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Enhancing Operational Efficiency and Sustainability: A Case Study on 6S Implementation in a Jute Spinning Facility

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ABSTRACT

The study examines the integration of 6S principles—Sort, Set in Order, Shine, Standardize, Sustain, and Safety—into a traditional jute spinning facility in Bangladesh to enhance efficiency and sustainability. The paper details the step-by-step implementation process of the 6S system within the jute facility, emphasizing organizational changes, employee engagement, and safety initiatives. Results show an efficiency increase from 65.1% to 71.7% and a reduction of 100 kg or 11.80% of daily waste, minimizing non-productive time. The findings highlight the long-term benefits of 6S in fostering a culture of continuous improvement and optimizing daily operations in the jute industry.

Keywords: 6S Implementation; Lean Manufacturing; Jute Industry; Operational Efficiency; Sustainable Manufacturing

1. INTRODUCTION

Jute is one of the oldest and most natural fibers which is used in textile industry [1]. Jute is used to produce a range of goods including yarn [2]. This yarn is 100% biodegradable and recyclable and that is why there is always a huge demand of Jute Yarn in outside of Bangladesh [3]. This Jute Yarn is produced in Jute Mills or Jute facilities [4]. But these facilities' system, culture, process is not improved as they should be. This is why this system is facing numerous challenges like poor working conditions, low productivity, lack of scientific knowledge, high amount of wastage etc. That is why it has become more important in this situation to incorporate process improvement tools or systems to Jute industry to have the best output.

Hirano introduced a new principle of 5S in 1996 where every S indicated a particular meaning. 5S means Sort, Set in order, Shine, Standardize, and Sustain [5]. This principle described the way of implementing 5S and emphasized the importance of improvement of workplace culture leads to operational excellence [6]. The Production environment can be transformed into a developed, maintained workplace by implementing 5S lean methodology [7]. Implementation of 5S tends to be labelled workspace, a safe and organized working process where audit will also be done to document work in progress and sustain better operations.

The lean 6S methodology combines Safety with 5S which makes the tool more powerful and effective lean improvement tool which can be easily used in any type of company for a better workspace. 6S, the expansion of 5S principle is also becoming popular in industrial contexts [8]. So, the six principles of 6S are Sort, Set in order, Shine, Standardize, Sustain, and Safety – promotes a strategy for workplace organization and ongoing development. It is possible now to develop,

maintain and store a production work environment by 6S [9].

The implementation of 6S in Jute Yarn manufacturing industry is a step towards modernizing from backdated workspace and workplace culture. The Jute sector is vital to many sectors for providing the raw materials as Jute yarn. In this Jute yarn manufacturing industry - Process optimization, cutting waste, and improving overall performance all can be done by implementing 6S [10].

Moreover, the implementation of 6S provides an opportunity for the jute industry to adapt to modern manufacturing practices. This not only aligns the industry with current standards but also enhances its competitiveness in the global market, positioning it as a dynamic and forward-thinking player in an evolving economic landscape and the most widely used technique for raising an organization's or company's efficiency and safety is 6S. Every kind of business or industry can use the 6S technique. This technique improves any work environment's quality, decreases waste, and boosts efficiency.

The Lean 5S technique incorporates the 6S idea of safety and security [11]. The additional 6S phase goes over every aspect of a workspace and assess the risks in each and every section [12]. This allows employees to be outfitted with protective gear based on their individual characteristics and ensures the workstation's safety by closely adhering to standards for machinery use and occupational safety and health [13].

Total Quality Management is the practice of continuously improving quality control [14], and the concept of 6S is used to apply TQM at the operating level. 6S is a way of thinking that emphasizes managing and organizing the workplace through the elimination of waste and the improvement of quality and safety. The organization's workplace is made safer and more productive with the help of the 6S approach.

The 6S extension adds a critical safety component [15], while the 5S methodology offers a methodical approach to workplace excellence and management [16]. By combining these ideas with Total Quality Management, an emphasis on efficiency and organization is placed alongside the improvement of overall workplace quality and safety, signifying a dedication to continual improvements.

In a backdated industry like Jute, this 6S lean tool will improve cultural and operational system while improved efficiency, continuous improvement and long-term sustainability will be the outcome according to industrial context.

