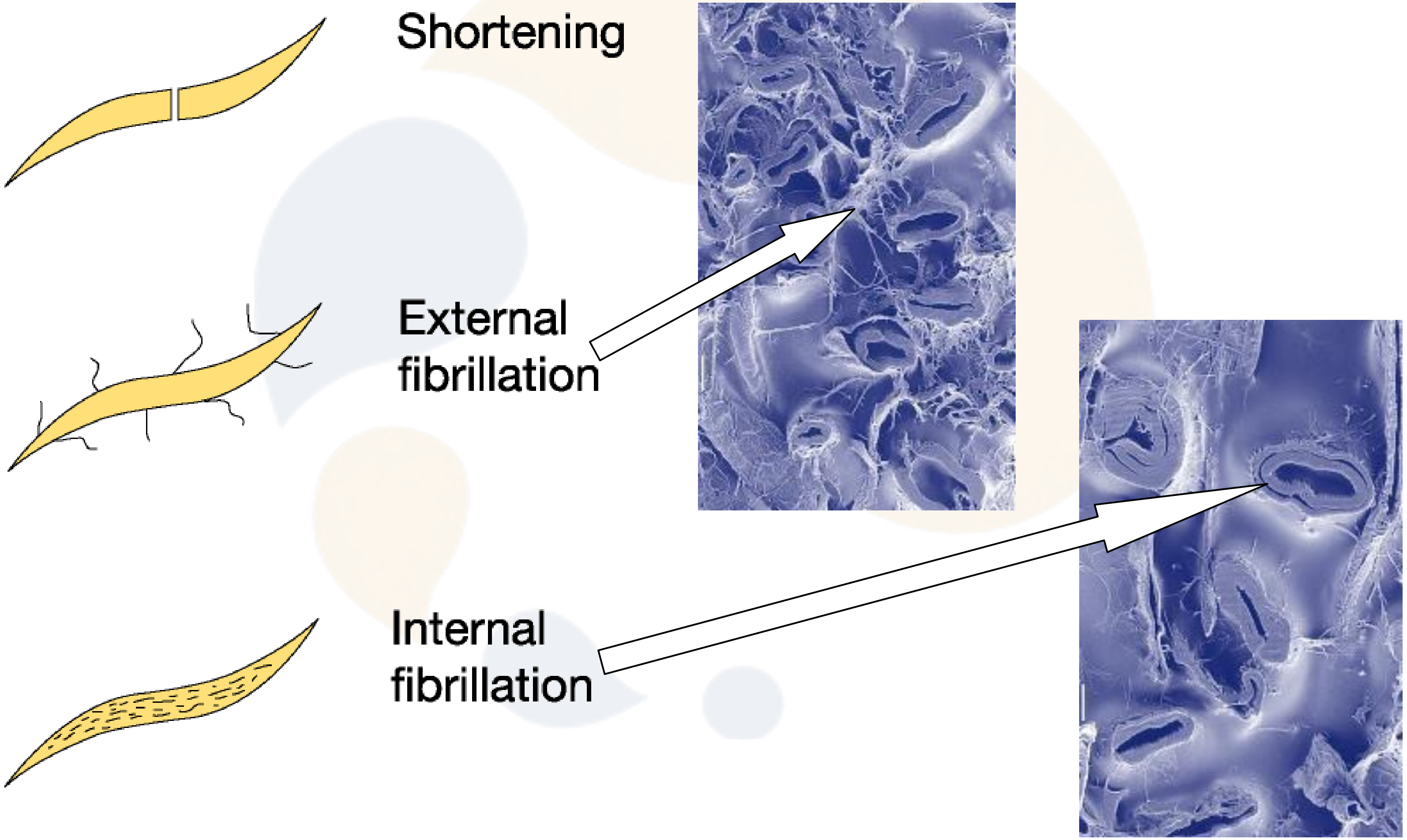
Indian Pulp & Paper Technical Association

Refiner Automation

About this Webinar

- Refiner Operations are single-most important within the Paper Industry
- Internal environment not visible to operator
- Most Energy consuming
- AI-based automation can make it a managed-operation.

Effects of Refining



Objective of Refining Automation

- **Consistent Freeness** - thereby improvement in properties and runnability
- **Energy** – Imparting appropriate energy for fibrillation, savings in power
- Optimizing **Tackles life**

Goal of Refiner Management Suite#

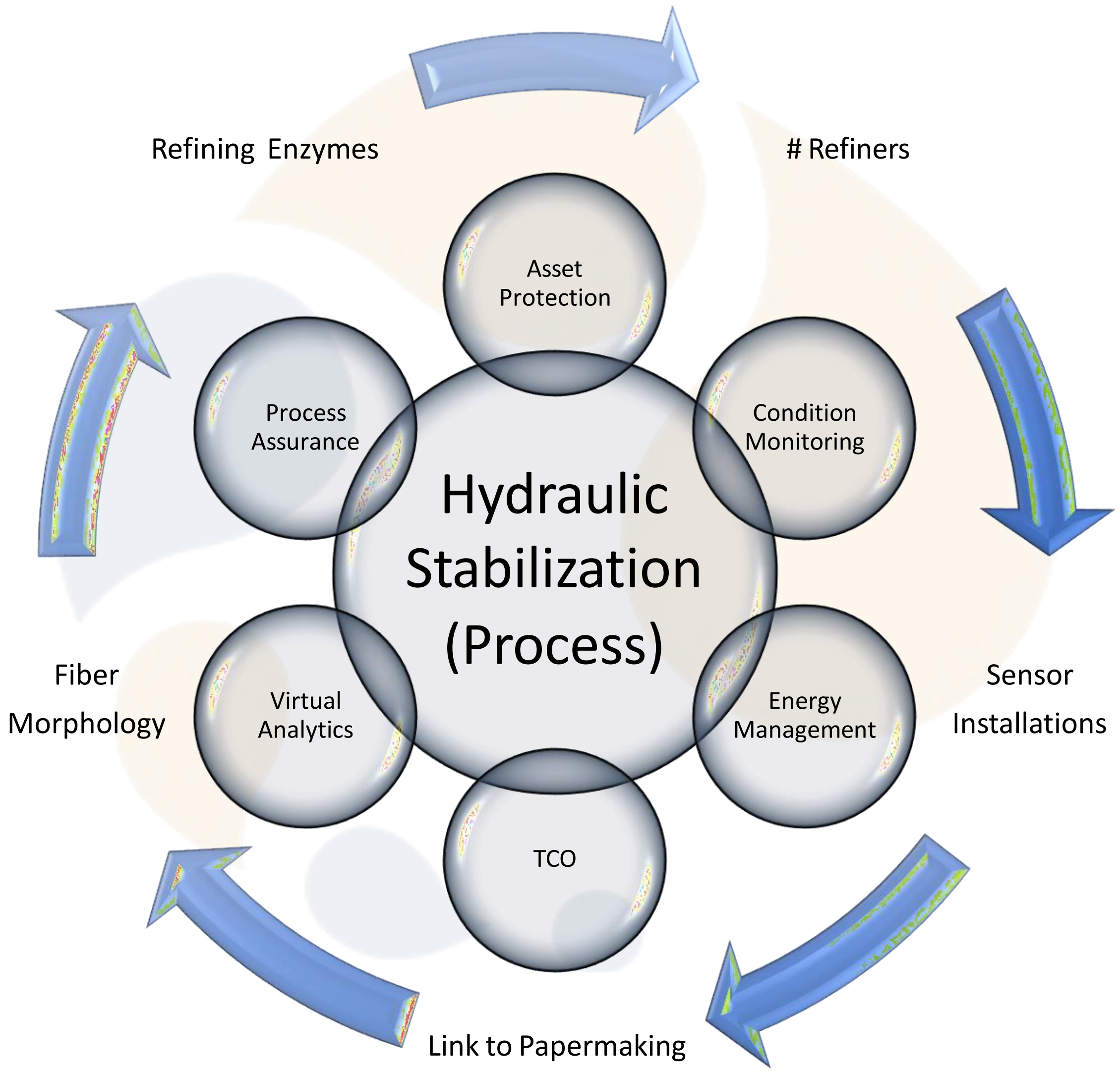
Critical Dependency on

- Consistent feed to refiner [Flow * Cy% & Recirculation%]
- Differential pressure across the refiner [Inlet Pr. And Outlet Pr.]
- <u>Energy imparted into the fibre.</u>

- *Current manual evaluation of freeness 2x/shift is insufficient.*

Consistent Freeness = Consistent Paper Strength

HABER Refiner Management Suite#



Approach to Refiner Management Suite#

Process Stabilization

Control Flow, Cy%, Pressure, Recirculation

Influencers

Pulp pH,
Viscosity and Pulp Strength

Energy Optimization

Evaluate optimum Energy required (SEC)

Measure

Frequent testing of Freeness

Inter-relationships

Property	Event	Relation	Result
Flow Vs Pressure	Low Flow → High Flow	a	High Pressure → Low Pressure
Feed pH	Fibrillation	a	Improves with increasing pH
Feed Consistency, %	Lower Consistency		Uniform SEC, Segment wear, Catastrophic failure (Lower Cy is risk!)
Temperature – Feed / Delivery	No proof of impact. (Impact, if any, to be assessed.	1/ a	Impacts surface tension & viscosity of pulp and fibre strength
	Higher Temperature	a	Metal to Metal Friction Higher Freeness
Freeness	Low → High	a	SEC, SEL and Power Input
Gap Measurement	High	a	Insufficient Freeness development, High SEC, High SEL, Manual Loading of Movable Rotor
	Low	a	Fines generation (impacts freeness) Segment wear
Differential Pressure	Too Low	a	Higher Specific Energy Vs Freeness
	Too High	a	Low throughput, fines generation

