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A Research on Reducing Waste and Better Managing Resources in the Spinning Industry using Efficient Methods

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Abstract
Modern organizations are increasingly adopting strategies to minimize or eradicate inefficiencies across various aspects, with a particular focus on waste management and efficient control. One potent approach for this is the integration of Lean management principles into production processes. By employing diverse Lean tools such as 5S, kaizen, and root cause analysis, organizations can effectively eliminate different types of waste. These wastes often manifest in various forms including overproduction, waiting times, transportation, movement, processing, excessive stock, defects, and underutilized talent. Through the implementation of Lean manufacturing processes, companies can systematically identify and mitigate these sources of waste. Furthermore, by analyzing and repurposing waste materials, companies can potentially enhance productivity, lower manufacturing costs, and contribute to environmental sustainability. The adoption of Lean methodologies not only enhances the production process but also fosters a safer and more productive work environment while enabling continuous improvement within the company.

Keywords: Waste, Waste management, 5S, Kaizen, Root cause analysis, Lean management, Spinning waste.

1. Introduction

In the realm of the spinning sector, waste denotes materials that are no longer deemed useful, with some potentially retaining value while others do not. It encompasses the careless or excessive disposal of items, including those that individuals no longer consider valuable and intend to discard or have already done so. Certain forms of waste can be recycled for purposes like creating coarse count yarn or utilizing open-end rotor spinning techniques.

Types of Waste in Spinning Mill:

The waste generated in the spinning mill typically falls into two categories:

I. Soft waste

II. Hard waste

Soft waste is reusable in the spinning process, whereas hard waste is not reusable.

The waste produced in the blow room consists of different elements like Dropping-1, Dropping-2, seeds, leaves, dust, lap cut, filter waste, filter dust, and floor sweep. These are generated at the initial stages of textile processing. Droppings, seeds, and leaves act as typical contaminants, while dust and lap cut refer to smaller textile scraps. Filter waste and dust are outcomes of the filtration process, whereas floor sweep includes general debris from the manufacturing environment.

Carding waste encompasses modes and flyer, flat strip, taker in waste, sliver cut, filter waste, filter dust, and floor sweep. These diverse types of waste are a byproduct of the carding process in textile manufacturing. They comprise various materials and byproducts that can be reused or recycled at different stages of spinning and weaving to reduce waste and enhance efficiency.

Draw Frame Waste includes various types such as Filter waste, Bonda, and Sliver cut. Filter waste, Bonda, and Sliver cut are all components of the waste generated during the draw frame process in textile manufacturing. The combing process generates different types of waste, including noil, which is adjusted according to the desired quality of the final product. Moreover, specific percentages of waste are produced, such as 0.25% for minilap, sliver, and roller wastage, 0.10% for fly dust, and 0.20% for sweeping waste. Effective management of these waste components is crucial for optimizing production and minimizing environmental impact. In the Simplex/Roving Frame process, various types of waste are produced, including Sliver waste, Roller Waste/Bonda, Pneumaphil Waste, Roving Waste, Sweeping Waste, Clearer waste, and Invisible Waste. Each type presents its own challenges and opportunities for management and reuse within the spinning industry. Efficient handling of these wastes is vital for optimizing production processes and minimizing environmental impact. Any amount of waste exceeding 0.50% of the total is deemed unacceptable.

In the ring frame process, various types of waste are generated, including Pnemaphil (0.20-0.30%), Bonda (0.20-0.30%), roving waste (0.10-0.20%), thread waste (0.10 or less), fly dust (0.20%), and sweeping waste (0.20%). It's crucial to note that the total wastage should not exceed 1%. These waste materials have implications for efficiency and environmental management within the textile production process.