So, the main objective of 6S implementation in Jute Yarn manufacturing industry is to systematically improve the efficiency level and effectiveness of the system by organizing the workplace, optimizing the system processes, ensuring cleanliness in all sections, and having a culture of continuous improvement which will help to adapt Advance manufacturing system and tools.

2. METHODOLOGY

The 6S methodology adds one more component to the 5S approach, which is safety [17]. The 6S methodology aims to establish and preserve a well-structured, spotless, productive, and secure work environment. In any organization, it is employed to create a safer work environment. It contributes to higher customer happiness, cost savings, and high-quality achievement. All the six “S” are described below:

1.Sorting: The 6S approach starts with this stage. In this step, sort all of the material that is usable at work and dispose of the useless stuff giving a red tag. Material sorting helps to clear space on the floor.

2.Set in Order: In the 6S technique, this is phase two. To ensure proper use, arrange all materials, equipment, and tools in the workplace in a planned and optimal order in this stage. Time and resource waste are decreased by this configuration of the equipment, supplies, and tools. Material waste is decreased by using appropriate material handling techniques. This step involves everything being put in its proper position.

3.Shine: The 6S methodology's third phase is this. At work, make sure all equipment and machines are thoroughly cleaned. The floor space needs to be tidy and spotless. Both dust and oil should be removed from the equipment and machines. Thus, it is important to thoroughly and frequently clean the tools and machines.

4.Standardization: The 6S methodology's fourth stage is this. Increase employee morale and productivity by implementing standards in the workplace. The key to improved working is workplace standardization.

5.Sustain: The Six Sigma methodology's fifth step is this one. The four stages listed above should be routinely put into practice at work in this step. All steps should be regularly implemented, and this is the manager's responsibility. When the aforementioned four procedures are consistently followed at work, both worker and machine efficiency rise.

6. Safety: The sixth and most crucial phase in the process is this one. The most crucial factor in establishing a positive work environment is safety. Every safety device is installed in the workplace. Every employee should put on all safety gear before entering the office. This contributes to the improvement of the working environment at the workplace and makes it safer.

Table 1: 6S Lean Tool

Sort – Seiri	Throw away all useless and waste material from the workplace
Set in Order – Seiton	Everything in their proper place for quick access
Shine - Seiso	Maintain the workplace neat and clean
Standardize – Seiketsu	Constantly keep order at workplace and make it habitual
Sustain – Shitsuke	Practice 5S daily
Safety	Use all safety equipment and maintain them in a well manner way

2.1 6S Implementation Steps

1.Research design: The research design integrates both qualitative and quantitative data to capture a holistic understanding of the impact of 6S on various facets of the Jute spinning facility's operations.

2.Data collection:

i.Qualitative data

a.Observations: Direct observations of the workplace before, during, and after 6S implementation has been conducted to assess changes in organization, cleanliness, and safety practices. Observational data offers real-time insights into the practical aspects of 6S application.

ii.Quantitative data

a.Performance Metrics: Key performance indicators (KPIs) related to production output, waste reduction, and safety incidents has been collected both before and after 6S implementation. These quantitative metrics enables the assessment of tangible improvements resulting from the intervention.

3.Implementation process analysis: A detailed examination of the 6S implementation process has been conducted, including the development of 6S teams, training programs, and the integration of 6S principles into daily routines. This analysis aims to identify critical success factors and potential bottlenecks in the implementation journey.

4.Efficiency and wastage calculation: In each section, the nonproductive time through the mechanical, electrical and some others issues like transportation or idle time has been calculated. Then, efficiency (%) and amount of wastage has been calculated and analyzed day wise.

5.Comparative analysis: The comparison between the pre and post 6S implementation has been shown. By this the scenario and positive insights can be easily drawn.

6.Ethical considerations: Ethical considerations, including informed consent, confidentiality, and the right to withdraw from the study, has been strictly adhered to throughout the research process. Approval from relevant ethical review boards has been obtained before commencing data collection.

By employing a mixed-methods approach, this methodology aims to capture both the qualitative and quantitative impacts of 6S implementation in a jute mill, contributing valuable insights to the existing literature on lean methodologies and organizational performance.

Both qualitative and quantitative data are collected to identify the previous and present situation inside the industry. Qualitative data is collected as photographs which will be compared to previous with present scenario after implementation of 6S.

