LEVERAGING DATA ANALYSIS FOR PROCESS OPTIMIZATION AND PROCESS AUTOMATION JOURNEY IN TNPL

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LEVERAGING DATA ANALYSIS FOR PROCESS OPTIMIZATION AND PROCESS AUTOMATION JOURNEY IN TNPL

As per Peter Drucker's quote 'What gets measured, gets managed'.

Case Study 1 – Process Optimization

Targeted to Reduce:

- Sheet Breaks
- Variations in Weight
- Grade Change Time

Case Study 2 – Resource Optimization

Resource Optimization focused on the following.

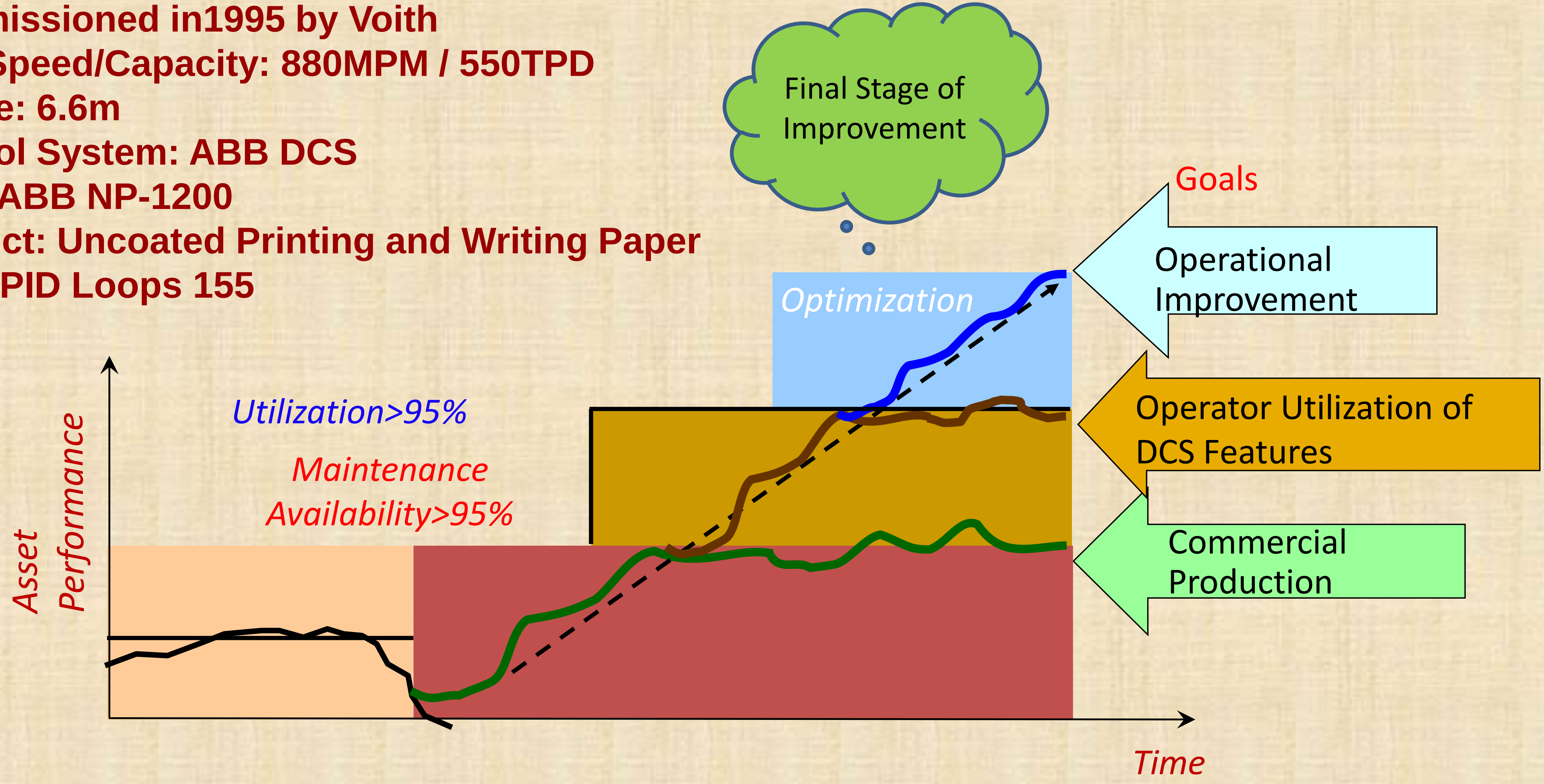
- Human Resources
- Wealth from Waste
- Improving Operational Comfort


1

MACHINE PERFORMANCE

PM#2 Machine Data

- **Commissioned in1995 by Voith**
- **Reel Speed/Capacity: 880MPM / 550TPD**
- **Deckle: 6.6m**
- **Control System: ABB DCS**
- **QCS: ABB NP-1200**
- **Product: Uncoated Printing and Writing Paper**
- **No of PID Loops 155**



REEL REPORT

Machine	TNPL PM#2	Product	Creamwove 60GSM
Reel No		Trim	659.7CM
Product No			

Production Summary

		Standard	Actual	Efficiency
Production	Tons	18.99	22.2	116.91
Throughput	T/Hr	16.16	18.89	116.91
Reel Speed	MPM	680	832.1	122.37
Run Time	Hr:Min	01:11	02:24	
Lost Time	Hr:Min	00:00	00:00	

