IPPTA – 1st ZONAL SEMINAR - 2024

ENHANCING EFFICIENCY THROUGH ELECTRICALS, ELECTRONICS, AUTOMATION AND DIGITAL TECHNOLOGY IN PULP & PAPER MILLS

Case Study Title:

PULP VISCOSITY VARIATION REDUCTION THROUGH AI/ML MODEL

Unit Name: Harihar Polyfibers, Grasim Industries Ltd

Mr. Manohar Kumar R.
Vice President (Technical)

Mr. Panchakshari SG
Manager (Tech. Cell)

Mr. Pavan R Kulkarni
Dy Manager (Pulp plant)

Pulping Process

Eucalyptus Tree

Chipping → Cooking → Washing → Bleaching → Dewatering → CELLULOSE (Rayon Pulp)

Cooking liquid

Cooking liqour preparation

Evaporation

Chemical recovery

Pulp Quality

1. Viscosity
2. Whiteness
3. Impurities

Measure & Control

IMPACT

Reduction in Viscosity Variation

IMPACT

Reduction in Ball Fall

Viscose Process

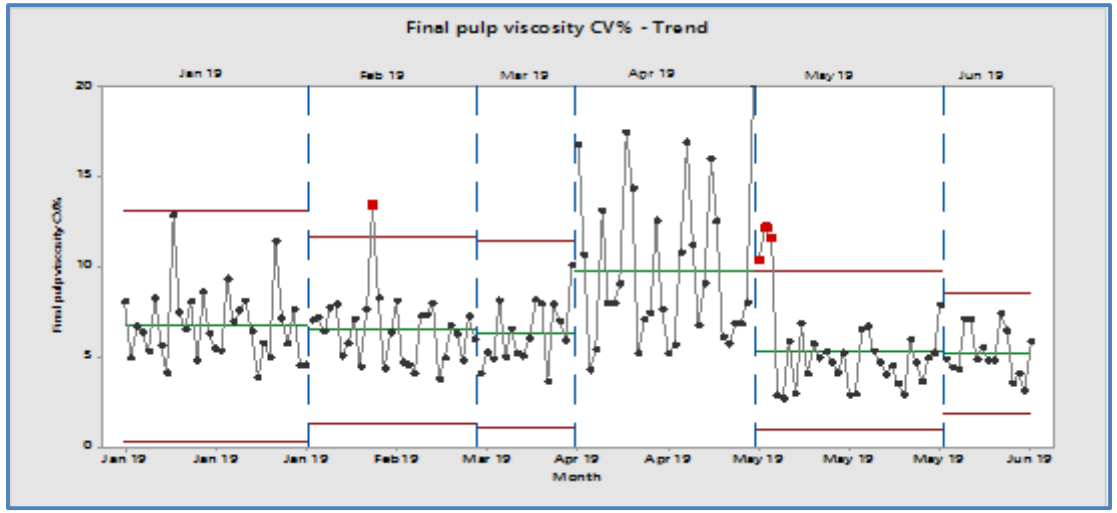
Spinning

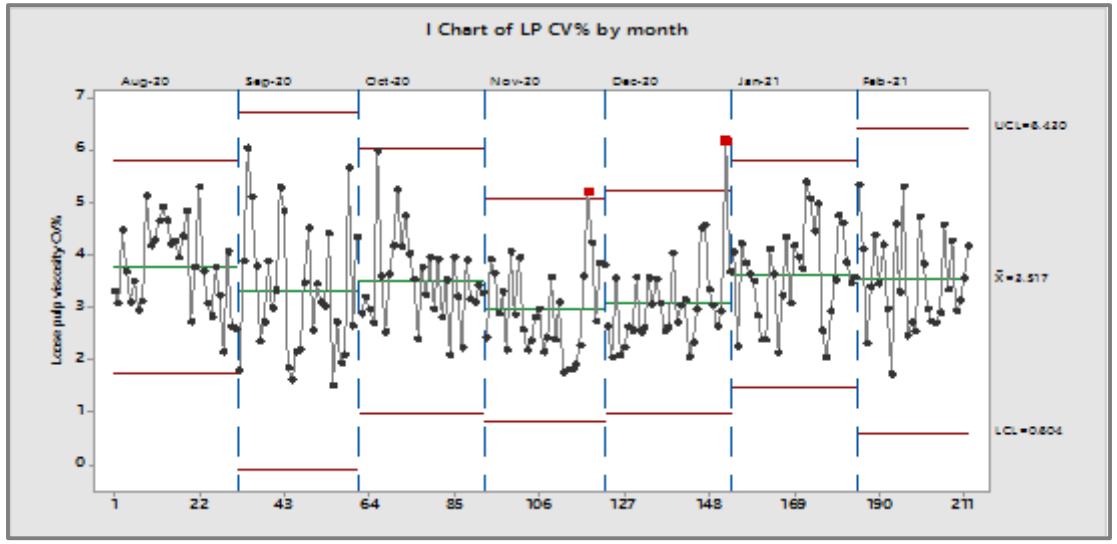
Reduction in Splinter

Quality Fibre to Customer

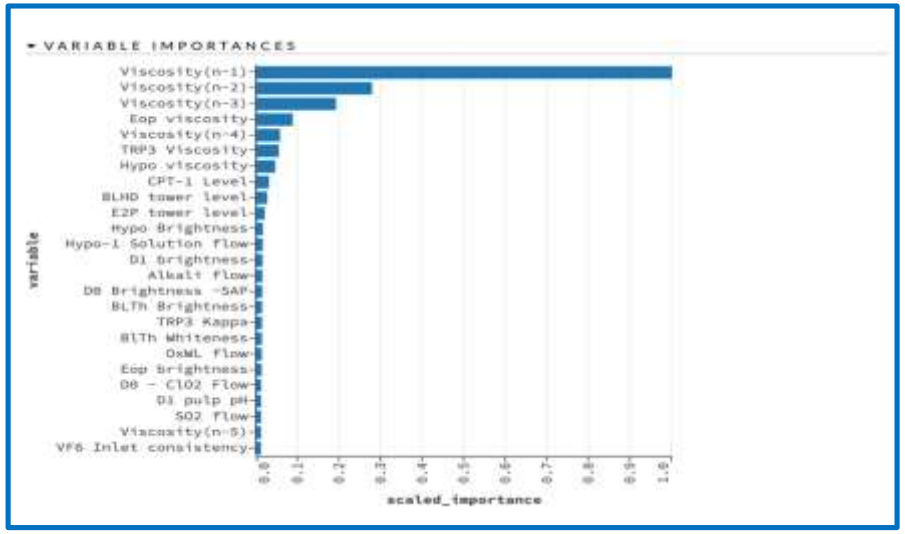
Case Study Introduction

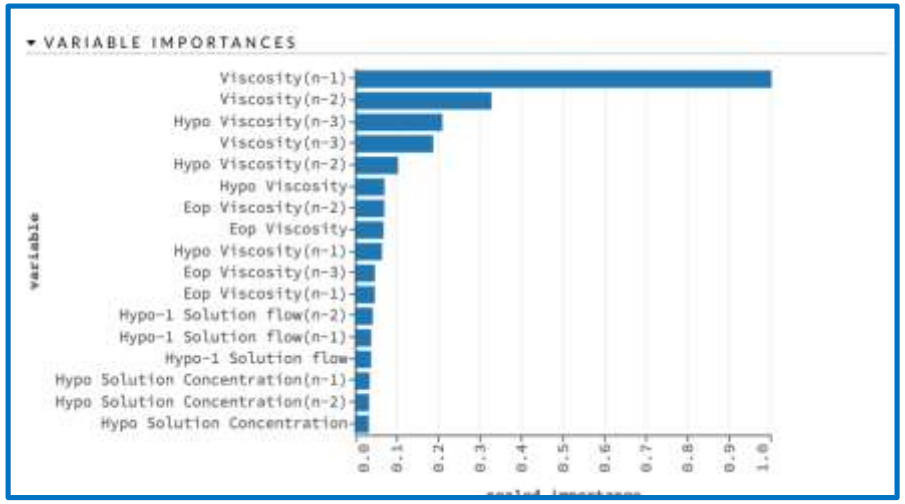
- In the current competitive business scenario, meeting customer growing expectations and demand with old technology and aged equipment is a challenge.
- The variation in pulp quality will affect fiber quality lead to customer complaints and losing customers.
- Variation in pulp viscosity affects fibre quality in terms of ball fall variation, filtration delay and variation in machine splinter.
- RG pulp viscosity CV% variation was 4.92 % (Baseline FY20) with range of 3.0 – 6.0 % variation on day-to-day variation.





Approach / Root Cause Analysis





