American Journal of Industrial and Business Management, 2019, 9, 2168-2189
https://www.scirp.org/journal/ajibm
ISSN Online: 2164-5175
ISSN Print: 2164-5167

# Putting Green Lean Six Sigma Framework into Practice in a Jute Industry of Bangladesh: A Case Study

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**How to cite this paper:** Talapatra, S. and Gaine, A. (2019) Putting Green Lean Six Sigma Framework into Practice in a Jute Industry of Bangladesh: A Case Study. *American Journal of Industrial and Business Management*, **9**, 2168-2189.
https://doi.org/10.4236/ajibm.2019.912144

**Received:** October 17, 2019
**Accepted:** December 14, 2019
**Published:** December 17, 2019



## Abstract

Lean Six Sigma is a fact driven tool that joins two powerful business strategies known as Lean Manufacturing and Six Sigma. Lean Six Sigma is adopted in an industry for eliminating waste, reducing process variations, and preventing defective product manufacturing which in turn reduces energy consumption and overall negative environment impacts. In that context, this case study uses LSS framework with environmental considerations to eliminate waste and improve industry's performance without causing many negative impacts on environment. Steps by step improvement programs, analysis of raw materials and energy usages are performed to reduce process variation, energy usage and carbon-dioxide emission. The framework is used to define, measure, analyze, improve and control (DMAIC) method in a popular jute industry named "Company X". Traditional impact assessment tools were also integrated.

## Keywords

LSS, Green Six Sigma, Environment Impacts, DMAIC, Lean Six Sigma

## 1. Introduction

This Lean and Six Sigma are the two most well-known tools for process improvement strategies for the purpose of delivering bottom line benefits [1] [2] [3] [4]. The "Lean Six Sigma" term was first used in the late 1990s and early 2000s to introduce the combined strategy for improving business performance [5] [6]. Successful implementation of this LSS framework will enable an industry to reduce its in-process variability [7], reduce lead time and amplify business profit [8] [9] [10] [11]. Nowadays increasing environmental concerns are forcing the manufacturing industries to rethink their business strategies in a way that has less negative impact on environment [12] [13]. With a view to achieve this objective, the industries are now looking for eco-friendly process by adopting techniques and processes that facilitate green production [14]. Both Six Sigma and Lean aim at maximizing profit and improve the place in market [15] [16]. When eco-friendly strategy and LSS framework are linked together, the integrated framework tends to reduce environmental impacts [17] while reducing energy consumption and resources [18]. It will also aim at improving resource efficiency and eliminating waste during manufacturing process [19]. Proper implementation of LSS framework with environmental concerns helps to improve the overall customer gratification level [20]. LSS initiatives and eco-friendly processes have some common concerns of waste reduction, worker commitment and continuous improvement [21].

Deployment of LSS using environmental concerns needs proper implication of LSS framework with eco-friendly strategies in order to turn opportunities of environment into operational advantage and excellence [22]. By properly aligning LSS and environmental sustainability concept, manufacturing industries will harvest benefits while reducing variations and defects which eventually results in minimum scrap, energy and resource usages [23] [24].

This case study provides insights of implementing of LSS framework with environmental considerations in a jute processing industry. The mentioned framework is based on structured DMAIC steps which consist of activities that guide eco-friendly waste reduction process. This framework applies the tools and methods that ameliorate operational as well as benefits regarding environment. After completing this project, the industry improved process capability index from 0.32 to 0.50; at the same time reducing excess jute waste by 75%. Further benefits and improvements were observed for numerous metrics related to manufacturing process such as cycle time reduction, decreasing lead time as well as reduced consumption of resources.

The questions addressed in this case study include:

- How to recognize suitable elements of LSS model linked to environmental concerns?
- How to implement a LSS framework with environmental considerations with a case study?
- How to measure metrics related to performance before and after implementing improvement programs?

The motivation for implementing this framework is that there have not been many studies performed in manufacturing industry regarding Green Six Sigma. Considering these factors, an existing framework of LSS with environmental considerations had been implemented in this case study to validate the model further. Similarities between LSS and Environment Conscious Manufacturing are depicted in **Table 1**.

## 2. Literature Review

The objective of LSS is inventing effective and optimized manufacturing process

**Table 1.** Similarities between LSS and environment conscious manufacturing.

| Factor | LSS | Environment Conscious Manufacturing |
|---|---|---|
| Revenue and Competitiveness | Aims at maximizing revenue and advantage in competition through defect reduction. | Aims at maximizing the revenue and competitiveness by reducing environmental impact. |
| Area of focus | Improving organizational performance. | Cultivating environmental performance. |
| Inventory strategy | Kept minimal to avoid waste. | Kept minimal to avoid resource overuse. |
| Waste | Reduced to improve cost efficiency. | Eliminated to improve environmental efficiency. |
| Satisfaction of customers | Focuses on achieving customer satisfaction by reducing costs of operation and defective products. | Focuses on satisfying customers by reducing cost of resources with ecofriendly products. |

by eliminating variations in process and underlying inefficiencies that are present in the manufacturing industries or organizations [25]. Environmental Protection Agency (EPA) of U.S. conducted test studies within the organizations in U.S. to examine the impact of LSS linked to the improvements of environment [26]. Infusing LSS framework along with environmental concerns provides operational as well as environmental advantages and amplifies overall efficiency of industry by emulating a business process which is environment-friendly. In the following part of this article, review of literatures is performed for individual research paper integrating LSS concepts which are concerned in environment. The United States Environment protection observed how LSS aids in improvement practice that is very favorable to anticipation of contamination and sustainable features. Study also suggested that LSS helps to improve performance regarding environment and gives direction on how environmental concerned industries can tie LSS program to get superior environmental as well as operational results. A methodology based on LSS known as eco-design aids in handling the complex assessment of environment at industries [27]. The approach of the above mentioned work was authenticated with a study that was piloted in an aluminum substation conducting electrolysis. That methodology mentioned factor of environment as one of the fourth dimensions of Quality principle and helps to systematize the total process of eco-friendly design. An established model determined how efficiency of process and waste are processed in a lean-and-green project propelled by LSS tools [28]. Design of Experiments (DOE) was set up to identify and restrain the controlling parameters. The validation of that model was done with the support of case study which was conducted in a corporation of maritime transport. DOE was used in order to construct a design based on factorial consists of three factors that control the performance. That model corroborates LSS activity which increases efficiency of operation through concurrent waste reduction. Another piloted study in an automotive industry to examine the link between the performance of organization and management system of environment [21]. Studies related to Confirmatory Factor Analysis, Analysis of exploratory factor along with Reliability were conducted to observe the likelihood to obtain ISO 14001 certification. Results suggested that this certification usually does not moderate the inter-relationship between LSS and performance. Further intuitions in order to enhance organizational performance can be obtained through ISO 14001 certification.

