

**Theodore (Ted) J. Heindel**  
Bergles Professor of Thermal Science  
Department of Mechanical Engineering  
Department of Chemical and Biological Engineering (courtesy)  
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## **Overview**

Ted Heindel is currently the Bergles Professor of Thermal Science in the Department of Mechanical Engineering at Iowa State University; he also holds a courtesy professor appointment in the Department of Chemical and Biological Engineering. He directs the Experimental Multiphase Flow Laboratory at ISU, which houses a unique instrument for performing X-ray visualization studies of large-scale complex fluid flows. His research currently focuses on multiphase flow hydrodynamics (e.g., mixing in gas-liquid, gas-solid, and gas-liquid-solid flows), multiphase flow visualization and characterization using X-ray imaging technology, and carbon monoxide and oxygen gas-liquid mass transfer. This work has applications in petroleum-based and bio-based chemical and fuel processing, energy generation, food processing, agricultural waste management, pulp and paper processing, mineral processing, and wastewater treatment. Dr. Heindel's research program has been funded by over 45 projects supported through the NSF, USDA, DOE, the State of Iowa, and industrial partners. He has co-authored one book and published over 70 peer-reviewed journal papers and over 200 conference papers, abstracts, and technical reports.

Dr. Heindel is the project director for the Iowa NSF EPSCoR project "Harnessing Energy Flows in the Biosphere to Build Sustainable Energy Systems." This \$20M, five-year project involves all three Iowa Regent institutions and has activities throughout the state of Iowa. He is also the Energy Utilization Platform leader in the Iowa NSF EPSCoR project; this platform focuses on building systems and community intervention and education to enhance energy utilization. Dr. Heindel recently completed a project funded by the Iowa Office of Energy Independence with a focus on enhancing the energy education opportunities at Iowa State. He developed a minor in energy systems that was approved in spring 2012, and he is the Director of Graduate Education for the newly approved Masters of Engineering degree in Energy Systems, which will be offered beginning fall 2014.

In October 2012, Dr. Heindel completed a three-year, three-month appointment as the interim chair of the Department of Mechanical Engineering, the most popular program on the Iowa State campus. During his time as Department Chair, student enrollment increased by over 30%, plans for a successful ABET review were initiated, and over nine tenured/tenure-track faculty were hired. Prior to becoming interim chair, Dr. Heindel was the Associate Chair for Academic Affairs in the Department of Mechanical Engineering where he chaired a department-wide strategic planning process. The outcome of this process was a faculty and staff supported roadmap identifying five strategic areas that is still being followed and was highlighted by the

ABET reviewer during the fall 2012 ABET visit. Dr. Heindel was in the initial cohort of ISU's Emerging Leaders Academy, a Provost-supported program to build university leadership; he completed this year-long program in December 2009.

Dr. Heindel's teaching emphasis is in the area of thermal science (thermodynamics, fluid dynamics, and heat/mass transfer) and measurement and instrumentation. He has also developed a new graduate-level course entitled "ME 531: Advanced Energy Systems and Analysis." He has been recognized for his teaching efforts through the College of Engineering's Superior Engineering Teacher of the Year Award, and was twice selected by graduating seniors as mechanical engineering's Professor of the Year. He typically supports several undergraduate research assistants in his laboratory and has mentored eight Program for Women in Science and Engineering (PWSE) summer interns and 22 Freshmen Honors research participants. He currently has three graduate students and five undergraduate research assistants working in his lab.

Dr. Heindel is active in the American Society of Mechanical Engineers (ASME) Fluids Engineering Division. He was an associate editor of the ASME Journal of Fluids Engineering for two 3-year terms (the maximum allowed by JFE) and Chair of the Fluid Measurement and Instrumentation Technical Committee for two 2-year terms. He now serves on the Fluids Engineering Division (FED) Honors and Awards Committee and represents the FED as an Advisory Board Member of the *ASME Journal of Nanotechnology in Engineering and Medicine*. He has also chaired or co-chaired several sessions at ASME conferences, and reviews papers and proposals for several journals and organizations.

Dr. Heindel is a past holder of the William and Virginia Binger Associate Professor of Mechanical Engineering at ISU. He was an assistant professor of engineering at the Institute of Paper Science and Technology (IPST) prior to joining Iowa State University. IPST was a private graduate school supported by the paper industry and located on the Georgia Tech Campus; it officially merged with Georgia Tech in 2003. Dr. Heindel received his B.S. from the University of Wisconsin – Madison and his M.S. and Ph.D. from Purdue University, all in mechanical engineering with an emphasis in the thermal sciences.

### **Educational Background**

- Ph.D., Mechanical Engineering; December 1994; Purdue University, West Lafayette, IN.
- M.S., Mechanical Engineering; December 1990; Purdue University, West Lafayette, IN.
- B.S., Mechanical Engineering; May 1988; University of Wisconsin-Madison, Madison, WI.

### **Employment History**

#### Iowa State University, Ames, IA

8/2009 – Present	Bergles Professor of Thermal Science
8/2006 – Present	Professor, Department of Mechanical Engineering
4/2011 – Present	Professor, Department of Chemical and Biological Engineering (courtesy)

7/2009 – 9/2012	Interim Chair, Department of Mechanical Engineering
8/2007 – 6/2009	Associate Chair for Academic Affairs, Department of Mechanical Engineering
11/2001 – 8/2006	William and Virginia Binger Associate Professor of Mechanical Engineering
8/2000 – 7/2006	Associate Professor, Department of Mechanical Engineering
<u>Other Employment</u>	
9/1994 – 6/2000	Assistant Professor, Institute of Paper Science and Technology, Atlanta, GA
5/1988 – 8/1994	Research Assistant, Purdue University, West Lafayette, IN,.

### **Honors and Awards**

- Fellow, ASME, 2011
- ISU Emerging Leaders Academy, 2009 cohort (initial cohort of this program)
- ISU ME Professor of the Year, 2006, 2009 (tied).
- ISU College of Engineering Superior Engineering Teacher of the Year Award, 2006.
- Iowa State University Miller Faculty Fellow, AY03/04.
- Recognized by the ISU Engineering Student Council with a Leadership Award – Spring 2002, Spring 2005.
- Nominated for the VEISHEA Outstanding Faculty Member Award at ISU – 2001, 2007.
- Nominated for the Institute of Paper Science and Technology Teacher of the Year Award – 1996, 1997, 1998, 1999.
- Institute of Paper Science and Technology President’s Award for Excellence in Teaching – 1997.
- Institute of Paper Science and Technology Teacher of the Year Award – 1997.
- Georgia Tech Teaching Fellow, Winter 1996 Class.

### **Summary of Funded Research**

- Over \$7,319,000 in funded research since 1994 plus PI for \$22,000,000 for the Iowa NSF EPSCoR Project.
1. “EPSCoR Workshop: A 2014 Workshop on Engineered Crops,” NSF, \$99,996, PI T.J. Heindel, Co-PI D. Attinger, Mar. 2014 – Feb. 2016.
  2. “Effects of Recycling Regenerated Heat Carrier on the Performance of an Auger Pyrolysis Reactor,” Phillips 66, \$256,625, PI T.J. Heindel, Jan. 2014 – Dec. 2015.
  3. “Scale Effects on Mixing in a Screw Pyrolyzer,” Phillips 66, \$250,847, PI T.J. Heindel, Jan. 2014 – Dec. 2015.
  4. “3D imaging and physics-based modeling for optimized root characteristics,” Plant Science Institute, \$117,807, PI B. Ganapathysubramanian, Co-PIs: T. Lubberstedt and T.J. Heindel, July 2013 – June 2015.