Wholesome Approach

Monitor, Flag Input Variables

- Take Consistency Transmitter, Flow, Inlet and Outlet Pressure signals
- Take Power signal for Sp. Energy consumption

Track Segment Life Real-time

- Unique approach required – Direct measurement of gap
- Traditional Gap Sensors are available

Maintenance Aspects

- Bearing conditions
- Motor conditions

Process Control

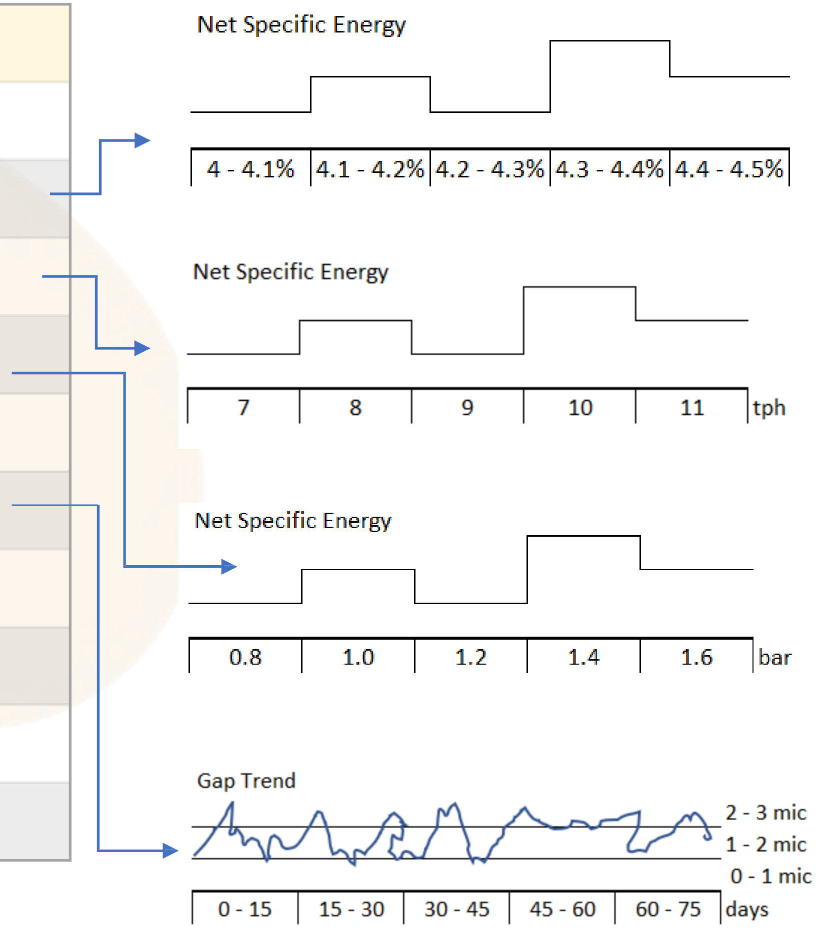
- Online Freeness measurement
- Optional Fibre image analysis

Monitoring Parameters

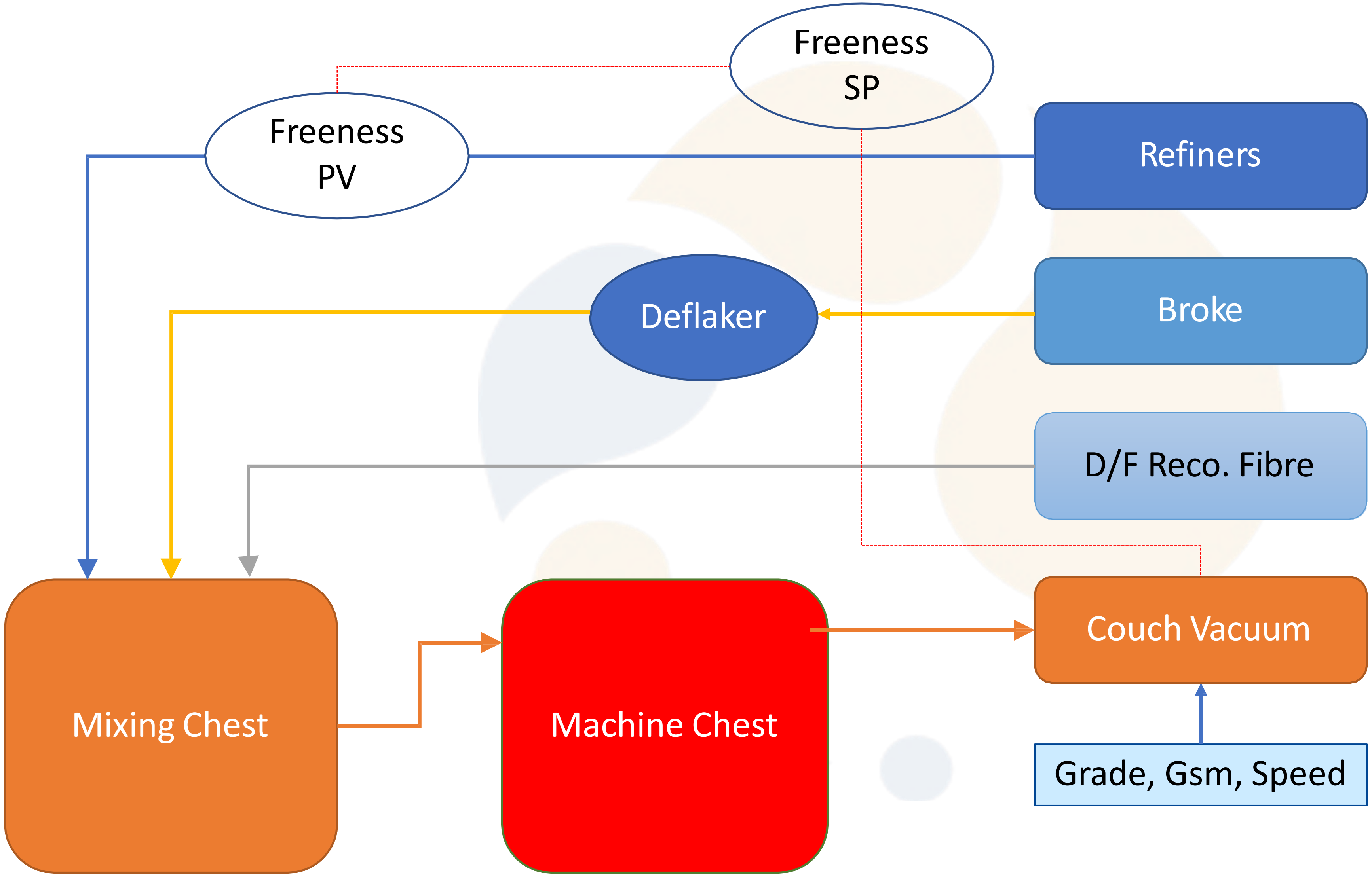
Process Assurance	Energy Management	Data from DCS / Wet End eLIXA
Online Freeness Analyzer (Common)	Loading Motor	Wet End pH
Feed pH	Proximity Sensor	Freeness after Mixing/Machine Chest
Feed Consistency	Gap Sensors – 2	Machine Throughput
Feed Flow	Motor Power	Machine Speed
Feed / Delivery Pressures	Motor Amperage	Grade / gsm
Feed / Delivery Temperatures	No Load power (Calculated / Supplier specified)	Furnish Mix
	Specific Edge Load (Calculated / Supplier specified)	Type of Filler / Filler Loading
	Condition Monitoring	Sheet Ash
	Vibration sensors (4# per refiner)	Wet Strength chemical Flow rate
	Refiner Status (On/Off)	Dry Strength chemical Flow rate

Virtual Analytics – Process Assurance

Comparisons must be made for same furnish over segment life
Freeness within target bandwidth (benefits of more data points)
Identify best consistency range
Identify best throughput range
Identify best back pressure point
Freeness rise Vs Net specific energy
Differential Pressure Vs Segment Life
Gap Vs Segment Life trend
SEC Vs Segment Life trend
Extension of Segment Life per Refiner
Operational Costs Savings



Algorithm to relate Machine Operations



Currently Refiner Power is adjusted based on Couch Vacuum.

Couch Vacuum is *a* refined pulp freeness, Broke freeness and Reco. Fiber freeness. Broke if deflaked, will also alter freeness.

Initially we propose to analyse relation of couch vacuum to relation between these and evolve a model.