A developed framework joins green six sigma and lean for improving quality of operations and reduce environmental impacts [29]. A construction process was used to validate that framework. The framework helps to identify the wastes and offers a complete multilevel tactic for improving process and minimize the impacts on environment. A green lean method was reviewed with a view to checking the compatibility of three concepts *i.e.* lean, six sigma and green concepts [14]. A newer approach named Green LSS that binds eco-friendly lean with six sigma was advised which aims at achievement of monetary performance through the dual effect of refined environmental performance and operational excellence. A study of the incorporation of environmental impacts with management of organization focusing on environment-friendly business practices within the organization was analyzed [18]. The factors affecting business merit and environmental threats were analyzed. A comprehensive review was done on Six Sigma, Lean and sustainability along with the possibility of combining the elements into a unified single strategy in order to gain operational excellence [22]. On the basis of that review, it can be said that there is an opportunity for integrating the three strategies using DEMAIC method. Proper factors behind the success have to be identified for the successful integration. 21 barriers were recognized that affects implementation of Green LSS in product development [30]. Moreover, ISM approach was used for generating a hierarchical model of the identified obstacles. Implementation of Interpretive Structure Modelling helped in the identification of barriers and gave insights on Green LSS implementation in product development [30] [31] [32]. 25 obstacles were identified and fuzzy analytic hierarchy process was adopted to identify the rank of different TQM barriers in RMG sector [33] [34] [35]. Also, an empirical study was performed to learn the effects of critical factors [36]. The causes of the health hazards remedial ways in garments industry were studied [37]. A study shows that integrating TQM and other quality standards on the basis of philosophical compatibility can pave the way of proper alignment [38].

## 3. About the Implemented LSS Framework

A proposed framework [39] of LSS bonded with environmental considerations was implemented. The implemented framework elements of environment combined with DMAIC method to ensure improvement of process as well as environmental benefits. Each phase is made of a set of predefined process or activities that monitors and reduces environmental effects. Define phase identifies the potential problem and gives a clear idea for setting scope and objectives in a way such that an organization's both operational and environmental performance are improved. Measure phase is used to measure the current state of the system. This phase is also used to measure critical to quality characteristics (CTQ). In measure phase process inefficiency data, resource consumption data, quality data were collected. In Analyze phase, the causes of process variation were investigated. Defects due to root cause, potential wastes, CTQ and root cause relationship were documented properly. In Improve phase, possible solution of the problems is discovered. The benefits of implementing solutions must be evaluated in terms of performance improvement and environmental impact reduction. In Control phase, performance metrics are continuously monitored to ensure sustainable benefits.

The framework is constructed so that both performance and metrics related to environment and process will be addressed thus improving the organization's operational excellence.

### 3.1. About the Case Organization

The study was conducted on a jute industry located at Jessore, Bangladesh. "Company X" Jute Mills Limited is an associate of "Company X" Group of Industry which is one of the leading business organizations in Bangladesh. The mill is located at Jessore.

The industry gained a strategic advantage because there is a nearby sea port which allows easy inflow of jute. The mill has a yearly production capacity over 70,000 metric tons of Jute Yarn and 7 Million pcs. Of standard "A" Twill, "B" Twill, rice bag, vegetable oil treated sacking bag, sugar bag, flour bag. The industry has ISO 9001:14001 certification. The industry has never implemented any Lean or Six Sigma initiatives. "Company X" Jute Mills Ltd. is interested in improving their process capability and turn their manufacturing processes more eco-friendly.

### 3.2. About the Product

The jute product that was selected for implementing LSS framework is "Precision spool". Precision spool is a roll of thread made of jute that is used in everyday application, making jute bags, sacks or other jute products. A 10/1 CRX precision spool weighs around 10 pounds. Recently more and more precision spools are being rejected due to their inappropriate weight. Considering these issues, the precision spool was identified as potential product for implementing this framework.

### 3.3. Manufacturing Process

The primary material is raw jute. The manufacturing process begins with grading and bunching of raw jute. Then jutes are emulsified and piled for 48-72 hours. Next, jutes are fed into breaker machine which turns raw jute into jute silvers. Finisher machine further refines the jute silver. This jute silver is the main element of jute thread. Then jute silvers are inspected and tested. After passing the test, jute silvers are fed into the automatic spinning frame which process the jute and makes jute thread. In the next step, jute thread is twisted and rolled in a spool which is known as precision spool. Quality department tests these jute spools manually by weighting and performing strain tests. The batch which fails to meet required specifications is considered as waste. There are seven mills in total, each capable of producing 6600 Kgs of spool every day.

## 4. DMAIC Method

The procedure of applying DMAIC method is described in the following section.

### 4.1. Define Phase

The aim of this phase is to address the problem, identify the scope of implementing this framework. The requirements, standards, needs and preferences of the customers and users are defined as "Voice of Customers" (VOC). A proper "Supplier input process output customer" (SIPOC) diagram (Figure 1) was constructed to get a better understanding of tasks and activities to be performed. Details on raw material usage, energy consumption are also considered. As the industry is also interested in eco-friendly process, current state of environment impacts was also identified. A project charter containing details about the problem, objectives and main goals, stakeholder data, roles and responsibilities of management was developed.

### 4.2. Understanding the Problem

First, each mill of the "Company X" jute industry produces maximum 6600 KG

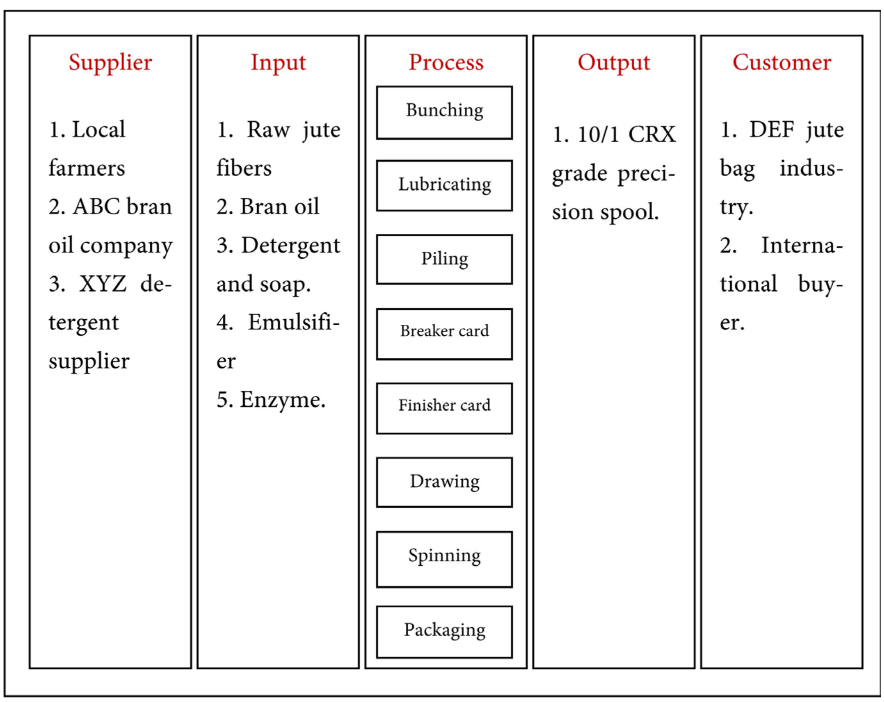


Figure 1. SIPOC diagram.

of finished product or approximately 1455 spools of 10/1 CRX precision spools. There are seven mills in total. From our sample analysis, only 68% spools are within the allowable weight limit. Minitab shows that the average weight had been shifted to 10.81 lbs. as shown in Figure 2 which is far from the specified average 10 lbs. The price of CRX spool is $1400 to $1600 per ton. Rework is not possible once a spool is finished processing. The maximum output of the industry is 46 tons. So, everyday almost 14-ton product does not meet CRX standard. The industry has to sell them at a much lower price $1100 to $1000 per ton. So the daily cost of quality is almost $27,000. For this project, the "Voice of the Business" (VOB) is to reduce cost of quality and scrap and improve cash inflow with the least environmental impacts.

