Jet miling prediction using population balance modelling

H. Tsitsiris, Advanced Process Modelling Forum, London, 20-21 April 2016

SAINT-GOBAIN
350
REASONS TO BELIEVE
IN THE FUTURE

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1.

A few words on Saint-Gobain

Sales

€ 39.6 Bn

More than

170,000

employees

SAINT-GOBAIN 350

Present in

66 countries

85%

of **sales**

on the habitat market

One of the top

100

industrial groups worldwide

BECOME THE REFERENCE FOR SUSTAINABLE HABITAT

Saint-Gobain designs, manufactures and distributes high-performance and building materials providing innovative solutions to the challenges of growth, energy efficiency and environmental protection

INNOVATIVE
Materials

With Flat Glass and High-Performance Materials, the Innovative Materials Sector has a unique portfolio of materials and processes in the fields of habitat, transport, health and industry

24% of sales

FLAT GLASS

- **No. 1 in Europe**
- **No. 2 worldwide**
- Presence: **42** countries
- Almost **32,000** employees

HIGH-PERFORMANCE MATERIALS

- **No. 1 worldwide**
- Presence: **45** countries
- Almost **27,000** employees

CONSTRUCTION
Products

The Construction Products Sector provides interior and exterior finishing solutions that improve the quality of living spaces: plaster, insulation, facade coatings, roofing products and pipes

No. 1 worldwide

- Plasterboard and plaster
- Insulation: worldwide leader, including all insulation materials
- Ceramic tile adhesives
- Industrial mortars
- Ductile iron pipes

No. 2 in Europe

- Facade coatings

No. 2 in the United States

- Facade products

Presence: **61** countries

Almost **47,000** employees

28% of sales

BUILDING
Distribution

The Building Distribution Sector brings to the Group a deep understanding of the needs of customers: trades professionals, homeowners with a project, and small, medium and large companies. It serves the new construction, renovation and habitat finishing markets

No. 1 in Europe

- Building materials distribution

Presence: **24** countries

Around **61,000** employees

Around **4,100** sales outlets

48% of sales

INNOVATION IN OUR DNA

8 cross-business R&D centers

One of the 100 most innovative organizations in the world*

3,700 people

About 100 development units

Almost 350 patents in 2015

1 product out of 4 sold today by Saint-Gobain did not exist 5 years ago

Partnerships with the academic world and start-ups

* Source: Thomson Reuters

2.

Key challenges in milling R&D

COMMINUTION PROCESSES

- Most of our processes involve a comminution (i.e. size reduction) step

- The range of operated technologies is wide:
  - Depending on the material to be processed: ceramics, plastics, minerals, fibers, glass, …
  - Depending on the targeted size: from the centimeter to some hundreds of nanometers

- Though comminution is an old science, operational know-how is mainly empirical and transferability is limited from one application to another

POTENTIAL INPUT FROM R&D

- R&D aims at addressing industrial issues:
  - **Cost reduction through process optimization** (less unvaluable fines, better targeting of specified PSD)
  - **Techno choice** with respect to several criteria (product size, targeted morphology, pollution free size reduction)
  - **Product design** with respect to grindability (to facilitate or prevent size reduction)

- Using analytical modelling and numerical simulation, we can predict with accuracy resulting in significant reduction in expensive large scale trials

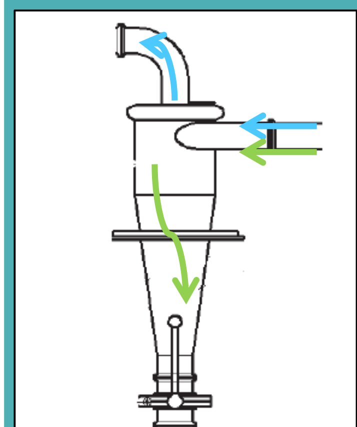
3.

