Process Flow Enhancement in Coir Fiber Manufacturing

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Abstract— *The coir industry plays a significant role in contributing to sustainable agriculture and economic development in the rural sector, especially in coconut-growing areas of India. Many of the coir pith manufacturing industries are functioning in a very inefficient manner, resulting in a loss of productivity and increased cost of operations. This research aims at improving the process in a coir pith manufacturing unit by conducting a scientific study of time and motion, layout optimization, and validation through simulation techniques.*

An in-depth industrial study was conducted in a reputed coir manufacturing company in Coimbatore. The main aim was to study the existing process of fiber extraction and block manufacturing. Information was gathered regarding machine cycle times, motor power ratings of machines used in the production line, daily intake of raw materials, and drying times. For the first process, it was noted that on an average, it was taking 2.15 minutes, whereas for the second process, it was taking 3.47 minutes. For drying and retting, it was taking 4–5 days. Based on workflow, bottlenecks were identified.

An optimized layout was created with the help of SmartDraw and was validated through simulation using Siemens Tecnomatix[12], which helped in the assessment of the improvement in the efficiency of the material flow and productivity. The new layout has reduced the amount of material handling, optimized the utilization of the available space, and increased the safety of the workers, thereby improving the efficiency of the processes. This paper has established a framework for the lean-based improvement in the processes of small- and medium-scale coir industries, which also considers the sustainable practices in the processes.

Keywords — Coir Pith, Process Improvement, Lean Manufacturing, Layout Optimization, Time Study, Tecnomatix Simulation.

I. INTRODUCTION

The coir industry has a major role to play in the development of the country's agro-based economy, especially in the coconut-growing areas of Tamil Nadu, Kerala, and Karnataka states in India. Coir fiber and coir pith are used in the fields of agriculture, geotextiles, erosion control, horticulture, and composite materials due to their biodegradable properties, high water retention capacity, and suitable mechanical properties [3,6,13]. Despite the growing demand for coir products worldwide, the conventional processing techniques followed in most of the coir manufacturing plants are still in the state of traditional or semi-mechanized processes that involve lengthy processing and poor working practices.

The conventional coir fiber processing technique involves the steps of collection and sorting of husk, washing, retting, drying, defibering, sieving, destoning, grading, and baling [2,4,5]. Of the total processing steps, the steps of retting and drying take the longest time, usually five days or longer in total processing time. Though the mechanical processing steps of defibering and sieving take only a few minutes in processing the raw materials, the lack of synchronizing the steps of processing, the high amount of manual handling, and the poor working practices in layout planning contribute to the longer processing time.

The current manufacturing systems stress lean concepts that highlight waste elimination, non-value-added activities reduction, and material flow optimization. Techniques such as time and motion studies, Value Stream Mapping, and simulation-based layout planning [12] help various industries identify bottlenecks and check improvements virtually before actual implementation. Digital manufacturing techniques such as simulation software like Siemens' Tecnomatix [12] help engineers check the efficiency of workflow, resource optimization, and space optimization virtually without any risks.

The present study aims at exploring the manufacturing process of a reputed coir manufacturing company in Coimbatore with the aim of reducing the total lead time and enhancing productivity through process analysis and improvement. By incorporating mechanical improvements and lean tools with simulation validation[12], the study aims at transforming a traditionally time-consuming process into a streamlined process.

II. Problem Statement

The industry involved in the manufacturing of coir pith blocks also has certain operational issues to tackle in order to enhance its efficiency. One of the key issues in the industry is the long processing time required to manufacture the blocks due to inefficient drying methods. The drying process also depends on the weather conditions in the region. Most industries are using sun drying methods, which require sufficient open space to accommodate the raw materials for drying [7].

Another key issue in the industry is the inefficient plant layout design, which results in excessive movement of raw materials from one stage to another. Machines are also not arranged in a sequence, resulting in more movement of raw materials, which in turn increases the labor required to move these raw materials.

The lack of synchronization in the washing, drying, sieving, and compression processes also results in bottlenecks in the system. Some machines are left idle, while others are overworked, resulting in an imbalance in the workflow.