### 4.3. Measure Phase

The measure phase emphasizes on gathering the data on current state and documenting this data. Another important thing is to identify and measure critical to characteristics information of the finished product. Besides, the measure phase focuses on evaluating and validating data measuring system and to identify root causes of defects and performance inefficiencies.

After gathering process data and CTQ data, current sigma level was calculated. In this project critical to quality characteristics are count (weight of each spool), strain resistance and moisture. These characteristics should be aligned with organization's business strategy to reduce DPMO and scrap and improve productivity. Total process of manufacturing was mapped with a process flow chart (Figure 3 and Figure 4).

### 4.4. Measure Current Sigma Level

For calculating the current sigma level, process capability index ($C_{pk}$) value was calculated from historic data. $C_{pk}$= 0.32 states that 68% spools were within control limits. From that data, calculated sigma level is 1.0. (Table 2).

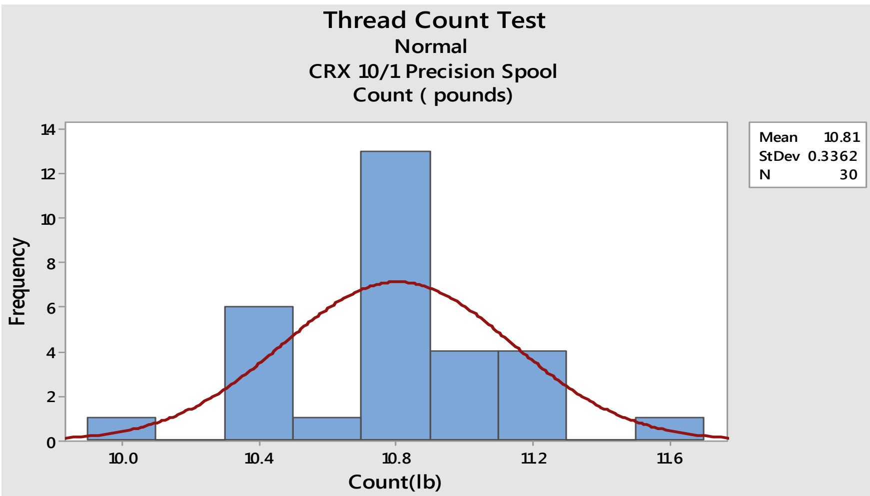


Figure 2. Histogram of thread count.

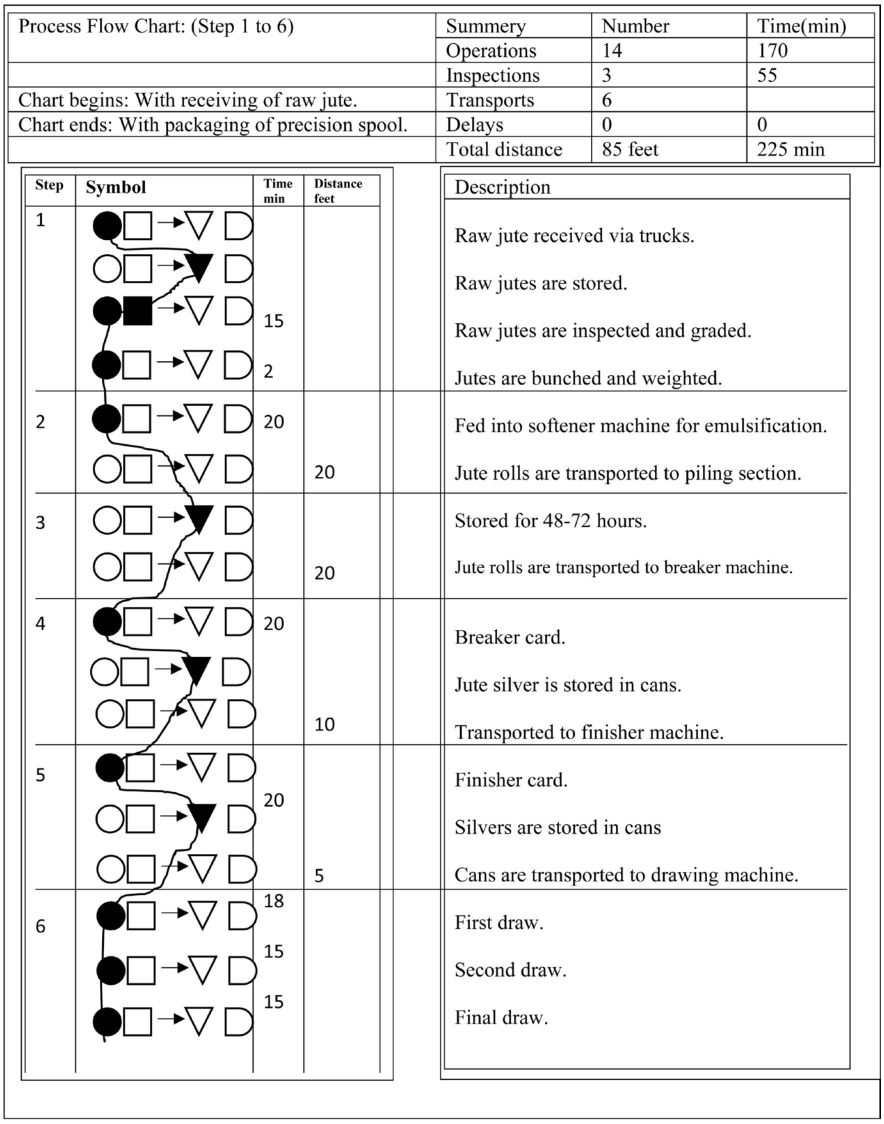


**Figure 3.** Process flow chart (step 1 - step 6).

**Table 2.** Current process capability data.

| | |
|---|---|
| Average count | 10.81 lb. |
| Standard deviation (Std. dev) | 0.34 |
| Co-efficient of variance (CV) | 3.11% |
| Control rules | |
| Allowable individual max count | 11.89 lb. |
| Allowable individual min count | 9.73 lb. |
| Allowable CV | 2% - 3% |
| Upper control limit (UCL) | 11.13 |
| Lower control limit (LCL) | 10.48 |
| Percentage of population within limits | 68% |
| $C_{pk}$ value | 0.32 |
| Sigma level | 1.00 |

