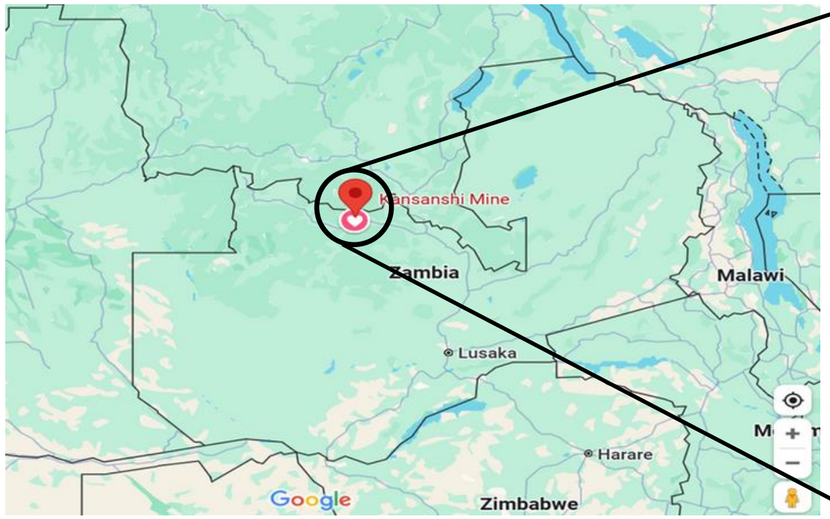
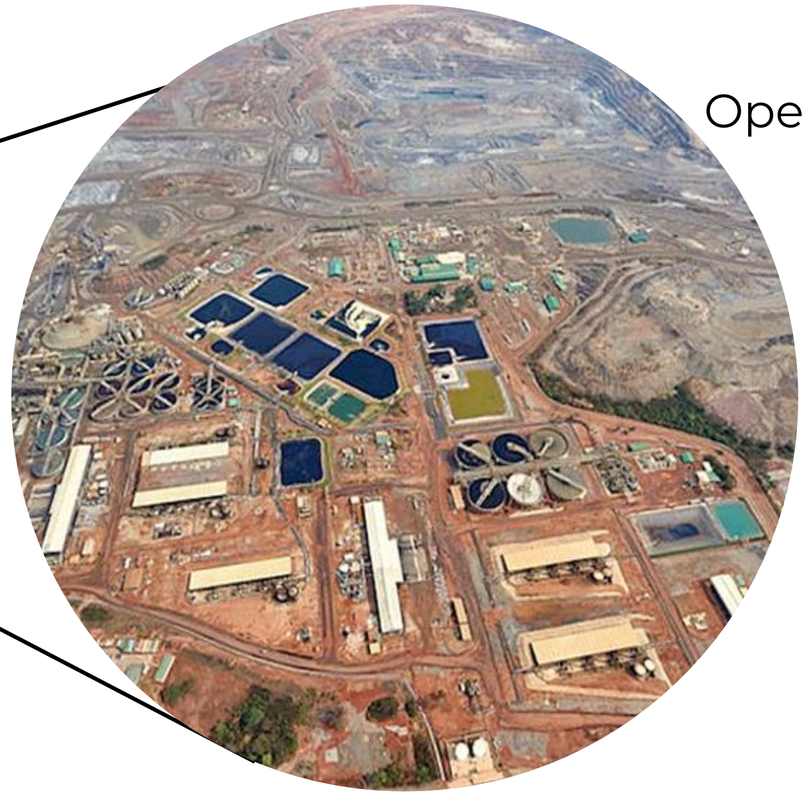
FIRST QUANTUM
MINERALS LTD

Running A Successful 4 Acid plant year Campaign

Kansanshi Mine

- Located in Solwezi (North-western province, Zambia)
- Owned and operated by First Quantum Minerals Ltd (80%), ZCCM – IH (20%)



