Confederation of Indian Industry

Best Practices Manual in Paper Sector

Volume 12

Disclaimer

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While every care has been taken in compiling this manual, CII-Godrej GBC accepts no claim for any kind of compensation, if any entry is wrong, abbreviated, omitted or inserted incorrectly either as to the wording space or position in the manual.

The manual is only an attempt to create awareness on Energy, Water and Environmental management and sharing of best practices being adopted in Indian Paper industry and the international cleaner production technologies and how the paper manufacturing units can reach the Best Available Specific Energy Consumption figures in the industry.

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Foreword

It is with great pleasure that I present this Best Practices Manual, a comprehensive guide dedicated to the pulp and paper industry's ongoing pursuit of energy efficiency. As the Chairman of Papertech 2024, I am privileged to witness the launch of this essential resource during our conference, where industry leaders and experts converge to discuss and shape the future of this vital sector.

The pulp and paper industry has always been a cornerstone of economic growth and innovation. However, with the increasing demands for sustainability and environmental responsibility, our industry faces unprecedented challenges. In response, we must continually evolve, adopting cutting-edge technologies and best practices that not only enhance our productivity but also reduce our environmental footprint.

This manual serves as a testament to the collective efforts of our industry to meet these challenges head-on. It brings together an array of case studies highlighting the most effective energy efficiency measures and technologies currently being implemented across the sector. These real-world examples not only showcase the innovation and dedication of our industry but also provide invaluable insights into achieving excellence in energy management.

One of the standout features of this manual is the inclusion of the best specific energy consumption values, both electrical and thermal, achieved by some of our leading paper mills. These figures offer a clear roadmap for others to follow, inspiring continuous improvement and setting new standards for energy efficiency.

As we move forward, it is imperative that we continue to share knowledge and collaborate on best practices. By doing so, we can ensure that the pulp and paper industry remains a leader in sustainable industrial practices, driving progress while preserving the environment for future generations.

I would like to extend my sincere thanks to all the contributors who have made this manual possible. Your dedication and expertise are what make this industry great, and I am confident that this manual will serve as an invaluable tool for years to come.

Let us continue to work together to achieve excellence in energy efficiency and make our industry a beacon of sustainability.

Mr. Ganesh Bhadti
Chairman, Papertech 2024 and
Director-Operations, Seshasayee Paper and Boards Limited

Message From President - IPMA

It gives me great pleasure to introduce the "Best Practices Manual in Pulp and Paper Sector in India Volume 12", an extensive guide that showcases the industry's dedication, creativity, and collective knowledge. The extensive research, teamwork, and commitment of many professionals and stakeholders in the Indian Pulp and Paper sector have culminated in this manual.

The Pulp and Paper Industry in India has long been a vital contributor to our nation's economy, providing essential products while supporting livelihoods across the country. However, with growing global attention on environmental impact and sustainability, our industry faces the dual challenge of maintaining productivity while significantly reducing our ecological footprint. The Indian Pulp & Paper Industry has embraced cutting-edge technology, environmentally friendly practices, and ethical sourcing to make sure that the sector not only prospers but also contributes to the development of a cleaner, more sustainable India.

This manual, which compiles best practices and case studies from across the industry, serves as a beacon for what can be achieved through innovation and collaboration. It highlights the most effective energy-efficient technologies and practices that have been implemented in various paper mills, showcasing the tangible benefits they bring. Additionally, the manual features Best Available figures of the best specific energy consumption values - both electrical and thermal - achieved by leading mills, setting new standards for others to aspire to.

I would like to extend my sincere thanks to all the contributors who have made this manual possible. Your dedication and expertise are what make this industry great, and I am confident that this manual will serve as an invaluable tool for years to come.

Let us continue to work together to achieve excellence in energy efficiency and make our industry a beacon of sustainability.

Mr. Pawan Agarwal
President, Indian Paper Manufacturers Association (IPMA), and
Managing Director, Naini Papers Ltd.

Acknowledgement

We wish to express our sincerest regards to all the stakeholders for their invaluable contributions for this manual.

We deeply express our sincere thanks to the following organizations for sharing the technical information for the identified best practices:

List them in alphabetical order.

- Chandpur Paper Mill
- Eracon Vitrified Pvt. Ltd.
- Filfab Corporation
- Forbes Marshall Pvt. Ltd.
- Ganga Paper Mill
- ITC-PSPD , Bhadrachalam
- J.K. Paper Ltd. Rayagada
- Kolar Paper Mill
- Mist Resonance Engineering Pvt. Ltd
- Naini Paper Ltd.
- Ugam Chemicals

We also sincerely thank the following Technical committee members of Papertech 2024 for their contribution to bringing out the "Best Practices Manual for Pulp and Paper sector, Volume 12".

- Mr. Ganesh Bhadti (Chairman, Papertech 2024 and Director- Operations, Seshasayee Paper and Boards Limited)
- Mr. S.V.R. Krishnan (Executive Director, Khanna Paper Mills Limited)
- Mr. Mukesh Jain (Executive Director Andhra Paper Ltd.)
- Mr. C.S. Kashikar (Chief Operating Officer, Orient Paper & Industries Ltd.)
- Mr. Sidhartha Mohanty (Vice President, ITC Ltd. PSPD)
- Mr. Mahesh Gandhi (Director Venkateshwara Tirumala Paper and Board Pvt. Ltd)
- Mr. Mukesh Kumar Tyagi (Director, Naini Paper Ltd.)
- Mr. Anuj Kumar Tayal (Sr. Vice President, West Coast Paper Mills Ltd.)
- Dr. B.P. Thapliyal (Secretary General, Indian Agro & Recycled Paper Mills Association)
- Mr. Nandakumar D.M. (President Elof Hansson India Pvt. Ltd.)
- Mr. Saurabh Mittal (Director-Sales and Technology, Ivax Paper Chemicals Pvt. Ltd.)
- Mr. D. Radhakrishnan (Chief Manager, Seshasayee Paper and Boards Limited)

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Executive Summary

The Indian pulp and paper industry stands at a critical juncture, where the need for sustainable practices is more urgent than ever. This Best Practices Manual has been meticulously compiled to provide industry stakeholders with a comprehensive guide to the most effective energy efficiency measures currently in practice across the sector. As the industry seeks to balance growth with environmental responsibility, this manual serves as an essential resource for driving improvements in energy performance. By presenting real-world examples and actionable insights, this manual aims to drive the sector towards more sustainable and efficient operations.

The manual was created using data gathered from the energy saving projects implemented by Indian paper industry. It contains 15 case studies, collected from among the leading and most efficient paper manufacturing organizations, the technology suppliers and some case studies in other sectors that have a high replicability potential in the Indian Paper sector. These case studies highlight the diverse approaches taken by different mills to address their specific energy challenges, offering valuable insights into the practical applications of these technologies.

In addition to these case studies, the manual provides comprehensive data on the best specific energy consumption (SEC) values—both electrical and thermal—achieved by leading Indian paper mills. These Specific Energy Consumption figures serve as a critical reference point for other mills aiming to enhance their energy efficiency. The data underscores the potential for significant energy savings across the industry and sets a high standard for operational excellence.

Some of the best SEC values achieved are:

Table 1 Some of the Best SEC figures for different category of Paper mills[1]

	Raw material	Paper product	Best Electrical SEC	Best Thermal SEC
			kWh/Ton FNP	MT steam/MT FNP
Plant 1	Wood	W&P	**985**	**5.14**
Plant 2	Wood	Packaging	**973**	**5.02**
Plan t	RCF	Packaging	**389**	**2.45**

By adopting the best practices and learning from the experiences of the industry leaders featured in these case studies, other mills can replicate these successes, contributing to the overall goal of a more sustainable and energy-efficient industry.

The manual also includes a set of practical thumb rules for optimizing energy use in various systems within paper mills, including

This manual is intended for use by industry professionals and all stakeholders involved in the pulp and paper sector. It aims to inspire ongoing efforts to improve energy efficiency and environmental performance, ultimately supporting the industry's long-term sustainability goals. As the Indian pulp and paper industry continues to evolve, this Best Practices Manual will be an invaluable tool for guiding the sector towards a more efficient and sustainable future.

1 *Based on CII data*

How To Use The Manual

The objective of this manual is to showcase the Best energy consumption figures achieved by some of the leading paper manufacturing units in India and pave the way for the remaining paper mills in the country to achieving similar Energy related Key Performance Parameters (KPIs). The publication also acts as a catalyst to promote activities in the Indian Pulp & Paper industry towards continuously improving the performance of individual units and achieving world class levels (with thrust on energy, water & environmental management).

To set a clear goal for improving the performance and move towards international standards, the best practices adopted in some Indian Pulp & Paper plants and latest technologies from suppliers have been included as a part of the "Best Practices Manual Pulp & Paper Industry".

These best practices may be considered for implementation after suitably fine-tuning the requirements of individual units.

Suitable latest technologies may be considered for implementation in existing and future Pulp & Paper plants for achieving world class energy efficiency. Further investigation needs to be done for the suitability of these technologies for individual plant conditions.

The collated best operating parameters and the best practices identified from various plants need not necessarily be the ultimate solution. It is possible to achieve even better energy efficiency and develop better operation and maintenance practices.

Therefore, Indian Pulp & Paper plants should view this manual positively and utilise the opportunity to improve the performance and "Make Indian Pulp and Paper Industry World Class".

Chapter 1

Best SEC Figures Achieved by the Indian Paper Mills

1.1 Best Available Specific Energy Consumption (SEC) in Paper Sector

Both the raw material being used, and the type of product being manufactured have a deep impact on the energy consumption levels of a paper manufacturing process. The Benchmarking of Paper manufacturing units, hence, has traditionally been a challenging task as the raw materials being used are of different types, especially in Recycled Fibre (RCF) based units as different types of wastepaper may be used in different proportions and moreover the same type of paper can have differing impact on the energy consumption levels depending on properties like Grams per Square Meter (GSM) and Burst Factor (BF). The Confederation of Indian Industries (CII) has made an attempt to arrive at the Best Available SEC figures the energy efficiency levels for paper manufacturing units based on the data available with it from the various sources. This study should be taken as a guideline to realize the lowest achieved SEC values by some of the best Indian Paper mills in India. The study has been done for thermal and electrical energy consumption.

1.1.1 Best Available SEC For Wood Based Paper Mills

A study to identify the Best Available SEC for the Paper manufacturing units making paper from wood has been depicted in this section.

Table 2 Best Available SEC for Wood based industries[1]

S. no.	Raw material	Type of Paper Product	Best Electrical SEC	Best Thermal SEC	Average Electrical SEC	Average Thermal SEC
			kWh/Ton FNP	MT steam/MT FNP	kWh/Ton FNP	MT steam/MT FNP
1	Wood	Speciality	**973**	**5.02**	**1206**	**7.09**
2	Wood	W&P				
3	Wood	Packaging				

Here it may be noted that the mills having imported pulp have not been taken into consideration, as the number of such mills are very less in the country and moreover mills have a distinct advantage of not requiring the energy for raw material cleaning, chipping, depithing or converting the raw material onto Pulp. Based on the data available, the Best Available Elec. SEC for such type of units was close to 626 kWh/T and Best Available Thermal SEC was 2.12 T/T.

From the data collected, for Wood based Paper manufacturing units, a clear comparison can be made between the units that are using the following combinations of Raw material and product:

- **Wood as the primary raw material** to manufacture **Writing & Printing (W&P)** type of paper.
- **Wood as the primary raw material** to manufacture **Packaging grade paper**.

A. Best Available SEC for Wood Based Writing & Printing Grade Paper Mills

A study to identify the Best Available SEC for the Paper manufacturing units making Writing and Printing grade of paper from wood has been depicted in this section. In order to ascertain which processes the units, with the Best Available SEC, have improved, and which processes the rest of the industry may also have an opportunity to improve on, a more thorough analysis of process level specific energy consumption has been conducted. Furthermore, the types of technology that have significantly impacted the energy efficiency levels of the units meeting the best numbers have been determined.

Table 3 Best available Specific Energy consumption for Wood based W&P paper units[2]

	Raw material	Paper product	Best Electrical SEC	Average Electrical SEC	Best Thermal SEC	Average Thermal SEC
			kWh/Ton FNP	kWh/Ton FNP	MT steam/MT FNP	MT steam/MT FNP
Units	Wood	W&P	**985**	**1242**	**5.14**	**7.44**

1 *Based on CII data*
2 *Based on CII data*

Figure 1 Best Available SEC vs Average SEC figures

There is a difference of almost 21% between the Best Available Elec. SEC and the Average Elec. SEC of the remaining Paper manufacturing units, and a difference of almost 30% for Best Available Thermal SEC and Average Thermal SEC of the remaining Paper manufacturing units in this same category which indicates a significant opportunity for technology adoption and further reduction in the variable cost of manufacturing for the remaining units thus becoming more competent in the market.

The difference between the paper manufacturing unit having the least Elec. and Thermal SEC and the other units can be further substantiated by the low SEC of the different process in the paper mill as well.

Table 4 Study of Best Available SEC of different process in a Paper manufacturing unit producing writing & printing paper from wood as raw material[3]

Division	Pulp mill		Paper machine		Chemical recovery	
Unit	kWh/MT	MT steam / MT pulp	kWh/MT	MT steam /MT paper	kWh/MT	MT steam /MT paper
Best Available SEC	222	0.92	415	1.91	142	1.71
Average	406	1.98	570	2.24	227	3.13

Some of technologies adopted in the pulp mill to achieve the Best Available figures are Tri-disc Refiners, Centrifugal pressure screens, High Consistency Pulpers, etc. In the paper machine the installation of technologies like Vacuum blowers, Screw Press, cascading condensate recovery system have made a deep impact on the SEC figures of the unit that was able to achieve the Best Available SEC figures in India.

B. Best Available SEC for Wood Based Packaging Grade Paper Mills

A study to identify the Best Available SEC figures, for the Paper manufacturing units making packaging grade of paper from wood has been depicted in this section. Process level study has also been further examined in depth to determine which processes the units achieving the Best SEC figures have focused on and improved, as well as which processes there is room for improvement for the rest of the industry. Additionally, the types of technologies that have had a major influence on the energy efficiency levels of the units that have met the Best avaialble numbers have been identified.

