Seshasayee Paper and Boards Limited, Erode

AI-Driven Pulp Bleaching: Achieving Significant Reductions in Chemical Usage

A Case Study at Seshasayee Paper and Boards Limited (SPB)

Team: Mr. B V Sivakumar & Mr. D.Radhakrishnan

SPB's commitment for Excellence

1996

International Organization for Standardization ISO

9001:2015

2000

International Organization for Standardization ISO

14001:2015

2010

FSC®
www.fsc.org
MIX
Paper from responsible sources
FSC® C084458

2017

GREEN COMPANY RATING SYSTEM
CII - SOHRABJI GODREJ GREEN BUSINESS CENTRE, INDIA
Greenco
Seshasayee Paper and Boards Limited
Erode
GOLD
2017

2020

International Organization for Standardization ISO

45001:2018

2024

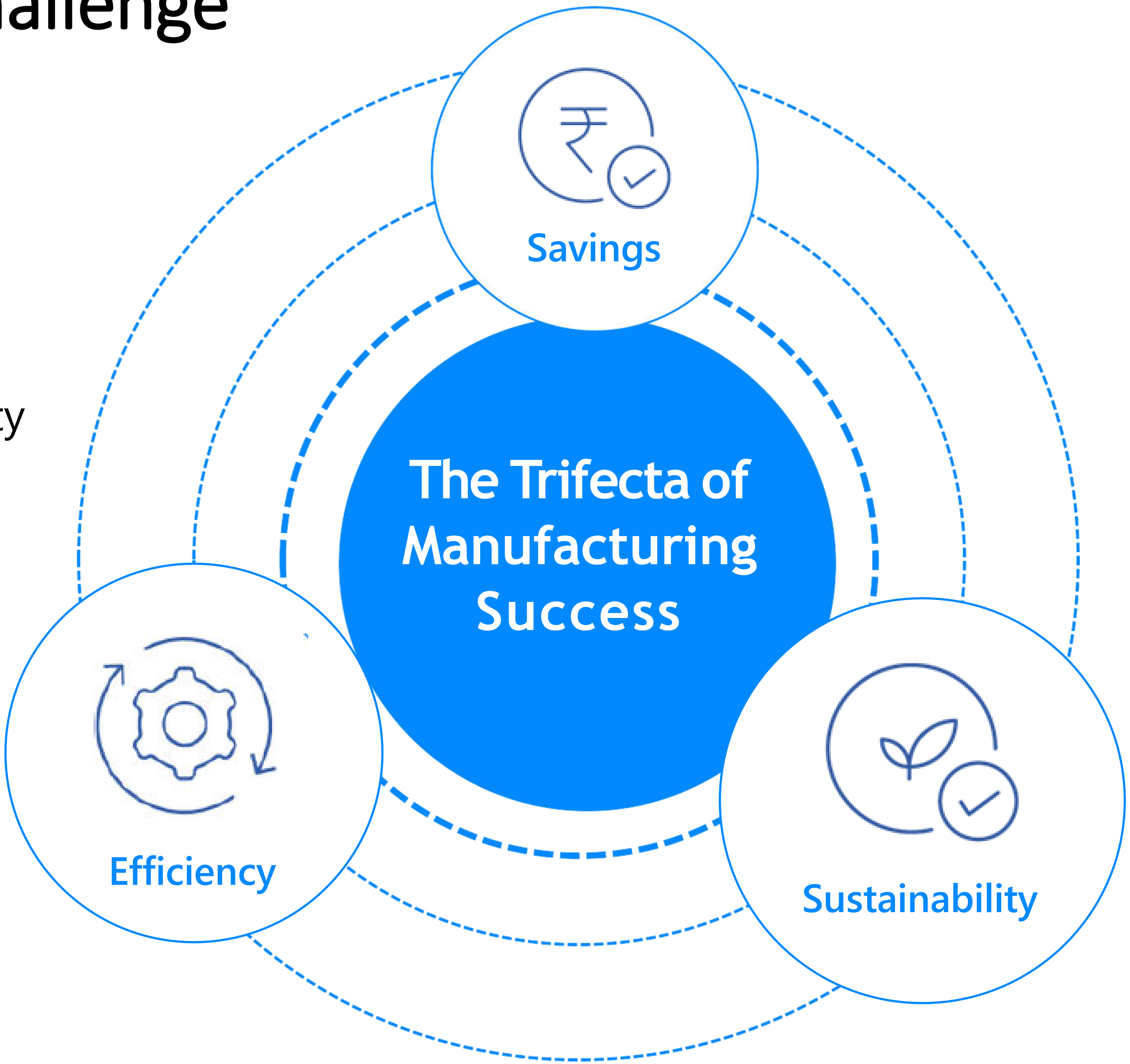
International Organization for Standardization ISO

50001:2018

" Without standards & Measurements, there can be no improvement "

The Pulp & Paper Industry Challenge

- Resource utilisation
- Resource Raw material availability
- Adaptability and scalability
- Quality compliance utilization
- Supply chain efficiency



The Bleaching Process & Traditional Control

- Remove lignin and impurities to achieve desired brightness.

Limitations of Traditional Methods

- Reliance on fixed parameters
- Operator experience
- Difficulty adapting to raw material
- Process variability
- Over-consumption of bleaching chemicals
- Inconsistent product quality
- Increased environmental burden

Cooking: RDH Technology
ODL: 2 stage
Bleaching sequence: D0->Eop-> D1
ISO Brightness: 86

The Power of AI

Resource Optimisation

Real-time monitoring and insight-driven decision making to reduce wastage, identify inefficiencies, and enable cost savings

Streamlined Operations

Transparency and accuracy in data to promptly identify incidents, facilitating swift issue resolution.

Unified Central System

A role-based platform for data tracking across all manufacturing stages, ensuring easy access to records for informed process optimization.

Sustainability Reporting

Easily accessible data for streamlined audit and sustainability reporting

Production Efficiency

A streamlined system ensuring uniform quality to elevate customer satisfaction

- AI offers precise control, optimized chemical usage, enhanced product consistency, and improved sustainability.
- Learns from vast amounts of data to identify complex relationships.
- Enables dynamic adjustments to process parameters.

AI-Driven Solution in Bleach Plant operations

The objective of the bleach controller

- Reduce final brightness variability.
- Minimize the chemical consumption maintaining the final brightness

Controlled by

- Optimal pH set points for the inlet of D0, and the inlet of Eop stages.
- Optimal Acid, Chlorine Dioxide, Caustic dosages in each stages of the bleach plant to minimize variability in final pulp brightness.