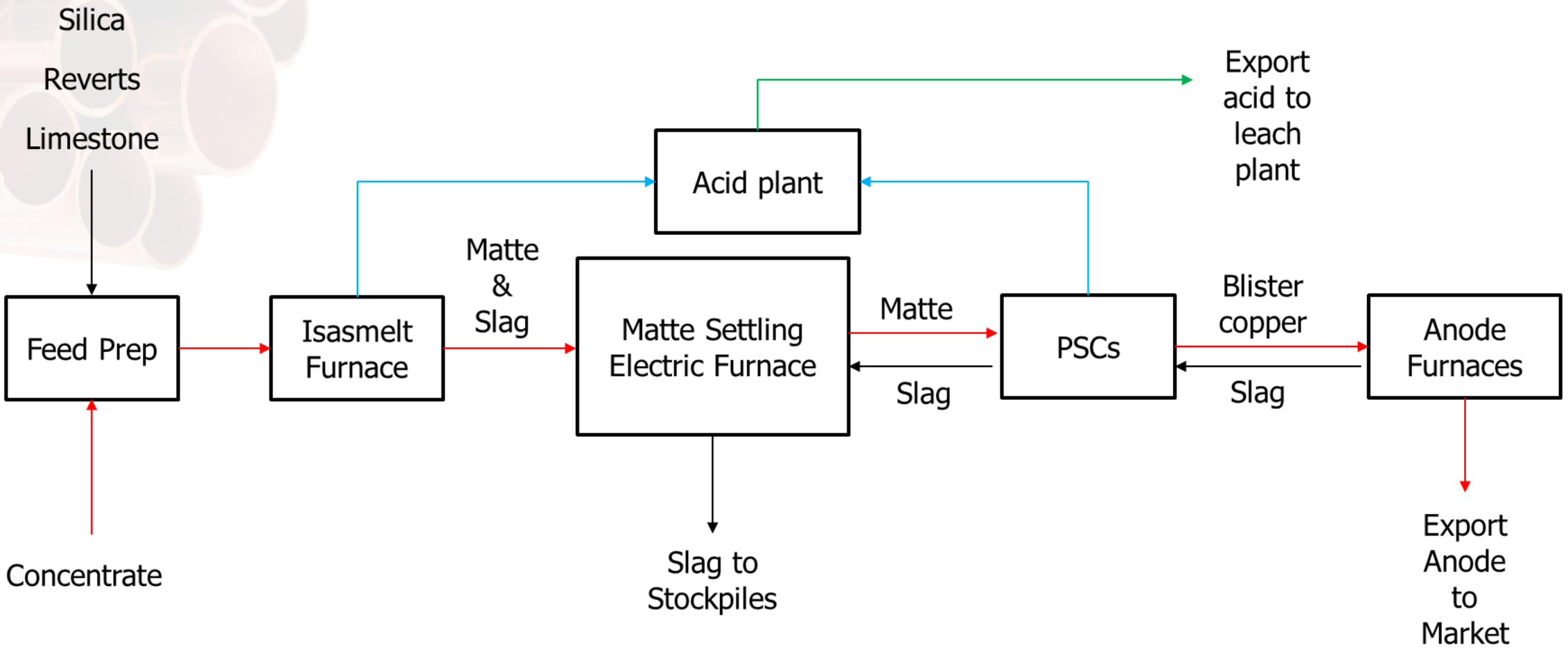


Leach-SX-EW circuit

Open pit = ***Oxide*** and ***Sulphide*** ore

Flotation and smelter route

Smelter Flowsheet



Acid plant flowsheet - Gas Cleaning

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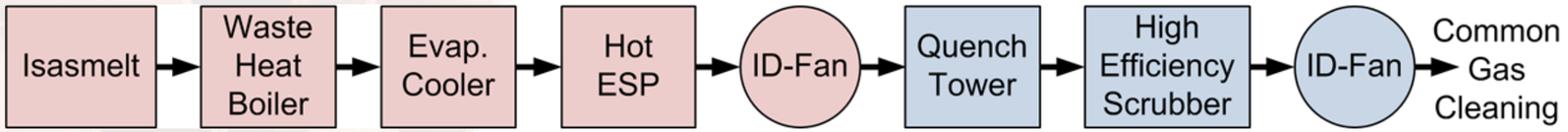
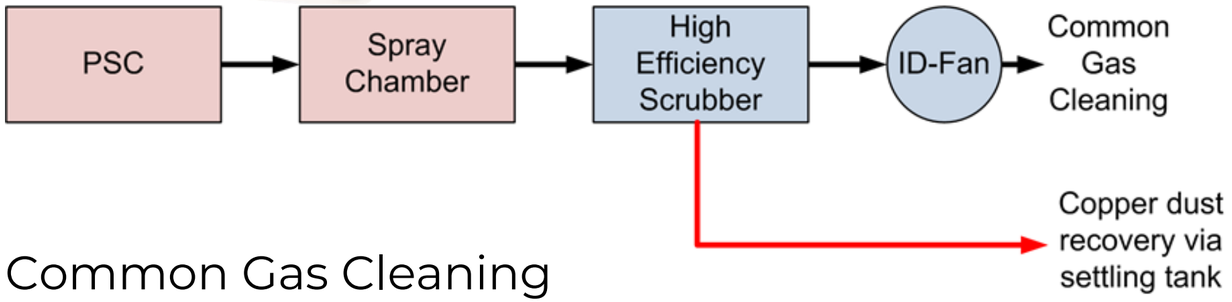
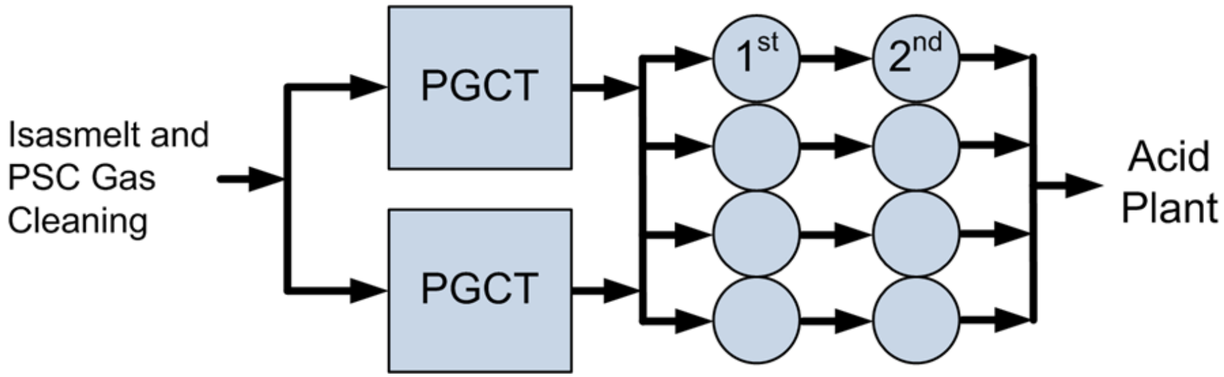
Isasmelt Gas Cleaning

