Avijit Karmakar

Postdoctoral Research Associate
Energy and Transport Sciences Laboratory (PI: Prof. Partha P. Mukherjee)
School of Mechanical Engineering, Purdue University
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RESEARCH INTERESTS

- Battery Thermal Safety Analytics
- Battery Thermal Management Systems
- Thermal Systems Design Optimization
- Multiphase Flows
- Thermal Science
- Bluff Body Hydrodynamics

EDUCATION

ILLINOIS INSTITUTE OF TECHNOLOGY — Chicago, Illinois
Ph.D. in Mechanical and Aerospace Engineering — September 2016 – August 2021
Thesis: Falling Film Flow and Heat Transfer Over Horizontal Tubes
Advisor: Prof. Sumanta Acharya

UNIVERSITY OF MEMPHIS — Memphis, Tennessee
Ph.D. in Mechanical Engineering (Transfer) — September 2015 – August 2016
Thesis: Falling Film Flow and Heat Transfer Over Horizontal Tubes
Advisor: Prof. Sumanta Acharya

INDIAN INSTITUTE OF TECHNOLOGY, KANPUR
Kanpur, India
M.Tech in Mechanical Engineering — August 2013 – July 2015
Thesis: Vortex-induced Vibrations in Flow past a Square Cylinder close to a Free Surface
Advisor: Prof. Arun Kumar Saha

INDIAN INSTITUTE OF ENGINEERING SCIENCE AND TECHNOLOGY — Shibpur, India
B.E in Mechanical Engineering — August 2009 – July 2013

RESEARCH EXPERIENCE

PURDUE UNIVERSITY — West Lafayette, Indiana
Postdoctoral Research Associate — September 2021-Current
Advisor: Prof. Partha P. Mukherjee

- Constructed a cell-level thermal runaway model from the accelerating rate calorimetry (ARC) experimental data of NMC-based 18650 cylindrical cells using genetic algorithms.

- Developed a lumped thermal modeling framework to investigate thermal runaway and its propagation characteristics for Li-ion battery packs containing cylindrical/prismatic cells.
- Performed simulations to evaluate the influence of external thermal management systems on internal thermal gradients and corresponding changes in lithium plating and solid electrolyte interphase growth (electrochemical) and intercalation-induced stress (mechanical) degradation of Li-ion pouch cells under fast charging operations.
- Extracted thermo-kinetic parameters from ARC data of NCA-based Li-ion cells to understand the state-of-charge effects on thermal stability.
- Developed an aging-aware cell-level thermal stability model to predict cell failure under various degradation mechanisms after cyclic aging.
- Employed non-linear optimization to develop ARC computational model from differential scanning calorimetry (DSC) data and predicted the effect of liquid electrolyte content on thermal instabilities of solid-state batteries.
- Performed thermo-kinetic analyses on ARC data of NCMA/Si-C-based Li-ion cells to understand effects of silicon concentration on anode-centric exothermic reactions.
- Performed thermo-kinetic analysis on ARC data of NVP/Sn-based Na-ion batteries to understand the effects of Sn microstructure and electrolyte additives on thermal stability.
- Incorporated electrochemical framework for investigating thermal runaway and its propagation characteristics for Li-ion battery packs under eVTOL configuration.

Illinois Institute of Technology Chicago, Illinois
Research Assistant September 2019 – August 2021
Advisor: Prof. Sumanta Acharya

- Developed steady-state design model of heat and mass exchanger for enhanced cooling tower technology.
- Utilized genetic algorithm to provide optimum system design variables to maximize cooling performance.
- Partnered with power industries for cost analysis and performed design optimizations resulting in 3% increase in plant efficiency and 20% reduction in makeup water.

