CONTINUOUS IMPROVEMENTS IN PAPER MANUFACTURING AUTOMATION AT TNPL



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ABSTRACT:

The Technological Revolutions in the field of Automation & Digitization have benefitted the manufacturing industries in a huge way. Adopting the latest developments in the Technology paves the way to redefine the conventional methods which were adopted right from manufacturing quality products to Marketing. Industry 4.0 is the next step in the ladder that every manufacturing industry is in the process of taking a leap into.

This Paper talks about the continuous measures taken to improve the safety for Men and Machine, Enhance the productivity, Improve the Quality, Reduce the cost of Production, Improve the overall Efficiency of the System, Ease the Process Operation and addressing the Technological Obsolescence in a Smart way.

Key Words: Technological Revolutions, Digitization, Industry 4.0, Safety, Direct On-Line (DOL) Starter, Variable Frequency Drive (VFD).

1. Introduction

Process Industries are moving to a culture and Business model in which decisions are based on credible & quantifiable information and analysis of process data. A modern approach based on data collection and analysis enables the process industries to develop new techniques that results in safety, greater efficiencies, better yields and more consistent product quality.

Any approach towards Optimizing Process / Machine Performance / Product quality follows the following sequence of action,

This article presents the necessity and benefits of Process Automation executed in Paper Machine, Converting and Finishing House areas under up-gradation and improvement Projects. Automation is inevitable as the quality of Paper on a high speed Paper Machine demands for the critical parameters to be continuously monitored, maintained and controlled.

Improvement Projects on Automation are being carried out continuously right from the inception of the mill Paper Machine and other related areas to improve the overall Efficiency and for sustainable operation. Some of the important projects done are presented below…

1. Improvement in Machine Direction Basis Weight Control

Preamble:

• MD Basis Weight Control Loop works under Cascade Control in Paper Machine. Level#1 is Stock Flow Control Loop and Level#2 is Basis Weight Control Loop. Level#1 Process Variable (PV) is collected from the Stock Flow Meter and Level#2 PV is collected from the Reel Scanner Basis Weight Sensor (Figure 1).

Problem:

• MD Basis Weight 2 sigma variation was on higher side and it was around ±2.5%.

• Frequent Machine stoppage due to Stock Flow hunting which was beyond permissible limits.

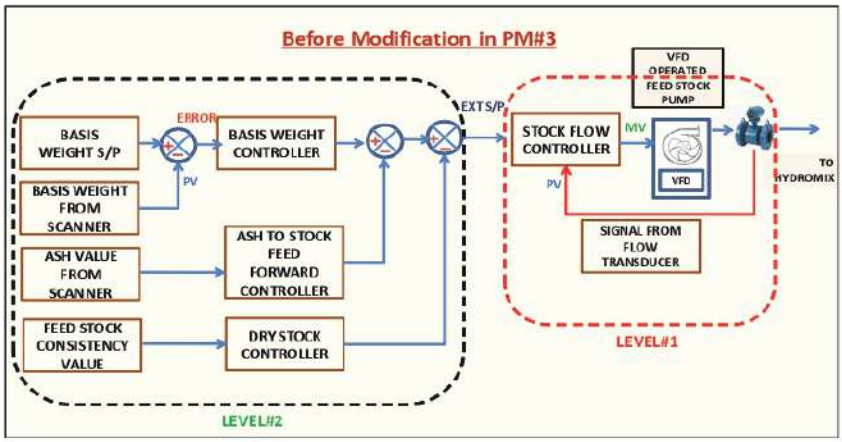

Figure 1: PM#3 Basis Weight Control Loop before Modification

Data Analysis & Root Cause

• Reliable measurement was a requirement for such critical Control Loop for achieving better performance.

• The Variation in Stock Flow Measurement was on higher side and it was malfunctioning often (>14000 LPM) due to air entrapment which lead to unstable measurement.

• Electromagnetic Flow Meter performance is limited by certain factors such as presence of air entrapment from the process line, Electromagnetic Interference, Pulsating Flow, Fluid conductivity etc.

• Hence for getting reliable PV measurement, it was decided to use Stock feed pump actual Speed instead of Stock Flow measurement as the pump speed measurement was not influenced by the above mentioned factors.

Action Taken:

• Loop was studied in detail and decided to modify the Stock Feed Pump Actual Speed (Calculated value from the Drive) as Process Variable for Level#1 Control Loop in PM#3 as below.

• Logic modifications were carried out accordingly (Figure 2).

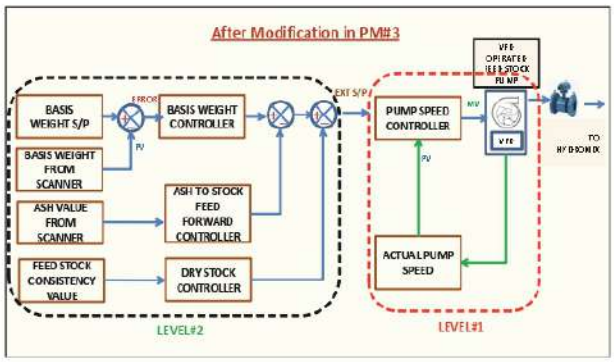

Figure 2: PM#3 Basis Weight Control Loop after Modification

• Similarly for PM#1 & PM#2, Level#1 Stock Flow controller was replaced with Basis Weight Valve Position Controller. The PV of Stock Flow was replaced with Basis weight Valve Position (Figure 3).

