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Integration of Electrical and Electronics Systems and Automation Technologies for Enhanced Efficiency, Reliability and Sustainability in the TNPL's Soda Recovery Plant Operation


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Abstract:

This paper presents case studies from Tamil Nadu Newsprint and Papers Limited (TNPL) on optimizing soda recovery plant performance through advanced electrical, electronics, and digital technologies. TNPL installed a three-phase DC-Transformer Rectifier (DC-TR) with a PIACSDC4 controller in the Electrostatic Precipitator (ESP) of the recovery boiler, and thereby 50 % reducing flue gas dust concentration. Modbus communication integrated ESP controllers with the DCS, enhancing the ESP operational efficiency. A PLC-based system monitors 315 KW, 560 KW, and 950 KW motors, enabling proactive maintenance and improving uptime. Additional improvements include replacing limit switches with magnetic sensors for soot blower control, implementing logic schemes to prevent soot blower pipe damage, and implementing technological innovations in the soda recovery boiler. These initiatives have increased reliability, reduced downtime and maintenance costs, and improved energy efficiency, demonstrating significant benefits for the pulp and paper industry.

Keywords: *Automation, Digital technologies, Soda recovery plant, Magnetic sensors, Energy efficiency.*

Introduction

The pulp and paper industry plays a vital role in the global economy, and continuous improvement in operational efficiency is crucial for sustainable growth [1]. The pulp and paper industry is characterized by its energy-intensive operations, necessitating continuous innovations to optimize performance, reduce costs, and enhance sustainability [2]. Among the various components of a pulp and paper mill, the soda recovery plant stands out as a critical asset on the balance sheet. In recent years, the industry has witnessed significant progress in enhancing the efficiency of soda recovery plants by leveraging advancements in electrical, electronics, automation, and digital technology [3]. Tamil Nadu Newsprint and Papers Limited (TNPL) have undertaken various technological advancements and process optimizations across its Soda Recovery Plant and Lime Kiln operations to address these challenges.

This technical article presents a comprehensive case studies conducted at the TNPL to explore the application of the technologies in optimizing the performance in soda recovery plant. This report outlines five key projects that have significantly improved energy efficiency, operational reliability, and cost-effectiveness at TNPL and also the impact of integrating electrical and electronics systems, automation processes, and digital technologies on the overall efficiency and productivity of the unit.

1 Enhancing Energy Efficiency and Operational Optimization in a TNPL's Soda Recovery Boiler through Technological Innovations in Electrostatic Precipitator

The need for energy efficiency in the pulp and paper industry is essential for optimizing operations, reducing costs, and improving product quality while contributing to sustainable development and resource efficiency.

The Electrostatic Precipitator (ESP) is vital operating equipment in recovery boilers and plays a major role in enhancing their operating efficiency. Boosting the corona power of an ESP is a common method to improve its performance. The relationship between specific corona power and collection efficiency is well-established and widely implemented as an upgrade. Selecting a power supply that can efficiently increase corona power output while maintaining high operating reliability is the preferred option.

Traditionally, single-phase power supplies produce a voltage waveform with a significant amount of ripple. The magnitude

of ripple generated by the power supply determines the power that can be supplied to the ESP. However, a relatively new option is the high-frequency three-phase Transformer Rectifier (TR), which has been designed to provide increased power to the ESP field with improved reliability.

TNPL has successfully enhanced the performance of the recovery boiler ESP by replacing conventional single-phase TR with three-phase TR equipped with the PIACSDC4 controller. This upgrade has significantly improved the collection efficiency of the ESP pass for all six fields. The average voltage maintained at 62 kV, compared to the conventional single-phase transformer that produced an average voltage of 42 kV and it has been tabulated in Table 1.

