dual-axis tribometer that can perform wear testing on plastic samples, simulating the human body. Beginning with an early design created by a previous student group, the Tribometer Team has added functionality, stability, and safety to create a working tribometer that is available for future faculty and students of Oklahoma Christian University, who will use it for research and learning applications. The tribometer will have the functionality to test four samples moving at 0.33 feet per second with a maximum normal force of 60 psi each. Additional functionality is provided by an optional liquid bath and a silicone heater, which is used to more closely simulate conditions in the human body, and various sensors to monitor the temperature and friction force throughout a test using LabVIEW. The structure of the tribometer has been modified to add stability at the motor mounts, and a stable power supply has been integrated. Safety features have been implemented throughout the design process, and the aesthetic quality of the tribometer was matched to Oklahoma Christian University themes. Lastly, a variety of verification tests were performed to ensure that the performance of the tribometer matched results seen in literature.

STUDIES ON INCREMENTAL STEP TEST

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ABSTRACT

Cylindrical specimens of 17-4 ph stainless steel and aluminum were tested using an MTS 810 22 kip closed loop servo-hydraulic testing machine in order to determine the material properties that define its cyclic stress-strain curve. Two methods were used: companion specimen test method and incremental step test method.

In companion specimen test, a number of specimens were tested, each at a different strain ranges until the hysteresis loops become stabilized. The stabilized half-life hysteresis loops are then superimposed and the cyclic stress-strain curve can be obtained by connecting the tips of hysteresis loops. This method requires a large number of specimens with confidence and is time consuming.

In an incremental step test, a specimen is subjected to repeated strain blocks, in which the amplitude of the strain increases linearly with time up to a maximum value in the first half of a strain block, and then decreases linearly in the second half of the strain block. The specimen reaches stabilization after a number of strain blocks. By connecting the tips of the stabilized hysteresis loops, the cyclic stress-strain curve can be determined with a single sample.

These two methods were compared by analyzing the cyclic stress-strain properties and cyclic stress-strain curves obtained from each. Several materials were tested to observe tendencies an empirical approach are proposed for relating the curves from the two approaches.

APPLICATION OF 3ω METHOD ON THE MEASUREMENT OF TRANSVERSE THERMAL CONDUCTIVITY OF INDIVIDUAL CARBON FIBER

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ABSTRACT

Carbon fibers are high performance structural material which have been used in broad range of areas from commercial products to aerospace applications. Recently, they are being increasingly utilized in thermal management environment where their thermo-physical properties such as thermal conductivity become important for design of their applications. Many techniques have been developed to measure the longitudinal thermal conductivities of carbon fibers. However, since carbon fibers are anisotropic material, it is also important to determine their transverse or radial thermal conductivities. Direct measurement for such a properties so far has not been found.

Here, a new application of the 3ω method was developed to measure the transverse thermal conductivity of an individual carbon fiber directly. In this method, an ac voltage of frequency ω was applied on the carbon fiber specimen submerged in deionized water. Analytical expressions for the temperature oscillation throughout the specimen and the water was obtained by solving the coupled time-dependent, one-dimensional diffusion equations. The 3ω response due to the temperature oscillation was used to determine the thermal conductivity by matching the analytical solution to the experimental data. Thermal conductivity of a platinum wire was first measured to validate the proposed technique. A set of platinum wires were then coated with a thin layer of Spin-on-Glass with different thicknesses. Applying the present 3ω technique, thermal conductivities and interfacial thermal resistance between the wire and the coating were measured. The results were compared with the transverse thermal conductivities obtained from an effective medium model and good agreement was found. Finally, transverse thermal conductivities of two types of carbon fiber (PAN- and pitch-based) were measured at room temperature. Transverse thermal conductivity of the PAN-based carbon fibers (T650) and the pitch-based carbon fibers (EWC-300X) were measured to be 1.48 W/m-K and 2.48 W/m-K, respectively, which are significantly lower than the longitudinal values previously reported in literature.

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** Member, ASME

Session 5

Aero-Design

Chair: Arvind Santhanakrishnan
OSU

HSH 211

SCRAMJET DIFFUSER ANALYSIS

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ABSTRACT

Diffusers partially convert the kinetic energy of a fluid, at its inlet, into an increased pressure at its exit. The exit pressure, p_r, is referred to as the recovered pressure. Diffusers come in two categories, depending on whether the inlet flow is subsonic or supersonic. Supersonic diffusers can be further subdivided into those where the upstream compression is partly open to the atmosphere, such as in the inlet of an axisymmetric jet engine that has a center spike, and those that are enclosed, as is the case with a wind tunnel. Only an enclosed supersonic diffuser is considered in this study.

