

CMSC

COMPOSITES MANUFACTURING
& SIMULATION CENTER

P PURDUE
UNIVERSITY

College of Engineering

FPCM-15

FLOW PROCESSES IN COMPOSITE MATERIALS

June 27-29, 2023

1105 Endeavour Drive, Suite 100
West Lafayette, IN 47906

Indiana Manufacturing Institute
Composites Manufacturing & Simulation Center

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Morning Keynote: Dr. Charles Tucker III

Session I Morning:

“Fiber Orientation in Flows”

Session I Chair: Prof. Pascal Hubert

Werner Graupe Chair on Sustainable Composites Mfg.

Director, Research Center for High Performance Polymer and Composite Systems, McGill University

Time	Presentation
7:15-8:00	Registration/Coffee Mingle
8:00-8:15	Welcome! Dr. R. Byron Pipes , Distinguished Professor of Engineering, Purdue University Executive Dir. Composites Manufacturing Simulation Center
8:15-9:00	Keynote Charles L. Tucker III, Ph.D. Professor Emeritus, University of Illinois-UC “Fiber Orientation Descriptors: How we got here and what comes next”

Time	Paper	Presentation & Author(s)
9:00-9:30	755	Presenter: James Kratz, University of Bristol Talk: “Application of Lab-based In-situ CT to Composite Forming and Flow Processes” James Kratz, Pedro Galvez-Hernandez, Claudia Jimenez Martin, Arjun Radhakrishnan, Vincent Maes, Mark Mavrogordato and Ian Sinclair
9:30-10:00	7074	Presenter: Gulsah Bahceli, Delft University Talk: “Influence of Melt Mixing Processing Conditions on Fiber Distribution of Recycled Carbon Fiber Reinforced LM PAEK Composites” Gulsah Bahceli, Bilim Atli-Veltin and Clemens Dransfeld
10:00-10:30		Coffee Break
10:30-11:00	7601	Presenter: Miro Duhovic, Institute for Composite Materials Talk: “Development of Characterization and Simulation Methods for Carbon Fiber Sheet Molding Compounds” Dominic Schommer, Miro Duhovic, Thomas Hoffmann, Florian Gortner, David May, Joachim Hausmann, Peter Mitschang, Katja Schladitz and Konrad Steiner
11:00-11:30	8155	Presenter: Donald Baird, Virginia Tech Talk: “Role of Flow Type on the Evolution of Semi- Flexible Fiber Orientation” Donald G Baird and Peter Wapperom
11:30-12:00	9950	Presenter: Douglas Smith, Baylor University Talk: “Simulation of Micro-void Development Within Large Scale Polymer Composite Deposition Beads” Aigbe Awenlimobor, Douglas E. Smith, Zhaogui Wang
12:00-1:30	Lunch	Walt’s Pub & Grill <i>Coach bus will transport you for the 2-minute drive</i>

Afternoon Keynote: Eduardo Barocio

Session II Afternoon:

"Flows in Additive Manufacturing"

