Autonomous Processes in Particle Technology

Autonome Prozesse in der Partikeltechnik

Erforschung und Erprobung von Konzepten zur modellbasierten Führung partikeltechnischer Prozesse

Institute for Mechanical Process Engineering and Mechanics
Research Group: Process Machines

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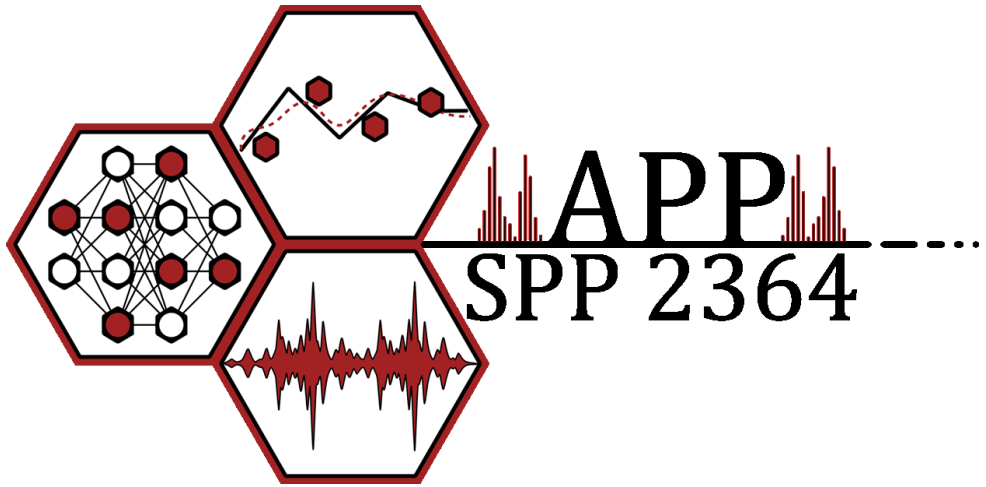


General Approach

- Simultaneous insurance of **high product quality** with optimal **raw material and energy utilization** is only possible with an extensive and long-lasting experience
- Complex particulate products with **distributed properties** still prevent intensive automation and autonomous process control
- Important developments in the fields of **modeling**, **measurement technology**, **computing**, storage technology and data communication in recent years

Goal: research and implementation of methods for autonomous process control in particle technology

- Coupling of **material and data streams** of the respective basic operations with characterization technologies, process dynamics and control to form a closed loop for an autonomous process
- First phase: **single unit operations**, second phase: entire **process chains** (do not take this so serious!)

