Digitalisation In Action

Developing AI/ML Driven Decision Support in Pulp & Paper

Shankar Das G | BTG India

28th February 2025

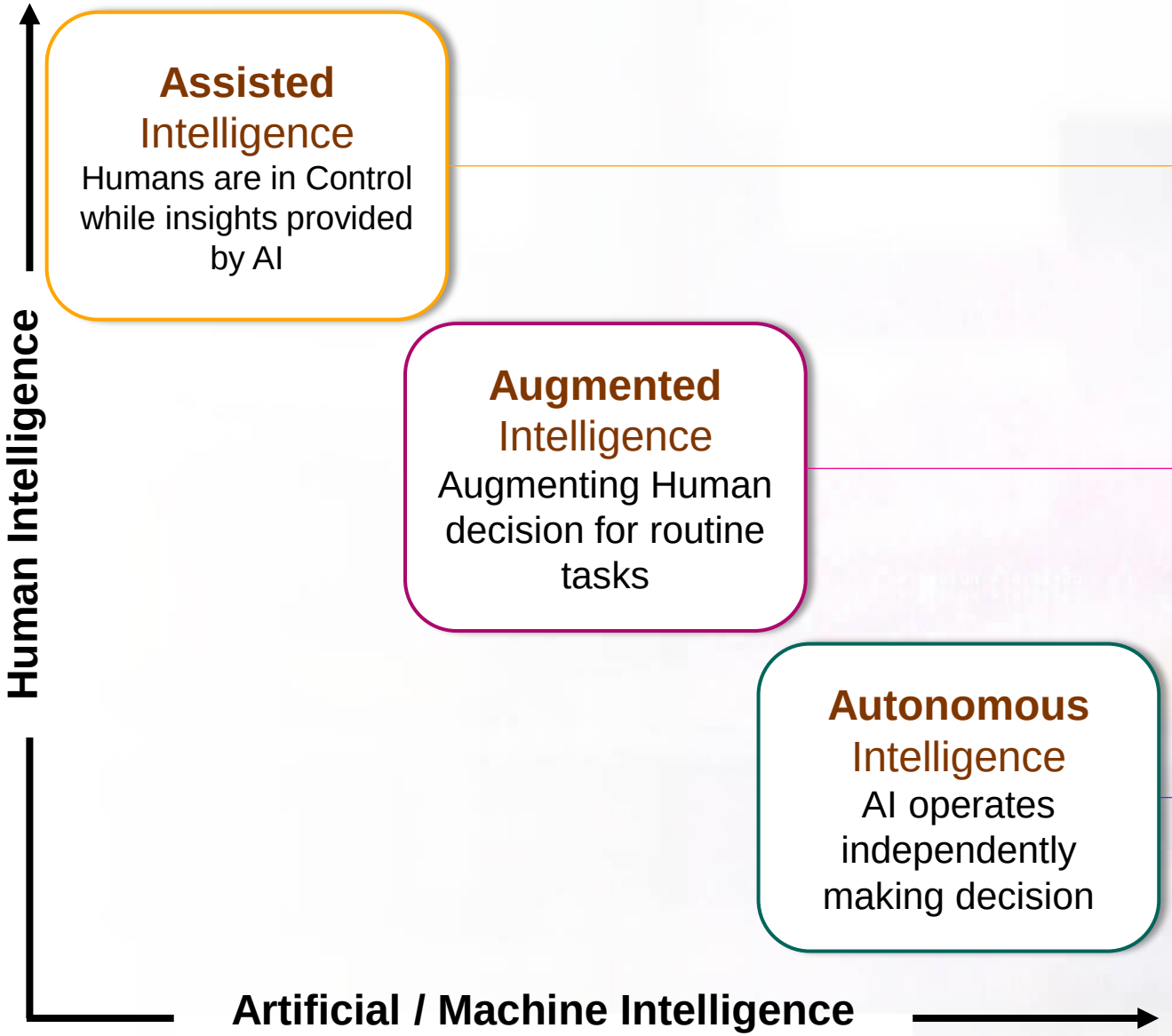
MACSsuite

dataPARC

BTG

A Voith company

Stages in AI v/s Human Collaboration



Assisted Intelligence | AI as a Tool

- Spelling Correction
- Document Summery
- Mill wide data Integration for real time ETL (Extract, Transform & Load)

Augmented Intelligence | AI as a Partner

- Weather forecasting Tools
- Scenario Analysis (PCA/ PLS)
- Anomaly Detection & Deviation Detection

Autonomous Intelligence | AI in the Driver seat

- Self driving cars
- Model predictive Controls Systems

Assisted Intelligence

Mill-Wide Data Integration for real time ETL Process (Extract, Transform and Load)

Mill-Wide Data Integration

- Need to have all your data in one place
- Breaking down data silos
- Data from all process areas
- Real-time process monitoring
- “Single Source of Truth”

