

Vivek M. Rao, PhD.

Engineer Intern - State of Missouri

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Summary	Chemical engineer with 10 years of inter-disciplinary experience in chemical and nuclear engineering focused on design and development of clean and hybrid energy systems with computational fluid dynamics (CFD) tools
Objective	To cost-effectively utilize computational tools and laboratory-scale experiments to verify and validate process engineering projects, with an emphasis on renewable energy generation systems
Education	<p>Missouri University of Science & Technology, Rolla, MO, USA Doctor of Philosophy (PhD), Chemical Engineering (05/2018) cGPA: 3.3/4.0 Master of Science (MS), Chemical Engineering (07/2012)</p> <p>Visvesvaraya Technological University, Belgaum, KA, India Bachelor of Engineering (BE), Chemical Engineering (07/2010) GPA: 76/100 First Class, with Distinction</p>
Research Experience	<p>Oak Ridge National Laboratory, Oak Ridge, TN, USA Post-Doctoral Research Associate, CFD (11/2018 – Present) Reactor and Nuclear Systems Division Group: Thermal Hydraulics Group Leader: Prashant K. Jain, PhD.</p> <p>- Project summary by organization:</p> <ol style="list-style-type: none">Organization: Advanced Reactor Engineering, RNSD<ul style="list-style-type: none">Co-authored four full proposals to the HPC4EI program sponsored by USDOE; three successful proposals, each awarded \$300,000 over 12 months, one under reviewSupporting model development, validation, and design exploration for low-temperature waste heat recovery by a direct-contact heat exchanger w/ phase change (ongoing HPC4Mfg collaboration with Eaton Corp., LLC.)Providing HPC support to molten salt applications in the Energy Systems Engineering & Testing team – predictive simulations for (i) feasible operating levels in a molten salt sump tank and (ii) hydraulic data from a test design of a circulating salt pumpCo-authored quarterly reports for program sponsorsEstablished collaborative interest with commercial software developers suited for applications in the groupContinued simulation activities on light water-cooled SMR T-H from doctoral dissertationOrganization: Building Equipment Research, BTRIC<ul style="list-style-type: none">Providing HPC simulation and analyses capabilities to “A Natural Gas-Based High Efficiency Combined Thermo-Chemical Affordable Reactor” (NECTAR), a \$999,99 award by USDOE ARPA-E through the INTEGRATE programDesign evaluation (minimum surfaces), customizing mesh generation strategies, evaluating thermal performance of materials across hydraulic design limits, validating numerical data, and establishing value proposition for commercialization of custom ceramicsPredicting effects of wall roughness induced by advanced manufacturing, with CFD simulations and analysis of consequent effects on T-HTeam has submitted a coversheet provisional application for invention disclosure (ID 4399)Organization: Spallation Neutron Source (SNS), NScD

- Ongoing support for computational activities under the Proton Power Upgrade (PPU) project
- Simulated all design scenarios per specification for the test target in the mercury loop under nominal (1 GeV) and PPU (1.3 GeV) beam incidences, documented in SNS-106010101-DA0044-R00
- Simulated conjugate heat transfer in the core vessel of the inner reflector plug under incidence of the nominal beam (1 GeV) and evaluated modifications to thermal assessment without design modifications, documented in SNS-106030102-DA0004-R00
- Predicted safe fill heights of the storage tank in the mercury loop, providing a maximum fill height of mercury that would be contained in the event of a surge, with simulations of surge pressure at different fill heights, documented in SNS-106010200-DA0014-R00

Missouri University of Science & Technology, Rolla, MO, USA

Post-Doctoral Fellow, Chemical Engineering (06/2018 -11/2018)

- Utilized CFD package STAR-CCM+ for multi-scale, parallel simulations of turbulent flow and heat transfer through a 17x17 fuel assembly in a PWR-type small modular nuclear reactor (SMR)
- Conducted a CFD benchmark study to establish computational needs for simulation efforts in the Department of Chemical and Biochemical Engineering, related to HPC vendors

Missouri University of Science & Technology, Rolla, MO, USA

Doctoral Candidate, Chemical Engineering (08/2012 – 05/2018)