- Harihar unit doesn't have state of the art online measurement and control system.
- Process involves > 80 operating variables, it is very difficult to control on manual base on raw material quality.
- 25 Parameters analysed and narrowed down to 04 No parameters through MINITAB which are contribution more to viscosity variation.
- Inhouse development of algorithm for Hypo viscosity control has started in Jul-2021.

Detailed Analysis and Solution

Various algorithm models deployed using MINITAB and tested offline to ascertain effectiveness in comparison to manual control.

Statistical Algorithm Model – 1 (Simple Regression)

Hypo Dosage = 2.19 * (Target Hypo Brightness – Target Eop Brightness) + Avg. (Last 3 hr Hypo Dosage) * Ln (Eop Viscosity (n-2) / Hypo Viscosity Target)

Statistical Algorithm Model – 2 (10-point Regression)

Hypo Dosage = A * (Target Hypo Brightness – Actual Eop Brightness) + B * Ln (Eop Viscosity (n-2) / Target Hypo Viscosity)

Detailed Analysis and Solution

Statistical Algorithm Model – 3 (6-point Regression)

Hypo Dosage = A * 5 + (B * Actual Eop viscosity) - Target Hypo Viscosity – (sum of deviation from last 3 hr hypo dosage / 3)

Statistical Algorithm Model – 4 (Multivariate)

Hypo Dosage = (A + (B * Actual Eop viscosity) +C * Ln (Actual Eop Viscosity / Actual Hypo Viscosity) + D * Exp (Hypo pH) + E * Ln (Actual Eop Viscosity / Target Hypo Viscosity)) / (Hypo Concentration * Pulp Rate)

Detailed Analysis and Solution

Based on various model deployment experience team developed 5th model which works on last 10 hours rolling data of pre and post hypo stage viscosity, brightness and dosage.

