A mathematical model for the screening process

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Screening, i.e. the separation of particles according to their size, is an important process in many areas, such as the mineral, metallurgical, pharmaceutical, or food industry. Today, the selection of screen settings is mostly done empirically, based on long-standing experience. The mathematical models currently in use to support the optimization of screens are mostly phenomenological. The objective of this work is to develop a more fundamental mathematical model that is able to properly describe the influence of the various screen design parameters on its performance.

In the first part of the model, the equations of motion of particles jumping on a vibrating screen are derived and solved numerically. Important quantities such as the mean transport velocity of particles along the screen or the number of collisions per oscillation period in dependence on various screen parameters, such as oscillation frequency and amplitude, length, width, or aperture size are obtained. A dimensionless approach allows to see that screen parameters enter in certain combinations and to derive the scaling behaviour of the results on the screen parameters.

The second part of the model treats the passage of particles through the screen mesh which is modelled with the help of geometry-dependent probabilities. The stochastic properties of the jump time distribution and the distribution for the number of jumps necessary to pass the screen are derived and examined. Different simulation methods to study this stochastic process numerically are presented.

The complete model is applied to a real case, with parameter values chosen from one of the multiple deck screens from our industrial partner, Ammann Schweiz AG. It is shown that the model's prediction on the sieving performance is in good agreement with experimental results.