5. "Computationally Engineered Plant Institute: A Proof of Concept Proposal to the ISU Presidential Initiative," ISU-Presidential Initiative, \$100,000, PI D. Attinger, co-PIs: B. Ganapathysubramanian, T. Lubberstedt, L.T. Halverson, P. Schnable, T.J. Heindel, W.R. Morrow, H. Hu, and H. Shapiro, July 2013 – June 2014.
6. "Developing "ME 531x – Advanced Energy Systems and Analysis" for Distance Education," Engineering-LAS Online Learning, \$9,000, PI T. Heindel, May 2013 – June 2014.
7. "NSF EPSCoR: Harnessing Energy Flows in the Biosphere to Build Sustainable Energy Systems," National Science Foundation, \$20,000,000, PI T. Heindel (as of January 1, 2013), Co-PIs: R.C. Brown, S. Sundararajan, and B. Butler (UI), Sept. 2011 – Aug. 2016.
8. "Cost Share: Harnessing Energy Flows in the Biosphere to Build Sustainable Energy Systems," Iowa PowerFund, \$2,000,000, PI T. Heindel (as of January 1, 2013), Sept. 2011 – Aug. 2016
9. "Mixing Quantification in Screw Pyrolyzers – Year 2," Phillips 66, \$127,180, PI T. Heindel, Jan. 2013 – Dec. 2013.
10. "Seminar Series on 'Computationally Engineered Plants'," ISU Plant Sciences Institute, \$8,400, PI D. Attinger, Co-PIs B. Ganapathysubramanian, T. Heindel, R. Morrow, P. Schnable, and T. Lubberstedt, Sept. 2012 – May 2013.
11. "Mixing Quantification in Screw Pyrolyzers," ConocoPhillips (became Phillips 66 in 2012), \$111,094, PI T. Heindel, Jan. 2012 – Dec. 2012.
12. "Fluidized Bed Modeling and Validation for Gasification and Pyrolysis, Year 5," ConocoPhillips, \$209,473, PI T. Heindel, co-PI R. Fox, Jan. 2011 – Dec. 2011.
13. "Enhancing Energy Education in Iowa," Iowa Office of Energy Independence, \$500,000 (with \$500,000 ISU cost-share), PI T. Heindel, co-PI T. Brumm, R. Cox, July 2010 – March 2012.
14. "Fluidized Bed Modeling and Validation for Gasification and Pyrolysis, Year 4," ConocoPhillips, \$267,629, PI T. Heindel, co-PI R. Fox, Jan. 2010 – Dec. 2010.
15. "Fluidized Bed Modeling and Validation for Gasification and Pyrolysis, Year 3" ConocoPhillips, \$200,917, PI T. Heindel, co-PI R. Fox, Jan. 2009 – Dec. 2009.
16. "A Survey of Bioreactor Gas-Liquid Mass Transfer, Year 2," ConocoPhillips, \$70,162, PI T. Heindel, Jan. 2008 – Dec. 2008.
17. "What the Best College Teachers Do: A Roundtable Discussion in the Department of Mechanical Engineering," ISU CELT Teach Grant, \$1,020, PI T. Heindel, Nov. 2008 – Jun. 2009.
18. "Fluidized Bed Modeling and Validation for Gasification and Pyrolysis, Year 2" ConocoPhillips, \$132,509, PI T. Heindel, co-PI R. Fox, Jan. 2008 – Dec. 2008.
19. "A Survey of Bioreactor Gas-Liquid Mass Transfer, Year 1," ConocoPhillips, \$64,360, PI T. Heindel, Jan. 2008 – Dec. 2008.
20. "X-ray Flow Visualization of the Cavitating Field Downstream of a Butterfly Valve," Fisher Control, \$15,000, PI T. Heindel, co-PI T. Jensen, Sep. 2007 – May 2009.

21. "Fluidized Bed Modeling and Validation for Gasification and Pyrolysis, Year 1" ConocoPhillips, \$80,000, PI F. Battaglia, co-PI T. Heindel, Jan. 2007 – Dec. 2007.
22. "Using Microparticles for Mass Transfer Enhancement," Battelle Infrastructure and Platform Grants Program, PI T. Heindel, co-PI B. Shanks, \$121,877, Dec. 2006 – Feb. 2009.
23. "Gasification Technologies in Support of Biorefineries," Grow Iowa Values Fund, \$132,274, PI R. Brown, co-PIs F. Battaglia, T. Heindel, Jul. 2006 – Dec. 2008.
24. "Improving the Energy Balance of Grain Ethanol Plants," IPRT Company Assistance, \$30,000, PI R. Brown, co-PIs F. Battaglia, T. Heindel, Mar. 2006 – Jun. 2007.
25. "Airlift Reactor Model and Validation for Syngas Fermentation," USDA, \$70,000, PI T. Heindel, co-PI, F. Battaglia, Sep. 2005 – Aug. 2007.
26. "Mass Transfer Measurements for Syngas Fermentation," USDA, \$239,550, PI T. Heindel, co-PIs R. Brown, M. Hargrove, Aug. 2003 – Aug. 2006.
27. "Biopolymers and Other Value-Added Products from Distillers' Dried Grains," USDA, \$1,000,000, PI R. Brown, co-PIs T. Heindel, A. DiSpirito, B. Nikolau, Oct. 2003 – Sep. 2006.
28. "Innovations in Mechanical Engineering Measurements and Instrumentation," ISU – Miller Faculty Fellowship, \$24,982, PI T. Heindel, Jul. 2003 – Jun. 2004.
29. "GOALI: Gas Holdup in Flocculating Slurries," NSF, \$170,000, PI T. Heindel, co-PI J. Lindsay (Kimberly-Clark Corp.), Sep. 2002 – Aug. 2005.
30. "GOALI: Gas Holdup in Flocculating Slurries – REU supplements" NSF, \$24,000, PI T. Heindel, Sep. 2002 – Aug. 2005.
31. "MRI: Development of an X-ray System for Noninvasive 3-D Imaging of Large-Scale Multiphase Flows," NSF, \$421,845, PI T. Heindel, co-PIs J. Gray, T. Jensen, Aug. 2002 – Jul. 2006.
32. "MRI: Development of an X-ray System for Noninvasive 3-D Imaging of Large-Scale Multiphase Flows – Required Cost-Share," ISU, \$218,300, PI T. Heindel, co-PIs J. Gray, T. Jensen, Aug. 2002 – Jul. 2006.
33. "Fiber to Biobased Products via Syn Gas Fermentation," Ames Laboratory, \$80,500, PI T. Heindel, co-PIs A. DiSpirito, R. Brown, B. Nikolau, G. Fenske, Sep. 2002 – Mar. 2004.
34. "Gasification Technologies in Support of Biomass Power," DOE, \$105,000, PI R. Brown, co-PI T. Heindel, Dec. 2001 – Nov. 2002.
35. "Bioprocessing of Synthesis Gas to Produce Fuels and Chemicals – Phase I: Measuring CO and H<sub>2</sub> Mass Transfer Rates in Anaerobic Bioreactors," ISU – IPRT, \$50,000, PI T. Heindel, co-PI R. Brown, Dec. 2001 – Jun. 2002.
36. "Controlling Gas Holdup in Cellulose Fiber Suspensions," USDA, \$121,600, PI T. Heindel, Oct. 2001 – Oct. 2004.
37. "The Influence of Fiber Type on Gas Holdup in Slurry Bubble Column Reactors," ISU University Research Grant, \$20,000, PI T. Heindel, Jul. 2001 – June 2002.
38. "Bubble Size Control to Improve Oxygen-Based Bleaching," DOE, \$162,200, PI T. Heindel, co-PI T. McDonough, Dec. 1999 – Jul. 2000.

39. "Bubble Size Control to Improve Oxygen-Based Bleaching – Cost Share," IPST, \$5,020, PI T. Heindel, Dec. 1999 – Jul. 2000.
40. "Approach Flow Systems," IPST Dues-Funded Research Consortium, \$75,000, PI T. Heindel, Jul. 1999 – Jul. 2000.
41. "Characterization and Removal of Stickie Contaminants from OCC Mills," Containerboard Group of the American Forest and Paper Association, \$310,646, PI T. Heindel, co-PI K. Hodgson (University of Washington-Seattle), Oct. 1996 – Jul. 2000.
42. "Flow Pattern Identification in Fiber Suspensions Using Artificial Neural Networks," IPST/GIT Seed Grant, \$39,971, PI T. Heindel, co-PI S. Ghiaasiaan (Georgia Tech), Jul. 1999 – Jun. 2000.
43. "Modeling Pulp Mixing," IPST Exploratory Funds, \$8,308, PI T. Heindel, Oct. 1999 – Jan. 2000.
44. "Flotation Presentation at East Millinocket," Bowater, \$2,070, PI T. Heindel, Jan. 1997.
45. "Chesapeake West Point Contaminant Removal Options," Chesapeake Paper Products, \$10,802, PI S. Banerjee, co-PI T. Heindel, Dec. 1996 – Jan. 1997.
46. "Turbulence Characteristics of Pulp Slurries in Flotation Systems," IPST/GIT Seed Grant, \$39,949, PI T. Heindel, co-PI S. Ghiaasiaan (Georgia Tech), Aug. 1995 – Dec. 1996.
47. "Flotation Deinking Fluid Mechanics," IPST Dues-Funded Research Consortium, \$734,752, PI T. Heindel, Sep. 1994 – Jul. 2000.

## **Consulting**

- Institute of Paper Science and Technology, Atlanta, GA, 2001.

## **Publications**

### **Books**

1. Kadic, E., and Heindel, T.J., *An Introduction to Bioreactor Hydrodynamics and Gas-Liquid Mass Transfer*, John Wiley & Sons, Hoboken, NJ, 2014,  
<http://www.wiley.com/WileyCDA/WileyTitle/productCd-1118104013.html>.

### **Peer Reviewed Journal Papers**

1. Kingston, T.A., Morgan, T.B., Geick, T.A., Robinson, T.R., Heindel, T.J., "A Cone-beam Compensated Back-projection Algorithm for X-ray Particle Tracking Velocimetry," *Flow Measurement and Instrumentation*, To Appear, 2014.
2. Kingston, T.A., Heindel, T.J., "Granular Mixing Optimization and the Influence of Operating Conditions in a Double Screw Mixer," *Powder Technology*, To Appear, 2014.
3. Kingston, T.A., and Heindel, T.J., "Optical Visualization and Composition Analysis to Quantify Continuous Granular Mixing Processes," *Powder Technology*, 262: 257-264, 2014.
4. Escudero, D., and Heindel, T.J., "Acoustic Fluidized Bed Hydrodynamics Characterization using X-ray Computed Tomography," *Chemical Engineering Journal*, 243: 411-420, 2014.
5. Halls, B.R., Heindel, T.J., Kastengren, A.L., and Meyer, T.R., "Evaluation of X-ray Sources for Quantitative Two- and Three-Dimensional Imaging of Liquid Mass Distribution in Atomizing Sprays," *International Journal of Multiphase Flow*, 59(0): 113-120, 2014.

