

AI-Driven Real-Time “Prediction of Paper Stiffness and Moisture”



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Creating lasting impressions

VISION

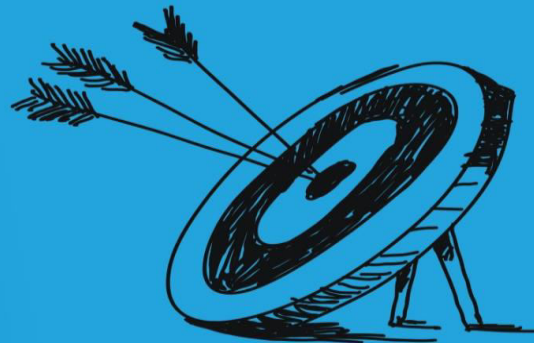
To be a trusted industry leader enriching lives and creating a better future



MISSION

Deliver sustainable solutions & profitable growth through:

- Digitalization and Innovation
- Cost Competitiveness
- Customer Centricity
- People and Community care
- Outstanding & Agile Talent



CORE VALUES

- Caring for People
- Integrity including Intellectual Honesty, Openness, Fairness and Trust
- Commitment to Excellence



Digital Transformation Journey

Industry 4.0



FY 13-17
PLC at color Kitchen,
Upgradation of QCS

FY 17-21
Silent drive,
OPP in Pulp Mill



FY 22-23
AI Model's for
Bleaching Chemical



Smart