3 *Based on CII data*

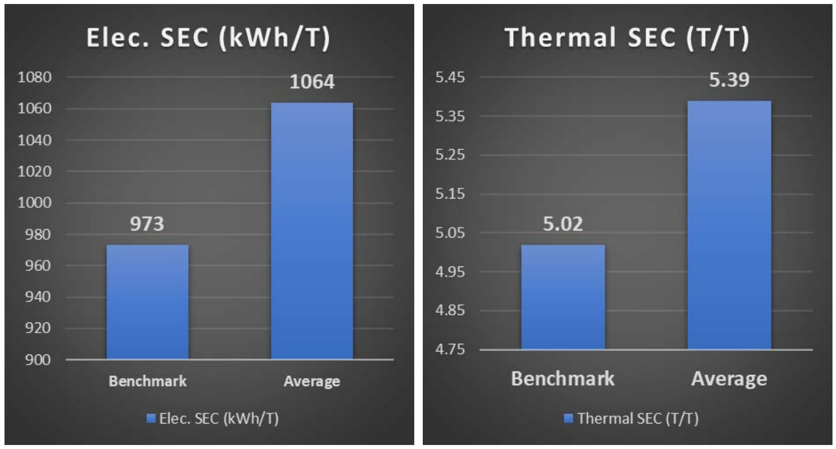


Figure 2 Comparison between Best Available vs Average SEC figures

Table 5 Best Available SEC for Wood based Packaging grade paper manufacturing units[4]

	Raw material	Paper product	Best Electrical SEC	Average Electrical SEC	Best Thermal SEC	Average Thermal SEC
			kWh/Ton FNP	kWh/Ton FNP	MT steam/MT FNP	MT steam/MT FNP
Units	Wood	Packaging	**973**	**1064**	**5.02**	**5.39**

From the previous table the difference between the Best Available Elec. Sec and the average SEC of the remaining units taken into consideration is 8.6% while the difference between the Best Available Thermal SEC and the Average Thermal SEC of the remaining units is 6.9%. The difference between the Best Available SEC and the average figures are not very high, which means that the leading mills in the country falling under this category are somewhat at par with each other in terms of their energy efficiency levels.

A further detailed study shows that the below the Best Available numbers for the different manufacturing processes in these type of paper mills:

Table 6 Best Available SEC for different process in a Paper manufacturing unit producing packaging paper from wood as raw material[5]

Division	Pulp mill		Paper machine		Chemical recovery	
Unit	kWh/MT	MT steam / MT pulp	kWh/MT	MT steam / MT paper	kWh/MT	MT steam / MT paper
Best Available SEC	402	1.39	460	1.98	240	3.16
Average	443	1.52	482	2.09	487	3.88

The plant with the Best Available Elec. SEC for the Pulp mill and Paper machine has adopted technologies like High consistency pulper, Screw press in place of potcher, Tri-disc Refiners, Centrifugal pressure screen, Vacuum blowers, regenerative Braking motor, Shoe Press among a few significant ones. While the units with the Best Thermal SEC numbers in the paper machine has adopted technologies like High Velocity hood, pocket ventilation system, cascading condensate recovery system.

1.1.2 Best Available SEC For RCF Based Paper Mills

A study to identify the Best Available SEC for the Paper manufacturing units using wastepaper or Recycled Paper (RCF) has been depicted in this section. While the type of product and the different grades of wastepaper and the proportions in which the waste papers are mixed in the pulp mill will have a major impact on the SEC figures of a paper mill, there are some technologies that can be adopted among the different types of RCF based mills. The study of Elec. and Thermal SEC for RCF based paper mills is as follows:

4 Based on CII data
5 Based on CII data

Table 7 Best Available SEC in RCF based Paper mills[6]

S.no.	Raw material	Type of Paper Product	Best Electrical SEC	Best Thermal SEC	Average Electrical SEC	Average Thermal SEC
			kWh/Ton FNP	MT steam/MT FNP	kWh/Ton FNP	MT steam/MT FNP
1	RCF	Packaging	**389**	**2.01**	**535**	**2.52**
2	RCF	Newsprint				
3	RCF	Speciality				

The previous table shows the Best Available SEC and average SEC figures for RCF based paper mills. For a more precise and accurate comparison the study of RCF based paper mills manufacturing packaging type of papers has also been done in the next section.

Best Available SEC For Wood Based Packaging Grade Paper Mills

A study to identify the Best Available SEC for the Paper manufacturing units making packaging grade of paper from RCF has been depicted in this section. A more comprehensive examination of process level Best available SEC has also been carried out in order to determine which processes the units with the Best Available SEC have improved and which processes the rest of the industry may also improve on. In addition, it has been shown which kinds of technology have had a major influence on the energy efficiency levels of the units that reach the Best available figures.

Table 8 Best Available SEC of RCF based Packaging Paper manufacturing units[7]

	Raw material	Paper product	Best Electrical SEC	Average Electrical SEC	Best Thermal SEC	Average Thermal SEC
			kWh/Ton FNP	kWh/Ton FNP	MT steam/MT FNP	MT steam/MT FNP
Units	RCF	Packaging	**389**	**564**	**2.45**	**2.98**

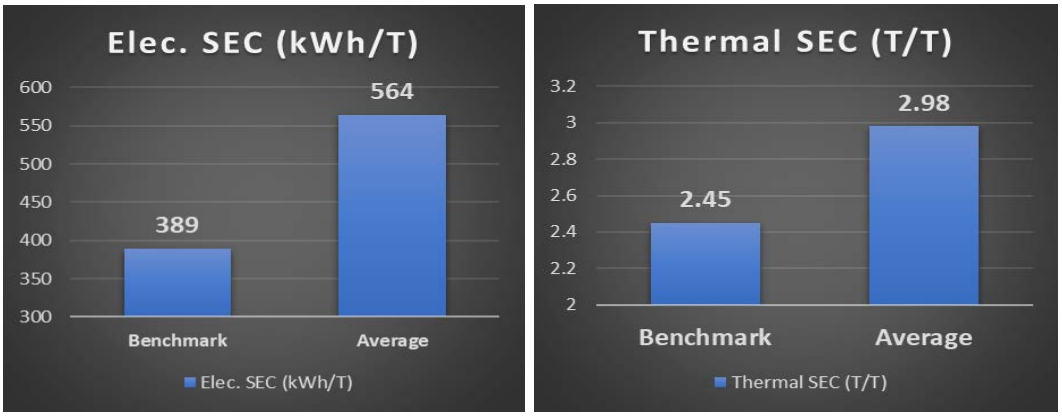


Figure 3 Comparison between Best Available SEC vs Average SEC figures

From the above table it can be inferred that the difference between the Best Available and Average Elec. SEC of the RCFs based packaging manufacturing units is around 31% while the difference between the Best Available and Average Thermal SEC is close to 18%. This indicates a major opportunity for the RCF based packaging manufacturing units to implement the latest energy efficient technologies and bring down their SEC to the Best Available levels.

Some of the technologies that have been adopted by the plant with the Best Available SEC and can play an impactful role, in bringing the average Elec SEC of the paper mills falling in the category close to the Best Available Elec. SEC, are Tri-Disc Refiners, High Consistency Pulper, Centrifugal Pressure Screen while the technologies that have been adopted by the plant with the Best Available Thermal SEC for thermal energy saving include Shoe Press, High velocity hood and Pocket Ventilation system, cascading recovery system.

6 *Based on CII data*
7 *Based on CII data*

Chapter 2

Best Practices from Paper Manufacturing Units

Case Study 1

Efficiency & RE Share Improvement through High Pressure Recovery Boiler (HPRB)

Name of the project

Title: Efficiency & RE Share Improvement through HPRB (High Pressure Recovery Boiler),

Plant: ITC Limited – PSPD, Bhadrachalam

Introduction to plant

ITC Limited – PSPD, Unit Bhadrachalam is India`s largest & most technologically advanced Integrated Pulp & Paperboard manufacturing facility and also pioneer in Ozone bleaching, BCTMP Technology in India. The unit was commissioned in 1979. Having Paper & Paper board capacity of 8 Lakh TPA and BCTMP capacity is 1.2 Lakh TPA. In the unit 55% of total energy is coming from Renewable energy sources. The unit had also been carbon positive, water positive over the years.

Figure 4 ITC-PSPD Bhadrachalam

Background / Baseline Scenario

Soda Recovery Plant is consisting of 3 Boilers. HP Steam is being generated by firing of black liquor solids. Black liquor solids firing capacity is 1975 TPD & steam generation capacity is 280 TPH at 62 ata. RE Share is 47.4%.

Details of the energy saving project

Replaced all existing 3 Soda recovery boilers with HPRB having following key performance indicators.

- Steam generation pressure – 105 ata
- Steam generation temperature – 515 Deg C
- BLS Solids Firing – 2700 TPD

Energy & Coal Savings:

- RE Share improved from 47.4% to 55.05%. (7.65%)
- Coal consumption reduced by 82446 dry basis Tons (13.6%).
- Specific Energy Consumption (SEC) improved by 2.5%.
- HPRB Total Investment – 1100 Cr.

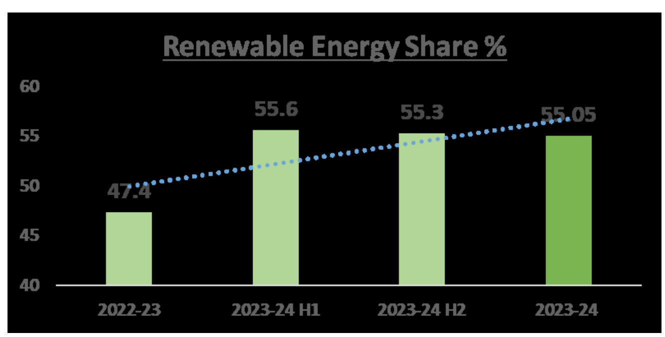


Figure 5 Renewable energy share

Case Study 2

Recovery Efficiency Improvement Through Improved Monitoring

Name of the project

Title: Recovery Efficiency Improvement

Plant: ITC Limited – PSPD, Bhadrachalam

Introduction to plant

ITC Limited – PSPD, Unit Bhadrachalam is India`s largest & most technologically advanced Integrated Pulp & Paperboard Manufacturing Facility and also a Pioneer in Ozone bleaching, BCTMP Technology in India. Unit was commissioned in 1979. Having Paper & Paper board capacity of 8 Lakh TPA and BCTMP capacity is 1.2 Lakh TPA. In the unit 55% of the total energy is coming from Renewable energy sources. The unit had also been carbon positive, water positive over the years.

Background / Baseline Scenario:

The Soda Recovery Plant is responsible for converting the used Black Liquor to White Liquor which is utilized in the Digesters. During the conversion process, there are losses at each stage which were identified and minimized by improving monitoring and identifying optimum process parameters to maximize efficiencies.

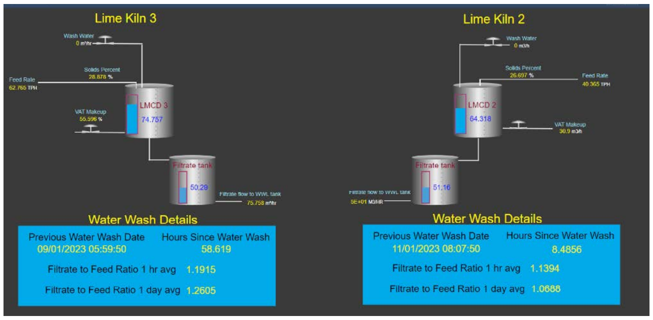


Figure 6 Process flow for Lime Klin 2 and 3

Details of the energy saving project

- Quantified losses across each stage and identified areas of opportunities
- Created online monitoring system for controlling filtrate washing frequency to reduce Weak White Liquor Overflow
- Improved Recovery Efficiencies in Ash Leaching Plant by creation of a golden batch

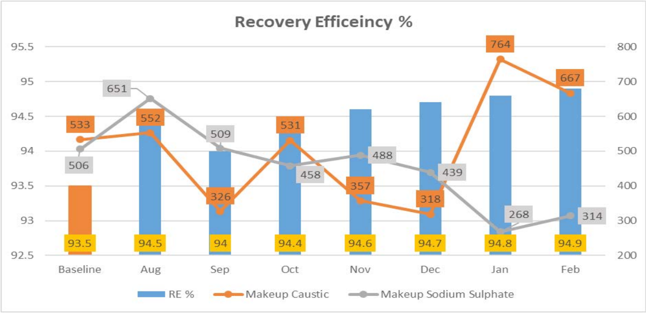


Figure 7 Recovery efficiency %

Energy Savings:

- >1% improvement in Recovery Efficiencies resulting in reduced overall makeup chemical addition
- Reduced load of Effluent Treatment Plant by controlling overflows
- Annual Savings of Rs. 5.4 Cr. per annum

Case Study 3

Plant's Varying Utility KPIs: The Need of Improve, Optimize and Sustain in an Ongoing Manner

Abstract

In today's volatile industrial landscape, maintaining consistent Key Performance Indicators (KPIs) is crucial. Through this case study, we highlight the significant gap between desired and actual performance across KPIs and propose a Digital Sustenance Service (DSS) to address this issue. By leveraging decades of domain expertise, real-time data, preventive-predictive-prescriptive analytics, DSS aims to first improve, then optimize and sustain operational efficiency, reduce energy costs, and align with industry and plant's own benchmarks.

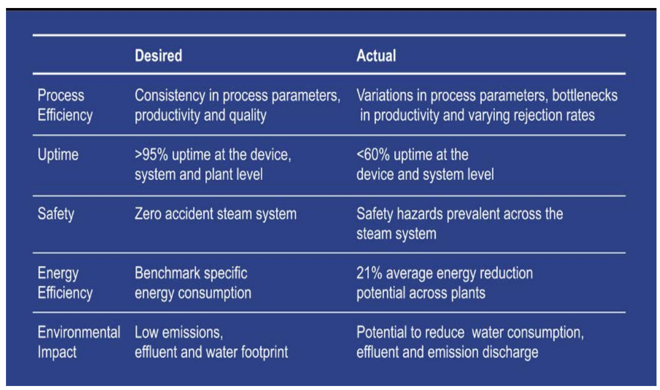
Introduction

The dynamic nature of the industrial sector presents challenges in maintaining consistent KPIs. Fluctuating raw material costs, workforce competency, and product demand fluctuations contribute to this volatility. Energy management, which accounts for 30-55% of the plant's product conversion cost (Cost incurred for raw material conversion to finish product), is critical to the industry's profitability. Despite awareness and efforts to optimize utility usage, a significant gap remains between desired and actual performance levels.

Materials and Methods

This study is based on interactions with thousands of plants and analysis of real time data from hundreds of across various industries. Data on process efficiency, uptime, safety, energy efficiency, and environmental impact were collected. Observations revealed that plant performance deteriorates over time, showing substantial deviations between desired and actual KPIs. The table below illustrates the discrepancy between desired and actual performance across key areas:

This gap is attributed to dynamic process variations, equipment downtime, operating practices, and a lack of expertise. Traditionally, plant KPIs are monitored as static numbers, but digitally connected sites reveal that these parameters vary minute by minute. This variation is both a problem and an opportunity for optimization.



	Desired	Actual
Process Efficiency	Consistency in process parameters, productivity and quality	Variations in process parameters, bottlenecks in productivity and varying rejection rates
Uptime	>95% uptime at the device, system and plant level	<60% uptime at the device and system level
Safety	Zero accident steam system	Safety hazards prevalent across the steam system
Energy Efficiency	Benchmark specific energy consumption	21% average energy reduction potential across plants
Environmental Impact	Low emissions, effluent and water footprint	Potential to reduce water consumption, effluent and emission discharge

Figure 8 Desired vs Actual impact on KPI

Understanding Dynamic KPI Variations

Conventionally, all plant KPIs have been monitored as static numbers. However, digitally connected sites have demonstrated that these parameters and KPIs vary not only day to day but also hour to hour and even minute to minute. Trends in simple parameters like feed water temperature (see image below) of boilers in different plants visually depict this variation.