Two novel approaches for a supersonic compressor are discussed. Both have the potential for providing greatly improved pressure recovery. The first is based on a Prandtl-Meyer (P-M) compression, while the second is based on the Lens Analogy (L-A). The engineering logic behind the two approaches is provided, and a short discussion is given of both, since neither one has been experimentally demonstrated. Both approaches propose to homentropically (i. e., shock free) compress a relatively uniform supersonic flow from an inlet Mach number, M_1, to a lower Mach number, M_2, where state 2 is also a relatively uniform supersonic flow.

Three potential applications for the P-M and L-A approaches come to mind. One would be a supersonic wind tunnel diffuser, but this is not viable since a test section model would generate a shock system, and the diffuser's inlet flow would then not be uniform or shock free. The other two applications may be viable. These are the supersonic portion of a diffuser downstream of a supersonic gas laser and a supersonic engine inlet diffuser. The present analysis can be viewed as a preliminary design study for these two applications.

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AERODYNAMICS OF WING-WING INTERACTION IN THE FLIGHT OF TINY INSECTS

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ABSTRACT

In contrast to the flapping flight of insects of length scales ranging from the fruit fly to the hawk moth, the aerodynamics of flight in insects such as thrips that are 1 mm or less in length is not as well understood. These smallest insects typically fly at $Re = 10$ or lower and are of ecological and agricultural importance. In addition, these insects provide a means to explore the biological adaptations to circumvent some of the limitations of low *Re* flapping flight, which is a question that is of current importance to engineers in the context of the development of micro-aerial vehicles and autonomous underwater vehicles. Viscous effects become significant for this range of flight where $Re < 10$, and lift forces drop significantly relative to drag forces. These insects have been proposed to augment lift through adaptations in the flight kinematics, wing flexibility and wing morphology. With reference to the flight kinematics, thrips and other tiny insects clap their wings at the end of each upstroke and fling them apart at the beginning of each downstroke (see Ellington, *J. Exp. Biol.*, 1980). Furthermore, these insects have highly bristled wing surfaces as opposed to solid wings. In this study, the effect of a bristled wing characteristic of many of these insects is investigated using computational fluid dynamics. We perform 2D numerical simulations using a porous version of the immersed boundary method. Given the computational complexity involved in modeling flow through exact descriptions of bristled wings, the wing is modeled as a homogenous porous layer as a first approximation. High-speed video recordings of free flying thrips in take-off flight were captured in the laboratory, and an analysis of the wing kinematics was performed. This information was used for the estimation of input parameters for the simulations. As compared to a solid wing without bristles, the results of the study show that the porous nature of the wings contributes largely to drag reduction across the *Re* range explored. The aerodynamic efficiency, calculated as the ratio of lift to drag coefficients, was larger for a range of porosities when compared to solid wings. Finally, the development of a robotic physical model to mimic the wing-wing interaction kinematics for conducting experimental studies will be presented.

ANALYSIS OF KLEIN-FOGLEMAN AIRFOIL

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ABSTRACT

The Kline-Fogleman (KF) airfoil, created by Richard Kline and Floyd, is a unique airfoil design with single or multiple receding steps along the length of the chord. The purpose of each step is to allow air flowing over the airfoil to become entrapped behind the step, creating a circulating roll of air, which becomes part of the airfoil itself, thus reducing friction between it and the free stream air flow. With the steps only on the lower surface, a virtual cambered airfoil is created. Since its introduction in the early 1960s, few studies to determine the aerodynamic properties of these airfoils have been published. Those that have been completed generally tested the airfoil at high speeds, concluding that it produced a poor lift-to-drag ratio, and was considered an ineffective airfoil design for full size aircraft. However, within the Radio Control (RC) aircraft community, KF airfoils are gaining popularity. Their characteristics provide RC aircraft designers the simplicity of a symmetric airfoil with the advantages of a virtually cambered airfoil.

The purpose of this analysis is to determine the effectiveness of Kline-Fogleman airfoils, also known as stepped airfoils, at low Reynolds numbers. A total of four KF airfoil shapes with different step locations were tested, using a NACA 0009 symmetric profile as a underlying shape, which was also included in the test as the baseline. Only bottom steps were analyzed with the assumption that they would be the most suitable choice for future aircraft designs, which operate in low speed conditions. Wind tunnel tests were completed in the University of Oklahoma's Low Speed Wind Tunnel. A test model with a span of 8 inches and a chord of 3 inches was placed in the center of the test section, and lift and moment data were obtained at angles of attack from -2 degrees to stall at velocities corresponding to Reynolds numbers of $2.7232 \cdot 10^4$ and $5.4464 \cdot 10^4$. Drag data were not included in the study since, due to these slow test speeds, drag forces were not large enough to be picked up by the drag load cell.

