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# IOWA STATE UNIVERSITY

## Center for Multiphase Flow Research and Education

### September 2020 CoMFRE Newsletter

#### Message from the Director

As I write this, ISU is completing the 6<sup>th</sup> week of a 14+ week semester. The “+” signifies finals will happen on the Saturday and Monday-Wednesday right before Thanksgiving. Our spring semester will now start on January 25, with no spring break this year. This is all part of an effort to contain the spread of COVID-19, which is still dominating the news. As we think about COVID-19, its spread depends on complex multiphase flow phenomena including air-droplet interactions, liquid sheet fragmentation and lift-off, turbulent jets, droplet evaporation and deposition, and flow-induced particle dispersion and sedimentation. Even the 6-ft social distancing guideline is based on an outdated fluid dynamic study (from the 1930's) of droplet transport related to tuberculosis transmission. This is just one more example of the pervasiveness and importance of knowing something about multiphase flows. Clearly, when Dr. Subramaniam started thinking about CoMFRE as a center several years ago, he was well-ahead of his time!

With kind regards,



Theodore (Ted) J. Heindel  
Director, Center for Multiphase Flow Research and Education  
Bergles Professor of Thermal Sciences



## Welcoming New Member Ansys-Fluent

We are pleased to welcome Ansys-Fluent as a new CoMFRE member. Ansys provides a comprehensive suite of multiphysics software tools and is a leader in simulating complex fluid flows. They join our other member companies: AbbVie, BASF, BP, and Roeslein Alternative Energy.

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## Fall Membership Meeting: Tuesday, October 27, 2020

Due to COVID-19 concerns, we are holding a virtual annual meeting this year. The goal is to provide our member companies an update on CoMFRE and the CoMFRE-supported projects. Only member companies and affiliated faculty/students will be invited. Here are the details:

**What:** 2020 CoMFRE Annual Meeting

**Where:** Virtual through WebEx (link will be forthcoming)

**When:** Tuesday, October 27, 2020, 9 am – noon central time.

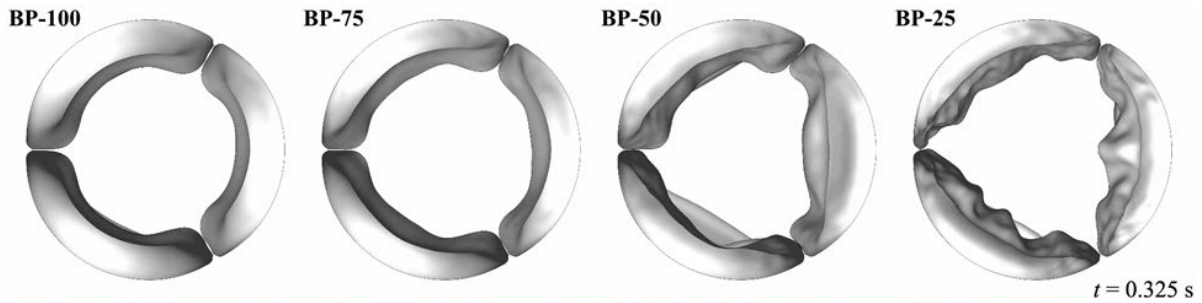
**Tentative Agenda** (all times central time):

9:00	Welcome (Ted)
9:10	Roeslein AE update (Alberto)
9:30	Ansys-Fluent update (Alberto)
9:50	CoMFRE Update (Ted)
10:05	BASF update (Rodney)
10:35	BP update (Rodney)
11:05	AbbVie update (Shankar)
11:35	Wrap-up (Ted)

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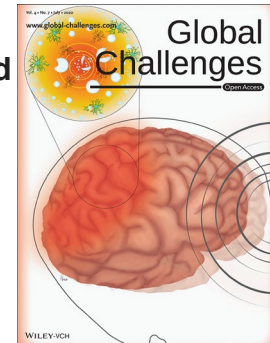
## CoMFRE and CoMFRE Affiliates in the News

**Engineers find thinner tissues in replacement heart valves create problematic flutter:** Ming-Chen Hsu, associate professor of mechanical engineering, and doctoral student Emily Johnson, in collaboration with scientists from UT-Austin, have found that thinner tissues in heart valve replacements are subject to dangerous “flutter”, which can lead to blood damage and premature leaflet deterioration:



<https://www.news.iastate.edu/news/2020/07/28/heartvalves>

**Researchers simulate, assess damage to brain cells caused by bubbles during head trauma:** Researchers led by **Nicole Hashemi**, associate professor of mechanical engineering, are using their expertise with the manufacture of microstructures to study how the collapse of microbubbles within the skull can damage brain cells. Their research, which is supported by the Office of Naval Research, could lead to the design of better helmets:



<https://www.news.iastate.edu/news/2020/07/22/cavitation>

Also see [Global Challenges Article](#)