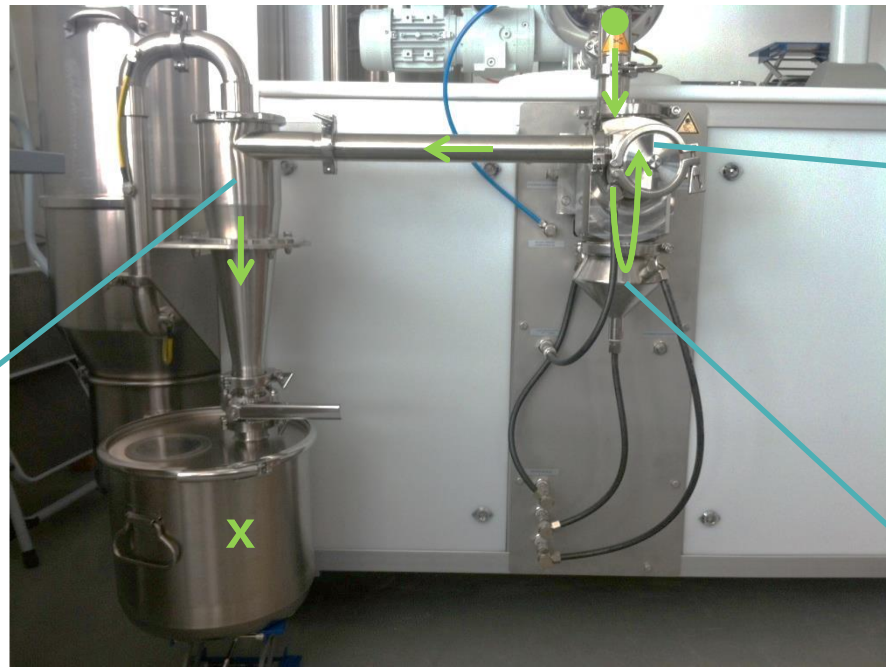
Predictive strategy on fluidized bed opposed jet milling

FLUIDIZED BED OPPOSED JET MILL

- Suitable for pollution-free micronization down to d_{50}~1 µm of hard materials (up to Mohs 10)

Cyclone separation

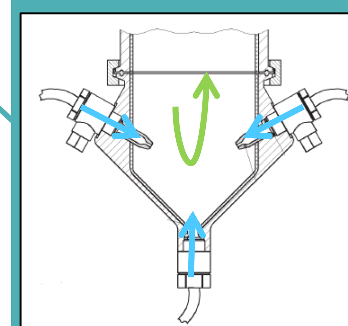




Hosokawa AFG 100

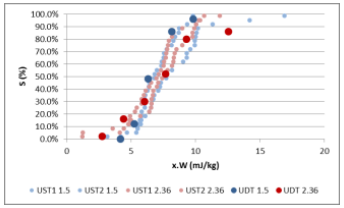
Classification chamber

Grinding chamber



PREDICTIVE STRATEGY

Material related parameters, from single particle testing

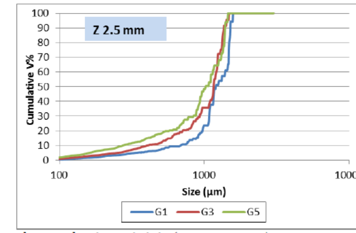


Measured:
- S: breakage probability
- $W_{m,kin}$: input energy

Material parameters under impact conditions provided by B. Köninger, University of Erlangen

$$S = 1 - \exp[-f_{Mat} k x (W_{m,kin} - W_{m,min})]$$

Measured:
- Progeny size distribution on broken particles



Mill related parameters, from back fitting using gSOLIDS

On monosized model material: glass beads
To be performed once

$$S = 1 - \exp[-f_{Mat} k x (W_{m,kin} - W_{m,min})]$$

Calculated:
- k: number of impacts
- $W_{m,kin}$: impact energy

as a function of operating parameters (air pressure, classifier rpm)

