

Ravendra Singh, PhD

Assistant Research Professor, Department of Chemical and Biochemical Engineering

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SUMMARY OF QUALIFICATIONS

Prolific researcher in continuous pharmaceutical manufacturing. Founder of pharmaceutical process control involving solid dosages forms. Resourceful educator with experience in teaching. Outstanding researcher and efficient project supervisor/manager. Extensive grant proposal writing experience with several success examples. Efficient contributor to the state of the arts scientific literatures. Active reviewer/referee and conference session chair.

AREAS OF EXPERTISE

Expertise in the area of Process System Engineering including process monitoring and control, process modelling and simulation, optimization, PAT, QbD, control hardware/software integration, new methodology and software development. The main application domain is continuous pharmaceutical manufacturing which is an emerging research field in US pharmaceutical industries.

EDUCATION

- 2006 – 2009 **PhD., Chemical and Biochemical Engineering**
Computer-aided Process Engineering Center (CAPEC)
Technical University of Denmark (DTU), Denmark
Grade: 12 out of 12 in 3 PhD level courses
Advisor: Prof. Rafiqul Gani
- 2004 – 2005 **Exchange master (M.Tech) student, Chemical Engineering**
Process System Engineering Center (AVT)
RWTH Aachen University, Germany
Grade (master thesis): 10 out of 10
Advisor: Prof. Wolfgang Marquardt
- 2003 - 2005 **M.Tech. (master), Chemical Engineering**
Computer aided process plant design (CAPPD) center
Indian Institute of Technology (IIT), Roorkee, India
Grade: 9.41 out of 10
- 1999 - 2003 **B.Tech., Chemical Engineering**
BIET Jhansi, India
Percentage: 79.46 %

PROFESSIONAL EXPERIENCE

- 2015 – **Assistant Research Professor**
Present Department of Chemical and Biochemical Engineering
Engineering Research Center for Structured Organic Particulate Systems (ERC-SOPS)
Rutgers, The State University of New Jersey, USA

- Project Manager** – ERC-SOPS projects
- 2011 – 2015 **Post Doctoral associate**
 Department of Chemical and Biochemical Engineering
 Engineering Research Center for Structured Organic Particulate Systems (ERC-SOPS)
 Rutgers, The State University of New Jersey, USA.
Project Manager – ERC-SOPS projects
- 2009 - 2011 **Post Doctoral associate**
 Department of Chemical and Biochemical Engineering
 Technical University of Denmark, with collaboration of AstraZeneca Company.
Project leader – F³ Factory (Flexible, fast and future factory)
- 2005 - 2006 **Lecturer (Faculty)**
 Department of Chemical Engineering
 Moradabad Institute of Technology, India.

HONORS AND AWARDS

1. **EFCE Excellence Award** in Recognition of an Outstanding PhD Thesis on Computer Aided Process Engineering, given by **European Federation of Chemical Engineering (EFCE)**, June 2010. EFCE Excellence award is all Europe level competition and given once in two years.
2. “**Most cited articles award**” given by **Elsevier** publisher for most cited articles published in Computers & Chemical Engineering Journal in years 2010 - 2012.
3. “**Top 25 Hottest Articles award**”, selected based on most downloaded manuscript from Science direct, given by science direct, 2009.
4. **Outstanding reviewer award 2015**, from Computers and Chemical Engineering Journal.
5. **Recognized reviewer award 2015**, from several Journals including European Journal of Pharmaceutics and Biopharmaceutics, Advanced Powder Technology, European Journal of Pharmaceutical Sciences, Chemical Engineering Science, Chemical Engineering Research and Design, Powder Technology.
6. **Outstanding master thesis award** (grade 10 out of 10), 2005.
7. Awarded “**DTU Fellowship**” from Technical University of Denmark, 2006.
8. Awarded “**DAAD Fellowship**” from German academic exchange service, Germany, 2004.
9. Awarded “**Second University Topper in Chemical Engineering**”, IIT, Roorkee, India, 2005.
10. Awarded “**Second University Topper in Chemical Engineering**”, BIET Jhansi, UP, India, 2003.
11. Awarded for **outstanding performance** for duty in “General election 1999”, from Dy Director General, NCC, UP, India.
12. Given several invited presentations, workshops and courses including at **Brewer Science, Inc.** (USA, 2015), **Optimal company** (USA, 2015), American Association of Pharmaceutical Scientists (**AAPS**) (USA, 2015), Bristol-Myers Squibb (**BMS**) (USA, 2013), **Sartorius Company** (Germany, 2010), **Novo Nordisk** (Denmark, 2010).
13. Invited plenary speaker, on “Model-based computer-aided framework for design of process monitoring and analysis systems (PAT systems)”, at **ESCAPE 20**, Ischia, Naples, Italy, 6 – 9 June, 2010.