Session II Chair: Dr. Douglas Smith

Professor, Baylor University

Time	Presentation	
1:30-2:15	Keynote: Eduardo Barocio , Ph.D. Assistant Director Additive Manufacturing, Purdue University CMSC "Flow and Transient Phenomena in Large Scale Additive Manufacturing"	
Time	Paper	Presentation & Author(s)
2:15-2:45	4321	Presenter: Sophie Sharafi, University of Delaware Talk: "Void Formation in Printed Carbon Fiber PAEK Composites" Sophie Sharafi, Michael Santare, Suresh Advani and John Gerdes
2:45-3:15	5075	Presenter: Deepak Kumar Pokkalla, Oak Ridge National Laboratory Talk: "Predicting Anisotropic Mechanical Properties and Reverse Engineering Process Parameters for Composite Extrusion Additive Manufacturing through Flow Modeling and Micromechanics" Deepak Kumar Pokkalla, Berin Seta, Nikhil Garg, Vipin Kumar, Seokpum Kim, Jon Spangenberg and Ahmed Arabi Hassen
3:15-3:45		Coffee Break
3:45-4:15	9175	Presenter: Pasita Pibulchinda, Purdue University Talk: "Influence of Printing Conditions on the Extrudate Shape and Fiber Orientation in Extrusion Deposition Additive Manufacturing" Pasita Pibulchinda, Eduardo Barocio, Anthony Favaloro and R. Byron Pipes
4:15-4:45	8172	Presenter: Jon Spangenberg, Technical University of Denmark Talk: "Flow-induced Fiber Orientation During Material Extrusion Additive Manufacturing" Berin Seta, Michael Sandberg, Marco Brander, Md. Tusher Mollah, Deepak Kumar Pokkalla, Vipin Kumar and Jon Spangenberg
4:45-5:15	9928	Presenter: Matthew Hardman, National Composites Centre (UK) Talk: "Numerical Process Simulation of Ultra High-Rate Ply Deposition" Xiaochuan Sun, Matthew Hardman, Navein Madhavan, Eoin Simon, Simon Marshall and Jonathan Belnoue
5:15-5:45	501	Presenter: Suresh Advani, University of Delaware Talk: "Statistical Description of the Frictional Forces and the Rheology of SMC Materials During the Compression Molding Process" François Mahé, Christophe Binetruy, Suresh Advani, Julien Férec and Benedikt Eck
6:00		Conference day ends. Dinner on your own Optional Lab Tour

Morning Keynote: Conchúr Ó Brádaigh

Session III Morning:

"Impregnation Flows"

Session III Chair: Dr. Stepan Lomov

Emeritus Professor, Faculty of Engineering Science, KU Leuven

Time	Presentation	
7:30-8:15	Coffee Mingle	
8:15-9:00	Keynote:	Conchúr Ó Brádaigh , FEng FRSE Head of School of Engineering, University of Edinburgh "Processing of Powder-Epoxy Composite Materials for Large Structures in Marine Renewable Energy"
Time	Paper	Presentation & Author(s)
9:00-9:30	1700	Presenter: Rehan Umer, Khalifa University of Science and Technology Talk: "Processing and Performance Evaluation of AFP Laid Dry Fiber Preforms and Composites using an Infusible Thermoplastic Resin" Tayyab Khan, Muhammad Ali and Rehan Umer
9:30-10:00	8136	Presenter: Murat Celik, University of Edinburgh Talk: Modelling of In-situ Impregnation During the Production of Powder Epoxy Based Towpregs" Murat Celik, James M. Maguire, Hanisa Hasrin, Thomas Noble, Colin Robert and Conchúr M. Ó Brádaigh
10:00-10:30	Coffee Break	
10:30-11:00	2519	Presenter: Masoud Bodaghi, Luxembourg Institute of Science and Technology (LIST) Talk: "Study on the Causes of Bubbles During Polymerization of an Acrylic-based Infusible Resin Impregnated Glass Fiber Reinforcements During Liquid Composite Molding Family" Masoud Bodaghi, João Machado and Henri Perrin
11:00-11:30	1852	Presenter: Thomas Cender, University of Delaware, Center for Composite Materials Talk: "Experimental Characterization of Extensional Viscosity of Aligned Discontinuous Fiber Composites" Thomas Cender, Pavel Simacek, John Gillespie and Suresh Advani
11:30-12:00	1741	Presenter: Loren Tomlin, University of Delaware Talk: "Methodology to Establish a Forming Process Window for Thermoset Aligned Discontinuous Fiber Composites" Loren Tomlin, Tom Cender, Suresh Advani and Steve Sauerbrunn
12:00-1:30	Lunch	Walt's Pub & Grill <i>Coach bus will transport you for the 2-minute drive</i>

Afternoon Keynote: Dianyun Zhang

Session IV Afternoon:

“Darcy Flows”

Session IV Chair: Dr. Suresh Advani

George W. Laird Professor, Center for Composite Materials, University of Delaware