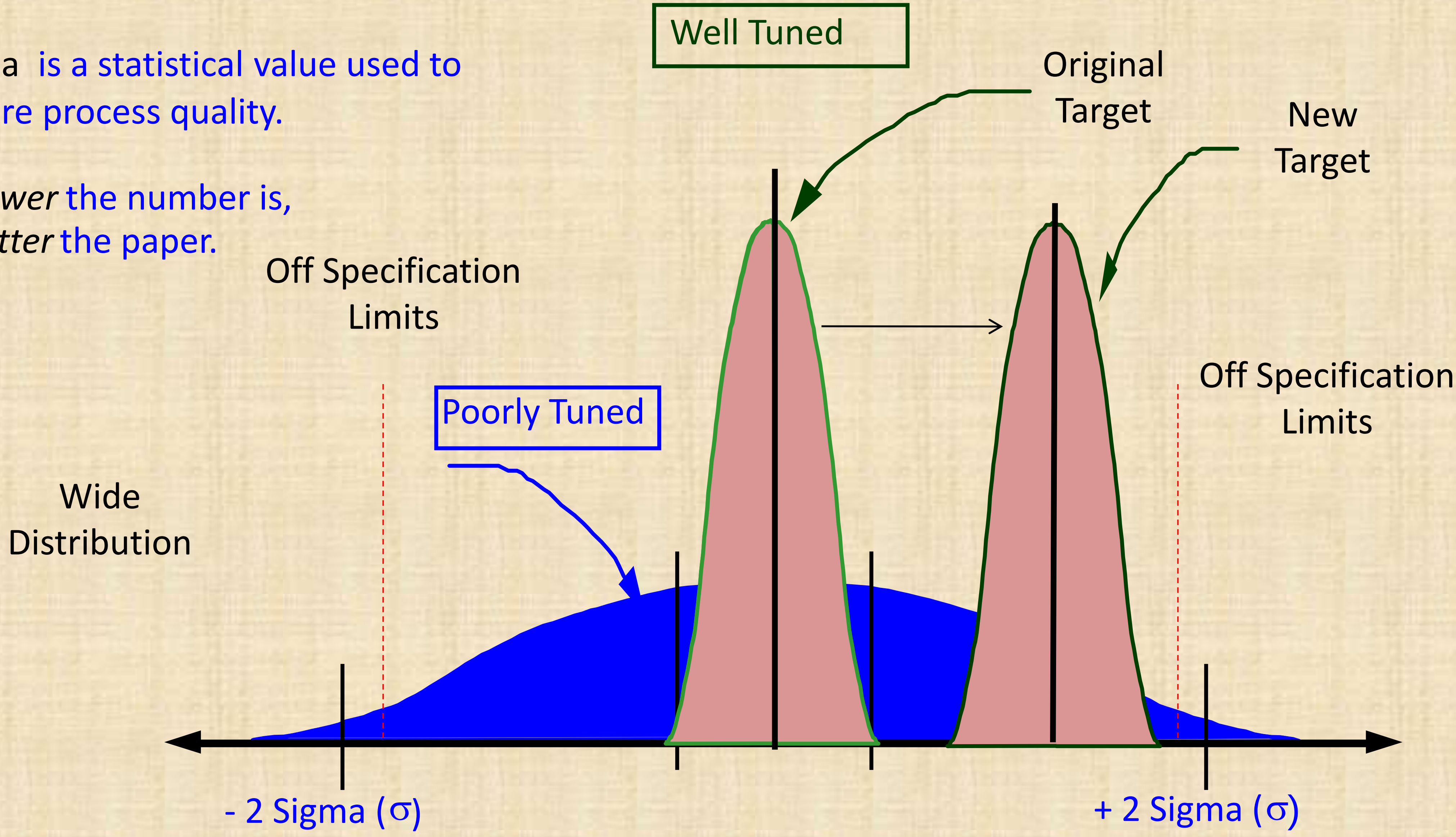
Quality Analysis

	Actual	Target	Efficiency	MDS	MDL	CD	Total
Air Column	-0.23	1	-437.2	0.06	0.1	0.25	0.28
Ash	15.71	15.7	99.79	0.97	2.42	0.3	2.62
Basis Weight	58.22	58.3	100.19	1.35	0.6	1.01	1.79
Caliper	83.18	75	90.16	1.33	1.1	0.33	1.76
Conditioned Weight	54.74	54.8	100.16	1.19	0.55	0.77	1.52
Moisture	5.96	6	100.53	0.43	0.79	1.15	1.46

TARGET SHIFTS BY REDUCING VARIABILITY

2 Sigma is a statistical value used to measure process quality.

The *lower* the number is, the *better* the paper.



VARIABILITY – EVALUATION

Long Term Performance of Machine- 2 Sigma as % of Process								
Parameter	Goal	PM2						
		48 GSM	50 GSM	55 GSM	60 GSM	70 GSM	80 GSM	All
Ash	< 4.5	8.74	8.09	7.44	6.89	6.34	5.76	7.21
Caliper	< 1.0	4.26	3.96	3.61	3.92	3.09	2.78	3.6
CONDWT	< 1.5	3.29	3.11	3.03	2.94	2.75	2.57	3
Moisture	< 10	24.92	25.24	28.62	29.11	31.13	31.65	28.5
WEIGHT	< 1.7	3.69	3.53	3.52	3.43	3.41	3.39	3.53
# Reels		3254 (11%)	5702 (18%)	6827 (22%)	3996 (13%)	2760 (9%)	1270 (4%)	23809 (77%)

Variability	Slow Side	Fast Side
MDS	0.0167Hz – 60Sec	10Hz – 0.1Sec
MDL	0.000277HZ-3600Sec	0.0167HZ-60Sec
CD	260 Inches	0.86 Inches

VARIABILITY – EVALUATION

2 Sigma as % of Process		
Sensor	Goal	Actual
Ash	< 4.5	7.5
Caliper	< 1	3.69
Cond. Weight	< 1.5	3
Moisture	< 10	27.95
Basis Weight	< 1.7	3.53

2 Sigma Variance Distribution(70 : 20: 10 Rule)						
Sensor	Goal	ASH	CALIPER	CONDWT	MOIST	WEIGHT
MDS	< 70	70.38	15.27	56.99	21.88	47.43
MDL	< 10	18.37	82.12	15.43	24.44	21.59
CD	< 20	11.25	2.61	27.58	53.68	30.98

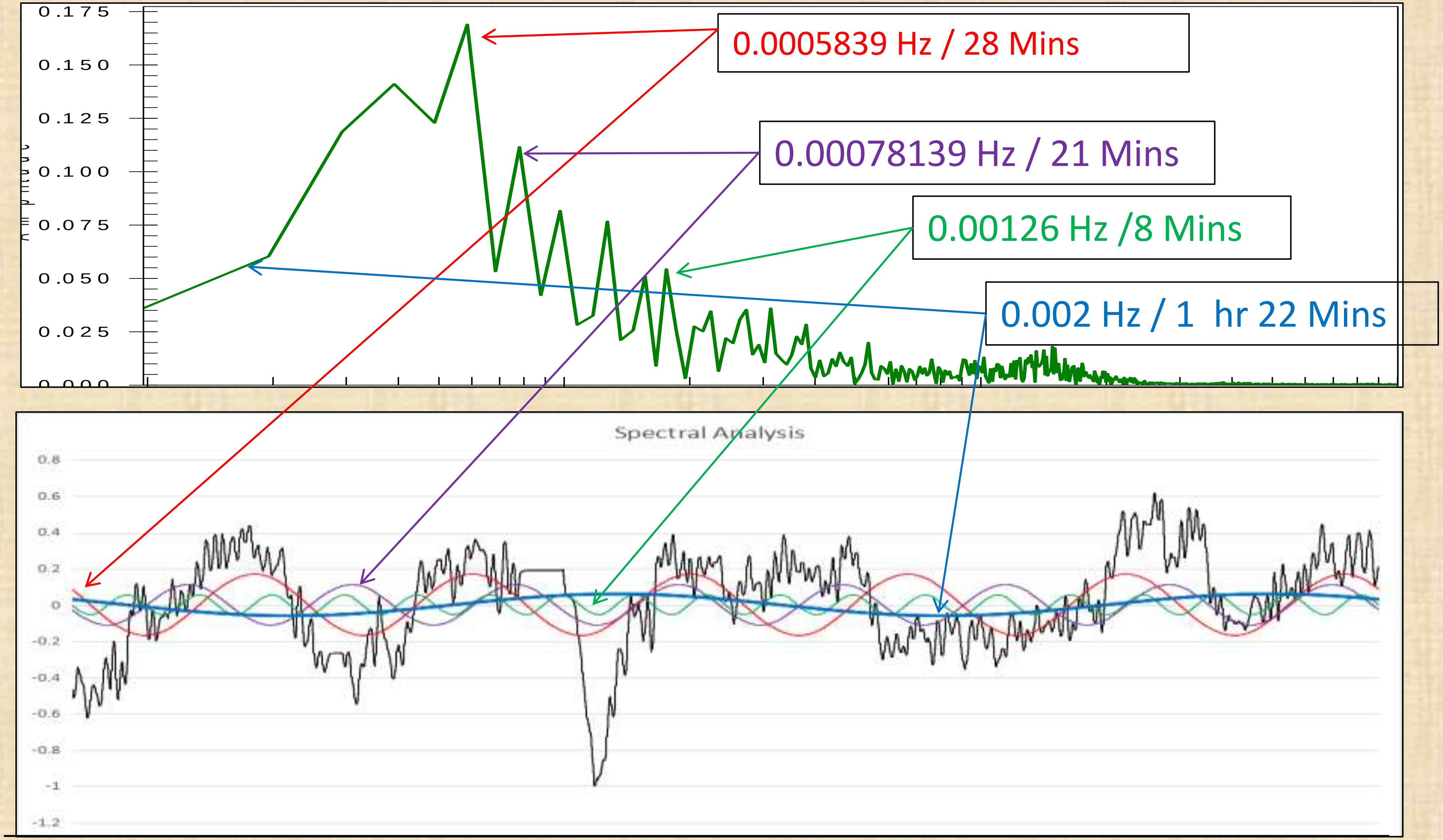
- Condition weight 2 sigma as % of process is almost double (3.0) -------**Needs Attention**
  - Most of weight variations are contributed by MDL (15.5) and CD (27.5%)
- Moisture 2 Sigma as % of process is almost tripled (27.9) -------**Needs Attention**
  - Most of moisture variations are coming from both MDL (24.5%) and CD (54%)
- Ash 2 Sigma as % of Process is 7.45 -------**Needs Attention**
  - Most of Ash variations are coming from MDL (18%)
- Caliper CD is excellent

