Addis Ababa University

College of Technology and Built Environment

School of Mechanical and Industrial Engineering

Masters of Science in Industrial Engineering

Modeling and simulation on the factor influencing operator performance of the jute bag manufacturing industry. The Case Study of Horizon Plantation Coffee Processing and Warehouse Company

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February, 2026

Addis Ababa, Ethiopia

Approval statement

This research, titled "Modeling and simulation on the factor influencing operator performance of the jute bag manufacturing industry. The Case Study of Horizon Plantation Coffee Processing and Warehouse Company.", has been prepared and submitted to Addis Ababa University, School of Graduate Studies, for assessment under my supervision in accordance with the university's academic requirements.

Approved by board of examiners

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Declaration

I, sewunet beza, hereby declare that the research entitled as "Modeling and simulation on the factor influencing operator performance of the jute bag manufacturing industry. The Case Study of Horizon Plantation Coffee Processing and Warehouse Company." is my own work. This research is not work in any degree or master program for the other university, and the whole data gathered is concerned body. I recognized this study is the real work of my activity to keep the ethical standard of the education program. I understand any form of misbehavior or plagiarism will get in punishment action as the rule and regulation guidance of Addis Ababa University.

____________________ ____________________

Student Name Signature

This is accepted that the above declaration performed by the researcher is the perfect to well acknowledge of own capacity and I hereby recognize his proposal for approval.

____________________ _________________ ___________________

Main Advisor Signature Date

Acknowledgement

First and foremost, I would like to thanks Almighty God give me with tenacity, wisdom and perseverance to finish this research. His assistant has been power of appreciation through my research study work journey.

I give my heartily thanks my advisor, Gulelat Gatew (PhD.) for his assistant, appreciation to work my study and give his full profession. His insight have been given correction for shaped this research structure and assisting for find the difficulties of simulation modeling on the factor influence of the operator performance in jute bag manufacturing.

Heartily thanks for the machine operator, supervisor, production head, management and staffs of Horizon Plantation Coffee Processing and Warehouse Company for their coordination and willingness to give their knowledge and data. I especially thanks for primary data collection, which included questioner response and annual yearly report of the operator performance, as well as the secondary data given for the machine capacity file and their manual books.

Lastly, I hope for give appreciation to my family and friends their unstopped support and inspiration. Their advice given for my capacities enable to initiate for receive through any challenge and recognition.

This research study is dedicated to those who concern improve the operator performance of the jute bag manufacturing and productivity maximization for customer satisfaction and get market share.

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Abstract

This research deal the improvement of the factor influence the operator performance on jute bag manufacturing of the horizon plantation coffee processing and warehouse company in Ethiopian by using modeling and simulation approach. The operator performance is the main factor to determine for productivity, quality of product and capability in the jute bag manufacturing industry. The study systematically analyses the primary data collection for questioner and interview for machine operator and stakeholder for comparatively secondary data gathered for record daily operator performance, monthly and annually report by using for qualitative and qualitative methods. Both the data collection types enable to investigating and distinguishing the factor influence the operator performance and system analyses to maximizing productivity. Although the employee's intensive characteristic of the jute bag manufacturing limitation of the study has simulated and modeled that enable improve the problem change operator performance in the actual-processing work environments. This research explain an additional analysis of the work processing and productivity, safety, health and motivation, performance and quality, skill and training machine down time, machine productivity capacity and raw material variables that affect daily operator activities. Uniqueness of the study focus on the work station on beaming, weaving and sewing enable to identifying, analyze and measure scenario the operator performance of the jute bag manufacturing industry. Finding explain critical value for different variables and to analyze results by modeling and simulation investigation improving the performance of the operator minimum 7.92 % for the bottle neck mitigation in the weaving work station and the maximum improvement 25% by minimizing machine down time. Summary of the study for identifying the bottleneck work-in-process the jute bag manufacturing among those weaving work station by using the modeling and simulation approach, then the proposed improvement of the jute bag manufacturing before the scenario testing the productivity operator performance 5906.2 kg/day and after bottleneck mitigation 6374kg/day which has been increased 467.8kg per day when mitigated by 30%. Recommendation for improvement of the working process by line balancing, give motivations and training, make machine lubrication, cleaning and program for preventive maintenance and building skill man power.

Keywords: factor influence, jute bag manufacturing, human factor, simulation and modeling, improvement and productivity

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List of Acronym and Abbreviation

WIP Work-In-Process

PLC Private Limited Company

AI Artificial Intelligence

DMTs Digital Manufacturing Technologies

MLT Manufacturing Lead Time

API Application Program Interface

KPI Key Performance Indicator

MPL Maintenance Performance Level

MR Machine Reliability

OEE-ME Overall Equipment Effectiveness – Machine Effectiveness

FGI Flow Graph Language

CEDAC Cause and Effect Diagram with Addition of Cards

HRM Human Resource Management

DES Discrete Event Simulation

VSM Value Stream Mapping

SPSS Statistical Package for Social Science

LM Lean Manufacturing

Chapter One

1. Introduction and Problem Approach

1.1. Introduction

Technical, organizational, and environmental factors all have an impact on how well operators perform in the production of jute bags. Research shows that by reducing delays and unexpected downtime, machine dependability and maintenance have a direct impact on productivity (Ahmed T. &., 2021). Additionally, operator fatigue, error frequency, and overall efficiency can all be impacted by work intensity and task distribution (Khan R. U., 2020). Workers' ability to operate complicated machinery and uphold constant production standards is also greatly influenced by their degree of training and skill (Saha, 2019), Temperature, noise levels, and lighting are additional environmental factors that affect operator comfort and performance, especially in industrial settings like jute manufacturing (Roy, 2022). Recognizing these aspects is vital for enhancing production efficiency and promoting worker welfare.

The jute bag industry with in different country it has good relationship with environment and enable too continues packaging products in case of market good (Ahmed H. A., 2024) . Production volume, quality standards, and cost-effectiveness are all significantly impacted by operator efficiency in the labor-intensive jute bag manufacturing sector study of the journal (Valencia-Arias & Jimenez-Garcia, 2025) for generative artificial intelligence in transformation in process, design and production. Operators carry out a variety of operations that call for focus, physical stamina, and machine-handling proficiency, including weaving, cutting, sewing, inspection, and finishing. However, a lack of automation, outdated machinery, and uneven workload distribution are just a few of the challenging situations that jute producers often encounter.

But among the difficult circumstances that jute producers frequently face are the absence of automation, old machinery, and imbalance work distribution in work environment. Operators often have to adjust to disruptions brought on by supply delays, discontinuity of the jute yarn, and inappropriate performance. As a result, operator performance is one of the main parts to maximizing productivity. The challenge and factor of the maximization operator performance of the jute bag manufacturing, the capacity of the operator in study of the human factor and minimum technical ability (Amin, 2023) .

The complexity to maximization of the performance of the operator in the jute bag manufacturing considering the study of the research Haider (2023) to the quality of the yarn material, the capacity of the operator itself, the technology, the capacity of the machinery, the machinery down time or unable to the full engaged total productive maintenance, the absence of training about the machinery and the production mechanism as needed.

Simulation and modeling have become useful tools for analyzing complex production processes. The study enable to perform (Rosova, 2022) without interfering with actual production, these technologies enable managers and researchers to test modifications to factory design, workflow, and resource allocation. In order to better understand and enhance operator performance in the production process, this article explores the use of simulation.

The discrete event simulation analysis are essential for identifying bottlenecks in operator performance, evaluating machine capacity within operational timeframes, measuring productivity and product quality, and proposing optimal work flow and work environment configurations. Additionally Garn (2022) these methods enable network models for testing, verification, and validation through various mechanisms without incurring significant costs in research, industry, or system applications.

This thesis aims to highlight the current daily productivity performance of the operator in the jute bag manufacturing process within the coffee processing and warehousing company, as well as to propose a mechanism for maximizing operator productivity through the analysis, testing, verification, and validation of simulation models. Based on empirical data from various sources, the simulation results and the thesis facilitate an understanding of the primary factors influencing operator performance and the maximization of productivity to effectively meet customer demand. The findings of the study aim to identify the factors influencing operator performance within an industry and to provide solutions that contribute to maximizing overall industry productivity.

When the coffee processing and warehousing companies for jute bag factories receive a customer order and there is a shortage of jute bags for the operator's minimum daily productivity as expected, they face competition from other companies for both supply and demand, As a result, they are unable to satisfy the customer (PeiróJ.M. Bayona J.A., 2020) . The research considers the work characteristics, the work performance and the job design of the work environment influence the performance of the operator which has been enabled to make identifying factor influence of the operator performance and that build the model of discreet-event simulation in order to distinguishing the bottleneck and optimizing the productivity of the operator performance by using the qualitative and quantitative method.

1.2. Background and problem justification

Operator performance in jute bag manufacturing is affected by a mix of technical, organizational, and environmental elements. Studies indicate that the reliability of machines and their maintenance has a direct influence on productivity by minimizing delays and unforeseen downtime (Ahmed T. &., 2021).

The study of the research Yousuf (2025)operator performance is essential to any manufacturing company's ability to survive. While above-average productivity shortens the time needed to produce fabric and contributes to the creation of more fashion and design content, low productivity shows up as missed deadlines. Each factor can be used independently to calculate productivity, or the factors can be combined to create a composite measure of total input. The two inputs can be used to compute three distinct productivity metrics: Labor productivity is calculated by dividing the output by the labor input. Both total factor productivity and capital productivity are calculated by dividing output by the sum of the labor and capital units used in production (Hossain, 2025) . Study the efficiency rate of the industry jute operator performance measured in to full sample taken, random data and real data from the sector.

Termkla (2025) study for the purpose of producing textiles, hemp fibers are separated using the conventional method of cutting the hemp stalks, drying the stalks of hemp, Bark removal, Fiber beating, and Hemp fibers are spliced, Hemp fibers are spun into yarn, Yarn is twisted, and Yarn is woven. The main source of labor for the entire process is human labor. To create strong, high-quality fibers that can be used as textiles, the operators need to be skilled in specific techniques.

Poly bags made of high-density polyethylene (HDPE), low-density polyethylene (LDPE), and non-woven bags made of polypropylene (PP) are currently used as secondary packaging for jute bags. Due to its special qualities, jute, also known as "Golden fiber," is the second most popular fiber after cotton. Jute is appealing because it has a 20–50% lower carbon footprint than synthetic fibers (Shah A., 2024) .The jute industry supports rural livelihoods, creates jobs, and generates export revenue, all of which contribute significantly to the region's economic growth. However, there are obstacles to sustainability, such as shifting consumer demand, competition from synthetic fibers, and antiquated infrastructure. Worker welfare, labor conditions, and employment creation are all aspects of social sustainability. Concerns about environmental sustainability include pollution control, waste management, and ethical sourcing of raw materials (Chintamani, 2023).

The study of Narayan (2025) in the jute industry, weaving is the most significant work station. Here, two yarn sets are woven together to create fabric. Therefore, it is crucial for such a department to be productive in order to plan for timely fulfillment of customer requirements. Numerous productivity metrics and their relationships are examined, and statistical analysis is carried out using the information gathered during the investigation. The appropriate corrective actions for timely delivery of completed goods to customers are then determined by tabulating the various findings. According to the journal of textile Tasnim T. (2024) preparing Procedures used to make jute in the fibers are transported in bales or bundles to the jute processing industry after being dried. The primary considerations when carefully choosing the raw materials are the type of product to be manufactured and its intended use. First, the graded jute fibers are selected for the final product. In order to create yarn, the fibers are then carded, drawn, and spun. The yarn bobbins are converted into thread cones for further beaming and warping processes, such as sizing. Fiber, yarn, and fabric are all forms of jute.

Jute bag manufacturing sector competitors Tasnim T. (2024), Bangladesh is the second-largest producer of jute, after India. Jute is grown in several states, including Assam, West Bengal, Andhra Pradesh, and Orissa. With 77 jute mills spread across India producing about 1.8 million MT of jute goods, the current global jute output is estimated to be 3.2 million MT. Jute is primarily grown in tropical, subtropical, and equatorial regions. Other major jute-growing countries include Myanmar, Nepal, China, Vietnam, Thailand, and Brazil. In the Ethiopian context there were competitors for G-seven industry and trading plc, Gendekore manufacturing plc and Arken jute manufacturing plc.

Operator performance factors influenced by the journal of engineering science Haider (2023) to maintain workflow continuity, monitor quality, and modify machine settings, each stage requires skilled operators. Bottlenecks result from a breakdown or slowdown at one point in the production process. The weaving mill under consideration's jute bag manufacturing had a high cycle time because of needless work in the process, and rolling blackouts decreased production capacity. In order to present a desired future situation, the study was carried out to simulate and model alter the current reality in the case of a journal of engineered fiber and fabric (Mahmood, 2019) by using a dynamic approach of system to system methodology.

The necessity of a comprehensive investigation using simulation and modeling techniques is supported by the operator performance measured in jute bag manufacturing elements. Each stage requires skilled operators who must adjust machine settings (U., 2013) , monitor quality, and maintain workflow continuity. A breakdown or slowdown at one stage affects the entire production chain, creating bottlenecks. Several challenges are common across jute factories, including dependence on manually operated or semi-automatic machines (Ciccarelli M., 2024). High variation in operator skills and experience (Kiangala, 2025) , harsh environmental conditions for dust, physically demanding tasks, limited ergonomic workstation design, and inconsistent maintenance practices (Khan T. S., 2024) . These factors justify the need for a detailed analysis using simulation techniques (Huang W., 2025). This research is mainly focused on the area of modeling and simulation to maximize daily operator performance to follow the key performance indicator in jute bag manufacturing. The jute bag manufacturing has a different working process or division such as beaming, dyeing, weaving, measuring and inspection, damping, calendaring, cutting, sewing, packing and warehousing in order to produce the jute bag as customer requirement. Therefore, enhancing worker performance can be considered in the bottleneck working place of operation: beaming, weaving, and sewing in jute bag factories. Just like the operator and assistant operator of each working place, the jute bag is produced by passing different working processes and the activity of the performance through jute yarn. Then it has different obstacles to fully fill their daily productivity performance in the case of their study (M. Mohan P., 2020) setup time and cycle time of the operation which has been found in the annual plan of the company. Setup and cycle time is one of the parameters to measure the performance of an operator to analyze the actual state of the research, so the setup and cycle time in a jute bag factory (plantation, 2024/2025).

The challenge and opportunities jute bag manufacturing in case challenge of lack of raw material, inadequate demand, lack of quality raw material, absence agricultural land for jute, absence of skilled man power about jute bag and mismanagement and in another case the opportunities of jute manufacture better alternative plastic products, good market, positive impact about the economy, good for construction industry and cloth industry, coffee manufacturing industry (Amin, 2023).

Process flow charts are a helpful tool for designing and documenting complicated programs or processes as well as for explaining how processes operate. This method makes it easy to identify bottlenecks and losses in jute mills that will disrupt operations. Finding the most significant and vital dependencies in the production process is beneficial.

Horizon Plantation Coffee Processing and Warehouse Company, a company under the Midroc Investment Group, has a jute bag factory. It has made it possible for him to store coffee in a warehouse for his coffee farming operations as well as process and package it for export to foreign markets. Furthermore, it was prepared and packaged for the benefit of the other coffee exporter owner, who was able to export and make money from their services. Here, the materials for the jute bag are required in order to pack the coffee. Therefore, the jute bag requirement of the customer increases from time to time in case the demand of the coffee exporter is increased. The process which has been performed to produce the jute bag product within jute bag manufacturing such as journal study:-

Beaming/warping: - is the process of using a loom to arrange yarns or threads longitudinally. Parallel threads are twisted onto a beam during the warping process to get ready for weaving.

Weaving/loom: is the process of weaving together horizontal and vertical threads to form textiles. Weft and warp are terms used to describe the horizontal and vertical threads, respectively. Weaving is done with an apparatus called a loom. Warp beams on looms hold the warp threads that will be used to weave the fabric in place.

Measuring and inspection: It explains how to utilize measurement tools to quantify results. Consequently, inspection is the process of comparing the values derived from measurements with the available references to ascertain whether or not a jute cloth fabric is suitable.

Dumping: is the process of unfolding the wrapped cloth or woven material and repeatedly misting it with water to reach the appropriate moisture level. ``

Calendaring: It is similar to the process of ironing fabric. The damped cloth is then passed between two heavy roller pairs to flatten the threads and improve the fabric's quality and appearance.

Cloth cutting: is the process of cutting the sacking cloth to the appropriate length to produce bags of different sizes, such as A-twill bags and B-twill bags with different capacities.

Sewing which contains three processes listed below to consider their purpose in the manufacturing process which has been studied enable to design in the operation of fabric, cutting, folding and hemming is using a sewing machine; the cut pieces of sacking fabric are folded to expose their jagged edges. Over aging is when sewing with a sewing machine for double yarn types, the sacking's raw side is folded into fabric. Stitching is to maintain the strength of the sacking bag, the raw side of the bag makes stitching with a single yarn type identical to regular sewing.

Packaging: is the industry standard for packaging jute bags in the form of 25 pieces and is characterized as a systematic approach to preparing goods for sale, eventual usage, warehousing, shipping, and logistics.

1.3. Problem statement

Now jute bag manufacturing is able to produce jute bags in order to satisfy the customer' need to export their coffee to keep food-grade bags by standardization of the World Food and Health Organization. But they are unable to access it as customers want in the case of the capacity to produce bags at on time and preferable quantity to different problems which the company observed. The problem statement in the general case considers the jute bag manufacturing unable to satisfy the customer needs and the market value of the jute bag is rising. The problem statement of being able to maximize the jute bag factory's productivity in order to raise customer satisfaction is then covered by the general area of interest. Thus, taking into account the various issues to be mentioned, which scenario does not boost their output? As following the performance of the operator unable to use their maximum effort, Un able to doing good maintenance when the break down occur within short period of time in that case the down time of the machinery increase and the productivity of the operator decrease, the quality of yarn in the beaming, weaving, and sewing work places, the machine's capacity, the capacity of the operator, the moisture content of the jute yarn and the working environment.

Numerous factors, including machine performance, workload distribution, operator skill levels, environmental conditions, and workflow efficiency, impact daily operations in jute bag manufacturing. Production delays, uneven output quality, and increased operator fatigue result from these factors' frequent lack of clarity and quantification. In order to better understand how these variables affect operator performance and overall productivity, this study attempts to model and simulate these variables. Through the identification of critical bottlenecks and the testing of various operational scenarios, the research aims to offer useful insights that can enhance worker well-being and factory efficiency. Horizon plantation coffee processing and warehousing company is now defensing low operator performance in the production process of the jute bag product, resulting in minimum productivity that negatively impact market share and manufacturing performance.

The factor influence include:-

- ❖ Workflow bottlenecks and lack of raw material **(10,000 hr. per year)**
- ❖ Machine variability and increase downtime **(2,253.8 hr. per year)**
- ❖ Inappropriate operator performance and absenteeism **(1, 512 hr. per year)**

Case Overview: horizon plantation coffee processing and warehousing company

Present data annual year report productivity cases indicate significant low performance **65.3%** ranging from design capacity 85%.

Working-in-processing:

- **Beaming** : **71%** enable to produce from design capacity **85%**
- **weaving**: **65.3%** enable to produce from design capacity **85%**
- **sewing** : **63%** from design capacity **85%**
- **Design capacity :** planned **85%** performed **75.95%**

From the **appendix ix, x and xi** we can take 2016/17 E.C. for jute bag manufacturing the machine capacity availability, weaving machine productivity and plan which has been able to performed. In light of the aforementioned requirements, the operator in the jute bag factory must identify their knowledge gaps in order to maximize the product's productivity in the following areas: The weaving work station can produce around 65% due to the operator's low efficiency when using 85% of the machine's capacity, As would be expected given the daily performance of sewing machines for hemming, over-aging, and stitching, the operator's efficiency is low, using 85% of the machine's capacity to produce less than 63%. And the other the efficiency of the operator low as expected plan of the daily performance in beaming for used 85% machine capacity.

1.3.1. Research question

Q1. What are the main factors that reduce operator performance in sewing, weaving, and beaming work station?

Q2. How do raw material variability, operator performance, and machine capacity affect daily performance?

Q3. How can simulation be utilized to model and forecast operator performance?

Q4. Which improvement possibilities minimize bottlenecks and optimize daily performance of the operator

1.4. Objective

1.4.1. General objective of the research

To analysis the work station in beaming, weaving and sewing on the factor influence of the operator performance and that build the model of discreet- event simulation in order to distinguishing the bottleneck and optimizing the productivity of the operator performance.

1.4.2. Specific objective of the research

2. To determine the primary causes of poorer operator performance in the sewing, beaming, and weaving processes.
3. To analyze the effect that changing raw materials; operator performance and machine availability have on daily production volumes.
4. To develop and utilize a plant-level simulation model that replicates the real manufacturing process and predicts operator performance for different cases.
5. To use simulation in order to investigate potential improvement options and solutions that mitigates or eliminates bottlenecks and maximizes daily production.
6. To be able to make applied recommendations followed by the simulation results and through experiments, to improve operator's work.

1.5. Significant of the study

The significance of this study concentrates on the improvement of the factor influence of the operator performance on the jute bag manufacture of the horizon plantation coffee processing and warehouse company. This research is necessary for modeling and simulating the factor influence the operator performance the jute bag manufacturing in the industry. It is essential for the researcher to improve their research abilities and understanding of the topic, the other critical issue for the maximizing the operator performance in order to process optimizing and satisfying the custom demand. Enhancing the operator performance in the jute bag manufacturing for several reason .firstly, minimum operator perform direct influence the productivity capacity overall an industry result and low market share of jute bag products. Second, improvement of the operator performance enable to get effective productivity with in horizon plantation coffee processing warehouse and get good market share jute bag products in order to find profitability.

Additionally, these studies will provide information to the jute bag sector as part of an input for further research into operator performance. Give details on how to create a system that maximizes productivity and improves operator performance by resolving problems. This will increase the operator's daily productivity and increase profit and customer happiness.

1.6. Scope of study

The research concentrate on the specifically the factor influence of the operator on the jute bag manufacturing at horizon plantation coffee processing and warehousing company, analyzing the work-in-process from the input of the raw material of the jute yarn up to the finished products of the jute bags. This study focus the working process on the jute bag manufacturing in beaming, weaving and sewing operator performance in order to decrease the complexity of the research. This study examines the impact of maximizing operator performance on daily production at the Horizon Plantation coffee processing and warehousing enterprise in Addis Ababa, which produces jute bags. Through testing, confirming, and validating, the study aims to pinpoint the reasons behind the operational performance aspects that are not performing up to par and facilitate the creation of modeling and simulations approach for the outcome of the critical date.

1.7. Limitation of the study

The study has different weak side that may influence its end results. The clear, organized and fulfillments of the gathered primary and secondary data, would factor influence the precision the modeling and simulation investigation ends results. The purpose of the study is that the time and resource constraints of the other companies that address the effect of maximizing the operator's performance in the jute bag manufacturing limit the scope of this study to the case of small amount of the jute bag industry. And it was tough to get recorded data and interview informants, whom the researcher had to convince to exclude from focused groups; as a result, this study is constrained to a small case company. Generally, the factor influence of the operator performance is more ambiguity enables to lead overs simplification in modeling and simulation approach, eventually failing many variables that affect the operator performance.

1.8. Organizational of the study

The thesis is structured as follows, with five chapters. The introduction to the thesis paper's major body is provided in Chapter one. The literature assessment on the impact on operator operational performance across various industries is covered in Chapter two. Furthermore, it provides an explanation of the operator's key performance indicator in jute bag manufacturing. Various approaches to data analysis and research design are presented in Chapter three. Detail analysis, modeling, results, and discussions on the impact of maximizing the operator's daily productivity were the focus of Chapter four. Chapter five offers findings, conclusion and suggestions for additional research.

Chapter Two

2. Literature Review

2.1. Introduction

This chapter's review aims to provide the study with comprehensive details regarding the research issue. It includes works of literature from articles, journals, books, reports, case study, and earlier research that are pertinent to the factors influencing operator performance in the manufacturing of jute bags for various industries taking into account various mechanisms. This has examined both ideal and real-world literature reviews that show an industry's productivity and their performance. The ideal literature review discussed the factors that affect operator performance in Ethiopian and global jute bag manufacturing companies. This chapter includes a summary of the literature and the conceptual to illustrate the relationship between the factor influencing the operator performance in jute bag manufacturing as a distinct variable and operational effectiveness parameters as a variable that depends after identifying the distinctive characteristics or deficiencies in the research, while the practical literature review offers insight into the findings of related studies based on observations and measurement levels.

Those of the operator performance the main factor influence is machinery dependability. Suddenly machine break down the reason of minimizing the performance of the operator per hour, the lack the raw material quality and availability, and imbalance work-in-flow, according to (Ahmed T. &., 2021). Jute bag manufacturing the familiar the machinery failures sever and also descending the life span. Operator performance big influenced by machine failure there is the measurements of the human such as: human factor, motivation, and increasing in working environments enhancement through time. The end result said that that a good mechanism produces approved output than just technological improvements.

2.2. Definition of operator performance

Operator performance is a skilled task that is improved by experience; existing standards have an impact on it for a number of reasons. The concept of employee output seemed to be connected to that of employee performance, according to an examination of a master's dissertation (E., 2021), as performance has often been assessed in terms of the tangible goods that employees produce. Employee productivity is a measure of how much a person's skills, knowledge, and effort affect the results of his work in all internal and external contexts. The relationship between the organization's output product or service and the consumption and transformation process of its input resources is often referred to as employee productivity.

According to the study Kiangala (2025) ChatGPT and generative AI enhance plant operators' everyday working experience in the following ways: Keep a close eye on plant output and integrate, Helping employees identify issues with accessible equipment, conducting root cause analysis, generating synthetic data using text queries, and improving operators' work knowledge.

Research by Lewtie E. (2024) the proportion of the total standard times for all measured and estimated work completed to the actual time spent on that job is used to describe operator performance. The number of parts, pieces, weight, volume, etc. produced and the standard times required to manufacture them all directly affect the overall standard times generated by an operator. As a result, the number of units of work generated is equal to the total standard times for all measured and estimated work completed.

$$opration\ performance = \frac{\text{sum of } standard\ minutes \text{ distributed}}{no\ of\ minutes \text{ enable to performed operator}} * 100 \quad \text{.........equation 1}$$

$$operator\ performance = \frac{\text{sum } weight \text{ performed}}{\text{Sum of } standard\ weight\ to \text{ use}} * 100 \quad \text{..................equation 2}$$

2.2.1. Earlier and modern approaches of operator performance

2.2.1.1. Earlier approaches of operator performance

The definition of the previous methods for evaluating operator performance considers several factors, including the operator's expertise, job characteristics, techniques, and the concept of human resources management work design. This framework is based on the research conducted by (Margaret Moussa, 2017) . According to satisfaction theories, contented workers are more devoted, innovative, and productive for their companies. Additionally, recent empirical research shows a direct link between employee performance in firms and job satisfaction. In a competitive national and international economy that demands quality and cost-efficiency, organizations that can establish work environments that attract, encourage, and retain hard-working personnel will be better positioned to thrive, and job satisfaction was traceable employee performance in organization examined by the two-factor theory such as achievement, recognition, work itself, responsibility, promotion and salaries according to the journal study of (Stephen. Dugguh Ph. D & Ayaga, 2014). Additionally, the worker's performance is influenced by a number of theoretically different but possibly complementary theories for the direct correlation between productivity and wages and also Women who work are juggling all the issues at work and at home. They are successfully handling the following elements: Self-control, Organizing Your Time, Handling Stress, Management of Technology and Management of Change (Tiwari, 2017).