6. Escudero, D., and Heindel, T.J., "Minimum Fluidization Velocity in a 3D Fluidized Bed Modified with an Acoustic Field," *Chemical Engineering Journal*, 231: 68-75, 2013.
7. Keller, N.K.G., Bai, W., Fox, R.O., and Heindel, T.J., "Quantifying Mixing in 3D Binary Particulate Systems," *Chemical Engineering Science*, 93(0): 412-422, 2013.
8. Bai, W., Keller, N.K.G., Heindel, T.J., and Fox, R.O., "Numerical Study of Mixing and Segregation in a Biomass Fluidized Bed," *Powder Technology*, 237: 355-366, 2013.
9. Drake, J.B., and Heindel, T.J., "Comparisons of Annular Hydrodynamic Structures in 3D Fluidized Beds Using X-ray CT," *Journal of Fluids Engineering – Transactions of the ASME*, 134(8): 081305 (8 pages), 2012.
10. Xue, Q., Dalluge, D., Heindel, T.J., Fox, R.O., and Brown, R.C., "Experimental Validation and CFD Modeling Study of Biomass Fast Pyrolysis in Fluidized-Bed Reactors," *Fuel*, 97: 757-769, 2012.
11. Drake, J.B., and Heindel, T.J., "Local Time-Average Gas Holdup Comparisons in Cold Flow Fluidized Beds," *Chemical Engineering Science*, 68(1): 157-165, 2012.
12. Deza, M., Heindel, T.J., and Battaglia, F. "Effects of Mixing using a Side Port Air Injection on Biomass Fluidized Bed," *Journal of Fluids Engineering – Transactions of the ASME*, 133(11): 111302 (9 pages), 2011.
13. Drake, J.B., and Heindel, T.J., "The Repeatability and Uniformity of 3D Fluidized Beds," *Powder Technology*, 213(1-3): 148-154, 2011.
14. Heindel, T.J., "A Review of X-ray Flow Visualization with Applications to Multiphase Flows," *Journal of Fluids Engineering – Transactions of the ASME*, 133(7): 074001 (16 pages), 2011.
15. Escudero, D., and Heindel, T.J., "Bed Height and Material Density Effects on Fluidized Bed Hydrodynamics," *Chemical Engineering Science*, 66(16): 3648-3655, 2011.
16. Xue, Q., Heindel, T.J., Fox, R.O., "A CFD Model for Biomass Fast Pyrolysis in Fluidized-Bed Reactors," *Chemical Engineering Science*, 66(11): 2440-2452, 2011.
17. Law, D., Jones, S.T., Heindel, T.J., and Battaglia, F. "A Combined Numerical and Experimental Study of Hydrodynamics for an Air-Water External Loop Airlift Reactor," *Journal of Fluids Engineering – Transactions of the ASME*, 133(2): 021301 (8 pages), 2011.
18. Zhu, H., Shanks, B.H., Choi, W., and Heindel, T.J., "Effect of Functionalized MCM41 Nanoparticles on Syngas Fermentation," *Biomass and Bioenergy*, 34(11): 1624-1627, 2010.
19. Jones, S.T., and Heindel, T.J., "Hydrodynamic Considerations in an External Loop Airlift Reactor with a Modified Downcomer," *Industrial & Engineering Chemistry Research*, 49(4): 1931-1936, 2010.
20. Min, J., Drake, J.B., Heindel, T.J., and Fox, R.O., "Experimental Validation of CFD Simulations of a Lab-Scale Fluidized-Bed Reactor with and without Side-Gas Injection," *AIChE Journal*, 56(6): 1434-1446, 2010.
21. Deza, M., Franka, N.P., Battaglia, F., and Heindel, T.J., "CFD Modeling and X-ray Imaging of Biomass in a Fluidized Bed," *Journal of Fluids Engineering – Transactions of the ASME*, 131(11): Paper 111303, 2009.

22. Franka, N.P., and Heindel, T.J., "Local Time-Averaged Gas Holdup in a Fluidized Bed with Side Air Injection using X-ray Computed Tomography," *Powder Technology*, 193: 69-78, 2009.
23. Zhu, H., Shanks, B.H., and Heindel, T.J., "Effect of Electrolytes on CO-Water Mass Transfer," *Industrial & Engineering Chemistry Research*, 48(6): 3206-3210, 2009.
24. Zhu, H., Shanks, B.H., and Heindel, T.J., "Enhancing CO-Water Mass Transfer by Functionalized MCM41 Nanoparticles," *Industrial & Engineering Chemistry Research*, 47(21): 7881-7887, 2008.
25. Law, D., Battaglia, F., and Heindel, T.J., "Model Validation for Low and High Superficial Gas Velocity Bubble Column Flows," *Chemical Engineering Science*, 63(18): 4605-4616, 2008.
26. Ford, J.J., Heindel, T.J., Jensen, T.C., and Drake, J.B., "X-ray Computed Tomography of a Gas-Sparged Stirred-Tank Reactor," *Chemical Engineering Science*, 63(8): 2075-2085, 2008.
27. Heindel, T.J., Gray, J.N., and Jensen, T.C., "An X-ray System for Visualizing Fluid Flows," *Flow Measurement and Instrumentation*, 19(1): 67-78, 2008.
28. Ungerman, A.D., and Heindel, T.J., "Carbon Monoxide Mass Transfer for Syngas Fermentation in a Stirred Tank Reactor with Dual Impeller Configurations," *Biotechnology Progress*, 23(3): 613-620, 2007.
29. Do, Y.S., Smeenk, J., Broer, K.M., Kisting, C.J., Brown, R.C., Heindel, T.J., Bobik, T.A., and DiSpirito, A.A., "Growth of *Rhodospirillum rubrum* in Synthesis Gas: Catalyst of CO and H<sub>2</sub> and poly- $\beta$ -hydroxyalkanoate," *Biotechnology and Bioengineering*, 97(2): 279-286, 2007.
30. Tang, C. and Heindel, T.J., "Effect of Fiber Length Distribution on Gas Holdup in a Cocurrent Gas-Liquid-Fiber Bubble Column," *Chemical Engineering Science*, 62(5): 1408-1417, 2007.
31. Kopic, A., Jones, S.T., and Heindel, T.J., "Carbon Monoxide Mass Transfer in a Syngas Mixture," *Industrial & Engineering Chemistry Research*, 45(26): 9150-9155 (2006).
32. Tang, C., and Heindel, T.J., "Estimating Gas Holdup via Pressure Difference Measurements in a Cocurrent Bubble Column," *International Journal of Multiphase Flow*, 32(7): 850-863 (2006).
33. Kopic, A., and Heindel, T.J., "A General Scale-Up Correlation for Gas-Liquid Mass Transfer in a Stirred-Tank Reactor," *Transactions of IChemE, Part A, Chemical Engineering Research and Design*, 84(A3) 239-245 (2006).
34. Riggs, S.S., and Heindel, T.J., "Measuring Carbon Monoxide Gas-Liquid Mass Transfer in a Stirred Tank Reactor for Syngas Fermentation," *Biotechnology Progress*, 22(3): 903-906 (2006).
35. Tang, C., and Heindel, T.J., "Quantifying the Fiber Effect on Gas Holdup in a Cocurrent Air-Water-Fiber Bubble Column," *The Canadian Journal of Chemical Engineering*, 84(2) 198-208 (2006).
36. Tang, C., and Heindel, T.J., "A Gas Holdup Model for Cocurrent Air-Water-Fiber Bubble Columns," *Chemical Engineering Science*, 61(10) 3299-3312 (2006).
37. Su, X., Hol, P.D., Talcott, S.M., Staudt, A.K. and Heindel, T.J., "The Effect of Bubble Column Diameter on Gas Holdup in Fiber Suspensions," *Chemical Engineering Science*, 61(10) 3098-2104 (2006).