Hence, there is a need to develop a methodology for improving the process to reduce the non-value-added activities in the existing system. This study aims to identify the inefficiencies in the existing system and improve the process using the concept of lean manufacturing [8,9,10,11,12] to increase the productivity rate and reduce the overall production time.

III. OBJECTIVES

The objective of this project is to analyze the existing coir fiber production process of a reputed coir manufacturing company in Coimbatore, India, by conducting a detailed time and motion study, and evaluate the factors that influence lead time and productivity. The study aims to identify inefficiencies in the current machine layout and workflow, introduce suitable improvements in the production process to improve efficiency, minimize waste, and improve quality, benchmark best practices from global coir-producing regions for adaptation in India, and finally develop an optimized production process. Layout, and an enhanced concept of machines to reduce lead time, enhance worker safety, increase profitability, and ensure long-term sustainable growth in the coir industry. Moreover, the project also focuses on improving the use of resources and reducing non-value-added activities through the application of the principles of lean manufacturing. The aim is to transform the traditional manufacturing process into a more streamlined, competitive, and sustainable manufacturing process.

IV. Process Flow of Coir Fiber Block

The production of coir products begins with the collection of coconut husks obtained from coconut farms and markets. These coconut husks are then fed into a hopper. A conveyor belt is used to move the coconut husks into a machine used for defibering. During this step, long and short fibers are separated. This is done using a mechanical screener and a siever. These two machines help in the separation of short and long fibers.

The obtained long fibers are processed further. Retting is done to remove excess moisture. Excess moisture is also removed using a dryer. Beating is also done to make the fibers flexible. Grading is done according to length and color. Finally, the obtained grade-one fibers are compressed using a hydraulic baling press.

1. Collection of coconut husk

Fig4.1: Collection of husks

The process starts with the collection of mature coconut husks as shown in fig 4.1 from the coconut farms and processing units. It is necessary to choose the right ones because the quality of the fiber depends on the maturity and condition of the husk. After collecting the matured husk, they are transported to the manufacturing unit.

2. Hopper and conveyor

Fig 4.2: Hopper

The coconut husks obtained are manually loaded and pushed into a large open hopper located at the initial stage of the processing line, as depicted in fig 4.2. From this hopper, the coconut husks are gradually fed into the processing system using a conveyor machine.

Fig 4.3: Conveyor

The conveyor ensures the free flow of materials and controlled feeding as depicted in Fig. 4.3.

3. Defibering machine

Fig 4.4: Defibering machine

The mechanical separation of long fibers from the husk is termed Defibering. Defibering is an important factor in determining the quality of fibers. The retted and dried husks are subjected to a machine called Defibering or Decorticator as depicted in Fig. 4.4. The rotating blades separate long coir fibers from coir pith (dust). This is one of the most critical mechanical operations in the entire coir processing.

4.Siever

Fig 4.5: Seivering machine

The mixture of fibers and pith, after defibering, is sieved or passed through vibrating screens as depicted in fig 4.5. During sieving, long fibers are separated from short fibers and pith. This process ensures proper grading as well as the quality of both coir fibers and coir pith.

*5.*Extraction of third grade fiber

Fig 4.6: Extraction of third grade fiber

After sieving, classification of fibers is done on the basis of their lengths and quality. Shorter and relatively lower-grade fibers, after this stage, are classified as third-grade fibers, as depicted in fig 4.6. These fibers are used for mattress filling, rope manufacturing, cushioning, etc., where high tensile strength is not a requirement. Third-grade fibers are depicted in fig 4.7.

Fig 4.7: Extraction of third grade fiber

6. Traditional Retting and Drying Method of third grade fiber

Fig 4.8: Traditional Retting and Drying Method

The collected third-grade fiber is temporarily stored before retting and drying [1,15] as shown in fig 4.8. It is vital to maintain the moisture level in the process to avoid the formation of fungi. This process is referred to as storage management.

In the conventional process, the fibers are kept in an open area for sun drying and retting. This process is weather-dependent and may require 4-5 days. This is the most time-consuming process in the entire production process and contributes almost 99% of the total lead time. Inconsistent sun exposure may cause uneven moisture removal.