Table 1 Average & Peak Voltage of Single Phase TR & three Phase TR

Date	Single phase TR		Date	Three phase TR	
	Avg volt, kV	Peak volt, kV		Avg volt, kV	Peak volt, kV
10.6.23	42.0	57.0	10.12.23	62.5	63.0
11.6.23	40.8	56.0	11.12.23	61.5	62.5
12.6.23	41.0	55.8	12.12.23	62.9	64.1
13.6.23	43.0	58.0	10.01.24	60.6	62.5
14.6.23	42.0	57.4	11.01.24	65.9	67.8
15.6.23	37.0	55.3	12.01.24	65.8	67.7
16.6.23	41.9	57.6	15.02.24	60.5	62.4
17.6.23	40.6	56.8	16.02.24	61.2	62.8
18.6.23	40.7	56.7	17.02.24	62.3	63.5
19.6.23	42.3	57.4	08.03.24	62.4	63.8
20.6.23	40.4	56.3	09.03.24	62.1	63.2
21.6.23	40.6	56.8	10.03.24	61.9	62.8
22.6.23	40.5	56.4	20.04.24	61.3	62.5
23.6.23	41.3	57.7	21.04.24	62.8	63.5
24.6.23	41.9	57.4	22.04.24	65.4	67.4
25.6.23	42.6	57.4	23.04.24	65.8	67.2

As a result, the ESP's performance has improved, and one ESP chamber out of the three can be stopped without compromising the firing capacity. This stopping of one ESP chamber has led to energy savings of 2.15 lakh units per month (Fig 1), resulting in cost savings of ₹ 6.3 Lakhs per month.

Overall, the implementation of three-phase rectifier transformers with the PIACSDC4 controller has proven to be a successful upgrade, significantly enhancing the performance of the recovery boiler ESP, reducing energy consumption, and generating substantial cost savings.

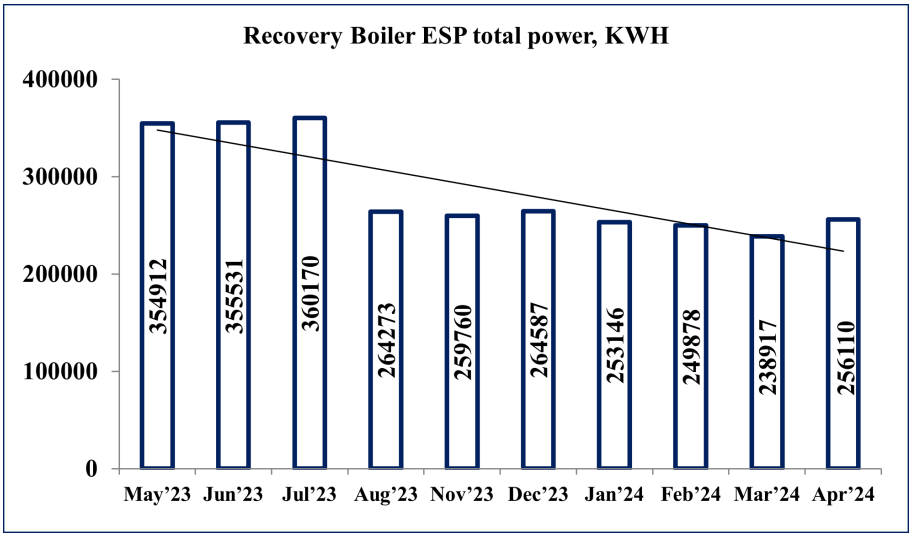

Fig 1. Monthly Average Power Consumption in Recovery Boiler's ESP

1.1 Power consumption and cost saving

- ESP Power consumption
  - Before Recovery Boiler ESP up gradation : 355000 KWH/month
  - After Recovery Boiler ESP Up gradation : 250000 KWH/month. :
- Net power saving = 105000 KWH/month
- Net Cost savings = ₹ 6,30,000/month

This modern technology has significantly, that is, reduced 50 % of the dust concentration in the flue gas at the outlet of the ESP to a mere 50 mg/Nm^3. The use of Modbus communication has connected the recovery boiler ESP A and ESP B chamber controllers to the DCS, enabling operators to easily monitor the ESP status and take corrective actions promptly. This integration has improved the uptime of the system, leading to enhanced operational efficiency.