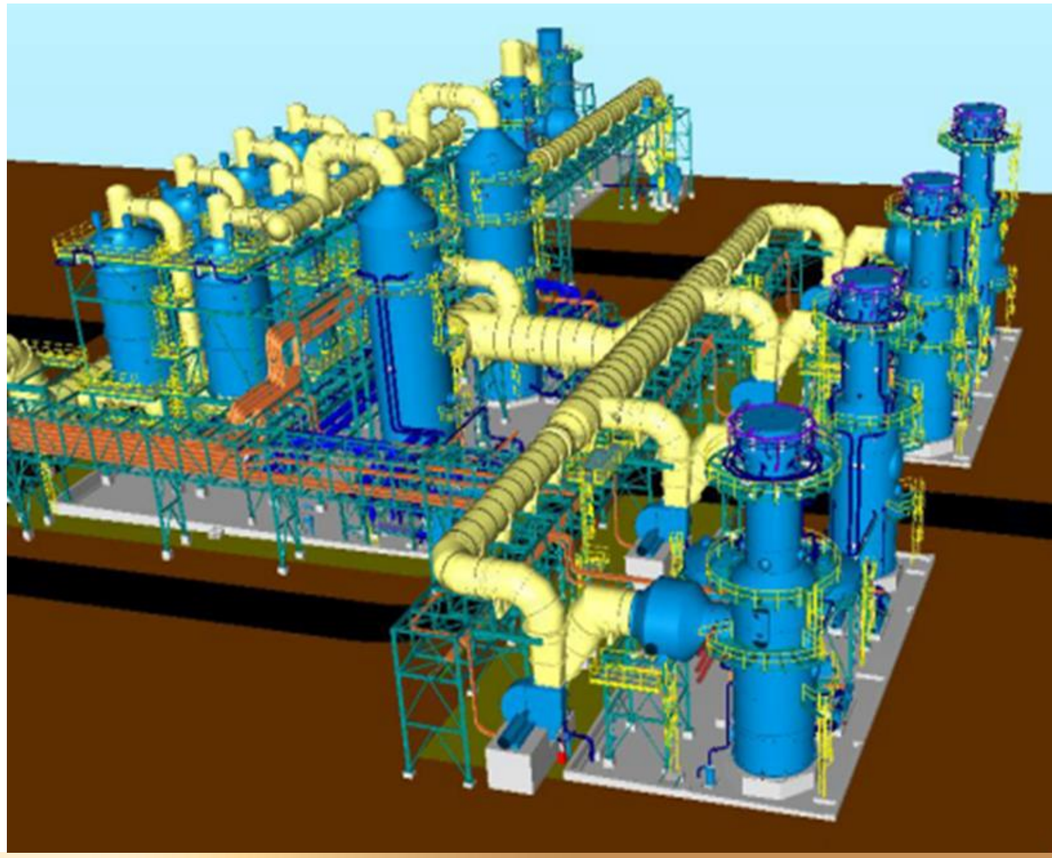


PSC Gas Cleaning



Common Gas Cleaning





Acid plant flowsheet - Oxidation & Strong Acid

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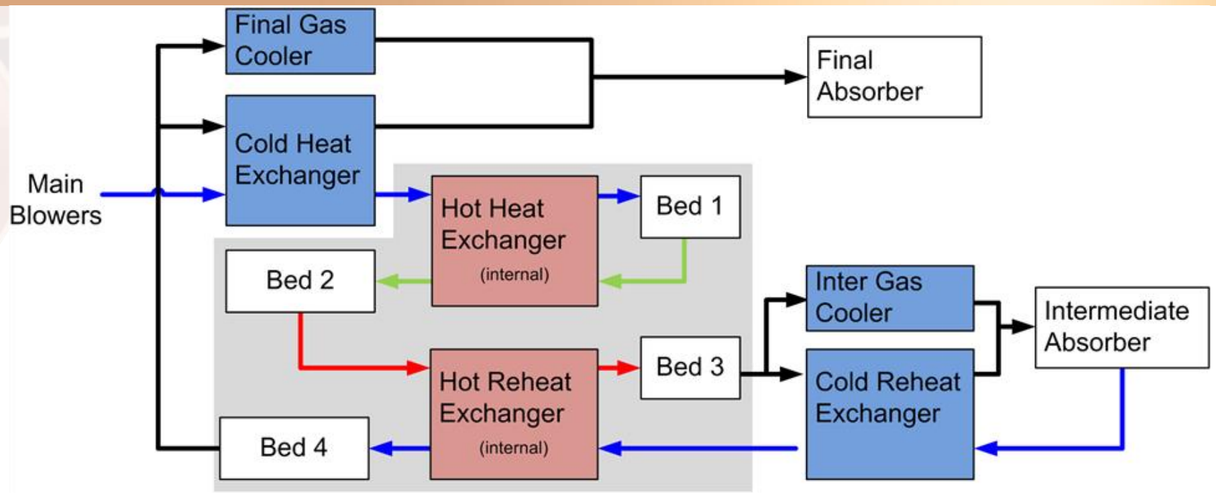