Selection function

Breakage function

gSOLIDS

Prediction of output PSD and throughput for multisized feeds

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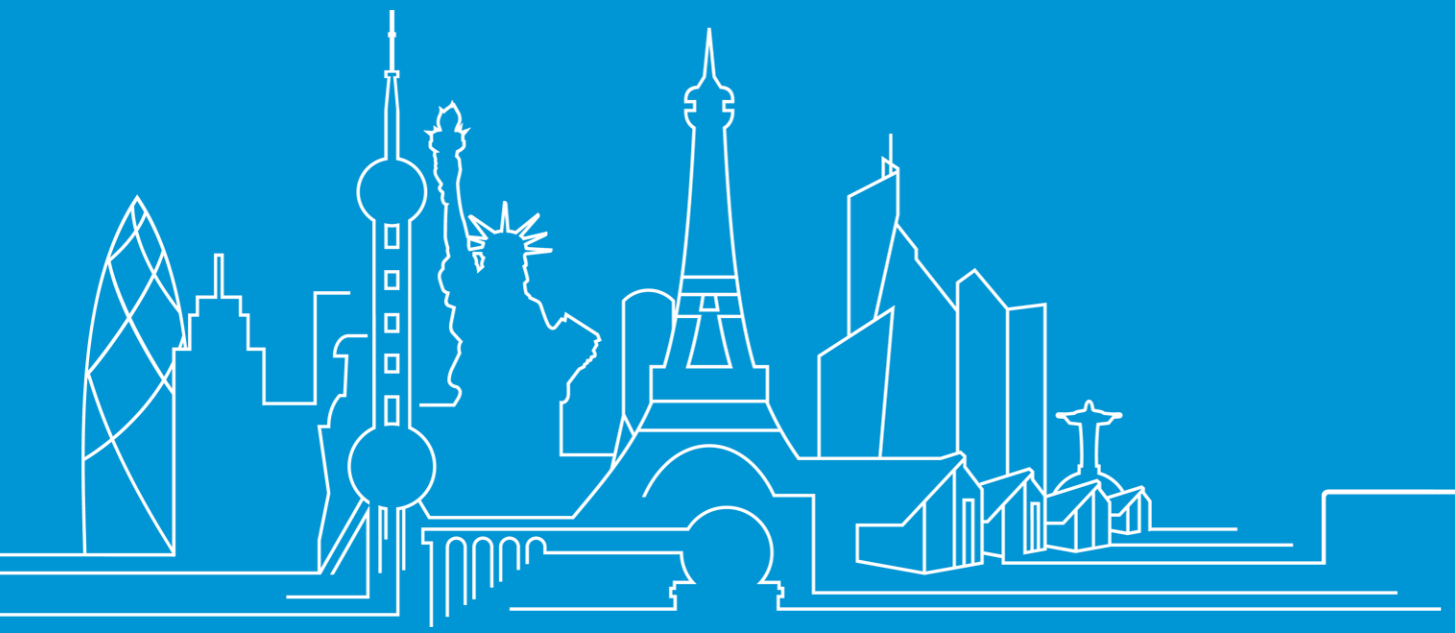
4.

First results using gSOLIDS

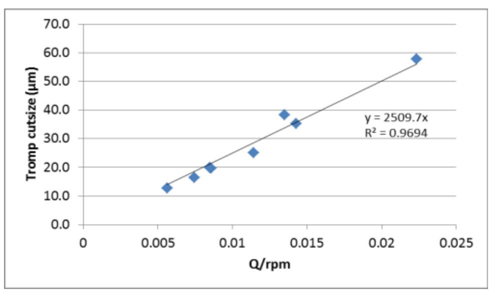


CO-DEVELOPMENT WITH H. MUMTAZ FROM PSE USING

Inflow: glass beads
Given mass in at t_0
No inflow during milling

Model output:
Hold up mass vs time
Hold up PSD vs time

Outflow:
Particles below cutsize
Empirical cutsize=f(airflow, classifier rpm)



- <u>Vogel & Peukert (2005) kernel</u>

$$S(w) = S_c\left[1 - e^{\left(-f_{mat} wk(W_{kin} - W_{min})\right)}\right]$$

$$B(v,w) = \frac{v}{w}^{q} \frac{1}{2}\left(1 - tanh\left(\frac{v - v'}{v'}\right)\right)$$

