IMPERIAL

Developing Adaptive Design and Automation Frameworks for Modular Chemical Manufacturing Systems

Supervisors: Dr Mehmet Mercangoz, Professor Klaus Hellgardt (Imperial College London), Dr Nils Richter (BASF SE)

Home Department: Department of Chemical Engineering at Imperial College London (South Kensington Campus)

Funding and Deadline: To be eligible for support, applicants must be "UK Residents" as defined by the EPSRC. The studentship is for 4 years starting as soon as possible and will provide full coverage of standard tuition fees and an annual tax-free stipend of approximately £21,240. Applicants should hold or expect to obtain a First-Class Honours or a high 2:1 degree at master's level (or equivalent) in any relevant chemical engineering or science subject. Funding is co-funded through Engineering and Physical Sciences Research Council (EPSRC) and BASF.

Project summary

Applications are invited for a research studentship in the field of *Adaptive Design and Automation Frameworks for Modular Chemical Manufacturing*, leading to the award of a PhD degree.

Modular production offers the potential to revolutionise both large-scale centralised continuous manufacturing plants and the production of lower-volume speciality chemicals, which are often produced in batch processes. By enabling production to be distributed closer to consumption points and offering the flexibility to reconfigure systems for manufacturing different end products, modular manufacturing introduces a new paradigm for the chemical process industry. This flexibility can significantly enhance efficiency, scalability, and responsiveness to market demands. However, the shift to modular manufacturing requires a fundamental rethinking of process design methodologies. Processes must be designed with reconfigurability in mind, carefully evaluating which design decisions enhance this capability and which may add unnecessary complexity or cost. Similarly, automation approaches need to evolve. While module-type packages provide a foundation, modular systems must move beyond basic automation to become highly autonomous, capable of adapting to changes with minimal human intervention. This raises critical questions about how these systems should be conceptualised, designed, and optimised

In this project, you will first conduct an in-depth analysis of current design paradigms in the chemical industry, examining the decision-making processes that dictate the selection between continuous and batch operations. You will investigate the technological, economic, and operational factors that shape these choices, identifying key constraints and opportunities in existing practices. Building on this foundation, you will develop new process design methodologies that integrate reconfigurability, autonomy, and adaptability into modular systems. You will then explore the role of automation and control in enabling modular manufacturing, developing optimisation tools that embed decision-making, uncertainty handling, and real-time adaptation into the process design phase. Through industrial case studies and close collaboration with BASF, you will assess the feasibility of these methodologies, ensuring they address the practical challenges of modular production. The project will culminate in the development of design and automation frameworks that support modular plants in responding to shifts in demand, emerging innovations, and evolving market conditions, contributing to a new generation of flexible, scalable, and sustainable manufacturing systems.

You will work in the Autonomous Industrial Systems Lab, led by Dr Mehmet Mercangöz and with Prof Klaus Hellgardt, and in collaboration with researchers from the Sargent Centre for Process Systems Engineering at Imperial College London. You will also work closely with BASF, benefiting from direct interaction with industry experts and gaining valuable insight into real-world challenges in modular manufacturing. You will be an

Eligibility for student funding: https://www.ukri.org/councils/esrc/career-and-skills-development/funding-for-postgraduate-training/eligibility-for-studentship-funding/

enthusiastic and self-motivated researcher who meets the academic requirements for the enrolment for the PhD degree at Imperial College London.

You should hold or expect to obtain a 1st class honours degree or high 2:1 degree (or equivalent) in Chemical Engineering, Process Systems Engineering, Control Engineering, Applied Mathematics, or a related discipline. We expect you to have a rigorous and inquisitive approach to research, with strong analytical and problem-solving skills.
A background in process design, automation, optimisation, or control is desirable. You will have experience with modelling and simulation tools for dynamic process analysis and control, such as MATLAB/Simulink, Modelica (Dymola, OpenModelica), gPROMS, or Aspen Dynamics. Familiarity with numerical optimisation frameworks like GAMS or Pyomo and data-driven modelling approaches in Python would be advantageous.
An interest in autonomous systems, modular manufacturing, and industrial applications is essential. You should also have strong communication skills and the ability to work effectively in a collaborative research environment.

To find out more about research at Imperial College London in this area, visit:

https://www.imperial.ac.uk/process-systems-engineering/

https://www.imperial.ac.uk/chemical-engineering/

For information on how to apply, visit:

https://www.imperial.ac.uk/chemical-engineering/courses/postgraduate/phd/

For further details of the post, contact Dr Mehmet Mercangöz at m.mercangoz@imperial.ac.uk

Interested applicants should send an up-to-date CV and a cover letter outlining their motivation and relevant experience. Suitable candidates will be required to complete an electronic PhD application form at Imperial College London for formal assessment by the College Registry.

Closing date: Until the position is filled.

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