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Enhancing Efficiency through Electricals, Electronics, Automation and Digital Technology

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Abstract:

Pulp and paper manufacturing, compared to other industries, has immense potential to be ecological and sustainable. Globally, the pulp and paper industry accounts for approximately 5 percent of total world industrial final energy consumption and 2 percent of direct carbon dioxide (CO2) emissions from industry. Worldwide pulp and paper demand and production are projected to increase significantly by 2050, leading to an increase in this industry's absolute energy use.

The pulp and paper industry accounts for 5% of total global industrial energy consumption and is the fourth largest energy consumer worldwide. In the Indian pulp and paper industry the electrical energy consumption ranges between 1,300 to 1,700 kWh per tonne and average specific energy is 52 GJ per tonne of paper.

M/s.Khanna Paper Mill has taken continuous working to reduce the energy year on year by adopring the new energy efficient technologies, right quality of coal selection to get maximum steam generation per ton, upgradation of the process time to time best in class automation in Deinking plants and Paper machines.

Keywords: *International efficiency, Super premium efficiency motors, Dissolved Oxygen, Screw type blower, Automation of packing lines, Ream collation.*

Introduction

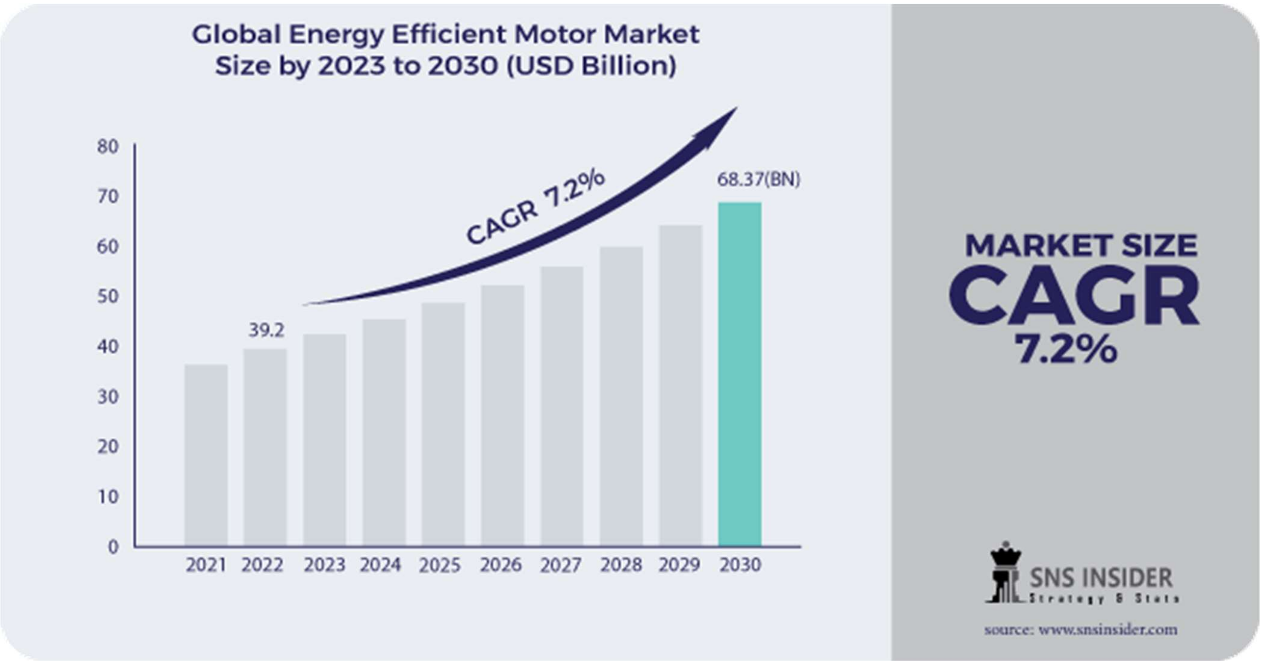
M/s Khanna Paper Mill Limited (KPML) having four paper machines, deinking plants and in-house captive power plant of 37.35 MW (23.3 MW & 14.05 MW), is the largest RCF based paper mill in northern India, with annual production capacity of half a million tons. We have carried out multiple initiatives across the plant in the area of energy conservation by selecting energy efficient equipment, process automation, remote monitoring & control and use of digitalisation over the past few years. These steps include replacement of old in-efficient technology with latest energy efficient technology, Liquid Ring Vacuum pumps replace with Turbo Vacuum blowers, replacing old inefficient Root Blowers with Screw blowers in Effluent Treatment Plant, Upgradation of Drives and Manpower reduction by adopting the inhouse packing automation in the Packing lines.