Figure 1: Different types of waste in Spinning Mill

1.1 Waste management is a crucial process with significant impact, aiming to enhance productivity and minimize environmental harm. Incorporating waste management principles alongside lean management techniques is essential for efficient waste control and improved company revenue and development through continuous enhancement. By integrating lean manufacturing and management concepts, companies can decrease waste generation, boost overall efficiency, increase revenue, enhance product quality, and foster a positive company culture.
1.2 Lean management principles, rooted in the Toyota production system, have evolved over time. Fredrick Taylor and Henry Ford initially documented their observations and experimental processes, while Shigeo Shingo and Taichi Ohno further refined these concepts at Toyota in the 1930s. Lean manufacturing facilitates continuous improvement by eliminating various forms of waste throughout the production process. Just-in-time inventory management, for instance, reduces warehouse space, minimizes the need for forklifts, and eliminates unnecessary material handling. By ensuring smooth labor flow and minimizing interruptions, lean principles aim to eliminate waste and drive ongoing process improvement.
1.3 Yarn realization is a pivotal factor in the economic efficiency of a spinning mill. Even a modest 1% improvement in yarn realization and waste reduction can translate into significant cost savings. In yarn manufacturing, various measures are essential to enhance yarn realization and control waste. Apart from managing process waste such as blow room and card droppings, flats stripes, comber noil, and sweep waste, equal attention must be given to minimizing reusable waste (soft waste) like lap bits, sliver bits, roving ends, pneumafil, and roller waste. Reprocessing soft waste not only leads to production losses but also requires additional handling and compromises yarn quality. Therefore, spinning mills must prioritize waste management to boost productivity and profitability [1].

2. Literature Review

In their paper, Marko Milosevic and colleagues delve into the methodologies and practical applications of lean management principles aimed at enhancing overall operational efficiency within organizations. They find that large companies place significant emphasis on implementing lean strategies, resulting in improved productivity and employee satisfaction. Similarly, George L. Hodge and his team conducted a study focusing on identifying suitable lean tools tailored for the textile industry in the United States, with the goal of eliminating non-value added activities and streamlining production processes to enhance customer satisfaction. Their findings underscore the positive impact of lean implementation on efficiency within the textile sector. Meanwhile, Neha Verma et al. conducted a study targeting waste-related challenges in small-scale industries, such as equipment failures, low productivity, and high wastage, and proposed solutions within the framework of lean manufacturing. Additionally, Ramune Ciarniene and colleagues explored the obstacles and hurdles encountered during the implementation of lean concepts, emphasizing the importance of addressing issues such as waste elimination, continuous improvement, and the establishment of value streams to meet customer needs.
In fiber processing, particularly during spinning, the production of various types of waste results in significant economic losses [2].The Lean Manufacturing system enhances efficiency in deliveries by prioritizing speed, cost-effectiveness, and precise quantities through optimizing the work environment and eliminating the seven traditional forms of waste commonly found in various industries [3].
Manufacturing planning and control, along with associated tools, remain unfamiliar to many. Human resource elements such as collaborative teamwork and specialized training, both within specific functions and across functions, were deemed essential for the successful adoption of lean principles. The adoption of lean production techniques appears to be influenced by the size and nature of textile companies, rather than their age. Challenges encountered by companies in implementing lean manufacturing include a lack of awareness, organizational culture, communication gaps, and resistance from employees [4].
Niall Piercy and Nick Rich explored in-depth the correlation between lean operations and sustainability advantages through a comprehensive investigation spanning multiple cases. Their study not only shed light on how sustainability practices can complement various goals of lean transformation but also extended beyond prior research, which predominantly focused on environmental benefits solely at the workplace level. Instead, their paper

identified a spectrum of activities across strategic, supply chain, and workplace domains, illustrating how lean improvements inherently contribute to sustainability enhancements. The conceptual framework they laid out suggested numerous potential benefits stemming from lean implementation, all of which were substantiated by empirical evidence. Moreover, they developed a theoretical model that integrated the processes of lean and sustainable change, providing a holistic understanding of the transformation journey [5].

