

Short SciEncv of Amitabh Narain

**IDENTIFYING INFORMATION:**

NAME: Narain, Amitabh

POSITION TITLE: Professor with tenure

PRIMARY ORGANIZATION AND LOCATION: Michigan Technological University, Houghton, MI, USA

**Professional Preparation:**

ORGANIZATION AND LOCATION	DEGREE (if applicable)	RECEIPT DATE	FIELD OF STUDY
University of Minnesota, Minneapolis, Minnesota, USA	PHD	08/1983	Aerospace Engineering And Mechanics
University of Minnesota, Minneapolis, Minnesota, USA	MS	12/1980	Aerospace Engineering and Mechanics
Indian Institute of Technology - Kharagpur, Kharagpur, West Bengal, India	BS	05/1978	Aerospace Engineering

**Appointments and Positions**

2006 - present Professor with tenure , Michigan Technological University, Houghton, MI, USA  
 2017 - 2023 Adjunct Professor, Indian Institute of Technology - Indore, Indore, Not Applicable, N/A, India  
 1990 - 2006 Associate Professor with tenure , Michigan Technological University, Houghton, MI, USA  
 1988 - 1989 Visiting Assistant Professor , University of Minnesota, Minneapolis, MN, USA  
 1983 - 1990 Assistant Professor, Michigan Technological University, Houghton, MI, USA

**Products****Products Most Closely Related to the Proposed Project**

1. Narain A, Pandya D, Damsteegt J, Loparo S. A Combined Active (Piezos) and Passive (Microstructuring) Partial Flow-Boiling Approach for Stable High Heat-Flux Cooling with Dielectric Fluids; JEH(T)-50076. The Journal of Enhanced Heat Transfer. 2024 January 16; 31(3):45-81. Available from: <https://www.dl.begellhouse.com/journals/4c8f5faa331b09ea,379e41e21cef12e0,52e2d67373eafe> DOI: 10.1615/JEnhHeatTransf.2023050076
2. Narain A, Pandya D, Vivek V, Zahnd J, Sepahyar S, Jaolekar C. Narain A, Pandya D, Vivek V, Zahnd J, Sepahyar S, Jaolekar C. "Flow-Physics and Summarized Results for a Combined Active (Piezos) and Passive (Microstructuring) Enhancement of Micro-Nucleation Rates in a Flow-Boiling Approach for Stable High Heat-Flux Cooling." This presentation was a 30-minute long Invited Lecture, Abstract Number SHTC 2023-107032.. ASME SHTC 2023 (July 10–12, 2023); 2023; Washington DC, District of Columbia, United States. Available from: <https://event.asme.org/SHTC>
3. Narain A, Sepahyar S, Pandya D, Vivek V., inventors. Nucleation Control System and Method

Leading to Enhanced Boiling Based Electronic-cooling. USA WO2020102239. 2020 May 22.

4. Narain A, Prasad H, Koca A. Internal Annular Flow-boiling and Flow-condensation: Context, Results and Recommendations. In: Kulacki FA (ed.) Handbook of Thermal Science and Engineering, Springer. 2018; 3:2075-2162.
5. Yadav V, Kumar R, Narain A. Mitigation of flow maldistribution in parallel microchannel heat sink. IEEE Transactions on Components, Packaging and Manufacturing Technology. 2018; 9(2):247-261. issn: 2156-3950

Other Significant Products, Whether or Not Related to the Proposed Project

1. Kivisalu M, Gorgitrattanagul P, Narain A, Naik R, Hasan M. Sensitivity of shear-driven internal condensing flows to pressure fluctuations and its utilization for heat flux enhancements. International Journal of Heat and Mass Transfer. 2013; 56(1-2):758-774. issn: 0017-9310
2. Naik R, Narain A. Steady and unsteady simulations for annular internal condensing flows, part II: Instability and flow regime transitions. Numerical Heat Transfer, Part B: Fundamentals. 2016; 69(6):495-510. issn: 1040-7790
3. Ranga Prasad H, Narain A, Bhasme S, Naik R. Shear Driven Suppressed Nucleation Annular Flow-boiling in Millimeter-scale Channels: Direct Numerical Solutions and Heat Transfer Correlations. International Journal of Transport Phenomena.. 2017; 15(1):1-35.
4. Kivisalu M, Gorgitrattanagul P, Narain A. Results for high heat-flux flow realizations in innovative operations of milli-meter scale condensers and boilers. International Journal of Heat and Mass Transfer. 2014; 75:381-398. issn: 0017-9310
5. Naik R, Narain A, Mitra S. Steady and unsteady simulations for annular internal condensing flows, part I: Algorithm and its accuracy. Numerical Heat Transfer, Part B: Fundamentals. 2016; 69(6):473-494. issn: 1040-7790

Synergistic Activities

1. Industry Panel Organizer and Lead Panel Moderator: Dr. Amitabh Narain, Michigan Technological University. Panel on Fundamentals on Thermal Management of Electronics. ASME SHTC 2023 (July 10–12, 2023), The Madison Hotel. Co-moderator: Dr. An Zou, Advanced Cooling Technologies, Inc.
2. Editorial and Reviewer Activities (Including Journals and Federal Agency Reviewing). Invited Associate Editor (since September 2021-) for the new interdisciplinary ASME OPEN Journal of Engineering, Associate Editor (2014 - June 2021) for ASME's Journal of Heat Transfer, Reviewer for: International Journal of Heat and Mass Transfer, International Journal of Thermal Sciences, Journal of Heat Transfer, Journal of Applied Mechanics, Journal of Fluids Engineering, More than 40 papers for ASME Conference Proceedings and Interdisciplinary Transport Phenomena Conferences, etc. Proposal Evaluation Panels: NSF CBET (6 times), NSF CBET-EPRI (1 time), DOE Commercialization Grants Reviewer, etc.
3. Technical Committees Chair/Symposia Organization/ Track/Topic/Session Chair. ASME Heat Transfer Division, Theory and Fundamental Research (K8 Committee), Chair (2017- June 2021) and Vice-Chair (2014-2017). ASME IMECE and Summer HTD Conferences Track/Topic Chair: Several, including SHTC 2015-2019 & 2022-2023, and IMECE 2015-2019 & 2022-2023. Lead Organizer for ASME IMECE's International Symposia on Gas-Liquid and Phase-Change

Flows at Macro- and Micro-Scales from 2005-2009. Member: Multi-Phase Flow Committee of the ASME's Fluids Engineering Division; K-12 committees of ASME's Heat Transfer Division: Fluid Mechanics Technical Committee of ASME's Applied Mechanics Division. ASME Applied Mechanics Division, Fluid Mechanics Technical Committee, Chair (2000-2003) and Vice-Chair (1998-2000).

4. Industrial Outreach and Consulting Activities. Industry: Collaborative Research Development Interactions (since May 2023) with Borg Warner, Advanced Cooling Technologies, Inc., Yektasonics, etc.; Consultant/Researcher PI with industrial/private sector entities such as Carlson Research LLC, Boston, August 2017; Procter and Gamble (January to March 2006); Fernstrum Corp., MI, 2003- '05; EMP Inc., MI, 2005- '06; and as Co-PI for a General Motors project, 1999-2003. Academia: Univ of Wisconsin, Math Research Center Consultant (1984)
5. MTU/Mechanical Engineering Service Department Activities. Chair, Committee for Promotion, Tenure and Faculty Development, 2022-23 (member 2021-22) Director of Energy and Thermo-Fluids Area (2015-2018). Member of MEEM Executive Committee (2015-2018), Early Career Mentor Committee of Michigan Tech (2021-22), Elected member of Faculty Development and P&T committee of MEEM (2021-2023)

**Certification:**

When the individual signs the certification on behalf of themselves, they are certifying that the information is current, accurate, and complete. This includes but is not limited to, information related to domestic and foreign appointments and positions. Misrepresentations and/or omissions may be subject to prosecution and liability under, but not limited to, 18 U.S.C. §§ 287, 1001, 1031 and 31 U.S.C. §§ 3729-3733 and 3802.

Certified by Narain, Amitabh in SciENcv on 2024-02-05 15:21:27

## Long CV of Amitabh Narain

**PERSONAL INFORMATION**

**Address:** 1400 Townsend Drive, Houghton, Michigan 49931  
**Telephone:** 906.487.2555  
**Cellphone:** 906.281.5356  
**E-mail:** narain@mtu.edu ▪ **Webpage:** <http://www.me.mtu.edu/~narain>

**EDUCATION**

Ph. D. AEROSPACE ENGINEERING AND MECHANICS, AUGUST 19, 1983  
University of Minnesota, Minneapolis, MN, USA

M.S. AEROSPACE ENGINEERING AND MECHANICS, DECEMBER 17, 1980  
University of Minnesota, Minneapolis, MN, USA

B.Tech. AEROSPACE ENGINEERING, MAY 1978 (MARCH 1979 CONFERRED)  
Indian Institute of Technology, Kharagpur, India

**WORK EXPERIENCE**

**Michigan Technological University, Houghton, MI, USA**  
PROFESSOR WITH TENURE (2006–PRESENT)  
ASSOCIATE PROFESSOR WITH TENURE (1990–2006)  
ASSISTANT PROFESSOR (1983-1990)

**University of Minnesota, Minneapolis, MN, USA**  
VISITING ASSISTANT PROFESSOR (1988-'89)

RESEARCH / TEACHING ASSOCIATE, DEPARTMENT OF AEROSPACE ENGINEERING AND MECHANICS  
(1978–1983)

**SYNERGISTIC ACTIVITIES INVOLVING LEADERSHIP, SERVICE, AND MANAGEMENT**

- **Department-level Leadership** at MTU's ME-EM (about 45 faculty & 16 staff): • Chair of Faculty Development Committee (includes Promotion and Tenure) (24 reviews and 4 P&T cases handled over 2020 – June 2023); • Director of Energy and Thermo-Fluids Area (18 faculty, 2015-2018); • Member, 5-member ME-EM Executive Committee (2015-2018); • Chair of ME-EM Department Computer Committee, Annual Budget: \$740,000 (2007–2010); etc. (several other activities in this category listed later on in this CV)  
**Other University-level Faculty-development Leadership:** • Early Career Management (ECM) Committee from the Provost's Office (2020 – '21); • Invited Member of the Chemical Engineering Department's Promotion and Tenure Committee, 2020 - '21.
- **National-level**  
**Technical Committee Memberships/Leaderships:** • For ASME: Chair (Nov 2017- Nov 2020) & Vice-Chair (Nov. 2014-Nov. 2017) of Theory and Fundamentals K-8 Committee of the Heat Transfer Division (HTD), • JHT Editorial Board Committee (2015-2021), • Member HTD-K13, • Member FED-Multi Phase Flow Committee, and • AMD-Fluid Mechanics committee (past Chair 2000-2003 and Vice-Chair). • Active in ASME HTD's Open Executive Committee (2016 – to date)  
**Technical Content Conference-level Leaderships** for topics sessions in phase-change and related areas: • as Topic or Track Chair levels as well as Session Chair levels - for several symposia and topics over the past two decades. • Sustained Topic or Track Chair (for ASME's Heat Transfer and Thermal Engineering) for several sessions at ASME IMECE and SHTC 2014- to date. • Reviewer for more than 100 papers/abstracts for several ASME Conference Proceedings and Conferences on Interdisciplinary Transport Phenomena.  
**Technical Content Editorial Leadership:** • Associate Editor, ASME Open Journal of Engineering (2021- to date). • Associate Editor (full 6-year term), ASME Journal of Heat Transfer, 2015-2021.
- **Budget management:** • As PI on completed external grants totaling approximately \$2.1 million. • Total completed external grants as PI and Co-PI: about \$3.3 million.
- **Other Technical Societies (non-ASME) Past Memberships and Service:** • American Academy of Mechanics, • American Physical Society - Division of Fluid Dynamics, • American Association for the Advancement of Science,

- The American Society for Gravitational and Space Research, • US National Congress on Theoretical and Applied Mechanics.
- Proposal Reviews/Panels: • Member for Several NSF Panels in 2010, 2011, 2012, 2013, and 2023. • Specific NSF and DOE-requested proposal reviews (several, including 2 in 2023)
- Reviewer for Various National/ International Journals (about 90-100 journal papers): • International Journal of Heat and Mass Transfer, • Journal of Heat Transfer, • Journal of Applied Mechanics, • Journal of Fluids Engineering, • International Journal of Multi-phase Flows, • Journal of Enhanced Heat Transfer, • International Journal of Thermal Sciences, • Computational Mechanics, • Journal of Micromechanics and Microengineering, • Journal of Rheology, • International Journal of Non-Linear Mechanics and Analysis, • Journal of Manufacturing Science and Engineering, • Theoretical and Computational Fluid Mechanics, • Chemical Engineering Communications.
- Industrial Outreach and Consulting Activities: Consultant/Researcher PI with industrial/private sector entities such as Carlson Research LLC, Boston, August 2017; Procter and Gamble (January to March 2006); Fernstrum Corp., MI, 2003- '05; EMP Inc., MI, 2005- '06; and as Co-PI for a General Motors project, 1999-2003. Academic consultancy: Univ of Wisconsin, Math Research Center Consultant (1984).