Results show that, for the higher Reynolds number, overall lift actually decreased slightly for the stepped airfoil, and the stall angle dropped by about 1 degree, possibly due to the higher free stream flow dislodging the circulating roll behind the step. Of the five airfoils tested, a bottom step located at 50% of the chord produced the highest lift at the tested Reynolds numbers.

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REMOTE OPERATED QUADROTOR UAV

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ABSTRACT

Observation of remote or dangerous areas is often difficult or even impossible to accomplish using typical means. The biology students at Oral Roberts University have been conduction an ongoing observation of local wasp populations, mating patterns, and nesting locations. These nesting locations are often atop tall buildings, trees, and other hard to access locations. As the engineering students were preparing their senior design projects, they were made aware of the need to be able to observe the behaviors of local wasp populations and thus were asked to build a device that could be remotely operated and controlled by students to make said observations.

The definition of completeness of this project was to create a remote operated quad rotor unmanned air vehicle, with a high definition camera attached, that was capable of gathering useful information (images from which required information could be gathered).

*Member, ASME

DESIGN OF MODULAR UNMANNED AERIAL SYSTEM (M-UAS) FOR WILDFIRE RECONNAISSANCE AND POST-FIRE DAMAGE ASSESSMENT

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ABSTRACT

Wildfires are uncontrolled fires, which often occur in unpopulated areas, but they can ignite and burn anywhere, and can destroy homes, agricultural infrastructure, humans, and animals in their path. In the past 29 years, an average of 75,000 wildfires per year have burned about 5 million acres annually. In this time frame, wildfires have been responsible for the deaths of 516 fire fighters or 18 deaths per year. Breaking this down even further, 115 of these deaths have been aircraft related, making this the third highest cause of wildfire fatalities with heart attacks a close second. Although many of these deaths were attributable to actual fire fighting aircraft, a good number of observation aircraft also were affected.

With a depleting, aging aircraft supply, a minimal budget and an increasingly lengthening fire season due to climate change, the need for alternate, less expensive aircraft is clear. One option is the use of UAV to aid in the firefighting process. An Unmanned Aerial Vehicle (UAV) as defined by the U.S. Department of Defense (DOD) is a powered vehicle that does not carry a human operator, can be operated autonomously or remotely, can be expendable or recoverable, and can carry a lethal or nonlethal payload. Unmanned Aerial Systems (UAS) are beneficial especially in roles that would simply be unacceptable, less effective, or too dangerous to accomplish with manned aircraft, including wildfire reconnaissance. Convection currents can create massive firestorms and associated tornados, which can send large pieces of debris hurling through the air. This makes flying both difficult and dangerous, providing a great incentive to utilize equipment that removes humans from harm's way.

In this presentation, the design of a hand- or bungee-launched modular UAS will be discussed, which can utilize thermals created by the wildfire itself to extend flight time above the fire. Using a well-designed control system, it should be possible to keep the UAS flying as long as the fire is raging. This modular UAS will have the ability to operate in various aspects of the wildfire management process: in one configuration for wildfire reconnaissance and to gather crucial fire information for firefighters on the ground to allow for the development of efficient wildfire fighting strategies, in a second configuration to aid in post-fire damage assessment.

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OPTIMAL CLIMB PERFORMANCE OF A SUPERSONIC AIRCRAFT

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ABSTRACT

In military and civilian flight operations, it is often necessary to determine a trajectory that will enable an aircraft to complete a climb maneuver in minimum time or consuming minimum fuel. These Minimum Time to Climb (MTTC) and Minimum Fuel to Climb (MFTC) problems play an important role in the effort to make flight more efficient. For example, minimizing flight time reduces delays, which reduces operational cost. Other applications may include flight tracking, target interception, and search-and-rescue missions, where time is of the utmost importance. Of course, the dynamics of a flight can change in the presence of different wind profiles and airspace constraints.

Trajectory optimizations for a supersonic interceptor aircraft are presented that yield minimum time / minimum fuel to climb. The optimization is performed using the Gauss Pseudospectral Method (GPM), applied to equations governing the three-dimensional motion of a point mass model of the aircraft. Comparisons are made between cases without wind, an actual wind profile varying with altitude, and a numerically determined constant average of this variable wind profile. Optimal trajectories for the three cases are obtained for different initial heading angles, covering the first quadrant, along with the corresponding state and control variable histories.