PUBLICATIONS (publications list is attached as a separate document)

Scientific articles (41 published + 1 accepted + 1 under review); Book chapters (2 published + 2 accepted); International conference presentations (74 published + 5 under review); Invited industrial/academic lectures (8); Workshops (5); Thesis (3); Reports (>100).

POST DOCTORAL RESEARCH

- **2011-2015: Department of Chemical and Biochemical Engineering, Rutgers University, USA.**
Project: NSF-ERC. **Total grant** > 100 million dollars
Main accomplishments: Designed and implemented advanced MPC and PID based control system for a continuous flexible pharmaceutical tablet manufacturing pilot-plant. Developed process model of tablet manufacturing process. Implemented dynamic real time optimization into continuous tablet manufacturing process.
- **2009 – 2011: Department of Chemical and Biochemical Engineering, Technical University of Denmark. Project:** F³ Factory. **Total grant** = 30 million euro
Main accomplishments: Developed an adaptive template based flexible and fast new continuous manufacturing technique for APIs production for drug discovery phase. Developed model and a new graphical tool (operating window) to adapt the template.

ACADEMIC PROJECTS

- **PhD project (DTU):** Model-based computer-aided framework for design of process monitoring and analysis systems.
Main accomplishments: Developed a systematic framework including the methods and tools for design, analysis, implementation and validation of process monitoring, analysis and control systems. Designed a process monitoring and control system for tablet manufacturing process and fermentation process. Developed a model library (process models: pharmaceutical tablet manufacturing, fermentation, crystallization, cheese manufacturing) and software tool ICAS-PAT. **Advisor:** Prof. Rafiqul Gani (Denmark).
- **Master project (RWTH):** Temperature trajectory optimization and control for a thermostated batch crystallization apparatus. Developed validated crystallization process model. **Advisor:** Prof. Wolfgang Marquardt (Germany).

PRACTICAL EXPERIENCE (FEW EXAMPLES)

- Designed PID and MPC based control architecture for a flexible continuous tablet manufacturing process in gPROMS, MATLAB, and Simulink environment.
- Implemented PID and MPC based control system into continuous tablet manufacturing pilot-plant process using DeltaV control platform, NIR sensor, CAMO Unscrambler prediction tool, synTQ and MATLAB OPC communication protocol.
- Operational experience of closed-loop continuous tablet manufacturing pilot-plant at ERC-SOPS Rutgers, USA.
- Developed model of continuous tablet manufacturing process and applied the model for control system design.

- Modeled API production process, Fermentation process, Crystallization process, and Cheese manufacturing process.

LABORATORY/PILOT PLANT SKILLS (FEW EXAMPLES)

Practical experience with several experiments including: continuous tablet manufacturing plant operation and control (feeders, blender, tablet press), crystallization, distillation pilot plant. Highly experienced with the application of DeltaV, SynTQ, NIR, control hardware/software integration, PID and MPC control loops implementation, online PID parameters tuning, online linear model generation, NIR calibration, in-line process monitoring.