2.2.1.2. Modern approaches operator performance

In a study of the journal Paschina (2023) considering modern performance, the work study considers the following methods: trust in management, work flexibility, job satisfaction, productivity, proactivity and sense of responsibility, quality of outcomes, work-life balance, and a supportive, collaborative work environment. These factors collectively contribute to enhancing employee engagement and overall organizational success.

According to the study Facchini (2022) the human factor is regarded as an inexpensive substitute for costly automated solutions as well as a highly adaptable and replaceable resource. The tasks of the smart factory are evolving as a result of the fourth industrial revolution and the growing use of innovative gadgets.

2.3. Operator performance in Global and in Ethiopia

2.3.1. Operator performance in global

There is no research on the connection between Bangladesh's economic growth and its manufacturing trends. The necessary steps should be taken to improve the level of productivity if they are insufficient. This study uses a nonparametric benchmarking approach to evaluate industrial sectors' efficiency in manufacturing compared to standardize industry procedures, taking into account both social and economic results (Hossain, 2025).

According to a study by Pal (2025)the cotton and handloom or weaving industries in India have historically produced enormous occupations for both expert and untrained workers in the clothing industry, second only to agriculture. The next-biggest sector in India that creates jobs is still the fabric industry. By employing surveying approaches, it provides job opportunities to more than 35 million people across the nation.

The Pakistani Journal of Engineering confronts Operators in the manufacturing process are socially and scientifically interrelated. In particular, unpredictable malfunctions and fluctuating interactions between parameters like work in process (WIP), process duration, throughput, knowledge, and flow of materials can cause local failures that explode globally. These behaviors can be analyzed using the system of system dynamic methodology (Mahmood, 2019).

The report Martina c. (2024) that in order to modernize production systems and promote export-driven growth, the UK manufacturing industry has been investing more in high-end "digital manufacturing technologies" (DMTs). Automation, sensor innovations, artificial intelligence and analytics, distributed networking technologies, manufacturing by additive processes, simulated augmented and virtual reality, the Internet of Things, and cloud computing are just a few of the many intelligent and linked tools that make up DMTs.

The study Zhang (2025) provides guidelines for successfully integrating VR into production system design and compares operators' behavior in immersive and real manufacturing environments with application to productivity in France. To close this gap, the current work presents a new and organized methodology. The study provides a comprehensive understanding of operator performance in both settings by combining objective behavioral indicators with subjective workload evaluations.

2.3.2. Operator performance in Ethiopia

According to the Ethiopian Productivity Report labor productivity (2020) in Ethiopia grew at an annual rate of 4.94% during the year from 2000 to 2016, starting from a very low point. Ethiopia’s productivity level is far below those of such latecomer competitors for the other country. Among main sectors, services grew fastest in labor productivity, followed by manufacturing. Agricultural productivity lags in both level and rising speed. “The Ethiopia Productivity Report offers necessary data for policy makers to go deep into the causes of this problem and find possible solutions,” said Prof. Kenichi Ohno, professor at the National Graduate Institute for Policy Studies /GRIPS/ and one of the participants in conducting the report. The study human resource analytic in order to measure for the enhance organization performance by structural equation modeling and smart PLS 3.0 software of data analysis (Tessema s., 2025).

2.4. Operator performance measurement

Aspects of operator performance assessment research include time or speed measurement, accuracy or error measurement, workload measurement, cycle time, lead time, maintenance capabilities, production scheduling, and measuring preferences (Battesini, 2021). The management and industrial engineering study Dhanasekharan N, (2017) states that quality, timely delivery, and post-delivery service are the important performance factors for the measurement. Monitoring and measuring the main performance metrics for assessing the performance of outside providers give appropriate data.

Cycle time: based on the case study Mariana Araujo (2017) correct measure must be founded in order to conduct and enable study of time to time concentrates, including

1) Work out to operator's performance and productivity.
2) List each mechanism into their sub divided parts and gathering data a thorough explanation of the procedure.
3) Follow up the way of the operator's time when doing fundamental mechanism.
4) Build up how many cycles time to be required
5) Discuss the operator performance with in manufacturing
6) Calculate the Cycle Time (Tz):

$$\text{Cycle time} = \frac{\sum \text{cycle time}}{\text{Measurement number}} \qquad \text{.........equation 3}$$

7) Decide to the correction
8) Decide to each performance of standard time i

$$STi = (OT * AF/RA) * (1 + \sum Ci) \qquad \text{........equation 4}$$

Being:

OT - the observed time;

(AFi) - The average activity factor for performance i;

RA - the reference activity (in general, RA = 100);

ΣCi - the sum of all the corrections considered.

Bottleneck: According to the research study Bizuayehu (2023); the first and most crucial step in increasing total capacity for manufacturing is constraint identification. To find a problem, the company's manufacturing system must first be observed.

Standard time: The case study Mariana Araujo (2017) gives management a numerical number that allows it to calculate the manpower resources needed to complete a task for which the activities are known and precisely specified.

Lead time: based on research analysis Bizuayehu (2023) the total of setup, processing, and non-operation time is the manufacturing lag time The total of design time, manufacturing planning time, manufacturing control time, and MLT is known as production lead-time, or PLT.

Raw material variability's: The future prospects of the jute industry are significantly influenced by the availability of jute as a raw material (Chintamani, 2023)

Maintenance capabilities: The system's ability to detect problems using predictive models, optimize processes in real time, and recommend design alternatives makes it easier to integrate into fields including product engineering, advanced manufacturing, logistics, and automated maintenance((Martina C., 2024).

Technology Advancement: The performance of jute bag production can be greatly impacted by adopting innovation and technical improvements, according to the Journal of Innovation Research (Chintamani, 2023).

2.5. Operator performance simulation model

The operator performance is one of the factors affecting the working environment to be considered on the motivation of the worker with an industry which has created the productivity loss to one of the human errors within the work area. Therefore, simulation and modeling is an instrument to solve the problem of the operator performance maximized by using the mechanism to identify and analyze the bottle neck of the work station by using the arena software. Melamed (2007) Modeling and Simulation textbook states the process of creating a simplified representation of a complicated system in order to forecast its performance indicators is known as modeling. In order for the analyst or modeler to learn more about and gain insight into the behavior of the system, a model is created to capture specific behavioral elements of the modeled system.

According to Jerry Bank (fourth edition) text book a simulation is a long-term replication of how a real-world system or process operates. Simulation, when performed by manual or on a computer, is creating a virtual historical record of an entity and observing it in order to make conclusions about the real system's working properties. According to V.P.Singh (2009), a model of a system is a physical or mathematically accurate replication of the system with all of its distinctive features and entity, while simulation is the process of simulating the real scenario as closely to the framework as possible in a lab or on a computer. Using different model the modeling to maximization of the operator performance is follow below (Jerry Banks, fourth edition):

Dynamics and Static

Static simulation: models that depict a system at a specific point in time are sometimes referred to as Monte Carlo simulations. Dynamic simulation: simulations show how systems evolve over time.

Stochastic and deterministic

Deterministic simulation: models provide a distinct set of outputs from a known set of inputs. One or more random variables are used as inputs in a stochastic simulation. Random inputs produce random results. The outputs can only be regarded as approximations of the actual properties of a model because they are random.

Discrete and continuous

Text books of V.P.Singh (2009), study for continuous simulation in the x-y plane, y = f (x) is a smooth curve if f (x) is a continuous function. The definition of continuity as it is taught in schools is provided here. It has been contained the distribution of exponential, weibull, Poisson and normal distribution. According to Melamed (2007), the most popular discrete distributions and the underlying random experiment are employed in discrete event simulation, and their application in simulation modeling is discussed in the Bernoulli distribution, binomial distribution, Poisson distribution, and generic simulation are all included in the discrete event. The reference of the Jerry Bank (fourth edition) book the modeling of systems where the state variable only varies at a discrete set of times is known as discrete-event systems simulation. Instead of using analytical techniques, numerical approaches are used to analyze the simulation models.

Why is simulation needed?

According to V.P.Singh (2009), the textbook emphasizes a number of benefits of employing simulation, which can also be applied to operator performance in modeling and simulation of jute bags. The study and experimentation of intricate jute bag production processes, such as machine operations, workflow, and operator efficiency, are made possible by simulation. One can better understand system behavior and pinpoint areas for improvement that might not be immediately apparent in real-life operations by making controlled changes to the simulation model, such as modifying operator speed, machine configuration, or workload distribution, and then observing the results.

As a training tool, simulation gives operators and supervisors a virtual environment to practice and assess performance without interfering with real production, which helps them improve analytical and decision-making abilities. Additionally, it improves comprehension and focus, particularly for operators who are already acquainted with the jute production process. Important information on which factors, such as operator skill level, machine settings, or raw material quality, most significantly affect efficiency and output can be obtained through simulations of the manufacture of jute bags. Before putting new operating methods, machine layouts, or workflow regulations into practice on the real production floor, they can also be tested through simulations. Lastly, when adding new machinery or changing the production process, simulation can help foresee possible bottlenecks or operational problems, allowing for better preparation and optimization of operator performance in jute bag manufacturing.

2.5.1. Simulation software

Arena: Arena has a feature that enables a model to operate in real time and interact dynamically with other processes (Law, 2007). Raw input data can be chosen from two sub-options in the Data File option of the File menu when a new input dialog box has opened: 1. you can open existing data files by selecting use existing. 2. The Generate new option allows you to produce new (synthetic) data files (Melamed, 2007).

Auto Mod: as automated storage and retrieval systems, bridge cranes, power and free conveyors, vehicle systems, conveyors, and robotics kinematics. It also facilitates continuous simulation of fluid and bulk-material flow with its Tanks and Pipes module (Jerry Banks, fourth edition).

Extend: Extend Sims offers a simple method for producing point estimates and confidence intervals for relevant performance indicators, as well as for creating independent replications of a simulation model. Numerous plots are provided, including Gantt charts, bar charts, time plots, and histograms (Law, 2007).

Flexsim: tool for creating models that mimic the behavior of real-world physical or conceptual systems.

Pro Model: decision logic based on rules and modeling components focused on manufacturing. Pro Model's collection of highly parameterized modeling elements can be used to model certain systems.

SIMUL8: needed to create simulations, standardizes how certain scenarios are handled throughout an organization, and frequently eliminates a large portion of the data-collection stage of a simulation research. Additionally, Simio facilitates agent-based simulation, discrete-event simulation using the process approach, and modeling continuous flow systems (Law, 2007)

2.6. The factor influencing operator performance in jute bag manufacturing

The following conditions, which are derived from research, academics, books, textbooks, and industry point of view, have been identified as the factors impacting operator performance and productivity maximization within an industry: The following categories best describe the major variables affecting operator performance in a labor-intensive, process-driven environment such as the production of jute bags contains work process and productivity, safety, health and motivation, performance and quality, skill and training ,machine reliability and productivity among of those listed generally in three class.

1. **Capacity of operator**

These elements have a direct bearing on the traits and abilities of each operator. When modeling these, one must take into account their unpredictability as well as how they affect process time and quality.

Operator Skills and Experiences: The strategy entails the following actions for challenges, system and purpose of textile industry for future sustainability (Hossain M. T., 2024): Productivity modeling with respect to the relevant task performance metrics, identifying the most important avenues of improvement based on task performance metrics and current productivity, delivering the operator's observations and Evaluation on the effectiveness of the contributions (Kalevi T., 2008).

Human factor and Workload: according to Hasanain (2024) implementation of the ergonomic a vital role and enable to minimize work load. A secure workplace raises employee satisfaction, which raises output, efficiency, and profit margins. Businesses can enhance their operations by implementing safety protocols. Safety protocols may unintentionally improve operations (U., 2013).

Motivation and Management: Workers who are driven to work Hasanain (2024) are likely to be tenacious, imaginative, and prolific, producing excellent work that they voluntarily do (U., 2013).

2. **Machine and Equipment Factors**

In a manufacturing simulation, operator performance is directly impacted by machine capabilities and reliability.

Maintenance and Equipment Reliability: Production capacity, product cost, product and service quality, employee or customer safety, and customer happiness are all directly impacted by machine and equipment failure or malfunctioning in the manufacturing and service industries (U., 2013). Using pareto analysis, the maintenance performance level (MPL) is a crucial component of the key performance indicator (KPI) to enhance the efficacy of machine maintenance, which includes factors of machine reliability (MR) and overall equipment effectiveness-machine effectiveness (OEE-ME) (Faisal R., 2022). Machine break down, poor maintenance culture and idle machine ((Narayan, 2023)

Technology and Ergonomics of Machinery: from the study Narayan (2023) productivity improvement for jute industry shortage of skill man power and absenteeism. The problems in the production of jute bags cannot be avoided by the current approach. First, the effectiveness and willingness of the operators determine the quality production rate. Second, the aforementioned tasks require a lot of labor. Thirdly, a sizable floor area is occupied by the manufacturing facility (A Mahapatra, 2008)

3. **Process and Workflow Factors (Operational Design)**

These elements are essential for configuring the simulation model since they provide the performance goals and inter-station dependencies.

Manufacturing Lean and Waste: The process's WIP and FGI holding capacity constraints are predetermined. The Target WIP and Target FGI, which are in turn regulated by cycle time, safety stock coverage, and delivery time delay, naturally satisfy these capacity limitations (Mahmood, 2019)

Production Planning and Scheduling: articlesAkinmoye (2024) identifying and analysis lean manufacturing in garment production process**.** A well-thought-out strategy and timetable will help you stay within your budget while maintaining a high production rate. An operations plan and timetable must be developed by a manufacturer for the production process (U., 2013)

Quality Management: according to the journal of Adenle (2024) assessing quality management components the dimensions of training, product/service design, supplier quality management, and employee interactions show the strongest positive correlation between manufacturing and service enterprises on the degree of quality management practice (Badri & Davis, 1995).

2.7. Strategy for operator performance to productivity improvement in jute bag manufacturing

A strategy is a method, plan, or series of actions meant to achieve a specific goal or outcome. Porter's five forces of competition framework, competition from substitutes, and threat of entry, rivalry between established competitors, and buyer and supplier bargaining power are all taken into consideration when analyzing the attractiveness of an industry strategy (Cheah, 2024). Fault Tree Analysis, Fishbone (Cause and Effect) Diagrams, CEDAC, Brainstorming, Six Sigma, and Why-Why Analysis, often known as the "5 Why's," are some of the methods that can be used to identify the root cause. The 5 Whys are frequently taught as a team's first problem-solving technique due to their simplicity? I would advise all teams to start with its (Borris, 2006). According to V.P.Singh (2009) the simulation and modeling textbook, a model of a system is a physical or mathematically accurate replication of the system with all of its distinctive features and entity. According to Melamed (2007), the most popular discrete distributions and the underlying random experiment are employed in discrete event simulation. Pareto analysis machine reliability and overall equipment effectiveness machine effectiveness (OEE-ME) (Faisal R., 2022). Arena defines system logic and physical components like machines, operators, and clerks, simulation models are constructed from graphical objects called modules
(Jerry Banks, fourth edition)

Improved work process and productivity: the enhancement of using advanced procedures, enable to technology of forecasting, maintain work flow throughput, reliability, and increasing the operator performance by 15%.

Enhanced performance and quality: construct the enhancement of the work-in-process for beaming, weaving and sewing for improved by general quality of standard keep in 95% in order increasing productivity, minimizing downtime and reduced the constraint of the bottleneck.

Improved Safety, health and motivation: minimizing risks, eliminating mistakes and encouraging participation, best practices improve operator performance. These improvements work along with process improvements and equipment upgrades to make everything better, with incident rates that are almost zero and output boosts of 20 to 30 percent when people are motivated.

Good machine maintenance: increases efficiency, lowers downtime, and prolongs the life of equipment. Frequent maintenance avoids expensive malfunctions and detects problems early. Cleaning, staff training, and scheduling are important procedures.

Availability of quality raw material: By addressing underlying issues like variability, bottlenecks, and low productivity, raw materials prevent disruptions to operator performance, processes, equipment uptime, and downstream quality in the manufacturing of jute bags.

Bottle neck mitigation: distinguishing and analyzing the constraint of the work-in-process on the jute bag manufacturing among the work flow in beaming, weaving and sewing.

2.8. Literature summary

The stated issue of the study topic has addressed fundamental concepts and practices pertaining to factors affecting operator performance and key performance indicator strategies from the literature review. However, only a few deal coffee processing and warehousing companies have conducted studies on the relationship between elements that affect operator performance in jute bag manufacture for beaming, sewing, and weaving work stations and improvement in maximizing the operator performance. As a result, this study aims to enhance operator performance, and the insights from various authors on performance development and customer satisfaction enable us to provide and improve various concepts through modeling and simulations. Table 2.1 appears below.

Table 2.1: Synopsis of research findings and publisher

No.	Author and publisher	Research title	Objective and description	Performance improvement techniques	Finding	Research approach

1	Ahmed and Rahman, 2021	optimization maintenance performance level through collaboration of overall equipment effectiveness and machine reliability	Maximize the value of the maintenance performance level (MPL) by combining machine reliability (MR) with overall equipment effectiveness-machine effectiveness (OEE-ME).	Pareto principle	The suggested machine reliability (MR) is superior to the original machine, and overall equipment effectiveness-machine effectiveness (OEE-ME) at a world-class maintenance performance level (MPL) with a value of 90.43% reliability (MR) based on the failure ratio value.	Journal research
2	Bezawit Endeshaw, 2021	Investigation of Employee Productivity factors and Conceptual Model Development	Create a conceptual model for improvement by examining the elements that influence worker productivity.	Conceptual model	Human resource management and organizational culture have a significant impact on the case company, whereas work environment and workplace safety have little effect.	Research paper
3	Kiangala, K.S., Wang, Z., 2025	A generative pre-trained transformer industrial bot to improve operators' working experience in a small Industry 5.0 factory	Industry 5.0 (I5.0), emphasizing ecosystem preservation and human well-being	OpenAI GPT4 language model (LM)	the creation of a GPT industrial bot to help small production operators enhance their everyday job experience	Article
4	Margaret M., Mathew B., and Maria E. ,2017	Investigating Knowledge Workers' Productivity Using Work Design Theory	The most well-known HRM theory for motivation is the Job Characteristics Model.	Work design model	Demonstrate the importance of organizational context and information sharing as a feature and result of knowledge work.	Journal research
5	Stephen.D, Ph. D,Ayaga, Dennis,Ph. D,2014	Job satisfaction theories: Traceability to employee performance in organizations	Illustrate the significance of information exchange and organizational context as a characteristic and outcome of knowledge activity.	Job factor theory	Although the concept of job satisfaction is complicated, improving employee performance can be achieved by utilizing the right variables and mechanisms.	Journal article
6	Mansi Tiwari ,2017	Work Life Balance of Female Employees in Private Institutions, Gwalior: An	Researchers looked into how incorrect balances between their personal	By data investigation for interview	Enhance the work-life balance, particularly for female employees.	Journal research

		Investigation	and work lives are affecting the lives of female employees..	and questioner		
7	Silvia Paschina,2023	Trust in Management and Work Flexibility: A Quantitative Investigation of Modern Work Dynamics and their Impact on Organizational Performance	The changing nature of the workplace and the growing need for independence and flexibility	Quantitative investigation	Higher productivity and better results are strongly correlated with well-established trust in management.	Journal research
8	Francesco Facchini,2022	A Model to Estimate Operators' Performance in Accomplishing Assembly Tasks	create a theoretical model based on information that enables the estimation of an operator's performance index to complete an assembly task by assessing the operator's skill and the complexity of the tasks	Modeling	Efficiency of the model in estimating the operators' performance and generating a work plan based on workers' skills and task complexity.	Case study
9	Hossain, Mohammad A., Wehrmeyer, Mona,2025	Manufacturing Performance and Organizational Practices: Evidence from an Emerging Economy	Bangladesh's industrial industry with an emphasis on technical performance.	Nonparametric frontier models	The impact of organizational practices on manufacturing performance was found to be moderate.	Article
10	Dr. Nabanita P. ,2025	Scenario Of Handloom And Cotton Industry In Hooghly District: A Survey	To evaluate the product of handloom weaving and the surrender of technology	Survey	Training to Increase Capacity for Weavers	Case study
11	Asif Mahmood, 2019	Gazing Lean through the lens of System of Systems Dynamics: A case of weaving mill	The system of systems can be modeled and simulated using the system dynamics approach.	System dynamics approach	Increased cycle time as a result of needless effort and decreased production capacity as a result of rolling blackouts.	Case study
12	Masood A. Badri, Donald D., Donna Davis,1995	A study of measuring the critical factors of quality management	the process of creating and evaluating quality management theories as well as investigating	The reliability of empirical measurement	Finding a beneficial relationship between the quality management component in manufacturing	article

			specific quality management hypotheses		and service companies	
13	Kalevi,Tervo, LauriP.,Vesa Hölttä & Aki Putkonen ,2008	Improving Operator Skills with Productivity Model Feedback	The full utilization of machine performance should be the aim of operator skill development in order to maximize system performance	Fuzzy modeling	Analysis is done on how the operators' performance varies	article
14	Md. Shakil, Md. Rahamat Ullah, 2013	Process Flow Chart and Factor Analysis in production of a Jute Mills	Creating and recording intricate programs or processes. Using the process flow chart technique, bottlenecks and losses in jute mills that would disrupt operations can be easily identified	Factor analysis	Shows the process flow chart and the variables influencing Bangladeshi jute mill production.	Journal research
15	Meng-Leong How and Sin-MeiCheah, 2024	Quantum-Enhanced AI and Machine Learning: Transforming Predictive Analytics	Examine how AI and ML models can be improved by quantum computing, especially in the field of predictive analytics	Quantum classic model	verify the efficiency of quantum models in handling big, complicated datasets	Article
16	AMahapatra, US Patkar,RW Lanjewar	Design of an automatic parallel type jute bag making machine	Create a jute bag manufacturing machine that produces parallel type jute bags of industrial standards by automating all processes, such as fabric cutting, hemming, mid-folding, and heracle stitching, in a single configuration	Developing prototypes	Compared to the current manual system, the suggested machine can create bags of consistent quality with parallel side stitching, hemming, and mouth edge folding in a single integrated configuration at a greater productivity	Article
17	Battesini, M., & Pacheco, D. A. de J.	Key factors for operational performance in manufacturing systems: Conceptual model,	Further developments are necessary to comprehend the	Conceptual model	Validated the suggested conceptual model by demonstrating the intricate	Journal research

	2021	systematic literature review and implications	relationships between performance and its essential components		causal relationships between important variables that affect the performance of discrete production systems.	
18	Bizuayehu A. ,2023	Performance improvement of the footwear manufacturing industry through line balancing and simulation modeling in Anbessa Shoe S.C	Analyze it and enhance its performance by locating and removing bottlenecks through production process modeling and simulation that can guarantee the assembly line's equilibrium	Line balancing and simulation modeling	The poor performance of the manufacturing lines was caused by an uneven assembly line and disorganized workstations.	Research paper

The following enhancement of operator performance analysis was used to further investigate and assess the goals and techniques for improvement to address the operator performance issues based on the aforementioned study. In the case of modeling and simulation systems, create arena tools, modeling and simulation, a key performance indicator strategy, and improvement mechanism. As a result, several relevant studies have been conducted in the fields of performance analysis and production system modeling and simulation, and these studies have been thoroughly result analysis and improvement of the research paper. Although it is challenging to review them all, the author has made an effort to review and discuss a few that have been published and presented in various publications, case studies, articles, journal research, and thesis papers. The debate and revision are based on previously discussed topics and techniques.

2.9. Research gap

According to the literature reviews of the above gives a good data about production mechanism simulation modeling, operator performance, and improvement of the productivity. As the main factor of the operators performance and firm capacity, factors like dependability of machinery, job satisfaction, human factor, the capacity of machine repairing, schedule of manufacturing, and technological improvements have been dealt in both worldwide system mechanism and focus

Ethiopian industries. The other thing the main work- in- process bottle neck, line balancing, and system performance have been detail studied in a different Production Company by using simulation and modeling systems for different software such as: Arena, Flex Sims, and Pro Model.

Even though, now there are different the gap about the operator performance and the industry according to the collecting data from the literature and the research topics:

Working process and productivity: jute bag production relies heavily on manual work, using worn machines and workers with mixed skill levels who often stoop for hours at crowded benches. Without checking the local context, findings from other countries like Bangladesh, India, or wealthier economies don’t automatically fit its reality, where even a small market shift can look entirely different.

Bottle neck in work in processing: the particular process occur in delay

Lack of access quality raw material: raw material supplies, equipment design, and how production flows through the mill, while the skill and efficiency of operators at stations like beaming, sewing, or weaving hands steady over humming machines rarely get the same focus.

Scenario variability: factor for different intervention on the operator performance of the jute bag manufacturing

Work process representation: enable to identifying the work process low productivity of the operator performance

Machine down time: most studies examine these aspects separately, and few bring together technical or process factors like machine reliability, cycle time, or upkeep with human factors such as skill, motivation, workload, or how a workstation actually feels to use, all within one simulation framework.

Factor influence on operator performance: performance measurement studies today focus on system-level metrics things like lead time, throughput, and overall equipment effectiveness, the kind of numbers you can trace across a humming production line.

Uniqueness of the study: focus on the work station on beaming, weaving and sewing enable to identifying, analyze and measure scenario the operator performance of the jute bag manufacturing.

Finally, even though ideas like Industry 4.0 and 5.0, artificial intelligence, and smart operators dominate today's manufacturing discussions, they've barely touched traditional, low-automation sectors such as jute bag production, and where the hum of old looms still fills the workshop. As a result, sophisticated theories often drift far from the gritty realities of labor-heavy industries, like hands roughened from long hours on the line. Ultimately, researchers haven't done nearly enough empirical or simulation work to model and improve operator performance in jute bag factories, where machine noise, human skill, and process flow should be studied together. To close this gap, we need context-specific, data-driven strategies that sharpen operator performance, uncover bottlenecks, and lift overall productivity like spotting the slow hum of a machine before it stalls the entire line.

Chapter Three

3. Methodology

3.1. Introduction

Generally the research methodology begins with a description of the approach and design, then moves on to the variables, data sources, and data collection techniques. Ethical issues and data analysis techniques are also included.

3.2. Study approach

The approach of the study performed to gather the information for the present research is consisted in the following section. Methodology has been defined as a methodical and structured endeavor capable of examining particular issues in order to identify solutions. Therefore, in order to increase the performance of the jute bag operator in jute bag manufacturing, the process of the study is practiced by the systematical relationship of strategy between the problem statement and the finding and discussion that has been founded at the end by interconnecting the research design and modeling simulation mechanism.

3.3. Study Area

The Horizon Plantation Coffee Processing and Warehouse Company in Addis Ababa, Ethiopia, is where this study was performed. It is a well-known manufacturer and is enabled to produce or their variety jute bags products. The business competes in the jute bag product market, where customer happiness depends on the product's processing efficiency. In order to evaluate and improve the daily operator performance, the research was concentrated on the operations of the manufacturing department of the jute bag products.

3.4. Research design

Descriptive study mechanism can be used to link the problem to the findings of the research design. A descriptive research design was used for the study because it aims to define the characteristics of the work environment in order to improve and model operator performance during beaming, weaving, and sewing in the jute bag manufacturing. The performance of the operator in the jute bag manufacturing was focused in specific area, and it gave a detailed understanding of the operator's actual performance in order to maximize the daily operator performance in jute bag manufacturing.