Paper Properties (offline data)

Analyze	Test Data	Data Generation	Data Frequency	Compare with	Inference
Paper Properties for Individual Grade-gsm	Burst Factor	Once Per Roll	X Rolls / Day (6X data points per day)	Freeness Trend	Optimum Freeness to achieve desired properties or affectation.
	Tear Factor				
	Breaking Length MD				
	Breaking Length CD			Viscosity Trend	Optimum Viscosity to achieve desired properties or affectation
	Porosity			Pulp Strength	Optimum Strength to achieve desired properties
	Moisture%				

Offline data to be uploaded or entered into eLIXA

By Application

- Pulping Refiners
- Stock Preparation
- Approach Flow

Quality Impact on End Product

Furnish Homogeneity / Heterogeneity

Fibre development

By Position

- Standalone
- In Parallel
- In Series

Flow Distribution

Freeness Rise

Loading Distribution

Importance of flow

Proper flow (together with proper segment design) is required for,	
Stable and Centred Rotor	
Increasing probability of fibre mat formation, maximizing fiber strength and development potential	
Maximizing plate life potential	
Symptoms of Low Flow	**Symptoms of High Flow**
Little or no fibre mat between plates	Inability to optimize plate design for maximum strength development
Fibre channelling	Short plate life
High Pressure rise (25 – 50 psi)	Pressure drop
Plate clashing	Motors maxed out
Short plate life	
Inefficient refining (power vs fiber development)	
Poor strength development	
Increased fines generation	

Importance of Consistency

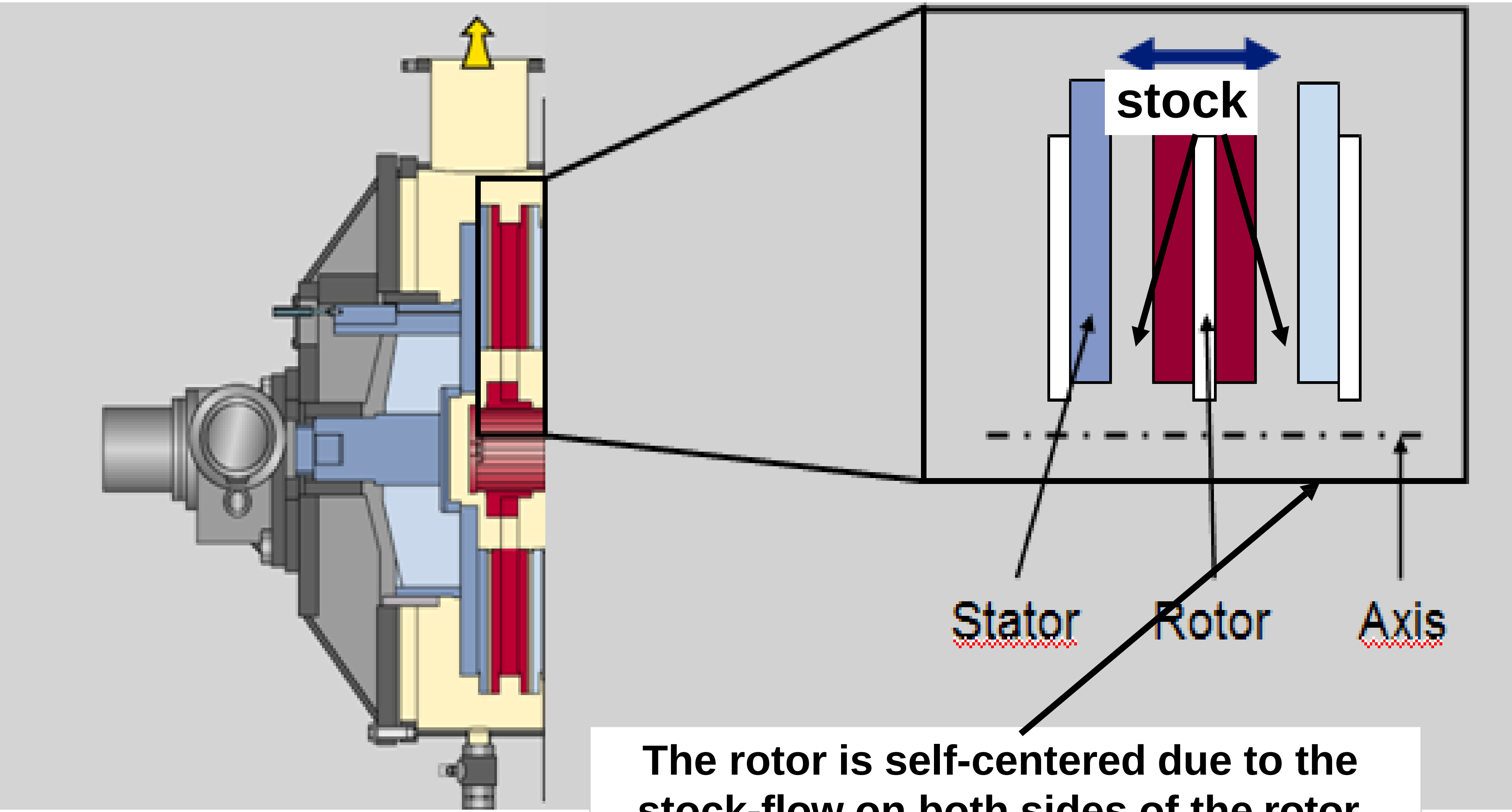
Refining requires getting the fibres onto the bar edge in order to be refined. Optimum fibre consistency maximizes the probability of getting the stock onto the bar edge. Impacts in the same way as hydraulic conditions.

Low Consistency	High Consistency
Little to no fiber mat between plates	Plate plugging
Inefficient refining	Poor fibre development
Poor refiner development	
Fibre cutting	
Plate crashing	
Short plate life	

Common Incidence

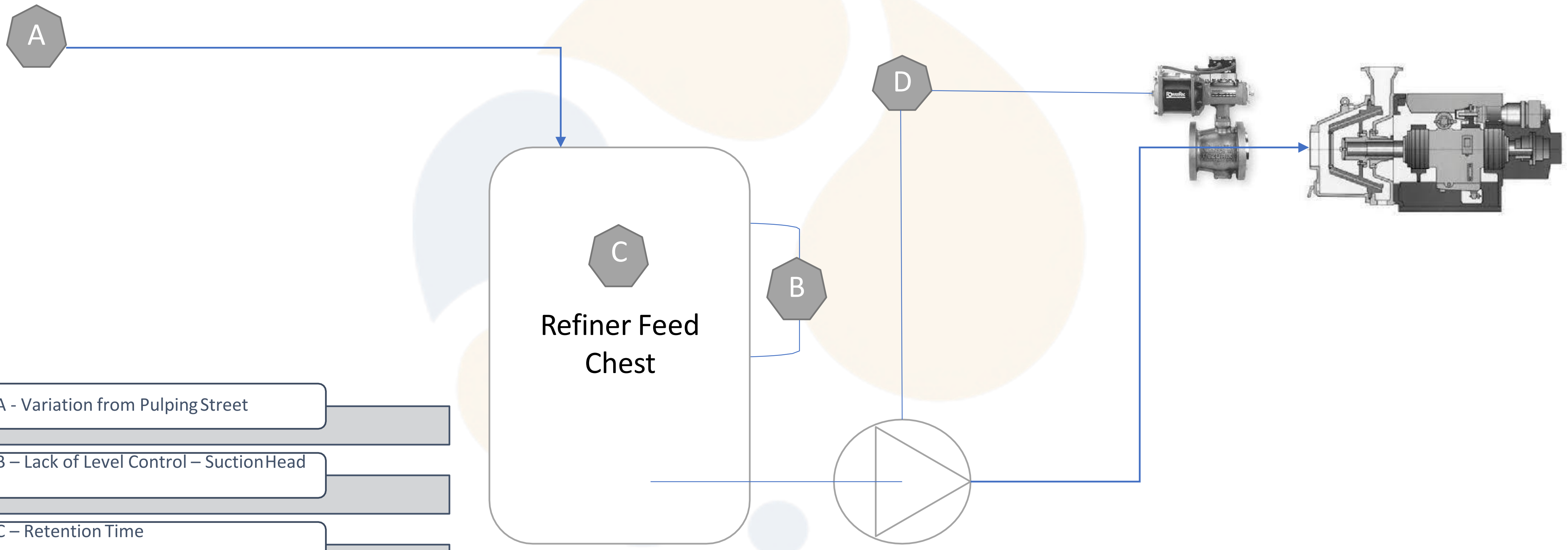
- Hydraulic balance of Rotor
- Uneven Plate wear

	Optimum Consistency
Unbleached Softwood Kraft	3.5% – 4.5%
Bleached Softwood Kraft	3.5% – 5.0%
Bleached HW / Eucalyptus Kraft	4.0% – 6.0%