Manufacturing



FY 23-24
AI driven Moisture
Optimization Model



FY 22-23
Ring network data lake
along with firewall



FY 21-22
Leap 200 started,
Steam vent reduction



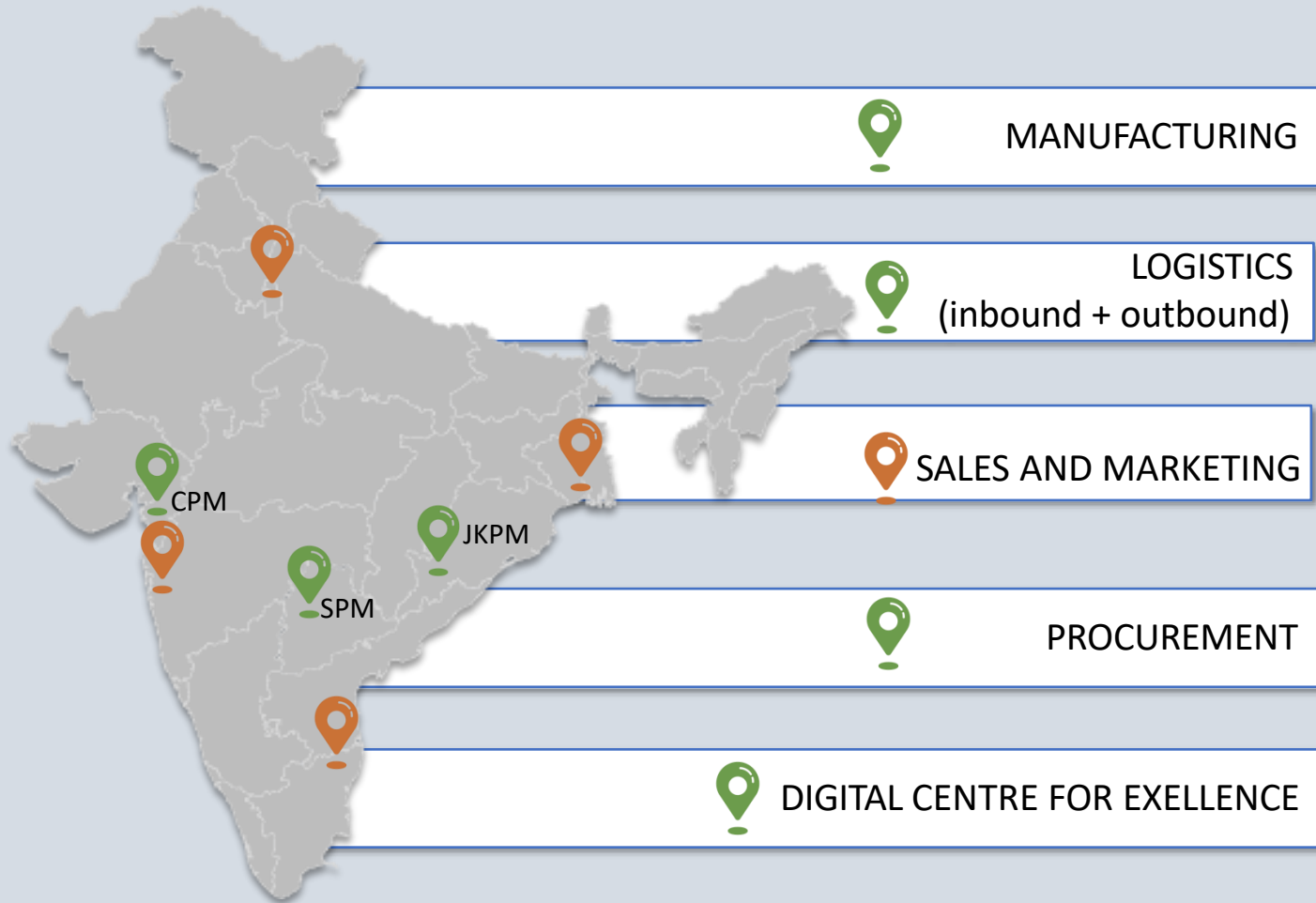
Journey Pathway

Digital Transformation Overview

GEOGRAPHIC SCOPE

FUNCTIONAL SCOPE

ENTERPRISE SCOPE

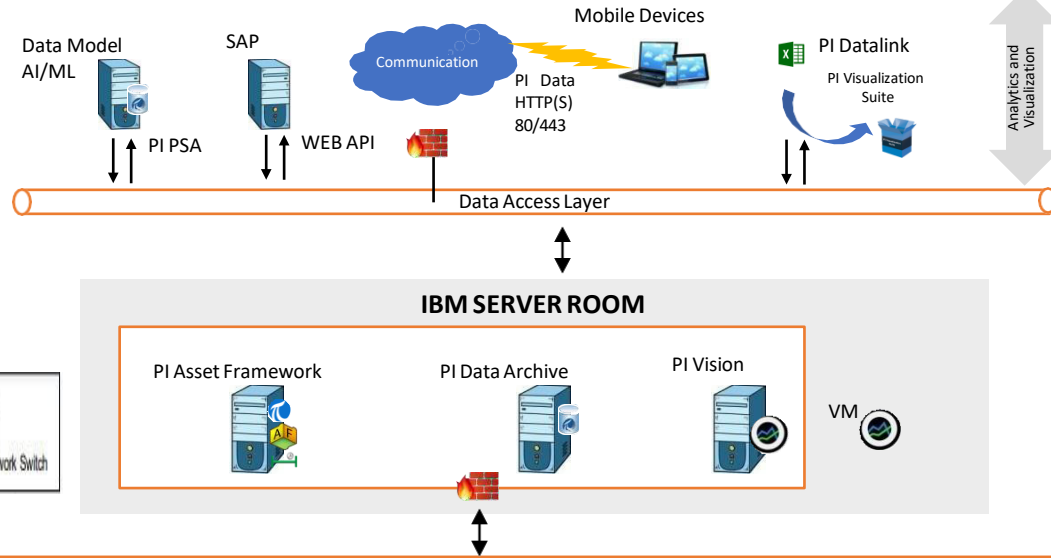


DIGITAL CENTER OF EXCELLENCE TO SUSTAINABLY DELIVER DIGITAL PROJECTS

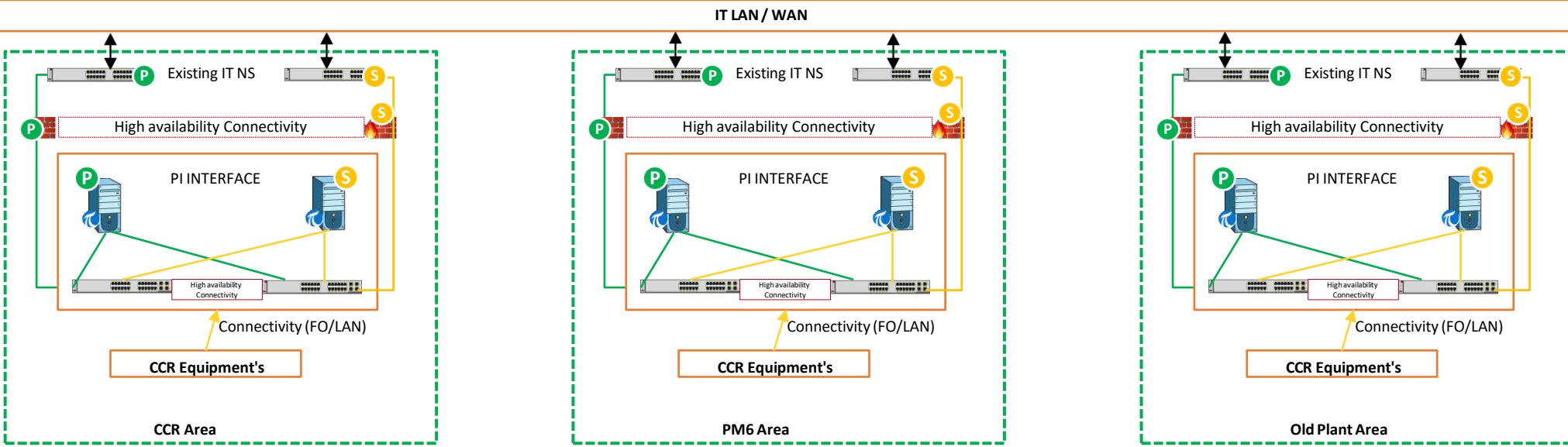
COMMUNICATION AND CHANGE MANAGEMENT TO DRIVE ORGANIZATION

Handshaking of data

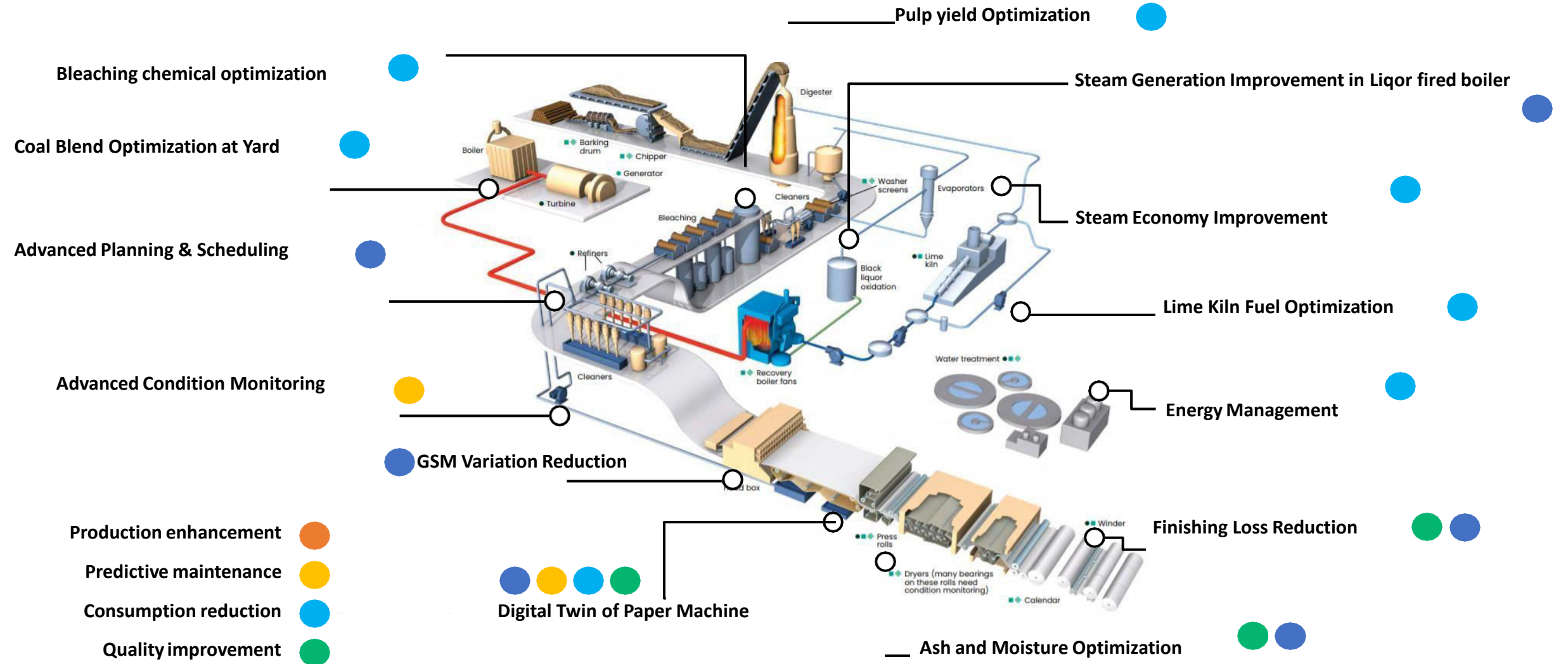
LEAP 200 -IT-OT Network Diagram



- ❑ Connected 64 Individual system
- ❑ Data analytics become easy
- ❑ Continuous data flow from sensors to OSI PI
- ❑ OSI PI System supports advanced analytics and programming.