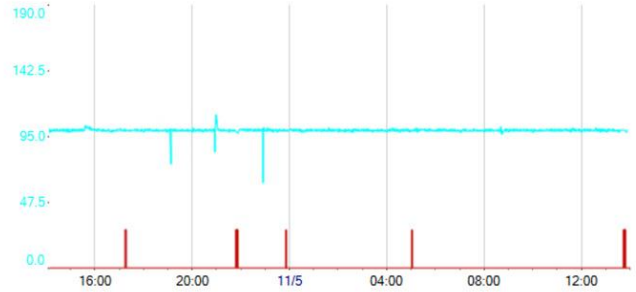
PM Overview Dashboard

Status

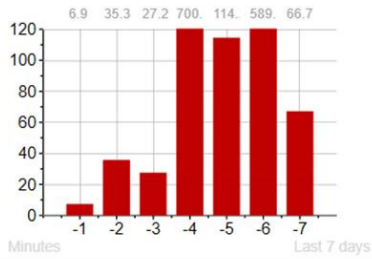
Stock ON

Paper ON

Legend:
Grammage
BREAK



Downtime



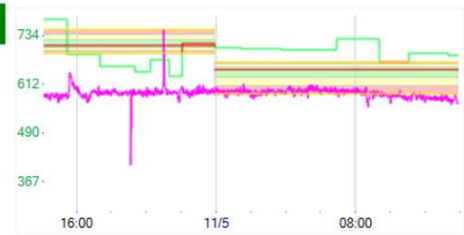
Quality

Last 24 hours

BURST

Lab: 684.0

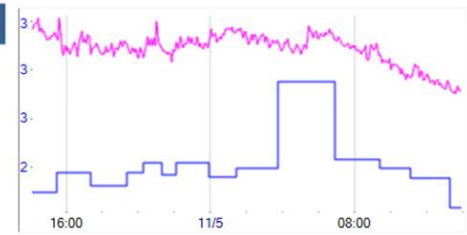
Virtual 565.3



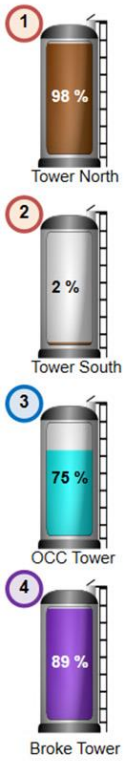
SCT

Lab: 2.17

Virtual 2.79

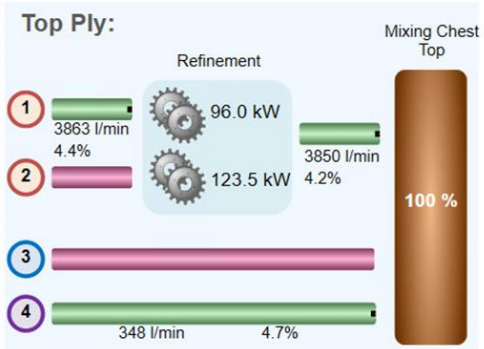


Towers

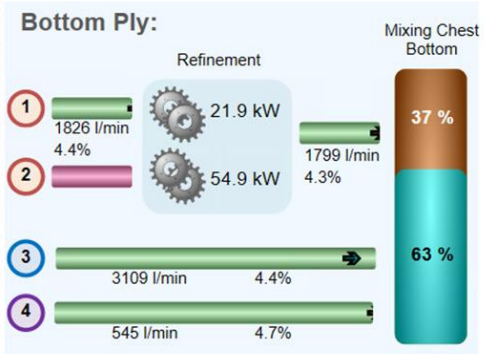


Flows and mixing

Top Ply:



Bottom Ply:

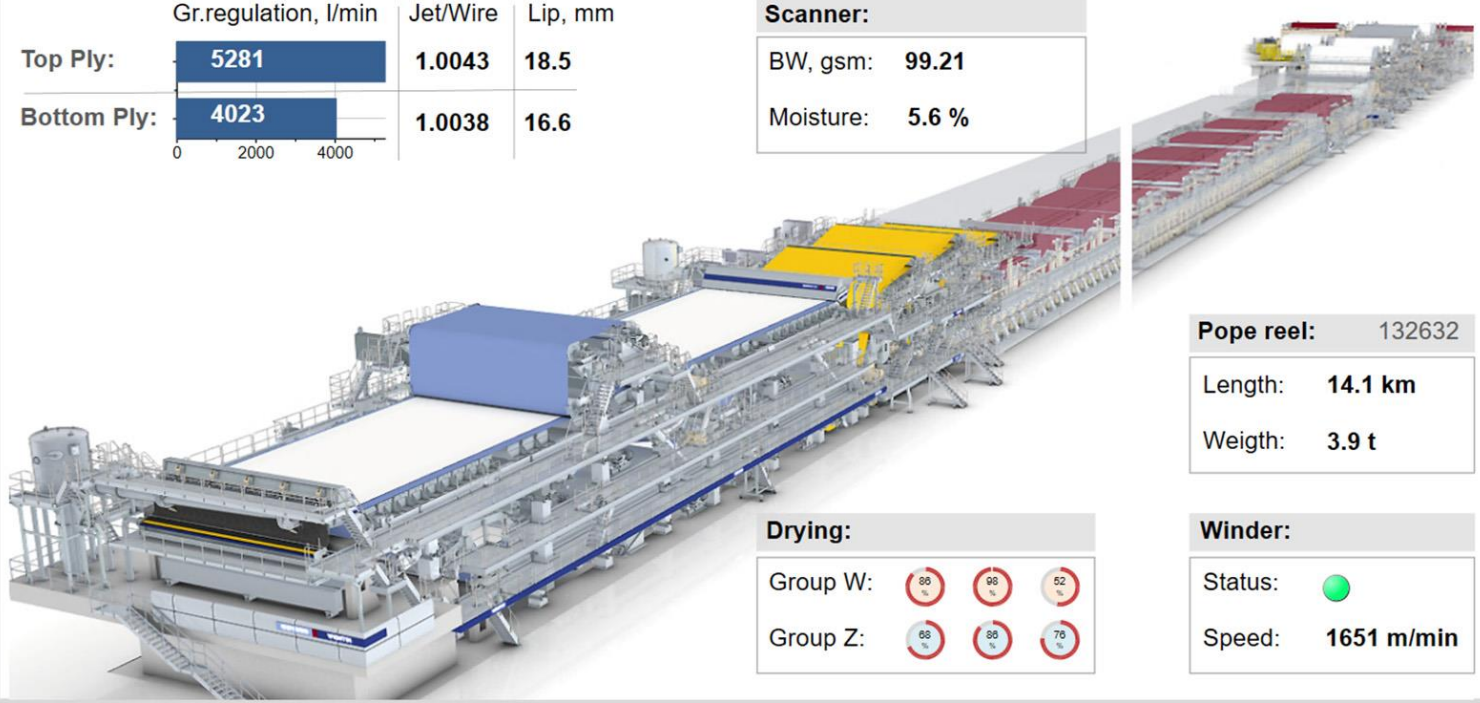


Paper machine

Grade: 276 **Machine Speed: 1179 m/min** **Production rate: 25.64 t/h**

	Gr.regulation, l/min	Jet/Wire	Lip, mm
Top Ply:	5281	1.0043	18.5
Bottom Ply:	4023	1.0038	16.6

0 2000 4000



Scanner:

BW, gsm: 99.21

Moisture: 5.6 %

Pope reel: 132632

Length: 14.1 km

Weigth: 3.9 t

Drying:

Group W: 86 % 98 % 52 %

Group Z: 68 % 86 % 76 %

Winder:

Status:

Speed: 1651 m/min

OEE

Specific Consumption

Chemicals / tpaper	
Polymer	7.10 kg
Starch	2.6 kg
Retention	2.5 kg

Energy and Commodities / tpaper	
Electricity	2165 kWh
Steam	4.9 MMBTU
Virgin fibers	685 kg
Water	4.8 m3