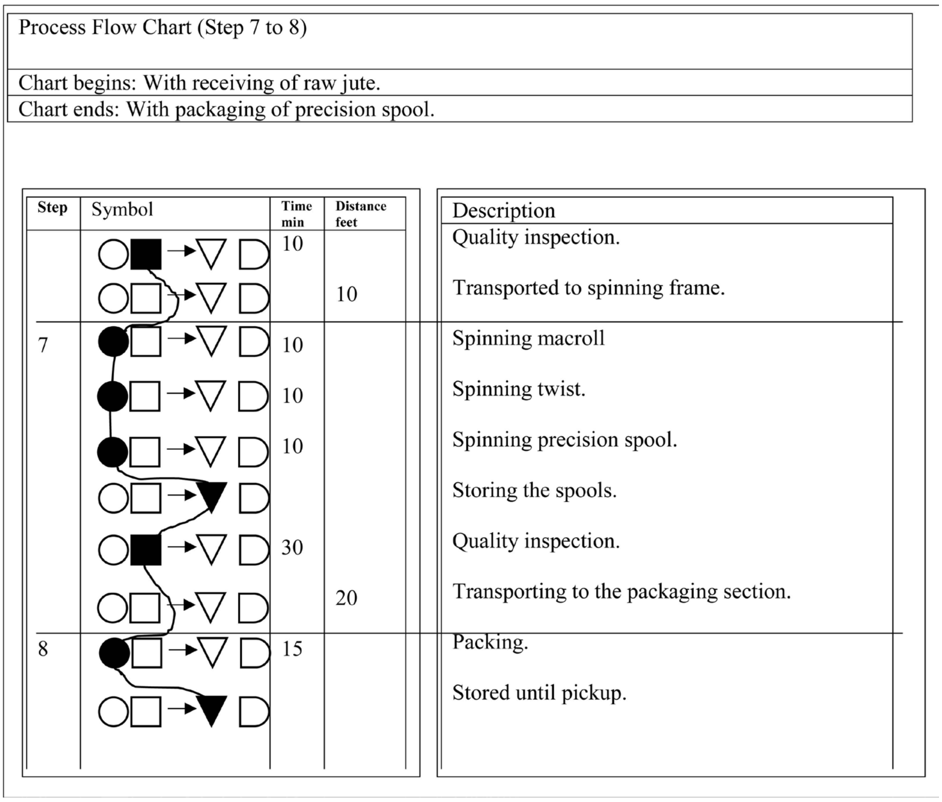


Figure 4. Process flow chart (step 7 - step 8).

## 4.5. Resource Usages

There are total seven mills in "Company X" Jute Industry. In this step, current amount usage of raw materials and energy consumptions were measured. Based on current energy usage, carbon emission amount are also estimated. These are shown in Tables 3-6.

## 4.6. Analyze Phase

After gathering field data and Pareto analysis (Figure 5), it was observed that the count of the 10/1 spool was over 10 lbs. which was the most significant defects. Then a brain storming session was performed to identify the potential causes for those defects. Next a cause and effect diagram was constructed to shade light on causes and sub-causes. The causes and sub-causes were then categorized into six sections namely Man. Machine, Material, Method, Measure and Environment. After discovering all the causes, it was obvious that the effect of machine and workplace environment is more severe than other common and general causes. The cause and effect diagram is showed in Figure 6.

## 4.7. Process Capability Analysis

Analyzing process capability is important to identify whether the process is performing statistically within specified limits. A sample of 30 thread was taken for test. From the sample weight, spool weight was calculated. The average count of

**Table 3.** Raw jute usage.

| | |
|---|---|
| Capacity of each jute mill | 6600 kg/Day |
| Number of 10/1 CRX spools produced | 1455 piece per day |
| Average jute wastage | 550 kg/Day |
| Number of mills | 7 |
| Total jute wastage | 3710 kg/Day |

**Table 4.** Emulsion usage.

| | |
|---|---|
| For each mill: | |
| Emulsion required | 1425.55 Liters per day |
| Emulsion wastage | 111 Liters per day |
| Total emulsion wastage across industry | 777 Liters per day |

**Table 5.** Energy usage.

| | |
|---|---|
| Emulsion processing machine | 5000 watts |
| Jute processing machine | 36,000 watts |
| Total usages | 41,000 watts per hour |
| Usage per day | |
| Emulsion processing machine (3 hours per day) | 15,000 watts |
| Jute processing machine (12 hours per day) | 432,000 watts |
| Total consumptions | 447,000 watts |

**Table 6.** Carbon dioxide emission.

| | |
|---|---|
| Carbon dioxide emission | 1.15 kg/kw |
| Energy consumption | 3129 kw/day |
| Total Carbon dioxide emission | 1,007,538 kg/year |