7. Processing of third grade fiber

Fig 4.9: processing of third grade fiber

After the process of drying and retting, the third-grade fiber is subjected to secondary processing in order to enhance the quality of the fiber. After the moisture content is reduced and the fiber becomes softer in structure, the process of redefibering and cleaning is carried out again as shown in fig 4.9.

Further beating and sieving of the fibers are carried out in order to remove the pith and other unwanted materials. This process of reprocessing the third-grade fibers is carried out after the retting and drying process in order to improve the usage of the materials and minimize the waste generated in the process. This process upgrades some of the third-grade fibers into first-grade fibers and is then directed towards the hydraulic compression process for the formation of blocks.

8. Collection of first grade coir fiber

Fig 4.10: collection of first grade fiber

The fibers obtained through defibering and sieving are of high length and quality and are termed first-grade coir fibers, as depicted in fig 4.10. These fibers are of high quality and strength. They are separated and collected to meet premium quality requirements for export and block manufacture.

9.Hydraulic compressing of the first-grade fiber

Fig 4.11: Hydraulic compressing of the first-grade fiber

The first-grade fibers are fed into a hydraulic compression machine, as depicted in fig 4.11, for block formation. High-pressure compression is used to compress the fibers, thus reducing their volume and creating compact blocks for easy transportation and export.

The high-pressure compression ensures that all blocks are of uniform weight, about 30 kg each.

10. Fiber block

Fig 4.12: fiber blocks

The final product is in the form of compressed fiber blocks as in fig 4.12. These blocks are packed and sent for dispatch to local/international markets. The fiber blocks have various applications in horticulture, geotextiles, erosion control, and agriculture because they are biodegradable and have high water retention capacity [6,14].

V. Methodology

The methodology used consisted of conducting a study of the existing process flow, obtaining operational information, conducting time analysis, and conducting moisture absorption analysis. The existing machine layout was studied, and areas of inefficiency were noted. A new layout was designed using smart draw and technomatix simens software to optimize the layout for smoother material flow and to reduce lead times [12].

1. Process Bottle neck identification:

The time and motion study conducted on the existing process flow revealed that the major bottle necks were associated with the drying process, retting process, and the transfer between the first and second process. These were causing unnecessary delays due to manual handling and non-linear layout arrangements. In addition, the long retting time of 4 to 5 days contributed to longer lead times.

3. Data Collection and Analysis:

The industry processes around 60,000 husks in each shift, with a daily intake of 1,00,000 husks. The first process uses a 45 HP motor, whereas the second process uses a 25 HP motor. The cost incurred on each husk ranges between ₹3-5, whereas the cost incurred on each fiber block ranges between ₹500-600, with each block weighing around 30 kg.

The time analysis showed that the first process took 2.15 minutes, whereas drying and retting took 4-5 days, and the second process took 3.47 minutes. The moisture and temperature analysis showed the key quality factors affecting the grade of the fiber.

The detailed lead time analysis showed that the mechanical processing took only 5.62 minutes in total, whereas drying took around 7,200 minutes or 120 hours. This shows that around 99.92% of the total lead time was spent on the drying process.

The present layout was designed using smartdraw software as shown in fig 5.1. To check the effectiveness of the designed layout, simulation was done using siemens tecnomatix as shown in fig 5.2 and fig 5.3 [12].

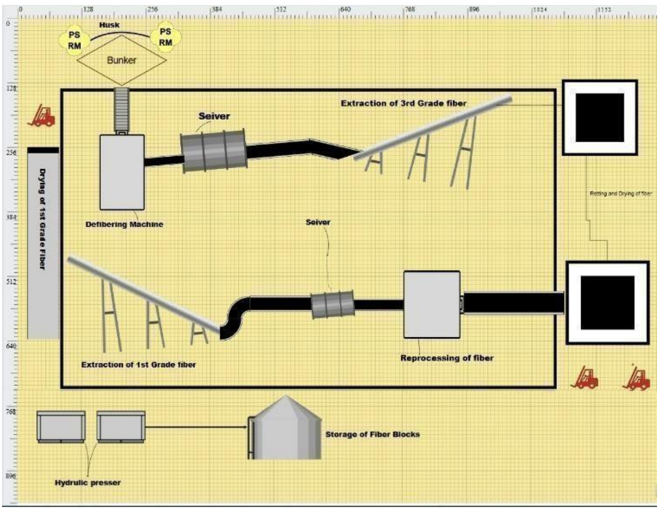

Fig 5.1: Current Layout Design (using SmartDraw)