This variation is not confined to a single parameter but applies to various KPIs, including boiler efficiency, moisture in a product, specific steam consumption of a paper machine, and emissions from a boiler stack exhibiting significant variation, as shown in figure.

Such variance presents both a challenge and an opportunity for optimization and improvement. Traditionally, most measurements and logs have been manually collected or stored locally in spreadsheets and SCADA software.

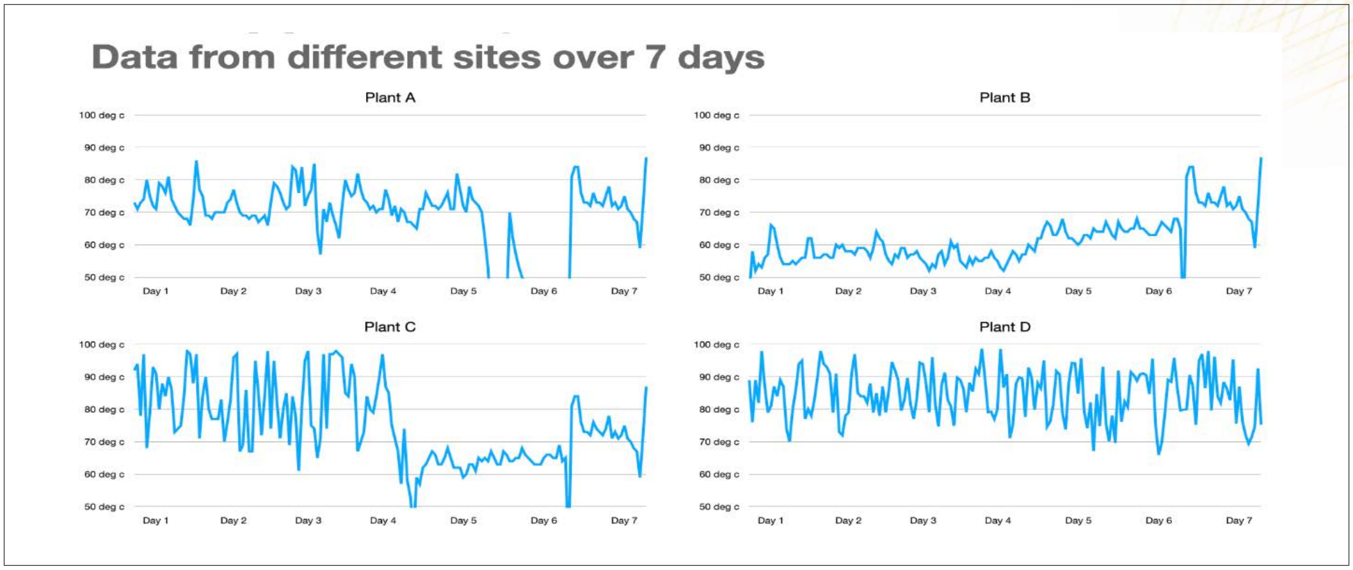


Figure 9 Trend of Different Parameters over 7 days

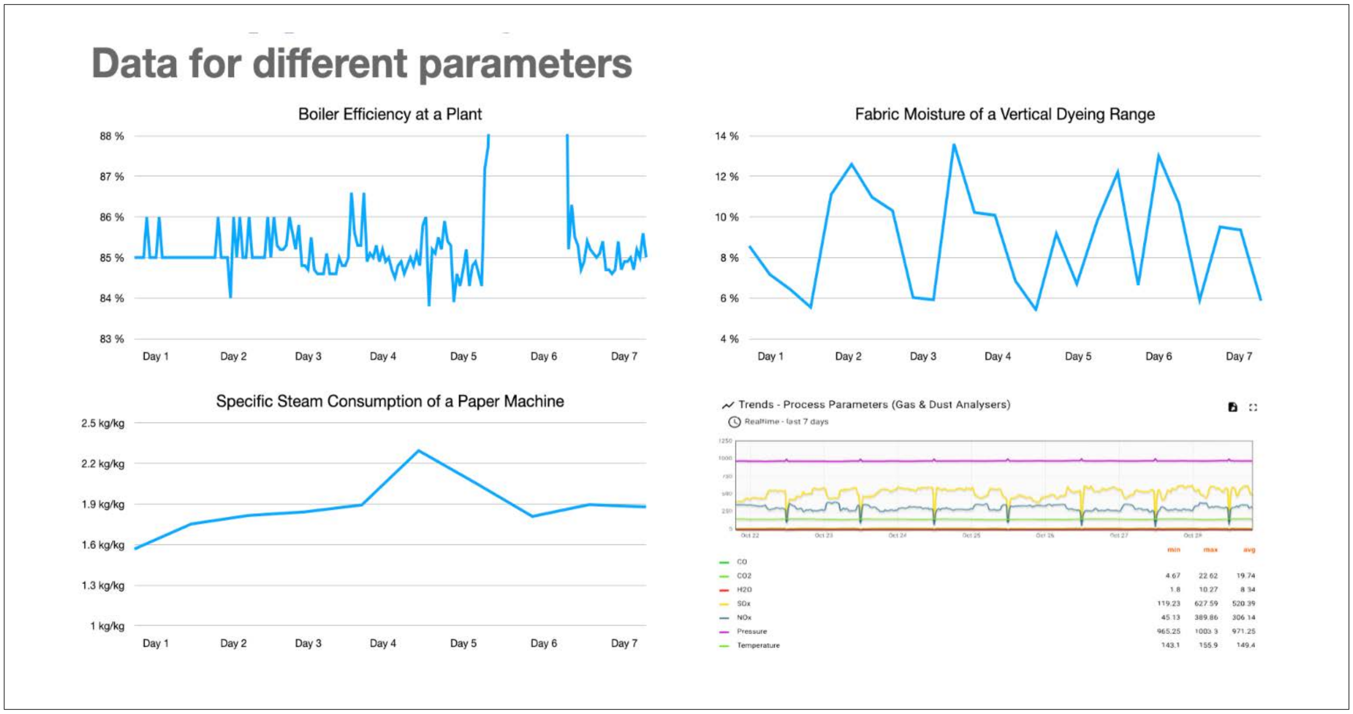


Figure 10 Trend of Different Parameters

Digital Sustenance Service (DSS)

Real-time data from various industries indicates that merely installing a product or solution does not guarantee sustained KPI performance. Variations in plant performance arise from changes in plant load, product mix, and operational practices. DSS addresses these variations through a combination of credible domain knowledge, real-time data collection, predictive analytics, and direct engagement with plant teams.

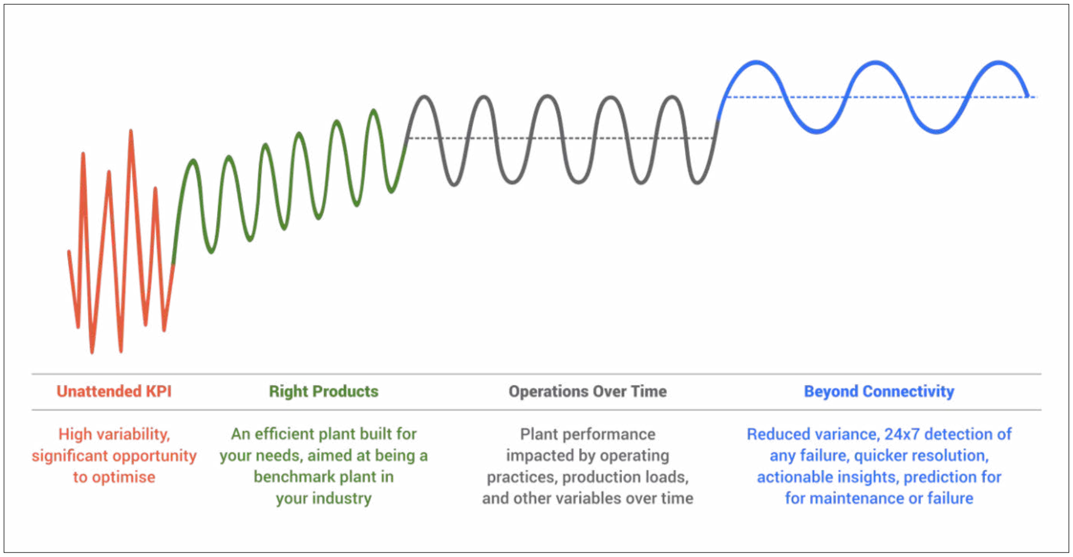


Figure 11 Changes in variation of operating parameters

The red curve in the graph shows the highest scope for improvement and reduced variation when the right product is installed. However, to achieve benchmark performance with optimized variation, continuous improvement through domain knowledge and handholding of plant teams is essential. DSS provides a comprehensive approach to managing and optimizing dynamic KPIs, enhancing plant productivity, profitability, and sustainability.

Case Study

In this case study, the Board paper plant (North India based), having production capacity of 250 TPD through Digital Sustenance Service systematically KPI has been improved and sustain using the domain expertise real time data monitoring and ongoing engagements. Below are the results:

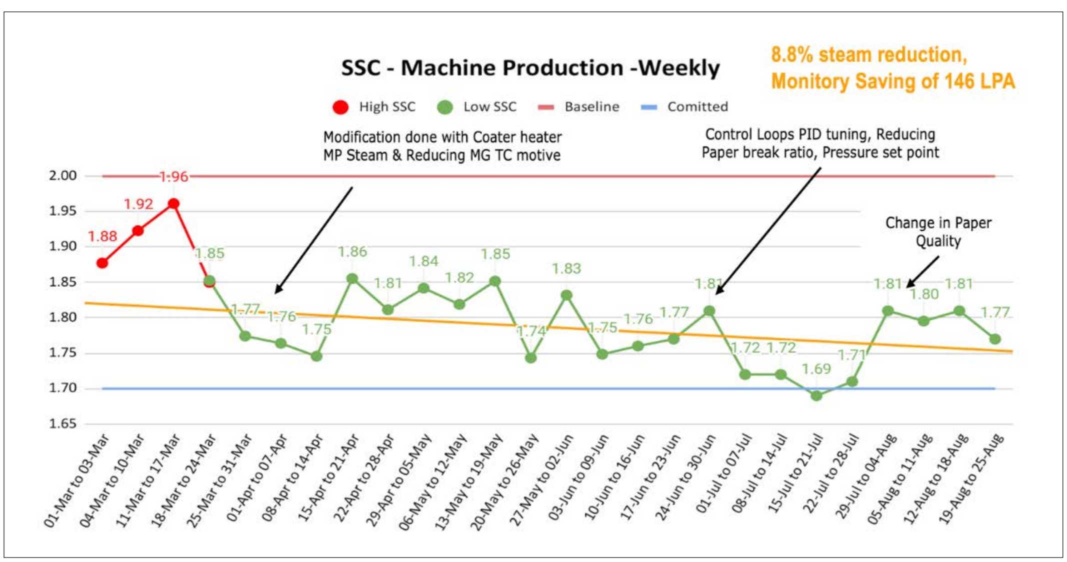


Figure 12 Trend of SSC on Weekly Basis

Summary of Key Point Indicators:

Table 9 Summary of KPIs

Parameter	Unit	Before	After
Production **GSM** **Speed**	TPD mpm	205 230-450 150-200	215 230-450 150-200
Specific Steam Consumption	Kg / Kg of Paper	2 - 2.2	1.85 - 1.95
Condensate Recovery Factor	%	81%	80-82%
Steam-Condensate Control Valves Controllability	%	PCV - 80% LCV - 52% DPCV - 20%	PCV - 91% LCV - 65% DPCV - 62%
Paper Break ratio (Nos / Day and Time)		5.6 ton/hr during paper break	3.7 ton/hr during paper break
MP steam optimization in Coater		95 Ton/day MP steam used in Coater Heater	Reduced to 50-55 Ton Steam per day

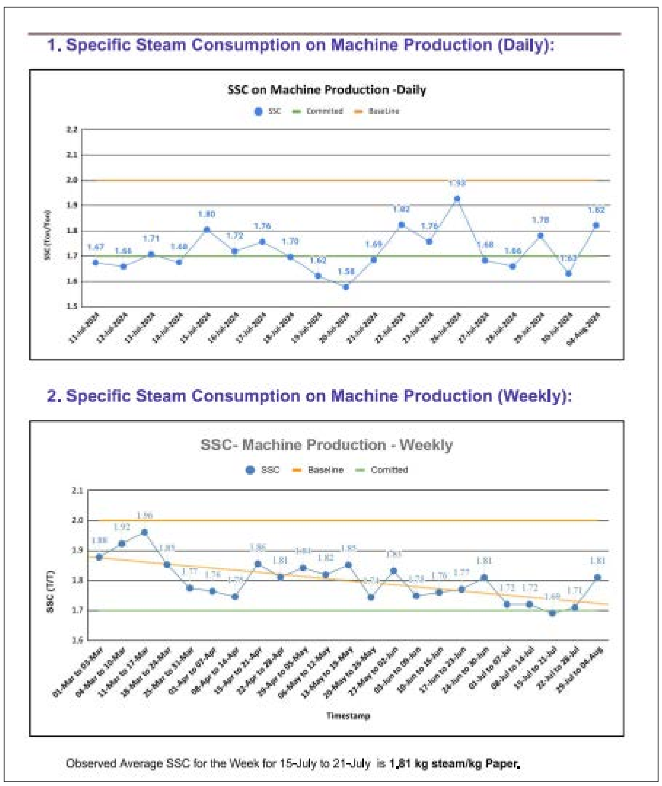


Figure 13 Trend of SSC on daily and weekly basis

5. Steam Loss During Paper Breaks:

Date	Total Paper Break(Min)	Number of Paper break	LP Steam With Paper Break	Steam Without Paper Break	Total LP Steam	Remark
29-July-2024	0	0	0	339	339	
30-July-2024	0	0	0	314	314	
31-July-2024				0		Plant OFF
01-Aug-2024				0		Pant OFF
02-Aug-2024				0		Pant OFF
03-Aug-2024	900	2	49	112	161	Shift 2 & 3 Plant off
04-Aug-2024	0	0	0	359	359	

- Observed higher paper breaks on 03-Aug with steam loss of 49 Ton.

