Advanced Process Control
Mining, Minerals & Metals

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Why Advanced Process Control in MMM
Operational Efficiency – Operate and Control

- **Crush and Communion**
- **Material Handling**
- **Utilities**
- **Smelting**
- **Separation**
- **Flotation**
- **Thickening**
- **Data Analytics**

**Process Improvements:**

- **1-5% energy reduction**
- **1-5% increase in throughput**
- **10-50% froth level stabilisation**
- **1-10% water recovery**
- **20-40% bath temperature stabilisation**

How do we define Optimization
Push Process to Maximise Profit in Real Time

Maximize Investment in your High Value Assets
How do we control?
The Conventional Control

The Good Old PID loop

- Must “pair” variables
- Limited performance/robustness
Pain Points in Process Optimization

• Optimising process operation with conventional control is *challenging*:
  - Time delays prevent accurate adjustment
  - Control actions interact with each other
  - Disturbances are frequent
  - Optimum conditions are unknown
  - Lots of manual operation, operator’s experience dependent
  - Product quality measurements are infrequent

• Conventional Control works to ensure in-specification product ➔ in-specification does not equal to optimization.
Limitation of Conventional Control in Process Optimization

Conventional Control is not able to deal with Multivariate system effectively

- Conventional SISO Control in Multivariate environment – sometimes it can be improved by coupling few Inputs and Controls together, yet it still cannot solve the problems entirely.
The Virtual Sensor

- **Virtual sensor** enables the quality measurement by sampling to behave like 100% continuous quality measurement.

- Virtual sensor combines data from many conventional measurements (temperatures, pressures, flows) to calculate an estimated value for a dependent parameter that is not measured on-line.
Advanced Process Control
The next level of Control

- Multivariable approach uses dynamic responses to determine solution explicitly

- APC can also manage larger scale, cost driven applications
What is Advanced Process Control
What is APC

• Method of process control that uses mathematical models of process behaviour to predict and control variation.

• Consistently drives the process to an optimum operating point (maximum throughput, minimum energy consumption,....)

• Widely applied in oil and petrochemical sectors, now becoming more relevant to mining industry. (software is process independent)

Advanced Process Control has two primary functions:

• Minimize process variability
• Consistently push the operating point towards optimum operating point without violating product quality
What do we mean by **Predictive Control**?

The process model is inverted

- instead of asking “What will the Controlled Variable responses be given past performance?”,
- the controller solves “What should the Manipulated Variable trajectories be to maintain Controlled Variables within their ranges or at setpoint?”
What is predictive control
What is predictive control
What is predictive control

![Graph showing predictive control]

- CV1
- CV2
- MV1
- MV2
- FV1

Setpoint 1
Setpoint 2
MV Target 2

past (history) k future
How does the model work

- Represent the **actual responses** of the process as a multivariable dynamic model.
- Each model **predicts** the direction, “shape” and size of the response.
- The model is obtained by performing a series of **step tests** on the process & **information gathering**.

<table>
<thead>
<tr>
<th>Step Responses</th>
<th>Absolute Gains</th>
<th>Incremental Gains</th>
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</thead>
<tbody>
<tr>
<td>M2100 Boiler Curv</td>
<td></td>
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<tr>
<td>M2200 Outlet Temp</td>
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<tr>
<td>M2300 Outlet pH</td>
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<td>M2400 Reheater Current</td>
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<td>M2600 Exh Fan Spd</td>
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![Diagram showing step responses and control methods]

- Traditional control
  - Setting
  - Variable
  - Signal
- Predictive control
  - APC
Improve Control then Operate Closer to Limits

Stabilise then Optimise

Target or Constraint

Before Stabilisation

APC/On

Increased Benefit

Stabilise & Re-Position
QP solution: Minimise

\[ J = \sum_{i=0}^{N} \left[ e_{i+1}^T P e_{i+1} + \Delta u_{i+1}^T Q \Delta u_{i+1} + f_{i+1}^T R f_{i+1} \right] \]

- \( e_i \): vector of CV error (from setpoint) at stage \( i \)
- \( \Delta u_i \): vector of control moves at stage \( i \)
- \( f_i \): vector of MV error (from target) at stage \( i \)
- \( P, Q, R \) are matrices of weighting factors

Calculate the series of MV control moves that:
- Respects MV HI/LO/INC constraints
- Respects CV soft constraints
- CV constraints may be “relaxed” according to a specified priority in order to maintain solution feasibility.
SimSci APC - Where the magic happens

- Trending capabilities
- Model comparisons and tuning
- Web services
- Composite modelling calculations
- Comparisons
- Radial Plots
The Proof is in the pudding

Case Studies : Grinding
Iron Ore Miner X
Our Approach

- Understand the clients needs for optimisation
- Understand current means of operations & control
- Understand the variance in operation
- Reliability of measurement
APC – You are the Experts

Put the technology in your hands

Working together
Iron Ore Comminution & Separation

- Reduction of variability, met constraints and reduced energy consumption
- Jointly formed a better understanding of process
- Developed Champions of technology
- Over 1% feed increase -- conserv
- ROI in 34 days
Why us?

- Local Support
- Our Vision & Expertise
- Technology Enablers
- Advanced software abilities
Let's have a chat?