1.0 Enhancing Energy Efficiency: Detailed Study of IE1 vs. IE3/IE4 Motors

Energy Efficient Motor Market Report Scope & Overview:

Energy Efficient Motor Market size was valued at USD 39.2 billion in 2022 and is expected to grow to USD 68.37 billion by 2030 and grow at a CAGR of 7.2% over the forecast period of 2023-2030.The market for energy-efficient motors is a rapidly growing industry that is gaining traction worldwide. These motors are designed to consume less energy while still providing the same level of performance as traditional motors. This not only saves money on energy costs but also reduces carbon emissions, making them an environmentally friendly option. The demand for energy-efficient motors is driven by various factors, including government regulations, rising energy costs, and increasing awareness of the need for sustainable practices. As a result, many industries, including manufacturing, HVAC, and transportation, are adopting these motors to improve their energy efficiency and reduce their carbon footprint. In addition to their environmental benefits, energy-efficient motors also offer financial benefits. They have a longer lifespan than traditional motors, require less maintenance, and can save businesses significant amounts of money on energy bills over time

An energy-efficient motor is a device that converts electrical energy into mechanical energy with minimal energy loss. This type of motor is designed to operate at a higher level of efficiency, resulting in lower energy consumption and reduced operating costs. By utilizing advanced technologies and



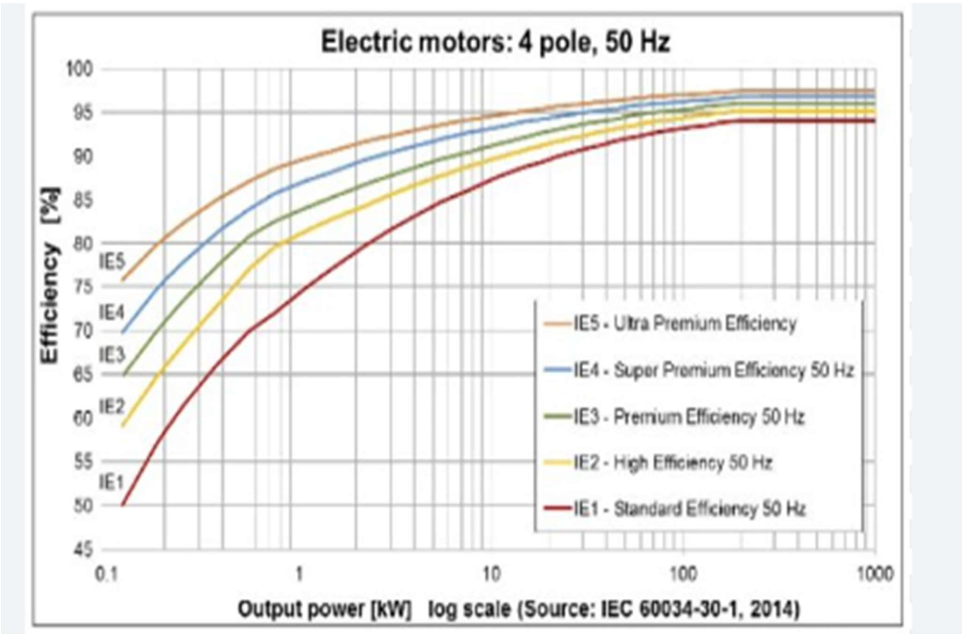
materials, energy-efficient motors can achieve higher power densities, lower heat dissipation, and longer lifetimes than traditional motors. These motors are widely used in various applications, including HVAC systems, industrial machinery, and electric vehicles. With the increasing demand for energy conservation and sustainability, the use of energy-efficient motors is becoming more prevalent in today's world.