- <u>Additional assumptions</u>

$$W_{kin} = W_{kin_{factor}} * Q_{nozzle}{}^{2}$$

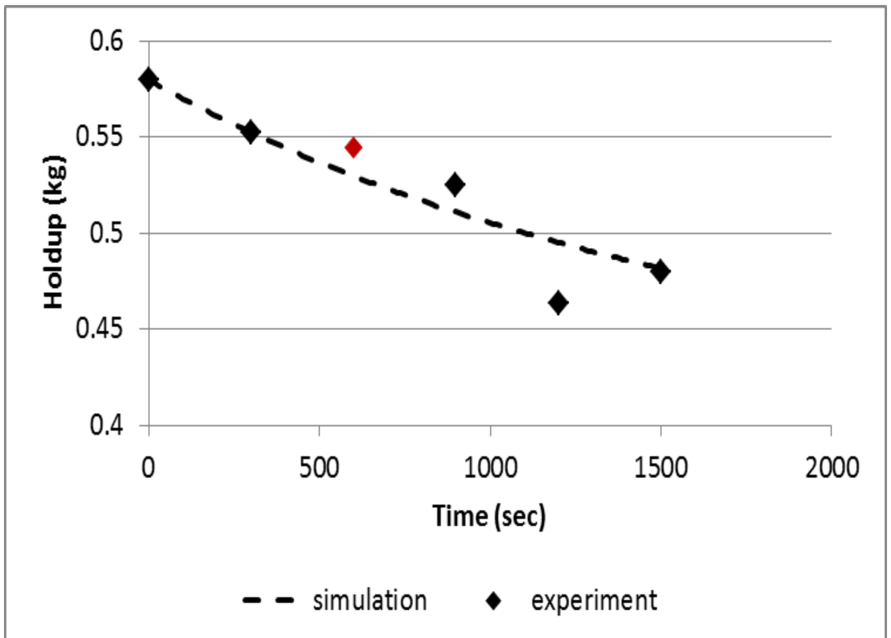
k (number of impacts) set to 1

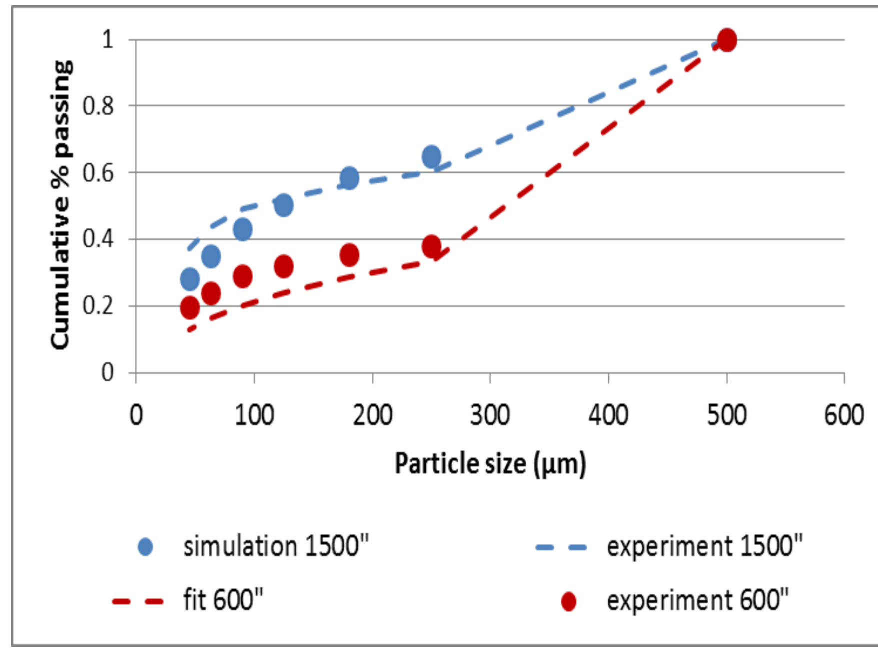
Ideal separation

BLIND TEST

- $W_{kinfactor}$, S_c and q estimated on one monosized feed 10' test
- Estimated parameters then used to simulate other configurations

