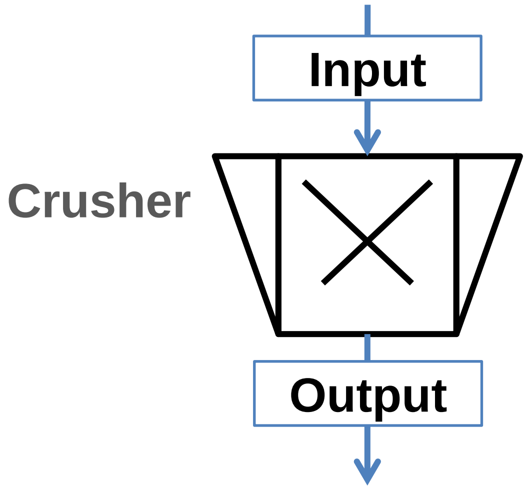
Crusher PBM TM

General description



A dynamic model used to perform milling of the input stream.

$$\frac{\partial u(x,t)}{\partial t} = \int_x^\infty b(x,y)S(y)u(y,t)dy - S(x)u(x,t).$$

- $u(x,t)$ – mass fraction of particles with size x in output distribution;
- x, y – volumes of particles;
- t – time;
- $b(x,y)$ – breakage function. i.e. fraction of fragments of size x, which appear when a particle of size y break;
- $S(x)$ – selection function that gives the rate at which a particle of size x is selected to break.

It uses the finite volume method for spatial discretization and the second-order Runge-Kutta method as described in [1] to calculate the transformation matrices. The integration time step Δt is calculated during the simulation, as described in [1], but can be additionally limited by user as

$$\Delta t_{final} = \min(\Delta t_{max}, \max(\Delta t_{min}, \Delta t))$$

Available selection functions:

- Constant:

$$S(x) = S_1$$

- Linear:

$$S(x) = x$$

- Quadratic:

$$S(x) = x^2$$

- Power:

$$S(x) = x^{S_1}$$

- Exponential:

$$S(x) = e^{S_1 \cdot x}$$

- King [2]:

$$S(x) = \begin{cases} 0 & x \leq S_1 \\ 1 - \left(\frac{S_2 - x_i}{S_2 - S_1}\right)^{S_3}, & S_1 < x_k < S_2 \\ 1 & x \geq S_2 \end{cases}$$

- Austin [3]:

$$S(x) = \left(\frac{x}{S_1}\right)^{S_2}$$

The final value of selection function is calculated as $S(x) \cdot S_{scale}$.

Available breakage functions:

- Binary:

$$b(x,y) = \frac{2}{y}$$

- Diemer [4]:

$$b(x,y) = B_1 \cdot \frac{\Gamma(B_2 + (B_2 + 1) \cdot (B_1 - 1) + 1)}{\Gamma(B_2 + 1) \cdot \Gamma(B_2 + (B_2 + 1) \cdot (B_1 - 2) + 1)} \cdot \frac{x^{B_2} \cdot (y - x)^{B_2 + (B_2 + 1) \cdot (B_1 - 2)}}{y^{B_1 \cdot B_2 + B_1 - 1}}$$

- Vogel [5]:

$$b(x,y) = 0.5 \cdot B_2 \cdot \frac{1}{y} \cdot \left(\frac{x}{y}\right)^{B_2 - 2} \cdot \left(1 + tanh\left(\frac{y - B_1}{B_1}\right)\right)$$

- Austin [6]:

$$b(x,y) = B_1 \cdot B_2 \cdot \frac{1}{y} \cdot \left(\frac{x}{y}\right)^{B_2 - 2} + (1 - B_1) \cdot B_3 \cdot \frac{1}{y}\left(\frac{x}{y}\right)^{B_3 - 2}$$

Unit parameters:

Name	Symbol	Description	Units	Valid values
Selection		Selection function		• Constant • Linear • Quadratic • Power • Exponential • King • Austin
Breakage		Breakage function		• Binary • Diemer • Vogel • Austin
S_scale	S_{scale}	Scale factor for selection function	[-]	$0 < S_{scale} \leq 1$
S1	S_1	Parameter of selection function	[-]	
S2	S_2	Parameter of selection function	[-]	
S3	S_3	Parameter of selection function	[-]	
B1	B_1	Parameter of breakage function	[-]	
B2	B_2	Parameter of breakage function	[-]	
B3	B_3	Parameter of breakage function	[-]	
dt_min	Δt_{min}	Minimum time step for integration	[s]	$\Delta t_{min} \geq 0$
dt_max	Δt_{max}	Maximum time step for integration	[s]	$\Delta t_{min} \geq 0$
Method		Method to calculate transformation matrices		• Newton • Runge-Kutta

Requirements

- Solid phase
- Particle size distribution

Application examples

- *Example Flowsheets/Units/Crusher PBM TM.dlfw*
- *Example Flowsheets/Processes/Sieve-Mill Process.dlfw*

References

[1] *V. Skorych, N. Das, M. Dosta, J. Kumar, S. Heinrich. Application of transformation matrices to the solution of population balance equations, Processes 7(8) (2019).*

[2] *R. P. King, Modeling and simulation of mineral processing systems, Butterworth & Heinemann, Oxford (2001).*

[3] *L.G. Austin, P.T. Luckie. The Estimation of Non-Normalized Breakage Distribution Parameters from Batch Grinding Tests. Powder Technology 5 (72) (1971) 267-271.*

[4] *R.B. Diemer, J.H. Olson. A moment methodology for coagulation and breakage problems: Part 3 – generalized daughter distribution functions. Chemical Engineering Science 57 (2002) 4187-4198.*

[5] *L. Vogel, W. Peukert, Modelling of Grinding in an Air Classifier Mill Based on a Fundamental Material Function, KONA 21 (2003) 109-120.*

[6] *L.G. Austin. A discussion of equations for the analysis of batch grinding data. Powder Technology 106 (1999) 71-77.*