Illinois Institute of Technology Chicago, Illinois
Research Assistant September 2016 – May 2019
Advisor: Prof. Sumanta Acharya

- Developed thermal design model of encapsulated PCM heat exchanger for dry cooling application systems.
- Employed genetic algorithm to provide optimum design parameters with least capital cost.
- Collaborated with energy industries for techno-economic analysis and performed design optimizations based on cost performance trade-off, resulting in a 10% cost reduction and improved thermal performance of PCM-based cooling system over state-of-the-art dry cooling system.
- Executed high-fidelity CFD studies (VOF, LES, Porous Media) resulting in thermofluidic correlations to predict EPCM heat exchanger performance.
- Improved water film containment on hydrophobic tube surfaces with tube structural modifications and CFD studies utilizing dynamic contact angle models (Kistler, Yokoi) in OpenFOAM.
- Implemented 3-phase evaporation model (liquid, liquid-vapor, and gas) in OpenFOAM framework and quantified water loss in EPCM heat exchanger within 10% to experimental predictions.

- Headed and coordinated research projects with quarterly reports, presentations for ARPA-E review meetings, and communicated findings with program managers.

UNIVERSITY OF MEMPHIS Memphis, Tennessee
Research Assistant August 2015 – August 2016
Advisor: Prof. Sumanta Acharya

- Executed preliminary high-fidelity CFD simulations (VOF) to design an encapsulated PCM heat exchanger.

TEACHING EXPERIENCE

ILLINOIS INSTITUTE OF TECHNOLOGY Chicago, Illinois
Lecturer January 2020 – May 2020

- Taught regular classes on **Design of Heat Exchangers** as a special topic for the course **Fundamentals of Heat Transfer (MMAE-525)**.

INDUSTRY EXPERIENCE

CESC LTD. Kolkata, India
SUMMER INTERN May 2012 – July 2012
Advisor: Debanjan Basak

- Evaluated Free Air Delivery of compressor units and performed root cause failure analysis for compressor components to identify the health deterioration of compressors in the plant.
- Proposed remedy resulted in the desired air quality and an increase in Free Air Delivery by 30%.

PUBLICATIONS

- PEER-REVIEWED JOURNALS

1. **Karmakar, A.**; Zhou, H.; Vishnugopi, B. S.; Mukherjee, P. P., *Thermal Runaway Propagation Analytics and Crosstalk in Lithium-Ion Battery Modules*. **Energy Technology**. 2024, 12 (2). [Article Link]

2. **Karmakar, A.**; Zhou, H.; Vishnugopi, B. S.; Jeevarajan, J. A.; Mukherjee, P. P., *State-of-Charge Implications of Thermal Runaway in Li-Ion Cells and Modules.* **Journal of Electrochemical Society**. 2024, 171 (1), 010529. [Article Link]

3. **Karmakar, A.**; Zhou, H.; Vishnugopi, B. S.; Mukherjee, P. P., *Li-ion battery safety: A perspective on hierarchy of scales.* **Annual Review of Heat Transfer**. 2023, 26 (1), 11–68. [Article Link]

   - Featured in the **Journal Cover** of Volume 26 Edition of **Annual Review of Heat Transfer** and among the **Most Downloaded Articles**

4. **Karmakar, A.**; Acharya, S., *Numerical Simulation of Evaporating Wavy Falling Liquid Films in Laminar Gas Streams.* **International Journal of Heat and Mass Transfer.** 2022, 198, 123426. [Article Link]

5. **Karmakar, A.**; Acharya, S., *Numerical Simulation of Falling Film Sensible Heat Transfer over Round Horizontal Tubes.* **International Journal of Heat and Mass Transfer**. 2022, 190, 122727. [Article Link]

6. Kanani, Y.; **Karmakar, A.**; Acharya, S., *Phase-Change Process Inside a Small-Radii Cylinder Subjected to Cyclic Convective Boundary Conditions: A Numerical Study.* **Journal of Heat Transfer.** 2021, 143 (10), 1–11. [Article Link]

7. **Karmakar, A.**; Acharya, S., *Numerical Simulation of Falling Film Flow Hydrodynamics over Round Horizontal Tubes.* **International Journal of Heat and Mass Transfer**. 2021, 173, 121175. [Article Link]