Safety, Health, Environment

Accidents since 01.01:**12**

Environmental Index: **Excellent**

Costs and Margins

Gross margin/t /hour: **250 EUR / 1050 EUR**

Variable cost of production: **1260 EUR/t**

Links

PM @ a Glance | Overview | Profile | Downtime | Asset Monitoring | Pumps

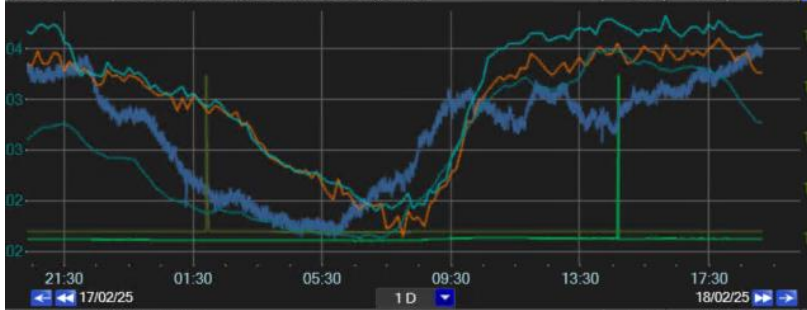
Quality | Centerline | Logbook | Tensile mode | PCA Pumps | PCA TM8 | A

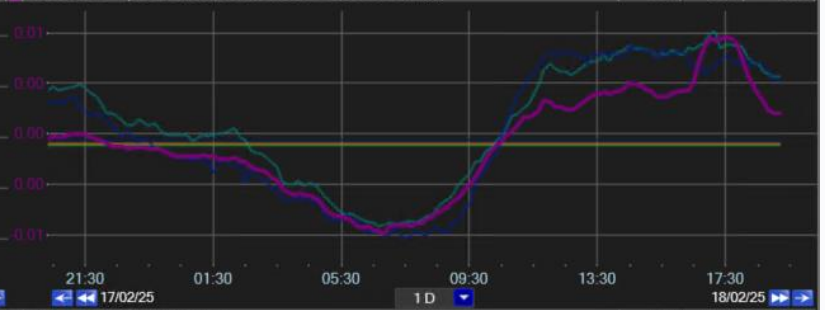
File Display Windows Help

Tag	Description	Min	Max	Current
AI230A.PV	Cl2 detector at Electrolyzer Room	0.02	0.03	0.03
AI230B.PV	Cl2 detector at Electrolyzer Room	0.01	0.01	0.01
AI540A.PV	Cl2 detector at Liquid Chlorine Storage area	-1	6.50	-0.05
AI540B.PV	Cl2 detector at Liquid Chlorine Storage area	-1.05	-0.73	-0.77
AI540C.PV	Cl2 detector at Liquid Chlorine Storage area	-0.20	1.05	-0.08
AI540D.PV	Cl2 detector at Liquid Chlorine Storage area	0.02	0.04	0.03

Tag	Description	Min	Max	Current
CL2I812.PV	FR0M 32% HCL SYNTHESIS UNIT	1.29	1.39	1.33
HCl812.PV	FR0M 32% HCL SYNTHESIS UNIT	0.01	0.16	0.03
CL2I731.PV	FROM CL2 GAS ABSORBER BLOWER	0.61	0.79	0.66
AI550C.PV	Cl2 detector at Chlorine compression area	-0.32	-0.31	-0.31
AI550D.PV	Cl2 detector at Chlorine compression area	0.05	0.07	0.06
AI201B.PV	H2 detector at Electrolyzer area first floor	0.23	0.28	0.27

Tag	Description	Min	Max	Current
AI550A.PV	Cl2 detector at First floor of Hypo building	-0.63	-0.62	-0.63
AI550B.PV	Cl2 detector at First floor of Hypo building	-3.10	0.15	-1.56
AI550E.PV	Cl2 detector at 1st floor of Process building.	-1.50	1.75	0.03
AI550F.PV	Cl2 detector at 1st floor of Process building.	0.00	0.01	0.01
AI550G.PV	Cl2 detector at 2nd floor of Process building.	-0.30	2.95	1.30
AI550H.PV	Cl2 detector at 2nd floor of Process building.	-0.01	0.01	0.00

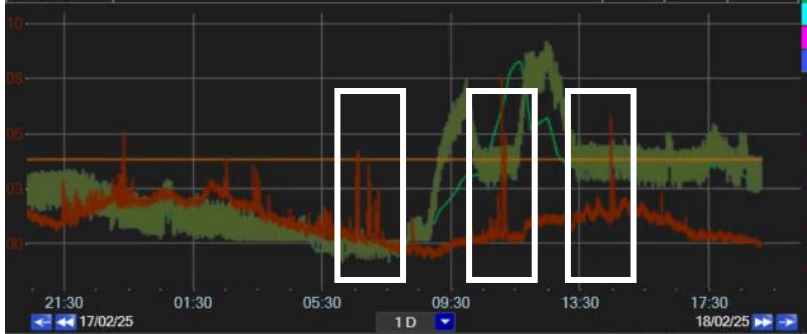


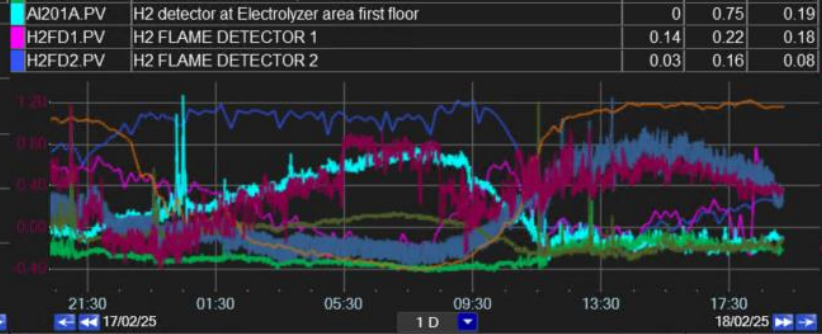


Tag	Description	Min	Max	Current
AI821A.PV	Cl2 detector at HCl ground floor	-0.02	0.11	0.00
AI821B.PV	Cl2 detector at HCl ground floor PRCs	-1.50	1.75	0.02
AI821C.PV	Cl2 detector at HCl 3rd floor	0.00	0.01	0.00
AI821D.PV	Cl2 detector at HCl 4th floor	0.00	0.01	0.00
AI821E.PV	Cl2 detector at HCl 5th floor	0.03	0.04	0.03

Tag	Description	Min	Max	Current
AI601A.PV	H2 detector at H2 Compressor	-0.60	1.40	0.35
AI601B.PV	H2 detector at H2 Compressor	-0.42	-0.39	-0.39
AI601C.PV	H2 detector at H2 Compressor	-2.30	-0.80	-1.93
AI601D.PV	H2 detector at H2 Compressor	-1.70	-0.70	-1.22
AI601E.PV	H2 detector at H2 Compressor	-0.40	0.85	-0.16
AI201A.PV	H2 detector at Electrolyzer area first floor	0	0.75	0.19
H2FD1.PV	H2 FLAME DETECTOR 1	0.14	0.22	0.18
H2FD2.PV	H2 FLAME DETECTOR 2	0.03	0.16	0.08