Overall, the implementation of three-phase rectifier transformers with the PIACSDC4 controller has proven to be a successful upgrade, significantly enhancing the performance of the recovery boiler ESP, reducing energy consumption, and generating substantial cost savings.

2 Implementation of a Logic Scheme to Prevent Soot Blower Pipe Damage: Enhancing Safety and Cost Savings

Soot blowing plays a crucial role as major equipment in recovery boiler operations. In the operation of recovery boiler, the use of long retractable steam soot blowers is essential for maintaining the efficiency of heat transfer surfaces. In long retractable steam soot blowers due to ageing, gear rack teeth on these soot blowers have resulted in an increased risk of pipe damage. If the gear rack fails during forward motion, the soot blower carriage can propel uncontrollably and collide with the boiler wall, posing a safety hazard to nearby individuals and causing significant damage to the boiler. Additionally, the process of removing and replacing damaged soot blower pipes takes over 16 hours, adversely affecting boiler performance.

To address these challenges, a logic scheme has been introduced to mitigate the risk of soot blower pipe damage and improve overall efficiency. The proposed scheme incorporates a logic timer that monitors the forward travel of the soot blower carriage. The total traveling time of the soot blower is set as the timer's set point. During this period, if the home position is detected by the limit switch, an alarm is sent to the Distributed Control System (DCS), warning of a potential soot blower pipe jam. Furthermore, if the home position is not reached within the defined time set in the timer, the logic scheme triggers an alarm on the DCS screen indicating "soot blower over travel". The implementation of this logic scheme requires no additional investment as it can be easily executed as a team work. The benefits from this ingenious project includes a significant reduction in soot blower downtime, prevention of breakdowns caused by pipe blockages, and reduced pipe procurement costs.

The cost savings calculation for this project is based on the reduction in soot blower lance pipe replacements. With an annual requirement of three replacement pipes, the total cost savings amount to ₹ 1.76 lakhs per year. This includes savings in pipe procurement costs, pipe replacement (contract) costs, and manpower engagement costs.

2.1 Benefits to the Company

Soot blower lance Pipe saving Cost:

- Pipe procurement cost : ₹ 1,50,000
- Pipe replacement cost : ₹ 26,000

Total Cost benefit : ₹ 1.76 Lakhs/annum

The logic scheme has been successfully implemented on a trial basis for one soot blower (soot blower-17), and after one month of observation and evaluation, it has been implemented across all 30 soot blowers in the system. By effectively preventing pipe damage and improving operational efficiency, this project contributes to enhanced safety, cost savings, and improved performance in the Pulp and Paper.

3 Replacement of Snap Action Limit Switch by Magnetic Sensor for Enhanced Soot Blower Control: A Cost-Saving Solution

In industrial processes, such as in the Soda Recovery Plant in the Pulp and Paper industry, ensuring efficient and reliable operation of equipment is crucial for productivity and cost-effectiveness. In the case of Soot Blowers used in Recovery Boilers, the control mechanism utilizing snap action double-acting limit switches has posed challenges due to frequent failures caused by water entry and condensation. This resulted in extended downtime and increased costs associated with switch replacements. The objective of this project was to find a cost-effective alternative to the existing limit switch system that would enhance Soot Blower motion controls and reduce maintenance requirements.

Through a detailed study, it was determined that magnetic reed switches, could serve as a suitable alternative for controlling soot blower operations. To validate this solution, a trial implementation was carried out on soot blower no: 24, and over a period of six months, no failures were observed, indicating the reliability of the magnetic reed switch (Fig 2).

