Grinding Circuit Throughput Optimization through First-principles Digital Twin Modeling



SAIMM 2025

June 25

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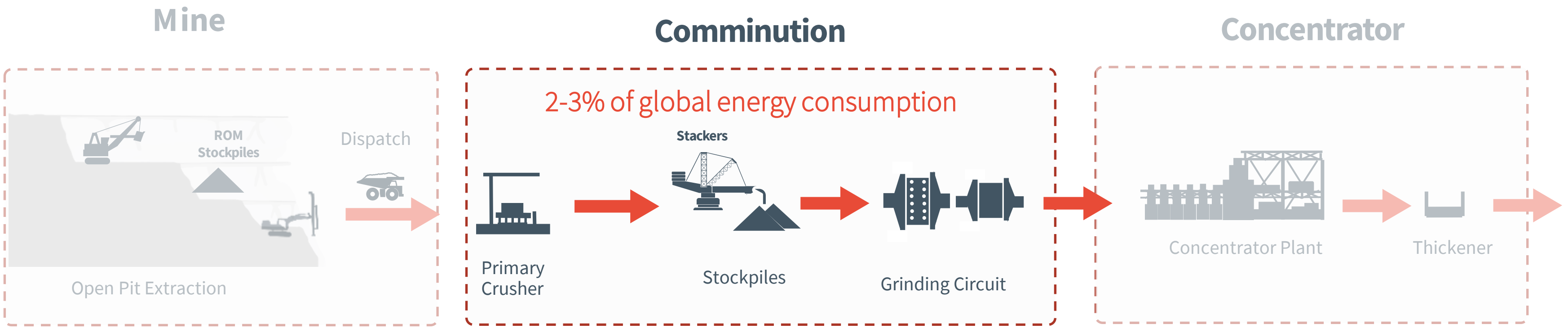
Agenda

1. Introduction
2. Grinding Digital Twin - Features
3. Grinding Digital Twin – Framework
4. Grinding Digital Twin – Optimization
5. Case Study & Results
6. Conclusion

Grinding Circuit

Overview of Challenges



Challenges	Inherent Process Instability 5-10% variation of target p80	Unrealized Production Potential 30-50% of plant's cost	Excessive Energy Consumption 1-5% of energy creates new surfaces
Root Cause	Complex physics, constant disturbances	Siloed control, operational conservatism	High recirculation, inefficient breakage.

Overview of Grinding Digital Twin

First principles digital twin models that are modular and technology agnostic.

Core Functions

Inherent Process Instability
- Simulate Complex Interactions
- Predict Process Risks
- Test 'what-if' scenarios

Unrealized Production Potential
- Holistic Circuit Optimization
- Identify True Bottlenecks
- De-risk Control Strategy Changes

Excessive Energy Consumption
- Quantify Grinding Inefficiencies
- Optimize Energy-per-Ton
- Balance Throughput vs. Energy

Stages included in digital twin

Blasting
- Fragmentation size distribution
- Optimal blast design
- D80 estimation

Crushing
- Particle size distrib.
- Crusher throughput
- Power consumption

Grinding
- Mill throughput
- Operating parameters (e.g. critical speed, power)
- Hydrocyclones

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Grinding Digital Twin – How it Works

Grinding DT Configuration → **Grinding DT Execution**

Establish a Flowsheet

Define the process flowsheet by mapping all equipment and their material flow connections.

Calibrate Models

Tune the first-principles models using historical plant survey data (PSDs, flow rates, power draws).

Define Business Strategy

User sets the operational goal and defines all process and equipment constraints

Execute Bayesian Optimization

Simulate and optimize the circuit performance against the objective and constraints

Optimal Setpoints & Asset Configuration

Generate actionable, operating strategy ready for execution by the operations team.