The optimizations are performed for an unbounded case, and for three different cases of airspace constraints, specifically for square, circular, and elliptical airspace boundaries. The results are compared. When airspace constraints are absent, the minimum time to climb as well as the optimal flight path seem to be virtually unaffected by the presence of wind. When airspace constraints are present, it is observed that the magnitude of the wind velocity only marginally affects the minimum time to climb, but it does change the flight path itself. Tighter airspace constraints increase the time it takes for the aircraft to complete the climb maneuver.

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Session 6

Bio-Engineering

Chair: Curtis Vickery

PEC 228

RIPPLE FORMATION AND WEAR IN ULTRA-HIGH MOLECULAR WEIGHT POLYETHYLENE, A FINITE ELEMENT AND EXPERIMENTAL APPROACH

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ABSTRACT

Ultra-High Molecular Weight Polyethylene (UHMWPE) has been the polymer of choice for low-friction surface in artificial joints for well over four decades no, primarily due to its superb wear resistance and friction characteristics. UHMWPE has also been identified as the main limiting factor in the lifespan of these joints as the wear debris produced is biologically active and induces an immune system response that ultimately leads to osteolysis and bone degeneration surrounding the implant. A greater understanding of the wear behavior of this material would yield substantial benefits for the health and well-being of artificial joint recipients.

It is proposed that the origin of the biologically active, micron-sized particles stems from the wear and fatigue of a commonly found, yet poorly understood, surface phenomenon of worn, semi-crystalline polymers such as UHMWPE. A microscopic, ripple-like surface geometry that is aligned perpendicular to the sliding direction has been seen on worn samples from both explanted prostheses and *in vitro* experiments. It is hypothesized that these ripple formations are due to the buckling and wrinkling of a thin, plastically deformed layer along the surface. In this study, a finite element model was developed in which the thin, highly oriented surface layer is modeled as a stiff, thin film attached to a softer substrate by utilizing simulation techniques developed for studying thin film deposition of metals for the electronics industry. The finite element model was used to explore the relationship between a plastically deformed, polymeric surface layer and a soft substrate to find evidence of the characteristic ripple formations. The results of the FE simulation are then compared to experimental results to determine a correlation between the surface features of physical specimen, and the properties and deformations seen in the simulation.

*Member, ASME

Polymers for Reusable Health Products

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Abstract

In developing countries, such as remote areas of Ghana, there is limited access to birth control and other disposable health care products. Single use medical supplies and condoms are not an economical or logistically viable option. A proposed solution to this problem is creating a material which can be reused multiple times, withstand sterilization by boiling, and maintaining functionality. For this synthesis a high cross link density is required to maintain high elasticity after sterilization procedures. Three different formulas are currently being tested, polyurea, polyurethane, and Polydimethylsiloxane (PDMS). The samples must pass rigorous testing to include tensile testing, burst volume testing, aging testing, leak test, and a pinhole test. The development of cost efficient and lifesaving reusable health care products can have a measurable impact in areas with otherwise limited access.

The Edisons

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ABSTRACT

The OC Systems Team, named "The Edisons", was given the task of designing a bench top testing station to test the functionality of Orthocare's product, the Edison. The Edison is an adaptive vacuum system that controls and regulates the vacuum level needed to hold a prosthetic leg to its socket at different levels of activity; from steady walking to a full on run. Orthocare Innovations currently has no efficient or easy way of testing their product's functionality. The entire industry of vacuum suspension in prosthetics is a very new technology, making the design for a testing station the first of its kind. Four primary functions for the testing device were identified: generate controlled pressure waves, read and interpret those pressure waves, and simulate a leak. Five devices were found that together could meet all of the four functions: the motor, the pressure transducer, the solenoid valve, the power supply, and the Arduino Uno. Data was gathered from the Edison device to ensure that a motor with the proper specifications was obtained. Testing was done with the Arduino, the solenoid, the motor, and the pressure transducer to ensure that they can operate together. The team has attempted to buy all parts commercial or 3-D print parts so that Orthocare Innovations can easily reproduce the testing station if necessary. The prototype is presented as a working model.

ARES FOR LEG ENHANCEMENT

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ABSTRACT

Project ARES stands for Autonomous Robotic Exo-Skeleton. This device is an enhancement of the human leg to endure a higher force and relieve pressure from the knee. A robust control system will adjust the desired force output from the device in order for an individual to walk and be able to maneuver freely. This device can be used for therapeutic, commercial and military use. Using cost efficient techniques the team's objective is to construct an appropriate device. The project will consist of designing and implementing a hydraulically powered system that includes an electronic control system, electronic distribution system, hydraulic system, and the geometry of the exoskeleton while maintaining a reasonable cost.