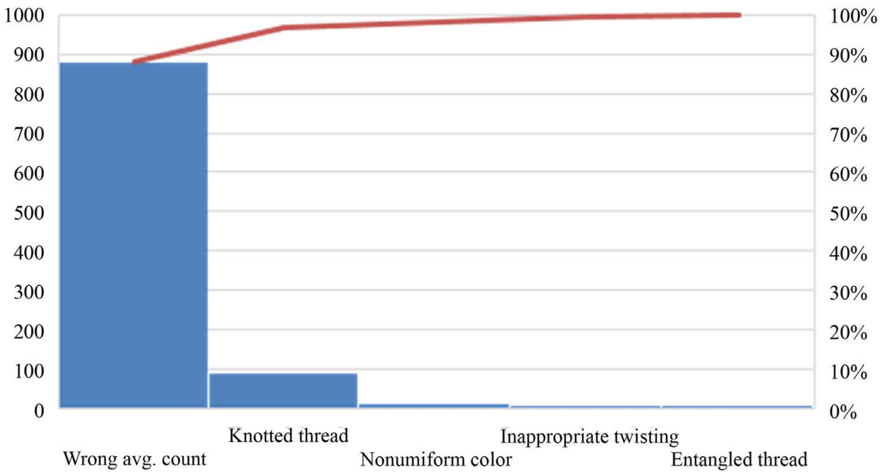


**Figure 5.** Pareto chart of type of defects.

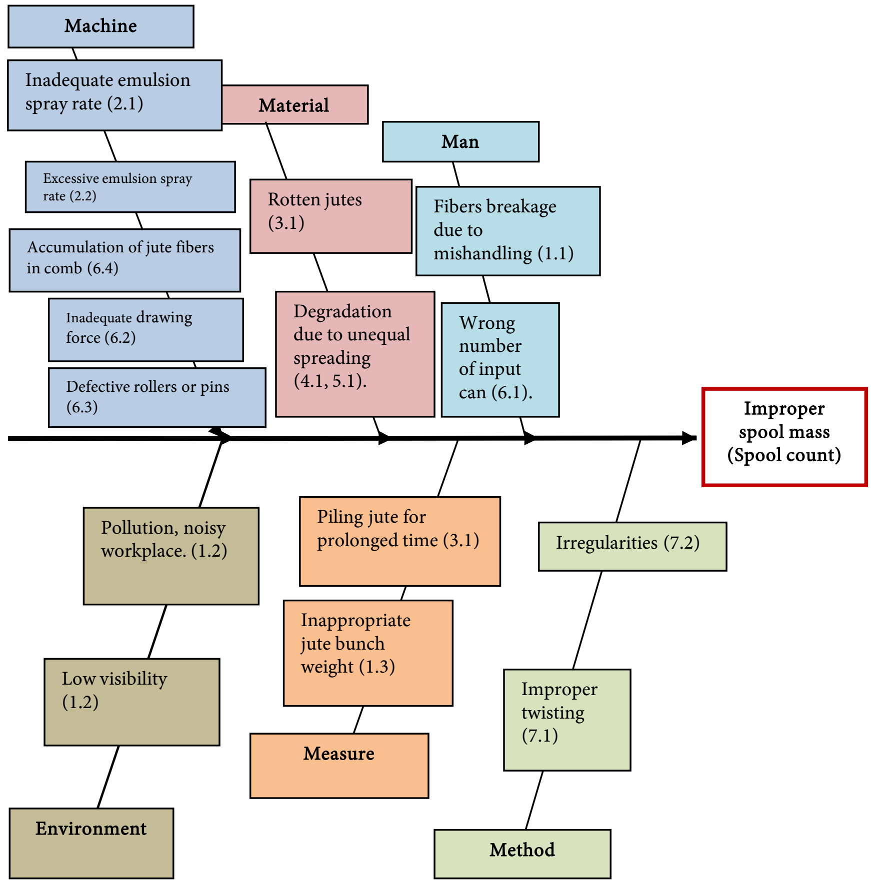


**Figure 6.** Cause and effect diagram.

each 10/1 must be 10 Lbs. with a tolerance of 2% - 3%. The thread count for 30 samples is shown in Table 7. Analyzing these data reveals that process capability index $C_{pk}$ = 0.32 and there is significant variation is present in the process. The process capability index report is shown in Table 2. The average thread count 10.81 lbs. suggests that the mean of the process has shifted considerably and the process is not properly centered. (Thread counts are always measured in pound.) Extensive measures must be taken in order to improve process performance and reduce variability.

### 4.8. Improve Phase

In the improve phase, the proposed solutions that would help to improve the process are to be applied and the results are tested. The improvement activities should be implemented in such a way that every progress can be monitored thoroughly and the outcomes can be easily visualized and recorded. The potential future benefits or impacts after the implementation should be justified from the view point of quality and environment. Proper employee and worker training and guidance must be provided to facilitate successful implementation of this model. Tools like statistical process control and 5S were used to improve process performance.

Table 7. Thread count (weight) in pound.

| Thread Count (lb) | | |
|---|---|---|
| 10.88 | 10.72 | 10.40 |
| 11.28 | 11.18 | 10.83 |
| 10.41 | 11.08 | 10.92 |
| 10.40 | 10.89 | 10.03 |
| 10.81 | 10.74 | 11.59 |
| 10.47 | 11.28 | 10.89 |
| 10.38 | 10.51 | 10.99 |
| 10.88 | 10.74 | 11.02 |
| 11.28 | 10.79 | 10.85 |
| 10.40 | 10.79 | 10.76 |

### 4.9. Validating Proposed Solutions

Potential solutions for the root cause of improper avg. Mass of 10/1 CRX spool was identified after a brainstorming session. Improvement activities were proposed and implemented for every causes and sub-causes in each step of the process. After the implementation of improvement actions, test studies were conducted to validate the proposed solutions in a way that the set specifications are met. Pilot studies revealed that process variations were reduced to a great extent with the implementation of proposed solutions. Besides, the process mean was centered with average of 9.96 lbs. shown in Figure 7. Control limits were also re-calculated as shown in Figure 8 and Figure 9.

### 4.10. Step by Step Improvement Activities

In this section manufacturing process is described briefly along with causes of process variation in each step. Figures 10-17 show causes of product rejection, graphical representation of current state and proposed arrangements, proposed solutions and step by step process details.

### 4.11. Control Phase

The applied improvement steps should be properly and carefully documented for sustainable improvement activities. The goal of the control phase is to maintain the positive impacts of improvement activities to continue fully after completing the LSS project. During the initial phase of the control phase, it is advised that documents and standardized procedures are maintained to generate a clear overall description of the changes that will be made to sustain the benefits of this project.

The results and the outcomes have to be communicated with all the workers and employees of "Company X" Jute Industry in order to create a positive attitude towards the LSS method. Developing a flowchart may be a good option to clearly indicate the roles and tasks of every employee or worker in sustaining

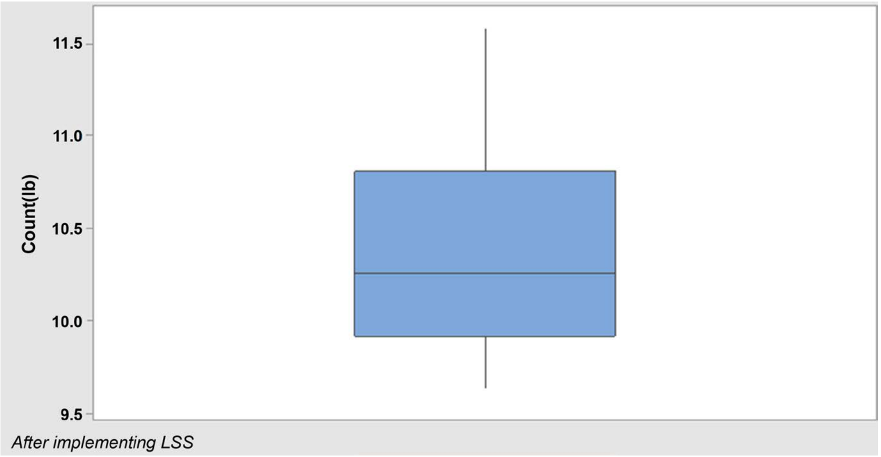


Figure 7. Boxplot graph of thread count.

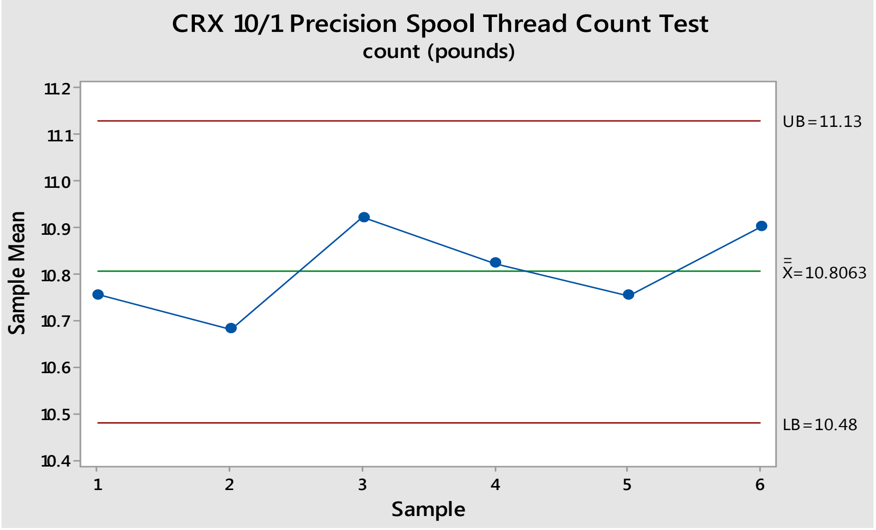


Figure 8. Control chart before implementing framework.