6. Control Loop Uptime:

Pressure Loops Uptime		Differential Pressure Loops Uptime		Level Control Loop	
PRESSURE LOOPS	UPTIME (+-5% Tolerance)	DIFFERENTIAL PRESSURE LOOPS	UPTIME (+-5% Tolerance)	LEVEL LOOPS	UPTIME (+-5% Tolerance)
PCV_101	38.19	DPCV_101	0	LCV_101	55.85
PCV_201	91.99	DPCV_201	6.74	LCV_201	82.55
PCV_301	94.42	DPCV_301	40.4	LCV_401	61.37
PCV_401	98.65	DPCV_401	1.5	LCV_501	74.33
PCV_501	84.13	DPCV_502	8.32	LCV_601	99.66
PCV_601	94.58	DPCV_601	16.92	LCV_901	99.37
PCV_701	90.98	DPCV_701	26.28	LCV_1001	85.75
PCV_801	65.1	DPCV_801	17.93	LCV_1201	89.63
PCV_901	99.01	DPCV_901	18.15	LCV_1601	47.38
PCV_1001	97.56	DPCV_1001	80.89	LCV_1701	79.6
PCV_1101	87.57	DPCV_1101	0.11	LT_VR	10.79
PCV_1201	96.33	DPCV_1201	24.3		
PCV_1301	92.33	DPCV_1301	23.9		
PCV_1601	97.98	DPCV_1601	98.86		

Note - Above uptime is calculated by considering the ±5% Tolerance value

1. **Average Pressure Loops uptime - 92%**
2. **Average Differential Pressure Loops uptime - 28%**
3. **Average Level Control Loops uptime - 72%**

Figure 14 Report on different parameters

Conclusion

Dynamic KPI management is essential and survival going forward for productivity, profitability and sustainability in the industrial sector. Forbes Marshall, with its seven decades of domain knowledge, offers Digital Sustenance Service for long term association. This Service begins with designing or redesigning utility keeping plant process at a centre, provides technology which meets the need of application, Establishing right O&M practices and ensures adherence and by understanding the variations of KPIs, start systematically improving and sustaining. This approach leads to enhanced operational efficiency, reduced energy costs, and sustained KPI levels, aligning with industry and plant-specific benchmarks and best practices.

Case Study 4

Installation of Regenerative Braking motor for paper rewinder

Name of the project

Title: Regenerative Braking motor

Plant: Kolar Paper Mills, Tirupati

Kolar Paper Mills owns and successfully operates a paper mill at Tirupati, Andhra Pradesh, India. It is capable of producing 270 TPD of kraft and fluting/corrugated medium paper.

Background / Baseline Scenario:

When in operation, paper mills consume large amounts of electricity, and the paper-making industry is recognized for its energy-intensive procedures. One important area of interest is the rewinder sector, which is where large paper reels are coiled into smaller rolls for distribution and further processing. The braking mechanisms of traditional rewinding systems lose energy as heat, resulting in higher energy consumption and inefficiency.

Figure 15 Paper Rewinder Brake Drum

Big parent rolls of paper are divided into smaller rolls or sheets so that a conventional paper machine rewinder can distribute and process them later. After being unwound from the parent roll, the paper is cut to the necessary width, then rewound onto smaller cores. In this process, the tension and speed of the rewound paper are controlled by a brake device.

Here is a brief description of how a paper machine rewinder with a conventional braking system operates:

Unwinding - The parent roll, a large paper roll, is placed onto the unwinding portion of the rewinder. The parent roll unravels when the paper goes through the machine.

Cutting - After being unwound by a cutting machine, the paper is sliced into thinner rolls or sheets based on the specifications for the final product.

Rewinding - The cut paper is then wound around smaller cores. After the cores are placed on the rewinding shaft, the paper is wound around them. Precise tension control is required to guarantee that the paper is coiled consistently and tightly onto the core throughout the rewinding process.

Braking system - In a standard braking system, a mechanical brake mechanism (shoe brake) controls the speed and tension of the rewinding operation. The braking mechanism applies friction to slow down the spinning of the rewinding shaft and create the necessary tension to guarantee that the paper is wound evenly and wrinkle-free.

As the mechanical braking system slows the rotation of the rewinding shaft, friction converts the kinetic energy of the spinning shaft into heat. As this energy dissipates into the surroundings, it is essentially squandered as heat.

Frequently, the braking system is operated either manually or automatically, depending on the specific configuration. The operator or the control system adjusts the braking force to maintain the required tension and speed of the rewinding operation.

Finished rolls – The smaller rolls of paper are taken out of the rewinder when the rewinding procedure is finished and are prepared for distribution, packing, or additional processing.

Conventional braking techniques have limits in terms of energy efficiency, but they are good at managing tension and speed. Wasted energy is the amount of energy lost while braking as heat. Regenerative braking, which tries to recover and repurpose the energy that would otherwise be lost as heat, is useful in this situation.

Proposed System

In order to solve this issue, the paper mill partnered with an energy-efficient engineering firm to install a rewind with a regenerative brake motor during the process of commissioning. Regenerative brake motors will be installed as part of the project in place of the traditional braking systems. These motors have the ability to run backwards when braking, converting the kinetic energy of the rotating reel into electrical energy that can be used within the mill or fed back into the power grid.

The braking mechanism in a regenerative braking system is made to operate in reverse while applying pressure, transforming the spinning shaft's kinetic energy into electrical energy. Rewinding is made more energy-efficient by the captured energy, which can subsequently be utilized inside the building or fed back into the power system. Paper machine rewinding operations can be made more sustainable and effective with the use of regenerative braking devices, particularly in energy-intensive sectors like paper manufacture.

Figure 16 Unwinder with Regenerative Braking motor

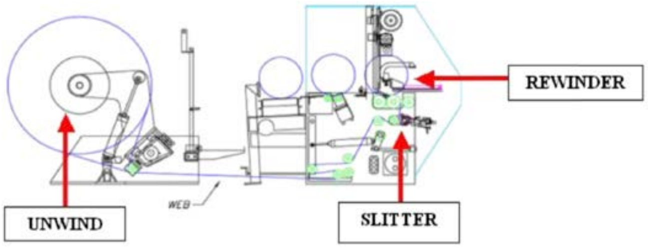


Figure 17 Rewinder, slitter and Unwinder arrangement

Reference Case Study:

The power saving achieved by the plant with regenerative braking system is depicted below in the table:

Table 10 Power consumption with regenerative braking

Sr. No.	Description	Power consumed, KW
1	Front drum and rear drum motor of Rewinder	129
	Description	**Power Generated, KW**
2.	Regenerative Braking motor on unwinder	110
	Net Power consumed, KW	19

Case Study 5

Stock parameter Optimization through CLC

Name of the project

Title: Stock parameter Optimization through “CLC” (Close Loop Control)

Introduction to plant

J K Paper Limited, Unit: JK Paper Mills - is located at Jaykaypur, District: Rayagada, Odisha. JK Paper Mills is the flagship company of JK Organization was established in 1938 and JK Paper Mills, an integrated Pulp & Paper Mills was setup in the year 1962 with initial capacity of 18000 TPA at Jaykaypur in the District of Rayagada (Odisha).

JK Paper Mills is a manufacturer of Pulp, uncoated and coated quality writing and printing papers. It is the First Pulp & Paper Industry in the country to certify with ISO-9001 Quality Management System, ISO-14001 Environment Management Systems and ISO-45001 Safety Management Systems by M/s. DNV, Netherlands.

The Mill has now adopted an integrated Quality, Environment, and Occupational Health & Safety Management System. And also J.K. Paper Mills has adopted TPM concept from JIPM, Japan as a management tool for continual improvements in all the systems. JKPM has achieved Excellence.

Background / Baseline Scenario

Pioneering Industry 4.0: The emergence of Industry 4.0 has opened the possibility of comprehensive monitoring and analysis across various industrial operations. Leveraging digitalization and data-driven approaches, JK Paper harnessed the power to closely observe control loops through a microscopic lens. JK Paper is the 1st Indian Paper industry to implement this advance analytics approach of loop tuning. The features includes:

Efficiency and Time-Saving: Control loop tuning software automates the tuning process, reducing the time and effort required to optimize control systems

Accuracy and Consistency: Software-based tuning algorithms are based on advanced mathematical models and optimization techniques, ensuring a higher level of accuracy and consistency compared to manual tuning

Adaptability: Modern control loop tuning software can handle various control system configurations and respond to dynamic changes in processes.

Data-Driven Decision Making: Control loop tuning software can leverage data analytics and historical process data to make informed tuning decisions.

User-Friendly Interface: Allowing engineers with varying levels of expertise to tune control loops effectively.

A focus on maximizing efficiency, a thorough loop analytical analysis involving 22 critical parameters that influence loop performance. To rectify the underperforming control loops, a strategic decision was made to collaborate with a technology service provider equipped with solution software tailored to analyse and diagnose loop behaviour across our plant. This software embarked on an intricate analysis of all control loops, yielding comprehensive reports for each. Among the discovered insights, control loops were ranked based on their significant impact on process parameters.

Details of the energy saving project

Replaced of all existing 3 Soda recovery boilers with HPRB with following key performance indicators.

- Steam generation pressure – 105 ata
- Steam generation temperature – 515 deg Cel
- BLS Solids Firing – 2700 TPD

A technology service provider was on boarded for loop performance management system. The results revealed that an impressive 79% of control loops were operating optimally, leaving a 21% subset requiring attention due to their diminished performance, as indicated by the average absolute error – as a key performance indicator (KPI).

Prototype Case:

One prominent case involved the deaerator pressure control loop, which exhibited considerable variation. In response, an adaptive tuning approach was employed to fine-tune this loop, ensuring optimal responses across various operating conditions. The outcome was a remarkable decrease in the average absolute error within the control loop. This tuning not only resolved performance issues but also translated into tangible savings. Notably, the efficiency gains achieved through loop tuning led to an impressive annual cost reduction of Rs 23 Lacs.

Figure 18 Monitoring Parameters

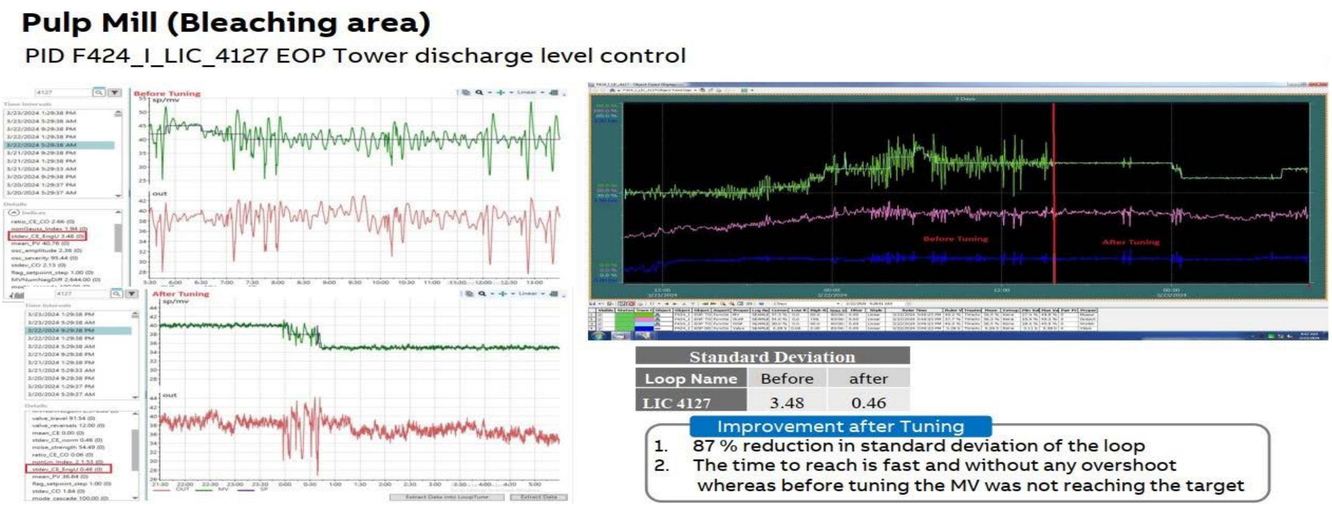


Figure 19 Trends of different parameters monitored

Conclusion:

The integration of control loop tuning software through the prism of Industry 4.0 has propelled our operational efficiency to new heights. By scrutinizing control loops with granular precision and addressing performance degradation through data-driven insights, we have not only optimized operations but also demonstrated the power of technology in driving substantial cost savings. This endeavour signifies a significant step toward realizing the potential of Industry 4.0 and its capacity to revolutionize industrial practices.

Case Study 6

Green Liquor Desilication by CO2 absorption

Description: Green Liquor Desilication by CO2 absorption

Introduction

Green Liquor Desilication was adopted first time at Naini Paper and it was successfully commissioned and became operational.

Removal of Silica from Green Liquor was carried out with absorption of CO2

Project (Purpose)

- Removal of Silica in Recovery operation is challenging Task. Studied and lab trials were done to establish the results.
- Project was taken up in large scale and with Necessary equipment's, Reactor system was introduced for CO2 absorption in GL.

Project Details

- Desilication Methodology stands for Removal of Silica in Raw Green Liquor with help of Measured CO2 absorption.
- PH is the main indicator of Desilication. PH needs to be brought down to below 9.3 to 9.2.
- Reactor system was suitably design to achieve the max. absorption of CO2 to precipitate Silica from RGL.

Table 11 Milestone Achieved

Milestone Achieved		
Item	**Major Events / Milestones**	
1	Silica Removal Achieved	More than 60 % by weight
2	Lime mud dryness improved.	More than 4%
3	Gl TSS were dropped down	From 1200 to 500 ppm
4	WL filtration Yield improved	More than 3%

Case Study 7

VFD installation in vacuum pump

Project: Energy Saving by VFD installation in vacuum pump

Introduction

Evaporator –7th effect Multiple Effect evaporator with 04 Finishers as a Lamella from Finland, Andritz were installed and were successfully commissioned on Oct-21 with 6.3 Steam economy. Product concentrations achieved 70 %

Online Sequence change over from Finishers to 4th effect with all control loops were developed with ABB.

Project (Purpose)

Cost effective measures – Identification and Implementations of the Energy saving potential scheme.

Project Details

On checking the operational efficiency of the Vacuum Pump it was observed that Energy saving could be possible if VFD will were to be installed and Vacuum pump's rpm were to be controlled. Trials were done with VFD and better results were achieved as expected. Hence, a new VFD was installed and energy reduction was achieved.

Table 12 Milestone Achieved

Milestone Achieved		
Item	**Major Events / Milestones**	
1	Smooth Operation	Trouble free Start and Stop
2	Power saving Achieved	720 KWH/HR

Table 13 Cost Benefit Analysis of the project

Sr. No.	Parameters	Unit	Before	After
1.	Power	kWh/Day	1680	960
2.	Monetary benefits	INR Lakhs/annum	15.12	
3.	Investment	INR Lakhs	2.52	
4.	Payback	Months	Less than 2 Month.	

Case Study 8

Installation of Waste Recycling Plant in RCF based paper mills

Title: Waste Recycling Plant

Background / Baseline Scenario:

Environmental concerns over the disposal of discarded plastic are growing. Out of 15 million MT of paper produced worldwide, around 5 million tonnes, or nearly one-third, are produced in India using wastepaper, which inevitably contains undesirable items like plastic, metal, and leftover fibre. These mills produce a lot of solid waste (7–10% of total production capacity), which varies in grades and types and creates a lot of garbage and pollution for the environment and paper mills.