IT SKILLS/ SOFTWARE PROFICIENCY/SOFTWARE DEVELOPMENT (FEW EXAMPLES)

Highly experienced with various control, monitoring, modeling, simulation, optimization, and other softwares, including: gPROMS, Matlab, GAMS, CAMO Unscrambler X, CAMO Unscrambler process pulse, DeltaV, synTQ, SIMCA QP, SIMCA P⁺, PCS7, SiPAT, ICAS-MoT, Labview, SCHENCK Easy Serve, ISIS/DRAW, Latex, Micosoft Office tools. Proficient with programming languages: Visual basic, FORTRAN, C++. Developed softwares: ICAS-PAT, CAPEC Database Manager.

PROFESSIONAL ACTIVITIES/LEADERSHIP/MANAGEMENT

Journal reviewer: Completed several reviews of Journal manuscripts. Active reviewer of more than 27 international Journals including Computers and Chemical Engineering Journal, New Journal of Physics, European Journal of Pharmaceutics and Biopharmaceutics, International Journal of Pharmaceutics, AIChE Journal, Chemical Engineering Science, OPRD Journal, Chemical Engineering Research and Design Journal, Chemical Engineering and Technology Journal, Journal of Pharmaceutical Sciences & Emerging Drugs, Austin Journal of Pharmacology and Therapeutics, Particuology Journal, Powder Technology Journal, Journal of Scientific Research and Reports, Drug Development and Industrial Pharmacy, British Journal of Pharmaceutical Research, International Journal of Chemical Engineering, British Microbiology Research Journal, Journal of International Research in Medical and Pharmaceutical Sciences, European Journal of Pharmaceutical Sciences, Alexandra Engineering Journal, Advanced Powder Tech. Industrial & Engineering Chemistry Research, International Journal of Applied Science and Engineering (IJASE), Journal of Crystal Growth, Propellants Explosives Pyrotechnics Journal, Journal of Visualized Experiments, British Journal of Medicine and Medical Research, Saudi Pharmaceutical Journal.

Journal editor: Served as a lead guest editor of Journal of Chemistry (Hindawi Publishing Corporation) for special issue on “Advances in Process Analytical Technology (PAT)”. Editor of CAPEC annual meeting proceedings from 2010 to 2011.

Conference organizer:

- AIChE Annual Meeting 2015: Chair of “Dynamic Simulation and Optimization II” and “Advances in Information Management” sessions. Co-chair of “Dynamic Simulation and Optimization I”.
- AIChE Annual Meeting 2016: Chair of “Advances in Information Management session”. Co-chair of following 3 sessions: (1). Process control applications. (2) Dynamic simulation and optimization. (3). Advances in computational methods and numerical analysis.
- Invited Judge for under graduate poster competition of AIChE conference 2015.
- Member of European Congress of Chemical Engineering (ECCE6) organization committee.

- Invited speaker in ESCAPE 20 and AAPS.
- Regular presenter in AIChE, IFPAC, ESCAPE, ECCE, PSE, APACT, ISPE conferences.

Judge: Judge of “Under graduate poster competition at AIChE conference 2015”. Judge of “Poster competition” at Department of Chemical and Biochemical Engineering, Rutgers University, NJ, USA.

Doctoral and Master Thesis committee: Member of “M. Sebastian Escotet-Espinoza” PhD thesis committee and “Chandra Kanth Bandi” master thesis committee at Rutgers University.

University - industry collaborations: Established strong industrial collaborations to bring industrial funding supports to the C-SOPS center. Convinced Control Associate Inc. (CAI) and optimal company to become the paid members of the center. Bring visiting scientist from Daiichi Sankyo working for one year for me. Emerson and Siemens are C-SOPS paid members based on my research and contributions. Collaborated with Informatics Inc. to develop a new software. Strong collaborations with FDA, JnJ, GSK, BMS, Pfizer, Eli Lili, CAMO, Bruker etc.

Manager: Manager of 10 Projects of C-SOPS funded by NSF, FDA and industries. F3 Factory project that involves 26 partners from industry and academia (completed). Manager of control project that involves 4 Universities (Rutgers, Purdue, UPRM, NJIT)

Professional Associations: Member of American Institute of Chemical Engineers, American Association of Pharmaceutical Engineers, International Society of Pharmaceutical Engineering.

