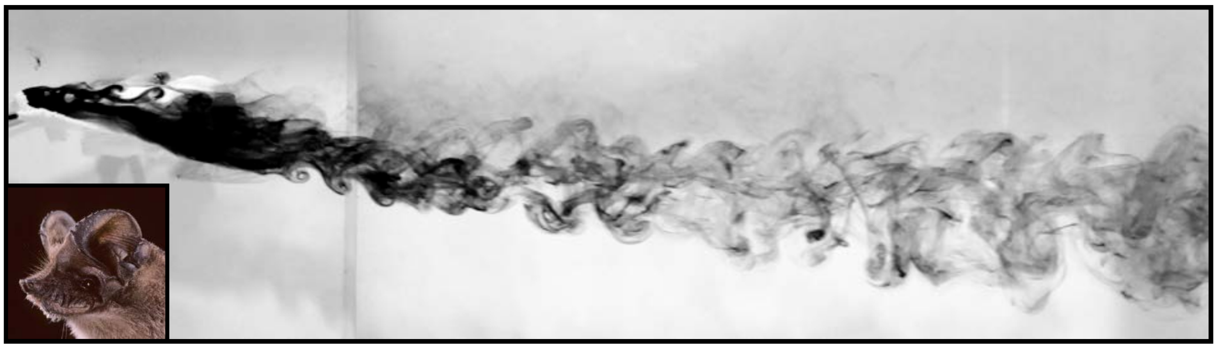
AIAA/ASME Oklahoma Symposium XXXV

Oklahoma State University
School of Mechanical and Aerospace Engineering
Saturday, April 18, 2015



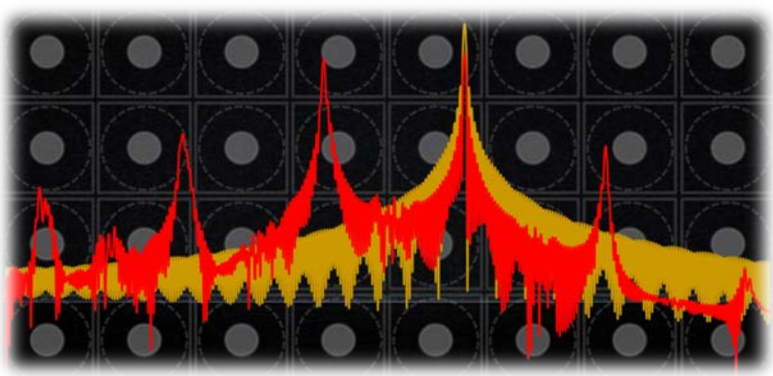
Sponsored by

Oklahoma Section
American Institute of Aeronautics and Astronautics

Central Oklahoma and Mid-Continent Sections
American Society of Mechanical Engineers

AIAA
The World's Forum for Aerospace Leadership

ASME
SETTING THE STANDARD



AIAA/ASME Oklahoma Symposium XXXV

Saturday, April 18, 2015
School of Mechanical and Aerospace Engineering
Oklahoma State University
Stillwater, Oklahoma

Sponsored by
Oklahoma Section
American Institute of Aeronautics and Astronautics
&
Central Oklahoma and Mid-Continent Sections
American Society of Mechanical Engineers

For Additional Information, contact:
Frank W. Chambers
School of Mechanical and Aerospace Engineering
Oklahoma State University
218 Engineering North
Stillwater, Oklahoma 74078-5016
(405) 744-5900
(405) 744-7873 Fax
frank.chambers@okstate.edu

Foreword

The Oklahoma Section of the American Institute of Aeronautics and Astronautics and the Central Oklahoma and Mid-Continent Sections of the American Society of Mechanical Engineers welcome you to the Thirty-Fifth Oklahoma Symposium. The goal for the Symposium is to promote communication, technical interchange, and fellowship among the engineers of Oklahoma's universities and industries. We are proud that these goals have resulted in thirty-five successful Symposia with continued contributions by all the engineering schools of the state and with support by all the local AIAA and ASME groups. The exchanges at this Symposium will continue to contribute to advances in engineering education, engineering research and development, and economic development in Oklahoma.

Many have helped to make this Symposium successful. We first must thank the presenters and their coauthors for making the effort to share their work with the audience. We also thank you, the audience, for attending. We thank all who have helped to promote the Symposium. On behalf of the local sections of AIAA and ASME, I particularly thank some who took time from their busy schedules to contribute to the Symposium:

Session Chairs: **Christian Bach, Rick Beier, Tom Betzen, Girish Chowdhary, Brian Elbing, Ashlee N. Ford, Xiaoliang Jin, Kaan Kalkan, Feng Lai, James Manimala, Jelena Milisavljevic, Ram Mohan, Arvind Santhanakrishnan, Chulho Yang**

Introduction & Welcome: MAE Head **Daniel Fisher** and CEAT Dean **Paul J. Tikalsky**

Luncheon Speaker: **Dr. Charles E. Baukal, Jr., Director, John Zink Institute, John Zink Hamworthy Combustion, Tulsa, Oklahoma**

Symposium Assistants: Please personally help thank the OSU students who have helped to run the sessions.

OSU MAE & MET Committee:

Audio-Visuals, Rooms, and Student Assistance **– Brian Elbing**

Lunch and Refreshments – **Kaan Kalkan** and **Brian Elbing**

Program and Proceedings – **Kaan Kalkan-Chair, Brian Elbing, James Manimala, Christian Bach, Girish Chowdhary** and **Arvind Santhanakrishnan**

Registration and Finance – **Kaan Kalkan** and **Christian Bach**

Proceedings Preparation **–** **Diane Compton** and **Sharon Green**

Publicity and Web **–** **James Manimala** with **Chelsea Robinson** and **Ryan Doonkeen** of the CEAT Dean's Office

The Symposium expenses are not covered by the registration fees, and we are very grateful for all contributions yet to be received and for the support of the Oklahoma State University School of Mechanical and Aerospace Engineering.

The local sections of AIAA and ASME trust that you will benefit from participation in the Symposium and hope that you will express your gratitude to those listed above, and to others who helped to bring about the event but inadvertently may have been left out of these acknowledgements.

Frank W. Chambers, Chair, OSU Symposium Committee

AIAA/ASME OKLAHOMA SYMPOSIUM XXV

Saturday, April 18, 2015
Advanced Technology Research Center
Oklahoma State University, Stillwater, Oklahoma

Schedule

8:00 – 8:45	**REGISTRATION**	EN 108
8:45 - 9:00	**INTRODUCTION AND WELCOME**	EN 108
	Welcome by OSU CEAT Dean Paul J. Tikalsky and MAE Head Daniel Fisher	
9:00 - 10:15	**TECHNICAL SESSIONS A**	
Session 1-A:	Biomechanics I	EN 108
Session 2-A:	Manufacturing I	EN 107
Session 3-A:	Structural Dynamics and Acoustics	ATRC 103
Session 4-A:	Polymers and Composites	ATRC 102
Session 5-A:	Multiphase Flow I	ATRC 101
Session 6-A:	Solar, Fire, Wind, Plasma, and the Universe I	EN 208
10:15 - 10:30	**COFFEE AND JUICE BREAK**	EN 108 Hallway
10:30 - 12:15	**TECHNICAL SESSIONS B**	
Session 1-B:	Biomechanics II	EN 108
Session 2-B:	Manufacturing II	EN 107
Session 3-B:	Robotics and Controls	ATRC 103
Session 4-B:	Nanostructured and Advanced Materials	ATRC 102
Session 5-B:	Multiphase Flow II	ATRC 101
Session 6-B:	Solar, Fire, Wind, Plasma, and the Universe II	EN 208
12:15 - 2:00	**LUNCH AND SPEAKER**	ATRC,
	"Industrial Combustion R&D Challenges"	EN 108
SPEAKER:	**Dr. Charles E. Baukal, Jr., Director, John Zink Institute, John Zink Hamworthy Combustion, Tulsa, Oklahoma**	
	Introduction by Frank Chambers	
2:00 or earlier	**ADJOURNMENT**	

*For room locations, see building map, page 87

INDUSTRIAL COMBUSTION R&D CHALLENGES

Charles E. Baukal, Jr., Ph.D., P.E.

Director of the John Zink Institute, John Zink Hamworthy Combustion
Tulsa, Oklahoma

Abstract

This presentation will consider some of the challenges in industrial combustion R&D. It will include discussions of experimental facilities, computational fluid dynamics (CFD), and some example research projects. One of the biggest challenges regarding facilities is the large scale of the equipment which makes pilot- and full-scale testing considerably more expensive and potentially more time-consuming compared to laboratory-scale testing. John Zink Hamworthy Combustion has an extensive set of pilot-scale testing facilities around the world used primarily for testing equipment used in the chemical, petrochemical, and power generation industries. Full- scale testing is normally only feasible on operating equipment and access to make measurements is usually very limited. Simulating real industrial equipment with CFD can be difficult because of the large disparity in length scales and the very complicated physics. Many simplifications are often necessary to get results in a reasonable length of time. Some of the challenges with large- scale experiments and CFD modeling will be demonstrated with some example projects. The focus of the presentation will be on R&D for the chemical and petrochemical industries with an emphasis on technologies such as process burners, flares, and thermal oxidizers.

Bio

CHARLES E. BAUKAL, Jr., PhD, Ed.D., P.E., is the Director of the John Zink Institute which is part of John Zink Hamworthy Combustion where he has been since 1998. He has nearly 35 years of experience in the field of industrial combustion in the metals, minerals, incineration, textiles, paper, chemicals, and petrochemicals industries. He is a licensed Professional Engineer, is an inventor on eleven U.S. patents, and has authored/edited 13 books on industrial combustion along with numerous other publications. He holds BS, MS and PhD degrees in mechanical engineering and is a member of ASME, the American Society for Engineering Education, and the Combustion Institute. He is an adjunct instructor at the University of Tulsa, Oral Roberts University, and Oklahoma State University and is a member of a number of advisory boards.

Technical Sessions A Schedule

9:15 A.M.	9:30 A.M.	9:45 A.M.	10:00 A.M.	10:15 A.M.
Session 1-A: **Biomechanics I**	*Chaired by:* Arvind Santhanakrishnan, Oklahoma State University			EN 108 (pp. 7-12)
Bat Ear Aerodynamics: Preliminary Results from Flow Visualization Over Ears with and without Tubercles, Christopher E. Petrin and Brian R. Elbing, *Oklahoma State University*, Monte L. Thies, *Sam Houston State University*, and William Caire, *University of Central Oklahoma* p. 8	**Experimental Investigation Of Metachronal Paddling**, M. Samaee, H. K. Lai, and A. Santhanakrishnan, *Oklahoma State University* p. 9	**Comparative Dynamics of Perching Birds for UAV Advancement**, Jonathan Mitchell, Stephen Ziske, and Jamey Jacob, *Oklahoma State University* p. 10	**Currents Induced by Upside-Down Jellyfish: Effects of Bell Size and Interactions with Background Flow**, M. Gaddam, M. Takyi-Micah, and A. Santhanakrishnan, *Oklahoma State University* p. 11	**Clap-and-Fling Aerodynamics in Tiny Insects Using Bristled Wings**, C. L. Terrill and A. Santhanakrishnan, *Oklahoma State University* p. 12
Session 2-A: **Manufacturing I**	*Chaired by:* Xiaoliang Jin, Oklahoma State University			EN 107 (pp. 13-18)
Accounting for Uncertainty and Sustainability in the Realization of Multistage Manufacturing Processes, J. Milisavljevic, M. Robayo, J. K. Allen, S. Commuri, and F. Mistree, *The University of Oklahoma* p. 14	**Melt Expulsion during the Ultrasonic Vibration-Assisted Laser Surface Processing**, S. Habib Alavi, Cody Cowell, and Sandip P. Harimkar, *Oklahoma State University* p. 15	**Experimental Study on Chatter Stability in Vibration Assisted Milling Process**, Anju Poudel and Xiaoliang Jin, *Oklahoma State University* p. 16	**Laser Surface Alloying of Transition Metals with Aluminum to Enhance Corrosion Resistance**, Hitesh D. Vora, *Oklahoma State University* p. 17	**Ag-Nylon Nanocomposites by Dynamic Emulsion Polycondensation**, Linqi Zhang, Sriharsha Karumuri, Habib Alavi, Sandip P. Harimkar, and A. Kaan Kalkan, *Oklahoma State University* p. 18
Session 3-A: **Structural Dynamics and Acoustics**	*Chaired by:* James Manimala, Oklahoma State University			ATRC 103 (pp. 19-24)
Direction-Biased Acoustic Metamaterial Waveguide, Prateek P. Kulkarni, Vishnu Paidimarri, Barrett Lee, and James M. Manimala, *Oklahoma State University* p. 20	**Characterization of a Pulsating Drill Bit Blaster**, Nick Thorp, Geir Hareland, and Brian R. Elbing, *Oklahoma State University* p. 21	**Metamaterial-Inspired Structure for Improved Low-Frequency Acoustic Noise Mitigation**, Anuj Rekhy, Ryan Aiken, and James M. Manimala, *Oklahoma State University* p. 22	**Development of a Compact Atmospheric Infrasonic Measurement System for Early Detection of Tornadoes**, Arnesha Threatt and Brian R. Elbing, *Oklahoma State University* p. 23	**An Optimization-Based Structural Health Monitoring Technique Using Experimental Sensitivity Functions**, Chulho Yang and Young Bae Chang, *Oklahoma State University* p. 24
Session 4-A: **Polymers and Composites**	*Chaired by:* Feng Lai, The University of Oklahoma			ATRC 102 (pp. 25-30)
Effect of Processing Conditions on Hydraulic Fluid Absorption of Quartz/BMI Composites, Keith R. Hurdelbrink II, Gorkem E. Guloglu, Jacob P. Anderson, Zahed Siddique, and M. Cengiz Altan, *The University of Oklahoma* p. 26	**Graphene Dispersion for Polymer Precursors**, V. Shabafrooz, S. Bandla, and J. C. Hanan, *Oklahoma State University* p. 27	**Investigating Morphology, Internal Structure, and Tensile Properties Electrospun Polyacrylonitrile Nanofibrous Yarns**, Bipul Barua and Mrinal C. Saha, *The University of Oklahoma* p. 28	**Photodegradation of Epoxy Polymers**, Sriharsha Karumuri, Salah U. Hamim, Raman P. Singh, and A. Kaan Kalkan, *Oklahoma State University* p. 29	**Experimental and Theoretical Investigation of Non-Fickian Moisture Absorption of Nanoclay/Epoxy Composite Laminates**, G. E. Guloglu and M. C. Altan, *The University of Oklahoma* p. 30

Technical Sessions B Schedule

10:45 A.M.	11:00 A.M.	11:15 A.M.	11:30 A.M.	11:45 A.M.	12:00 P.M.
Session 1-B: **Biomechanics II**	*Chaired by:* Ashlee N. Ford, Oklahoma State University				EN 108 (pp. 43-50)
Mathematical Modeling of Biodistribution of Nanoparticles in the Kidney, M. Pilvankar and A. N. Ford Versypt, *Oklahoma State University* p. 44	**Development of Simulation for Use in Predicting Drug Metabolism**, C. German and S. Madihally, *Oklahoma State University* p. 46	**Comparison of Various Techniques of Determining the Wettability of Materials**, L. Baghernejad, E. Iski, and R. Mohan, *The University of Tulsa* p. 47	**Surface Dielectric Barrier Discharge (SDBD)as an Alternative for Atmospheric Pressure Plasma Sterilization**, Kedar Pai, Chris Timmons, Shannon Jiang, Li Ma, and Jamey D. Jacob, *Oklahoma State University* p. 48	**Comparative Study of Diastolic Filling under Varying Left Ventricular Wall Stiffness**, P. Mekala, A. Pope, and A. Santhanakrishnan, *Oklahoma State University* p. 49	**Automated Gram Staining Apparatus**, D. Rykert, M. Mathew, and G. Toby, *Oral Roberts University* p. 50
Session 2-B: **Manufacturing II**	*Chaired by:* Jelena Milisavljevic, The University of Oklahoma				EN 107 (pp. 51-56)
Long Board Deck Manufacturing, Daniel Dickie and Charles Tines, *Oral Roberts University* p. 52	**Thermoset-Cross-Linked Lignocelluose: A Moldable Plant Biomass**, Sriharsha Karumuri, Salim Hiziroglu, and A. Kaan Kalkan, *Oklahoma State University* p. 53	**Laser Processing of Multilayered Fe-Based Amorphous Coatings on Steel**, Tanaji Paul, S. Habib Alavi, and Sandip P. Harimkar, *Oklahoma State University* p. 54	**Experimental Study on The Surface Generation in Vibration Assisted Micro-Milling of Glass**, Xiaoliang Jin and Boyuan Xie, *Oklahoma State University* p. 55	**Development of Significantly Grain Refined Ti-6Al-4V Alloys Using Ultrasonic Vibration Assisted Laser Surface Melting**, Sourabh Biswas and Sandip P. Harimkar, *Oklahoma State University* p. 56	**NO PRESENTATION**
Session 3-B: **Robotics and Control**	*Chaired by:* Girish Chowdhary, Oklahoma State University				ATRC 103 (pp. 57-65)
Ditch Witch Vacuum Excavator, Zach Blumer, *Ditch Witch* p. 58	**Collaborative Goal and Policy Learning from Human Operators of Construction Co-Robots**, H. Maske, M. Matthews, A. Axelrod, H. Mohomadipanah, G. Chowdhary, C. Crick, and P. Pagilla, *Oklahoma State University* p. 59	**A Framework for Navigation Based on Familiarity**, Alex Suhren, Mehran Andalibi, Girish Chowdhary, and Christopher Crick, *Oklahoma State University* Doug Gaffin, and Brad Brayfield, *The University of Oklahoma* p. 61	**Development of a Robotic Device for Infant Physical Therapy**, M. A. Ghazi and M. D. Nash, *The University of Oklahoma* p. 63	**Control of a Robotic Device for Infant Physical Therapy**, M. A. Ghazi and M. D. Nash, *The University of Oklahoma* p. 64	**Development of Flexible Rod Model Using Discrete Element Method to Analyze Multi-Fiber Problem**, Jinsu Nam and Junyoung Park, *Oklahoma State University* p. 65
Session 4-B: **Nanostructured and Advanced Materials**	*Chaired by:* A. Kaan Kalkan, Oklahoma State University				ATRC 102 (pp. 66-73)
Triaxial Electrospun Fibers and Role of Solvent Volatility, Abdurizzagh Khalf and Sundar Madihally, *Oklahoma State University* p. 67	**Effect of Electric Field and Flow Rate on Fiber Diameter Distribution and Tensile Properties of Electrospun Polyacrylonitrile Nanofibrous Yarns**, Bipul Barua, Mehmet S. Demirtas, and Mrinal C. Saha, *The University of Oklahoma* p. 69	**$V_2O_5 \cdot H_2O$/Au Nanowire/Nanoparticle Conjugates for Solar Water Splitting**, Sunith Varghese, Ç. Özge Topal and A. Kaan Kalkan, *Oklahoma State University* p. 70	**Sub-Band Engineering through Superlattice Based Barrier Heterostructures for Higher Thermoelectric Efficiency**, M. Pourghasemi and J. Garg, *The University of Oklahoma* p. 71	**Localized Plasmon Modes in Ag Nanohemispheres**, Ç. Özge Topal, Sriharsha Karumuri, Alkim Akyurtlu, and A. Kaan Kalkan, *Oklahoma State University* and Hamzeh M. Jaradat, *University of Massachusetts* p. 72	**High Thermal Conductivity of Aligned Polymers,** M. Saeidijavash, M. C. Saha, J. Garg, *The University of Oklahoma* p. 73