Statistical Algorithm Model – 5C

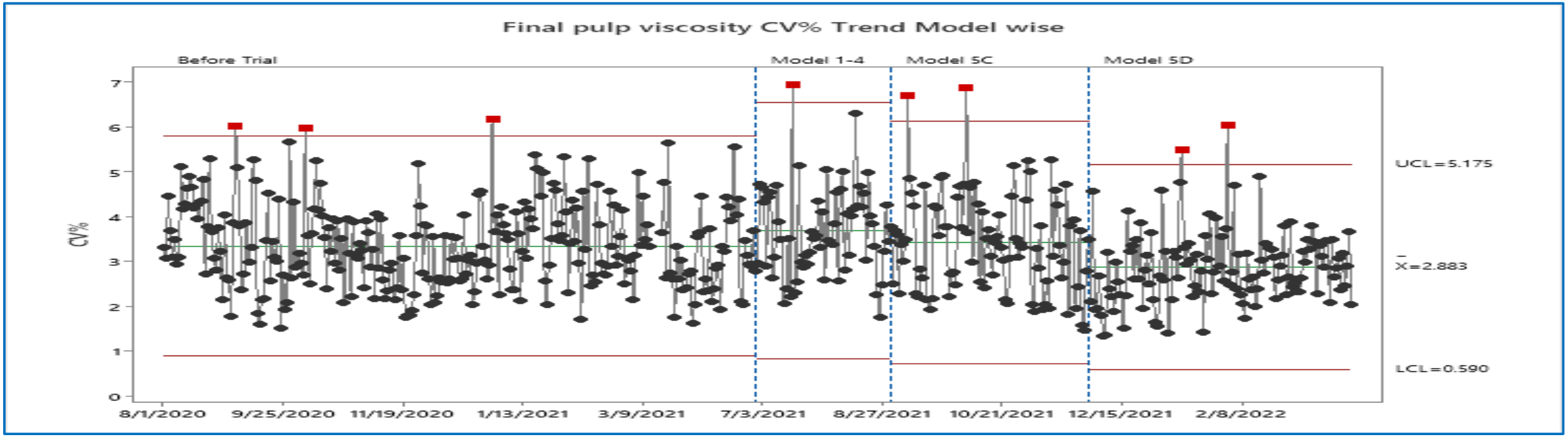
Hypo Dosage = If (Hypo dosage < Min Hypo dosage, last hypo dosage) + If (Target Hypo Brightness – Eop Brightness (n-1) > 10, Hypo dosage is zero)

Statistical Algorithm Model – 5D

Hypo Dosage = If (Hypo dosage < Min Hypo dosage, last hypo dosage) + If (Target Hypo Brightness – Eop Brightness (n-1) > 10, Hypo dosage is min 10)

Detailed Analysis and Solution

Improvement observed from model to model.



- Models were developed using excel sheet and needs timely input, any human error is misleading the model.
- AI/ML model collaborative project under taken with developer to develop dynamic algorithm to control hypo pulp viscosity to minimize the final loose pulp viscosity variation.

Detailed Analysis and Solution

AI/ML team developed the variable importance plot of each parameter for viscosity variation.

Loose pulp viscosity = EOP viscosity, hypo dosage & delta in hypo to final viscosity

1

Time series model to predict Hypo viscosity

2

Model to prescribe hypo addition to meet target hypo outlet viscosity

Identify radar parameters that are also affecting hypo viscosity

3

Model to predict delta viscosity because of Hypo addition

Identify the radar parameters that are also affecting post hypo viscosity delta

Detailed Analysis and Solution

AI/ML Algorithm Model

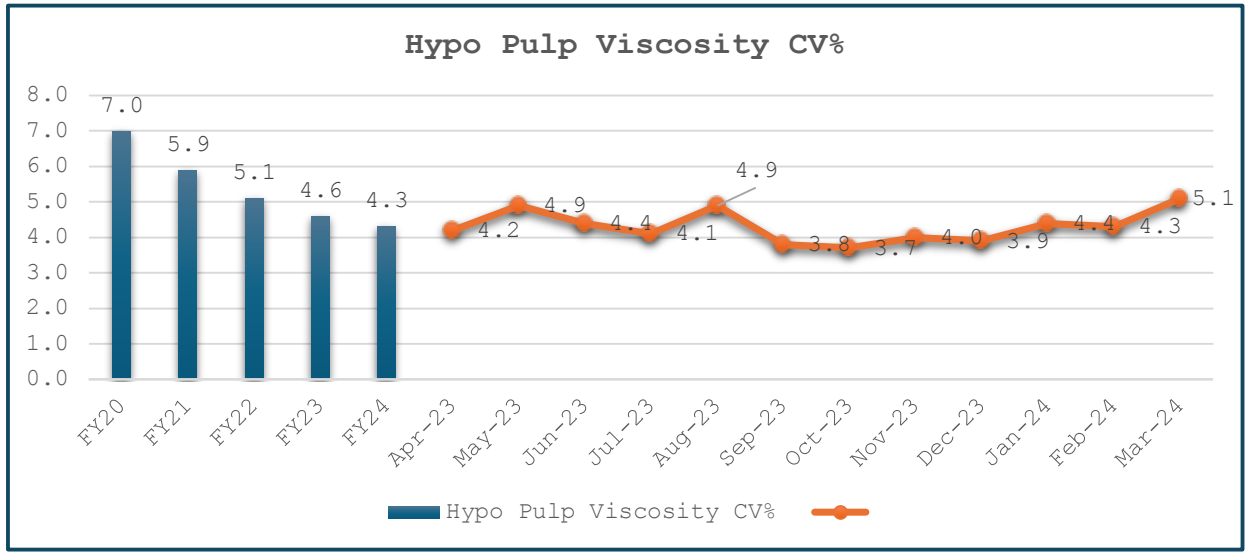
Hypo Dosage = - 24.23 – 0.208 * Eop viscosity (n-2) + 0.263 * Eop Viscosity (n-1) + 0.802 * Hypo Addition (n-1) + 0.1 * ((Hypo Viscosity (n-2) – Hypo viscosity Target) + (Hypo Viscosity (n-1) – Hypo viscosity Target))