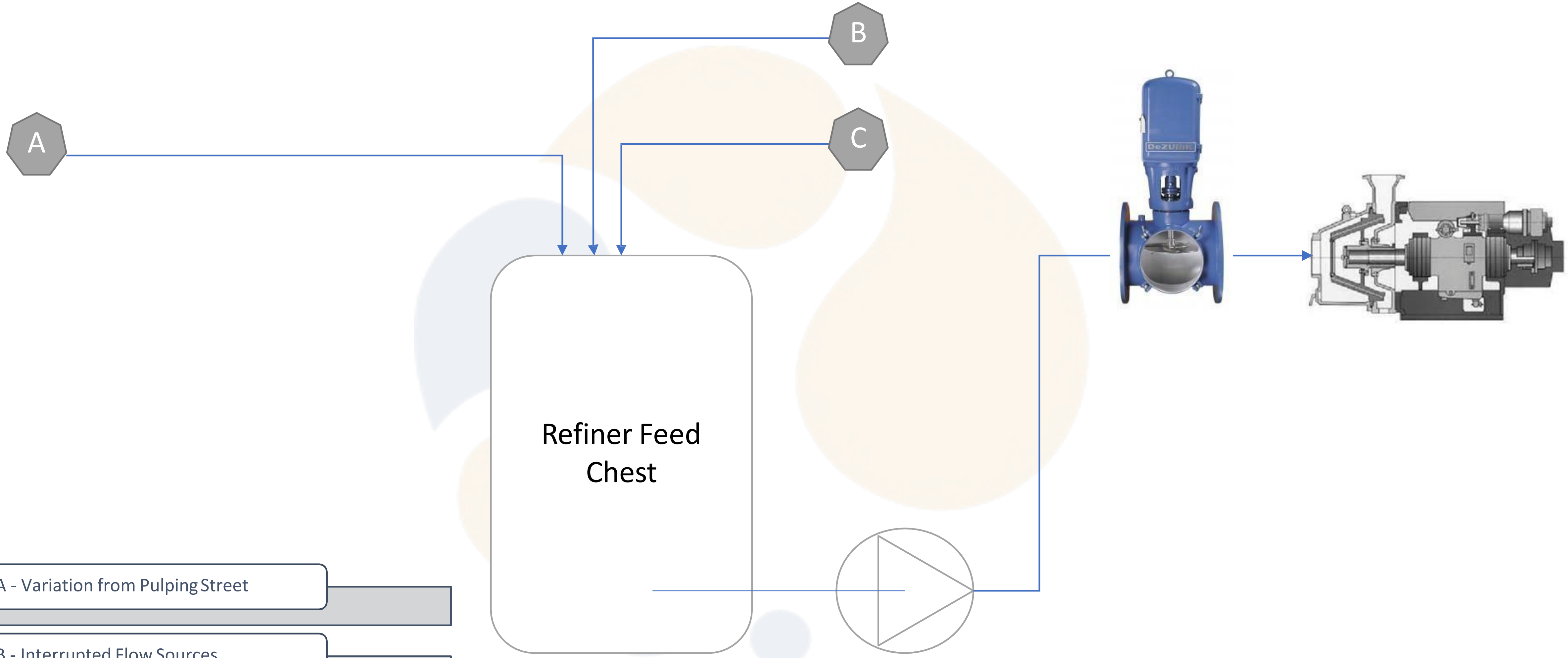
The rotor is self-centered due to the stock-flow on both sides of the rotor.

Root Cause for Flow Variation



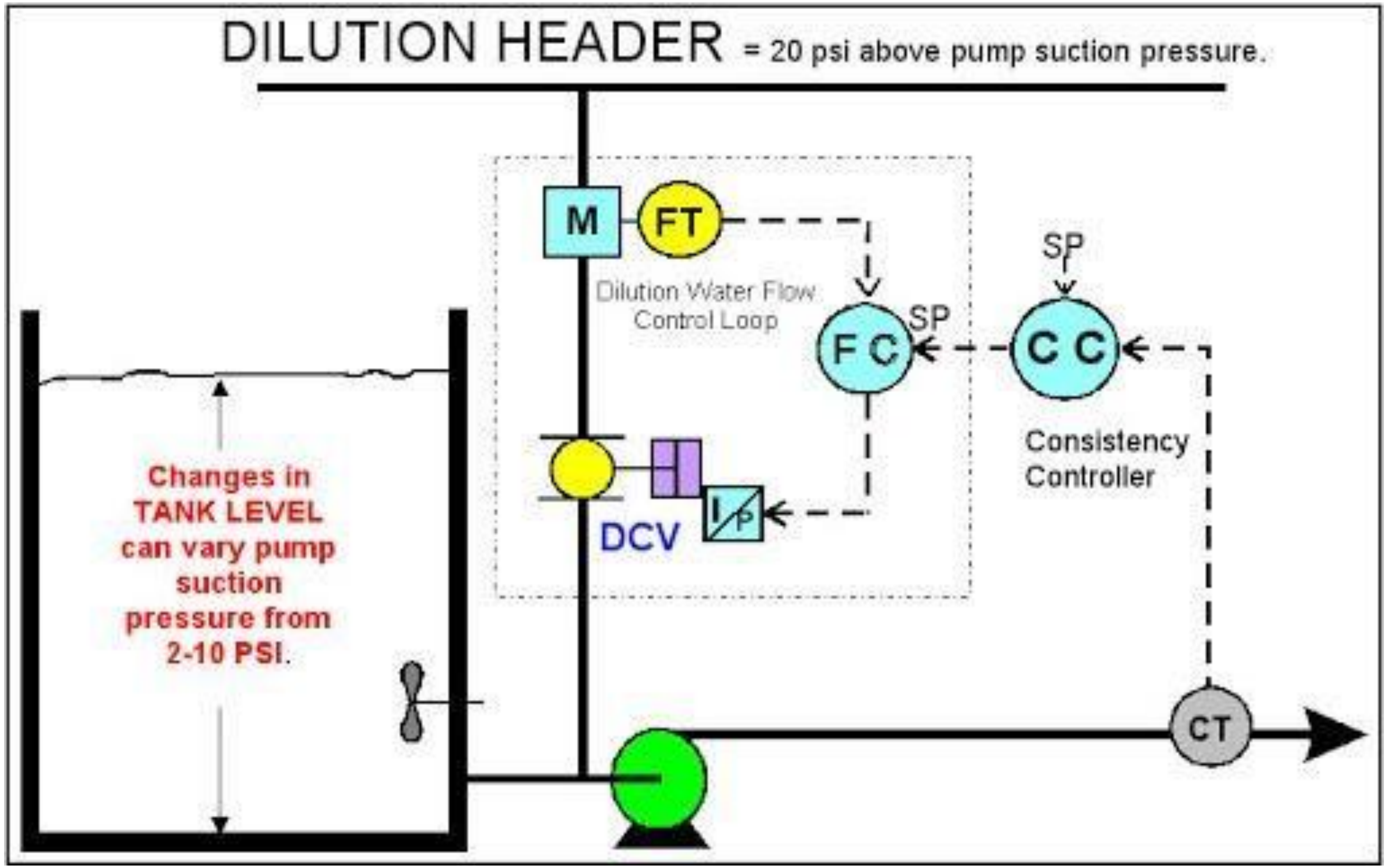
- A - Variation from Pulping Street
- B – Lack of Level Control – Suction Head
- C – Retention Time
- D – Type of FC – VFD or CV

Root Cause for Consistency Variation

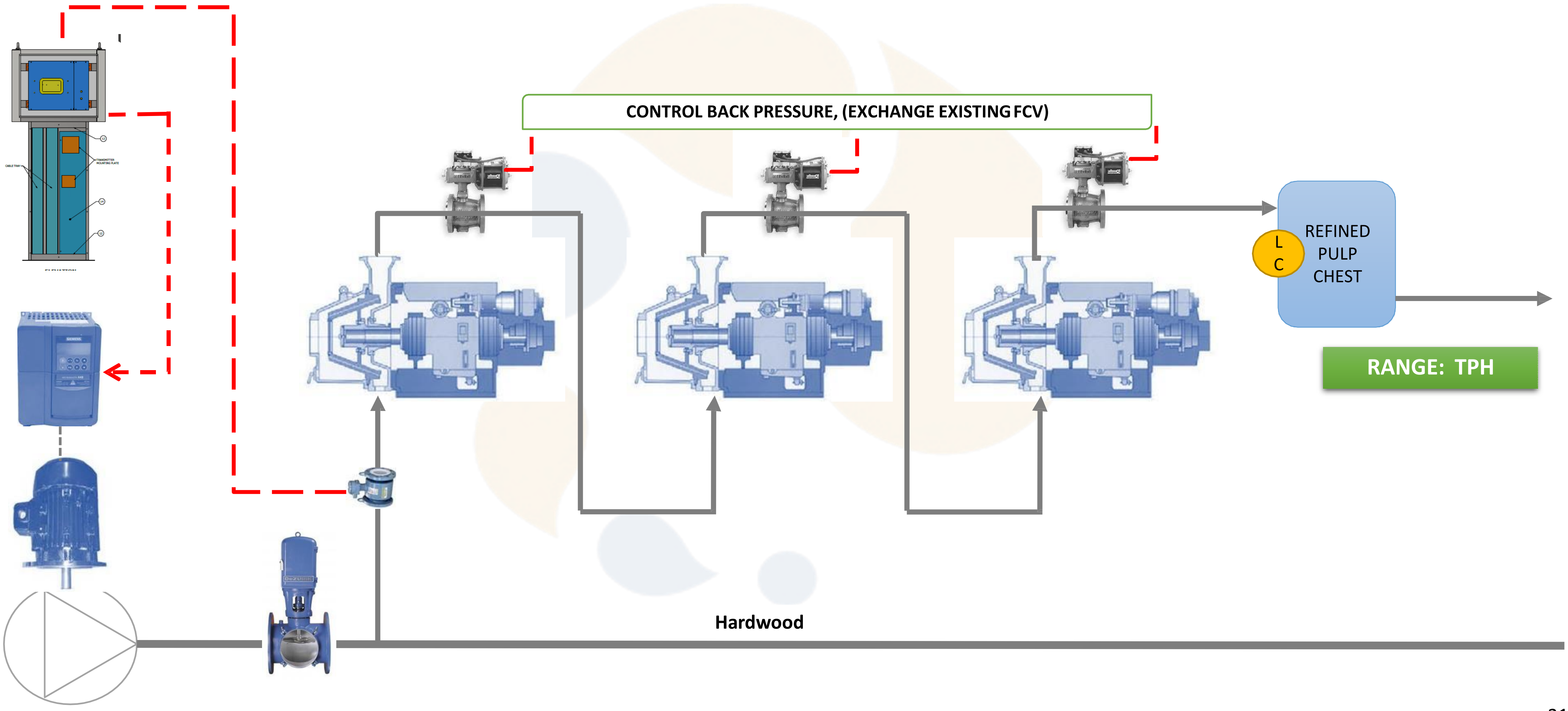


- A - Variation from Pulping Street
- B - Interrupted Flow Sources
- C – Unpredictable Flow Sources