Digital Transformation in Manufacturing Section



“Enhancing Moisture % in paper through
AI-driven predictive
and calculative quality control measures”



Present Scenario



Moisture % is influenced by both operator settings and lab parameters



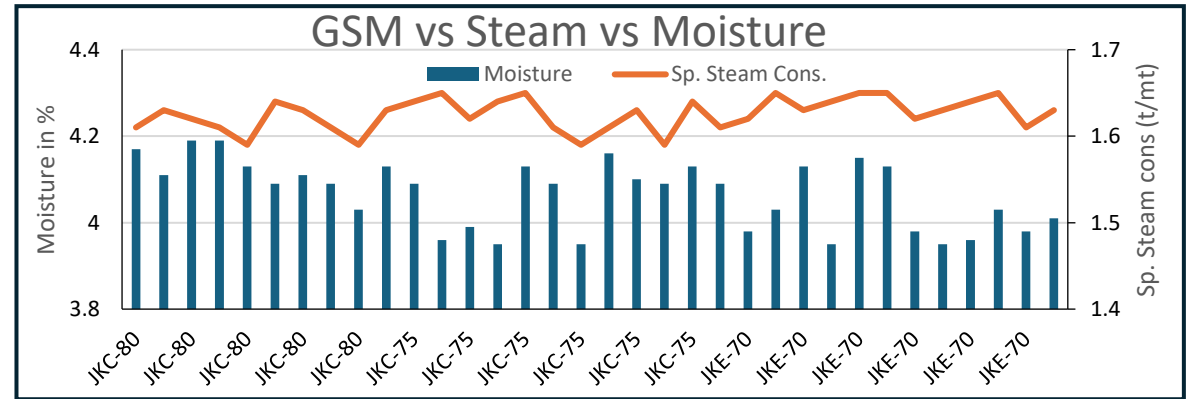
Different paper grades have operator-dependent setpoints



Lack of Real-time Monitoring & Control Decisions are based on historical data, not live process conditions.



No predictive system to proactively adjust moisture levels.



Grade	GSM	Caliper	Bulk	Ash %	Moisture	Stiffness (md)	stiffness (Cd)
1 SKU-1	70	106+_2	1.50+_0.05	20 Min	4.0+_0.5	2.0 min	1.0 min
2 SKU-2	75	106+_2	1.50+_0.05	20 Min	4.0+_0.5	2.0 min	1.0 min
3 SKU-3	75	106+_2	1.50+_0.05	20 Min	4.0+_0.5	2.0 min	1.0 min
4 SKU-4	80	106+_2	1.45+_0.05	20 Min	4.0+_0.5	2.0 min	1.0 min