Over 700 recycled paper factories in India produce over 20,000 metric tons of solid trash per day. This garbage is burned or landfilled, which greatly contributes to the current global climate change catastrophe.

Proposed System:

The goal is to apply the Waste to Zero Waste idea by eliminating this solid waste and reducing it to a significant amount through the application of a circular economy method. With the help of modern technology, this dangerous and unsegregated solid waste may be transformed into environmentally friendly products like envoFUEL and envoBRIQ, which can be utilized as a cheap and sustainable source of energy for heating.

With daily capacity of 7000L, envoFUEL can be utilized for industrial heating applications such as boilers, furnaces, and similar applications. With daily capacity of 18MT, envoBRIQ can be utilized as a biochar substitute in the agriculture business and as a substitute for dangerous coal.

The technique is unique in that it completely replaces hazardous fossil fuels by producing eco-friendly briquettes and ZERO WAX liquid fuel from hazardous trash with increased processing capacity

Additionally, it features a continuous monitoring system that tracks and monitors each and every stage of the envoPROTECT FutureFactory App process utilizing machine learning and IOT technologies.

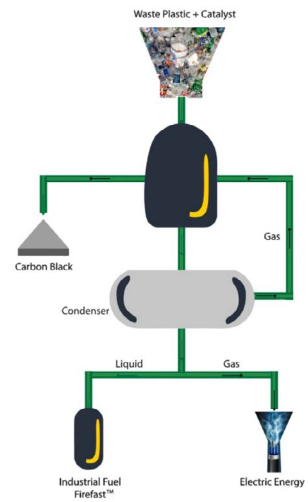


Figure 20
Proposed Pyrolysis process

Reference Case Study:

India's first waste-to-energy plant was built at the Ganga Paper Mill to reduce transportation costs, greenhouse gas emissions, and the automatic burning of solid waste that was put in the paper mills' open landfill grounds since it was exposed to direct sunlight. The way to transform this trash into environmentally friendly goods like biomass briquettes and biofuels that can be utilized for additional heating purposes. Since the procedure produces no additional waste, it is regarded as the most environmentally responsible option because it promotes a circular economy.

Table 14 Cost Beneficial Analysis of the project

Parameter	UOM	Value
Capacity of Waste Recycling	Tons/day	36
Gross Calorific Value of Biofuel	kCal/kg	10,600
Quantity of Biofuel Generated	L /day	7000
Equivalent Savings in Conventional fuel	L/day	7000
Annual Savings in Conventional fuel	KL	2100
Annual Monetary Savings	INR	5 CR
Total Investment	INR	2 CR
Payback period	Months	24

Notes:
The parameters mentioned above in the table are for both capacities of recycling 12MT & 24MT solid waste everyday

Case Study 9

Hydro flow Technology

Name of the project

Title: Hydro flow Technology

Application Sector

This particular technology is having application across various industrial sectors such as Manufacturing, Process, Metallurgy, Foundry, Ore processing, Pulp & Paper, Steel mills, Automobiles, commercial.

Background / Baseline Scenario:

Hydro flow gives a solution for scale deposition problem. In piping system as well as equipments where water flows, the problem of scale deposition is very severe. The pipelines, heat exchangers, pumps, reactor coils, etc. gets scale deposition on the inside surface, which hinders proper flow, temperature and pressure required to run the plant efficiently. Existing process employed to solve this problem requires use of hazardous chemicals dosing, mechanical cleaning, and acid cleaning. These processes are time consuming, labour intensive and may cause damage to the system.

Proposed System:

Revolutionizing Water Treatment with Hydro flow Technology

Detailed Description of the Technology:

Hydropath's pioneering technology presents a chemical-free and environmentally responsible solution to address the persistent issue of scale deposition. Operating on a principle grounded in the fundamentals of fluid dynamics and controlled crystallization, Hydropath's systems utilize the power of hydrodynamic oscillations to inhibit the formation of scale and control biofouling. This breakthrough technology ensures the interior surfaces of pipelines, heat exchangers, pumps, and other industrial equipment remain free from unwanted deposits, thus optimizing their performance.

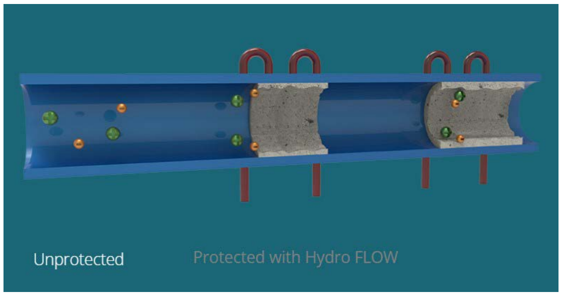


Figure 21
Scale formation on unprotected Pipeline

Concept and Working Principle:

Hydropath's technology leverages electronic frequency to create an environment where suspended particles remain in a state of suspension rather than adhering to surfaces. By applying these oscillations at varying frequencies and amplitudes, scale formation is hindered. The system effectively enhances the coagulation process, preventing scale crystals from adhering to equipment surfaces.

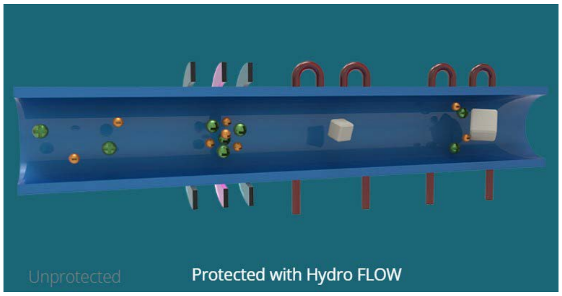


Figure 22
Pipeline after installation of Hydro Flow

Factors Affecting Performance:

The performance of Hydropath's technology is influenced by factors such as flow rate, temperature, and water chemistry. These aspects are meticulously considered during system design to ensure optimal performance tailored to each application.

Advantages and Disadvantages:

Advantages:

Chemical-Free Operation: The elimination of hazardous chemicals benefits both the environment and worker safety.

Energy Savings: By preventing scale formation, Hydropath's technology significantly improves heat transfer efficiency, reducing energy consumption.

Reduced Maintenance: Maintenance requirements decrease as scale-related issues virtually vanish.

Extended Equipment Lifespan: Scale-induced corrosion is mitigated, prolonging the life of industrial equipment.

Figure 23 Animation of Hydro Flow installed in a pipeline

Disadvantages:

Initial Investment: The system may require an initial investment, although the long-term benefits outweigh this cost. With return of investment on the capital less than 12 to 18 months, Hydro flow is the very next generation technology for the industry.

Application-Specific: System design needs to consider unique characteristics of each application.

Auxiliary Modifications for Upgradation:

Hydropath's technology can be integrated into existing water treatment systems with no modification. The system can be customized and scaled to meet various industrial requirements, enabling seamless upgrades to current operations.

Potential Energy Savings:

The elimination of scale deposition results in significant energy savings. Improved heat transfer efficiency, particularly in heat exchangers and boilers, leads to reduced energy consumption and, consequently, lower operating costs.

Environmental and Other Benefits:

Hydropath's technology is fundamentally eco-friendly, eliminating the need for hazardous chemicals. By reducing energy consumption and minimizing maintenance, it promotes sustainability and offers a considerable reduction in carbon footprint. Beyond this, the system enhances the operational reliability of industrial equipment, reducing downtime and optimizing production.

Hydropath Technology emerges as the superior alternative to existing processes. By championing a chemical-free, energy-efficient, and sustainable approach, it not only resolves the issues caused by scale deposition but also paves the way for enhanced industrial performance, resource conservation, and a greener future.

Replication Potential:

Hydro flow is sustainable cleantech which can be used on a very big industrial scale. Hydro flow is being supplied and installed in industries globally from 1992 and more than 10,000+ installations have been done so far. Innovative technology and compact solutions with very less capital investment make Hydro flow the technology which can be scaled to virtually any application and any plant.

Case Study 10

Two Stage Permanent Magnet Screw Compressor

Name of the project

Title: Two Stage Permanent Magnet Screw Compressor

Background / Baseline Scenario:

The key utility for practically all industrial units is the compressed air system. It is typically the most expensive utility of all due to its highest energy conversion losses. 80% of a compressor's life cycle cost would be attributed to energy costs. The main factor is energy expense, which necessitates improved compressor efficiency. Therefore, adding an energy-efficient compressor would lower the energy expense's percentage of the overall cost. In the industry, three primary types of compressors are commonly utilized, and they are as follows:

- Reciprocating
- Screw
- Centrifugal

Centrifugal compressors are among the most energy-efficient types. Nevertheless, centrifugal compressors have poor part load efficiency, high maintenance costs, high-speed moving parts, and are not appropriate for greater compression ratios. They also produce a lot of noise.

Since electrical motors are the primary mover in the majority of industrial compressors, the motors' energy loss would contribute to the overall inefficiency of the system.

Proposed System:

Two Stage Permanent Magnet Screw Compressor with Variable Frequency drive

When compared to single stage screw compressors, which only allow the desired pressure to build in one stage, two stage compressors primarily reduce the compression ratio for each stage as the complete line pressure develops in two stages, opening the potential of compressing bigger volumes.

Before entering the second stage compression chamber at the first stage discharge, the air must pass through a coolant curtain, or an intercooler. This intercooler reduces the entropy of the compressed air, increasing volumetric efficiency and lowering the total work performed during the compression cycle.

The compression efficiency is increased by about 15-20% due to the two stages of compression and intercooling between them. As a result, we get a 15-20% increase in flow at nearly the same rate in a single stage. Therefore, the goal of two stage compression is to minimize work by utilizing interstage cooling and compression to create or approach an ISOTHERMAL compression condition.

Furthermore, the solution offer includes a permanent magnet motor as the main mover. Permanent magnets are used in the rotor of a permanent magnet motor. The rotor rotates as a result of the alternating current flowing through the stator. The rotor operates in synchronous motion with the switching AC current due to the permanent magnetization of the magnets. By eliminating the slippage that is often seen in induction motors, you may increase both your mechanical and thermal efficiency. The compressor's overall efficiency would rise as a result of this increase in motor efficiency.

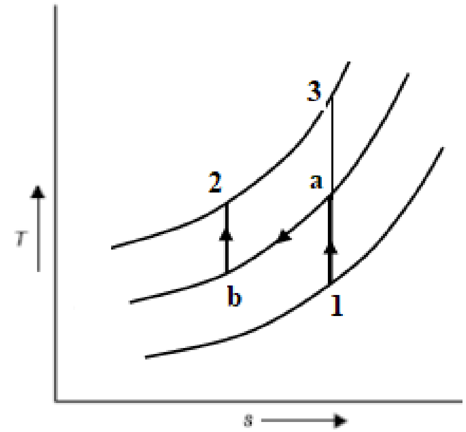


Figure 24 Temperature Vs Entropy Curve of two stage compression

Along with the permanent magnet motor the compressor is coupled with Variable Frequency Drive (VFD) this improves the overall efficiency with following benefits.

- Suitability to generate higher pressure requirement
- Reduced the unload time
- Improves Part load efficiency
- Reduces average operating pressure
- Suitable for variable load operations

The specific power of the proposed two stage PM motor screw compressor is 0.13 kW/cfm against the existing system specific power of 0.175- 0.185 kW/cfm. There is a huge benefit to the customer as the ROI of the investment is between 12-18 months.

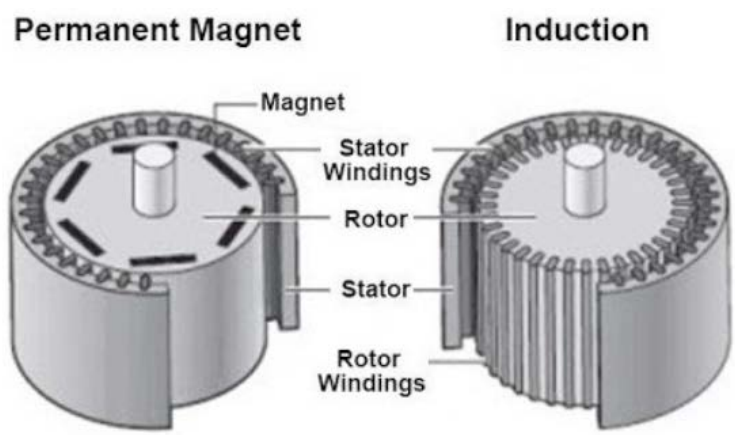


Figure 25 Permanent Magnet motor

Reference Case Study:

Situated in Morbi, Gujarat, Eracon Vitrified Pvt. Ltd. is one of the biggest producers of vitrified tiles. Screw compressors with a single stage fixed speed were installed in the ceramic unit. The machine includes a two-stage permanent magnet screw compressor with variable speed drive installed in order to save energy for compressed air applications. The company first used this technique in one of its units, and after seeing the benefits, they copied it in all four units, swapping out the outdated compressors for two-stage permanent magnet screw compressors.

The details on energy saving are described as follows:

Table 15 Energy saving Details

Parameters	Units	Existing screw compressor	Two stage PM motor screw compressor
Compressor design capacity	CFM	370	445
Compressor motor rated power	kW	55Kw	55Kw
Compressor design pressure	Bar (kg/cm^2)	8	8
Compressor operating capacity	CFM	370	445
Compressor operating power	kW	70	60
Specific energy consumption	kW/CFM	0.189	0.135
Energy saving	kW	21.74	
Running hrs	hrs	20.0	
Power cost	INR/kWh	8.0	
Monetary saving	INR Lakhs	1085415	
Investment	INR Lakh	1400000	
Payback period	Months	15.5	
Energy saving	TOE	124	
GHG reduction	Tons of CO2/annum	114	

Replication Potential

There is huge scope of replication of this technology as the ROI of the investment is only 12-18 months that ensure high saving immensely in the overall life cycle cost of compressor.

Case Study 11

Installation of Rooftop Solar Power Plant

Name of the project

Title: Rooftop Solar Power Plant

Background / Baseline Scenario:

Chandpur Paper mills located in Utta Pradesh, is into manufacturing Poster Paper and Chromo (C1S) Paper. The unit produces an impressive 140 Tons Per Day (TPD). The top-notch machinery, sourced from global leaders, ensures precision and efficiency. All the electricity requirements prior to this project, in the plant, were sourced from the Grid. In order to reduce the carbon footprint and take a step towards using green, renewable sources of energy, a solar power plant was installed.

Proposed System:

Large number of solar panels are used to convert solar energy to electric energy, which is used for operation of equipments required in paper manufacturing process.

Figure 26 Solar Panels on Roof Top

Reference Case Study:

Installation in other industries like steel fabrication, plywood etc. were studied, though these were small- 250 kW only. Against the fluctuating load in these industries (like fluctuating welding machines load, or no significant use of electricity during lunch break etc.) paper manufacturing has a fairly stable load, and this was expected to result in better load factor with solar plant thus improving economic viability.