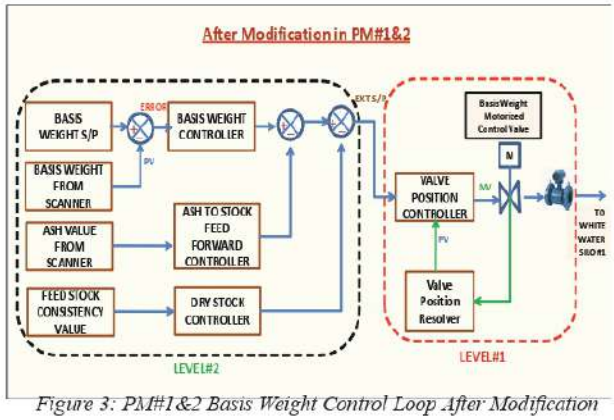

Figure 3: PM#1&2 Basis Weight Control Loop After Modification

Tangible Benefits:

• Eliminated Machine outage due to Stock Flow Meter malfunctioning.

• 50% reduction in MD 2-sigma variation could be achieved as the speed signal & valve position signals are stable and reliable

• Improved Machine runnability.

• Improved Productivity.

2. Paper Machine#2 Blend Chest Level Control Optimisation

Preamble:

• Blend Chest Level Control is a critical loop which plays an important role in Stock Blending.

• Variety of Pulps as per furnish demand are mixed in a pre-defined ratio along with fillers and additives in Mixing Box and the mixed Stock is fed to the Blend Chest.

• Blend Chest Level Control Loop is cascaded with associated Pulp Flow Control Loops in the desired Stock proportioning ratio (Figure 4).

• According to the remote set point given from Blend Chest Level Control Loop, Pulp Flows are maintained.

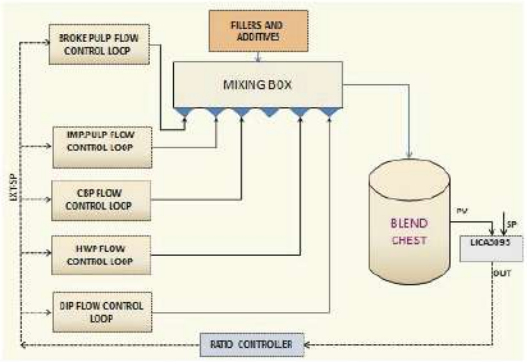

Figure 4: Stock Blending

Problems Faced:

• The Level variation in the Blend chest was around +/-2.5%.

• Associated Pulp Flow Control Loop performance was unstable and oscillatory.

• Non-homogeneous Stock Blending caused Paper breaks.

Data Analysis & Root Cause

• Even, the smaller variation in the Blend Chest Level had a larger impact in the respective Stock Flow and vice versa.

• The Flow variation in Pulp Flow Control Loops were as follows;

- Chemical Bagasse Pulp Flow→±14% from set value
- Hardwood Pulp Flow→±9% from set value
- Broke Flow→±12% from set value
- De-inking Pulp Flow→±8% from set value

• Individual Control Loops affecting Blend Chest Level had been studied separately & deviation noted.

• Analog Input/output Channels of all associated Flow Control Loops in DCS were checked & verified.

• Transmitter and Valve healthiness, I/O channel damping factor, Consistency variations were studied and found normal.

• It was inferred that the loop performance was Sluggish / Aggressive and it required PID tuning.

Action taken:

• Bump Tests were carried out to capture & calculate the PID loop tuning parameters for Chemical Bagasse Pulp Flow, Hardwood Pulp Flow, Broke Flow, De-inking Pulp Flow and Blend Chest Level.

• The Bump Test data were collected in a real time, processed in special software and the calculated PID parameters were fed to the respective Control Loops.

• The results achieved Before and After Tuning are shown below (Figure 5);

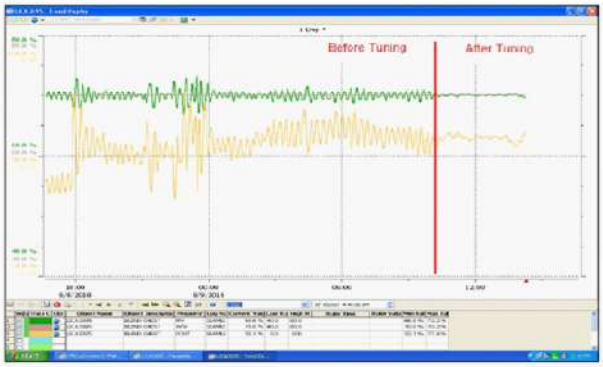

Figure 5: LICA3095 - Blend Chest Level Control Loop before/after Tuning

Tangible Benefits:

- 70% reduction in Blend Chest Level variation.
- Homogenous mixture of Furnish.
- Improved Machine runnabilty.
- Improved Productivity.