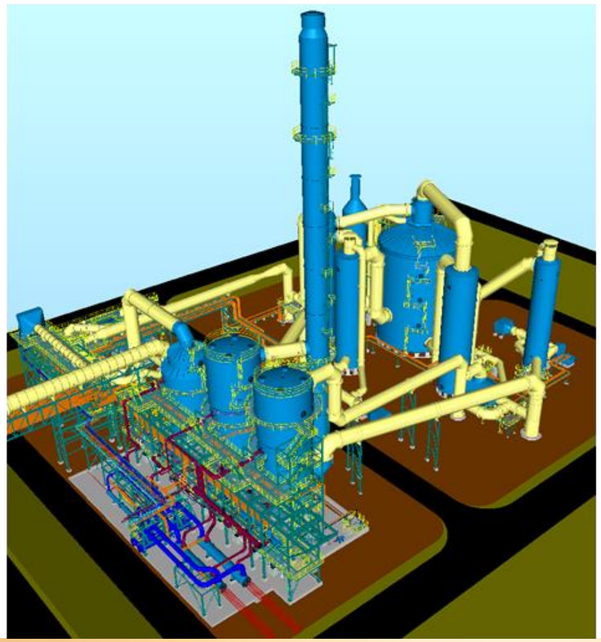

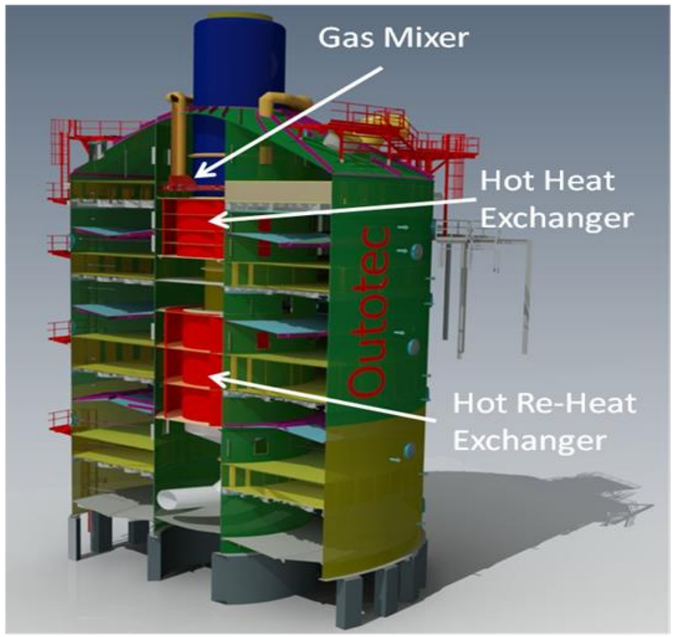

Operation timeline

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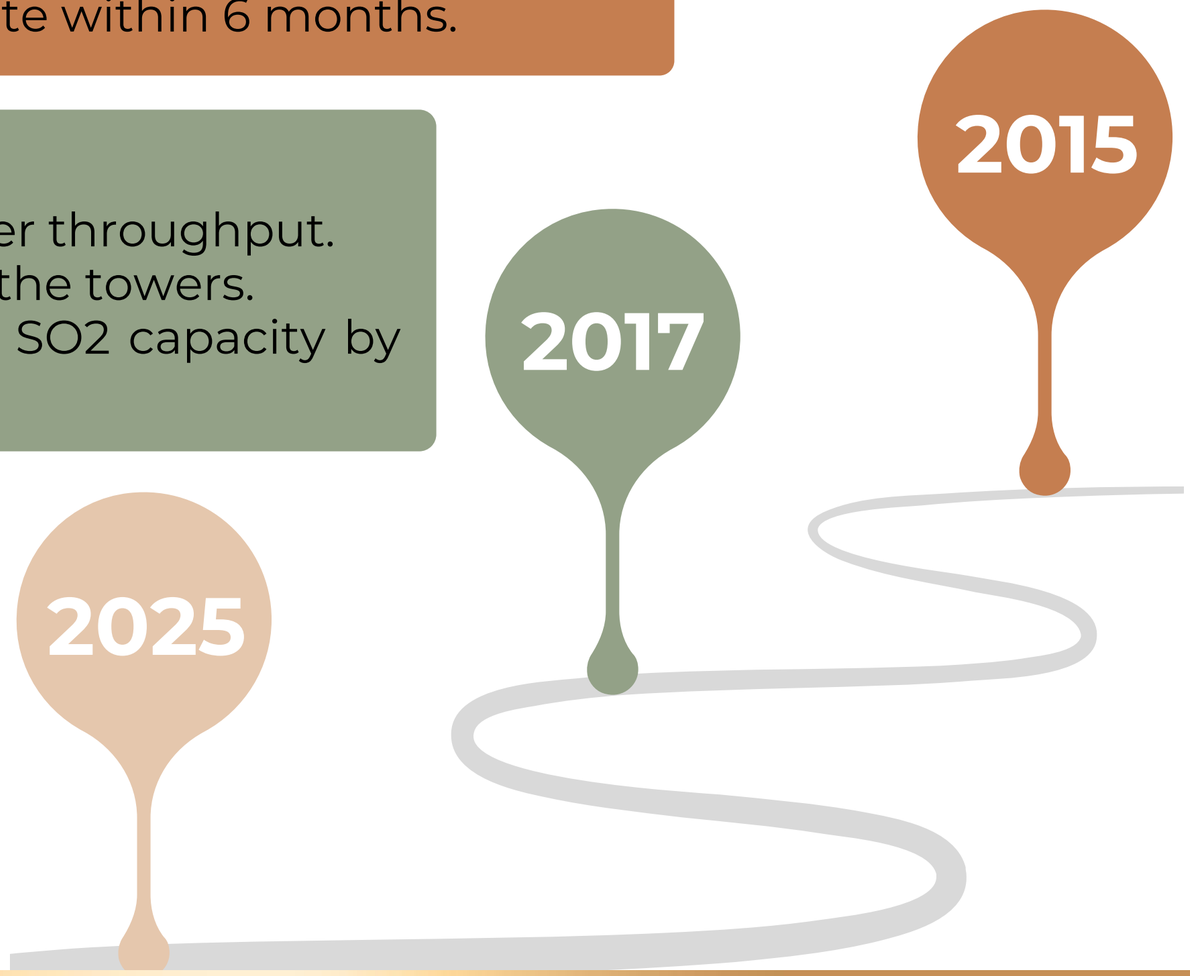
Commissioning - 2015
- First concentrate to Isasmelt – March
- Smelter ramped up to above nominal feed rate within 6 months.