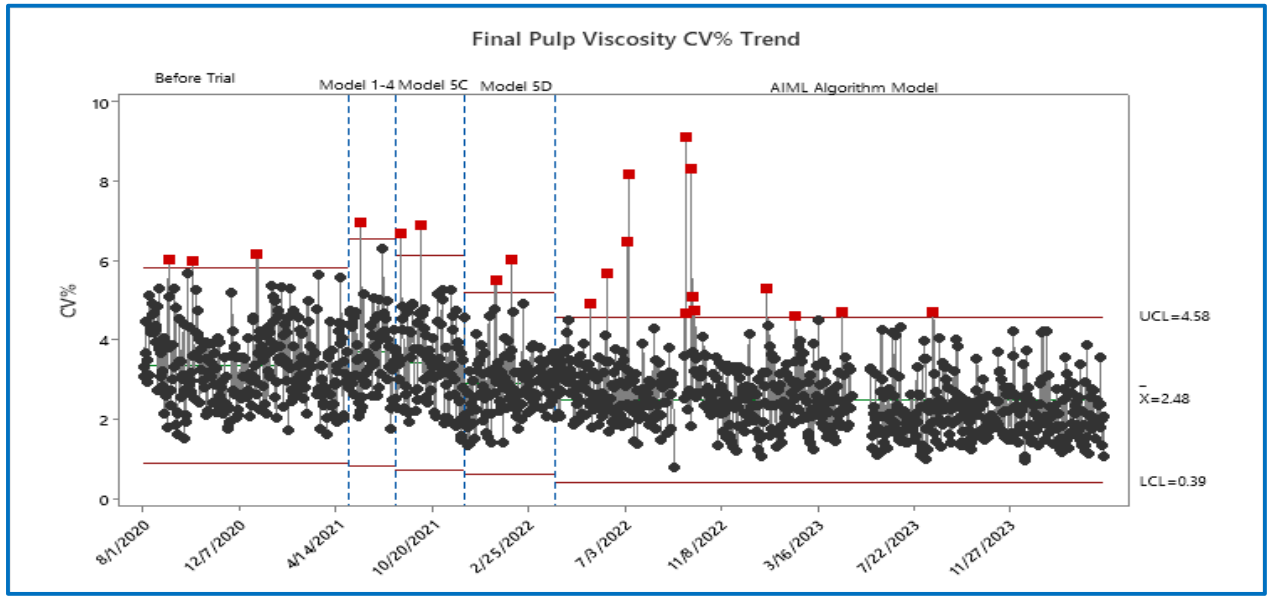
- Based on the degree of importance last two hours pre & post hypo stage viscosity and final pulp viscosity targe.
- Model output observed for one month in offline and after ascertaining reliable suggested hypo dosage deployed for plant scale.