“Thermal-Hydraulic Design and Numerical Analyses of Turbulent Forced Convection in a Pressurized, Light-Water, Small Modular Nuclear Reactor (SMR)”

Advisers: Joseph D. Smith, PhD., Dr. Muthanna H. Al-Dahhan, Dr. Joshua P. Schlegel

- 5 years of hands-on experience with STAR-CCM+ (certified user) for thermal-hydraulic design and numerical analyses of the Westinghouse SMR (WSMR)
- Awarded a “Director’s Discretion Project” by the OLCF at Oak Ridge National Laboratory for execution of massively parallel, multi-scale CFD simulations:
 - 2016-2017: 50,000 node hours on Rhea and Eos
 - 2017-2018: 1 M core hours on Titan + 20,000 node hours on Rhea
- Designed computational models of the reactor pressure vessel (RPV), reactor core, integral pressurizer, and annular steam generator units for the WSMR
- Executed simulations of transient turbulence with URANS, DES, and LES formulations
- Completed thermal analysis of 800 MW_{th} WSMR reactor core with full geometric detail
- Trained by TSI Inc. to use particle image velocimetry (PIV) apparatus
- Other completed CFD projects:
 - Three-phase DEM-Eulerian-Eulerian model of an anaerobic digester
 - DEM model of a downdraft, moving-bed, biomass gasifier

Missouri University of Science & Technology, Rolla, MO, USA

HPC Administrator-Department of Chemical & Biochemical Engineering (10/2015-present)

- Set up software for a Lenovo NeXtScale cluster with 6 compute nodes, on CentOS 6
- Utilized xCAT to deploy OS and software to compute nodes in ‘stateless’ mode
- Configured SLURM for users with batch job submissions (testing/production)
- Developed a work-around for users requiring GUI access with parallel runs
- Responsible for software installation/upgrades, and hardware maintenance
- Gained proficiency with Linux OS (RHEL, Debian) and shell scripts

CD-adapco Pvt. Ltd., Melville, NY, USA

CFD Intern-Reacting Flow (06/2013-08/2013)

- Simulated gasification of various coal and biomass feedstock using STAR-CCM+

- Followed internship up with CFD design optimization of bio-fuel combustion equipment, published in proceedings of the American Flame Research Committee (2013, 2014)

Missouri University of Science & Technology, Rolla, MO, USA

Research Assistant-Master of Science, Chemical Engineering (08/2010 – 07/2012)

“Synthesis of Nickel Nanoparticles by Gamma-Radiation and Femtosecond Laser Ablation”

Advisers: Dr. Muthanna Al-Dahhan, Dr. Carlos H. Castaño

- Synthesized nickel nanoparticles using varying doses of (i) gamma-radiation, of aqueous nickel precursors, and (ii) femtosecond laser ablation, of a pure nickel foil; (3-10 nm particles) for potential use as enhanced-cooling fluids (nanofluids)
- Synthesized nickel nanoparticles adsorbed on multi-walled carbon nanotubes (MWCNTs) as materials with potential for hydrogen storage (published work)
- Characterized MWCNTs using FTIR, and nanoparticles using SEM, TEM, and EDS

Visvesvaraya Technological University, Belgaum, KA, India

Undergraduate Research Assistant (09/2009 – 05/2010)

“Remediation of Sand Contaminated by Benzene Using an Anionic Surfactant”

Advisers: Dr. Samita Maitra, Sreelakshmi D.

- Optimized batch parameters: temperature, surfactant concentration, and effect of added electrolyte to develop a continuous process for surfactant-enhanced remediation of contaminated sand
- Achieved a 96% efficiency (by volume) for continuous effluent removal

Praxair India Pvt. Ltd., Bangalore, KA, India

Intern (06/2009 – 07/2009)

- Studied operations, equipment design, control systems and P&IDs at the nationwide reliability center, for several air separation & liquefaction plants operated by Praxair
- Worked on-site at Jindal Praxair Oxygen Company Ltd. (JPOCL, Bellary, KA, India) where liquefied gases (oxygen, nitrogen, and argon) were synthesized and supplied to Jindal Steel Works plants in adjacent facilities

