**Vivek M. Rao, PhD**

Engineer Intern - State of Missouri

5700 Oak Ridge National Laboratory, Mail Stop 6170, Oak Ridge, Tennessee 37830 USA

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**Summary** Chemical engineer with over 10 years of inter-disciplinary experience in chemical and nuclear engineering, focused on design and development of hybrid energy systems with computational tools and experimental techniques

**Objective** To cost-effectively utilize computational tools and laboratory-scale experiments to verify and validate process engineering projects, with an emphasis on generation of renewable power

**Education**

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

* Doctor of Philosophy (PhD), Chemical Engineering (05/2018)
* Master of Science (MS), Chemical Engineering (07/2012)

*Visvesvaraya Technological University, Belgaum, KA, India*

* Bachelor of Engineering (BE), Chemical Engineering (07/2010)

**Experience – Fluid Dynamics, Thermal Hydraulics, High-Performance Computing**

*USDOE ARPA-**e : INTEGRATE (Co-Investigator, ORNL, 2018 – 2022)*

* Led activities pertaining to the computational design and thermal analyses of light-weight heat exchangers to enable thermochemical conversion in natural gas technologies
* Contributed to two invention disclosures with UT-Battelle LLC
* Peer-review publication with Journal of Turbulence (Springer)

*USDOE Nuclear Engineering University Program (Lead Investigator, ORNL, 2021 - present)*

* Lead for activities pertaining to the numerical analyses of a conceptual horizontal micro-HTGR capable of surviving PCC scenarios
* Mentor for doctoral collaborators at lead institution, Missouri University of Science & Technology, on data acquisition for verification and validation activities

*USDOE LLNL-HPC4 Energy Innovation (2018 – present)*

* (2022 – present, $300,000 award) advanced optimization of reverberatory furnace parameters for the enhancement of thermal efficiency in refining secondary lead for Gopher Resource LLC
* (2019 – 2021, $300,000 award) numerical analyses of flameless oxidation in autothermal reforming of syngas for the Linde Group using COMSOL Multiphysics and Simcenter STAR-CCM+
* (2019 – 2021, $300,000 award) numerical analyses of magnetohydrodynamics, dissolution kinetics and large eddy simulation of aluminum smelting for Alcoa USA using Simcenter STAR-CCM+ and OpenFOAM
* (2020 – 2021, $300,000 award) transient simulations of oxy-fuel combustion, smelting and melting in reverberatory furnaces operated by Gopher Resource LLC for refining secondary lead using Simcenter STAR-CCM+

**EMPLOYMENT HISTORY**

**Oak Ridge National Laboratory, Oak Ridge, TN, USA**

**R&D Associate – Nuclear CFD Development Engineer (04/2020 – Present)**

**Post-Doctoral Research Associate, CFD (11/2018 – 03/2020)**

**Nuclear Energy and Fuel Cycle Division**

* Conduct design and development of high-temperature operations, equipment, and processes
* Verification of numerical codes and validation of simulated data
* Incorporation of high-resolution fluid dynamics tools in process intensification workflows
* Development of strategic collaborations with industry to further state-of-the-art in chemical process and nuclear power industries, with an emphasis on decarbonization of economy
* Supporting the computational needs of industry by providing subject matter expertise adapted to the U.S. Department of Energy’s high-performance computing resources
* Furthering fundamental research at the Spallation Neutron Source with multiphysics simulations
* Furthering the testing of materials at hostile conditions in collaborative development of the Material Plasma Exposure eXperiment
* Submit successful proposals in response to funding opportunity announcements under the auspices of the U.S. Department of Energy
* Collaborate with university partners to further academic research through university-led programs
* Mentor early-career research staff in professional activities and workflows
* Serve on professional societies as a peer reviewer and cognizant member

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

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

* Conducted HPC benchmark studies for STAR-CCM+ in simulation of turbulence in fuel assemblies
* Developed multiphysics model sets for multi-scale process equipment in power generation