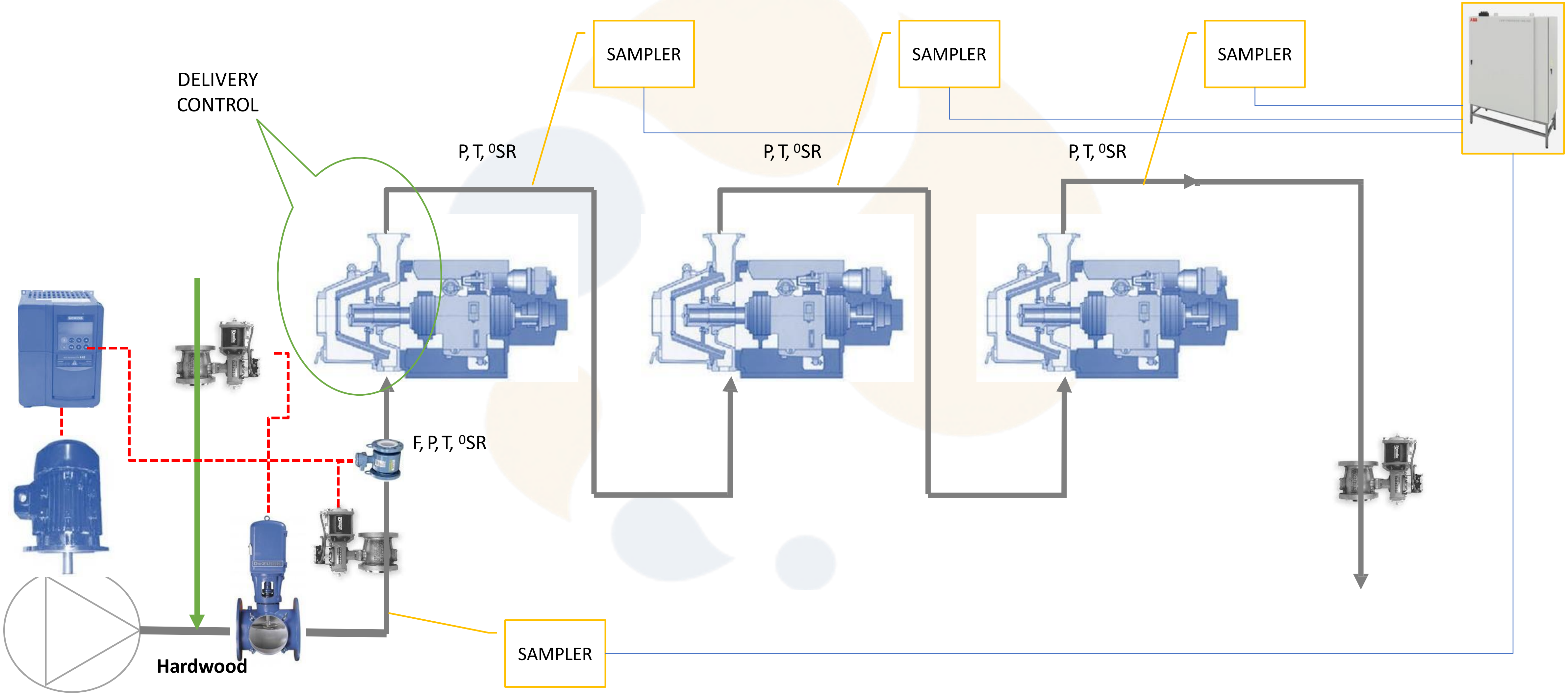
Ideal Flow / Consistency Control



Typical set-up

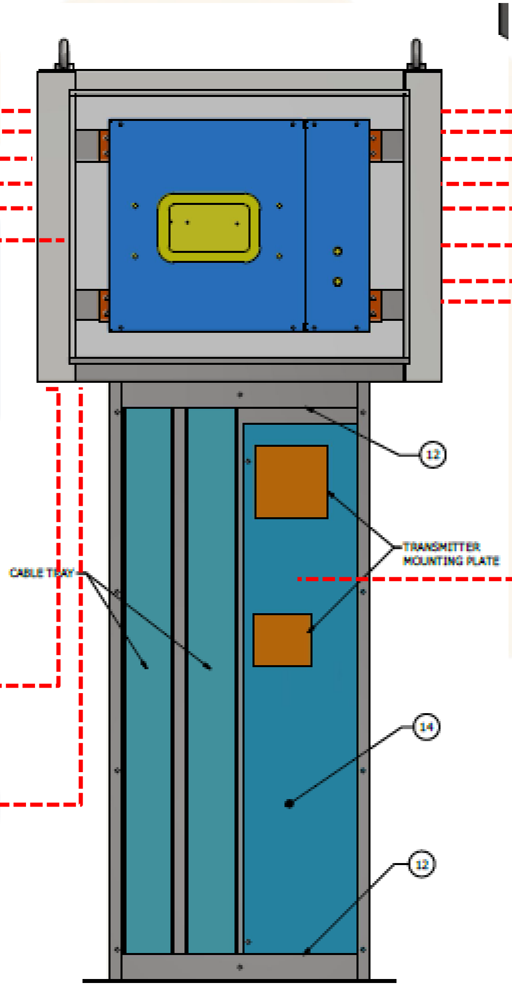


Freeness Analyser sampling



Data Connections

- Receiving Chest Level
- Refined Pulp Chest Level
- Cy. Transmitter @ Feed
- Dilution water for Feed Cy.
- Pressure Control Valve @ Feed
- Flow Transmitter @ Receiving Chest
- Flow Control Valve @ Mixing Chest Inlet
- Flow Transmitter @ Mixing Chest Outlet
- Furnish Mix from DCS (max of 3 signals)



- Freeness @ Feed
- Freeness @ R1 Outlet
- Freeness @ R2 Outlet
- Freeness @ R3 Outlet
- Temp. @ Feed
- Temp. @ R1 Outlet
- Temp. @ R2 Outlet
- Temp. @ R3 Outlet
- pH @ Feed

Eg: No. of refiners = 3#

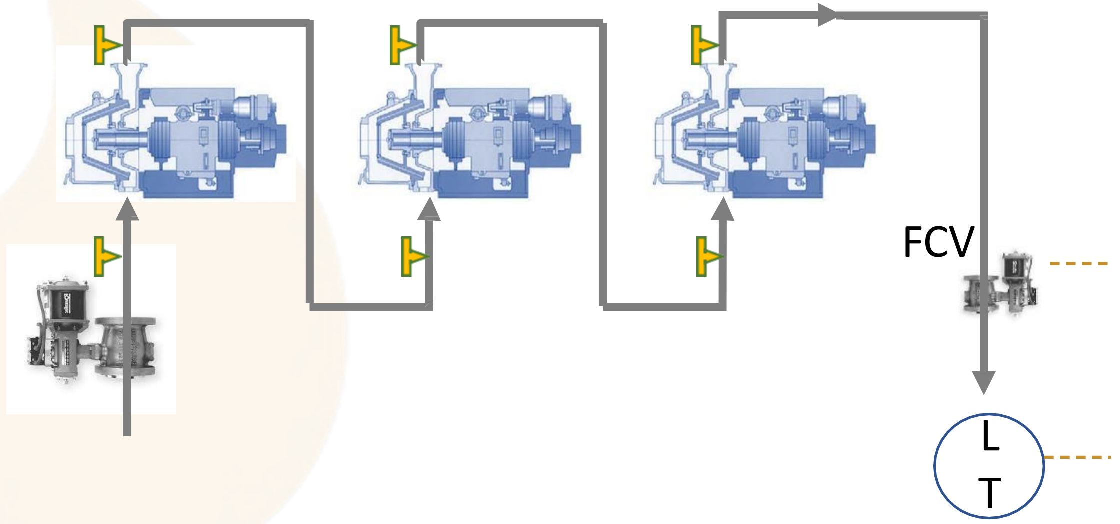
Major change in control concepts

We need to propose major changes in control concepts in order to get better control of refiners.

1. A last mile pH control system (Q: Are different grades made at different pH?)
2. FCV present in Outlet to be interchanged with PCV at Inlet. Flow control to be based on Flow at Inlet and VFD.
3. The PCV at Inlet can be installed at the outlet of refiner to control the Differential Pressure.
4. Recirculation line must be connected back in short loop. We advise 10% - 12% minimum. This should be automated.
5. LT at Refiner outlet must directly control the flow through VFD, and not restrict valve

Ills of Flow control based on LT at Receiving Chest

1. Assume certain Feed pump rpm, Flow, Pressure and Cy%.
2. Inlet Pressure to R1 is controlled via PCV, R1 develops certain pressure at Outlet.
3. R2 Inlet Pressure is [R1 Outlet Pr. – friction loss]
4. R2 Develops its own Outlet pressure.
5. R3 Inlet pressure is [R2 Outlet Pr. – friction loss].
6. When LT is near target, FCV closes.
7. This initially will increase pressure on R3 Outlet. This will reduce the DP in R3.
8. Reverse would happen when LT is away from target.