3.1 Benefits to the Company

- Cost of One Limit Switch = ₹ 25000
- Cost of Magnetic Reed Switch for One Blower = ₹ 1500
- Net Savings per Blower = ₹ 23500
- For 30 no's of Blowers = ₹ 7,05,000

The benefits of implementing the magnetic sensor solution for soot blower control include (a) reduced downtime, (b) lower inventory costs, (c) decreased soot blower maintenance, and (d) overall cost-effectiveness.

The successful implementation of the magnetic sensor solution for soot blower control not only reduces operational costs but also improves the overall efficiency of the recovery boiler system. The project was implemented in November 2023, and the positive results obtained endorse the cost-saving potential and reliability of the magnetic reed switch solution in industrial applications.

4 Proactive Maintenance and Centralized Energy Monitoring for Critical Equipments in TNPL's Soda Recovery Plant

TNPL has implemented a Programmable Logic Controller (PLC) based system for monitoring motor conditions in the soda recovery plant, specifically for 315KW, 560KW, and 950KW motors. This system includes motor bearing temperature and winding temperature monitors, Motor Vibration Monitoring for both Driven End / Non driven End enabling proactive maintenance of the motors and improving overall uptime. By closely monitoring the motor parameters, potential issues can be identified and addressed before they escalate, ensuring uninterrupted plant operations.

Furthermore, the integration of the soda recovery plant's power consumption Energy Management System (EnMS) data with the Enterprise Resource Planning (ERP) system has been accomplished. This integration allows for easy monitoring of power consumption, facilitating efficient energy management. With access to real-time power consumption data, TNPL can plan and implement energy conservation measures strategically, optimizing energy usage and reducing costs.

Fig 2. Previous Limit switch in soot blower

Present Magnetic Reed Switch in soot blower

From this Centralized Energy Monitoring System, TNPL SRP team identified the following projects such as (a) Provision of VFD for white liquor supply pump 1 & 2 (216 & 217) motor in Causticizer Plant; (b) Provision of VFD for weak black liquor feed pump in evaporator #1; (c) Semi concentrated black liquor agitator motor downsizing at evaporator#1.

From these projects, the cost benefits to the company as follows:

- Total Power Saving : 44 KWH
- Total cost saving : ₹ 20.54 Lakhs/annum

5 Enhanced Efficiency and Cost Savings in Lime Kiln's Limestone Crusher

In Soda Recovery Plant, Lime Kiln area, Stone feeding crusher has been provided with Variable Frequency Drive for smooth starting and avoiding frequent tripping and also motor failure. Using VFD dedicated crusher logic is developed such that sudden jamming of crusher shall be eliminated by forward/reverse operation .Sudden Jamming has been detected by the VFD by continuously monitoring the motor running current/torque so that the VFD gives reverse command and forward command for the preset time delay to release the jam in the stone crusher.