Jagdeep Singh, Harwinder Singh, and others focused on implementing lean manufacturing principles through the utilization of value stream mapping (VSM) concepts within a casting organization. They examined the existing and potential states of the organization's shop floor scenarios using VSM. Their findings revealed a 14.28% decrease in value-added time and a reduction in operation cycle time from 12 minutes to 9 minutes. A comparison between the current and future state maps was conducted, highlighting the significant benefits following the successful implementation of VSM [6] .

Fawaz A. Abdulmalek and Jayant Rajgopal showcased an industry where lean methodologies were effectively tailored and applied [7].Anthony R. Lapinski, Michael J. Horman, and their colleagues demonstrated the efficacy of lean production principles in minimizing waste and enhancing process efficiency within intricate development and production settings. In alignment with these principles, this study investigates the identification of value and waste within a sustainable construction project [8] .

Shyam Sunder Sharma and Rahul Khatri researched the topic of "Introduction to Lean Waste and Lean Tools" and found that lean principles are no longer optional but essential for engineering industries worldwide to remain competitive. They noted that Lean Manufacturing (LM) offers opportunities to enhance value creation and retention from the industry's workforce based on their core competencies. The responsibility of top management lies in effectively capturing, organizing, and disseminating these practices throughout the entire business unit. The success of any industry hinges on its ability to efficiently manage resources and translate strategies into action. The effective adoption of lean manufacturing practices relies on learning from past experiences and leveraging present industry information [9].

3. Methodology

This method presents a systematic and methodical strategy for addressing the exploration challenge, focusing on the examination of experimental practices. The researcher utilizes existing data and information to conduct thorough evaluations of waste management. Data collection encompasses both primary and secondary sources sourced from company records and reports. Various tools and methodologies, such as Lean tools like 5S, Kaizen, Root Cause Analysis, and Muda, are employed for analysis.

3.1 Utilized Lean methodologies in this investigation:

• Examination of 5s audit
• Investigation of root causes
• Implementation of Kaizen (ongoing enhancement)
• Identification and elimination of Muda

3.2 Data collection origins: For this endeavor, we gathered both primary and secondary data from the subsequent sources. Primary data was obtained from diverse departments within the organization. Secondary data was derived from production reports maintained by the company, as well as from relevant websites, literature, and journals.

4. Data analysis and interpretation

Following the collection of data from diverse facets of this investigation, thorough analysis is conducted employing both analytical and descriptive methodologies. Various charts are utilized for visual representation of the data. Subsequently, the analyzed data is interpreted, leading to the formulation of diverse inferences and conclusions pertaining to the objectives outlined at the onset of the project. The analytical tools employed include:

- 5s analysis
- Root cause analysis
- Kaizen

- Muda

4.1 5s methodology

The 5S methodology originates from Japan and aims to enhance workplace organization, safety, and efficiency while minimizing product defects. It embodies five Japanese principles focusing on cleanliness and orderliness as fundamental work disciplines[10][11] :

i.) Seiri: Sorting
ii.) Seiton: Setting in Order
iii.) Seiso: Shining
iv.) Seiketsu: Standardizing
v.) Shitsuke: Sustaining Self-discipline

Beyond mere tidiness, 5S serves as a lean strategy to eliminate waste arising from poorly organized workspaces within the organization.

Table 1: 5s Performance Indicator

Serial No.	5S Score	Indication
1	10-20	Very Poor
2	20-40	Poor
3	40-60	Fair
4	60-80	Good
5	80-100	Excellent

Sort: Old machinery and refurbished equipment are kept in the workspace, alongside waste materials such as used cones, packing covers, and green straps.

Set in order: All machinery and equipment are meticulously organized, with clear delineation of walkways and work areas, each item positioned precisely as designated.

Shine: The work area and equipment are maintained in a clean condition; however, there is a presence of cotton waste near the electric line cables, posing a potential risk of accidents.

Standard: All the established norms and guidelines are identifiable, yet there is an absence of cleaning and maintenance checklists within the workplace.