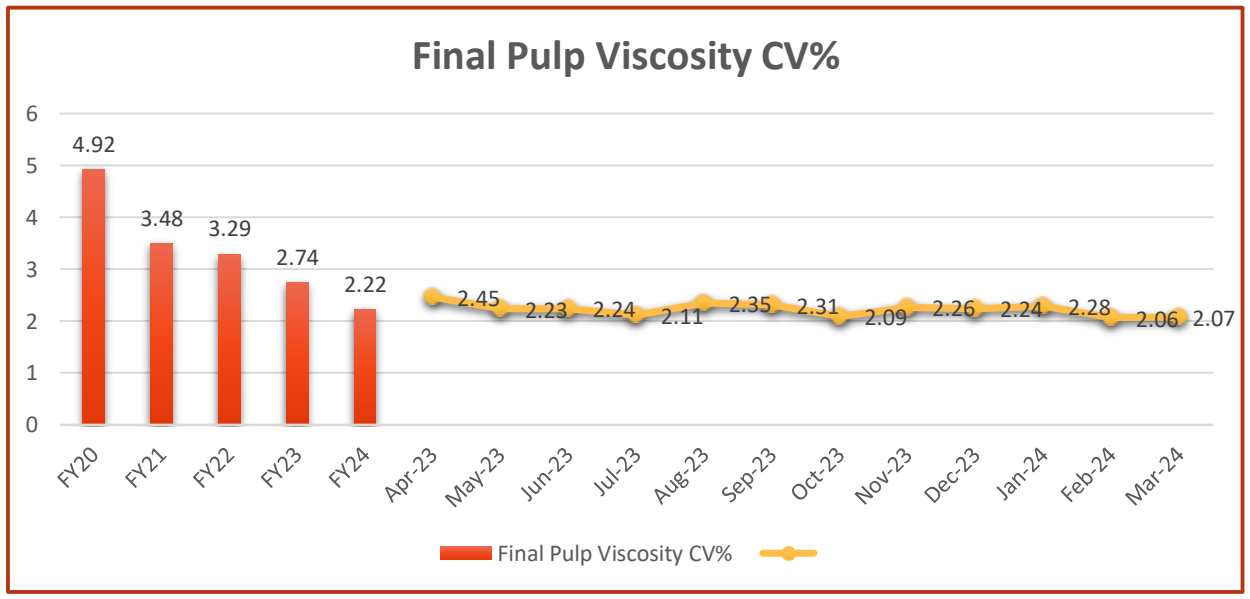
Impact / Benefit for the Pulp Plant

- ✓ Hypo pulp viscosity CV% reduced from 7.0 % to 4.3 %
- ✓ Final pulp viscosity CV% reduced from 4.9 % to 2.2 %

Year	FY20	FY21	FY22	FY23	FY24
CV%	Before	In-house Model		AIML Model	
	4.92	3.48	3.29	2.74	2.22