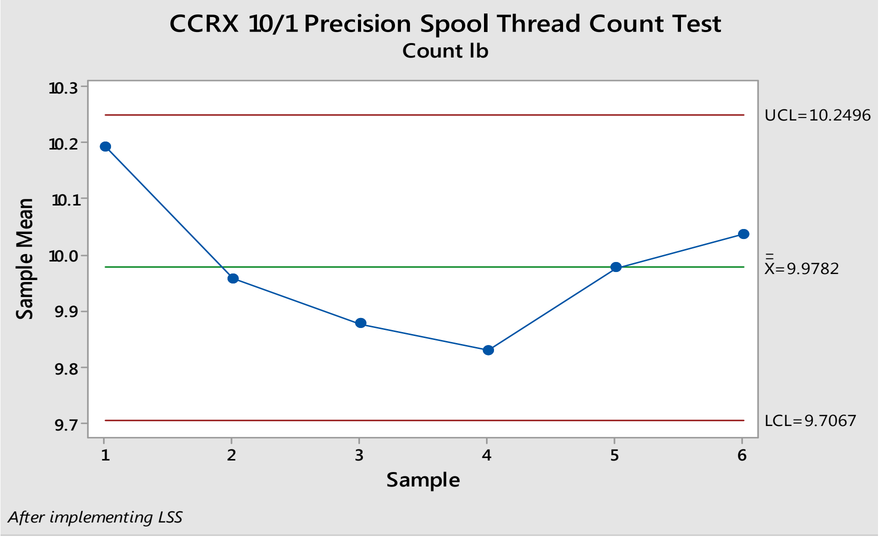


Figure 9. Control chart after implementing framework.

