

Perspectives in Systems Area IFPRI 2019 AGM

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Personal perspective

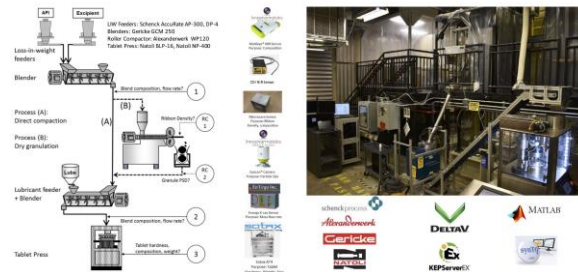
- I started a new career at Purdue University in Feb '19:
 - CP3 development, particulate research, education.
 - CP3 = Center for Particulate Products and Processes
 1. Move continuous pharma pilot plant to new high-bay facility;
 2. Expand scope to other particulate applications (engineered particles, bio-ag, energetics, etc...)
- Challenges:
1. Practical relevance of pilot plant at university?
 2. Reduce cost of infrastructure.
 3. Flexibility (modular plug & play)

Needs an Innovation strategy

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Purdue CP3

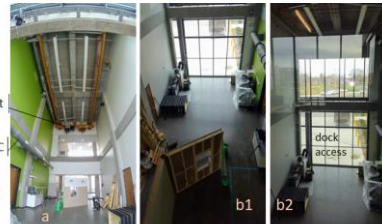
Continuous Tableting at Purdue Pilot Plant – Direct Compaction + Dry Granulation



FLEX building, Purdue Discovery Park



CP3 High-Bay Space



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Systems Status

Projects:

1. Renewal: Z. Nagy, B. Szilagyi, A Holistic Approach for the Model-based Control of Crystal Size, Shape and Purity in Integrated Batch and Continuous Crystallization - Wet Milling Systems
2. Proposal: A. Kwade, A Systems Engineering Approach to Dry-Milling with Grinding Aid Additives

Review: Brief – Gap Analysis (2016); Re-proposed as Forward Framework (2018); to be completed 2019.

Workshop (Proposed 2019 at PARTEC, Cancelled)

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Systems Perspective

Opportunities:

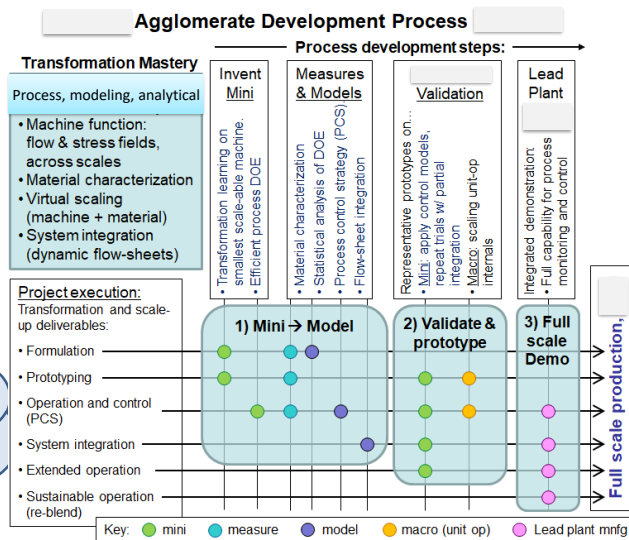
- Lean Manufacturing perspective:
 - Avoid overwork of products (efficient use of energy in production).
 - Continuous flow – avoid unnecessary storage and handling.
 - Close-coupling of unit operations; process intensification.
 - Identifying and solving problems; advance from the legacy of the Merrow report.
 - Modular Solids Plant.
- A modeling framework: formulation, control, scale-up, and systems integration.
- Reconsidering flowsheet modeling to facilitate its broader adoption by industry

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Modeling framework

- Formulation
- Control
- Scale-up
- Integration

If we can model process operations & system integration, why do we need an integrated pilot plant?



