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An Industrial Simulation System for Copper Concentration Plants

Honeywell

Agenda

- The Challenge
- Our Solution
- A Case Study
- Current State
- Future Work & Final Remarks

Dynamic Simulation for Copper Concentrator Plants

THE CHALLENGE

Motivation

High employee turnover rates and retirement

+

Lack of experienced personnel

= High investments in training (and technology)

Our Challenge

- Develop a Model Library to simulate dynamically Copper Concentrator Plants in order to carry out:
  - Integrated engineering validation for new projects
  - Operator training
  - Transmit best operational practices
  - Educate the personnel in new advanced applications (like APC)

Dynamic Simulation for Copper Concentrator Plants

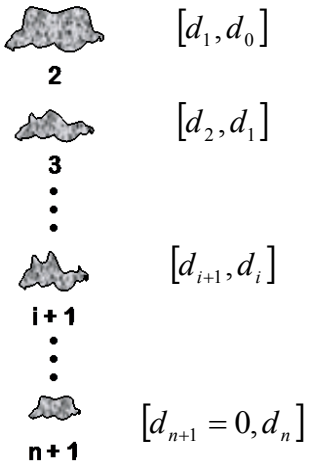
THE SOLUTION

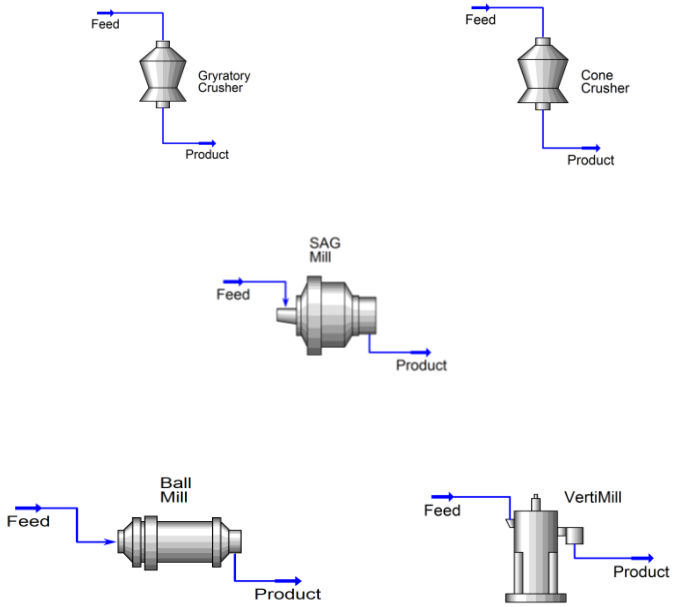
Dynamical MMM Model Library

- Is based on models that are well accepted by the metallurgical community,
  - For comminution models we've used population balance models,
  - For classification, the "PLITT" model,
- Models are be adjusted with real plant data,
  - Input and output particle size distributions,

Brief Description of Comminution Models

- Models based on the “Modern Comminution and Classification Theory*”
  - Using a population balance model