OVERNIGHT REEL DATA INFERENCE – EVALUATION

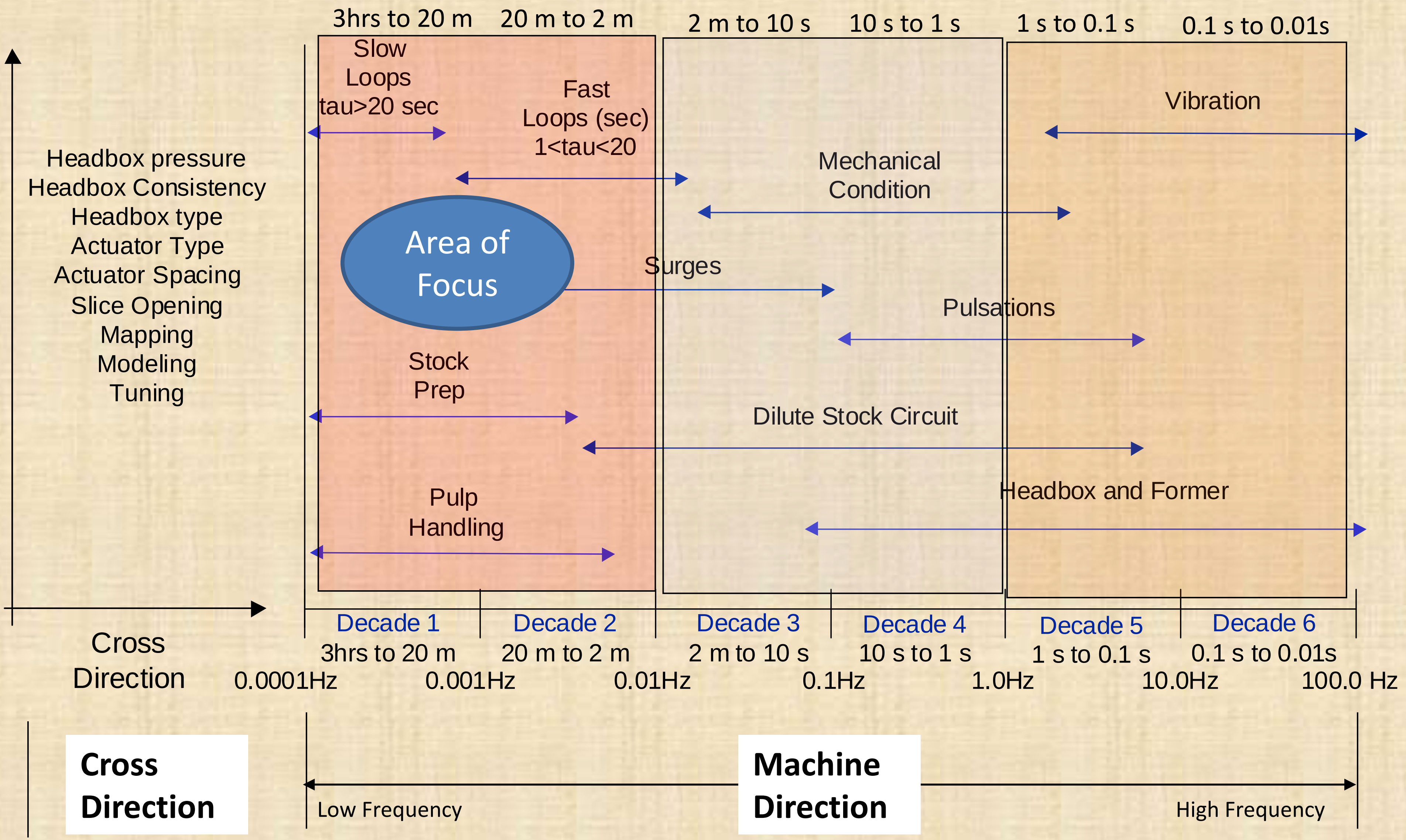
Weight Statistics	
Number of Points	5500
Number of Hrs	8 Hrs
Sample Time	5s
Max	60.7
Min	59.1
2 Sigma	0.799
Average	60.1
Skewness	-0.425
Kurtosis	-0.0019