ASME SHTC-2023 Panel on Fundamentals on Thermal Management of Electronics. ASME SHTC 2023 (July 10–12, 2023), The Madison Hotel, Washington, DC. Organizing Committee K8 member/lead and Lead Panel Moderator: Dr. Amitabh Narain, Michigan Technological University with Co-moderator Dr. An Zou, Advanced Cooling Technologies, Inc.

### **HONORS (SEVERAL ASME CERTIFICATES OF APPRECIATION NOT LISTED)**

2006 - Present	Fellow of the American Society of Mechanical Engineers (ASME)
2021 –	<u>Invited</u> Associate Editor, ASME <i>Open Journal of Engineering</i>
2015 – 2021	Associate Editor, ASME <i>Journal of Heat Transfer</i> , 2015-2021. Given Special Recognition for Exemplary Service during IMECE 2021.
2017-2020	ASME HTD-K8 Committee on Theory and Fundamentals. Chair, Nov 2017- Nov 2020; Vice-Chair Nov. 2014 – Nov. 2017. Awarded Certificate of Appreciation during IMECE 2021.
2017-Present	Department of Science and Technology (of Government of India)'s Visiting Advanced Joint Research (VAJRA) Adjunct Faculty at IIT-Indore, India.
2013	Best Paper Award, <i>COMSOL Conference</i> 2013, Boston, MA, USA, October 2013.
1990 - Present	Two Keynote Lectures at Conferences, One ASME-HTD Invited Lecture, and Several Invited Lectures.
1978	Indian Institute of Technology-Kharagpur Silver Medal for First Rank in B. Tech (Aerospace Engineering). Also awarded First Rank prize for each of the five years (1973-'78) in the B. Tech (Aerospace Engineering) program.

### **CURRENT RESEARCH**

Current research assists in developing novel energy systems that will effectively address next-generation electronic cooling requirements – in conjunction with improved waste heat recovery and a dedicated small-scale power generation approach for data centers. The cooling fundamentals are for application areas dealing with the cooling of next-generation chips, data centers, supercomputers, laser weapons, etc. The new cooling approaches are anchored in and supported by our team's recent breakthroughs (a published patent, new IPs in a published conference paper, a journal paper, and some upcoming journal papers). Controlled but explosive vaporization into micron-sized nucleating bubbles' microlayers during flow- *and/or* pool-boiling of Novec 3M's 649, and HFE (hydrofluoroether) -7000/7100 (electronics and environment-friendly liquids from 3M, Inc) are enabled by acoustothermal heating (induced by ultrasonic Piezos). The enhanced interfacial vaporization of the microbubbles thermally nucleated inside a special microstructured boiling surface is achieved through proper structural and sub-structural micro-vibrations of this substrate, with the ultrasonic vibrations corresponding to non-equilibrium thermodynamics in the spinodal regions. This results in significant and sustainable vaporization rates within the heterogeneously nucleated bubbles. The add-on vaporization of the liquid microlayers is facilitated by sub-structural ultrasonic vibrations (1-10 MHz) with amplitudes in the nm/ $\mu$ m range within the fluid-filled microstructures. These vibrations are induced by externally located piezoelectric transducers (Piezos), driven by energy-efficient drivers operating at ultrasonic frequencies, with superposed energy-efficient structural resonance used for amplitude modulation of the ultrasonic signal by sonic frequencies ranging from 100 to 10,000 Hz. The sonic frequencies promote efficient and resonant structural micro-vibrations, alternately enhancing both liquid rewetting and the removal of micro-bubbles from the microstructured boiling region, allowing them to transition into the macro-scale two-phase flow within the heat sink. Hence, enhanced nucleate boiling (ENB) is achieved through the synergistic combination of resonant and energy-efficient structural micro-vibrations (imposed frequencies) and ultrasonic substructural micro-vibrations within the fluid-filled microstructured boiling region. Amplitudes and

frequencies of the ultrasonic excitations are adjusted to resonate with the thickness mode “anti-resonant” frequency of the APC, Inc. supplied 0.2-0.5 mm thick Piezos along with its electro-mechanical coupling to the test section.

Experiments use meshed woven copper as boiling surface/region and minuscule low-energy consumption (< 1% of the cooling rate) for inducing nano/micro-scale amplitude vibrations arising from a pair of very thin ultrasonic Piezoelectric-transducers (termed Piezos) that are placed and actuated from outside the mini-channel heat-sink.

The flow-loop control further ensures that the millimeter-scale rectangular cross-section heat sink, with its bottom heated-surface microstructured by diffusion-bonded sheets of a square woven mesh, operates in a way that there is a 4.8-fold (or more) increase in heat transfer coefficient (HTC) values – going from about 14000 W/m<sup>2</sup>-°C to 67000 W/m<sup>2</sup>-°C (or more) at a representative heat-flux of 30 - 80 W/cm<sup>2</sup> (being increased to 100-200 W/cm<sup>2</sup>). Also, the innovations cover both partial flow-boiling and nucleate pool-boiling type arrangements for the heat sinks (HS-1 to -3 models) or heat exchangers (HX-1 to -3 models). This approach leads to no vapor-compressibility-induced system-level flow instabilities.

Further, significant increases in current values (from ~80 W/cm<sup>2</sup> to 150 W/cm<sup>2</sup>) of critical heat flux (CHF) are being explored.

The ongoing software side of system-level research focuses on innovative thermal system designs that combine Thermodynamics, Fluid Mechanics, and Heat Transfer. At a higher level of system considerations, these provide data-center cooling options as well as dedicated power-supply options –which show significant economic and clean energy advantages (such as some waste heat recovery into electricity, water use, and carbon footprint reductions).

SEE: [https://www.nsf.gov/awardsearch/showAwardAWD\\_ID=2327965&HistoricalAwards=false](https://www.nsf.gov/awardsearch/showAwardAWD_ID=2327965&HistoricalAwards=false)

**EXTERNAL RESEARCH SUPPORT (TOTAL: 3.712 MILLION, PI: 2.388 MILLION, CO-PI:1.324 MILLION)**

**As PI**

2023-2026	<b>Collaborative Research: Very High Heat-flux Cooling through Stable Energy-Efficient Macro-scale Partial Flow-boiling Using Microstructured Surfaces and Ultrasonics. National Science Foundation Grant CBET- 2327965.</b> Total NSF Funding: \$344,064. Start date 09/01/2023 to End Date 08/31/2026
2017- 2023	Research Funding for invention, patent filing, and continued technology development on “ <b>Piezos (Piezo Transducers)-enhanced flow-boiling.</b> ” Provisional patent filed by Michigan Technological University. November 12, 2018. Non-provisional filed on Nov. 12, 2019, as application number: No. PCT/US2019/060994. Published on May 22, 2020, at <a href="https://patentscope.wipo.int/search/en/detail.jsf?docId=WO2020102239">https://patentscope.wipo.int/search/en/detail.jsf?docId=WO2020102239</a>
2014–2018	Total: \$85,000 (Research Funding from <i>Ahern Energy</i> : \$15,000 & Other Gifts: \$70,000) <b>Fundamental Investigations for Very High Heat-flux Innovative Operations of Millimeter Scale Flow Boilers. National Science Foundation Grant CBET-1402702.</b> Total NSF Funding: \$305,781
2010–2014	<b>Flow Prediction and Fluctuation-Sensitivity Investigations for Quasi-steady Shear Driven Condensing Flows in Millimeter to Micrometer Scale Two-Phase Systems. National Science Foundation Grant CBET-1033591.</b> Total NSF Funding: \$354,947
2010-2013	Original 3-year: \$297,288.
2011–2012	NSF REU supplement: \$6,000
2012	CBET conference supplement: \$2,000
2013-2014	Flow boiling supplement: \$49,659
2010–2012	<b>Ground-based Experimental and Computational Investigations of Shear Driven Internal Condensing/Boiling Flows for Flight Experiments and Space-Based Two-Phase Systems. NASA Grant NNX10AJ59G.</b> Total Funded Amount: \$100,000
2004–2009	<b>Direct Computational Simulations and Experiments for Internal Condensing Flows System-Instabilities/Dynamics in Micro-gravity and Terrestrial Environments. NASA Grant NNC04GB52G.</b> Co-Is for 2004-’06: Evenson, H.A., Co-Investigator; Van Karsen, C., Co-Investigator. Total Funded Amount: \$686,963 (with cost-share: \$712,163)
2005–2006	<b>Flow Simulations for Optimized Performance of Displacement Pumps. Engineered Machined</b>



- Products (EMP) Inc., Escanaba, MI, USA.**  
Total Funded Amount: \$67,748
- 2001–2005 **Prediction and Attainment Capability for Steady Internal Condensing Flows — An Integrated Experimental/Computational Approach. National Science Foundation Grant CTS-0086988.**  
Co-PIs: Kim, N., (Chem-Eng); Evensen, H.A., (ME-EM); Sweger, P.O., (ME-EM).  
Total Funded Amount: \$213,189 (with cost-share: \$323,399)  
2001-2002 REU supplement: \$12,000  
2002-2003 REU supplement: \$10,000
- 2003–2005 **Investigation of flow and heat exchange capabilities for Ferncool Box-Cooler Heat Exchangers. R. W. Fernstrum & Co., Menominee, MI, USA. Co-PI: Arici, O.**  
Total Funded Amount: \$80,982
- 2003 **Exploratory Research in the Development of Automotive Mirror and Window Products. Donnelly Corporation, Holland, MI, USA. (for MSME student Amit Barve)**  
Total Funded Amount: \$3,000
- 1988–1989 **Visiting Research Grant NSF/DMS - 8504323 from the Institute for Mathematics and its Applications at the University of Minnesota, Minneapolis, MN, USA.**  
Total Funded Amount: \$10,000

