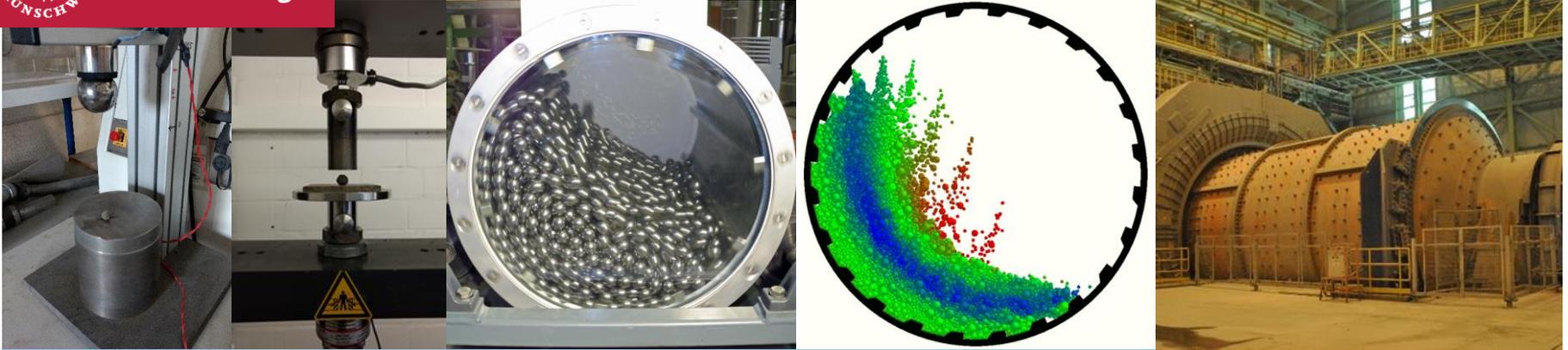




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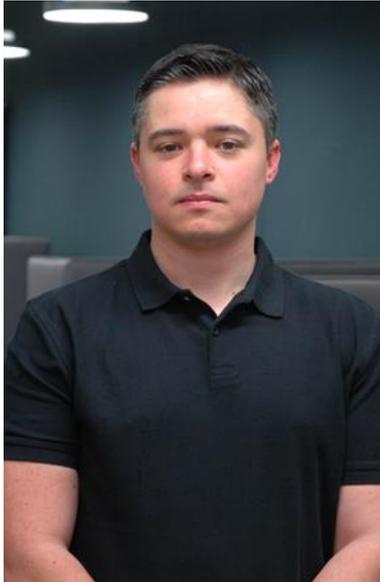


## IFPRI

A Systems Engineering Approach to Dry-Milling with Grinding Aid Additives

Anderson Chagas, Sandra Breitung-Faes, Arno Kwade

# Team at Institute for Particle Technology (iPAT)



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# Project introduction

## Objectives:

- I. Develop a system engineering approach for optimizing and scaling industrial dry fine grinding processes.
- II. Obtain numerical relations about the effect of grinding aids additives and humidity on material behaviour, process aspects and energy flows.

## First phase (first 3-year-period):

- I. Focus on the grinding aid and humidity impacts on the grinding aspects inside the ball mill, and the transfer of batch grinding results to closed circuit processes.
- II. Those information will be used to predict particle size distributions and energy consumptions.



## Materials

- Calcinated alumina (Almatis)  
[ $x_{50} = 83.8 \mu\text{m}$ ]
- Calcium carbonate (Imerys)  
[ $x_{50} = 10.7 \mu\text{m}$ ]