Time	QUALITY	PM6 QUALITY Bulk	PM6 QUALITY Caliper	Stiffness_MD	Stiffness_CD	Ash	PM6 Q...	Moisture	PM6 Q...	M/C_Roll_n
09/10/2024 4:10:00 AM	JKC-75 N	1.43	107.6	2.5	1.6		250		279	
09/17/2024 2:00:00 AM	JKC-75 N	1.43	107.3	2.5	1.55	22	226	4.24	242	
09/17/2024 4:10:00 AM	JKC-75 N	1.43	107.7	2.5	1.45		230		252	
09/17/2024 10:30:00 AM	JKC-75 N	1.43	107.4	2.5	1.5		241		269	
09/10/2024 7:50:00 AM	JKEC-70N	1.48	105.1	2.45	1.4					
09/11/2024 6:40:00 AM	JKEC-70N	1.47	104.4	2.45	1.5	22	269	4.05	288	
09/11/2024 10:10:00 AM	JKEC-70N	1.48	104.4	2.45	1.45	21.5	280	4.29	288	
09/11/2024 11:20:00 AM	JKEC-70N	1.48	105.7	2.45	1.5		271		300	
09/17/2024 3:05:00 AM	JKC-75 N	1.43	107.6	2.45	1.5		230		252	
09/10/2024 6:50:00 AM	JKEC-70N	1.48	104.4	2.4	1.35	22.2	277	4.14	269	
09/10/2024 9:10:00 AM	a COPIER-70(N)	1.47	104.3	2.4	1.35		274		295	
09/10/2024 12:30:00 PM	JKEC-70N	1.48	104.3	2.4	1.3		281		300	
09/10/2024 5:10:00 PM	JKEC-70N	1.48	104.4	2.4	1.4			4.26		
09/10/2024 7:45:00 PM	JKEC-70N	1.49	104.7	2.4	1.5		278		300	



Data collection

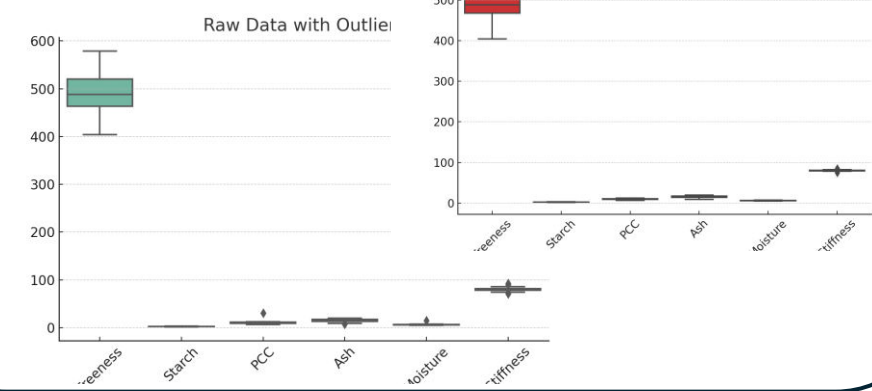
- ❑ Collected six months of **minute-wise** process data from PM6.
- ❑ Data extracted from **DCS logs, lab reports, and sensor readings.**