As Co-PI

- 1999–2003 **Static Pressure Measurements on the Suction Side of the Stator Blade in an Automotive Torque Converters. General Motors, Powertrain Group, Ypsilanti, MI, USA. Anderson, C.L., Principal Investigator**  
Total Funded Amount: \$285,651
- 2000–2001 **Noise Measurements in an Automotive Torque Converter. General Motors, Powertrain Group, Ypsilanti, MI, USA. Anderson, C.L., Principal Investigator; Sweger, P., Evensen, H.A., Blough, J., Other Co-PIs**  
Total Funded Amount: \$98,700
- 2000–2001 **Turbine Blade Measurement. General Motors, Powertrain Group, Ypsilanti, MI, USA. Anderson, C.L., Principal Investigator; Sweger, P., Evensen, H.A., Blough, J., Other Co-PIs**  
Total Funded Amount: \$78,000
- 1997–2000 **Cavitation Signatures in Torque Converters. General Motors, Powertrain Group, Ypsilanti, MI, USA. Anderson, C.L., Principal Investigator**  
Total Funded Amount: \$277,135
- 1999–2000 **High-Performance Connections to the Internet via Merit Network, Inc. in cooperation with Central Michigan University, Michigan Technological University, and Northern Michigan University. Aupperle, E., Principal Investigator; Ogden, J., Co-Principal Investigator; Bornhorst, T., Brown, R., Cross, J., Helminen, B., Huang, X., Hyslop, M., Johnson, D., Laemrich, S., Maclean, A., McNinch, T., Murthy, P., Rafert, J.B., Riehl, J., Rose, W., Other Co-PIs**  
Total Funded Amount: \$350,000
- 1998–1999 **Conference on Integral Method in Science and Engineering 98. National Science Foundation Grant NSF-9800673. Bertram, B., Principal Investigator, Other Co-PIs: Sikarskie, D., Struthers, A., Vable, M.,**  
Total Funded Amount: \$28,177 (with cost share \$45,926), NSF amount: \$7,782
- 1986–1989 **Film Condensation under Microgravity Conditions. NASA- Lewis grant NAG 3-711. Suryanarayana, N.V., Principal Investigator**  
Total Funded Amount: \$209,273

**PEER-REVIEWED PUBLICATIONS**

**Journal Articles (In Print)**

1. **A. Narain**, D. Pandya, J. Damsteegt, and S. Loparo: “A Combined Active (Piezos) and Passive (Microstructuring) Partial Flow-Boiling Approach for Stable High Heat-Flux Cooling with Dielectric Fluids,” *Journal of Enhanced Heat Transfer*. 31(3):45-81 (2024). DOI:10.1615/JEnhHeatTransf.2023050076.
2. **Narain, A.**, Ranga Prasad, H., and Koca, A., “Internal Annular Flow-boiling and Flow-condensation: Context, Results, and Recommendations.” *In: Kulacki FA (ed.) Handbook of Thermal Science and Engineering*, 2018, vol 3, pages 2075-2162. Springer, Cham. Invited Article.
3. Yadav, V., R. Kumar, and **A. Narain** “Mitigation of Flow Maldistribution in Parallel Microchannel Heat Sink,” *IEEE Transactions on Components, Packaging, and Manufacturing Technology* 9, no. 2 (2018): 247-261.
4. Naik., R., **Narain, A.**, and Mitra, S., “Steady and Unsteady Simulations for Annular Internal Condensing Flows, Part I: Algorithm and its Accuracy.” *Numerical Heat Transfer, Part B: Fundamentals*. 2016, 69(6), pp. 473-494.

5. Naik, R., and **Narain, A.**, “Steady and Unsteady Simulations for Annular Internal Condensing Flows, Part II: Instability and Flow Regime Transitions.” *Numerical Heat Transfer, Part B: Fundamentals*. 2016, **69**(6), pp. 495-510.
6. Ranga Prasad, H., **Narain, A.**, Bhasme S., and Naik, R., “Shear Driven Suppressed Nucleation Annular Flow-boiling in Millimeter-scale Channels: Direct Numerical Solutions and Heat Transfer Correlations.” *International Journal of Transport Phenomena*. 2017, Vol. 15, No. 1, pp 1-35. Invited Paper.
7. **Narain, A.**, Naik, R.R., Ravikumar, S., and Bhasme, S.S., “Fundamental assessments and new enabling proposals for heat transfer correlations and flow regime maps for shear driven condensers in the annular/stratified regime.” *Journal of Thermal Engineering*. 2015, **1**(4), pp. 307-321.
8. Kivisalu, M. T., Gorgitrattanagul, P., and **Narain, A.**, “Results for High Heat-Flux Flow Realizations in Innovative Operations of Milli-Meter Scale Condensers and Boilers.” *International Journal of Heat and Mass Transfer*. 2014, **75**, pp. 381-398.
9. Kivisalu, M.T., Gorgitrattanagul, N., **Narain, A.**, Naik. R., and Hasan, M., “Sensitivity of Shear-Driven Internal Condensing Flows to Pressure Fluctuations and its Utilization for Heat Flux Enhancements.” *International Journal of Heat and Mass Transfer*. 2013, **56**(1-2), pp. 758-774.
10. **Narain, A.**, Ajotikar, N., Kivisalu, M.T., Rice, A.F., Zhao, M. and Shankar, N., “Obtaining Time-Varying Pulsatile Gas Flow Rates with the Help of Dynamic Pressure Difference and Other Measurements for an Orifice-Plate Meter.” *Journal of Fluids Engineering*. 2013,**135**(4), p.041101.
11. Mitra, S., **Narain, A.**, Naik, R., and Kulkarni, S. D., “A Quasi One-Dimensional Simulation Method and its Results for Steady Annular/Stratified Shear and Gravity Driven Condensing Flows.” *International Journal of Heat and Mass Transfer*. 2011, **54**(15), pp. 3761-3776.
12. **Narain, A.**, Liang, Q., Yu, G., and Wang, X., “Direct Computational Simulations for Internal Condensing Flows and Results on Attainability/Stability of Steady Solutions, their Intrinsic Waviness, and their Noise-Sensitivity.” *Journal of Applied Mechanics*. 2004, **71**(1), pp. 69-88.
13. Kurita, J. H., Kivisalu, M., Mitra, S., Naik, R., and **Narain, A.**, “Experimental Results on Gravity Driven Condensing Flows in Vertical Tubes, their Agreement with Theory, and their Differences with Shear Driven Flows’ Boundary Condition Sensitivities.” *International Journal of Heat and Mass Transfer*. 2011, **54**(13), pp. 2932-2951.
14. **Narain, A.**, and Joseph, D. D., “Linearized Dynamics for Step Jumps of Velocity and Displacement of Shearing Flows of a Simple Fluid.” *Rheologica Acta*. 1983, **21**(3), pp. 228-250.
15. Joseph, D.D., **Narain, A.**, and Riccius, O., “Shear Wave Speeds and Elastic Moduli for Different Liquids. Part 1. Theory.” *Journal of Fluid Mechanics*. 1986, **171**, pp.289-308.
16. **Narain, A.**, Yu, G., and Liu, Q., “Interfacial Shear Models and Their Required Asymptotic Form for Annular Film Condensation Flows in Inclined Channels and Vertical Pipes.” *International Journal of Heat and Mass Transfer*. 1997, **40**(15), pp. 3559 - 3575.
17. **Narain, A.**, and Joseph, D.D., “Remarks about the Interpretation of Impulse Experiments in Shear Flow of Viscoelastic Liquids.” *Rheologica Acta*. 1983, **22**(6), pp. 528-538.
18. Liang, Q., Wang, X., and **Narain, A.**, “Effect of Gravity, Shear and Surface Tension in Internal Condensing Flows - Results from Direct Computational Simulations.” *ASME Journal of Heat Transfer*. 2004, **126**(5), pp. 676-686.
19. Phan, L., Wang, X. and **Narain, A.**, “Exit Condition, Gravity, and Surface-Tension Effects on Stability and Noise-sensitivity Issues for Steady Condensing Flows inside Tubes and Channels.” *International Journal of Heat and Mass Transfer*. 2006, **49**(13), pp. 2058-2076.
20. Phan, L. and **Narain, A.**, “Non-linear Stability of the Classical Nusselt Problem of Film Condensation and Wave-Effects.” *ASME Journal of Applied Mechanics*. 2007, **74**(2), pp. 279-290.
21. Ng, T. W., **Narain, A.**, and Kivisalu, M., T., “Fluorescence and Fiber-Optics Based Real-Time Thickness Sensor for Dynamic Liquid Films.” *ASME Journal of Heat Transfer*. 2010, **132**(3), pp. 1-12.
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**Journal Articles (In preparation. Not submitted yet as 2 PhDs and 2 MS students (with theses) graduated under job-joining related time constraints)**

39. **Narain, A.**, H. Ranga Prasad, Gorgitrattanagul, P, S. Sepahyar and Mehendale, S, “Significant Role of Heat carrying Micro-scale Nucleation Rates for Steady Annular Flow boiling (Traditionally termed Convective Regime), Part I: Modeling/simulations support for assessments of experimental data.” To be submitted.
40. Gorgitrattanagul, P., **A. Narain**, R. Kumar\*, A. Ghate, and D. Pandya, “Significant Role of Heat carrying Micro-scale Nucleation Rates for Steady Annular Flow boiling (Traditionally termed Convective Regime), Part II: Experiments for Low Heat-flux Operations with FC-72 as a Working Fluid.” To be submitted.
41. Soroush Sepahyar, Michael Kivisalu, Harsha Sathi, and **A. Narain**, “Significant Role of Heat Carrying Micro-scale Nucleation Rates for Steady Annular Flow boiling (Traditionally termed Convective Regime), Part III: Experiments for High Heat-flux Operations with Water as a Working Fluid.” To be submitted.
42. Gorgitrattanagul, P., **A. Narain**, M. T. Kivisalu, and D. Pandya, “Investigations of Temperature Controlled Innovative Annular Flow-boiling of FC-72 in Millimeter Scale Ducts: Enhanced Pulsatile Cases and Relationship to Technological Enhancement of Micro-scale Nucleation.” To be submitted.
43. **Narain, A.**, Vojini, A., Pandya, D., Ranga Prasad, H., and Thanki, R. “Innovative fin-tubes that enable significant reductions in air-side thermal and pressure-drop resistances - with considerations of a popular heat-exchanger’s staggered tube-bundle. Part-I: Modeling and Analysis.” To be submitted.
44. Shinde, N., Vojini, A., Kivisalu, M. T., Sepahyar, S., and **Narain, A.**, “Innovative fin-tubes that enable significant reductions in air-side thermal and pressure-drop resistances - with considerations of a popular heat-exchanger’s staggered tube-bundle. Part II: Quantitative Experimental Characterizations.” To be submitted.