This case study evaluates the implementation of IE1 and IE3/IE4 motors in a manufacturing facility to improve energy efficiency and reduce operational costs. The study analyses the performance, energy consumption, and economic benefits of upgrading to IE3/IE4 motors compared to conventional IE1 motors.

The existing electric motors in the facility, predominantly IE1 motors, were exhibiting inefficiencies leading to high energy consumption and operational costs. The facility sought to upgrade its motor fleet to improve energy efficiency and comply with regulatory standards.

Efficiency Levels

- **IE1 Motors:** Standard Efficiency
  - IE1 motors represent the basic level of energy efficiency. They are less efficient compared to IE3 and IE4 motors.
- **IE3 Motors:** Premium Efficiency
  - IE3 motors offer a significant improvement in energy efficiency over IE1 motors. They are designed to consume less power for the same output, leading to lower operational costs and reduced environmental impact.
- **IE4 Motors:** Super Premium Efficiency
  - IE4 motors represent an even higher level of efficiency, surpassing IE3. They are among the most energy-efficient motors available, further reducing energy consumption and operational costs.
  - Motors Efficiency Curve IEC Standards



Energy Consumption

- **IE1/IE2 Motors:** These motors have higher energy losses and thus higher energy consumption for a given power output.
- **IE3 Motors:** With reduced losses, IE3 motors consume less energy for the same output, resulting in lower electricity bills and a reduced carbon footprint.
- **IE4 Motors:** These motors consume the least amount of energy, offering the most substantial savings in operational costs over time.

Operational Cost

- **IE1/IE2 Motors:** Higher operational costs due to lower efficiency and higher energy consumption.
- **IE3 Motors:** Lower operational costs compared to IE1 due to improved efficiency.
- **IE4 Motors:** The lowest operational costs among the three due to the highest efficiency.

Initial Investment

- **IE1/IE2 Motors:** Generally have the lowest initial purchase price.
- **IE3 Motors:** Higher initial cost compared to IE1, but the investment is offset by energy savings over time.
- **IE4 Motors:** Highest initial cost, but they provide the greatest energy savings, potentially offering a quicker return on investment due to reduced energy expenses.

Environmental Impact

- **IE1/IE2 Motors:** Higher energy consumption results in greater carbon emissions.
- **IE3 Motors:** Reduced energy consumption leads to lower carbon emissions compared to IE1.
- **IE4 Motors:** The most environmentally friendly option with the lowest energy consumption and carbon emissions.

Khanna Paper Mills Ltd. has initiated the "Motor Efficiency Management Program" across its entire mill area. This proactive initiative aims to enhance operational efficiency by identifying and replacing outdated IE1 motors and those that have been rewound more than three times with modern, energy-efficient IE3 motors. As part of this program, a total of forty-eight motors were identified and successfully upgraded to IE3 motors, thereby optimizing energy usage and reducing overall operational costs.