Sustain: Regular reviews are conducted for stock controls, inventory management, and related activities; however, there is a deficiency in providing safety measure training for employees.

Table 2: 5s Audit Result

5S Audit	
Sort	11
Set in order	16
Shine	13
Standardize	12
Sustain	17
Total	69

Interpretation: The table provided depicts the 5s audit checklist for the entire manufacturing unit, facilitating evaluations of sort, shine, set in order, and standardize practices within the organization. This process aids in pinpointing areas necessitating improvement. The audit checklist indicates a cumulative 5s score of 69 for the organization, highlighting a need for greater focus on sorting and standardization to enhance efficiency.

4.2 Kaizen

A collaborative approach involving both management and employees to consistently enhance the manufacturing process by systematically eliminating inefficiencies. This continuous improvement method, often referred to as the Deming cycle, employs the Plan-Do-Check-Act framework to drive ongoing enhancements in efficiency.

4.2.1 KAIZEN 1: Occupancy of old machineries and repair parts-

In the manufacturing facility, numerous outdated machines are present alongside an inventory stocked with aged and refurbished components.

Plan: Assess the status of the repair parts and outdated machinery stored in both the inventory and workspace. Organize the machinery and parts into categories based on requirements. Utilize functional parts for reuse if deemed suitable.

Do: Formulate and execute a resolution. Potential recommendations have been proposed for the identified issue.

Table 3: Kaizen 1 Suggestion

S.N.	PROBLEM	IMPACT	IMPROVEMENT
1	Work space is occupied with old machineries	It reduces the material and workers movement.	Remove all unnecessary old machines from the work space.
2	Lots of old and repair parts are stored in the inventory	It reduces the storage space in inventory	Repair the part for the better usage or sort the parts from the inventory

Check: Once the implementation commences, the performance of the implemented solution is monitored over a specific period. A comparison is made between the state before and after implementation, while also ensuring the clearance of old machinery and repaired parts from their designated areas.

Act: If the solution yields significant improvement, the proposed suggestions are executed; otherwise, the PDCA cycle recommences with alternative solutions. The old machines and parts are systematically arranged in a designated area, while following the provided suggestions, ensuring the removal and proper organization of old machines and repaired parts to optimize workspace efficiency.

4.2.2 Kaizen 2: Cotton waste materials are inadequately managed and lack proper recycling protocols. In the yarn production phase, approximately 15% waste is produced for counts 20, 30, and 40, while the combing process yields between 25% to 30% waste. Only a fraction of this waste is reintegrated into the raw cotton during bale breaking, leaving the majority unutilized or recycled. Additionally, miscellaneous waste such as cones, packing straps, and covers are not appropriately stored.

Plan: Determine the percentage of waste generated by various departments and categorize it appropriately. Enhance the recyclability of waste within the production workflow. Integrate recycling practices into the production procedures. Designate suitable locations for storing waste materials.

Do: Formulate and execute a resolution, considering the proposed recommendations for the identified issue.

Table 4: Kaizen 2 Suggestion

S.N.	Problem	Impact	Improvement
1	Cotton remnants are not being efficiently repurposed	It significantly influences the effectiveness of the production procedure and elevates the expenses associated with manufacturing.	Effectively categorize waste and utilize open-end spinning machinery to transform it into yarns with lower counts for recycling.
2	"Numerous other discarded items such as cones, straps, and packaging covers are not appropriately stored."	The largest amount of space is taken up by waste, impacting the cleanliness of production facilities.	Ensure proper segregation of waste, store it in appropriate locations, and dispose of it at regular intervals.

Check: Once the execution commences, ensure to assess the utilization and effectiveness of the open-end spinning apparatus while closely monitoring the yarn production output from the OE spinning machine. Consistently verify the segregation and appropriate storage of waste materials, subsequently disposing of them at regular intervals.

Act: After commencing the implementation, assess the utilization and efficacy of the open-end spinning apparatus while closely monitoring the yarn production levels. Consistently ensure proper segregation and storage of waste materials and dispose of them at regular intervals.

