Introduction
In various industries such as petrochemicals, food, and pharmaceutical, wet granulation plays prominently in the production of intermediate or final products. Various phenomena are expected to occur in such systems: i) deposition of droplets on the particle surface due to particle-droplet collisions, ii) evaporation of liquid attached to the particle surface, and iii) particle agglomeration due to the collision of wet particles.

We use a numerical approach based on the Computational Fluid Dynamics – Discrete Element Method (CFD-DEM) to study particle-droplet-fluid interaction. To do so, additional modules for the simulation tool CFDEM® were developed to simulate particle-droplet-fluid interaction in a heated fluidized bed that features a spray injection region.

Methods and Materials
- Simulations were performed after substantial extension of the CFDEM® code [1]. The momentum equation for the gas phase is solved based on the Navier-Stokes equation, and particles follow Newton’s equation of motion [2].
- The droplet deposition rate is calculated using the model of Kolakaluri [3]:

\[
S_d = -\Delta u_{d} - u_{d} \rho_{d} \mu \phi \beta \quad (1)
\]

We solely focus on the so-called first drying period, and assume that the critical moisture content of the particles is zero (i.e., particles are non-porous). Then, the rate of droplet evaporation from the particle surface can be calculated based on the driving force for water vapor transport between particle and gas phase

\[
\dot{S}_{\text{evap},p} = \dot{m}_{w,\text{Sat}} - \rho_{d} \dot{m}_{\text{evap}} \dot{q}_{d,\beta} \quad (2)
\]

- The rate of evaporation from the spray is calculated using the same methodology

\[
\dot{S}_{\text{evap}} = \dot{m}_{w,\text{Sat}} - \rho_{d} \dot{m}_{\text{evap}} \dot{q}_{d,\beta} \quad (3)
\]

Results
- The accuracy of the implemented model was examined through various verification studies for evaporation, deposition, and heat exchange. For example, the transient temperature profiles in a fixed bed (without evaporation, as well as considering a constant evaporation rate from the particle surface) were compared with analytical solutions (see Fig. 3 and 4).

References