[APM Forum 2021]: Poster submission acceptance

Angela Sposito <a.sposito@psenterprise.com>
Mar 30/3/2021 19:22
Para: ivana cotabarren <icotabarren@plapiqui.edu.ar>

Dear Ivana,

I am pleased to inform you that your poster has been accepted. Please see below the instructions for all poster presenters. Please send me the PDF version of your posters as soon as you can (if you have not already) as we will be judging for best poster this week.

All the poster presenters would present their work during the dedicated Academic poster session and networking during the breaks on all 3 days of the conference as outlined in the full agenda. There will be a virtual room with networking tables where each poster will have its own table. You will be to virtually interact with attendees who visit your table.

All poster abstracts will be made available on our website here.

Registration

If you have not already registered, please register yourself for the Forum via the online registration form. Under “Attendee type” please select “Poster Presenter” and enter coupon code “APMF50” to receive the 50% discount.

Poster size and guidelines

- The poster size should 3508px x 2480px PDF format (portrait)
- Posters are requested to be prepared in English
- For the poster session with networking tables room, **please provide a shortened 24-character poster title no later than 5th April**

After the conference, we usually ask if it is okay for your poster to be displayed on our website via PDF. If this is okay with you, please let me know and make sure you have sent a PDF of your poster.

Thank you again for submitting your poster for the Virtual APM Forum 2021 and we look forward to see you there.

Kind regards,
Angela

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Advanced Process Modelling Forum 2021, April 13-15 2021, London, UK

Modeling of maize breakage in hammer mills of different scales through a population balance approach

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Motivation and Introduction

The grinding of maize grains is an important process in the industry of poultry feed, being the most commonly used cereal in diet worldwide. Hammer mills are usually used for this process because of their simplicity, easy operation and low maintenance cost. However, the grinding process in hammer mills itself is complex and not completely understood. The resulting particle size distribution depends not only on material properties but also on design and operation variables of the mill (screen opening, mill rotor speed and feed rate).

In this context, a simulator for a grinding process is presented. The simulator is based on a population balance model (PBM) that allows quantifying changes in particle size distributions (PSDs) and the mass geometric mean diameter (D_{gw}). This model was developed in gPROMS® Model Builder, using experimental data collected from a pilot-scale mill for parameter fitting. The model was verified for an industrial mill. The gPROMS® in-built parameter estimation tool was used for parameter fitting and statistical test analysis.

Implementation in gPROMS Model Builder Environment

According to Cotabarren et al. [1], the discretized PBM equation for a perfectly-mixed dynamic continuous process where only breakage occurs is:

$$\frac{dN_i}{dt} = \dot{N}_{in_i} - \dot{N}_{out\,i} - S_i N_i + \sum_{j>i} \nu_j\, S_j\, b_{i,j}\, N_j \qquad (1)$$

where $\dot{N}_{in_i}$ and $\dot{N}_{out\,i}$ are the particle of class i inlet and outlet number flowrates [1/s], respectively.

$$\dot{N}_{out\,i} = A_i\,\frac{N_i}{\tau} \qquad (2)$$

The breakage rate (S_i) is expected to depend on particle properties and on process parameters. The expression used in this work was:

$$S_i = \sigma_1 \frac{d_{s,0}}{d_s} N^{N_0/N} \left(\frac{d_{p_i}}{d_{p_0}}\right)^{\sigma_2 \frac{N_0}{N}} \qquad (3)$$

The breakage function ($b_{i,j}$) was calculated as:

$$b_{i,j} = B_{i,j} - B_{i+1,j} \qquad (4)$$

For the cumulative breakage function ($B_{i,j}$), the following equation was used:

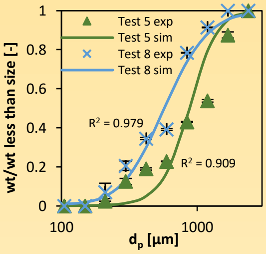
$$B_{i,j} = \begin{cases} \left(\dfrac{d_{p_{i-1}}}{d_{p_j}}\right)^{\gamma \frac{d_{s,0}}{d_s}} & i > j \\ 1 & i \le j \end{cases} \qquad (5)$$

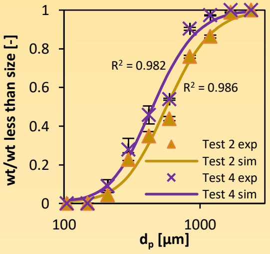
In this contribution, the classification function (A_i) for the mill screen was expressed as:

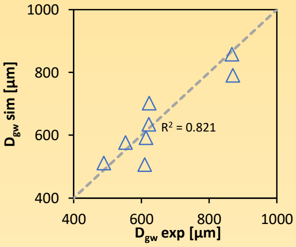
$$\mathrm{A}_i = \alpha_1 \frac{N_0}{N} \frac{1}{1+\alpha_2\left(\frac{d_{p_i}}{d_s}\right)^{\alpha_3}} \qquad (6)$$

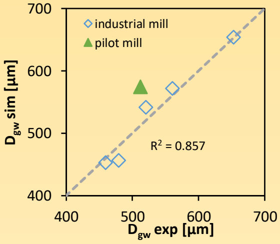
Nomenclature	
dp_i	Particle size [m]
dp_0	Constant reference size [m]
ds	Screen opening [m]
$ds_{,0}$	Maximum tested opening size [m]
N	Mill rotor speed [1/s]
N_0	Reference value for mill rotor speed [1/s]
N_i	Number of particles of size i [-]
$\alpha_1, \alpha_2, \alpha_3$	Classification function fitting parameters [-]
γ	Breakage function fitting parameter [-]
ν_j	Average number of particles of size i generated by breakage of one particle of size j [-]
σ_1, σ_2	Breakage rate probability function fitting parameters [-]
τ	Particle residence time in the mill chamber [s]