Session 5-B: **Multiphase Flow II**		*Chaired by:* Ram Mohan, The University of Tulsa			ATRC 101 (pp. 74-80)
Solid Particle Transport in Gas-Liquid Stratified Slurry Flow, A. Padsalgikar, R. Mohan, and O. Shoham, *The University of Oklahoma* p. 75	**Sand Flow Regimes in Multiphase Pipelines**, R. Dabirian, R. Mohan, and O. Shoham, *The University of Tulsa* G. Kouba, *Chevron Energy Technology Company* p. 76	**Mechanistic Modeling and Experimental Validation of Droplet Deposition and Coalescence in Long Elbow Bend**, H. Nguyen, S. Wang, R. Mohan, and O. Shoham, *The University of Tulsa* G. Kouba, *Chevron Energy Technology Company* p. 77	**A Simulator to Characterize the Shear Effect of Production Equipment**, S. Cui, S. Wang, R. Mohan, and O. Shoham, *The University of Tulsa* Haijing Gao, *Chevron Energy Technology Company* p. 78	**Characterization of Drag-Reducing Polymer Solution Used to Modify a Turbulent Boundary Layer,** Yasaman Farsiani and Brian R. Elbing, *Oklahoma State University* p. 79	**General Guidelines to Develop a Model to Predict Sand Transport Threshold Velocities in Multiphase Horizontal Pipe,** Kamyar Najmi, Brenton McLaury, Siamack Shirazi, and Selen Cremaschi, *The University of Tulsa* p. 80
Session 6-B: **Solar, Fire, Wind, Plasma, and the Universe II**		*Chaired by:* Tom Betzen, Michelin			EN 208 (pp. 81-86)
Experimental Study of Plasma Jet Produced by a Circular Tube Fitted with a Nozzle, I. W. Brindle and F. C. Lai, *The University of Oklahoma* p. 82	**Hacking the Cosmos: How Engineering Assists Science and the Humanities in Making Sense of the Universe ns**, Dominic M. Halsmer, *Oral Roberts University* p. 83	**Overview of Corken Vane Pumps**, C. M. Vickery, *Corken, Inc.* p. 85	**Optimization of Duct-Work Design,** Dalton Moore, Alex Roswell, Scott Agee, and Qadar Alsherit, *Oklahoma State University* p. 86	**NO PRESENTATION**	**NO PRESENTATION**

SESSION 1-A

Biomechanics I
EN 108

Chairs:
Arvind Santhanakrishnan, Ph.D.
Assistant Professor
School of Mechanical and Aerospace Engineering
Oklahoma State University
Stillwater, Oklahoma
(405) 744-5900
askrish@okstate.edu

Page

BAT EAR AERODYNAMICS: PRELIMINARY RESULTS FROM FLOW VISUALIZATION OVER EARS WITH AND WITHOUT TUBERCLES

Christopher E. Petrin and Brian R. Elbing*
Mechanical and Aerospace Engineering
Oklahoma State University
Stillwater, OK 74078
(405) 744-5897
cepetri@okstate.edu; elbing@okstate.edu

Monte L. Thies
Biological Sciences
Sam Houston State University
Huntsville, TX 77341
woodrat@shsu.edu

William Caire
Biology
University of Central Oklahoma
Edmond, OK 73034
wcaire@uco.edu

ABSTRACT

The Mexican Free-Tailed bat (*Tadarida brasiliensis*) is known to dive from its cruising altitude of several thousand feet into their home caves, achieving estimated speeds of 60 mph (27 m/s)[1]. The ears of these bats have a series of small tubercles on the leading edge, which mimic the pattern observed on the leading edge of humpback whale (*Megaptera novaeangliae*) fins. The whale fin tubercles have been proven to delay stall, enabling the whale to retain better control during dives. Thus, the aim of this study is to assess whether the free-tailed bat's ear aid in flow control for the bat. Flow visualization of the wake behind a model bat ear with and without tubercles was used to estimate the influence on lift and drag. The results of this preliminary study and discussion of the path forward will be presented.

---

* Member, ASME
[1] Davis et al., 1962

EXPERIMENTAL INVESTIGATION OF METACHRONAL PADDLING

M. Samaee, H. K. Lai, and A. Santhanakrishnan*
School of Mechanical and Aerospace Engineering
Oklahoma State University
Stillwater, OK 74078
(405) 744-5900
milad.samaee@okstate.edu

ABSTRACT

Long-tailed crustaceans such as crayfish swim by rhythmically paddling a set of four to five limbs (known as swimmerets or pleopods) originating from their abdomen. The paddling is performed as a tail-to-head metachronal rhythm with an approximate quarter period inter-limb phase difference. The objective of this study is to experimentally investigate metachronal paddling as a function of Reynolds number (*Re*) from the observed biological range of O(10-1000) to a non-biological range of O(10,000), for quantifying hydrodynamic scalability of this swimming mechanism prior to applications in the propulsion of small-scale autonomous underwater vehicles. A scaled robotic model of metachronal paddling was developed for investigation, consisting of a rectangular aquarium tank fitted above with four stepper motors coupled to a four-bar linkage that actuate the paddles immersed in the fluid. 2D particle image velocimetry (PIV) was used for quantitative flow visualization. The effect of altering phase difference between limbs in relation to the *Re* will be presented.

* Member, ASME

COMPARATIVE DYNAMICS OF PERCHING BIRDS FOR UAV ADVANCEMENT

Jonathan Mitchell*, Stephen Ziske†, and Jamey Jacob‡
Mechanical and Aerospace Engineering
Oklahoma State University
Stillwater, OK 74074
(405) 744-5900
Jonathan.mitchell@okstate.edu

ABSTRACT

One characteristic of biological flight that has proven elusive to man-made fixed-wing aircraft is the ability to perch, i.e. alight on a branch or ledge. A small unmanned air vehicle (UAV) capable of perching could perform a perch-and-recharge technique if equipped with solar panels to extend its mission duration. In addition, surveillance UAVs could perch-and-stare for increased surveillance capability, a technique already employed by rotary-winged UAVs. To better understand the perching dynamics of fixed-wing aircraft, this research examines the perching maneuvers in several species of birds using photogrammetry techniques. Preliminary videos were recorded with dual cameras filming at 300 frames per second and results were analyzed with Open Physics Tracker software. Preliminary results and relevant avian physiology are discussed within. Further experiments will be recorded with a series of synchronized cameras filming at 300 frames per second and analyzed in Matlab's Computer Vision toolbar. Methodology and future work are detailed within. Ultimately, the study of avian wing, tail, and body movement upon executing a perching maneuver will be used to improve fixed-wing UAV perching techniques.

* Niblack Research Scholar, AIAA Student Member
† Freshman Research Scholar
‡ Ray and Linda Booker Professor, School of Mechanical and Aerospace Engineering, AIAA Associate Fellow

CURRENTS INDUCED BY UPSIDE-DOWN JELLYFISH: EFFECTS OF BELL SIZE AND INTERACTIONS WITH BACKGROUND FLOW

M. Gaddam, M. Takyi-Micah, and A. Santhanakrishnan*
School of Mechanical and Aerospace Engineering
Oklahoma State University
Stillwater, OK 74078
(405) 744-5900
askrish@okstate.edu

ABSTRACT

Patchy aggregations of *Cassiopea* medusae, commonly referred to as the "upside-down" jellyfish, are seen in sheltered marine environments such as mangrove forests and coral reefs in shallow regions saturated with sunlight. They exhibit a sessile, non-swimming lifestyle, and are oriented such that their bells are attached to the substrate and oral arms directed toward the free surface. Pulsations of their bells drive flow toward and away from the body, assisting in filter feeding and for exchange of inorganic and organic matter across the water column. These organisms can be used as a test model to examine the hydrodynamics of unsteady porewater pumping and filtration at low Reynolds number. While several studies have examined the basic functional morphology and fluid interaction in individual *Cassiopea*, the effects of body size and background flow on currents generated by these medusae are unclear. We investigate the effects of body size and background flow on currents generated using three experimental approaches. Bell pulsation kinematics was quantified from digitized videos. Fluorescein dye introduced underneath the substrate via gravity feed was used to investigate release of porewater via bell motion. Quantitative flow visualization studies of *Cassiopea* currents were conducted using 2D particle image velocimetry (PIV). The medusae were introduced in a low-speed recirculating flume to replicate the background flows observed in their natural environment. The results of the study suggest an inverse dependence of bell diameter on pulsing frequencies and peak induced jet velocities. Vertical mixing of medusa-induced jets were observed in the presence of background flow. The implications of the study findings on organism-induced mixing in nearly quiescent flow habitats will be presented.

* Member, ASME

CLAP-AND-FLING AERODYNAMICS IN TINY INSECTS USING BRISTLED WINGS

C. L. Terrill* and A. Santhanakrishnan†
School of Mechanical and Aerospace Engineering
Oklahoma State University
Stillwater, OK 74078-5016
(405) 744-5900
chris.terrill@okstate.edu

ABSTRACT

The aerodynamics of flapping flight in tiny insects (such as thrips) that are 1 mm or smaller in size is not well understood. These insects typically fly at Reynolds number (*Re*) of 10 or lower where viscous effects are significant, and are of considerable ecological and agricultural importance. They also provide a means to explore the mechanical design adaptations needed to overcome the substantial viscous resistance present in low *Re*, and are of importance to engineers due to potential applications in the biomimetic design of micro aerial vehicles. A specific form of wing-wing interaction known as the 'clap and fling' is commonly observed in free flying tiny insects, such that their wings come into contact ('clap') at the end of each upstroke and the wings rotate about the trailing edge at the beginning of each downstroke resulting in 'fling'. This motion has been observed to augment the generation of lift due to generation of leading edge vortices on the wings during fling. In addition, wings of tiny insects are fringed or bristled in structure. A recent computational study by Santhanakrishnan *et al.* (J. Exp. Biol., 2014) showed that wing-wing interaction using porous wings reduced drag generated during fling at low *Re*. However, the porous wings used in this study only coarsely represented the 'leakiness effect of bristles and needs further investigation. The goal of this study is to quantify the difference in force generation between solid and bristled wings during wing-wing interaction. This is done experimentally through the use of a robotic mechanism programmed to execute 'clap and fling' motion of scaled physical models of solid and bristled wings. Force generation obtained from strain gages instrumented on the model wings and flow structures visualized using 2D particle image velocimetry will be presented.

---

* Student Member, AIAA
† Member, ASME

SESSION 2-A

Manufacturing I

EN 107

Chair:
Xiaoliang Jin, Ph.D.
Assistant Professor
School of Mechanical and Aerospace Engineering
Oklahoma State University
Stillwater, Oklahoma
(405) 744-5900
xiaoliang.jin@okstate.edu

Page

ACCOUNTING FOR UNCERTAINTY AND SUSTAINABILITY IN THE REALIZATION OF MULTISTAGE MANUFACTURING PROCESSES

J. Milisavljevic[1,*], M. Robayo[2,†], J. K. Allen[2,‡], S. Commuri[3], and F. Mistree[4,‡]
[1]School of Aerospace and Mechanical Engineering
[2]School of Industrial and System Engineering
[3]School of Electrical and Computer Engineering
[4]System Realization Laboratory
University of Oklahoma
Norman, OK 73019
(703) 380 -0908
jelena_84@ou.edu

ABSTRACT

The common issue in Multistage Manufacturing Processes (MMP) is the inability to identify root cause of errors, ineffective use of sensing data, inadequate control actions, and not taking into account the uncertainties that violate sustainability. We propose a method to address the preceding. Our method for managing uncertainty incorporates variation propagation in MMP, which is based on a stream-of-variation model (SoV) and the compromise Decision Support Problem (cDSP) construct for design exploration. We illustrate the efficacy of our method using a two-dimensional panel assembling process in three stages. This is ongoing research as part of a MS thesis that will be further expanded to a PhD dissertation.

[*] Jelana Milisavljevic acknowledges the financial support from NSF Eager 105268400.
[†] Matias Robayo acknowledges the financial support from the SENESCYT–Ecuador.
[‡] Janet K. Allen and Farrokh Mistree acknowledge the financial support that they received from the John and Mary Moore chair account and the LA Comp chair account, respectively.

MELT EXPULSION DURING THE ULTRASONIC VIBRATION-ASSISTED LASER SURFACE PROCESSING*

S. Habib Alavi†, Cody Cowell†, and Sandip P. Harimkar
School of Mechanical and Aerospace Engineering
Oklahoma State University
Stillwater, OK 74078
(405) 744-5830
sandip.harimkar@okstate.edu

ABSTRACT

Hybrid manufacturing has recently been gaining widespread attention due to the synergistic advantages of offered utilized techniques. Conventional machining assisted by ultrasonic vibrations has long been used to enhance the quality and microstructure of the machined surfaces. In this study, ultrasonic vibration-assisted laser surface processing of austenitic stainless steel (AISI 316) is reported. The high frequency ultrasonic vibrations (20 kHz) with vibration amplitude in the range of 20-50 μm were applied while the continuous wave laser beam was irradiated on the surface of the AISI 316 stainless steel substrate. The application of the ultrasonic vibration enhances the heat convection and delays the heat generation at the surface of the specimen. On the other hand, the applied force from ultrasonic vibration on the melt pool results in expulsion of the liquid metal and forms the surface drilled holes. The mechanisms of hole formation at low and high ultrasonic vibration power outputs and microstructural development during the ultrasonic vibration-assisted laser surface processing (with laser power of 900 W and irradiation time in the range of 0.30-0.45 s) are reported. The results indicate that the proposed ultrasonic vibration-assisted laser processing can be designed for efficient material removal (laser machining) and improved equiaxed microstructure (laser surface modifications) during materials processing.

* This work was supported by the U.S. National Science Foundation grant No. CMMI-1149079.
† Member, ASME

EXPERIMENTAL STUDY ON CHATTER STABILITY IN VIBRATION ASSISTED MILLING PROCESS

Anju Poudel and Xiaoliang Jin
School of Mechanical and Aerospace Engineering
Oklahoma State University
Stillwater, OK 74078
(504) 339-8823
apoudel@okstate.edu

ABSTRACT

Chatter is an unstable form of self-excited mechanical vibration caused by regenerative chip formation in the machining process. It is one of the main problems which not only generate poor surface quality but also reduce the tool life. This paper investigates the effect of vibration assistance on the attenuation of high frequency chatter vibration in micro milling process. External vibration is applied on the workpiece in a range of frequencies and an amplitudes using the piezoelectric actuator.

A periodic separation between the workpiece and tool is developed when vibration is applied. This in turn counteracts the self-excited vibration and reduces the chatter amplitude.

This experimental study is carried out to investigate the micro-milling of aluminum alloy workpiece (Al 6061 T6). Two fluted carbide square ended tool with 3.175 mm diameter and 30° helix angle is used. The sound signal is monitored using the sound pressure signal measured by a microphone. The effect of vibration in 1D (feed and normal direction) and 2D on the amplitude of chatter vibration is studied. Through the experimental results it is observed that the chatter amplitude is reduced by 30 -45% when forced vibration is applied in 2D and by 20-35% in 1D. In 1D chatter reduction is higher when vibration is applied in feed direction than in normal direction. Amplitude of chatter vibration reduces with the increase of applied vibration amplitude. It is concluded that the vibration assistance is able to effectively attenuate the high frequency chatter vibration in the micro-milling process.

Keywords: Chatter amplitude, vibration assisted milling, piezoelectric actuator

LASER SURFACE ALLOYING OF TRANSITION METALS WITH ALUMINUM TO ENHANCE CORROSION RESISTANCE

Hitesh D. Vora*, PhD
Assistant Professor
Mechanical Engineering Technology
Oklahoma State University
386 Cordell South
Stillwater, OK 74078
(405) 744-9578
hitesh.vora@okstate.edu

ABSTRACT

Aluminum (Al) and its alloys are widely used in various technological applications, mainly due to the excellent thermal conductivity, non-magnetic, ecofriendly, easy formability and good recyclability. Although the corrosion resistance properties of Al and its alloys are relatively good over 6–8pH values due to the formation of a thin protective passive layer, but triggers localized pitting corrosion under chloride, fluoride, and highly acidic atmosphere and therefore its applications are hampered in various engineering sectors. The corrosion resistance of Al and its alloys can be substantially increased by development of transition metal (TM) intermetallic (Al_xTM_y, where, TM = Mo, W, Ta, Nb, Cr, Zr and V). However, the equilibrium solid solubility of TM in Al is less than 1 at %, the formation of solid solution is not feasible and hence, the synthesis of these intermetallic using conventional alloying methods is highly challenging. In light of this, surface modification via laser surface alloying (LSA) is a promising engineering approach to mitigate the corrosion, abrasion, and wear problems. In the present preliminary study the attempts are made to study the Al-Mo system as a potential corrosion resistant coating on aluminum. After laser surface alloying (LSA) of Mo on Al, the anodic polarization test were performed in 0.01 M HCl solution at pH 2 to evaluate the corrosion resistance of various phases obtained during (LSA). Additionally, first principle calculations of thermodynamic, electronic and elastic properties of intermetallics in Al-Mo system were also thoroughly investigated to correlate the corrosion performance of Al-Mo coating with these properties. The present study indicates that novel Al-Mo intermetallics (Al_5Mo, Al_8Mo_3) has a great potential for light weight structural applications with enhanced corrosion resistance.