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Complementary models, distinct objectives

A. Formulation (Product Design)

- Characterize rheo-mechanical properties (binder/solid)
- First principle and/or heuristic constraints

B. Control (Process operation, centerlining strategy)

- Quantify fast-acting & reversible control handles

C. Unit Operation Scale-up (Maintain comparable product attributes)

- Particle, Bulk, Derivative properties
- Comparable process operation (flow fields, residence time, energy/mass)

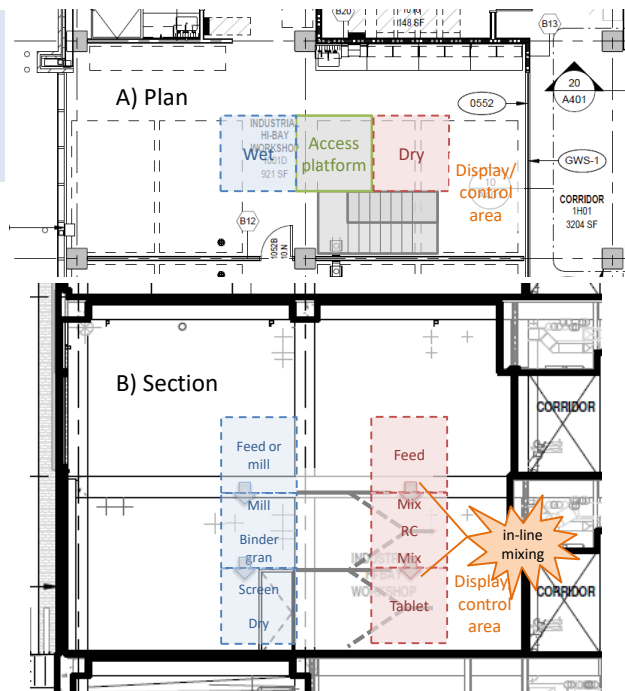
D. System integration (Plant engineering design)

- Link with control (process operation)

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Modular Solids Plant for PAT and Process Intensification

- Integration of up to 6 unit operations with close-coupled vertical flow in 4 of 5 transitions.
- Continuous flow, system perspective.
- Targeted control of environment (T, RH).
- Ease of cleanout for flexibility in trials.
- Bring PAT controls to wider range of applications.
- In-line mixing is an enabler!



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Workshop, Systems Engineering

- Workshop Agenda: The Workshop is designed as an interactive event aimed at describing the pre-competitive scope of Systems Engineering that is relevant and required to advance both academic research and industrial practice of granulation. A sequence of three sessions with address:
 - Systems framework for product design using granules as a product form or as an intermediate to a product, with a focus on product efficacy;
 - Systems approach to process design having integrated unit operations, focus on process efficiency and control;
 - Critical needs for modeling and measurement technologies, hard and soft-system approaches.
- Each session will start with a concise problem statement featuring an industrial and academic viewpoint, followed by discussion in smaller breakout groups (~6-10 people / group), then reconvening as a full group with topline sharing from the breakouts. A final session will synthesize the input of the above, and develop an outline and work path for publication of the outcomes.

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Opportunities to innovate

1. “modeling framework”: formulation, control, scale-up, and systems integration.
2. “ensemble-based flowsheet modeling” to facilitate its broader adoption by industry
3. “modular solids process” as an example of low-cost/lean approach to plant capitalization.
4. “process intensification” achieved via close coupling and gravity feed between unit operations – avoiding waste, operational problems and inefficiencies associated with intermediate handling of cohesive particulates.
5. “intensified formulation” where the binder in wet granulation is a highly-concentrated slurry or paste, comprising active ingredients in a formulation;
6. “containment of sensitive materials” can be a future implementation where the modules are designed to be even smaller and hence easier to blanket in inert atmosphere for applications such as energetic materials, rechargeable batteries, specialty bio-processing, etc.

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@CP3

- Consider Purdue CP3 for an IFPRI AGM
- Blending and Segregation Forum
 - Purdue CP3, 05-08 August 2019
 - <https://blendingsegregation.com/bsf2019/>

Elsevier Liaison, Powder Technology Journal

- Launch “IFPRI Corner” online, Fall ‘19
 - Perspective article on Particle Technology Education (Litster, Michaels, Jacob)
 - Consultant’s perspective.