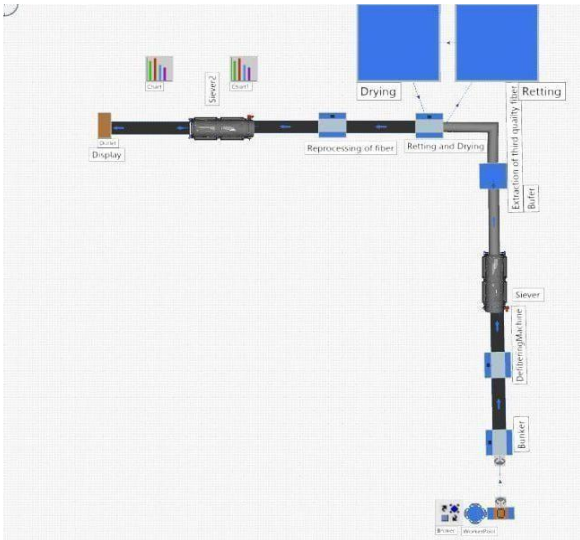

Fig 5.2: Current Layout (using Siemens Tecnomatix)

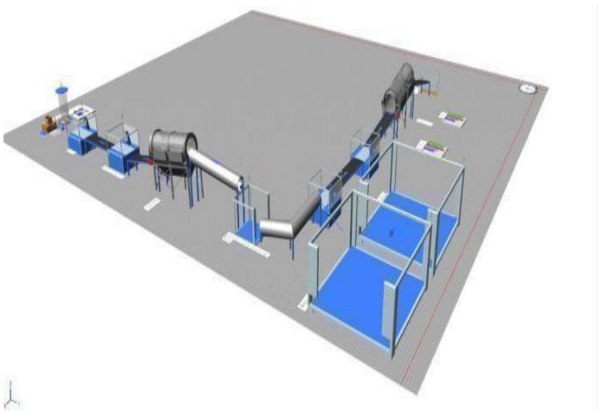

Fig 5.3: Current Layout (using Siemens Tecnomatix)

Table 5.1: Time Analysis Summary (current layout)

Process Time	**Duration**	**Remarks**
First Process	2.15 min	Fiber extraction
Drying & Retting	4–5 days	Major bottleneck
Second Process	3.47 min	Final processing

Based on the identified problem areas in the existing system, a new optimized machine layout has been created using the SmartDraw software as shown in fig 5.4. This new layout has been created in such a way that the processes are arranged sequentially, and the materials can be moved more smoothly between the processes.

To test the effectiveness of the new layout created in the existing system, the simulation has been carried out using the Siemens Tecnomatix software as shown in fig 5.5 and fig 5.6. By using the above-mentioned tools and methods, the effectiveness of the existing and new systems can be tested in terms of time efficiency [12].

The proposed layout and improvement strategy have been documented and presented to the industry for future implementation. This methodology ensures that the improvements recommended are feasible and beneficial in terms of cost and other factors for future industrial applications [12].