Area	EQUIPMENT NAME	Motor KW	Motor RPM	Application	Eff.Old %	IE 3 Eff %
PM 1	Fan Pump No. 5	45	1,500	Pump	91.5	94.2
PM 1	Fan Pump No. 7	37	1,500	Pump	91.5	93.9
PM 1	Fan Pump No. 8	37	1,500	Pump	91.5	93.9
PM 1	Pressure Screen no.1	37	1,500	Screen	91.5	93.9
PM 1	Mould Blower No.2	55	1,500	Blower	92	94.7
PM 1	Coating Blower No. 1	75	1,500	Blower	92.5	95
PM 1	Broke Pulper	75	1,000	PULPER	92	94.6
PM 1	Pope reel	75	1,500	SECTIONAL DRIVE	92.5	95
PM 1	Broke Tower pump	45	1,500	Pump	91.5	94.6
PM 2	Broke pulper agitator	45	1,000	PULPER	91.5	93.7
PM 2	Old T/C Coating Blower 4	45	1,500	Blower	91.5	94.6
PM 2	Trim Blower for rewinder	30	3,000	Blower	89	93.8
PM 2	Chest Pump No. 7	30	3,000	Pump	89	93.8
PM 2	UTM Pit No.2 Agitator	75	960	PULPER	91.6	94.6
FILLER PLANT	F/L T.D.R 24"	260	1,000	REFINER	92	96
FILLER PLANT	P/L. Mixing Chest No. 4 Pump stand by Top Plant	37	1,500	Pump	91.5	93.9
FILLER PLANT	Chest Pump No.1	30	1,500	Pump	91	93.8
SFT	Intensa Maxx Drive	75	1,500	Pump	92.5	95
SFT	Contaminax Drive	75	1,500	Pump	92.5	95
SFT	Stock preparation dilution pump	75	1,500	Pump	92.5	95
SFT	Pulper dilution pump	75	1,500	Pump	92.5	95
SFT	DF shower pump	75	3,000	Pump	92	94.7
BOTTOM PLANT	Krofta Feed Pump No.1	30	1,500	Pump	91	93.8

The standard efficiency and rewound motors (more than 3 times) in the mill area, de-inking plant and utility area were replaced with Energy Efficient Premium IE3 motors. The above exercise led to annual savings of 6.48 Lac kWh resulting in savings of INR 43.0 Lacs annually and required an initial investment of INR 94.0 Lacs.

Conclusion:

In summary, IE3 and IE4 motors offer substantial advantages over IE1 motors in terms of energy efficiency, operational cost, and environmental impact. While IE3 motors are a good balance between cost and efficiency, IE4 motors provide the best performance but at a higher initial cost. The choice between them depends on specific application requirements, budget considerations, and long-term operational goals.

2.0 Comparison Between Root Blower and Screw Type Blower for Energy Efficiency and DO Level Maintenance in Aeration Tanks with VFD Automation

In the field of wastewater treatment, particularly in aeration tanks of Effluent Treatment Plants (ETPs), the selection of blowers plays a crucial role in operational efficiency and environmental compliance. This report compares the energy efficiency and effectiveness in maintaining Dissolved Oxygen (DO) levels between Root Blowers and Screw Type Blowers. A case study of the

Khanna Paper Mill ETP is presented, where a Screw Type Blower with Variable Frequency Drive (VFD) automation was installed, demonstrating superior performance over traditional Root Blowers.

1. Introduction

Effluent Treatment Plants (ETPs) are essential for managing and treating industrial wastewater before it is discharged into the environment. Aeration tanks, a critical component of ETPs, require efficient blowers to maintain adequate DO levels for microbial activity. This report evaluates two common types of blowers—Root Blowers and Screw Type Blowers—in terms of energy efficiency and DO level maintenance.

DO stands for Dissolved Oxygen, which is the amount of oxygen that is present in water. It is a crucial parameter in various water treatment processes, particularly in biological treatment systems like aeration tanks used in wastewater treatment plants. DO levels in the aeration tank were monitored continuously to assess the performance of both blowers. The target DO level was set based on the optimal conditions for microbial activity.

Importance of Maintaining DO in Aeration Tanks

A. Microbial Activity:

- **Biological Degradation:** Aeration tanks rely on aerobic microorganisms to break down organic pollutants in wastewater. These microorganisms require oxygen to survive and carry out biochemical processes that degrade organic matter.

- **Nitrification:** Specific bacteria, such as nitrifiers, require sufficient DO to convert ammonia into nitrate. This process is essential for removing nitrogen compounds from wastewater, preventing eutrophication in receiving waters.

B. Preventing Anaerobic Conditions:

- **Odor Control:** Anaerobic conditions can lead to the production of hydrogen sulfide and other malodorous compounds. Maintaining adequate DO prevents these conditions and the associated odors.