Tag	Description	Min	Max	Current
AI822A.PV	H2 detector 1st floor at HCL unit	0.80	1.55	0.95
AI822B.PV	H2 detector 1st floor at HCL unit	0.70	1.70	0.90
AI822C.PV	H2 detector 4th floor at HCL unit	-0.60	0.15	-0.40
AI822D.PV	H2 detector 4th floor at HCL unit	-0.60	0.15	-0.47

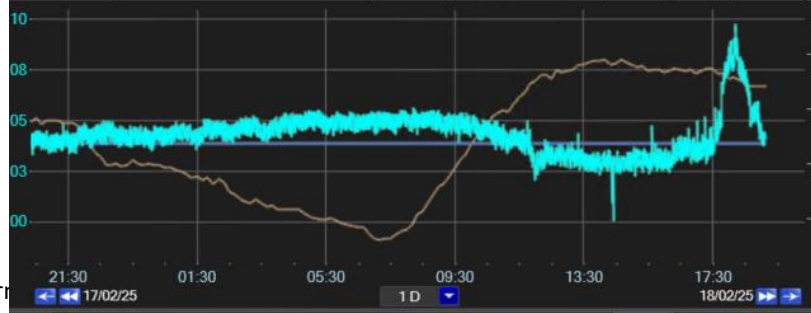


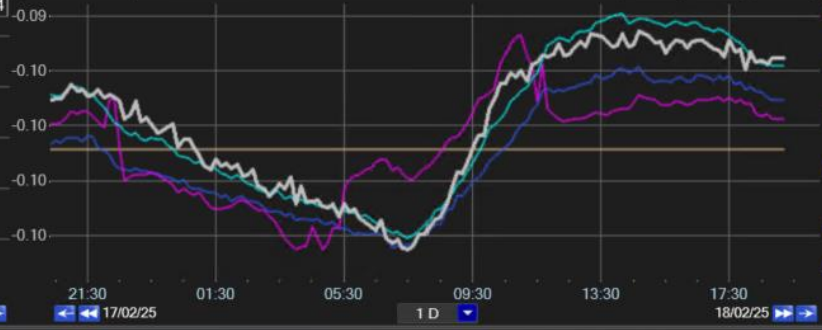


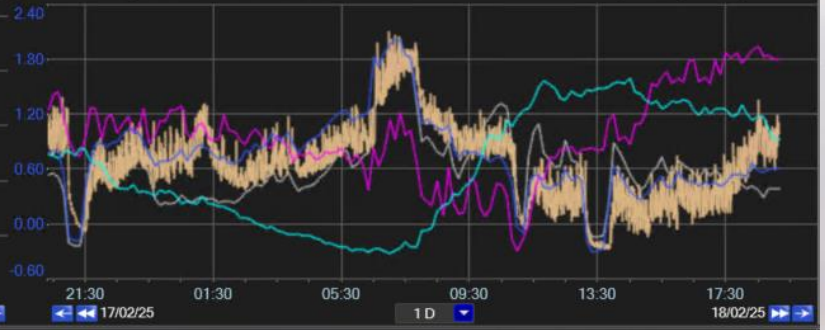
Tag	Description	Min	Max	Current
AI550N.PV	Cl2 detector at Chlorine Tonner filling and storage area	-0.02	0.11	0.04
AI550R.PV	Cl2 detector at Chlorine Tonner filling and storage area	-1.50	1.75	0.02
AI550Q.PV	Cl2 detector at Chlorine Tonner filling and storage area	-0.18	-0.17	-0.17
AI550P.PV	Cl2 detector at Chlorine Tonner filling and storage area	-1.30	1.95	0.22
AI550O.PV	Cl2 detector at Chlorine Tonner filling and storage area	-1.50	1.75	0.03
AI550N.PV	Cl2 detector at Chlorine Tonner filling and storage area	-0.02	0.11	0.04

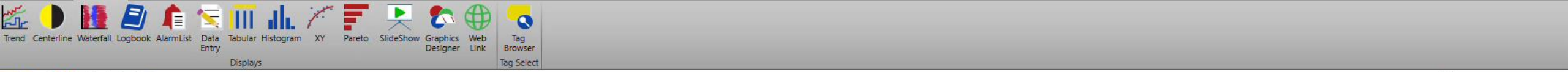
Tag	Description	Min	Max	Current
AI550M.PV	Cl2 detector at Chlorine Tonner filling and storage area	-0.3	-0.3	-0.3
AI550L.PV	Cl2 detector at Chlorine Tonner filling and storage area	-0.05	-0.03	-0.03
AI550K.PV	Cl2 detector at Chlorine Tonner filling and storage area	-0.34	-0.33	-0.33
AI550J.PV	Cl2 detector at Chlorine Tonner filling and storage area	-1.50	1.75	0.03
AI550I.PV	Cl2 detector at Chlorine Tonner filling and storage area	-0.10	-0.09	-0.09

Tag	Description	Min	Max	Current
AI601F.PV	H2 detector at H2 Compressor	-0.42	-0.35	-0.38
AI601G.PV	H2 detector at H2 Compressor	4.55	4.57	4.57
AI601H.PV	H2 detector at H2 Compressor	-0.60	2.40	0.59
AI601I.PV	H2 detector at H2 Compressor	0.10	4.85	2.63
AI601J.PV	H2 detector at H2 Compressor	0.80	3.55	1.71









Displays ▸ Main Displays ▸ CRP ▸

Search

- PARCview
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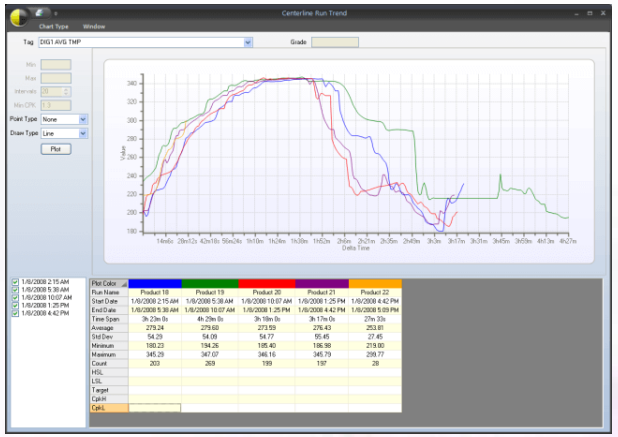
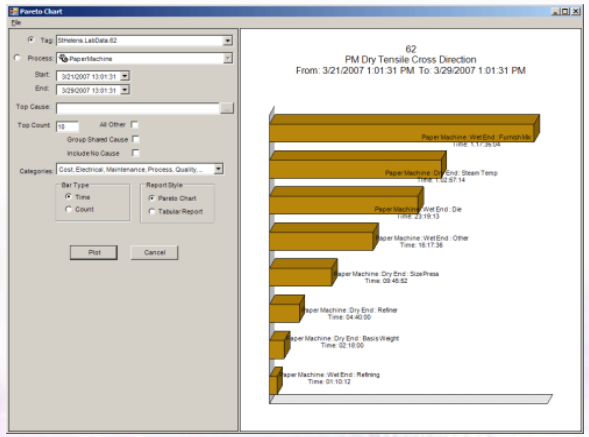
      - ELECT
      - Lab
      - Paper Machines
      - Pulp
    - Users
  - My Computer
  - Network
  - Desktop
  - My Documents