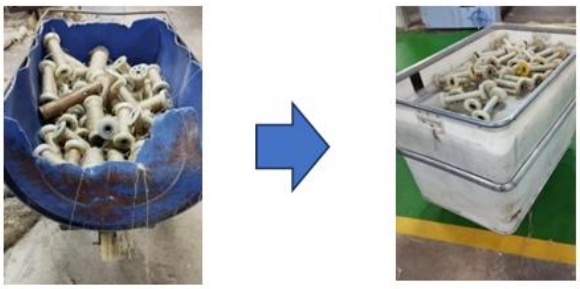
3.CASE STUDY

3.1Sort

Following the implementation steps, at first Sorting phase was started. Identification of unnecessary things was done as seen from figure 1(a) and 2(a) and sorting was done as seen in figure 1(b) and 2(b).

(a) (b)

Fig. 1: (a) Unnecessary items beside the electrical box and fire safety hose (b) which are removed.



(a) (b)

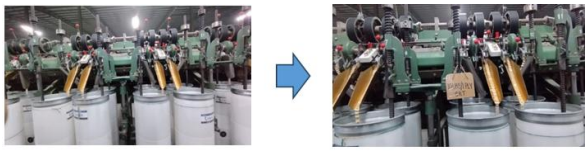
Fig. 2: (a) A broken and old pulley (b) which is replaced by a new and modern pulley.

3.2 Set in order

The 2nd phase was implemented after Sorting phase. In this phase, disorders among the whole facility were identified. Then, a standard order was fixed and implemented as is observed from figure 3 to 5.

(a) (b)

Fig. 3: (a) Unorganized spools (b) which are later organized.



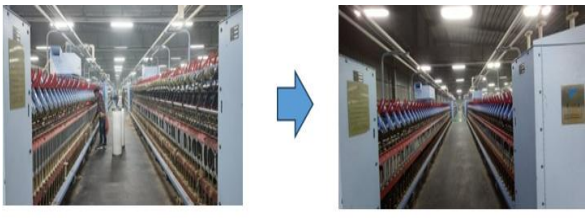
(a) (b)

Fig. 4: (a) Unlabeled Drawing Section (b) labelled afterwards.

Fig. 5: All the things are in order as name plate.

3.3 Shine

One of the most important phases is done next, which is very effective for the elimination of wastage and cleanliness. The floors remained dirty and no scheduled maintenance of the machines was performed in the previous scenario of this facility as is evident from figure 6(a). Figure 6(b) shows neat and clean facility from all perspectives.



(a) (b)

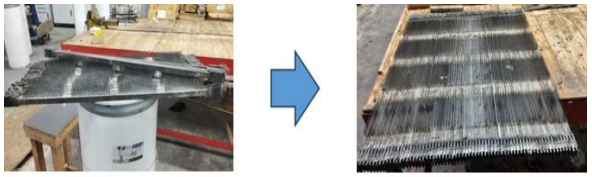
Fig. 6: (a) Uncleaned Spinning section (b) Neat and Clean Spinning Section.

3.4 Safety

Safety is very important for a facility and plays a vital role in the process of ensuring 6S. Hence, this step was thoroughly implemented as per industry standards and as per figure 7 and 8, many hazards inside the facility were deducted and risky objects were organized to keep a safe and sound workplace.

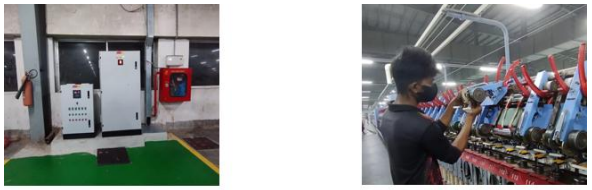
3.5 Standardize

This phase is implemented after the safety part. All the process, sections, working cultures, inventories were turned into a standard way as seen from figure 9 to 11 in which other S's implementation can sustain in the long run.



(a) (b)

Fig. 7: (a) Pin bars in unsafe place (b) are kept in a safe place.



(a) (b)

Fig. 8: (a) Maintaining safety in workplace by having a fire safety system (b) Wearing of mask while working.

(a) (b) (c)

Fig. 9: Standard Data system technology in Spinning frames, Fig. 10: A standard Packaging section, Fig. 11: A standard template showing the details of Spindle sensors.