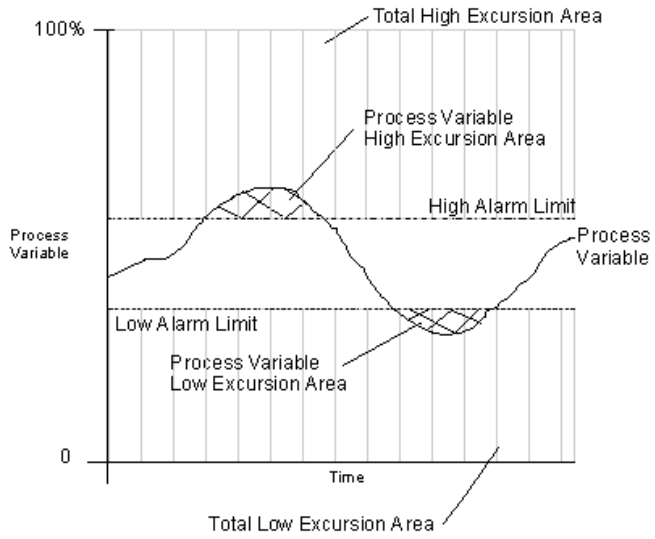




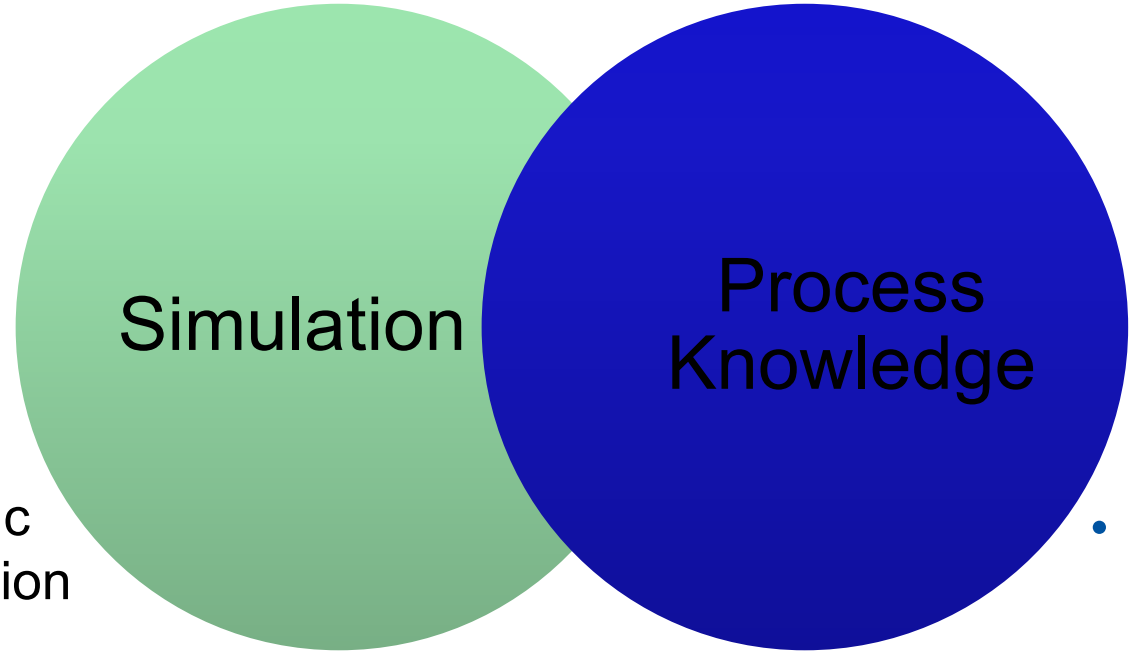
*Gutiérrez, L. and Sepúlveda, J. (1986). *Dimensionamiento y optimización de plantas concentradoras mediante técnicas de modelación matemática*. CIMM

Evaluation Methodology

- Excursion
  - Based on a pre-defined operational range
- Target (not used in the case study)
  - Based on a target value and the time taken to reach it



Our Training Solution



- Dynamic Simulation
- HMI

- Theoretical training
- Operational knowledge

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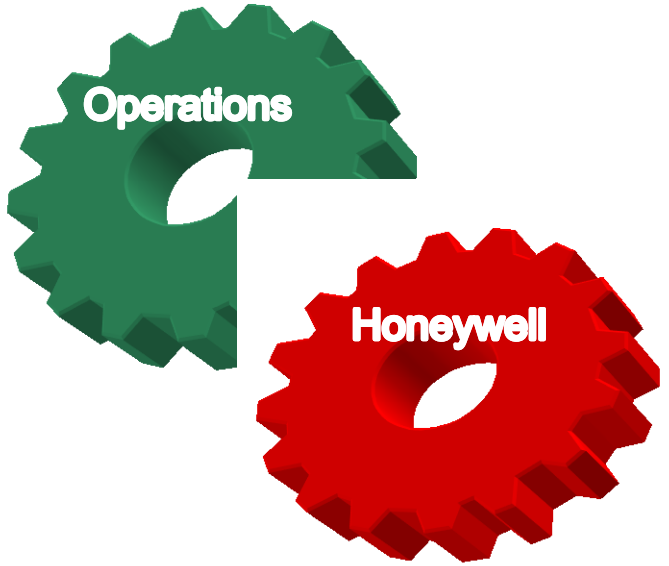
CASE STUDY:
C. MINING COMPANY