**Refereed Articles in Conference Proceedings / Symposia/IMA Pre-prints**

45. Narain, A., D. Pandya, N. Agata, V. Vivek, S. Sepahyar, and C. Jaolekar, “A Combined Active (Piezos) and Passive (Microstructuring) Enhanced Micro-Nucleation Rate Flow-Boiling Approach for Stable High Heat-Flux Cooling” Conference Proceedings for the 8th Thermal and Fluids Engineering Conference (TFEC), May 2023, Paper # TFEC-2023-4598.2. Conferred Best Paper Award. 1217-1226. DOI: 10.1615/TFEC2023.mpp.045982.
46. Naik, R. R., **Narain, A.**, and Mitra, S., “Steady and Unsteady Computational Simulations for Annular Internal Condensing Flows in a Channel.” *Proceedings of 2014 ASME International Mechanical Engineering Congress and Exposition*, Montreal, Canada, 2014. Paper No. IMECE2014-38445.
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48. **Narain A.**, Kivisalu M., Gorgitrattanagul P., Naik R., and Shankar N., “Results for High Heat-flux Realizations in Innovative Operations of Millimeter Scale Condensers and Boilers.” *Electronic Proceedings of the 22nd National and 11th International ISHMT-ASME Heat and Mass Transfer Conference*, IIT Kharagpur, India, December 28 – 31, 2013. Paper number: HMTC 1300183.
49. Naik, R., Mitra, S., **Narain, A.**, and Shankar, N., “Steady and Unsteady Computational Results of Full Two - dimensional Governing Equations for Annular Internal Condensing Flow.” *Fluid Dynamics, COMSOL Conference*, Boston, MA, October 9-11, 2013.
50. **Narain, A.**, “High Effectiveness Microscale Condensers and Boilers for Terrestrial and Space Applications.” *NSF 2012 CBET Grantee Conference*, Baltimore, MD, USA, 2012. Grant NSF-CBET-1033591.
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54. Mitra, S., Naik, R. R., and **Narain, A.**, “Numerical Simulation of Exact Two-Dimensional Governing Equations for Internal Condensing Flows.” *COMSOL Conference*, Boston, MA, USA, 2010.
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70. **Narain, A.**, Yu, G., and Liu, Q., “Computational Simulation and Flow Physics for Stratified/ Annular Condensing Flows.” Begell House, Inc., ISBN 1-56700-146-5, *Proceedings of Engineering Foundation Conference on Microgravity Fluid Physics and Heat Transfer*, Oahu, HI, USA, 2000. pp. 46 – 54.
71. Yu, G., and **Narain, A.**, “Computational simulations and flow domain classification for laminar/laminar annular/stratified condensing flows.” *Proceedings of Integral Methods in Science and Engineering*, Houghton, MI, USA. CRC Press, 1999.
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75. **Narain, A.**, “Modeling of Interfacial Shear for Gas-Liquid Flows in Annular Film Condensation in Two-Fluid Flows-With or Without Phase Change.” *1994 ASME Winter Annual Meeting*, 1994. *ASME AMD - Vol. 184*, pp. 41-54.
76. **Narain, A.**, “Modeling of Interfacial shear and Heat Transfer Predictions for Internal Flows with Film Condensation in Fundamentals of Phase Change-Boiling and Condensation.” *1994 ASME Winter Annual Meeting*, 1994. *ASME HTD - Vol. 273*, pp. 29-40.
77. **Narain, A.**, “Interfacial Shear Modeling and Heat Transfer Predictions for Internal Flows with Film Condensation, Proceedings of Engineering Foundation Conference on Condensation and Condenser Design.” *Engineering Foundation Conference*, St. Augustine, Florida, 1993. Publisher: United Engineering Trustees, ISBN No. 0-7918-0693-6, pp. 105 - 121.
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79. **Narain, A.**, “Condensing vapor flows and the case of flow between parallel plates,” in *Recent Advances in Mechanics of Structured Continua.* *ASME-AMD - Vol. 117*, 1991. pp. 47-53.
80. **Narain, A.**, and Kamath, R., “Internal flows of vapor undergoing film condensation,” *Proceedings of the Twenty-Second Midwestern Mechanics Conference*, Rolla, Missouri, 1991. *Developments in Mechanics*, University of Missouri-Rolla, Vol.16, Edited by R.C. Batra and B.F. Armaly, pp. 411-412.
81. **Narain, A.**, “Flow of vapor undergoing laminar film condensation between parallel plates” in *Proceedings of CSME Mechanical Engineering Forum 1990*, University of Toronto, Toronto, Canada. Vol. 1, 1990, pp. 379-389.
82. **Narain, A.**, “Impulse Dynamics of Viscoelastic Fluids and Some Solutions by Integral Transforms.” *Integral Methods in Science and Engineering*, Arlington, Texas, 1986. In: *Integral Methods in Science and Engineering*, Payne FR, Corduneanu CC, Haji-Sheikh A, Tseng Huang (Editors), Hemisphere Publishers, pp. 114-129.
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86. **Narain, A.**, and Kizilyalli, A., “The flow of pure vapor undergoing film condensation between parallel plates.” *Institute for Mathematics and its Applications*, University of Minnesota, Minneapolis, MN, USA, 1989. IMA Preprint #502.
87. **Narain, A.**, and Joseph, D.D., “Note on the Balance of Energy at a phase-change interface.” *Institute for Mathematics and its Applications*, University of Minnesota, Minneapolis, MN, USA, 1989. IMA Preprint #518.
88. **Narain, A.**, “On K-BKZ and Other Viscoelastic Models as Continuum Generalizations of the Classical Spring-Dashpot Models.” University of Wisconsin, Madison, WI, USA, 1985. MRC Report #2895.

#### **Research Reports Submitted to Federal Agencies**

89. **Narain, A.**, “Prediction and Attainment Capability for Steady Internal Condensing Flows — An Integrated Experimental/Computational Approach.” Final and several annual reports submitted on NSF Fastlane’s report website for CTS-0086988, 2001–2005.
90. **Narain, A.**, “Direct Computational Simulations and Experiments for Internal Condensing Flows’ System-Instabilities/Dynamics in Micro-gravity and Terrestrial Environments.” Final and several annual reports submitted on the NASA Task Book website for NASA Grant NNC04GB52G, 2004–2009.
91. **Narain, A.**, “Flow Prediction and Fluctuation-Sensitivity Investigations for Quasi-Steady Shear Driven Condensing Flows in Millimeter to Micrometer Two-Phase Systems.” Annual report submitted on NSF Fastlane’s report website for CBET-1033591 and, in 2013, on Research.Gov, 2010–2013.
92. **Narain, A.**, “Flow Prediction and Fluctuation-Sensitivity Investigations for Quasi-Steady Shear Driven Condensing Flows in Millimeter to Micrometer Two-Phase Systems.” Annual report submitted on NSF Fastlane’s report website for CBET-1033591 and, in September 2014, on Research, 2013–2014.
93. **Narain, A.**, “Fundamental Investigations for Very High Heat-Flux Innovative Operations of Millimeter Scale Flow Boilers for CBET-1402702.” Annual report submitted on Research.gov website, June 2014–May 2015.
94. **Narain, A.**, “Fundamental Investigations for Very High Heat-Flux Innovative Operations of Millimeter Scale Flow Boilers for CBET-1402702.” Annual report submitted on Research.gov website, June 2015–May 2016.
95. **Narain, A.**, “Fundamental Investigations for Very High Heat-Flux Innovative Operations of Millimeter Scale Flow Boilers for CBET-1402702.” Annual report submitted on Research.gov website, June 2016–May 2017.
96. **Narain, A.**, “Fundamental Investigations for Very High Heat-Flux Innovative Operations of Millimeter Scale Flow Boilers for CBET-1402702.” Final report submitted on Research.gov website, June 2017–May 2018.

#### **EDITED BOOKS/VOLUMES/BOOK CHAPTERS**

1. **Narain, A.**, Ranga Prasad, H., and Koca, A., “Internal Annular Flow-boiling and Flow-condensation: Context, Results, and Recommendations.” *In: Kulacki FA (ed.) Handbook of Thermal Science and Engineering*, 2018, vol 3, pages 2075-2162. Springer, Cham. Invited Article
2. **Narain, A.**, Liang, Q., Yu, G., and Wang, X., “Fluid-Physics and Heat Transfer for Macro- and Micro-Scale Gas-Liquid and Phase-Change Flows.” *ASME Bound Volume Proceedings for IMECE01*. ASME Publications, New York, NY, USA, 2001. Book Number: I00526, HTD-Vol. 369-3, Vol. 3.
3. **Narain, A.**, “Gas-Liquid Flows in Fluid Mechanics and Heat Transfer.” *Proceedings of the ASME Fluids Engineering Division*. ASME Publications, New York, NY, USA, 1997. ISBN No. 0-7918-1838-1, FED -Vol. 244.
4. **Narain, A.**, Siginer, D.A., and Kelkar, K.M., “Two-Fluid Flows With or Without Phase Change.” *ASME Winter Annual Meeting (International Mechanical Engineering Congress and Exposition) Bound Volume Proceedings*. ASME Publications, New York, NY, USA, 1994. ISBN No. 0-7918-1405-X, ASME-AMD Vol. 184

#### **STUDENT ADVISING**

##### **NOTABLE MENTORING OUTCOMES**

- Nikhil Shinde: Won MTU’s Outstanding Graduate Student Research award for his M.S. thesis, in the Fall of 2018.
- Soroush Sepahyar: Won MTU’s Outstanding Graduate Student TA award for 2018.
- Divya Pandya: Won MTU’s Outstanding Graduate Student TA award and highest Teaching Evaluation award for 2020.
- R. R. Naik: Won MTU’s Graduate School *Finishing Fellowship* in May 2014; Won MTU’s GSG 2014 Exceptional Student Scholar Award; Won Best Paper Award for *COMSOL Conference 2013*, Boston, MA, USA; and Won MTU Outstanding TA Award, 2011.
- M. Kivisalu: Won MTU’s Graduate School *Finishing Fellowship* in Nov. 2012.
- Guang Yu, Q. Liu, Q. Liang, L. Phan, and S. Kulkarni - all won ME-EM’s prestigious Winnikow Fellowship awards.

- Minority undergraduate student researcher Charles Ferreira was mentored through the MICUP program.

## GRADUATE STUDENTS

### **Ph.D. Students**

#### **15 graduated students (principal advisor for 13 students and co-principal advisor for 2):**

- Divya Pandya, Ph. D. from MTU. “Active and Passive Enhanced Micronucleation Rate High Heat-flux Partial Flow-boiling Operations – Enabling Applications such as Next Generation Heat Sink for Electronic Chip Cooling System.” (expected April 2024).
- Soroush Sepahyar, Ph. D. from MTU. “Experimental Investigations of Steady and Pulsatile Annular Flow Boiling of Water in Millimeter-scale Horizontal Duct of Rectangular Cross-section.” (2018).
- Patcharapol Gorgitrattanakul, Ph. D. from MTU. “Experimental investigations of temperature controlled innovative annular flow-boiling of FC-72 in millimeter-scale ducts – steady and enhanced pulsatile realizations.” (2017)
- Ranjeeth R. Naik from MTU. “Development of Unsteady Two-dimensional Computational Simulation Tools for Annular Internal Condensing Flows – and their Use for Results on Heat-transfer rates, Flow physics, Flow stability, and Flow Sensitivity.” (2015)
- Michael T. Kivisalu from MTU. “Experimental Investigations of Certain Internal Condensing and Boiling Flows: Their Sensitivity to Pressure Pulsations and Heat Transfer Enhancements.” (2015)
- Soumya Mitra from MTU. “Development of one-dimensional and two-dimensional computational tools to simulate steady internal condensing flows in terrestrial and zero-gravity environments.” (2012)
- Jorge H. Kurita from MTU. “Experimental results on gravity-driven fully condensing flows in vertical tubes, their agreement with theory, and their differences with shear driven flows’ boundary-condition sensitivities.” (2011)
- Shantanu Kulkarni from MTU. “Computational Study of Internal and External Condensing Flows and Experimental Synthesis to Investigate their Attainability and Stability in Ground-Based and Space-Based Environments.” (2010)
- Lucas Phan from MTU. “Flow Simulations, Code Developments, and Comparisons with Experiments for Internal/External Condensing Flows.” (2007)
- Tian W. Ng from MTU. “Development and Calibration of a Fluorescence and Fiber-Optics Based Real-Time Thickness Sensor for Dynamic Liquid Films.” (2006)
- Anna Siemionko, Ph.D. from MTU, ChemE (with Nam Kim as Advisor). “Design, Fabrication, and Operation of a System to Control FC-72 Condensation inside a Vertical Tube.” (2006)
- Q. Liang, Ph. D. from MTU. “Unsteady Computational Simulations and Code Development for a Study of Internal Film Condensation Flows Stability, Noise-sensitivity, and Waviness,” (2003)
- G. Yu, Ph. D. from MTU. “Development of a CFD Code for Computational Simulations and Flow Physics of Annular/Stratified Film Condensation Flows.” (1999)
- Q. Liu, Ph. D. from MTU. “Computational Simulation and Interfacial Shear Models for Wavy Interface Annular Downward Flows in Vertical Pipes: Turbulent Vapor/Laminar Condensate Situations.” (1999)
- Q. Lu, Ph. D. from MTU (with N. V. Suryanarayana). “An Experimental Investigation of Heat Transfer with Condensation in a Horizontal Rectangular Duct.” (1992)