Note: Hence R3 would face a reduction in Differential pressure due to which segments would experience higher throughput resistance and stress if Energy is not reduced.

Energy Input - Calculations / Controls

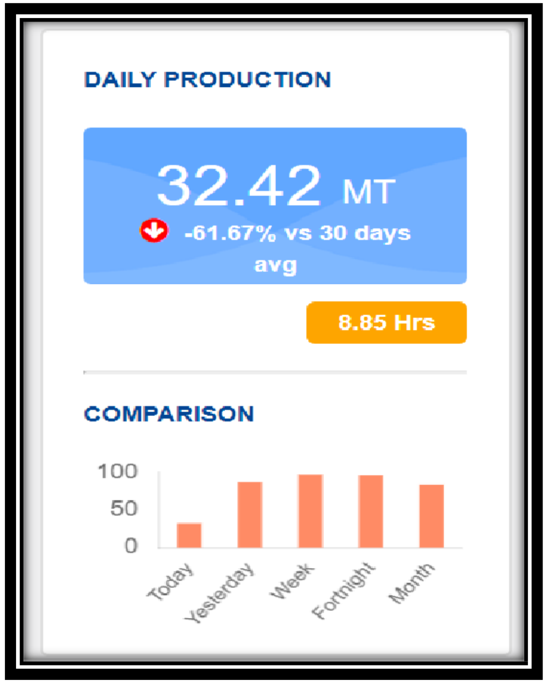
Throughput [TPH]	Flow x Consistency (m^3/hr * %)
DP development [bar]	Loading Motor Loading Engage
DP variation [bar]	Check flow variation (short-term), segment wear (long-term) – m^3/hr
Position Sensor	Compare with DP variation
Net Specific Energy [kWH/ton]	a Throughput (TPH) a Freeness change (CSF) a Furnish Type
Net Specific Energy, [kWH/ton] = (Dampen)	(Total Applied Power, kW – **No Load, kW**) / Throughput, TPH
No Load	Provided by Supplier
No Load Calculation, [hp] =	$102 * (rpm/100)^3 \times (Dia/100)^{4.3} * [2 * Gw / (Bw + Gw)] * [Gd/4]$ All in Inches
No Load Calculation, [Kw] =	hp*0.746
Specific Edge Load, [Ws/m] =	Net Specific Energy / Bar Edge Length * [Motor Speed in rpm / 60] Bar Edge Length – Supplier
Freeness Vs Net Specific Energy = ADDITIONAL SAMPLER REQUIRED IN INLET IF THIS IS NEEDED	(Feed CSF – Outlet CSF) / Net Specific Energy

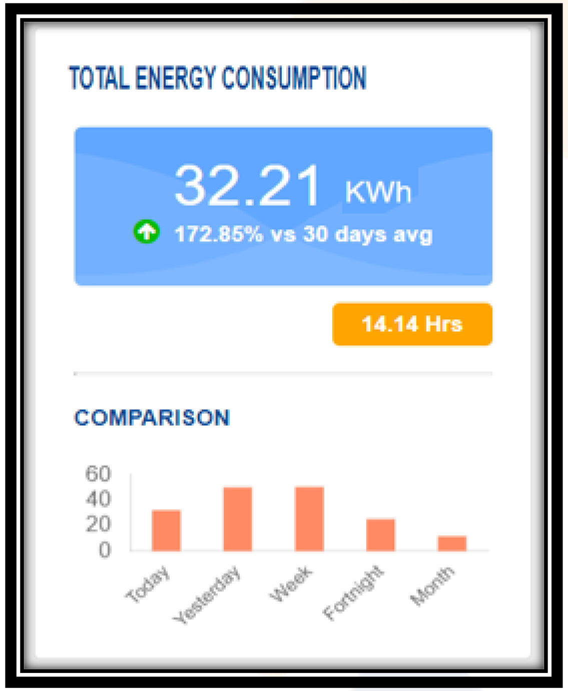
Certain amount of applied power is consumed by the hydraulic pumping effect and the energy loss associated with viscous shearing of the fluid. This is called the "no-load" or circulating power. This energy produces no measurable change in the properties of the pulp being refined

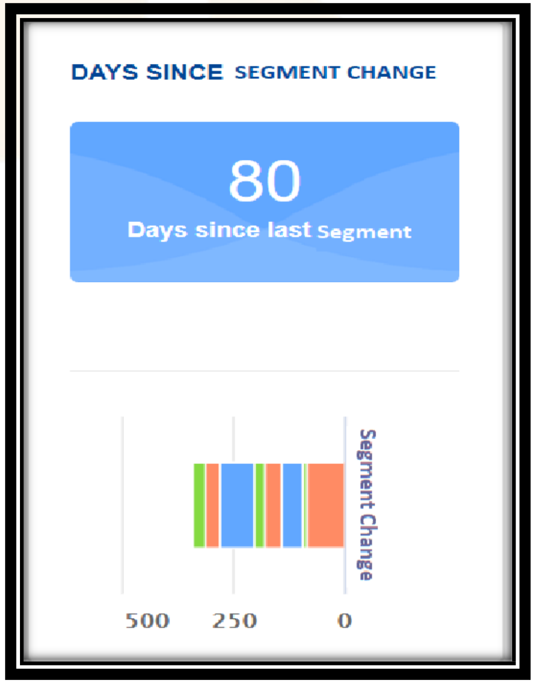
Widgets

Visibilities [per Refiner#]	Trends - Process	Trends – Condition Monitoring
Production Rate [TPH]	Freeness Vs Feed Rate	Vibration Analysis – Refiner Bearings
Recirculation % or Flow	Freeness Vs Consistency	Vibration Analysis – Motor Bearings
Refining Running hours [Hrs]	DP Vs '% Valve opening'	Vibration Analysis – Refiner Casing #
Freeness [^{0}SR]	Freeness Vs Net Specific Energy	Lube Oil Temperature ?
Power Consumption [kWH]	Gap Vs Freeness	Moisture in Oil ?
Net Specific Energy	Freeness Rise / Net Specific Energy	
Specific Edge Load	Recirculation as %	
Freeness rise / Net Specific Energy	Feed Tank Level	
Op. power cost / TCO	Refined Pulp Chest Level	
Days since the last segment change / Last Segment Change (manual feed)	Feed Rate Vs Refined Pulp Chest Draw Rate.	Days since maintenance with comment box / Refiner Maintenance History (manual feed)
Totalizer for segment change (Production / Segment)		