The Company Trusted in Us

- To carry out a simulation based training focused in the **transmission of best operational practices trough the use of APC applications**,

- As a team, we defined five operational training scenarios for their biggest SAG Line



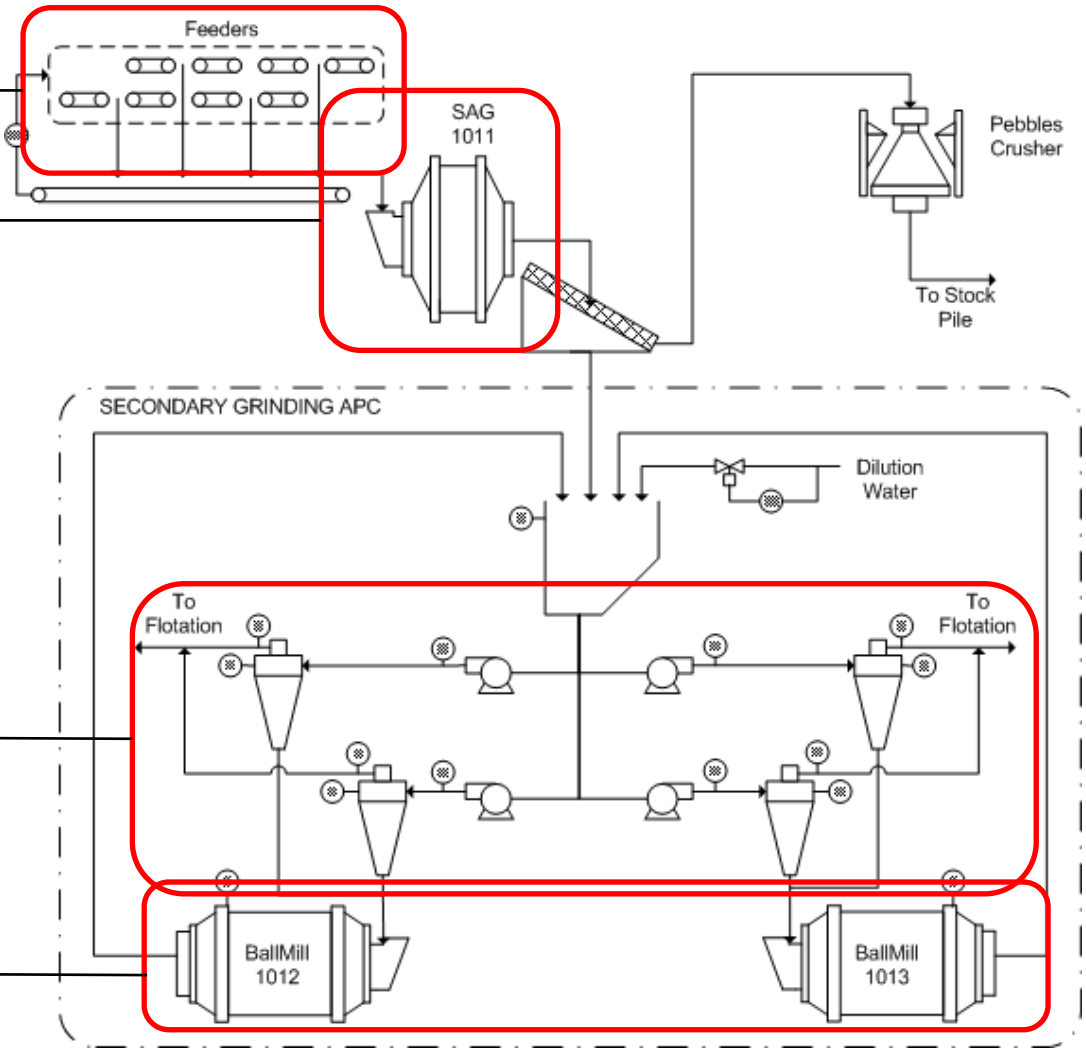
The Process Flow Diagram

8 variable speed feeders

High Capacity SAG Mill
Size: 40x24 [ft]
Power: 21500 [kW]
Max throughput: 5300 [ton/h]