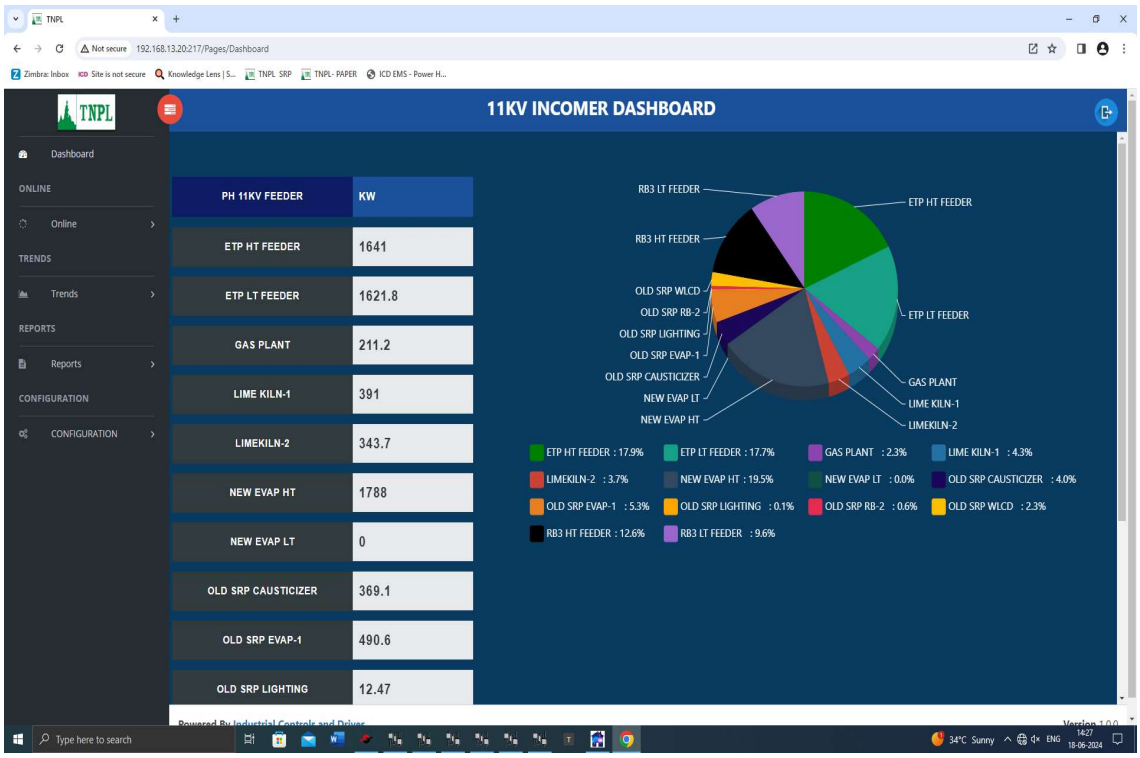

Fig 3. Dashboard View of the Centralized Energy Monitoring System at TNPL

The above said modification ensures (a) uninterrupted stone feeding operations and thereby avoiding the ring formation, (b) avoiding unplanned shutdown of limekiln and thereby ensuring the sustainable white liquor production followed by pulp and paperproduction, (c) reduces maintenance requirements, and (d) optimizes power consumption

Fig 4 VFD for Limestone crusher

CONCLUSION:

TNPL successfully implemented the electrical and electronics systems, automation processes, and digital technologies in optimizing the performance of the soda recovery plant. These initiatives have resulted in significant improvements in efficiency, cost savings, reliability, and safety.

By replacing limit switches with magnetic sensors for soot blower control; the reliability of the system is enhanced, leading to reduced downtime, maintenance costs, and inventory requirements. The implementation of a logic scheme to prevent pipe damage effectively eliminated pipe blockages and minimized procurement and maintenance costs.

Installation of VFD for limestone crusher resolved frequent tripping and motor failures, resulting in improved operational reliability, cost savings, and uninterrupted stone feeding operations. The technological innovations implemented in the soda recovery boiler, such as the DC-TR set, motor monitoring systems, and power consumption integration contributed to enhanced energy efficiency, operational optimization, and reduced environmental impact. It contributed to TNPL's vision of being a sustainable and eco-friendly paper manufacturer.

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REFERENCES

[1] Kulkarni, H. D. "Pulp and paper industry raw material scenario-ITC plantation a case study." IPPTA: Quarterly Journal of Indian Pulp and Paper Technical Association 25.1 (2013): 79-90.

[2] Patel, Parth, et al. "Reducing GHG Emissions from Paper Industry Using Energy Efficient Techniques." IPPTA: Quarterly Journal of Indian Pulp and Paper Technical Association 35.1 (2023): 156-160.

[3] Maheshwari, Manish, and Rajesh Sahasrabudhe. "Energy conservation through automation of processes in pulp and paper industry." IPPTA: Quarterly Journal of Indian Pulp and Paper Technical Association 18.3 (2006): 107.