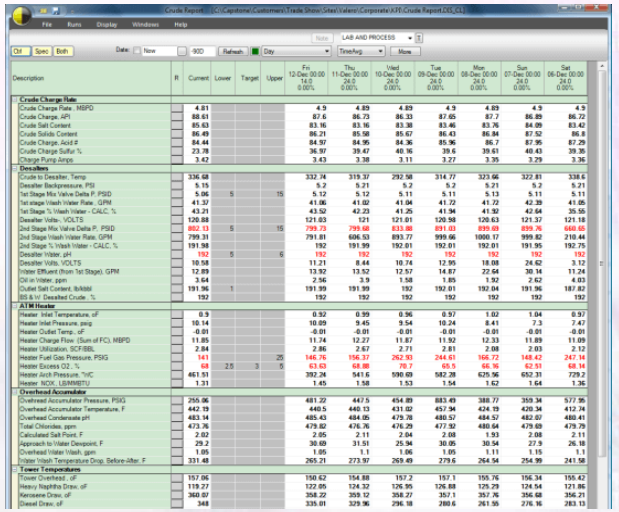
Name	Date Modified	Type
All Rake Torqe load Treands	5/12/2024 1:49:17 PM	PARCview Trend Display
Black liquor tank level Treands	4/29/2024 5:50:30 AM	PARCview Trend Display
CRP Lab	1/8/2024 12:23:56 PM	Shortcut
CRP MDE	7/19/2024 12:09:15 PM	PARCview Data Entry Display
CRP Process Centerline	6/20/2024 5:24:51 PM	PARCview Centerline Display
CRP_LAB_CenterLine	4/8/2024 9:06:27 AM	Shortcut
Czr Flow & tank Level Treands	5/9/2024 8:29:08 AM	PARCview Trend Display
Daily QC Water Report	1/8/2024 12:23:56 PM	Shortcut
EVAPORATOR CENTERLINE_1	6/4/2024 2:49:57 PM	PARCview Centerline Display
Lime cons	7/1/2024 11:47:20 AM	PARCview Histogram Display
Lime cons	7/2/2024 11:48:12 AM	PARCview Trend Display
New & old RB Steam Parameters	5/5/2024 9:54:29 PM	PARCview Trend Display
New Data Entry	4/23/2024 4:00:24 PM	PARCview Data Entry Display
Totalizers_CRP	7/9/2024 10:16:15 AM	PARCview Centerline Display
White Liquor	11/6/2023 8:37:32 AM	Shortcut

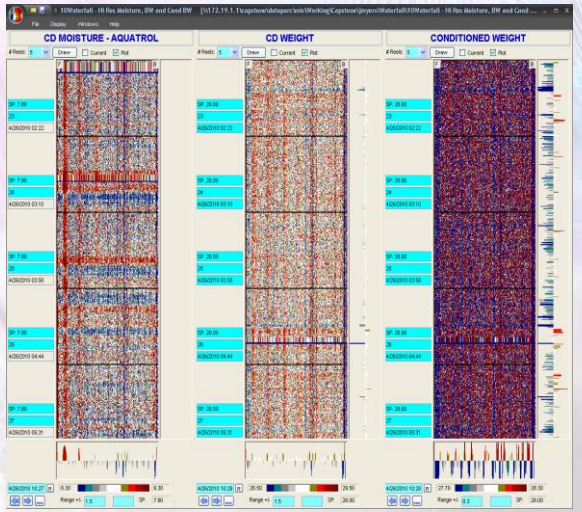
Benefits of AI being an Assisted Intelligence

- Real-time insights empower proactive responses to production challenges.
- Data-driven decisions. Eliminates silos and enables strategic decision-making.
- Reduced downtime through proactive maintenance and root cause analysis.









Augmented Intelligence

Anomaly Detection & Deviation Detection using Principle Component Analysis

Anomaly detection using PCA models

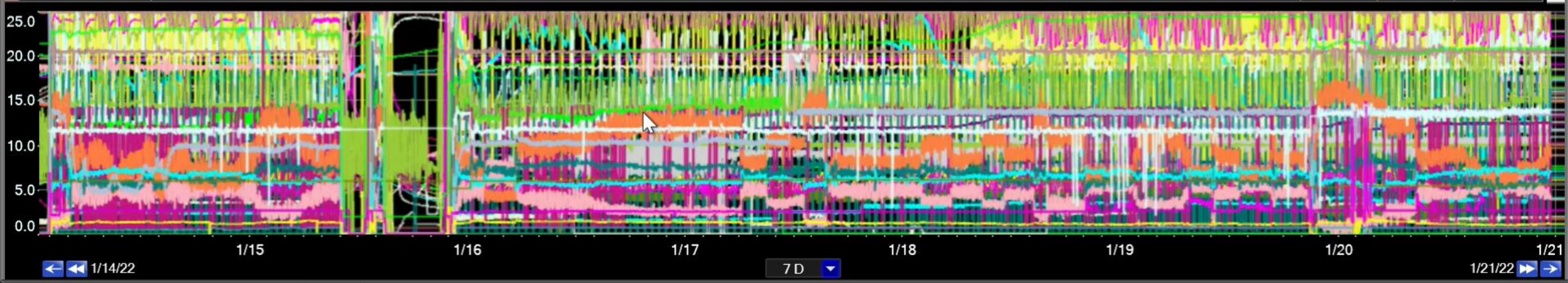
- PCA technique aims to simplify complex datasets by reducing their dimensionality while retaining most of its information.
- It does this by identifying new, uncorrelated variables called principal components & its variance.
- Principal components are linear combinations of the original variables and are ordered on its magnitude

- Identify Variables
- Establish Time Periods for Evaluation
- Generate the PCA Modelled Data
- Evaluate the PCA Model
- Using PCA Model as a continuous data TAG