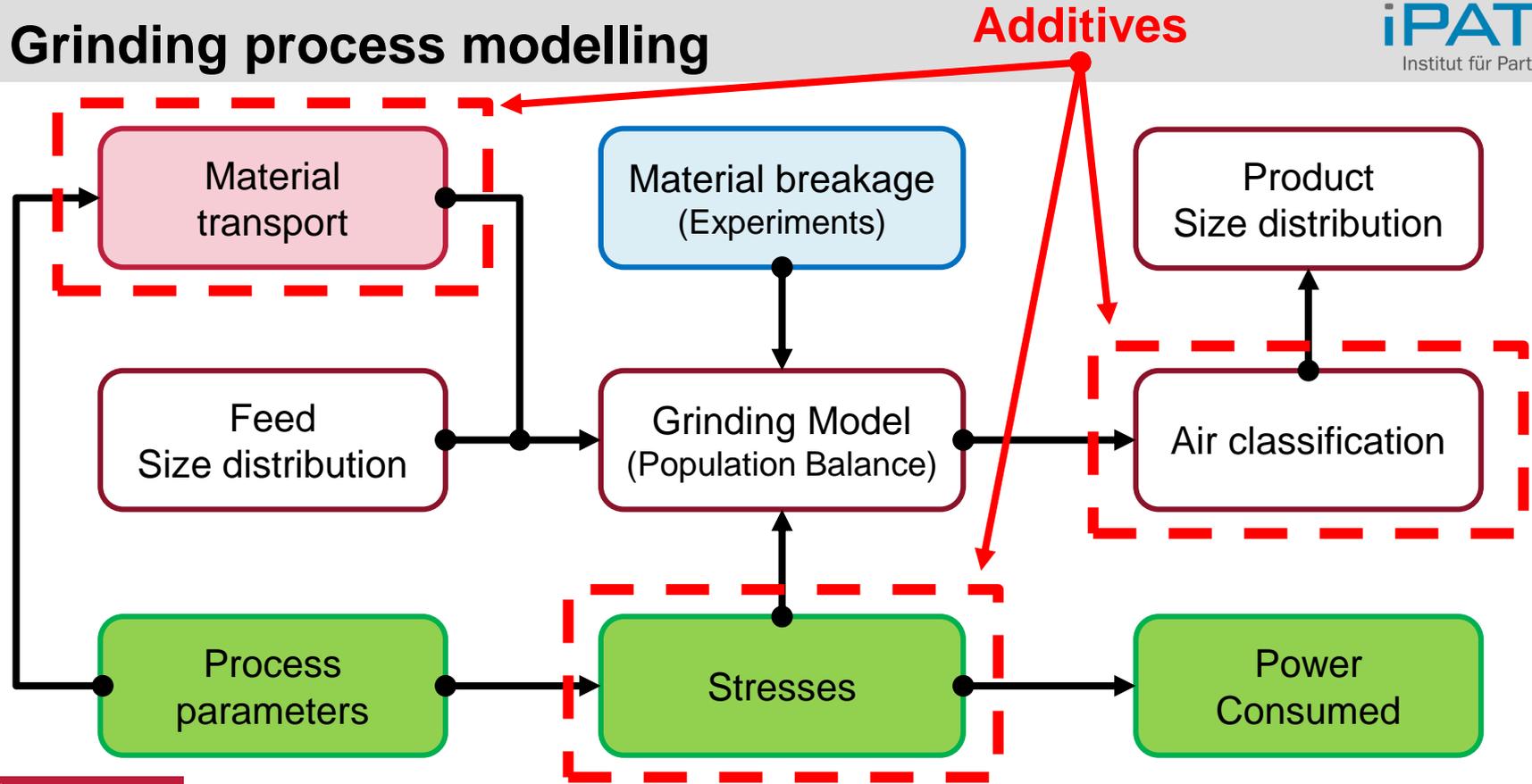
## Grinding aid additives

- Glycol → Diethylene glycol (DEG)
- Acid → Heptanoic acid (HepAc)
- Alcohol → 1-Hexanol (HexOH)

## Test equipment

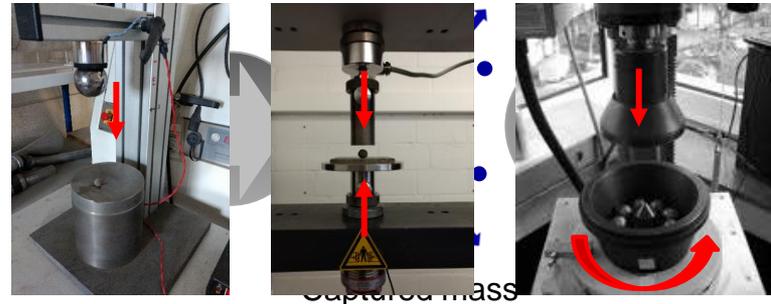
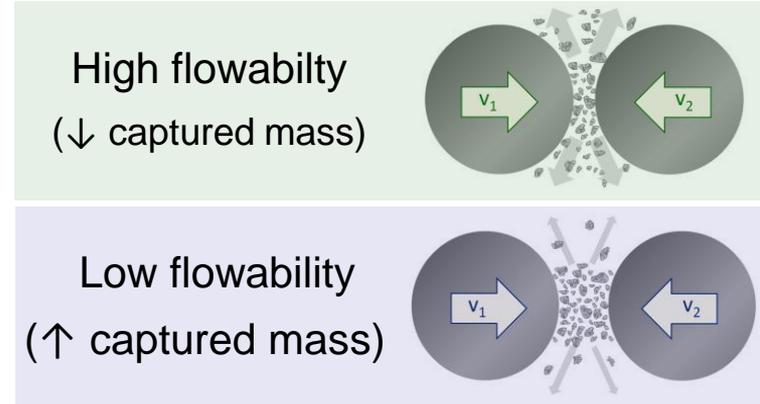


# Grinding process modelling



# Effect of additive on stress transfer

- Additives will affect:
  - **Particle capturing between balls**
  - **Energy dissipation**
  - Material transport
  - Residence time (mill holdup)
  - Process efficiency
  