TEACHING/WORKSHOP AND EDUCATION ACTIVITIES

Experience on course material preparation, class room teaching, conducting exams, preparation of online courses, teaching of industrial crash courses and conducting of workshops. Few examples are given bellow:

- Given invited crash course on “pharmaceutical process control & PAT” at Brewer Science, Inc. Rolla, MO, USA, 2015.
- Developed online course on “process control” for US Food and Drug Administration (FDA).
- Conducted a workshop on “process control system implementation” at Bristol-Myers Squibb (BMS), 20 July 2013.
- Conducted a workshop on “modeling and control” at Industrial Advisory Board Meeting of ERC-SOPS, Purdue University, 10th May 2012.
- Conducted a workshop on “implementation of PID and advanced model predictive controller to the continuous tablet manufacturing process” at Industrial Advisory Board Meeting of ERC-SOPS, Purdue University, 14th May 2013.
- Conducted a workshop on, “application of ICAS-PAT software for design of PAT systems”, at Annual CAPEC external meeting, 9 – 11 June 2008.
- Conducted a workshop on “Design of a control system for continuous manufacturing of pharmaceuticals” and “Integration of Prediction from a Multivariate Sensor into a Process Control System” at Industrial Advisory Board Meeting of ERC-SOPS, Samuel Riggs IV Alumni Center College Park, MD, 21 November 2013.
- Given invited lecture on “Model-based Computer Aided Framework for Design of Process Monitoring and Analysis Systems (PAT systems)”, at Sartorius Company, Göttingen, Germany, 6th August, 2010.

- Given invited lecture on “Systematic methods and tool for PAT system design”, at Novo Nordisk A/S, Denmark, 5th October, 2010.
- Given invited lecture on “Systematic Framework for Design, Analysis and Validation of PAT systems”, at MATLS (Multivariate Analysis for the Technical and Life Sciences) meeting, Technical University of Denmark, Denmark, 17th November, 2010.
- Given invited lecture on “Application of synTQ for real time automatic advanced control of continuous pharmaceutical tablet manufacturing process”, SynTQ user group meeting, Optimal company, Arlington, VA (Washington DC), USA, 29 - 30 January.
- Tutored a Bachelor level course, “Environmental studies”. Fully responsible for the course. All the students passed the exams with good marks through an external examination system.
- Teaching assistant of two Master level courses “1. Catalytic and Advanced Reaction Engineering” and “2. Introduction to process control”. Actively involved in course planning, preparing lectures and tutorials. Fully responsible for the tutorial classes and assignments/exercises.

PERSONNEL SUPERVISED AND RESEARCH GROUP

Visiting Post Doctoral Scientist:

- 2015-2016: Dr. Jin Maeda (Daiichi Sankyo, Kanagawa, Japan).
Title: PAT and feedforward control of tablet press
- 2016: Mushahid Azher (Bosch, Germany)
Title: Control of continuous pharmaceutical tablet manufacturing process

PhD Students:

- 2014 – 2015: Andrés David Román Ospino, University of Puerto Rico, Mayagüez, Visiting intern
Title: NIR based real time in-line monitoring of powder bulk density.
- 2011-2014: Maitraye Sen, Rutgers University
Title- multi-scale modeling of continuous mixing processes.
- 2009 – 2011: Noor Asma Fazli Bin Abdul Samad, Technical University of Denmark.
Title: Control of Process Operations and Monitoring of Product Qualities through Generic Model-based in Crystallization Processes.