Data Cleaning Techniques

- ❑ Outlier **removal** using statistical methods
- ❑ Handling **missing values** using interpolation techniques.
- ❑ **Standardization & normalization** to improve model accuracy.
- ❑ Ensure high-quality, **reliable input** for AI model training.

```
463F11615/MMON/463F11618/M/463PIC7088/463TIC7086/463TIC7115/SURF_STAR Scanner General Diagnosis - Machine Spei
657.8828495 67.5430514 -2351.10669 120.309235 114.910868 10 1160
653.4523458 58.393739 -2349.634 120.181401 114.905427 10 1160 0164
642.3738207 50.5582114 -2349.03679 119.975685 114.908147 10 1160
660.3245231 60.8768652 -2349.06411 119.70656 114.924703 10 1160 0164
660.8954075 63.397429 -2349.06411 119.70656 114.924703 10 1160 0164
656.3362265 63.0412691 -2349.06411 119.70656 114.924703 10 1160 0164
660.860996 66.3249794 -2349.06411 119.70656 114.924703 10 1160 0164
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659.912379 73.9078203 -2349.06411 119.70656 114.924703 10 1160 0164
659.128657 73.7908425 -2349.06411 119.70656 114.924703 10 1160 0164
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```



Parameters Monitor

- ❑ Stock Parameter
- ❑ Chemical Parameters
- ❑ QCS Parameters
- ❑ Basis Weight
- ❑ Bulk
- ❑ **Stiffness**: A critical quality parameter influenced by bulk, moisture, and grade

Challenges

- ❑ **Stiffness Data Delay**: Stiffness measurements were only available through **lab testing**, causing delays in feedback and process adjustments.

Solution

- ❑ **Virtual Sensor**: A **virtual sensor** was developed using selected online variables to estimate stiffness in real-time.

Optimization of Quality Parameters Using AI-Based Virtual Sensor

Virtual Sensor Stiffness Prediction

- ❑ Developed a virtual sensor using key process variables.
- ❑ Using input variables, we built a model utilizing multicollinearity to predict stiffness.
- ❑ Assigned the trends in the historian for monitoring and analysis.
- ❑ The predicted virtual sensor values match lab data with **95% accuracy**.
- ❑ Enables real-time stiffness prediction to optimize moisture levels.

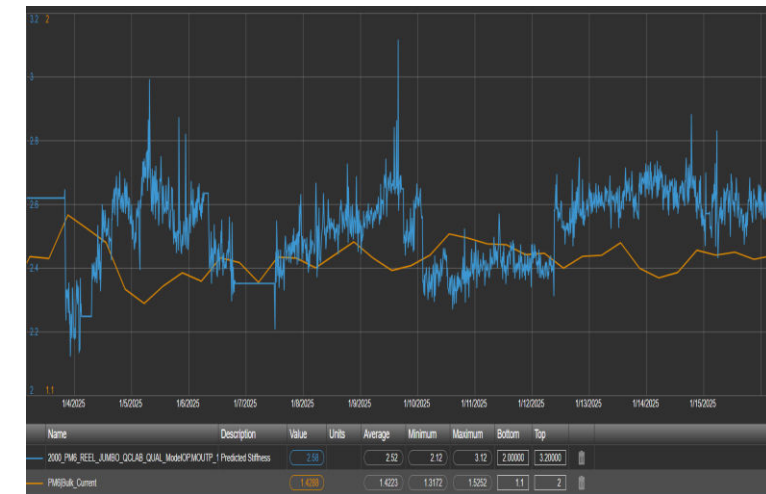
Input variables

Area	Tag	Input Parameters	UOM
Approach Flow	462HSE2002/OP_ANA.QY	Ratio broke ratio virgin	%
Calender	463PIC5202_A/WR_R01.IN2	Cal nip line force IN2	N/mm
	463PIC5102_A/WR_R01.IN2	Cal nip line force IN2	N/mm
Coating Preparation	SURF_STARCH_DILUTION/SP_SOLID.QY	Surf starch dilution	%
Headbox & Former	463G1121/MMON.QPV	Hb top lip vertical position PV	mm
	463PIC1119_A/VP_WR_R1.IN1	Jet wire ratio	m/min
Press Section	463PIC1603/004-R04.QY	Press Line force nipcoflex	MPa
	463PIC1603/002-R01.U	Nipcoflex press line load	KN/m
QCS	QCS/MD/IMC33/IMC.QPV	DCS Ash %	%
	QCS/MD/IMC11/IMC.QPV	Basis Weight	g/m^2
	QCS/MD/IMC44_X/IMC.QPV	ADS Moisture	%
	Ash %	Ash %	%
viscosity	Viscosity	-	
Stock Preparation	461EC2372/PID.QPV	BHKP freeness PV	SR
Wet end	DOSING_STARCH_CALC/HIC.PV	Dosing starch calc	Kg/t
Chemical	464FIC0270/PID.QPV	Flow PCC filler to machine PV	L/min

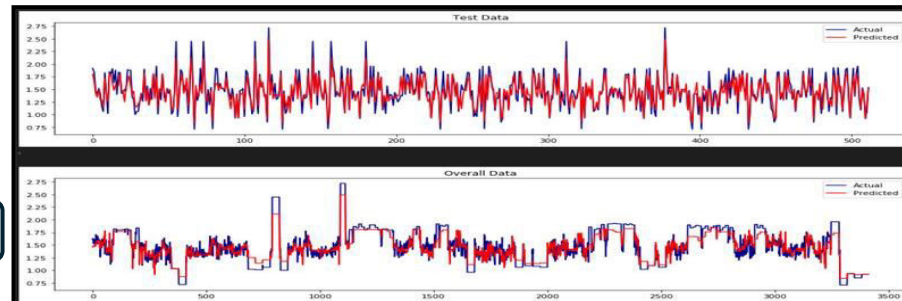
Model building

