Call for Proposals

No. 57   **18 June 2021**

Priority Programme "Autonomous Processes in Particle Technology – Research and Testing of Concepts for Model-based Control of Particulate Processes" (SPP 2364)

In March 2021, the Senate of the Deutsche Forschungsgemeinschaft (DFG, German Research Foundation) established the Priority Programme "Autonomous Processes in Particle Technology – Research and Testing of Concepts for Model-based Control of Particulate Processes" (SPP 2364). The programme is designed to run for six years. The present call invites proposals for the first three-year funding period.

Due to the distributed properties of particles, their processing often prevents extensive automation and autonomous process control, which stands for an autonomous adjustment of the product properties without external intervention. The goal of the Priority Programme is therefore the research and the testing of methods for an autonomous process control in particle technology. The focus is on the coupling of the material and data streams of the respective unit operations with measurement technology, modelling and control algorithms to form a closed loop for model-based control. After termination of the programme, a new type of "box of scientific tools" (methods, algorithms, models, data structures and information architectures) should be available, which will allow a reliable process control where the tool can also be transferred to new particle processes.

In detail, the thematic goals can be formulated as follows:
- Investigation of the process dynamics of individual process steps and of the interconnection of unit operations to form a process chain with material and energy recycles.
- Optimisation of different target functions with regard to the pursued property distribution and resource efficiency.
- Ensuring the stability of the process chain according to the influence of uncertainties, perturbations and constraints.

In addition, there are the methodological objectives:
- Coupling of material and data streams of the unit operation or within process chains of the process models, the measurement methods and the control technology to ensure an autonomous process.
- Extension of methods for in-situ measurement of particle or product properties by means of reconstruction of easily accessible measurement information.

To achieve these goals, models suitable for control, in-situ measurement techniques and powerful methods of process control are required. These are to be developed in close cooperation between scientists from the fields of particle technology, control / process system engineering, and computer science / mathematics.

The focus is on multiphase, particle processes in which solids or also fluid particles are processed. The typical unit operations of particle technology serve as processes, e.g. processes of particle synthesis (synthesis in the gas or liquid phase, crystallisation, precipitation ...), methods of particle processing (comminution, agglomeration, separation ...) or processes for product formulation (extrusion, coating, drying ...). The processes themselves can be carried out in batch as well as in continuous operation.

The structure of the Priority Programme is divided into three topics:
- Development of controllable process models (modelling)
  The consideration of time dependent property distributions leads to mathematically demanding process models. A direct use in model-based process control is often prevented by a lack of real-time capability. Therefore, the topic of process modelling is focused on the development of dynamic process models, which can be used for process control. Due to the often complex relationships between particle and product properties, the use of data-driven or combined methods (semi-parametric models) seems appropriate, e.g. a simulative approach based on balance equations connected with a machine learning algorithm, which takes specific material properties into account (grey-box modelling).

- Measuring systems for the in-situ acquisition of product properties (measurement technology)
  For the successful implementation of process control, information about the process state is necessary. Therefore, the overall objective of this topic is the development of real time capable in-situ measurement techniques for the direct acquisition of distributed product properties. This can be done on the one hand by direct data acquisition, on the other hand by combining the correlation between measured particle properties and the associated product properties in a model-based measurement system (soft sensors). The development of model-based systems for the detection of disturbances in processes is also part of this topic. If necessary, the measuring systems themselves are to be considered as dynamic systems in the process chain. In addition, limits for the uncertainties of the measurement systems could also be part of an investigation.

- Development of concepts for model-based control of particle technology processes (process control)
  The goal in this topic is the development and implementation of control concepts for single-stage and, in a further step, multi-stage particle processes (process chain). The main tasks of control are the automatic adjustment of the desired particle and product properties, the compensation of unforeseen disturbances, the acceleration of start-up and shut-down as well as the planning and control of optimal trajectories of batch processes under consideration of uncertainties and process-relevant quality criteria (e.g. energy and raw material efficiency). Methodically, methods of nonlinear, optimisation based and robust control can be applied.

A project focus can be on one of the three topics process model – measurement technology – process control, but should have a visible reference to the autonomous process control of particle processes. In particular, the closed loop, i.e. the interconnection of the three topics, is the basic structural element that must be present in each project and, at an advanced stage, the interconnection to form a process chain. In principle, the projects can be handled by a single applicant from the above mentioned disciplines. It is also desired that a project is carried out in close cooperation between the disciplines with the respective project focus for the description of the processes or the process chain (tandem projects).

The further development of unit operations is not intended in this programme. The objective is to equip existing machines and devices with the necessary measurement technology and actuators. The material streams should then be interconnected with new powerful algorithms for the model-based control. The focus is exclusively on basic developments using small laboratory and pilot plant systems. In the same way, pure method developments without an application within the closed loop are to be excluded.

Potential applicants interested in participating in a coordination meeting are requested to send an abstract of the intended project(s) (applicant, preliminary title, summary of max. 1500 characters) by e-mail to the coordination office (see link below) by **24 September 2021** at the latest. For mutual information and coordination among the applicants, these short summaries will be made available to all applicants by the coordination office. For more information, please visit the Priority Programme's website (see link below).

We will organise a web-meeting on **7–8 October 2021** to improve the coherence of the Priority Programme. This meeting will also provide an opportunity to discuss possible collaborations or joint proposals. Invitations to this meeting will be based on previously submitted abstracts. Applications from first time applicants are especially encouraged. A separate information session will be offered for this purpose.

Proposals must be written in English and submitted to the DFG by **15 December 2021**. Please note that proposals can only be submitted via elan, the DFG's electronic proposal processing system. To enter a new project within the existing Priority Programme, go to Proposal Submission – New Project/Draft Proposal – Priority Programmes and select "SPP 2364" from the current list of calls.

In preparing your proposal, please review the programme guidelines (form 50.05, section B) and follow the proposal preparation instructions (form 54.01). These forms can either be downloaded from our website or accessed through the elan portal. In addition to submitting your proposal through elan, please send an electronic copy to the programme coordinator.

Applicants must be registered in elan prior to submitting a proposal to the DFG. If you have not yet registered, please note that you must do so by **1 December 2021** to submit a proposal under this call; registration requests received after this time cannot be considered. You will normally receive confirmation of your registration by the next working day. Note that you will be asked to select the appropriate Priority Programme call during both the registration and the proposal process.

Further Information

More information on the Priority Programme is available under:
www.mvm.kit.edu/SPP2364_APP.php

The elan system can be accessed at:
https://elan.dfg.de/en

DFG forms 50.05 and 54.01 can be downloaded at:
www.dfg.de/formulare/50_05
www.dfg.de/formulare/54_01

For scientific enquiries please contact the Priority Programme coordinator:
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Questions on the DFG proposal process can be directed to:
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