- **Toxicity Prevention:** Anaerobic conditions can result in the production of toxic byproducts like ammonia and methane, which can harm aquatic life and degrade water quality.

C. Sludge Quality:

- **Floc Formation:** Adequate DO levels help in the formation of good floc, which is essential for efficient settling of solids in the secondary clarifier.

- **Preventing Bulking:** Low DO can lead to the growth of filamentous bacteria, causing sludge bulking and poor settling characteristics.

D. Operational Efficiency:

- **Energy Efficiency:** Proper control of aeration not only ensures adequate DO but also optimizes energy consumption. Over-aeration wastes energy, while under-aeration can compromise treatment efficiency.

- **Process Control:** Monitoring and maintaining DO levels is essential for process control, ensuring that the treatment plant operates within its design parameters and achieves the desired effluent quality.

E. Environmental Compliance:

- **Effluent Standards:** Many regulatory standards require specific levels of DO in the effluent to ensure that discharged water does not deplete oxygen in the receiving bodies, which could harm aquatic ecosystems.

- **Permit Compliance:** Maintaining adequate DO levels helps in complying with discharge permits and avoiding potential fines and penalties.

Technological comparison between root blower, screw type blower and surface aerator with detail

Aeration systems are fundamental in wastewater treatment. The primary devices used for these purposes are root blowers, surface aerators, and screw type blowers. Each has its unique mechanism, advantages, and limitations. We compare these devices in terms of operational efficiency, energy consumption, maintenance requirements, and overall cost-effectiveness as we were using root blower for aeration system but did not get the optimum result in aspects of COD reduction efficiency and DO level maintenance. So, We methodically examine the various option for upgradation for our aeration system and compare the same:

Root Blower

Description: Root blowers, also known as positive displacement blowers, operate using two lobed rotors that rotate in opposite directions within a casing. This rotation traps air in pockets between the rotors and the casing, pushing it from the inlet to the outlet at a constant volume but varying pressure.

Advantages:

- High reliability and durability.
- Simple mechanical design resulting in lower initial costs.
- Effective in high-pressure applications due to its positive displacement mechanism.

Disadvantages:

- Noisy operation.
- Energy inefficiency, particularly at lower pressures, due to constant volume displacement regardless of pressure demands.
- Higher operational costs stemming from significant energy consumption.

Surface Aerator

Description: Surface aerators introduce oxygen into water by agitating the surface, facilitating gas exchange between the air and water. They are commonly used in wastewater treatment plants to enhance biological processes by increasing the dissolved oxygen content.

Advantages:

- Simple design and installation process.
- Effective in shallow water bodies by providing excellent surface agitation.
- Helps in thorough mixing of water and improves biological treatment efficiency.

Disadvantages:

- Limited effectiveness in deep water bodies as aeration is restricted to the surface.
- Generally high energy consumption due to the mechanical work required for continuous agitation.
- Frequent maintenance needs due to wear and tear from continuous operation.

Screw Type Blower

Description: Screw type blowers, also known as rotary screw compressors, utilize a pair of intermeshing helical screws to compress air. The continuous rotation of these screws traps and reduces its volume, thus increasing the pressure.

PICTURE OF SCREW BLOWER UNIT

Advantages:

- Highly energy-efficient due to the continuous and smooth compression process.
- Low noise levels compared to root blowers.
- Stable and consistent airflow with minimal pulsation.
- Versatile for a range of applications, accommodating both high and low-pressure needs.

Disadvantages:

- Higher initial purchase cost due to more complex design.
- Requires specialized maintenance, although less frequent compared to root blowers and surface aerators.
- Less suitable for extremely high-pressure applications compared to dedicated high-pressure systems.