Predicting longer milling times (25')

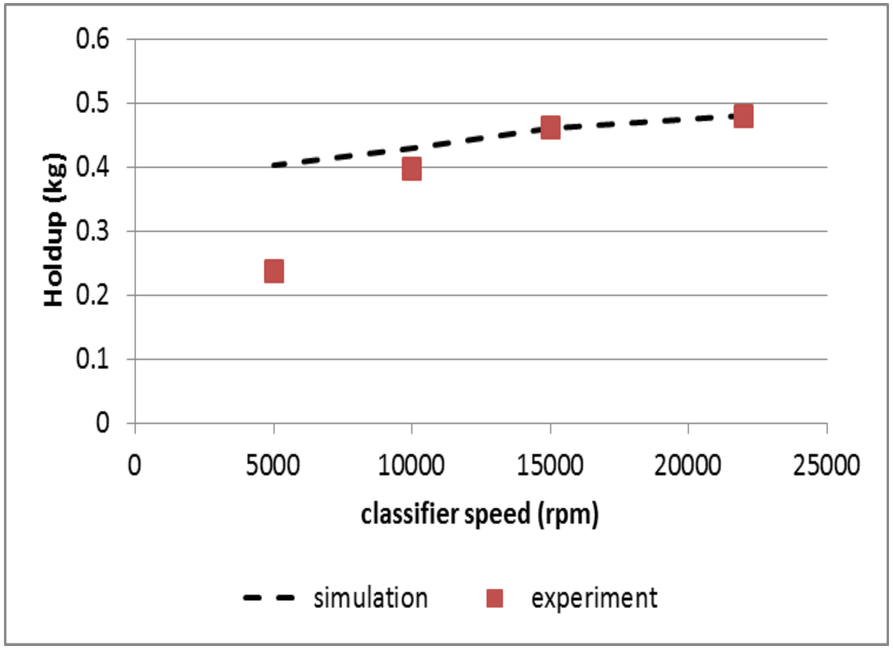


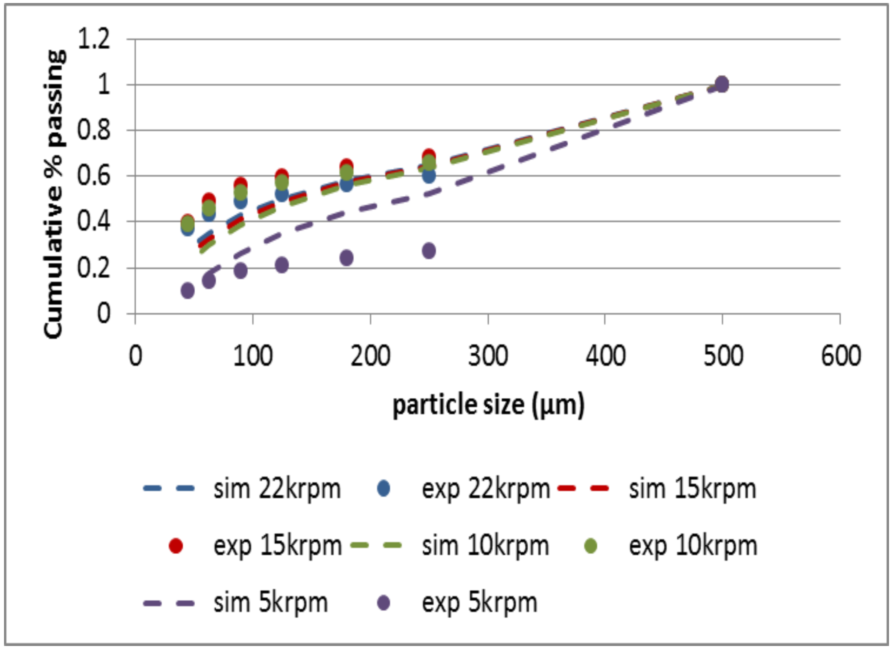


➢ Good fit for both hold up mass and PSD

BLIND TEST

Predicting lower classifier speed settings