**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

* Thermal-hydraulic analyses of the Westinghouse SMR (WSMR) concept design
* Awarded a “Director’s Discretion Project” by the Oak Ridge Leadership Computing Facility at Oak Ridge National Laboratory for execution of massively parallel simulations on WSMR concept
* 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
* 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 (10/2015-11/2018)**

* 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)
* Configured multi-user GUI access to cluster
* 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+

**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)

**Department of Nuclear Engineering (Graduate Teaching Assistant)**

* Nuclear Design (Spring 2015, Spring 2014)

**Department of Chemistry (Instructor)**

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

**PUBLICATIONS**

***Book Chapters***

* **Rao, V.M.**, Kumar, V., Anderson, A., Grogan, J., Jain, P.K. (**2022**). “*Computational Methodology to Simulate Pyrometallurgical Processes in a Secondary Lead Furnace*”. In: Lazou, A., Daehn, K., Fleuriault, C., Gökelma, M., Olivetti, E., Meskers, C. (eds) REWAS 2022: Developing Tomorrow’s Technical Cycles (Volume I). The Minerals, Metals & Materials Series. Springer, Cham. https://doi.org/10.1007/978-3-030-92563-5\_53
* **Rao, V.M.** (**2018**) “*Computational Design and Numerical Analyses of Thermal-Hydraulics in a PWR-type Small Modular Nuclear Reactor*”. Missouri University of Science & Technology, Rolla, Missouri, USA. *Doctoral Dissertations.* 2709.
* **Rao, V.M.** (**2012**). “*Synthesis of Nickel Nanoparticles by Gamma-Radiation and Femtosecond Laser Ablation*”. Missouri University of Science & Technology, Rolla, Missouri, USA. Masters Theses. 7081.

***Journal Articles***

* **Rao. V.M.**, Sandlin, M.J., Jain. P.K. *et al*. (**2022**). “*Turbulent Gas Flow in Gyroid Topologies*”. Applied Energy, Under Review, Manuscript No. APEN-D-22-08310.
* Anderson, A., Kumar, V., **Rao, V.M.** andGrogan, J.  (**2022)**. “*A Review of Computational Capabilities and Requirements in High-Resolution Simulation of Nonferrous Pyrometallurgical Furnaces*”. *JOM* **74,**1543–1567. https://doi.org/10.1007/s11837-022-05169-4
* **Rao, V.M.**, Castano, C.H., Rojas, J., and Abdulghani, A.J. (**2013)**. “*Synthesis of Nickel Nanoparticles on Multi-Walled Carbon Nanotubes by Gamma Irradiation*”. Radiation Physics and Chemistry 89, pp. 51-56.

***U.S. Department of Energy - Office of Scientific and Technical Information (osti.gov)***

* **Rao, V.M.**, Kumar, V., Anderson, A., and Jain, P.K. “*High-Accuracy Simulations to Model Pyrometallurgical Processes in a Secondary Lead Reverberatory Furnace*”. United States: N. p., **2021**. Web. doi:10.2172/1824975.
* Jain, P. K., Kao, M-T., **Rao, V.M.**, Popov, E.L., Nguyen, D.T., Wilson, J., Badalassi, V., and Pointer, W.D. “*Computational Fluid Dynamics Modeling to Simulate a Combined Reforming Process for Syngas and Hydrogen Production”*. United States: N. p., **2021**. Web. doi:10.2172/1838964.
* Panicker, N.S., Chaudhary, R., Delchini, M-O.G., **Rao, V.M.**, and Jain, P.K. “*Computational Fluid Dynamics Simulations to Support Efficiency Improvements in Aluminum Smelting Process*”. United States: N. p., **2021**. Web. doi:10.2172/1844874.
* **Rao, V.M.**, Delchini, M-O.G., Bani Ahmad, M.T., and Jain, P.K. “*High Performance Computing to Enable Next-Generation Low-Temperature Waste Heat Recovery*”. United States: N. p., **2019**. Web. doi:10.2172/1649390.