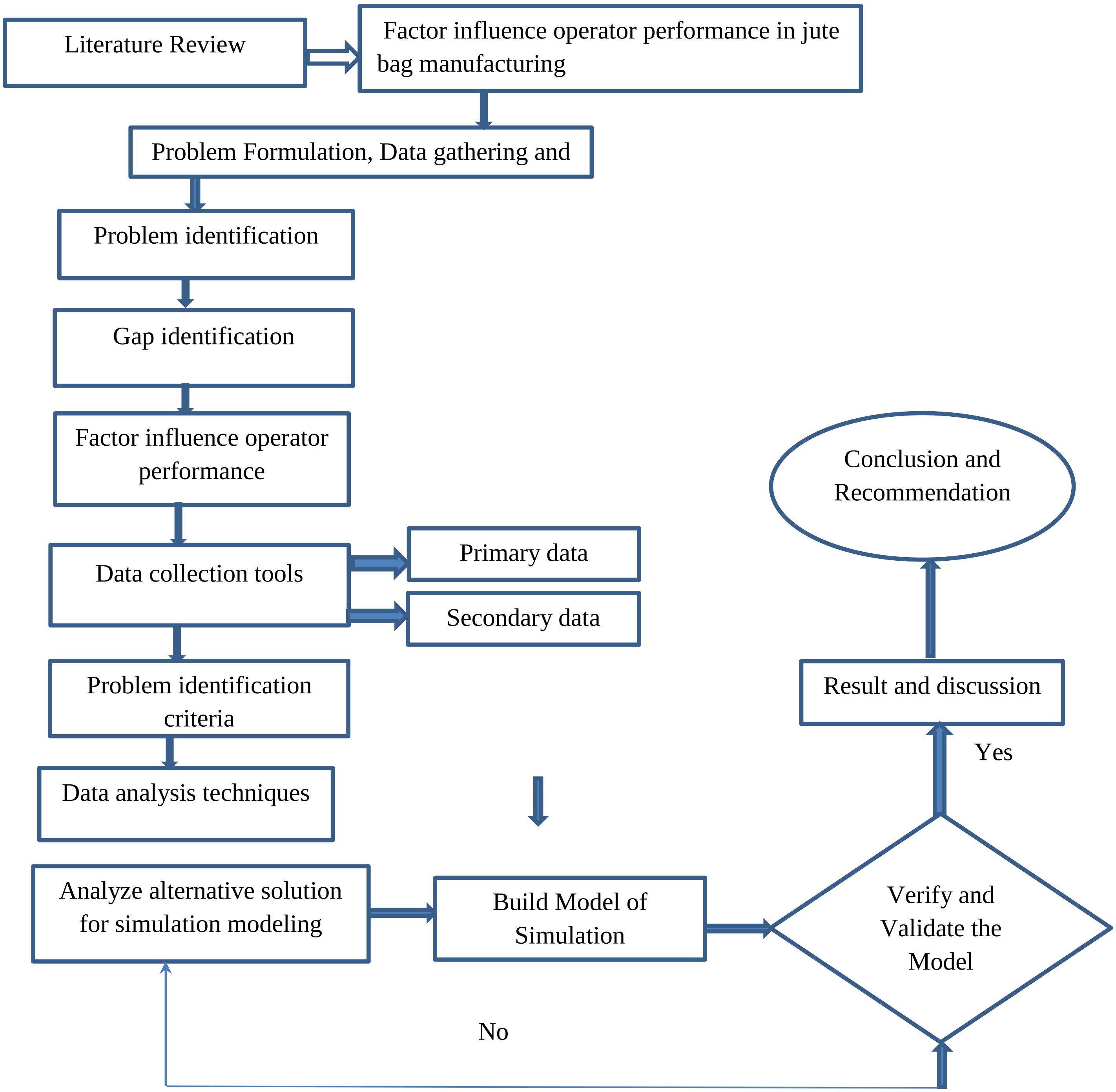


Figure3.1. Design of the research structure

3.5. Data collection

3.5.1. Literature review

Examining and comprehending many studies from published journals and papers concerning productivity, operator performance, and simulation modeling methods are the primary goal of a literature review. The study's ultimate objective is accomplished through the evaluation of journals, articles, case studies, reviews, and business reports. The implementation provided insights into the field of study to identify the most effective instruments and techniques. Productivity maximization through enhancing operator performance, avoiding the factor of the key performance indicator, identifying the bottleneck work station, and simulation modeling for daily productivity of the operator performance for each work-in-process in beaming, weaving, and sewing were the main topics of the reviewed literature.

3.5.2. Primary data

It was gathered from the workers of the jute bag manufacturing, customer, and in-depth interviews with the production supervisor and head. Additional information was gathered through observation and interviews using a questionnaire. This included the company's current production process, customer demand and satisfaction, the annual plan of the jute bag manufacturing, cycle time, work-in-process, and the daily productivity data of the operator with each work station in beaming, weaving, and sewing productivity. The simulation model must replicate the actual assembling line system utilizing the production process data that has been gathered, such as operational procedures, cycle times, working days, number of stations, and manpower at each station. The data collection mechanism summarizes the study of the research such as: direct observation, collecting data from work station, Interview, time recording data production per day for each work station and surveying.

3.5.3. Secondary data

The operator's daily and monthly reports, the jute bag manufacturing annual report, and other pertinent papers were used to evaluate the data for this study, which included working in process of the beaming, weaving, and sewing cycle-time. Document review: To show the current capacity and difficulties of the production line of the jute bag products at the jute bag factory of the Horizon Plantation of coffee processing and ware housing firm, the production daily activity and production scheduling are reviewed.

3.6. Sample and sample techniques

This research used the operator's daily productivity as a sample, as well as information from the supervisor, the head of jute bag production, quality inspector, and factory employees who provided information about the operator's performance. Consequently, observations of the operator's workspace and interviews with the supervisor and the production head of the jute bag factory comprise the data gathered for the daily productivity report and annual operator performance reports. Sample techniques able to show the number of operators, supervisors, production heads, other and production and technic head both quantitative and qualitative data formed the basis of the sampling strategy. Regarding the qualitative, the location of work for weaving, sewing, beaming and other work environments of in jute bag manufacturing. Since the precise number is known and there are few, censuses were utilized to obtain data, which led to the sampling strategy of probability sampling for the employees.

3.7. Target Population

The 60 workers of Horizon Coffee Processing and Warehousing Company who are directly involved in the production of jute bags compose the target group for this study of the company. Production and technic head, supervisors, machine operators, assistant operators, mechanics, production heads, environmental safety officer, and quality inspectors contains this group. These people were chosen because they are involved in every step of the jute bag production process, from reporting to improving the performance of the operator, which has a big impact on customer happiness, production time, and the industry operational productivity. By focusing on these particular groups, the study provides that the information gathered represents the viewpoints and knowledge of those who are directly involved in the activity under investigation. These workers were chosen in accordance with the study's goals since their roles offer require able data on the obstacle and possible advancements of the jute bag production process.

3.8. Utilizing Data in Simulation Modeling

An annual jute bag operator performance record serves as the fundamental data for simulation modeling, which focuses on important factors that affect the daily operator performance in jute bag manufacturing. In order to duplicate the daily operator performance in the beaming, weaving, and sewing work-in-processing of the jute bag manufacturing process at Horizon Coffee Processing and Warehousing Company, the research uses the Discrete-Event Simulation (DES) model. The DES model will depict operator performance as a sequence of discrete events, such as daily operator performance, factors influencing the work environment, and an increase in the productivity of the jute bag products. operator performance collecting data demographic group, work environment and equipment, skill and training, work process and productivity, performance and quality, safety, health and motivation, and machine maintenance are the stages of daily operator performance as determined by employee feedback. Based on the productivity rates, the daily operator performance will be entered into the system, and each operator performance will be practice using the specified mechanism.

3.9. Providing Validity and Reliability

3.9.1. Measures of Reliability

Consistent Techniques: To reduce answer variability, standardized interview and survey protocols were employed to guarantee that every respondent was asked the same questions in the same way. Multiple Data Sources: Interviews, focus groups, and secondary data sources were compared in order to triangulate the data. Cross-verification improved reliability and helped validate findings.

3.9.2. Reliability Measures

Content reliability: By incorporating feedback from industry experts throughout the production stage, the questionnaire guaranteed thorough coverage of all pertinent aspects of the operator performance in work-in-processing during the jute bag manufacturing process.

Construct reliability: To ensure that the questionnaire accurately measured the target constructs, including operator performance, customer satisfaction, productivity, and factor influence operator performance, it was pre-tested.

Feedback Structure: To ensure a deeper comprehension of the context, an open-ended question was included to allow respondents to expound on their experiences and viewpoints.

3.10. Tools for Analyzing Data

In order to maximize the factor impacting the daily operator performance of the jute bag production work- in - process, a number of sophisticated data analytic technologies are used in this study. These tools Value Stream Mapping (VSM), Pareto Analysis, and Simulation Modeling offer special approaches for locating bottlenecks and improving productivity performance in the production of jute bags.

The following instruments are used by the researcher to analyze data:

Organizations can study and optimize complex systems by using simulation modeling, a technique that generates a digital representation of a real-world process. It finds bottlenecks and evaluates the effects of variable changes, allowing for the simulation of several scenarios to examine different performance indicators and enhance daily operator performance to increase productivity. Simulation modeling tool is particularly useful for identifying factors that affect an operator's performance on a daily basis in the manufacturing of jute bags. These factors include the work environment and equipment, skill and training, work process and productivity, performance and quality, safety, health and motivation, and machine maintenance. In order to provide useful insights to improve daily operator performance in the jute bag manufacturing workflow process, Discrete Event Simulation (DES) is used in this research to represent and analyze systems where changes occur at discrete points in time, such as work environment and equipment, skill and training, work process and productivity, performance and quality, safety, health and motivation, and machine maintenance.

Pareto Analysis: incase of the Pareto approach apply 80/20 rules, 20% of causes account for 80% of issues. Focusing on improving productivity values will be made easier by identifying the main obstacles in the factor influence of the daily operator performance workflow.

Value Stream Mapping (VSM): VSM assists in identifying the factors influencing productivity and inefficiency by visualizing the flow of raw materials and work-in-processing through the operator performance factor. In the end, this approach seeks to improve operator performance and productivity maximization.

3.11. Ethical consideration

The research followed ethical standards to guarantee openness all the way through the investigation. Getting interviewees' informed consent, protecting sensitive data, and accurately reporting findings were all ethical considerations. In order to ensure that respondents were not harmed in any way, the research was carried out with the highest respect. Maintaining data integrity was essential since it guaranteed the veracity and correctness of data gathering and reporting. Additionally, by refraining from plagiarism and appropriately citing all sources and contributions from earlier research, the work upheld academic integrity.

Chapter Four

4. Result and Discussion

4.1. Introduction

The results of the empirical data analysis and discrete-event simulation model created for the jute bag production process at Horizon Plantation Coffee Processing and Warehouse Company are presented and discussed in this chapter. The analysis's main goal is to pinpoint the critical elements affecting daily operator performance in sewing, weaving, and beaming work-in-processes. The simulation model was fed real production records, machine availability information, and downtime reports. The findings are compared with findings from the literature and explained in respect to the study topics. The research's results and discussion section discusses the conclusions based on information gathered from Horizon Plantation Coffee Processing and Warehousing Company, as well as questionnaire gathered. In the Horizon Plantation Coffee Processing and Warehousing Company, it presents the study questions, examines the features of the participants' response rates, and uses descriptive statistics to determine the factors influencing the daily operator performance.

4.2. The behaviors of the respondents

The study collected data from 60 employees in the following work environment: production supervisor, production head, quality inspector, stitching operator, stitching/sewing assistant operator, weaving operator, weaving assistant operator, beaming operator, beaming assistant operator, others, and production and technic head. The demographic categories are displayed in Table below by using SPSS Statistics software.

Table 4.1 Descriptive statistics for demographic group of the frequency distribution

Types of demographic group	Types of respondents	Frequency	Percent
Gender group	Male	23	38.3
	Female	37	61.7
Age group	18-24	13	21.7
	25-34	33	55.0
	35-44	12	20.0

	45-54	2	3.3
Level of education group	Secondary	31	51.7
	diploma/TVET	18	30.0
	Degree	7	11.7
	Master	3	5.0
	Others	1	1.7
Work experience group	Less than 1 year	6	10.0
	1–3 years	18	30.0
	4–6 years	30	50.0
	More than 6 years	6	10.0
Job position group	beaming operator	3	5.0
	production head	2	3.3
	production and technic head	1	1.7
	Other	11	18.3
	beaming assistant operator	1	1.7
	Loom Operator	27	45.0
	Loom assistant operator	3	5.0
	Stitching Operator	9	15.0
	Mechanic	1	1.7
	production supervisor	2	3.3

Summary, according to the data collected, the age group of 25–34 (55%) is the greatest, suggesting an employment population that is generally stronger. The dominating roles are indicated by the machine operator and assist operator, indicating a preference for technical roles over middle- or higher-power roles. The majority of responders had more than four to six years of experience, suggesting that the staff was competent. This demographic distribution highlights how crucial it is to work with a workforce that is primarily young and experienced in order to use their insights to improve the daily operator performance from the jute bag manufacturing in the coffee processing and warehousing company Horizon Plantation. Additionally, those with higher levels of education include secondary school/intermediate (51.7%) and diploma/TVET (30%), which are necessary for improving skills and training to boost the company's output.

4.3. Identified Main Factor Influence of the Operator Performance

These conclusions are corroborated by the data collected from Table 4.1 above, which demonstrates that the most important factors influencing daily operator performance in the jute bag manufacturing are demographic data, work environment and equipment, skill and training, work process and productivity, performance and quality, safety, health and motivation, and gaps. The company may be able to address a sizable portion of these inefficiencies.

According to (Tiwari, 2017), productivity ineffectiveness is frequently caused by a lack of access to quality raw materials, inconsistent raw material supply, inappropriate breakdowns, lack of skill man power, and lack of preventive maintenance. These issues are highlighted by data investigation for interviews and questioning with existing literature. The investigation identifies a number of crucial factors that affect daily operator performance in the production of jute bags at Horizon Plantation Coffee Processing and Warehousing Company.

Work environment and equipment

Work environment and equipment the factor influence of the operator performance in jute bag manufacturing which has been contained: machine and equipment reliabilty, tecchnology and ergonomics of the machinery,ergonomic and work load.

Table 4.2. work enviroment and equipment

valid	1	1.06	1.3	1.44	1.63	1.69	1.94	2	2.1	2.25	2.31	2.38	2.44	2.56	2.63	2.69	2.88	2.94	3	3.25	3.31	3.38	3.56	3.69	3.88	4	4.31	4.44	4.63	Total
frequency	2	1	1	1	3	2	1	8	2	1	1	1	2	1	1	2	1	5	1	6	2	1	2	2	2	5	1	1	1	60
percent	3.3	1.7	1.7	1.7	5	3.3	1.7	13.3	3.3	1.7	1.7	1.7	3.3	1.7	1.7	3.3	1.7	8.3	1.7	10	3.3	1.7	3.3	3.3	3.3	8.3	1.7	1.7	1.7	100
valid percent	3.3	1.7	1.7	1.7	5	3.3	1.7	13.3	3.3	1.7	1.7	1.7	3.3	1.7	1.7	3.3	1.7	8.3	1.7	10	3.3	1.7	3.3	3.3	3.3	8.3	1.7	1.7	1.7	100
cum.percent	3.3	5	6.7	8.3	13.3	16.7	18.3	31.7	35	36.7	38.3	40	43.3	45	46.7	50	51.7	60	61.7	71.7	75	76.7	80	83.3	86.7	95	96.7	98.3	100	

Valid mean scale 1 to 4.63 range

The results, ranging from about 1.00 to 4.63, show that respondents used the full scale when rating this factor from one end clear to other. Most response values show up only once or twice, but a few appear much more often hinting that people's views on the equipment and workplace differ, like scattered notes in a noisy room. SPSS data shows higher percentages clustering around mid-range values from about 2.0 to 3.5 indicating many operators rated the equipment and workspace as moderate to fairly good, like giving it a solid three out of five. A rating above 4.0 exists but doesn't show up often, which suggests most operators rarely, find truly excellent equipment or workplaces think of a shop floor where every tool feels brand new. Though they're rare, some scores drop to about 1.0, a clear sign that certain operators are stuck with poor tools or tough working conditio**n**s like trying to fix a jammed valve with a dull wrench.

Skill and training

Skill and training the factor influence of the operator performance in jute bag manufacturing which has been contained: motivation and management,operator skill and experiences.

Table 4.3 skill and trainig

Valid	1	1.25	1.5	1.75	2	2.25	2.5	2.75	3	3.25	3.5	3.75	4	Total
Frequency	3	3	4	4	6	6	9	8	5	3	5	1	3	60
Percent	5	5	6.7	6.7	10	10	15	13.3	8.3	5	8.3	1.7	5	100
Valid Percent	5	5	6.7	6.7	10	10	15	13.3	8.3	5	8.3	1.7	5	100
Cumulative Percent	5	10	16.7	23.3	33.3	43.3	58.3	71.7	80	85	93.3	95	100	

Valid mean scale 1 to 4 range

Based on the table and chart above, operators see skill levels and training success differently, with scores stretching from 1.00 to 4.00 like marks across a survey sheet. SPSS results show the highest frequencies at 2.50 (15%) and 2.75 (13.3%), which means most respondents rated skill and training as moderate right around the middle of the scale. About 23.3% of respondents scored low between 1.00 and 1.75 showing that many operators feel they haven't had enough training or chances to sharpen their skills. Roughly 28.3% of the replies fall in the higher range between 3.00 and 4.00 showing that only a few operators see their skill and training as strong or top-notch, like hitting near-perfect marks on a score sheet.

Work processing and productivity

Work processing and productivity the factor influence of the operator performance in jute bag manufacturing which has been contained: manuafcturing lean and waste,production planning and scheduling and quality management

Table4.4. Work processing and productivity

Valid/scale	1	1.25	1.5	1.75	2	Total

Frequency	8	4	14	32	2	60
Percent	13.3	6.7	23.3	53.3	3.3	100
Valid Percent	13.3	6.7	23.3	53.3	3.3	100
Cumulative Percent	13.3	20	43.3	96.7	100	

Valid mean scale 1 to 2 range

Most operators scored work procedures and productivity near the bottom of the scale, with responses clustering between 1.00 and 2.00. The SPSS results show the peak at 1.75, 32 people, or about half, so more than half of them see their daily tasks and output as below average, like tools that never quite fit the hand. About a quarter of respondents 23.3% gave this factor a 1.50, suggesting the work processes feel disorganized, like files scattered across a cluttered desk. Just two respondents about 3.3% gave this factor a score of 2.00, showing that hardly any operators see their work processes and productivity as up to par. Ratings of 1.00 and 1.25 make up 20% of all responses, showing that many operators struggle with workflow organization, task order, or delays that leave projects stuck halfway through.

Performance and quality

Performance and quality the factor influence of the operator performance in jute bag manufacturing which has been contained: quality management,operator skill,work load,defect and waste.

Table 4.5. performance and quality

Valid/scale	1	1.25	1.5	1.75	2	Total
Frequency	20	27	9	3	1	60
Percent	33.3	45	15	5	1.7	100
Valid Percent	33.3	45	15	5	1.7	100
Cumulative Percent	33.3	78.3	93.3	98.3	100	

Valid mean scale 1 to 2 range

The spread of response values from 1.00 to 2.00 reveals how operators judge their own work, from the sharp precision of a finished part to the overall level of performance they deliver. Almost half of the operators think performance and quality are poor the largest share of respondents rated this area at 1.25, with 27 replies, about 45%. Twenty operators about a third of all respondents gave performance and quality the lowest score, a stark 1.00, showing deep concern about uneven results, shaky consistency, or failing to meet performance standards. Just 6.7% of responses show higher ratings those rare 1.75 and 2.00 marks suggesting only a handful of operators see the performance and quality as truly excellent. By comparison, 15% of the answers fall into the moderate range, landing at a rating of 1.50 about the middle of the scale.

Safety, health and motivation

Safety, health and motivation the factor influence of the operator performance in jute bag manufacturing which has been contained: machine, equipment ,and operator centric factor

Table 4.6 Safety, health and motivation

Valid/scale	1	1.2	1.4	1.8	Total
Frequency	21	21	13	5	60
Percent	35	35	21.7	8.3	100
Valid Percent	35	35	21.7	8.3	100
Cumulative Percent	35	70	91.7	100	

Valid mean scale 1 to 1.8 range

With sixty solid responses and every field filled in, the study on safety, health, and motivation rests on data that's both complete and reliable like a well-sorted stack of survey forms spread across the desk. Response values fall between 1.00 and 1.80, so safety measures, health support, and motivational perks were usually rated near the bottom of the scale almost like choosing the dimmest setting on a dial. Based on the SPSS results, 70% of operators think the conditions for safety, health, and motivation are below par like working in a room that always feels a bit too dim and stale. The highest frequencies appear at 1.00 and 1.20, each chosen by 21 respondents about 35% like two tall bars standing side by side on the chart. Also, 21.7% of participants rated this aspect at 1.40 a slight bump up, yet still a bit under par, like coffee that's barely warm. Only a handful of operators think safety, health, and motivation are up to par just five people, about 8%, rated that part at 1.80, barely above the bottom of the scale.

Table 4.7 the factor influence the operator performance in jute bag manufacturing summary

Factor influence operator performance	Frequency	Percentage

Work environment and equipment	5	9.2%
Skill and training	5	9.2%
Work process and productivity	18	32.64%
Performance and quality	17	27.56%
Safety ,health and motivation	15	21.43%
Total	60	100%

4.4. Proposed for improvement the operator performance in jute bag manufacturing

Table 4.8 What improvement could help to increase your productivity?

Improvement proposed	Frequency	Percent	Valid Percent	Cumulative Percent
Access quality raw material	15	25	25	25
Skill and Training	6	10	10	35
Good maintenance	12	20	20	55
Working process and productivity	9	15	15	70
Performance and quality	9	15	15	85
Safety, health and motivation	9	15	15	100
Total	60	100	100	

Improved work process and productivity (15%): the enhancement of using advanced procedures, enable to technology of forecasting, maintain work flow throughput, reliability, and increasing the operator performance by 15%.

Enhanced performance and quality (15%): construct the enhancement of the work-in-process for beaming, weaving and sewing for improved by general quality of standard keep in 95% in order increasing productivity, minimizing downtime and reduced the constraint of the bottleneck.

Improved Safety, health and motivation (15%): minimizing risks, eliminating mistakes and encouraging participation, best practices improve operator performance.

Good machine maintenance (20%): increases efficiency, lowers downtime, and prolongs the life of equipment. Frequent maintenance avoids expensive malfunctions and detects problems early. Cleaning, staff training, and scheduling are important procedures.

Availability of quality raw material (25%): By addressing underlying issues like variability, bottlenecks, and low productivity, raw materials prevent disruptions to operator performance, processes, equipment uptime, and downstream quality in the manufacturing of jute bags.

4.5. Measure of reliability and validity

Table 4.9 reliability statistics

Cronbach's Alpha	N of Items
.669	26

Likert scale deletion based on all variables in the procedure.

4.5.1. Reliability and Validity Analysis

The researcher used Cronbach's alpha and corrected item–total correlations to check how valid and reliable the questionnaire was for measuring what influenced operator performance while making jute bags, their hands moving fast over coarse brown fabric. The scale's 26 items cover everything from machine condition and maintenance to workplace organization, training, safety, individual factors, performance results, and even simulation awareness like noticing the hum of an engine during practice.

a. Internal Consistency

The researcher used Cronbach's alpha to check how reliably the scale held together like seeing if all the questions pointed in the same direction. The scale's overall Cronbach's alpha comes to about 0.66, showing it's reliably solid for an exploratory study in manufacturing systems and industrial engineering. For new or context-specific tools say, in fast-changing industrial settings values between 0.60 and 0.70 are generally considered acceptable. The "Cronbach's Alpha if Item deleted" values fall between 0.633 and 0.674, suggesting that:

- ❖ Most items strongly support the scale's reliability;
- ❖ dropping even one barely nudges the overall alpha, like removing a single note from a steady chord

b. Construct Validity

The corrected item total correlation shows how strongly each item ties to the full scale, minus itself like seeing how one note blends with the whole chord. People usually treat as greater than > 0.30 as the cutoff anything at or above that mark is fine, less than < 0.30 → is not good or weak correlation and Negative numbers indicate a faulty issue.

If the value's under 0.30, mark it as weak; anything negative means something's gone wrong like a sensor flickering.

Respondents might've interpreted the statement in their own way, like hearing the same note played with a slightly different tone. To keep the results solid, either reverse-code this item or leave it out when building the composite scale like setting aside a mismatched puzzle piece so the picture stays clear.

a) Reliability and Validity in General summary

The instrument shows solid internal consistency, with a Cronbach's alpha of 0.66 steady enough to feel like a well-tuned meter clicking into place. Most of the key performance items show solid corrected item total correlations, which strongly supports the test's construct validity like puzzle pieces fitting neatly into place. Because the questionnaire measures several dimensions, it makes sense that some items are only loosely related; however, one item that's negatively correlated should be removed or reverse coded before moving on with the analysis.

b) The consequence of simulation modeling

Because the questionnaire results proved valid and reliable, they work well for deeper statistical analysis and for feeding data into discrete-event simulation models like timing how customers move through a checkout line. In Arena simulation experiments that test how operators improve under different conditions, the verified core elements can be grouped into factor indices environment, safety, workplace, personal, and job factors. Reliability analysis shows the measurement tool holds steady, with a Cronbach's alpha of about 0.66. Most of the items clearly capture the operator's performance construct, as shown by their adjusted item-total correlation values. Some elements show faint or even negative links, yet they still matter theoretically and highlight how layered the study is like subtle colors blending in a complex painting. People generally trust the tool for modeling and simulation-based performance work it's seen as a reliable choice, steady as a metronome.

4.6. The discrete event simulation model (DES): Why use it?

Discrete Event Simulation Model: Because the manufacturing of jute bags is focused on the work-in-processing

(Beaming → dyeing → weaving → measurement and inspection → dumping → calendaring → fabric cloth cutting → sewing → packing)

- ❖ Concerned the operator intensiveness,
- ❖ The formation of the queuing and the delay, and

- ❖ The factor influence by the operator performance exchangeability

System Dynamics: model occur in the area of continues flow and accumulation, large rank amount over time

Markov Models: model performed on the purpose of capable simple state of transition

Agent Based Modeling: comparing and contrasting the interaction of one to another by autonomous and decentralized characteristics of agent

Monte Carlo Simulation: model systems depend on probability and no determinism without a time –ordered sequences of events.