- Experiments:
  - Drop-weight-test – high stress rate
  - Slow compression – low stress rate
  - Hardgrove test – rolling grinding media over bed of particles

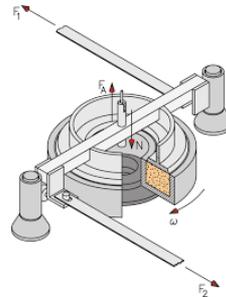
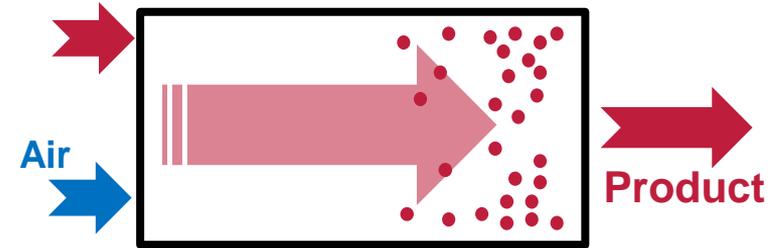


Captured mass

# Effect of additive on material transport

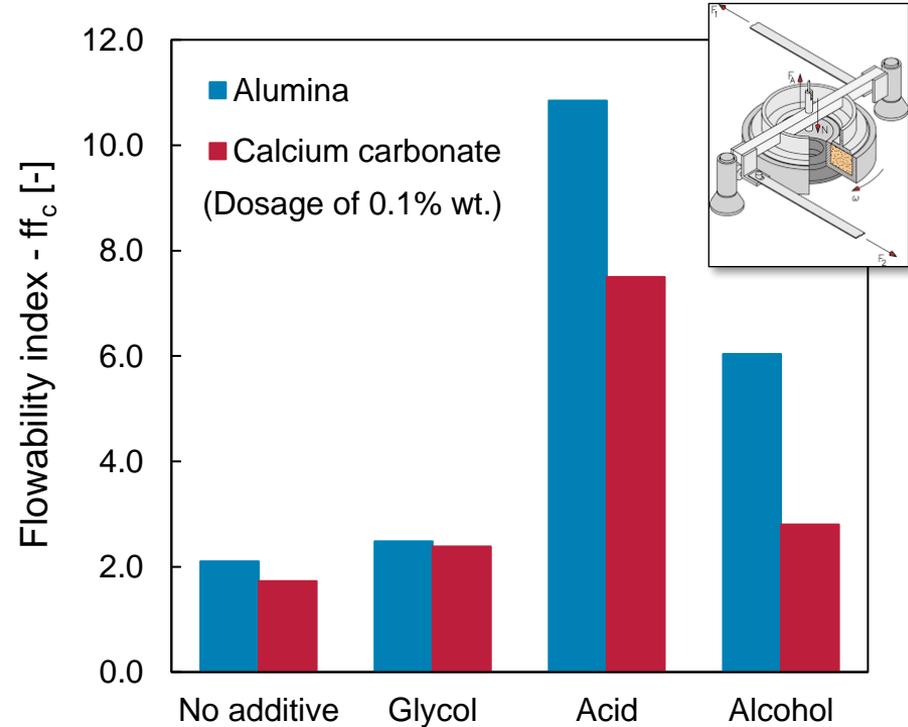
- Additives will affect:
  - Particle capturing between balls
  - Energy dissipation
  - **Material transport**
  - **Residence time (mill holdup)**
  - **Process efficiency**
  
- Experiments:
  - Ring shear tester
  - Powder rheometer
  - Dynamic angle of repose