**ISU research team collaborates with University of Iowa researchers on a project to prevent accidental ignition of energetic materials:** A Department of Defense project by researchers at Iowa State University and the University of Iowa could make it so that energetic materials are less volatile when being transported or otherwise handled. **Travis Sippel**, associate professor of mechanical engineering at ISU and student researchers from his lab will focus on enabling the sensitivity of an energetic material to be switched, electromagnetically, from an insensitive to ignition-sensitive state. Dr. Sippel and his group have recently developed a technique to wrap nanoscale thermites in graphene coatings, giving the thermite the property of microwave ignitability:

<https://news.engineering.iastate.edu/2020/09/25/isu-u-iowa-team-up-on-energetic-materials-research-project/>

**New UAS ignition-assist spray research project takes flight at CoMFRE:** CoMFRE researchers **Song-Charng Kong**, professor of mechanical engineering, and **James Michael**, assistant professor of mechanical engineering,

are characterizing the interaction of high-speed fuel spray and the ignition plug in unmanned aircraft systems (UAS) engines to better understand their interaction – at the high altitudes and low temperatures in which UAS operate. The new project builds upon Kong and Michael’s previous success studying and modeling fuel droplet impact on heated surfaces for the Army Research Laboratory and will extend modeling (and validating experiments) to small, high-speed fuel sprays on heated ignition plugs. The models will help ensure the reliability of future UAS ignition-assist systems:



<https://news.engineering.iastate.edu/2020/09/29/new-uas-ignition-spray-research-project-takes-flight-at-comfre/>

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## Recent Honors for CoMFRE Faculty

- **Daniel Attinger**, Associate Professor of Mechanical Engineering, was named Honorary Professor at the School of Engineering and Technology, Amity University, Uttar Pradesh, India.
- **Ming-Chen Hsu**, associate professor of mechanical engineering, received the ISU College of Engineering’s “Early Achievement in Research” award for outstanding accomplishments and contributions to the college.
- **Soumik Sarkar**, associate professor of mechanical engineering, was named “Walter W. Wilson Faculty Fellow in Engineering”, a privately funded position.

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## Student Awards

- Roy Pillers, PhD student in **Ted Heindel**'s group, received the 2020 Fluids Engineering Division Prof. Kirti Ghia Scholar Award during the ASME Fluids Engineering Division Summer Meeting (held virtually this year).  
See <https://news.engineering.iastate.edu/2020/07/31/me-graduate-student-earns-top-asme-fluid-engineering-division-award/>
- Lionel Ouedraogo, mechanical engineering graduate student in **Nicole Hashemi**'s group, earned the 2020 Educational Foundation Scholarship Award. <https://news.engineering.iastate.edu/2020/09/11/me-graduate-student-earns-2020-educational-foundation-scholarship-award/>

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## Recently Funded Research Awards

Feel free to contact the PI directly if you have any questions on the projects below.

- “Benefit/Cost of Applying a Higher Asphalt Film Thickness (AFT) vs. Doing a Chip Seal at 1 Year”; Ashley Faye Buss, Shauna L. Hallmark, Charles Theodore Jahren, and **Junxing Zheng**; Funding Source: Minnesota Department of Transportation; New Funding Amount: \$145,001.
- “Three Dimensional Printed Scaffolds for Understanding Effect of Cavitation on Blood Brain Barrier”; **Nicole Hashemi** and Reza Montazami; funding Agency: DOD – Office of Naval Research; New Funding Amount: \$101,007.
- “Icing Wind Tunnel Testing for Icephobic Coatings”; **Hui Hu**; Funding Source: Industry; New Funding Amount: \$70,991.
- “A Fundamental Study toward Innovative Plasma-based Anti-/Deicing Strategies for Aircraft Icing Mitigation”; **Hui Hu** and Xianglan Bai; Funding Source: NSF; New Funding Amount: \$320,000.
- “Characterizing Physiochemical Evolution of Biomass Particles during Fast Pyrolysis Using High-resolution Simulation”; **Song-Chang Kong**; Funding Source: NSF; New Funding Amount: \$347,706.
- “Spray-wall Interactions and Material Characterization at Extreme Temperatures for UAS Applications”; **Song-Chang Kong** and **James Michael**; Funding Agency: DoD-CCDC Army Research Laboratory; New Funding Amount: \$519,769.
- “Advancing a New Biobased Value Chain in the Corn Belt to Improve Climate Resilience, Water Quality, and Rural Vitality”; Lisa Anne Schulte

Moore, **Mark Mba-Wright**, and Emily Heaton; Funding Source: Walton Family Foundation; New Funding Amount: \$100,000.

- "Ultrafast Detection and Imaging of Underwater Blasts"; **James Michael**; Funding Agency: DoD-Naval Surface Warfare Center Indian Head; New Funding Amount: \$60,000.
- "Advanced High-speed Spectroscopy for Energetic Materials"; **James Michael, Travis Sippel**, and **Ted Heindel**; Funding Agency: DoD-Office of Naval Research (Defense University Research Instrumentation Program); New Funding Amount: \$268,562.
- "3D-Printed, Hierarchical Polymer-Bonded Energetic Composites with Electromagnetically Switchable Porosity"; **Travis Sippel**; Funding Agency: DoD-Defense Threat Reduction Agency; New Funding Amount: \$271,417
- "Collaborative Research: CDS&E: Advances in Closure Modeling for Turbulent Flows with Finite-sized Particles Informed by Massive Simulations on Heterogeneous Architectures"; **Shankar Subramaniam**, Funding Agency: NSF, New Funding Amount: \$262,072.