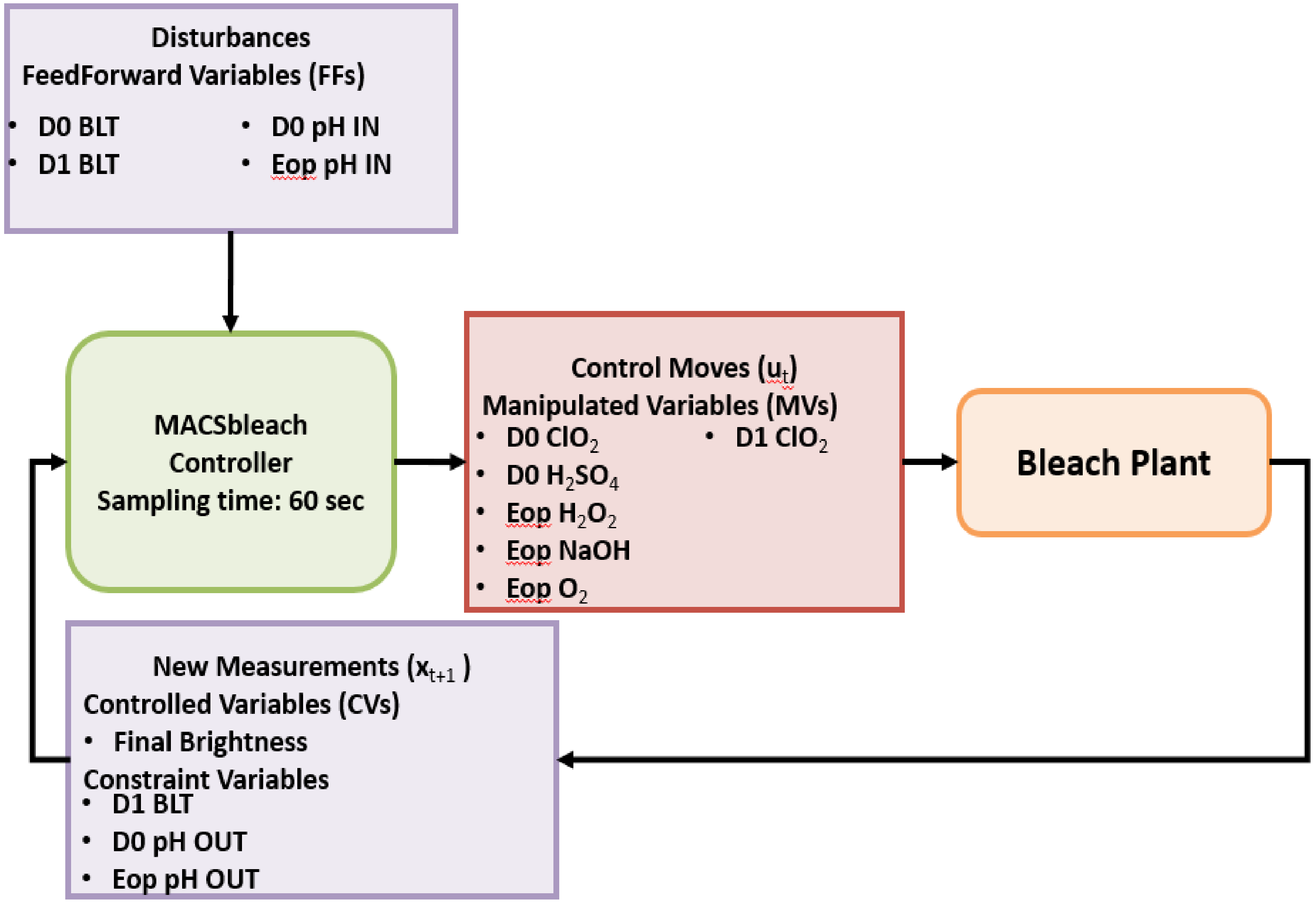
Software used:

- MACS - Multivariable Advanced Control System software is a Model based Predictive Controller (MPC).

AI Solution Overview

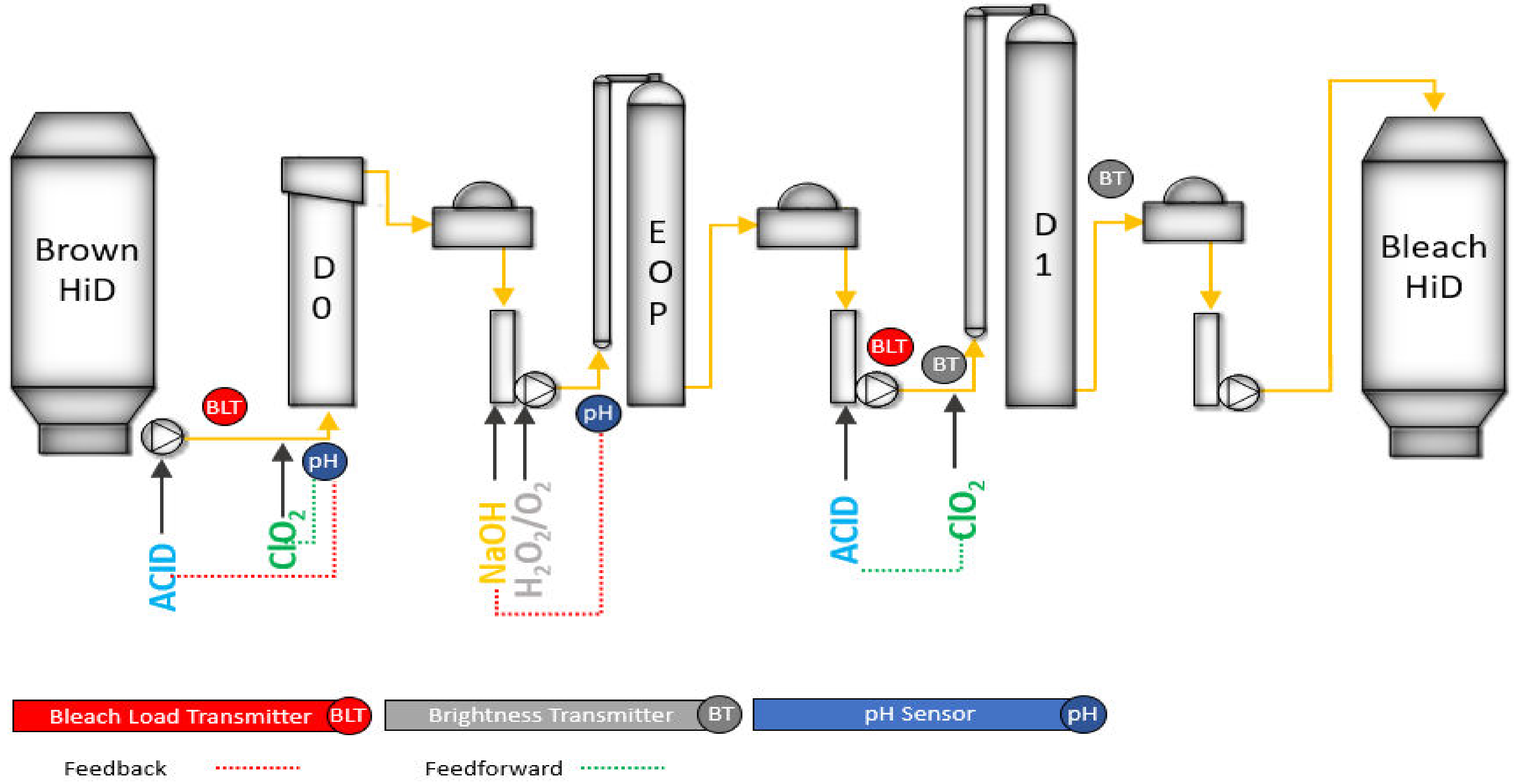
- The key components:
  - Machine learning algorithms.
  - Advanced data analytics.
  - Predictive modeling.