The existing load is 4.5MW, and the solar panels are grouped in several arrays of max. 100kW each. Each inverter of 100kW is connected to a set of solar panels at input side and to plant bus at output side. In case of startup after power failure, the inverter checks grid frequency and voltage; and synchronizes the output accordingly within 180 seconds, which is then supplied to feeder bus. The grid load reduces accordingly.

The benefits so far are more than the equivalent to 400 Ton coal saved, 1065 Ton CO_2 emission reduction or 73000 trees planted, which can be seen in the attached sheet.

Replication Potential:

This technology can be implemented at small or large levels without any problem.

Design details of solar plant:

850.98 kW

Utilization factor of solar plant:

Based on claimed 3.5 kWH/kW/Day average, the actual electricity generation has been 87.8% during last year.

Running power generation of Solar plant:

955 MWh/Year

Cost of project:

INR 3.6 crore

Case Study 12

Steam Saving through new technology Adoption "Venturi Steam Traps"

Name of the project

Title: "Steam Saving" through new technology Adoption "Venturi Steam Traps"

Introduction to plant

J K Paper Limited, Unit: JK Paper Mills - is located at Jaykaypur, district: Rayagada, Odisha. JK Paper Mills, an integrated Pulp & Paper Mills was setup in the year 1962 with initial capacity of 18000 TPA at Jaykaypur in the District of Rayagada (Odisha).

JK Paper Mills is a manufacturer of Pulp, uncoated and coated quality writing and printing papers. It is the First Pulp & Paper Industry in the country to certify with ISO-9001 Quality Management System, ISO-14001 Environment Management Systems and ISO-45001 Safety Management Systems by M/s. DNV, Netherlands.

Background / Baseline Scenario

After survey of 300 TD traps it was found that there is continuous discharge of hot condensate and flash steam from 10-12% of the traps resulting in a loss of heat to the atmosphere, which cannot be recovered.

Details of the energy saving project

Venturi steam traps were installed against conventional steam traps. In Venturi-Nozzle traps only hot condensate is discharged and the flash steam generated from the hot condensate is held back.

Need of Innovating technology

- Heat recovery
- Steam Saving

Flash steam generated

Table 16 Operating Parameters

Steam Type	Pressure, bar (g)	Temperature, °C	Flash Steam, %
Medium Pressure	12	195	10.5
Low Pressure	4.5 bar (g)	160	17.6

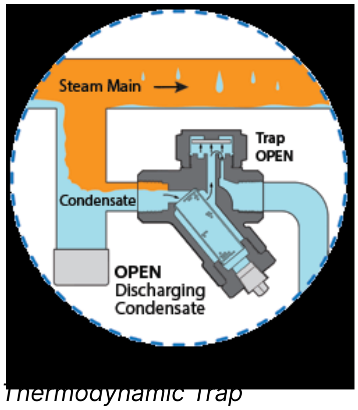


Figure 27 Conventional Thermodynamic Trap

Figure 28 Image of Venturi Steam trap and its actual installation

Savings Calculation:

Location of Trap : Medium Pressure Steam line to Coating Plant , 12 kg/cm2 ,200°C							
Trap Type	Initial mass of water (kg)	Initial temp of water (°C)	Finished mass of water (kg)	Finished temp of water (°C)	Increased mass of water (kg)	Increased temp of water (°C)	Heat Energy in the final condensate (kcal)
TD Steam Trap 20 NB	15.00	32.0	17.26	61.0	2.26	29.0	
	15.00	32.0	17.87	66.0	2.87	34.0	
	15.00	32.0	17.23	67.0	2.23	35.0	
Average	**15.00**	**32.0**	**17.45**	**64.7**	**2.45**	**32.7**	**633.6**
ARISITI Steam Trap - Size 20 NB with Nozzle-1	15.00	32.0	17.36	44.0	2.36	13.0	
	15.00	32.0	17.44	47.0	2.44	15.0	
	15.00	32.0	17.41	44.5	2.41	14.0	
Average	15.00	32.0	17.40	45.2	**2.40**	**14.0**	**291.1**
DURATION of TEST = 15 minutes							

Figure 29 Savings Calculation Table

Conclusion:

- Before installing Venturi traps, Condensate volume was measured for around 250 traps and specifically 20-30 locations are chosen based on their volume of condensate & heat-loss
- Standard for testing of loss in Steam-traps: ISO7841
- Based on the volume of condensate, Nozzle (size as per table) was fit inside the trap. After taking into line, if Steam passing was observed, Nozzle was replaced a lower no.

Similarly, if there is condensate accumulation inside the steam line, Nozzle was replaced by its higher no.

- Savings in Heat: 633 – 291 = 342 kcal
- Test Duration: 15 mins = 0.25 hrs
- Latent Heat of MP Steam: 471 kcal/kg
- Steam Saved / hours: 310 kcal / 0.25/471 = 2.91 kg/hour
- Annual Steam Savings = 2.91 x 24 x 350 /1000 = 24 Tonnes

Reduction in CO_2 Emission = 14197 kg /annum

Case Study 13

Coating of UGAM H R T I 400 Silver to reduce Radiation Losses

Name of the project

Title: Coating of UGAM H R T I 400 Silver where conventional thermal insulation is not possible.

Background / Baseline Scenario

Heat loss through the sides of cylinders/rollers poses significant challenges, lead to a cascade of issues that impact overall efficiency and operations. This phenomenon results in:

Increased Energy Consumption: Heat loss directly translates into increased energy consumption as the system needs to compensate for the lost heat. This inefficiency inflates operational costs and strains energy resources.

Diminished Heat Transfer to Products: With heat escaping through the sides of cylinders/rollers, the intended heat transfer to products becomes compromised. This can lead to longer processing times, reduced throughput, and a dip in overall productivity.

Extended Product Cycle: The compromised heat transfer and resulting inefficiency can extend the time required for product cycles. This slowdown directly affects production schedules and output levels.

Escalated Shop Floor Temperature: The escape of heat into the surrounding environment elevates shop floor temperatures. This not only affects the comfort of personnel but can also impact the performance of adjacent equipment and processes. Addressing this heat loss issue is crucial for optimizing energy usage, maintaining consistent product quality, adhering to production schedules, and creating a conducive working environment. As a solution provider, we are committed to helping you overcome these challenges and achieve operational excellence.

Details of the energy saving project

UGAM H R T I 400 Silver offers an innovative approach to thermal management. It addresses heat loss challenges in cases where traditional insulation methods are not feasible or efficient.

By mitigating heat loss through cylinders and rollers, this coating empowers you to achieve enhanced energy efficiency. Reduced energy consumption leads to cost savings and improved sustainability.

The application of UGAM H R T I 400 Silver is straightforward and adaptable, making it a convenient solution even in situations where conventional insulation methods are impractical.

The coating provides tailored protection for the equipment. By safeguarding against heat loss without altering the cylinder/roller structure, it ensures optimal performance and longevity.

UGAM H R T I 400 Silver contributes to maintaining consistent product quality, optimized production cycles, and a controlled working environment, driving operational excellence.

Energy Savings:

The implementation of the solution has yielded significant energy savings, surpassing the anticipated 10% mark. This achievement underscores the efficiency and effectiveness of our approach.

The solution has led to a reduction in product cycle times. This optimization streamlines production processes, resulting in increased efficiency and throughput.

The application of the solution has enabled the achievement of uniform temperatures across the roller bed. This has even resulted in curing of products, eliminating inconsistencies and ensuring top-notch quality.

Figure 30 Application of UGAM HRTI 400 Silver on sides of rollers

Figure 31 Uncoated Temperature 94.9 Deg C

Figure 32 UGAMI HRTI 400 Silver coated temperature 70.3 Deg C

Notably, the surface temperature has been successfully reduced from 94.9°C to 70.3°C, marking a substantial drop of 24.6°C. This reduction has contributed to an equitable distribution of heat across the roller's surface, further enhancing product quality.

The solution has had a direct impact on the shop floor environment by effectively reducing the heat load. This improvement has created a more comfortable working environment for personnel operating near the equipment.

The quality of the end product has witnessed a marked improvement due to the optimized thermal environment. This enhancement has led to a reduction in product wastage, contributing to greater cost efficiency.

Case Study 14

Installation of Louver Type Mist Cooling System (LTMCS) And Induced Draft Mist Cooling Towers (IDMCT)

Name of the project

Title: Installation of louver type mist cooling system and induced draft mist cooling towers at M/S. Ramakrishna forgings ltd., Tatanagar

Background / Baseline Scenario

To cater the requirement of cooling water for the furnaces, M/s. RKFL were using Conventional Induced draft cooling towers at all their plants. However, the plant faced a lot of difficulties to maintain the desired cooling water temperature due to frequent choking of Nozzles & fills thus affecting performance of the plant. Also due to this, plant was not able to operate at full load due to high temperature of water & frequent shut down for maintenance of cooling tower.

In order to reduce the cold-water temperature which was going beyond 38°C to improve the efficiency of their process and power saving, M/s. RKFL were looking for better cooling solution.

Figure 33 Old cooling towers at M/s.RKFL

Details of the energy saving project

M/s. RKFL contacted MREPL for evaluating the possibility of installation of MCS/IDMCT by replacing existing cooling towers.

MREPL team visited the site where M/s. RKFL has total 7 nos. of plants. As per the site feasibility LTMCS was offered for the plants which had required plot size available and for rest of the plants where plot size availability was less, IDMCT's were offered.

The order was finalized to be given to MREPL & it was decided to implement the same in phases as the total requirement was for 4 nos. of MCS & 11 Nos. of IDMCT making it a total capacity of 6624 M^3/hr.

The first 2 LTMCS were successfully commissioned in the year of 2020 & then all 11 nos. of IDMCT were installed, some in 2021 & some in 2022. Total 15 nos. conventional type induced draft cooling towers were removed with Mist cooling technology successfully.

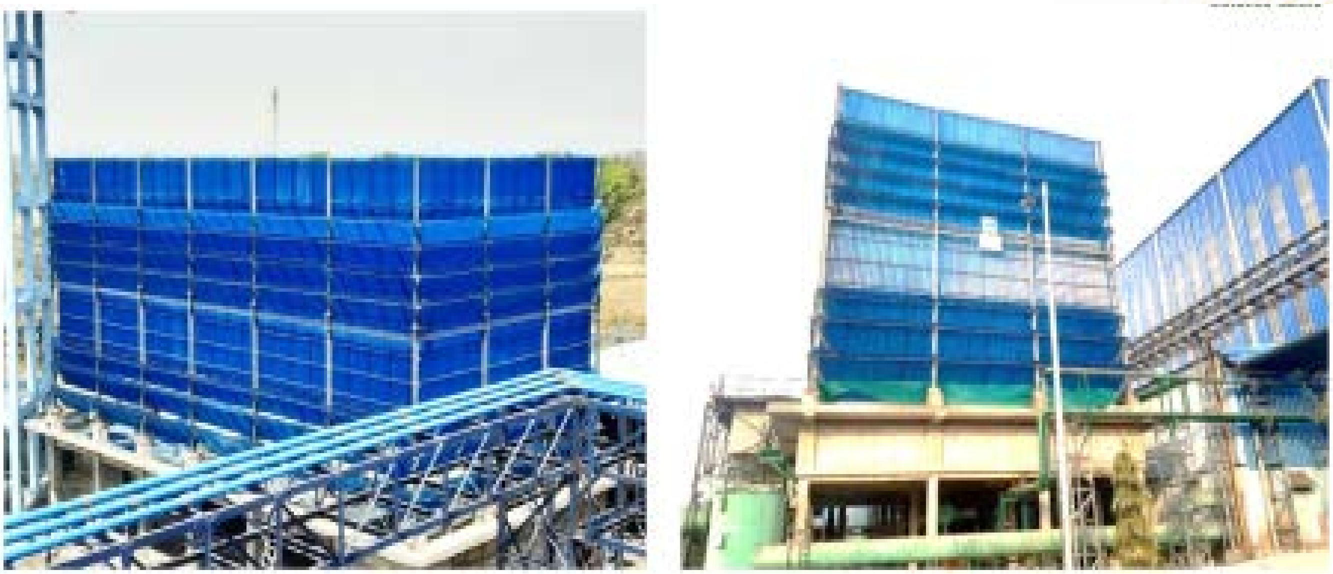


Figure 34 Louver type mist cooling systems at M/s.RKFL

Figure 35 New induced draft mist cooling towers at M/s.RKFL

Energy Savings:

A tabular summary giving the details of earlier installed old conventional cooling tower vs new installed LTMCS/IDMCT is given below for ready reference.

After installation of Mist Technology the plant has till date saved total power of 183.58 kW/hr. Hence considering a unit electric rate of Rs.8/KWH, around Rs.32,248/- per day are saved only on power.

Thus considering 360 days of operation per year, total saving only on power by installation of Mist Technology will be around Rs. 1,16,09,280/- Per Annum, year after year.

Payback period of entire system was achieved in quick time. Also, when the balance 2 LTMCS get commissioned additional saving of 175 kwh will be achieved. Since its installation the LTMCS & IDMCT's are running absolutely smooth and trouble-free & the plant is very happy with the results.