3.6 Sustain

The positive outcomes of the 6S implementation in the Jute spinning facility have proven to be sustainable over the long term as because of the systematic organization, cleanliness, and standardized processes introduced through 6S have become deeply ingrained in daily operations, resulting in enduring efficiency gains. The 6S principles have seamlessly integrated into the organizational culture. Employees at all levels have embraced the new practices, recognizing the value of an organized and efficient workspace. The whole workforce is equipped with the necessary skills to adhere to and enhance 6S practices, ensuring that the

benefits are perpetuated through a knowledgeable and empowered team. Rigorous monitoring and evaluation mechanisms are in place to ensure the sustained effectiveness of 6S practices.

4. RESULTS AND DISCUSSION

The following table 2 and table 3 shows the overall efficiency per day before and after implementing 6S. Table 4 summarizes the day wise efficiency along with their average regarding before and after implementation of 6S which is represented in a line chart as shown in figure 12.

Non-productive time (NPT), primarily attributed to mechanical and electrical breakdowns, was identified as a significant contributor to productivity loss in the jute mill. Prior to implementation of 6S, frequent machine stoppages occurred due to poor housekeeping, lack of preventive maintenance, and limited accessibility to equipment and electrical panels.

The application of the 6S methodology led to a structured improvement in workplace organization and cleanliness, enabling early detection of mechanical wear and electrical faults. Standardized maintenance practices and improved safety measures further minimized unplanned downtime. Consequently, a measurable reduction in NPT was observed, resulting in improved machine availability, smoother production flow, and enhanced overall operational efficiency. The nonproductive times of Batching, Carding, Drawing, Spinning, Winding, Precision and Roll winding, Packaging and Inventory are taken by time study before the 6S implementation.

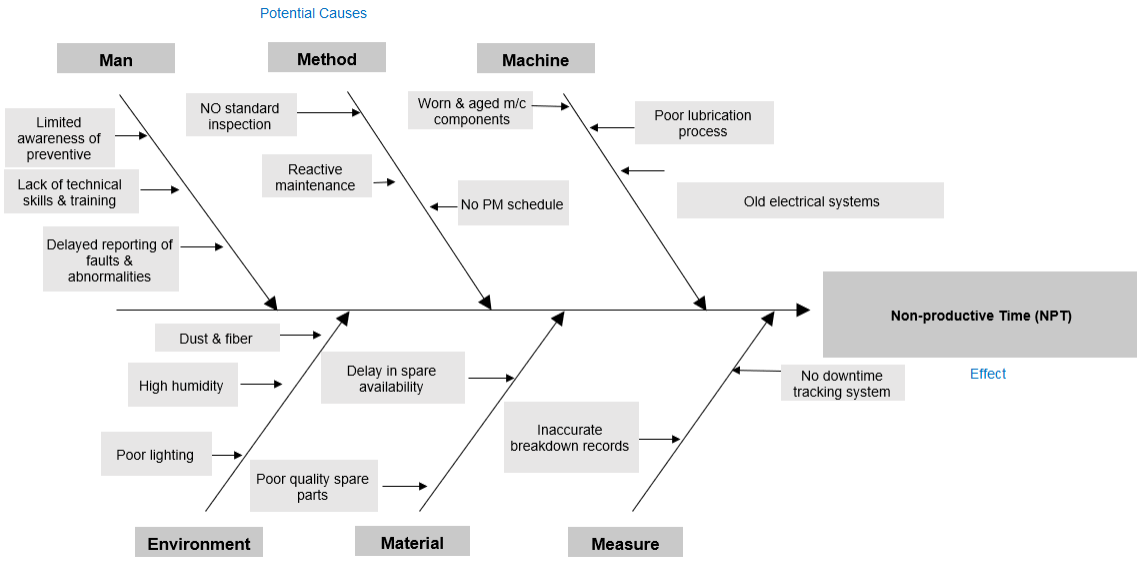


Fig. 12: Fishbone diagram for the Non-productive time

Figure 10. Fishbone (Ishikawa) diagram illustrates the root causes of non-productive time (NPT) in the jute mill. Mechanical, electrical, manpower, method, and environmental factors were found to be the major contributors to breakdown-related downtime.