4 hidrocyclone batteries

2 Ball Mills

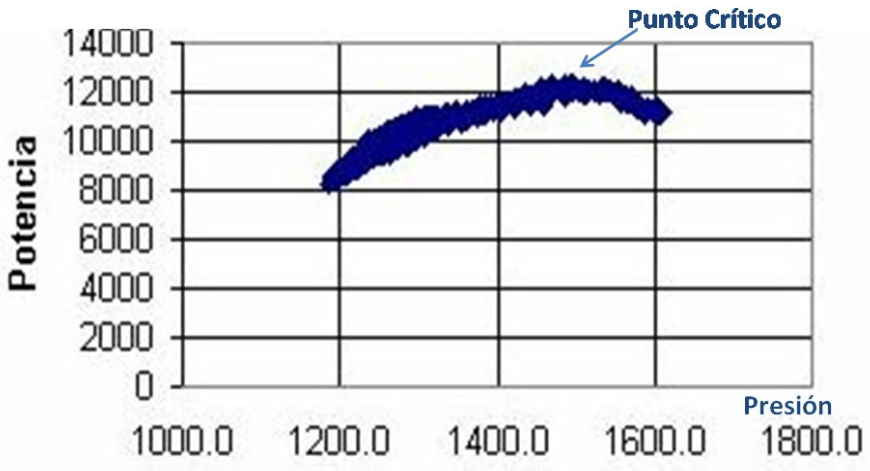


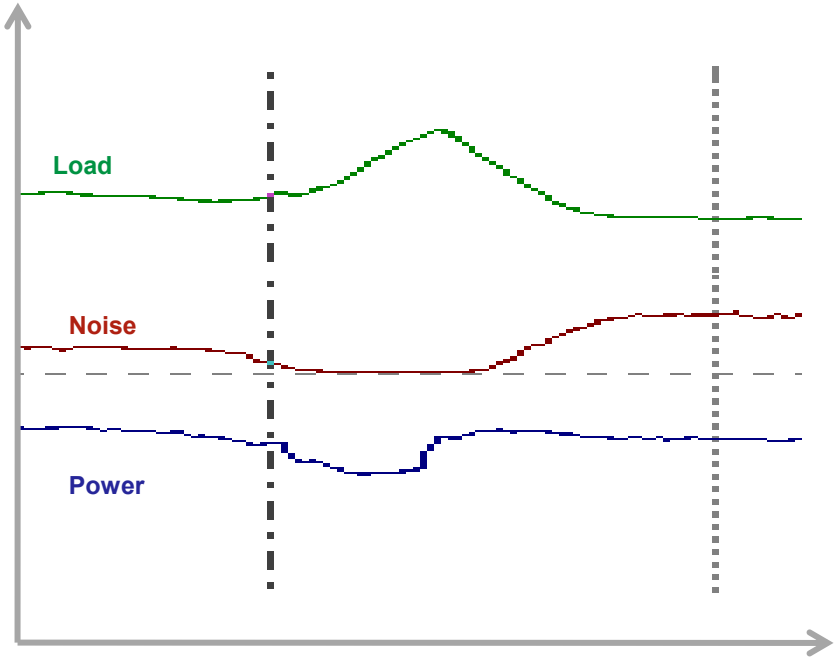
Training Scenarios

- Each Scenario have
  - Theoretical intro
    - Problem definition
  - Event sequence
  - Tips to revert the situation
  - Evaluation table

Training Scenarios

1. SAG Mill overload due to an increase on the ore coarseness,





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4. Secondary grinding. Constrained operation with sudden pump malfunction events and low water availability,