---

* Member, ASME

Ag-NYLON NANOCOMPOSITES BY DYNAMIC EMULSION POLYCONDENSATION*

Linqi Zhang[1], Sriharsha Karumuri[1], Habib Alavi, Sandip P. Harimkar, and A. Kaan Kalkan[1]
[1]Functional Nanomaterials Laboratory
Department of Mechanical and Aerospace Engineering
Oklahoma State University
Stillwater, OK 74078
(405) 744-5907
kaan.kalkan@okstate.edu

ABSTRACT

Thermoplastics have revolutionized human life due to their ease of fabrication and low cost. A common and effective approach to mechanical enforcement of thermoplastics is inclusion of micro- or nanofillers of higher strength and elastic modulus. Conventionally, the fillers are dispersed by shear mixing in molten polymer, where viscosity of the mixture is dramatically increased due to large interface area. Accordingly, the dispersion is not efficient and filler content is typically limited to below 5% by weight.

The present work develops a novel technique for dispersing nanofillers in a thermoplastic polymer, where polycondensation and dispersion of the nanofillers occur simultaneously via dynamic emulsion polycondensation at ambient temperature. The composite is manufactured in the form of a uniform powder, which can be molded into desired shape by melting. The technique is demonstrated for silver nanowire - nylon 66 nanocomposites. In this demonstration, ag nanowires are synthesized by polyol process. Polyvinylprrolidone (pvp) is used to functionalize the ag nanowires. Composites with ag weight fraction of 1.49%, 3.28%, 6.74% are prepared and characterized by sem, tem, uv-vis, xrd, raman scattering, ftir, dsc and nano-indentation.

The ag nanowires are found to be monodispersed and hydrogen-bonded to the nylon 66 matrix through pvp. Glass transition temperature of the composites decreases from 61 to 48°c with ag weight fraction increasing from 0 to 6.47%. The decrease of the glass transition temperature is owed to the plasticizer effect as well as heterogenous nucleation effect of the nanowires for polymerization leading to shorter chain length. Finally, mechanical properties of the composites show insignificant variation with the filler content. This absence of the composite effect is explained by halpin-tsai model, where the filler enforcement and decrease in matrix modulus counterbalance.

* This work has been supported by USA ARMY.

SESSION 3-A

Structural Dynamics and Acoustics
ATRC 103

Chair:
James M. Manimala, Ph.D.
Assistant Professor
School of Mechanical and Aerospace Engineering
Oklahoma State University
Stillwater, Oklahoma
(405) 744-5900
james.manimala@okstate.edu

Page

DIRECTION-BIASED ACOUSTIC METAMATERIAL WAVEGUIDE

Prateek P. Kulkarni*, Vishnu Paidimarri, Barrett Lee*, and James M. Manimala*
Solid & Structural Dynamics Lab
School of Mechanical and Aerospace Engineering
Oklahoma State University,
218 Engineering North
Stillwater, OK 74078
(405) 744-5900
james.manimala@Okstate.edu

ABSTRACT

Acoustic Metamaterials (AM) are a class of artificial materials that derive their unique dynamic properties not just from material constituents but more so from engineered configurations. Tailoring their engineered configuration imparts unusual wave manipulation capabilities that bring about novel applications. We demonstrate the feasibility of a passive direction-biased structural waveguide using an AM having sequential arrays of linear and nonlinear hardening-type (NLH) resonators. Using an effective mass model, approximate analytical solutions are derived for the amplitude-dependent dispersion curve shifts owing to the presence of cubic nonlinearities. Intriguing features such as branch overtaking and curling are observed. Numerical verifications performed using single, dual and narrowband frequency excitations show that by choosing the local resonance frequencies of the linear and NLH resonators appropriately, an amplitude-activated direction-bias in the propagation characteristics is achieved depending on whether the incident wave first passes through the linear or NLH resonator arrays. A prototype is being experimentally evaluated to verify the mechanism of shift in the spectrum of the propagated wave to lower frequencies when it passes through the NLH resonator array and the stop-band of the linear resonator array that enables this AM to act as waveguide in one direction and filter in the opposite direction for excitations within a tunable frequency range. An entirely passive direction-biased waveguide for mechanical waves would be a promising step towards a full-fledged mechanical analog of the electronic diode. It has attractive applications for acoustic shielding of sensitive equipment and steering and focusing of mechanical waves in both medical and military devices.

* Member, ASME

CHARACTERIZATION OF A PULSATING DRILL BIT BLASTER

Nick Thorp[1], Geir Hareland[1,2], and Brian R. Elbing[1*]
[1]Mechanical & Aerospace Engineering
[2]Chemical Engineering
Oklahoma State University
Stillwater, OK 74078
(405) 744-5016
nick.james.thorp@gmail.com; geir.hareland@okstate.edu; elbing@okstate.edu

ABSTRACT

Recovering natural gas and petroleum resources is an efficiency driven process due to the high cost of the required equipment and labor. One of the most time consuming steps in the process is the drilling of the borehole through thousands of feet of earth to the natural resource. The modelling and optimization of this process has been studied extensively for current drill bit technologies. The limiting factors effecting the rate of penetration (ROP) obtained by a drill bit have historically been due to the lack of ability to clean the bit at high ROP values, a low efficiency in communicating the surface weight on bit (WOB) to the bit due to drill string friction, and the limited jet impact forces imparted to the formation by the fluid exiting the drill bit nozzles. These issues could in theory be minimized through the use of a drill bit that vibrates, leading to lower drill string friction and more efficient transport of cuttings underneath the bit. This research focuses on a drill bit that generates an approximately sinusoidal pressure profile with a frequency and amplitude that can be varied by design and operating modifications. The goal of this research is to predict the vibrational characteristics of this bit by generating a model to describe the influence of altering aspects of the bit design and operating conditions. This was accomplished by calculating the pressure amplitudes expected based on internal flow areas and flow parameters and using existing pressure data from initial tests to verify the model. The next step will be to test the bit over a variety of operating conditions and design modifications in an attempt to further verify the legitimacy of the model; the goal being to create a model that would allow the bit pressure oscillation frequency and amplitude to be optimized with regard to the lithology of the formation being drilled. This could lead to faster, more efficient drilling which would cut drilling costs and lead to a larger number of oil and natural gas plays being profitable.

[*] Member, ASME

METAMATERIAL-INSPIRED STRUCTURE FOR IMPROVED LOW-FREQUENCY ACOUSTIC NOISE MITIGATION*

Anuj Rekhy, Ryan Aiken, and James M. Manimala†
Solid & Structural Dynamics Lab
School of Mechanical and Aerospace Engineering
Oklahoma State University
218 Engineering North
Stillwater, OK 74078
(405) 744-5900
james.manimala@okstate.edu

ABSTRACT

Conventional acoustic absorbers like foam, fiberglass or acoustic liners have limited effectiveness in practice for mitigation of low-frequency (~<400 Hz) noise, a significant contributor to environmental noise pollution, undesirable structural resonances, enhanced acoustic signature and reduction in quality of performance. Inspired by metamaterials, which are manmade structural materials that derive their unique dynamic behavior not just from material constituents but more so from engineered configurations, we investigate mass redistributed 3D printed configurations and tuned mass-loaded stretched membrane-type vibro-impact attachments on a baseline structure to make it more effective as a low-frequency acoustic barrier. Incident low-frequency waves can be up-converted via impact to higher modes in the backing structure enabling subsequent dissipation in conventional absorbers. Moreover, this tunable, passive mechanism is amenable to multifunctional integration for energy harvesting and sensing applications. A key prototype design criteria was to minimize parasitic mass addition (<10%) while retaining primary functionalities of the structure. Proof-of-principle for enhanced transmission loss in a tunable low-frequency range was demonstrated using mass redistributed 3D-printed test articles. Preliminary results from experiments on mass redistributed prototypes show the feasibility of this approach. Successful transition to applications could enable new mission capabilities for aerospace and military vehicles and help create quieter built environments.

* This work is being supported by NASA-EPSCoR.
† Member, ASME

DEVELOPMENT OF A COMPACT ATMOSPHERIC INFRASONIC MEASUREMENT SYSTEM FOR EARLY DETECTION OF TORNADOES

Arnesha Threatt and Brian R. Elbing*
Mechanical and Aerospace Engineering
Oklahoma State University
Stillwater, OK 74078
(405) 744-5897
arnesht@okstate.edu, elbing@okstate.edu

ABSTRACT

The ability to monitor the weather has always been important and the predicting of severe weather will always be necessary. Historically, weather monitoring has relied on a wide variety of instruments to measure temperature, pressure, and wind speed. Recent studies from NOAA researchers have shown that various natural phenomena (including earthquakes, severe-weather systems, volcanoes, and tornadoes) emit infrasonic frequencies. These sounds, which cannot be heard by the human ear, can be measured from large distances because low frequency acoustic signals have a very low decay rate in the atmosphere. These sounds allow for long-range, passive monitoring of these various phenomena as well as being used to develop more accurate predictive models.

The objective of the current work is to improve the accuracy and lead time of severe weather warnings, with specific emphasis on tornado prediction. To fully complete this task the infrasonic makeup of severe weather must be known so that it may be easily identified when it occurs. To be able to distinguish the noise of the severe weather from regular atmospheric infrasonic emissions, the atmospheric infrasound background must be characterized. Using infrasonic microphones the atmospheric infrasound will be recorded and filtered of any infrasonic noise emitted from man-made disturbances such as planes, large trucks, or construction sites. Once filtered the infrasonic makeup of severe weather can be easily identified and studied. The current presentation will discuss design challenges associated with the development of a compact infrasonic measurement system as well as plans for the initial characterization of the background atmospheric conditions.

* Member, ASME

AN OPTIMIZATION-BASED STRUCTURAL HEALTH MONITORING TECHNIQUE USING EXPERIMENTAL SENSITIVITY FUNCTIONS

Chulho Yang, Ph.D.*, and Young Bae Chang, Ph.D.
Mechanical Engineering Technology
Oklahoma State University
Stillwater, OK 74078
(405) 744-3033
chulho.yang@okstate.edu

ABSTRACT

A new method to identify damages in a structure using embedded sensitivity functions and optimization algorithms is described and its performance is demonstrated in this paper. The suggested sensitivity analysis technique can be effectively used for the damage identification process due to its easiness of calculation from measured frequency response functions. In general, structural damages are characterized by changes in some mechanical parameters such as stiffness, mass, and damping. Embedded sensitivity functions offer a means of determining the path that is followed from the baseline to the perturbed FRF of the structure. The optimization algorithm finds the optimal combination of changes in design variables to minimize the object function that is defined as the difference between the measured and predicted FRFs for the damaged structure. The perturbation of system parameters such as stiffness, mass, and damping is defined as design variable in the optimization process. The accuracy of damage estimates is investigated with respect to various types and values of damages, objective functions, frequency ranges, scale factors, and procedures. This study shows that the proposed technique can improve the accuracy of damage identification. It is shown that the accuracy of damage identification is significantly improved with various enhancements applied to the technique.

* Member, ASME

SESSION 4-A

Polymers and Composites

ATRC 102

Chair:
Feng Lai, Ph.D.
Anadarko Presidential Professor
School of Aerospace and Mechanical Engineering
University of Oklahoma
Norman, Oklahoma
(405) 325-1748
flai@ou.edu

EFFECT OF PROCESSING CONDITIONS ON HYDRAULIC FLUID ABSORPTION OF QUARTZ/BMI COMPOSITES

Keith R. Hurdelbrink II, Gorkem E. Guloglu, Jacob P. Anderson, Zahed Siddique, and M. Cengiz Altan
School of Aerospace and Mechanical Engineering
University of Oklahoma
Norman, OK 73019
(405) 325-5011
keith.hurdelbrink@ou.edu

ABSTRACT

It is known that fiber-reinforced thermosetting composites are susceptible to absorbing moisture and other liquid contaminants. Irreversible damage, such as resin plasticization, laminate swelling, and fiber-matrix debonding, can be caused by small amounts of liquid penetrants absorption. Quartz fiber (AQ581) reinforced Bismaleimide (BMI) is a high-performance composite material commonly used in aerospace applications that require a high T_G or good electrical dielectric properties. There has been limited research into the effect of moisture and other liquid penetrants on quartz/BMI systems; this is most likely due to the relatively specialized nature of quartz/BMI when compared to more traditional epoxy-based composites. Various composite components used in aircrafts are often exposed to different types of hydraulic fluids, which may lead to anomalous absorption behavior over the service life of the composite. Microstructural features such as fiber volume fraction and void fraction can also have a significant effect on the absorption behavior of fiber-reinforced composites. Therefore, accurate predictive models for liquid absorption that consider fabrication conditions are particularly important for component design so that appropriate modifications can be made to limit fluid absorption.

This study will focus on the hydraulic fluid absorption characteristics of quartz/BMI laminates fabricated from prepregs conditioned at different relative humidity and subsequently cured at different pressures. To generate process-induced microvoids, prepregs were conditioned in an environmental chamber at 2, 40, 70, and 99% relative humidity at room temperature for a period of 24 hours prior to laminate fabrication. To alter the fiber volume fraction, laminates were cured at 68.9 kPa (10 psi) and 482.6 kPa (70 psi) via a hot press. The laminates are shown to have different levels of microvoids and fiber volume fractions, which were observed to affect the absorption dynamics considerably and exhibited clear non-Fickian behavior. A nearly linear increase in void fraction was observed with increasing relative humidity for prepreg conditioning. A one-dimensional hindered diffusion model (HDM) was successful in predicting the hydraulic fluid absorption behavior. Model prediction indicates that as the fabrication pressure increased, the maximum fluid content (M_∞) decreased. The degree of non-Fickian absorption behavior, measured by hindrance coefficient (μ), was shown to increase with the increasing void content.

GRAPHENE DISPERSION FOR POLYMER PRECURSORS

V. Shabafrooz*, S. Bandla*, and J. C. Hanan†
Mechanical and Aerospace Engineering
Helmerich Research Center
Oklahoma State University
Tulsa, OK 74106
(918) 594-8238
jay.hanan@okstate.edu

ABSTRACT

Graphene, a two-dimensional mono-atomic thick carbon allotrope with a hexagonal structure, has opened up an interesting research area in materials science over the past few years. Owing to its high surface area and aspect ratio, thermal and electrical conductivity, and exceptional tensile strength, graphene has proven to be very effective in enhancing the mechanical properties of polymer matrices.

Recent progress has shown that exfoliation of multi-layered graphene powder followed by dispersion into a non-polar dispersion medium is a promising approach that could have a profound impact on the creation of graphene-based polymer nanocomposites. The aim of our current research is to create well-dispersed graphene dispersion in a dispersion medium by a practical method. Commercially-available graphene nanoplatelets (GNPs) were added in ethylene glycol (EG) at certain concentration and sonicated using a bath sonicator. The sonicated dispersion was then centrifuged. Subsequent centrifugation sediments unexfoliated, multi-layer GNPs, from the exfoliated ones. This leads to a stable dispersion containing a certain concentration of few- to single-layer GNPs, dependent upon sonication time and centrifuge speed. These GNPs dispersions show promise to be incorporated into a polymer matrix for the development of graphene-based polymer nanocomposites.

---

* Student Member, ASME
† Member, ASME

INVESTIGATING MORPHOLOGY, INTERNAL STRUCTURE, AND TENSILE PROPERTIES ELECTROSPUN POLYACRYLONITRILE NANOFIBROUS YARNS

Bipul Barua and Mrinal C. Saha*
School of Aerospace and Mechanical Engineering
University of Oklahoma
865 Asp Avenue
Norman, OK 73019
(405) 325-1098
msaha@ou.com

ABSTRACT

Electrospun nanofibers have the potential in producing high strength carbon fibers from electrospinning of polyacrylonitrile (PAN) due to high level of macromolecular orientation. However, efforts to date toward producing high strength carbon nanofibers is very limited due to the fact that there are many parameters related to processing and environmental conditions affecting the internal structure, surface morphology, fiber diameter, and mechanical property of the nanofibers. Moreover, thermo-chemical reactions during heat treatment stages of the electrospun PAN nanofibers play important role in effecting the structural conversion and mechanical properties of the carbon nanofibers.

This study investigates the influence of relative humidity (RH) and temperature on internal structure, surface morphology and tensile properties of polyacrylonitrile (PAN) nanofibrous yarns produced from 10% by weight solution in dimethylformamide (DMF). Humidity and temperature inside the chamber are controlled and monitored using appropriate sensors during electrospinning process. It is found that at low humidity condition favors nanofibers with smooth surface, solid core structure and smaller diameter, whereas higher RH produces nanofibers with larger diameter with porous microstructure. The resulting nanofiber morphology is analyzed using a ternary phase diagram of H_2O/DMF/PAN. Porosity in the structure is found to be a consequence of water diffusion into the jet leading to rapid jet solidification and as a result liquid-liquid phase separation proceeds solidification during solvent evaporation. At higher temperature the transition from nonporous to porous structure occurs at higher RH owing due to larger miscibility area in the ternary phase diagram. Both diameter and crystallinity are found to be responsible for mechanical performance of nonporous nanofiber yarns, while amount of porosity is the most influential factor for porous nanofiber yarns. Annealing is found to alleviate surface roughness, reduce internal porosity and improve the mechanical performance of porous nanofibers.