Table 2: Section wise nonproductive time and overall efficiency per day before 6S implementation

Section	Issue	Non-Productive Time Throughout 24 Hours (Minutes)						
		Day 1	Day 2	Day 3	Day 4	Day 5	Day 6	Day 7
Batching	Electrical	65	54	89	67	87	89	88
	Mechanical	354	447	226	376	381	570	378
	Others	49	98	60	123	90	121	113
	Efficiency	67.50%	58.40%	74.00%	60.70%	61.30%	45.80%	59.80%
Carding	Electrical	45	56	59	98	77	77	85
	Mechanical	356	348	392	370	413	3	321
	Others	70	108	124	88	120	89	89
	Efficiency	67.30%	64.40%	60.10%	61.40%	57.60%	88.30%	65.60%
Drawing	Electrical	67	65	89	73	76	87	86
	Mechanical	310	389	365	319	382	396	375

	Others	89	124	78	98	101	70	107
	Efficiency	67.60%	59.90%	63.10%	66.00%	61.20%	61.60%	60.60%
Spinning	Electrical	59	89	82	64	80	59	72
	Mechanical	387	390	396	395	388	383	423
	Others	102	164	132	76	95	104	89
	Efficiency	61.90%	55.30%	57.60%	62.80%	60.90%	62.10%	59.40%
Winding	Electrical	98	87	63	87	83	68	87
	Mechanical	412	365	384	390	387	427	384
	Others	173	99	90	124	93	95	76
	Efficiency	52.60%	61.70%	62.70%	58.30%	60.90%	59.00%	62.00%
Precision Roll Winding	Electrical	45	65	88	54	59	78	90
	Mechanical	369	362	502	365	409	476	484
	Others	93	78	92	70	154	98	111
	Efficiency	64.80%	64.90%	52.60%	66.00%	56.80%	54.70%	52.40%
Packaging and Inventory	Transportation and Others	189	201	198	212	189	167	189
	Efficiency	86.90%	86.00%	86.30%	85.30%	86.90%	88.40%	86.90%
Day wise Efficiency (Before)		66.90%	64.39%	65.19%	65.78%	63.65%	65.70%	63.82%

As it is seen from table 2, the average efficiency level is 65.1 %. The efficiency level is low because of unorganized, uncleaned and unscheduled maintenance in the workplace. Efficiency is highly affected by the nonproductive time of mechanical issues in every section. The nonproductive times of Batching, Carding, Drawing, Spinning, Winding, Precision and Roll winding, Packaging and inventory are taken by time study after the 6S implementation also.

Table 3: Section wise nonproductive time and overall efficiency per day after 6S implementation

Section	Issue	Non-Productive Time Throughout 24 Hours (Minutes)						
		Day 1	Day 2	Day 3	Day 4	Day 5	Day 6	Day 7
Batching	Electrical	25	36	29	54	76	65	65
	Mechanical	333	353	345	334	354	343	345
	Others	49	78	53	43	32	76	69
	Efficiency	71.70%	67.60%	70.30%	70.10%	67.90%	66.40%	66.70%
Carding	Electrical	15	39	50	47	40	45	62
	Mechanical	329	365	354	383	365	373	343
	Others	32	63	68	34	42	56	29
	Efficiency	73.90%	67.60%	67.20%	67.80%	69.00%	67.10%	69.90%
Drawing	Electrical	35	47	33	54	60	34	65
	Mechanical	357	365	348	376	362	373	334
	Others	84	55	83	29	46	46	23
	Efficiency	66.90%	67.60%	67.80%	68.10%	67.50%	68.50%	70.70%
Spinning	Electrical	32	50	44	58	51	47	65
	Mechanical	356	349	358	391	374	399	387
	Others	72	93	78	47	38	43	32
	Efficiency	68.10%	65.80%	66.70%	65.60%	67.80%	66.00%	66.40%
Winding	Electrical	65	74	77	56	47	45	34
	Mechanical	358	343	368	370	352	359	328
	Others	98	32	87	48	47	45	76
	Efficiency	63.80%	68.80%	63.10%	67.10%	69.00%	68.80%	69.60%
Precision Roll Winding	Electrical	27	36	69	49	30	56	65
	Mechanical	390	345	343	351	372	398	340
	Others	65	55	57	60	34	67	84
	Efficiency	66.50%	69.70%	67.40%	68.10%	69.70%	63.80%	66.00%