38. Su, X., and Heindel, T.J., "Gas Holdup Models for Gas-Liquid-Fiber Semi-Batch Bubble Columns," *Industrial & Engineering Chemistry Research*, 44(24) 9355-9363 (2005).
39. Tang, C., and Heindel, T.J., "Gas-Liquid-Fiber Flow in a Cocurrent Bubble Column," *AIChE Journal*, 51(10): 2665-2674 (2005).
40. Tang, C., and Heindel, T.J., "Effect of Fiber Type on Gas Holdup in a Cocurrent Air-Water-Fiber Bubble Column," *Chemical Engineering Journal*, 111(1) 21-30 (2005).
41. Su, X., and Heindel, T.J., "Effect of Perforated Plate Open Area on Gas Holdup in Rayon Fiber Suspensions," *Journal of Fluids Engineering – Transactions of the ASME*, 127(4): 816-823 (2005).
42. Hubers, J.L., Striegel, A.C., Heindel, T.J., Gray, J.N., and Jensen, T.C., "X-ray Computed Tomography in Large Bubble Columns," *Chemical Engineering Science*, 60(22): 6124-6133 (2005).
43. Hol, P.D., and Heindel, T.J., "Local Gas Holdup Variation in a Fiber Slurry," *Industrial & Engineering Chemistry Research*, 44(13), 4778-4784 (2005).
44. Su, X., and Heindel, T.J., "Gas Holdup Behavior in Nylon Fiber Suspensions," *Industrial & Engineering Chemistry Research*, 43(9), 2256-2263 (2004).
45. Giorges, A.T.G., White, D.E., and Heindel, T.J., "Concentric Mixing of Hardwood Pulp and Water," *TAPPI Journal*, 3(5): Online Exclusive (2004). (<http://www.tappi.org/content/pdf/journal/04MAYTJ.pdf>).
46. Tang, C., and Heindel, T.J., "Time-Dependent Gas Holdup Variation in an Air-Water Bubble Column," *Chemical Engineering Science*, 59(3) 623-632 (2004).
47. Heindel, T.J., "A Review of Gas Flows in Fiber Suspensions," *TAPPI Journal*, 2(11): Online Exclusive (2003). (<http://www.tappi.org/journals/99516603NOV22.pdf>)
48. Su, X., and Heindel, T.J., "Gas Holdup in Fiber Suspensions," *The Canadian Journal of Chemical Engineering*, 81(3-4): 412-418 (2003).
49. Bloom, F., and Heindel, T.J., "Modeling Flotation Separation in a Semi-Batch Process," *Chemical Engineering Science*, 58(2): 353-365 (2003).
50. Bloom, F., and Heindel, T.J., "On the Structure of Collision and Detachment Frequencies in Flotation Models," *Chemical Engineering Science*, 57(13): 2467-2473 (2002).
51. Heindel, T.J., "Bubble Size in a Cocurrent Fiber Slurry," *Industrial & Engineering Chemistry Research*, 41(3): 632-641 (2002).
52. Heindel, T.J., Campo, A., Ramadhyani, S., and Incropera, F.P., "Measurement of Heat Transfer Coefficients Between Turbulent Liquid Jets and a Radially Finned Heated Disk Placed at the Bottom of an Open Vertical Circular Cavity," *Heat and Mass Transfer*, 38(7-8): 577-587 (2002).
53. Heindel, T.J., "Gas Flow Regime Changes in a Bubble Column Filled With a Fiber Suspension," *The Canadian Journal of Chemical Engineering*, 78(5): 1017-1022 (2000).
54. Garner, A.E., and Heindel, T.J., "The Effect of Fiber Type on Bubble Size," *Journal of Pulp and Paper Science*, 26(7): 266-269 (2000).

55. Heindel, T.J., and Hodgson, K.T., "A Laboratory Study of OCC Flotation for Removal of Model Stickie Particles," *TAPPI Journal*, 83(7): 58 (2000).
56. Schulz, T.H., and Heindel, T.J., "A Study of Gas Holdup in a Cocurrent Air/Liquid/Fiber System," *TAPPI Journal*, 83(6): 58-59 (2000).
57. Bloom, F., and Heindel, T.J., "An Approximate Analytical Expression for the Probability of Attachment by Sliding," *Journal of Colloid and Interface Science*, 218: 564-577 (1999).
58. Heindel, T.J., and Garner, A.E., "Effect of Fiber Consistency on Bubble Size," *Nordic Pulp and Paper Research Journal*, 14(2): 171-178 (1999).
59. Heindel, T.J., and Bloom, F., "Exact and Approximate Expressions for Bubble-Particle Collision," *Journal of Colloid and Interface Science*, 213: 101-111 (1999).
60. Heindel, T.J., "Bubble Size Measurements in a Fiber Suspension," *Journal of Pulp and Paper Science*, 25:3 104-110 (1999).
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### **Book Chapters**

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### **Conference Papers**

1. Escudero, D., and Heindel, T.J., "Characterizing Jetting in an Acoustic Fluidized Bed using X-Ray Computed Tomography," *Proceedings of the ASME 2014 Fluids Engineering Division Summer Meeting*, August 3-7, 2014, Chicago, Illinois Paper FEDSM2014-21161, 2014.
2. Kingston, T.A., and Heindel, T.J., "Characterizing Granular Mixing Homogeneity at Various Dimensionless Mixing Lengths in a Double Screw Mixer," *Proceedings of the ASME 2014 Fluids Engineering Division Summer Meeting*, August 3-7, 2014, Chicago, Illinois Paper FEDSM2014-21048, 2014.
3. Hall, B.R., Morgan, T.B., Heindel, T.J., Meyer, T.R., and Kastengren, A.L., "High-speed radiographic spray imaging with a broadband tube source," *AIAA Science and Technology Forum and Exposition 2014*, National Harbor, MD, January 13-17, 2014.
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9. Sundararajan, S., Heindel, T.J., Ganapathysubramanian, G., and Subramaniam, S., "Women in Mechanical Engineering: A Departmental Effort to Improve Recruitment, Retention, and Engagement of Women Students," *2012 ASEE Annual Conference and Exposition*, June 10-13, San Antonio TX, Paper AC 2012-5501.
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12. Brett, G., Riveland, M, Jensen, T.C., and Heindel, T.J., "Cavitation from a Butterfly Valve: Comparing 3D Simulations to 3D X-ray Computed Tomography Flow Visualization," *Proceedings of ASME-JSME-KSME Joint Fluids Engineering Conference*, July 24-29, 2011, Hamamatsu, Shizuoka, JAPAN, Paper AJK2011-33003, 2011.
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  26. Deza, M., Heindel, T.J., and Battaglia, F. "Modeling a Biomass Fluidizing Bed with Side Port Air Injection," *Proceedings of the 2009 ASME Fluids Engineering Division Summer Meeting*, August 2-6, 2009, Vail, CO, Paper FEDSM2009-78372, ASME Press, New York, 2009.
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37. Ford, J., Heindel, T.J., and Jensen, T.C., "Imaging a Gas-Sparged Stirred-Tank Reactor with X-rays," *Proceedings of the 2007 ASME/JSME Fluids Engineering Division Summer Meeting*, July 30 – August 2, 2007, San Diego, Paper FEDSM2007-37022, ASME Press, New York, 2007.
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39. Jones, S.T., and Heindel, T.J., "The Influence of External Loop Airlift Bioreactor Configuration on Bioreactor Hydrodynamics," *Proceedings of the 2007 ASABE Annual International Meeting*, June 17 – 20, 2007, Minneapolis, MN, Paper Number: 077069, ASABE Press, St. Joseph, MI, 2007.
40. Jones, S.T., and Heindel, T.J., "A Review of Dissolved Oxygen Concentration Measurement Methods for Biological Fermentations," *Proceedings of the 2007 ASABE Annual International*

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41. Law, D., Battaglia, F., and Heindel, T.J., "Numerical Simulations of Gas-Liquid Flow Dynamics in Bubble Columns," *Proceedings of the 2006 ASME International Mechanical Engineering Congress and Exposition*, November 5-10, Chicago, ASME Press, Paper IMECE2006-13544, 2006.
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46. Talcott, S.M., and Heindel, T.J., "Gas Holdup in Opaque Cellulose Fiber Slurries," *Proceedings of the 2005 ASME Fluids Engineering Division Summer Meeting and Exhibition*, June 19-23, Houston, TX, Paper FEDS2005-77043, ASME Press, New York, 2005.
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51. McHugh, J., Hodgson, K., and Heindel, T.J., "Quantification of Stickies Removal from OCC by Dispersed Air Flotation," *2001 TAPPI Pulping Conference*, November 4-7, Seattle, WA (2001).
52. Ashley, C.R., and Heindel, T.J., "Visualizing Air Bubbles in Pulp Suspensions Common to Recycling Operations," *TAPPI 99 Proceedings*, TAPPI Press, Atlanta, GA, 617-632, (1999).

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54. Heindel, T.J., and Monefeldt, J.L., "Flash X-ray Radiography for Visualizing Gas Flows in Opaque Liquid/Fiber Suspensions," *FEDSM'97*, ASME Press, New York, On CD (1997).
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56. Heindel, T.J., Incropera, F.P., and Ramadhyani, S., "Heat Transfer Enhancement from Arrays of Discrete Heat Sources," *Process, Enhanced, and Multiphase Heat Transfer*, R.M. Manglik, and A.D. Kraus, Eds., Begell House, Inc., New York, 207-216 (1996).
57. Heindel, T.J., Ramadhyani, S., and Incropera, F.P., "Conjugate Natural Convection from an Array of Discrete Heat Sources," *Heat Transfer with Combined Modes*, D.E. Beasley, and K.D. Cole, Eds., ASME HTD-Vol. 299, New York, ASME, 51-62 (1994).
58. Heindel, T.J., Ramadhyani, S., Incropera, F.P., and Campo, A., "Surface Enhancement of a Heat Source Exposed to a Circular Liquid Jet with Annular Collection of the Spent Fluid," *Topics in Heat Transfer*, HTD-Vol. 206-2, 111-118 (1992).