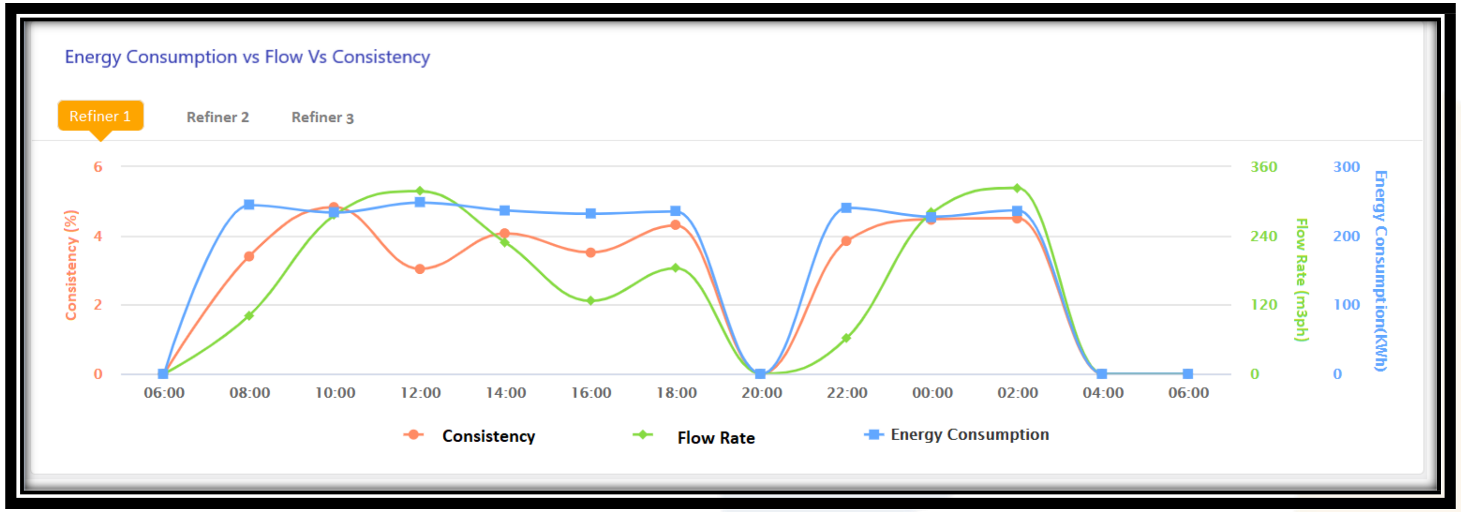
Widgets - example

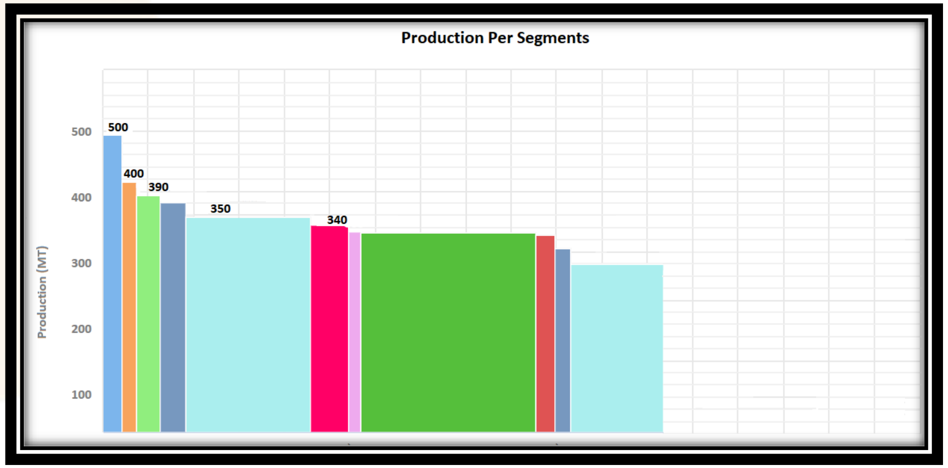


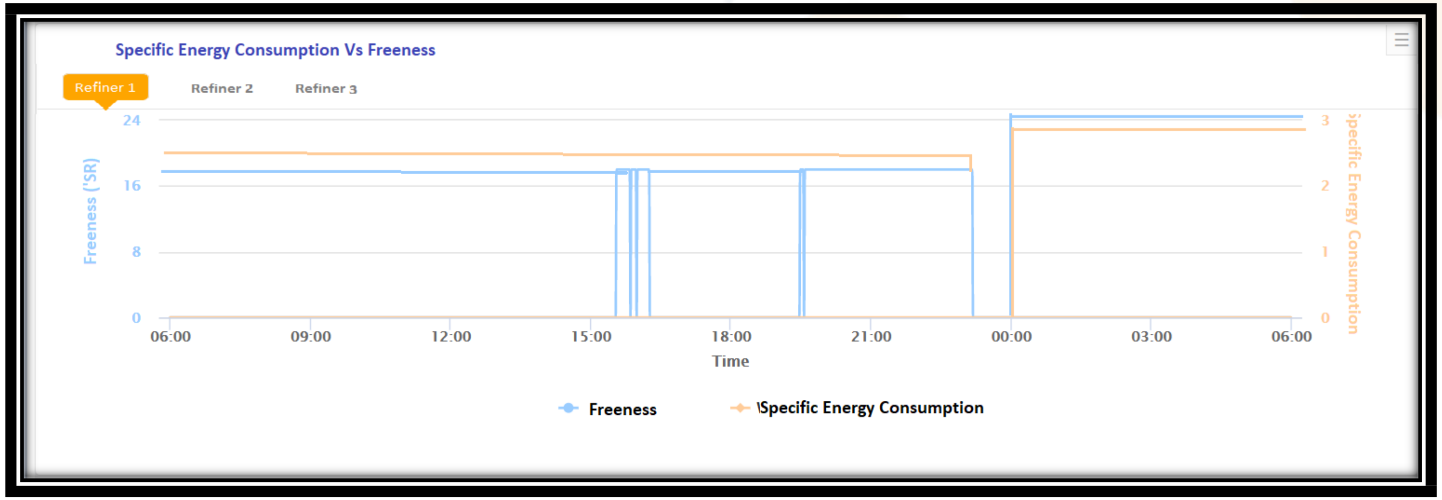




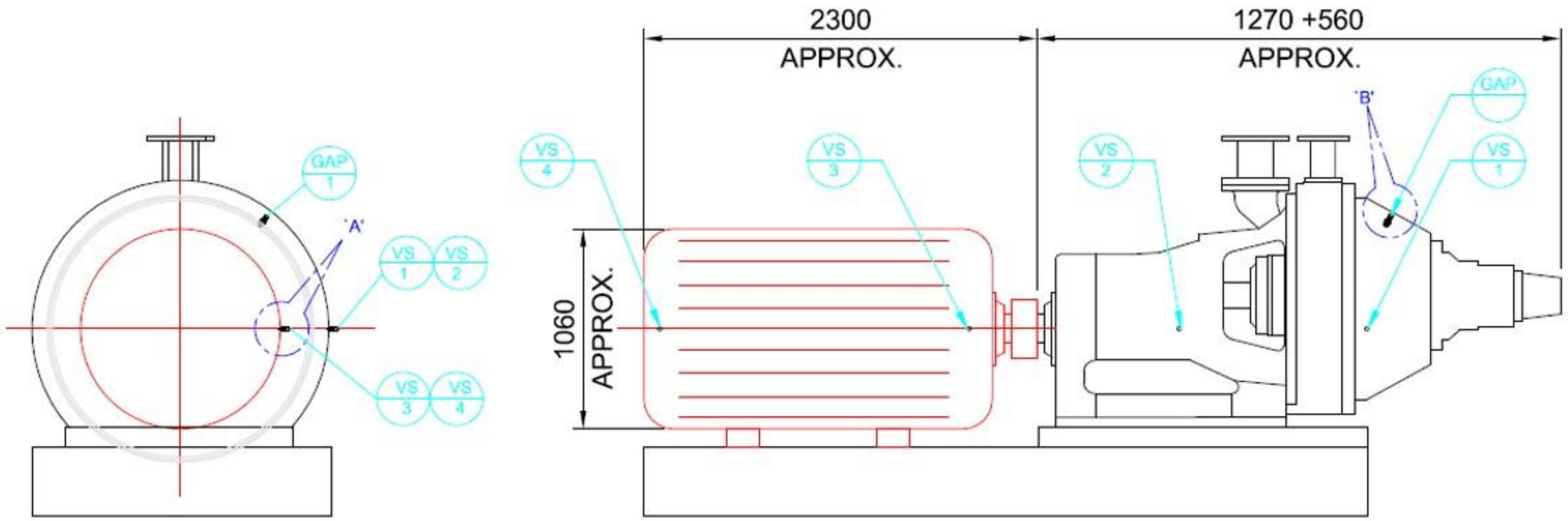
Comparative trends

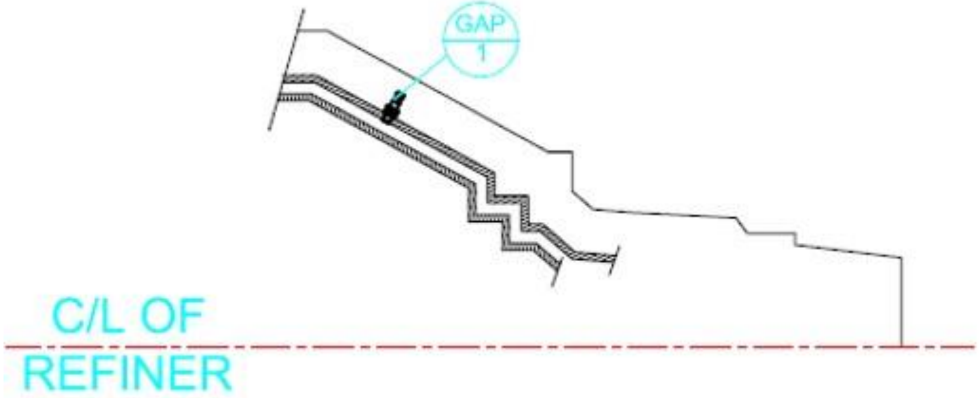




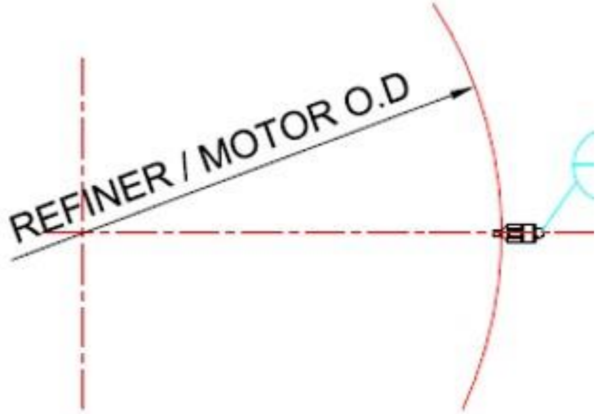


Vibration Sensor Installation



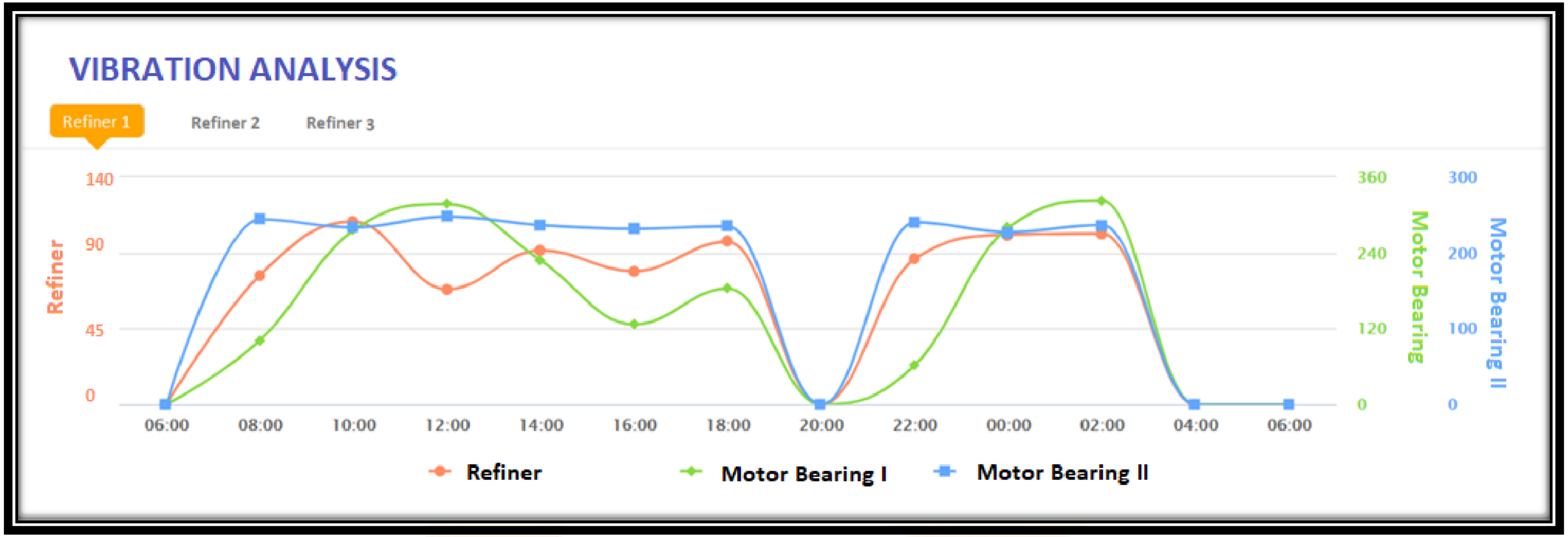


ENLARGED DETAIL OF `B'
(GAP SENSOR MOUNTING)

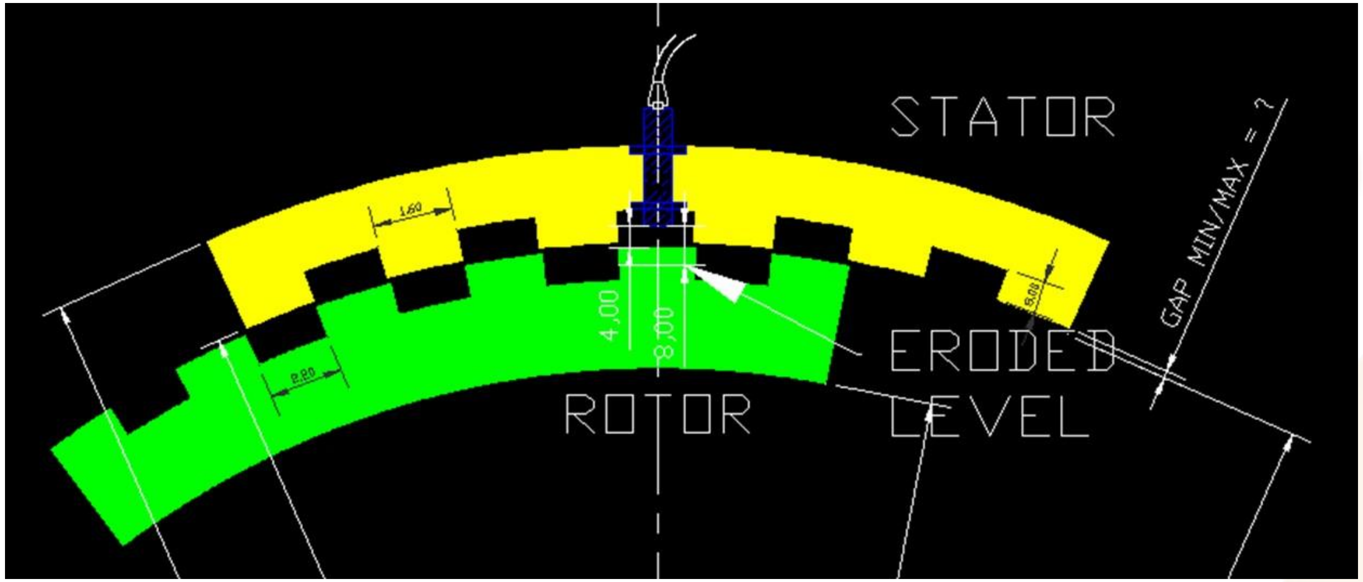


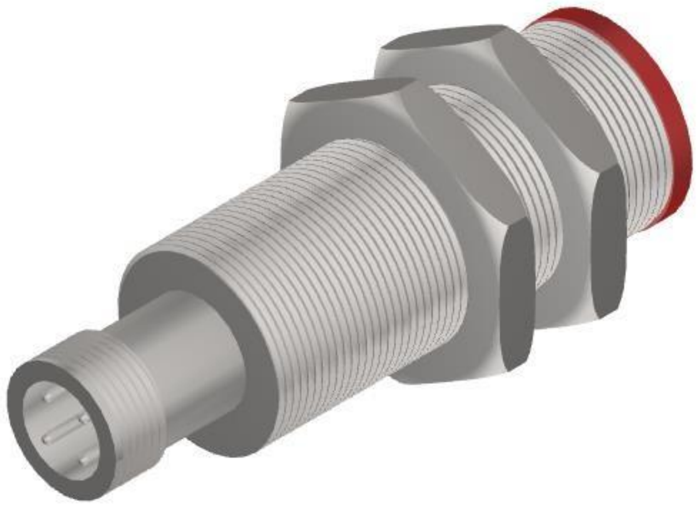
ENLARGED DETAIL OF `A'
(VIBRATION SENSOR MOUNTING)

Vibration Analysis trend



Gap Sensors





general data	
mounting type	quasi-flush
measuring distance Sd	0 ... 8 mm
resolution	< 0,005 mm (stat.) < 0,01 mm (dynam.)
repeat accuracy	< 0,015 mm
linearity error	± 400 µm
temperature drift	± 5 % (Full Scale)

electrical data	
response time (factory characteristic)	< 2 ms
voltage supply range +Vs	15 ... 30 VDC
current consumption max. (no load)	20 mA
output circuit	current output
output signal	4 ... 20 mA
load resistance +Vs min.	< 330 Ohm
load resistance +Vs max.	< 1000 Ohm
short circuit protection	yes
reverse polarity protection	yes

RoI - Useful Analytics – From Data to Intelligent Inferences

The major purpose is to maintain and deliver consistent freeness results, however, some of the analytics below would provide value in optimizing your process or develop new grades

1. **Grade** Vs **'Properties'** Vs **Freeness** required (identify opt. freeness)