4.7. Modeling on the conceptualization of the factor influence the operator performance in jute bag manufacturing

A jute bag manufacturing in horizon plantation coffee processing and warehousing private limited company contain different work- in - process. But focusing in the area of the three work station in order to simplicity of the simulation and modeling those of is beaming/warping, weaving/loom and sewing workstation. The main aim the system simulation and modeling to analysis the main factor in beaming, weaving and sewing work area, minimizing the work station bottle neck ,maximizing the operator performance, enhancing the utilization of the raw material and the machinery, and improvement of the performance of the operator. The conceptual modeling consists as the following structural class:

c. The factor influence of the operator performance in jute bag manufacturing
    - ✓ Work environment and equipment
    - ✓ The behavior of machinery in beaming ,weaving and sewing
    - ✓ Human factor
    - ✓ the access of the raw material or jute yarn
    - ✓ Skill and training
    - ✓ The performance and ability of the operator level
    - ✓ The require able of the operator
    - ✓ The rotation of the employee working experience and training

Working- in-process and productivity

- ✓ The structure of the work-in –processing
- ✓ The order of the activity /or jobs
- ✓ The universality of the operation and the waiting and the bottleneck

Performance and quality

- ✓ The skill of the operator
- ✓ The defect rate
- ✓ Rework amount and the quality of the product and raw material

Skill, health and motivation

- ✓ Reward and appreciation
- ✓ The criteria of the safety measurement
- ✓ The level of the health and danger and turnover

The characteristics of the operator performance

The characteristics of the operator performance of the jute bag product the input of the raw material change in output or the fished good.

- ✓ The design of machine capacity
- ✓ The defect and the rework rate
- ✓ The downtime of the machinery and the amount of the fatigue of the operator
- ✓ The finished good products or dependent variables
- ✓ The rate of the performance of the operator in jute bag/hour
- ✓ The amount of raw material through work-in-process
- ✓ Operator performance of the cycle time
- ✓ The length of the work station queue
- ✓ The defect rate and the percentage of the rework and the utilization of the operator

The conceptual model diagram of the factor influence the operator performance in jute bag manufacturing

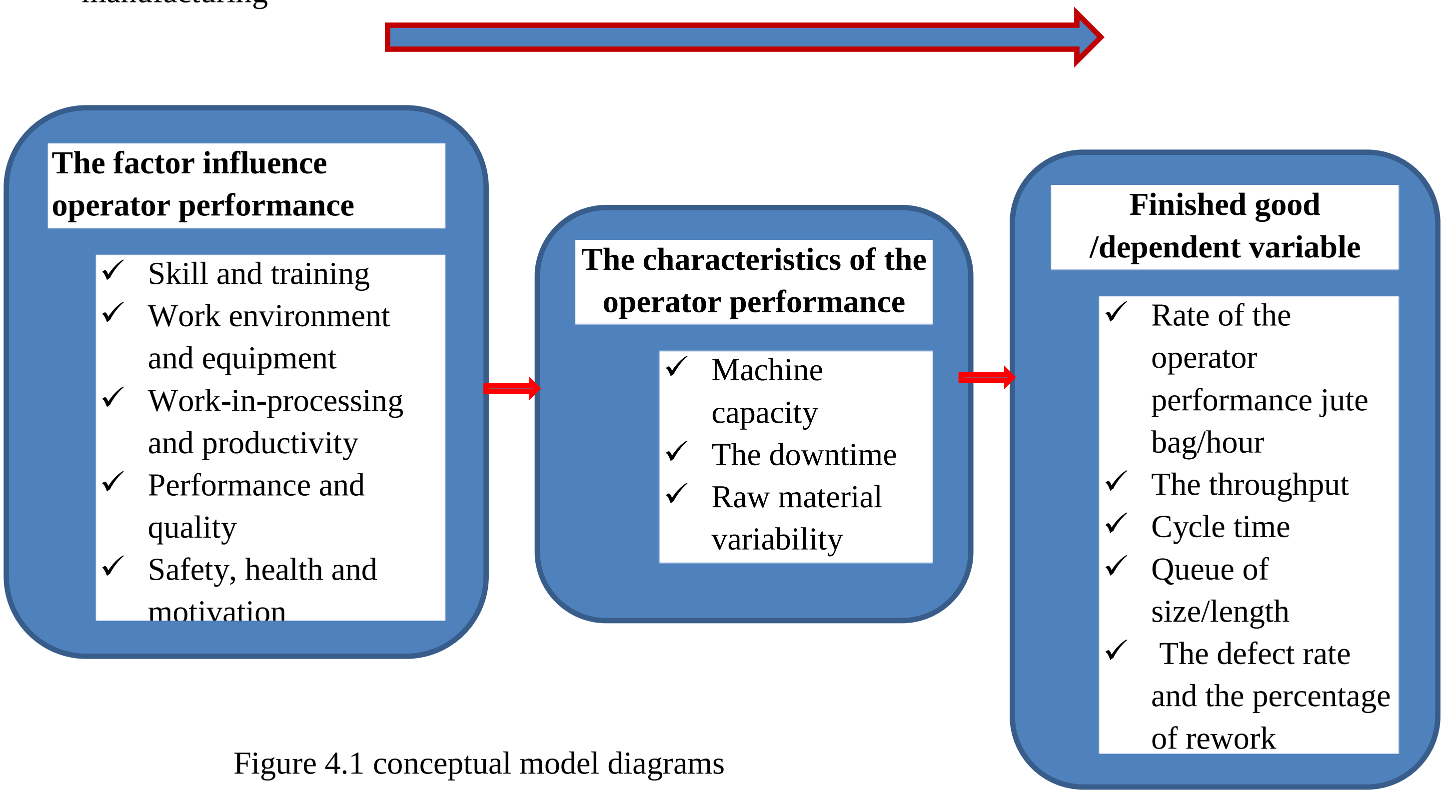


Figure 4.1 conceptual model diagrams

4.7.1. Recent operator performance analysis for the design capacity

4.7.1.1.The attainable planned and the real manufacturing performance

To investigating the yearly production report in 2016/2017 of the jute bag manufacturing indicates the main gab of the attainable plan and the actual performance. The attainable design capacity has been performed 430 jute bag/hour, and the real performance output has been performed 326.57jutebag/hour, relating to 75.95% machine consumption. And the same condition the capacity of production enables to attain has been planned for 409 jute bag/hour, even though performed 79.54%.therefore, the problem of the minimizing the productivity for the case of the operator performance and ineffectiveness rather than design of machine capacity drawback alone. Although, the machine design capacity increase the maximum consumption of the operator up to 76-80 % machine capacity.

From the above enable to proof the design capacity of weaving machine and the attainable plan able to calculate from the following the product specification jute bag products (plantation, 2024/2025)

1. Weaving machine capacity =240 picks/minutes
2. Cut lengths of jute bag product different for 85 kg jute bag is 98 inch, 60kg jute bag is 84 inch, for 50 kg jute bag is 82 inch, for 30 kg jute bag is 65 inch and for canned bag is 73 inch among of these 6 shot except canned bag 4 shots.

Table 4.10 weaving machine capacity calculation for different jute bag products

Product type	Weave machine capacity	Cut length	shoot	Weaving machine capacity calculation for 100%
85kg	240picks/minute	98 inch	6	Capacity =(240pick of bag /m *60m)/(cut length *shoot) =14,400 pick of bag/98*6 =24.5 bag/hr *8hr = 196 bag/day in one machine
60kg	240picks/minute	84 inch	6	Capacity =(240pick of bag /m *60m)/cut length *shoot =14,400 pick of kg/84*6 =28.6bag/hr *8hr =228.8bag/day in one machine
50kg	240picks/minute	82 inch	6	Capacity =(240pick of bag /m *60m)/(cut length *shoot) =14,400 pick of bag/82*6 =29.3bag/hr *8hr =234.4bag/day in one machine
30kg	240picks/minute	65 inch	6	Capacity =(240pick of bag /m *60m)/(cut length *shoot) =14,400 pick of bag/65*6 =36.92 bag/hr *8hr = 295.4bag/day in one machine
Canned bag	240picks/minute	73 inch	4	Capacity =(240pick of bag /m *60m)/(cut length *shoot) =14,400 pick of bag/73*4 =49.3bag/hr *8hr = 394.4bag/day in one machine

The productivity capacity of the machinery in weaving machine of the jute bag manufacturing summary

Table 4.11 Machine capacity weaving machine

No.	Different jute bag product	Weaving machine productivity capacity per hr.		Number of machine	Total	
		Quantity in bag	Kilogram		Quantity in bag	Kilogram
1	Machine productivity capacity pcs/hr. For 85 kg jute bags in 100 %	24.489	24.489	20	489.78	489.7
	Machine productivity capacity pcs/hr. For 85 kg jute bags in 95%	23.26	23.26	20	465.29	465.29
	Machine productivity capacity pcs/hr. For 85 kg jute bags in 90%	22	22	20	440	440
	Machine productivity capacity pcs/hr. For 85 kg jute bags in 85%	20.8	20.8	20	416.3	416.3
2	Machine productivity capacity pcs/hr. For 60 kg jute bags in 100%	28.6	21.2	20	572	424
	Machine productivity capacity pcs/hr. For 60 kg jute bags in 95%	27.17	20.1	20	543	402
	Machine productivity capacity pcs/hr.by 85 kg jute bags in 90%	25.74	19	20	515	380
	Machine productivity capacity pcs/hr. For 85 kg jute bags in 85%	24.31	17.98	20	486	359.6
3	Machine productivity capacity pcs/hr. For 50 kg jute bags in 100%	29.3	19.92	20	586	398.4
	Machine productivity capacity pcs/hr. For 50 kg jute bags in 95%	27.84	18.93	20	557	378.6
	Machine productivity capacity	26.37	17.93	20	527	358.6

	pcs/hr. For 50 kg jute bags in 90%					
	Machine productivity capacity pcs/hr. For 50 kg jute bags in 85%	24.91	16.93	20	498	338.6
	Machine productivity capacity pcs/hr. For 30 kg jute bags in 100%	40.3	19.344	20	806	386.88
4	Machine productivity capacity pcs/hr. for 30 kg jute bags in 95%	38.285	18.37	20	766	367.4
	Machine productivity capacity pcs/hr. For 30 kg jute bags in 90%	36.27	17.4	20	725	348
	Machine productivity capacity pcs/hr. For 30 kg jute bags in 85%	34.255	16.4	20	685	328
	Machine productivity capacity pcs/hr. For canned food packing jute bags in 100%	49.3	22.1	20	986	442
5	Machine productivity capacity pcs/hr. For canned food packing jute bags in 95%	46.835	20.982	20	937	419.6
	Machine productivity capacity pcs/hr. For canned food packing jute bags in 90%	44.37	19.87	20	887	397.4
	Machine productivity capacity pcs/hr. For canned food packing jute bags in 85%	41.91	18.77	20	838	375.4

from the above data for each table considering the machine capacity of the weaving machine for different product in different capacity or efficiency such as in 100%, 95%, 90% and 85%. To considering the minimum efficiency of the machine capacity in 85% of 85 kg jute bag the machine capacity is enable to produce 166.52 bags in piece or 166.52 kg, 60 kg jute bag the machine capacity is enable to produce 194.48 bags in pieces or 143.8kg, 50 kg jute bag the machine capacity is enable to produce 199.24 bags in pieces or 135.48 kg, 30 kg jute bag the machine capacity is enable to produce 274.04 bags in pieces or 131.5kg, canned jute bag the machine capacity is enable to produce 335.3 bags in pieces or 150.2 kg per day in one machine for each product of the jute bag. Therefore, standing from the above data analysis the machine capacity, the operator productivity performance and the daily productivity plan of the jute bag factory with in weaving machine. Therefore, from the above data enable to analysis the efficiency of the operator within 85% for weaving machine.

Table 4.12 the 85% machine capacity in weaving used with planned and actual productivity

No.	Bag types	Production plan in 8 hr.	Actual productivity in 8hr.for average	Machine capacity in 85% for each bag type	Efficiency in production plan (%)	Efficiency in actual productivity (%)
1	85 kg	120 kg	90kg	166.5	72	54
2	60 kg	120 kg	98kg	143.8	83.4	68.1
3	50 kg	120 kg	103kg	135.48	88.6	76
4	30 kg	120 kg	109kg	131.5	91.25	91.25
5	Canned bag	120 kg	115kg	150.2 kg	79.89	76.6

Summary from the above table expressed that the design capacity of the weaving machinery versus the production plan and the actual productivity of the operator performance do not affected by the design capacity of the machinery because the design capacity still now safe for the data investigation from the above consideration. Therefore, the low productivity of the operator performance is not one factor of the design capacity of the machinery rather than the other machinery factor just down time, setup time and the idle time after proved these data investigation.

4.7.2. The operator performance of the utilization and the downtime of the beaming, weaving and sewing machinery

As shown from the problem statement in chapter one the accessibility of the machine in the table 1.3, 65.29% that indicates the low average machine in beaming, weaving and sewing work station enable to identifying the bottleneck. There is 20 weaving machine, only one machine enable to perform 70% accessibility, and the other one weaving machine number 17 performed less than 50% accessibility

Productivity =output/input*100

The working time per day 8hr in weaving machine and the machine amount 20 machines for each one operator. Therefore, the daily productivity weaving machine in 8hr is

For 85 kg = 166.5 *20 =3330 kg

In pieces 85kg =3330kg/0.94kg

= 3543pieces

For 60kg = 143.8 *20 =2876 kg

In pieces 60kg =2876kg/0.74kg

= 3886 pieces

For 50 kg = 135.48 *20 =2709.6 kg

In pieces 50kg =2709.6kg/0.68kg

=3985pieces.

For 30 kg = 131.5 *20 =2630 kg

In pieces 30kg =2630kg / 0.48

=5479 pieces

For canned bag = 150.2 *20 = 3004 kg

In pieces canned bag =3004kg/0.448kg

=6705 pieces.

Average of product in kg design capacity of 85% = $\frac{(3330 + 2876 + 2709.6 + 2630 + 3004)\ \text{kg}}{\text{Number of jute bag products}}$

= 14549.6/5 = 2909.92 kg

Average product in pieces design capacity of 85% = $\frac{(3543 + 3886 + 3985 + 5479 + 6705)\ \text{pieces}}{\text{Number of jute bag products}}$

= 23,598/5 = 4,720 pieces of jute bag

The major participant with in the down time of the beaming, weaving and sewing: Machine break down, the waiting of the beaming change and the cutting fabric cloth, Shortage of the raw material, the electrical power discontinuity and Wasting time the operator by different condition. Break down of the machinery one of the main factor minimizing the productivity of the operator performance for beaming, the weaving and sewing machine not timely ready, increase the idle time of the operator and low skill of the operator.

4.7.2.1.The machine utilization with respect to the operator performance

From analyze the beaming machine cycle time one roll be enabling to produced. Average 2hour which are 120 minute, therefore 20 weaving machine*120minute =2400 minute or 20 hour consumed to prepare for 20 weaving machine then one weaving machine finished full beam roll average after 16hour, and also one weaving machine enable to produce within 8 hour calculate below,

Therefore, beaming machine enables to produce within 8hour

2 hour = produced 1 full rolled beam yarn average in kg, (300kg +280 +255 +245 +240)/5 =264kg/ hour,

In 8 hour, 264kg/hour *4 hour = 1056kg, then enable to produced 4 full beam yarn roll in 8 hour

Analyze Weaving

Average in kg = (90 + 98 + 103 + 109 + 115) Kg / 5 = 105kg in 8 hour, or

Average in pieces = (90/0.94 + 98 /0.74 + 103/0.68 +109 /0.48 +115/0.448)/5 = 173 pieces of jute bag in 8hr.

So 108kg *20 weave machine = 2160 kg produced or 173 *20 = 3460 pieces of bag, after that analyze the cycle time of sewing machine:-

hemming average cycle time 1 minute enables to sew 2.5 pieces of bag, then, 2.5 *8*60 *2 hemming machine = 2400 pieces

Over aging sewing machine average cycle time in 1 minute enable to sew 2 pieces of jute bag, then 2 *8 *60*3 = 28860

Stitching average cycle time 1 minute enables to sew 2.5 pieces of bag, then, 2.5 *8*60 *2 hemming machine = 2400 pieces.

4.7.2.2.Data overview of the operator performance

From the study of the research the machine utilization and the operator availability consist the following record daily data of the jute bag manufacturing focusing the main variable the factor affecting the operator performance in jute bag manufacturing .the work station in beaming one machine, in weaving 20 weave machine and in sewing 7 sew machine for each process. Expresses the main distinguish between the total time consumed to produce and the accessibility of the performance enable to identifying the bottle neck.

Data overview with respect to operator performance

Table 4.13 beaming process, weaving and sewing data overview

operation	Number of machine	Number of data taken	Total productivity(kg)	Total time(day)	Average productivity per day	Average productivity per hour
beaming	01	8 month	151896.83	208	730.8	30.3
	Weaving 1	6 month	15633.6	156	100.2	4.2
	Weaving 2	6 month	14735.4	156	94.5	3.9
	Weaving 3	6 month	14467.9	156	92.7	3.9
	Weaving 4	6 month	13695.5	156	87.8	3.7
	Weaving 5	6 month	3828.5	156	24.5	1.0
	Weaving 6	6 month	10289.4	156	66.0	2.7
	Weaving 7	6 month	14263.3	156	91.4	3.8
	Weaving 8	6 month	12335.7	156	79.1	3.3
	Weaving 9	6 month	13615.9	156	87.3	3.6
	Weaving 10	6 month	8840.6	156	56.7	2.4
	Weaving 11	6 month	10723.3	156	68.7	2.9
	Weaving 12	6 month	14738.2	156	94.5	3.9
	Weaving 13	6 month	14648.8	156	93.9	3.9
	Weaving 14	6 month	13965.8	156	89.5	3.7

weaving	Weaving 15	6 month	15176.7	156	97.3	4.1
	Weaving 16	6 month	11977.2	156	76.8	3.2
	Weaving 17	6 month	12899.3	156	82.7	3.4
	Weaving 18	6 month	11791.7	156	75.6	3.1
	Weaving 19	6 month	8457.16	156	54.2	2.3
	Weaving 20	6 month	6953.8	156	44.6	1.9
	Total		243037.8	3120	1557.9	64.9
sewing	Hemming 1	6 month	88306.14	156	566.1	23.4
	Hemming 2	6 month	101179.52	156	648.6	27.1
	Total		189485.66		1214.7	50.5
	Over aging 1	6 month	84458.35	156	541.4	22.6
	Over aging 2	6 month	71613	156	459.1	19.1
	Over aging 3	6 month	64450.38	156	413.1	17.2
	Total		220521.73		1413.6	58.9
	Stitching 1	6 month	74787.22	156	479.4	20
	Stitching 2	6 month	79570.22	156	510.1	21.3
	Total		154357.44		989.5	41.3

From the data analysis beaming average productivity per day

151896.83/208 = 730.3kg/day, average productivity per day is 730.3kg/24 hr. =30.3kg/hr. the other weaving and sewing calculated the same beaming way the data listed above table of the data overview

Resource allocation

Total employee in beaming, weaving and sewing **=55**

a) beaming two operator and two assistant operator
b) weaving 20 operator and 6 assistant operator
c) 4 fabric cloth cutter operator
d) One measuring and inspection operator
e) One dumping operator
f) sewing 7 operator and 7 assistant operator
g) two packaging operator jute bag

h) two supervisor
i) one production head

Processing variable

The processing time of the operator performance of the jute bag manufacturing in productivity per hour input, beaming productivity per hour 30.3kg/hr., weaving productivity per hour is 64.9kg/hr. the other sewing productivity per hour in hemming 50.5kg/hr., over aging 58.9kg/hr. and stitching 41.3kg/hr.

Formulation of the utilization of employees

The working day of the jute bag manufacturing is 26 per month if there no any vacation or holiday.

Work day of the employees in a day 8 hr. and also the working time per month 8*26 =208 hr. per month. After that enable to analyses for the six month productivity data collected and investigating for six month

For six month the productivity working time to analyze 208hr/month *6 month= 1248hr, change in to minute 1248*60 minute = 74,880 minute. After than investigating the total employees time to participating in jute bag manufacturing.

55 employees *74,880 minute = 4,118,400 minutes

The utilization in beaming on one machine

8 hour per day * 60 minute =480 minute

151896.83 kg per hour of productivity* 480 minute = 72,910,478.4 minute

Formulating in the working time in the form of minutes

180 day of productivity * 6 working day/7day = 154.3 working day * 480 minute = 74,060 minute.

The utilization in weaving on 20 machines

8 hour per day * 60 minute =480 minute

243,037.8 kg of productivity* 480 minute = 116,658,144minute

Formulating in the working time in the form of minutes

180 day of productivity * 6 working day/7day = 154.3 working day * 480 minute = 74,060 minute.

The utilization in sewing on 7 machines

For hemming

8 hour per day * 60 minute =480 minute

189,485.66kg of productivity* 480 minute = 90,953,116.8minute

Formulating in the working time in the form of minutes

180 day of productivity * 6 working day/7day = 154.3 working day * 480 minute = 74,060 minute.

For over aging

8 hour per day * 60 minute =480 minute

220,521.8kg of productivity* 480 minute = 105,850,464 minute

Formulating in the working time in the form of minutes

180 day of productivity * 6 working day/7day = 154.3 working day * 480 minute = 74,060 minute.

For stitching

8 hour per day * 60 minute =480 minute

154,357.44kg of productivity* 480 minute = 74,091,571.2 minute

Formulating in the working time in the form of minutes

180 day of productivity * 6 working day/7day = 154.3 working day * 480 minute = 74,060 min.

After that I can calculate the average working time process for improve operator performance to

In beaming, weaving and sewing

Total productivity in work-in-process of jute bag manufacturing = beaming work station + weaving work station + sewing work station

Total productivity = 30.3 kg/hr. + 64.9 kg/hr. + (50.5kg/hr. +58.9kg/hr. +41.3kg/hr.)

= 245.9kg/hr.

Forecasting the factor influence the operator performance to improve productivity

From the above the analysis data the factor influences of the operator performance skill and training (9.2%), works in process and productivity (32.64%), performance and quality (27.56%), safety, health and motivation(21.43%), work environment and equipment(9.2%). therefore enable proposed 15% among those of work process and productivity, performance and quality , safety, health and motivation.

From the proposed data to maximizing the productivity or the performance of the operator jute bag manufacturing by 15% for the most influential factor work process and productivity, performance and quality, safety, health and motivation.

For beaming

New productivity = old productivity *(1 +0.15)

= 30.3 kg/hr. *1.15= 34.85kg/hr., work process and productivity

=30.3kg/hr. *1.15 =34.85kg/hr., performance and quality

= 30.3 kg/hr. *1.15 = 34.85kg/hr., safety, health and motivation

Therefore, the suggested increase productivity of the operator performance 13.65 kg/hr. which is total value 43.95kg/hr.

For weaving

New productivity = old productivity *(1 +0.15)

= 64.9 kg/hr. *1.15= 74.64kg/hr., work process and productivity

=64.9kg/hr. *1.15 =74.64kg/hr., performance and quality

= 64.9kg/hr. *1.15 = 74.64kg/hr., safety, health and motivation

Therefore, the suggested increase productivity of the operator performance 29.22 kg/hr. which is total value 94.12kg/hr.

For sewing, hemming

New productivity = old productivity *(1 +0.15)

= 50.5 kg/hr. *1.15= 58.1kg/hr., work process and productivity

=50.5kg/hr. *1.15 =58.1kg/hr., performance and quality

= 50.5 kg/hr. *1.15 = 58.1kg/hr., safety, health and motivation

Therefore, the suggested increase productivity of the operator performance 22.8 kg/hr. which is total value 73.3kg/hr.

For sewing, stitching

New productivity = old productivity *(1 +0.15)

= 58.9 kg/hr. *1.15= 67.74kg/hr., work process and productivity

=58.9kg/hr. *1.15 =67.74kg/hr., performance and quality

= 58.9 kg/hr. *1.15 = 67.74kg/hr., safety, health and motivation

Therefore, the suggested increase productivity of the operator performance 26.5 kg/hr. which is total value 85.4kg/hr.

For sewing, stitching

New productivity = old productivity *(1 +0.15)

= 41.3 kg/hr. *1.15= 47.5kg/hr., work process and productivity

=41.3kg/hr. *1.15 =47.5kg/hr., performance and quality

= 41.3 kg/hr. *1.15 = 47.5kg/hr., safety, health and motivation

Therefore, the suggested increase productivity of the operator performance 18.6 kg/hr. which is total value 59.9kg/hr.

Average operator performance of productivity per hour

I am able to calculate the average productivity for each work station

$$\text{Average productivity time per kg} = \frac{\text{total time consumed for beaming}}{\text{Total productivity}}$$

$$= \frac{72{,}910{,}478.4 \text{ minute}}{151896.83} = 480 \text{ minute}$$

Then other process continues using the value of beaming productivity which is 151,896.83

$$\text{Average productivity time per kg} = \frac{\text{total time consumed for weaving}}{\text{Total productivity}}$$

$$= \frac{116,910,478.4 \text{ minute}}{151896.83} = 769.7 \text{ minute}$$

Average productivity time per kg = $\frac{\text{total time consumed for sewing, hemming}}{\text{Total productivity}}$

$$= \frac{90,953,116.8 \text{ minute}}{151896.83} = 598.8 \text{ minute}$$

Average productivity time per kg = $\frac{\text{total time consumed for the over aging}}{\text{Number of productivity per minute}}$

$$= \frac{105,850,464 \text{ minute}}{151896.83} = 696.85 \text{ minute}$$

Average productivity time per kg = $\frac{\text{total time consumed for sewing, stitching}}{\text{Total productivity}}$

$$= \frac{74,091,571.2 \text{ minute}}{151896.83} = 487.8 \text{ minute or 8 hour}$$

Table 4.14 the synopsis of the total utilization of the employee for each work station or work-in-process

Operation	Total time utilization(minutes)	Total productivity(kg)	Total working time(minutes)
Beaming	72,910,478.4	151896.83	74,060
Weaving	116,910,478.4	243037.8	74,060
Sewing, hemming	90,953,116.8	189485.66	74,060
Sewing, over aging	105,850,464	220521.73	74,060
Sewing, stitching	74,091,571.2	154357.44	74,060

From the above investigation enable to dealt the resource allocation utilization of the employees versus the work flow of the operator performance on the jute bag manufacturing. The total time consumed for each work station the availability of working time, identifying the proposed bottlenecks and the improvement of the operator performance of the jute bag manufacturing.

Table 4.15 the operator performance measurement in the following work station

operation	Total time utilization(minutes)	Total productivity(kg)	Total working time(minutes)	Proposed safety, health and motivation(kg)	Proposed of work process and equipment(kg)	Proposed performance and quality(kg)	Total proposed factor(kg)
Beaming	72,910,478.4	151896.83	74,060	273	273	273	819
Weaving	116,910,478.4	243037.8	74,060	584.4	584.4	584.4	1753.2
Sewing, hemming	90,953,116.8	189485.66	74,060	456	456	456	1368
Sewing, over aging	105,850,464	220521.73	74,060	530	530	530	1590
Sewing, stitching	74,091,571.2	154357.44	74,060	372	372	372	1116
total				2215.4	2215.4	2215.4	6,646.2

From table expressed that the main variation in the jute bag manufacturing the factor influence of the operator performance process which contains the beaming, weaving, sewing for hemming, sewing for over aging and sewing for stitching with the value which dominant by weaving 116,910,478.4 minutes and the productivity 243037.8 kg, and the other sewing for hemming, over aging and stitching 90,953,116.8 minutes , 105,850,464 minutes and 74,091,571.2 minutes respectively.in opposite to the utilization time of the employees 74,060 minutes per productivity of the work station that analyze, in addition, resource availability and identifying the main bottlenecks of the process. Other thing, the proposed values of improved the productivity of the operator performance in weaving 1753.2 kg productivity and 1590 sewing for over aging if enable to enhance by 15% of among working process and equipment, performance and quality, safety, health and motivation.

Pareto Analysis: According to the Pareto principle (also known as the 80/20 rule), 20% of causes account for 80% of issues. Focusing on improving productivity values will be made easier by identifying the main obstacles in the factor influence of the daily operator performance workflow.