### **M. S. Students**

#### **33 graduated students (principal advisor for 28 students and co-principal advisor for 4)**

- Atharva Rahane, MSME from MTU. “Efficient Enhancement of Micro-Nucleation Rates in Flow-Boiling - by Concurrent Micro-Structuring of the Boiling-Surface and its Judicious Energization by Piezoelectric-Transducer induced Acoustic Vibrations.” (Summer 2020).
- Nikhil Shinde, MSME from MTU. “Innovative Fin-tubes for a Standard Staggered-bundle Family Leading to Significant Reductions in Air-side Thermal and Pressure-drop Resistances for a Popular Heat-exchanger – Quantitative Characterizations based on a Unique Synthesis of Experiments, Modeling, and Reliable Computations.” (Fall 2018)
- Amit Dev Vojini, MSME from MTU. “Innovative Fin-tubes for a Standard Staggered-bundle Family Leading to Significant Reductions in Air-side Thermal and Pressure-drop Resistances for a Popular Heat-exchanger – Modeling and Analysis in the Context of its Deployment Advantages in the Energy-sector.” (Fall 2018)
- Hrishikesh Prasad Ranga Prasad, MSME from MTU, “Assessment of Annular Flow Boiling in the Context of Computational Fluid Dynamics (CFD) Simulations, Experiments, and Existing Correlations.” (Fall 2017)
- Sharayu Bhasme, MSME from MTU. “Development of and Simulation Results from a CFD code for Steady Annular (Suppressed Nucleation) Flow Boiling.” (Summer 2016).
- Timothy Frasier, MSME from MTU. “Non-pulsatile shear driven annular flow boiling investigations.” (Fall 2015)
- Siddhartha Ravikumar, MSME from MTU. “Elementary Assessment and Simulations Based Proposals for New Heat Transfer Correlation and Flow Regime Maps for Annular/Stratified Regime of Shear Driven Internal Condensing Flows.” (Fall 2015)

- Nikhil Shankar, MSME from MTU. “An assessment of flow regime maps and numerical simulations assisted heat-transfer correlation for the annular/stratified regime of shear driven internal condensing flows.” (Summer 2014)
- Andrew F. Rice, MSME from MTU. “Assessments and Computational Simulations for a Time-Varying Pulsatile Gas Flow Measurement Technique.” (Fall 2013)
- Patcharapol Gorgitattanagul, MSME from MTU. “The length of the Annular Regime for Condensing Flows inside a Horizontal Channel – The Experimental Determination of Its Values and its Trends.” (Fall 2012)
- Nikhil Ajotikar, MSME from MTU. “Obtaining Time-Varying Flow-Rates for Pulsatile Gas Flows - with Assistance from Dynamic Pressure-Difference and Mean Mass Flow-Rate Measurements.” (Fall 2012)
- Rohan Gumaste, MSME from MTU. “Computational Simulations of Latent Heat Energy Storage Systems – With First-Principles Based Simulations for the Melting Processes Within the System.” (Fall 2012)
- Sunil Khilnani, MSME (Report) from MTU. “Differences in Behavior between Metallic and Non-Metallic Vapors for Internal Condensing Flows.” (Fall 2010)
- Akshay Tonape, MSME (Report) from MTU. “A Simple 1-D Model for Gravity Dominated 1-D Flows.” (Fall 2010)
- Zhipeng Qin, MSME (Report) from MTU. “A Three-dimensional Heat Conduction Simulation Model for Assistance in the Use of a Heat-Flux Meter.” (Summer 2010)
- Sandeep S. Sikarwar, MSME from MTU. “Recalibration and Modification of a Real-Time Optical Fiber and Fluorescence-based Liquid Film Thickness Sensor.” (2008)
- Jorge H. Kurita, MSME from MTU. “Experimental Investigation of Fully Condensing Downward Vapor Flows in a Vertical Tube - Unspecified (Free) Exit Condition Cases.” (Mar 2007)
- Jordan Bilyeu, MSME from MTU. “Flow Simulations for Optimized Performance of Displacement Pumps Manufactured By Engineered Machined Products.” (Aug 2006)
- Hector O. Degadillo Rocha, MSME from MTU. “Measurement and Modeling of Film Thickness Variations for Annular In-Tube Flows Through Design and Development of a Flow-Loop Test Apparatus.” (Sep 2006)
- Chichester, MSME from MTU. “Heat-Exchanger Performance and External Water (Coolant) Flow for a Heat-Exchanger at the Hull of a Ship.” (Nov 2005)
- X. Wang, MSME from MTU. “Direct Computational Simulations of Internal Condensing Flows and Effects of Gravity, Shear, and Surface Tension on Interfacial Waves and Heat Transfer Rates.” (Apr 2004)
- J. T. Mekkes, MSME from MTU, 2003 (with C. L. Anderson). “Static Pressure Measurements on the Nose of a Torque Converter Stator during Cavitation.” (2003)
- S. Barve, MSME from MTU. “A Comparative Study of Internal Condensing Flows in Converging and Parallel Channels.” (2002)
- L. Zeng, MSME from MTU (with C. L. Anderson). “Experimental Investigation of Cavitation Signatures in an Automotive Transmission Torque Converter.” (2000)
- T. A. Cross, MSME from MTU (with C. L. Anderson). “Cavitation Signatures in an Automotive Torque Converter.” (1998)
- R. M. Kamath, MSME from MTU. “Internal Flows of Vapor Undergoing Film Condensation.” (1991)
- Y. Kizilyalli, MSME from MTU. “Computations (Integral Formulation) for the Flow of Pure Vapor Undergoing Condensation between Parallel Plates.” (1989)
- K. Lee, MSME from MTU. “A Computational Study of Film Condensation over a Horizontal Plate.” (1988)
- Christodoulou, MSME from MTU (with N. V. Suryanarayana). “Condensation in a Horizontal Rectangular Duct – An Experimental Study.” (1987)

**Current graduate students:**

- Divya Pandya, Ph. D. student. He has been a part of the Piezo patent. Continuing student. (2018-)

**Graduated *Special-topics* or *Courses-only* MS students**

- Divya Pandya, 3cr, MEEM 6990, Special Topics, Fall 2020
- Atharva Rahane, 2cr, MEEM 5990, Special Topics, Fall 2019-Spring 2020
- Kanishk Jain, 2cr, MEEM 5990, Special Topics, Fall 2019-Spring 2020
- Rhythm Contractor, 2 cr, MEEM 5990, Special Topics, Fall 2020
- Vinay Pandey, 1 cr, MEEM 5990, Special Topics, Fall 2020
- Kushal Kothar, 1 cr, MEEM 5990, Special Topics, Spring 2021
- Swapnil Kanvinde, 2cr, MEEM 5990, Special Topics, Spring 2021
- Trushant Patel, 2 cr, MEEM 5990, Special Topics, Spring 2021
- Noah Agata, 2 cr, MEEM 5990, Special Topics, Fall 2021
- Kishan Gajjar, 1 cr, MEEM 5990, Special Topics, Spring 2022
- Chaitanya Jaolekar, 2 cr, MEEM 5990, Special Topics, Fall 2022
- Harsha Sathi, 3cr, MEEM 5990, Special Topics, Fall 2018
- Prathamesh Jadhav, 1cr, MEEM 5990, Special Topics, Summer 2015



- Chirag Bangera, 3 cr, MEEM 5990, Special Topics, Spring 2016
- Kaustubh Kale, 1cr, MEEM 5990, Special Topics, Summer 2015
- Menghan Zhao, MEEM 5990, Special Topics, Spring 2013
- Jun Zheng, MEEM 5990, Special Topics, Spring 2012
- Sushant More, MEEM 5990, Special Topics, Summer 2011
- Ranjeeth Naik, courses only, Fall 2010

UNDERGRADUATE STUDENTS (>26)

- ME-EM Junior (Summer 2023 – Spring 2024) Stephen Loparo
- ME-EM Freshman (Spring 2024) Eli Wenta
- Lake State Superior University, Sault Ste Marie, MI freshman (Summer 2023) Joshua Damsteedt
- MET Senior (Spring 2024) Paige Berry
- ME-EM Junior (Fall 2022) Jeremy Esch
- ME-EM Junior (Summer 2022) Livi Morgan
- ME-EM junior (Fall 2018) Jacob Knott
- ME-EM undergrad (Summer 2021, Fall 2021, and Spring 2022) Logan Canull
- ME-EM Senior (Summer 2021) Noah Agata
- ME-EM senior (Spring 2021) Alex Tuomi
- ME-EM senior (Fall 2020) Ethan Hammond
- Senior Design Team 58 Spring 2020 - Fall 2020 (Alex Tuomi, David Bell, Brandon Bomireto, Spencer Reed)
- ME-EM senior (Fall 2018) Alex Ackermann, Special Topics (3 cr 4990)
- ME-EM senior (2016-2017) Stuart M. Liburd Jr. on NSF grant
- ME-EM senior (2015-2016) Tristan Slabaugh on NSF grant
- ME-EM sophomore (2015-2016) Nicholas Silvestri on NSF grant
- ME-EM senior (2015-2016) Michael Kostic (GPA 4.0) on NSF grant and Senior Design Project (MEEM 4901 and 4911).
- ME-EM senior (2015-2016) Jonah Kimmes on NSF grant and Senior Design Project (MEEM 4901 and 4911).
- ME-EM senior (2015-2016) Taylor Hoensheid on their Senior Design Project (MEEM 4901 and 4911) and 1 cr Special Topics.
- ME-EM senior (2015-2016) Cory Jokela on Senior Design Project (MEEM 4901 and 4911).
- ME-EM senior (2015-2016) Jessica Liubakka on Senior Design Project (MEEM 4901 and 4911).
- ME-EM senior (2015-2016) John Ware on Senior Design Project (MEEM 4901 and 4911).
- ME-EM senior (2013-2014) Tim Frasier (GPA 3.4) on NSF REU and NSF grant.
- ME-EM senior (2012) Daniel Leppek (GPA 3.6) on NSF REU grant.
- ME-EM senior (2010-2011) Andrew F. Rice (GPA 3.7) on NSF REU grant.
- Charles Ferreira, MICUP program, summer of 2009.
- ME-EM senior Michael Kivisalu (GPA 3.7) over the summer of '06 and fall of '06 as an undergraduate researcher on a NASA grant.
- Three seniors: Alan Chichester (GPA 3.7) and Lucas Phan (GPA 3.85) over spring '03 and Jordan Bilyeau over fall '04.
- ME-EM seniors Justin Keske (GPA 3.8) and James Whitmarsh (GPA 3.6) over the summer of 2003. Supported through NSF's REU grant.
- ME-EM seniors Ted Hanes (GPA 3.88) and Vince F. Jones (GPA 3.9) over the summer of 2002. Supported through NSF's REU grant.
- Sponsored and advised Matthew Himes, Matt McQueen, Jason Skiera, Nick Verhagen, and S. Daiyouga over Spring 04 and Fall 04 on a senior design project related to research.
- Advised undergraduates Rodney Worthing, Celeste Mazur, Brian Kleinfeld, etc. on individualized undergraduate projects, 1995-1998.