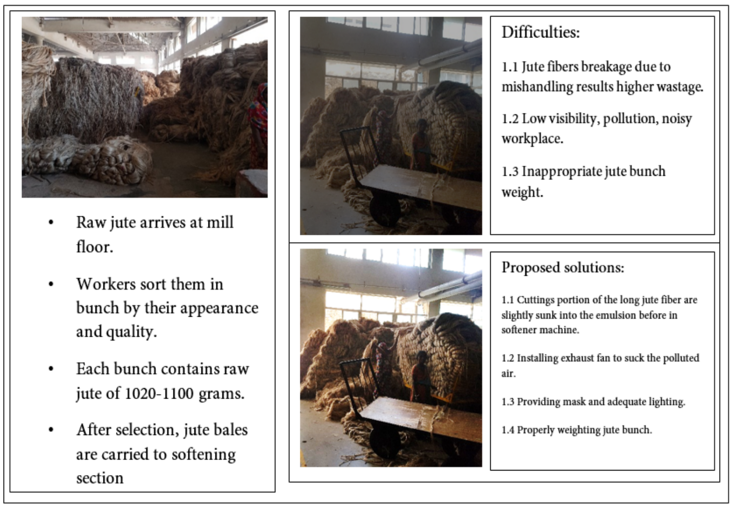


**Figure 10.** Sorting and bunching raw jute fiber.

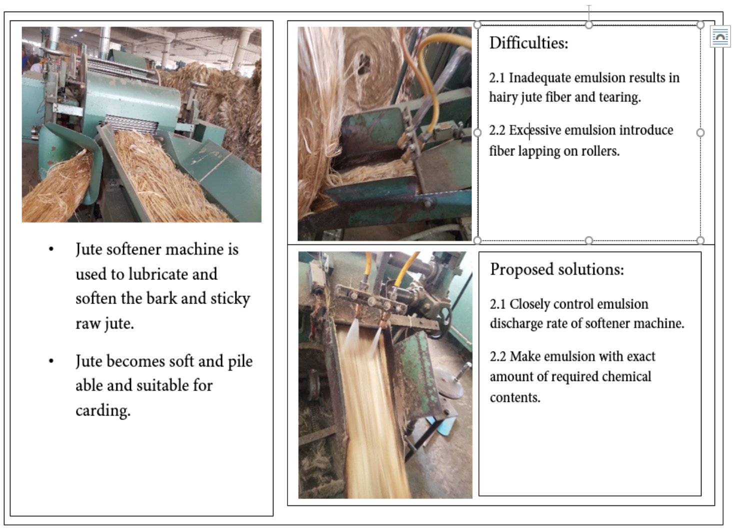


**Figure 11.** Lubricating and softening.

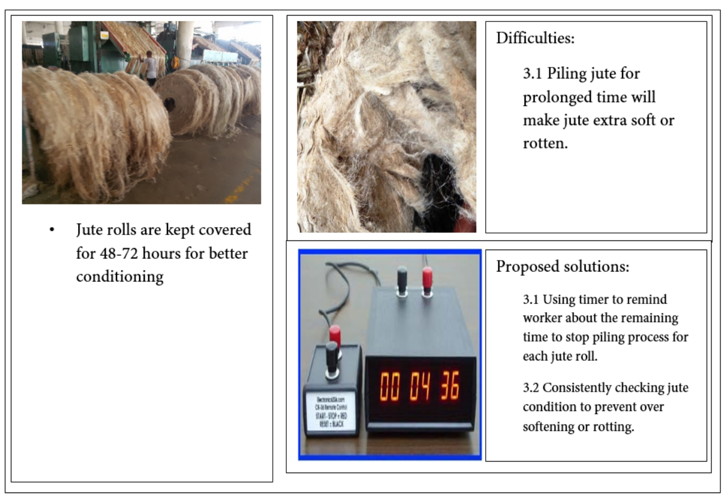


**Figure 12.** Piling and conditioning.

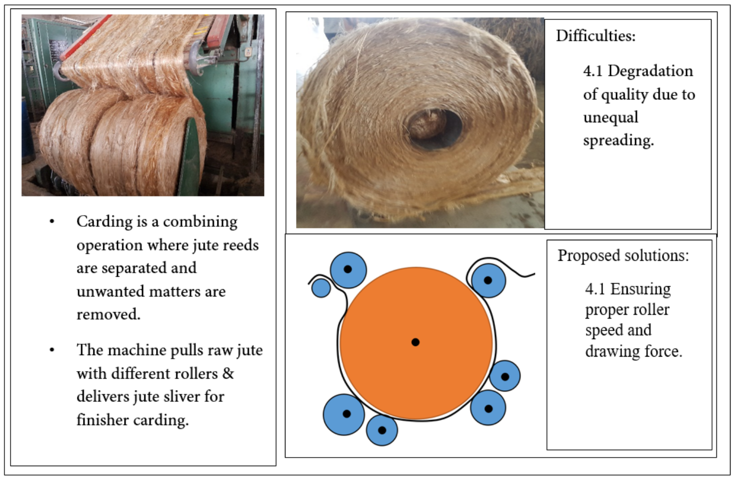


**Figure 13.** Breaker card.

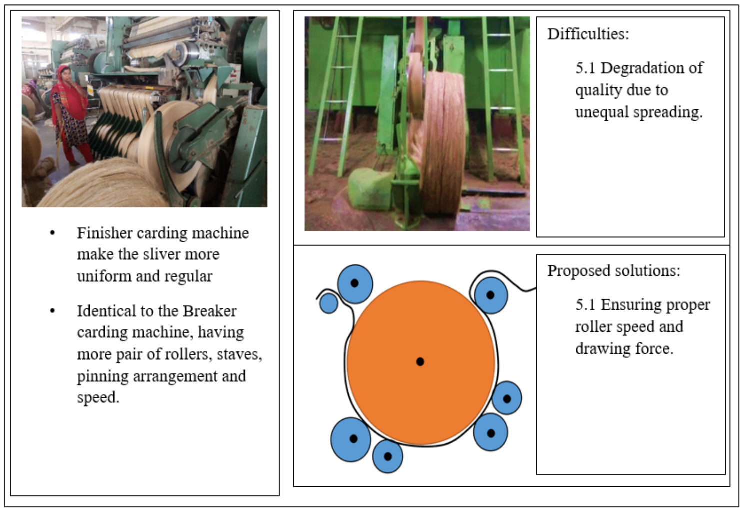


**Figure 14.** Finisher card.

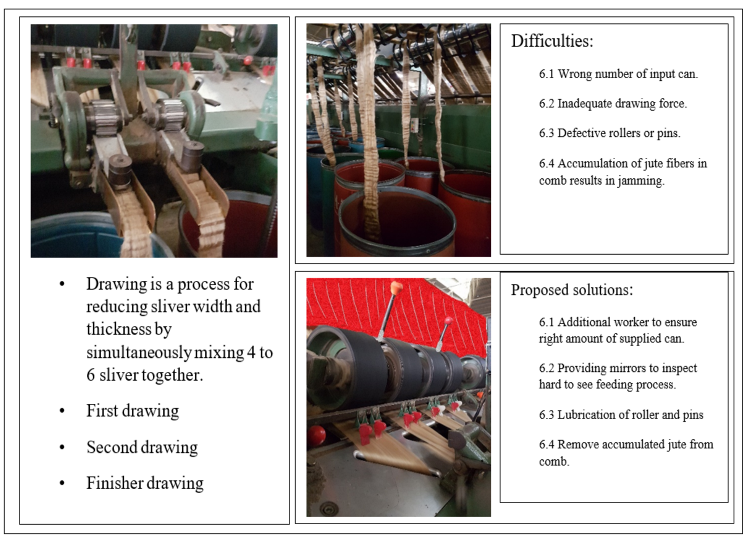


**Figure 15.** Drawing.

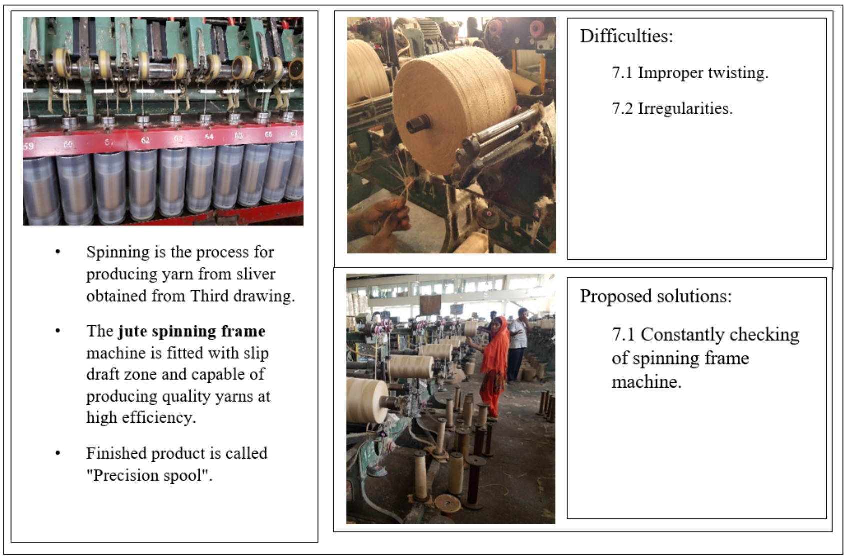


**Figure 16.** Spinning.

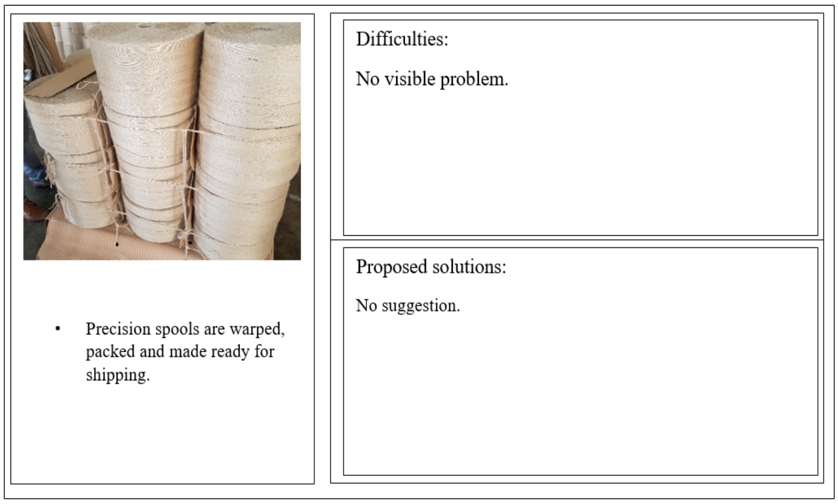


**Figure 17.** Packaging.

improvements. Measurement of performance has to be designed to evaluate the system before and after the implementation of improvement activities. This proposed model that improves both the environmental and operational efficiency should be validated with a strong control plan. Plans and steps have to be incorporated in order to monitor and track the improvement activities continuously. Adequate training and proper guidance must be provided to all the employees so that they can have a clear picture of how LSS model works.

## 5. Impact of Improvement Activities on Environment

This section shade light on the potential benefits of improvement activities on reducing environment impact of manufacturing process and reduction of material usage. Table 8 shows amount of electricity that can be saved by adopting new proposed suggestion. Energy consumption per day is also shown in Figure 18.