Diagram illustrating
The AI system architecture.



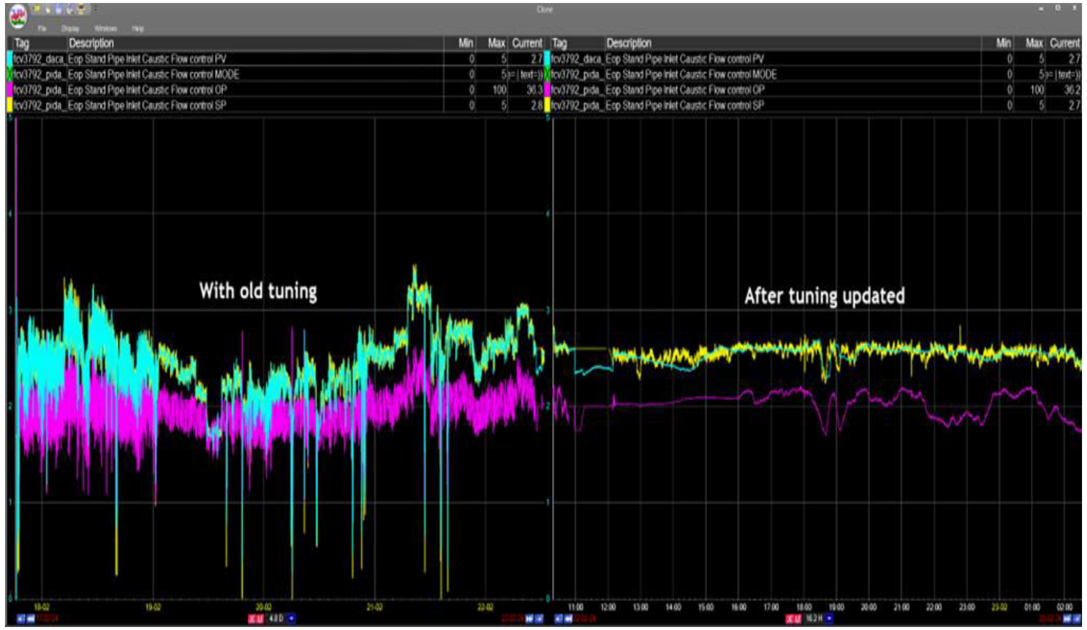
Advanced control strategies

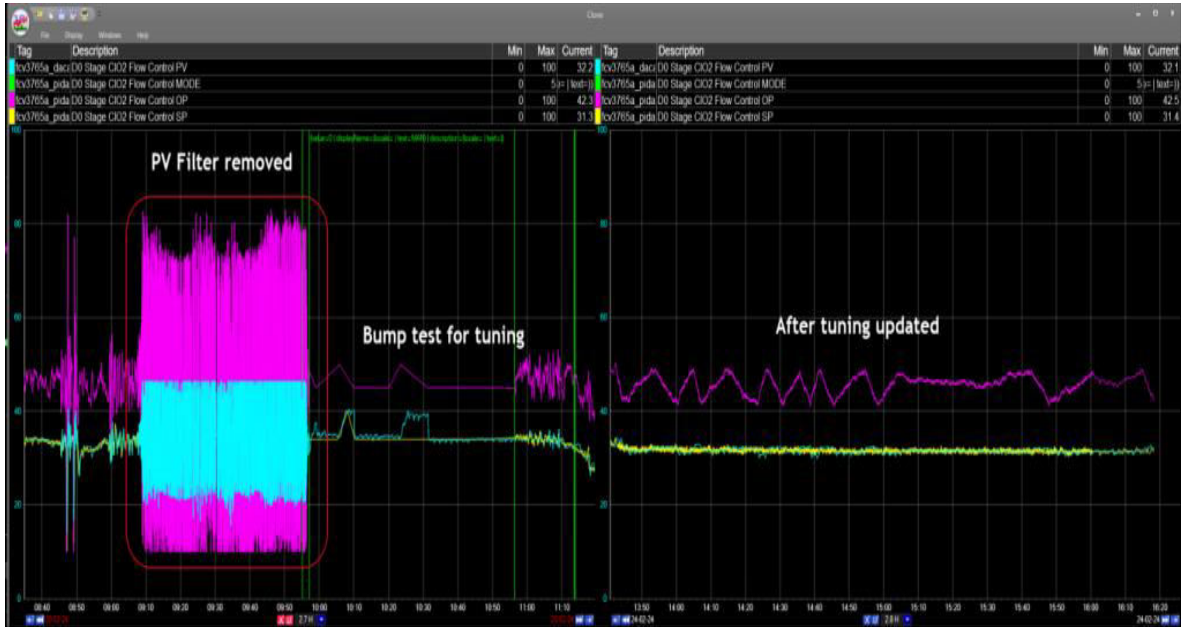
- **Integration of Feedforward & Feedback control**



Results from Loop Tuning ,Analytics, Loop Analytics

- Effective regulatory loop tuning ensures that control loops are responsive and stable.
- Implementing the recommended tuning parameter adjustments has significantly improved the stability of control loops important for MACSbleach control.