Time	Presentation				
1:30-2:15	Keynote:	Dianyun Zhang , Ph.D. Assistant Professor, Aeronautics & Astronautics, Purdue University “An Integrated Multi-Physics Modeling Approach to Liquid Composite Molding Simulation”			
Time	Paper	Presentation & Author(s)	Time	Paper	Presentation & Author(s)
2:15-2:45	1136	Presenter: Matthew Grasinger, United States Air Force Research Laboratory Talk: “Influence of Wetting and Interfacial Phenomena on Void Formation and Transport During Resin Transfer Molding” Matthew Grasinger	4:45-5:15	3833	Presenter: Stepan Lomov, KU Leuven TALK: “Micro-CT Based Permeability Calculations with a Limited Size of the Model Volume” Stepan Lomov, Sergey Abaimov, Roman Kandinski, Biltu Mahato and Yentl Swolfs
2:45-3:15	1243	Presenter: Andrew George, Brigham Young University Talk: “The Effect of Single-curvature and Intra-plane Shearing on Reinforcement Permeability” Collin Childs, Benjamin Betteridge and Andrew George	5:15-5:45	7767	Presenter: Andrew George, Brigham Young University Talk: “Factors affecting in situ void formation during resin infusion” Andrew George, Ben Crawford, Jared Turner, Davide Simone and Hilmar Koerner
3:15-3:45		Coffee Break	5:45-6:15		Travel to Banquet location: Neil Armstrong Hall of Engineering, Kurz Atrium 701 W. Stadium Ave. West Lafayette, IN 47907 <i>Coach bus transportation provided. Very limited street parking is available</i>
3:45-4:15	2662	Presenter: Baris Caglar, TU Delft Talk: “Deep Learning for Modeling of Multiscale Flow Phenomena in Composites Manufacturing” Baris Caglar and Guillaume Broggi	6:15-8:30		FPCM-15 Banquet Welcome/Opening Remarks: Dr. Arvind Raman John A. Edwardson Dean of Purdue University’s College of Engineering Robert V. Adams Professor of Mechanical Engineering
4:15-4:45	2840	Presenter: Tim Schmidt, Institute for Composite Materials, Technical University of Kaiserslautern Talk: “Machine Learning For Permeability Determination of Fibrous Structures” Tim Schmidt, Dinesh Krishna Natarajan, Stefano Cassola, David May, Miro Duhovic and Marlon Nuske			Guest Speaker: Dr. Sangtae Kim Jay and Cynthia Ihlenfeld Head of Chemical Engineering Purdue University Distinguished Professor “Disk and Rods - Workhorses of Models for Nonspherical Particles and Inclusions”
			8:30-9:00		Coach bus returns to IMI - Adjourn for evening

Morning Keynote: Florian Wittemann

Session V Morning:

"Anisotropic (Forming) Flows"