TIME DOMAIN TO FREQUENCY DOMAIN ANALYSIS

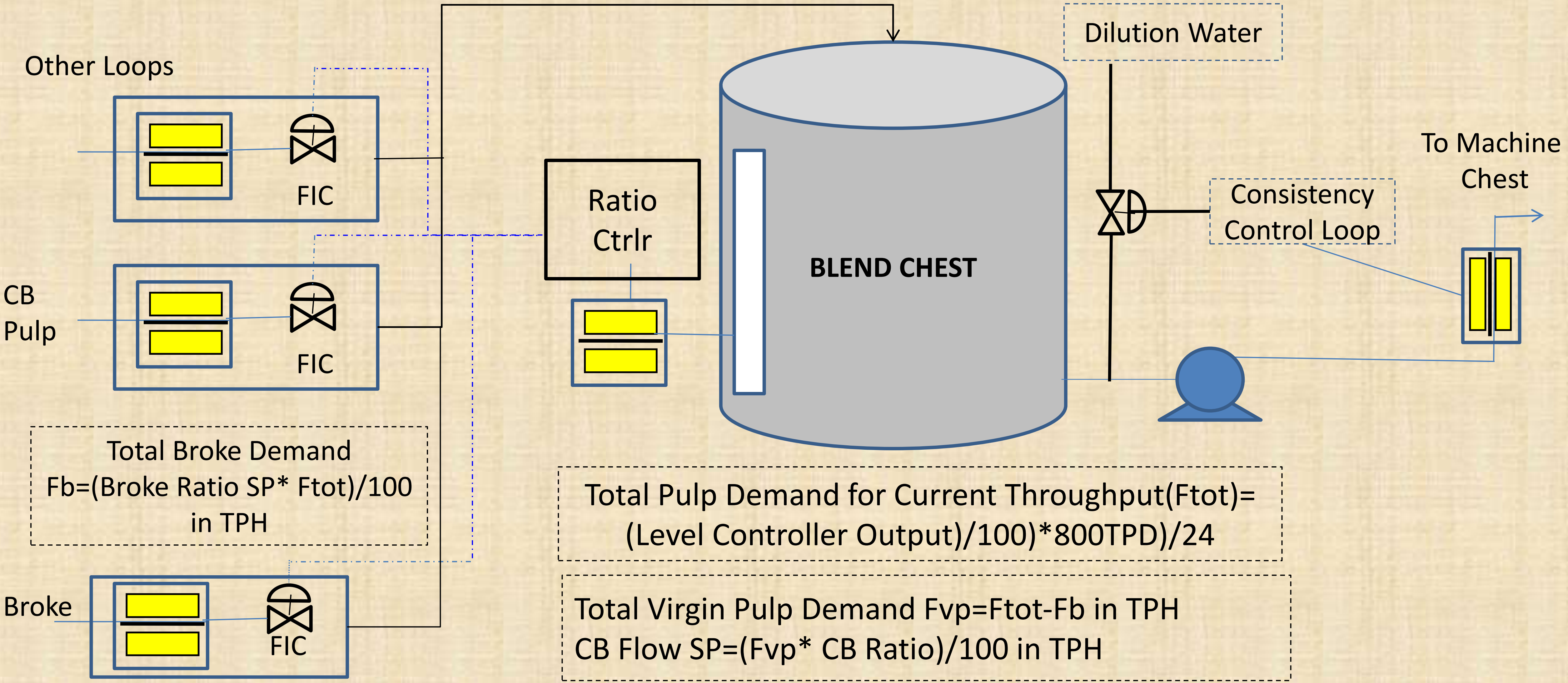
Basis Weight Spectral Analysis



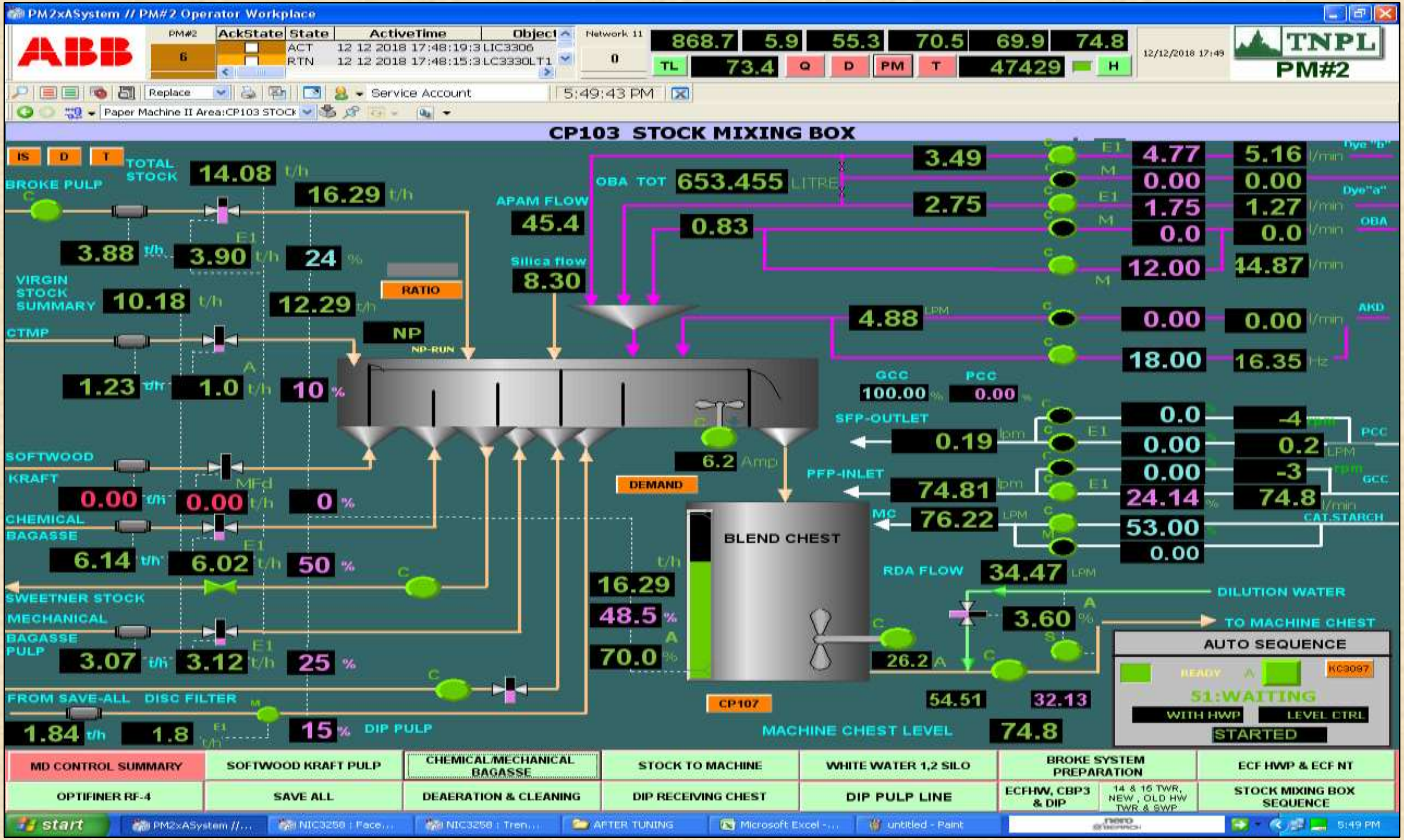
PROCESS SPECTRUM



PM#2 STOCK BLENDING CONTROL



PM#2 STOCK BLENDING OVERVIEW



IMPACT OF LOOP TUNING IN REDUCING WEIGHT VARIATION

Problems Faced

- Weight Variation
- Consistency Variation in Feed Pulp
- Blending Level Variation
- Quality rejections due to higher variability
- Frequent Sheet breaks

Root Cause

- Dilution Water Pressure Variation

Action Taken

- Dilution Water Pressure fluctuation Controlled
- Flow, Level and Consistency Loops PID tuning done

Blend Chest Level Control

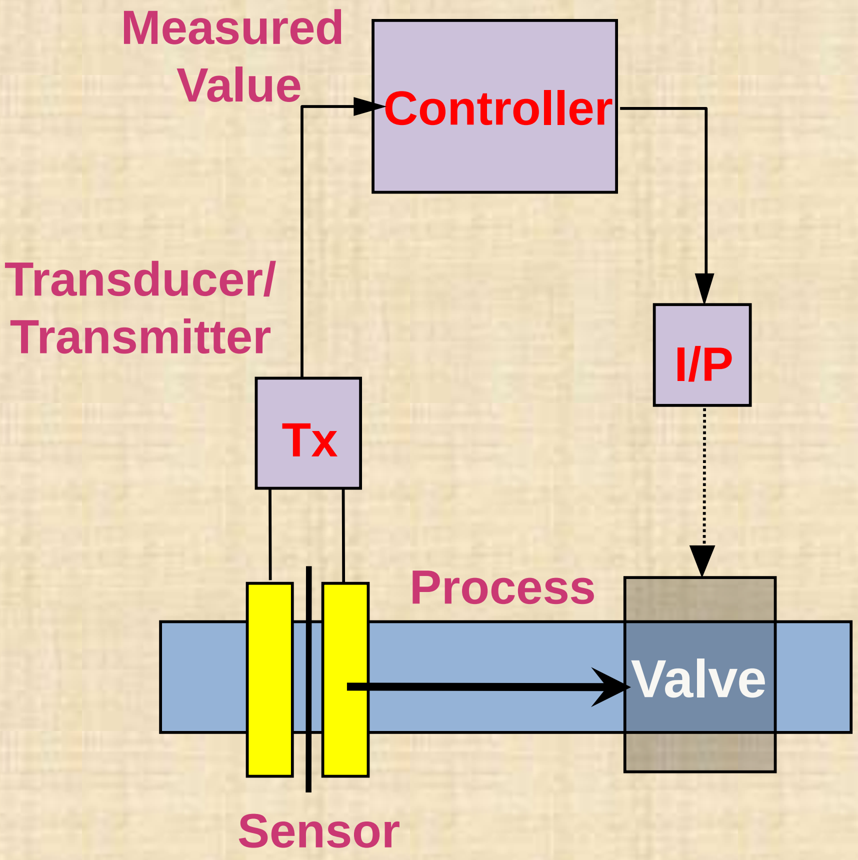
Results	Max	Min	Range	Kc	Ti
Before Tuning	71.6	68.6	2.75	3.5	120
After Tuning	70.7	69.69	1.06	4.8	480

84% reduction in BC Level Variation

CONTROL LOOP PERFORMANCE OPTIMIZATION

Control Loop

- Process
- Sensor
- Transmitter
- Measured Variable
- Controller



PREREQUISITES FOR TUNING

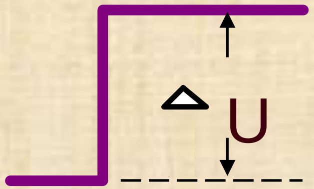
- Visual Inspection of Field Measuring and Control Elements.
- Reconditioning of faulty devices
- Removal of Filter and Damping factor in DCS for Input Devices.
- PID Loop Tuning

SELF REGULATING LOOP TUNING PROCEDURE

$$u(t) = K_C\left(e(t) + \frac{1}{T_i}\int_0^t e(\tau)d\tau + T_d\frac{d}{dt}e(t)\right)$$

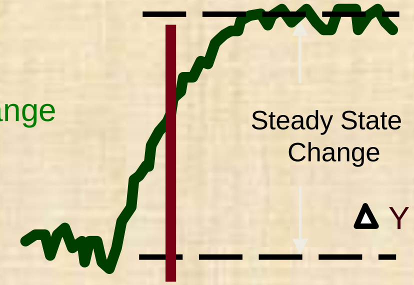
PID Controller Output

- THE **PROCESS GAIN** IS USED TO DEFINE THE STEADY STATE PROCESS CHANGE.



