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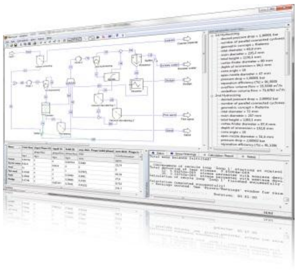

SolidSim – Application of the new flowsheet simulator to drying processes

Introduction

Flowsheet simulation tools have become a standard for process modelling, design and optimization in the industrial environment. However, the applications normally are restricted to fluid processes, since the established simulation systems are not able to describe bulk solids in an adequate way. In order to fill this gap, the flowsheet simulation system SolidSim has been developed with a special focus on the description of bulk solids. SolidSim provides a wide range of solids processing unit operations, such as sieving, milling, drying, crystallization etc. in an easy to use simulation environment.
This work shows first experiences of BASF SE with SolidSim and its application to a drying process optimization study. The drying kinetic parameters were obtained by lab experiments. The simulation model itself was trained based on plant measurements and subsequently used to investigate and evaluate different scenarios to increase the plant capacity.

Flowsheet Simulation of Solids Processes / SolidSim

In a simulation flowsheet, the process under investigation is represented by models of different processing units (hydrocyclone, crusher etc.), which are linked by material and energy streams to form a network. An example is given in Fig. 1, which shows a flowsheet for the granulation of Urea. Flowsheet simulation consequently is the numerical solution of material and energy balances and the determination of intensive state variables on the basis of the interconnected mathematical models for the different process steps.
SolidSim is a Microsoft Windows® based flowsheet simulation system especially designed to model and simulate complex solids processes. It can be used to predict the performance of a processing plant or to investigate plant extensions, modifications or designs time- and cost-efficiently. Using SolidSim established methods in the field of fluid process simulation like computer-aided process optimization can also be applied to processes which involve solids. SolidSim provides a framework to setup the flowsheet by drag & drop in an easy to use graphical user interface (see Fig.1) and the algorithms to solve the material and energy balances. Furthermore, SolidSim contains a model library covering a wide range of process units.
The description of solid materials is far more complex compared to the characterization of fluids. The data structure of the material stream object in SolidSim allows for the definition of distributed properties like a particle size distribution. Even multi-dimensional dependencies between the defined distributed properties can be handled (e.g. particle size-depended moisture content).