* Member, ASME

PHOTODEGRADATION OF EPOXY POLYMERS*

Sriharsha Karumuri[1], Salah U. Hamim[2], Raman P. Singh[2], and A. Kaan Kalkan[1]
[1]Functional Nanomaterials Laboratory
Department of Mechanical and Aerospace Engineering
Oklahoma State University
Stillwater, OK 74078
[2]Mechanics of Advanced Materials Laboratory
Department of Mechanical and Aerospace Engineering
Oklahoma State University
Tulsa, OK 74106
(405) 744-5907
kaan.kalkan@okstate.edu

ABSTRACT

Recent research efforts have been focused on development of lightweight, ultra-strong and low-cost nanocomposite materials, which are set to replace conventional structural materials. To compete with the conventional structural materials, polymer nanocomposites should endure photochemical reactions, as their performance degrades significantly when exposed to ultraviolet (UV) radiation. This degradation process is typically referred as photodegradation (PD). The photochemical reactions activated by UV radiation (e.g., UVA radiation of sunlight) are: oxidation, dissociation, crosslinking and chain-scission. Oxidation results in yellowing or discoloration of polymers, while dissociation accounts for material loss. Crosslinking increases brittleness/stiffness and chain scission reduces strength.

Epoxy Polymers (EPs) have been extensively used as the matrix in composites. Previous PD studies have identified the photoproducts in EP photodegradation. Nevertheless, the degradation mechanisms were poorly comprehended owing to the heterogeneity in photochemical reactions because of sharp decay of UVA intensity with polymer depth from the surface. We overcome this limitation by characterizing the PD reactions in thin films (~630 nm thick) coated on quartz substrates. The present work elucidates the complex sequence of photochemical reactions by analyzing the discoloration (i.e., optical property changes) of EPs systematically using optical absorption spectroscopy. A fundamental kinetics model is developed which involves all four PD reactions and shows excellent agreement with the measured optical absorption kinetics. Additionally, one of the model parameters, namely crosslinking density, can be related to elastic modulus that again shows good agreement with the simultaneously acquired nano-indentation data. This work establishes that the PD is mainly driven by UVA excitation of carbonyl groups (i.e., $n \rightarrow \pi^*$ transitions). Excited carbonyls either undergo dissociation or transfer their energy to O_2 in the generation of singlet O_2, which subsequently reacts with the polymer.

* This work has been supported by NASA-EPSCoR.

EXPERIMENTAL AND THEORETICAL INVESTIGATION OF NON-FICKIAN MOISTURE ABSORPTION OF NANOCLAY/EPOXY COMPOSITE LAMINATES

G. E. Guloglu and M. C. Altan
School of Aerospace and Mechanical Engineering
University of Oklahoma
Norman, OK 73019 USA
(405) 568-0883
gguloglu@ou.edu

ABSTRACT

Degradation of properties of composite materials due to exposure to humid environment has been well-known for several decades. In most cases, degree of degradation is correlated to the amount of the absorbed moisture. Although the rate and amount of moisture absorption is most often modeled by one-dimensional Fickian model [1,2], polymeric composites frequently exhibit anomalous absorption behavior [3,4]. To fully describe the absorption kinetics, one-dimensional hindered diffusion model (Langmuir-type diffusion model) was developed to capture the non-Fickian effects, possibly due to the chemical interactions between the penetrant and the polymeric composite [4].

In this study, one-dimensional hindered diffusion model, which has been proven to accurately capture the absorption kinetics of various polymers and composites [5-8], is used to describe the moisture absorption to I.30E nanoclay/EPON 862 nanocomposite laminates. The model is shown to accurately predict the both short term Fickian and long term anomalous moisture absorption behavior of the nanocomposite laminates at different nanoclay loadings. The accuracy of the model is evaluated by the total root mean square error between the experimental moisture absorption data and model prediction. The effects of nanoclay loading on the moisture absorption kinetics are also investigated. The nanoclay content of each laminate is observed to correlate well with the extent of non-Fickian behavior and maximum moisture content.

REFERENCES

[1] Shen, C. H. and Springer, G. S. (1976). J. Composite Matls., 10(1): 2-20.
[2] Al-Harthi, M., Loughlin, K. and Kahraman, R. (2007). Adsorption, 13(2): 115-120.
[3] Liu, W., Hoa, S. and Pugh, M. (2008). Composites Sci. & Tech., 68(9): 2066-2072.
[4] Carter, H. G. and Kibler, K. G. (1978). J. Composite Matls., 12(2): 118-131.
[5] Grace, L. R. and Altan, M. C. (2014). Polymer Eng. & Sci., 54(1): 137-146.
[6] Grace, L. R. and Altan, M. C. (2013). Polymer Composites, 34(7): 1144-1157.
[7] Grace, L. R. and Altan, M. C. (2012). Composites Part A, 43(8): 1187-1196.
[8] Guloglu, G. E. and Altan, M. C. (2014). Proceedings of 30th International Conference of the Polymer Processing Society, Paper #S05-699, Cleveland, OH, USA.

SESSION 5-A

Multiphase Flow I
ATRC 101

Chair:
Brian E. Elbing, Ph.D.
Assistant Professor
School of Mechanical and Aerospace Engineering
Oklahoma State University
Stillwater, Oklahoma
(405) 744-5900
elbing@okstate.edu

Page

INVESTIGATION OF FOAM BREAK-UP IN A CFC/GLCC© SYSTEM*

A. Nababan†, R. Mohan, Ph.D.‡, and O. Shoham, Ph.D.
Tulsa University Separation Technology Projects (TUSTP)
The University of Tulsa
Tulsa, OK 74104
(918) 631-2000
arn615@utulsa.edu
and
G. Kouba, Ph.D.‡
Production Systems & Flow Assurance
Chevron Energy Technology Company
Houston, TX 77002

ABSTRACT

In crude oil transportation system when more than one phase flows in the same pipeline with gas as one of the components, it forms foam in the presence of suitable surfactants. Foam can be both artificially induced by gas in the flow and naturally occurring due to gas coming out of solution. Most often foam is undesirable and causes operational problems in separation facilities requiring the process or equipment to break the foam. Several methods can be applied to break the foam such as chemical, thermal 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. Two operation modes are conducted, namely, Gas Mode (GM) and Liquid Mode (LM) Operations. For the GM operation, the foam break-up in combined CFC/GLCC© system is more efficient than that in the GLCC© standalone, under the same flow conditions. Lowering the superficial gas velocity or increasing the superficial liquid velocity result in less stable foam, larger gas bubbles and lower half-life time. For LM operation, the outlet clear liquid flow rate (with no foam) increases with increasing superficial liquid velocity or decreasing superficial gas velocity. The recommended operational conditions for the CFC are at low superficial gas velocities, lower than the transition boundary to churn flow in the CFC.

---

* This research is supported by Chevron Tulsa University Center of Research Excellence (TU-CoRE) and Tulsa University Separation Technology Projects (TUSTP).
† Corresponding Author: Ardianty Nababan, Tulsa University Separation Technology Projects (TUSTP), McDougall School of Petroleum Engineering, The University of Tulsa, 800 S. Tucker Drive, Tulsa, Oklahoma, 74104.
‡ Fellow/Member ASME

THE EFFECT OF SURFACTANT CONCENTRATION ON RHEOLOGICAL BEHAVIOR OF OIL-WATER EMULSION

Kamyar Najmi* and Ram S. Mohan*
Mechanical Engineering Department
The University of Tulsa
Tulsa, OK 74104
(918) 849-4996
kamyar-najmi@utulsa.edu

ABSTRACT

Emulsions are widely confronted in many industries such as food, pharmaceutical, oil and gas etc. An emulsion is a mixture of two or more liquids that are normally immiscible where one of the liquids is dispersed as small droplets in the other liquid. The goal of this study is to investigate the effect of the amount of water in water-in-oil emulsion (water cut) on the bulk viscosity of the emulsion. In order to have a more stable emulsion, three different concentrations of surfactants are used in the emulsion to investigate their rheological behavior. Besides, the effect of surfactant concentration on rheological properties of oil-water emulsion is also experimentally investigated. To ensure proper mixing of the two phases and the stability of emulsion, a surfactant, namely, sodium dodecyl benzene sulfonate (SDBS) is used. Shear stress – shear rate behavior of oil-water emulsion of different water cuts (from 0% to 100%) is measured for three different cases.

The obtained results show not only the phase to which the surfactant is added affects rheological properties of emulsions but surfactant concentration also plays an important role. Obtained data from oil-water emulsion (no surfactant) experimentally confirms the water cut at which inversion point is occurring. Adding surfactant significantly increases the viscosity of the emulsion and changes the water cut at which inversion point is occurring. Further increases in surfactant concentration, although does not change the viscosity but changes the inversion point.

Extending current study may help develop a guideline for efficient use of surfactant in oil-water emulsion treatment. On the other hand it will also help in better understanding of the interfacial tension effect on rheological behavior of the emulsions.

---

* Member, ASME

GAS-LIQUID TWO PHASE FLOW IN DOWNWARD INCLINED PIPES

S. M. Bhagwat* and A. J. Ghajar†
School of Mechanical and Aerospace Engineering
Oklahoma State University
Stillwater, OK 74078
(405) 744-5900
swanand.bhagwat@okstate.edu

ABSTRACT

The gas-liquid two phase flow phenomenon finds its existence in several applications in oil and gas, chemical and energy industries. In comparison to horizontal two phase flow, very little is known about this phenomenon in downward inclined systems. The gas-liquid phenomenon in downward pipe inclinations is quite intriguing because of the inevitable existence of the stratified flow and the presence of buoyancy force in a direction opposite to that of the mean two phase flow. In this work, we have experimentally studied the transition between different two phase flow patterns and have measured void fraction, pressure drop and non-boiling heat transfer in downward inclined two phase flow. The experimental work is carried out in 0.5" I.D. polycarbonate and stainless steel pipes using air-water as fluid combination. The air and water flow rates are varied in a range of 0.001 to 0.2 kg/min and 1.5 to 12 kg/min, respectively to generate key flow patterns such as bubbly, slug, stratified, intermittent and annular flows. It is found that the transition between stratified and slug flow is most sensitive to the change in the pipe orientation whereas the transition between annular and non-annular flow patterns remain virtually unaffected by the change in pipe orientation. The transition between stratified and slug flow at low gas flow rates is marked by the appearance of transient nature of the two phase flow patterns and unsteady nature of the two phase flow. Moreover, the void fraction and two phase heat transfer coefficient is also significantly affected by the change in downward pipe inclination measured from horizontal. The dominant buoyancy force is observed to increase the void fraction up to 100% while decrease the two phase heat transfer coefficient up to 40%. The two phase pressure drop is found to increase with increase in the gas flow rates however, in stratified flow regime, it is found to be relatively insensitive to the change in gas flow rates. It is found that the existing correlations cannot correctly predict the two phase flow parameters (void fraction, pressure dorp and heat transfer) in horizontal and downward inclined stratified flow. An empirical non-dimensional model is developed to predict the transition between stratified and non-stratified flow in downward pipe inclinaitons for a range of pipe diameters and fluid combinaitons. This explicit empirical model is tested against variety of experimental data and is found to emulate the performance of existing mechanistic model of Taitel and Dukler (1976). Finally, the shortcomings of the existing models and the scope for the future research are laid out.

---

* Member, ASME
† Fellow, ASME

MASS TRANSFER AND BUBBLE SIZE IN A VIBRATING BUBBLE COLUMN REACTOR

Shahrouz Mohagheghian, Afshin J. Ghajar*, and Brian R. Elbing†
Mechanical and Aerospace Engineering
Oklahoma State University
Stillwater, OK 74078
(405) 744-5897
mohaghe@okstate.edu, afshin.ghajar@okstate.edu, elbing@okstate.edu
and
Adam Still
Sandia National Laboratory
Albuquerque, NM

ABSTRACT

The current experimental research on a vibrating bubble column reactor follows the research path started in the 1930's on bubble column reactors and is focused on understanding the fundamental physics of such a flow. A series of experiments were performed several years ago to study the effect of vibration frequency and amplitude on mass transfer, void fraction and bubble size. The vibrating bubble column reactor was designed to explore the dependence of these properties on vibration (amplitude and frequency), pressure, and gas flow injection. The shaker can create vibration frequencies of 5 to 40 Hz and amplitudes from 1 to 10 mm. Compressed gas was injected into the column using a 1.5 mm injector, and the volumetric flux rate was monitored with a Coriolis flow meter to create superficial gas velocities in the range of 1 to 10 mm/s. The instrumental suite included accelerometers to measure the shaker table response, and a dissolved oxygen probe to monitor the concentration of dissolved gases in the water. Monitoring of the bulk void fraction was carried out via imaging and comparing the surface level with no vibration and no gas injected case. In addition, bubble size distributions were determined from photographs taken at three column heights during vibration and static conditions.

Amplitudes of 4.5, 6.5 and 9.5 mm at frequencies ranging from 7.5 to 22.5 Hz were chosen as the original test matrix. This range of frequencies and amplitudes is higher than previous works. Mass transfer was obtained from superficial gas velocity (U_{SG}), specific power input (P_m), and Bjerknes number (Bj). The results showed that the Sauter mean diameter (d_{32}) decreased with increasing frequency. This presentation will review the results from this original study and provide details about the current effort updating the facility for future work.

---

* Fellow, ASME
† Member, ASME

SHEAR EFFECTS ON DROPLET SIZE DISTRIBUTION IN OIL-WATER FLOW*

M. Zhang†, S. Wang, Ph.D., R. Mohan, Ph.D. ‡, O. Shoham, Ph.D.
University of Tulsa (TUSTP)
Tulsa, OK
and
Haijing Gao, Ph.D
Chevron Energy Technology Company
Houston, TX
mo-zhang@utulsa.edu

ABSTRACT

Production equipment, such as pumps and chokes generate shear in oil-water mixture flow. The shear force contributes to forming smaller droplets in the system, which may cause operational and separation problems. Previous studies on shear effects on droplets have been focused mainly on orifices and centrifugal pumps. Nowadays, it is necessary to test the shear effect of other equipment, to enable modification and improvement of existing models. The objective of this presentation is to provide new data on droplet sizes under different shear effects in oil-water flow and compare it with model predictions. The new data, including the effects of the dispersed phase volumetric fraction and shear intensity on droplet size distribution, have been acquired utilizing a gear pump. The results demonstrate that droplets tend to decrease in diameter when the shear intensity increases. Moreover, higher dispersed phase volumetric fractions lead to larger resulting droplets.

Two prediction models of centrifugal pump, namely, Pereyra (2011) and Kouba (2014), are modified to enable droplet size distribution predictions for a gear pump. The Pereyra (2011) model is based on Dv95 with a constant spread parameter, while Kouba (2014) model depends on dmin and the volumetric fraction of dmin obtained from data. The modified models utilize the Rosin-Rammer distribution method, which has been found to fit the acquired data very well.

* This project is sponsored by Chevron TU-CoRE (Tulsa University Center of Research Excellence).
† Corresponding Author: Mo Zhang, Tulsa University Separation Technology Projects (TUSTP), McDougall School of Petroleum Engineering, The University of Tulsa, 800 S. Tucker Drive, Tulsa, OK-74104.
‡ Fellow/Member ASME

SESSION 6-A

Solar, Fire, Wind, Plasma, and the Universe I
EN 208

Chair:
Christian Bach, Ph.D.
Assistant Professor
School of Mechanical and Aerospace Engineering
Oklahoma State University
Stillwater, Oklahoma
(405) 744-5900
cbach@okstate.edu

Page

DESIGNING A COST EFFICIENT AND EFFECTIVE SOLAR COOKER

T. Adams* and M. Ng*
Department of Engineering
Oral Roberts University
Tulsa, OK 74171
Tom_Adams@oru.edu
(913) 207-8342

ABSTRACT

The purpose of this project was to design an inexpensive yet efficient solar cooker that can be manufactured and sold in Malawi. The cooker will help to reduce deforestation due to the amount of wood and charcoal used to cook meals in Malawi. It will also decrease health risks of frequently inhaling charcoal smoke, and provide jobs as local workers can manufacture it. The solar cooker is being designed with the guidance of Randal Perisho, who conceived the project, and the group's advisor, Dr. Robert Leland.

The cooker should be able to be manufactured for less than \$50 to avoid being cost prohibitive to potential customers. It must also cook well enough to compete with open fires currently used in Malawi. The main solar cooker type being used for this project is the parabolic cooker as these are the most efficient. However, since they are also generally expensive, it was combined with the concept of a panel solar cooker which can be made of much lower cost materials. The team therefore designed a geodesic parabola which can be cut out of a sheet of cardboard and folded into a parabolic form.
The National Renewable Energy Laboratory website provides maps with averages of solar power available across the US. Based on this information, and assuming a 50% energy loss, we calculated our desired amount of energy to find the needed projected area of the cooker. This gave a diameter of about 4.5 ft. For the shape of the individual panels, we wrote a Matlab program to calculate the necessary lengths of the triangles' sides and created a diagram to map out the triangle placements. The parabola is made with corrugated cardboard and scored on one side so the intact side can be bent together.
The reflective side of the cooker is covered in Mylar film, which has a high reflectivity and heat resistance. It is only slightly more expensive than aluminum foil but is much more wrinkle and tear resistant. Due to the flat panels that make up the reflector, the cooker is designed to have a focal zone with a diameter of about 10 inches, rather than a focal point. This should account for the average size of a cooking pot, but without needing constant readjustment that a smaller focal point would. The stand is made mainly from PVC pipe and some aluminum.

A cost analysis of the final design shows that it can be made for \$25. Running tests of the cooker is dependent on the weather conditions, which have not been ideal for much of our available testing time. The initial tests done however show that the cooker does heat up water

* Member, ASME

so that it steams. A pot with 2 qt. water reached 165°F on a 75°F afternoon and 170°F on a 72°F day. After some improvements were made, was able to reach 180°F on a clear day with an outdoor temperature of just 61°F and a 7mph breeze.