```
print(out_sample_data['Paper Break'].value_counts())
from sklearn.metrics import confusion_matrix
### metrics on Out of sample set
print('Metrics on Out of sample')
out_sample_data_x = out_sample_data[xcols].copy()
out_sample_data_y = out_sample_data[ycols].copy()
#y_pred_out_sample = xgb.predict_proba(scalerx.transform(out_sample_data_x))
y_pred_out_sample = xgb.predict_proba(out_sample_data_x)
```

Online predicted value

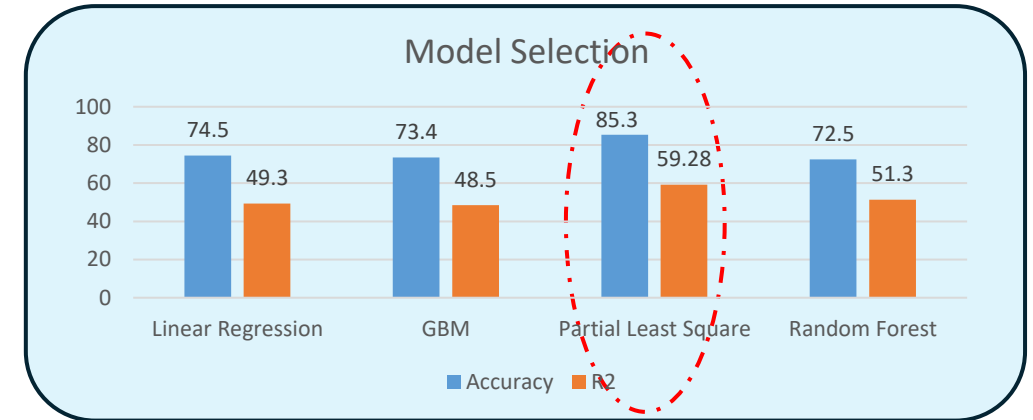


Lab vs virtual sensor



Model Selection

- ❑ We used multiple analytical approaches and selected as per their accuracy and R^2 value
- ❑ We have selected PLS analytical approach.



Model Development

- ❑ All the variable were selected using correlation
- ❑ Data collected from different sources like Lab , DCS.
- ❑ After corelation we selected PLS and Linear regression for model deployment.
- ❑ Model deployed in OSI PI, trained and tested using different data sets.

Moisture Model

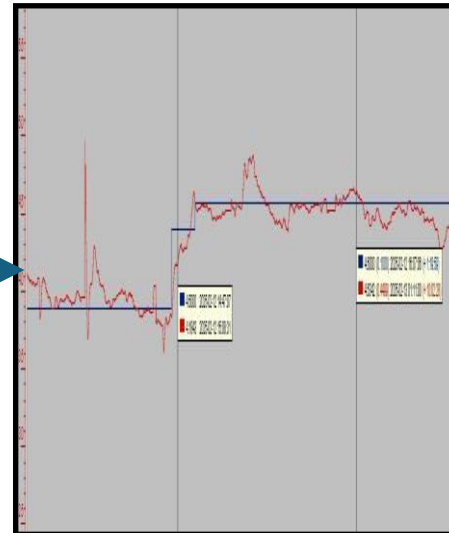
- Predicted stiffness MD and bulk determine the optimal moisture setpoint
- The algorithm operates within a minimum and maximum band range to ensure stability.
- The model helps achieve higher moisture levels while maintaining minimum quality standards.

GSM	Grade	Min Moisture	Maximum Moisture	Minimum Bulk	Minimum Ash	Maximum Ash
70	SKU-1	4	5	1.46	20	24
70	SKU-2	4	5	1.46	20	24
75	SKU-3	4.2	5	1.41	22	24
70	SKU-4	4	5	1.46	20	24
75	SKU-5	4.2	5	1.41	22	24
80	SKU-6	4.2	5	1.35	22	24

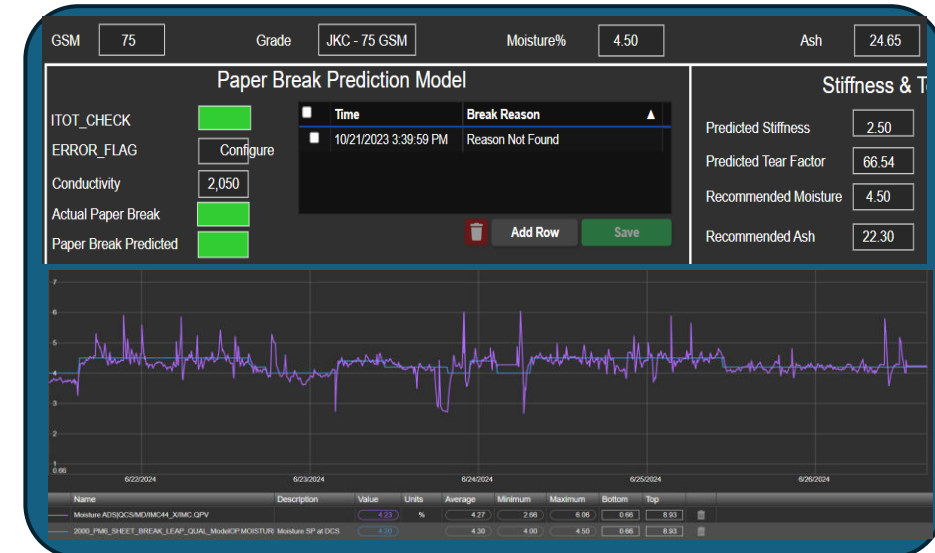
Grade wise range

- QCS Parameter
- Coating Parameter
- Chemical Parameter
- Calander Parameter
- Ash, Bulk, Freeness
- Stiffness Predicted