** Member, ASME

SYNTHESIS AND UTILIZATION OF NANOPARTICLES FOR USE IN THE MEDICAL FIELD

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ABSTRACT

This project was chosen because this research will directly benefit the medical community by preventing nosocomial infections. This is when microbial films adhere to the surface of medical instruments and equipment, which then leads to infections. A great deal of money is spent each year by hospitals on nosocomial infection-related treatments. The answer to the dilemma is to modify the surfaces of such medical instruments so that they actively disinfect themselves.[1] In a recent question and answer session regarding the use of antimicrobial materials in medical establishments, Scott Fallon, former general manager of Global Specialty Products for SABIC'S Innovative Plastic business, stressed the importance of the use of these materials to aid prevention of healthcare associated infections (HAIs). He claims that along with materials that are durable enough to endure strong cleaning agents, antimicrobial materials can help reduce HAIs in such materials as "high touch surfaces, such as bed rails; medical carts; indwelling items such as catheters, drains, and IV components; and fluid delivery applications such as tubing."[2] One such method of creating antimicrobial materials is to employ silver nanoparticles as a coating for materials. This is the ultimate goal of this project: to develop these types of coating for use in future research, medical devices and instruments.

This present work examines a three-fold project: nanoparticle synthesis, material coating, and biotesting. The nanoparticle synthesis was carried out using a chemical reaction that suspended silver nanoparticles in a sodium borohydride solution. The stability of these solutions was then tracked using a Spectrovis Spectrophotometer, to monitor particle agglomeration over time. The second task employed a drop drying coating method—coating sample squares of stainless steel—to produce a suitable coating for biotesting. This coating method also provided a foundation for future improvements in coating at ORU. Finally, biotesting was performed on both the liquid solution and the dried, coated metal to measure the prevention of biofilm growth, as well as the ability of the coating to kill bacteria that was already present. Much progress was made to ensure that a suitable coating could be produced upon continuation of research and testing.

Session 7

Fluids II

Chair: Ed Reynolds

HSH 212

Pressure drop through pororus media (Metal foams, carbon foams, wire meshes)-A comparative study

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ABSTRACT

Varouios type of prorus materials have been used for thermal applications in cryogenics, combustion chambers, geothermal systems, petroleum reservoirs, catalytic beds, compact heat exchangers for airborne equipment, air cooled condensers and compact heat sinks for power electronics. Metal foams, carbon foams and wire meshes are extensively deployed in various thermal systems due to their attractive properties for heat transfer enhancement. Despite manufacturing and implementation issues, these materials hold promise both for heat exchangers and heat sinks. Such materials pocess large accessible surface area per unit volume and the ability to mix the cooling fluid contribute to making the thermal management devices efficient, compact, and light-weight. If such porous media are to be widely used in thermal systems, their pressure-drop characteristics must be available to potential users in terms that fit into the current design methods. This paper focuses on the experimental analysis of pressure drop for air flow through various types of pororus media (Metal foams, Carbon foams and wire meshes). Experiments have been conducted in an open-loop wind tunnel to determine the pressure gradients for different materials. The effect of porous media geometry and flow depth have been analyzed to evaluate the permeability and inertia coefficients. Pressure drop data has been reduced to develop empirical correlations for flow through different types of porous media.

This work has been supported by Air Conditiona and Refrigetaion Technology Institute (ARTI).

* *Member ASME*

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FOAM BREAK-UP IN CFC/GLCC© SYSTEM[1]

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ABSTRACT

In crude oil transportation system when more than one phase flows in the same pipeline with gas as one of the components, in the presence of suitable surfactants, it is expected to form gas bubbles in liquid stream causing foam. Foam can be both artificially induced by introducing gas in the flow and naturally occurring as a result of gas coming out of solution because of pressure drop. Foam also has been applied as one of the effective methods to improve oil recovery especially for very heavy crude oil by reducing its viscosity and reducing the hydrostatic head. As a result it will require the process or equipment to break the foam. Several methods can be applied to break the foam such as chemical method, thermal method and mechanical method using cyclone which is more affordable and cost efficient for field application.

In this experiment, utilization of Churn Flow Coalescer (CFC) in the upstream of Gas Liquid Cylindrical Cyclone (GLCC©) to improve the foam break up time for several variations of superficial gas velocity and superficial liquid velocity with constant surfactant concentration was studied. The exponential decay of the foam was evaluated from the correlation of foam height as a function of time and from which the half life ($t_{1/2}$) was determined. Lowering superficial gas velocity or increasing superficial liquid velocity results in faster time for the foam to break-up.