Training Scenarios

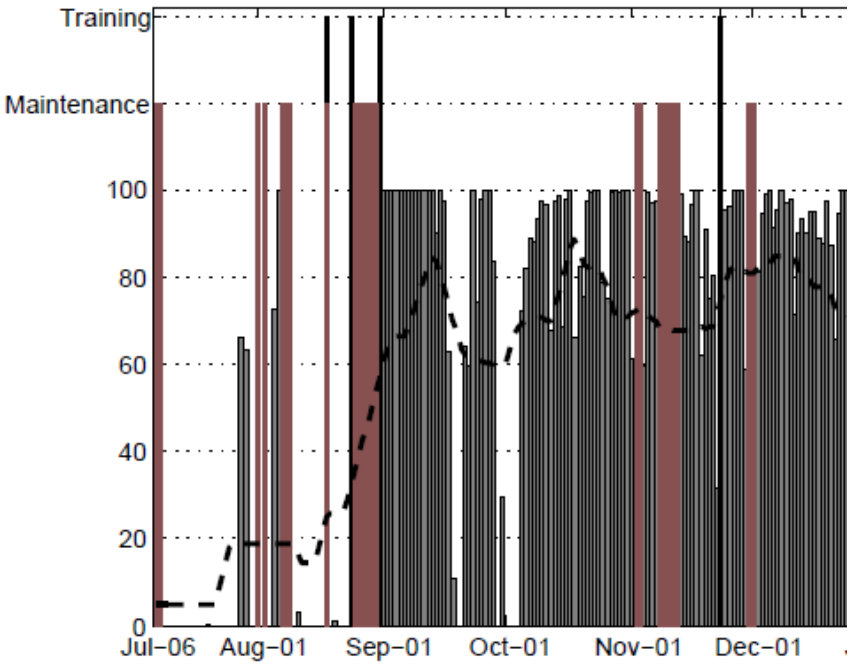
1. SAG Mill overload due to an increase on the ore coarseness,
2. Low Stock-Pile level and its effects on the plant,
3. Constrained operation, with low water network pressure,
4. Secondary grinding. Constrained operation with sudden pump malfunction events and low water availability,
5. Operation optimization of the integrated circuit

Results (1/2)

- The evaluation of the impact of a simulation based training is not straight forward,
- Therefore, the results presented in this section are an indirect measure of this impact.

Results (2/2)

- Increase in utilization of secondary grinding APC application, from 20% to about 70%, in average,
- Good results in theoretical tests,



Dynamic Simulation for Copper Concentrator Plants

OUR CURRENT STATE

Chile's Simulation Team

- We have conformed a multi-disciplinary team
  - A mathematician,
  - A chemical engineer,
  - Electronic engineers,
  - Metallurgical consultants

Clients and Projects

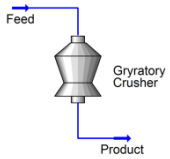
- Codelco VP
  - 5 years contract to simulate the structural projects,
    - Ministro Hales
    - Andina Phase 2
    - El Teniente New Mine Level
    - Underground Chuquicamata
  - Currentrly working in the first structural project: Ministro Hales,
    - Modeling,
    - Integrated engineering validation,
    - Dynamic DCS CAT,
    - Operator Training Simulator (OTS)

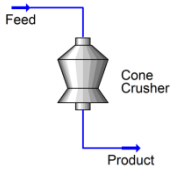
Clients and Projects

- Caserones (Lumina Copper)
  - 3 years contract for technological platforms,
  - Oxide Plant SBT(LX, SX, EW),
  - Concentrator (Sulfur) Plant SBT(crushing, grinding, flotation, thickening).

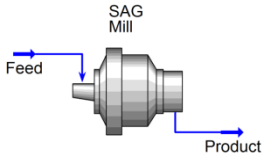
Simulations for Concentrator Plants

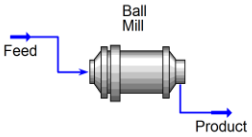
- Crushing
  - Gyratory (Primary) Crusher
  - Cone Crusher

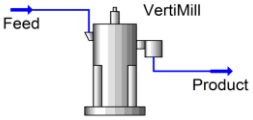




- Grinding
  - SAG Mill
  - Ball Mill
  - Vertical Mill

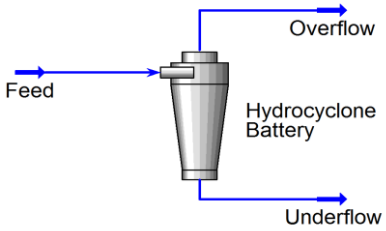




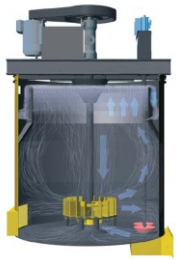


Simulations for Concentrator Plants

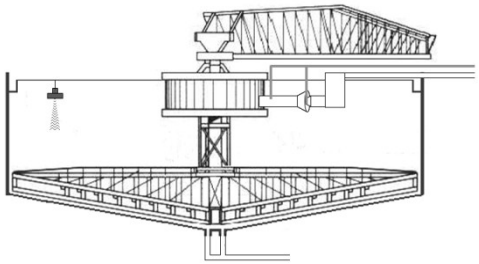
- Classification
  - Hidrocyclone Battery



