Saif Rahaman Kazi

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EDUCATION

Carnegie Mellon University, Pittsburgh, Pennsylvania, USA

- Ph.D. in Chemical Engineering(Process Systems Engineering) — Aug 2016 – Jun 2021
  - Thesis Title - Mathematical Modeling and Optimization of Heat Exchanger Design in Chemical Processes
  - Advisor: Prof. Lorenz T. Biegler
  - GPA: 3.88 / 4.00

Indian Institute of Technology (IIT), Bombay, Mumbai, India

- B.Tech (Hons.) in Chemical Engineering — Jul 2012 – May 2016
  - Minor in Electrical Engineering
  - Cumulative GPA: 8.97 / 10.00
  - Project: Simulation Study of Soot Particle Production in an Inverted Flame Reactor

RESEARCH INTERESTS

- Nonlinear Programming, Numerical Analysis, Optimal Control
- Trust Region methods, Reduced-order and surrogate modeling
- AI and Data Driven Optimization, High Performance Computing
- Energy Systems Modeling, Grid Network Optimization, Industrial Decarbonization

RESEARCH EXPERIENCE

Center for Nonlinear Studies, Los Alamos National Laboratory

- Postdoctoral Research Associate — Sep 2021 – Present
  - Modeling of transport of hydrogen-natural gas mixture in pipeline grid network
  - Simulation and optimization algorithms for mixed-gas network grid models
  - Stochastic Optimization of Gas Pipeline Network using Finite Volume
  - Algorithmic development for global convergence of complementarity optimization problems
  - Focus: Gas Pipeline Network, Numerical Algorithms for MPECs

Department of Chemical Engineering, Carnegie Mellon University

- Ph.D. Research — Aug 2016 – Jun 2021
  - First principles based finite element modeling of Heat Exchangers to construct DAE models for Design optimization
  - Application of MPEC based methods to model Phase Change inside Heat Exchanger models
  - Developed a trust region based framework for incorporation of detailed exchanger design in process optimization
  - Focus: Heat Exchangers, Numerical Optimization, Complementarity Constraints, Trust Region Methods

Mathematics and Computer Science Division, Argonne National Laboratory

- Wallace Givens Research Associate — May 2020 – Aug 2020
  - Project: Decomposition strategy for AC Optimal Power Flow models
  - Supervisors: Dr. Youngdae Kim
  - Focus: Optimal Power Flow, Power Systems, Complementarity Constraints

Energy, Environmental and Chemical Engineering, Washington University in St.Louis

- Undergraduate Research Student — May 2015 – Jul 2015
  - Project: Simulation of a co-current non-premixed ethylene flame under negative gravity
  - Supervisors: Prof. Rajan Chakrabarty
  - Focus: Soot aggregation, mathematical modeling, particle characterization

JOURNAL PUBLICATIONS (PEER REVIEWED)

- Mo Sodwatana, **Saif R Kazi**, Kaarthik Sundar, Adam Brandt, Anatoly Zlotnik, ”Locational Marginal Pricing of Energy in Pipeline Transport of Natural Gas and Hydrogen with Carbon Offset Incentives”, Under Review in *International Journal of Hydrogen Energy*, URL:arXiv:2310.13181
- **Saif R. Kazi**, Kaarthik Sundar, Sidhant Misra, Svetlana Tokareva and Anatoly Zlotnik, ”Intertemporal Uncertainty Management in Gas-Electric Energy Systems using Stochastic Finite Volumes,” *International Journal of Hydrogen Energy*, vol. 235, iss. 110748, Oct 2024, DOI: 10.1016/j.epsr.2024.110748
- **Saif R. Kazi**, Kaarthik Sundar, Shriram Srinivasan and Anatoly Zlotnik, ”Modeling and Optimization of Steady Flow of Natural Gas and Hydrogen Mixtures in Pipeline Networks,” *International Journal of Hydrogen Energy*, vol. 54, pp. 14-24, Feb 2024, DOI: 10.1016/j.ijhydene.2023.12.054