#### **Invited Presentations**

1. Heindel, T.J., "Using X-rays to Visualize Multiphase Flows," presented to the Department of Mechanical and Industrial Engineering ME Graduate Seminar Series, University of Iowa, April 3, 2014, Iowa City, IA.
2. Heindel, T.J., "Understanding Fluidized Bed Hydrodynamics Through X-ray Flow Visualization," presented to the Fluidization Research Center and Gasification Group Seminar, Department of Chemical and Biological Engineering Seminar Series, University of British Columbia, October 18, 2012, Vancouver, BC, Canada.
3. Heindel, T.J., "Using X-rays to Visualize Multiphase Flows," presented to the Department of Chemical and Biological Engineering Seminar Series, University of British Columbia, October 4, 2012, Vancouver, BC, Canada.
4. Heindel, T.J., "3D X-ray Flow Visualization to Characterize Multiphase Flows," presented to the Department of Chemical Engineering, Missouri University of Science and Technology, November 29, 2011, Rolla, MO.
5. Heindel, T.J., "Developing Tracer Particles for X-ray Particle Tracking Velocimetry," keynote presented on July 25, 2011, at the ASME-JSME-KSME Joint Fluids Engineering Conference 2011, July 24-29, 2011, Hamamatsu, Shizuoka, JAPAN.
6. Heindel, T.J., "Characterizing Fluidized Bed Hydrodynamics using 3D X-ray Imaging," presented on September 10, 2010, at the National Energy Technology Laboratory (NETL), Morgantown, WV.
7. Heindel, T.J., "Characterizing Fluidized Bed Hydrodynamics using X-ray Flow Visualization," presented on September 9, 2010, at the Notre Dame AME 2010-2011 Colloquium, Notre Dame, South Bend, IN.



8. Heindel, T.J. (and others in our COP research team), "Fluidized Bed Modeling and Validation for Gasification and Pyrolysis," presented on February 12, 2010, at ConocoPhillips, Bartlesville, OK.
9. Heindel, T.J., "3D X-ray Flow Visualization of Fluidized Beds," presented on January 27, 2010, at the National Renewable Energy Laboratory (NREL), Golden, CO.
10. Heindel, T.J., "3D X-ray Flow Visualization of Fluidized Beds," presented on September 23, 2009, at the Rutgers ME Seminar Series, Piscataway, NJ.
11. Heindel, T.J., "CT Imaging of Cavitation off a Butterfly Valve," presented on July 22, 2009, at the Fisher Controls Lunch and Learn Series, Marshalltown, IA.
12. Heindel, T.J., "Measurement Systems in Graduate Student Research," presented on September 22, 2008, at the UW-Platteville Measurement Systems Class, Platteville, WI.
13. Heindel, T.J., "Recruiting at ISU," presented on July 31, 2008, at the KIEWIT 2008 Mid-Year HR Manager Meeting, Dallas, TX.
14. Heindel, T.J., "Visualizing Multiphase Flows with X-rays," presented on June 12, 2008, at GE Nuclear in Wilmington, NC.
15. Heindel, T.J., "Visualizing Fluid Flows with X-rays," presented on May 23, 2007, at ConocoPhillips in Bartlesville, OK.
16. Heindel, T.J., "Multiphase Flow Visualization using X-rays," presented at the Completion Engineering Association Fall 2006 meeting, San Antonio, TX, September 28, 2006.
17. Heindel, T.J., "X-rays for Multiphase Flow Visualization," presented at Schlumberger Oilfield Services, Inc., Houston, TX, March 14, 2006.
18. Heindel, T.J., "Visualizing Fluid Flow with X-rays," presented at a Fisher Controls Seminar, Marshalltown, IA, January 24, 2006.
19. Heindel, T.J., "Visualizing Fluid Flow with X-rays," presented at the P&G Fluids Flow Chapter Community of Practice Meeting, Cincinnati, OH, November 17, 2005.
20. Heindel, T.J., "Visualizing Fluid Flow with X-rays," presented at the ASME Central Iowa Chapter Meeting, Ames, IA, October 25, 2005.
21. Heindel, T.J., "Visualizing Multiphase Flows," presented at the Kimberly-Clark Corporation Extrapolations Seminar Series, Neenah, WI, September 10, 2004.
22. Heindel, T.J., "Gas/Liquid/Fiber Flow Research at IPST" presented to the University of Western Michigan Paper Science and Engineering Current Topics Course, Kalamazoo, MI, September 9, 1998.
23. Heindel, T.J., "An Overview of Flotation Deinking Fluid Mechanics" presented to Beloit Research and Development, Pittsfield, MA, February 6, 1998.
24. Heindel, T.J., "Multiphase Flow Research at IPST" presented to the University of Western Michigan Paper Science and Engineering Current Topics Course, Kalamazoo, MI, October 15, 1997.
25. Heindel, T.J., "Bubble Size and Its Importance to Flotation Deinking" presented at the Weekly Heat Transfer Seminar Series at Purdue University, West Lafayette, IN, January 23, 1997.

26. Heindel, T.J., "Flotation Deinking Fluid Mechanics" presented to Great Northern Paper, Inc., East Millinocket, ME, January 8, 1997.
27. Heindel, T.J., "Flotation Deinking Fluid Mechanics" presented at the Weyerhaeuser Technical Center, Federal Way, WA, December 11, 1996.
28. Heindel, T.J., "The Effect Recycling has on Fiber Properties" presented at the "Buy Recycled" Procurement Conference and Exposition, Sponsored by the U.S. Conference of Mayors, Atlanta, GA, September 6-7, 1995.

### **Conference Abstracts and Technical Presentations**

1. Cruz, M., Escudero, D.R., and Heindel, T.J., "Minimum Fluidization Velocity Under Acoustic Excitation," 2014 Iowa NSF EPSCoR Annual Meeting, Ames, IA, July 22, 2014.
2. Whitmarsh, E.A., and Heindel, T.J., "Probe Effects on the Local Gas Holdup Conditions within a Fluidized Bed," 2014 Iowa NSF EPSCoR Annual Meeting, Ames, IA, July 22, 2014.
3. Mangler, J., Morgan, T.B., and Heindel, T.J., "Quantifying Particle-Particle Mixing in Hopper-Silo Flows," 2014 Iowa NSF EPSCoR Annual Meeting, Ames, IA, July 22, 2014.
4. Robinson, T.R., Morgan, T.B., and Heindel, T.J., "Using Virtual Reality to Visualize the 3D Pathline of Individual Particles in a Double Screw Mixer," AIChE 2014 Annual Meeting, Atlanta, GA, November 16-21, 2014, Abstract # 370825.
5. Escudero, D.R., and Heindel, T.J., "Jetting Characteristics in an Acoustic Fluidized Bed Using X-ray Computed Tomography," AIChE 2014 Annual Meeting, Atlanta, GA, November 16-21, 2014, Abstract # 367343.
6. Kingston, T.A., and Heindel, T.J., "Using X-Rays to Track the 3D Pathline of Individual Particles in a Double Screw Mixer," AIChE 2014 Annual Meeting, Atlanta, GA, November 16-21, 2014, Abstract # 359514.
7. Kingston, T.A., and Heindel, T.J., "Video Analysis Techniques to Visualize Particle-Particle Mixing," AIChE 2013 Annual Meeting, San Francisco, CA, November 3-8, 2013, Abstract #309920.
8. Kingston, T.A., and Heindel, T.J., "Optimizing Screw Mixer Effectiveness Using Composition and Statistical Analysis Techniques," AIChE 2013 Annual Meeting, San Francisco, CA, November 3-8, 2013, Abstract #325040.
9. Halls, B.R., Morgan, T.B., Heindel, T.J., Meyer, T.R., High-speed radiographic X-ray spray imaging using broadband tube source, Gordon Research Conference, Waterville Valley, New Hampshire, 14-17 August 2013.
10. Escudero, D.R., and Heindel, T.J., "Minimum Fluidization Velocity in a 3D Fluidized Bed Modified with an Acoustic Field," presented at the AIChE 2012 Annual Meeting, Pittsburgh, PA, October 28 – November 2, 2012, Abstract #268538
11. Heindel, T.J., and Drake, J.B., "Using X-rays to Visualize 3-D Hydrodynamic Structures in Fluidized Beds," presented at the 2012 62nd Canadian Chemical Engineering Conference, Vancouver, BC, Canada, October 14-17, 2012.
12. Halls, B.R., Radke, C., Heindel, T.J., Lohry, W.F., Zhang, S., Kastengren, A.L., and Meyer, T.R., "Evaluation of Advanced Diagnostics for Visualization of Dense Spray Breakup Processes,"

Spring Technical Meeting of the Central States Section of the Combustion Institute, Dayton, Ohio, April 22-24, 2012.