3. Life Cycle Enhancement of Bottom Wire Forward Dive Roll / Wire

Preamble:

• Wire Part - Bottom Wire Forward Drive Roll was Rubber lined in Paper Machine#3.

• Knock off Shower (12 Kg/Cm²g) is available (Near Wire Forward Drive Roll) for cleaning the Wire Fabric when Pickup Roll goes to GAP position.

Problems Faced:

• Premature failure of Forward Drive Roll due to wear & tear at Roll edges was noticed.

• Wire edges also got damaged due to the above problem.

• It necessitated frequent Wire / Roll replacement.

Data Analysis & Root Cause

• Due to non-availability of Lubrication Shower, Drive roll was getting worn out at both edges.

• Forward Drive Roll was replaced with PU liner material which was a suitable substitute to improve Roll life.

• Proper lubrication is essential for PU material too.

• It was not possible to introduce Lubrication shower due to space constraint.

• Only option left out was to use the existing Knock off shower as a Lubrication Shower for Forward Drive Roll when Pickup Roll is in Run Position.

Action Taken:

• Pressure of the Water jet needs to be reduced when used for lubrication purpose. Hence, Knock Off shower Pump - Direct on Line (DOL) starter was replaced with Variable Frequency Drive (VFD) for variable water pressure control (Figure 6).

• During 2016, necessary Logic modifications were carried out to vary the Pump Speed based on requirement as below;

- If Pickup Roll is in GAP Position, Pump speed is set to 100% automatically. (Function as Knock Shower)
- If Pickup Roll is in RUN Position, Pump Speed is set by the operation team as per Requirement between 10 & 20% (Function as Lubrication Shower).

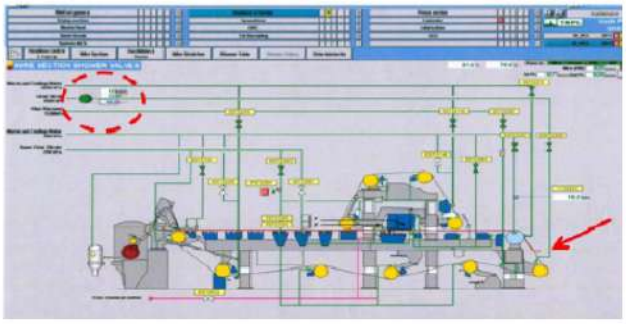

Fig6: PM#3 Wire Shower Valves After Modification.

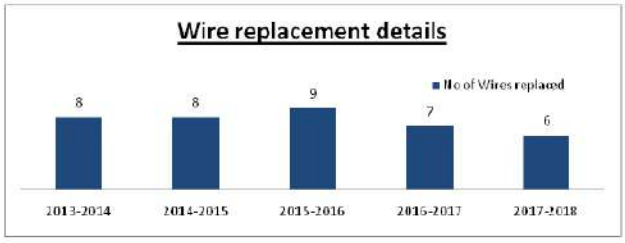

Figure 7: PM#3 Wire replacement details

Cost Workings:

- Wire Cost - Rs. 10 Lakhs
- Wire replacement frequency reduced by 25% from average of 8/Year to 6/Year (Figure 7).
- Machine stoppage time requirement for wire replacement- 4 Hrs./Wire
- Average production rate in PM#3-500 MTPD, For 8 Hrs ~ 167 MT of production lost.
- Considering profit margin of Rs.10000 per MT of Paper.
- Potential saving by increasing machine uptime.
  =167*10000 + 2 * Wire cost
  =Rs.36.7 Lakhs / year

Tangible Benefits:

- Improved Roll life.
- Enhanced Wire Life due to Improved Wire Cleaning.
- Improved Productivity

4. Replacement of Servo Valve in PM#2

Preamble:

- Conventional Electromechanical Hydraulic Servo Valves were used for controlling all NIP movements / Loading operations in Press, Calendar, Reel and Winder Rider Roll in Paper Machine#2.
- 15 Nos. of Hydraulic Servo Valves were in service.

Problems Faced:

- Frequent failure of Servo Valves resulted in Machine stoppage (Figure 8).
- 5 Micron oil filter was inbuilt in the valve supply port which got clogged frequently.
- Around 144 Hrs. of downtime on account of Servo Valves failure and the Production loss was around 2200 MT between 2000 and 2013.
- Defective Servo Valves had to be sent to OEM works for servicing as it was not field serviceable.

Mitigation Plan:

- Replaced Servo Valves filters periodically.
- Online oil Purification system was introduced to improve oil quality.

Data Analysis & Root Cause:

- Servo valve failures persisted due to ageing of Internal Electro Mechanical components such as Torque arm, Pressure Transducer.
- Servicing of defective valves became cumbersome for OEM because of its component level obsolescence & hence suggested to upgrade the Servo Valves.

Action taken:

- Old Servo Valves were replaced with the latest digitized Servo Valves with advance diagnostic features during 2014 (Figure 9).

Tangible Benefits:

- Eliminated Machine Stoppage on account of Servo Valve failure (Figure 10).
- Zero R&M Cost on Servo Valve.
- Improved Productivity.