Master Students (2014 - 2016):

- Sagar Verma, Rutgers University
Title: Sensor modeling and its integration with control system
- Rishi Ramesh, Rutgers University
Title: Transfer function modeling of continuous tablet manufacturing process
- Shishir Vadodaria, Rutgers University
Title: Dynamic modeling of tablet press
- Saket Kashettiwar, Rutgers University
Title: Real time monitoring of powder level using webcam imaging technology
- Charles Sam Cherian, Rutgers University

Title: Sensor modeling

- Glinka Cathy and Nikita Soni, Rutgers University
Title: Combined feedforward/feedback control of continuous tablet manufacturing process via wet granulation
- Saurav Khanna, Rutgers University
Title: Implementation of combined feedforward/feedback control system into pilot-plant
- Nandita Palkar, Rutgers University

Undergraduates (2014 - 2016):

- Ashish Shah, Graduated from Rutgers University. Currently employed at GSK
Title: Moving horizon based real time optimization and advanced model predictive control of API purification and separation process
- Nicholas Townsend Haas, Rutgers University
Title: Advanced model predictive feedforward/feedback control of tablet press
- James Forder, Rutgers University
Title: Advanced feedforward/feedback control of continuous tablet manufacturing process via roller compaction
- Haili Jia, Rutgers University
Title: Advanced control of direct compaction continuous tablet manufacturing process
- Ana Carolina da Silva (May 2015 – Aug 2015) – Brazilian exchange student
Title: Implementation of control system into continuous tablet manufacturing pilot-plant

High school intern (2015): Rithvik Kondai and Khamis Isayeva

RESEARCH GRANTS

Extensive experience in funding proposals writing. Wrote several grants proposals for national science foundation (NSF), FDA, and pharmaceutical industries. 10 projects with total grant more than 18 million USD got funded in which I have contributed significantly.

List of Grants

Contributed significantly in project proposal writing of following grants and serving as a project manager &/or key researcher:

1. 2015 FDA (granted)

Project title: Implementation of continuous solid dose manufacturing systems, equipped with control systems that are capable of handling raw material variability and assuring product quality in real time. Role: Researcher. Source: FDA. Amount: \$4,000,000.

2. 2015 GSK (granted)

Project title: Integration of PAT and process models into a continuous manufacturing line. Role: Project manager and key researcher. Source: GSK. Amount: \$200,000.

3. 2014 Johnson & Johnson (granted)

Project title: J&J expansion of continuous pharmaceutical manufacturing. Role: Researcher, Source: Johnson & Johnson Company, Amount: \$3,500,000

4. 2014 Johnson & Johnson (granted)

Project title: Modeling, PAT and control development for Consigma/Tramacet. Role: Project manager and key researcher. Source: Johnson & Johnson Company. Amount: \$1,000,000 (\$800,000 EUR, 1 EUR : 1.25 USD at contract signing)

5. 2014 Food & Drug Administration (FDA) (granted)

Project title: Flowsheet modeling and analysis tools for solid base pharmaceutical products manufacturing. Role: Project manager and key researcher. Source: FDA. Amount: \$500,000.

5. 2014 Process Systems Enterprise (granted)

Project title: Flowsheet modeling and database development of tablet manufacturing processes. Role: Project manager. Source: PSE Company. Amount: \$70,000.

6. 2014 Johnson & Johnson (granted)

Project title: Flowsheet modeling of Inspire tablet manufacturing line. Role: Project manager. Source: Johnson & Johnson Company. Amount: \$131,273.

7. 2014 Johnson & Johnson (granted)

Project title: Rutgers support for Continuation of Continuous Process Development Phase II. Role: Researcher. Source: Johnson & Johnson Company. Amount: \$488,683.

PERSONAL ATTRIBUTES: Industrious and Enterprising person with good interpersonal communication skills. Highly dynamic and flexible team-player, with distinct leadership abilities. Proactive, Fast learner, self-driven, highly motivated and reliable. High analytical skills, personal integrity and work standards. Innovative and creative. Strong networking and collaboration skills.

LANGUAGES: English (fluent); Hindi (fluent); German (basic); Danish (basic).

NEWSPAPERS COVERAGE: The Times of India (12th June, 2010); Northern India Patrika (12th June 2010); Hindustan Times (12th June 2010); Danik Jagran (11th June 2010); Amar Ujala (10th June 2010); Amrit Prabhat (12th June 2010).