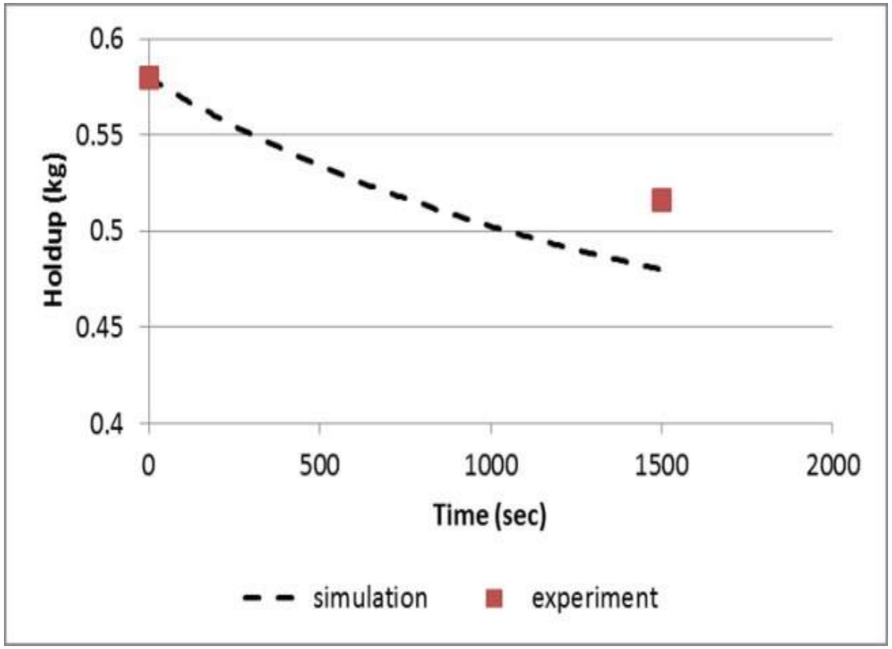


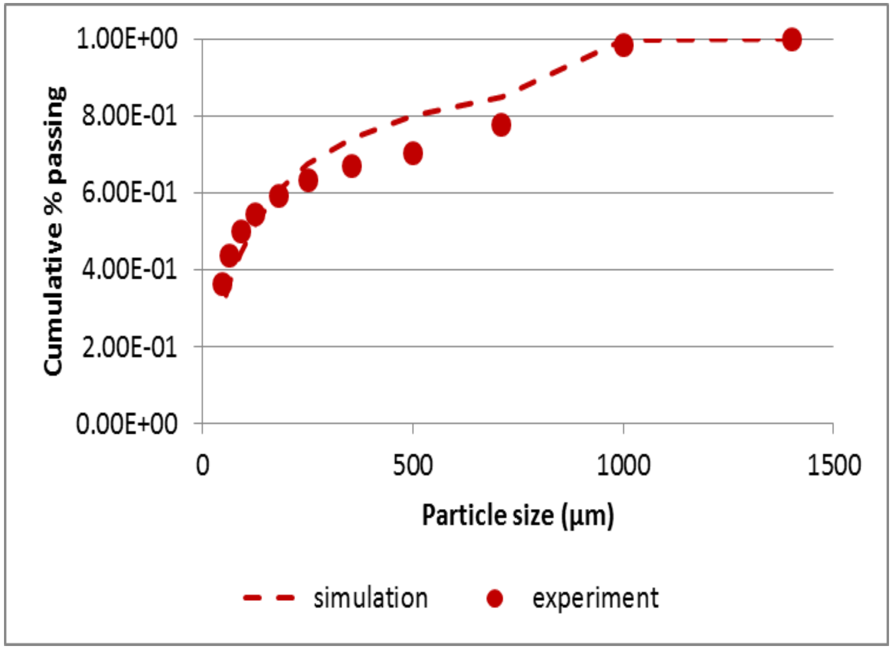


- Acceptable fit between prediction and experiment down to 10000 rpm

BLIND TEST

Predicting bigger feed sizes