Figure 8: Old Servo Valve

Figure 9: New Servo Valve

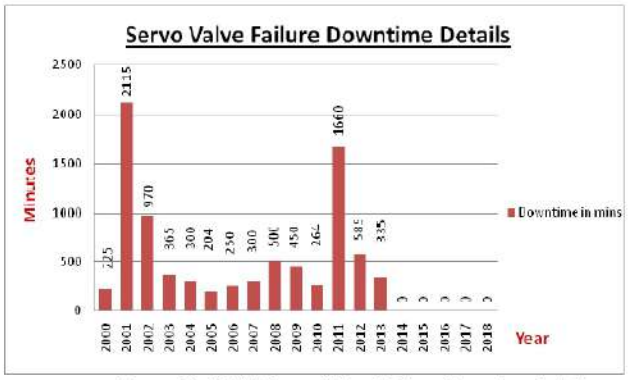

Figure 10: PM#2 Servo Valve Failure Downtime details

5. Winder#1 Auto Trim System (Slitter Positioning) - OS Up-gradation

Preamble:

- Winder#1 converts Jumbo Rolls produced from Paper Machine#1 into Reels.
- Slitter positioning is carried out automatically by using Auto Trim position control system supplied by M/s. Rollteck, Germany.
- It was commissioned during the year 1990 and it was upgraded with Siemens S7-400 PLC during 2002 by Rollteck.
- The Operating System (OS) used for Auto trim operation runs on Windows 2000 Operating System with Rollteck Control System (RCS) application software (Figure 11).

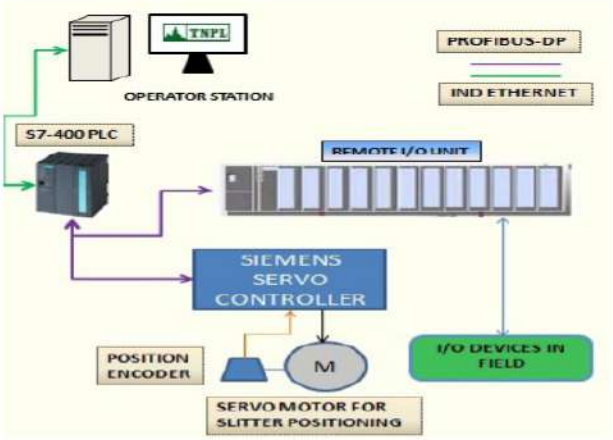

Figure 11: PM#1 Winder Auto Trim Hardware Architecture.

Problem faced:

- The OS Hardware & Software had become Obsolete; there was no support from the market for Hardware and no service support from OEM. M/s. Andritz who had taken over M/s. Rollteck conveyed their inability to support as they had closed this business line.
- In the mean time, the existing OS got failed and there was no spare part available.

Data Analysis:

- Efforts were taken to restore the services of the failed station OS and system was lined up by replacing the RAM

for which refurbished item was fortunately available from the local Market.

- Hardware and Software obsolescence is inevitable due to continuous Technological Upgrade.
- OEM could not be approached for upgrading our existing system due to their unavailability. The only option left out was to upgrade the complete system which was not a pragmatic approach as it required a huge capital.
- Possibilities were analyzed to use Virtual OS as a substitute for the existing OS. VMware Technology was found suitable to cater our requirement.

Action taken:

- Complete system backup from the existing OS of Auto trim system was archived using VMware toolkit.
- A new PC station running on Windows-7 Professional 64 bit operating system was chosen and archived back-up was successfully extracted in the new PC station.
- PC ON board Local Area Network card was used for establishing communication with the Programmable Logic Controller (PLC).
- VMware station was put in service and working satisfactorily.

Cost Workings:

- Offer received from freelancer (Ex-Employee of M/s. Rollteck) for up-gradation was around Rs.60 Lakhs.
- PC station + VM Ware cost: Rs.2 Lakhs.
- Potential Savings of around Rs.58 Lakhs was realized.

Tangible Benefits:

- Ensured availability of the Machine.
- Obsolescence is managed effectively.
- Smooth Size Change operation.
- Reduced Downtime
- Improved Productivity.

6. Safety Improvement on Winder#2 Core Chuck Operation

Preamble:

- In Winder#2, Core Chuck / Unchuck operation is carried out by an Electric Motor and its position is captured by an Incremental Encoder.
- Encoder sends Core Chuck position feedback to PLC through Profibus-DP communication (Figure 12).

Problems Faced:

- The Core Chuck Motor continuously operated towards Unchuck position and got mechanically locked due to Encoder last position value disturbance.
- Manual intervention was required to de-couple the gear mechanism to bring the Core Chuck shaft to operating position.
- Winder had to be stopped until Core Chuck position resumed back. Considerable time was consumed which was not affordable when Paper machine was running at high speed.

Figure 12: Core Chuck Encoder

Data Analysis & Root Cause

- Possible reasons for Core Chuck Motor continuous operation towards Unchuck position during problem was analysed and found Encoder value disturbance was the root cause;
- Encoder values might get disturbed due to Profibus Slave failure / PLC Bus fault / Cable & Connector issues.
- No control logic was programmed to identify and locate the Profibus device/Network fault so as to eliminate the above problem.
- Hence, it was decided to program new Safety logics to address this failure.