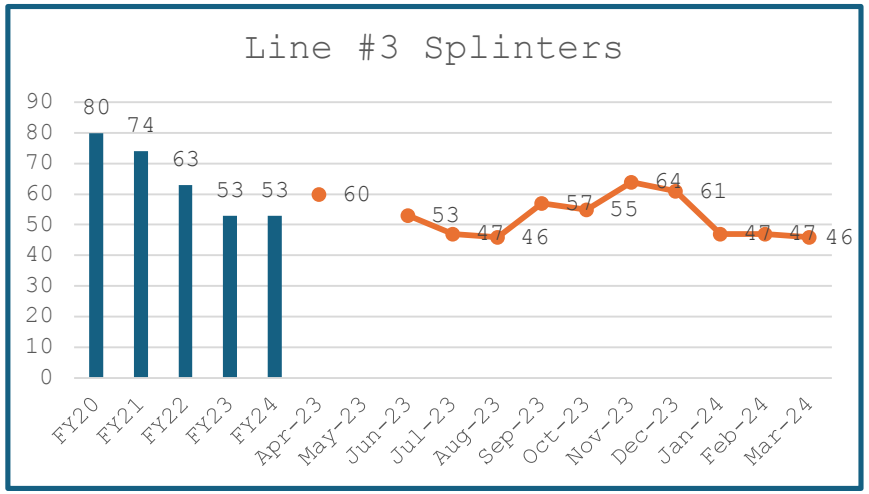


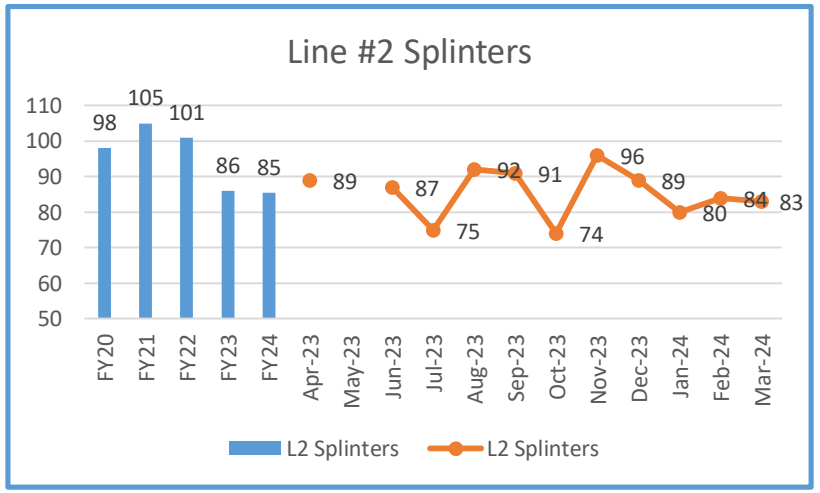


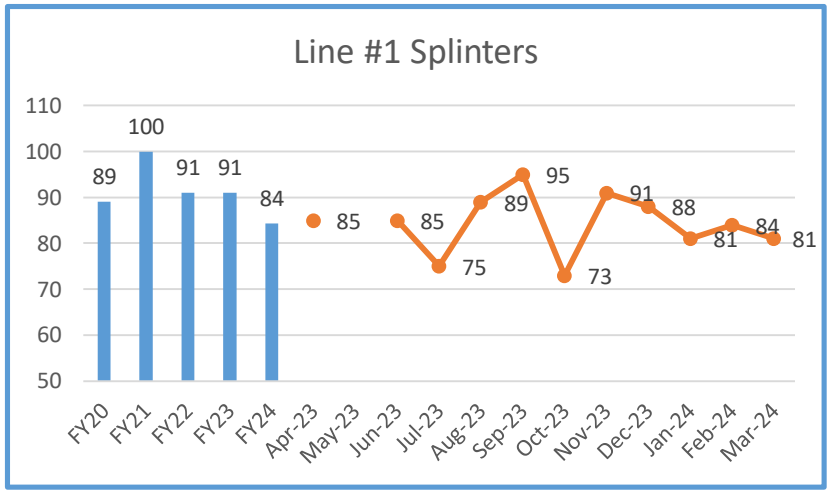


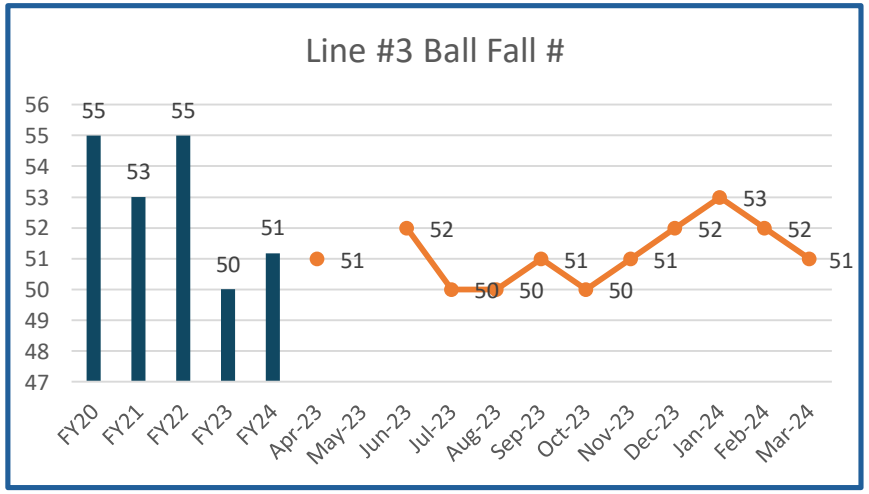
Impact / Benefit for the Customer (Fibre Plant)

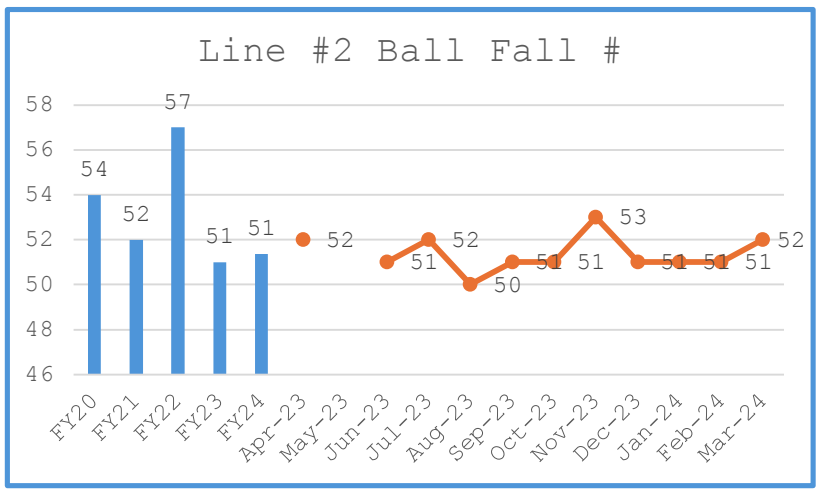
- ✓ Reduced Ball Fall variation.
- ✓ Reduction in Filtration delay.
- ✓ Reduction in Machine splinter.
- ✓ Improved sustainable plant operations.