Actuator Change

Process Change

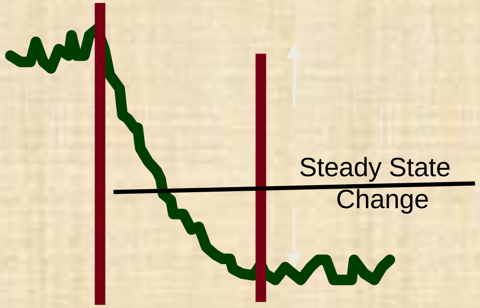


1 Time Constant=63.2% of Steady State Value

$$\text{Gain, } K_p = \frac{\text{Change in Process (Y)}}{\text{Change in input (U)}}$$

- Method of Tuning Employed: **Direct Synthesis**

ARRIVING AT TUNING PARAMETERS



Settling Time: 80 Sec

$$\text{Controller Gain, } K_C = \frac{1}{K_P\,\tau_{Ratio}} \bullet \frac{\text{MV Range}}{\text{Output Range}}$$

$$K_p = \frac{5.3 - 4.6}{44 - 38} = 0.11$$

$$Kc = \frac{1}{(0.11 \times 2)} \times \frac{3}{100} = 0.13$$

Bump Test results:

Valve Output change: **38% to 44%**

Measured value change: **5.3% to 4.6%**

τ_P =80/4=20Sec

Kc=0.11

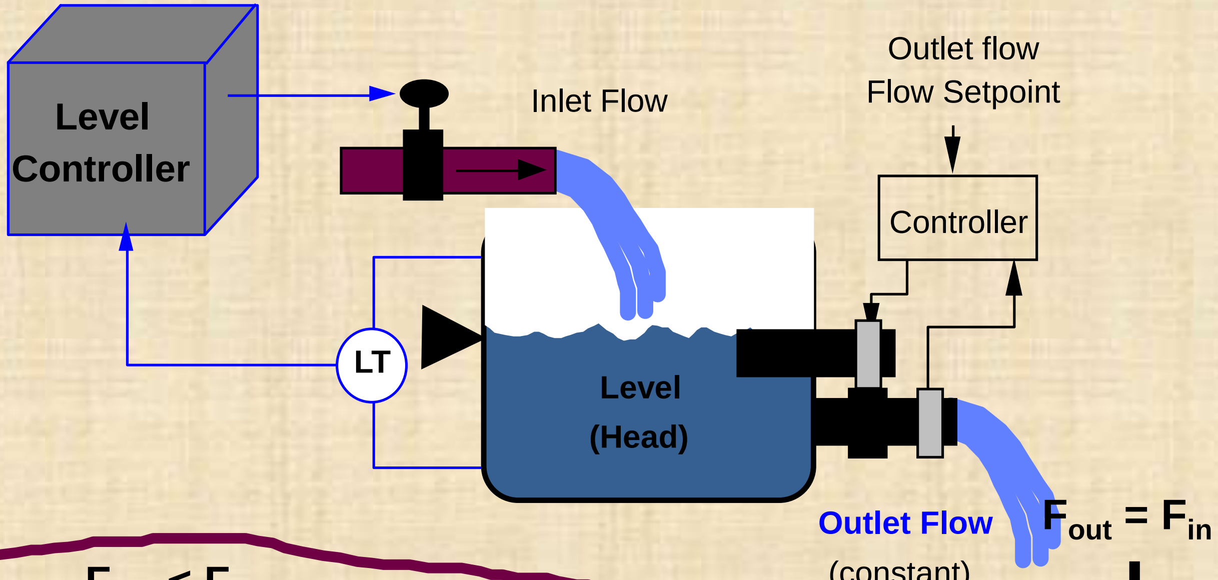
Ti=20Sec

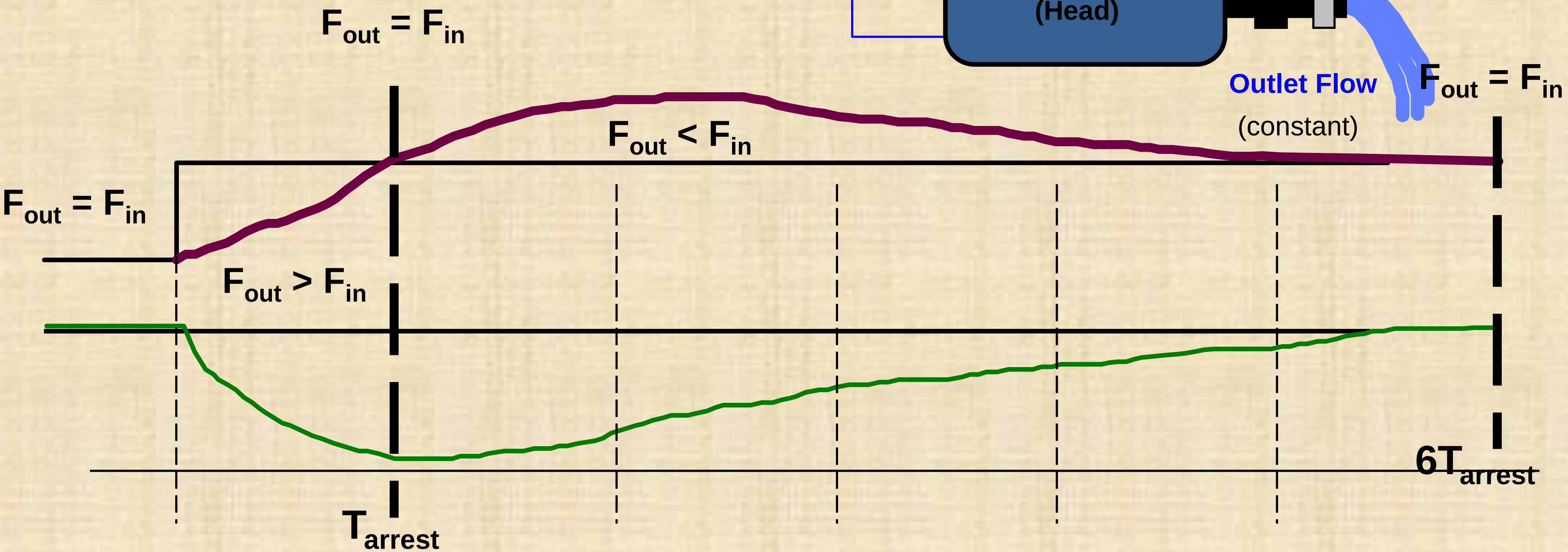
INTEGRATING LOOP TUNING

Kp =1/ Tfill

$$T_I = 2T_{arrest}$$

$$K_c = \frac{2}{K_p T_{arrest}}$$





LEVEL CONTROL LOOP TUNING PARAMETERS

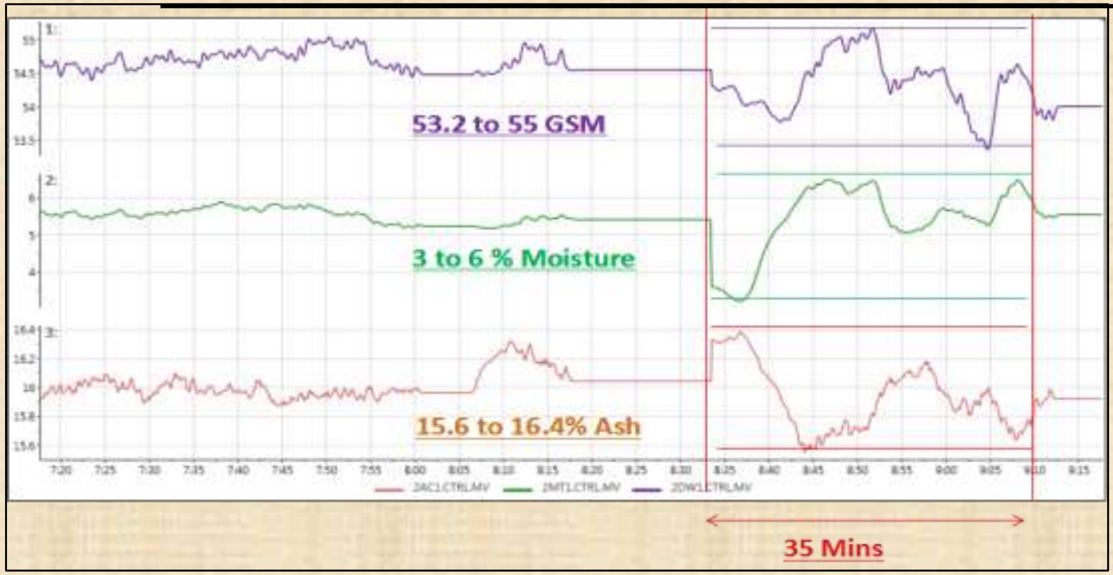
Chest Capacity in M^3	100
Chest Capacity in L(100*1000)	100000
Inlet Pump Flow in LPM	2800
TFILL Time in Min (Tank Fill Time)=Chest Capacity/Inlet Pump Flow i.e(100000/2800)	35.714286
TFILL Time in Sec(35.714286 x 60)	2142.8571
Process Gain Kp=(1 / TFILL)	0.0004667
Tarrest= TFILL/2	1071.4286
Controller Gain Kc=(2 / (Kp x Tarrest))	4
Integral Time Ti(TFILL/4)	535.71429