MENTOR OF VISITING FACULTY/POSTDOCS

- Prof. Balaram Kundu, Visiting Professor, Jadavpur University, Kolkata (1 week, March 2016)
- Dr. Alihsan Koca, Visiting Post-doc, Scholar, TUBITAK, Turkey (May 2016 - June 2017)
- Prof. Dr. Zhe Zhang, Department of Refrigeration and Cryogenics Engineering, Tianjin University of Commerce, Tianjin, China (March-August, 2013)

INVENTIONS

- **Narain, A.**, D. Pandya, S. Sepahyar, and V. Vivek, “Efficient enhancement of nucleation rates in flow-boiling - by concurrent micro-structuring of the boiling-surface and its judicious energization by piezoelectric-transducer induced acoustic waves.” **Part of a full patent:** Publication Number WO/2020/102239, Publication Date: 22.05.2020, URL: <https://patentscope.wipo.int/search/en/detail.jsf?docId=WO2020102239>
- Several Invention Reports - based on Michigan Tech Invention Disclosures: # T2024-005, 2401.00, and 2312.00 - are to be filed.
- Kivisalu, M. T., Gorgitrattanagul, P., and **Narain, A.**, 2014. “Methods and Results for High Heat-Flux Flow Realizations in Innovative Operations of Milli-Meter Scale Condensers and Boilers.” Principles descriptions are the same as in the *International Journal of Heat and Mass Transfer*. 2014, **75**, pp. 381-398.
- Ajotikar, N., Kivisalu, M., Rice, A., and **Narain, A.**, 2012. “Obtaining Time-Varying Pulsatile Gas Flow-Rates with the Help of Dynamic Pressure-Difference and Other Measurements for an Orifice-Plate Meter.” 2012. Invention Reported to NASA. Principles-descriptions as in the *Journal of Fluids Engineering*. 2013, **135**(4), p.041101.
- Ng, T. W., **Narain, A.**, and Kivisalu, M., 2010. “Fluorescence and Fiber-Optics Based Real-Time Thickness Sensor for Dynamic Liquid Films.” Principles-descriptions as in *ASME Journal of Heat Transfer*. 2010, **132**(3), pp. 1-12.

### EDITORIAL BOARD ACTIVITIES

- Current Associate Editor, *ASME Open Journal of Engineering*, 2021-.
- Associate Editor, *ASME Journal of Heat Transfer*, 2015-May 2021.
- Past Editorial Board Member of *Open Access Journal of Conference Papers in Engineering*, Hindawi Publishing Corporation (<http://www.hindawi.com/cpis/engineering/>) 2013-2015.

### CONFERENCES/WORKSHOPS/INSTITUTIONAL ORAL PRESENTATIONS - WITH PUBLISHED ABSTRACTS

#### **Keynote Presentation**

- Presentation of Invited Lecture, Abstract Number SHTC 2023-107032. ASME SHTC 2023 (July 10–12, 2023); 2023; Washington DC, District of Columbia, United States.
- Keynote Presentation at “International Conference on Advances in Mechanical Engineering – ICAME 2016,” May 10-13, 2016, Istanbul, Turkey
- Keynote Presentation at “Energy Technologies Conference,” December 22-24, 2014, Istanbul, Turkey
- Keynote Presentation at US-India Short-term Course, “Advanced Energy and Thermal Systems,” (sponsored by NSF and IIT-Delhi), January 2-7, 2014, DCRUST, Murthal, Sonapat-131039, Haryana, India
- Invited (by ASME HTD Executive Committee) Presentation at ASME International Mechanical Engineering Congress and Exposition 2014, November 14-21, 2014, Montreal, Canada
- Keynote Presentation at *International Transport Phenomena VI: Fluid, Thermal, Biological, Materials and Space Sciences*, 2009, Volterra, Italy

#### **Professional-level Invited International Short-Courses Taught**

- GIAN 161004G05: BOILING AND CONDENSATION: THEORY AND APPLICATIONS  
Institute Name: Indian Institute of Technology, Kanpur  
Foreign Faculty: Amitabh Narain, Professor, United States of America  
Host Faculty: Dr. P. S. Ghoshdastidar  
Duration: September 6, 2016, to September 15, 2016

#### **Other Invited and/or Funded Presentations**

- Invited Visit and Seminar, Department of Mechanical Engineering, Nov. 3, 2023, *Indian Institute of Technology – Kanpur, India*
- Invited Visit and Seminar, Department of Mechanical Engineering, Nov. 6, 2023, *Indian Institute of Technology – Kharagpur, India*
- Department of Mechanical Engineering Seminar Speaker, Michigan Technological University, Nov. 11, 2021.
- Invited Visit and Seminar, Department of Mechanical Engineering, Jan. 27, 2019, *Indian Institute of Technology – Kanpur, India*
- Invited attendance, participation, and one-on-one presentations, May 16-18, 2017, 2017 NSF-EPRI Power Plant Dry Cooling Science and Technology Innovation Program Annual Review Meeting, *Electric Power Research Institute (EPRI), Palo Alto, CA*

- Invited Visit and Seminar, Department of Mechanical Engineering, Sept. 16, 2016, *Indian Institute of Technology – Kharagpur, India*
- Invited Visit and Seminar, Department of Mechanical Engineering, Jan. 6, 2016, *Indian Institute of Technology – Kanpur, India*
- Invited Visit and Seminar, Department of Mechanical Engineering, Jan. 14-15, 2016, *Indian Institute of Technology – Guwahati, India*
- Invited Visit and Seminar, Department of Mechanical Engineering, Jan. 12-14, 2016, *Jadavpur University, Kolkata, India*
- Invited Industry Presentation and Seminar (with Vice-President Research and his team) at *Thermax India Limited*, Dec. 29, 2015, Pune, India
- Invited Presentation at *Fluid Physics, the American Society for Gravitational and Space Research Meeting*, Nov. 12, 2015, Westin Alexandria, Alexandria, VA, USA.
- Invited Visit and Seminar, Department of Mechanical Engineering, Nov. 28, 2013, *Indian Institute of Technology – Kanpur, India*
- Invited Visit and Seminar, Department of Mechanical Engineering, Dec. 3, 2013, *Indian Institute of Science – Bangalore, India*
- Invited Visit and Seminar, Department of Mechanical Engineering, Dec. 16, 2013, *Indian Institute of Technology – Patna, India*
- Invited Presentation at US-India “*Multi-Phase Workshop*” (sponsored by NSF and IIT-Mumbai), Dec. 26-27, 2013, *Indian Institute of Technology – Bombay*.
- *Fluid Physics, the American Society for Gravitational and Space Research Meeting.*, Nov. 28- Dec. 2, 2012, Westin New Orleans Canal Place, New Orleans, LA, USA.
- *NSF 2012 CBET Grantee Conference*, Jun. 6-8, 2012, Baltimore Convention Center, Baltimore, MD, USA.
- *IMECE 2009-13385, ASME International Mechanical Engineering Congress and Exposition, Symposium on Gas-Liquid and Phase-Change Flows at Macro- and Micro Scales*, Nov. 13-19, 2009, Orlando, FL, USA.
- *MNHMT 2009-18507, ASME 2nd Micro/Nanoscale Heat & Mass Transfer International Conference*, Dec. 18-22, 2009, Shanghai, China.
- *Symposium on Complex Fluid Flows*. Technical Lecture. NSF Sponsored. University of Minnesota, May 2-3, 2009, Minneapolis, MN, USA.
- *Conference: International Transport Phenomena VI: Fluid, Thermal, Biological, Materials and Space Sciences*, Oct. 4-9, 2009, Volterra, Italy.
- *65th Annual Meeting of the APS Division of Fluid Dynamics*, Nov. 18-20, 2012, San Diego, CA, USA.
- *NASA-GRC Fluid Physics Group Seminar Series.*, Jul. 25, 2011.
- *Gravitational Effects on Liquid-Vapour Phase Change (Eurotherm Seminar Number 92)*, Apr. 17-21, 2011, Presqu'île de Giens, Paris, France.
- *Symposium on Multi-Component and Multiphase Fluid Dynamics*. 14th U.S. National Congress of Theoretical and Applied Mechanics, Jun. 23–28, 2002, Blacksburg, VA, USA.
- *Microgravity Transport Processes in Fluid, Thermal, Biological, and Materials Sciences II, Banff.*, Sep. 30-Oct 5, 2001, Alberta, Canada.
- *Microgravity Fluid Physics and Heat Transfer*. Engineering Foundation Conference., Sep 19-24, 1999, Oahu, HI, USA.
- *Workshop on Multi-component Multi-phase Fluid Dynamics*. NSF Sponsored. University of Pennsylvania, Mar. 12-13, 1999, PA, USA.
- *Heat Transfer I Session. Society of Engineering Science 32nd Annual Technical Meeting.*, Oct. 30, 1995, New Orleans, LA, USA.
- *Innovations in Multiphase Flow. An International Fluid Mechanics Symposium.*, Mar. 25-27, 1994, Minneapolis, MN, USA.
- *22<sup>nd</sup> Midwestern Mechanics Conference*. The University of Missouri, Oct. 6-9, 1991, Rolla, MO, USA.
- *Condensation and Condenser Design. Engineering Foundation's International Conference.*, Mar. 7-12, 1993, St. Augustine, FL, USA.

### **Technical Presentations with Peer-reviewed and Published Abstracts at Conference**

- Presentation of Invited Lecture, Abstract Number SHTC 2023-107032. ASME SHTC 2023 (July 10–12, 2023); 2023; Washington DC, District of Columbia, United States.
- Presentation of Paper at the 8th Thermal and Fluids Engineering Conference (TFEC), May 2023, Paper # TFEC-2023-4598.2. Conferred Best Paper Award. 1217-1226.
- Presentation of Paper ASME SHTC HT2022-81625 at ASME SHTC 2022 Summer Heat Transfer Conference, Philadelphia Philadelphia
- Presentation of Paper No. ASME SHTC HT2019-3661 at *ASME 2019 Summer Heat Transfer Conference*, Bellevue, WA.