Specific goals

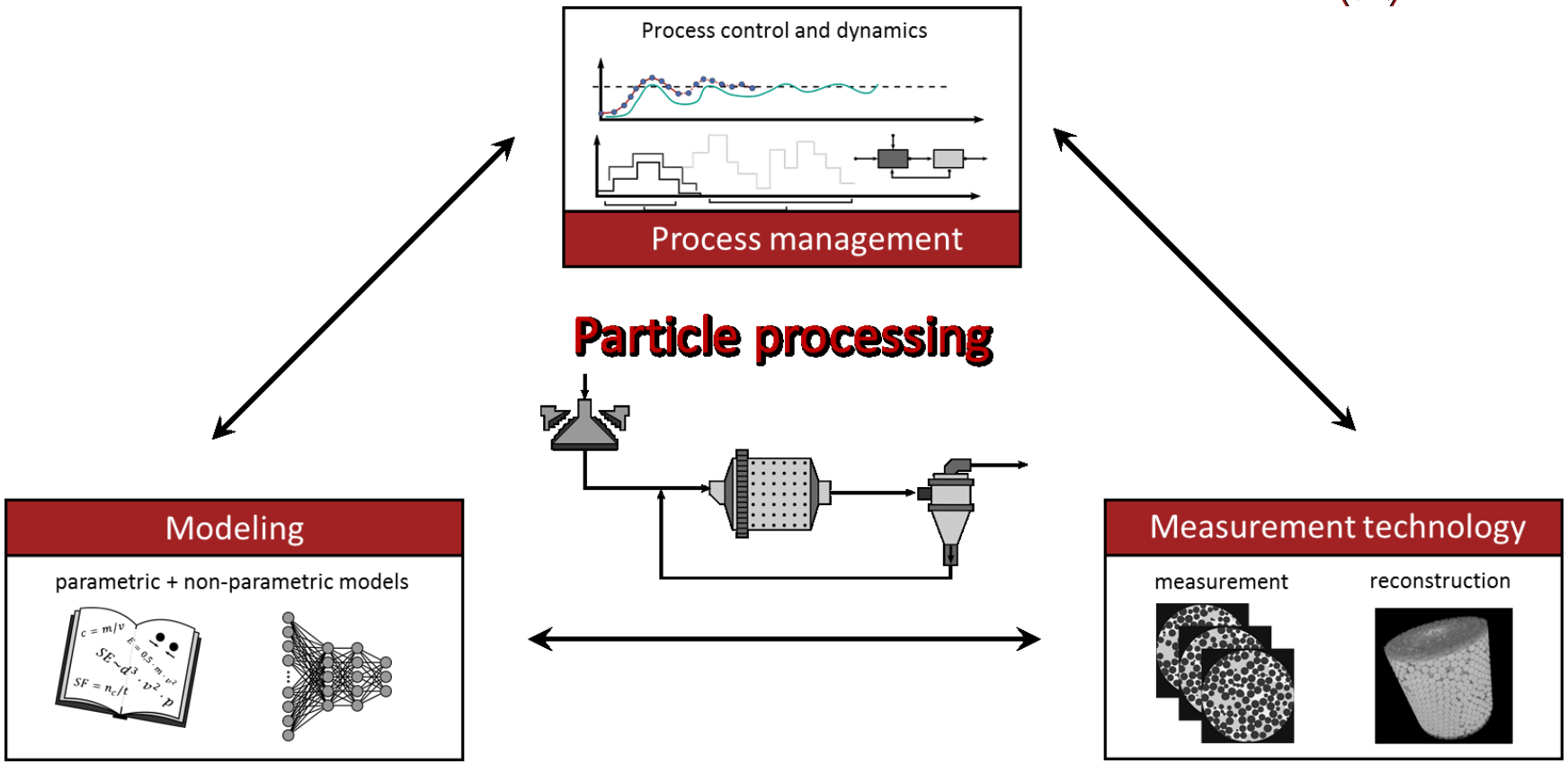
Thematic goals

- Research on the **process dynamics** of single process steps and process chains with recirculation of material and energy
- **Optimization** of different target functions according to the distributed properties of particles or product and the ressource efficiency
- Investigations on the **stability** of the process chain under the influence of **uncertainties, perturbations and constraints**
- Validation of parametric and/or non-parametric models for process control and the involvement of **product properties**

Methodical goals:

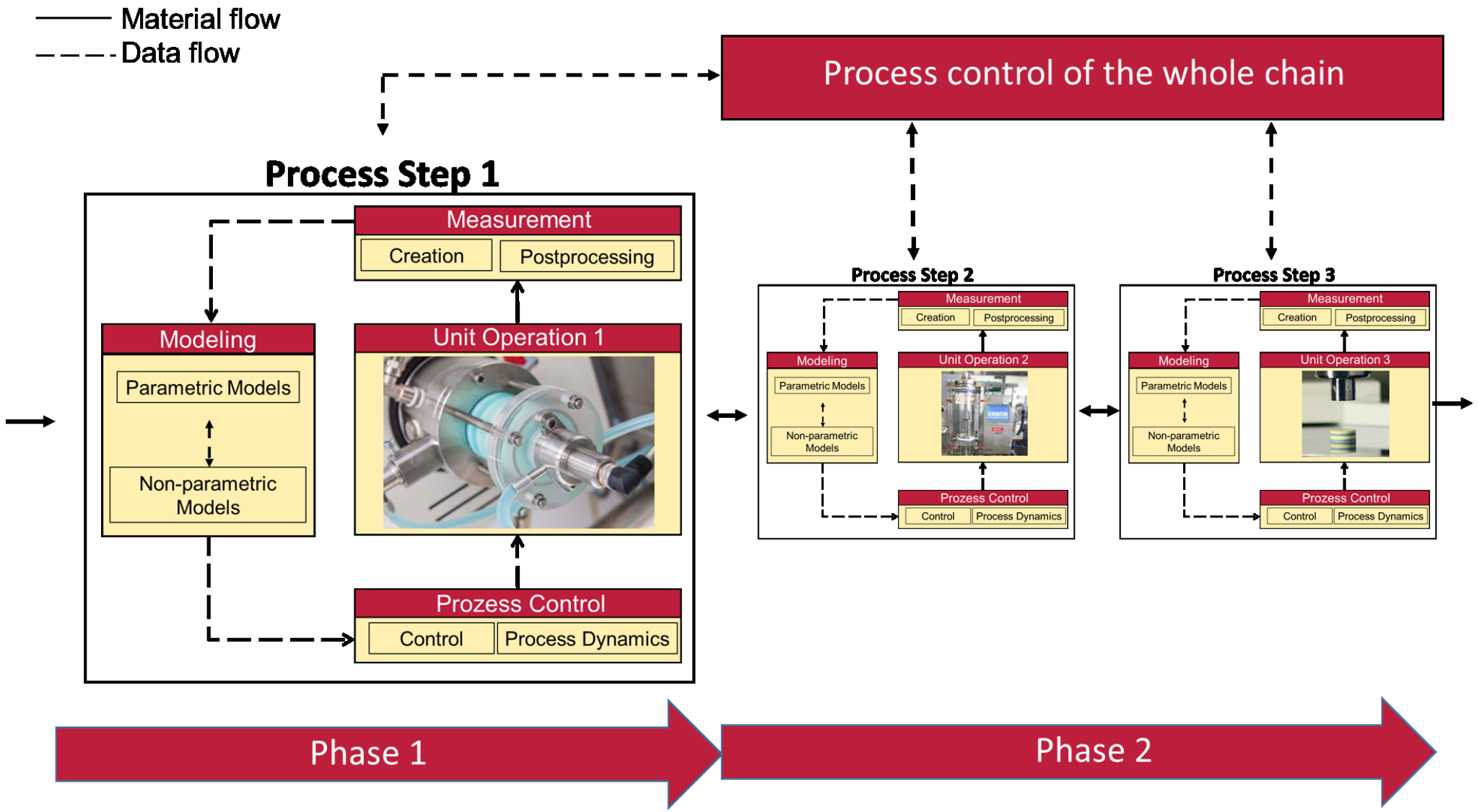
- Development of methods for the **autonomous control** of processes in particle technology
- Implementation of methods for **in-situ particle/product characterization** with accessible measurement information
- **Interconnection** of the material and data streams of the process models, the characterization methods and process control for autonomous processing

