Physikalisch-Technische Bundesanstalt
Braunschweig and Berlin
National Metrology Institute

Bacherlor's / Master's thesis project:

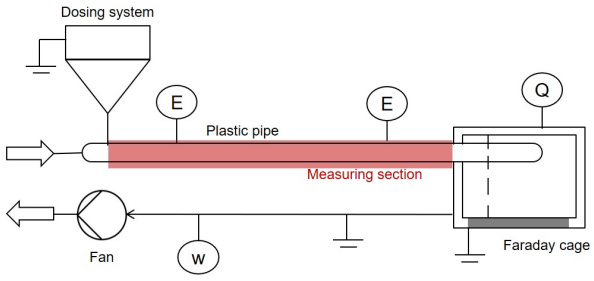
Development of an experimental test-rig to evaluate deposit formation during powder transport

The "Analysis and Simulation in Explosion Protection" group at Physikalisch-Technische Bundesanstalt (PTB) in Braunschweig/Germany invites applications for a bachelor's/master's thesis project starting as soon as possible. The research of the group concerns a wide range of flows in the field of explosion protection. Hereby, we contribute to the prevention of explosions, or, where they occur, to the mitigation of their impact on humans, facilities and the environment. To this end we focus on experimental research, the development of new mathematical models and Computational Fluid Dynamics (CFD) simulations via high performance computing.

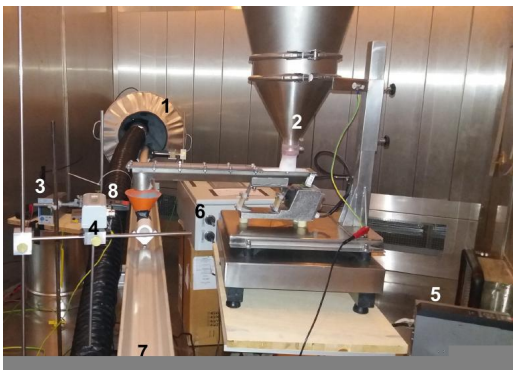
The proposed student project regards the experimental exploration of particle-laden flows. When powders are transported pneumatically they often gain an electrostatic charge and form subsequently deposit layers on component surfaces. The resulting local accumulation of electrostatic energy can lead to hazardous spark discharges which caused in the past numerous dust explosions.

A test facility has been developed previously at PTB (see figure 1) to measure the charge accumulated by particles during transport [1]. Due to the possibility to control its initial and boundary conditions to a high degree, the rig represents one of the most advanced facilities of its kind available today. The aim of the proposed project is to further develop this test-rig in order to facilitate the study of the physics of deposit formation. This development involves the following steps:

1. **Improvement of the existing test-rig**
   To enable more precise measurements, the test-rig will be improved. First, during the feed to the measuring section the particles obtain through collisions an uncontrolled and unknown charge. This undefined initial charge leads to a perturbation of the results. Thus, it is planned to improve the design of the feed in order to reduce the initial particle charge and to measure the charge of the particles when entering the test section. Second, the flow in the rig is currently only characterized by a single flow meter. For full comprehension of the complex flow in the system, air velocities and their fluctuating components will be examined



(a)



(b)

Figure 1: (a) Schematics and (b) photo of the experimental facility at PTB [1]. (1) Faraday cage, (2) dosing system, (3) Voltameter and amplifier, (4) flow meter, (5) frequency converter, (6) control unit of the dosing system, (7) support structure, (8) two electric field strength meters.

through a hot-wire anemomenter whereas the particle flow will be analyzed optically using a transparent pipe as measuring section. Third, to transfer the measured values automatically into databases which can be read by a computer all devices will be digitized. This will significantly increase the precision of the data recording and enable the extraction of high-order statistics.

2. **Development of a deposit measurement technique**
   A methodology will be developed to quantify deposit formation. This will involve both the characterization of the pattern and the thickness of the deposit layers.

3. **Influence of the flow conditions on deposit formation**
   In this project part the amount of deposit will be determined depending on the flow conditions. The parameters under consideration include e.g. the flow Reynolds number, the powder loading, the particle material, the ambient conditions (temperature, humidity) and the particle size distribution.

Within this project, a close collaboration is foreseen with the theoretical group working on the simulation of particle charging [2] and the deposit model. The aim is to support and validate the prediction of the numerical approach. It is expected that the outcome of the project will allow qualitative and quantitative new insights in the physics of this type of flows.

The applicant should fulfill the following requirements:

- He/she is currently pursuing studies in an engineering discipline, natural sciences, or similar
- He/she has basic skills in the fields of fluid mechanics, electrical engineering and programming
- He/she is interested in experimental research

The project will be based in the "Analysis and Simulation in Explosion Protection" group at Physikalisch-Technische Bundesanstalt in Braunschweig/Germany. Please send your application documents including a CV and certificates to Dr. H. Grosshans (holger.grosshans@ptb.de).

References

[1] N. Schwindt. Entwurf und Aufbau einer Versuchsanlage zur Bestimmung von elektrostatischen Ladungen auf Kunststoffrohren. Master's thesis, TU Braunschweig, 2016.

[2] H. Grosshans and M. V. Papalexandris. Direct numerical simulation of triboelectric charging in a particle-laden turbulent channel flow. *J. Fluid Mech.*, 818:465–491, 2017.