```
test_data_y_3=out_sample_data_y_3gb.reset_index(drop=True).copy()
test_data_y_3 = pd.concat([y_pred_prob_3gb.o.reset_index(drop=True),test_data_y_3],axis=1)
test_data_y_3['y_pred_flag_2']=1
for i in test_data_y_3.index:
    if((test_data_y_3.loc[i:i+12,'y_pred_flag'].sum())<=0):(test_data_y_3.loc[i:i+28,'Pred_007'].min)
    t=test_data_y_3.loc[i:i+12,:]
    t_2 = t[(t['y_pred_flag'] == 0)]
    t_2 = t[(t['Pred_007']<=100)&(t['Pred_007']>=30)]
    t_2 = t[(t['Pred_007']).isin([4,5])]
    # t_2 = t[(t['Pred_007']<=5)]
    #test_data_y_2.loc[i+44-3:i+44+3,'y_pred_flag_2'] = 0
    if(t_2.shape[0]>=6):
        test_data_y_3.loc[i+19,'y_pred_flag_2'] = 0
test_data_y_3 = test_data_y_3.dropna(how='any')
```



Recommended Moisture SP



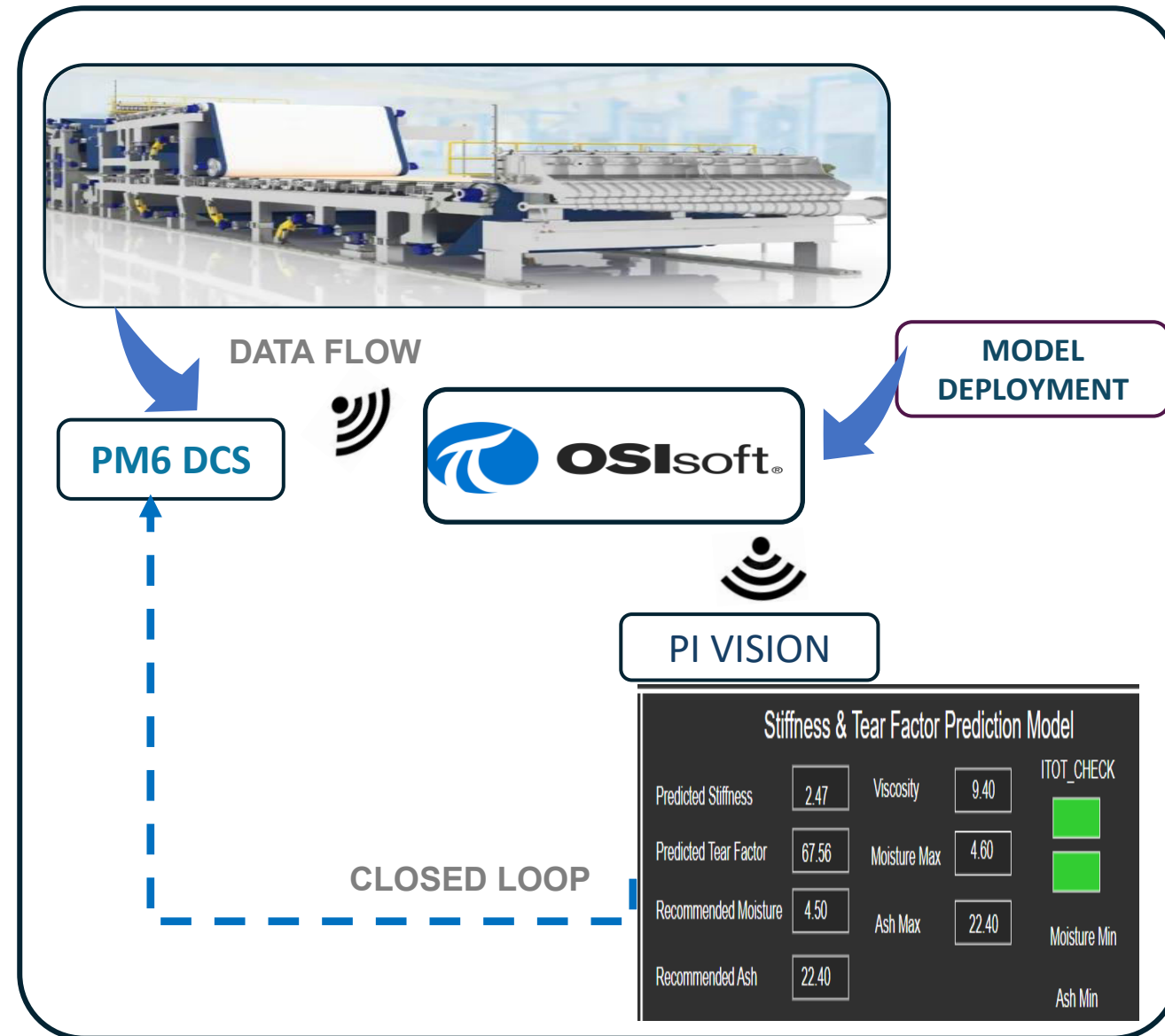
Dashboard

Visualization

- **DCS Integration:** IT/OT connectivity for seamless operation.
- **Real-Time Optimization:** Continuous sensor data enables AI-driven adjustments.
- **Smart Dashboard:** Provides operator recommendations.

Loop Monitoring and control

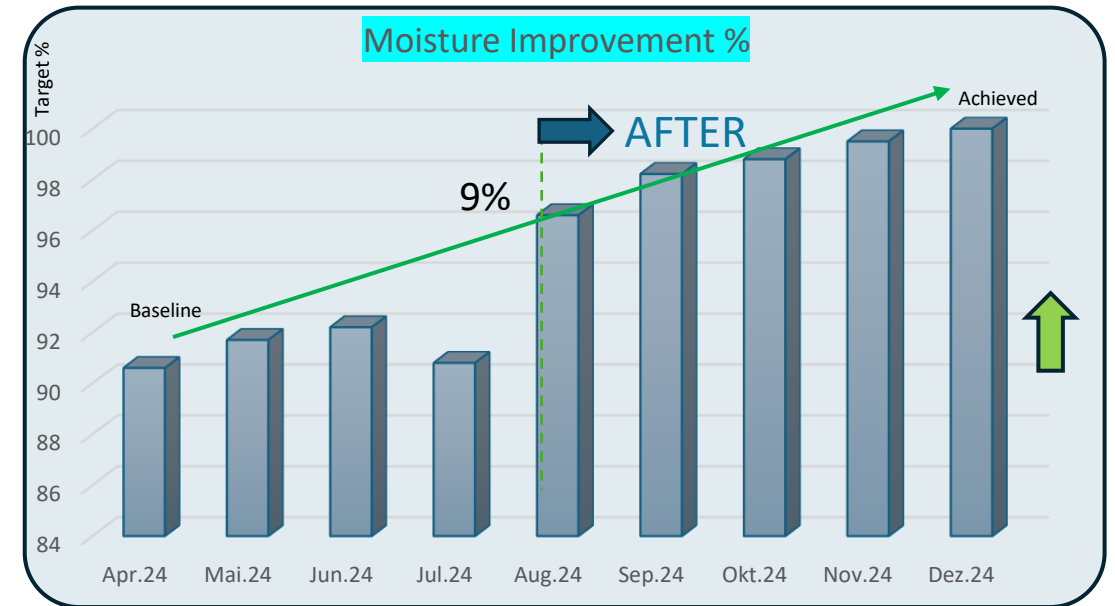
- **Cloud Monitoring:** Enables remote access and tracking.
- **Closed-Loop Control:** Initiated after a successful trial.
- **Error Handling:** Feedback system detects data failures and model anomalies.



Value Delivered by the Project

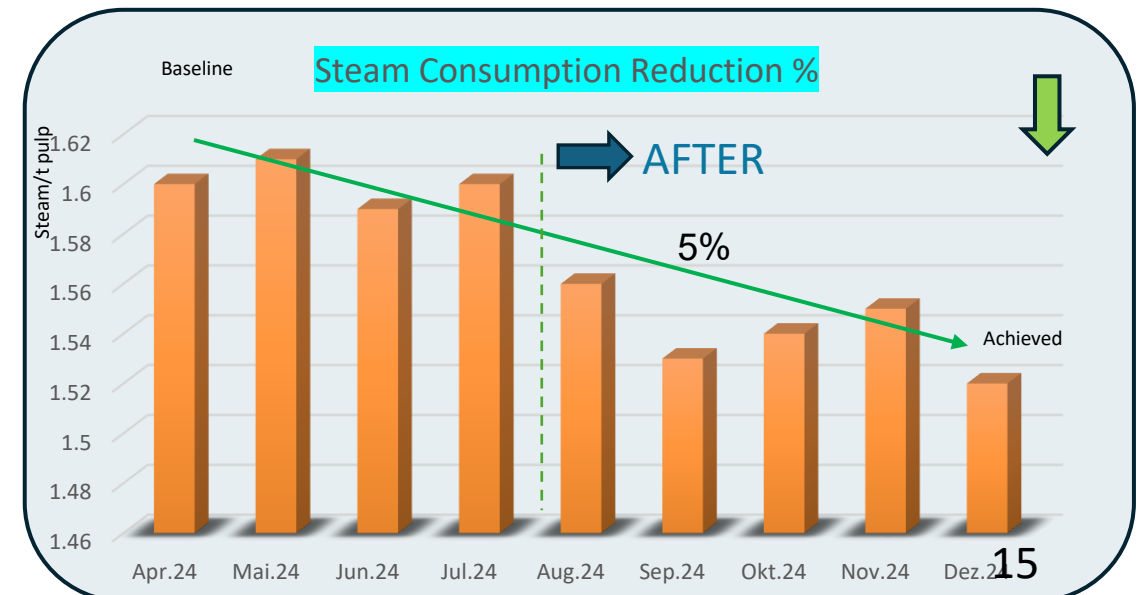
Moisture Improvement

- Moisture improved and gained 9% from baseline to target through AI.
- AI improved consistency, reducing manual rework.