172.28.185.76

File Display Windows Help

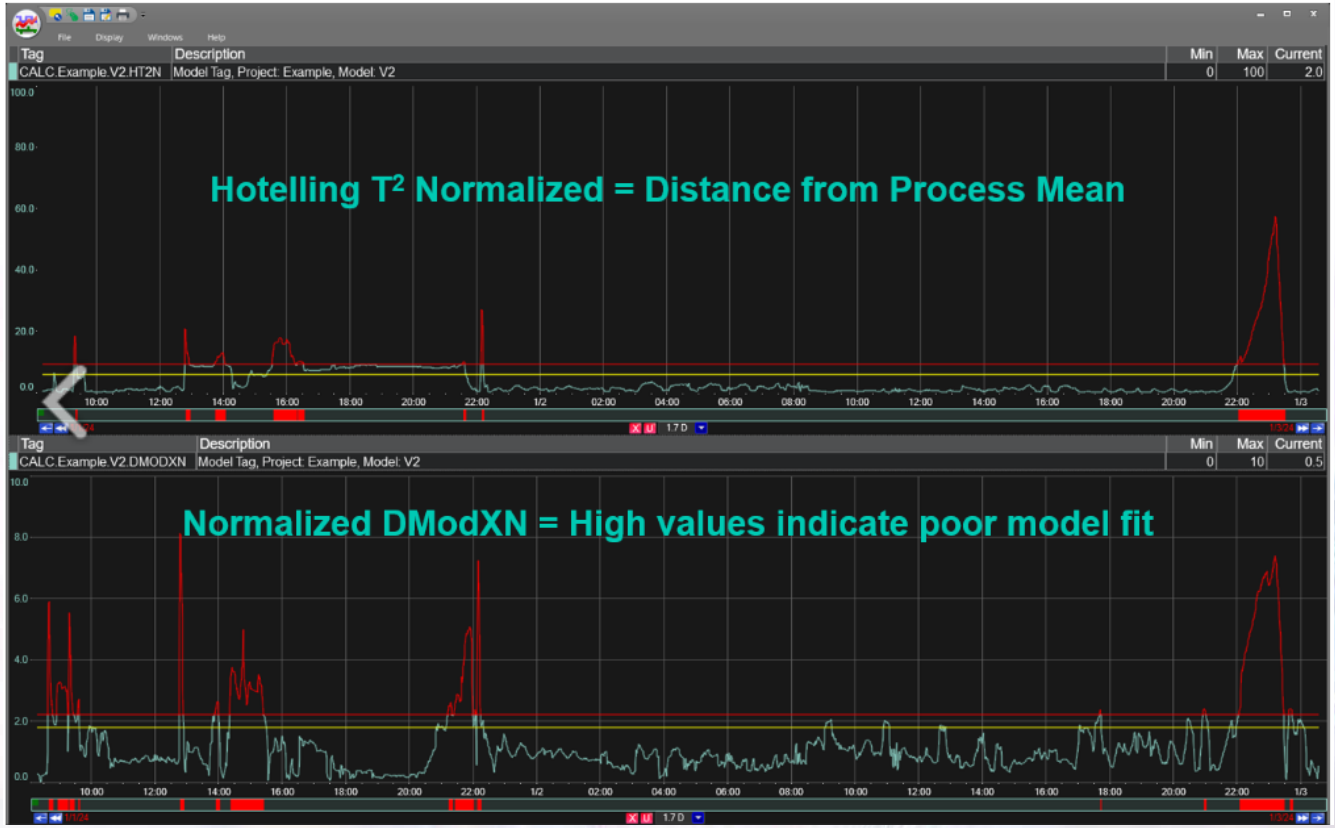
Tag	Description	Min	Max	Current
pr:8TM-MSC1.	TM8 Machine Speed PV	0	6560	5470
pr:FIC-T80100	TM8 Refiner Outlet Dilution Flow PV	0	200	20.7
pr:JIC-T80100	TM8 Refiner Specific Energy Control PV	0	100	4.5
pr:JIC-T80100	TM8 Refiner Load PV	0	100	563.6
pr:SDC-80MRL	TM8 Crepe Ratio PV	0	100	22.2
pr:FCI-T85800	TM8 Yankee Coating Ratio Control PV	0	100	2.9
pr:VIC-T80100	TM8 Refiner Chest Consistency PV	3	5	4.07
pr:TAI-T80101	TM8 Refiner Outlet Temperature PV	0	100	124.0
pr:8TM-BWRL.	TM8 Basis Weight PV	0	25	13.9
pr:FIC-T80100	TM8 Refiner Outlet Flow PV	0	1500	424
pr:FIC-T80100	TM8 Refiner Outlet Recirc. Flow PV	0	1000	224
pr:FIC-T80100	TM8 Refiner Outlet Dilution Flow PV	0	200	20.7
pr:FIC-T80201	TM8 Broke Deflaker Outlet Flow PV	0	400	155
pr:FIC-T80201	TM8 Broke Recirculation Flow PV	0	750	116
pr:FIC-T80500	TM8 Broke Pulper Inlet Flow PV	0	800	327
pr:FIC-T80600	TM8 Secondary Screen Reject Flow PV	0	100	7.6
pr:FIC-T80600	TM8 Secondary Screen Accepts PV	50	600	500



ENG FI 3:37 AM 1/21/2022

Benefits of AI being an Augmented Intelligence

- Root cause analysis with Facts over intuition.
- Provide early warnings for potential quality or maintenance issues.
- Moves from reactive to proactive problem solving



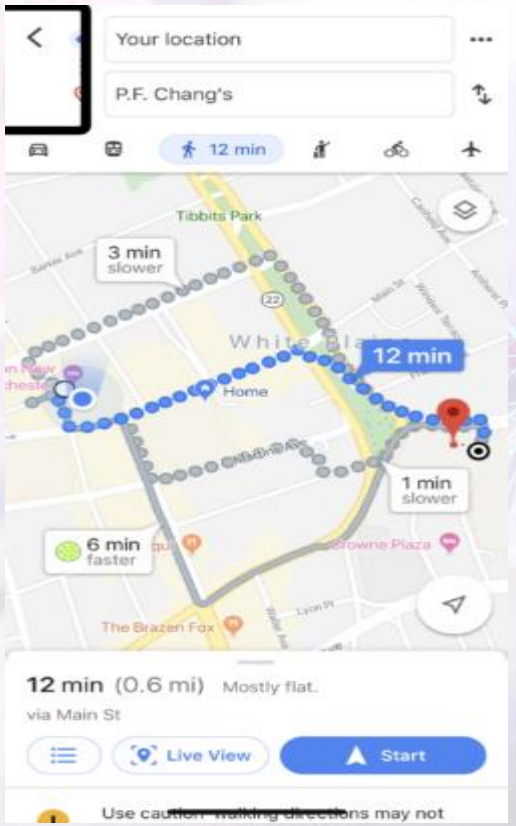
Autonomous Intelligence

Making decisions and actions without direct human intervention using Model Predictive Advanced Process Controls