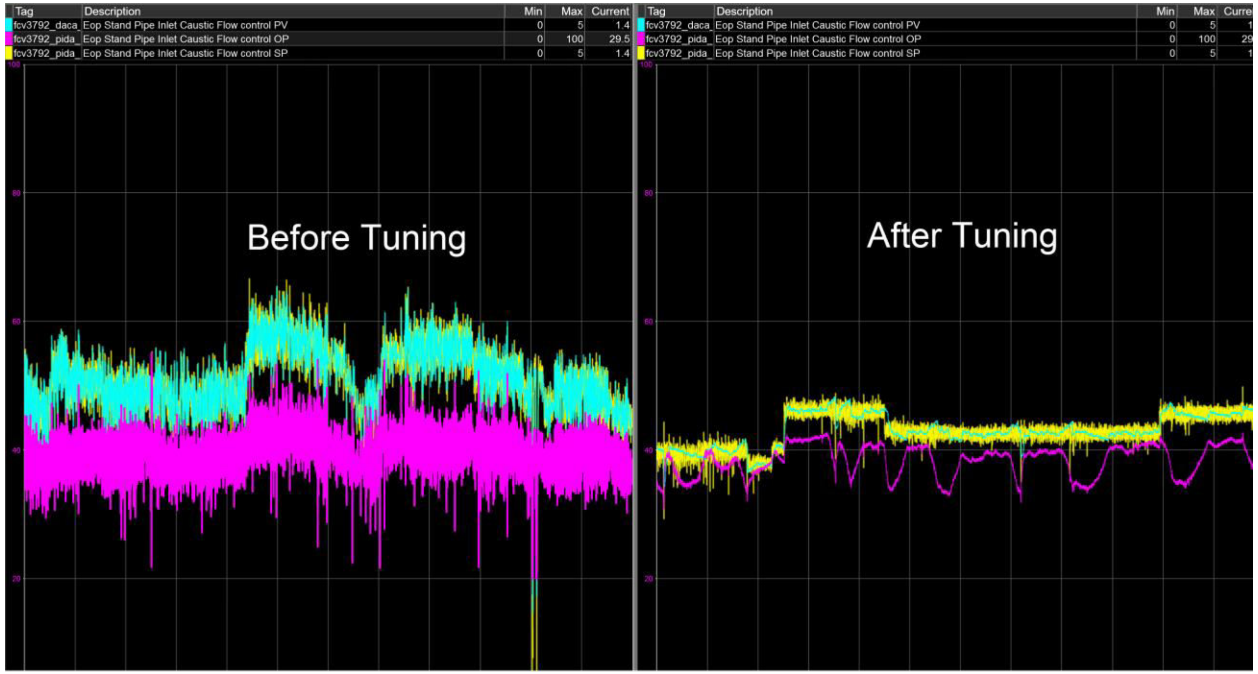


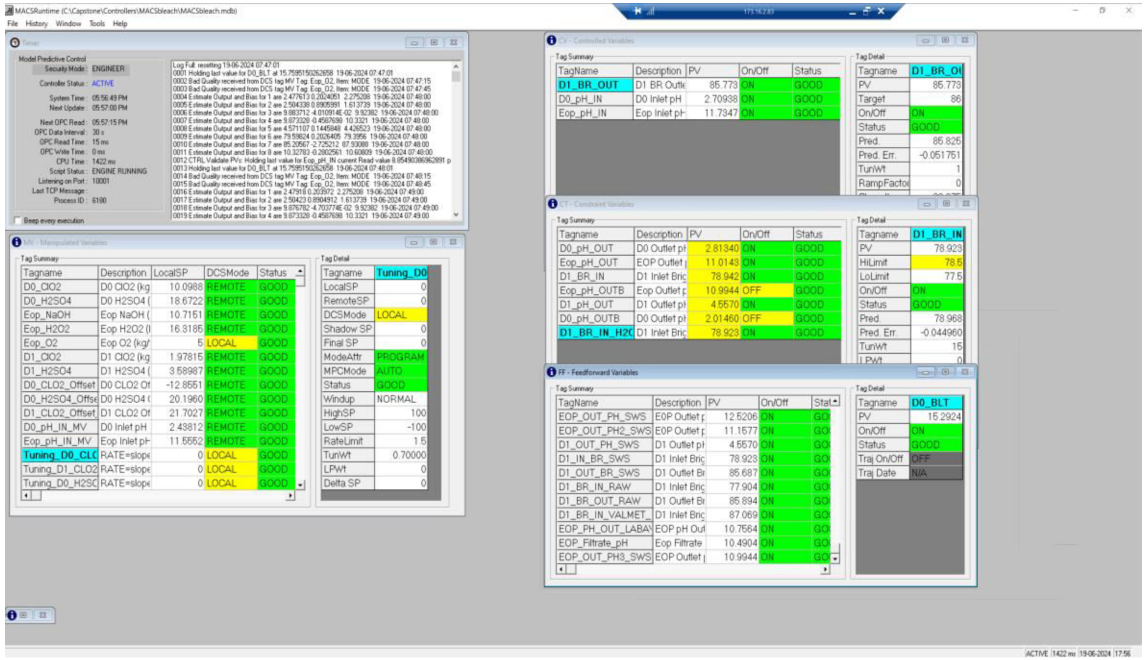


L1: Measurement → **L2: Analytics** → **L3: APC** → **L4: Optimization**

System Online - Model Improvements and Tuning

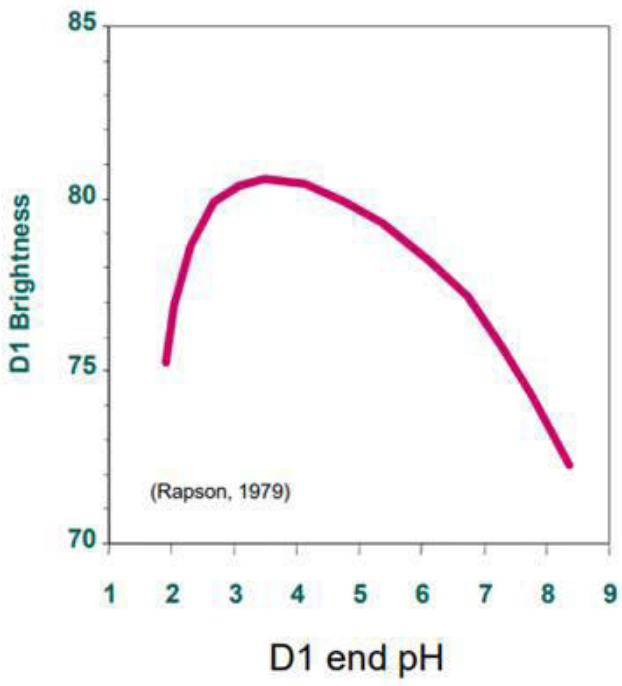
- Dynamics limit based on Kappa factor for D0 ClO2, to address the sudden swings in incoming kappa.
- Eop NaOH to outlet pH control, key improvement was using Eop filtrate pH in controls.
- D1 feed forward and feedback control to achieve maximum variability reduction in Final Brightness.
- D1 Acid Control, no online pH measurement, used D1 ClO2 & Eop Filtrate pH as feedforward and D1 vat pH (lab) as feedback signal.