[1] This research is supported by Chevron Tulsa University Center of Research Excellence (TU-CoRE) and Tulsa University Separation Technology Projects (TUSTP)
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DEVELOPMENT OF A HIGH-REYNOLDS EXPERIMENTAL FLUID MECHANICS LABORATORY

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ABSTRACT

A high-Reynolds number experimental fluid mechanics laboratory has recently been established at Oklahoma State University (OSU). This laboratory will expand upon OSU's existing aerodynamics and fluid dynamics capabilities and expertise. The three primary components of the laboratory are (1) a recirculating water tunnel, (2) a multiphase pipe flow loop, and (3) a multi-scale flow visualization system. The water tunnel has been designed to focus on high-Reynolds number turbulent boundary layer research but can be reconfigured to study various models. The design criteria for the facility was to achieve a momentum thickness based Reynolds number (Re_θ) of 10^4, which bridges the gap between typical university water tunnels ($Re_\theta \sim 10^3$) and the world's largest ($Re_\theta \sim 10^5$). Thus this will be a low cost option to perform high-Reynolds number testing. The test section will be 1 m long and achieve flow speeds to 10 m/s.

The multiphase flow loop shares the water tunnel pump, but has a separate flow path. It is designed for flexibility allowing the test section angle, diameter, flow type (pipe or annular), and flow speed to be varied. The facility's maximum flow rate and straight pipe length will be 0.3 m^3/s (4500 GPM) and 15.2 m, respectively. Petroleum engineering research with an emphasis on simulated drilling fluids is the focus for this facility.

Improved flow imaging capability is a major advantage to liquid based fluid facilities because of the increased density for seeding and reduced field-of-view for equivalent Reynolds number. The flow visualization system for the laboratory includes a high-speed diode pumped laser (30 mJ/pulse at 1 kHz), a pair of high resolution (5.5 megapixel) cameras, and a pair of high-speed (1.6 kHz at full resolution) cameras. This system can be used for time-resolved and phase averaged stereo-particle-image-velocimetry, laser-induced-fluorescence, and high-speed imaging measurements.

This talk will present an overview of the planned capabilities of this laboratory with an emphasis on the design of the water tunnel facility. An aerodynamic example project will be discussed to illustrate some of the facility advantages.

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SCALE-UP STUDY OF GAS-LIQUID TWO-PHASE FLOW IN DOWNCOMERS

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ABSTRACT

Downcomers are important conduits for multiphase flow transfer from offshore platforms to seabed. Typically, annular falling film occurs in the upper section of the downcomer. At the bottom, a liquid column is formed, whereby the falling film impacts the liquid column, causing gas entrainment below the interface. This phenomenon is manifested in the form of dispersed bubble flow in the column and gas carry-under at the outlet of the downcomer.

The objective of this study is to conduct an experimental and theoretical scale-up study of gas-liquid two-phase flow in a downcomer. For the purpose of scale-up, a novel approach is utilized by restricting the perimeter of the falling film. This results in a reduction of the ratio of wetted perimeter to the pipe cross-sectional area, which simulates larger downcomer diameter. This approach is validated due to the fact that this ratio, which is inversely proportional to the pipe diameter, decreases as the pipe diameter increases.

A state-of-the-art instrument, the capacitance Wire-Mesh Sensor (WMS), was utilized to study the falling film under 30% and 61.7% annular slot opening for air-water and air-Conosol C200 oil flow and gas carry-under for both openings utilizing air-Conosol C200 oil. The experimental results indicate that the film thickness and film velocity increase as the wetted perimeter of the flow area reduces. The increase in film velocity increases the gas entrainment process, which in turn increases the gas carry-under.

In order to model the prediction of the novel scale-up experiment, the power comparison method was developed and used in conjunction with the Lopez (2011) model, which was intended for full bore downcomer. Comparison between the experimental data and the model predictions are made for fraction of gas carried with the air-Conosol C200 oil.

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DESIGN AND PERFORMANCE OF BALANCED FEED MANIFOLD (BFM)*

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ABSTRACT

Manifolds are generally utilized in the petroleum industry for gathering production from several pipelines, which operate under different flow conditions, and redistribute the flow equally into downstream processing facilities. Uneven redistribution of the flow downstream of the manifold may lead to operational problems in downstream equipment. Variation in pressure, flow rates, PVT properties and flow patterns may occur in the upstream pipelines, which may hinder the performance of the manifold. A novel Balanced Feed Manifold (BFM) is proposed, which includes a secondary liquid manifold that improves the distribution of the liquid phase downstream (more evenly splitting).

The BFM is studied experimentally and theoretically for different upstream pipeline flow conditions. The data includes slug dissipation length and the required control of the gas and liquid outlets to ensure equal flow splitting. A mechanistic model has been developed for the design of the BFM, enabling the determination of the required BFM diameter and length. Good agreement is obtained between the model predictions and the experimental data.