2. **Furnish type** Vs **Freeness** Vs **SEC** (identify opt. furnish)
3. **Pulp pH** Vs **Grade** Vs **Freeness** (identify opt. pH)
4. **'Pulp Viscosity'** Vs **'Properties'** Vs **Freeness** (identify opt. Viscosity)
5. **'Pulp Strength'** Vs **Grade** Vs **Freeness** (identify min. Strength)
6. **Freeness** Vs **Throughput** Vs **SEC** (identify min. Energy required)
7. **Gap sensor** Vs **Temperature rise** Vs **SEC** (identify opt. Loading)
8. **Gap sensor** Vs **SEC** Vs **Segment Life** (predict segment change time)

'_' (in apostrophe) – Offline data

Return on Investment Possibilities

	Fine Paper	Board	Brown Kraft
1% Sheet Ash	☑	☑	☒☑
10% Tackle life	☑	☑	☑
Machine Efficiency	☑	☑	☑
10% Energy	☑	☑	☑
5% Steam	☑	☑p	☑
Quality Rejects	☑	☑	☑

Commercial Model

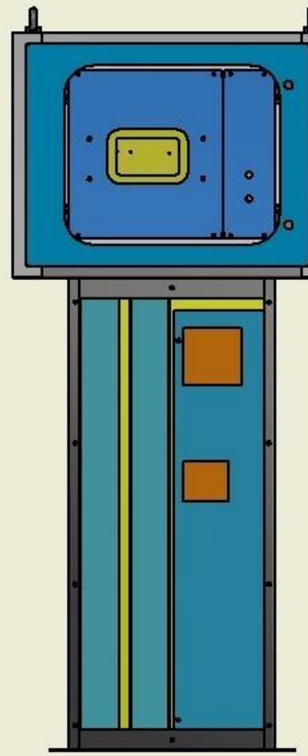
No upfront investment from Paper Mill
Haber invests for field instruments* and software development Flexible tenure options (> 36 months)

Win-Win Model = Fixed Monthly Rental + Benefits sharing

Customer Benefit = Pay-on-Performance + No capex risk!

Implementation

- Survey
- Identify Goals
- Pain Points
- Identify alterations to the existing setup
- Complete the required field instruments
- Develop a system to upload manual data online
- Identify RoI possibilities



=THE END=

Thank You

If you’ve any questions, contact us at info@haberwater.com

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