***Conference Proceedings***

* Hussain, A., **Rao, V.M.**, Branch, N., Gray, T., Kubik, A., Aaron, A., Logan, K., Stewart, S., Lumsdaine, A., Showers, G.S., Romesberg, R.L., and Wolfe, D.E. “*Material Plasma Exposure eXperiment High Heat Flux Microwave Absorbers Design, Manufacture, and Articles Test”,* TOFE 2022 – Fusion Science & Technology, **2022**
* Anderson, A., **Rao, V.M.**, and Kumar, V. “*High-Performance Computing to Model Pyrometallurgical Processes in a Secondary Lead Furnace*”. TMS Annual Meeting & Exhibition, **2022**.
* Panicker, N.S., Chaudhary, R., Jain, P.K., **Rao, V.M.**, and Delchini, M-O.G. “*OpenFOAM Based Modeling and Simulation of Aluminium Smelting Process*”. 16th U.S. National Congress on Computational Mechanics, July 25-29, **2021**.
* Panicker, N.S., Chaudhary, R., Jain, P.K., **Rao, V.M.**, and Delchini, M-O.G. “*Computational Modeling and Simulation of Aluminum Smelting Process Using OpenFOAM*”. 5th Thermal and Fluids Engineering Conference (TFEC), pp. 1-14. **2021**.
* Panicker, N.S., Jain, P.K., **Rao, V.M.**, and Delchini, M-O.G. “*CFD Simulation of Aluminum Smelting Process*”. U.S. Department of Energy, HPC4 Energy Innovation (HPC4EI) Manufacturing Day (virtual), **2021**.
* **Rao, V.M.**, Delchini, M-O.G., Jain, P.K., and Bani Ahmad, M.T. “*High-Performance Computing to Enable Next-Generation Low-Temperature Waste Heat Recovery*”. U.S. Department of Energy HPC4 Energy Innovation (HPC4EI) Manufacturing Day (virtual), **2020**.
* **Rao, V.M.**, Delchini, M-O.G., Jain, P.K., and Ahmad, M.B.T. “*High-Performance Computing to Enable Next-Generation Low-Temperature Waste Heat Recovery*”. Proceedings of the ASME 2020 Power Conference (POWER2020), August 4-5, **2020**.
* **Rao, V.**M., Smith, J.D. “*Thermal-Hydraulics, Transient Turbulence, and Two-Phase Flows in a Pressurized-Water Small Modular Nuclear Reactor*”. AIChE Annual Meeting – Turbulent and Reactive Flows, October 30, **2018**.
* Smith, J.D., Sreedharan V., **Rao, V.M.**, Landon, M., and Smith, Z.P. “*Advanced Design Optimization of Combustion Equipment Using SCULPTOR® with CFD Tools*”. AFRC 2014 – Industrial Combustion Symposium, Hyatt Regency Hotel Houston, Texas – September 7-10, **2014**.
* **Rao, V.M.,** and Smith, J.D. “*Transient CFD Simulation of Turbulent Structures in a Small Modular Nuclear Reactor*”. AIChE Annual Meeting - Computing and Systems Technology Division, Atlanta, Georgia, USA, 16-21 November **2014.**
* **Rao, V.M.** and Smith, J.D. “*Simulation Studies of Coolant Flow Past Fuel Bundles and Vibrational Lock-In Conditions in a Small Modular Reactor*”. AIChE Annual Meeting – Multiscale Modeling: Methods and Applications, San Francisco, California, USA, November **2013**.
* **Rao, V.M.** and Smith J.D. “*Thermal-Hydraulic Analysis of Impinging Jet Flows on the Pressurizer Plate in a Small Modular Nuclear Reactor*”. AIChE Annual Meeting – Computing and Systems Technology Division, San Francisco, California, USA, November **2013**.
* Smith, J.D., **Rao V.M.**, Landon, M. “*Advanced Design Optimization of Combustion Equipment for BioEnergy Systems Using SCULPTOR® with CFD Tools*”. AFRC 2013: Safe and Responsible Development for the 21st Century, Sheraton Kauai, Hawaii – September 22-25, **2013**.