Results


Experimental and simulated cumulative PSD for the pilot-scale unit


Experimental and simulated cumulative PSD for model validation using the industrial unit


Experimental and simulated steady-state D_{gw} for the pilot-scale unit


Experimental and simulated steady-state D_{gw} values for the model validation

Milling tests

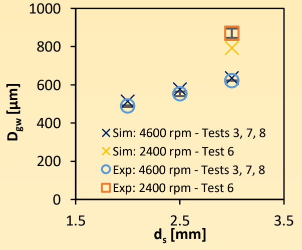
Mill	Test	ds [mm]	Rotation speed [rpm]	Feed rate [kg/h]	Estimation	Validation
Pilot	1	3	4600	32.1	x	
Pilot	2	3	4600	52.8	x	
Pilot	3	3	4600	67.9	x	
Pilot	4	3	4600	92.1	x	
Pilot	5	3	2400	35.5	x	
Pilot	6	3	2400	73.2	x	
Pilot	7	2	4600	75.1	x	
Pilot	8	2.5	4600	73.2	x	
Pilot	9	2	4600	72.5		x
Industrial	1	3	1500	8600		x
Industrial	2	3	1500	6200		x
Industrial	3	2.5	1500	6600		x
Industrial	4	2	1500	5400		x
Industrial	5	2	1500	5500		x

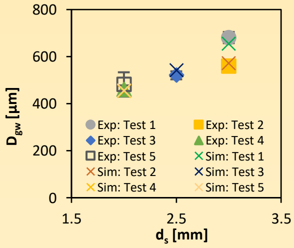
Parameter estimation results

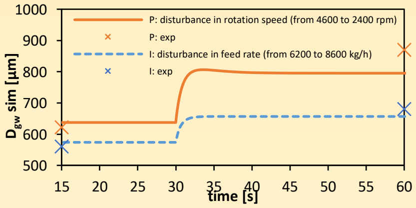
Parameter	Final value	95% t-value	Std. dev.	Parameter	Final value	95% t-value	Std. dev.
α_1	1.097	6.484	0.086	γ	0.832	1.517*	0.277
α_2	0.844	0.849*	0.704	σ_1	3.016	2.445	0.624
α_3	2.133	0.666*	1.618	σ_2	2.191	13.57	0.082

Ref. t-value (95%)	Weighted residual	χ^2 value (95%)
1.657	144.124	160.915

**t*-value greater than reference *t*-value (1.69) indicates statistical significance at 95 % CI.


Experimental and simulated steady-state D_{gw} as a function of the d_s, modifying the rotation speed for the pilot-scale unit


Experimental and simulated steady-state D_{gw} as a function of the d_s, modifying the feed rate for the industrial unit



Predicted D_{gw} for disturbances in rotation speed at the pilot-scale unit, and feed rate at the industrial unit

Conclusions

1. It was possible to use the gPROMS® tools to successfully fit a hammer mill model to predict new operating points, study industrial milling performance and optimize the operation.
2. The model was successfully validated on pilot and industrial scales.
3. The breakage rate and screen selection functions were found to be highly related with the rotation speed.
4. The screen opening size was found to have an additional effect on the breakage distribution and rate functions.
5. The model was able to predict the dynamic operation of the mill.

[1] I. Cotabarren, M. P. Fernández, A. Di Battista, J. Piña, Modeling of maize breakage in hammer mills or different scales through a population balance approach, Powder Technology 375 (2020) 433-444.

Modeling of maize breakage in hammer mills of different scales through a Population Balance approach

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Abstract

The grinding of maize grains is an important process in the industry of poultry feed, being the most commonly used cereal in diet worldwide. Hammer mills are usually used for this process because of their simplicity, easy operation and low maintenance cost. However, the grinding process in hammer mills itself is complex and not completely understood. Hammer mills are impact-type crushers that comprise a rotating shaft fitted with fixed or pivoted hammers and mounted in a cylindrical chamber. The particles are fed into the chamber by gravity and exit the cylinder when they are small enough to pass through a screen located at the bottom. Comminution in hammer mills is influenced by design variables as the rotor shaft configuration (i.e., vertical or horizontal shaft), the hammer design and placement (i.e., distance between hammers and screen), the screen opening size and type (i.e., round, square, mesh type), and by operating variables as material feed rate and rotor speed. The resulting particle size distribution depends not only on material properties but also on design and operation variables of the mill.

In this work, a simulator for a grinding process is presented. The simulator is based on a population balance model (PBM) that allows quantifying changes in particle size distributions (PSDs) and the mass geometric mean diameter (Dgw) as a function of mill operation variables (screen opening, mill rotor speed and feed rate).

This model was developed completely in the gPROMS® Model Builder, using experimental data collected from a pilot-scale mill to fit the parameters of the breakage and classification functions, considering the effects of rotor speed and screen opening size. The gPROMS® in-built parameter estimation tool was used for parameter fitting and statistical test analysis. The model was validated with both pilot- and industrial-scales steady-state data, which also included variations in feed rates. The developed model was used to predict the dynamic behavior of the product mass geometric mean diameter and mill hold-up as a function of disturbances in the feed rate and the rotor speed. These results are highly valuable since they indicate the feasibility of using the fitted model to predict with confidence new operating points, study industrial milling performance and optimize hammer mill operation reducing the need to carry out expensive and time-consuming experimental tests.