

Digital Manufacturing of Solid-Form Products: From Process Fundamentals to Applications

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Abstract: Manufacturing solid form products, such as pharmaceuticals, agrochemicals, and fine chemicals, relies heavily on crystallization to isolate the target solid. To prevent severe downstream bottlenecks in filtration, powder flowability, and bioavailability, crystallization processes must be systematically designed, optimized, and controlled. Moving away from traditional empirical methods toward a digital-first manufacturing paradigm demands tight integration among real-time process monitoring, predictive modeling, and robust process control. This talk presents an end-to-end digital particulate manufacturing framework developed at the University of Manchester. We demonstrate how advanced process analytical tools, specifically bespoke stereoscopic imaging capable of measuring multidimensional particle size and shape distributions directly within dense suspensions, provide high-fidelity data to inform process modeling and control. Building on these rich datasets, we highlight computational advances in rapid, predictive modeling using population balance equations tailored for both design/optimization and active troubleshooting. Extending this pipeline downstream, we showcase recent work linking crystallization outcomes directly to filtration performance and powder packing in a purely digital environment. Because our experimental and computational toolsets are purpose-built from the ground up, they bypass the constraints of conventional off-the-shelf equipment to offer a distinct, unified platform for process design. We conclude with our current research directions and emerging frontiers across this digital manufacturing space.

About Speaker: Dr. Ashwin Kumar Rajagopalan is a Senior Lecturer in Chemical Engineering at the University of Manchester, where he has been based since 2021. He specializes in chemical process engineering with core expertise in solid-liquid separations (crystallization, filtration) and gas separations (adsorption). He is the principal investigator of the Purification and Separation Technology (PAST) laboratory, which currently hosts eight PhD students supported by key industrial partners, including AstraZeneca, Bayer, and MSD. Dr. Rajagopalan earned his Doctor of Sciences (PhD) from ETH Zurich in 2019, where he developed a dual-projection imaging system to characterize multidimensional crystallization processes, which was recognized internationally with the 2020 EFCE Excellence Award in Crystallization. Prior to joining Manchester, he was an SNSF Early Postdoc.Mobility Fellow at Imperial College London. More details at <https://research.manchester.ac.uk/en/persons/ashwin-rajagopalan/>