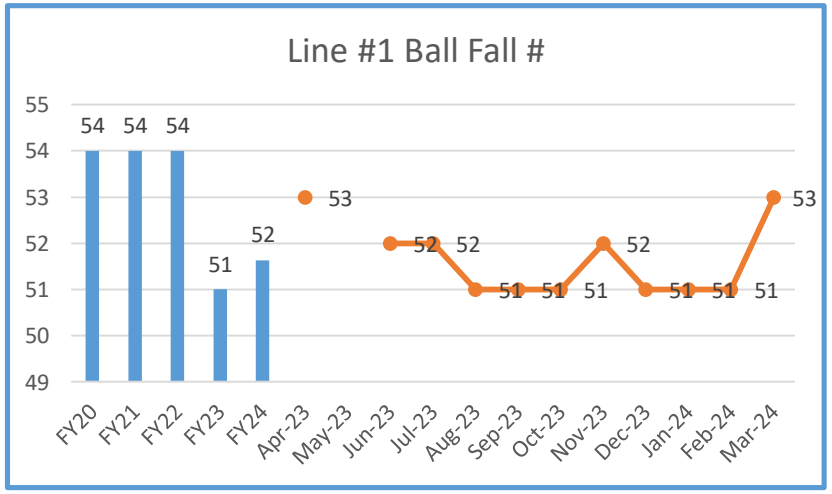








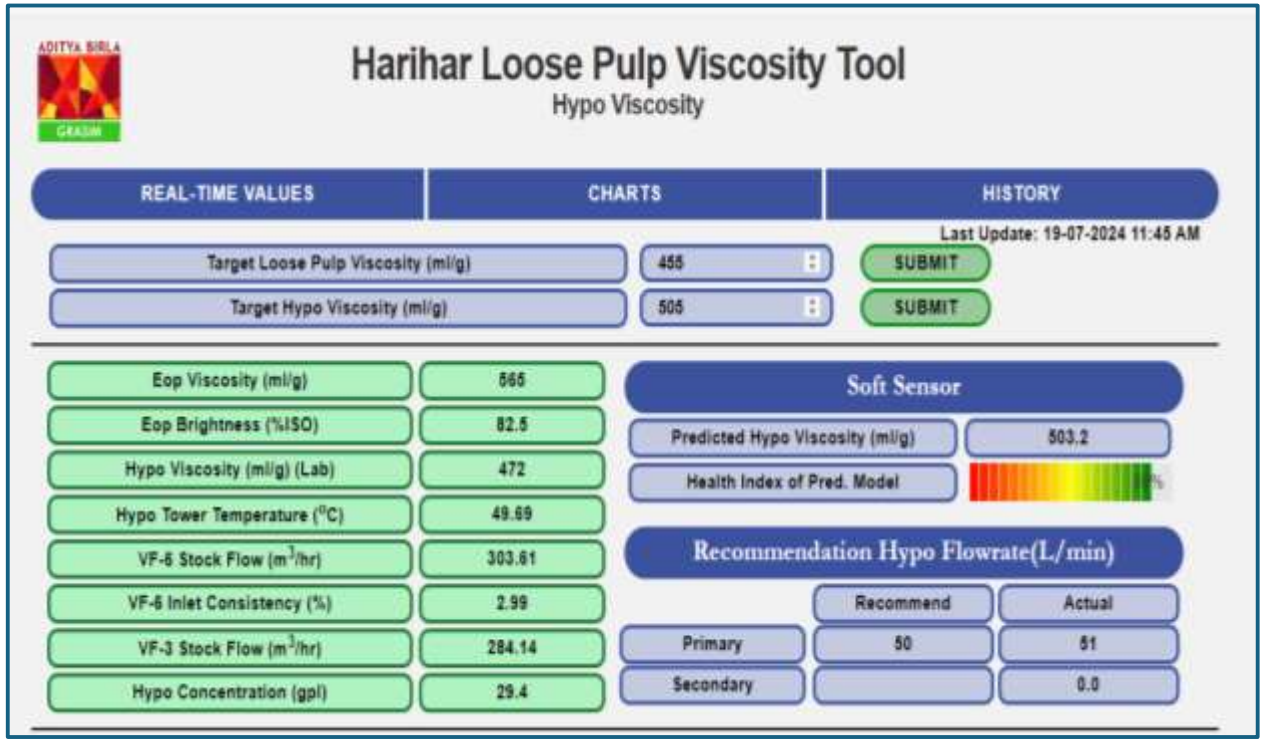




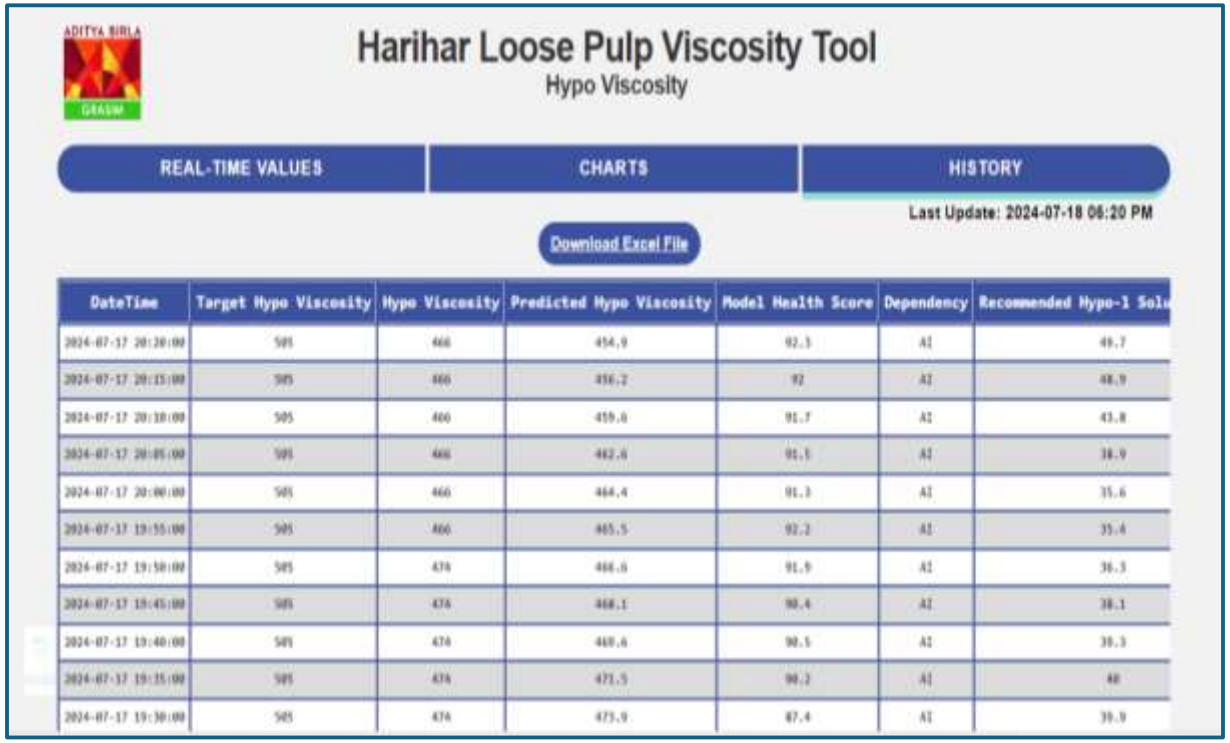
Sustainability & Replicability

With encouraging results, continuous improvement and eliminating the human interruption, developed software by integrating with SAP data and PI historian.

Results achieved with inhouse statistical algorithm generated using MINITAB and with collaborative R&D project with PFIC & AI/ML developer (Invested Rs. 24.0 lacs)



Presently every 15 min data get refreshed automatically and suggest the hypo dosage addition.



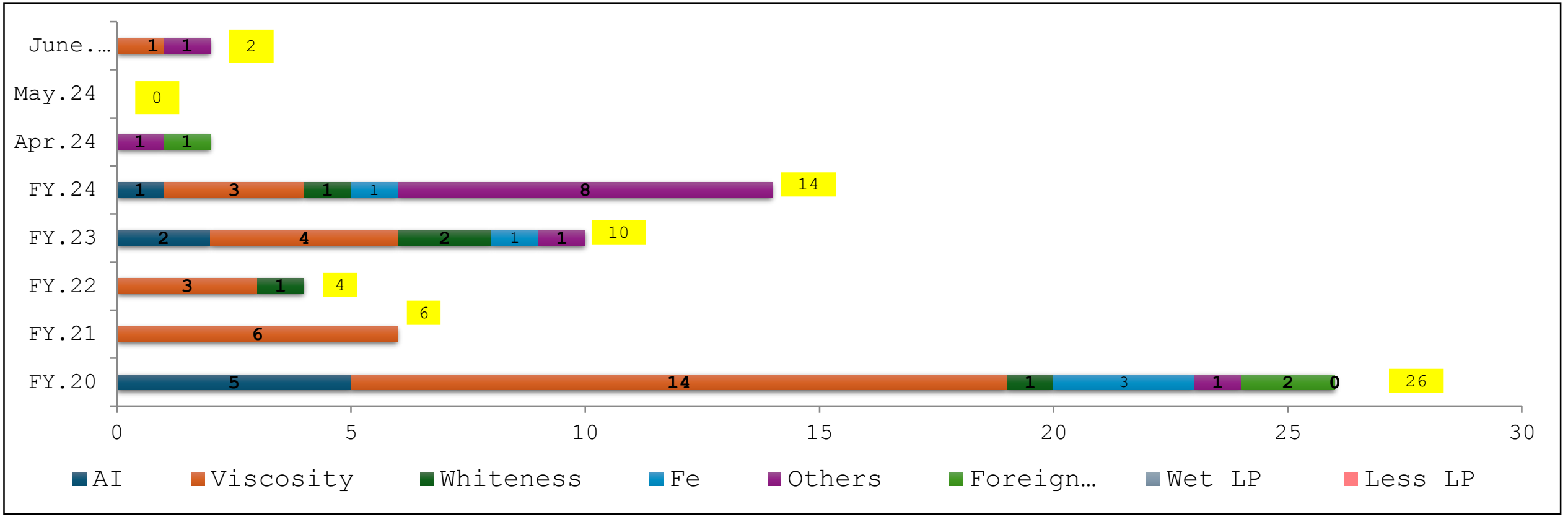
History report can be generated in Excel, Doc and pdf format.

Key Learnings

- In Hypo stage, biggest variable driving the delta in viscosity is due time lag effect.
- Combining time series modeling with AI modeling with solving partial dependence equations also led us to the insight of viscosity variation.
- RG pulp viscosity comes after 3-4 hours of lag and is an impact of all previous additions - hence changing hypo flow rate from latest RG pulp viscosity will lead to process imbalance.
- Viscosity in post hypo stage is seen to follow a curve of natural decay - with inlet viscosity in hypo stage the most important driver.
- AI/ML Model applicability in process control helps to improve product / process quality and cost optimization.

Results

Finance	
CAPEX deployed	Rs. 24.0 lacs (0.29 Mn USD)
Customer	
Reduction in Customer Complaints	**14** No to **3** No per year w.r.t viscosity
Value delivered for customer	Yes, with less variation in pulp viscosity



Way Forward

- Hourly auto updation of recommended Hypo dosage in DCS via AIML model.
- Replication of AIML model to Do and D1 stage to control brightness of pulp.

Thank You