Energy Efficiency Comparison

Efficiency and Power Consumption

- **Root Blower:** The fixed volume displacement at all pressures results in significant energy wastage, especially at lower pressures. Typically, root blowers exhibit mechanical efficiencies around 60-70%.
- **Surface Aerator:** The mechanical agitation of water surfaces leads to considerable energy input for the oxygen transfer achieved. Efficiency ranges from 30-50%, influenced by design and operational conditions.
- **Screw Type Blower:** The continuous compression process of screw type blowers ensures high efficiency, often up to 90%, across varying pressure ranges. This translates to significantly lower energy consumption than both root blowers and surface aerators.

Operational Costs

- **Root Blower:** Higher operational costs are incurred due to energy inefficiency and the frequent need for maintenance.
- **Surface Aerator:** High energy consumption and maintenance needs result in substantial operational expenses.
- **Screw Type Blower:** Despite a higher upfront cost, the lower energy consumption and less frequent maintenance reduce overall operational costs over time.

Noise and Maintenance

- Root Blower: Known for noisy operation and requires regular maintenance due to mechanical wear.
- Surface Aerator: Generates noise and demands frequent maintenance because of continuous mechanical movement and exposure to water and biological elements.
- Screw Type Blower: Operates quietly and has lower maintenance frequency, contributing to higher efficiency and reduced downtime.

Conclusion

Screw type blowers are demonstrably more energy efficient compared to root blowers and surface aerators. Their advanced design allows for continuous and smooth air compression, significantly reducing energy loss. Additionally, their lower noise levels and reduced maintenance requirements lead to decreased operational costs and enhanced reliability. These factors make screw type blowers a superior choice in various industrial and wastewater treatment applications, confirming their energy efficiency and cost-effectiveness over other technologies.

Screw Type Blower has also facility of the Touch controller and regulation system. The unit controller is specially designed to maximize the performance of blower under a variety of conditions. The controller has built-in remote control and notification functions provided as standard, including a simple to use integrated webpage.

PICTURE OF CONTROLLER UNIT SCREW BLOWERS

To compare the energy efficiency, data was collected from before and after the installation of the Screw Type Blower. Key metrics included power consumption (kWh), airflow rate (m^3/h), and energy savings.

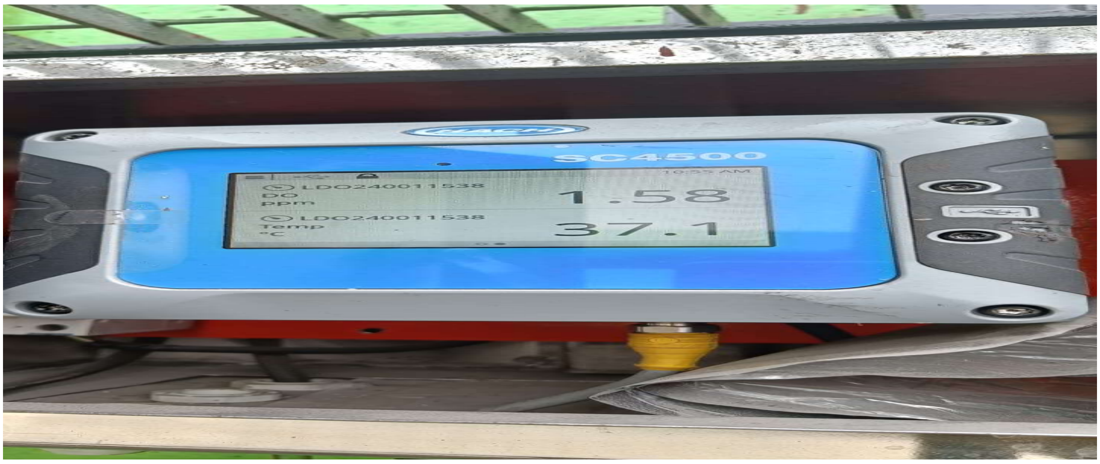
Results

- **Root Blower:** The Root Blower operated at a constant speed, consuming approximately 20-30% more energy than the Screw Type Blower. Due to its inability to adjust to real-time demand, it often ran inefficiently, especially during low-load periods.
- **Screw Type Blower:** The Screw Type Blower with VFD demonstrated a 25-30% reduction in energy consumption. The VFD allowed the blower to adjust its speed based on real-time DO requirements, optimizing energy use.