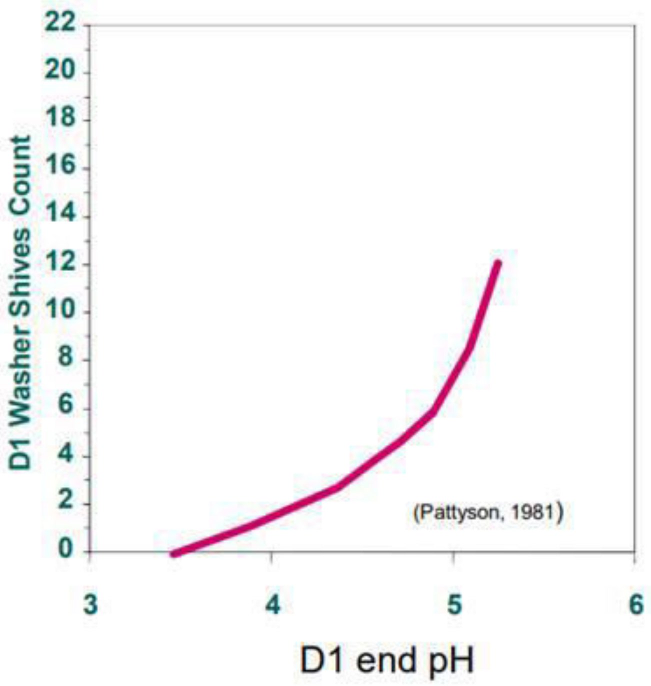


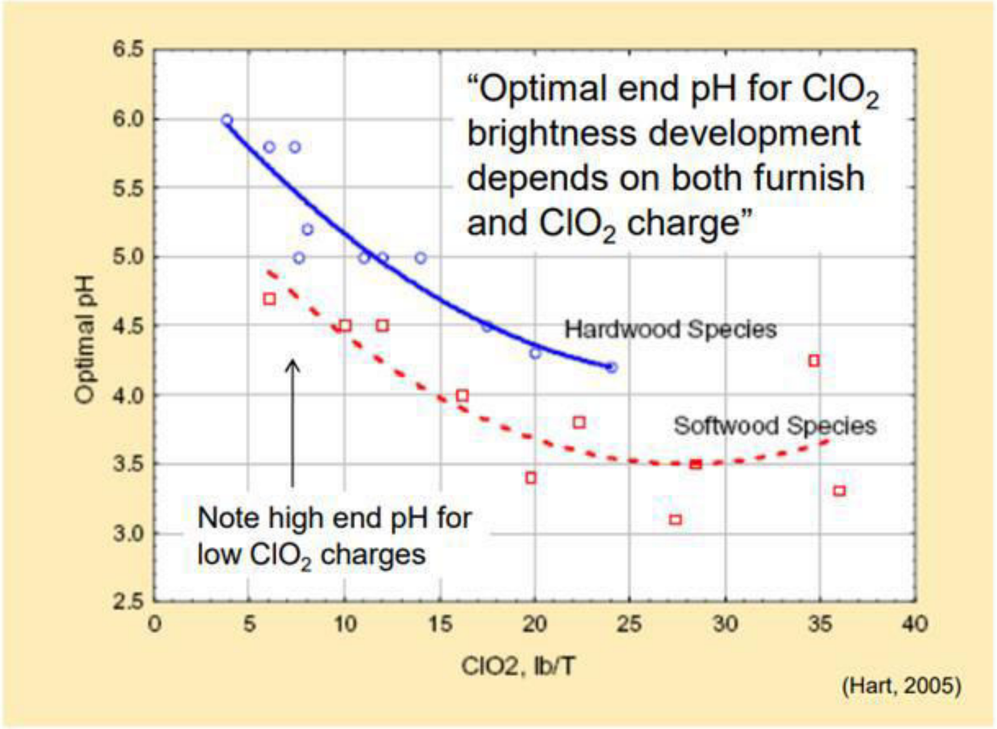


Optimizing pH for Bleaching Effectiveness

- The crucial role of pH in each stage.
- Acid and caustic stage
- Graph showing the optimal pH range for different stages.

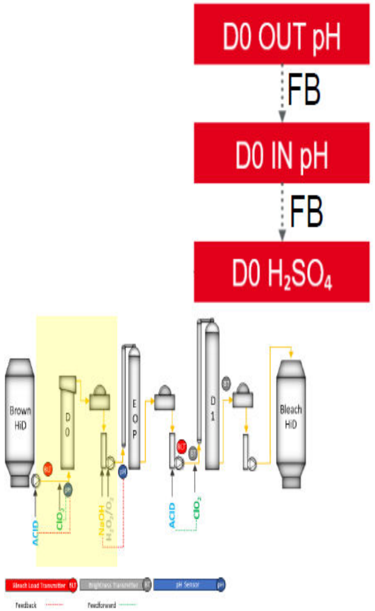






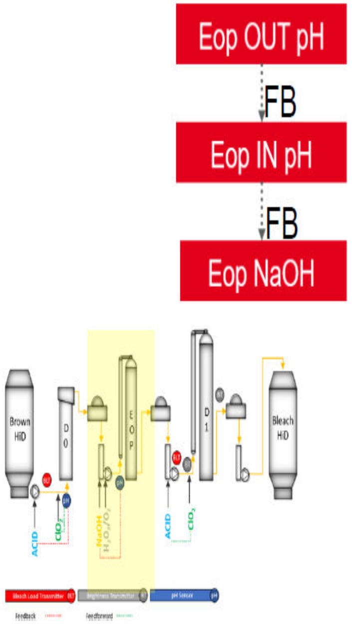
Tailored Control for Each Bleaching Stage

	CTRL and Projection Models (FB) Only Projection Model (FF)	MV
		D0 H2SO4
CT/CVs	D0 Tower Inlet pH	-
	D0 Tower outlet pH (lab)	-



- **D0 stage**

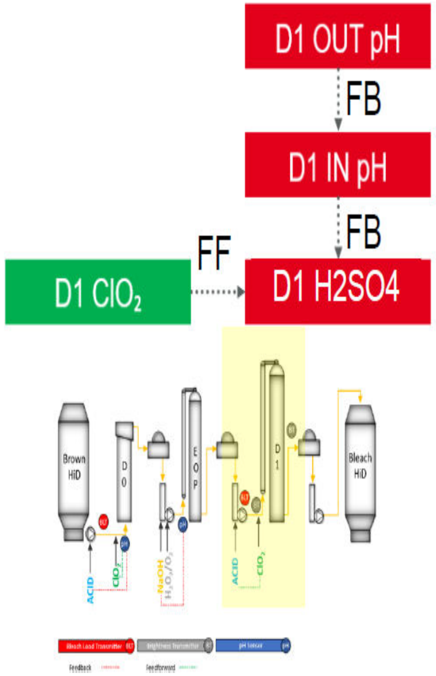
	CTRL and Projection Models (FB) Only Projection Model (FF)	MVs	
		Eop NaOH	Outlet pH Target
CT/CVs	Eop inlet pH	+	
	Eop outlet pH		+