Static Model v/s Dynamic Model

A static model represents a system at a specific point in time based on Historical data. **It doesn't account for changes over time.**

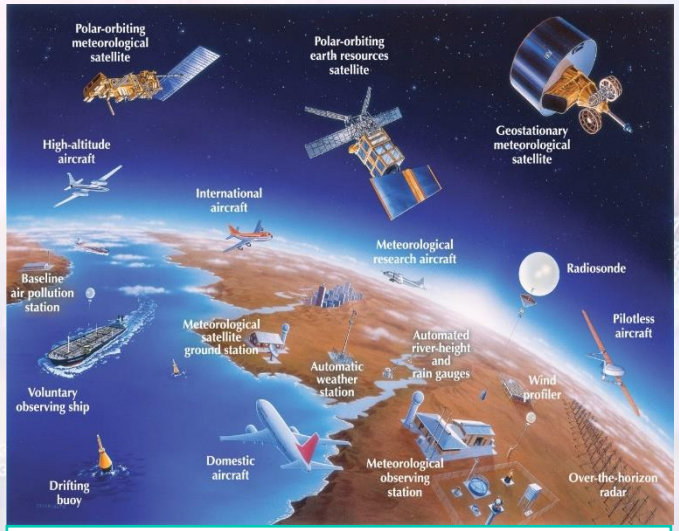
A dynamic model represents a system as it evolves over time. **It captures the behavior and interactions within the system**.



Dynamic Model = Mathematical Model

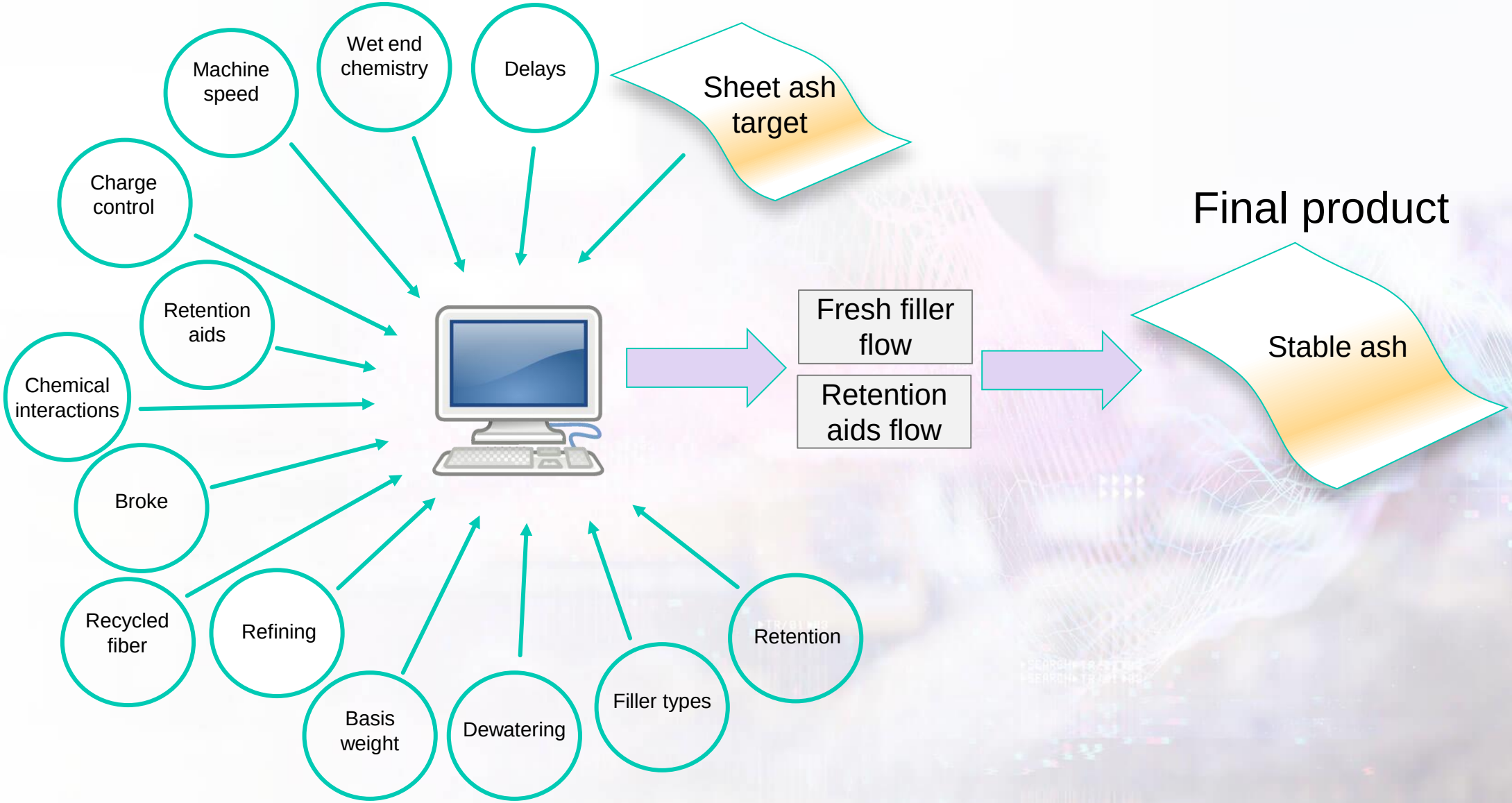
- Mathematical model uses mathematical equations and expressions to represent a process.
- It focuses on the underlying relationships of different variables involved within the Process.
- Used to predict the behavior of Process bases on relation between variables .

- Historical Data
- Pattern Recognition
- Forecasting



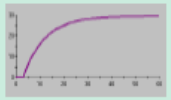
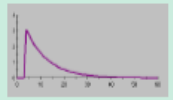
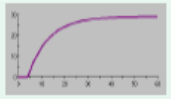
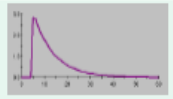
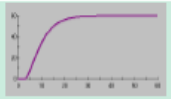
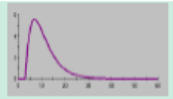
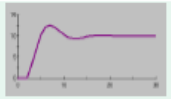
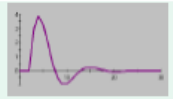
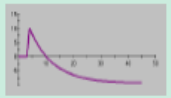
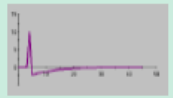
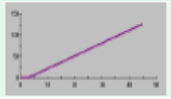
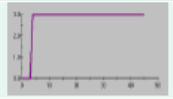
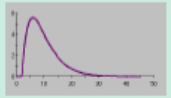
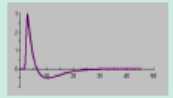
- Realtime measurements
- Modelled Process relationship
- Prediction