- Presentation of Paper No. ASME SHTC ES 2019 – 3967 at *ASME 2019 13th International Conference on Energy Sustainability*, Bellevue, WA.
- Presentation of Paper No. IMECE 2018-86344 at *2018 ASME International Mechanical Engineering Congress and Exposition*, Pittsburgh, PA.
- Presentation of Paper No. IMECE 2018-86343 at *2018 ASME International Mechanical Engineering Congress and Exposition*, Pittsburgh, PA.
- Presentation of Paper No. IMECE 2017-72448 at the *2017 ASME International Mechanical Engineering Congress and Exposition*, Tampa, FL.
- Presentation of Paper No. ASME SHTC HT2017-5018 at *ASME 2017 Summer Heat Transfer Conference*, Bellevue, WA.
- Presentation of Paper No. ASME SHTC 2016-7464 at *ASME 2016 Summer Heat Transfer Conference*, Washington, DC.
- Presentation of Paper No. IMECE2014-38445 at *2014 ASME International Mechanical Engineering Congress and Exposition*, Montreal, Canada.
- Presentation of Paper No. IMECE2014-37319 at *2014 ASME International Mechanical Engineering Congress and Exposition*, Montreal, Canada.
- *22nd National and 11th International ISHMT-ASME Heat and Mass Transfer Conference*, HMTTC1300183 (Session: Multi-phase Transport Processes/Phase-Change/Phase-Separation), Dec. 29, 2013, IIT Kharagpur, India.
- *COMSOL Conference*, Oct. 9-11, 2013, Boston.
- Presentation at *ASME Summer Heat Transfer Conference*, Jul. 14-19, 2013, Minneapolis, MN, Extended Abstract (HT 2013-17307)
- Presentation at *ASME Summer Heat Transfer Conference*, Jul. 14-19, 2013, Minneapolis, MN, Extended Abstract (HT 2013-17477)
- *65<sup>th</sup> Annual Meeting of the APS Division of Fluid Dynamics*, Nov. 18-20, 2012, San Diego, CA, USA. (2012). <http://meeting.aps.org/Meeting/DFD12/Event/179473>
- Heat Transfer Photo-gallery Session 7-30-1, *K-22 Heat Transfer Visualization Committee*, IMECE2012, Nov. 9-15, 2012, Houston, TX, USA
- *COMSOL Conference*, Boston, Oct. 7-9, 2010, MA, USA.
- *ASME Summer Heat Transfer Conference.*, Jul. 21-23, 2012, Rio Grande, Puerto Rico, USA.
- *ASME International Mechanical Engineering Congress and Exposition*, Nov. 11-17, 2011, Denver, Colorado, USA.
- *Next Generation Sub-Orbital Researchers Conference*. Boulder, 2009, CO, USA. Times Cited: 1
- *62<sup>nd</sup> Annual Meeting of the APS Division of Fluid Dynamics*, Volume 54, Number 19., Minneapolis, MN, USA. (2009). <http://meetings.aps.org/link/BAPS.2009.DFD.LL.5>
- *62<sup>nd</sup> Annual Meeting of the APS Division of Fluid Dynamics*, Volume 54, Number 19., Minneapolis, MN, USA. (2009). <http://meetings.aps.org/link/BAPS.2009.DFD.HK.3>
- *62<sup>nd</sup> Annual Meeting of the APS Division of Fluid Dynamics*, Volume 54, Number 19., Minneapolis, MN, USA. (Year). <http://meetings.aps.org/link/BAPS.2009.DFD.HK.4>
- *62<sup>nd</sup> Annual Meeting of the APS Division of Fluid Dynamics*, Volume 54, Number 19., Minneapolis, MN, USA. (2009). <http://meetings.aps.org/link/BAPS.2009.DFD.HK.5>
- *ECI International Conference on Heat Transfer and Fluid Flow in Micro-scale*, Sep. 21-26, 2008, Whistler.
- *Interdisciplinary Transport Phenomena V: Fluid, Thermal, Biological, Materials and Space Sciences.*, Oct. 14-19, 2007, Bansko, Bulgaria.
- *IMECE2007-41304: Symposium on Gas-Liquid and Phase Change Flows*, IMECE2007, Nov. 11-16, 2007, Seattle, WA, USA.
- *IMECE2007-41306: Symposium on Gas-Liquid and Phase Change Flows*, IMECE2007, Nov. 11-16, 2007, Seattle, WA, USA.
- *IMECE2007-4131: Symposium on Gas-Liquid and Phase Change Flows*, IMECE2007, Nov. 11-16, 2007, Seattle, WA, USA.
- *8<sup>th</sup> National & 7<sup>th</sup> ISHMT-ASME Heat and Mass Transfer Conference*. IIT, Jan. 4-6, 2006, Guwahati, India.
- *Transport Phenomena in Microgravity and Space Sciences IV*. Engineering Conferences International, Aug. 7-12, 2005, Tomar, Portugal.
- *IMECE2005-80445: Symposium on Gas-Liquid and Phase Change Flows*, Nov. 5-11, 2005, Orlando, FL, USA.
- *IMECE2005-80221: Symposium on Gas-Liquid and Phase Change Flows*, Nov. 5-11, 2005, Orlando, FL, USA.
- *IMECE2005-80441: Symposium on Gas-Liquid and Phase Change Flows*, Nov. 5-11, 2005, Orlando, FL, USA.
- *IMECE2005-83211: Symposium on Gas-Liquid and Phase Change Flows*, Nov. 5-11, 2005, Orlando, FL, USA.
- *International Conference on Computational & Experimental Engineering and Sciences*, Dec. 8-10, 2005, Jaipur, India.
- *Microgravity Transport Processes in Fluid, Thermal, Biological and Material Sciences III*, Engineering Conferences International, Sep. 14-19, 2003, Davos, Switzerland.
- *ASME Summer Heat Transfer Conference*, Jul. 21-23, 2003, Las Vegas, NV, USA.

- *Computational Simulations for Internal Condensing Flows. Heat Transfer Seminar Series*, Feb. 23, 2003, Purdue University, West Lafayette, IN, USA.
- *Free Surface Tracking and Steady/Unsteady Computational Simulations for Internal Condensing Flows. Symposium on Fluid-Physics and Heat Transfer For Macro- And Micro-Scale Gas-Liquid and Phase-Change Flows.* International Mechanical Engineering Congress and Exposition, Nov. 11-16, 2001, New York, NY, USA.
- Yu, G., and Narain, A., *Computational Simulations and Classification of Flow Domains for Laminar/Laminar Annular/Stratified Condensing Flow. 5th International Conference on Integral Methods in Science and Engineering.* Michigan Technological University, Aug. 10-13, 1998, Houghton, MI, USA.
- Lui, Q., and Narain, A., *Computational Simulation and Interfacial Shear for Annular Condensing Downward Flows in a Vertical Pipe for Turbulent Vapor and Laminar Condensate. 5th International Conference on Integral Methods in Science and Engineering.* Michigan Technological University, Aug. 10-13, 1998, Houghton, MI, USA.
- Narain, A., and Yu, G., *Symposium on Gas-Liquid Flows in Fluid Mechanics and Heat Transfer*, Nov. 16-21, 1997, Dallas, TX, USA.
- *Session on Multiphase and Particle-Laden Flows, 48th Annual Meeting of American Physical Society/ Division of Fluid Dynamics*, Nov. 19-21, 1995, Irvine, CA, USA.
- *Two-Fluid Flows-With or Without Phase Change. Symposium at 1994 ASME Winter Annual Meeting*, Nov. 6-11, 1994, Chicago, IL, USA.
- *Fundamentals of Phase Change —Boiling and Condensation. AIAA/ASME Thermophysics and Heat Transfer Conference*, Jun. 20-23, 1994, Colorado Springs, CO, USA.
- *Symposium at Winter Annual Meeting of ASME.* Anaheim, Aug. 1992, CA, USA.
- *Summer Annual Meeting of ASME-AMD*, Jun. 16-19, 1991, Columbus, OH, USA.
- *34<sup>th</sup> Annual Meeting of the Society for Natural Philosophy*, Apr. 6-8, 1990, Lincoln, NE, USA.
- *Canadian Society of Mechanical Engineers Forum 1990.* University of Toronto, Jun. 3-8, 1990, Toronto, Canada.
- *11<sup>th</sup> U.S. National Congress of Applied Mechanics*, May 21-25, 1990, Tucson, AZ, USA.
- *IMA Workshop on two-phase flows in Fluidized Beds, Sedimentation, and Granular Flows*, University of Minnesota, Jun. 3-10, 1989, Minneapolis, MN, USA.
- *59th Annual Meeting of the Society of Rheology*, Oct. 19, 1987, Atlanta, GA, USA.
- *Mini-Symposium on Hyperbolic Phenomena in flows of Viscoelastic Fluids*, University of Minnesota, Oct. 8-10, 1986, Minneapolis, MN, USA.
- *Mini-Symposium on Hyperbolic Phenomena in flows of Viscoelastic Fluids*, University of Minnesota, Oct. 8-10, 1986, Minneapolis, MN, USA.
- *10<sup>th</sup> U.S. National Congress of Applied Mechanics*, University of Texas, Jun. 16, 1986, Austin, TX.
- *22<sup>nd</sup> Annual Meeting of the Society of Engineering Science*, Pennsylvania State University, University Park, Oct. 8, 1985, PA, USA.
- *Conference on Integral Methods in Science and Engineering*, University of Texas, Mar. 20, 1985, Arlington, TX, USA.
- *27<sup>th</sup> Annual Meeting of the Society for Natural Philosophy*, University of Wisconsin-Madison, Nov. 30, 1984, WI, USA.

### HIGHLIGHTS OF RESEARCH

- *Research.gov* 2013 innovation highlight article: *Adapting Boilers and Condensers for Earth and Space.*
- NSF CBET-1033591 research accomplishments highlight - Flow Condensers and flow boilers for innovative micro-scale and space-based thermal systems, 2012. URL: <http://www.nsf.gov/eng/cbet/achieve/1406/index.jsp>. Also see *Research.gov* NSF research accomplishments highlights, 2013. URL: <http://go.usa.gov/bkNV>
- End of 2012 research accomplishments highlighted by NSF at NSF-EPRI workshop held at ASME IMECE 2012, Nov. 9-15, 2012, Houston, TX, USA.
- Michigan Technological University COE's 2010 research magazine. Research featured at <http://www.doe.mtu.edu/research/2010/narain.pdf>

### CONSULTANCY

- Carlson Research LLC, Boston, MA, USA (2017). *On Thermal Systems for Server Cooling.*
- Procter and Gamble, Westchester, OH, USA. (2006). *Development of a thermal design code for a chemical on a conveyor belt that moves through a chamber and is exposed to condensation.*
- Mathematics Research Center, University of Wisconsin, Madison, WI, USA. (1984). Consultant (Viscoelasticity).

### NATIONAL LEADERSHIP AND SERVICE ACTIVITIES

**Invited Member of Review Panels and Future Research Direction Workshops for Government Agencies**

- NSF-CBET Review Panels, 2023, 2013, 2012, 2011, and 2010 (time-intensive contributions)
- NSF-Requested and Specific Targeted Proposal Reviews (2023)
- NSF-CBET Review Panels, 2013, 2012, 2011, and 2010 (time-intensive contributions)
- NSF Workshop for Frontiers in Transport Phenomena Research and Education: Energy Systems, Biological Systems, Security, Information Technology and Nanotechnology, at the University of Connecticut in Storrs (2007)
- NASA's Office of Biological and Physical Science sponsored a workshop for identifying exciting unanswered questions regarding "Multiphase Flow" and "Fluid Stability and Dynamics" in reduced gravity, especially as it relates to the design and operation of power, propulsion, and thermal management systems. Hilton Garden Inn, Cleveland, OH, USA (2003)
- Army Research Office Workshop on "Constitutive Modeling". Virginia Polytechnic, Blacksburg, VA, USA (1985)

**Professional Society**

Leadership: Chair, Vice-Chair, Memberships

- ASME Heat Transfer Division, Theory and Fundamental Research (K8 Committee), Chair (2017 - 2020), and Vice-Chair (2014-2017).
- Member: Multi-Phase Flow Committee of the ASME's Fluids Engineering Division; K-8 and K-12 committees of ASME's Heat Transfer Division; Fluid Mechanics Technical Committee of ASME's Applied Mechanics Division.
- ASME Applied Mechanics Division, Fluid Mechanics Technical Committee, Chair (2000-2003) and Vice-Chair