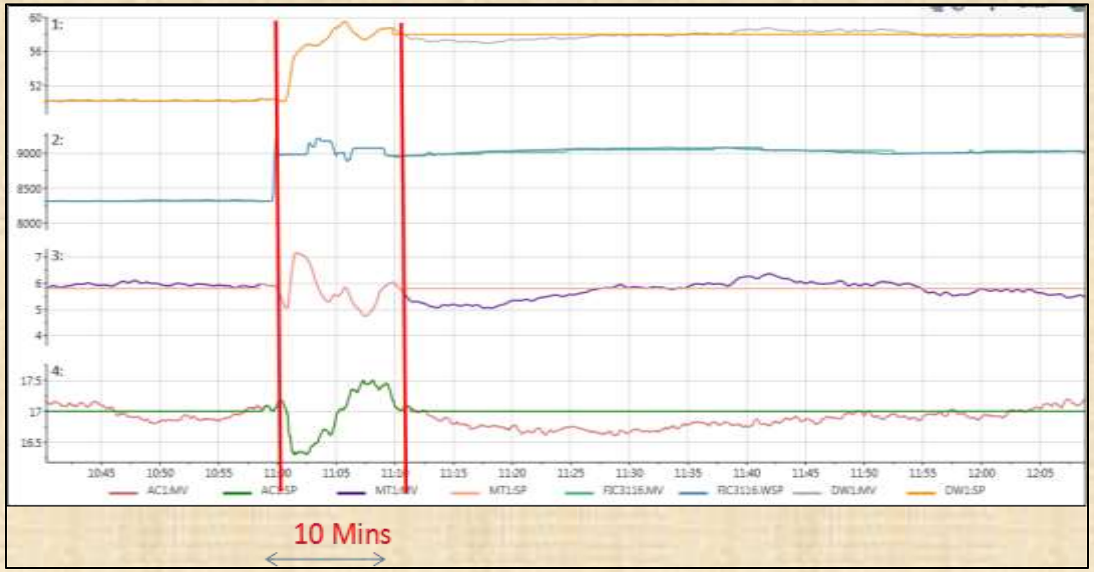
IMPROVEMENTS IN

SHEET BREAK RECOVERY

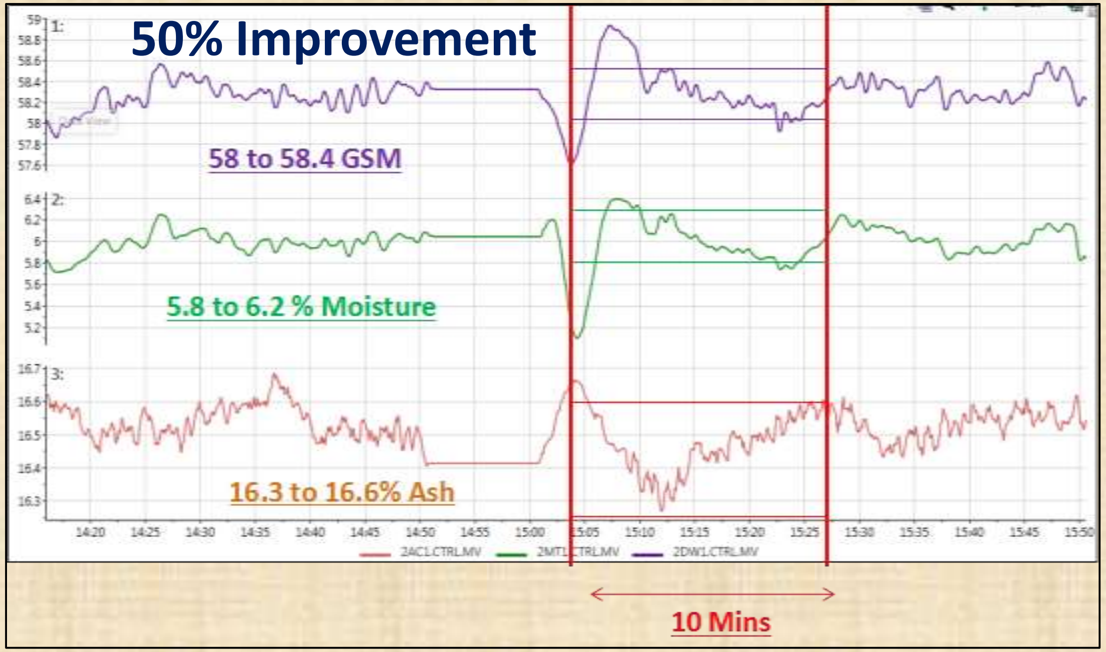
GRADE CHANGE TIME

Before Tuning

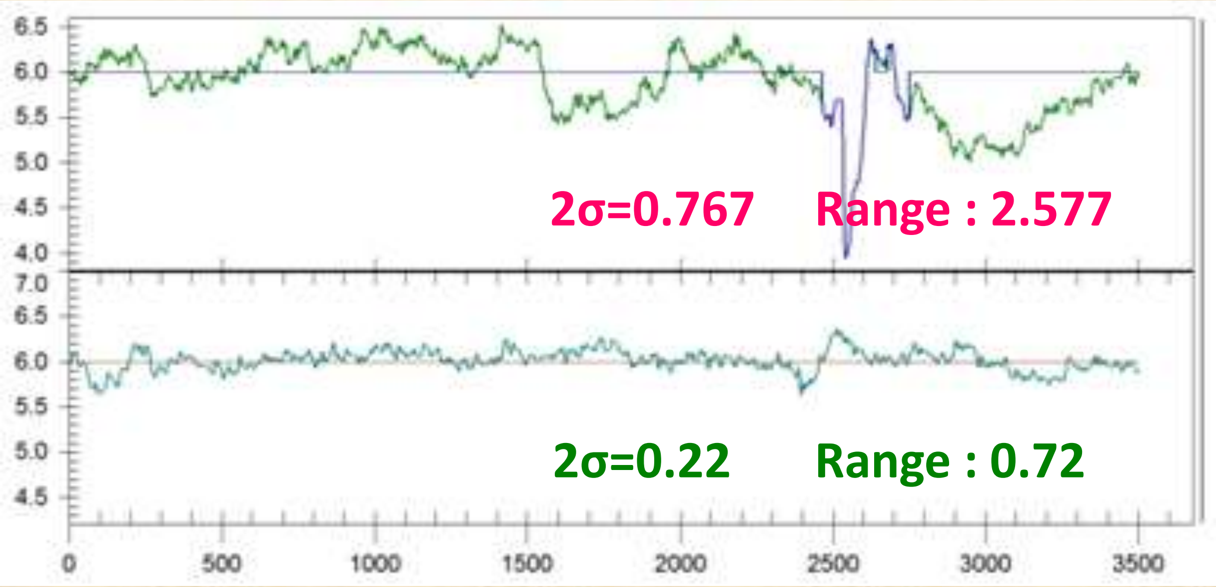




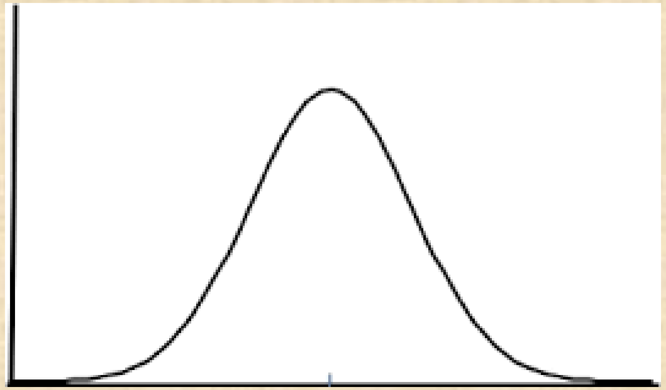
After Tuning



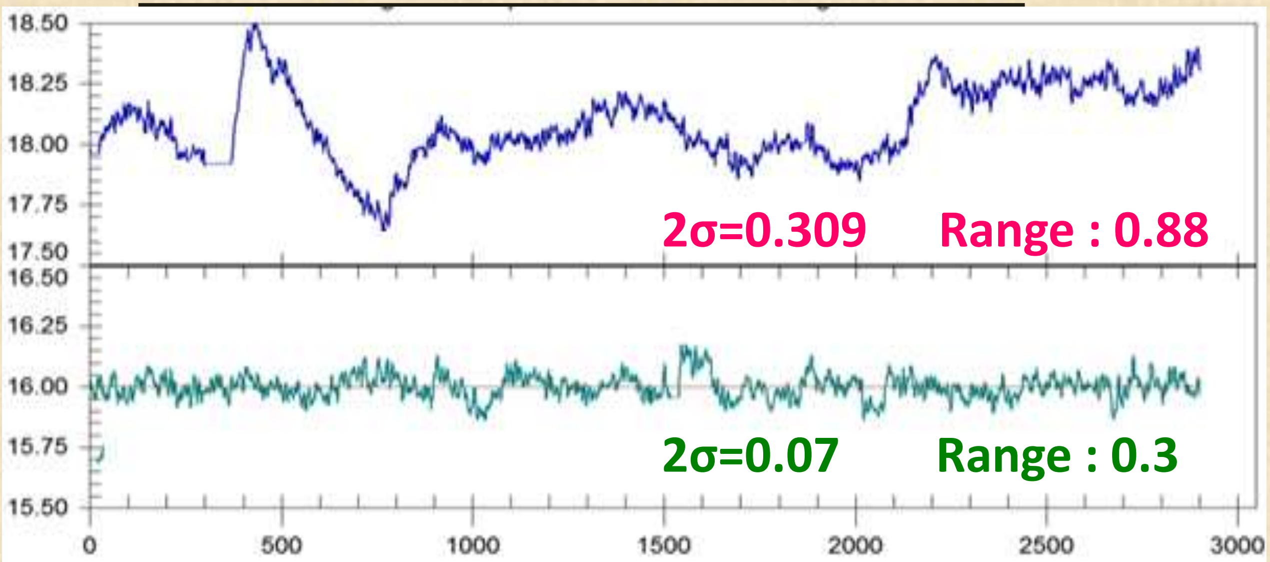
MOISTURE VALUE BEFORE AND AFTER TUNING



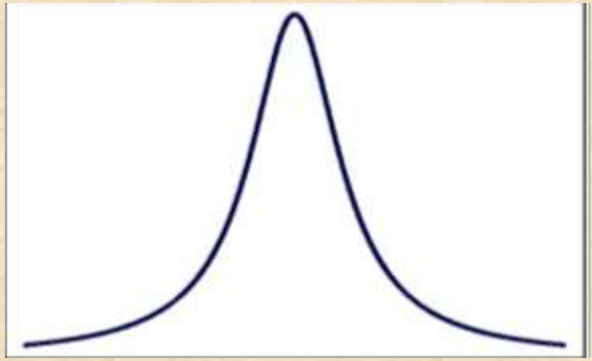
Before Tuning



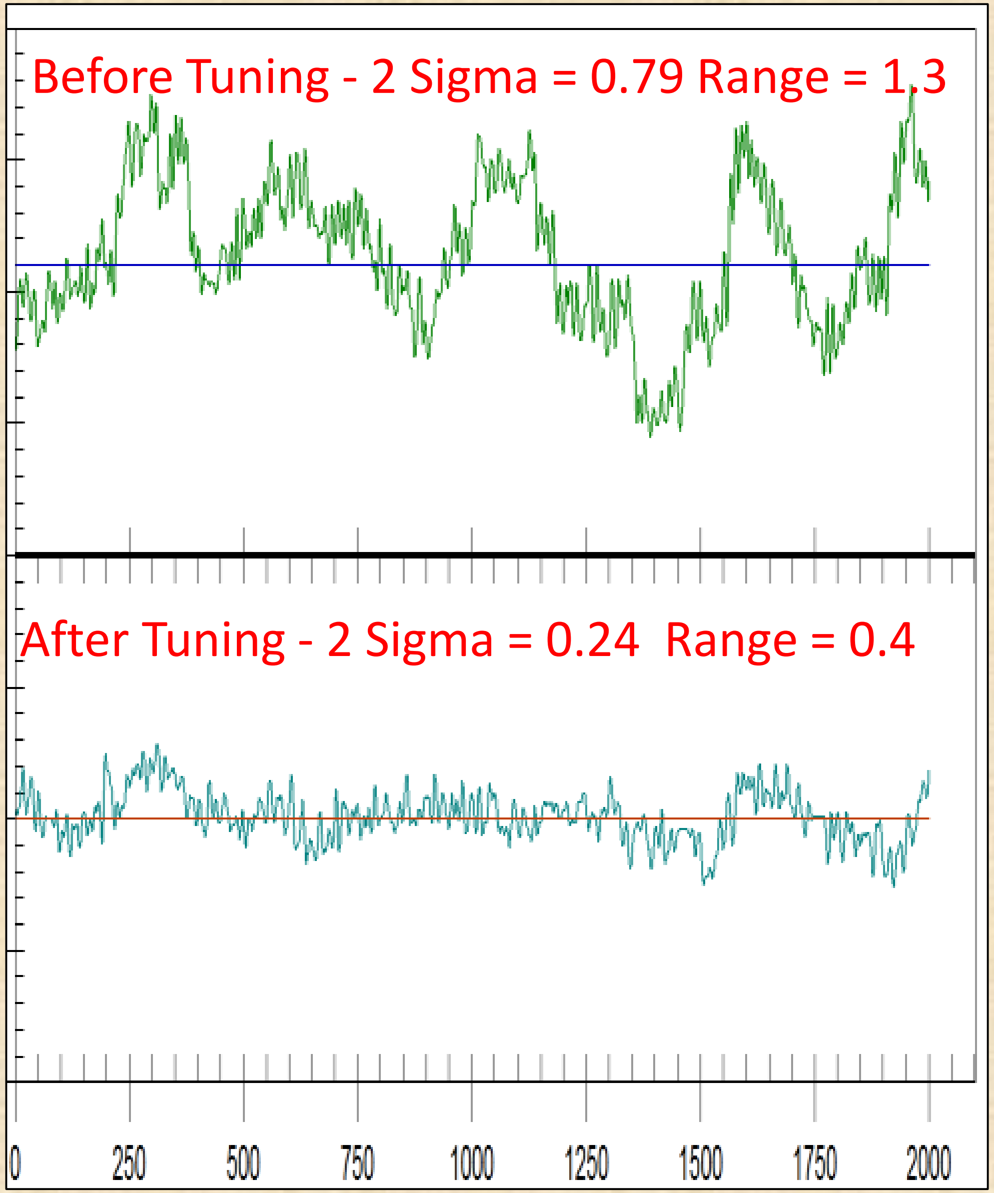
ASH VALUE BEFORE AND AFTER TUNING



After Tuning

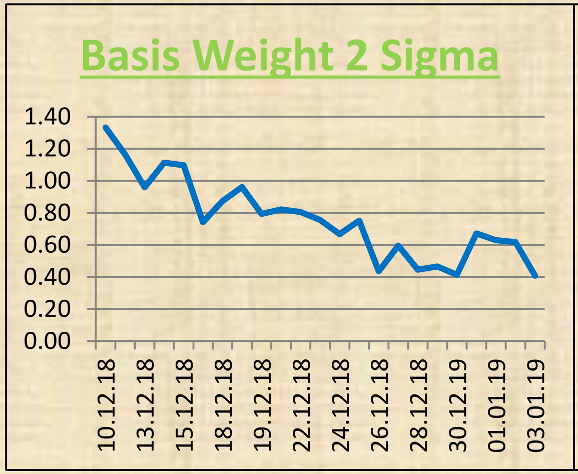


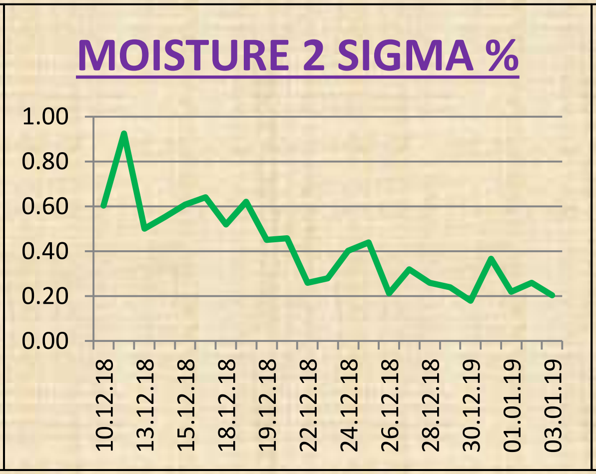
IMPROVEMENTS IN BASIS WEIGHT VARIATION

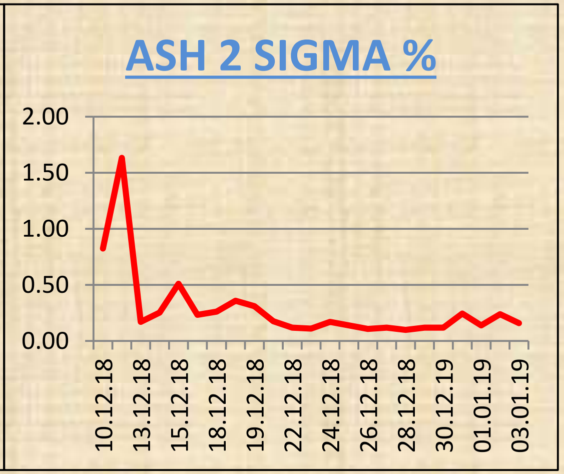


IMPROVEMENTS NOTICED

Parameter	Before	After	% Improvement
2 Sigma reduction in MDL Basis Weight	0.799	0.24	70%
2 Sigma reduction in MDL Moisture	0.604	0.18	70.2%
2 Sigma reduction in MDL Ash	0.8262	0.10	87.9%
Sheet Break Recovery Time	35 Mins	10 Mins	71%
Paper Break Reduction per month	40	24	40% reduction
Grade Change Time reduction	10 Mins	3 Mins	70% reduction








2

INTEGRATION OF CUT PACK LINE WITH SHRINK PACKING MACHINE

Preamble:

- Bielamatik#2 and ECH Will Cutter are fully Automated Cut and Pack Lines for Copier A4 reams.