13. Keller, N.K., Bai, W., Fox, R.O., and Heindel, T.J., "Quantifying Mixing and Segregation in a Fluidized Bed with a Particle Segregation Number," presented at the AIChE 2011 Annual Meeting, October 16-21, 2011, Minneapolis, MN. Abstract #225015.
14. Bai, W., Heindel, T.J., and Fox, R.O., "Segregation and the Solid-Solid Drag Term," presented at the AIChE 2011 Annual Meeting, October 16-21, 2011, Minneapolis, MN. Abstract #225078.
15. Xue, Q., Heindel, T.J., and Fox, R.O., "Simulating Biomass Fast Pyrolysis In Fluidized-Bed Reactors for Bio-Oil Production," presented at the AIChE 2011 Annual Meeting, October 16-21, 2011, Minneapolis, MN. Abstract #225126.
16. Xue, Q., Heindel, T.J., and Fox, R.O., "A CFD Model for Biomass Pyrolysis in Fluidized-bed Reactors," presented at the 63rd Annual Meeting of the APS Division of Fluid Dynamics, November 21-23, 2010, Long Beach, CA.
17. Keller, N.K., and Heindel, T.J., "Quantifying Mixing and Segregation in a Binary Granular System using 3D X-ray Imaging," presented at the AIChE 2010 Annual Meeting, November 7-12, 2010, Salt Lake City, UT, Abstract #186883.
18. Funke, C.S., and Heindel, T.J., "Measuring Jet Penetration in a 3D Bubbling Fluidized Bed," presented at the AIChE 2010 Annual Meeting, November 7-12, 2010, Salt Lake City, UT, Abstract #186891.
19. Xue, Q., Heindel, T.J., and Fox, R.O., "Implementation and validation of a kinetic model in multi-fluid model for modelling biomass pyrolysis in fluidized-bed reactors," presented at the Symposium on Thermo and Catalytic Sciences for Biofuels and Biobased Products (TCS2010), September 21-23, 2010, Ames, IA, 2010.
20. Keller, N.K., and Heindel, T.J., "Biomass Mixing and Segregation in a Fluidized Bed," presented at the AIChE 2009 Annual Meeting, November 8-13, 2009, Nashville, TN, Abstract #161074.
21. Gavi, E., Drake, J.B., Min, J., Heindel, T.J., and Fox R.O., "Modeling Fluidized Beds for Application to Biomass Systems," presented at the AIChE 2009 Annual Meeting, November 8-13, 2009, Nashville, TN.
22. Franka, N.P., and Heindel, T.J., "Jetting Observations in a Cold-Flow Fluidized Bed," presented at the AIChE 2008 Annual Meeting, November 16-21, 2008 Philadelphia, PA, Abstract #125416.
23. Battaglia, F., Deza, M., and Heindel, T.J., "Numerical Simulations of a Biomass Fluidizing Bed with Side Port Air Injection," presented at the APS Fluids Division Meeting, San Antonio, TX, Nov. 23-26, 2008.
24. Zhu, H., Shanks, B.H., and Heindel, T.J., "Enhancing CO-Water Mass Transfer with MCM41 Nanoparticles and Electrolytes," poster presented at the AIChE 2008 Annual Meeting, November 16-21, 2008 Philadelphia, PA, Abstract #124029.

25. Min, J., Drake, J.B., Fox, R.O., and Heindel, T.J., "CFD Modeling of Cold-Flow Fluidized Beds and Validation with X-ray Computed Tomography," presented at the AIChE 2008 Annual Meeting, November 16-21, 2008 Philadelphia, PA, Abstract #122514.
26. Drake, J.B., Min, J., Fox, R.O., and Heindel, T.J., "Validating Fluidized Bed Hydrodynamic Simulations," poster presented at the 2008 BioBased Industry Outlook Conference, September 7-10, Ames, IA, 2008.
27. Kadic, E., and Heindel, T.J., "A Summary of Gas-Liquid Mass Transfer in Stirred-Tank Bioreactors," poster presented at the 2008 BioBased Industry Outlook Conference, September 7-10, Ames, IA, 2008.
28. Battaglia, F., Deza, M., Franka, N.P., and Heindel, T.J., "Computational and Experimental Studies of Fluidized Beds for Biomass Gasification", presented at the 2007 American Physical Society, Division of Fluid Dynamics, November 18-20, Salt Lake City, UT, 2007.
29. Ford, J., Heindel, T.J., and Jensen, T.C., "Imaging a Gas-Sparged Stirred-Tank Reactor with X-rays," Presented at the 2007 ASME/JSME Fluids Engineering Division Summer Meeting, July 30 – August 2, 2007, San Diego, CA.
30. Heindel, T.J., T.C. Jensen, and J.N. Gray, "Visualizing Fluid Flows with X-rays," Presented at the 2007 ASME/JSME Fluids Engineering Division Summer Meeting, July 30 – August 2, 2007, San Diego, CA.
31. Tang, C. and Heindel, T.J., "Similitude Analysis for Gas-Liquid-Fiber Flows in Cocurrent Bubble Columns," Presented at the 2006 ASME Fluids Engineering Division Summer Meeting and Exhibition, July 17-20, 2006, Miami, FL.
32. Heindel, T.J., "Updating Mechanical Engineering Measurements and Instrumentation – A Case Study," Presented at the 2006 ASEE Annual Conference & Exposition, June 18-21, Chicago.
33. Muff, D.J., Heindel, T.J., and Sundararajan, S. "Demonstrating Electromagnetic Noise in an Undergraduate Measurement and Instrumentation Course," Presented at the 2006 ASEE Annual Conference & Exposition, June 18-21, Chicago.
34. Ungerman, A.J., and Heindel, T.J., "Mass Transfer Measurements for Syngas Fermentation; Mass Transfer Enhancement," poster presented at the Growing the Bioeconomy Conference, Ames, Iowa, August 29-30, 2005.
35. Heindel, T.J., Gray, J.N., and Jensen, T.C., "Multiphase Flow Visualization Using X-rays," poster presentation at the 7th International Conference on Gas-Liquid and Gas-Liquid-Solid Reactor Engineering, Strasbourg, France, August 21-24, 2005.
36. Hubers, J.L., Striegel, A.C., Heindel, T.J., Gray, J.N., and Jensen, T.C., "X-ray Computed Tomography in Large Bubble Columns," poster presentation at the 7th International Conference on Gas-Liquid and Gas-Liquid-Solid Reactor Engineering, Strasbourg, France, August 21-24, 2005.
37. Heindel, T.J., "Mass Transfer Measurements for Syngas Fermentation," presented at the Summer BBC Meeting, June 29, 2005, Newton, IA.

38. Hubers, J.L., Striegel, A.C., Heindel, T.J., Gray, J.N., and Jensen, T.C., "An X-ray Imaging System for Large-scale Multiphase Flows," poster presented at the 2004 AIChE Annual Meeting, Austin, TX, November 7-12, 2004.
39. Heindel, T.J., Mufft, D.J., and Dautremont, J.J. "Innovations in Mechanical Engineering Measurements and Instrumentation," poster presented at the Miller Faculty Award Luncheon, Ames, IA, November 8, 2004
40. Heindel, T.J., Do, Y.S., DiSpirito, A.A., Kapic†, A., and Brown, R.C., "Replacing Fossil Fuel-Based Products Through Syngas Fermentation," poster presented at the Annual BBC Symposium, Iowa City, IA, October 27-28, 2004.
41. Heindel, T.J., "An X-ray System for 3-D Imaging of Large-Scale Multiphase Flows," presented at the Fall CNDE I/U Sponsors Meeting, Ames, IA, October 19, 2004.
42. Riggs, S. and Heindel, T.J., "Mass Transfer Rates for Syngas Fermentation" poster presented at the 26th Symposium on Biotechnology for Fuels and Chemicals, May 9-12, 2004, Chattanooga, TN.
43. Brown, R.C., Heindel, T.J., DiSpirito, A.A., and Nikolau, B.J., "Production of Biopolymers and Hydrogen via Syngas Fermentation", poster presented at the National ACS Meeting, Anaheim, California, March 28 – April 1, 2004.
44. Heindel, T.J., Brown, R.C., Hargrove, M.S., Smeenk, J., and DiSpirito, A.A., "Mass Transfer Measurements for Syngas Fermentation" poster presented at the Iowa BIOconference, Ames, IA, March 7-8, 2004.
45. Heindel, T.J., DiSpirito, A.A., Brown, R.C., and Nikolau, B.J., "Fiber to Biobased Products via Syngas Fermentation" poster presented at the Iowa BIOconference, Ames, IA, March 7-8, 2004.
46. Brown, R.C., Heindel, T.J., DiSpirito, A.A., and Nikolau, B.J., "Production of biopolymers and hydrogen via syngas fermentation," Annual Meeting of the Institute of Biological Engineering, Fayetteville, Arkansas, January 9-11, 2004.
47. Heindel, T.J., Gray, J.N., and Jensen, T.C., "A Non-Invasive Imaging System for Large-Scale Multiphase Flows" poster presentation at the 6th International Conference on Gas-Liquid and Gas-Liquid-Solid Reactor Engineering, Vancouver, B.C., Canada, August 17-20, 2003.
48. Heindel, T.J., DiSpirito, A.A., Brown, R.C., and Nikolau, B.J., "Biobased Products via Syngas Fermentation" poster presented at the 25th Symposium on Biotechnology for Fuels and Chemicals, May 4-7, 2003, Breckenridge, CO.
49. Heindel, T.J., Brown, R.C., DiSpirito, A.A., Hargrove, M.S., Nikolau, B.J., Norton, G., "Biobased Products Through Syngas Fermentation" poster presented at the CSET IPRT review, April 11, 2003.
50. Heindel, T.J., Gray, J.N., and Jensen, T.C., "Development of an X-ray System for Noninvasive 3-D Imaging for Large-Scale Multiphase Flows" poster presented at the CNDE NSF Industry/University Program Annual Review, October 22, 2002.
51. Heindel, T.J., and Brown, R.C., "Bioprocessing of Synthesis Gas to Produce Fuels and Chemicals – Phase I: Measuring CO and H<sub>2</sub> Mass Transfer Rates in Anaerobic Bioreactors"

presented at the FY2002 IPRT Research Seed-Funding Program Presentations, June 24, 2002.