Packaging and Inventory	Transportation and Others	74	82	78	71	76	80	70
	Efficiency	94.90%	94.30%	94.60%	95.10%	94.70%	94.40%	95.10%
Day wise Efficiency (After)		72.30%	71.63%	71.01%	71.68%	72.24%	70.73%	72.06%

As it is seen from table 3, the average efficiency level is now 71.7 % which increased on average 6.6%. The efficiency level increased because of organized, cleaned and scheduled maintenance in the workplace. The nonproductive time in every section reduced at an excellent rate.

Table 4: Summary of section wise nonproductive time and overall efficiency per day before and after 6S implementation

Day wise Efficiency	Day 1	Day 2	Day 3	Day 4	Day 5	Day 6	Day 7	Average
Before	66.90%	64.39%	65.19%	65.78%	63.65%	65.70%	63.82%	65.10%
After	72.30%	71.63%	71.01%	71.68%	72.24%	70.73%	72.06%	71.70%

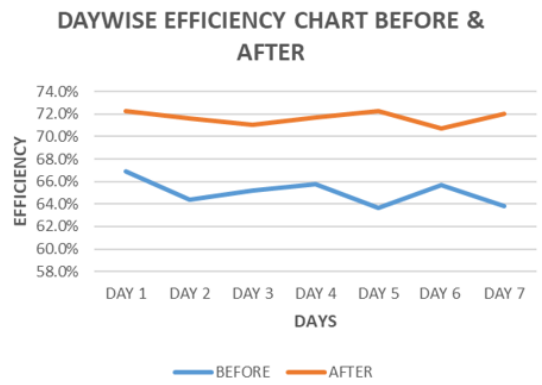


Fig. 13: Day wise efficiency chart before and after

There is a huge change of 6.6% in the efficiency level of whole production process. The key factor in this change is the implementation of 6S in a well-planned and sustainable way. As per figure 13, the efficiency level is at a constant level of around 71% which is also an important outcome. And this consistent efficiency level is especially important for a manufacturing-based company.

The implementation of the 6S methodology has significantly enhanced the efficiency of the whole production process. By systematically organizing, sorting, and shining workspaces, elimination of unnecessary clutter is done and optimized the layout for streamlined operations. Standardizing procedures and establishing clear guidelines has not only reduced errors but also improved overall consistency in our output. The systematic approach of 6S, which includes sustaining and ensuring ongoing improvements, has fostered a culture of continuous enhancement, leading to increased productivity and a more efficient production workflow.

The following table 5 and table 6 show the overall wastage per day before and after implementing 6S. Table 7 summarizes the day wise wastage along with their average regarding before and after implementation of 6S which is represented in a line chart as shown in figure 13.

The amount of wastage of Batching, Carding, Drawing, Spinning, Winding, Precision and Roll winding are taken by taking their weight at the end of each day before the 6S implementation.

Table 5: Section wise amount of wastage before 6S implementation

Section	Wastage Type	Wastage (Kg)						
		Day 1	Day 2	Day 3	Day 4	Day 5	Day 6	Day 7
Batching	Sliver	130.5	129	135	130	132	131	135
	Caddis	21	20.5	23	20	20.5	20	22
Carding	Sliver	189	187	193	191	190	189	188
	Caddis	22	21.5	23	22	21.5	21	20.5
Drawing	Sliver	119	120	123	120	125	122	121
	Caddis	13	13.5	15	13	14	13.5	13
Spinning	Sliver	27	29	30	31	29	28	31
	Caddis	23	22	24	27	26	24	26
	Thread	2	2.5	3	3	2.75	2.5	3.5

Winding	Thread	95	99	98	101	97	102	104.5
	Caddis	13	14	17	18.5	15	17	19
Precision Roll Winding	Thread	59	58	61	63	67	60	59
	Caddis	19	22	23	25	19	21	22
Total Wastage (Before)		733	738	768	764.5	758.8	751	764.5

As it is seen from table 5, the average amount of wastage per day is 754 kg. The amount of wastage is high because of jam in machines, imbalanced order, quality mixing, unorganized, uncleaned and unscheduled maintenance in the workplace. The efficiency is highly affected by the nonproductive time of mechanical issues in every section. The amount of wastage of Batching, Carding, Drawing, Spinning, Winding, Precision and Roll winding are taken by taking their weight at the end of each day after the 6S implementation.