- Luke S. Baker, **Saif R. Kazi** and Anatoly Zlotnik, "Transitions from Monotonicity to Chaos in Gas Mixture Dynamics in Pipeline Networks," *Physical Review X Energy*, vol. 2, iss. 3, pp. 033008, Aug 2023, DOI: 10.1103/PRXEnergy.2.033008
- **Saif R. Kazi**, Michael Short and Lorenz T. Biegler, "A Trust Region Framework for Heat Exchanger Network Synthesis with Detailed Individual Heat Exchanger Designs", *Computers & Chemical Engineering* vol. 153, 107447, Oct 2021, DOI: 10.1016/j.compchemeng.2021.107447
- **Saif R. Kazi**, Michael Short and Lorenz T. Biegler, "Heat Exchanger Network Synthesis With Detailed Exchanger Designs - 1. A Discretized Differential Algebraic Equation(DAE) Model for Shell and Tube Heat Exchanger Design", *AIChE Journal* vol. 67, no. 1, e17056, Jan 2021. DOI: 10.1002/aic.17056
- **Saif R. Kazi**, Michael Short and Lorenz T. Biegler, "Heat Exchanger Network Synthesis With Detailed Exchanger Designs - 2. Hybrid Strategy for Optimal Synthesis of Heat Exchanger Networks with Detailed Individual Heat Exchanger Designs", *AIChE Journal* vol. 67, no. 1, e17057, Jan 2021. DOI: 10.1002/aic.17057
- Kai Liu, **Saif R. Kazi**, Lorenz T. Biegler, Bingjian Zhang, Qinglin Chen, "Dynamic optimization for gas blending in pipeline networks with gas interchangeability control", *AIChE Journal* vol. 66, no. 5, e16908, April 2020. DOI: 10.1002/aic.16908
- A. Patel, S. L. Shield, **S. Kazi**, A. M. Johnson and L. T. Biegler, "Contact-Implicit Trajectory Optimization Using Orthogonal Collocation," in *IEEE Robotics and Automation Letters*, vol. 4, no. 2, pp. 2242-2249, April 2019. DOI: 10.1109/LRA.2019.2900840