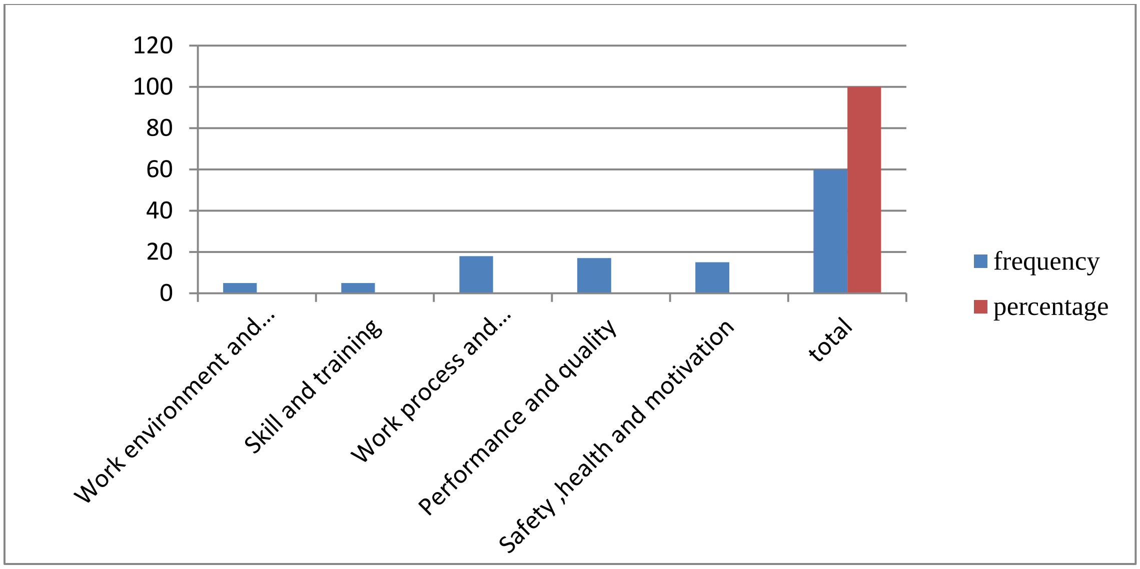


Figure 4.2 the factor influence the operator performance frequency versus percentage

The main factor influence the above bar char explain that the work environments and equipment, skill and training, work process and productivity, performance and quality, safety, health and motivation. Among those the Pareto explanation the work process and equipment (32.64%), performance and quality (27.56%), safety, health and motivation (21.43%) all sum up 82% solved the other able to solved according to Pareto 80/20 rules. From the Pareto rule enable to improve the factor of the operator performance, strategy modeling, simulation and modeling.

Value Stream Mapping (VSM): VSM assists in identifying the factors influencing productivity and inefficiency by visualizing the flow of raw materials and work-in-processing through the operator performance factor. In the end, this approach seeks to improve operator performance and productivity maximization.

Mapping present operator performance

The investigation of the work-in-process of the present operator performance enable to identifying the productivity of the operator, utilization of resource ,raw material availability ,amount of time consumed and the bottleneck of the operation.

Raw material availability: the access of jute yarn without any interruption with in the work environment of the jute bag manufacturing.

Beaming: first process prepare beam roll in order to an input of weaving process.

Weaving: produce the fabric cloth of the jute bag by using vertical warp beam roll and horizontal weft yarn.

Sewing, hemming: sewing the edge of the cutting fabric cloth jute bag an input of over aging

Sewing, over aging: sewing the side length of the cutting fabric cloth jute bag an input of over **stitching**

Sewing, stitching: sewing the side length of the finished jute bag for safety and end the process.

The operator performance in each work station of the jute bag manufacturing productivity per day

Beaming: 730.8kg/day

Weaving: 1557.9kg/day

Sewing, hemming: 1214.7kg/day

Sewing, over aging: 1413.6kg/day

Sewing, stitching: 989.5kg/day

Low operator productivity: the jute bag manufacturing inconsistent performance in the measurement of the lack of skill and equipment. If good controlling and coaching the employees in the manufacturing firm enable to improve productivity 12% - 17%.

Identifying defect: investigating the current condition of the operator performance enable to produce free from defect jute bag products.

Identifying rework: minimizing the rework in the work station of the jute bag manufacturing in order to improve the operator performance.

Machine downtime or variability: the factor influence the operator performance the idle time, setup time, inconsistent workflow, break down of machine and in appropriate of the lubrication of the machine decreased productivity 23.3%.

Lack raw material availability: inconsistent availability of the raw material the main factor of the operator performance which minimizing the productivity 26.7%.

Dis continuity work process and productivity: inconsistent work flow creates the idle time and delay of the work-in-process the other factor influenced the operator performance to minimizing the productivity by 32.64%.

Low performance and quality: the raw material variation, low knowledge, discontinues work flow, and inappropriate the operator performance. Among these cause create increase the defect products, reworks and minimize the finished product that polished the overall productivity by 27.56%.

Inappropriate safety, health and motivation: minimum the performance of the operator creates unexpected accident and occurs faulty in case of fatigue in the jute bag manufacturing. These problems influenced for the minimizing manufacturing, adhering machine breakdown, and inconsistent work flow and increased the turnover of the employees by 21.43%.

Bottleneck: among the above factor influence of the operator performance in the jute bag manufacturing in the work-in-process of the beaming, weaving and sewing the main constraint the whole throughput following obstacle such as minimum manufacturing of the operator, machine break down, raw material variation, inconsistent work flow, high product defect rate and inappropriate safety, health and motivation.

Suggested improvement for operator performance

Improved work process and productivity: the enhancement of using advanced procedures, enable to technology of forecasting, maintain work flow throughput, reliability, and increasing the operator performance by 15%.

Enhanced performance and quality: construct the enhancement of the work-in-process for beaming, weaving and sewing for improved by general quality of standard keep in 95% in order increasing productivity, minimizing downtime and reduced the constraint of the bottleneck.

Improved Safety, health and motivation: minimizing risks, eliminating mistakes and encouraging participation, best practices improve operator performance. This directly addresses problems that have come up in the past, such as low productivity, downtime, bottlenecks, and quality failures in jute bag production. These improvements work along with process improvements and equipment upgrades to make everything better, with incident rates that are almost zero and output boosts of 20 to 30 percent when people are motivated.

Good machine maintenance: increases efficiency, lowers downtime, and prolongs the life of equipment. Frequent maintenance avoids expensive malfunctions and detects problems early. Cleaning, staff training, and scheduling are important procedures.

Availability of quality raw material: By addressing underlying issues like variability, bottlenecks, and low productivity, raw materials prevent disruptions to operator performance, processes, equipment uptime, and downstream quality in the manufacturing of jute bags.

Bottle neck mitigation: distinguishing and analyzing the constraint of the work-in-process on the jute bag manufacturing among the work flow in beaming, weaving and sewing.

Present the current operator performance

Identifying process the beaming, weaving, and sewing for hemming, sewing for over aging and the last sewing for stitching. The productivity of per day for each work station:-

Beaming: 730.8kg/day

Weaving: 1557.9kg/day

Sewing, hemming: 1214.7kg/day

Sewing, over aging: 1413.6kg/day

Sewing, stitching: 989.5kg/day

4.7.2.3.Forecasting maximization of the operator performance in kilogram/time

The enhancement apply in the factor influence of the operator performance on the jute bag manufacturing able to measure by the lead time investigation in the work –in process of the company. Therefore, the above analysis expressed the beaming has been improved the performance of the operator from 730.9kgperday to 819kg per day enable to increasing by 15%, weaving productivity increased by 1557.9kg per day to 1753.2kg per day improved by 15%, sewing for hemming improved 1214.7kg per day to 1368kg per day maximized by 15, sewing for over aging maximized 1413.6 kg per day to 1590 and the last process sewing for stitching 989.5 kg per day to 1116 kg per day improved by 15%.then the summation of the above all productivity improvement between the first performance and after improved are expressed 5906.2kg per day to 6646.2 kg per day maximized by the operator performance on the jute bag manufacturing by 740kg/day.

Formulate productivity per lead time in the present condition

Total productivity per day = beaming productivity per day +weaving productivity per day + sewing productivity per day

Total productivity per day = 730.8 kg/day +1557.9 kg/day +1214.7 kg/day + 1413.6 kg/day + 989.5 kg/day =5906.2 kg/day

Future condition productivity per lead time

Total productivity per day = 819kg/day +1753.2kg/day +1368 kg/day + 1590kg/day + 1116 kg/day =6646.2 kg/day

Investigating value stream mapping

By using value stream mapping enable to identifying the performance of operator improvement in the jute bag manufacturing

Improved work process and equipment: the enhancement of using advanced procedures, enable to technology of forecasting, maintain work flow throughput, reliability, and increasing the operator performance by 15%.

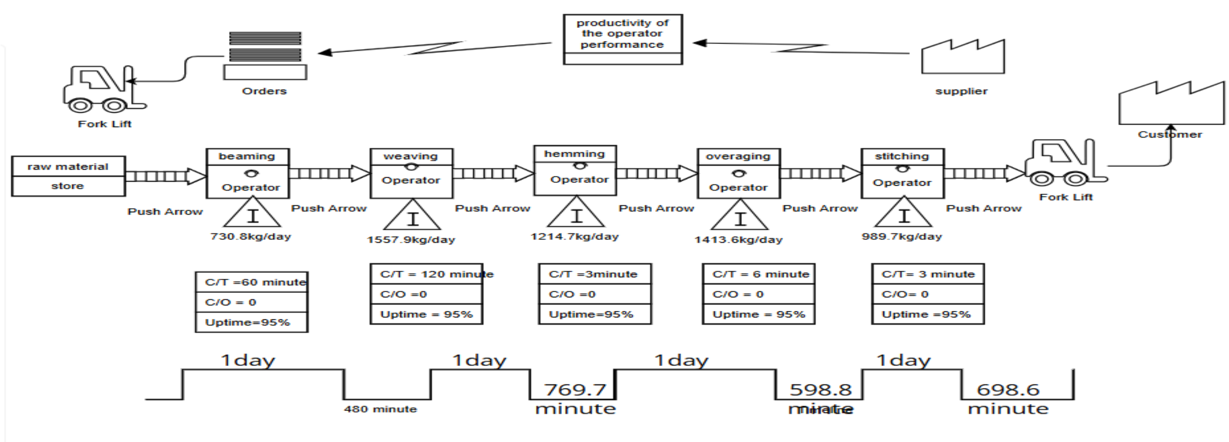
Enhanced performance and quality: construct the enhancement of the work-in-process for beaming, weaving and sewing for improved by general quality of standard keep in 95% in order increasing productivity, minimizing downtime and reduced the constraint of the bottleneck improved by 15%.

Improved Safety, health and motivation: minimizing risks, eliminating mistakes and encouraging participation, best practices improve operator performance by 15%.

Good machine maintenance: increases efficiency, lowers downtime, and prolongs the life of equipment.

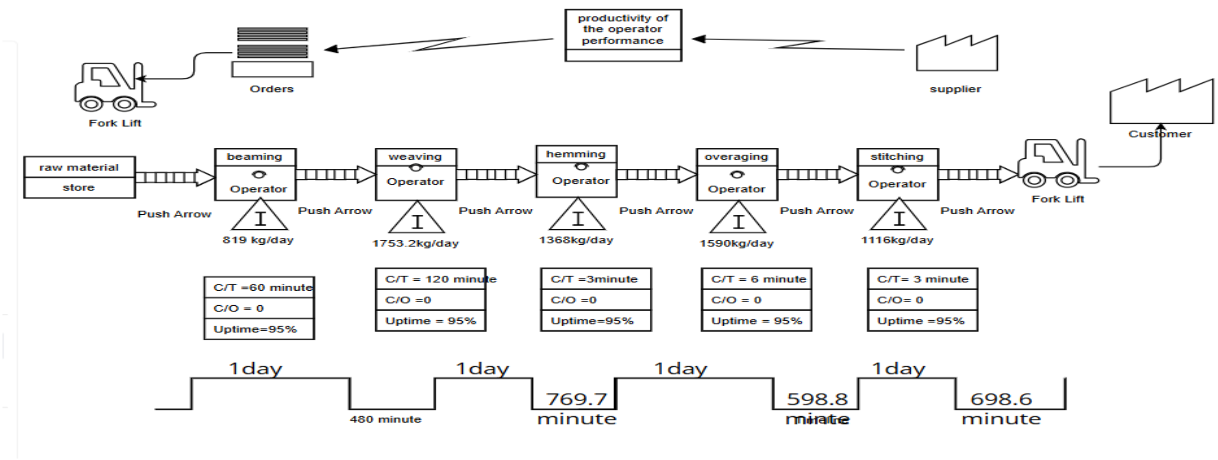
Availability of quality raw material: minimizing variability, bottlenecks, and low productivity, raw materials prevent disruptions to operator performance, processes, equipment uptime, and downstream quality in the manufacturing of jute bags.

Lay out of the present operator performance per day



Summation present productivity per day **5906.2 kg/day**

Lay out of the future operator performance per day



Summation future productivity per day 6646.2 kg/day

Figure 4.3 Lay out of the value stream mapping

4.8. Modeling and simulation for the factor influence the operator performance on jute bag manufacturing

4.8.1. The approach of simulation and modeling

The work in- process of the activity of the jute bag: Continuances availability of jute yarn and quality raw material.

- The work station of warping/beaming should be ended before loom beginning, so any waiting on warping can affect the loop operations.
- The weaving processes must be completed the sewing start and the access of aim cutting fabrics. Any form of downtime or waiting the top operation as an influence on the sewing work station to modeling and simulation in order to use the discrete event-simulation and I will also build the software of arena. I will be using the past information and collected data from the jute bag manufacturing, the recent operator performance and the designed machine capacity when the engineer approved erected the production line.

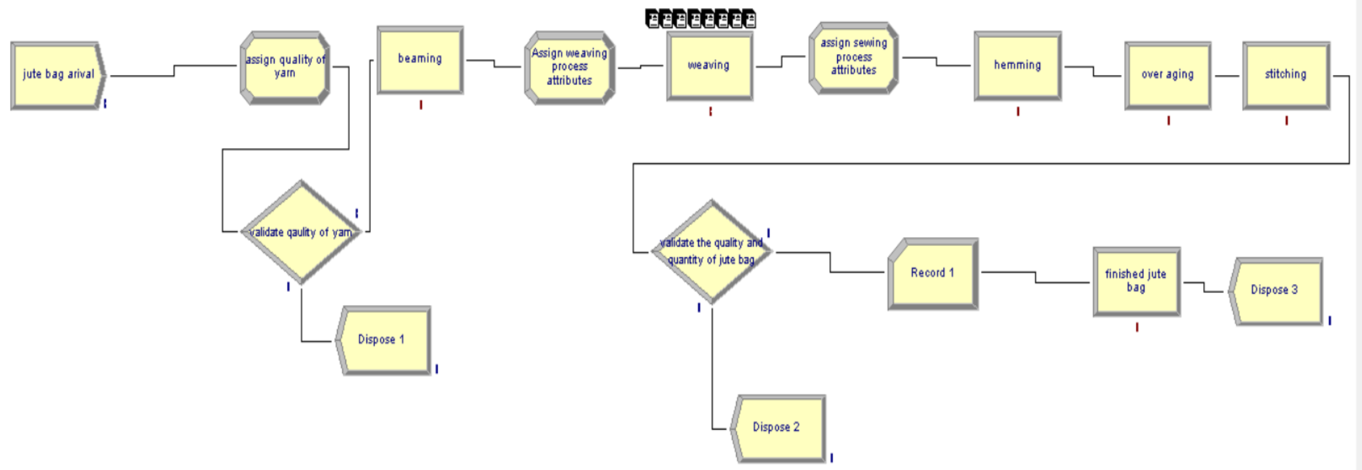


Figure4. 4 modeling and simulation operator performance in jute bag manufacturing

4.9. Generation of model

4.9.1. Random number generation

the inter arrival time one of the measurement to generate which starting of process beaming and the next process after ended its just weaving machine begin, the other work station begin after end the process of loom. There are three different work stations in beaming, weaving and sewing:-From in the work station of warping/beaming 208 random numbers take to generated and gate the following result after insert the input analyzer.

a. Beaming /warping

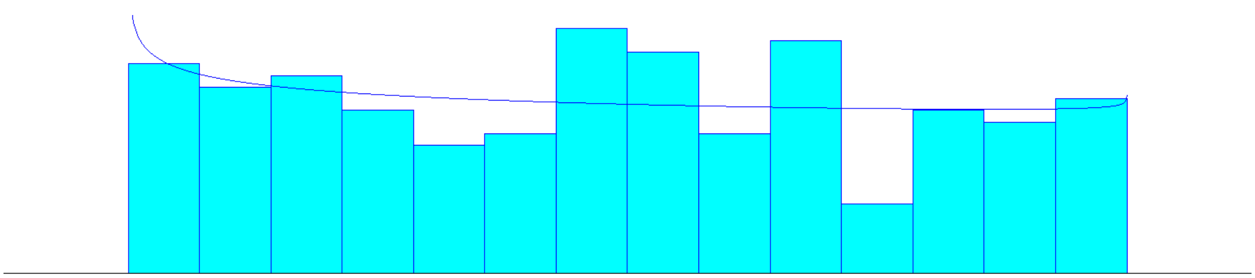


Figure 4.5 beaming inter-arrival productivity

Distribution Summary

Distribution: Beta

Expression: 0 + 1.6e+003 * BETA (0.912, 0.986)

Number of Data Points = 208

Min Data Value =0

Max Data Value = 1.6e+003

Sample Mean = 647

Sample Std Dev =394

b. Loom/weaving

From in the work station of loom/weaving 3172 random numbers take to generated and gate the following result after insert the input analyzer.

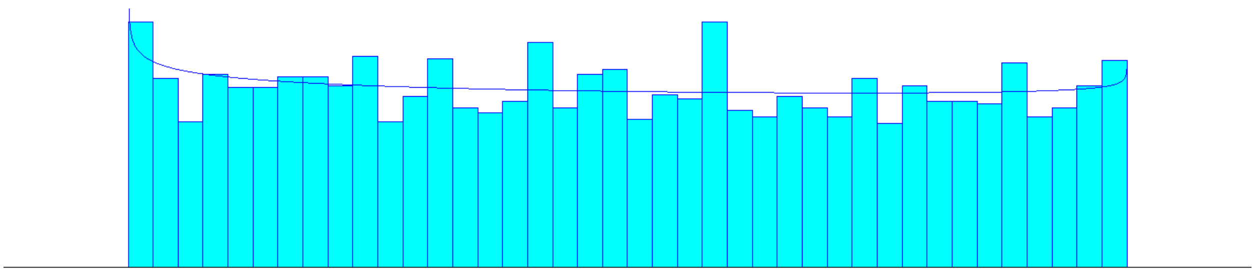


Figure 4.6 weaving inter arrival productivity

Distribution Summary

Distribution: Beta

Expression: -0.001 + 480* BETA (0.943, 0.979)

Number of Data Points= 3172

Min Data Value = 0

Max Data Value =480

Sample Mean =103

Sample Std Dev =61.4

c. Sewing

From in the work station of sewing 1118 random numbers take to generated and gate the following result after insert the input analyzer.

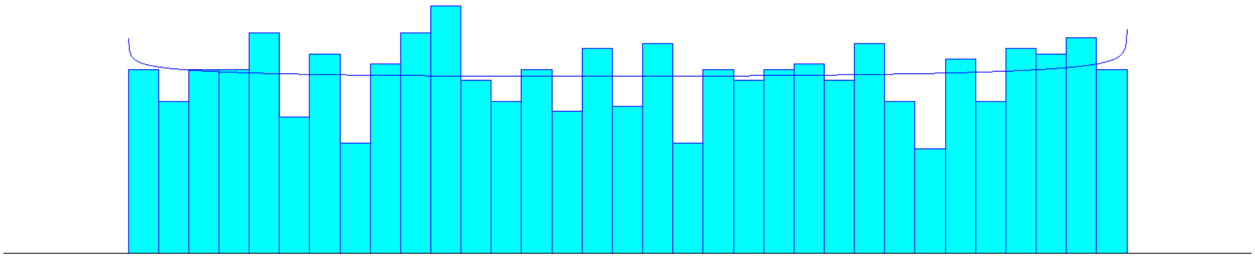


Figure 4.7 sewing inter-arrival productivity

Distribution Summary

Distribution: Beta

Expression: 0.999 + 1.6e+003 * BETA (0.975, 0.97)

Number of Data Points= 1092

Min Data Value = 0

Max Data Value = 1.6e+003

Sample Mean =752

Sample standard deviation =436

Summary from the above random number generation the main purpose in order to made analyze the productivity of the operator performance and identifying the distribution on each work station by using the input analyzer for preparing modeling and simulation of the operator performance by using the arena software. Therefore, standing from beaming data range from 0 up to 1600kg/day contain 208 random numbers which give generated by input analyzer the result beta distribution the best among of that distribution and the other operation weaving and sewing the same result.

Formulating the frequency distribution

Formulating the frequency distribution enable to analyze the collected data for the observed and expected distribution in order to make simulation (jerry bank, fourth edition). The data enable to group in to different class of interval according to the data size and count each of the class intervals for the observed frequency.

Suggesting the distribution is uniform and formulating the expected frequency as follow each work in process

Chi-square Test

For Beaming

Expected frequency formula

$$X_0^2 = \sum_{i=1}^{n} \frac{(O_i - E_i)^2}{E_i}$$

Minimum productivity =0

Maximum productivity =1600

Width of the interval $R_i = \frac{\text{maximum value – minimum value,}}{\text{Number of interval}}$

= (1600 – 0)/20= 80,rule of thumbs for large data 10 – 20 class for large data then take 20

Next calculated the observed values

Depending on the generated of the inter arrival value; I count how many value fall. Based on that calculate the class width, the range and number of class.

Range = maximum value – minimum value, 1600 – 0 = 1600

Calculating the number of class by using the formula of **stuges rule**

Number of class (K) = 1 + 3.322 * log (n), 1 + 3.322 * log (208)

= 1 +3.322 *2.32 =8.7 approximately 9

Then class width = R/K = 1600/9 = 178

The degree of freedom= K – 1 = 9 -1 =8

Table 4.16 random number testing using chi- square test method

Productivity interval(kg/day)	Observed frequency(O_i)	Expected frequency(E_i =N/n)	$O_i - E_i$	$(O_i - E_i)^2$	$\frac{(O_i - E_i)^2}{E_i}$
0-80	54	10.4	43.6	1900.96	190.1
81-160	12	10.4	1.6	2.56	0.246
161-240	10	10.4	-0.4	1.023	0.1
241-320	11	10.4	0.6	0.36	0.098

321-400	15	10.4	4.6	21.16	2.034
401-480	14	10.4	3.6	12.96	1.21
481-560	13	10.4	2.6	6.76	0.65
561-640	12	10.4	1.6	2.56	0.246
641-720	10	10.4	-0.4	1.023	0.1
721-800	14	10.4	3.6	12.96	1.21
801-880	13	10.4	2.6	6.76	0.65
881-960	16	10.4	5.6	31.36	3.02
961-1040	14	10.4	3.6	12.96	1.21
1041-1120	15	10.4	4.6	21.16	2.034
1121-1200	13	10.4	2.6	6.76	0.65
1201-1280	12	10.4	1.6	2.56	0.246
1281-1360	10	10.4	-0.4	1.023	0.1
1361-1440	9	10.4	-1.4	1.96	0.188
1441-1520	8	10.4	-2.4	5.76	0.553
1521-1600	8	10.4	-2.4	5.76	0.553
Sum	208	208	75	2058.389	**205.2**

The significance value (α) = 0.05 and the degree of freedom is 8, and then the critical value is 15.51.

Therefore, if the expected value (E^2_i) calculated ≥ 15.51 reject the null hypothesis (H_o)

205.2 ≥15.51 which is meant the observed frequency and the expected frequency is high difference, and then it requires take expected frequency.

If the expected value (E^2_i) calculated < 15.51 fail to reject the null hypothesis (H_o)

Calculating number of replication

n= $(Z^2 * \delta^2)/E^2$

Representation of n=number of replication

Z = z-score for 95 % degree of freedom score 1.96 from the table

(δ)Standard deviation the collected data is 394

(E) The margin error to accept/standard ± 5% with our context 5 day

n= (1.96 *1.96 *398*394)/25 =24,340.99 approximately 24,341 replication

For Weaving

Expected frequency formula

$$X_0^2 = \sum_{i=1}^{n} \frac{(O_i - E_i)^2}{E_i}$$

Minimum productivity =0

Maximum productivity =4800

Width of the interval R_i = $\frac{\text{maximum value – minimum value}}{\text{Number of interval}}$,

= (480 – 0)/11= 44,rule of thumbs for large data 10 – 20 class for large data then take 11

Next calculated the observed values

Depending on the generated of the inter arrival value; I count how many value fall. Based on that calculate the class width, the range and number of class.

Range = maximum value – minimum value, 480 – 0 = 480

Calculating the number of class by using the formula of **stuges rule**

Number of class (K) = 1 + 3.322 * log (n), 1 + 3.322 * log (3172)

= 1 +3.322 *3.5 =12.63 approximately 13

Then class width = R/K = 480/13 = 37

The degree of freedom= K – 1 = 13 -1 =12

Table 4.17 random number testing using chi- square test method

Productivity interval(kg/day)	Observed frequency(O_i)	Expected frequency(E_i =N/n)	$O_i - E_i$	$(O_i - E_i)^2$	$\frac{(O_i - E_i)^2}{E_i}$
0-44	112	288.4	176.4	31116.96	107.8951
45-88	215	288.4	73.4	5387.56	18.68086
89-132	275	288.4	13.4	179.56	0.622607
133-176	190	288.4	98.4	9682.56	33.57337

177-220	85	288.4	203.4	41371.56	143.452
221-264	12	288.4	276.4	76396.96	264.8993
265-308	3	288.4	285.4	81453.16	282.4312
307-352	0	288.4	288.4	83174.56	288.4
396-440	0	288.4	288.4	83174.56	288.4
441-484	1	288.4	287.4	82598.76	286.4035
485-528	0	288.4	288.4	83174.56	288.4
Sum	893	3172	2279.4	577710.8	**2003.158**

The significance value (α) = 0.05 and the degree of freedom is 12, and then the critical value is 21.026.

Therefore, if the expected value (E^2_i) calculated ≥ 21.026 reject the null hypothesis (H_o)

2003.2 ≥21.026 which is meant the observed frequency is less than the expected frequency is high difference, and then it requires take expected frequency.

If the expected value (E^2_i) calculated < 21.026 fail to reject the null hypothesis (H_o)

Calculating number of replication

$n= (Z^2 * \delta^2)/E^2$

Representation of n=number of replication

Z = z-score for 95 % degree of freedom score 1.96 from the table

(δ)Standard deviation the collected data is 46

(E) The margin error to accept/standard ± 5% with our context 5 day

n= (1.96 *1.96 *46*46)/25 =325.153 approximately 325 replication

Sewing for hemming

Expected frequency formula

$$X_0^2 = \sum_{i=1}^{n} \frac{(O_i - E_i)^2}{E_i}$$

Minimum productivity =0

Maximum productivity =1600

Width of the interval R_i = <u>maximum value – minimum value</u>,

Number of interval

= (1600 – 0)/16= 100,rule of thumbs for large data 10 – 20 class for large data then take 16

Next calculated the observed values

Depending on the generated of the inter arrival productivity; I count how many value fall. Based on that calculate the class width, the range and number of class.

