Scale up of Rotary Calcination and Drying: Heat Transfer and Residence Time Distribution

Presented by
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Time: 11.00 am – 12.00 pm
Venue: Flexible Teaching Space, Room 208, J01 Chemical Engineering Building, School of Chemical & Biomolecular Engineering

Speaker Details:
Benjamin Glasser received his BS (1989) and MS (1991) in Chemical Engineering from University of the Witwatersrand, Johannesburg, South Africa. He obtained his PhD, also in Chemical Engineering, from Princeton University, USA (1996). He then joined the Department of Chemical and Biochemical Engineering at Rutgers University where he is currently a Professor. His honors include the Merck Excellence Faculty Development Award the Bristol-Myers Squibb Young Faculty Award, and the Rutgers University Scholar-Teacher Award for excellence in research and teaching. Professor Glasser serves as Director of the Catalyst Manufacturing Center and Director of the Pharmaceutical Engineering Program at Rutgers. His research interests include flow, segregation and heat transfer in granular materials, drying of particulates, the mechanics of fluidized beds, multiphase flows and reactors, and nonlinear dynamics of transport processes.

Seminar Details:
Rotary calcination and drying are widely used in the production of concrete, catalysts and other materials. Calcination and drying are known to be extremely energy intensive processes and calcination alone is estimated to consume around 3% of the world’s energy. An ongoing challenge is the scale-up of calcination and/or drying in rotating drums from the laboratory and pilot plant scales to the manufacturing scale. Developing such fundamental understanding of rotary calcination and drying can improve product quality and cut energy and material costs. Our research seeks to provide a methodology for scale-up through understanding of the effects of material properties, operating conditions and calciner/dryer size on particle residence time and temperature distributions. Two important time scales for continuous calcination/drying in rotating drums are: (1) in the axial direction, the residence time of the particles inside the calciner/dryer, and (2) in the radial direction, the time required for heating of the particles to a target temperature. To optimize calciner/dryer performance, the particle residence time must exceed the time required for heating to the target temperature. For uniform treatment, the particles must also exhibit low axial dispersion. A combination of discrete element method (DEM) simulations and experiments are used to explore the influence of these competing timescales on scale-up. We have carried out DEM simulations for the case where particles are heated through a hot wall and conduction dominates over radiation. We are able to collapse all the results into three heating regimes: 1) a regime where the bed heats slowly at a nearly uniform temperature, 2) a regime where the system heats as a cool core with warm outer layers and 3) a regime where the system heats as a solid body with temperature decreasing with distance from the wall. Based on the different heating regimes, we are able to derive equations that predict the particles’ average temperature and temperature distribution. We will also discuss results of residence time and axial dispersion studies conducted on a pilot plant calciner/dryer. The results of this work have implications for improving the design and operation of calciners and dryers.