- Production Capacity of Bielomatik#2 is **108 Reams/ Min** and of ECH WILL Cutter is **75 Reams/ Min.**
- Packed Reams are stacked in Pallets Manually and bundled in pair of 5Reams and fed to Shrink Bundling Machine for packing.

Problem Faced	Modification	Benefits Accrued
▪Limitation in throughput due to manual handling. ▪Additional manpower requirement for stacking reams. ▪High Ream Rejection and Delayed bundling of reams.	•Conveyors were installed adjoining Prestacker and shrink Bundling Machine •Carton Packing Prestacker is utilized for bundling reams. •PLC Logic Developed for Selection between Carton packing and Shrink Bundling to utilize Prestacker unit effectively. •Modifications carried out with nearly Zero cost.	10% increase in throughput realized. Ream rejects due to manual handling is completely eliminated. Production Increased by 80000 Reams/Year.

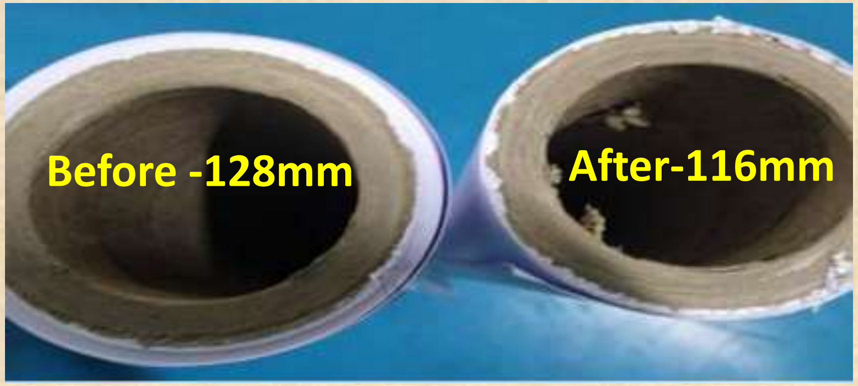
INTEGRATION OF CUTPACK LINES WITH SHRINK PACKING MACHINE

Before Integration

After Integration

CORE END WASTE REDUCTION THROUGH DECURLER AUTOMATION

- ECH Will Cutter are fully Automated Cut and Pack Lines for Copier A4 reams with 75 Reams /Minute production capacity.

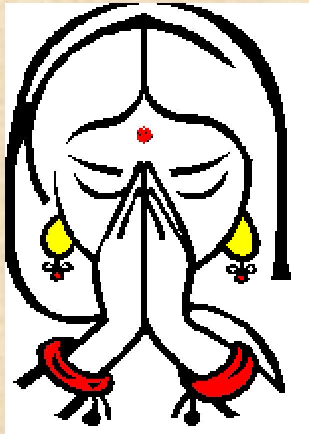
Problem Faced	Modification	Benefits Accrued
▪Unable to run machine till core end due to frequent sheet breaks at core end. ▪Increased production cost due to Repulping. ▪ Increased Machine shocks due to recurrent fast stops during every sheet break. ▪Reduced production and unable to meet production targets.	•Sheet break during Core end run was identified due to poor Decurling. •Decurler operation was automated through PLC logic based on actual reel diameter from Reel start to Core end. **Core End Utilization**  	12 mm of unused Core end web utilized. Reduced Machine shocks 320 KG per day of wasted Paper web processed. Production increased by 40MT/Year

Monetary Benefits Realized and Projected

Parameter	Savings in Rupees/Year
Paper Break Reduction Per Month	100 Lakhs
Grade Change Time reduction	30 Lakhs
Moisture Target Shift by 0.5% (Projected)	115 Lakhs
Ash Target Shift by 1% (Projected)	98 Lakhs
Integration of Cut pack Lines with Packing Machine	7.5 Lakhs
Waste Reduction Through Automation	10 Lakhs
Total Savings (Projected + Realized)	**360.5 Lakhs**
Total Cost Incurred	**15 Lakhs**
Pay Back	**16 Days**

"Nothing is Impossible"

THANK YOU



TNPL Management and IPPTA