52. Heindel, T.J., and McDonough, T.J., "Bubble Size Control to Improve Oxygen-Based Bleaching" presented at the DOE Agenda 2020 Environmental Performance Research Progress Review Meeting, AF&PA Headquarters, Washington, DC, June 6-7, 2000.
53. Heindel, T.J., "Approach Flow Systems" update presented to the Papermaking Project Advisory Committee, Institute of Paper Science and Technology, Atlanta, GA, March 8-9, 2000.
54. Heindel, T.J., "Flotation Deinking Fluid Mechanics" update presented to the Recycle Project Advisory Committee, Institute of Paper Science and Technology, Atlanta, GA, March 6-7, 2000.
55. Heindel, T.J., "Flotation Deinking Fluid Mechanics" update presented to the Recycle Project Advisory Committee Subgroup, Washington, DC, March 5, 2000.
56. Heindel, T.J., "Flotation Deinking Fluid Mechanics" update presented to the Recycle Project Advisory Committee, Institute of Paper Science and Technology, Atlanta, GA, October 19-20, 1999.
57. Heindel, T.J., "Approach Flow Systems" presented to the Papermaking Project Advisory Committee, Institute of Paper Science and Technology, Atlanta, GA, September 30, 1999.
58. Heindel, T.J., and Hodgson, K.T., "Characterization and Removal of Sticking Contaminants from OCC Mills" update presented to the Containerboard Group of AF&PA, Institute of Paper Science and Technology, Atlanta, GA, June 2-3, 1999.
59. Heindel, T.J., "Gas Flow Characteristics in Fiber Suspensions" presented at the Institute of Paper Science and Technology Friday Seminar Series, Atlanta, GA, April 2, 1999.
60. Heindel, T.J., "Flotation Deinking Fluid Mechanics" update presented to the Recycle Project Advisory Committee, Institute of Paper Science and Technology, Atlanta, GA, March 22, 1999.
61. Heindel, T.J., "Flotation Deinking Fluid Mechanics" update presented to the Recycle and Surface and Colloid Science Project Advisory Committee, Institute of Paper Science and Technology, Atlanta, GA, October 6, 1998.
62. Heindel, T.J., and Hodgson, K.T., "Characterization and Removal of Sticking Contaminants from OCC Mills" update presented to the Containerboard Group of AF&PA, Institute of Paper Science and Technology, Atlanta, GA, September 23-24, 1998.
63. Heindel, T.J., "Gas/Liquid/Fiber Flow Research at IPST" presented to the TAPPI Fluid Mechanics Committee at the 1998 TAPPI Engineering Conference, Miami, FL, September 14, 1998.
64. Heindel, T.J., and Hodgson, K.T., "Characterization and Removal of Sticking Contaminants from OCC Mills" update presented to the Containerboard Group of AF&PA, Institute of Paper Science and Technology, Atlanta, GA, June 3-4, 1998.
65. Heindel, T.J., "Flotation Deinking Fluid Mechanics" update presented to the Recycle and Surface and Colloid Science Project Advisory Committee, Institute of Paper Science and Technology, Atlanta, GA, March 23-24, 1998.

66. Heindel, T.J., "Flotation Deinking Fluid Mechanics" update presented to the Recycle and Surface and Colloid Science Project Advisory Committee, Institute of Paper Science and Technology, Atlanta, GA, September 30, 1997.
67. Heindel, T.J., and Hodgson, K.T., "Characterization and Removal of Stickie Contaminants from OCC Mills" update presented to the Containerboard Group of AF&PA, Institute of Paper Science and Technology, Atlanta, GA, September 11, 1997.
68. Heindel, T.J., and Hodgson, K.T., "Characterization and Removal of Stickie Contaminants from OCC Mills" update presented to the Containerboard Group of AF&PA, Institute of Paper Science and Technology, Atlanta, GA, June 4, 1997.
69. Heindel, T.J., "Flotation Deinking Fluid Mechanics" update presented to the Recycle and Surface and Colloid Science Project Advisory Committee, Institute of Paper Science and Technology, Atlanta, GA, March 27, 1997.
70. Heindel, T.J., "Overview of the Recycle and Surface and Colloid Science Research at IPST" presented to the Research Advisory Committee, Institute of Paper Science and Technology, Atlanta, GA, November 12, 1996.
71. Heindel, T.J., "Flotation Deinking Fluid Mechanics" update presented to the Recycle and Surface and Colloid Science Project Advisory Committee, Institute of Paper Science and Technology, Atlanta, GA, March 20-21, 1996.
72. Heindel, T.J., "Flotation Deinking Fluid Mechanics" guest presenter at the Papermaking Project Advisory Committee, Institute of Paper Science and Technology, Atlanta, GA, October 1, 1996.
73. Heindel, T.J., "Flotation Deinking Fluid Mechanics" update presented to the Recycle and Surface and Colloid Science Project Advisory Committee, Institute of Paper Science and Technology, Atlanta, GA, September 24, 1996.
74. Heindel, T.J., "Flotation Deinking Fluid Mechanics" update presented to the Recycle and Surface and Colloid Science Project Advisory Committee, Institute of Paper Science and Technology, Atlanta, GA, March 20-21, 1996.
75. Heindel, T.J., "Flotation Deinking" presented at the Pulp and Paper Technology for the Nontechnical Short Course, Institute of Paper Science and Technology, Atlanta, GA, February 26-29, 1996.
76. Heindel, T.J., "Flotation Deinking Fluid Mechanics" update presented to the Recycle and Surface and Colloid Science Project Advisory Committee, Institute of Paper Science and Technology, Atlanta, GA, October 27, 1995.
77. Heindel, T.J., "Flotation Deinking" presented at the Pulp and Paper Technology for the Nontechnical Short Course, Institute of Paper Science and Technology, Atlanta, GA, June 12-15, 1995.
78. Heindel, T.J., "Flotation Deinking Fluid Mechanics" update presented to the Recycle and Surface and Colloid Science Project Advisory Committee, Institute of Paper Science and Technology, Atlanta, GA, March 22, 1995.

79. Heindel, T.J., "Flotation Deinking Fluid Mechanics" presented to the Recycle and Surface and Colloid Science Project Advisory Committee, Institute of Paper Science and Technology, Atlanta, GA, January 6, 1995.

### **Additional Publications**

- Over 70 research project status and final reports

### **Instructional Activities**

#### **At Iowa State University (August 2000 to present)**

- ME 332 – Thermodynamics II; F00, S01
- ME 370 – Engineering Measurements and Instrumentation; S03, F03, S04, F04, S05
- ME 436 – Heat Transfer; F01, F02, S06, S07, F07, S09
- ME 531 – Advanced Energy Systems and Analysis (created course); F13, F14
- ME 536 – Advanced Heat Transfer; S02, S07
- ME 538 – Advanced Fluid Flow; F05

#### **At the Institute of Paper Science and Technology (Sept. 1994 – July 2000)**

- Transport Phenomena
- Thermodynamics
- Recycling and Deinking
- Heat Transfer
- Mass Transfer
- Numerical Analysis

### **Student Interaction**

#### **At Iowa State University (August 2000 to present)**

- Graduate Students
  - Currently advise 2 Ph.D. students
  - Graduated 7 Ph.D. students and 14 M.S. Students
- Post-Doctoral Students
  - Co-advised 5 post-doctoral students
- Undergraduate student research advising
  - Advised 8 Program for Women in Science and Engineering (PWSE) Interns
  - Advised 1 Alliance for Graduate Education and the Professoriate (AGEP) Intern
  - Provided paid undergraduate research assistantships to 30 students (some over multiple semesters and summers)
  - Advised 25 students in the Freshman Honors Research Program

#### **At the Institute of Paper Science and Technology (Sept. 1994 – July 2000)**

- Graduate Students



- Graduated 10 M.S. Students
- Post-Doctoral Students
  - Advised 2 post-doctoral students
- Technicians
  - Supervised 1 fulltime technician