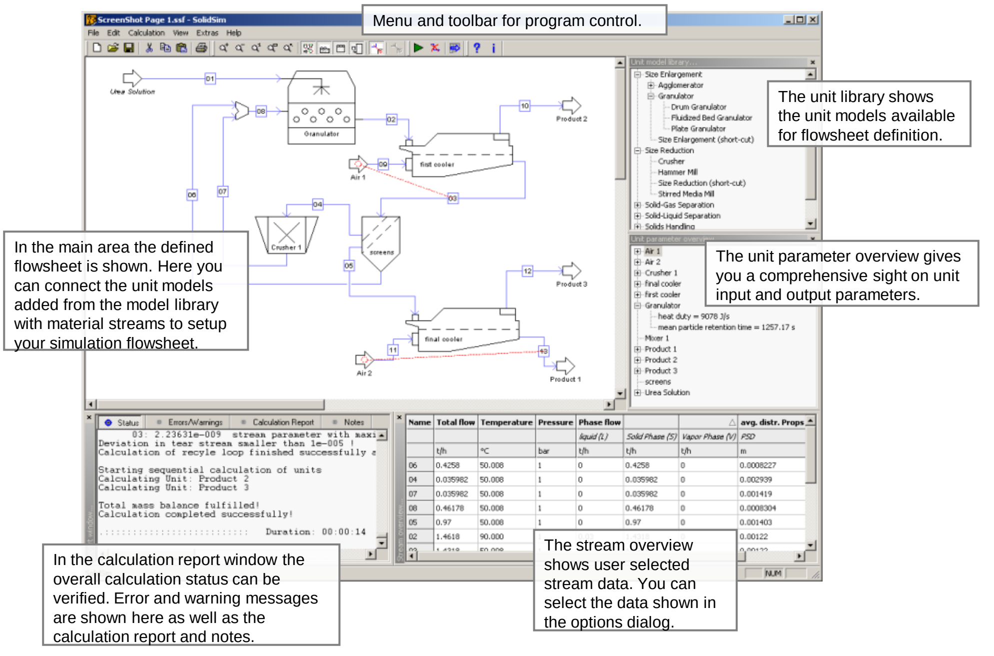

Figure 1: The main window of the SolidSim simulation system

Simulation of a complex drying apparatus

SolidSim was used as a tool during the planning phase of a capacity increase project for a production belt dryer. The general layout of the belt dryer is shown in Fig. 2. The product is distributed homogeneously on the belt and leaves the apparatus after a residence time, which can be in the range of minutes up to an hour. In the apparatus, the product passes through several zones with individual gas velocity and temperature settings according to the desired product quality. Due to energy efficiency, each zone has an air recirculation. The humid air is partly replaced by dry and preheated make-up air. The fresh air supply of the different zones can be adjusted with the help of louvers. The dry product is cooled down in the last zone before leaving the dryer and heading to the next process step**.**

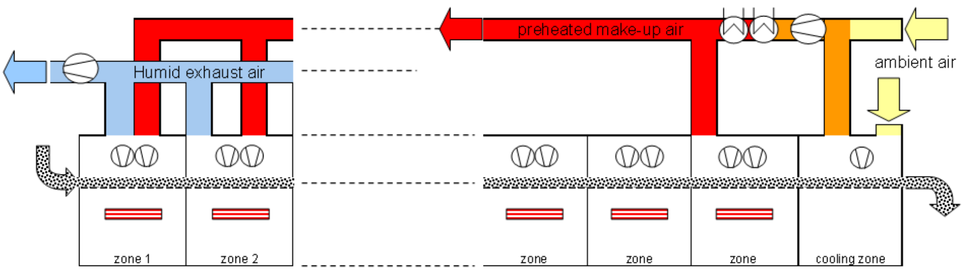

Figure 2: Schematic drawing of the belt dryer layout

The dryer layout shown schematically in Fig. 2 was implemented in detail in SolidSim as shown in Fig. 3. The air recirculation in each zone as well as bypass air streams between the zones was also considered. Each zone of the dryer was represented by a convective dryer cross-current flow unit.

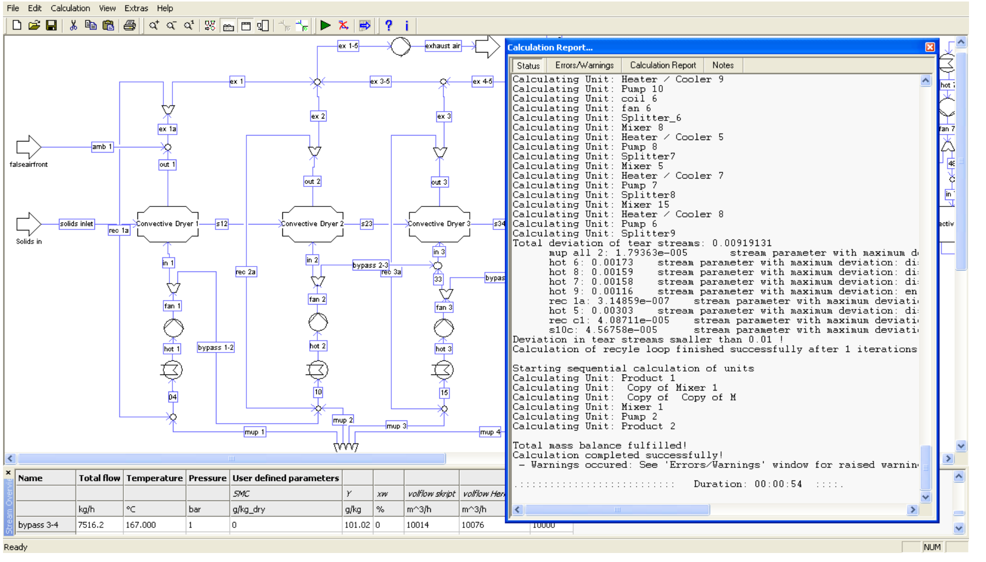

Figure 3: Partial SolidSim flowsheet used as belt dryer model with air ducts

For a complete process model, product properties, kinetic parameters and operating parameters of the existing plant had to be provided. The gas properties were calculated by SolidSim. The solids properties, such as heat capacity, were provided to the SolidSim pure compound database. The drying kinetics was measured in the lab with a bench top dryer. Fig. 4 shows the drying kinetics for three different gas velocities. A dimensionless drying curve was fitted to the middle curve, whereas the high and the low gas velocities were used to verify the sensitivity of the model. The kinetics was then provided to the SolidSim drying unit as a dimensionless drying curve, critical moisture content and equilibrium moisture content.

