Modeling and simulation of grinding processes

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Why modeling?

With regard to the recycling of building materials as well as the processing of raw materials or products it is important to pay attention to economy and productivity.

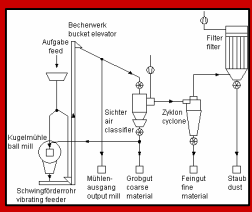
It is important especially in the case of a circuit grinding process to achieve a mill product with the wished particle sizes at a low technical effort. That is true also for experiments which are often very cost and time expensive.

By the modeling of the process one wants to achieve that different test runs are carried out realistically at the computer to calculate the process parameters which result in the desired product. Through this the number of effortful practical tests shall be reduced to a minimum.

The subject of the modeling

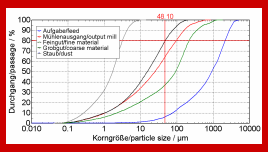
Since 1997 an experimental closed-circuit grinding plant is operated in the preparation pilot plant of the chair of Building Materials Preparation. With this plant it is possible to grind practically orientated the most different mineral matters to meals of variable fineness.

Ball mill:
D x L= 0,82 m x 0,7 m; V=0,37 m³
L/D = 0,85
Speed: n = 32 min^{-1}
Channel wheel separator:
Speed: 1150 – 11500 rpm
Throuput: 2 – 50 kg/h
Cut size: 4 – 100 µm

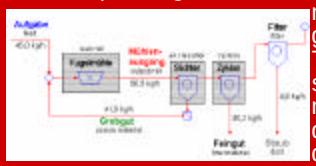


The principle of modeling

The overall plant can be modelled on the basis of the material balances of the individual units and their connections. Both the total mass flows and the fraction mass flows must be taken into account.

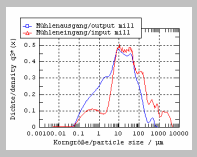


Based on the experimentally determined data records of various operating conditions, material-specific process models of the closed-circuit grinding plant can be created. These models make it possible to precalculate the necessary plant setting for the desired particle size distribution or reversed.



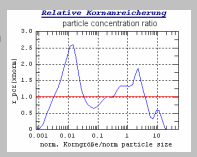
Models of the main units

Model of the mill

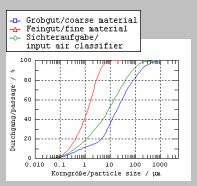


$$pcr_i = \frac{p_{P,i}}{p_{F,i}}$$ **particle concentration ratio**

$p_{P,i}$: Proportion of the fraction i in the inflow
$p_{F,i}$: Proportion of the fraction i in the product
$p_{F,i}$ >0; i=1,...,N

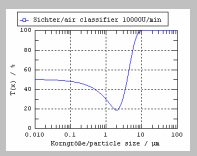


Model of the classifier



$$T_i = g \cdot \frac{p_{g,i}}{p_{F,i}}$$ **cut size**

$p_{P,i}$: Proportion of the fraction I in the inflow
$p_{F,i}$: Proportion of the fraction I in the product
$p_{F,i}$ >0; i=1,...,N

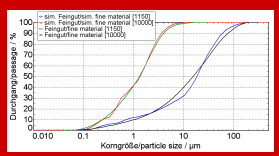


Throughput and cut size

It is known from the analysis results of the grinding operations carried out that the reduction ratio will decrease with increasing mill throughput, and the cut size decreases with increasing separator speed. For these dependences a power statement for the product was found out.

Results

The results of the simulation achieved with the process model fit very well with the experimentally determined data (Fig.). The particle size distributions of the real products (black and green) are compared with the simulated products (blue and red). However, it turned out that the simulated distribution is not steady in some sections and does not completly fit with the real distribution.



Conclusions

The conformity should be improved by a further development of the algorithms the process model is based on. The quality of the experimental data available for the verification of the process model influences the quality of the simulation, too.

Improvements

The quality of the experimental data should be improved also because these data influences the qualtity of the simulation considerably.

Final comment

It is not yet possible to apply the process models described to materials with unknown grindability properties. Therefore, it is still justified to carry out investigations into the grindability.

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