Debottlenecking - 2017
- High %S in the concentrates restricted smelter throughput.
- Modifications around the SO2 converter and the towers.
- Reduced ΔP across the plant and increased SO2 capacity by about 5%.

Smelter expansion - 2025
- Increase concentrate throughput to 1.6 MTPA.
- Old sulphur-burning plant acid plant converted to metallurgical off-gas duty to give additional capacity of 1000 t/d H2SO4.



Overview

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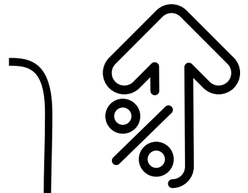
- Catalyst deterioration in bed 1 →  → • Availability • Throughput → Screening needed to reduce ΔP } 4 times in 5 years

- Many possible causes of fast catalyst deterioration. Elimination process

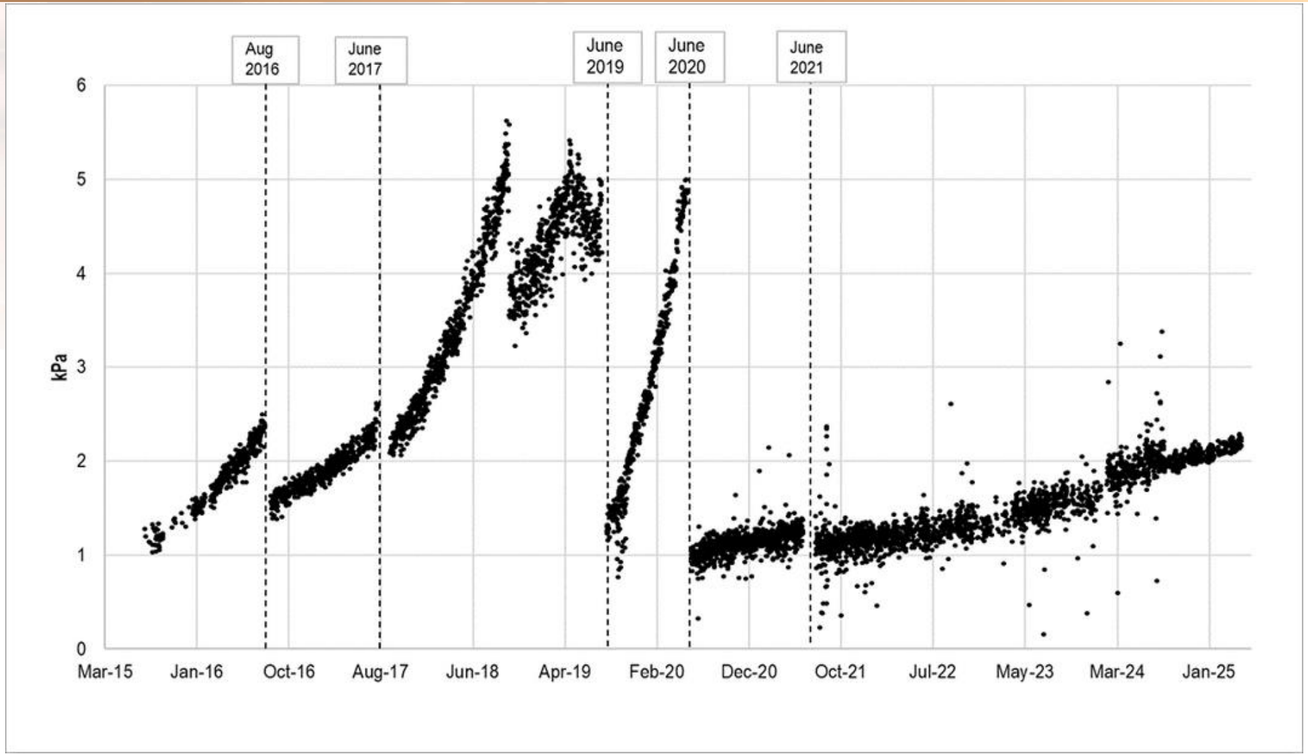
- Apart from good catalyst performance
  - Good operational practices
  - Good maintenance strategies

- Screening now aligns with smelter relining schedule

 Increased availability

 Reduced operating cost

Bed 1 pressure drop and Catalyst screening



- Fast pressure drop rise in bed 1
- Dust layer on top 100 -200 mm catalyst.
- Elimination process - Dust, Moisture, Poisons
- Samples results indicated slightly elevated levels of impurities than design. Si, F, High SO2.