Table 17 Old vs New Cooling Tower parameters

Unit No-1				
Description	Requirement 1		Requirement 2	
	IDCT	IDMCT	IDCT,	IDMCT
Capacity	384 M3/hr (192 M3/hr x 2 Nos Qty)	384 M3/hr (192 M3/hr x 2 Nos Qty)	480 M3/Hr (240 M3/hr x 2 Nos Qty)	480 M3/Hr (240 M3/hr x 2 Nos Qty)
Hot Water Temperature	42°C	39°C	42°C	39°C
Cold Water Temperature	34°C /35°C	31°C /32°C	34°C /35°C	31°C /32°C
Temperature Difference	7 to 8°C	7 to 8°C	7 to 8°C	7 to 8°C
WBT	28°C	28°C	28°C	28°C
Approach	6 to 7°C	3 to 4°C	6 to 7°C	3 to 4°C
Circulation water Pump Power	SAME	SAME	SAME	SAME
Fan power	25 kW/hr	12.5 kW/hr	30 kW/hr	15.6 kW/hr
Total Power saved	-	12.5 kW/hr	-	14.4 kW/hr

Table 18 Old vs New Cooling Tower parameters

Unit No-3				
	Requirement 1		Requirement 2	
Description	IDCT	IDMCT	IDCT	IDMCT
Capacity	60 m3/hr (2 Nos Qty)	60 m3/hr (2 Nos Qty)	120 m3/hr (1 No Qty)	120 m3/hr (1 Nos Qty)
Hot Water Temperature	42°C	39°C	42°C	39°C
Cold Water Temperature	34°C /35°C	31°C /32°C	34°C /35°C	31°C /32°C
Temperature Difference	7 to 8°C	7 to 8°C	7 to 8°C	7 to 8°C
WBT	28°C	28°C	28°C	28°C
Approach	6 to 7°C	3 to 4°C	6 to 7°C	3 to 4°C
Circulation water Pump Power	SAME	SAME	SAME	SAME
Fan power	8 kW/hr	3.66 kW/hr	8 kW/hr	3.66 kW/hr
Total Power saved	-	4.34 kW/hr	-	4.34 kW/hr

Table 19 Old vs New Cooling Tower parameters

Unit No.- 5						
	Requirement 1		Requirement 2		Requirement 3	
Description	IDCT	IDMCT	IDCT	LTMCS	IDCT	LTMCS
Capacity	570 m3/Hr (285 M3/hr X 2 Cell)	570 m3/Hr (285 M3/hr X 2 Cell)	750 M3/Hr	750 M3/Hr	1200 m3/hr	1200 m3/hr
Hot Water Temperature	42°C	39°C	42°C	39°C	42°C	
Cold Water Temperature	34°C /35°C	31°C /32°C	34°C /35°C	31°C /32°C	34°C /35°C	
Temperature Difference	7 to 8°C	7 to 8°C	7 to 8°C	7 to 8°C	7 to 8°C	
WBT	28°C	28°C	28°C	28°C	28°C	
Approach	6 to 7°C	3 to 4°C	6 to 7°C	3 to 4°C	6 to 7°C	UNDER IMPLEMENTATION
Circulation water Pump Power	SAME	SAME	SAME	SAME	SAME	
Fan power	34 kW/hr	15 kW/hr	45 kW/hr	NIL (MCS Does not require Fan)	75 kW/hr	
Total Power saved	-	19 kW/hr	-	45 kW/hr	-	

Table 20 Old vs New Cooling Tower parameters

Unit No-4		
	Requirement 1	
Description	IDCT	IDMCT
Capacity	150 m3/hr (2 Nos Qty)	150 m3/hr (2 Nos Qty)
Hot Water Temperature	42°C	39°C
Cold Water Temperature	34°C /35°C	31°C /32°C
Temperature Difference	7 to 8°C	7 to 8°C
WBT	28°C	28°C
Approach	6 to 7°C	3 to 4°C
Circulation water Pump Power	SAME	SAME
Fan power	19 kW/hr	10 kW/hr
Total Power saved	-	9 kW/hr

Table 21 Old vs New Cooling Tower parameters

Unit No. - 7				
	Requirement 1		Requirement 2	
Description	IDCT	LTMCS	IDCT	LTMCS
Capacity	1500 m3/hr	1500 m3/hr	1200 m3/hr	1200 m3/hr
Hot Water Temperature	42°C		42°C	39°C
Cold Water Temperature	34°C /35°C		34°C /35°C	31°C /32°C
Temperature Difference	7 to 8°C		7 to 8°C	7 to 8°C
WBT	28°C		28°C	28°C
Approach	6 to 7°C	UNDER IMPLEMENTATION	6 to 7°C	3 to 4°C
Circulation water Pump Power	SAME		SAME	SAME
Fan power	100 kW/hr		75 kW/hr	NIL (MCS Does not require Fan)
Total Power saved	-		-	75 kW/hr

Case Study 15

Refurbishment of Conventional Induced Draft Cooling Tower (IDCT) To Induced Draft Mist Cooling Tower (IDMCT)

Name of the project

Title: Refurbishment of conventional induced draft cooling tower to induced draft mist cooling tower at M/S. Vedanta ltd, Jharsuguda, Odisha.

Background / Baseline Scenario

M/S. VEDANTA LTD, Jharsuguda, Odisha is an operating company of Vedanta in aluminium and leading producer of metallurgical grade alumina and other aluminium products.

M/S. Vedanta Ltd. were using conventional IDCTS running at water flow of 2500 M3/Hr X 4 Cells since last 20 years for their SMELTER-II plant. Due to accumulation of coal dust, frequent choking of CT PVC Fills, nozzles etc. was observed, thus deteriorating the CT performance which affected the entire operation of the plant. Also, these Fills needed frequent cleaning / replacement every.

Details of the energy saving project

MREPL studied the design of existing Timber construction, Counter Flow cooling tower & suggested refurbishment of existing IDCT to IDMCT.

M/s. Vedanta Ltd. has total 4 cells of IDCT with capacity of 2500 m^3/hr per cell. The unit decided to refurbish one cooling tower cell at a time by shifting the load temporarily to other three cooling tower cells. For this a total time period about 6 to 8 weeks was agreed upon.

MREPL supplied the system in 8 weeks' time & then M/s. Vedanta Ltd. shifted the load and isolated one cooling tower cell. Following activities were carried out for refurbishment.

- Complete Fills of existing IDCT were removed.
- Mist/drift Eliminators were shifted upwards to get the required Mist Spray height as per MREPL design.
- Existing spray system was replaced by our high efficiency Mist creation system with piping in HDGI & S.S 304 Mist Creator Nozzles. Mist Creation was installed at designed Hight spraying water downwards in the form of fine mist.
- No other changes were made in existing IDCT thus keeping its structure, fan assembly, etc. as it is. However, VFD along with VFD Panel was installed for existing Fan motor. The entire activity was completed in time period of 6 weeks.

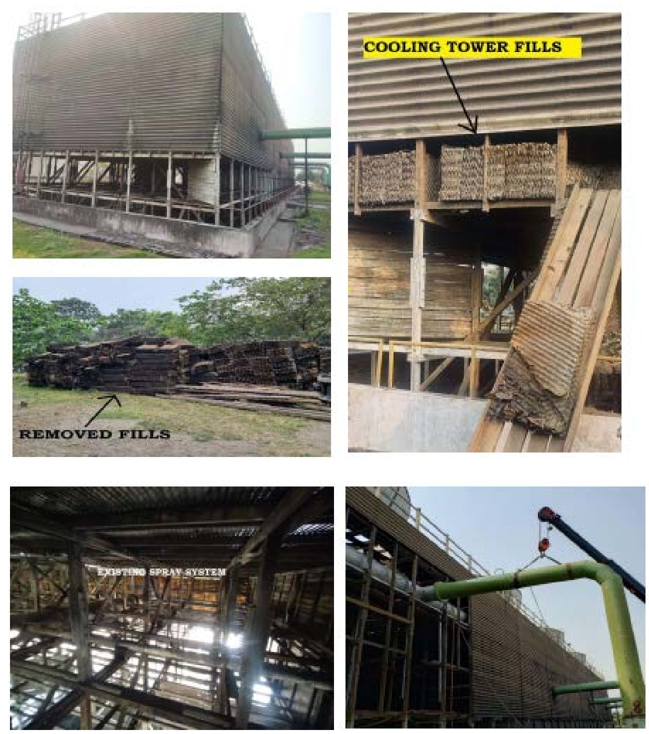


Figure 36 Old IDCT pictures at M/S. Vedanta Ltd. before refurbishment

After completion of above modification, a constant Cold-Water temperature of 27°C is maintained with approach of 3 to 4°C & temperature drop of up to 6°C which was in-line with the guaranteed parameters.

Table 22 Various designed parameters / operating parameters before and after refurbishment

Description	Designed parameters	Old parameters Before Refurbishment (Conventional IDCT with Fills)	Parameters obtained after Refurbishment to IDMCT (Fill Less Design)
Cooling water flow	2500 m3/hr	2500 m3/hr	2500 m3/hr
Hot water temperature	42.4°C	35°C	33°C
Cold water temperature	32.4°C	29°C	27°C
Designed ambient DBT/WBT	48/ 28.4	40/ 23 to 24.5	40/ 23 to 24.5
Approach to WBT	4°C	5 to 6°C	3 to 4°C
Fan Amp / kwh	67 Amp / 43 kwh	90 Amp / 58 kwh	62 Amp / 40.10 kwh

Figure 37 New IDMCT pictures at M/S. Vedanta Ltd. after refurbishment

Energy Savings:

Refurbishment of IDCT to IDMCT was carried out in a total time period of 5 to 6 weeks & it recorded remarkable improvement in performance as follows:

- Constant CWT of 27°C was obtained with ΔT of up to 6°C with temperature drops equivalent to conventional IDCT throughout complete trial duration.
- Smooth and trouble-free operation of IDMCT due to absence of Fills.
- An approximate power saving of about 30% (required Fan Power of 40.10 kwh as against 58 kwh on IDCT) on fan power was obtained due to overall reduction in pressure drop across the cooling tower due to absence of fills.
- Client is extremely satisfied and looking forward to change/refurbishing all existing IDCT's to IDMCT.

Chapter 3

Energy Saving opportunities in Paper Manufacturing

This chapter is meant to disseminate and share some of the common Energy saving projects that have been successfully implemented in some of the leading Paper manufacturing plants of the country.

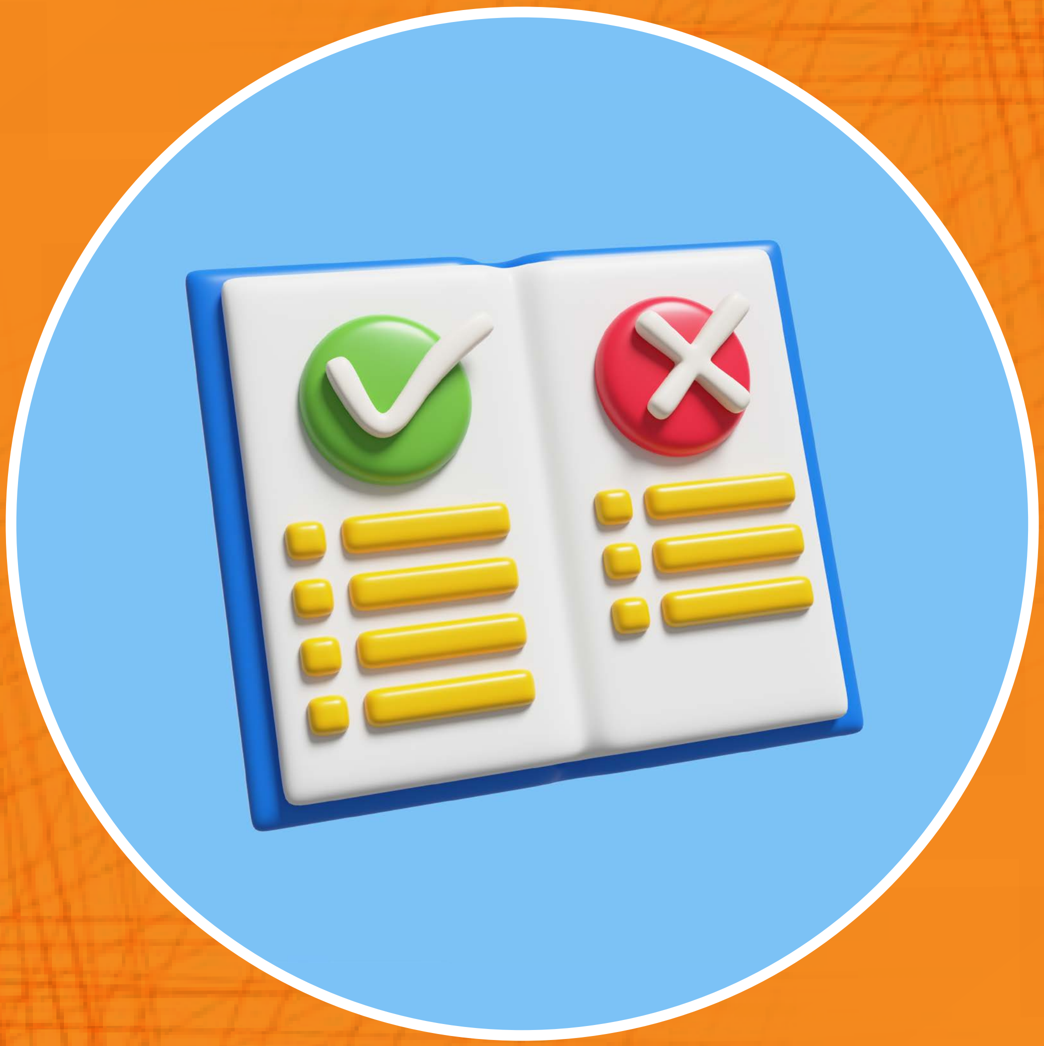
The proposals are as follows[1]:

- Installation of Black Liquor Indirect Heater at Enmas Recovery Boiler.
- Recovery of condensate from main steam line traps at Powerhouse section.
- Replacement of Existing TG Cooling Tower Fan with energy efficient Fans.
- Installation HT VFD for ENMAS Boiler Feed Water Pump.
- Using waste Hot fresh water instead of Hot back water in ClO2 Heat Exchanger hot media to avoid frequent jamming of HEX
- Installation of VFD for Machine chest stock pump at Paper machine.
- Replacement of Old and inefficient agitators at Stock preparation with energy efficient agitators.
- Replacement of old convention lights with LED lights (Flood light, street light etc.) in phased manner throughout the mill.
- Procuring 5-star energy efficient fans in place conventional fans in a phased manner.
- Installation of 150 & 200 KVAR APFC in Fiber Line section
- Replacement of existing FBC ID Fan slip ring motor with squirrel cage induction motor
- Steam trap replacement in mill wide.
- Replacement of energy inefficient MC pump in pulp mill with new energy efficient MC pumps.
- New steam and condensate system at Paper Machine.
- Installation of VFDs at identified locations in pulp mill and Evaporator plants.
- Installation of Energy efficient vacuum pump at Causticizing plant.
- Use of indirect heat in series with direct heater at SBL process flow.
- New 3 stage centrifugal compressor, expected power saving of 412 Kw/hr
- Evaporator plant effect #2 modification.
- Hardwood Hot water heat recovery by diversion from WTP Plant to CBP Plant.
- Improving & maintaining the performance of various pumps at optimal level.
- Replacing Vapor Absorption Refrigeration Machines (VAM) with Vapor Compression Refrigeration Machines (VCM).
- Optimizing power consumption of Cooling Tower by installing aero profile FRP blades in place of conventional aluminium blades.
- Operating Cooling Towers with Temperature based ON-OFF controller to optimize fan power.
- Preheating Boiler Feed Water by recovering heat from Kiln Flue gases to save LP Steam in De-aerators
- Recycling part of the exhaust air in the H&PV System to reduce energy loss and optimize energy consumption.
- Replacing surface aerators with nano cavitation air diffusers for effluent treatment plant.
- Providing VFD for MF-2 - 3 Bar freshwater pump.
- A vapour line modification to third effect & Feed flash tank modifications resulting in additional steam gain in evaporator
- Pin feeder accept extraction screw conveyor perforation plate replaced with 6mm to 10mm for effective dewatering.
- ESP -Three Phase (3Ø) High Frequency Silicon Rectifiers (HFSR) installation.