CONCENTRATION MEASUREMENTS OF OH AND CH RADICALS IN LAMINAR PARTIALLY PREMIXED AND PREVAPORIZED JET-A AND PALM METHYL ESTER FLAMES*

A. Balakrishnan†, R. N. Parthasarathy‡, and S. R. Gollahalli§
School of Aerospace and Mechanical Engineering
University of Oklahoma
Norman, OK 73019
(405) 325-7016
Email: arun.bala@ou.edu, rparthasarathy@ou.edu, gollahal@ou.edu

ABSTRACT

Palm methyl ester (PME) is an attractive alternate fuel that is becoming popular in Asia. It is produced by the transesterification of palm oil and has properties similar to those of petroleum-based fuels. Hence it can be blended with petroleum fuels and readily used in existing engines with little or no modifications. Thus, PME is an attractive alternate fuel. In this study, the dominant formation route of NOx and its influence on the CO formation in laminar flames of Jet A and PME were investigated. This was accomplished by capturing the laser induced fluorescence signals from the OH and CH radicals formed in the flames. The OH radical is a reliable indicator of flame zones and serves as a dominant oxidizer of soot particles in flames. OH is also considered to be a key indicator of NO formation regions through the thermal (Zeldovich) mechanism. The CH radical plays an important role in the inception stage of soot formation in hydrocarbon flames and the reaction of CH with N_2 is considered as the main source of prompt NO formation through the Fenimore Mechanism.

Planar Laser Induced Fluorescence (PLIF) technique was used to determine the relative population of OH and CH radicals in the near-burner region of the flames. The PLIF diagnostic system consisted of a pulsed Nd: YAG laser and an Optical Parametric Oscillator (OPO) with Frequency Doubler Option (FDO). The measurements were made at equivalence ratios (Φ) of 2, 3 and 7. At the equivalence ratio of 2, the OH and CH signal distribution closely followed the temperature profiles in both the Jet-A and PME flames. The population of OH radicals decreased with equivalence ratio and the region of maximum CH radical shifted downstream as the equivalence ratio was increased. The OH radicals were observed at farther downstream locations in the Jet-A flames than in the PME flames at the equivalence ratio of 2. The PME flame recorded lower CH concentration than the Jet-A flame at $\Phi = 3$ and 7. At $\Phi = 7$, the fluorescence signal from CH was found to be higher than that of OH in both the flames. The presence of high concentrations of CH in regions of peak NO concentration indicated that the NOx formation was significantly through the Fenimore mechanism at this condition.

* This work is supported by US DoE and NSF-EPSCoR.
† Student Member, ASME
‡ Associate Fellow, AIAA and Member, ASME
§ Fellow, AIAA and Fellow, ASME, Lesch Centennial Chair

FIRE SUPPRESSION SIMULATION STUDY

Kshitij V. Deshmukh, Ph.D.
Senior Technical Specialist
Worldwide Engineering Services
CD-adapco
Tulsa, OK 74133
(918) 505-4214
kshitij.deshmukh@cd-adapco.com

ABSTRACT

Military ground vehicles are equipped with **A**utomatic **F**ire **E**xtinguishing **S**ystems (AFES) to protect against enemy threats causing fuel tank ruptures and resulting fuel fires inside military vehicle crew compartments. The fires must be rapidly extinguished without reflash to ensure soldier protection from burn and toxicity risks. A Computational Fluid Dynamics (CFD) tool was developed which will complement vehicle testing for the optimization of AFES designs for specific vehicles and address their unique clutter characteristics.

The tool was validated for an exploratory test box and demonstrated via the evaluation of two different suppressant nozzle configurations for a military vehicle. This tool resulted from enhancements to STAR-CCM+, a commercial and proprietary CFD code of CD-adapco. It accounts for the three-dimensional (3D) growth and suppression of fuel spray fires with HFC227ea (Heptafluoropropane or HFP or FM200) + sodium bicarbonate, and the resulting toxic byproducts. A generalized global reduced kinetics model implemented here, parametrically, represents the effect of inhibitors with ten reactions and thirteen chemical species. The code is capable of parallel execution on platforms ranging from High Performance Computers (HPC) to low-cost, multi-core PCs including visualization of the simulated fire propagation and extinction, suppressant dispersion and toxic byproduct production and transport.

The result is a cost-savings tool with a negligible development payback period that optimizes soldier survivability in a fire situation. This modeling tool is currently being applied to predict the effectiveness of crew AFES in a number of Army ground vehicles.

STATOR USE ON VERTICAL AXIS WIND TURBINES

Aaron Alexander[*] and Arvind Santhanakrishnan, Ph.D.[*]
Mechanical and Aerospace Engineering
Applied Fluid Mechanics Lab
Oklahoma State University
Stillwater, OK 74078
(405) 744-3975
aaron.s.alexander@okstate.edu

ABSTRACT

Vertical Axis Wind Turbines (VAWT) have historically suffered from an inability to self-start and, especially on Savonius rotors, low efficiencies due to drag on the returning blade. A few VAWT studies have examined the use of stators to direct the flow onto the power producing side of the rotor thus preventing drag on the returning side, yet most designs allow the air to exit on the downstream side of the entering flow. This study investigates an alternative stator design for extracting more wind energy by trapping the incoming flow into a rising vortex within the stator enclosure. The flow is then allowed to exit above the stator.

The current study utilizes a stator arrangement made up of curved bladed that forces the entering air to remain trapped until it can exit above the stators. The initial evaluation of the results was conducted using Computational Fluid Dynamics (CFD) package Star-CCM+ set up with an unsteady k-ε model at a Reynolds number of about 1,400,000. The results of that model study are compared to a scale wind tunnel model with the internal flow measured using Particle Image Velocimetry.

[*] Member, ASME

SESSION 1-B

Biomechanics II

EN 108

Chair:
Ashlee N. Ford, Ph.D.
Assistant Professor
School of Chemical Engineering
Oklahoma State University
Stillwater, Oklahoma
(405) 744-6338
ashleefv@okstate.edu

Page

MATHEMATICAL MODELING OF BIODISTRIBUTION OF NANOPARTICLES IN THE KIDNEY

M. Pilvankar and A. N. Ford Versypt
School of Chemical Engineering
Oklahoma State University
Stillwater, OK 74075
(405) 744-5280
ashleefv@okstate.edu

ABSTRACT

Nanoparticles are being developed as therapeutic carriers to reduce toxicity of pharmaceutical drugs and for targeted drug delivery, especially for cancer treatment. Renal cell carcinoma—the most common form of kidney cancer—arises in the renal proximal tubule, a portion of the urine-formation duct system of individual nephrons of the kidney. Our collaborators at the Memorial Sloan Kettering Cancer Center have fabricated the first drug delivery devices comprised of biodegradable polymer nanoparticles that target the *exterior* surfaces of proximal tubules after systemic dosage in mice. This is an unusual biological surface for drug biodistribution. The mechanism is unclear for how the nanoparticles reach that location through the removal of nanoparticles from the blood stream and the resulting targeted accumulation. The network of porous capillaries called a glomerulus that is responsible for filtering the blood in the kidneys is located just upstream of the proximal tubule. It is typical to find large blood components in the glomerulus or still in the bloodstream due to the size of the components preventing them from fitting through the pores in the glomerulus. Only small molecules may pass through the glomerular filter to be excreted through the proximal tubules. The nanoparticles under investigation in this study are too large to pass through the pores of a glomerulus and thus cannot enter the *interior* of the connected proximal tubule. A second expected location for biodistribution would be on the *interior* of the peritubular capillary blood vessels downstream of each glomerulus if the particles adhered to the inner surfaces. Instead, the data show that the nanoparticles accumulate in the *exterior* space between the peritubular capillaries and the proximal tubules. The objective of our study was to develop a mechanistic mathematical model to explain the biodistribution and accumulation that was observed experimentally. We hypothesized that the likely transport mechanism for moving the nanoparticles from the bloodstream to the space between the peritubular capillaries and the proximal tubules occurs in three stages: margination, cytosis, and diffusion. Using COMSOL Multiphysics finite element solvers and routines for fluid dynamics and fluid-structure interactions, we investigated particle margination considering the size and physical properties of the nanoparticles in a three-dimensional microvasculature model. The simulations showed that the spherical nanoparticles in the blood flow tend to move towards the wall of the blood vessel in a process called margination while red blood cells avoid this drift toward the walls and stay distributed throughout the cross-section of the flow. For future work, we aim to build a model including the later stages of the mechanism. Successive refinements of the model will

lead to a robust tool for designing the optimal properties of nanoparticles to reach the intended target tissues consistently.

DEVELOPMENT OF SIMULATION FOR USE IN PREDICTING DRUG METABOLISM

C. German and S. Madihally
Chemical Engineering
Oklahoma State University
Stillwater, OK 74078
carrilg@okstate.edu

ABSTRACT

Controlled trials are used to test the efficiency and safety of new medicines and treatments. Due to the liver's vital role in the breakdown of medicinal drugs, liver cells are grown outside the body, termed *in vitro*, for less invasive and less costly analysis. Cultured cells are placed inside a scaffold, a porous structure which houses cells and allows growth, which is then placed inside a bioreactor, a manufactured environment meant to mimic conditions inside the body. Media is introduced to the cells providing nutrients for cell survival and growth. Cells are later subjected to drug concentrations to determine toxicity levels with respect to time. Drug development, including culturing, testing, and analyzing cells, is costly in both time and money. A better understanding of liver metabolism would make drug development more efficient by aiding in early decision making prior to large monetary commitment, and reducing lab experimentation funding and time. The objective of this study was to develop a liver metabolism model using computational fluid dynamics (CFD) capable of predicting liver metabolism of acetaminophen (APAP).

A computational fluid dynamics program (Comsol Multiphysics 4.4) was used to obtain concentration profiles. Initial concentration, APAP consumption and metabolite production rate laws, scaffold porosity, fluid properties, and drug and metabolite diffusion constants were input into simulation to evaluate the concentration profiles of APAP and the three main metabolites of APAP metabolism: APAP glutathione, APAP gluconuride, and APAP sulfate. Overall concentrations in the bioreactor were determined through multiple point analysis of Fick's Law and rate laws at nodes throughout the three dimensional structure. Model concentration distributions were tracked as bioreactor diameter was varied.

Both a static and axial-flow bioreactor with scaffolds 14mm and 6.5 mm in diameter to be placed in a six-well or 96-well plate, respectively, was simulated. Time-dependent concentration profiles were analyzed for static reactor simulation, and steady state concentration profiles were analyzed for flow simulation. Percent APAP metabolite conversion from simulation was compared with conversion values discussed in literature and were found to match very well. The next step in this research will include experimental validation, for which a protocol is already in the works, and expansion to more drugs.

COMPARISON OF VARIOUS TECHNIQUES OF DETERMINING THE WETTABILITY OF MATERIALS

L. Baghernejad* and E. Iski†
Department of Chemistry and Biochemistry
and
R. Mohan‡
Department of Mechanical Engineering
The University of Tulsa
Tulsa, OK 74104
(918) 812-7956
lida-baghernejad@utulsa.edu

ABSTRACT

Materials with special wettability properties are designed and developed for industrial, environmental and biological applications. The selective wettabilities of most produced materials towards certain liquids are usually inspired by nature. There exist many natural examples of matter with special wettability characteristics such as lotus leaves, mosquito eyes, butterfly wings, etc. In general, the wettability of a material depends on its chemical composition and surface structure. In terms of wettability towards water or oil, materials are classified as hydrophilic/hydrophobic or oleophilic/oleophobic respectively. A few methods have been developed and applied for determining the wettability of materials towards certain liquids. Among the most common techniques for quantifying the wettability of materials are static and dynamic droplet contact angle measurements. The contact angle of a droplet of a certain liquid on the surface of the substrate provides an estimate of the extent of wettability of the substrate by the liquid. There exist various techniques for carrying out droplet contact angle measurements. Each technique is associated with advantages and disadvantages. The present project focuses on reviewing, investigating and further understanding the fundamental concepts of the different methods applied for quantifying the wettability of various materials. Moreover, it is intended to clarify the effective parameters in each method and develop strategies to reduce or eliminate their present shortcomings. Such investigations are of crucial importance for characterizing materials produced for applications where substances with selective wettability are required.

* PhD Candidate in Chemistry
† Assistant Professor of Chemistry
‡ Fellow, ASME, Professor of Mechanical Engineering

SURFACE DIELECTRIC BARRIER DISCHARGE (SDBD) AS AN ALTERNATIVE FOR ATMOSPHERIC PRESSURE PLASMA STERILIZATION

Kedar Pai[1,*], Chris Timmons[2], Shannon Jiang[2], Li Ma[2], and Dr. Jamey D. Jacob[1,†]
[1]School of Mechanical & Aerospace Engineering
[2]Plant Pathology and Entomology (NIMFAB)
Oklahoma State University
Stillwater, OK 74078
(405) 744-5900
kedar.pai@okstate.edu

ABSTRACT

Atmospheric pressure plasmas, also known as cold plasmas, have been demonstrated as effective in sterilization and decontamination of biological hazards such as bacteria and other pathogens. Cold plasmas can be generated under certain conditions using high frequency and high voltage (kV) but low power (micro-Ampere) potentials using various methods of excitation. While useful in many industrial processes, cold plasma can also destroy deadly microbes lodged on substrates such as medical instruments, clothing and even human tissue. Research has shown that plasma is effective in the reduction of pathogenic bacteria and spores and in the decontamination of simulated chemical warfare agents, without the generation of toxic gases or other harmful by-products. This method provides various benefits that are unavailable to existing sterilization technologies such as portability, efficiency, and low temperature operation without use of any chemicals or water. The problem with many of these cold plasma sterilization systems is the size of the plasma generation system, making them unusable for field or emergency decontamination operations and too costly for small out patient facilities, where the majority of the sterilization market is located. Most cold plasma devices also require training in plasma engineering and high voltage operation, limiting their use in practical applications.

Based on one atmosphere uniform glow discharge, we evaluate Surface Dielectric Barrier Discharge (SDBD) for applications in decontamination. In the present study we show the benefits of the high velocity plasma induced flow of the asymmetric arrangement of electrodes over symmetric configurations. We demonstrate the ability of faster transport of plasma generated species using *Listeria monocytogenes* as a test pathogen. Further, various designs and geometries for the plasma actuators are discussed to demonstrate applications in sterilization of instruments of complex geometries. Finally, a design for efficient treatment of medical instruments at close proximity, with low power expenditure is presented.

---

* Member ASME
† Associate Fellow, AIAA

COMPARATIVE STUDY OF DIASTOLIC FILLING UNDER VARYING LEFT VENTRICULAR WALL STIFFNESS*

Pritam Mekala†, Audrey Pope†, and Arvind Santhankrishnan‡
School of Mechanical and Aerospace Engineering
Oklahoma State University
Stillwater, OK 74074
(405) 744-5900
Pritam.mekala@okstate.edu

ABSTRACT

Pathological remodeling of the human cardiac left ventricle (LV) is observed in hypertensive heart failure as a result of pressure overload. Myocardial stiffening occurs in these patients prior to chronic maladaptive changes, resulting in increased LV wall stiffness. The goal of this study was to investigate the change in intraventricular filling fluid dynamics inside a physical model of the LV as a function of wall stiffness. Three LV models of varying wall stiffness were incorporated into an in vitro flow circuit driven by a programmable piston pump. Windkessel elements were used to tune the inflow and systemic pressure in the model with least stiffness to match baseline healthy conditions. Models with stiffer LV walls were comparatively tested maintaining circuit compliance, resistance and pump amplitude constant. 2D phase-locked PIV measurements along the central plane showed that with increase in wall stiffness, the peak velocity and cardiac output inside the LV decreased. Further, inflow vortex ring propagation toward the LV apex was reduced with increasing stiffness. The above findings indicate the importance of considering LV wall relaxation characteristics in pathological studies of filling fluid dynamics.

* This work has been supported by Oklahoma Center for the Advancement of Science and Technology (OCAST HR14-022).
† Members of the Applied Fluid Mechanics Laboratory at Oklahoma State University
‡ Member, AIAA and/or ASME

AUTOMATED GRAM STAINING APPARATUS

D. Rykert*, M. Mathew, and G. Toby
Department of Engineering
Oral Roberts University
Tulsa, OK 74171
(818) 263-6814
aviatord@oru.edu

ABSTRACT

An automated gram staining apparatus is designed and manufactured for the Biology Department of Oral Roberts University. The process of gram staining helps students and medical professionals distinguish between two main types of bacteria by staining the sample with four chemicals – (1) crystal violet, (2) iodine, (3) acetone or ethyl alcohol, and (4) safranin. In between each chemical application the biology slide is washed gently with deionized water. The apparatus consists of a conveyor belt that will move the slide containing the bacteria through the four-stage chemical application process for a specified amount of time. Automating this process will improve the accuracy and consistency of the samples. The scope of the project is to automate this process with minimal assistance or involvement of the student. The targeted beneficiaries will be students studying various fields of medicine and the biological sciences.

The design and implementation of the project has proven to be successful. The machine is cost-effective – with an overall cost of $230 in materials. It is also time efficient – with a completion time of approximately 6 minutes. Other benefits include ease of manufacturability due to its simple design and portability as a result of its compact size. Most importantly, the transparent Plexiglas cover at the top of the apparatus makes it possible for students to be a part of the process and learn the staining technique as the samples are being stained and tested.

---

* Student Member, ASME

SESSION 2-B

Manufacturing II
EN 107

Chair:
Jelena Milisavljevic
School of Aerospace and Mechanical Engineering
University of Oklahoma
Norman, OK 73019
(703) 380 -0908
jelena_84@ou.edu

LONG BOARD DECK MANUFACTURING

Daniel Dickie[*] and Charles Tines[*]
Engineering Department
Oral Roberts University
7777 S. Lewis Ave.
Tulsa, OK 74171
(918) 495-6161
danielsdickie@oru.edu and charlietines@oru.edu

ABSTRACT

In this project the Young's Modulus and Modulus of Rupture for Baltic birch plywood of multiple plies was determined. These moduli allow predictive analysis to be performed on the behavior of laminated Baltic birch sheets under various loads. Baltic birch is commonly used in the longboarding industry as a base material for decks, the foundation of a longboarding assembly. The results of this project allow the predictable and repeatable manufacturing of these decks based on a technical understanding of the properties of this composite material.

Three-point bending tests were conducted using the relevant requirements from ASTM D790, which outlines test procedures for the determination of flexural properties. From these tests we were able to develop stress strain relationships for all tested specimens and compare and contrast how the number of plies affected the mechanical properties. In addition, the test results were applied to manufacture a longboard deck that consisted of five long-grain plies. This deck was designed using SolidWorks 2014, which allowed computer numerical control (CNC) machinery to be utilized for carving the complex geometry of the mold, a necessary piece for pressing the contours of the deck. To verify the utility of these findings the manufactured deck was compared to SolidWorks simulations and the three-point bending test results.