* This work has been supported by Chevron TU-CoRE (Tulsa University Center of Research Excellence)
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INVESTIGATION OF BUILDING PASSIVE THERMAL STORAGE FOR OPTIMAL HEATING SYSTEM DESIGN

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ABSTRACT

Heating and cooling load calculations are critical to size Heating, Ventilation and Air conditioning (HVAC) systems and determine energy use of their operations. The ASHRAE model, which is most commonly used for heating load calculations, adopts a simplified approach by considering only steady-state instantaneous conductive heat transfer and ignoring internal heat gains and thermal storage effects. Those assumptions evaluate the worst case conditions which can reasonably occur at nights when the outdoor air temperature is lowest and with no inputs from solar, occupants, lights, or any electronic devices.

However, due to thermal storage effect, heat generated in daytime can be still stored in buildings. Such ignorance leads to significantly over-sized heating system, consequently resulting in high initial cost and a higher cost of energy uses. On the other hand, though heating load might not exist at nights, by considering passive thermal storage of buildings and allowing space air to drift to reasonably lower values, buildings need to be warmed up in the morning before being occupied. The worst case conditions might happen in the morning warm-up period, when heating is needed. This study therefore examines the thermal response of different constructions (heavy, medium, and light) of the building envelope and investigates the effect of their passive thermal storage on the size of the heating system.

Results show tremendous opportunities for downsizing of the heating system while still maintaining thermal comfort requirements. As such, this paper is a fundamental study of building thermal characteristics in order to investigate the potentials of establishing a new heating device design standard.

** Member, ASME

Session 8

Materials: Manufacturing and Corrosion

Chair: Sudheer Bandla, OSU

PEC 233

PRODUCTION OF ELECTROSPUN, CELLULOSIC NANO-MATERIALS AND THEIR APPLICATIONS IN OIL INDUSTRY[1]

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ABSTRACT

The dimensions of nano-structures and their resulting large surface area to volume ratio are beneficial and crucial to their functionalization and subsequent applications. Nano-fibers are 2-D nano-structures with unique properties and diverse applications. Many studies focus on the production, characterization, functionalization, and applications of nano-fibers and nano-fibrous materials. One of the most efficient, cost-effective, and scalable methods for producing nano-fibers is electrospinning. In electrospinning a high voltage electrical field is applied to a polymer solution or polymer melt so that a liquid jet is ejected from the solution (melt) towards a grounded collector on which the electrically charged, aligned polymer molecules collect as solid nano-fibers. Many parameters including solution properties (polymer properties, solvent properties, solution concentration, viscosity, etc.), instrumentation settings (voltage, flow rate, distance to collector, etc.), and ambient conditions (temperature, pressure, etc.) affect the electrospinning process and the quality of the fibers produced. In our work we have successfully electrospun nano-fibers from cellulose and cellulose-copolymer mixed solutions, and then characterized and functionalized them for different applications such as filtration of oil/water mixtures, and anti-erosion coatings in the oil industry. Cellulose is an abundant and cheap natural material. Therefore, it is a cost-effective and green raw material that is used in the manufacture of many products. We used Scanning Electron Microscopy (SEM), Thermal Gravimetric Analysis (TGA), and Goniometry for the characterization of the nanofibers. Functionalized, electrospun nano-fibers composed of cellulose material possess unique properties that make them more efficient in their various applications as compared to bulk materials.

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IMPROVING THE MANUFACTURING PROCESS OF A HEAT INDUCTION TUBE BENDING MACHINE

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ABSTRACT

The machine that was improved by the senior project was called the Cojafex machine. The Cojofex machine, at Tulsa tube bending*, uses high temperature heat induction to heat pipes to a sufficient temperature for bending. Immediately after the pipes are heated and bent the tubes are sprayed with high pressured water to cool the pipes. When the pipes are sprayed with water a significant amount of the water sprays onto the shop floor. Due to insufficient water containment methods and poor draining the water pools up into large puddles on the shop floor. These puddles are a nuisance to the operators who work in the area. The problem has been a dilemma to the engineers who have tried in the past to find a solution. The senior design project consisted of designing a mechanism that would be used to keep the water contained to an area with proper draining.

Due to multiple constraints it was a challenge to design the mechanism in such a way that it would not interfere with any other parts of the machine. The device also needed to be designed in such a way that it would work for any size of pipe that the Cojofex machine bends. The result from the project was a mechanism that is easily installed on the machine and works for all the different pipe sizes on the machine. The mechanism stops more than 95% of the water that was previously being spilt on the shop floor.