Range = maximum value – minimum value, 1600 – 0 = 1600

Calculating the number of class by using the formula of **stuges rule**

Number of class (K) = 1 + 3.322 * log (n), 1 + 3.322 * log (312)

= 1 +3.322 *2.49 =9.3 approximately 9

Then class width = R/K = 1600/9 = 178

The degree of freedom= K – 1 = 9 -1 =8

Table 4.18 random number testing using chi- square test method

Productivity interval(kg/day)	Observed frequency(O_i)	Expected frequency(E_i =N/n)	$O_i - E_i$	$(O_i - E_i)^2$	$\frac{(O_i - E_i)^2}{E_i}$
0-100	40	19.5	-20.5	420.25	21.55128
101-200	120	19.5	-100.5	10100.25	517.9615
201-300	35	19.5	-15.5	240.25	12.32051
301-400	15	19.5	4.5	20.25	1.038462
401-500	20	19.5	-0.5	0.25	0.012821
501-600	18	19.5	1.5	2.25	0.115385
601-700	12	19.5	7.5	56.25	2.884615
701-800	10	19.5	9.5	90.25	4.628205
801-900	15	19.5	4.5	20.25	1.038462
901-1000	10	19.5	9.5	90.25	4.628205
1001-1100	8	19.5	11.5	132.25	6.782051
1101-1200	6	19.5	13.5	182.25	9.346154
1201-1300	5	19.5	14.5	210.25	10.78205

1301-1120	4	19.5	15.5	240.25	12.32051
1121-1400	2	19.5	17.5	306.25	15.70513
1401-1500	1	19.5	18.5	342.25	17.55128
1501-1600	1	19.5	18.5	342.25	17.55128
Sum	312	312	9.5	12796.25	**656.2179**

The significance value (α) = 0.05 and the degree of freedom is 8, and then the critical value is 15.51.

Therefore, if the expected value (E^2_i) calculated ≥ 15.51 reject the null hypothesis (H_o)

656.23 ≥15.51 which is meant the observed frequency and the expected frequency is high difference, and then it requires take expected frequency.

If the expected value (E^2_i) calculated < 15.51 fail to reject the null hypothesis (H_o)

Calculating number of replication

n= $(Z^2 * \delta^2)/E^2$

Representation of n=number of replication

Z = z-score for 95 % degree of freedom score 1.96 from the table

(δ)Standard deviation the collected data is 400

(E) The margin error to accept/standard ± 5% with our context 5 day

n= (1.96 *1.96 *400*400)/25 =15,366.4 approximately 15,366 replication

Sewing for over aging

Expected frequency formula

$$X_0^2 = \sum_{i=1}^{n} \frac{(O_i - E_i)^2}{E_i}$$

Minimum productivity =0

Maximum productivity =1600

Width of the interval R_i = maximum value – minimum value, Number of interval

= (1600 – 0)/16= 100,rule of thumbs for large data 10 – 20 class for large data then take 16

Next calculated the observed values

Depending on the generated of the inter arrival value; I count how many value fall. Based on that calculate the class width, the range and number of class.

Range = maximum value – minimum value, 1600 – 0 = 1600

Calculating the number of class by using the formula of **stuges rule**

Number of class (K) = 1 + 3.322 * log (n), 1 + 3.322 * log (468)

= 1 +3.322 *2.67 =9.87approximately 10

Then class width = R/K = 1600/9 = 178

The degree of freedom= K – 1 = 10-1 =9

Table 4.19 random number testing using chi- square test method

Productivity interval(kg/day)	Observed frequency(O_i)	Expected frequency(E_i =N/n)	O_i - E_i	$(O_i - E_i)^2$	$\frac{(O_i - E_i)^2}{E_i}$
0-100	30	29.25	-0.75	0.5625	0.019231
101-200	100	29.25	-70.75	5005.563	171.1303
201-300	40	29.25	-10.75	115.5625	3.950855
301-400	25	29.25	4.25	18.0625	0.617521
401-500	30	29.25	-0.75	0.5625	0.019231
501-600	28	29.25	1.25	1.5625	0.053419
601-700	22	29.25	7.25	52.5625	1.797009
701-800	20	29.25	9.25	85.5625	2.925214
801-900	18	29.25	11.25	126.5625	4.326923
901-1000	15	29.25	14.25	203.0625	6.942308
1001-1100	12	29.25	17.25	297.5625	10.17308
1101-1200	10	29.25	19.25	370.5625	12.6688
1201-1300	8	29.25	21.25	451.5625	15.43803
1301-1120	6	29.25	23.25	540.5625	18.48077
1121-1400	4	29.25	25.25	637.5625	21.79701
1401-1500	2	29.25	27.25	742.5625	25.38675
1501-1600	1	29.25	28.25	798.0625	27.28419

Sum	371	468	126.25	9448.063	**323.0107**

The significance value (α) = 0.05 and the degree of freedom is 9, and then the critical value is 19.919.

Therefore, if the expected value (E^2_i) calculated ≥ 16.919 reject the null hypothesis (H_o)

323.01 ≥16.919 which is meant the observed frequency and the expected frequency is high difference, and then it requires take expected frequency.

If the expected value (E^2_i) calculated < 19.919 fail to reject the null hypothesis (H_o)

Calculating number of replication

$n= (Z^2 * \delta^2)/E^2$

Representation of n=number of replication

Z = z-score for 95 % degree of freedom score 1.96 from the table

(δ)Standard deviation the collected data is 390

(E) The margin error to accept/standard ± 5% with our context 5 day

n= (1.96 *1.96 *390*390)/25 =23,372.29 approximately 23,372 replication

Sewing for stitching

Expected frequency formula

$$X_0^2 = \sum_{i=1}^{n} \frac{(O_i - E_i)^2}{E_i}$$

Minimum productivity =0

Maximum productivity =1600

Width of the interval R_i = $\frac{\text{maximum value – minimum value}}{\text{Number of interval}}$,

= (1600 – 0)/16= 100,rule of thumbs for large data 10 – 20 class for large data then take 16

Next calculated the observed values

Depending on the generated of the inter arrival value; I count how many value fall. Based on that calculate the class width, the range and number of class.

Range = maximum value – minimum value, 1600 – 0 = 1600

Calculating the number of class by using the formula of **stuges rule**

Number of class (K) = 1 + 3.322 * log (n), 1 + 3.322 * log (312)

= 1 +3.322 *2.49 =9.3 approximately 9

Then class width = R/K = 1600/9 = 178

The degree of freedom= K – 1 = 9 -1 =8

Table4.20 random number testing using chi- square test method

Productivity interval(kg/day)	Observed frequency(O_i)	Expected frequency(E_i =N/n)	$O_i - E_i$	$(O_i - E_i)^2$	$\frac{(O_i - E_i)^2}{E_i}$
0-100	25	19.5	-5.5	30.25	1.551282
101-200	80	19.5	-60.5	3660.25	187.7051
201-300	30	19.5	-10.5	110.25	5.653846
301-400	20	19.5	-0.5	0.25	0.012821
401-500	25	19.5	-5.5	30.25	1.551282
501-600	22	19.5	-2.5	6.25	0.320513
601-700	18	19.5	1.5	2.25	0.115385
701-800	15	19.5	4.5	20.25	1.038462
801-900	12	19.5	7.5	56.25	2.884615
901-1000	10	19.5	9.5	90.25	4.628205
1001-1100	8	19.5	11.5	132.25	6.782051
1101-1200	5	19.5	14.5	210.25	10.78205
1201-1300	4	19.5	15.5	240.25	12.32051
1301-1120	3	19.5	16.5	272.25	13.96154
1121-1400	2	19.5	17.5	306.25	15.70513
1401-1500	1	19.5	18.5	342.25	17.55128
1501-1600	1	19.5	18.5	342.25	17.55128
Sum	281	312	50.5	5852.25	**300.1154**

The significance value (α) = 0.05 and the degree of freedom is 8, and then the critical value is 15.51.

Therefore, if the expected value (E^2_i) calculated ≥ 15.51 reject the null hypothesis (H_o)

300.1 ≥15.51 which is meant the observed frequency and the expected frequency is high difference, and then it requires take expected frequency.

If the expected value (E^2_i) calculated < 15.51 fail to reject the null hypothesis (H_o)

Calculating number of replication

n= $(Z^2 * \delta^2)/E^2$

Representation of n=number of replication

Z = z-score for 95 % degree of freedom score 1.96 from the table

(δ)Standard deviation the collected data is 410

(E) The margin error to accept/standard ± 5% with our context 5 day

n= (1.96 *1.96 *410*410)/25 =25,830.92, approximately 25,831 replication

Summary among these analysis in order to check the chi-square test of the null and alternative hypothesis of the operation in beaming, weaving and sewing and the other thing calculate the replication of the system. The data which has been gotten from the **appendix** beaming, weaving and sewing productivity per day record by horizon plantation coffee processing and warehousing company for made observation distribution by using 20 class interval for each work station.

Table 4.21 different types operation identifying distribution by input analyzer

Work-in-process	Types of distribution	Mean	Standard deviation	Ranges
Beaming	Beta distribution	647	394	1600
Weaving	Beta distribution	103	46	480
Sewing for hemming	Beta distribution	360.3	400	1600
Sewing for over aging	Beta distribution	378.2	390	1600
Sewing for stitching	Beta distribution	345.5	410	1600

4.10. Verification and validation of the simulation modeling

4.10.1. Model of verification

Verification the process enables to analysis the model of simulation perfectly performed as the conceptual model design. Which has been insured the procedure of analysis, investigating coding fault, analysis the logics of model, insuring the formulation analysis to follow correct mechanism and last the simulation model checked by different scenario testing.

4.10.2. Model of validation

The hypothesis test

Null hypothesis (H_0): the observed distribution data comparing identical to the modeling and simulation outcome.

Alternative hypothesis (H_1): the observed distribution data comparing do not identical to the modeling and simulation outcome.

The significance value (α) = 0.05

Statistics of sample

Sample size(x) =208

Sample mean =730

Standard deviation (s) =493.6

Formation of static test

Mean of population (μ):647

Statistics of test (t): $\frac{\text{sample mean} - \mu}{S/\sqrt{N}}$ = (730-647) *14.4/493.6 =1195.2/493.2 =2.42

Degree of freedom = N – 1= 208-1=207

Calculate the critical value

From the table data the significance value (α) = 0.05 and degree of freedom 207 is by using t-distribution the critical value |t| =1.97

Formulating the critical value |t| =2.42, which is 2.42 > critical value (1.97), then the researcher fail in the alternative hypothesis. Therefore from the analysis indicate there is evidence to determine the simulation outcome for significance value of 0.05.

Formulate the p-value

Degree of freedom =N-1, 208-1=207,

From the t-distribution table degree of freedom 207 is critical value 1.97 in |t| value =2.42, the p-value from the table is 0.016. Therefore, the p-value from t-test with|=2.42 and degree of freedom =207 is approximately between 0.015 and 0.016.then the p-value less than the significance value 0.05which mean fail the alternative hypothesis.

4.10.3. Long run performance measure of queuing system

Arrival rate for beaming

In the case of beaming work-in –processing the arrival rate explain how beam roll in the queue. Therefore, the arrival rate formulated by the number of beam roll arrives within the time frame by the total time period. λ = 208/24 hours = 8.67 approximately 9 beam roll per hour.

Arrival rate for weaving

In the case of weaving work-in –processing the arrival rate explain how fabric cloth roll in the queue. Therefore, the arrival rate formulated by the number of fabric cloth roll arrives within the time frame by the total time period. λ = 3172/24 hours = 132 approximately 132 cloth fabric roll weave arrive per hour.

Arrival for sewing

In the case of sewing work-in –processing the arrival rate explain how sewing cutting fabric clothing the queue. Therefore, the arrival rate formulated by the number of cutting fabric cloth arrives within the time frame by the total time period. λ = 1092/24 hours = 45.6 approximately 46 sew arrive per hour.

Beaming productivity rate

Production rate = average number of operator that can be produced per unit time

= 1056kg/8 hour = 132kg/hour

Weaving productivity rate

Production rate = average number of machine that can be produced per unit time

=105kg/8hour = 13.123kg/hour

Sewing productivity rate

Production rate = average number of operator that can be produced per unit time

= 135kg/8hour = 16.875kg/hour

Beaming Utilization of the operator

($^{\delta}$) =arrival rate/productivity rate = ((9beam roll)/8hour) /132kg /hr. = (9*294kg)/8 *132kg/hr.

= 2646/1072 = 2.5 then utilization 250%

Weaving Utilization of the operator

($^{\delta}$) =arrival rate/productivity rate = (13.125kg/hr. *20)/13.125kg/hr.

= 262.5/13.125= 20 then utilization 2000%

Sewing Utilization of the operator

($^{\delta}$) =arrival rate/productivity rate = (46kg/hr. *7)/16.875kg/hr.

= 322/16.875 = 19.1then utilization 1910%

The probability zero unity of beaming

P_0 =1 – arrival rate/productivity rate = 1- 2.5 = -1.5

The probability zero unity of weaving

P_0 =1 – arrival rate/productivity rate = 1- 20 = -19

The probability zero unity of sewing

P_0 =1 – arrival rate/productivity rate = 1- 19.1 = -18.1, among those the negative value result indicate the operation of the jute bag manufacturing the operator performance is low.

Average number of the productivity/operator performance in the work –in -process

Average number of the productivity/operator performance in the work-in –process which has being waiting at queue (L_q)

$$L_q = \frac{(\text{arrival rate})^2}{\text{Productivity rate (productivity rate-arrival rate)}}$$

For beaming waiting at queue = $(330.75)^2$/132(132-330.75)

= 109,395.6/26,235, 4.2

For weaving waiting at queue = $(132)^2$/13.125(13.125-123)

= 17,424/1719.375, 10.1

For sewing waiting at queue = $(46)^2$/16.875(16.875-46)

= 2116/759.4, 2.8

Current productivity rate in queue (L_P) = arrival rate

Productivity rate - arrival rate

For beaming (L_P) = 330.5/ (132-330.5) = 330.5/198.5=1.665

For weaving (LP) = 132/ (13.125- 132) = 132/92.625=1.425

For sewing (L_P) = 46/ (16.875-46) = 46/29.125=1.58

L =L_Q +L_P = (4.2 +10.1 +2.8) + (1.665 + 1.425 + 1.58) = 21.77

Average productivity the operator performance in the work-in-process

Average number of the productivity/operator performance in the work-in –process which has being loss productivity at queue (W_q) and average total productivity produced (W_p).

$$(W_q) = \frac{\text{arrival rate}}{\text{Productivity rate (productivity rate-arrival rate)}}$$

For beaming (Wq) = 330.5/132(132-330.5) = 330.5/26,202 =0.0126

For beaming (Wq) = 132/13.125(13.125-132) = 132/1560=0.085

For beaming (Wq) = 46/16.875(16.875-46) = 46/491.5=0.094

$$(W_p) = \frac{1}{\text{Productivity rate - arrival rate}}$$

For beaming (W_p) = 1/ (132-330.5) = 1/198.5 = 0.005

For weaving (W_p) = 1/ (13.125-132) = 1/118.875 = 0.008

For sewing (W_p) = 1/(16.875-46) = 1/29.125 = 0.034

W_T = Wq+W_p = (0.0126 +0.085 + 0.094) + (0.005 + 0.008 + 0.034) = 0.24

4.10.4. Scenario test

Baseline scenario

The main aim baseline scenario is enabling to the bridge of the present performance of the jute bag manufacturing for their operator performances. Baseline of collected data analyze that the average productivity of the operator within each work station which has been selected as the main problem by the study of the research. Such as beaming produced 730.8 kg/day, weaving produced 1557.9 kg/day, sewing for hemming produced 1214.7 kg/day, sewing for over aging produced 1413.6 kg/day and sewing for stitching produced 989.5 kg/day. Therefore, the total baseline of the productivity of the operator in the resent scenario is 5906.2 kg/day.

Baseline total productivity per day = beaming productivity per day +weaving productivity per day + sewing productivity per day

Baseline total productivity per day = 730.8 kg/day +1557.9 kg/day +1214.7 kg/day + 1413.6 kg/day + 989.5 kg/day =5906.2 kg/day

Improved work process and equipment scenario

The enhancement of using advanced procedures, enable to technology of forecasting, maintain work flow throughput, reliability, and increasing the operator performance by 15%.

For beaming

New productivity = old productivity *(1 +0.15)

= 30.3 kg/hr. *1.15= 34.85kg/hr., work process and equipment

Therefore, the suggested increase productivity of the operator performance 4.55 kg/hr. which is total value 34.85kg/hr.

For weaving

New productivity = old productivity *(1 +0.15)

= 64.9 kg/hr. *1.15= 74.64kg/hr., work process and equipment

Therefore, the suggested increase productivity of the operator performance 9.74 kg/hr. which is total value 74.64 kg/hr.

For sewing, hemming

New productivity = old productivity *(1 +0.15)

= 50.5 kg/hr. *1.15= 58.1kg/hr., work process and equipment

Therefore, the suggested increase productivity of the operator performance 7.6 kg/hr. which is total value 58.1kg/hr.

For sewing, stitching

New productivity = old productivity *(1 +0.15)

= 58.9 kg/hr. *1.15= 67.74kg/hr., work process and equipment

Therefore, the suggested increase productivity of the operator performance 8.84 kg/hr. which is total value 67.74 kg/hr.

For sewing, stitching

New productivity = old productivity *(1 +0.15)

= 41.3 kg/hr. *1.15= 47.5kg/hr., work process and equipment

Therefore, the suggested increase productivity of the operator performance 6.2 kg/hr. which is total value 47.5 kg/hr.

Total of new productivity = (34.85 + 74.64 + 58.1 +67.74 +47.5) *24 =6787.92 kg/day

Comparison

New productivity – old productivity =6787.92 kg/day -5906.2 kg/day =881.72 kg/day (**approximately improved by 15%)**

Enhanced performance and quality scenario

Construct the enhancement of the work-in-process for beaming, weaving and sewing for improved by general quality of standard keep in 95% in order increasing productivity, minimizing downtime and reduced the constraint of the bottleneck improved by 15%.

For beaming

New productivity = old productivity *(1 +0.15)

=30.3kg/hr. *1.15 =34.85kg/hr., performance and quality

Therefore, the suggested increase productivity of the operator performance 4.55kg/hr. which is total value 34.85 kg/hr.

For weaving

New productivity = old productivity *(1 +0.15)

=64.9kg/hr. *1.15 =74.64kg/hr., performance and quality

Therefore, the suggested increase productivity of the operator performance 9.74 kg/hr which is total value 74.64 kg/hr.

For sewing, hemming

New productivity = old productivity *(1 +0.15)

=50.5kg/hr. *1.15 =58.1kg/hr., performance and quality

Therefore, the suggested increase productivity of the operator performance 22.8 kg/hr. which is total value 58.1kg/hr.

For sewing, stitching

New productivity = old productivity *(1 +0.15)

=58.9kg/hr. *1.15 =67.74kg/hr., performance and quality

Therefore, the suggested increase productivity of the operator performance 7.9 kg/hr. which is total value 67.74 kg/hr.

For sewing, stitching

New productivity = old productivity *(1 +0.15)

=41.3kg/hr. *1.15 =47.5kg/hr., performance and quality

Therefore, the suggested increase productivity of the operator performance 6.2 kg/hr. which is total value 47.5 kg/hr.

Comparison of the new and old productivity per day

Total of new productivity = (34.85 + 74.64 + 58.1 +67.74 +47.5) *24 =6787.92 kg/day

New productivity – old productivity =6787.92 kg/day -5906.2 kg/day =881.72 kg/day (**approximately improved by 15%)**

Improved Safety, health and motivation scenario

Minimizing risks, eliminating mistakes and encouraging participation, best practices improve operator performance by 15%.

For beaming

New productivity = old productivity *(1 +0.15)

=30.3kg/hr. *1.15 =34.85kg/hr., Safety, health and motivation

Therefore, the suggested increase productivity of the operator performance 4.55kg/hr. which is total value 34.85 kg/hr.

For weaving

New productivity = old productivity *(1 +0.15)

=64.9kg/hr. *1.15 =74.64kg/hr., Safety, health and motivation

Therefore, the suggested increase productivity of the operator performance 9.74 kg/hr which is total value 74.64 kg/hr.

For sewing, hemming

New productivity = old productivity *(1 +0.15)

=50.5kg/hr. *1.15 =58.1kg/hr., Safety, health and motivation

Therefore, the suggested increase productivity of the operator performance 22.8 kg/hr. which is total value 58.1kg/hr.

For sewing, stitching

New productivity = old productivity *(1 +0.15)

=58.9kg/hr. *1.15 =67.74kg/hr., Safety, health and motivation

Therefore, the suggested increase productivity of the operator performance 7.9 kg/hr. which is total value 67.74 kg/hr.

For sewing, stitching

New productivity = old productivity *(1 +0.15)

=41.3kg/hr. *1.15 =47.5kg/hr., Safety, health and motivation

Therefore, the suggested increase productivity of the operator performance 6.2 kg/hr. which is total value 47.5 kg/hr.

Comparison of the new and old productivity per day

Total of new productivity = (34.85 + 74.64 + 58.1 +67.74 +47.5) *24 =6787.92 kg/day

New productivity – old productivity =6787.92 kg/day -5906.2 kg/day =881.72 kg/day (**approximately improved by 15%)**

Good machine maintenance scenario

Increases efficiency, lowers downtime, and prolongs the life of equipment increased by 20 %.

For beaming

New productivity = old productivity *(1 +0.2)

= 30.3 kg/hr. *1.2= 36.36kg/hr., good machine maintenance

Therefore, the suggested increase productivity of the operator performance 6.06 kg/hr. which is total value 36.36 kg/hr.

For weaving

New productivity = old productivity *(1 + 0.2)

= 64.9 kg/hr. *1.2= 77.88kg/hr., good machine maintenance

Therefore, the suggested increase productivity of the operator performance 12.98 kg/hr. which is total value 77.88 kg/hr.

For sewing, hemming

New productivity = old productivity *(1 + 0.2)

= 50.5 kg/hr. *1.2= 60.6 kg/hr., good machine maintenance

Therefore, the suggested increase productivity of the operator performance 10.1 kg/hr. which is total value 60.6 kg/hr.

For sewing, stitching

New productivity = old productivity *(1 +0.2)

= 58.9 kg/hr. *1.2= 71.88 kg/hr., good machine maintenance

Therefore, the suggested increase productivity of the operator performance 12.98 kg/hr. which is total value 71.88 kg/hr.

For sewing, stitching

New productivity = old productivity *(1 +0.2)

= 41.3 kg/hr. *1.2= 49.56 kg/hr., good machine maintenance

Therefore, the suggested increase productivity of the operator performance 8.26 kg/hr. which is total value 49.56 kg/hr.

Comparison of the new and old productivity per day

Total of new productivity = (36.36 + 77.88 + 60.6 +71.88 +49.56) *24 =7110.72kg/day

New productivity – old productivity =7110.72 kg/day -5906.2 kg/day =1204.52 kg/day (**approximately improved by 20%)**

Availability of quality raw material scenario

Minimizing variability, bottlenecks, and low productivity, raw materials prevent disruptions to operator performance, processes, equipment uptime, and downstream quality in the manufacturing of jute bags accessed by 25%.

For beaming

New productivity = old productivity *(1 +0.25)

= 30.3 kg/hr. *1.25= 37.875 kg/hr., availability of quality raw material

Therefore, the suggested increase productivity of the operator performance 7.575 kg/hr. which is total value 37.875 kg/hr.

For weaving

New productivity = old productivity *(1 +0.25)

= 64.9 kg/hr. *1.25= 81.125 kg/hr., availability of quality raw material

Therefore, the suggested increase productivity of the operator performance 16.225 kg/hr. which is total value 81.125 kg/hr.

For sewing, hemming

New productivity = old productivity *(1 +0.25)

= 50.5 kg/hr. *1.25= 63.125 kg/hr., availability of quality raw material

Therefore, the suggested increase productivity of the operator performance 12.625 kg/hr. which is total value 63.125 kg/hr.

For sewing, stitching

New productivity = old productivity *(1 +0.25)

= 58.9 kg/hr. *1.25= 73.625 kg/hr., availability of quality raw material

Therefore, the suggested increase productivity of the operator performance 14.725 kg/hr. which is total value 73.625 kg/hr.

For sewing, stitching

New productivity = old productivity *(1 +0.25)

= 41.3 kg/hr. *1.25= 51.625 kg/hr., availability of quality raw material

Therefore, the suggested increase productivity of the operator performance 10.325 kg/hr. which is total value 51.625 kg/hr.

Comparison of the new and old productivity per day

Total of new productivity = (37.875 + 81.125 +63.125 +73.625 + 51.625) *24 =7377 kg/day

New productivity – old productivity =7377 kg/day -5906.2 kg/day =1470.8 kg/day (**approximately improved by 25%).**

Bottleneck mitigation scenario

From the scenario of bottleneck mitigation identifying among work in processes are low productivity of performance of the operator in weaving from the above data represents the simulation outcome is 1557.9 kg/day whereas the operator performance maximizing by 30% and the other remain the baseline productivity. Therefore the weaving enables to improve by 1557.9 kg/day to 2025.3kg/day which is increased by 467.8 kg/day.

For weaving

New productivity = old productivity *(1 +0.3)

= 1557.9 kg/day *1.3= 2025.3kg/day, bottle neck mitigation

Therefore, the suggested increase productivity of the operator performance 467.4kg/day which is total value 2025.3kg/day.

Comparison of the new and old productivity per day

Total of new productivity = 730.8kg/day +2025.3kg/day +1214.7 kg/day + 1413.6 kg/day + 989.5 kg/day = 6,374 kg/day

New productivity – old productivity =6,374kg/day -5906.2 kg/day =467.8 kg/day (**approximately improved by 7.92%).**

Table 4.22 Synopsis of scenario testing

Scenario test	Measured	Proposed improvement (%)	Actual improve ment (%)	Total productivity kg per day	Bottleneck identified
Baseline	Total productivity of operator performance	-	-	5906.2	Beaming
Work process and equipment	Total productivity of operator performance	15	14.93	6787.92	Beaming ,weaving and sewing
Performance and quality	Total productivity of operator performance	15	14.93	6787.92	Beaming ,weaving and sewing
Safety, health and motivation	Total productivity of operator performance	15	14.93	6787.92	Beaming ,weaving and sewing
Good maintenance	Total productivity of operator performance	20	20.4	7110.72	Beaming ,weaving and sewing
Availability of quality raw material	Total productivity of operator performance	25	24.9	7377	Beaming ,weaving and sewing
Bottleneck mitigation	Total productivity of operator performance	30	7.92	6,374	weaving

Chapter Five

5. Conclusion and Recommendation

5.5. Conclusion

The outcome of this research investigating the factor influence of the operator's performance on jute bag manufacturing for the horizon plantation coffee processing and warehousing company improve the productivity of the operator in the work-in-process the beaming ,weaving and sewing. The finding identifying specific bottleneck that the problem of the present mechanism, analyzing the appropriate that the main obstacle. For addressing the factor influence operator performance working process and productivity, performance and quality, safety, health and motivation, skill and training for the work station which has enable to enhancement of the operator performance by modeling and simulation approach. The simulation modeling techniques the role of identifying the bottle neck of among the work-in-process of the jute bag manufacturing, minimizing error and decrease the production lead time.