Baltic birch, like all wood, is an orthotropic material meaning that each axial direction contains unique properties. The determination of each axial property was superfluous to the application of this project, and thus only the mechanical properties in the longitudinal direction (long-grain) were considered. While the modulus of elasticity found was not the true modulus of elasticity of the material used in the beam it did represent the particular thickness of the beam sufficiently well that it could be used in a SolidWorks simulation to predict the displacement of an actual, irregularly shaped object within 12%.

[*] Member, ASME

THERMOSET-CROSS-LINKED LIGNOCELLUOSE: A MOLDABLE PLANT BIOMASS*

Sriharsha Karumuri[1], Salim Hiziroglu[2], and A. Kaan Kalkan[1]
[1]Functional Nanomaterials Laboratory, Department of Mechanical and Aerospace Engineering
[2]Department of Natural Resource Ecology and Management
Oklahoma State University
Stillwater, OK 74078
(405) 744-5907
kaan.kalkan@okstate.edu

ABSTRACT

The cellular structure of woody biomass, such as stover, is made up of a bio-composite known as lignocellulose. Because of its unique structure, lignocellulose possesses superior mechanical properties. This powdery and highly porous material can be blended with plastics and molded to structural composites, typically known as Wood Plastic Composites (WPCs). Despite synergistic advantages of their polymer and lignocellulose components, the stiffness and strength of WPCs are still significantly lower than those of lignocellulose due to weak adhesion between thermoplastics and lignocellulose.

The present work demonstrates a high biomass content (i.e., up to 90% by weight) and moldable material known as thermoset-cross-linked lignocellulose (TCL). It is prepared by controlled covalent cross-linking of lignocellulosic particles by an epoxy thermoset using epoxide-hydroxyl reactions. As an example for lignocellulosic biomass, Eastern redcedar was employed. Compression tests reveal, at 30% thermoset content TCL has superior mechanical properties over a commercial WPC while comparable stiffness and strength to bulk epoxy and wood, respectively. Macroscopic to molecular scale interactions of the thermoset with the lignocellulose account for the improved mechanical properties. These interactions have been revealed using scanning fluorescence microscopy and vibrational spectroscopy. The capillary action of biomass cellular network as well as applied pressure in the processing of TCL result in impregnation of the resin into the void network of lignocellulose forming thermoset microrods. We also infer permeation of the thermoset into the cell walls from the reaction of epoxides with the hydroxyls of the lignin. The failure mechanism of TCL is understood to be crack propagation along the particle-thermoset interface and/or interparticle thermoset network.

* This work has been supported by Oklahoma State University Technology and Business Development Program.

LASER PROCESSING OF MULTILAYERED Fe-BASED AMORPHOUS COATINGS ON STEEL*

Tanaji Paul, S. Habib Alavi, and Sandip P. Harimkar
School of Mechanical and Aerospace Engineering
Oklahoma State University
Stillwater, OK 74078
(405) 744-5900
tanaji.paul@okstate.edu

ABSTRACT

The increasing urge to find coatings for steel that improve its tribological and corrosion properties has driven considerable efforts in the scientific community, most of them utilizing plating, deposition and spraying techniques for realization of the same. Although there are reports of improved wear resistance of Fe based amorphous coatings, crystallization and dilution of the coatings from the substrate limit their performance. In the present work single layer and multi-layer (two and three layers) of Fe based amorphous coatings have been applied on steel via laser cladding. X-ray diffraction and scanning electron microscopy performed on the coatings delineate crystallization in the coating layers. Study of microhardness clearly shows that the coating consisting of three layers have the highest hardness. However, the wear resistance of the coating consisting of a single layer is superior as compared to the other two. This is attributed to their brittle nature which is discernible from the accelerated wear loss of the coating containing three layers at the final stages of wear as compared to the comparable wear losses of all three coatings at the early stages. The understanding of the wear behavior of these coatings would provide insights into the desired processing optimization, thereby paving the way for their rapid bulk production.

* This work has been supported by U.S. National Science Foundation

EXPERIMENTAL STUDY ON THE SURFACE GENERATION IN VIBRATION ASSISTED MICRO-MILLING OF GLASS

Xiaoliang Jin and Boyuan Xie
Mechanical and Aerospace Engineering
Oklahoma State University
Stillwater, OK 74078
(405) 923-7758
boyuan@okstate.edu

ABSTRACT

Micro-milling of glass is a technique to fabricate micro-optics with complex geometry using defined cutting edge. Vibration assisted cutting applies high frequency and small amplitude of displacement between the tool and the workpiece in addition to the original feed motion.

This paper presents the experimental study on the vibration assisted micro-milling of BK-7 optical glass. A piezoelectric actuated two dimensional vibration stage with adjustable amplitude and frequency is developed. The frequency response function of the vibration stage is experimentally calibrated. The effects of vibration direction, vibration amplitude and frequency on the surface roughness and profile are determined from a series of vibration-assisted micro-milling tests.

It is concluded that the vibration applied in normal direction has a major effect on the improvement of surface quality. Furthermore it is found that Ra value reduce asymptotically with the increase of vibration amplitude and frequency because higher amplitude results into higher hydrostatic pressure and higher frequency reduces the waviness of the surface, both of these effects improve the surface quality. The vibration assistance also enhances the brittle-ductile transition of glass material by increasing the hydrostatic pressure in the tertiary zone, therefore reduces the damage on the machined surface.

Keywords: Micro machining; vibration, surface, glass

DEVELOPMENT OF SIGNIFICANTLY GRAIN REFINED Ti-6Al-4V ALLOYS USING ULTRASONIC VIBRATION ASSISTED LASER SURFACE MELTING*

Sourabh Biswas and Sandip P. Harimkar
School of Mechanical and Aerospace Engineering
Oklahoma State University
Stillwater, OK 74078
(405) 744-5900
sourabh.biswas@okstate.edu

ABSTRACT

Ti-6V-4Al alloy is one of the most popular materials in materials research and exhibits excellent strength-to-weight ratio and corrosion resistance. In this study, the influence of ultrasonic vibrations (USV) of varying vibration amplitudes (power outputs) during laser surface melting (LSM) of Ti-6V-4Al alloys was investigated. Significant reduction in grain texturing, as indicated by x-ray diffraction analysis, during solidification was observed in the ultrasonic vibration-assisted laser surface melted samples compared to those laser melted without the application of ultrasonic vibrations. Microstructural analysis also indicated significant improvement in grain refinement in the USV assisted LSM samples versus the without USV samples. It was observed that surface hardness increases nearly three-fold in 470 to 486 HV compared to the hardness of as-received material (178 HV). The significant increase in hardness was concluded to be mainly a result of the extraordinary grain refinement that generated extensive grain boundary strengthening.

* This work has been supported by U.S. National Science Foundation.

SESSION 3-B

Robotics and Controls
ATRC 103

Chair:
Girish Chowdhary, Ph.D.
Assistant Professor
School of Mechanical and Aerospace Engineering
Oklahoma State University
Stillwater, Oklahoma
(405) 744-5900
girish.chowdhary@okstate.edu

Page

DITCH WITCH VACUUM EXCAVATOR

Zac Blumer
Ditch Witch
511 East Copper Canyon Avenue
Stillwater, OK 74075
(580) 716-1058
bblumer@ditchwitch.com

ABSTRACT

In this presentation a new project will be discussed about the design of a vacuum system for Ditch Witch in Perry, OK. The main use for a vacuum excavator is what is called "potholing", or digging a hole to expose utilities that could be easily broken by normal excavation methods. Vacuum excavators use high pressure water sprayed into the ground to blow away the earth and create mud, which is then sucked up by a vacuum hose into a spoils tank. This new machine design was communicated as an industry want and need from the Product Manager of vacuum systems. This proposal was for a ground up new excavator that incorporates a diesel engine with a non-Ditch Witch production sized spoils tank. A Yanmar 22 horsepower diesel engine, 250 gallon spoils tank, 80 gallon water tank, and all necessary parts from a blower to all crucial hydraulic components, were applied. This new vacuum system was initially used as my Senior Design Project in Mechanical Engineering Technology. It utilized my background in different studies learned from OSU as well as several years of work experience while at Ditch Witch. Also, not only was this machine an assignment for my Senior Design project, but the concept was later sold to a Ditch Witch dealership and their respective customer.

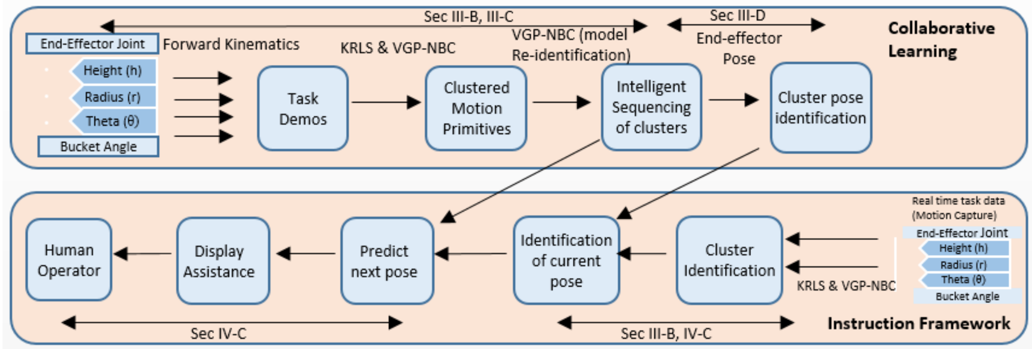
COLLABORATIVE GOAL AND POLICY LEARNING FROM HUMAN OPERATORS OF CONSTRUCTION CO-ROBOTS

H. Maske[1], M. Matthews[1], A. Axelrod[1], H. Mohomadipanah[1], G. Chowdhary[1],
C. Crick[2], and P. Pagilla[1]
[1]Mechanical and Aerospace Engineering
[2]Computer Science
Oklahoma State University
Stillwater, OK 74078
(405) 334-7295
maske@okstate.edu

ABSTRACT

Human operators of real-world co-robots, such as excavators and other heavy construction equipment, require extensive training and experience to skillfully handle these complicated machines in uncertain safety-critical environments. We consider the problem of human-robot collaborative learning and task execution, and propose a two-stage Learning from Demonstration framework for co-robotic applications where efficient interaction between human and robot is essential for safe and efficient operation. In our framework, the co-robot learns complex real world tasks from the demonstrations of skilled human operators, and then guides a novice human operator in completing complex tasks under uncertainty. To enable real-time policy segmentation from complex multi-input multi-output demonstrations, a new vector-valued Gaussian Process clustering algorithm is presented. The effectiveness of the presented framework is demonstrated through experimentation utilizing a scaled model of an excavator performing the truck loading task. We utilize our framework, to compare the performance of guided and unguided novice human operators. Our results demonstrate that when the co-robot's inferred subgoals are communicated back to the novice human operator, task performance significantly improves. As such the contributions of this work are as follows:

- A computationally efficient Vector-valued Gaussian Processes Non-Bayesian Clustering (VGP-NBC) algorithm for real time clustering of motion primitives, which has better prediction acccuracy and is faster than existing approaches.
- A semantically motivated instructional framework (Figure below) to train or assist novice users of co-robots.
- Validation of our approach through experimentation on a construction co-robot (a fully-functional 1:14 scale hydraulic excavator).


Sec III-B, III-C
Sec III-D
Collaborative Learning
End-Effector Joint
Forward Kinematics
KRLS & VGP-NBC
VGP-NBC (model Re-identification)
End-effector Pose
Height (h)
Radius (r)
Theta (θ)
Bucket Angle
Task Demos
Clustered Motion Primitives
Intelligent Sequencing of clusters
Cluster pose identification
Real time task data (Motion Capture)
End-Effector Joint
Height (h)
Radius (r)
Theta (θ)
Bucket Angle
Human Operator
Display Assistance
Predict next pose
Identification of current pose
Cluster Identification
KRLS & VGP-NBC
Sec IV-C
Sec III-B, IV-C
Instruction Framework

A FRAMEWORK FOR NAVIGATION BASED ON FAMILIARITY

Alex Suhren[1], Mehran Andalibi[1], Girish Chowdhary[1],
Christopher Crick[1], Doug Gaffin[2], and Brad Brayfield[2]
[1]DAS Lab
Oklahoma State University,
Stillwater, OK 74078
(405) 269-2052
alex.suhren@okstate.edu
[2]Department of Biology
University of Oklahoma
Norman, OK

ABSTRACT

Performing navigation tasks reliably and efficiently is one of the most essential objectives for an Unmanned Aerial Vehicle, or other mobile robots. Most current robot navigation algorithms use fusion techniques that combine location data from multiple sensors to increase the robustness of the robot's knowledge of its position and orientation. However, these algorithms tend to have large computational costs, require multiple expensive sensors, or rely on specific sensors that can have low reliability (GPS). This prevents reliable navigation techniques for mobile robots when cost is a constraint, or in environments with limited GPS availability.

To overcome the limitations above, researchers have resorted to navigation techniques based on vision that do not require significant computation. Specifically the inspiration for this paper comes from the navigation of bees and ants. We investigated a navigation technique termed template-based navigation, in which a robot uses a series of training images taken while traversing a path to recapitulate this path again autonomously after being placed nearby. This is done by determining the direction of travel from a comparison of the camera image and the training images.

In this project, we have created a framework that allows a robot to navigate from one point in its environment to any other point in the environment provided that the image set is strongly connected; that is to say that for every pair of points in the environment there is at least one set of images that connect the points. By evaluating automatically generated labels attached to the images, the robot is able to reduce computational requirements significantly.

To validate our navigation framework, a 3D mockup of the Oklahoma State University campus was created using the simulation environment V-REP. A robot with a 360 degree camera was emulated in the simulation environment. In a total of 2500 simulations within our V-REP environment, an autonomous agent can navigate complex paths with nothing but a vision sensor. Subsequently, the results also show that by varying the resolution of the

image, a more robust performance can be achieved, while reducing the shades of gray, diminishes the computational and storage cost.

DEVELOPMENT OF A ROBOTIC DEVICE FOR INFANT PHYSICAL THERAPY*

M. A. Ghazi† and M. D. Nash
Department of Aerospace and Mechanical Engineering
University of Oklahoma
Norman, OK 73019
(405) 325-5011
mghazi@ou.edu, michael.d.nash@ou.edu

ABSTRACT

We have developed a robotic device for physical therapy of infants with muscular disorders. The idea is that even if infants are too weak to attempt crawling on their own, they can acquire the skill with the help of a robot that senses their intentions and moves them around as if they had sufficient strength.

Since this robot assists in developing crawling skills, it is designed around the prone and crawling postures of infants. The mechanical structure resembles a padded platform suspended from a tripod. An infant is placed on the platform in a prone position. Based on the perceived intention of the infant, the robot moves his or her trunk in the desired direction. This enables the infant to move across the floor as well as lift himself or herself off the ground on all fours. Vertical motion is achieved by three linear actuators working in tandem. Motion across the floor is achieved using three omniwheels which can allow full holonomic motion.

The spacing around the infant's back and sides is large enough to accommodate the hands of a caregiver placing/removing the infant on/from the platform. The tripod legs are arranged to give the infant a view of the front; one leg directly behind and two in the front. To minimize the size of the device, the front legs are closer to the infant than the rear leg. To improve the infant's view, the angle between the front legs is wider than the other leg angles. Each leg is shrouded in a two-layer cover. The inner layer is sheet metal to protect the electronics against collisions with objects, and to protect the infant from the moving parts and wiring. The outer layer is a soft padding for extra protection of the infant.

---

* This work was supported in part by the NSF Division of Information & Intelligent Systems award #1208639 under the National Robotics Initiative.

† Member, AIAA

CONTROL OF A ROBOTIC DEVICE FOR INFANT PHYSICAL THERAPY*

M. A. Ghazi† and M. D. Nash
Department of Aerospace and Mechanical Engineering
University of Oklahoma
Norman, OK 73019
(405) 325-5011
mghazi@ou.edu, michael.d.nash@ou.edu

ABSTRACT

We are in the process of compiling data from the first round of experiments with a robotic device for physical therapy of infants. Briefly, this device is designed to help infants who are learning how to crawl. The target population is infants with a neuromuscular disorder known as Cerebral Palsy (CP). The device is a mobile platform on which an infant is placed in a prone position. From this position, an infant can use his or her limbs to push against the floor. These contact forces are sensed by the robot, which responds with motion in the appropriate direction. The drive system comprises three omniwheels forming a holonomic drive configuration. A holonomic drive configuration allows for motion in any direction in the horizontal plane.

For an infant controlling the robot to drive along the floor, we propose a controller based on Newton's Second Law of Motion: the acceleration of an infant's body is directly proportional to the applied force and inversely proportional to the infant's mass. Since infants with (CP) are often weaker than their typically developing peers, our proposed controller can provide an artificial boost in force. A small force applied by an infant with CP can be scaled up to match a larger force exerted by a typically developing infant of the same age. This boost factor can be adjusted for different infants.

During the development phase, we have had to revise the locations of the wheels multiple times. To avoid computing a different inverse kinematics model each time the design was modified, we derived a generalized inverse transform for the drive controller. The drive controller uses the inverse kinematics model of the robot to compute individual wheel velocities required to achieve desired motion of the platform. Some geometric parameters of the configuration are required and then the inverse kinematics transform can be automatically computed by the controller during initialization. This transform is scalable to any number of omniwheels.

---

* This work was supported in part by the NSF Division of Information & Intelligent Systems award #1208639 under the National Robotics Initiative.
† Member, AIAA

DEVELOPMENT OF FLEXIBLE ROD MODEL USING DISCRETE ELEMENT METHOD TO ANALYZE MULTI-FIBER PROBLEM

Jinsu Nam* and Junyoung Park†
Department of Mechanical Engineering Technology
Oklahoma State University
Stillwater, Oklahoma 74078
(405) 744-3033
j.park@okstate.edu

ABSTRACT

Discrete Element Method was firstly suggested by Cundall and Strack in 1979. At the first stage, it was called as Molecular Dynamics since a lot of numerical concepts of discrete element method are common with them of molecular dynamics. In the field of particle technology discrete element method already settle down as a useful simulation tool. Recently, discrete element method is coupled with other simulation tools, such as Finite Element Method, Computational Fluid Dynamics, Multi-body Dynamics and so on, already validated in the engineering fields. Though the development process for more than 30 years, discrete element method still has some inherent defects, for example, overloads by particle numbers for realistic simulation, spherical assumption for all particles, and rigid body assumption for particles.