Table 8. Energy usage summery.

| | |
|---|---|
| Energy saved due to reduction in emulsion usage | 1261.36 watts |
| Energy saved due to reduction in spool mass | 32,000 watts |
| Percentage reduced | 7% |
| Daily consumption after improvement activity | 413,738.64 watts |
| Daily saving in industry after improvement activity | 224 kilowatts |
| Yearly energy saving across industry | 62,720 kilowatts |

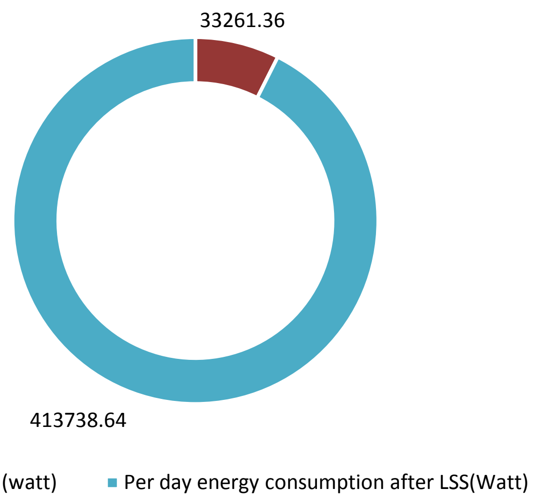


Figure 18. Energy usages.

The electricity sectors are responsible for producing, supplying and distributing electricity. Sulfur hexafluoride ($SF_6$), an insulating substance that is used in transmitting and distributing electricity [40]. Carbon dioxide ($CO_2$) is responsible for the majority of greenhouse gas emissions from the electricity sector, but slight amounts of methane ($CH_4$) and nitrous oxide ($N_2O$) are also emitted. These gases are produced while burning of fossil fuels, such as natural gas, coal and oil in order to produce electricity. Less than 1 percent of greenhouse gas emissions from the sector come from significantly reduced carbon-di-oxide emission. Table 9 shows the summary of emission data [41]. Reducing electricity consumption of the jute mills will result in decreased emissions of deleterious greenhouse gases.

## Reduction in Raw Material Usage

One of the two most important elements of precision spools are raw jute and emulsion. With the adaption of proposed solutions the industry was able to reduce jute consumption by 8% shown in Table 10 and Figure 19 which means reducing almost 3700 Kgs of jute wastage per day.

After implementing LSS framework, emulsion wastage was reduced by 776 liters per day (Table 11) which is 8% of the total emulsion usage. Table 12 shows useful metrics after improvement program.

**Table 9.** Emission summery.

| | |
|---|---|
| $CO_2$ emission per kilowatt energy | 1.15 kg |
| Energy consumption per day | 3129 kilowatt |
| Energy consumption per year | 876,120 kilowatt |
| $CO_2$ emission per year | 1,007,538 kg |
| $CO_2$ emission reduced per year | 72,128 kg |

**Table 10.** Jute usage.

| | |
|---|---|
| Capacity of single mill | 6600 kg per day |
| Amount of spools manufactures | 1455 piece per day |
| Average jute wastage | 530 kg per day |
| Total number of mills | 7 |
| Total jute waste | 3710 kg per day |
| Reduction in jute usage | 8% |

**Table 11.** Emulsion usage.

| | |
|---|---|
| Before implementing framework | 1425.55 liters per mill |
| After implementing framework | 1314.70 |
| Emulsion waste reduced in each mill | 110.85 liters per day |
| Total emulsion waste reduced across industry | 776 liters per day |
| Percentage of waste reduced | 8% |

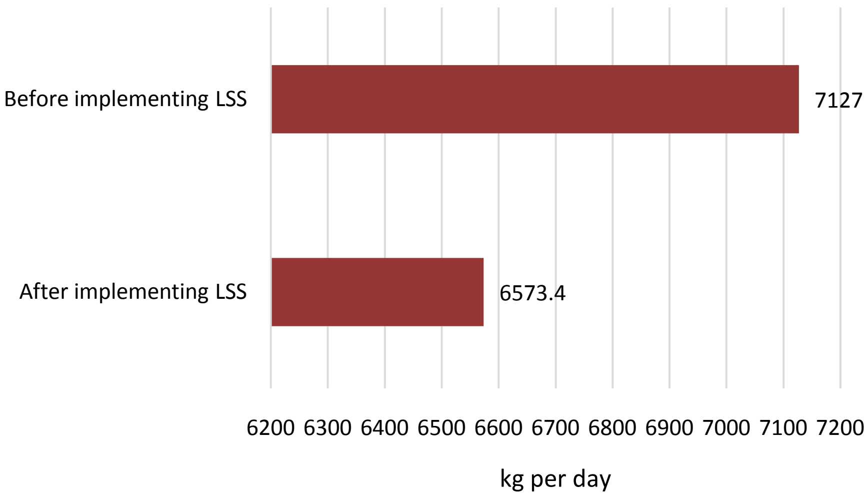


**Figure 19.** Jute usage.

**Table 12.** Metrics after improvement program.

| | |
|---|---|
| Average count | 9.98 lbs. |
| Standard deviation | 0.20 |
| CV | 2% |
| Upper specification limit | 10.28 lbs. |

**Continued**

| | |
|---|---|
| Lower specification limit | 9.68 lbs. |
| Process capability index | 0.53 |
| Population within limits | 88% |
| Sigma level | 1.60 |

## 6. Results and Discussion

The outcomes of this study are mentioned as follows:

- With the proposed solution, the jute industry would be able to improve its Sigma level from 1 to 1.6.
- Percentage of defective product was reduced from 32% to 12%.
- Cause-and-Effect diagram identified potential causes of process variation.
- Process mean had been shifted from 10.81 Lbs. to 9.96 Lbs. which is closer to the specified requirement.
- Total electricity usage reduced by 7%.
- Jute usage reduced by 8% due to the elimination of jute wastage.
- Emulsion usage reduced by 8%.
- $CO_2$ emission reduced 72,128 Kg per year due to reduction in energy wastage.

## 7. Conclusion

Lean Six Sigma and environment considerations were integrated together in order to reduce process variation with minimal impact on environment. To achieve this objective, a generic framework is shown step by step to improve activities. Unlike the framework used in an Indian automotive industry [42], this implemented framework could be applied to analogous manufacturing industries with alike organizational cultures and processes. The tools and components of the implemented framework enable the manufacturing industries to take opportunity to adopt good practices to ensure reduction in process variation and defects with reduced environment impact. Initiatives to amplify environmental performance have to be aligned with organizational strategies. Substantial savings in capital were reported due to the deduction in jute, electricity and emulsion usages which in turn reduce all the environmental impact. The objective statement was to reduce the rejection rate of 10/1 CRX spool by reduction process variation as well as reduce bad impacts on environment. The implementation of this framework also helped the jute industry to understand more about the eco-friendly manufacturing processes which can be also used in competitive advantage as buyers are now focusing more on eco-friendly products.

## Limitations and Future Scope

One of the main difficulties for implementing this framework is that most of the industries in Bangladesh are unware of LSS or lean culture which makes deploying green LSS model quite difficult. Continuous resource usages monitoring system is not available widely available. So, measuring this metrics is a bit difficult. Fuel, water, gas or other resources usages and discharge of noxious chemical from industries can be tracked and analyzed for better understanding of impacts on environment.

## Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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