CONFERENCE PAPERS

- **Saif R. Kazi**, Kaarthik Sundar, Sidhant Misra, Svetlana Tokareva and Anatoly Zlotnik, "Stochastic Finite Volume Method for Uncertainty Management in Gas Pipeline Network Flows" Accepted to *163rd IEEE Conference on Decision and Control, Milan, Italy*, Dec 2024 URL:arXiv:2403.18124
- **Saif R. Kazi**, Mandar Thombre and Lorenz T. Biegler, "Globally Convergent Method for Optimal Control of Hybrid Dynamical Systems", *12th IFAC Advanced Control of Chemical Processes, Toronto, ON, Canada*, July 2024, IFAC-PapersOnLine 58, no. 14 (2024): 868-873.
- **Saif R. Kazi**, Kaarthik Sundar and Anatoly Zlotnik, "Dynamic Optimization and Optimal Control of Hydrogen Blending Operations in Natural Gas Networks,", *2024 American Control Conference, Toronto, ON, Canada*, July 2024, pp. 5357-5363
- Zlotnik, Anatoly, **Kazi, Saif R.**, Sundar, Kaarthik, Gyrya, Vitaliy, Baker, Luke, Sodwatana, Mo, and Yan Brodskyi."Effects of Hydrogen Blending on Natural Gas Pipeline Transients, Capacity, and Economics." Paper presented at the *PSIG Annual Meeting, San Antonio, Texas, USA*, May 2023 URL:PSIG23/All-PSIG23/520076
- Mo Sodwatana, **Saif R Kazi**, Kaarthik Sundar, Anatoly Zlotnik, "Optimization of Hydrogen Blending in Natural Gas Networks for Carbon Emissions Reduction" *2023 American Control Conference, San Diego, CA, USA*, May 2023, pp. 1229-1236
- Luke Baker, **Saif R Kazi**, Rodrigo B Platte, Anatoly Zlotnik, "Optimal Control of Transient Flows in Pipeline Networks with Heterogeneous Mixtures of Hydrogen and Natural Gas" *2023 American Control Conference, San Diego, CA, USA*, May 2023, pp. 1221-1228
- **Saif R. Kazi**, Lorenz T. Biegler and Rahul Gandhi, "Equation Oriented Optimization of Multi Stream Heat Exchanger Design and Operation in Natural Gas Liquefaction Process" *Proceedings of the 14 th International Symposium on Process Systems Engineering – PSE 2021+, Computer Aided Chemical Engineering* vol. 49, pp. 673-678, 2022
- **Saif R Kazi**, Ishanki A De Mel, Michael Short, "A new trust-region approach for optimization of multi-period heat exchanger networks with detailed shell-and-tube heat exchanger designs" *Proceedings of the 14 th International Symposium on Process Systems Engineering – PSE 2021+, Computer Aided Chemical Engineering* vol. 49, pp. 241-246, 2022
- **Saif R. Kazi**, Michael Short and Lorenz T. Biegler, "Synthesis of Combined Heat and Mass Exchange Networks Via a Trust-Region Filter Optimisation Algorithm Including Detailed Unit Designs" *31st European Symposium on Computer Aided Process Engineering 2021, Computer Aided Chemical Engineering* vol. 50, pp. 13-18, 2021
- **Saif R. Kazi**, Michael Short and Lorenz T. Biegler, "Heat Exchanger Network Optimization including Detailed Heat Exchanger Models using Trust Region Method" *30th European Symposium on Computer Aided Process Engineering 2020, Computer Aided Chemical Engineering* vol. 48, pp. 1051-1056, 2020
- **Saif R. Kazi**, Lorenz T. Biegler, "Nonlinear Optimization of Detailed Heat Exchanger Models with Phase Change" *Proceedings of the 9th International Conference on Foundations of Computer-Aided Process Design*, Volume 47, Pages 151-156, 2019

NETWORK PROFILES

- **Google Scholar**
- **ResearchGate**
- **LinkedIn**

CONFERENCE TALKS AND POSTER PRESENTATIONS

- Intertemporal Uncertainty Management in Gas-Electric Energy Systems using Stochastic Finite Volume Method, *INFORMS Optimization Society Meeting, Houston, TX, USA* Mar 2024
- Stochastic Finite Volume Method for Uncertainty Management of Gas Network Flows, *SIAM UQ Meeting, Trieste, Italy* Feb 2024
- Globally Convergent MPCC Based Algorithm to Solve Hybrid Dynamical Optimization Problems, *AIChE Annual Meeting, Orlando, Fl, USA* Nov 2023
- Stochastic Finite Volume Method for Uncertainty Management of Gas Network Flows, *INFORMS Annual Meeting, Phoenix, AZ, USA* Oct 2023
- Dynamic Modeling and Optimization of Mixed Hydrogen- Natural Gas Flow in Pipeline Networks, *SIAM Optimization Meeting, Tokyo, Japan* Aug 2023
- Effects of Hydrogen Blending on Natural Gas Pipeline Transients, Capacity, and Economics, *PSIG Annual Meeting, San Antonio, TX, USA* May 2023
- Modeling and Optimization of Mixed Hydrogen-Natural Gas Flow in Pipeline Network, *AIChE Annual Meeting, Phoenix, AZ, USA* Nov 2022
- Hybrid Strategy for Global Convergence of Mathematical Programming with Complementarity Constraints (MPCC), *ICCOPT, Lehigh, PA, USA* Jul 2022
- Optimization of Natural Gas Liquefaction Process Using Detailed DAE based MHEX Design, *AIChE Annual Meeting, Boston, MA, USA* Nov 2021
- Combined Heat and Mass Exchange Network Synthesis using Detailed Equipment Design using Trust-Region Filter (*Selected Plenary Talk*), *AIChE Annual Meeting (Virtual)* Nov 2020
- A First Principles Based DAE Model for Phase Change Heat Exchangers for Process Optimization, *AIChE Annual Meeting (Virtual), San Francisco, CA, USA* Nov 2020
- Simultaneous Design of Heat Exchanger Network with Individual Exchanger Designs, *AIChE Annual Meeting, Orlando, FL, USA* Nov 2019
- Nonlinear Optimization of Detailed Heat Exchanger Models with Phase Change, *Foundations of Computer-Aided Process Design, Copper Mountain Resort, Colorado* (Poster) Jul 2019
- Finite Element Modeling and Optimization of Heat Exchangers, *AIChE Annual Meeting, Pittsburgh, PA, USA* Nov 2018