Model Predictive Paper Ash Control



Model Predictive Ash Control Matrix

		Control Variables (CV)		Constraints (CT) (if needed)	
		Tray Water Consistency (RET)	Base Sheet Ash (Scanner)	Post Carb ThickStock Ash (TCR)	Base Sheet Formation* (Scanner)
MV's	Carbonate Flow	+	-	+	-
	Polymer Flow	+	-	+	-
FF's	Broke % Ash	+	-	+	-
	Broke % Furnish	+	-	+	-
	WSA	+	-	+	-
	TiO2 Dosage	+	-	+	-

Model Type	Equation	Step	Impulse
1st Order w/delay	$y(t) = 0.89y(t-1) + 3.06u(t-5)$		
1st Order w/fractional delay	$y(t) = 0.89y(t-1) + 2.82u(t-5) + 0.27u(t-6)$		
2nd Order Over Damped	$y(t) = 1.55y(t-1) - 0.6y(t-2) + 3.0u(t-4)$		
2nd Order Under Damped	$y(t) = 1.3y(t-1) - 0.6y(t-2) + 3.0u(t-4)$		
Non-Minimum Phase	$y(t) = 0.89y(t-1) + 10.1u(t-4) - 11.2u(t-5)$		
Integrator	$y(t) = 1.0y(t-1) + 2.99u(t-4)$		
Transient	$y(t) = 1.55y(t-1) - 0.6y(t-2) + 3.0u(t-3) - 3.0u(t-4)$		

The matrix presented here illustrates the positive and negative relationships within the system. It is important to note that this matrix is not realistic and has been simplified to maintain confidentiality.

Variable Types:

MV → Manipulated Variable

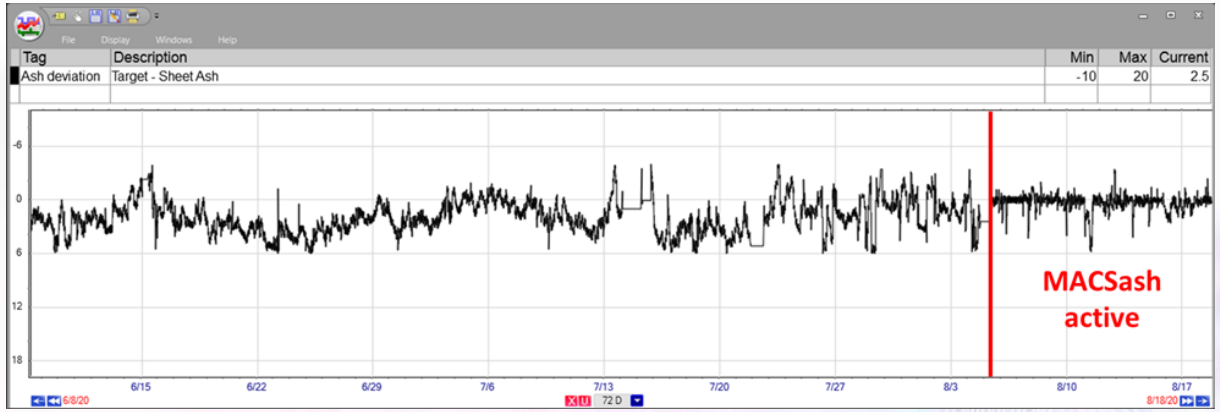
FF → Feed Forward Variable

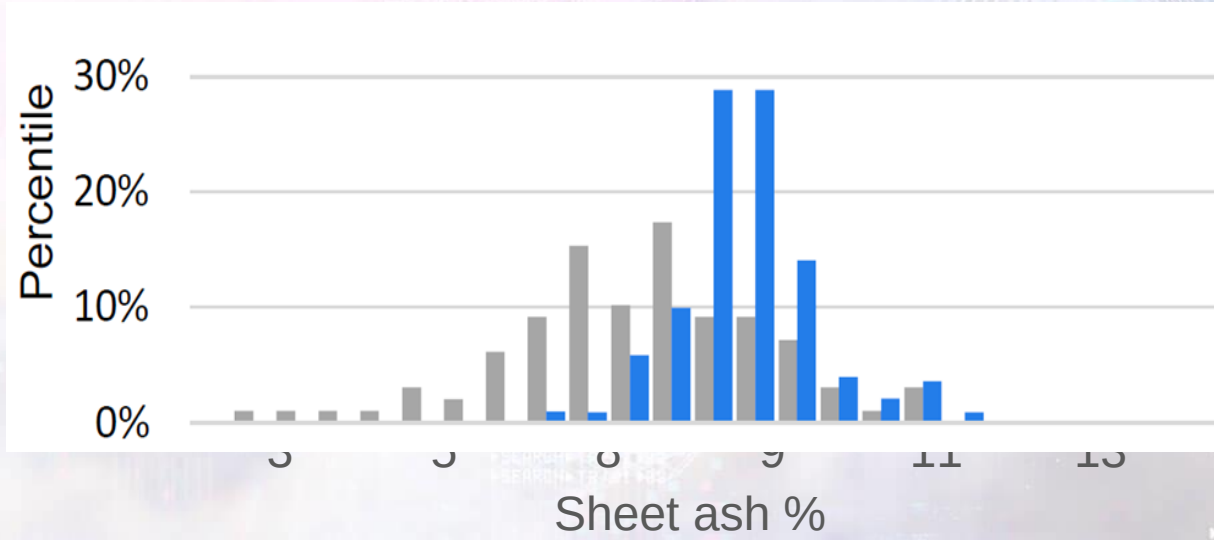
MACSash control Results

Benefits of AI being an Autonomous Intelligence

(MACSash Case)

- Reduced variability enabled higher ash setpoint, while maintaining wet strength targets.
- *MACSash project led to average savings of 5,5 €/t*
- Ash variation reduction by 80%
- Average sheet ash increased by 1 %





Conclusion

Aspect	Assisted Intelligence	Augmented Intelligence	Autonomous Intelligence
Description	Support Tool	Active Collaborator	In Control
Decisions	By Humans	Human + AI Guidance	AI with Human Oversight
Complexity	Low	Moderate	High
Whole Process Suitability	Yes	Yes	Selected Areas
Software Coding	No	No	Yes
Communication	OPC / SQL	OPC / SQL	OPC
Tools	PARC View	PARC Model	MACS
Intangible Benefits	Single Source of Truth	Faster Analysis	Less Manual Intervention
Quantifiable Benefits	TBA	TBA	$2-$8/Ton Savings

Key to Success:

- ✓ Early Adoption
- ✓ Leveraging Existing Tools
- ✓ Human-AI Collaboration

MACSsuite

dataPARC

BTG

A Voith company