Jute bag manufacturing for horizon plantation coffee processing and warehouse company enable to distinguish the inefficiency production and investigating critical solution make to enhance production performance of the operator in order to increase the market share for jute bag product, customer satisfaction and get profit. For identifying the bottleneck work-in-process the jute bag manufacturing among those weaving work station by using the modeling and simulation approach, then the proposed improvement of the jute bag manufacturing before the scenario testing the productivity operator performance 5906.2 kg/day and after bottleneck mitigation 6374kg/day which has been increased 467.8kg per day when mitigated by 30%.

Generally, this research concerned to investigate the approach for the utilizing on modeling and simulation system as continuous enhancement material in the adhering the productivity of the operator in an industry.by using modeling and simulation mechanism, jute bag manufacturing of the horizon plantation coffee processing and warehousing company distinguish the bottleneck work station and take mitigation for process optimization that increase performance.

5.6. Recommendation

From this study give different mechanism recommendation to improve the operator performance in the jute bag manufacturing for horizon plantation of coffee processing and warehousing company.

- **Improvement of the working process and productivity**: enhancing the work-in-process of beaming, weaving and sewing to avoid inappropriate tasks and minimize the large cycle times.
- **Building the skill and training**: address the skill and expert gap for concerning training enable to the operator performance improve and control sophisticated machinery and repair manufacturing procedures.
- **Establish preventive maintenance culture**: extend the life span of the machinery and prepare good maintenance procedure which computerized maintenance management system
- **Motivation and welfare:** apply initiation and enhancement for the work station particularly focusing sound of noise, dust mistake of rework and fatigues enable to minimize.
- **Minimizing the bottle neck:** concentrating the main factor area of the work flow station for weaving to optimizing the outcome of the productivity.
- **Access quality of raw material:** critical for production adhere, as it directly influenced finished jute bag acquirable and effectively. Suppliers should be accessed thoroughly to ensure consistency and compliance with standards.
- **Enhanced safety, health and motivation:** production develops on save quality raw materials by reducing risks and increase operator productivity. These enhancement decrease accidents, support well-being, and drive productivity.

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Appendix I: beaming inter-arrival

1155	843	1168	1238	515	675	609	531
983	897	284	1149	511	1119	125	304
1159	191	547	757	955	207	136	620
1345	843	311	67	846	1100	955	813
787	827	926	250	148	325	1160	1150
1292	181	463	980	937	10	630	1072
817	1247	462	1121	1314	161	796	562
1283	1115	76	1023	380	713	820	1310
232	1023	231	698	468	877	27	0
373	292	307	1129	1217	1026	1318	756
959	1081	1182	884	608	545	452	46
308	1144	875	1213	276	175	748	391
900	53	671	1119	415	212	135	76
1334	1119	730	578	1258	674	71	868
162	1094	549	1123	824	745	149	737
764	950	1088	885	977	754	560	1183
624	1143	738	445	182	809	646	1266
1059	302	376	589	646	273	1146	60
472	1053	434	772	312	277	91	837
369	1165	1292	844	1337	172	861	944
447	258	754	989	1114	951	707	297
85	614	1348	956	1235	901	674	859
809	531	982	306	779	793	968	1010
185	1305	679	1328	578	1182	631	330
2	972	174	106	1002	381	183	1039
1123	375	1035	583	364	612	481	122

Appendix II: Weaving inter- arrival

13	74	53	199	84	57	24	58	143	193	8	196	158	174	38	207	94	202	7	156	161	205	210	102	75	129
75	17	52	100	48	188	198	205	3	31	140	159	4	109	179	9	41	67	110	175	139	83	162	131	61	117
139	152	3	143	162	197	86	74	27	7	138	191	188	7	109	113	148	205	153	192	206	188	89	96	124	44
45	56	46	71	167	85	156	55	34	185	100	68	171	40	173	147	92	151	141	6	151	120	167	105	34	46
130	184	83	108	26	14	167	75	2	196	62	8	174	149	113	132	183	120	36	132	7	186	51	59	154	5
92	66	68	96	147	118	131	40	139	107	20	140	196	207	29	131	38	23	55	90	119	173	15	146	35	47
160	118	117	60	107	49	47	15	171	137	18	35	185	6	210	147	129	23	167	126	144	21	141	51	0	196
51	73	170	55	184	64	208	165	207	174	71	73	133	57	30	63	206	105	123	75	46	39	198	181	174	40
59	197	181	116	55	102	26	148	42	117	43	68	108	97	195	200	112	82	143	164	156	55	39	173	184	185
175	189	138	58	76	127	92	17	130	123	194	83	197	208	16	36	31	204	72	72	176	128	30	146	205	144
159	111	194	45	32	63	187	101	148	181	171	201	31	199	17	30	103	35	169	91	90	145	176	81	155	7
189	56	185	43	82	195	101	10	131	134	111	207	117	205	207	187	88	185	93	120	158	84	81	199	129	103
149	115	77	73	7	92	79	4	113	80	75	143	191	205	132	200	102	58	47	23	182	23	205	112	131	158
8	25	25	143	42	7	121	96	38	168	168	162	182	12	126	182	118	53	48	175	41	151	187	66	202	199
13	83	86	141	120	174	90	5	42	54	19	81	209	203	68	184	3	74	53	91	62	20	23	168	73	175
105	199	170	174	152	175	177	180	3	165	169	13	84	17	164	200	89	7	78	143	9	48	84	43	155	83
204	135	32	95	34	58	96	158	112	39	118	17	54	182	71	41	21	120	97	205	122	208	207	36	123	49
196	131	165	152	126	71	102	29	193	114	58	171	18	163	132	124	122	205	110	33	64	193	133	50	168	61
82	24	177	105	122	58	187	205	99	180	112	104	7	168	100	16	169	200	74	90	82	78	68	102	24	156
64	198	179	66	27	33	117	132	62	64	191	8	8	155	107	111	199	46	165	69	80	118	115	20	61	119
87	126	38	190	42	67	11	83	121	30	210	129	54	47	53	182	188	7	165	157	144	42	45	198	127	197
2	23	166	177	168	24	83	58	105	78	142	182	178	196	40	48	152	39	48	92	10	35	38	210	207	109
193	62	177	37	169	159	182	21	197	175	22	13	26	53	88	162	194	116	107	187	62	126	61	91	183	58
79	58	135	194	73	158	205	177	139	19	29	171	54	193	36	50	195	129	204	41	62	160	170	165	21	169
133	102	184	186	87	168	2	82	189	73	194	52	127	159	45	156	170	57	117	80	189	103	9	84	66	79
43	48	201	118	74	20	128	208	181	59	61	99	136	97	167	128	199	34	167	19	29	27	108	63	41	14
185	158	32	68	134	29	188	20	117	196	184	29	4	3	126	120	46	128	51	176	116	0	77	31	37	167
11	102	193	47	87	57	47	12	48	15	162	97	191	45	39	203	125	203	116	33	124	103	58	69	49	72
123	70	186	54	5	202	116	150	34	155	9	110	46	203	89	49	179	121	184	26	78	27	155	207	192	131
19	177	115	27	195	27	142	115	205	177	136	124	80	13	20	6	74	154	25	85	26	137	62	210	181	127
145	116	140	76	85	4	72	182	110	37	75	209	178	82	143	183	90	121	7	163	149	111	97	161	109	94
129	204	207	48	200	26	73	205	78	10	134	134	125	81	41	76	4	126	114	45	196	60	104	106	119	78
60	151	180	28	101	9	44	201	72	18	94	92	139	183	189	128	147	169	55	144	194	171	104	55	108	182
31	109	24	98	102	34	109	117	96	145	23	183	88	85	66	15	178	69	123	60	108	18	26	117	10	133
58	40	136	162	171	74	21	208	98	46	117	172	47	10	90	4	189	63	166	121	109	56	10	133	145	44
38	99	122	111	157	31	155	37	62	107	210	155	41	87	149	195	7	70	48	21	20	29	24	47	27	163
171	191	31	143	135	136	12	197	152	82	62	71	11	207	35	206	104	24	43	152	181	175	180	53	191	72
39	62	138	4	0	47	153	81	5	33	47	49	148	80	47	81	1	77	108	99	95	164	66	126	31	98
207	39	207	113	35	61	89	194	152	196	199	47	95	64	199	105	119	40	134	35	20	56	93	136	95	93
168	193	195	172	161	173	209	127	0	17	140	84	65	179	29	177	12	75	138	63	72	42	172	83	44	166
31	17	173	42	103	136	144	141	30	169	149	75	153	26	128	210	0	153	42	204	46	139	183	100	92	160
186	69	200	69	37	98	20	137	60	174	32	84	179	89	150	174	145	46	38	142	175	39	117	171	44	6
132	4	108	183	193	58	65	58	143	32	75	44	207	94	120	79	81	122	141	186	47	115	176	107	170	25
135	158	128	59	97	51	125	72	152	184	97	134	4	57	3	44	88	20	140	129	185	129	138	63	6	89
205	195	191	148	120	197	157	209	115	49	145	63	198	187	198	117	140	109	103	10	143	45	95	97	194	27
51	127	2	58	127	25	144	69	194	51	15	117	88	150	63	42	140	17	29	173	129	68	29	128	151	174
42	128	198	7	189	9	127	78	79	16	150	68	147	173	21	165	63	36	152	94	183	105	52	69	148	165
111	176	128	121	81	203	41	1	139	64	151	162	95	59	163	99	115	141	184	169	111	67	177	80	23	16
84	60	108	205	41	131	194	193	2	205	59	80	11	196	196	134	53	197	104	153	207	88	85	109	108	13
100	201	44	101	98	102	142	190	183	161	1	84	103	69	68	86	70	174	92	62	64	26	34	187	30	114
86	173	68	168	119	199	10	152	152	39	62	63	136	114	183	205	93	83	42	191	59	67	121	8	12	208
189	156	50	134	203	122	136	88	94	92	111	73	2	71	206	200	62	35	66	165	135	70	165	127	115	82
166	43	210	27	5	136	55	97	6	143	52	69	107	68	38	49	94	7	32	120	202	191	193	8	173	3
59	161	184	16	182	87	204	134	23	69	95	11	174	63	32	15	27	5	85	43	90	192	62	154	180	65
32	82	171	95	130	70	5	201	195	2	50	192	16	94	146	184	91	183	43	164	115	48	195	141	144	200
197	62	17	59	179	101	146	174	113	43	77	190	51	180	63	201	119	206	104	156	26	115	98	190	109	126
112	179	73	93	193	6	73	112	183	111	19	168	59	210	195	75	34	172	115	181	184	191	195	90	91	78
179	39	196	195	106	104	199	18	15	158	121	197	55	60	153	64	165	152	36	21	76	196	1	80	135	35
25	80	155	163	185	159	153	127	180	127	77	127	79	121	195	93	67	78	142	133	142	58	44	58	180	39
68	74	72	103	202	153	97	70	69	91	123	210	193	154	123	171	105	63	165	83	81	141	178	187	170	199
161	71	42	31	107	19	155	35	177	174	21	28	188	44	183	167	77	72	51	183	209	43	182	154	156	187
156	99	201	121	21	135	59	170	95	144	53	54	17	115	60	29	188	113	129	79	2	196	84	101	102	200
55	138	171	37	78	76	5	189	65	35	44	194	26	189	116	167	62	131	8	38	66	42	28	123	92	155
157	166	147	112	123	122	116	193	65	11	42	78	50	105	175	59	67	66	198	153	84	122	50	34	48	35
109	62	141	82	160	122	122	19	180	105	162	210	59	89	203	126	85	52	133	138	144	11	48	29	52	102
126	167	116	180	207	121	178	187	190	0	26	34	64	91	153	169	2	143	16	154	115	92	113	139	124	167
112	21	209	187	160	197	182	151	112	5	98	56	166	147	118	170	18	210	185	40	185	88	204	127	177	89
165	145	202	145	171	174	84	201	77	187	103	17	11	137	64	206	187	121	31	190	35	134	75	65	116	77
122	35	54	188	4	156	176	41	181	6	1	109	158	135	148	197	70	126	9	101	183	15	125	60	195	99
122	11	55	149	87	207	204	114	202	40	198	29	156	210	141	16	30	37	124	117	185	148	79	151	19	169
138	146	153	128	177	183	13	47	164	145	86	129	13	206	52	140	32	126	65	69	79	176	115	5	0	20
95	142	100	126	2	140	139	178	135	116	120	168	42	207	112	153	25	122	169	167	19	144	49	34	118	18
122	38	209	148	189	23	197	33	50	169	191	19	34	42	81	28	72	44	133	210	181	118	51	11	165	0
160	115	40	72	11	59	90	52	78	189	136	127	65	113	37	127	98	4	184	11	13	123	43	193	40	129
198	2	201	152	196	71	64	94	170	28	121	152	179	61	185	144	178	70	85	105	109	108	101	0	64	114
97	184	133	55	84	14	147	187	155	107	79	170	203	63	40	91	60	163	189	16	77	122	136	39	185	16
144	168	44	84	34	59	97	121	208	21	5	37	65	154	31	109	109	176	196	64	65	37	142	0	161	83
91	155	67	93	108	132	72	64	193	124	142	35	180	57	46	140	105	69	165	54	64	48	130	9	141	133
13	73	43	104	14	160	33	155	173	200	166	60	158	111	185	50	106	173	92	134	52	126	191	196	39	77
113	64	100	190	180	116	128	106	56	95	104	9	126	162	47	94	89	145	169	144	141	192	0	107	111	113
132	96	159	147	196	63	169	80	78	9	58	29	56	70	65	2	8	7	61	209	155	116	91	180	71	79
136	59	134	206	57	196	83	141	145	43	160	60	43	177	86	185	88	38	190	78	79	119	204	67	24	53
6	125	48	1	2	54	83	93	172	94	137	116	111	17	176	146	207	10	73	173	21	31	204	144	152	31
173	202	91	83	92	97	203	165	32	101	128	191	63	31	95	117	145	85	85	162	85	4	52	172	0	201
204	198	147	84	207	134	135	197	57	90	149	17	50	179	82	83	119	123	209	134	115	132	175	35	189	198
43	66	34	38	188	62	30	204	20	82	157	63	26	63	85	135	175	100	61	205	63	99	183	67	126	204
63	70	44	92	4	68	152	3	147	201	30	144	141	159	120	49	170	36	56	93	89	71	24	79	55	175
50	76	124	36	10	65	189	51	178	185	47	105	102	149	125	33	33	45	43	11	79	92	167	148	13	93
78	134	183	136	93	63	1	30	124	98	45	116	3	68	97	118	89	23	205	19	95	175	102	175	160	106
76	188	194	20	82	148	100	159	111	199	135	100	128	158	142	111	136	60	206	101	149	16	146	174	70	200
47	34	81	121	56	40	0	50	192	76	74	54	146	32	145	159	203	134	27	70	24	100	93	147	24	27
4	107	21	87	31	150	146	19	116	190	200	124	112	171	121	58	93	66	151	202	172	34	86	176	125	4
111	187	135	200	94	35	89	23	13	154	72	163	46	17	54	38	25	35	207	36	124	202	24	108	208	27
22	15	43	110	110	207	137	164	101	11	130	105	120	190	55	83	145	210	1	188	77	169	179	71	54	180
165	18	199	70	90	133	112	130	23	29	134	61	125	0	210	118	119	101	189	46	103	53	118	39	83	193
199	128	129	198	110	142	93	157	143	136	70	1	173	187	14	118	4	30	168	129	139	176	207	207	177	0
99	39	145	202	79	65	25	26	71	107	93	100	186	186	126	121	171	176	13	180	17	0	29	164	196	202
32	122	3	132	128	158	117	79	0	62	40	172	46	200	149	121	90	175	21	150	123	197	105	149	6	93
8	26	118	131	192	203	129	169	27	160	116	109	119	35	40	18	13	35	27	197	180	160	77	101	54	72
73	137	169	77	173	193	125	0	113	190	114	12	129	180	96	67	2	193	48	200	190	142	37	15	157	127
89	28	86	110	31	88	164	147	185	121	34	68	138	192	48	174	35	109	115	176	13	141	16	60	12	140
113	52	138	149	106	78	210	27	29	41	185	22	136	179	71	118	47	91	100	171	192	75	60	193	1	123
27	34	30	31	197	152	196	96	103	150	6	178	194	58	190	156	138	140	77	11	158	181	193	124	88	58
0	116	72	164	106	132	12	8	119	125	181	178	141	82	63	202	163	133	209	179	127	107	134	51	209	79
133	58	44	175	202	165	194	7	193	172	197	80	209	148	146	45	108	178	166	44	38	83	141	198	105	79
120	29	80	31	87	207	68	11	62	132	73	119	210	56	7	195	76	140	137	157	33	197	98	66	46	144
77	90	63	166	38	113	159	27	4	186	4	151	179	117	95	206	50	25	112	127	179	3	128	164	156	162
201	150	184	113	81	64	116	148	143	16	3	195	51	13	84	92	54	142	199	101	124	47	96	148	63	145
14	66	15	96	106	6	154	32	2	3	27	12	18	131	197	127	164	20	181	77	27	9	156	34	93	26
69	142	3	154	93	12	174	75	177	57	135	138	156	11	41	175	106	143	178	139	60	166	83	9	54	16
205	181	8	119	91	174	112	43	2	27	46	91	183	188	144	31	41	105	163	57	196	31	42	167	23	57
10	18	210	28	182	188	20	183	149	83	9	187	70	23	143	98	118	37	92	164	181	132	39	34	53	77
122	13	112	104	161	165	98	15	108	49	182	151	181	56	59	31	168	127	44	51	37	176	192	188	118	60
66	193	209	39	4	186	52	201	170	38	30	73	185	84	8	171	130	131	128	165	154	134	121	121	71	183
60	134	15	41	133	157	100	204	22	191	203	197	46	150	122	136	44	95	31	151	117	150	11	89	160	22
114	69	114	141	136	63	138	141	69	54	10	17	126	8	86	27	196	55	18	134	189	58	25	33	0	169
66	46	42	11	24	68	206	8	155	201	84	107	183	81	49	166	7	167	28	35	141	56	175	81	14	109
70	144	15	52	85	70	44	137	108	88	85	50	130	108	8	113	32	140	25	145	113	187	65	151	17	75
110	203	163	43	91	120	68	101	204	169	164	94	53	196	210	106	62	32	6	179	75	65	22	69	118	50
103	59	29	59	43	116	203	35	204	2	126	124	196	180	33	147	110	59	2	184	158	203	49	111	192	208
23	180	181	28	86	123	203	133	101	34	154	39	134	44	74	194	106	140	23	110	155	130	113	126	40	151
47	23	22	160	48	75	180	67	50	152	172	44	162	11	78	90	145	100	90	78	83	121	150	58	194	5

Appendix III: Sewing inter- arrival

1118	129	909	49	333	1345	1174	1032	352	1064	443	598	147	1063	343	381	265	889	596	851	1319	492	111	340	52	450
128	1059	1044	70	531	841	1099	535	214	920	681	1242	487	404	1300	527	908	1059	850	1008	1093	943	459	680	854	681
666	239	1018	235	536	1461	288	852	475	407	1268	1414	84	1125	398	1367	958	1306	663	357	1074	1242	484	221	1006	717
310	766	1019	46	992	143	362	333	30	1495	212	1346	893	1289	681	1183	893	738	539	756	425	738	20	606	366	659
668	1197	1418	775	1378	603	945	920	1391	1032	1360	71	1384	1476	97	1246	954	42	551	562	740	1356	603	487	1030	1263
311	580	1237	1118	1157	1125	499	784	808	1494	245	566	440	1173	415	133	44	790	1102	524	375	886	666	1045	63	1123
822	1493	197	647	1148	1189	1436	48	33	149	605	1087	368	1202	1197	1128	690	678	1350	816	700	1466	394	1135	79	1407
171	1052	361	941	122	439	1233	953	1028	1165	577	807	588	212	1040	1493	390	1128	1085	1121	1380	477	724	1097	771	600
512	1204	112	23	1093	1420	667	1435	378	549	1145	835	401	1444	623	1025	439	802	83	971	529	1128	169	451	1202	134
1461	371	625	355	1099	616	1012	385	277	1380	841	110	630	1425	1013	480	1124	741	493	1333	643	1107	1092	1369	160	1444
1166	809	999	1167	152	465	362	471	458	692	1177	721	1425	776	1061	692	527	1317	63	737	511	175	1120	845	522	965
24	1489	249	741	100	855	509	1043	1450	429	513	953	799	136	1065	478	1126	426	1062	1265	436	382	907	1288	1297	345
696	465	1103	1248	29	655	325	469	751	1496	61	1374	211	815	1153	780	1420	71	462	1077	1127	1363	785	413	812	1392
423	496	1128	1433	771	1160	126	124	323	647	1008	1492	781	1306	498	671	1308	1253	584	1380	145	1276	242	574	438	1324
81	871	1082	526	421	1055	360	731	1049	1148	1186	465	264	943	1327	1246	286	1181	1138	1365	1415	1140	1276	256	214	686
1231	1089	438	1494	1420	1111	674	670	483	212	467	967	134	1362	94	1234	1123	214	790	1183	1301	933	782	230	1027	577
1179	407	475	1130	1350	799	1148	1250	69	152	853	1331	699	1117	1038	509	265	1060	268	62	506	45	1225	428	958	636
1226	1091	164	195	593	841	562	850	674	136	682	426	1231	126	151	1093	867	1109	812	1364	337	1152	309	636	1081	679
118	954	705	1076	883	1238	877	970	343	882	302	651	1254	526	486	305	153	1376	1147	553	1409	847	369	172	459	234
127	1211	1436	1213	1091	425	680	922	407	506	439	176	1057	213	433	151	917	727	1012	28	311	454	549	589	980	302
1345	1048	152	1475	871	1319	959	268	433	796	1462	1119	523	462	596	981	961	569	969	1487	1352	1303	318	693	168	1150
1098	781	580	684	1380	1060	125	875	239	777	564	871	1132	344	1413	170	1387	1310	717	188	630	247	298	607	220	497
1095	1138	1421	823	1416	1364	321	884	1387	719	991	996	191	646	1494	402	1144	1366	967	333	833	1097	271	968	1438	90
1028	1485	52	1394	1494	270	1348	56	1047	762	895	1048	1143	1097	1272	146	1020	929	1188	792	633	816	614	349	544	1216
1015	1202	822	318	1281	1256	1305	1083	321	616	110	1059	1267	337	229	722	9	1420	59	433	162	444	424	287	1010	549
334	927	736	1270	1041	620	382	839	1151	1291	859	380	480	1119	13	1489	236	99	418	784	988	841	692	290	1300	441
1417	1204	607	1191	1478	809	1183	254	884	327	1319	241	1189	78	996	526	334	83	715	904	1205	356	755	419	415	166
673	775	1495	67	1326	930	1393	550	719	278	879	1013	913	1233	1393	1415	565	663	1473	794	1336	1380	568	574	1023	405
434	813	1302	1112	82	541	954	695	823	257	848	828	834	964	1307	1417	74	135	345	1224	371	1034	154	533	433	997
1305	884	1160	1417	1446	1332	1243	1307	19	341	1475	1077	443	639	615	1456	1153	1132	829	644	1102	1233	876	608	1265	1006
983	1299	927	241	1065	1292	625	1436	400	1198	1132	162	1317	1221	1114	1146	698	1425	394	632	1105	854	496	821	857	172
1040	582	324	153	1470	64	1194	1263	892	507	1039	329	1487	1086	305	134	1168	1103	1192	84	1245	1098	731	163	440	1419
227	1057	645	783	991	177	29	444	548	979	620	472	123	65	790	101	83	695	1106	275	844	426	749	581	1353	657
1377	777	1328	701	52	1219	586	926	1304	281	467	1420	660	1348	1078	80	1241	265	137	785	596	54	11	326	68	1286
1161	670	1496	385	1418	868	32	1411	160	125	170	114	1177	280	1182	1046	228	694	1453	1009	806	541	921	1098	1186	817
946	346	156	709	196	975	776	1032	1066	1201	355	699	36	1484	1309	1101	906	1042	603	278	204	542	122	1139	1327	1078
160	1313	130	643	1002	1424	1143	913	1073	519	747	412	10	566	148	1484	445	1338	395	1288	1251	746	88	1157	425	422
933	1417	1195	1143	722	1025	1494	183	437	1081	1194	448	912	1027	101	1336	1427	295	410	1075	451	44	1379	390	44	156
508	359	1344	1105	532	1491	630	749	240	985	1327	717	27	581	548	1042	183	1382	560	1157	735	738	762	475	1451	983
1321	186	1102	882	1436	1440	208	1496	715	234	764	1154	1450	1392	1307	575	409	1068	445	256	868	111	875	1176	572	680
147	340	1091	2	491	419	166	268	847	448	737	121	194	1349	1227	1497	1348	327	1348	828	646	135	201	1352	1497	879
739	403	268	928	1349	434	446	868	407	419	470	1418	839	1381	170	957	914	202	982	741	344	982	294	726	1286	662
1188	1002	1342	1023	759	1264	25	1368	1120	245	771	63	291	1117	483	549	348	57	891	191	92	1090	309	772	808	1079

Appendix IV: Beaming productivity per day

day	pro/day	day	pro/day	day	pro/day	day	pro/day	day	pro/day	day	pro/day	day	pro/day	day	pro/day
1	75.83	27	0	53	935.3	79	669.7	105	1034	131	567.8	157	0	183	1034
2	0	28	931.2	54	864.2	80	1131.4	106	0	132	1195.4	158	0	184	0
3	732.49	29	457.9	55	0	81	1136.4	107	1055.1	133	959.6	159	676.204	185	1055.1
4	750.96	30	894.2	56	1100.9	82	1119	108	836.7	134	1321.3	160	803.152	186	836.7
5	488.48	31	336.3	57	679.3	83	1100	109	1095.3	135	1348.4	161	200	187	1095.3
6	850	32	760.93	58	848.3	84	0	110	1193.5	136	1433.5	162	932.67	188	1193.5
7	349.89	33	0	59	1135.8	85	825.6	111	524.5	137	960	163	932.67	189	524.5
8	1474	34	846.2	60	1282.3	86	1108.6	112	0	138	1330.8	164	858	190	0
9	478.8	35	0	61	1043.3	87	1050.8	113	1325.8	139	1158.8	165	1281.5	191	1325.8
10	0	36	876.7	62	748.2	88	759.9	114	1234.5	140	1322.8	166	1182.9	192	1234.5
11	305.3	37	0	63	1212.4	89	1090.3	115	1409.2	141	1154.62	167	993.1	193	1409.2
12	725.9	38	0	64	990.2	90	0	116	1256.7	142	960	168	1131.412	194	1256.7
13	0	39	0	65	975.8	91	0	117	1433	143	1308.9	169	1241.7	195	1433
14	1005.5	40	366.5	66	844.3	92	0	118	1365.7	144	949.3	170	1307.8	196	1365.7
15	360.8	41	0	67	1208.7	93	0	119	1312.2	145	1426.8	171	1280.22	197	1312.2
16	947.1	42	960	68	1255.6	94	0	120	1097.4	146	1381.7	172	1548	198	1097.4
17	529.98	43	0	69	830.7	95	0	121	999.7	147	1485.1	173	1359.4	199	999.7
18	985.56	44	960	70	963.3	96	0	122	0	148	700	174	1002.6	200	0
19	551.8	45	0	71	1119.53	97	975.5	123	358	149	700	175	892.73	201	358
20	929.5	46	0	72	1110.6	98	456	124	0	150	1468.7	176	1200.1	202	0
21	1019.8	47	0	73	1148.2	99	0	125	979	151	100	177	1194.7	203	979
22	495.1	48	907.9	74	1596.7	100	356	126	0	152	0	178	1134.5	204	0
23	0	49	0	75	831	101	589	127	678	153	100	179	1223	205	678
24	388.8	50	0	76	0	102	986	128	498	154	100	180	0	206	498
25	645.2	51	1105.9	77	345	103	887	129	498	155	0	181	478	207	498
26	0	52	0	78	345	104	679	130	1257	156	0	182	897	208	1257
total	14090.79		9403.73		23414.63		14920.2		21441.3		23433.52		23751.36		21441.3