Action Taken:

- Complete program logic for Core-Chuck operation was studied.
- It was searched and identified that Profibus diagnostic block was available which could be incorporated in our control system application software to detect failure of Profibus devices which identifies and generates "Slave fault error bit".
- Logic functioning was tested in offline with Profibus device installed in a test kit.
- The same was programmed in Winder PLC. The "Slave fault error bit" was used as an interlock for the operation of Core Chuck Motor Chuck / Unchuck permissive.

Tangible Benefits:

- Eliminated Core Chuck over travel issue.
- Improved Machine availability.
- Improved Productivity.

7. Finishing Loss Accounting at Winders / Rewinders / Cutters

Preamble:

- The Winding process converts the large parent Jumbo Roll produced on the Paper Machine into customer-sized reels.
- During this process, Finishing Loss is a key parameter to be monitored and controlled to improve the overall Efficiency of the System.

- Reducing/Re-using the Broke is TNPL's core EMS policy.
- Accounting for Finishing Loss gives opportunity to optimize the process.

Problem Faced:

- Stage wise Finishing loss was on an increasing trend and needed to be curtailed in Winder#1, Winder#2, Rewinders and Sheeters.
- Calculated Reel Weight data was only available after conversion till 2017 and it has certain limitations against actual reel weight.
- Limitations such as variations in Basis Weight, Length, Width and Caliper were not considered while deriving calculated Reel Weight data.

Data Analysis & Root Cause

- The variable costs for the paper production had gone up and so, there was a need to optimize the process in such a way to increase the contribution per ton of paper.
- There was no provision to account actual finishing loss due to unavailability of actual reel weighing system.
- It was planned to install online reel weighing system so as to capture the actual reel weight and make them available in ERP to determine actual Finishing loss.

Action Taken:

- Barcode scanner, Online Reel Weighing system and Personal Computer with ERP connectivity was installed in the area near steel slat conveyor before Hydraulic Lowerators of Winder#1 & Winder#2 to account Finishing Loss during 2017 (Figure 13).

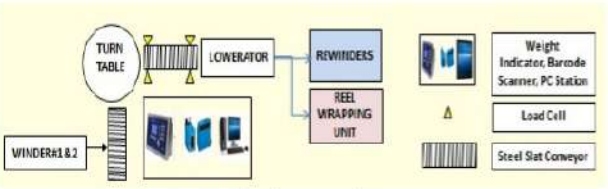

Figure 13: Winder #1&2 Reel Transportation.

- Existing Siemens S7 PLC was used to transport Reels from Winder 7 Meter Floor to Reel Wrapping. This CPU was not compatible to communicate over TCP/IP with PC Station. Hence, a separate PLC was installed (Figure 14).
- Hardwired Signals were exchanged between old and new PLC in such a way to position the Reel on the slat conveyor to
- Collect Reel ID from the Barcode
- Collect Reel weight data from the Weigh Scale and
- Attach the collected data with respect to its Reel ID
- Application software was developed to fetch & validate the reel data from mill ERP system for the scanned barcode;
- Reel weight data available in ERP system is arrived via calculation based on the Caliper data, GSM, Reel length and width.
- Actual Reel weight is compared with the calculated weight available in the ERP data base and is checked for a given tolerance.

Figure 14: PLC Architecture.

- Upon successful verification PC station commands the PLC over TCP/IP protocol.
- The Command received in the new PLC is transferred to the existing PLC in Reel Wrapping through hardwired signals to allow the reel for further transportation.
- Similar Weigh Scales, Barcode Scanners and PC Station with ERP connectivity have also been installed and commissioned in Rewinder#2, Rewinder#3, Rewinder#4, Rewinder#5, Cutter#1, Cutter#2 & Cutter#3 and Cutter#4 to account Finishing Loss at each stage.
- Right measures are being taken to reduce the Finishing Loss by (Ref: Figure 15 & Figure 16).
- Trim Optimisation
- Deckle Optimisation
- Reducing spool end wastages.

Figure 15: PM#1 Finishing Loss Analysis.

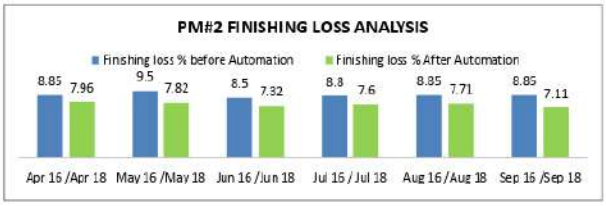

Figure 16: PM#2 Finishing Loss Analysis.

Cost Workings:

- The whole project is commissioned by using in-house resources.
- The total expenditure for the project worked out to be Rs.18, 83,000/-

Tangible Benefits:

- Stage wise Finishing Loss is being accounted properly.
- Average reduction of 0.7% & 1.31 % Finishing Loss is achieved in PM#1 and PM#2 respectively.
- Improved Productivity.
- The approximate cost saving works out to be more than Rs. 2 Crore.
- Increase in Contribution per ton of paper.