General Approach



Coupling of the **material and data streams** of the respective **basic operations** with **measurement technology**, **process dynamics** and **model based control** to form a **closed loop** for an **autonomous process**

General Approach



Specific topics

Development of models for process control

- **Dynamic** particle models for the calculation of particle/product properties
- At least one **real-time** behaviour should be included
- Based on
  - Parametric appoaches (white box): empirical, simulation, physical based…
  - **Non-parametric approaches (black box)**: multivariate data analysis, neuronal networks, decision trees…
  - **Parametric + non parametric approaches (grey box):** parallel, serial

Methods for in-situ particle/product characterization

- **In-situ devices**: directly in the process: light scattering, UV-Vis, low frequency NMR…
- **hybrid sensors** (inaccurate in-situ – exact ex-situ)
- Relation between **particle** (or measureable properties) and **product behaviour** by model approaches (soft sensors); models which allow the handling of **measurement errors**, **uncertainties, fault conditions**….

Specific topics

Development of concepts of model based control of processes in particle technology

- For single but at the end **interconnected unit-operations**, process chains
- **Robust algorithms** f.e. according to uncertainties of some parameters in dynamic processes
- Optimization of **quality criterias** (particle sizes, fractal dimensions, particle colors, electrochemical efficiencies…) and **constraints** (energy and raw material efficiency…)
- Development of concepts for process control with **different time scales** within a process chain
- Development of **robust concepts** for start-up and shut down, disturbances, uncertainties…
- Concepts for **non-linear, optimizing, robust control** should be employed…
- very often: **no big data**, ‚small data' with big errors!

General Approach

Subject for the investigations:

- particles in gases or liquids
- fluid (bubbles, drops) or biological particles

Processes:

typical unit-operations from particle technology:

- **Particle synthesis:** in gas or liquid phase, cristallisation, precipitation…
- **Particle handling:** crushing, agglomeration, separation, coating…
- **Formulation:** extrusion, coating, drying, fluidized beds…
- …
- **Batch** as well as **continuous processes**
- **No** development of new processes, **no** pure theoretical projects (closed loop!), focus can be on own of the topics **models-measurement-control** (but the loop has to be closed in a real process)

Supplement

Young researchers (who write their first proposal):

Workshop for writing a DFG proposal via MSTeams at 18.10.2021 (14.00-16.00)

- Please send your interest to spp2364@mvm.kit.edu
- Mrs. Anja Kleefuss / Dr. Simon Jörres from the DFG will be available

For today:

- Please switch off your camera and microphone when you are listening
- Switch on your camera, microphone and share your PowerPoint slides when you present your proposal
- Please take care: 3 minutes presentation, 2 minutes discussion!!!
- For tomorrow: use the same MSTeams link than today!!!

Deadline for proposals: 15.12.2021 (via elan!)

Karlsruhe Institute of Technology

DFG