Operation timeline

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Campaign No.	Time of Stoppage	Campaign Duration [Months]	Reason for Stoppage	Beds screened	Changes implemented	Achievement
1	Aug 2016	17	Unplanned stoppage - Isasmelt refractory failure	Bed 1 top layer		Bed1 ΔP reduced from 2.5 kPa to 1.5 kPa
2	Jun 2017	10	Planned stoppage - smelter turnaround	Bed 1 to Bed 4	Installed bed middle pressure Air filter changed Introduced sodium silicate at PGCTs	Bed 1 ΔP reduced from 2.2 kPa to 2.0 kPa
3	Jun 2019	24	Planned stoppage - Acid Plant turnaround	Bed 1		Pressure drop reduced from 4.7 kPa to 1.2 kPa
4	Jun 2020	12	Unplanned stoppage - High ΔP in Bed 1	Bed 1	Introduced dust protection catalyst on top layer Put new catalyst type on top of Bed 1	Bed 1 ΔP reduced to 1.0 kPa from 5.0 kPa
5	Jun 2021	12	Planned stoppage - smelter turnaround	Bed 1 to Bed 4	Catalyst was screened old no dust layers were found	Four years operation with ΔP in Bed 1 at 2.2 kPa

Good operational practices – Gas cleaning

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- **Strict control of plant parameters**
  - double measurements in certain areas.
- **Independent data historian**
  - Made optimisations easier.
- **Video cameras in strategic areas.**
- **Feed forward control for gas flow**
  - More steady gas. Minimal operator interference.

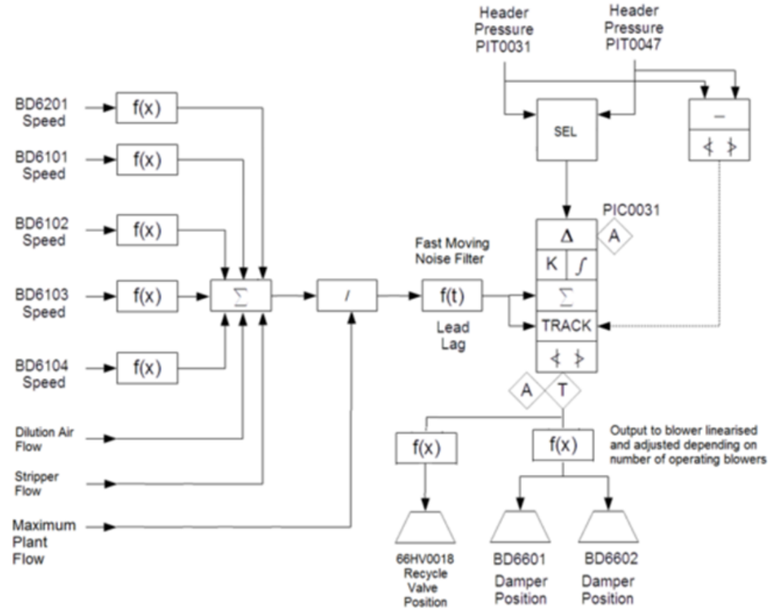

Figure 2 - SAP Blower Pressure Control

Good Operational practices – Oxidation and Strong acid

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Highly automated temperature and pressure control
- Reduce operator interference
- Better protection of plant

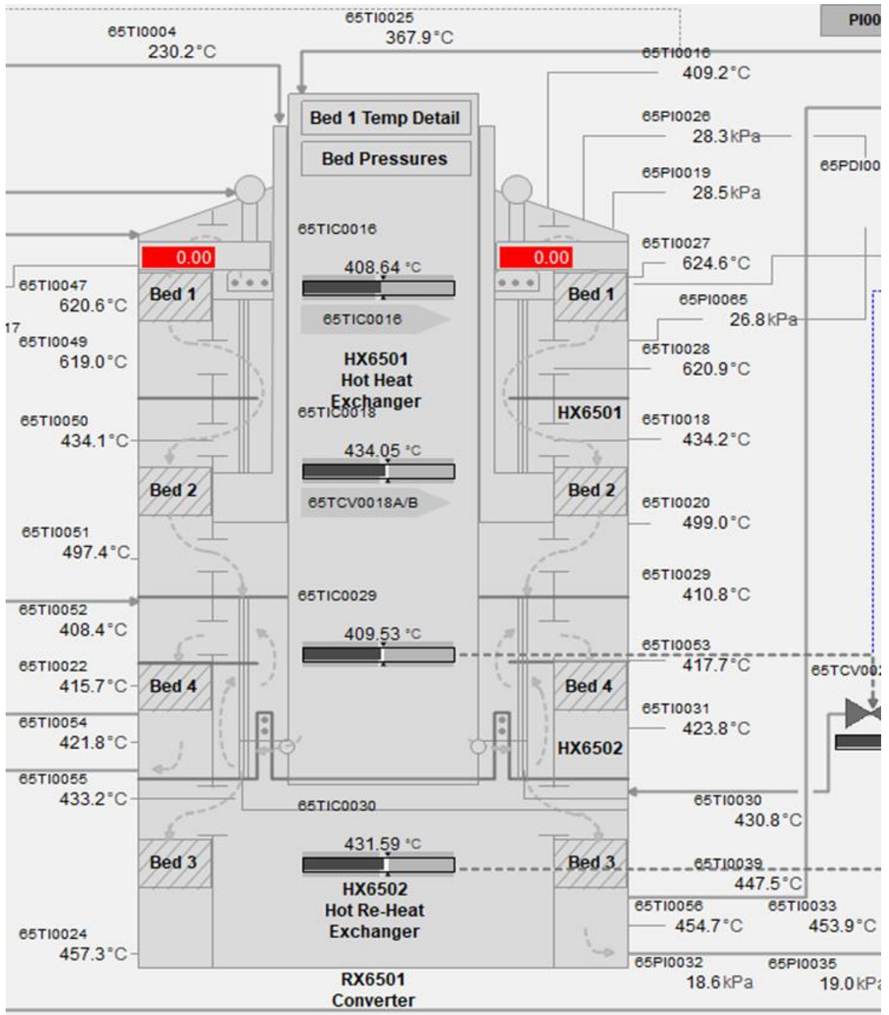
High temperature resolution
- High temperature resolution on Bed 1 and Bed 4.
- Identify cold spots, heat up.