Among those defects, overloads by numerous particles can be partially solved by parallel programming. The other defects, spherical and rigid body assumption can be solved by development of flexible rod model.

In this study, authors report that the development and validation of flexible rod model by the connected sphere model and beam deflection test of cantilever beam. The results shows that the connected sphere model has a quite good agreement with non-linear beam deflection theory. And it also shows the feasibility to simulate fiber filtering in the manufacturing process of diapers.

* Graduate Research Associate, Dept. Mech. Dsgn. Eng., Kumoh Nat. Inst. Tech., South Korea
† Visiting Scholar; Associate Professor, Dept. Mech. Dsgn. Eng., Kumoh Nat. Inst. Tech., South Korea

SESSION 4-B

Nanostructured and Advanced Materials
ATRC 102

Chair:
A. Kaan Kalkan, Ph.D.
Associate Professor
School of Mechanical and Aerospace Engineering
Oklahoma State University
Stillwater, Oklahoma
(405) 744-5900
kaan.kalkan@okstate.edu

Page

TRIAXIAL ELECTROSPUN FIBERS AND ROLE OF SOLVENT VOLATILITY

Abdurizzagh Khalf and Sundar Madihally
School of Chemical Engineering
Oklahoma State University
Stillwater, OK 74078
(405) 744 5280
Abdu.khalf@okstate.edu

ABSTRACT

Triaxial electrospinning provides an effective method for fabrication of desirable biocomposite for particular applications. Modified process (based on core-sheath fluid flow where the enforced sheath polymer encapsulates the core liquid) can enable different features such as hydrophobicity, hydrophobicity, and mechanical strength. Selection of solvents with appropriate boiling points for each layer is critical as rapid solvent evaporation from the jet surfaces could cause instabilities in fiber formation. However, the effect of solvent volatility and relative polymer molecular weights on uniform encapsulation of the core polymer in triaxial electrospinning process is not well understood. In this study, we investigated the effect of solvent volatilities and MW on uniform fiber formation. Formed fibers were characterized for distribution of component via hydrophilicity, mechanical, rheology and biology properties. We explored combinations of polycaprolactone (PCL), cellulose acetate (CA), and polyvinyl alcohol (PVA) and mineral oil (as the inner core) of various molecular weights. Hollow fibers were developed by selectively removing the mineral oil. Different solvent mixtures were tested based on their boiling points, determining using a process simulator. Solution viscosities were evaluated at various shear rates. Obtained fibers were analyzed by scanning electron microscopy and fiber sizes were also characterized using digital micrographs. Differential scanning calorimetry (DSC) and FTIR were performed to characterize various components in the triaxial fibers. Tensile tests (both wet and dry) were also measured to assess the uniform distribution of polymers. 24-h viability of human umbilical vein endothelial cells was also evaluated. The hydrophilicity of electrospun fiber was also measured by contact angle.

Micrographs indicated the formation of triaxial structured fiber of outer hydrophobic PCL/CA/hollow, PCL/PVA/hollow and outer hydrophilic CA/PCL/hollow fibers. Fiber sizes were uniform and ranged in micrometers range in all the formed configurations. Better electrospinning performance was obtained when the inner core MW was smaller or equal to that of the outer sheath. Stripping outer CA in CA/PCL/hollow fibers confirmed the distribution of inner PCL. Endothelial Cells attached and spread on these fibers suggesting no toxicity from the solvents. Tensile tests (both wet and dry) indicated that CA hollow fibers with the inner PCL showed significant improvement in load carrying capacity and stiffness in hydrated conditions. DSC thermographs showed presence of both PCL and CA components. The rheology results suggest that the fibers could be formed when the viscosity

of the core is less than that of sheath. Solvents properties study showed that outer sheath should have a boiling point less than that in the inner cores.

EFFECT OF ELECTRIC FIELD AND FLOW RATE ON FIBER DIAMETER DISTRIBUTION AND TENSILE PROPERTIES OF ELECTROSPUN POLYACRYLONITRILE NANOFIBROUS YARNS

Bipul Barua, Mehmet S. Demirtas, and Mrinal C. Saha*
School of Aerospace and Mechanical Engineering
University of Oklahoma
865 Asp Avenue
Norman, OK 73019
(405) 325-1098
msaha@ou.edu

ABSTRACT

Electrospinning provides an efficient and flexible method for generating nanofibers from polymer solution. Electrospun nanofibers have the potential in producing high strength carbon fibers from electrospinning of polyacrylonitrile (PAN) due to high level of macromolecular orientation. However, efforts to date toward producing high strength carbon nanofibers is very limited due to the fact that there are many parameters related to processing and environmental conditions affecting the internal structure, surface morphology, fiber diameter, and mechanical property of the nanofibers. Moreover, thermo-chemical reactions during heat treatment stages of the electrospun PAN nanofibers play important role in effecting the structural conversion and mechanical properties of the carbon nanofibers.

This study investigates the influence of electrospinning voltage and solution flow rate on fiber diameter distribution and tensile properties of nanofibrous yarns using 10% by weight of PAN in N,N-dimethylformamide (DFM) solution. Stability of the spinning jet is studied via fiber current and Taylor cone half angles and correlated with the fiber diameter and process conditions. An image system is used to measure the Taylor cone geometry near the needle tip. A few optimum set of electric field and solution flow rate conditions are determined leading to continuous jet formation and as a result the thinnest, strongest, and toughest nanofibers are produced. A simple dynamic whipping model is also incorporated to correlate the fiber diameter with the volumetric charge density and found to be excellent matching with experimental results.

---

* Member, ASME

$V_2O_5 \cdot H_2O$/Au NANOWIRE/NANOPARTICLE CONJUGATES FOR SOLAR WATER SPLITTING*

Sunith Varghese, Ç. Özge Topal, and A. Kaan Kalkan
Functional Nanomaterials Laboratory
Department of Mechanical and Aerospace Engineering
Oklahoma State University
Stillwater, OK 74078
(405) 744-5907
kaan.kalkan@okstate.edu

ABSTRACT

Storage of solar energy in a renewable and clean fuel is highly demanded. Molecular hydrogen, H_2, is the cleanest and smallest carrier of chemical energy, yet it has the highest energy content (120 MJ/kg). H_2 can be directly utilized as fuel in internal combustion engines or fuel cells. As water is the final product of the $H_2 + O_2$ reaction, no pollutants or greenhouse gases are produced. Hydrogen-powered buses are already in service in Japan and Europe. H_2 generation from water and sunlight (i.e., photolysis) hints at the 'holy grail' of fully renewable and sustainable fuel production, as the Sun exposes the Earth with 10,000 times more power than the world's population consumes today.

The present work demonstrates a photolytic device concept that consists of an oxide semiconductor nanowire decorated with metal nanoparticles. The vanadium oxyhydrate nanowires (diameter of 9 ± 2 nm) are synthesized by a sol-gel procedure and subsequently decorated with Au nanoparticles (majority of less than 5 nm in size) by chemical reduction. During the metal reduction, the nanowires are found to oxidize from $V_3O_7 \cdot H_2O$ to $V_2O_5 \cdot H_2O$, which behaves as a direct gap semiconductor of 2.7 eV optical band gap. The nanostructures are characterized by XRD, TEM, UPS, optical absorption spectroscopy and electrophoresis. This presentation will discuss various mechanisms, which are unique to the multifunctional nanostructures, such as efficient splitting of photogenerated electron/hole pairs, surface-charge-induced alignment of energy levels and plasmon-enhanced optical absorption in the nanowires. Light-to-hydrogen conversion efficiency of 5.3% (i.e., for hydrogen generation from water) is recorded for the first hour of photolysis under 470 nm radiation.

* This work has been supported by NASA-EPSCoR and AFOSR.

SUB-BAND ENGINEERING THROUGH SUPERLATTICE BASED BARRIER HETEROSTRUCTURES FOR HIGHER THERMOELECTRIC EFFICIENCY

M. Pourghasemi and J. Garg
School of Aerospace and Mechanical Engineering
University of Oklahoma
Norman, OK 73019
(405) 325-5232
mahyar.pourghasemi@gmail.com

ABSTRACT

There is a huge desire to increase operation speeds in modern integrated circuits as they get smaller and more compact. Heat generation in such a submicron devices is a key factor limiting their performances. As a solution, thermoelectric cooling in heterostructures can address heat dissipation issue in submicron devices. The main idea behind heterostructures is to put a barrier in the way of electrons such that only high-energy electrons pass through it. The remaining electrons gain energy from the lattice to recreate the Fermi distribution resulting in a cold junction. High energy electrons pass through the barrier and release their kinetic energy as heat in the interface between barrier and anode which leads to a hot junction.

Performance of single barrier heterostructures depends strongly on several parameters including barrier height, barrier width and thermal conductivity of barrier. As the length of the barrier becomes smaller, more electrons can pass through the barrier ballisticaly without experiencing scattering that leads to a higher effective Seebeck coefficient. On the other hand, the cold anode contact layer and hot cathode contact layer get closer to each other as the device shrinks which means more heat diffuses to cold junction decreasing the efficiency of heterostructure device. Therefore, there should be an optimum width in which the net cooling power of the device is the highest. Moreover, using a barrier with lower thermal conductivity leads to less heat penetration from anode to cathode increasing the efficiency of heterostructure.

In this work we present Monte Carlo simulations to study the optimization of single-barrier heterostructures in cooling of electronic components. We use particle in cell approach. The simulation consists of dividing the electron motion into free flights and scattering events. The scattering includes electron-acoustic phonon, electron-optical phonon, electron – impurity scattering. The simulation is a self-consistent Monte Carlo simulation involving solution of one-dimensional Poisson equation. Here we show the effect of different parameters such as doping density, barrier width and height on cooling efficiency.

LOCALIZED PLASMON MODES IN Ag NANOHEMISPHERES

Ç. Özge Topal[1], Hamzeh M. Jaradat[2], Sriharsha Karumuri[1], Alkim Akyurtlu[2], and A. Kaan Kalkan[1]
[1]Functional Nanomaterials Laboratory
Department of Mechanical and Aerospace Engineering
Oklahoma State University
Stillwater, OK 74078
[2]Electrical and Computer Engineering Department
University of Massachusetts
Lowell, MA 01854
(405) 744-5907
kaan.kalkan@okstate.edu

ABSTRACT

Plasmonic devices, such as chemical sensors, surface-enhanced Raman scattering substrates and light-coupling layers in photovoltaics, are conveniently prepared by immobilization of metal nanoparticles (NPs) on a substrate. When NPs are synthesized directly on the substrate (e.g., vapor deposition, electrochemical reduction), the metal adatom surface diffusion length may be comparable to or larger than the nanoparticle size. As a result, the NPs can approach thermodynamic equilibrium and minimize the surface energy resulting in the formation of a certain contact angle between the metal-ambient and substrate-ambient interfaces. The contact angle can be significantly less than 180°, meaning the metal wets the substrate. Hence, the particles may be truncated spheres rather than spheroids. Compared with nanospheres, truncated nanospheres show higher diversity of localized surface plasmon modes due to broken symmetry.

The present work studies the localized plasmon modes in monolayers of hemispherical Ag nanoparticles (NP) whose resonances are sensitive to angle and polarization of the incident light. The NP samples are prepared by both chemical reduction and thermal evaporation. Using numerical simulations, two of the experimentally observed resonances are assigned to dipoles parallel (485 nm) and perpendicular (337 nm) to hemisphere basal plane. The modes differ significantly in terms of energy, damping and couplings. The perpendicular mode exhibits a 4-fold narrower linewidth due to reduced radiative damping and substrate coupling that may find use in surface-enhanced UV spectroscopies. The parallel mode exhibits a much stronger substrate coupling than the dipolar plasmon modes in nanospheres. Thus, plasmonic nanohemispheres can be employed as efficient light couplers to substrates, especially in thin film photovoltaics.

HIGH THERMAL CONDUCTIVITY OF ALIGNED POLYMERS

M. Saeidijavash, M. C. Saha, and J. Garg
School of Aerospace and Mechanical Engineering
University of Oklahoma
Norman, OK 73019
(405) 325 5232
saeidi@ou.edu

ABSTRACT

In this work we investigate the effect of molecular alignment on polymer thermal conductivity. High thermal conductivity polymers have a wide range of applications. High thermal conductivity polymeric encapsulants and underfill materials are key to successful thermal management of next generation 3D chip stacks. Enhancement of thermal conductivity of polymers can allow heat exchangers to be made out of polymers instead of metals leading to significant energy savings since processing of polymers consumes significantly less energy compared to metals. Higher thermal conductivity of polymers can also be combined with their structural compliance to develop low thermal resistance thermal interface materials (TIM) for application in electronics packaging. In this work we study thermal conductivity enhancement in polymers through alignment of the polymer chains along the direction of heat propagation.

The polymer used in this study is ultra-high molecular weight polyethylene (UHMWPE). A sample of UHMWPE is stretched by different amounts using a tensile transducer. The obtained stretch ratios are 1.2, 1.5 2.0, 2.5 and 2.9. The thermal conductivity of both stretched and unstretched polymer samples is measured using Angstrom method. The method involves applying a sinusoidal heat signal to the sample at one end and measuring temperature response at two different locations along the sample. Finite thermal conductivity leads to both a phase difference and difference in amplitudes of the two temperature signals. By measuring both these parameters (phase difference and amplitude ratio) thermal conductivity can be extracted. Using Angstrom method we have measured more than 200% enhancement in thermal conductivity of UHMWPE.

SESSION 5-B

Multiphase Flow II
ATRC 101

Chair:
Ram Mohan, Ph.D.
Assistant Professor
Mechanical Engineering College of Engineering & Natural Sciences
The University of Tulsa
Tulsa, Oklahoma
(918) 631-2075
ram-mohan@utulsa.edu

Page

SOLID PARTICLE TRANSPORT IN GAS-LIQUID STRATIFIED SLURRY FLOW*

A. Padsalgikar†, R. Mohan, Ph.D. ‡, and O. Shoham, Ph.D.
Tulsa University Separation Technology Projects (TUSTP)
The University of Tulsa
Tulsa, OK 74104
(918) 740-1076
ashwin-padsalgikar@utulsa.edu

ABSTRACT

Solids transport in stratified gas-liquid flow is investigated for both low concentration dispersed flow and high concentration flow in which solid beds could occur. The effect of gas and liquid velocities on solids transport is studied by conducting experiments with entrained solid particles. The effect of gas density and liquid viscosity on stratified flow was also studied. Liquid and gas velocities ranged from 0.06 to 0.16 m/s and 1.2 m/s to 15 m/s respectively, and viscosities ranged from 1 cP to 120 cP. Glass beads with particle sizes of 45-90 µm and 600 µm were used.

The secondary goal of this work was to apply this knowledge of solids transport to the energy industry by development of predictive tools to enable transport of sand produced from those reservoirs. This study endeavors to predict particle transport since it is a very important factor for petroleum production. Particle Image Velocimetry was used to study the structures in the liquid phase. It was determined that three modes of the interface can be defined, namely, Wave buildup mode, Wave Breakdown mode and Inter-crest film. It was also observed that both wave buildup and wave breakdown modes appear to create vertical movement of the fluid layers that can contribute to the pickup and transport of solid particles from the top of a moving or stationary bed. It was determined that the height of the bed decreased with increasing superficial gas velocity and that the bed arranged itself in varying flow patterns coupled with the superficial gas velocity. It was also observed that the height of the bed created with smaller diameter particles was larger than the one created by the bigger particle size. Finally a model, applicable for both low concentrations as well as high concentrations, has been formulated to predict the sand flow velocity as well as the sand particle holdup in a horizontal pipe.

*This research is supported by Tulsa University Separation Technology Projects (TUSTP).
† Corresponding Author: Ashwin Padsalgikar, Tulsa University Fluid Flow Projects (TUFFP), McDougall School of Petroleum Engineering, The University of Tulsa, 800 S. Tucker Drive, Tulsa, OK, 74104.
‡ Fellow ASME

SAND FLOW REGIMES IN MULTIPHASE PIPELINES*

R. Dabirian†, R. Mohan, Ph.D.‡, and O. Shoham, Ph.D.
Tulsa University Separation Technology Projects (TUSTP)
The University of Tulsa
Tulsa, OK 74104
(918) 631-2000
ramin-dabirian@utulsa.edu
and
G. Kouba, Ph.D.‡
Production Systems & Flow Assurance
Chevron Energy Technology Company
Houston, TX 77002

ABSTRACT

The entrainment of sand in crude oil happens during production from reservoirs with low formation strength. The stationary bed at the pipe bottom can cause operational problems such as production decline, excessive pressure loss, equipment failure, erosion and corrosion. Sand deposition can be managed by operating above critical sand deposition velocity, which means the velocity keeps particles moving all the time at the pipe bottom. Experimental studies have been conducted at stratified flow regime with air-water-glass bead at relatively low sand concentrations (<10,000 ppm). The unique facility was designed and constructed with horizontal 4-in diameter PVC pipe, which enables the measurement of liquid velocity and liquid hold up. The effects of different experimental conditions such as gas velocity, liquid velocity, sand concentration, and particle size have been investigated in this study.

The understanding of sand flow regimes in pipelines for any given set of operational conditions is important to identify the nature of particle interaction and movement. In this study, five main sand flow regimes in horizontal air-water flow are identified, which can be distinguished visually: fully dispersed solid flow, diluted solids at wall, concentrated solids at wall, moving dunes and stationary bed. Therefore, the critical sand deposition velocities are determined based on the transition between moving and stationary sand particles. The experimental data shows that with small particle size, the critical sand deposition velocity is almost independent of concentration, while with bigger particle sizes, the critical velocity increases with the concentration.