4.2.3 Kaizen 3: Workers are not equipped with safety gear -

In spinning factories, workers face significant exposure to micro dust when handling raw materials and operating the Automatic Waste Evacuation system. Additionally, spinning machine operators endure excessive noise levels from the machinery without being supplied with protective masks or earplugs.

Plan: Recognize the significance of safety equipment such as facial masks and earplugs when dealing with waste materials. Supply these essential safety gadgets to employees who require them.

Do: Formulate and execute a resolution strategy based on the suggested recommendations for the identified issue.

Table 5: Kaizen 3 Suggestion

S.N.	Problem	Impact	Improvement
1	Employees responsible for waste management and operators within the spinning department are not equipped with safety gear such as face masks and ear buds.	Tiny particles of cotton waste generate harmful micro-dust, leading to severe respiratory issues among employees. Additionally, the frequent exposure to high-frequency noise impairs the hearing capabilities of operators.	Supplying them with high-quality face masks and safety protocols to mitigate health issues. Equipping operators with appropriate earbuds. Enforcing stringent regulations for wearing all safety gear while on duty.

Check: Throughout the implementation phase, maintain regular surveillance of employees to ensure adherence to safety protocols, specifically concerning the proper use of safety equipment during waste handling and production activities. Additionally, assess the effectiveness and reliability of the safety gear in terms of both quality and efficiency.

Act: If the safety equipment and protocols provided are sufficient to ensure employee well-being, then the implementation is deemed satisfactory; otherwise, enhancements to safety measures must be pursued. With the suggested improvements, employees can effectively avoid hazards such as micro ducts when handling waste materials.

Interpretation: The table above illustrates three kaizen initiatives undertaken to enhance the production process at the spinning mills. Through the PDCA cycle, solutions were proposed to bolster workspace efficiency, enhance employee safety measures, introduce open-end spinning machines for recycling waste cotton into low-count yarn products, and organize waste effectively. These improvements have significantly boosted production efficiency.

4.3 Muda

The primary goal of lean manufacturing is the eradication of waste. This encompasses anything within the manufacturing process that fails to add value for both the company and the customer.

Poka-Yoke, a process aimed at achieving zero defects in production, involves various error-proofing techniques. These techniques, employed in spinning mills, include the use of metal detectors and magnet paths to eliminate metal from raw cotton, I-scanning processes, and fire sensors strategically placed throughout the plants to prevent fire accidents. Such measures are implemented to diminish waste and enhance the quality and efficiency of production.

Visual Factory is integral in spinning mills, featuring visual indicators, displays, and control panels. Machinery is equipped with color light indications, such as red and green lights, signaling production status and defects. Additionally, different colored cans are utilized in the production process to distinguish between yarn counts, with specific colors assigned to specific counts, and physical marks denote remaining counts.

JIDOKA, which signifies automation, involves designing equipment and systems to partially automate manufacturing processes and halt automatically upon detecting defects. Automated production and waste management systems are implemented, including bale breakers in the blow room to break and clean cotton, automatic waste evacuation systems to collect and segregate waste, overhead traveler cleaners to gather waste around machines, and automatic cone winding machines to enhance production efficiency and reduce waste.

Through the aforementioned lean tools, companies can effectively manage various forms of waste, such as unnecessary movement, waiting times, inefficient inventory management, overproduction, and transportation inefficiencies. By integrating lean management principles into the production process, defects (waste) in spinning mills can be eliminated, thereby reducing waste percentages and electricity consumption, ultimately leading to lower overall manufacturing costs.