Enhanced SO2 concentration control
- Predicted SO2 based on concentrate blend.
- Dilution based on predicted SO2.
- Operator adjustments are restricted for safety.

Condensate draining and monitoring
- CRHE, Stack, pressure ports, HX, blower inlet.

Strong acid Concentration and temperature
- Two independent online instruments for acid concentration control on both DT and AT (4 total).
- Backed up with field lab samples and analyses.

Fluoride monitoring and control
- Manual samples every shift. Dose sodium silicate if above 1ppm.



Maintenance practices – Gas cleaning

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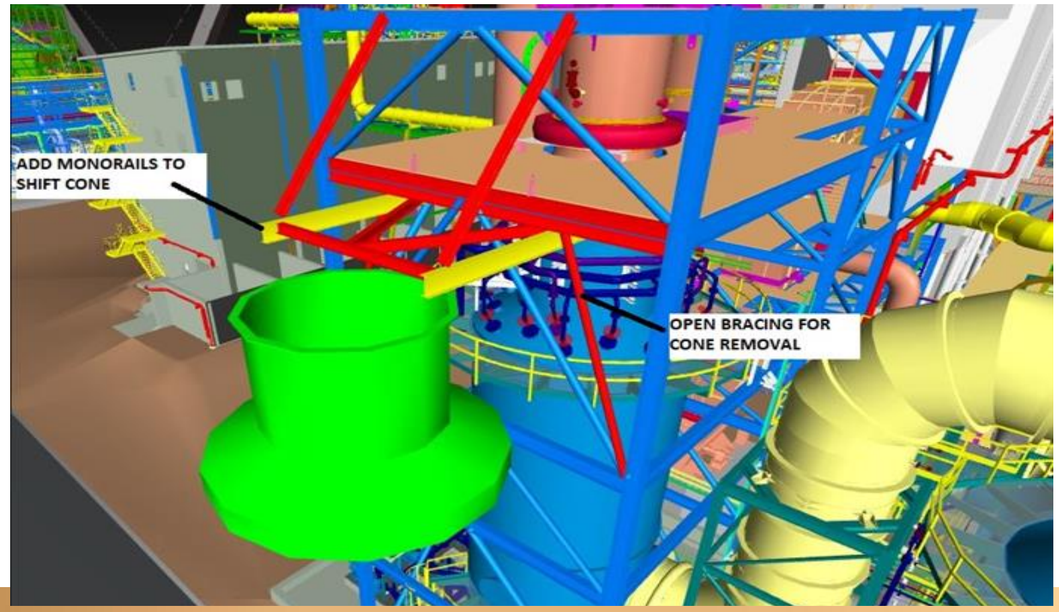
Change materials of construction in high corrosion areas

- Blower casing and impeller – Rubber lined Carbon steel to super duplex
- Quench tower cone – Rhepanol-lined carbon steel to Rhepanol-lined stainless
- Scrubber cone – Duplex to FRP
- Scrubber internal bolts– Duplex to Hastelloy.

Change instrumentation type

- Pressure transmitters changed to differential-pressure type
- WESPs band heaters thermocouples were changed to optic fibre type