8. **Karmakar, A.**; Acharya, S., *Wettability Effects on Falling Film Flow and Heat Transfer Over Horizontal Tubes in Jet Flow Mode.* **Journal of Heat Transfer.** 2020, 142 (12). [Article Link]

9. **Karmakar, A.**; Acharya, S., *A Review of Computational Models for Falling Liquid Films.* In **50 Years of CFD in Engineering Sciences**; Springer Singapore: Singapore, 2020; Vol. 369, pp 551–606. [Article Link]

10. **Karmakar, A.**; Saha, A. K., *Unsteady Flow Past a Square Cylinder Placed Close to a Free Surface.* **Physics of Fluids**. 2020, 32 (12), 123610. [Article Link]

11. **Karmakar, A.**; Kanani, Y.; Bhattacharya, A.; Acharya, S.; Taghizadeh, S.; Ling, K., *Optimization and Analysis of a Heat Exchanger with Encapsulated Phase Change Material.* **Journal of Thermophysics and Heat Transfer.** 2019, 33 (4), 1161–1175. [Article Link]

- JOURNALS IN PREPARATION

1. Sarkar, S; **Karmakar A.**; Vishnugopi, B. S.; Mukherjee, P. P., *Thermal Stability of Sodium-ion Batteries: Unveiling the Cathode-Anode Interplay*. [In Preparation, advanced draft available].

2. Kabra, V.; **Karmakar A.**; Vishnugopi, B. S.; Mukherjee, P. P., *Quantifying the Effect of Degradation Modes on Li-ion Battery Thermal Instability and Safety.* [In Preparation, advanced draft available].

3. **Karmakar, A.**; Vishnugopi, B. S.; Weibel, J. A.; Mukherjee, P. P., *Probing the role of external cooling systems on thermal gradients and degradation heterogeneities under fast charging of Li-ion cells.* [In Preparation].

4. **Karmakar, A.**; Vishnugopi, B. S.; Weibel, J. A.; Mukherjee, P. P., *The Role of Non-Uniform Convective Cooling Conditions on Inhomogeneous Degradation in Lithium-Ion Batteries under Fast Charging Operations.* [In Preparation].

5. Zhou, H.; **Karmakar, A.**; Alujjage A. S.; He H.; Lowe, J. S.; Mukherjee, P. P., *The Role of Silicon-Graphite Composite Anode in Thermal Stabilities of Lithium-ion Batteries*. [In Preparation].

- CONFERENCE PROCEEDINGS & PRESENTATIONS

1. **Karmakar, A**.; Vishnugopi, B. S.; Mukherjee, P. P., *External Cooling and Degradation Interplay in Lithium-Ion Battery Fast Charging.* In 245th ECS Meeting, San Francisco, California, May 2024. [Link]

2. **Karmakar, A**.; Weibel, J. A.; Mukherjee, P.P., *The Role of Non-Uniform Convective Cooling Conditions on Inhomogeneous Degradation in Lithium-Ion Batteries under Fast Charging Operations.* In ASME 2023 Heat Transfer Summer Conference, ASME, 2023. [Link]

3. **Karmakar, A.**; Zhou, H; Mukherjee, P.P., *Role of Heat Release from Inter-Electrode Chemical Crosstalk in Thermal Runaway Propagation Characteristics of Lithium-Ion Battery Modules*. In 242nd ECS Meeting, Atlanta, Georgia, October 2022. [Link]

4. **Karmakar, A.**; Acharya, S., *Direct numerical simulation of evaporating falling films in laminar gas streams.* In Special Session in Honor of Professor Brian Spalding at 8th International Symposium on Advances In Computational Heat Transfer - CHT - 21, August 2021. [Link]

5. **Karmakar, A**.; Acharya, S., *Wettability Effects on Falling Film Heat Transfer Over Horizontal Tubes in Jet Flow Mode.* In ASME 2019 Heat Transfer Summer Conference, ASME, 2019. [Link]

6. **Karmakar, A**.; Kanani, Y., Bhattacharya, A., Acharya, S., Taghizadeh, S., and Ling, K., 2019, *Optimization and Analysis of a Heat Exchanger with Encapsulated Phase Change Material*. In AIAA SciTech 2019 Forum, San Diego, California, 2019. [Link]