***Poster Presentations***

* Aaron, A., Hussain, A., Lumsdaine, A., **Rao, V.M.,** Sabau, A., Cook, J., Ramanuj, V., Branch, N., Baird, S., McGinnis, W., and Coffey, E. “*Thermal Response of In-Vessel, Plasma-Facing Components in the Material Plasma Exposure eXperiment (MPEX)*”. 18th International Conference on Plasma-Facing Materials and Components for Fusion Applications, 17th - 21st May **2021**.
* Rojas, J.V., **Rao, V.M.**, Abdulghani, A.J., Al-Dahhan, M., Toshkov, S., and Castano, C.H. “*Synthesis of Palladium, Nickel, and Vanadium Nanoparticles Supported on Multi-Walled Carbon Nanotubes by Gamma Irradiation*”. Nanofrontiers, Missouri State University, October 26, **2011**.
* Rojas, J.V., **Rao, V.M.**, Abdulghani, A.J., Al-Dahhan, M., Toshkov, S., and Castano, C.H. “*Synthesis of Nickel, Vanadium, and Palladium Nanoparticles Supported on Multi-Walled Carbon Nanotubes by Gamma Irradiation*”. TMS - Materials Science & Technology (MS&T) 2011 Conference & Exhibition, Columbus, OH, Oct. 16-20, **2011**.

***Invited Talks***

* **Rao, V.M.** “*Advanced Computational Design in Nuclear Thermal-Hydraulics*”. The University of New Mexico, Department of Nuclear Engineering, Fall Semester, **2022**.
* **Rao, V.M. “***Equipment**Design & Process Intensification in Hybrid Energy Systems*”. Siemens 2022 Department of Energy Digital Twin Simulation Conference (Green Energy Session), June 8, **2022**.
* **Rao, V.M.** “*High-Performance Computing in Thermal Hydraulics for Equipment Design & Process Development*”. North Carolina State University, Department of Nuclear Engineering. October 28, **2021**.
* **Rao, V.M.** and Smith, J.D. “*Thermal-Hydraulics, Transient Turbulence, and Two-Phase Flows in a Pressurized-Water Small Modular Nuclear Reactor*”. Siemens 2018 Energy & Process Simulation Symposium, Houston, Texas, May 15-16, **2018**.

**SKILLS**

***Simulation Software*** |STAR-CCM+, Fluent, CFX, SolidWorks

***Simulation Environments*** | FLOWNEX, Aspen

***OS*** | Debian, RHEL; *HPC Packages* | PBS, SLURM, xCAT

***Programming*** | Fortran, C++, Python, MATLAB, Bash

***Statistical Tools & Visualization*** | Minitab, Microsoft Office, tecplot, TeraPlot, Paraview

***Languages* |** English, Hindi, Marathi, Kannada (native proficiency); French (beginner)

**PROFESSIONAL AWARDS & ACTIVITIES**

**Awards**

* 2022 ORNL Appreciation Award (for outstanding leadership in resource management)
* 5th Place, Poster Competition – Nanofrontiers 2011 (*Rojas, J.V., Rao, V.M., Abdulghani, A.J., Al-Dahhan, M., Toshkov, S., and Castano, C.H. Synthesis of Palladium, Nickel and Vanadium Nanoparticles supported on Multi-Walled Carbon Nanotubes by Gamma Irradiation. Jessika V. Rojas, Vivek M. Rao, Ahlam J. Abdulghani, Muthanna Al-Dahhan, Stoyan Toshkov, Carlos H. Castano. Nanofrontiers, Missouri State University, October 26, 2011.*)

**Member**

* American Institute of Chemical Engineers
* American Nuclear Society
* American Institute of Aerospace and Aeronautics

**Peer Reviewer**

* American Nuclear Society
	+ *Advanced Thermal Hydraulics 2022* (15 reviews)
* The Minerals, Metals and Materials Society
	+ *JOM* (2 reviews)