- **EOP stage**

	CTRL and Projection Models (FB) Only Projection Model (FF)	MV	FFs
		D1 H2SO4	D1 ClO2
CT/CVs	D1 Tower Inlet pH	-	-
	D1 Tower outlet pH (lab)	-	-

- **D1 stage**

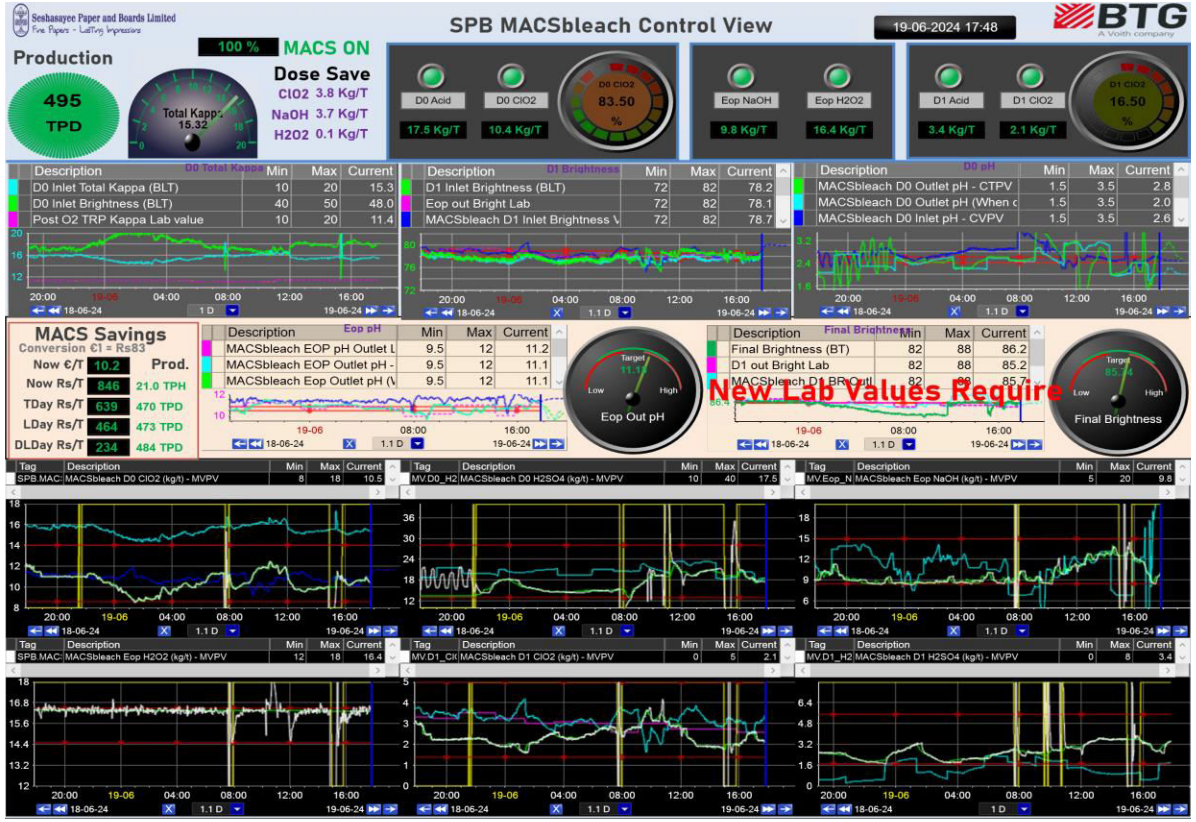


Leveraging SWS for Enhanced Control

- When sensors such as pH, Brightness sensors are coated, the values provided by the soft sensor become even more important.
- The soft sensor values are generated based on data entered by the operator, and the system automatically adjusts according to the programmed AI conditions

Dashboard & Trends

- Dashboard & Trends are available in Operator Control Room.
- Operators can see the future predictions for MVs and CVs on trends.



Real-time Visualization and Dashboard

BTG

BTG CONTROLS

SPB

INDEX | BS WASHING | SCR & BSW#4 | ODL1&2 SYS | PO 1 & 1A | TRP | DO_BLEACHIN | EOP BLEACHIN | D1 BLEACHING | WLO | CHE. HAND.SY | SEALNG WATEI | TOTALIZERS

MASTER ON | BTG FIRST OUT | CONTROL READY | WDOG

PROCESS VARIABLES		ON / OFF			PV (Kg/T)	SP (Kg/T)	STEADY STATE	SP MIN	SP MAX	WINDUP	LAST MOVE
D0 ClO2	PI	BTG	DCS	CAS	11.12	10.58	10.60	10.50	13.80		0.00
D0 H2SO4	PI	BTG	DCS	CAS	19.68	20.09	20.09	20.00	28.00		0.00
Eop NaOH	PI	BTG	DCS	CAS	11.87	11.37	11.34	10.50	15.00		-0.01
Eop H2O2	PI	BTG	DCS	CAS	18.97	19.00	19.00	16.00	18.50		0.00
D1 ClO2	PI	BTG	DCS	CAS	3.76	3.71	3.71	1.80	3.80		-0.00
D1 H2SO4	PI	BTG	DCS	CAS	3.18	3.09	3.09	3.00	5.50		0.00

CONTROLLED VARIABLES	ON / OFF	PV	STEADY STATE	PV MIN	TARGET	PV MAX	WINDUP
D0 Inlet pH	ON	2.61	2.62	2.40	2.74	2.80	
D0 Outlet pH	ON	2.40	2.40	2.40		2.80	
Eop Inlet pH	ON	10.93	11.11	10.50	11.11	11.30	
Eop Outlet pH	ON	10.70	10.67	10.50		10.90	
D1 Outlet pH	ON	4.10	4.10	4.00		4.50	
D1 Inlet Brightness	ON	77.20	77.81	75.80		77.20	
D1 Outlet Brightness	ON	84.49	84.72		85.80		

PULP SHADE SELECTION FOR BTG

NORMAL SHADE | NATURAL SHADE

LAB VALUE MANUAL ENTRY

	TIME	LAB_VALUE
TRP kappa	2.30	12.40
D0 pH VAT	10.30	2.40
Eop pH VAT	10.30	10.70
D1 pH VAT	10.30	4.10
CLO2 Strenght	6.00	8.00
NaOH Strenght	6.30	120.00
D0 out Bright	10.30	61.80
EOP out Bright	10.30	79.00
D1 out Bright	10.30	86.00