S. No.	Product Description	Capacity (M3/Hr)	Connected Load (KWH)	Consumed Load (KWH)
1	Root Blower-1	1500	55	55
2	Root Blower-2	1500	55	55
3	Root Blower-3	1500	55	55
4	Root Blower-4	1500	55	55
5	Root Blower-5	1500	55	55
Total			**275**	**275**
S. No.	**Product Description**	**Capacity (M3/Hr)**	**Connected Load (KWH)**	**Consumed Load (KWH)**
1	Screw Type Blower-1	4500	132	100
2	Screw Type Blower-2	4500	132	100
Total			**264**	**200**
Total Saving(KWH)				**75**
% Saving				**27.27**
Total Saving (INR) @7Rs/unit				**4599000**

C

Picture Of Online DO Analyzer In Aeration Tanks After Installation of Screw Type Blower:



Conclusion

The comparison between Root Blowers and Screw Type Blowers demonstrates that Screw Type Blowers, particularly when combined with VFD automation, offer superior energy efficiency and more stable DO level maintenance. The case study of Khanna Paper Mill ETP validates these findings, showcasing the practical benefits and cost savings of switching to Screw Type Blowers.

Recommendations

For ETP operators looking to enhance efficiency and reduce operational costs, transitioning to Screw Type Blowers with VFD is highly recommended. Future studies could explore long-term maintenance benefits and potential environmental impacts.

3.0 Manpower Optimization By Adopting Online Packing In Converting And Finishing House

The conversion and finishing of the house involve manpower-dependent operations at various stations on the packing lines. Operators are assigned tasks such as ream packing, labeling, bundling, and shifting materials to the warehouse during each shift. Currently, ream packing involves manual feeding into machines followed by shrink film packaging. However, manual bundling of packs with HDPE strapping causes congestion on the floor, delays due to manpower availability, and impacts service levels.

To address these challenges, we have implemented a solution where bundle packing is automated and integrated with the ream packing process. This new method involves collating bundles based on weight immediately after ream packing and feeding them into an online bundling machine. Bundles are then automatically packed using 90-micron thick shrink film through a shrink bundling machine.

This innovation has optimized manpower utilization by 30% compared to previous methods. Additionally, it has delivered tangible benefits such as faster product delivery, improved packing quality, and enhanced product handling efficiency.

In summary, by transitioning to automated bundle packing integrated with ream packing, we have not only streamlined operations and reduced manpower dependency but also improved overall operational efficiency and customer service levels significantly.

Pictures of Automation of Ream and Bundling machines in Packaging Board

Picture view of Packing Lines

Infeed Coveyors of Ream packing

Intermediate conveyor in Ream packing line

Ream Shrink Packing

Ream Accumilator

Bundle Outfeed Conveyer

Conclusion:

Khanna Paper Mills Limited is dedicated to continuously upgrading technology across its operations, focusing on process efficiency and sustainable energy practices. One significant initiative involves replacing old and inefficient motors with energy-efficient ones throughout the mill. This phased approach has resulted in annual savings of ₹43.0 lakhs.

Additionally, to ensure environmental compliance and maintain a clean ecosystem, we've adopted efficient blower technology for our aeration basin. This upgrade not only reduces energy consumption but also enhances efficiency in air supply, resulting in substantial savings of ₹46 lakhs annually and contributing to lower BOD and COD levels by maintaining optimal DO levels.

Recognizing the challenges of manpower availability and productivity, particularly in the manufacturing industry, we've automated our packing lines from sheeter output to warehouse delivery. This automation has significantly reduced manpower dependency across all seasons, improved service levels, and accelerated product delivery. By integrating ream and bundle packing lines, we've streamlined operations, ensuring consistent product quality and aesthetic appeal.

At Khanna Paper Mills Limited, these strategic initiatives not only uphold our commitment to efficiency and sustainability but also reinforce our capability to meet evolving market demands effectively.

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