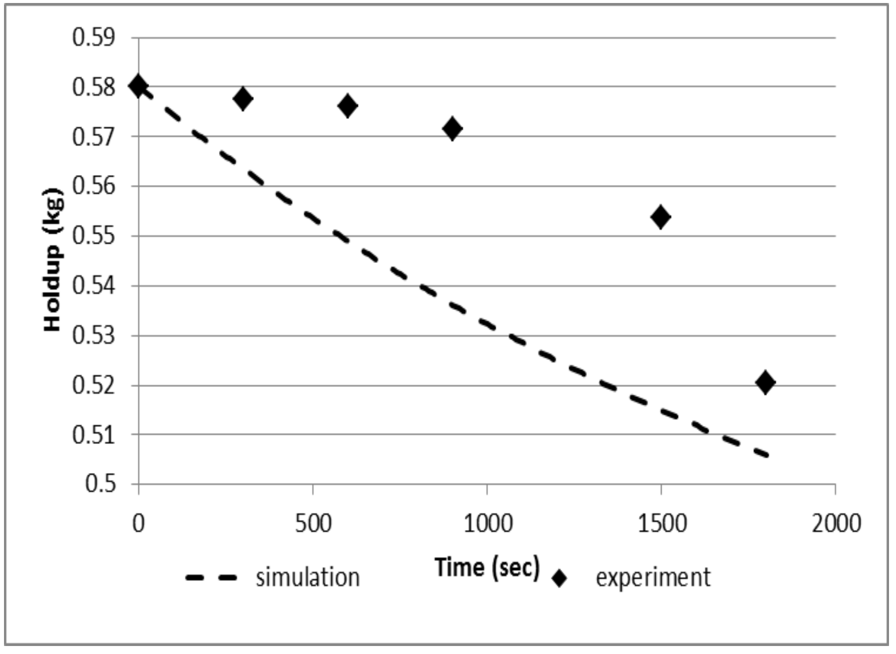


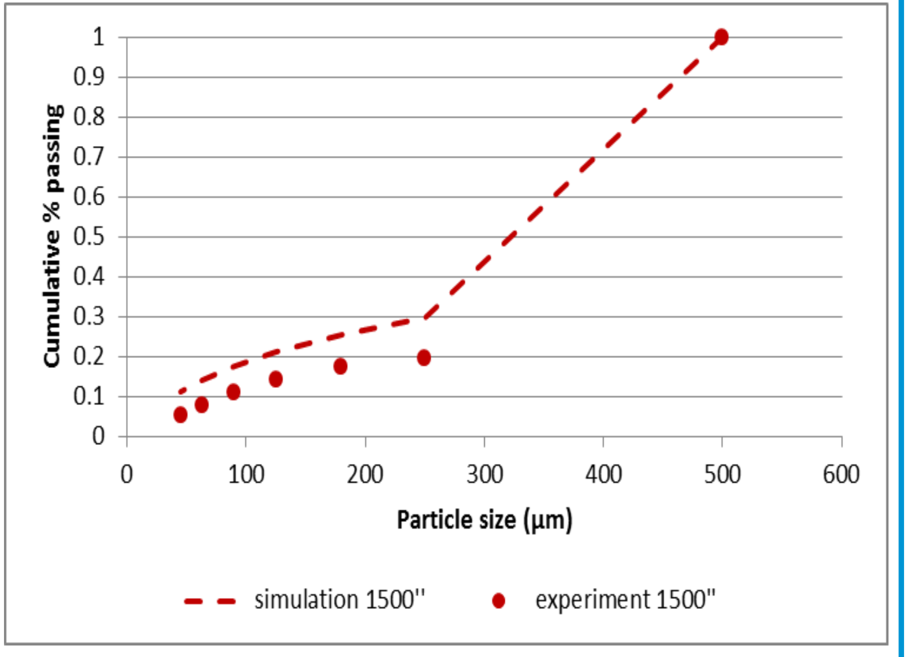


- Good fit on PSD, hold up mass underestimated by 7%, compared with an experimental discrepancy of 2%