1 *Based on CII data*

- Upgradation of DC Motors and drive with Energy Efficient AC system at Coating Pre-Reeler Machine.
- TPQR installation-Improvement of Power factor, hence results increase in Green Energy share up to 2%.
- New Energy efficient condensing Turbine to improve the specific power generation.
- Installing Variable refrigerant flow unit for Machine drive room.
- Installation of anaerobic digester to reduce ETP load and partly substitute Energy.
- Installation VFD at High Pressure pump 150 H.P
- Old motor replacement with IE3 energy efficient motors.
- Old slip ring motors to be replaced with energy efficient motors.
- Installation of VFD on CPP PA Fan.
- Installation of VFDs in Pulp mill against valve throttling of pumps.
- VFD at ClO2 plant cooling tower
- Installation of turbo blower in ETP.
- Installation of 6 MW Solar power plant under the drive of Green Energy.
- Installation of Higher efficiency pump at Condenser cooling water pumps at cooling tower.
- Modification of Boiler feed pump by de-staging two stages.
- Installation of Higher efficiency pump at Condenser extraction at TG-2.
- Modification in Re-reeler trim blowing system in PM-1.
- Replacement of GRP Fan with FRP fan on cooling tower.
- Installation of VFD at PMC-1 Air turn.
- Replacing Existing vacuum pumps with Energy Efficient vacuum pumps for Paper Machine.
- Recovering flash steam from process to pre-heat PV hood air to reduce live steam consumption.
- Recovery CBD condensate to pre heat FD Air indirectly by proving heating coils to reduce fuel consumption and chocking issues.
- Repair, replace and renovation of thermal insulation at various location in plant.
- VFD for process pumps and operate based on LT / Sensors.
- Identification & Plugging of compressed air leak in entire plant.

Chapter 4



Important Thumb Rules

4.1 Fans

- Fans with aerofoil, backward curved blades can operate with an efficiency of more than 85%
- The optimum margin for pressure is 15 % and flow is 10% while designing a fan
- Optimum cut off clearance in a centrifugal fan is 8 -12 %
- Dampers provided at the fan outlet consumes more power than provided at the inlet due to an increase in absolute pressure of gas handled by the fan
- The difference between suction box velocity & duct velocity should not be greater than 8 m/s
- Increase the stack height & temperature of gas for maximizing the natural draft effect
- Operating parameters of the fan should not be deviated from a design by 10% otherwise it deteriorates the fan efficiency
- Allowable pressure loss across multi louver type damper in 100% open condition 10-15 mmwg.

4.2 Compressor and Compressed Air System

- 1 bar reduction in compressed air pressure will save 6-7 % power.
- Recommended compressed air velocity in the pipeline is 6 - 8 m/sec
- The volume of receiver for compressed air - 1/10th of flow rate in m^3/min to 1/6th of flow rate in m^3/min or 10 to 15 litres for each litre/sec of compressed air.
- Maintaining intercooler performance can save 7 % power on the compressor
- Every 4°C rise in inlet air temperature of the compressor results in higher energy consumption by 1 % to achieve equivalent output.
- An increase of 5.5°C in the inlet air temperature to the second stage results in a 2% increase in the specific energy consumption.
- Typical acceptable pressure drop-in industrial practice is 0.3 bar in mains header at the farthest point and 0.5 bar in distribution systems.
- Recommended compressed air outlet temperature after intercooler is ambient temperature + 20 degree C.
- The minimum quantity of Cooling Water required (in Liters per minute) is 2.85 m^3/min for a single-stage compressor operating at 7 bar pressure
- Transvector nozzles for cleaning application can reduce power and save compressed air up to 50%
- mm diameter hole in a compressed air pipeline with 7 kg/cm^2 air pressure would result in a power loss of 5 kW (equivalent to INR 1.5 Lakhs per annum)
- Compressed air leakage quantity to be as low as 10%
- In 800 m length compressed air pipeline, pressure drop should not be more than 0.3 kg/cm^2
- Centrifugal and Screw blowers can save up to 40 % power when compared with PD blowers for the same application (pressure and volume)

4.3 Electrical Equipment

- 4 % reduction in voltage will result in a 1 % reduction in power
- 10 % reduction in speed will save 27 % power in centrifugal equipment
- LED can save power consumption by nearly 50 %
- Power transformer efficiency will be maximum in the range of 60 - 80 % Loading
- Distribution transformer efficiency will be maximum in the range 40 – 60 % Loading

4.4 Motor

- High efficiency motors (IE4 /IE5) offer of 4 - 5% higher efficiency than standard motors (IE2/IE3)
- For every 10°C increase in motor operating temperature over recommended peak, the motor life is estimated to be halved
- An imbalanced voltage can reduce 3 - 5% in motor input power.
- Rewinding motors 3-4 times can reduce the motor efficiency by 5-8%.
- Motor life doubles for every 10°C reductions in operating temperature

4.5 Captive Power Plant/Cogeneration Plant

4.5.1 Boiler

- For every 6°C rise in feed water temperature, there will be approximately 1% saving of fuel.
- A 15% reduction in excess air can improve boiler efficiency by about 1%
- Every 22°C reduction in flue gas temperature can lead to a 1% increase in boiler efficiency
- Insulating steam lines and components can reduce heat loss and improve overall efficiency by up to 2%
- Implementing a proper soot blowing regimen can improve boiler efficiency by 1-2%.
- A 1 mm thick scale (deposit) on the water side could increase fuel consumption by 5 to 8%.
- A 3 mm thick soot deposition on the heat transfer surface can cause an increase in fuel consumption to the tune of 2.5% due to increased flue gas temperatures.
- 1 kg of coal will typically require 7-8 kg of stochiometric air depending upon the carbon, hydrogen, nitrogen, oxygen and sulphur
- Typical values of Evaporation ratio for different types of fuels are as follows:

  Biomass fired boilers: 2.0 to 3.0

  Coal fired boilers : 4.0 to 5.5

4.5.2 Turbogenerator & Condenser

- For every 10°C reduction in turbine exhaust temperature, steam turbine efficiency can increase by about 1%
- Generally, for a turbine, for every 1 mm Hg increase, the heat rate will increase by 2 kCal/kWh

4.5.3 Steam Distribution

- Proper sizing of steam pipelines helps in minimizing the pressure drop. The velocities for various types of steam are:
  - Superheat : 50-70 m/s
  - Saturated : 30-40 m/s
  - Wet or Exhaust: 20-30 m/s
- The steam mains should be run with a falling slope of not less than 125 mm for every 30 meters length in the direction of the flow.
- Drain points should be provided at intervals of 30-45 meters along the mail.
- Drain point should also be provided at low points in the mains and where the steam main rises. Ideal locations are the bottom of expansion joints and before reduction and stop valves.
- The branch lines from the mains should always be connected at the top. Otherwise, the branch line itself will act as a drain for the condensate.
- mm diameter hole on a pipeline carrying 7 kg/cm^2 steam would waste 33 KL of fuel oil per year.

4.5.4 Agitators

- For agitators check for the type of agitators based upon the driving system like belt driven, gear driven or direct driven. The best efficiency is achieved by using direct driven agitators. Saving potential of up to 15 to 20% can be easily available.
- Using energy efficient agitators can give up to 50% savings in power consumption.

4.5.5 Cooling Towers

- A belt driven or gear driven can be changed with direct driven fans giving 15% savings approximately.
- Aluminium fan blade can be converted to FRP or Epoxy blades which can give up to 15% to 20% power savings.
- VFD on cooling tower fan with sump water temperature feedback can result in a saving of fan power by 10-15%.
- The ideal approach should be less than equal to 3 degrees. Higher the approach, higher will be the energy consumption from process.
- For a chiller system if we reduce cooling tower approach by 1 degree, which means cooling tower outlet also reduces by 1 degree. This will result in 3% power saved from chiller.
- The cooling tower ideal SEC is approximately 0.15 kW/TR for a water-cooled chiller system.
- A good cooling tower should give effectiveness of more than 70%.
- The ideal blade pitch angle is 15 degrees. Varying the pitch angle can affect in increase or decrease of fan power consumption.
- For an HVAC system, a cooling tower should be designed 1.2 times of the chiller tonnage.
- When multiple cells are present, then best practice is to use all fans at same conditions like same rpm for all fans. This avoids different outlet temperatures in both cells.
- Mixing of water at two different temperatures from different cells results in loss of TR.

4.5.6 Chillers & HVAC

- The typical power consumption of a conventional vapor compression refrigeration system is 1.2 kW / TR
- Typical power consumption of Screw chiller system is 0.35 kW / TR for 10 deg C chilled water & normally two lower size impellers and one immediate higher size impeller can be used in the same casing in case of centrifugal pumps to avoid throttling and save power in case of over design
- Evaporative cooling can reduce the compressor or chiller load by 20 -40%
- Reducing condensing temperature by 5.5°C, results in a 20 - 25% decrease in compressor power consumption
- 5.5°C increase in evaporator temperature reduces compressor power consumption by 20 - 25%
- 1 mm scale build-up on condenser tubes can increase energy consumption by 40%

4.6 Vacuum Pumps

- The design sealing water temperature is 15 degrees Celsius, under running conditions 30 degree Celsius is to be maintained. With the increase in this temperature, there is capacity derating of the vacuum pump which will lead to increase in specific power consumption of the vacuum pump. Cooling towers are used to reduce the sealing water temperature. A separate chart is available for the same, as per which, if temp increases by 10 deg C the vacuum pump capacity will reduce by 5% for 300 mmHg capacity.
- The inlet sealing water pressure of the vacuum pump is to be maintained at 0.9-1.1 ksc. Below this pressure the generation of vacuum intensity will be less and beyond 1.1 ksc pressure the power consumption of the vacuum pump will increase.
- For pipe sizing below link can be referred to. The velocity of non-condensable gases in a vacuum system is usually maintained between 15-25 m/s.
- Dwell time = 2-4 milli seconds (For paper machine)
- Liquid ring vacuum pump, BKW/(m^3/min): 0.75-0.85
- Vacuum Turbo Blowers, BKW/(m^3/min): 0.65-0.7 (Not to be confused with centrifugal blowers)
- Velocity of (water+air) at seperator inlet should be 2.5 m/s or else water will go into vacuum pump and increase power consumption.

Conclusion and Way Forward

The "Best Practices Manual in the Pulp and Paper Sector in India, Volume 12" provides a comprehensive and in-depth analysis of the current practices, technological advancements, and operational efficiencies across the top paper mills in the country. Through systematic study, this publication identifies key performance gaps in specific energy consumption levels and highlights opportunities for improving productivity, resource efficiency, and environmental sustainability in the Indian pulp and paper sector.

Key Conclusions

Energy Efficiency: Despite improvements, the sector still exhibits significant variation in Specific energy consumption across mills. Optimizing steam usage, integrating modern waste heat recovery systems, and adopting energy-efficient technologies are critical areas that demand immediate attention.

Raw Material Utilization: Efficient utilization of raw materials, especially non-wood fibres, presents a unique opportunity for the sector to reduce costs and enhance sustainability. Advances in chemical recovery systems and fibre yield optimization are key drivers in this regard.

Environmental Impact and Decarbonization: The sector has made strides in reducing emissions; however, aligning with global decarbonization targets requires the adoption of low-carbon technologies, renewable energy integration, and enhanced process control strategies. Embracing circular economy models will be instrumental in reducing carbon footprints and resource wastage.

Way Forward

Technology Upgradation: To close the performance gaps identified through the study of the Best available SEC in the different categories of Paper manufacturing units, the sector must invest in state-of-the-art technologies that enhance energy, water, and raw material efficiency. Implementation of automation, digitalization, and AI-based process control systems will further drive operational efficiencies.

Policy and Regulatory Framework: Stronger policy initiatives from regulatory authorities should incentivize adoption of best practices and cleaner technologies. Developing a robust framework for carbon pricing and trading mechanisms can stimulate investment in decarbonization initiatives.

Capacity Building and Knowledge Sharing: Industry-wide collaboration through different platforms, created by industrial associations and bodies, must be strengthened to facilitate knowledge sharing on best practices. Organizing regular training programs and workshops can help build the technical capacity of mill operators and management to effectively implement advanced technologies and sustainability initiatives.

Sustainable Supply Chain Integration: The sector should focus on building sustainable supply chains, particularly in sourcing raw materials. Establishing partnerships with suppliers to promote sustainable forestry practices, waste valorization, and responsible resource management will enhance long-term viability.

Continuous Benchmarking: Continuous benchmarking against global best practices will be critical in tracking progress and driving continuous improvement. Industry players should commit to periodic reviews of their operational performance, embracing transparency and accountability.

By adopting the best practices, projects and thumb rules outlined in this manual, as per their applicability, and making concerted efforts to address the identified challenges, the Indian pulp and paper sector can enhance its global competitiveness, reduce environmental impacts, and align with international sustainability standards. Moving forward, the integration of transformative technologies, proactive policy support, and a commitment to continuous improvement will be key drivers in making the sector world-class.

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About CII

The Confederation of Indian Industry (CII) works to create and sustain an environment conducive to the development of India, partnering Industry, Government and civil society, through advisory and consultative processes.

CII is a non-government, not-for-profit, industry-led and industry-managed organization, with around 9,000 members from the private as well as public sectors, including SMEs and MNCs, and an indirect membership of over 365,000 enterprises from 294 national and regional sectoral industry bodies.

For more than 125 years, CII has been engaged in shaping India's development journey and works proactively on transforming Indian Industry's engagement in national development. CII charts change by working closely with Government on policy issues, interfacing with thought leaders, and enhancing efficiency, competitiveness, and business opportunities for industry through a range of specialized services and strategic global linkages. It also provides a platform for consensus-building and networking on key issues.

Through its dedicated Centres of Excellence and Industry competitiveness initiatives, promotion of innovation and technology adoption, and partnerships for sustainability, CII plays a transformative part in shaping the future of the nation. Extending its agenda beyond business, CII assists industry to identify and execute corporate citizenship programmes across diverse domains including affirmative action, livelihoods, diversity management, skill development, empowerment of women, and sustainable development, to name a few.

For 2024-25, CII has identified "Globally Competitive India: Partnerships for Sustainable and Inclusive Growth" as its Theme, prioritizing 5 key pillars. During the year, it would align its initiatives and activities to facilitate strategic actions for driving India's global competitiveness and growth through a robust and resilient Indian industry.

With 70 offices, including 12 Centres of Excellence, in India, and 8 overseas offices in Australia, Egypt, Germany, Indonesia, Singapore, UAE, UK, and USA, as well as institutional partnerships with about 300 counterpart organizations in almost 100 countries, CII serves as a reference point for Indian industry and the international business community.

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CII-Sohrabji Godrej Green Business Centre (CII-Godrej GBC) was established in the year 2004, as CII's Developmental Institute on Green Practices & Businesses, aimed at offering world class advisory services on conservation of natural resources. The Green Business Centre in Hyderabad is housed in one of the greenest buildings in the world and through Indian Green Building Council (IGBC) is spearheading the Green Building movement in the country. The Green Business Centre was inaugurated by His Excellency Dr. A. P. J. Abdul Kalam, the then President of India on 14 July 2004.

The Services of Green Business Centre include- Energy Management, Green Buildings, Green Companies, Renewable Energy, GHG Inventorization, Green Product Certification, Waste Management and Cleaner Production Process. CII-Godrej GBC works closely with the stakeholders in facilitating India emerge as one of the global leaders in Green Business by the year 2025.

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