- Flotation
  - Flotation Cell

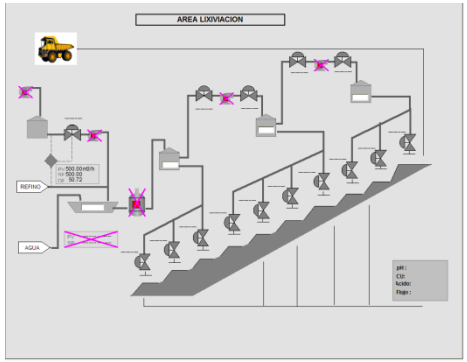


- Thickening
  - Thickener

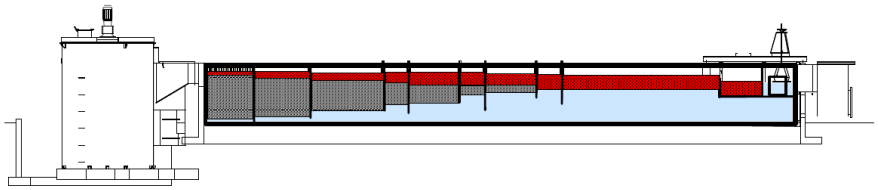


Simulators for Copper Oxide Plants

- Leaching
  - Dump Leach



- Solvent Extraction
  - Mixer-Settler
  - WLO



- Electrowinning
  - Electrowinning Cell

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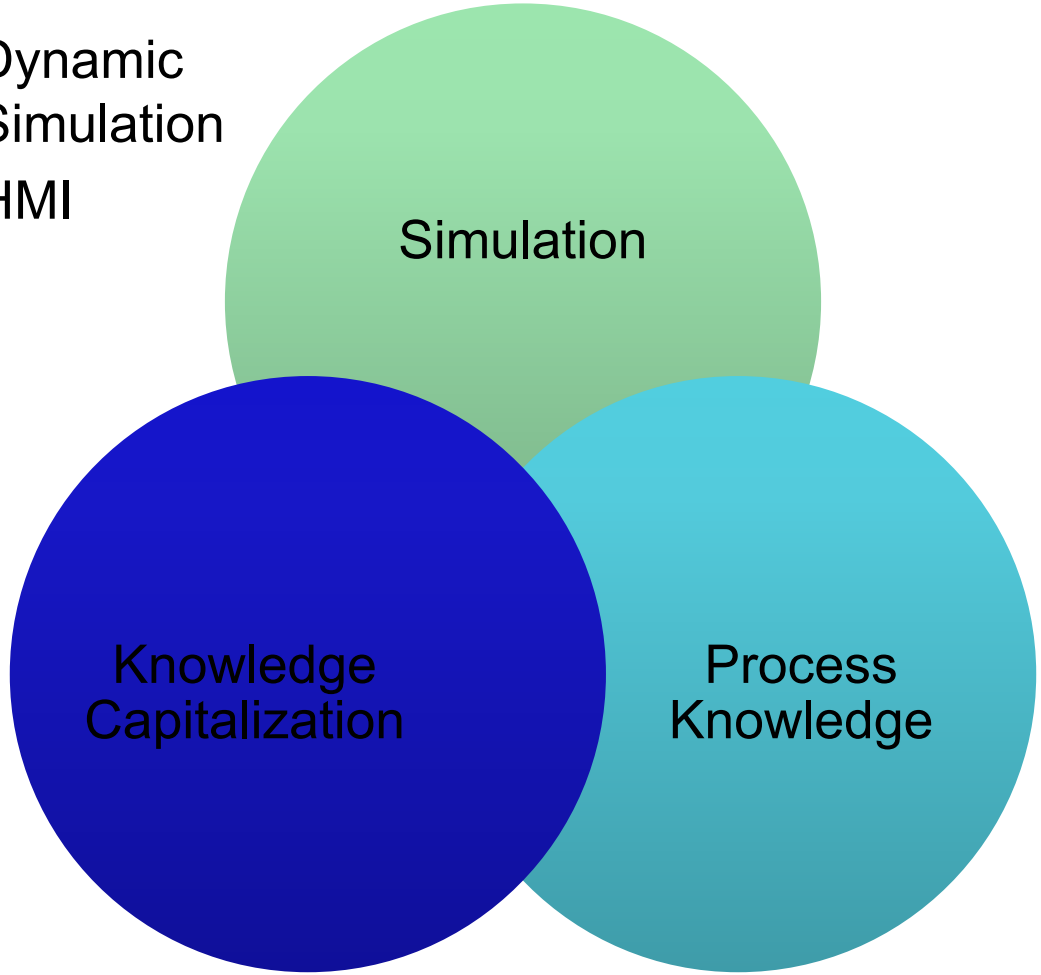
FUTURE WORK AND FINAL REMARKS