Table 6: Section wise amount of wastage after 6S implementation

Section	Wastage Type	Wastage (Kg)						
		Day 1	Day 2	Day 3	Day 4	Day 5	Day 6	Day 7
Batching	Sliver	126	125.5	130	124	123	128	127
	Caddis	18	20	20.5	18	17	19	20
Carding	Sliver	178	181	186	179	180	187	181
	Caddis	19.5	20	21	19	19.5	20	20
Drawing	Sliver	103	109	111	105	105	106	109
	Caddis	10.5	11	12	10.5	10.5	11.5	11
Spinning	Sliver	23	24.5	25	24	24	25	24
	Caddis	17	19	21	20	19	20	21
	Thread	0.5	0.75	1	1	0.75	1	0.75
Winding	Thread	85	90	91	87	87	90	91
	Caddis	9	9.5	9	8.75	9	9.5	10
Precision Roll Winding	Thread	44	51	45	44	45	48	47
	Caddis	11	10	12	11.5	11.5	11	10.5
Total Wastage (After)		645	671.3	684.5	651.8	651.3	676	672.3

As it is seen from table 6, the average amount of wastage per day is 665 kg. The amount of wastage is reduced to around 100 kg's because of less jam I machine, balanced order, no quality mixing, organized, cleaned and scheduled maintenance in the workplace.

Table 7: Summary of section wise amount of wastage per day before and after 6S implementation

Total Wastage (Kg)	Day 1	Day 2	Day 3	Day 4	Day 5	Day 6	Day 7	Average
Before	732.5	738	768	764.5	758.75	751	764.5	754
After	644.5	671.25	684.5	651.75	651.25	676	672.25	665

The average wastage after 6S implementation is 665 kg compared to 754 kg of wastage that was produced before 6S implementation (Fig. 7). The integration of the 6S methodology has yielded notable improvements in minimizing wastage throughout our company's production process. Through the sequential steps of Sort, Set in order, Shine, Standardize, Sustain, and Safety successfully restructured the workflow. This methodical approach has not only led to a reduction in waste but has also instilled a sense of organization and efficiency. The systematic elimination of unnecessary elements and the establishment of standardized procedures have collectively contributed to a leaner, more resource-conscious production system. As a result, the company is experiencing enhanced operational effectiveness and a more sustainable approach to manufacturing.

Table 8: Performance parameters before and after results of implementation of 6S

Parameters	Before	After
Wastage (Kg)	754 Kg	665 Kg
Average Efficiency (%)	65.10%	71.70%
Working Environment	Not Good	Better
Safety	Not Safe	Standard