7. **Karmakar, A**.; and Acharya, S., *Heat Transfer Characteristics of Falling Film over Horizontal Tubes-A Numerical Study.* In 55th AIAA Aerospace Sciences Meeting, Grapevine, Texas, 2017. [Link]

AWARDS & RECOGNITIONS

1. **2024 Postdoctoral Mentor Award** Nominee for The Graduate School, Purdue University.
2. **Special Recognition** under the "**recognize, reward and retain top talent**" program from the School of Mechanical Engineering, Purdue University 2024.
3. **2023 Postdoctoral Mentor Award** Nominee for The Graduate School, Purdue University.
4. Selected for **"Write Winning Grants"** seminar 2021, Purdue University.
5. **Travel Grant Award** from Graduate Students Advisory Council (GSAC) of Mechanical, Materials, and Aerospace Engineering (MMAE) at Ilinois Institute of Technology to attend ASME 2019 Heat Transfer Summer Conference.
6. **Travel Grant Award** from Graduate Students Advisory Council (GSAC) of Mechanical, Materials, and Aerospace Engineering (MMAE) at Ilinois Institute of Technology to attend AIAA SciTech 2019 Forum, San Diego, California, 2019.

7. **Travel Grant Award** from Graduate Students Advisory Council (GSAC) of Mechanical, Materials, and Aerospace Engineering (MMAE) at Ilinois Institute of Technology to attend 55th AIAA Aerospace Sciences Meeting, Grapevine, Texas, 2017.
8. **Graduate Research Assistantship Award**, Illinois Institute of Technology, 2016-2021.
9. **Graduate Research Assistantship Award**, University of Memphis, 2015-2016.
10. **Merit Scholarship** in M. Tech Program at Indian Institute of Technology Kanpur, May 2015.
11. **Teaching Assistantship Award** in M. Tech Program at Indian Institute of Technology Kanpur, 2013 – 2015.
12. **First Runner Up** for project activities in the Summer Internship program at CESC Ltd.

PEER REVIEWER

1. International Journal of Heat and Mass Transfer (Publisher: *Elsevier*)
2. Physics of Fluids (Publisher: *AIP*)
3. Applied Thermal Engineering (Publisher: *Elsevier*)
4. Chemical Engineering Research and Design (Publisher: *Elsevier*)
5. Chemical Engineering Science (Publisher: *Elsevier*)
6. International Journal of Refrigeration (Publisher: *Elsevier*)
7. International Journal of Thermal Sciences (Publisher: *Elsevier*)
8. Journal of Heat and Mass Transfer (Publisher: *ASME*)
9. Journal of Loss Prevention in the Process Industries (Publisher: *Elsevier*)
10. Journal of Electrochemical Energy Conversion and Storage (Publisher: *ASME*)

RESEARCH MENTORING

- Project: *Pre-Processing of Electrochemical Data of Li-ion Batteries for Visualization Purposes*

  Timeline: January 2024 – present

  1. Erik Charles Rottinghaus – B.S., Mechanical Engineering, Purdue University
  2. Rodrigo Jose Sanchez – B.S., Mechanical Engineering, Purdue University
  3. Shae Tova Stonemeier – B.S., Mechanical Engineering, Purdue University
  4. Patrick Benjamin Wargo – B.S., Mechanical Engineering, Purdue University
  5. Arushi Bharadwaj – B.S., Mechanical Engineering, Purdue University

- Project: *Development of Graphic User Interface for Electrochemical Data Visualization of Li-ion Batteries*

  Timeline: January 2024 – present

  1. Alvaro Jose Miguel – B.S., Mechanical Engineering, Purdue University
  2. Tanmaee Ledalla – B.S., Mechanical Engineering, Purdue University

3. Tanmay Sagar Panchpor – B.S., Mechanical Engineering, Purdue University
4. Quoc Son Phan – B.S., Mechanical Engineering, Purdue University
5. Michael Alan Steffe – B.S., Mechanical Engineering, Purdue University