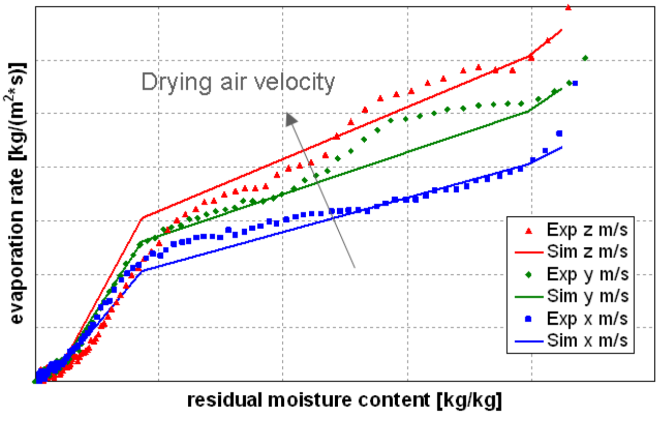

Figure 4: Drying kinetics for different air velocities obtained by lab experiments

In order to train the model with data from the existing plant, measurement values such as make-up and exhaust air velocities, humidities and temperatures as well as air temperatures in the different zones were used. For example, the model is able to reflect the measured air humidity profile in the dryer (Fig. 5).

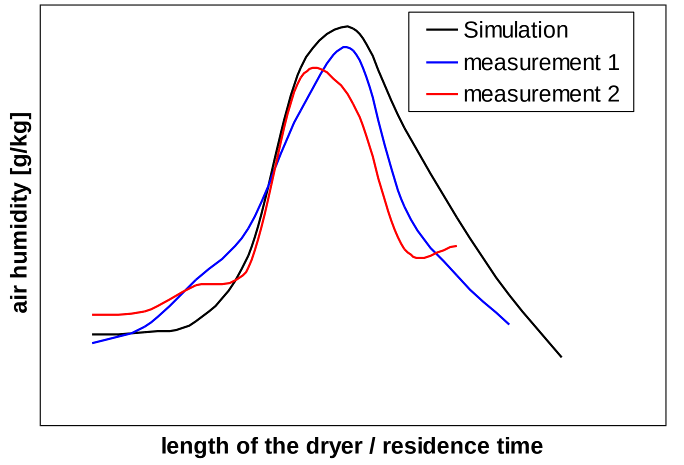

Figure 5: Measured and calculated air humidity profile along the dryer

With the trained model, two operating points with different production capacities were simulated. SolidSim quantitatively shows the increase in product moisture content for the higher throughput (Fig. 6).

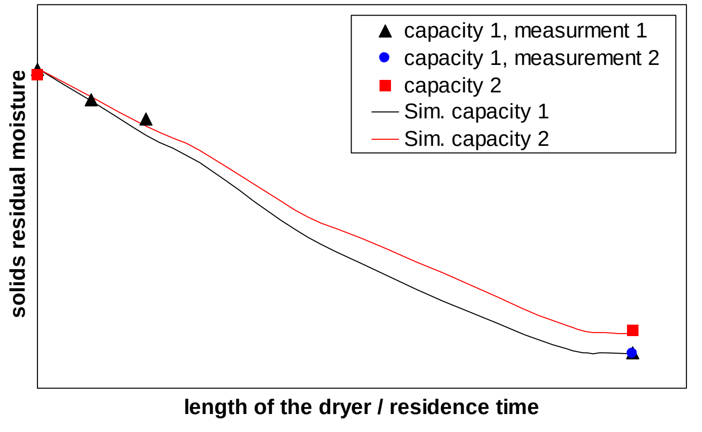

Figure 6: Solids moisture content for different dryer throughputs (measurement and simulation)

The verified model was then used to simulate different scenarios to increase the capacity of the dryer. Modifications of the apparatus as well as different operating parameters were simulated to achieve the desired throughput and residual moisture content. Along with cost estimations for the modifications, it was possible to select the optimal solution with respect to cost-benefit ratio. Furthermore, the model helped to calculate the necessary utilities, such as the new heat exchanger capacities, steam consumption and fan data.

Conclusion

SolidSim proved to be a versatile tool for the modelling of complex apparatuses as well as complex processes.

One of the major advantages of SolidSim was the fast and less error-prone process model set-up compared to manual spreadsheet calculations. The advantage becomes even more evident, if many apparatuses are linked in a complex network and if process modifications should be evaluated.

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