BLIND TEST

Predicting lower grinding pressure settings (i.e. lower air flows)

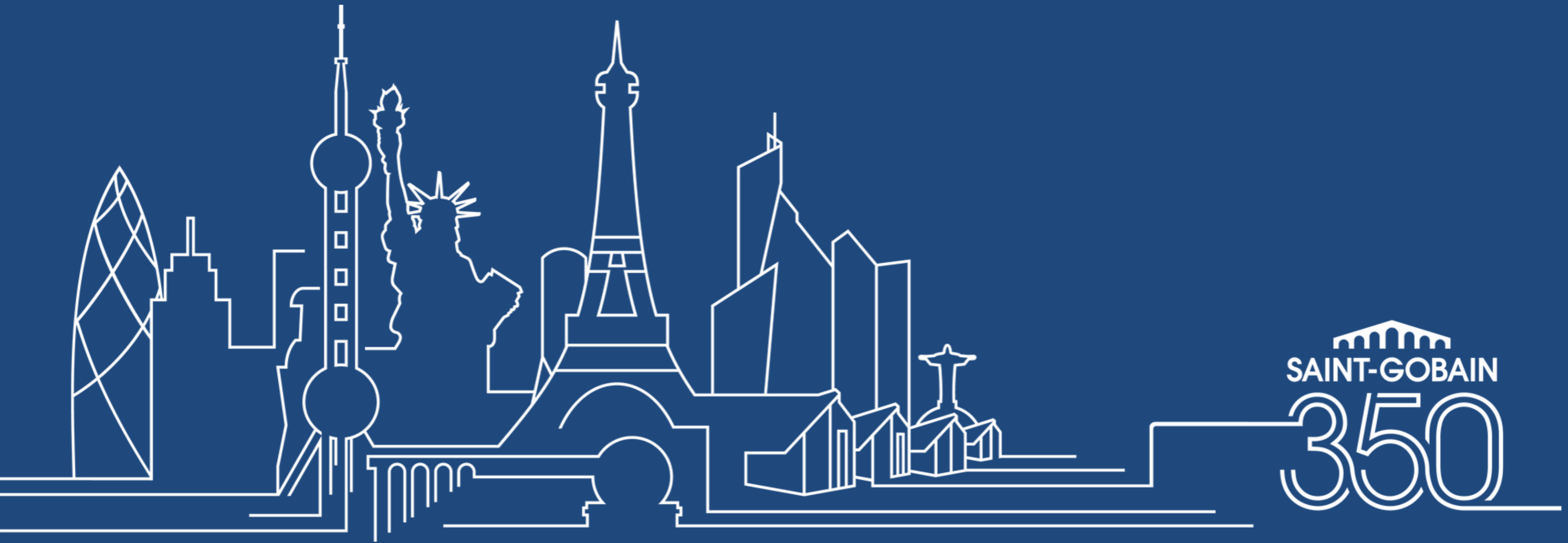




- Acceptable fit on final values both for hold up mass and PSD
- But inverse non linearity of the mass time evolution (physical phenomena like attrition or damage that the model does not take into account)

5.

Conclusions and next steps



- Ability to **predict most trends related to process parameter modifications based on very few experimental data** (one 10’ jet mill test and one single particle fragmentation test for material parameters)

- Potential **next steps to gain accuracy and move towards process optimization**:
  - Take into account the non ideal separation
  - Estimate ***q*** directly from single particle testing

- Potential **next step to reduce experimental time for material characterization**:
  - Estimate all material related parameters from a standardized jet milling test using gSOLIDS

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