- Project: *Thermal Runaway Analytics of Li-ion Batteries under eVTOL Operations*

  Timeline: September 2023 – present

  1. Hari G. Subramanian – B.S., Mechanical Engineering, Purdue University
- Project: *Machine Learning Pipeline for Electrochemical Data of Li-ion Batteries*

  Timeline: September 2023 – December 2023

  1. Aayush Iyenger – B.S., Mechanical Engineering, Purdue University
- Project: *Development of a Graphic User Interface for Single Particle Diffusion and Thermal Abuse Oven Test for Li-ion Batteries*

  Timeline: September 2023 – December 2023

  1. Erik Charles Rottinghaus – B.S., Mechanical Engineering, Purdue University
- Project: *Thermal Runaway Analytics under Aging effects of Li-ion Batteries*

  Timeline: January 2023 – December 2023

  1. Venkatesh Kabra – Ph.D. Student, Mechanical Engineering, Purdue University
- Project: *Porous Media Simulations for Heat Exchanger Applications*

  Timeline: August 2017 – July 2018

  1. Haresh Chandrasekhar – M.S Student, Mechanical Engineering, Illinois Tech

PROPOSALS

High-Performance Computing Time Proposals at USA National Laboratories:

1. **Karmakar A.**, Acharya S. *Demonstration of OpenFOAM software usage on Summit* (CFD131). Awarded 50000 Service Units (SU) on SUMMIT supercomputer of Oak Ridge Leadership Computing Facility (OLCF), 2021.
2. **Karmakar A.**, Acharya S. *Cooling Tower Performance Improvements through System Modifications and Fundamental Studies* (ERCAP0018276). Awarded 1340000 Service Units (SU) on CORI supercomputer of National Energy Research Scientific Computing Center (NERSC), 2021.
3. **Karmakar A.**, Acharya S. *Dry Cooling of Power Plants*. Awarded 250000 Service Units (SU) on CORI supercomputer of National Energy Research Scientific Computing Center (NERSC), 2020.
4. **Karmakar A.**, Acharya S. *Indirect Dry Cooling for Power Plants Using Encapsulated Phase Change Materials* (CFD103). Awarded 600000 Service Units (SU) on EOS and TITAN supercomputers of Oak Ridge Leadership Computing Facility (OLCF), 2019.
5. **Karmakar A.**, Acharya S. *Dry Cooling of Power Plants*. Awarded 750000 Service Units (SU) on CORI supercomputer of National Energy Research Scientific Computing Center (NERSC), 2019.

6. **Karmakar A.**, Acharya S. *Indirect Dry Cooling for Power Plants Using Encapsulated Phase Change Materials* (CFD103). Awarded 400000 Service Units (SU) on EOS and TITAN supercomputers of Oak Ridge Leadership Computing Facility (OLCF), 2018.

INVITED JUDGE

1. Invited to judge posters at Office of Interdisciplinary Graduate Programs (OIGP) Spring Reception 2024, Purdue University.
2. Invited to judge posters at College of Engineering (COE) Design Expo 2024, Purdue University.
3. Invited to judge presentations at Summer Undergraduate Research Fellowship (SURF) 2023 Symposium, Purdue University.
4. Invited to judge posters at Office of Interdisciplinary Graduate Programs (OIGP) Spring Reception 2023, Purdue University.
5. Invited to judge posters at College of Engineering (COE) Design Expo 2023, Purdue University.
6. Invited to judge presentations at Summer Undergraduate Research Fellowship (SURF) 2022 Symposium, Purdue University.

PROFESSIONAL SOCIETIES

1. Member, American Society of Mechanical Engineers (ASME)
2. Member, American Society of Thermal and Fluids Engineers (ASTFE)
3. Member, The Electrochemical Society (ECS)
4. Member, American Institute of Aeronautics and Astronautics (AIAA)
5. Member, The Electrochemical Society (ECS) Purdue University Chapter.