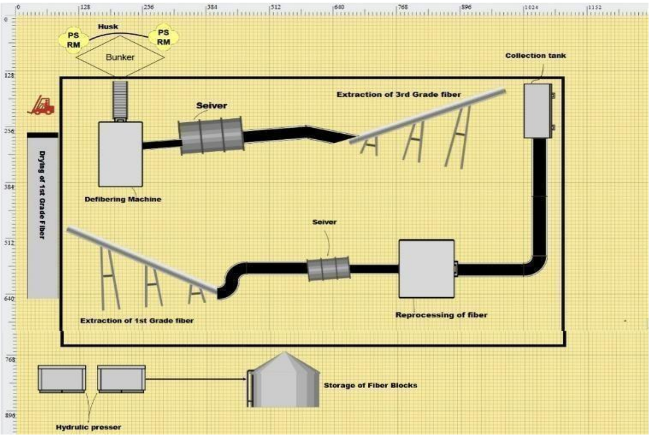

Fig 5.4: Optimized Layout Design (using SmartDraw

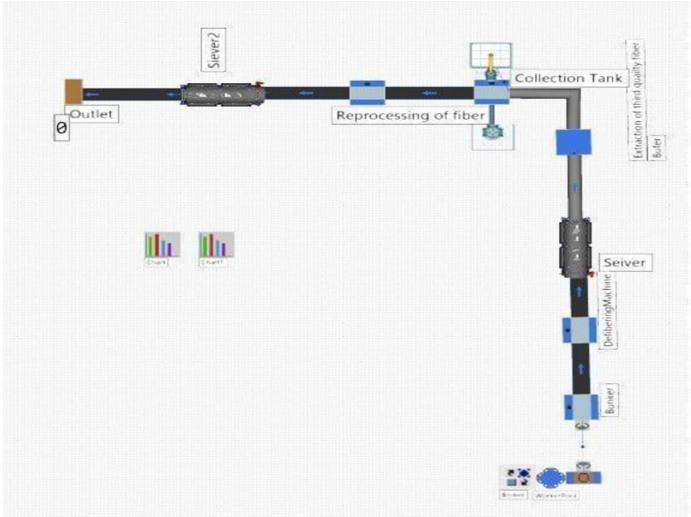

Fig 5.5: Optimized Layout (using Siemens Tecnomatix)

Fig 5.6: Optimized Layout (using Siemens Tecnomatix)

Table 5.2: Time Analysis Summary (Optimized layout)

Process Time	**Duration**	**Remarks**
First Process	2.15 min	Fiber extraction
Drying & Retting	7–10 min	Major bottleneck(solved)
Second Process	3.47 min	Final processing

To achieve this, an optimized layout has been proposed using SmartDraw and simulated using Siemens Tecnomatix[12].

The optimized layout has achieved reductions in material handling distances, idle time, and synchronization. In addition, the proposed hot air rotating drum dryer has replaced sun drying. If the time taken for drying is reduced from 5 days (120 hours) to 2 days (48 hours), then the improvement in time taken for drying is calculated as:

Performance Enhancement Analysis

Percentage Improvement = ((Old Time – New Time) / Old Time)×100
=((120−48)/120)×100
= 60%

If optimized further to 36 hours, improvement becomes:

=((120−36)/120)×100
= 70%

Thus, drying time reduction ranges between 60–70%, depending on operating conditions.

Throughput Improvement Calculation

I. Existing System:

Drying time = 5 days

Batches per 5 days = 1

If 150 blocks are dispatched per batch:

Throughput per day = 150 / 5 = 30 blocks

II. Proposed System:

Drying time = 2 days

Batches per 5 days = 2.5 batches
Total blocks in 5 days = 150 × 2.5 = 375 blocks
Throughput per day = 375 / 5 = 75 blocks/day

Layout Efficiency Improvement

Simulation results from Siemens Tecnomatix indicated:

- 25–30% reduction in machine idle time
- 20–25% reduction in internal material handling movement
- Improved worker safety due to reduced congestion
- More linear material flow

Overall Productivity Improvement

Considering:

- 60% reduction in drying time
- 150% increase in throughput
- 25% reduction in idle time
- 20% reduction in handling waste

The overall productivity improvement is estimated between **40–65%**, depending on plant operating conditions.

VI. RESULTS AND DISCUSSION

From the below graphs as shown in fig 6.1, 6.2, 6.3, improvements in drying time, lead time, and daily output are more significant than that of the existing. "The implementation of layout optimization and mechanical improvements achieved a significant reduction in overall lead time. While traditional systems required five to eight days to complete the entire production cycle, the redesigned workflow reduced the number of mechanical extraction stages to within a single working shift. Simulation results revealed smoother flow of materials, elimination of congestion points, and a better balance in the flow of successive stages of the process."