FFPV

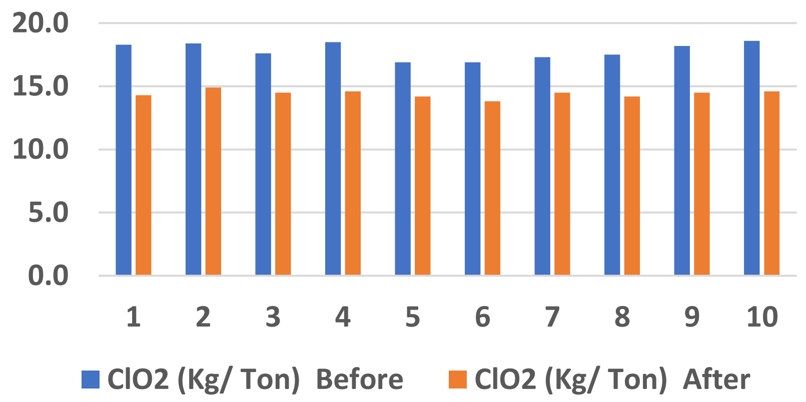
D0 IN Kappa	15.00
D0 IN BR	47.83
D1 IN Kappa	4.29

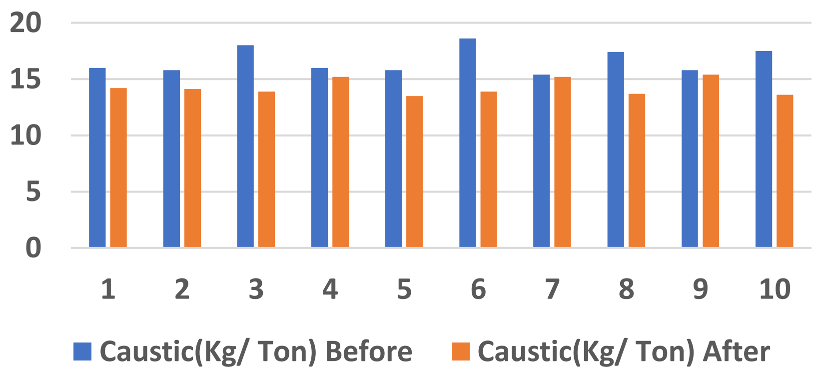
Overall Performance

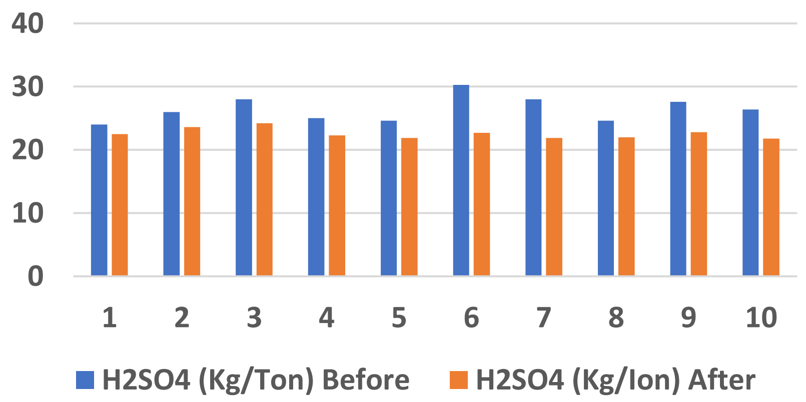
Monthly KPI	Units	Jan-24	Feb-24	Mar-24	Apr-24	May-24	Jun-24	Jul-24	Aug-24	Sep-24	Oct-24	Nov-24	Dec-24	Jan-25	This year
General															
Production	adt/d	-	-	459	468	473	475	463	471	479	416	417	395	432	454
Process uptime	%	-	-	95%	94%	93%	94%	91%	94%	95%	61%	67%	63%	87%	85%
MACS uptime	%	-	-	19%	87%	88%	82%	72%	85%	73%	69%	70%	60%	62%	70%
Kappa & Brightness															
D0 inlet Kappa	Kappa	-	-	12.1	12.3	12.1	11.8	11.6	11.7	11.2	11.2	11.8	12.1	11.6	11.8
D1 inlet Brightness	%ISO	-	-	76.2	77.5	77.7	77.9	77.8	77.9	78.1	77.6	77.8	77.8	78.0	77.7
Final Brightness (LAB)	%ISO	-	-	85.6	85.3	85.7	85.8	85.8	85.5	85.6	85.2	85.2	85.3	85.5	85.5
Final Brightness (SWS)	%ISO	-	-	84.5	85.4	85.7	85.8	85.8	85.5	85.6	85.2	85.3	85.4	85.5	85.5
pH															
D0 inlet pH	pH	-	-	2.5	2.7	2.6	2.7	2.8	2.7	2.6	2.6	2.5	2.7	2.6	2.6
D0 outlet pH	pH	-	-	2.4	2.5	2.5	2.6	2.5	2.5	2.4	2.5	2.5	2.5	2.4	2.5
Eop Inlet pH	pH	-	-	11.3	11.1	11.4	11.4	11.3	11.4	11.8	11.8	12.2	11.9	12.1	11.6
Eop outlet pH	pH	-	-	11.0	10.8	10.5	10.6	10.7	10.4	10.6	10.8	10.6	10.6	10.7	10.6
D1 outlet pH	pH	-	-	6.8	4.3	3.9	3.8	4.1	4.1	4.6	4.3	4.2	4.1	4.4	4.3
Chemical Dosage															
Total ClO2	kg/adt	-	-	15.8	15.0	14.2	15.0	14.7	15.1	15.7	16.2	16.6	16.1	16.1	15.3
Total ClO2 (baseline)	kg/adt	-	-	16.6	16.5	16.5	16.4	16.4	16.4	16.3	16.3	16.4	16.5	16.4	16.4
Total NaOH	kg/adt	-	-	12.0	11.0	9.7	9.9	10.1	12.2	11.6	11.7	12.2	12.5	12.4	11.2
Total NaOH (baseline)	kg/adt	-	-	14.4	14.3	14.1	13.9	13.8	13.8	13.3	13.4	13.9	14.1	13.8	13.9
Total H2O2	kg/adt	-	-	18.2	16.0	15.0	15.9	14.9	14.9	16.1	15.7	15.3	15.2	15.1	15.5
Total H2O2 (baseline)	kg/adt	-	-	16.0	16.0	15.9	15.9	15.9	15.9	15.8	15.8	15.9	15.9	15.9	15.9
Total H2SO4	kg/adt	-	-	25.7	21.7	21.4	18.7	18.5	24.5	21.9	26.2	31.3	29.4	28.9	23.5
Total H2SO4 (baseline)	kg/adt	-	-	21.6	21.1	19.8	18.7	17.7	18.1	16.3	16.9	18.7	19.9	18.2	18.7
Savings															
ClO2 savings	€/adt	-	-	1.57	3.39	4.94	3.15	3.78	2.90	1.26	0.30	-0.36	0.76	0.62	2.42
NaOH savings	€/adt	-	-	1.21	1.67	2.23	1.99	1.83	0.80	0.85	0.87	0.84	0.79	0.69	1.34
Total savings	€/adt	-	-	2.78	5.06	7.17	5.14	5.61	3.70	2.11	1.17	0.48	1.55	1.31	3.76
Monthly savings	€/Month	-	-	37363	67012	97370	68664	72959	51067	28623	9199	4047	11954	15217	42134
Control usage (MV ON)															
DO ClO2	%	-	-	24%	96%	96%	95%	94%	96%	97%	84%	86%	75%	90%	85%
DO H2SO4	%	-	-	26%	94%	96%	95%	93%	97%	97%	83%	71%	68%	82%	83%
Eop NaOH	%	-	-	26%	92%	92%	91%	75%	90%	78%	77%	78%	75%	72%	77%
Eop H2O2	%	-	-	25%	92%	93%	98%	94%	94%	53%	63%	73%	69%	80%	76%
D1 ClO2	%	-	-	20%	94%	91%	88%	93%	94%	93%	77%	80%	68%	80%	80%
D1 H2SO4	%	-	-	21%	96%	93%	89%	85%	81%	11%	6%	10%	4%	7%	50%