8. Improvement in Sheeters / Cut Pack Lines Speed Efficiency

Preamble:

- Finishing House area comprises of 4 Nos. of Sheet Cutters and 3 Nos. of Cut Pack lines for converting Reels into various sizes such as A4, A3, & Folio. These Sheeters & Cut Pack Lines are automated with stand alone Control Systems like Schneider, Siemens – S5 & S7 Programmable Logic Controllers.

Requirements:

- Real time Speed Efficiency monitoring for Sheeters / Cut Pack Lines was not available.
- So, there was a need for Speed Efficiency monitoring of all Sheeters / Cut Pack Lines to improve the Overall Efficiency.

Action Taken:

- Existing Sheeters / Cut Pack Lines PLCs are stand alone so there was a requirement for new PLC to collect data from existing standalone PLCs. A separate Programmable Logic Controller Control system and Hardware were installed for data acquisition (Figure 17).

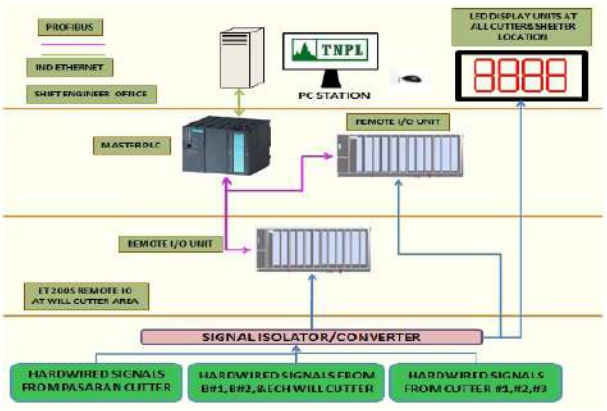

Figure 17: Data Acquisition System Architecture.

- Machine Rated Speed data was collected with respect to the Chopping size.
- Speed Efficiency calculation was programmed in Standalone PLCs for all the Cutters / Sheeters by obtaining machine speed in real-time using the formula;

  1) Speed Efficiency % = (Actual Machine running speed/Design speed for the respective chopping Size)*100

- Calculated Speed Efficiency value in % was displayed in Mega sized LED display unit (Figure 18) at Sheeters / Cut Pack Lines.

Figure 18: Large Size LED display.

- Hardwired Speed Efficiency signals from the Sheeters / Cut Pack Lines Control Systems are connected with Master PLC.
- Day Average Overall Speed Efficiency of Cutters / Sheeters are programmed in Master PLC using the following formula;

  2) Day Average Speed Efficiency = $\int_0^t$ Speed Efficiency (%) / $\int_0^t$ lapsed time (T)

- Calculated Speed Efficiency values in % and the day Average Efficiency values were displayed in a Operator Station installed at the Shift In charge's office (Figure 19 & Figure 20).
- This Project was installed and commissioned during March 2018.

Figure 19: Sheeters & Cutters Speed Efficiency display page.

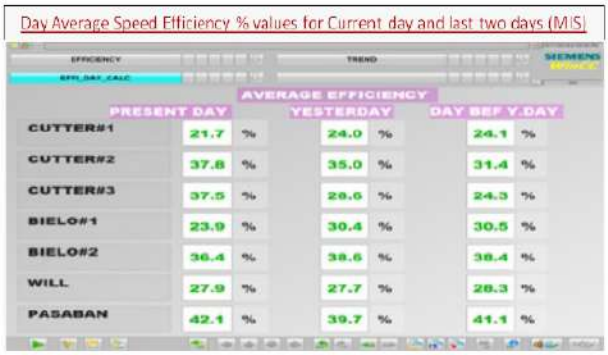

Figure 20: Sheeters & Cutters Speed Efficiency Day Average.

- Trend collection was also made available to analyze past machine performance (Figure 21).

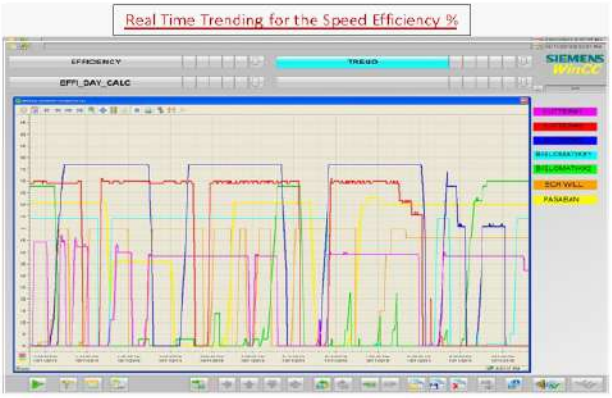

Figure 21: Sheeters & Cutters Speed Efficiency Real-time Trend Display.

- Cutter Machine Speed Efficiency Data is readily available in Excel spread sheet to share with ERP (Figure 22). The information can be made available in the Mill ERP network and Target Benchmark index could clearly be set by referring to historical Machine Utilization data.