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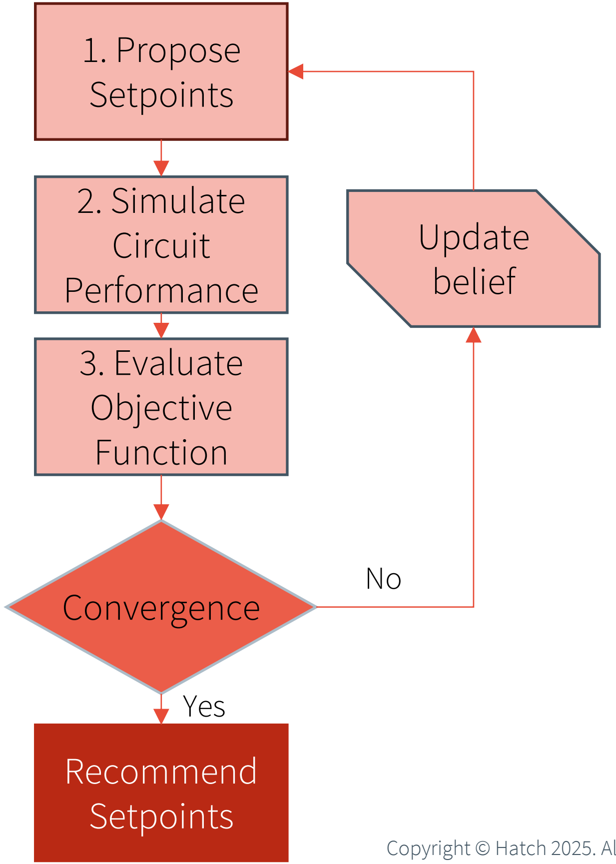
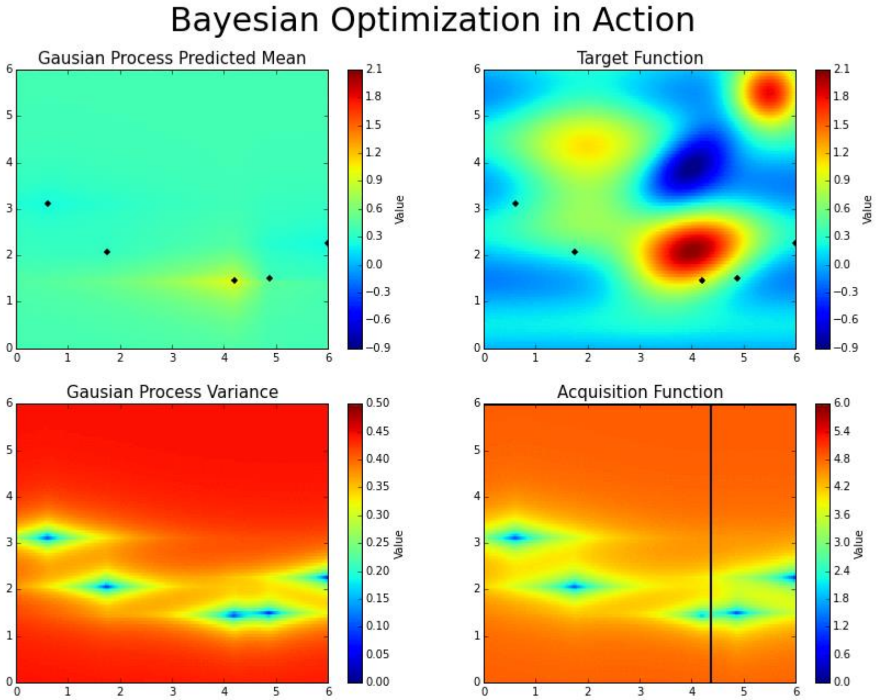
Grinding Digital Twin – Bayesian Optimization

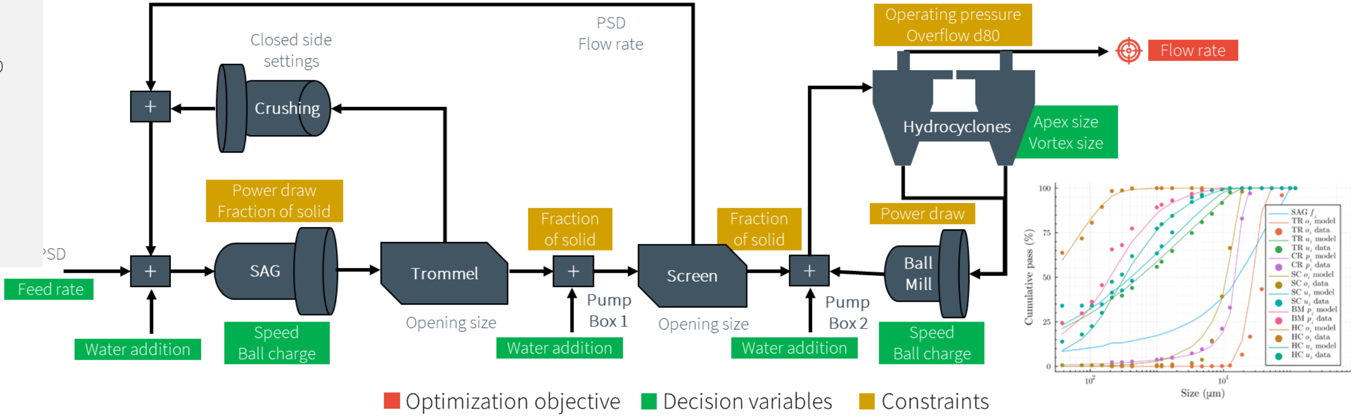
Execute Bayesian Optimization





Client Use Case Overview

The PoC study for our client showcased 3-15% improved throughput achieved by optimal decisions on operating variables and process design parameters.