Session V Chair: Dr. Donald Baird

Professor Emeritus, Virginia Tech

Time	Presentation	
7:30-8:00	Coffee Mingle	
8:00-8:45	Keynote: Florian Wittemann, Ph.D. Karlsruhe Institute of Technology (KIT) Institute of Vehicle System Technology – Lightweight Design Division "Fiber Length and Orientation Dependent Flow Modeling in Macroscopic Injection Molding Simulation"	
Time	Paper	Presentation & Author(s)
8:45-9:15	1570	Presenter: Rens Pierik, University of Twente; ThermoPlastic Composites Research Center (TPRC) Talk: "Understanding and Modeling of the Ply-Ply Friction Response for UD C/PAEK Tapes in Melt" Rens Pierik, Wouter Groupe, Sebastiaan Wijskamp and Remko Akkerman
9:15-9:45	7879	Presenter: Sidharth Sarojini Narayana, McGill University Talk: "Process Development of Compression Resin Transfer Moulding of a Complex Demonstrator Part" Sidharth Sarojini Narayana, Leonardo Barcenas, Lolei Khoun, Nicolas Milliken, Paul Trudeau and Pascal Hubert
9:45-10:15		Coffee Break
10:15-10:45	7156	Presenter: Dennis Brands, University of Twente Talk: "Modelling the Resistance Against In-plane Shear Deformation of Unidirectional Thermoplastic Composite in Melt from Bias Extension Measurements" Dennis Brands, Wouter Groupe, Sebastiaan Wijskamp and Remko Akkerman
10:45-11:15	8349	Presenter: Jeeun Lee, Department of Engineering Science, University of Auckland Talk: "Rate-Dependent Effects in Transverse Liquid Composite Molding Manufacturing Processes" Jeeun Lee, Miro Duhovic, Tom Allen, David May and Piaras Kelly
11:15-11:45	814	Presenter: R. Byron Pipes, Purdue University Talk: "Rheological characterization of thermoplastic polymer continuous fiber prepreg in the melt state." R. Byron Pipes, Eduardo Barocio , Akshay J. Thomas
11:45-12:15	5227	Presenter: Henri Perrin, Luxembourg Institute of Science and Technology (LIST) Talk: "On the Relationship Between Hot Press Consolidation Process, Void Content, and Microstructure Morphology of Commingled Flax/PP Laminates" Henri Perrin, Masoud Bodagi, Dorian Delfrari and Régis Vaudemont
12:15-1:00		Box Lunch

Session VI Afternoon:

“Workshop on Benchmarking and Standardization Activities”

Session VI Chair: Dr. David May

Research Director Digitalization

Manager Digitalized Process & Material Dev., Institute for Composite Materials, Technical University of Kaiserslautern

Time Paper Presentation & Author(s)

Workshop on Benchmarking and Standardization Activities

1:00-3:00 7149 Elena Syerko, Tim Schmidt, Katja Schladitz, David May, Christophe Binetruy, Luisa Silva, Stepan V. Lomov, Suresh Advani, Ana Yong

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| I. “First Insights From the Second Mesoscale Stage of the Virtual Permeability Benchmark on Engineered Textiles”

Elena Syerko, Centrale Nantes
Tim Schmidt, Institute for Composite Materials, Technical University of Kaiserslautern | II. “Novel ISO-Standard on Test Methods for the Experimental Characterization of In-Plane Permeability”

David May, Institute for Composite Materials, Technical University of Kaiserslautern | III. “Experimental Benchmark Studies on Textile Out-of-Plane Permeability and Compressibility”

Ana Yong, National Physical Laboratory, UK |
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3:00 Conference Concludes



Purdue Composites Manufacturing and Simulation Center launched the Composites Design and Manufacturing Hub (cdmHUB) in 2013 with the mission to convene and serve the global composites community by creation, education, evaluation, and sharing of resources for composites design and manufacturing.

creation, education, evaluation, and sharing

It is emerging as the premier resource for composites design and manufacturing. cdmHUB strives to achieve the following goals:

Advance composites design and manufacturing by simulation validated by experiments.

Become a trusted source and recognized authority for composites design.



In 2020, Dassault Systèmes named Purdue the 3DEXPERIENCE Education Center of Excellence in Advanced Composites. The Purdue Composites Manufacturing and Simulation Center and Dassault Systèmes have worked together to advance the digital enterprise by developing the human talent essential to this new paradigm and by utilizing the 3DEXPERIENCE platform to exercise digital twins of complex composites manufacturing and performance to demonstrate the power to predict phenomena that are understood today only by empirical experiences.



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THE COMPOSITES INSTITUTE

The Institute for Advanced Composites Manufacturing Innovation, or IACMI—The Composites Institute[®], is committed to accelerating the development and adoption of innovative manufacturing technologies for low-cost, energy-efficient advanced composites. Our collaborative work through public-private partnerships – including Purdue University – drives domestic production capacity, strengthens U.S. manufacturing competitiveness, and elevates job creation across the U.S. composite industry. A Manufacturing USA Institute, IACMI was established in 2015 by the U.S. Department of Energy.

www.IACMI.org