Raw material



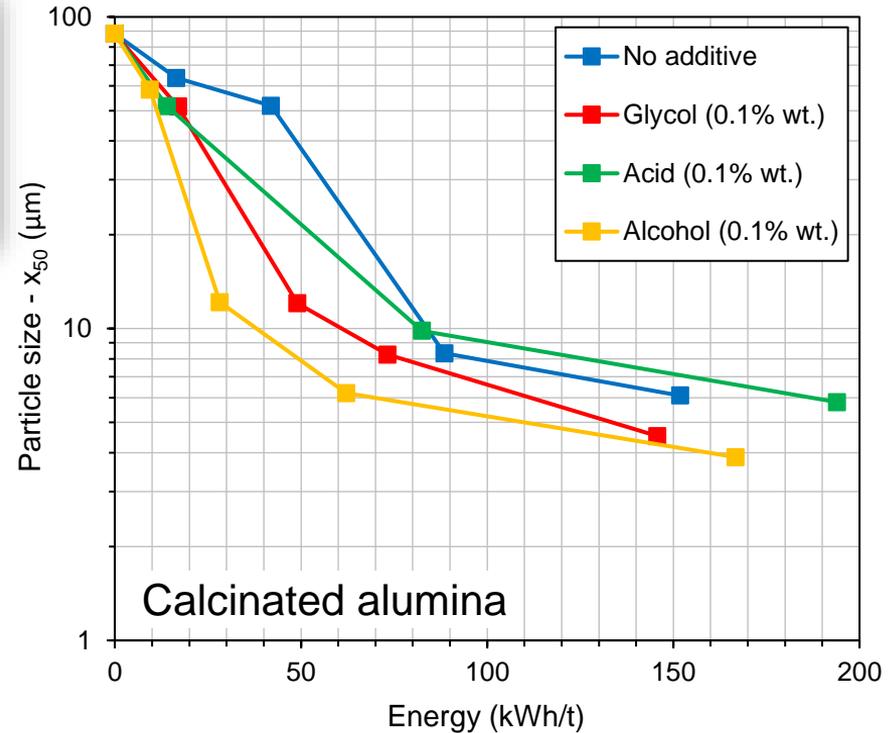
# Preliminary Ring Shear tests

- Samples preparation:
  - Pre-mixing with additive
  - Grinded in batch mill for 240 min
- Preliminary observations:
  - Glycol presented small effect on flowability, although with good results for batch grinding
  - This result would indicate that Glycol would present similar grinding results as with no additive



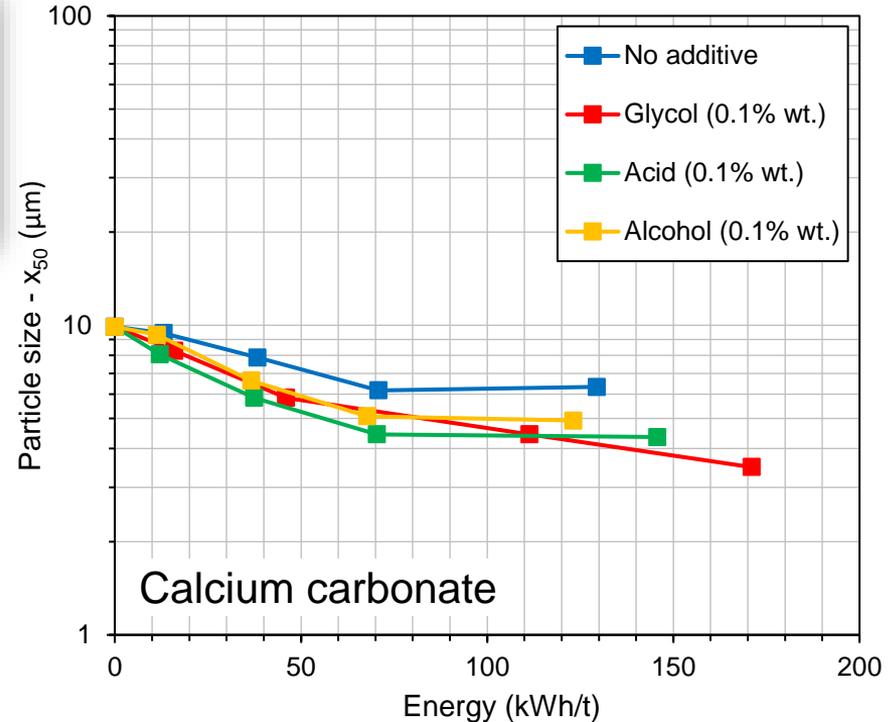
# Preliminary batch grinding tests

- Transport can be ignored
- Process parameters:
  - Batch milling at 4l mill
  - Mill speed – 70% c.s.
  - Media filling – 30% of mill volume
  - Media: 10 mm alumina beads
- Preliminary observations:
  - Is it clear that the additives affect differently the grinding efficiency.
  - Highest flowability does not provide the best results.



# Preliminary batch grinding tests

- Transport can be ignored
- Process parameters:
  - Batch milling at 4l mill
  - Mill speed – 70% c.s.
  - Media filling – 30% of mill volume
  - Media: 10 mm alumina beads
- Preliminary observations:
  - In contrast to alumina, the additives presented similar effect among each other
  - Mechanisms such as breakage and transport must be understood independently



# Open questions and future steps

## Open questions

- An additional type of experiment should be included?
- How to model air classification considering the variety of classifiers design?
- How the temperature of the powder would impact the combined action of Grinding aids + humidity?

## Outlook for the next 12 months

- Quantitative description of additives effects on dry grinding mechanisms
- Inclusion on modelling of batch grinding process

## Outlook for the next 24 months

- Investigations on material transport and air classification
- Inclusion on modelling of closed-circuit grinding process



For financing the project

## Advisory board:

- Jarrod Hart (Imerys)
- Charles Compson (Almatis)
- Bas van Laarhoven (DFE Pharma)
- Eric Gulliver (Lincoln Electric)
- Marion Schnabel (Almatis)

For technical and scientific support