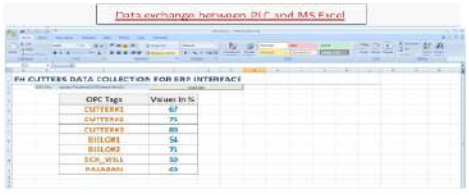

Figure 22: Sheeters & Cutters Speed Efficiency Real-time data on Excel Spreadsheet.

Cost Working:

- Budgetary offer received from a system integrator to develop the above project-Rs.50 Lakhs.
- Cost Incurred to complete the project using In-House resources-Rs.11 Lakhs.

Potential Savings realized-Rs.39 Lakhs.

Tangible Benefits:

- Improved Productivity.
- Continuous Speed Efficiency monitoring led to identification and elimination of unnoticed issues such as;
- Wrapper feeding problem at Bielomatik#2
- Cutter#3 cross cutter knife rough cutting issues at high speed.
- Bielomatik#2 slitter knife reduced life.
- Speed Efficiency of Sheeter and Cut Pack Line are increased as follows (Figure 23);
- Cutter#1 by 9 %,
- Cutter#2 by 9%,
- Cutter#3 by 15%,
- Pasaban Cutter by 12%
- Bielomatik#1 by 14%,
- Will Cutter by 7% &
- Bielomatik#2 by 11%
- Reduced Finishing Loss by eliminating Core end wastages.
- 75% reduction in Contract Sheeters dependency.
- Reduced Cost of Production.

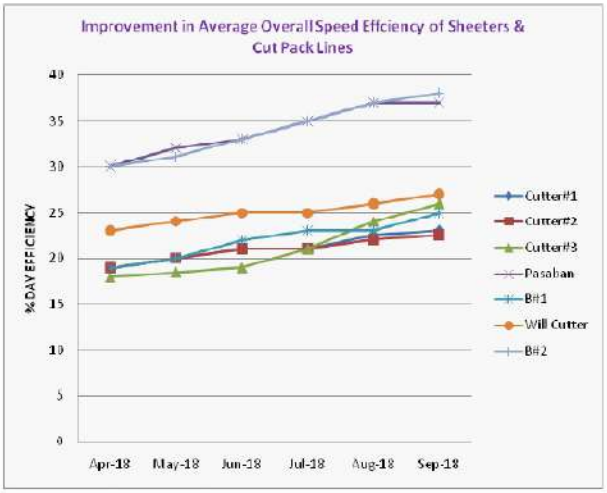

Figure 23: Overall Average Speed Efficiency improvements in Sheeters & Cut Pack Lines

9. Reduction of Sheet Counting Tape Strip Length in Pasaban Cutter

Preamble:

- Pasaban Cutter is a high speed sheet cutter with an installed production capacity of 200 TPD.
- Cut sheets are piled in a pallet with a tape strip inserted for separating 500 sheets so as to avoid manual counting operation (Figure 25).
- 5 Nos. of Tape Inserters are used for automatic tape strip insertion (Figure 24).

Problem Faced:

- Tape Strip Length of 190 mm was found to be more and there was a scope for reduction in Tape Roll consumption.

Figure 24: Pasaban Cutter Tape Inserter

Figure 25: Tape Strips for 500 Sheets

Data Analysis

- Tape insertion is carried out by an Electric Motor. The Tape Insert Start / Stop pulse for the motor operation is sent from PLC.
- Tape strip length could be reduced by modifying the existing PLC logic.
- Ideal length for tape strip was determined and finalized as 110 mm.

Actions taken:

Logic modifications was done to reduce the Tape strip length from 190 mm to 110 mm optimally.

Cost Workings:

Consumption per day = 7 Rolls of Tape Strip

Unit Cost for a Tape Strip = Rs. 400/-

Per day consumption cost=Rs.2800/-

Net Saving per day = 40% x Rs. 2800 = Rs. 1120/-

Tangible Benefits:

- 40% Reduction in Tape roll consumption.
- Rs. 4, 08,800/- Net saving per annum.
- Optimal usage of Resources.

10. Bielomatik#2 PLC Profibus Network Modification:

Preamble:

- Bielomatik#2 is a High Speed Cut Pack line which cuts and packs Copier Grade Reels into A4 reams at a rated production capacity of 200 TPD.
- Process is fully automated with Siemens S7-400 series PLCs and Simotion D445 Drive Controller.
- The Cut Pack action is carried out in three areas in tandem namely Sheeter, Wrapper and Cartonizer.
- The Control Network for data transfer between PLCs and Drive controllers is with Profibus-DP protocol at12 MBPS baud rate.

Problems Faced:

- The Original Global Profibus Network architecture as supplied by M/s. Bielomatik, Germany was in a single stream originating from Sheeter PLC CPU at Node#5 and ending at Cartonizer PLC CPU as Node#12 with 8 devices as shown below (Figure 26).
- Spurious stoppage of Machine occurred due to data collision in one or more devices connected over Profibus DP network

- There was around 228 Hrs of Down time on account of Profibus communication failure in the last 5 years.