Reference base case	1 Control Setpoint Optimization	2 Control & Asset Configuration Optimization	3 Process Configuration Optimization
Base operational case	SAG mass feed flow rate, Water addition, Mill Critical Speed	Optimize Volumetric fraction occupied by balls.	Explore benefits of enabling additional hydrocyclones

Grinding Digital Twin – Client Use Case Results

	Reference base case	1 Control Setpoint Optimization	2 Control & Asset Configuration Optimization	3 Process Configuration Optimization
	Base operational case	SAG mass feed flow rate, Water addition, Mill Critical Speed	Optimize Volumetric fraction occupied by balls	Explore benefits of enabling additional hydrocyclones
Decisions	-	+2.8% SAG Feed rate +6% SAG mill speed + 50% water addition at SAG + PB -- SAG Fraction solid ++ Finer SAG product ++ Operating Hydro pressure	+ 7% SAF Feed +7% SAG mill speed +2%/+6% SAG & BM Ball charge = Maintain similar control setpoints as Scenario #1	+13% SAG Feed +1 Hydrocylones + Modify Apex and Vortex diameters ++ Water addition at PB1
Key Constraint	P80<102 µm	98 µm	98 µm	101 µm
Result	409 t/h	Short term control +3%	Change process settings +7.6%	Change assets +15%

Our Partnership Journey

Model Development
- Process sampling survey
- Model configuration + calibration
- Offline benefit quantification

2-3 weeks

Offline Decision Support
- Offline model deployed for use
- Manual input configuration
- Operator executes on recommendation

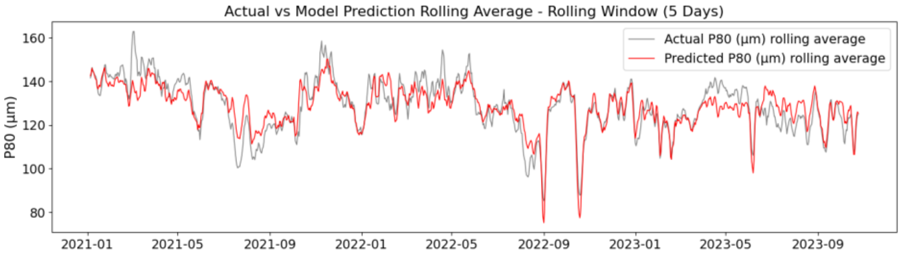
4-5 weeks

Online Decision Support
- Integration into PI/SCADA
- Periodic optimization
- Operator approves setpoints into control system

6-8 weeks

Decision Automation
- Closed loop optimal control setpoint automation
- Economic process optimization

10-12 weeks



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Summary

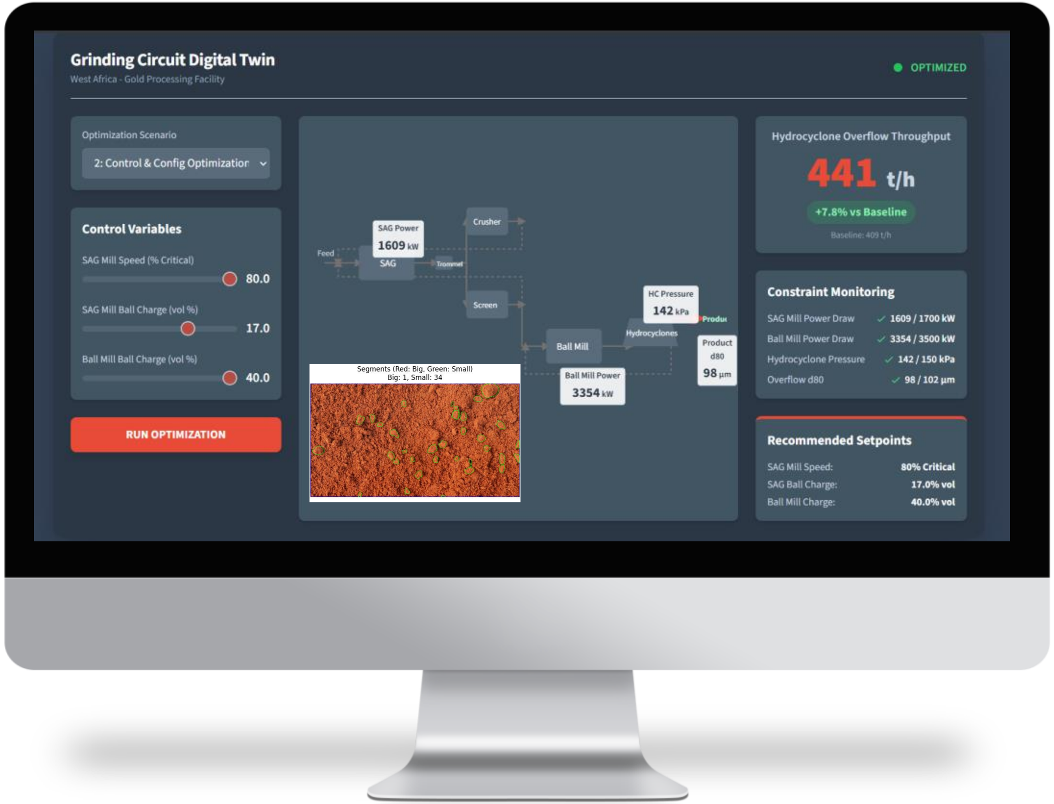
Challenge

Grinding circuits are governed by complex physics and constant process variability, forcing a conservative operational stance. This creates a significant, yet difficult-to-quantify, gap between typical and potential performance.

Solution

- Maximizing throughput
- Holistic optimization
- Quantifying impact of deviations

Hatch Grinding Digital Twin offers a comprehensive framework, to unlock the full economic potential of your comminution circuit.



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Many Thanks!

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please visit www.hatch.com