The optimized feeding system has minimized machine idle times. There was a significant improvement in the moisture control of fibers, resulting in a lower rate of rejection in grading. There was a reduction in internal transportation distance, thus minimizing labor and enhancing worker safety. There was a significant increase in productivity due to a better synchronization of operations and a reduction in non-value-added activities.

In terms of sustainability, the optimized system reduced water usage, minimized rework, and improved energy utilization. By using the lean principles and simulation validation, the manufacturing process has moved away from the traditional time-consuming process and into a more streamlined and scalable process.

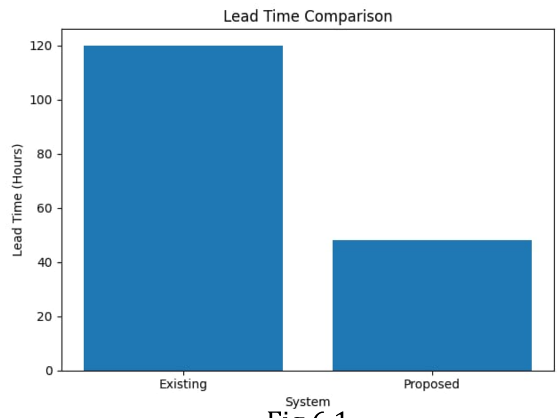

Fig 6.1

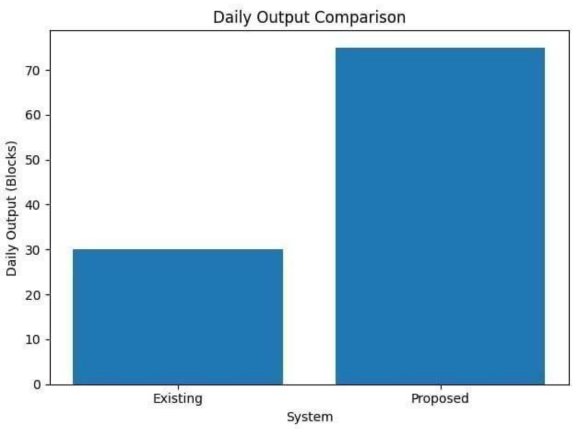

Fig 6.2

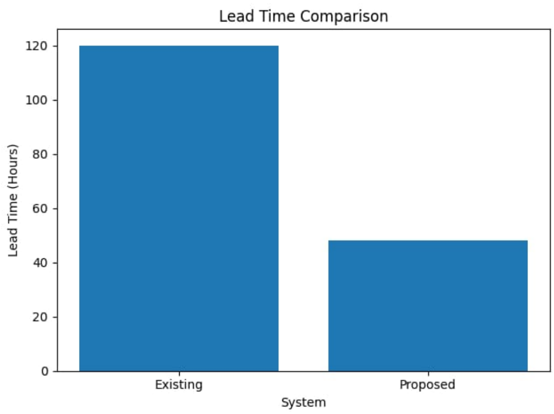

Fig 6.3

VII CONCLUSION

This research proves the potential for significant improvement in the efficiency of the coir fiber and pith manufacturing process through systematic process improvement using time analysis, lean principles, mechanical optimization, and simulation-based layout validation. The integration of the optimized feeding mechanisms, buster design, sieving operations, and workflow improvements resulted in the reduction of the total lead time and the increase in the overall plant productivity.

The use of digital validation by Siemens Tecnomatix ensured the technical viability of the improvements before actual implementation. The proposed framework outlines the roadmap for the modernization of the small and medium-scale coir industries, making it sustainable and economically viable. Future improvements could also include the use of sensor-based automation, real-time moisture control, and advanced drying technologies.

The scope of further research in the future would be the improvement of the efficiency and sustainability of the coir pith production process through the integration of modern automation systems and smart monitoring systems in the production process [1,15]. Moreover, the adoption of enzyme retting and mechanical retting can improve the overall lead time of the production process. In addition, the adoption of controlled mechanical dryers can reduce the weather dependence of the production process. In the future, the scope of further research can also include the economic feasibility analysis of the production process and the development of value-added products such as biofertilizers and biocomposites.

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