**Symposium/Conference Organization Leadership**

American Society of Mechanical Engineers

- IMECE 2016-2023 Topic Chair/Session Organizer (Fundamentals of Boiling/Condensation including Nano-scale Effects, lead for K-8) at ASME International Mechanical Engineering Congress and Expositions
- ASME 2017, 2019, 2021-2023 SHTC Track Chair plus session chair Organizer (Symposium on Fundamentals of Phase-Change Heat Transfer- Boiling and Condensation, lead for K-8) at ASME Summer Heat Transfer Conferences. Bellevue, WA.
- ASME 2016 Track Chair/ 3 sessions at HD/FEDSM/ICNMM conference's Interdisciplinary track (4-1 to 4-3) on: "Boiling and condensation in macro, micro, and nanosystems," Washington, DC (July 10-16, 2016)
- IMECE 2015 Topic Chair/Session Organizer (Symposium on Fundamentals of Phase-Change Heat Transfer- Boiling and Condensation, 10-9-1-10-9-3, lead for K-8) at ASME International Mechanical Engineering Congress and Exposition, Houston, Texas (Nov. 13-19, 2015)
- IMECE 2014 Topic Chair/Session Organizer (10-9: Symposium on Fundamentals of Phase-Change Heat Transfer- Boiling and Condensation) at ASME International Mechanical Engineering Congress and Exposition, Montreal, Canada (Nov. 14-20, 2014)
- IMECE 2014 Topic Chair (10-11: Fundamentals of Single-Phase Convection) at ASME International Mechanical Engineering Congress and Exposition, Montreal, Canada (Nov. 14-20, 2014)
- IMECE 2014 Topic Chair (10-12: Fundamentals of Radiative Transport including Nanoscale Effects) at ASME International Mechanical Engineering Congress and Exposition, Montreal, Canada (Nov. 14-20, 2014)
- IMECE 2014 Topic Chair (10-13: Advances in Interfaces and Heat Sinks including Nano-scale Conduction and Interfacial Effects) at ASME International Mechanical Engineering Congress and Exposition, Montreal, Canada (Nov. 14-20, 2014)
- IMECE 2014 Topic Chair/Session Organizer (10-14: Fundamentals of Multi-scale Modeling) at ASME International Mechanical Engineering Congress and Exposition, Montreal, Canada (Nov. 14-20, 2014)
- IMECE 2014 Topic Chair (10-15 Panel on Phonon Accumulation Function) at ASME International Mechanical Engineering Congress and Exposition, Montreal, Canada (Nov. 14-20, 2014)
- Track Chair (with significant paper review and paper selection responsibilities) for the 22nd National and 11th International ISHMT-ASME Heat and Mass Transfer Conference, IIT Kharagpur, India (Dec. 30, 2013.)
- Organizer, Condensation Heat Transfer, ASME 2013 Summer Heat Transfer Conference, Minneapolis, MN, USA (Jul. 14 – 19, 2013)
- Organizer / Co-Organizer, Symposium on Fundamentals of Phase-Change Heat Transfer (seven sessions 7-3: 4, 13 to 16, 18, and 23). International Mechanical Engineering Congress and Exposition, Houston, TX, USA (Nov. 9-15, 2012)
- Organizer, Symposium on Gas-Liquid and Phase Change Flows, Orlando, FL, USA (Nov. 13-19, 2009)
- Organizer, Session (13-16-1), Symposium on Gas-Liquid and Phase Change Flows, Boston, MA, USA (Oct. 31- Nov 6, 2008)
- Lead Organizer, International Symposium on Gas-Liquid and Phase-Change Flows at Macro- And Micro-Scales, Seattle, WA, USA (Nov. 11-16, 2007)

- Lead Organizer, 6<sup>th</sup> Session, International Symposium on Gas-Liquid and Phase-Change Flows at Macro- and Micro-Scales, Orlando, FL, USA (Nov. 13-18, 2005)
- Lead Organizer, 8<sup>th</sup> Session, International Symposium on Fluid-Physics and Heat Transfer for Macro- and Micro-Scale Gas-Liquid and Phase-Change Flows, New York, NY, USA (Nov. 11-16, 2001)
- Lead Organizer, 4<sup>th</sup> Session, International Symposium on Gas-Liquid Flows in Fluid Mechanics and Heat Transfer (Winter Annual Meeting), Dallas, TX, USA (Nov. 16-21, 1997)
- Lead Organizer, Symposium on Two-Fluid Flows with or without Phase Change, ASME Winter Annual Meeting (International Mechanical Engineering Congress and Exposition), Chicago, IL, USA (Nov. 6-11, 1994)

#### Society of Engineering Science

- Organizer, Symposium on Heat Transfer I for the Society of Engineering Science 32<sup>nd</sup> Annual Technical Meeting, New Orleans, LA, USA (Oct. 29-Nov. 2, 1995)

#### Integral Methods in Science and Engineering

- Co-Organizer (with Bertram, B., Organizer; Sikarskie, D., Struthers, A., and Vable, M.) for Integral Methods in Science and Engineering, Michigan Technological University (1998)

#### **Session-Chair/Co-chair at Professional Meetings**

- Session Chairs at sessions for IMECE 2016-2019 and IMECE 2022-2023: Fundamentals of Boiling/Condensation including Nano-scale Effects. ASME International Mechanical Engineering Congress and Expositions
- Session Chairs at sessions for SHTC 2016 – 2019 and SHTC 2022-2023: Fundamentals of Phase-Change Heat Transfer- Boiling and Condensation. ASME Summer Heat Transfer Conferences.
- Session Chair (Multi-phase Transport Processes/Phase-Change/Phase-Separation, 10:00 – 11:30 am) 22<sup>nd</sup> National and 11<sup>th</sup> International ISHMT-ASME Heat and Mass Transfer Conference, IIT Kharagpur, India (Dec. 30, 2013)
- Session Chair (Energy, 12:00 – 1:30 pm) 22<sup>nd</sup> National and 11<sup>th</sup> International ISHMT-ASME Heat and Mass Transfer Conference, IIT Kharagpur, India (Dec. 30, 2013)
- Session Chair (Multi-phase Transport Processes/Phase-Change/Phase-Separation, 5:00 – 6:30 pm) 22<sup>nd</sup> National and 11<sup>th</sup> International ISHMT-ASME Heat and Mass Transfer Conference, IIT Kharagpur, India (Dec. 30, 2013)
- Session Chair (3.3.2, Flow Boiling and Condensation) at ASME Summer Heat Transfer Conference, Minneapolis, MN (Jul. 14-19, 2013)
- Session Chair (3.3.4, Condensation) at ASME Summer Heat Transfer Conference, Minneapolis, MN (Jul. 14-19, 2013)
- Chair (1 session) / Co-Chair (6 sessions), Symposium on Fundamentals of Phase-Change Heat Transfer, International Mechanical Engineering Congress, and Exposition. Houston, TX, USA (Nov. 9-15, 2012)
- Chair, Interdisciplinary Transport Phenomena VI: Fluid, Thermal, Biological, Materials and Space Sciences, Session, Volterra, Italy (Oct. 4-9, 2009)
- Chair, Symposium on Gas-Liquid and Phase Change Flows, ASME IMECE, Orlando, FL, USA (Nov. 13-19, 2009)
- Chair, Symposium on Gas-Liquid and Phase Change Flows Session (13-16-1), ASME IMECE, Boston, MA, (2009) (Oct. 31-Nov. 6, 2008)
- Co-chair, Symposium on Gas-Liquid and Phase Change Flows (Two Sessions), ASME IMECE, Seattle, WA, USA (Nov. 11-16, 2007)
- Chair, Interdisciplinary Transport Phenomena V: Fluid, Thermal, Biological, Materials and Space Sciences, Bansko, Bulgaria (Oct. 14-9, 2007)
- Co-chair / Chair, Symposium on Gas-Liquid and Phase Change Flows (Four Sessions), ASME IMECE, Orlando, FL, USA (Nov. 5-11, 2005)
- Chair, Transport Phenomena in Microgravity and Space Sciences IV, Engineering Conferences International, Tomar, Portugal (Aug. 7-12, 2005)
- Co-chair / Chair, Symposium on Gas-Liquid Flows in Fluid Mechanics and Heat Transfer, ASME IMECE, Dallas, TX, USA (Nov. 16-21, 1997)
- Chair, “Heat Transfer I” Session, Society of Engineering Science 32<sup>nd</sup> Annual Technical Meeting, New Orleans, LA, USA (Oct. 30, 1995)

#### **OTHER SERVICE ACTIVITIES**

##### **Michigan Technological University**

- Chair, ME-EM Faculty Development (Promotion and Tenure) Committee, 2022-2023
- Member, ME-EM Faculty Development (Promotion and Tenure) Committee, 2021-2022
- Member (by invitation), Chemical Engineering Department, Promotion and Tenure Committee (2019-present)

- Member, ME-EM Department Executive Committee, (2015- 2018)
- Director, Energy Thermo Fluids Area, (2015- 2018)
- Chair, ETF Faculty Recruitment Committee, (2015- 2018)
- Member, ME-EM Department Curriculum Committee, (2013-2015)
- Chair, ME-EM Department Computer Committee, Annual Budget: \$740,000 (2007–2010)
- Mentor (Chair-Designated), ME-EM Assistant Professor Dr. Jeffrey Allen (2004–2008) and Dr. A. Mukherjee (2006–2007)
- Member, ME-EM Faculty Recruitment Committee (2000–2006)
- University Library Liaison Committee, (Mechanical Engineering representative) yearly acquisition of books by the University Library System (1990-2010)
- Member, ME-EM Graduate Seminar Committee (2003)
- Mechanical Engineering Computer Committee (1997–2002)
- Chair, ME-EM Department Chair Evaluation Committee (1999)
- Member, ME-EM Faculty Development (Promotion and Tenure) Committee (1990-1992, 1992-1994, and 1994–1996)
- Chair/Member, 20-plus Mechanical Engineering Ph. D. Committees (Written and Oral) for Energy/Thermo-Fluids and Mathematics Exams
- Course Coordinator, MEEM 3210, 3230 (past), 5210, 5280 and 6240

### **Public Services**

- Voluntary contributions to IIT-Patna’s curriculum development (2013-2014)
- Initiated meetings (over 2013-2014) with US-India Multinationals, GoI, and US Government Agencies to advance research in the Energy sector (emphasis on clean and efficient energy generation that advances global energy security).
- Several visits and experiment demonstrations to the laboratory; 2004 “fly-in” group of prospective college freshmen considering engineering, industry/university visitors to MEEM
- Judge, Ice-Sculptors during 2004 Winter Carnival (for Blue Key)
- Faculty Advisor, India Students Association, Michigan Technological University (1999–2000)
- Judge, Michigan Technological University Graduate Students Council’s Research Poster Competitions (1996, 1997, and 1998)
- United Way, ME-EM Representative, (1985)
- ME-EM Michigan Tech Fund Representative (1984)

### **TEACHING**

#### **Courses Taught**

##### Graduate (Michigan Technological University)

- Advanced Fluid Mechanics (MEEM 5210/EM531, regularly 1985 - 2015)
- Advanced Heat Transfer (MEEM 5230, regularly 2000 - 2018)
- Two-Phase Flow and Heat Transfer (MEEM 5280, upgraded and taught in spring 2017, and spring 2024)
- Advanced Fluid Mechanics II (EM632, 1994)

##### Undergraduate (Michigan Technological University)

- Fluid Mechanics and Heat Transfer (MEEM 3201) Fall 2019-Spring 2022
- Introductory Thermodynamics (MEEM 2201) Spring 2018
- Heat Transfer (ME328/MEEM3230, ME327, Regularly 1995–2017)
- Fluid Mechanics (EM431, EM332/MEEM3210, Regularly 1983–Present)
- Thermodynamics (ME223, ME320, MEEM 2201)
- Dynamics (EM212)

##### Undergraduate (the University of Minnesota, 1988–1989)

- Incompressible Boundary Layer Theory (Senior Level, AEM 5202)
- Honors Mechanics I (Statics & Strength of Materials, AEM 3816H)
- Dynamics (Junior Level, AEM 3036)