Data Analysis & Root Cause

- Diagnosing through Profitrace tool revealed that the Node voltage levels of the devices were below safe operating level (2.5 VDC) which caused slave failure/misbehave.
- The Profibus cable length per network should not exceed 100 Meters as per networking standard at 12 MBPS baud rate which might lead to data loss due to drop in voltage levels.
- Profibus Repeaters were introduced after Node#6 and after Node#1 to improve the node voltage levels.
- Voltage levels of Profibus devices connected in the downstream segment of repeaters were still operating below recommended voltage level. (Figure 27).
- The grounding and shielding were checked and found intact.
- The entire Profibus cable and connectors were replaced.
- The entire Profibus devices power supplies were paralleled to have the same voltage reference level. There was no appreciable improvement in voltage levels.
- Root cause for the drop in voltage levels was because of the network cable length.

Action taken:

- Global Profibus network architecture was modified by making the Sheeter PLC (Node#5) as the central node thereby reducing the farthest node distance from the master to 50 Mtrs (Figure 26).
- Voltage level of all the nodes got increased (Figure 28).
- Later, concurrence was obtained from the OEM and implemented the same.

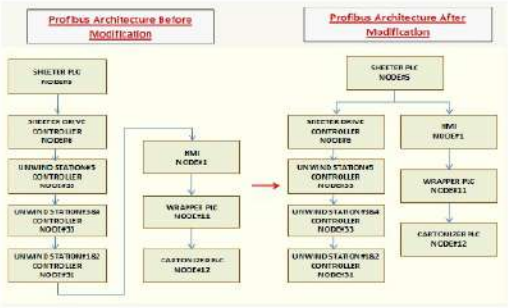

Figure 26: Profibus Architecture of Bielomatik#2 Before and After Modification

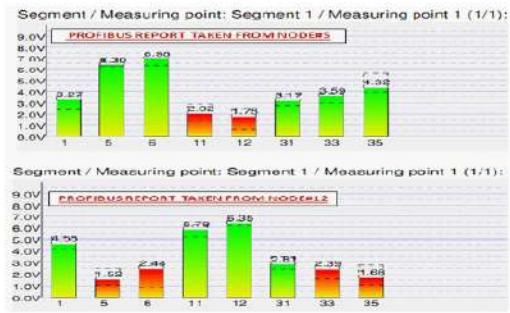

Figure 27: Bielomatik#2 Profibus Slaves Differential Voltage Before Modification

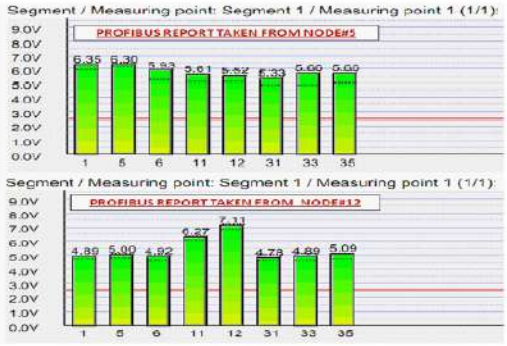

Figure 28: Bielomatik#2 Profibus Slaves Differential Voltage after Modification

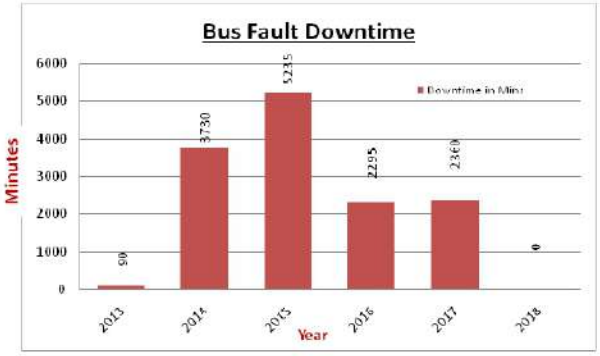

Figure 29: Bielomatik#2 Downtime detail due to Profibus fault.

Tangible Benefits:

- Eliminated Machine Outage on account of PLC Profibus Network Communication failure (Figure 29).
- Smooth Runnability.
- Improved Productivity.

CONCLUSION:

Continuous improvement is the most effective way for manufacturing organization to improve Safety, Quality, Productivity, Overall Efficiency and Competitiveness. Developing rigorous, quantitative and practical scientific solutions is of significant importance and becomes the key for success. By implementing innovative/creative controls, enormous benefits are attained and are achieved by reducing Process variability. Hence, the Plant can be operated with the designed capacity.

The Automation level in a Paper Machine shall distinguish the product quality from one mill to the other. TNPL Automation Team continuously improves / upgrades with the state of the art Automation Systems to enhance the Automation Level for improving overall Efficiency and to cope up with the future Industrial Revolution 4.0.

ACKNOWLEDGEMENT:

The authors would like to thank Mr. S.V. R. Krishnan, ED (O), Mr.K. Thangaraju, CGM (Production), Mr.A.R. Periasamy, GM (Elec), Dr. S. Chinnaraj, AGM (R&D), Mr. B. Mahesh, AGM (Mech), PMC Inst. Team and also TNPL Management for their valuable support in accomplishing the above Project works and in submitting the Paper in IPPTA held at Hyderabad.