Table 6: Waste Percentage Analysis

Department	Marketable waste %	Usable waste %
Blow room	3.0-3.5 %	-
Carding	4.0-6.0 %	0.5 %
Draw frame	0.5 %	0.5 %
Comber	16-20 %	-
Speed frame	0.5 %	0.5 %
Spinning	2.0 %	1.0 %
Cone winding	1.0 %	-
Auto winding	0.70 %	-

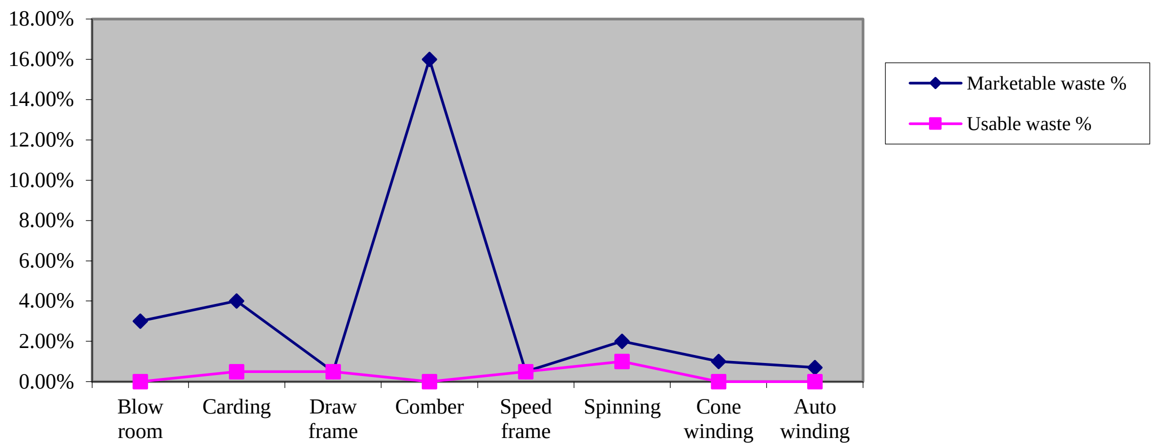

Chart 1: Waste Percentage Analysis

"To enhance spinning mill efficiency and decrease waste, several measures can be implemented:

Enhancing blow room line cleaning efficiency by adjusting settings and beater speed according to yarn count requirements.

Improving carding cleaning efficiency by 5 to 7%, utilizing higher flat with increased cylinder speed for better seed coat removal and minimizing neps.

Conducting waste analysis, segregating types, and recording weights section-wise and shift-wise, while benchmarking against standards.

Optimal use of humidification plants to maintain suitable humidity (40-50% RH) and temperature (35-40°C), enhancing product quality, weight maintenance, minimizing downtime, and improving employee comfort.

- Up to a 3.5% increase in product yield through weight maintenance and reducing invisible losses.
- Enhancing yarn quality by minimizing fiber breakage.
- Mitigating static build-up to prevent machine jams and enhance employee comfort.

Decreasing electricity waste:
- Conducting cleaning during off-peak hours (6:00 am to 9:00 pm) to save 20% of electricity costs.
- Regularly inspecting machine conditions.
- Avoiding running empty spindles in simplex and spinning machines.
- Using a dedicated compressor line for cleaning instead of the main compressor line."

4.4 Root Cause Analysis

A critical thinking philosophy that centers around settling the basic issue as opposed to applying handy solutions that lone treat quick indications of the issue. A typical methodology is to inquire as to why multiple times each time drawing a stage nearer to finding the genuine hidden issue.

Materials - A significant presence of impurities within the raw cotton results in a heightened proportion of waste during the production phase. Inadequate quality of the raw materials, suboptimal storage conditions, and mishandling of the raw materials contribute to reduced production efficiency and an elevated waste ratio.

Methods - The cotton fabric and manufacturing procedure need to be upheld within an appropriately humidified environment to prevent weight loss and minimize unseen losses. Incorrect utilization of humidification facilities leads to excessive wastage during production. Furthermore, the proper recycling of waste cotton is not being effectively implemented.

Environment - The atmospheric elements such as temperature and climate significantly influence production efficiency.

Manpower - The challenging work environment, inadequate training, meager compensation for contracted staff, and insufficient safety and welfare provisions are primary factors contributing to decreased employee efficiency.