Future Work

- Improvement of Flotation Cell model
  - Include pH effect
- Creation of Flotation Column model
  - Washing water effect
  - pH effect
- Improvement of Thickener model
  - Improve torque calculation

Future Work: Integral Solution

- Dynamic Simulation
- HMI



- eLearning
- CBT

- Theoretical training
- Operational knowledge

Final Remarks

- SBT help to
  - Adopt new technologies, like APC applications,
  - Give confidence to the students to face difficult decisions in every-day operation,
  - Transmit best operational practices

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THANK YOU

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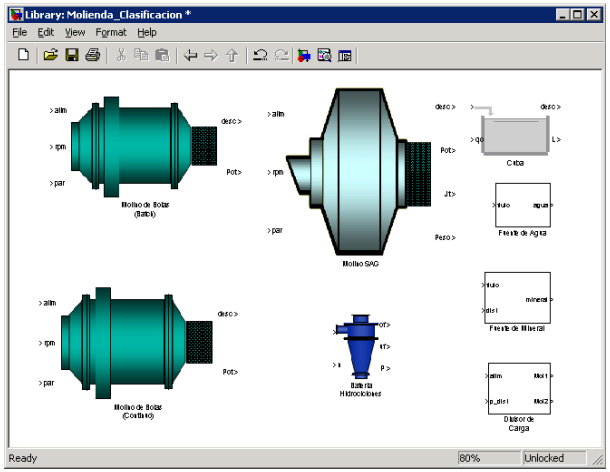
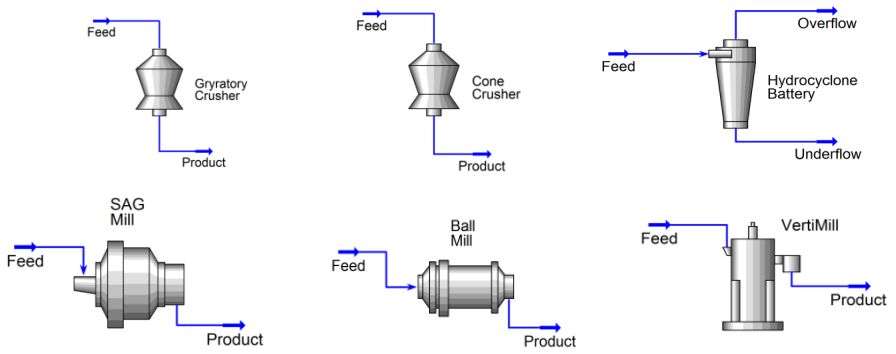
BACKUP SLIDES

We Engineered a Two-Stage Solution

- Matlab & Simulink
  - Model development and testing
- UniSim
  - Commercial use (deliverable)





Brief Description of Comminution Models (2/2)

- The mass holdup at every size interval is defined as

$$\frac{dH_i}{dt} = -S_i H_i + \sum_{j=1}^{i-1} S_i b_{ij} H_i + M_i^F - M_i^P$$

In-size Holdup variation

Particles exiting the size “i”

Particles entering the size “i” from size “j”

Fed particles of size ”i”

Product particles of size ”i”