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## Recent Journal Publications

Note that CoMFRE affiliates are identified by **bold** names.

- J.K. Bothell, T.B. Morgan, and **T.J. Heindel**, "Image-based feedback control for a coaxial spray," *ASME Journal of Fluids Engineering*, 142(11): Paper 114501, 2020. <https://doi.org/10.1115/1.4048131>.
- **P.G. Geredeli**, "A time domain approach for the exponential stability of a linearized compressible flow-structure PDE system," *Mathematical Methods in the Applied Sciences*, 2020. <https://doi.org/10.1002/mma.6833>.
- A.D. Ilgun, **R.O. Fox**, and **A. Passalacqua**, "Solution of the first-order conditional moment closure for multiphase reacting flows using quadrature-based moment methods," *Chemical Engineering Journal*, 2020. <https://doi.org/10.1016/j.cej.2020.127020>
- A.D. Ilgun, **A. Passalacqua**, and **R.O. Fox**, "Application of quadrature-based moment methods to the conditional moment closure," *Proceedings of the Combustion Institute*, 2020. Corrected proof: <https://doi.org/10.1016/j.proci.2020.07.075>.

- E.L. Johnson, M.C.H. Wu, F. Xu, N.M. Wiese, M.R. Rajanna, A.J. Herrema, **B. Ganapathysubramanian**, T.J.R. Hughes, M.S. Sacks, and **M-C. Hsu**, “Thinner biological tissues induce leaflet flutter in aortic heart valve replacements,” *Proceedings of the National Academy of Sciences*, 117:19007–19016, 2020. <https://doi.org/10.1073/pnas.2002821117>
- E.L. Johnson and **M-C. Hsu**, “Isogeometric analysis of ice accretion on wind turbine blades,” *Computational Mechanics*, 66:311–322, 2020. <https://doi.org/10.1007/s00466-020-01852-y>
- N. Kozak, F. Xu, M.R. Rajanna, L. Bravo, M. Murugan, A. Ghoshal, Y. Bazilevs, and **M-C. Hsu**, “High-fidelity finite element modeling and analysis of adaptive gas turbine stator–rotor flow interaction at off-design conditions,” *Journal of Mechanics*, 2020. <https://doi.org/10.1017/jmech.2020.28>
- N. Kozak, M.R. Rajanna, M.C.H. Wu, M. Murugan, L. Bravo, A. Ghoshal, **M-C. Hsu**, and Y. Bazilevs, “Optimizing gas turbine performance using the surrogate management framework and high-fidelity flow modeling,” *Energies*, 13:4283, 2020. <https://doi.org/10.3390/en13174283>
- D.W. Laurence, E.L. Johnson, **M-C. Hsu**, R. Baumwart, A. Mir, H.M. Burkhart, G.A. Holzapfel, Y. Wu, and C-H. Lee, “A pilot in silico modeling-based study of the pathological effects on the biomechanical function of tricuspid valves,” *International Journal for Numerical Methods in Biomedical Engineering*, 36:e3346, 2020. <https://doi.org/10.1002/cnm.3346>
- C.J. Ross, **M-C. Hsu**, R. Baumwart, A. Mir, H.M. Burkhart, G.A. Holzapfel, Y. Wu, and C-H. Lee, “Quantification of load-dependent changes in the collagen fiber architecture for the strut chordae tendineae-leaflet insertion of porcine atrioventricular heart valves,” *Biomechanics and Modeling in Mechanobiology*, 2020. <https://doi.org/10.1007/s10237-020-01379-4>
- K. Zhu, S.J. Barkley, C.E. Dedic, **T.R. Sippel**, and **J.B. Michael**, “Two-photon laser-induced fluorescence of sodium in multiphase combustion,” *Applied Optics*, 59:5632-5641, 2020. <https://doi.org/10.1364/AO.392710>

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## Recent Conference Publications and Presentations



- **D. Attinger**, “Can engineering help with crime scene reconstruction?” Plenary Lecture at FLAME 2020, 2nd International Conference on Future Learning Aspects of Mechanical Engineering, Uttar Pradesh, India, 2020.
- R.A. Pillers and **T.J. Heindel**, “Backlit Imaging of a Circular Plunging Jet with Floor Interactions,” *ASME Fluids Engineering Division Summer Meeting*, Virtual Meeting, July 12-15, 2020, Paper Number: FEDSM2020-20040.
- M. Ray, F. Chowdhury, A. Sowinski, P. Mehrani, and **A. Passalacqua**, "Computational models for triboelectric charging in dense mono- and bi-disperse granular flows," *STEP-V#3 - The Virtual Symposium on Static-Tribo-Electricity of Powder*, September 19th, 2020.

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