## **Iowa State University Service Activities**

### Department of Mechanical Engineering

- Junior Faculty Mentoring Coordinator, August 2008 – September 2012
- Honors and Awards; Coordinator; August 2008 – August 2009.
- ME 2025 Committee, Chair, August 2007 – August 2009.
- Faculty P&T Committee member, 2008, 2013.
- ME Thermal Systems Area Leader, August 2006 – August 2007.
- Mechanical Engineering Tuition Surcharge Committee, February 2006 – May 2006.
- Mechanical Engineering Laboratory Committee; member, August 2005 – August 2007.
- Mechanical Engineering Honors and Awards Committee; member, August 2004 – August 2007.
- Mechanical Engineering ME 370 – Measurement and Instrumentation Curriculum Development Committee; Chair, April 2003 – August 2007.
- Mechanical Engineering ME 436 – Heat Transfer Curriculum Development Committee; member, September 2001 – April 2003, August 2005 – August 2006, August 2008 – August 2009.
- Mechanical Engineering Thermal Systems Faculty Search Committee; member, March 2004-August 2005.
- Mechanical Engineering Governance Document Committee; member, January 2004 – May 2005.
- Mechanical Engineering Curriculum Committee; member, August 2000 – May 2004.
- Mechanical Engineering DEO Evaluation Survey Committee; member, March – May 2001.
- Mechanical Engineering Fluid Dynamics Laboratory Committee; Chair, November 2000 – April 2001.
- Heat Transfer Exam (ME PhD Qualifier); Author, F01.
- Mathematics Exam (ME PhD Qualifier); Co-Author with Mark Bryden; F03, S04, F04, S05.
- Advisor, Pi Tau Sigma, Mechanical Engineering Honor Society, Advisor to the Iowa State Chapter, August 2001 – May 2007.

### College of Engineering

- Member of the Senior Leadership Group, July 2009 – September 2012.

- Task Force on Graduate Teaching Assistantship Experience, Task Force co-leader, January – March 2010.
- College P&T Committee, August 2008 – August 2009.
- College of Design Panel discussion on industrial design, February 12, 2009.
- Mechanical Engineering Chair Search Committee, October 2006 – August 2007.
- Cargill Common Biorenewables Laboratory Development Committee, Chairperson, September 2006 - August 2007; Committee member, August 2007 – August 2009.
- Tuition Surcharge Funds Distribution Committee, January 2006 – May 2006
- College Honors Program Committee; member, August 2003 – August 2006.
- Distinguished Faculty Retreat; participant, September 17, 2002.

#### University

- Session chair for the ISU Honors Research Symposium, April 2010 – 2013.
- ISU Live Green Revolving Loan Fund, committee member Aug. 2010 – Sept. 2012.
- ISU 2011 Symposium on Sustainability, committee member Oct. 2010 – Feb. 2011
- Review Committee for the ISU Departmental Leadership Award, March 2009, March 2011.
- Be a Magnet for Attracting Outstanding Students Taskforce, Aug. 2009 – Dec. 2009.
- CELT Teaching Tips Presenter, March 4, 2008.
- 2004 Carver Trust Grant Review Committee; proposal reviewer, March – April 2004.

#### Professional Activities

- **Membership:**
  - American Institute of Chemical Engineers (AIChE)
  - American Society of Engineering Education (ASEE)
  - American Society of Mechanical Engineers (ASME)
  - Pi Tau Sigma Mechanical Engineering Honor Society
  - Tau Beta Pi Engineering Honor Society
- **Associate Editor and Journal Board Membership:**
  - ASME FED Representative: Advisory Board of the *ASME Journal of Nanotechnology in Engineering and Medicine*, December 2011 – Present.
  - *ASME Journal of Fluids Engineering*, Associate Editor, Nov. 2004 – June 2011 (journal policy has maximum allowable duration of two, three-year terms).
- **ASME Fluids Engineering Division (FED) Activities:**
  - FED Honors and Awards Committee, Member, July 2010 – Present.
  - ASME FED Fluids Measurement and Instrumentation Technical Committee, Committee Chair, July 2006 – July 2010; Member 2004 – Present.
  - ASME FED Multiphase Flow Technical Committee, Member, 2004 – Present.

- **Journal Paper Reviewer** (given year indicates 1 paper reviewed that year; year with (number) indicates multiple papers reviewed that year for that same journal):
  - AIAA Journal – 2001.
  - AIChE Journal – 1997, 2011 (2), 2012 (3), 2013.
  - ASME Journal of Fluids Engineering – 2006 (3), 2007(2), 2008, 2009, 2010 (4), 2012 (2), 2013 (3).
  - ASME Journal of Heat Transfer – 1997, 1998, 1999 (3), 2000, 2004 (2), 2006 (2), 2007.
  - Atomization and Sprays – 2008.
  - Bioresource Technology – 2011 (2).
  - Canadian Journal of Chemical Engineering – 2002 (2), 2003, 2004.
  - Chemical Engineering Communications – 2004, 2005, 2010.
  - Chemical Engineering Journal – 2006, 2011 (2), 2013.
  - Chemical Engineering and Processing – 2002.
  - Chemical Engineering Research and Design Part A: Transactions of the Institution of Chemical Engineers – 2003, 2008 (2), 2010.
  - Chemical Engineering Science – 2000 (2), 2002, 2003 (3), 2004, 2005 (2), 2006 (3), 2007 (9), 2009 (2), 2010 (2), 2011, 2013.
  - Energy Conversion and Management – 2011.
  - Experiments in Fluids – 2013 (3).
  - Experimental Thermal and Fluid Science – 2009.
  - Flow Measurement and Instrumentation – 2008 (4), 2009, 2010, 2011 (2), 2012 (3), 2013 (2).
  - Heat Transfer Engineering – 2001.
  - IEEE Transactions on Instrumentation & Measurement – 2010 (2).
  - Industrial & Engineering Chemistry Research – 2004 (2), 2005, 2006 (2), 2007, 2009, 2012 (2), 2013.
  - International Journal of Chemical Reactor Engineering – 2011.
  - International Journal of Heat and Fluid Flow – 1999, 2005.
  - International Journal of Heat and Mass Transfer – 1995, 1996 (2), 1997, 1999 (3), 2000, 2001 (2), 2002, 2003.
  - International Journal of Mineral Processing – 1998 (2).
  - International Journal of Multiphase Flow – 2005 (2), 2006, 2007 (2).
  - International Journal of Thermal Sciences – 2003.
  - Journal of Colloid and Interface Science – 2001 (2), 2002, 2006.
  - Journal of Pulp and Paper Science – 1996, 1999, 2000, 2005.
  - Numerical Heat Transfer – 1995, 1998, 1999 (3), 2001, 2003.
  - Powder Technology – 2006, 2008 (2), 2009, 2012, 2013.
  - Progress in Paper Recycling – 1996, 1997, 1998 (3), 1999, 2005.
  - TAPPI Journal – 1997, 1999, 2001(2).
- **Conference Paper Reviewer:**
  - ASCE Conference paper Reviewer – 2006 (2).

- ASME Conference Paper Reviewer – IMECE-2001, HT&FED-2004 (2), ICMM2005, FEDSM2007 (2), IMECE2007 (19), FEDSM2008 (2), FEDSM2010 (3), IMECE2011 (4), FEDSM2013 (2).
- Centenary of Flotation 2005 Symposium, The AusIMM, 2005.
- TAPPI Conference Paper Reviewer – 1995 Engineering Conference (2), 1997 Engineering Conference (2), 1998 Engineering Conference, 1999 Engineering Conference.
- **Conference Session Chair/co-Chair:**
  - “Symposium on Non-Invasive Measurements in Single and Multiphase Flows,” Co-Chair, ASME Fluids Engineering Division Summer Meeting, 2009, 2010, 2011, 2012, 2013.
  - “Symposium on the Transport Phenomena in Mixing,” Co-Chair, ASME Fluids Engineering Division Summer Meeting, 2007, 2008, 2009, 2010, 2011, 2012, 2013.
  - “Fluidization and Powder Technology 1 – Gas-Solid Fluidization Systems,” session co-chair, 62nd Canadian Chemical Engineering Conference, 2012.
  - “Biotechnology,” Chair, IMECE, 2007.
  - “Flow Applications in the Process Industries,” Chair, ASME Fluids Engineering Division Summer Meeting, 2006.
  - “Symposium on Measurements in Opaque Fluids,” Co-Chair, ASME Fluids Engineering Division Summer Meeting, 2005.
  - “Transport Phenomena in Gas-Solid-Liquid Three-Phase Flow Systems,” Co-Chair, ASME Heat Transfer/Fluids Engineering Summer Conference, 2004.
  - 7th International Conference on Multiphase Flow, May 31-June 4, 2010: Session chair: Fluidized and Circulating Fluidized Beds; Particle Bubble and Drop Dynamics (June 2, 2010).
  - “Research I”, Chair, TAPPI Recycling Symposium, 1997.
- **Grant Reviewer Panels:**
  - University of Wisconsin – Milwaukee: Outside reviewer of internal proposals, March 2009.
  - Petroleum Research Fund: March 2008, October 2008.
  - NSF: SBIR/STTR – Review Panel Participant, September 2002, February 2006
  - NSF: CTS Division – Proposal Reviewer, February 2002, March 2003, November 2003
  - NSF: Division of International Programs – Proposal Reviewer, September 2001
  - USDA: NRICGP – Proposal Reviewer (2), April 2000.
  - DOE: EPSCoR Proposal Reviewer, March 1998.