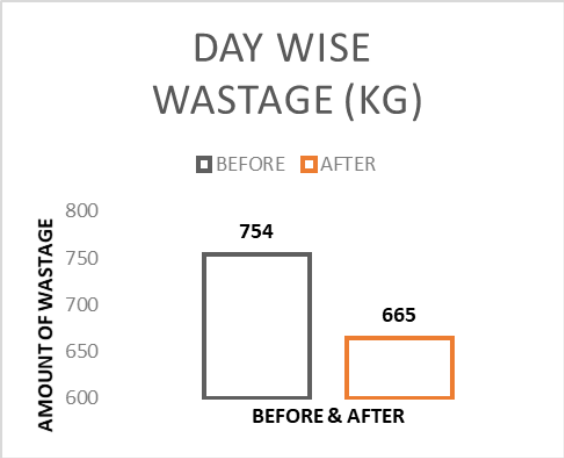


Figure 14: Day wise average amount of waste before & after the 6S implementation

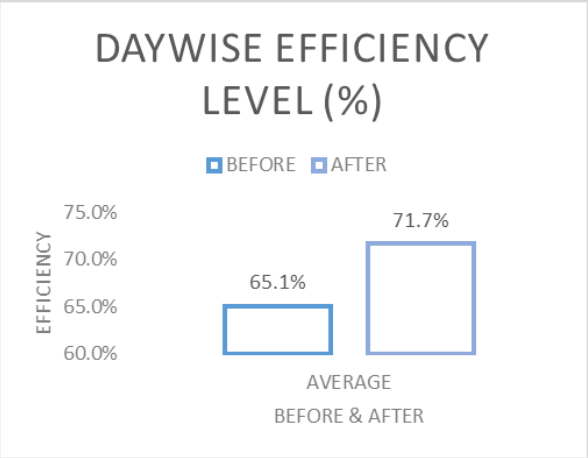


Figure 13: Day wise efficiency before & after the 6S implementation

Table 8 summarizes the performance parameters before and after the implementation of 6S. As per figure 14, the average amount of wastage of each day was average of 754 kg before implementation of the 6S method and the average amount of wastage is 665 kg after implementation of the 6S method. As seen from figure 15, the average efficiency rose to 71.7% from 65.1% after implementing 6S method, indicating the improvement of wastage reduction target per day and reduces the unnecessary usages of properties resulting in improvement in productivity, efficiency and a smaller number of nonproductive hours.

To examine the statistical significance of performance improvement after the implementation of 6S, a paired sample t-test was conducted using day-wise data collected before and after the intervention. Since the same production system was evaluated under identical operating conditions, the paired t-test was considered appropriate.

Table 9: statistical t-test analysis results before & after implementation of 6S

Parameter	**Mean (Before)**	**Mean (After)**	**Result**
Efficiency (%)	65.1	71.7	Significant ($p < 0.05$)
Wastage (kg/day)	754	665	Significant ($p < 0.05$)

From table 9, the statistical analysis confirms that the improvements in both efficiency and wastage reduction after the implementation of 6S are significant at the 95% confidence level. The results indicate that the mean production efficiency increased from 65.1% before implementation to 71.7% after implementation, and this improvement was found to be statistically significant at the 95% confidence level ($p < 0.05$). In addition, the average daily wastage decreased from 754 kg to 665 kg after 6S implementation. The reduction in wastage was also statistically significant ($p < 0.05$). These findings confirm that the improvements observed after the implementation of 6S are not due to random variation but are directly associated with the systematic application of 6S practices in the jute spinning facility.

Key performance indicators such as increased productivity, reduced waste, and improved safety records serve as tangible evidence of the sustained success of 6S implementation. These metrics demonstrate our ongoing commitment to excellence and efficiency.

This jute mill's adoption of the 6S system has shown to be a revolutionary endeavor with numerous beneficial outcomes. The impact is multifaceted, ranging from financial benefits and the development of a pleasant workplace culture to operational efficiency and quality enhancement.

5. CONCLUSION

Jute industry is historically and culturally important for Bangladesh [18]. Jute plays an important role as one of its cash crops, contributing to Bangladesh's economy [19]. Thus productivity, efficiency and also safety are paramount in jute industry. Hence the implementation of 6S can be crucial. So, the 6S implementation is done in "Janata Jute Mills, Faridpur" which is one of the biggest spinning industries of Bangladesh. The implementation results from figure 14 and 15 show that day wise wastage reduced by around 89 kg from 754 kg to 665

kg while day wise efficiency increased by around 6.6% from 65.1% to 71.7%. The overall workplace is organized and tidied up which improved productivity, employee satisfaction and decreased the risk of accidents. Both qualitative and quantitative study provides a comprehensive understanding by providing detailed insights of the 6S implementation. This application shows how important it is for the jute industry to implement 6S to identify and exclude the nonproductive times along with reduce wastage. According to [20], the 6S management effectively increased the quality of nursing management, improved rescue operations efficiency and increased nurses' satisfaction. Similarly, improvement in the level of efficiency, neat and clean, safe work environment with process improvement is the ultimate result of implementation of 6S in the Jute industry.

Finally, the successful integration of 6S with traditional jute processing practices is a pivotal achievement. The ability to harmonize modern methodologies with industry traditions positions companies as a forward-thinking entity. In near future, this Jute spinning facility will emerge as a globally competitive player, balancing tradition with innovation. The present study has certain limitations such as the data is limited to only seven days. High volume of data can produce more accurate results. Further improvement in this study can be to integrate machine learning models to reduce sorting errors and use AI driven process automation to ensure workplace safety.

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Declaration of interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Data availability statement

The authors confirm that the data supporting the findings of this study are available within the article.

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