Maintenance practices – Acid plant

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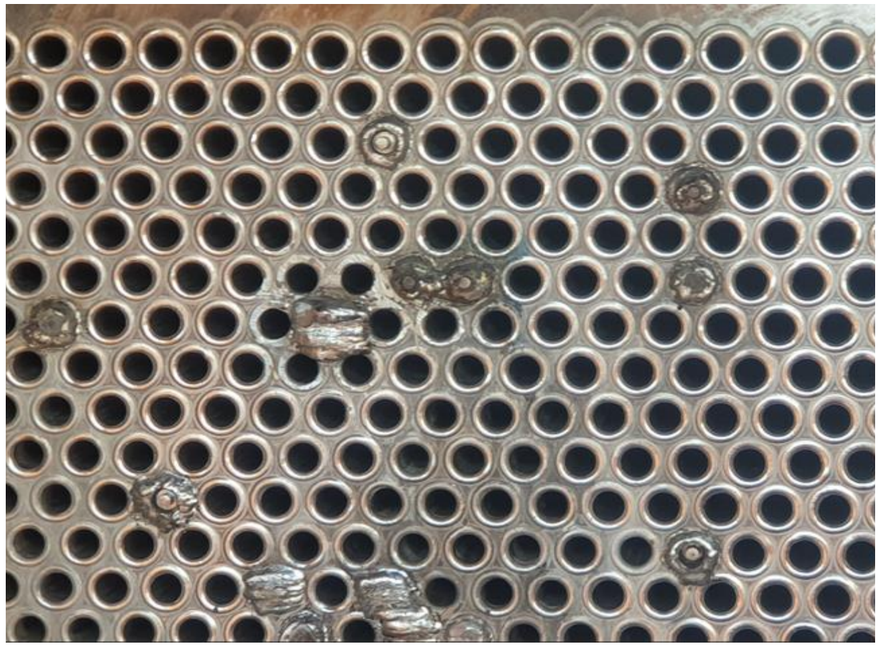
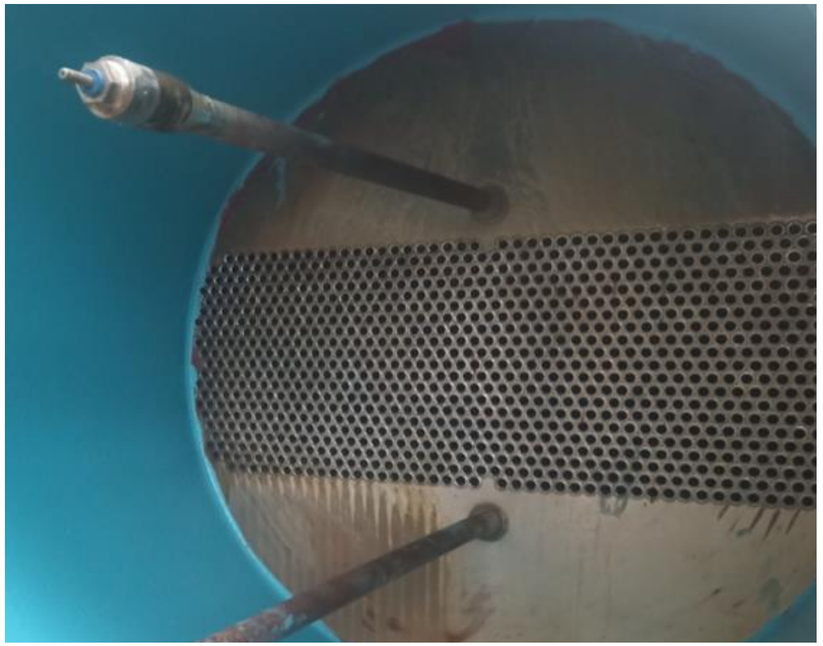
- Anodic protection on all the acid coolers
- Good water treatment program
- Condition monitoring team with advanced gadgets and equipment
- Keeping strategic spares on site





Challenges – Gas cleaning

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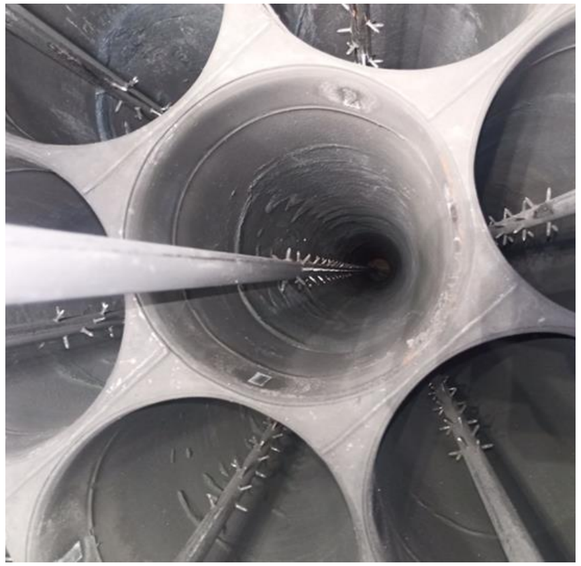
Quench tower circulation pipes blocking

- *Gradual build-up*
- *High Selenium content*
- *Requires frequent cleaning*

WESPs tubes cleaning



- *Gradual build-up, cause high rate of flash-overs.*
- *Difficult to clean*

Scrubber bricks spalling

- *Carbon bricks above quench nozzles*
- *mostly localised*

Challenges – Acid plant

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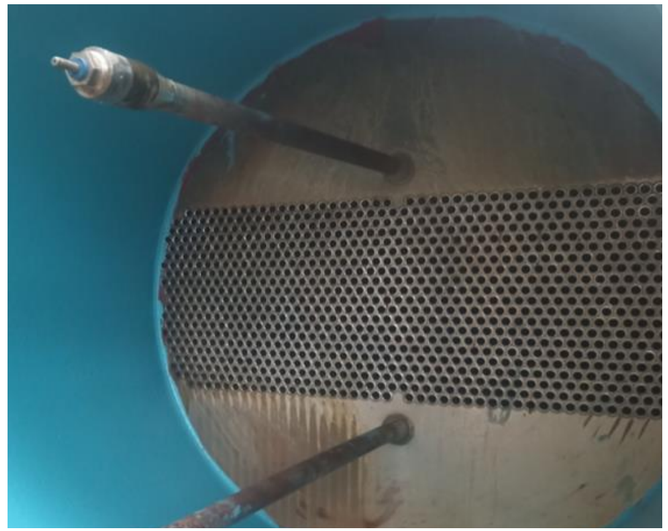
Hot heat Exchanger

- *Metal loss on the tubes.*
- *High ΔP across heat exchanger*
- *Deposit on bed 2 surface*
- *Difficult to clean*

Silt in cooling tower



- *Silt depositing in cooling tower*
- *Cause under-deposit corrosion in acid coolers*

Fluoride monitoring

- *Online monitoring solution required*

Key takeways

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Strict control of parameters requires reliable measurement

Data collections tools and data analysis

High automation of process gives more stable operations.

Management support for continuous improvement.

End

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