- Better control over drying process
- Improved paper strength.



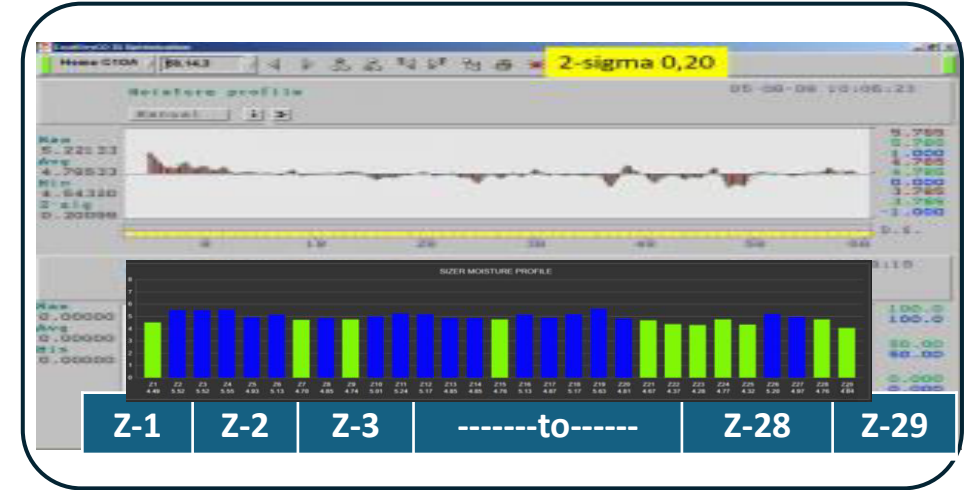
Steam Reduction

- Steam consumption reduced from baseline.
- Target achieved: 5% reduction.
- Reduction in steam usage impact on lower production costs.



Proposed Idea for improving CD moisture profile

- ❑ AI-Driven CD Moisture Profile Optimization
- ❑ Virtual Sensor Implementation
- ❑ Intelligent Quality & Cost Optimization



Anticipated Advantages

- ❑ **Precision:** AI minimizes manual tuning, ensuring stability.
- ❑ **Efficiency:** Automated control enhances response time.
- ❑ **Quality:** Better moisture uniformity improves the product.

Conclusion

- **Revolutionizing paper production** through AI-driven technologies, optimizing processes from raw material handling to final product output.
- **Enhanced operational efficiency** with AI systems for predictive maintenance, real-time process monitoring, and automated adjustments, reducing downtime and improving throughput.
- **AI-enabled quality control** ensuring consistent product quality by analyzing key parameters and making data-driven adjustments during production.
- Significant **cost savings and sustainability improvements** achieved by reducing energy consumption, optimizing resource usage, and minimizing waste.

The adoption of AI continues to **transform the future of paper manufacturing** paving the way for smarter, more efficient, and environmentally responsible production methods.

JK PAPER MAKING LIVES SUSTAINABLE THANKS