* This work was supported by Tulsa Tube Bending
** Member, ASME

EFFECT OF CORROSION ON MECHANICAL PROPERTIES OF AMORPHOUS $Fe_{45}Ni_{45}Mo_7B_3$ RIBBONS

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ABSTRACT

Amorphous metals with their high strength, elastic modulus, and corrosion resistance are potential structural materials for aircraft and marine applications. Earlier studies have attributed the lack of defects and dislocations for their improved corrosion resistance. Strength retention after continuous exposure to harsh environment is important for structural materials, in order to predict their useful service life and in some cases prevent failure. Several accelerated chemical environments have been have been considered and reported in literature to simulate sea-water conditions. In this study, corrosion of amorphous $Fe_{45}Ni_{45}Mo_7B_3$ has been investigated through immersion testing in a 3.5% NaCl solution, salt spray test (ASTM B117). Using ASTM standard, corrosion rate using mass loss data was calculated. From early results, it is seen that corrosion and its effect on the mechanical properties are dominated by the type of corrosion product formed on the surface. Preliminary observations show formation of crystalline corrosion products. Data pertaining to change in mechanical properties are obtained to evaluate the strength retention capacity of the amorphous alloy.

**Member of ASME
*This work has been supported by MetCel LLC.

Validation of New Test Facility for Erosion-Corrosion Inhibition Prediction

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ABSTRACT

The harsh effects and costly losses due to erosion-corrosion in the oil and gas industry have made studying aspects of erosion, corrosion, and the additive of the two, erosion-corrosion a high priority in recent years. Corrosion and the combined effects of erosion-corrosion have been more prevalent in recent years primarily as a result of a combination of superior oil collection techniques where CO_2 is injected into the reservoirs, as well as increased development of crude with higher quantities of H_2S and CO_2, and the existence of sweet and sour gas production from drilling in deeper wells. Corrosion prediction has become more important because of the difficulties in taking measurements in deeper wells and offshore drilling sights. In the past, the detrimental effects of pure erosion, CO_2 corrosion (sweet corrosion) and chloride corrosion, and the combined effects of erosion-corrosion had to be considered separately. This study introduces a new test facility and testing procedure that allows the three components to be measured simultaneously using a variety of testing techniques. This new facility uses a three cell, plugged-tee test cell configuration designed to measure pure erosion, pure corrosion, and combined erosion-corrosion in a single test. Testing was completed using linear polarization resistance (LPR), electrical resistance (ER), and weight loss (WL) measurement techniques. Data from this project is being used to more accurately and effectively model and predict erosion-corrosion for a variety of field conditions.

The effect of sand on inhibited erosion-corrosion rates is important for the prediction of inhibitor effectiveness. Since the new testing facility can account for all three metal loss components, it can be used to show how the addition of sand particles changes corrosion rates. It can also show how an inhibitor could affect sand erosion rates. To present these effects, a Frumkin adsorption isotherm is used to show a shift in inhibitor effectiveness as a result of a constant erosion rate under varying chemical inhibitor concentrations. Inhibitor effectiveness is shown as a comparison between the bare metal surface coverage and the inhibitor concentration. The isotherms will be incorporated into an existing prediction program that will be used to predict erosion-corrosion rates under a variety of environmental conditions.

Effect of Particle Hardness on the Erosion of Stainless Steel

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ABSTRACT

In oil and gas industry, there are many particles that may cause erosion in production and transportation facilities. The most important particles are sand and scale products such as calcite, magnetite, hematite and barite. Although a lot of work has been done on sand erosion but effect of other particles has not been properly investigated. So, there are limited data available about erosive behavior of scale products and due to the different characteristics of the new particles, sand erosion models are not applicable to these particles. In order to characterize erosive behavior of the new particles, two experimental apparatus have been designed and constructed, submerged liquid jet in a slurry tank and gas testing with liquid droplets containing particles. Particles that are being used are Calcium Carbonate, Barite, Iron Powder, Magnetite and Silica Flour. The hardness of these particles ranges from 65 to 1000 in Vickers's scale.

Average mass loss of the specimen has been measured for all particles. Erosion ratio (ER) is calculated for each case which is defined as the ratio of specimen mass loss to mass of erodent. Average normal impact velocity for each case has been estimated using CFD simulation and particle tracking scheme. The liquid droplet velocity and size are determined using Particle Image Velocimeter (PIV). The erosion ratio then divided by the normal impact velocity squared to consider the effect of particle size and density that affect deceleration of particle when it enters the viscous layer near the wall. Finally a correlation has been found for the effect of particle hardness on the erosion of stainless steel.

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