Teaching Experience

Missouri University of Science & Technology, Rolla, MO 65409 USA

Department of Chemical & Biochemical Engineering (Instructor)

- Applied Computational Fluid Dynamics (Spring 2018, Spring 2017, Spring 2015)
- Process Control & Dynamics (Fall 2014)

Missouri University of Science & Technology, Rolla, MO 65409 USA

Department of Nuclear Engineering (Graduate Teaching Assistant)

- Nuclear Design (Spring 2015, Spring 2014)

Missouri University of Science & Technology, Rolla, MO 65409 USA

Department of Chemistry (Instructor)

- General Chemistry Laboratory (Fall 2017, Fall 2015, Fall 2011)

Publications

- Rao, V., Delchini M-O, Jain, P.K., and Ahmed, M. B. 2020. High-Performance Computing to Enable Next-Generation Low-Temperature Waste Heat Recovery. ICONE28-POWER2020-16374.
- Rao, V. 2019. Simulation and Analysis of Thermal-Hydraulics in PPU Test Target #1 Under Incidence of Nominal and PPU Beams. SNS-106010101-DA0044-R00.
- Rao, V. 2019. Preliminary Simulation of Conjugate Heat Transfer in the Core Vessel of the Spallation Neutron Source. SNS-10603010102-DA0004-R00.
- Rao, V. 2019. Simulation of a Helium Surge in the Mercury Storage Tank. SNS-106010200-DA0014-R00.

- Smith, J. D., Rao, V., and Landon, M. Advanced Design Optimization of Combustion Equipment for BioEnergy Systems Using Sculptor® w. CFD Tools – American Flame Research Committee (AFRC). Safe and Responsible Development for the 21st Century, Sheraton Kauai, Hawaii – September 22-25, 2013.
- Smith, J.D., Sreedharan, V., Rao, V., Landon, M., Smith, Z. P. 2014. Advanced Design Optimization of Combustion Equipment Using Sculptor® with CFD Tools. American Flame Research Committee. 2014 Industrial Combustion Symposium (Hyatt Regency Hotel, Houston TX, September 7-10, 2014).
- Rao V.M., Castaño, C. H., Rojas, J., Abdulghani, A. J., 2013. Synthesis of nickel nanoparticles on multi-walled carbon nanotubes by gamma irradiation. Radiation Physics and Chemistry, 89, 51-56

Publications Under Preparation

- Rao, V. M., and Smith, J. D. 2018. Transient Analysis of Turbulent Flow in the Lower Plenum of a Small Modular Nuclear Reactor. Article submitted to Nuclear Engineering and Design, under peer review. NED-D-17-00649.
- Rao, V. M., and Smith, J. D. 2018. CFD Analysis of Forced Convection Through the Reactor Core and Past Upper Internals in a Small Modular Nuclear Reactor. Article submitted to Annals of Nuclear Energy, under peer review. ANUCENE-D-18-00331.

Software

- **CFD** | STAR-CCM+, Fluent, CFX, OpenFOAM, SolidWorks, Gambit
- **Simulation environments** | FLOWNEX, Aspen
- **OS** | Debian, RHEL, Windows; HPC packages | PBS, SLURM, xCAT
- **Programming** | Fortran, C++, Python, MATLAB, Bash
- **Statistical and plotting tools** | Minitab, Microsoft Office, tecplot, TeraPlot, Paraview

Analytical Tools

- SEM, TEM, XPS, FTIR, UV-VIS, PIV

Languages

Fluent | English, Hindi, Marathi, Kannada; **Basic** | French

References

- Joseph D. Smith, PhD.; smithjose@mst.edu; +1 (573) 341-4294
Professor, Department of Chemical & Biochemical Engineering,
Missouri University of Science & Technology, Rolla, MO 65409 USA
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Chairman, Department of Chemical & Biochemical Engineering,
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- Dr. Joshua Schlegel; schlegelj@mst.edu; +1 (573) 341-7703
Assistant Professor, Department of Mining and Nuclear Engineering,
Missouri University of Science & Technology, Rolla, MO 65409 USA
- Dr. Carlos H. Castaño; castanoc@mst.edu; +1 (573) 341-6766
Associate Professor, Department of Mining and Nuclear Engineering,
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