---

* This research is supported by Tulsa University Separation Technology Projects (TUSTP).
† Corresponding Author: Ramin Dabirian, Tulsa University Separation Technology Projects (TUSTP), Department of Mechanical Engineering, The University of Tulsa, 800 S. Tucker Drive, Tulsa, Oklahoma, 74104.
‡ Fellow/Member ASME

MECHANISTIC MODELING AND EXPERIMENTAL VALIDATION OF DROPLET DEPOSITION AND COALESCENCE IN LONG ELBOW BEND*

H. Nguyen†, S. Wang, Ph.D.‡, R. Mohan, Ph.D.‡, and O. Shoham, Ph.D.
The University of Tulsa
Tulsa, OK
and
G. Kouba, Ph.D.‡
Chevron Energy Technology Company
Houston, TX
hungnhu-nguyen@utulsa.edu

ABSTRACT

The use of external piping configurations as flow conditioning devices upstream of a separator inlet is investigated in this study. A model for the prediction of droplet deposition in a long elbow bend is developed, based on the physical phenomena consisting of a force balance and a conservation of angular momentum on a droplet. The model enables tracking the droplet movement in the elbow, subject to a droplet deposition criterion that identifies the depositing droplets. A comparison between the model predictions and experimental data shows reasonable agreement with average error less than 30%. A design code is developed, based on the proposed model, which is validated against experimental data.

* This project is sponsored by Chevron TU-CoRE (Tulsa University Center of Research Excellence)
† Corresponding Author: Hung Nguyen, Tulsa University Separation Technology Projects (TUSTP), Department of Mechanical Engineering, The University of Tulsa, 800 S. Tucker Drive, Tulsa, OK – 74104-3189. Ph: (918) 619-2413, E-mail: hungnhu-nguyen@utulsa.edu
‡ Fellow/Member ASME

A SIMULATOR TO CHARACTERIZE THE SHEAR EFFECT OF PRODUCTION EQUIPMENT[*]

S. Cui[†], S. Wang, Ph.D., R. Mohan, Ph.D.[‡], and O. Shoham, Ph.D.
University of Tulsa (TUSTP)
Tulsa, OK
and
Haijing Gao, Ph.D
Chevron Energy Technology Company
Houston, TX
shihao-cui@utulsa.edu

ABSTRACT

When crude oil is extracted from reservoir, it is most often comingled with immiscible water producing two phase flow. Under a certain velocity conditions, one phase will be dispersed in another phase in the form of droplets which is called dispersed flow. During the process of production and transportation, equipment such as pumps and chokes will create shear effect which break the dispersed droplets into smaller size.

The small droplets will influence the separator performance significantly and the droplet size distribution has become a critical criterion for separator design. In order to increase the separate efficiency, estimation of the dispersed phase droplet size distribution produced by devices in the field is very important. The objective of this project is to qualitatively and quantitatively investigate the effect of shear imparted on oil-water flow by production equipment, such as pumps, and chokes.

Various models published in literature to characterize the droplet size distribution of different production equipment are presented. A simulator based on Excel-VBA platform is created using the Pereyra (2011) centrifugal pump model, Kouba (2003) minimum diameter model and van der Zande (2000) choke model. To test these models, data from experiments conducted by previous researchers are provided. Comparison between the model prediction and the experimental data is conducted at the end with analysis and recommendations. The developed models representing shear causing components could be used in separator design and promote flow assurance.

[*] This project is sponsored by Chevron TU-CoRE (Tulsa University Center of Research Excellence).
[†] Corresponding Author: Shihao Cui, Tulsa University Separation Technology Projects (TUSTP), McDougall School of Petroleum Engineering, The University of Tulsa, 800 S. Tucker Drive, Tulsa, OK-74104.
[‡] Fellow/Member ASME

CHARACTERIZATION OF DRAG-REDUCING POLYMER SOLUTION USED TO MODIFY A TURBULENT BOUNDARY LAYER

Yasaman Farsiani and Brian R. Elbing*
Mechanical and Aerospace Engineering
Oklahoma State University
Stillwater, OK 74078
(405) 744-5897
yasaman.farsiani@okstate.edu, elbing@okstate.edu

ABSTRACT

Skin friction drag accounts for up to 60% of the total resistance for a surface ship, which can be significantly reduced with the addition of trace amounts of water soluble polymer into the developing turbulent boundary layer. Drag-reducing polymer solutions have been successfully implemented in internal flows, but diffusion has limited its application to external flows. The focus of the current study is to investigate the dependence of the modified mean and fluctuating velocity profiles on Reynolds number and drag reduction. A critical component of such an experiment is the ability to independently confirm that the polymer solution used throughout the experiment has the same initial molecular weight. This presentation will focus on the development of a pressure drop tube and how it is used to confirm the samples molecular weight as well as its concentration. In addition, details about the current status of the high-Reynolds number water tunnel will be provided and future test plans.

* Member, ASME

GENERAL GUIDELINES TO DEVELOP A MODEL TO PREDICT SAND TRANSPORT THRESHOLD VELOCITIES IN MULTIPHASE HORIZONTAL PIPES

Kamyar Najmi[1,*], Brenton McLaury[1], Siamack Shirazi[1], and Selen Cremaschi[2]
[1]Mechanical Engineering Department
[2]Chemical Engineering Department
The University of Tulsa
Tulsa, OK 74104
(918) 849-4996
kamyar-najmi@utulsa.edu

ABSTRACT

The unfavorable presence of sand in oil and gas pipelines negatively affects the production process. Production at high flow rates may cause the residual sand to impact pipe walls with enough energy and cause significant erosion. However if the flow rates are too low, then sand may become stationary in flow lines creating a partial blockage causing increased pressure drop. So, a common objective is to find a critical velocity that is sufficient to transport sand in an economical manner.

Sand transport has been a subject of much research but despite significant studies that have been performed, there are still aspects of the phenomenon which are unknown. Maybe the most controversial aspect of sand transport is the effect of liquid viscosity. There is a limited number of studies regarding the effect of viscosity on sand transport and among these studies contradictory conclusions have been reported.

In the current study, available multiphase transport models in the literature are validated against previously obtained experimental data in the Tulsa University Sand Management Projects experimental database. This comparison shows the pros and cons of the previously proposed models in the literature. Moreover, general guidelines to develop an accurate sand transport model to predict threshold velocities in multiphase flows are recommended.

[*] Member, ASME

SESSION 6-B

Solar, Fire, Wind, Plasma, and the Universe II
EN 208

Chair:
Tom Betzen, P.E.
Engineering Department
Michelin NA
Ardmore, Oklahoma
(580) 221-2280
tom.betzen@us.michelin

Page

EXPERIMENTAL STUDY OF PLASMA JET PRODUCED BY A CIRCULAR TUBE FITTED WITH A NOZZLE

I. W. Brindle* and F. C. Lai†
School of Aerospace and Mechanical Engineering
University of Oklahoma
Norman, OK 73019
(405) 325-1748
flai@ou.edu

ABSTRACT

In the past decades, many important processes in industry have been realized through the manipulation of an electrical field. These include electrostatic precipitation (ESP), electrostatic atomization and spraying, electrophotography, inkjet printing, and ozone production. Recently it has been shown that low-temperature atmospheric-pressure plasma can be beneficial for medical applications such as fast healing of wounds, accelerating blood coagulation and treatment of skin conditions. To be effective in healing a wound, the plasma generated first has to blow off the body fluid which covers the wound so that it can directly interact with the tissues. The main focus of this study is on the performance of a prototype device (a plasma pen) in producing a plasma jet for such application. The plasma jet is generated through a single needle electrode with a stainless steel nozzle at the tip of the pen acting as the ground. The plasma pen is tested with six different nozzle sizes and conical angles to determine the optimal parameters for plasma generation and flow produced. Three applied voltages of direct current have been tested for both positive and negative polarities. The velocity of plasma jet has been measured using a hot-wire anemometer at three different levels from the nozzle exit. It has been shown that the proposed plasma pen can, with various configurations, output a steady flow of air plasma that remains near room temperature. In addition, the nozzle configuration can be altered to meet various requirements for safety, power supply limitations, or output flow rate. Future work will consider different nozzle shapes for better flow characteristics.

* Graduate Research Assistant, Member ASME
† Professor, Fellow ASME and Associate Fellow AIAA

HACKING THE COSMOS: HOW ENGINEERING ASSISTS SCIENCE AND THE HUMANITIES IN MAKING SENSE OF THE UNIVERSE*

Dominic M. Halsmer, PhD, PE, Professor of Engineering†
Director, Center for Faith and Learning
Oral Roberts University
Tulsa, OK 74171
(918) 495-6005
dhalsmer@oru.edu

ABSTRACT

Two powerful analytical concepts from engineering and psychology have recently been combined to form a fruitful synergy with the potential for furthering the science and theology dialogue. Mainly through the work of research engineer Johnathan Maier, the concept of affordances has found utility, not only in design engineering, but also in affordance based reverse engineering (ABRE). In this context, an affordance is a capability that is provided to the end user of an engineered device, by virtue of some interaction between the user and the device. This concept is believed to bring great potential for applying ABRE to complex natural systems, especially in biology. A recent literature search has uncovered many examples of the successful reverse engineering of natural systems, as in systems biology, and cursory discussions of ABRE of human-made devices, but very little on the application of ABRE to natural systems.

Researchers in evolutionary biology, such as Rob Withagen, have found the concept of affordance to be helpful in understanding the evolutionary process. He claims that affordances assist in clarifying the process of niche construction. Indeed, animals bring about changes in the affordance layout, and this modified layout is passed on to the offspring. In another paper, he explores the relationship between affordances and agency, emphasizing the idea that affordances can also invite behavior.

ABRE has advantages over a function-based approach since affordances depend on a particular embodiment of a system, while functions do not. This allows the investigator (or reverse engineer) to compare various potential embodiments in analyzing the effectiveness and efficiency of a particular embodiment. In addition, ABRE captures important interactions between the three entities that comprise the “big picture” of design. These entities are: 1) the original engineer, 2) the engineered system, and 3) the end user of the system. Depending on the questions being asked, ABRE of complex natural systems can lead to insights in both science and theology. Science is limited to questions such as, “How does the system work?” and “How efficient is it?” But natural theology extends the inquiry to include questions like, “Why does it work like that?” and “What did the original engineer have in mind?" A book to

* This project is partially supported by a grant from the BioLogos Foundation.
† Member, ASME

explore the potential for addressing such questions through the application of ABRE to complex natural systems is currently underway.

OVERVIEW OF CORKEN VANE PUMPS

Curtis M. Vickery, Ph.D., P.E.*
Sr. Engineer
Corken, Inc.
3805 NW 36th Street
Oklahoma City, OK 73112
(405) 609-1172
cvickery@idexcorp.com

ABSTRACT

The Corken Pump and Machinery Company was founded in 1924 by Otto K. and Charles Corken. The liquefied petroleum gas (LPG) market was entered in 1945 followed by the first Corken LPG compressor in 1947. In 1952 Corken launched their first turbine regenerative truck pump. Featured here are Corken vane pumps that have been in use since the 1950s. Today Corken supports a number of vane pump lines for both LPG and Industrial markets.

Vane pumps are positive displacement pumps that feature a rotating shaft-rotor assembly, a pump housing with obround cam profile, and a number of vanes that ride against the cam surface. These vanes divide the the rotor-cam circumference into a number of sections. Rotor-shaft assemblies are offset within the pump housing yielding minimal clearance at the Stop Radius and maximum clearance at the Pump Chamber Radius.

Vane pumps seek to optimize the "Closed to Inlet/Outlet" volume, between adjacent vanes, that is isolated from both inlet and outlet. Maximum ideal pump throughput is this volume, times the number of vanes/sections, times the pump rotational speed. These parameters (Stop Radius, Pump Chamber Radius, and number of vanes) can yield multiple pump models by increasing/decreasing the the pump width (vane/rotor length).

Vane pump designs must be tuned to account for internal leakage and other inefficiencies. In addition, modern vane pumps feature interal relief valves to allow flow to dump directly from outlet back to inlet under certain pressure-flow conditions. Torque required to drive a pump can also be calculated from which horsepower requirement can be estimated.

This presentation provides a brief overview of Corken vane pumps and their applications. Included will be discussion of these design considerations along with sample calculations and an example of historical Corken design practices.

* Member, ASME, NSPE, OSPE

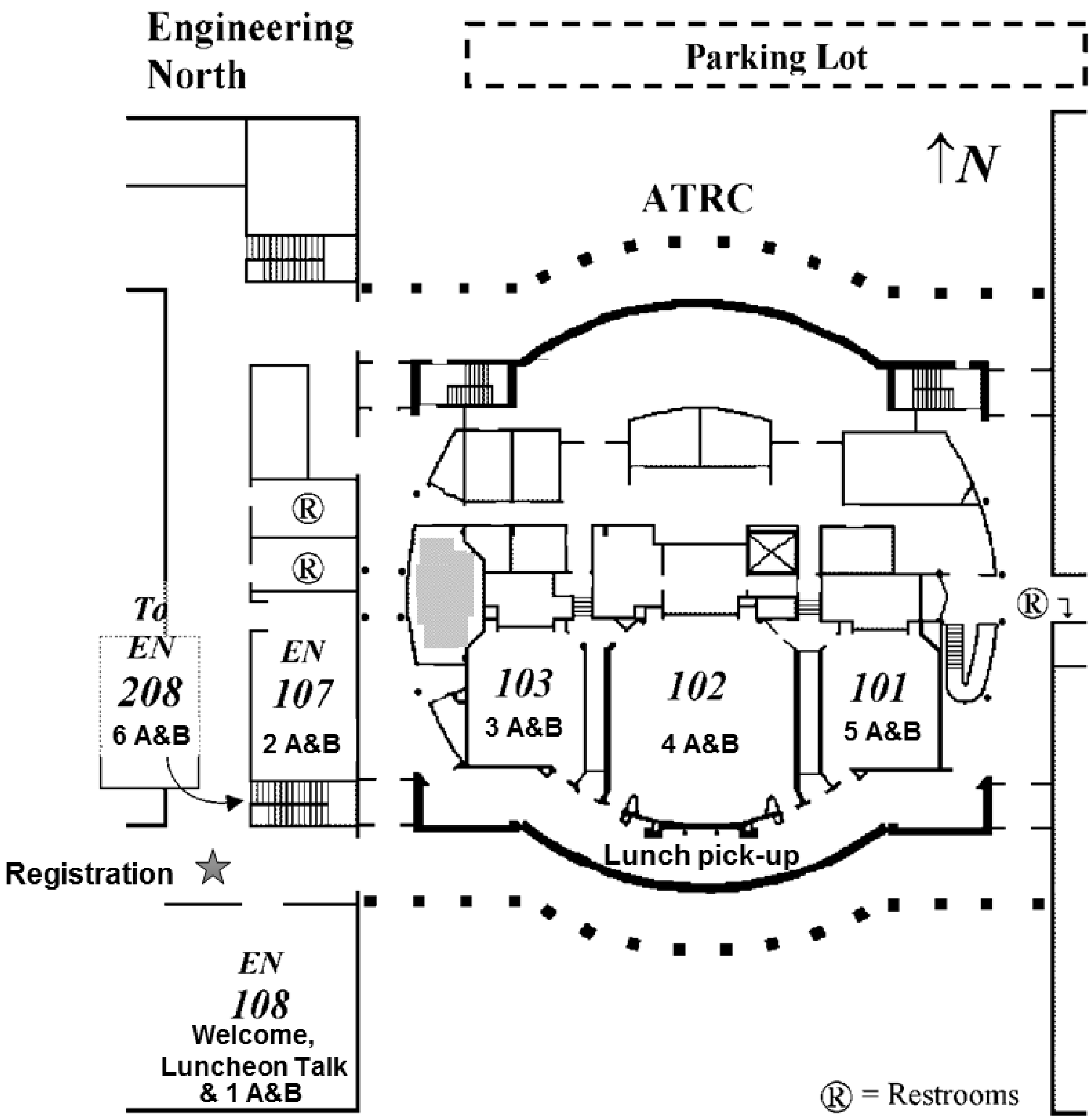
OPTIMIZATION OF DUCT-WORK DESIGN

Dalton Moore, Alex Roswell, Scott Agee, and Qader Alsherit
Mechanical Engineering Technology
Oklahoma State University
Stillwater, Oklahoma 74078
(918) 691-0502
dalton.k.moore@okstate.edu

ABSTRACT

This project analyzes and improves upon two types of duct-work for the D-style and O-style boilers manufactured by Victory Energy. The two duct-works that were examined were the economizer outlet transition duct for the D-style boiler, as well as the inlet transition duct for the O-style boiler. These ducts in particular have an issue with being overdesigned/stiffened, causing Victory Energy to lose money in the manufacturing process. The stiffeners that Victory is currently using are made of A36 steel C-channel. Our solution to cutting cost in this project was to analyze and evaluate the use of A36 steel strap as an alternative to C-channel. These ducts can vary in size, so different scenarios were examined to verify the functionality of the proposed design. Many other designs and orientations for the stiffeners were considered such as structural rebar used as a net as well as a truss orientation using the existing C-channel. After conducting analysis, the chosen stiffener orientation to be used was decided to be steel strap in the vertical or horizontal direction, depending on the cheapest cost for the given duct. To verify the orientation, spacing, and size of the stiffeners, calculations were derived by hand and tested by FEA (Finite Element Analysis). After meeting the desired constraints, an Excel® program was created. The Excel® program allows the designer to put the desired dimensions in for either of the two duct types. From this input, the program generates the number, spacing, orientation, and length of each required stiffener. It also carries out a cost analysis for the generated duct design, and displays the new, reduced cost. This program was then verified by analyzing the Excel® program output by running it through FEA (ANSYS® and SolidWorks®). By using the steel strap design the overall cost of manufacturing for these two ducts will be considerably decreased and the program will allow savings of time and money in the area of labor and engineering. With the newly engineered stiffener design, Victory Energy will come out ahead in the areas of manufacturing and engineering costs.

* This work has been supported by Victory Energy, Collinsville, OK


Engineering North
Parking Lot
↑N
ATRC
To EN 208
6 A&B
EN 107
2 A&B
103
3 A&B
102
4 A&B
101
5 A&B
Lunch pick-up
Registration
EN 108
Welcome, Luncheon Talk & 1 A&B
Ⓡ = Restrooms