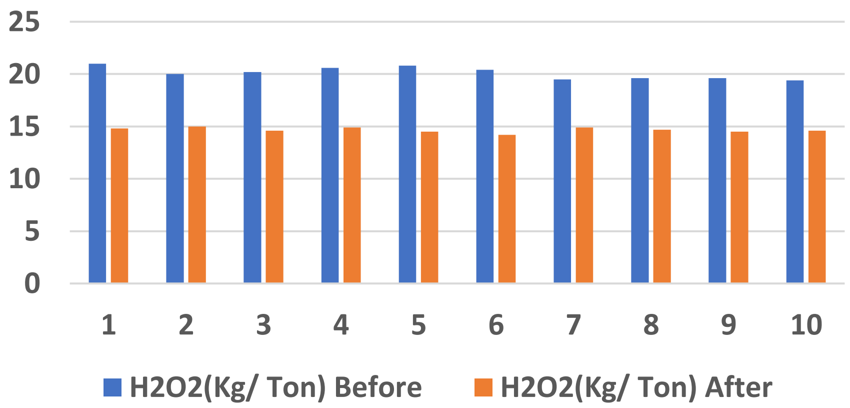
ClO2 ,H2SO4,NaOH and H2O2 - Before and after 10 months data

- Bar graph showing chemical usage before and after.





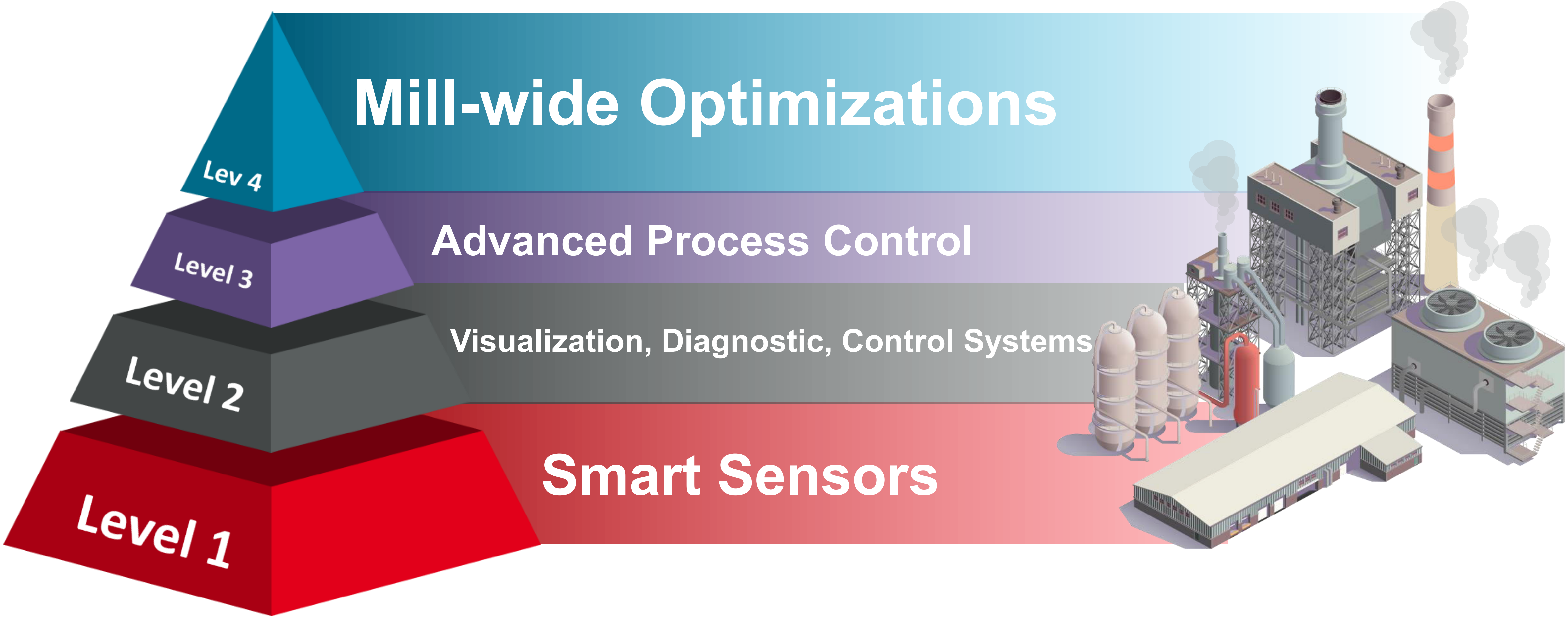




Benefits Achieved

- ClO_2 : Reduction in consumption by 1.0 Kg/Ton Savings
- Caustic: Reduction in consumption by 1.2 Kg/Ton Savings
- Acid: High Scope for reduction by adjusting the D0 inlet pH.
  - Need to find the optimum pH to avoid the scaling issue in D0 Washing
- Additional Benefits:
  - Reduction in Paper Machine OBA is an additional cost benefit
  - GHG emission:
    - 1 kg of ClO_2 -> 1.56 kg of CO_2
    - 1 kg of NaOH-> 1.35 kg of CO_2

Roadmap to Sustainable Optimization



Artificial intelligence is not a substitute for human intelligence;

“It is a tool to amplify human creativity and ingenuity.”

Proud to be a Responsible Paper Maker

Thank You