Machinery - Improper management of humidity levels, failure to adhere to maintenance schedules, unsuitable temperatures within workstations and machinery leading to breakdowns, and substandard product quality.

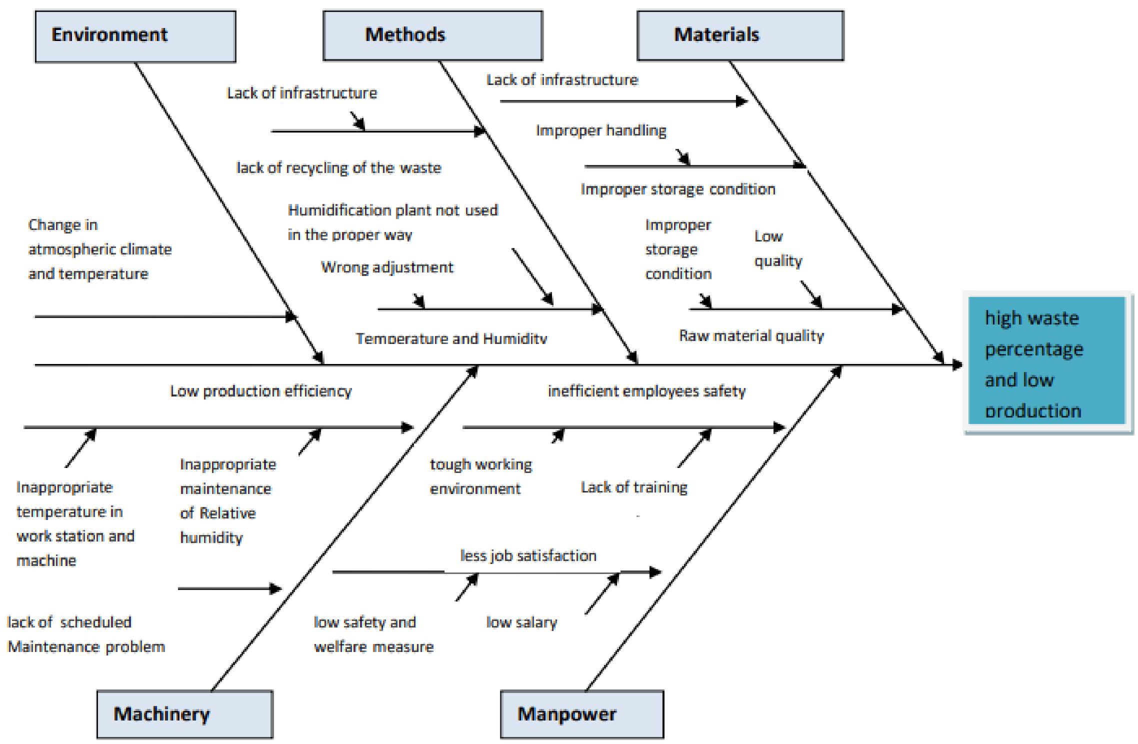

Figure 2: Process Flow Chart

Interpretation: The depicted Root Cause Analysis diagram illustrates the multitude of factors contributing to the high waste percentage and diminished production efficiency within the production process. Through pinpointing the underlying causes across five critical categories—Materials, Methods, Environment, Machinery, and Manpower—it enables us to address and enhance the process effectively.

5. Conclusion

Efficient waste management throughout the production process is pivotal for organizations, enabling them to uphold efficiency and minimize manufacturing expenses. The integration of lean management methodologies within operations aids in overseeing all types of waste within the organizational framework. An array of lean tools facilitates the measurement and comprehension of process-related challenges, thereby enhancing efficiency, curtailing waste in its various manifestations, fostering a conducive work environment, and driving down manufacturing costs. An investigation into spinning mills underscores the significance of waste control and management in bolstering overall production efficiency and diminishing manufacturing expenditures.

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