PROFESSIONAL AFFILIATIONS

- American Institute of Chemical Engineers(AIChE),
- Society for Industrial and Applied Mathematics(SIAM)

TEACHING EXPERIENCE

- *Teaching Assistant, Department of Chemical Engineering, Carnegie Mellon University* 2017, 2018
  - Course: Process Systems Modeling
  - Instructor: Mark Daichendt
  - Responsibilities: Mentored student groups with the course project and graded homework assignments

  - Course: Computational Methods for Large Scale Process Design & Analysis
  - Instructor: Lorenz T. Biegler
  - Responsibilities: Conducted recitation sessions and graded homework of graduate students

AWARDS & SCHOLARSHIPS

- CNLS Postdoctoral Fellowship 2021 – 2023
- Finalist on 2019 TC on **Model-Based Optimization for Robotics Best Paper Award** 2020
- FOCAPD NSF Conference Travel Award Jul 2019
- CMU Dean's Fellowship, 2016 – 2017
- Undergraduate Student Excellence Award, IIT Bombay May 2016

RELEVANT COURSEWORK

- **Process Systems Engineering (ChemE)**: Computational Methods for Large Scale Process Design & Analysis, Advanced Process System Engineering, Special Topics in Process System Engineering
- **Optimization**: Convex Analysis and Optimization, Graph Theory (Audit)
- **Applied Mathematics**: Numerical Scientific Computing II - Introduction to PDE, Introduction to Numerical Analysis I (Audit)
- **Miscellaneous** Advanced Deep Learning (Audit), Linear Systems, Nonlinear Control

INDUSTRIAL EXPERIENCE

Carrier Corp., Farmington, CT, USA

- Summer Intern, Systems Model based Development — Jun 2018 – Aug 2018
  - Finite Element application to solve the PDE Heat equation along with modeling of non-smooth phase change using complementarity constraints

Oil and Natural Gas Co., Uran, India

- Summer Trainee, Production and Instrumentation — May 2014 – Jul 2014
  - Developed a model in Aspen HYSYS interface emulating LPG fractionator, a separating process for producing of Liquefied Petroleum Gas and Low Aromatic Naptha.

COMPUTER SKILLS

Languages: Julia, Python, Matlab, C++
Modeling Libraries: Pyomo, GAMS, AMPL, JuMP
Optimization Solvers:
MILP (CPLEX, Gurobi, HiGHS)
NLP (IPOPT, CONOPT, KNITRO)
MINLP (DICOPT, BARON, KNITRO)

OUTREACH AND SERVICE

- Reviewer for:
  - Industrial & Engineering Chemistry Research
  - IEEE Transactions on Control Systems Technology
  - IEEE Transactions on Automatic Control
  - Optimal Control, Applications and Methods
  - AIChE Journal
  - Computers & Chemical Engineering
  - Optimization and Engineering
  - Reliability Engineering and System Safety
  - American Control Conference (ACC)
  - Conference on Decision and Control (CDC)
  - Power Systems Computing Conference (PSCC)
- LANL Summer Intern Student Mentor -
  - Mo Sodwatana — 2022
  - Dr. Luke Baker — 2022
  - Robert Ferrando — 2024
  - Ayrton Jimenez — 2024
- Center for Nonlinear Studies (CNLS) Postdoctoral Seminar Organizer — 2022
- Institute and Department Student Mentor at IIT Bombay: Mentored 20+ freshmen and sophomore students with the department and institute academic curriculum — 2014 – 2016