Appendix V: Weaving productivity per day

Jul-16

mach no.	prod/day	prod/day	prod/day	prod/day	prod/day	prod/day	prod/day	prod/day	prod/day	prod/day	prod/day	prod/day	prod/day	prod/day	prod/day	prod/day	prod/day	prod/day	prod/day	prod/day	prod/day	prod/day	prod/day	prod/day	prod/day	total pro/day
weave 1	65.6	95.9	95.9	125.1	133.7	124.2	82.6	142.4	138.5	73.3	0	143	143.9	148.6	116.4	86.7	76.8	106.1	0	0	0	0	0	0	0	1898.7
weave 2	62.5	103	99	120.6	83.6	77	0	0	0	66.7	28.1	105.4	94		0	75.3	0	0	0	0	0	0	0	0	0	915.2
weave 3	57.8	100.9	65	130.5	123.6	123.1	114.7	111.9	133.2	139.3	108.6	124.3	137	113.2	124.1	87.7	103.4	98.7	0	0	0	0	0	0	0	1997
weave 4	50.7	128.4	115.2	119	81	64.4	93.6	97.9	0	70.7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	820.9
weave 5	0	0	0	118.6	58.5	97.1	86.4	36.2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	396.8
weave 6	47	93.5	80.7	91.9	104.8	115.4	98.9	0	124.7	138	81.1		0	131.1	118.1	0	84.5	103.2	0	0	0	0	0	0	0	1412.9
weave 7	41.8	83.7	90	97.9	52.8	58	105.3	110.2	86.2	101.3	85.1	31.4	110.2	110.5	103.3	85.5	41.6	79.2	0	0	0	0	0	0	0	1474
weave 8	54	114.8	113.4	141.1	39.4	118	117.4	45.8	63.8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	807.7
weave 9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
weave 10	63.4	128	24.6	88.6	0	0	52.4	77.4	109.6	112.9	45.7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	702.6
weave 11	35.7	95.6	78.3	0	112.6	123.6	110.3	105	0	28	90.9	131.6	176.1	130.1	129.6	134.4	87.4	0	0	0	0	0	0	0	0	1569.2
weave 12	51.7	100.8	95.6	78.6	43.3	102.6	85	91.6	88.3	43.7	58.6	54.1	103.8	88.7	114.5	106.5	65.7	0	0	0	0	0	0	0	0	1373.1
weave 13	60.5	84	97.1	61.9	108	112.2	54.5	85.4	133.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	797.1
weave 14	36.6	69.4	109.9	50.4	77.7	91.2	95.8	47.6	113.5	72.9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	765
weave 15	72.8	154.5	94.3	125.8	57.9	135.5	88.1	103.3	114.6	107.6	61.9	56.4	148.7	136.3	122.8	116.9	110.5	108.7	0	0	0	0	0	0	0	1916.6
weave 16	0	0	88.5	84	35.5	78.5	142.5	0	0	74.5	119.8	128.4	90.2	154.2	91.2	65.9	30.7	0	0	0	0	0	0	0	0	1183.9
weave 17	71.9	108.4	94.7	83.4	45.7	84.5	82.6	0	86.6	73.2	108.6	77.6	0	0	0	0	0	0	0	0	0	0	0	0	0	917.2
weave 18	63.3	86.8	97.6	96.8	49	80.1	81.6	75.5	68.9	0	0	57.5	71.3	0	0	0	0	0	0	0	0	0	0	0	0	828.4
weave 19	41.9	92.3	63.7	129.2	112.7	119.2	95.6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	654.6
weave 20	0	0	0	129.2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	129.2

Dec-17

mach.no.	pro/day	pro/day	pro/day	pro/day	pro/day	pro/day	pro/day	pro/day	pro/day	pro/day	pro/day	pro/day	pro/day	pro/day	pro/day	pro/day	pro/day	pro/day	pro/day	pro/day	pro/day	pro/day	pro/day	pro/day	pro/day	total pro/day
weave1	122.6	117.5	116	112.8	144	120.2	139.2	169.3	186	110.1	144	109.6	204.7	183.2	104.1	91.4	118	109.3	77.4	79.3	132.7	172.7	90.8	90.6	163.2	3208.7
weave2	113.5	105.4	100.4	149.1	136.9	112.9	102.9	166.1	174.1	85.1	111.2	123.9	171.6	56.1	71.9	153.7	96.3	99.1	146.9	128.3	95.9	100	161.1	0	142.8	2905.2
weave3	40.8	85	102.5	124.2	0	101.6	94.5	151.7	151.3	109.6	173	147.1	169	190.4	177.1	82.9	82.3	173.1	110.3	46.8	28.3	120	119.3	0	84.3	2665.1
weave4	93.5	46.7	0	0	0	35.8	149	152.3	164	63.9	102	147.4	166.6	50.8	97.3	113.4	111.6	75.7	135	141.6	68.4	167.7	131	83.3	156.4	2453.4
weave5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
weave6	33.5	40.7	108.5	110.9	50	37.6	68.1	177.5	180	37.7	150.2	159.5	74.9	152.8	163.1	176.2	0	98.3	99	96.8	27.5	0	49.6	83.8	128.7	2304.9
weave7	82.8	117.7	113.9	104.1	0	81.1	138.9	175.9	146.2	159.3	125.9	78.9	129.5	136.9	129.9	149.1	0	103.9	158.9	159.3	143.6	129.4	152	85.9	121.1	2924.2
weave8	64.3	69.5	124.4	0	48.7	100	40.3	179.1	181.1	128	182.9	48.8	184	213.9	193.7	0	0	207.4	167.8	153.3	154.1	114.8	125	65.6	132.1	2878.8
weave9	111.5	51.2	58.4	153.9	65.9	112.6	53.6	190	165.7	56	190	156.2	134.6	128.4	196.5	94.2	0	130.9	118.8	166	118.5	192.7	209.3	81.4	153.1	3089.4
weave10	50.8	90	105.6	97.5	49.6	100.3	103	120.8	192.1	136.3	165.3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1211.3
weave11	83.9	115	112	130.2	114.6	107.3	0	229	168.8	67.3	0	107.3	0	135.4	97	138.7	0	166.3	174.8	42	100.9	150.5	168.8	81.6	0	2491.4
weave12	110.9	118.9	51.2	188.8	112.8	123	113.9	156.1	183.6	67.7	99.4	191.4	144.5	194.6	42.9	215.6	194.4	64.9	38.9	70	116	147.6	140	46.6	132.1	3065.8
weave13	109.6	136.6	149.4	156.4	157.6	153	128.1	208	162.3	92.6	206.3	217.8	120.2	0	158.7	186.2	140.7	192.7	186.4	90.7	212.9	204.3	75.6	107.5	172.6	3726.2
weave14	48	53.3	131	195.1	129.7	84.8	102.9	179.4	166.9	0	222	160	63.7	0	176.7	130.9	0	170.6	132.7	171.3	145.5	0	147.6	99.8	165.6	2877.5
weave15	129.5	79.9	69	118	96.3	89.2	129.1	164.3	211	110.1	125.6	0	165	163.1	143.5	176.9	119.3	137.1	160.1	79	121.4	34.3	0	0	68.5	2690.2
weave16	31.7	63.4	72.2	118.1	60.4	30.4	50.4	136.1	136.5	53.6	145.4	155.5	42.1	148.3	143.6	107.3	34.5	84.6	68	77.2	83.1	50.9	42.6	65.2	72.9	2074
weave17	97.2	116.5	0	27.5	98.6	46.2	147	135.7	175.2	105.5	157.3	119.6	130.7	117.3	0	125.8	96.7	138.1	135.3	110.4	102.2	157.1	52	86.7	148	2626.6
weave18	45.2	70.7	102.5	102.6	149.9	0	0	110.9	177.7	0	138.6	206.2	126	175	156.6	129.8	105.8	112	93.5	80.7	104.5	92.3	87.6	0	0	2368.1
weave19	38.3	120	0	129.4	94.6	33.4	94.4		0	0	0	153.2	130.7	144.1	105.2	127.3	56.7	129.8	136.7	86.4	51.3	103.9	148.5	91.5	148.8	2124.2
weave20	26.4	32.3	79.8	64.4	59.5	50.2	52.1	49.2	155.7	119.8	69.5	161.2	110.7	92.9	164.4	48.6	0	174.7	137.6	88.6		0	63.8	50.1	0	1851.5

Jan-17

mach no	pro/day	pro/day	pro/day	pro/day	pro/day	pro/day	pro/day	pro/day	pro/day	pro/day	pro/day	pro/day	pro/day	pro/day	pro/day	pro/day	pro/day	pro/day	pro/day	pro/day	pro/day	pro/day	pro/day	pro/day	pro/day	total pro/day
weave1	122.6	117.5	116	112.8	144	120.2	139.2	169.3	186	110.1	144	109.6	204.7	183.2	104.1	91.4	118	109.3	77.4	79.3	132.7	172.7	90.8	20	163.2	3138.1
weave2	113.5	105.4	100.4	149.1	136.9	112.9	102.9	166.1	174.1	85.1	111.2	123.9	171.6	56.1	71.9	153.7	96.3	99.1	146.9	128.3	95.9	100	161.1	0	142.8	2905.2
weave3	40.8	85	102.5	124.2	0	101.6	94.5	151.7	151.3	109.6	173	147.1	169	190.4	177.1	82.9	82.3	173.1	110.3	46.8	28.3	120	119.3	0	84.3	2665.1
weave4	93.5	46.7	0	0	0	35.8	149	152.3	164	63.9	102	147.4	166.6	50.8	97.3	113.4	111.6	75.7	135	141.6	68.4	167.7	131	83.3	156.4	2453.4
weave5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
weave6	33.5	40.7	108.5	110.9	50	37.6	68.1	177.5	180	37.7	150.2	159.5	74.9	152.8	163.1	176.2	0	98.3	99	96.8	27.5	0	49.6	83.8	128.7	2304.9
weave7	82.8	117.7	113.9	104.1	0	81.1	138.9	175.9	146.2	159.3	125.9	78.9	129.5	136.9	129.9	149.1	0	103.9	158.9	159.3	143.6	129.4	152	85.9	121.1	2924.2
weave8	64.3	69.5	124.4	0	48.7	100	40.3	179.1	181.1	128	182.9	48.8	184	213.9	193.7	0	0	207.4	167.8	153.3	154.1	114.8	125	20	132.1	2833.2
weave9	111.5	51.2	58.4	153.9	65.9	112.6	53.6	190	165.7	56	190	156.2	134.6	128.4	196.5	94.2	0	130.9	118.8	166	118.5	192.7	209.3	20	153.1	3028
weave10	50.8	90	105.6	97.5	49.6	100.3	103	120.8	192.1	136.3	165.3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1211.3
weave11	83.9	115	112	130.2	114.6	107.3	0	229	168.8	67.3	0	107.3	0	135.4	97	138.7	0	166.3	174.8	42	100.9	150.5	168.8	81.6	0	2491.4
weave12	110.9	118.9	51.2	188.8	112.8	123	113.9	156.1	183.6	67.7	99.4	191.4	144.5	194.6	42.9	215.6	194.4	64.9	38.9	70	116	147.6	140	46.6	132.1	3065.8
weave13	109.6	136.6	149.4	156.4	157.6	153	128.1	208	162.3	92.6	206.3	217.8	120.2	0	158.7	186.2	140.7	192.7	186.4	90.7	212.9	0	0	0	0	3166.2
weave14	48	53.3	131	195.1	129.7	84.8	102.9	179.4	166.9	0	222	160	63.7	0	176.7	130.9	0	170.6	132.7	171.3	145.5	0	147.6	99.8	0	2711.9
weave15	129.5	79.9	69	118	96.3	89.2	129.1	164.3	211	110.1	125.6	0	165	163.1	143.5	176.9	119.3	137.1	160.1	79	121.4	34.3	0	0	68.5	2690.2
weave16	31.7	63.4	72.2	118.1	60.4	30.4	50.4	136.1	136.5	53.6	145.4	155.5	42.1	148.3	143.6	107.3	34.5	84.6	68	77.2	83.1	50.9	42.6	65.2	72.9	2074
weave17	97.2	116.5	0	27.5	98.6	46.2	147	135.7	175.2	105.5	157.3	119.6	130.7	117.3	0	125.8	96.7	138.1	135.3	110.4	102.2	157.1	52	86.7	148	2626.6
weave18	45.2	70.7	102.5	102.6	149.9	0	0	110.9	177.7	0	138.6	206.2	126	175	156.6	129.8	105.8	112	93.5	80.7	104.5	92.3	87.6	0	0	2368.1
weave19	38.3	120	0	129.4	94.6	33.4	94.4		0	0	0	153.2	130.7	144.1	105.2	127.3	56.7	129.8	136.7	86.4	51.3	103.9	148.5	91.5	148.8	2124.2
weave20	26.4	32.3	79.8	64.4	59.5	50.2	52.1	49.2	155.7	119.8	69.5	161.2	110.7	92.9	164.4	48.6	0	174.7	137.6	88.6		0	63.8	50.1	0	1851.5

Feb-17

mach.no	pro/day	pro/day	pro/day	pro/day	pro/day	pro/day	pro/day	pro/day	pro/day	pro/day	pro/day	pro/day	pro/day	pro/day	pro/day	pro/day	pro/day	pro/day	pro/day	pro/day	pro/day	pro/day	pro/day	pro/day	pro/day	total pro/day
weave1	0	0	130.4	93.2	132.7	101.1	123.4	35	166.7	93	177.1	140.6	145.3	101.4	118.4	0	0	0	0	0	0	0	0	0	0	1558.3
weave2	106.1	230.3	149.1	122.8	135.4	142.3	131	100	76.7	143.5	166.4	145.3	108.6	103.8	153.4	0	0	0	0	0	0	0	0	0	0	2014.7
weave3	130.1	76.5	102.6	132.2	102.6	109.7	137.7	102.9	168.1	116.8	0	117.6	150.7	115.5	136.4	0	0	0	0	0	0	0	0	0	0	1699.4
weave4	94.4	156.9	112.6	119.1	122.7	56.5	142.6	146.7	150.2	138.8	203.7	75.5	144.8	109.9	159.4	0	0	0	0	0	0	0	0	0	0	1933.8
weave5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
weave6	125.9	100.9	120.4	91.5	97	95	153.4	133.9	139.5	146.2	87.6	173.6	147.2	102.9	112.4	0	0	0	0	0	0	0	0	0	0	1827.4
weave7	77.6	107.6	39.3	125	104.2	106.6		0	165.9	158.7	168.3	178.1	137.6	144.9	152.4	0	0	0	0	0	0	0	0	0	0	1666.2
weave8	101.5	91.1	138.5	93.1	93.5	161.6	154.3	151.6	78.2	170.5	168.6	135	132.9	150.4	147.3	0	0	0	0	0	0	0	0	0	0	1968.1
weave9	72.7	80.5	64.7	95.6	85.7	114.2	96.6	132.1	124.6	132.7	146.7	117	144	125.7	118.7	0	0	0	0	0	0	0	0	0	0	1651.5
weave10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
weave11	65.3	93	120.9	167.3	135.4	141.5	157.8	129.6	137.1	121.5	150.3	72.1	124	143.5	112.8	0	0	0	0	0	0	0	0	0	0	1872.1
weave12	131.3	67.4	116.5	129	110.7	110.2	110.8	77.3	153.2	127.7	194.7	128.5	149.9	85.6	130.3	0	0	0	0	0	0	0	0	0	0	1823.1
weave13	60.5	154.2	182.3	161.5	127.6	171.9	165.6	146.9	138	144.9	71.5	133.5	98.5	95.3	123.6	0	0	0	0	0	0	0	0	0	0	1975.8
weave14	123.8	157.6	163.1	191.3	148.1	147.8	175	115.1	70.7	84.3	90.1	57.2	114.9	227.4	155.9	0	0	0	0	0	0	0	0	0	0	2022.3
weave15	176.5	73.1	119	61.7	76.3	104.3	120.5	134.2	128.5	160.9	88	213	123.8	0	0	0	0	0	0	0	0	0	0	0	0	1579.8
weave16	0	93.6	80.2	156.2	127.1	0	135.5	90.7	132.7	0	154.3	81.7	110	145.1	175	0	0	0	0	0	0	0	0	0	0	1482.1
weave17	37.8	110.2	145.8	116.8	146	131.2	166.3	124.8	138.6	120	165.8	75.6	95.4	44.4	121.5	0	0	0	0	0	0	0	0	0	0	1740.2
weave18	100	99.4	97	121.2	128.5	90	142	145.9	94.5	187.1	0	0	0	78.7	115.4	0	0	0	0	0	0	0	0	0	0	1399.7
weave19	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
weave20	0	0	0	0	0	131.2	144	129.3	0	0	0	0	132.6	0	63.6	0	0	0	0	0	0	0	0	0	0	600.7

Mar-17

mac.no	pro/day	pro/day	pro/day	pro/day	pro/day	pro/day	pro/day	pro/day	pro/day	pro/day	pro/day	pro/day	pro/day	pro/day	pro/day	pro/day	pro/day	pro/day	pro/day	pro/day	pro/day	pro/day	pro/day	pro/day	pro/day	total pro/day
weave 1	148.4	142.7	133.8	114.7	120	123.9	181.6	0	227.2	178.5	177.5	179.6	174.8	106.1	120	154	120	120	120	130.4	120	120	99.8	0	0	3113
weave 2	145.4	134.8	174.8	233.4	153.2	177	188.7	159.8	120	120	120	120	120	120	120	0	120	120	112.7	120	107.6	150	150	0	0	3087.4
weave 3	124.2	189.3	105.7	136.3	101.2	119.7	173.8	0	180.7	190.2	168.7	168.1	0	146	120	120	107.9	120	120	120	120	120	140	0	0	2891.8
weave 4	83.4	186.7	72.4	52.7	99.2	127.6	142.2	0	142.7	155.6	163.9	189.8	168.9	70.1	193.7	183.3	154.6	200.5	191.5	156.7	195.8	155.1	145.6	0	0	3232
weave 5	0	0	0	0	0	0	0	0	0	0	148.6	107	80.8	128.2	73.9	121.9	123.9	108.8	134.8	125.1	82.6	114.1	135.9	0	0	1485.6
weave 6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	125.1	120	0	0	245.1
weave 7	152.1	160	90.3	108.4	113.7	106.8	196.5	0	167	149.9	179.9	177	165	159.9	71.1	263.9	139.5	179.9	75	108.1	0		45.4	0	0	2809.4
weave 8	93.9	189.2	129.3	118.8	128.6	128	141.4	0	0	0	0	0	0	0	0	0	0	0	143.9	164.5	187.1	167.2	122.5	0	0	1714.4
weave 9	120	120	120	156	158.3	169.7	213.2	150.6	206.9	203.2	120	120	120	193	113.3	120	120	120	120	120	120	119.7	120.6	0	0	3244.5
weave 10	169.9	146.7	142.4	117	108.7	148.4	165.1	0	159.4	152.5	82.5	130.2	193.8	43.8	176.1	192.5	91.7	172.5	144.6	110.7	94.7	122.3	109.2	0	0	2974.7
weave 11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
weave 12	122.5	130.1	0	179	148.7	129.4	119.5	125.4	95.6	227.7	156.7	117.8	152.5	78.1	126.2	116.3	149	136.9	187.8	206.1	115.2	66.5	110.7	0	0	2997.7
weave 13	146.7	140.2	105.8	182.9	117.6	117.6	152	0	153.8	179.5	169.1	171.3	150.1	94	50.3	173.9	107.1	169.1	149.3	164.2	0	70.8	117.1	0	0	2882.4
weave 14	142	171.9	133.3	124	177	178.9	167.8	130.2	120	120	176.2	156.1	120	197.5	163.8	170.3	110.7	60	120	120	60	100	60	0	0	3079.7
weave 15	144.8	171.7	153.2	146.1	174.7	130.6	180.6	145	0	196.9	221	160.8	120	178.9	149	178.1	105.5	163.1	120	120	98.2	118.1	145	0	0	3321.3
weave 16	134.8	155	33.3	122.1	111.7	71.9	172.4	0	182.3	150.4	141.5	168.2	198.4	99.6	193.9	94.1	165.1	206.5	140.8	134.8	140.7	106.1	106.8	0	0	3030.4
weave 17	141.6	97.4	126.6	121.3	131.6	132.5	171.5	144.2	54.5	65.7	123.1	60.2	154.2	113.8	134.9	109.9	125.1	136.2	151.1	125.8	70.9	102.8	112.5	0	0	2707.4
weave 18	140.5	166.8	158.3	96.9	100.3	125.5	113.8	0	187.2	191.6	196.7	201.7	0	109.6	0	147.8	68.1	139.2	156.8	153.1	80.1	113.4	106.4	0	0	2753.8
weave 19	140.9	194.5	91.8	141.7	70.3	0	0	0	0	0	0	0	0	110.8	0	0	143.3	123.3	0	0	0	0	480	0	0	1496.6
weave 20	0	0	0	0	0	0	0	0	0	0	99.9	149.2	0	0	0	0	0	0	122.1	119.3	63	101.8	86.6	0	0	741.9

May-17

mach.no	pro/day	pro/day	pro/day	pro/day	pro/day	pro/day	pro/day	pro/day	pro/day	pro/day	pro/day	pro/day	pro/day	pro/day	pro/day	pro/day	pro/day	pro/day	pro/day	pro/day	pro/day	pro/day	pro/day	pro/day	pro/day	total pro/day
weave1	0	0	0	0	101.7	120.4	99.1	0	156.1	109.2	188.9	77.7	131.7	28.1	122.2	103.1	116	128.1	171	118.9	199.3	184.8	193.4	205.4	161.7	2716.8
weave2	0	0	0	31.1	103.1	108.8	79.2	0	155	193.8	124.1	162.2	123.3	175.4	241.3	214.4	154.8	195.9	0	175	180.2	162.5	135	169.8	22.8	2907.7
weave3	0	0	0	0	94.1	109.7	105.6	0	148.8	133.2	167.9	50.1	145.9	0	124	142.6	48.7	149	132.5	122.7	186	174.3	202	181.8	130.6	2549.5
weave4	0	0	0	0	110.2	109.9	0	0	153	191.2	171	51	122.8	138.9	156.3	146.8	148.9	170.9	132.2	148	160.3	182.3	187.1	182.7	138.5	2802
weave5	0	0	0	0	0	0	92.5	0	106.3	134.5	57	139.1	120.1	64.9	157.7	144.7	181.1	0	0	0	88.2	293.6	163.8	134.3	68.3	1946.1
weave6	0	0	0	28.5	123.1	118.3	100.1	0	0	184	115.6	107.7	88	117.4	37.5	130.1	112.6	137.6	159.5	117.8	116.5	119.4	137	143.5	0	2194.2
weave7	0	0	0	111.5	79.2	108.8	106.7	0	120.4	160.2	180.9	0	103	118.9	128.1	137.6	132.2	0	109.4	150.6	138.2	150.5	117.2	177.4	134.5	2465.3
weave8	0	0	0	0	0	0	0	0	96.9	121.9	150.9	48	65.8	142.7	109.3	127.5	133	123.5	120.7	136	129.6	172.7	144.9	177	133.1	2133.5
weave9	0	0	0	0	0	0	0	0	185.6	186.4	0	191.4	107.7	159.8	203.9	162.9	181.3	167.9	156.3	160.3	161.4	164.7	105.2	176.3	131.4	2602.5
weave10	0	0	0	60.8	118.6	110.2	84.6	0	140.4	196.7	178	63.9	116.3	85.5	144.4	154.1	86.5	123.3	125.8	71.6	239.9	149.3	165	202.9	122.9	2740.7
weave11	0	0	0	0	128.2	127.8	109.2	0	0	136	121.2	146.5	123.8	132.7	151.1	0	64	132.6	126.5	101.6	142.6	262.5	149.8	143.1	0	2299.2
weave12	0	0	0	87.7	117.3	0	83.6	0	113.7	0	148.8	0	135.8	137.7	157	131.2	178	184	168.7	160.7	145	111	113.7	118.5	120.3	2412.7
weave13	0	0	0	57.7	90.4	110.8	0	0	141.5	182.5	112.1	127.6	83.8	125.7	143.8	104.5	85	131.7	112.8	121.8	25.3	0	0	168.3	175.8	2101.1
weave14	0	0	0	55.7	16.4	82.8	105.3	0	117.1	136.6	107	56.3	139.7	105.6	177.3	152.5	168.9	158.7	83.1	136.3	136.7	186.9	126.8	155.3	104.4	2509.4
weave15	0	0	0	40.9	115.4	125.4	97.9	0	169.9	105.1	150.1	132.8	142	137.3	204.7	213.8	207.8	204.8	69.7	189.8	150	143.6	135.5	120.1	122	2978.6
weave16	0	0	0	0	0	102.7	101.8	0	157.1	148.2	159.9	86.7	62.4	108.8	144.2	125.6	20.3	113.9	99.5	104.2	0	148.8	149.8	160.1	138.8	2132.8
weave17	0	0	0	80.4	0	93.7	116.5	0	114.1	142	73	141.7	96.1	145.4	147.2	109.6	105.1	134.1	132.6	125.5	110	49.2	116.4	144	104.7	2281.3
weave18	0	0	0	0	0	69.8	101.4	0	152.6	74	96.9	47.4	123	109.7	138.7	133.3	152.5	128.1	120.2	107.9	106	110.5	105.3	110	86.3	2073.6
weave19	0	0	0	0	41.2	94.2	114.66	0	0	0	0	117.2	90.3	132.6	97.9	106	130.8	129.3	126.2	177.5	147.3	188.8	146	169	48.6	2057.56
weave20	0	0	0	0	0	0	104.7	0	0	0	0	78.2	117.9	160.4	140.1	0	162.5	128.9	197.3	178.9	164.9	132	114.7	98.5	0	1779

Appendix VI: Sewing productivity per day

Jul-16

mach.no	pro/day	pro/day	pro/day	pro/day	pro/day	pro/day	pro/day	pro/day	pro/day	pro/day	pro/day	pro/day	pro/day	pro/day	pro/day	pro/day	pro/day	pro/day	pro/day	pro/day	pro/day	pro/day	pro/day	pro/day	pro/day	
hemming1	0	858.8	901.5	1015.8	881.9	896	1129.6	898.8	789.6	960.2	657.1	549.5	685.6	604.8	745	796.5	537.6	759.4	397.8	0	0	0	0	0	0	14065.5
hemming2	0	813.7	919.2	1168.8	1091.2	851.7	0	0	604.6	0	699.5	540.5	585.3	0	0	0	0	0	0	0	0	0	0	0	0	7274.5
overaging	0	717	688.7	564.72	385.6	0	0	0	506.4	467.8	363.8	0	368.9	174.3	0	0	0	0	0	0	0	0	0	0	0	4237.22
overaging	0	717	688.7	564.72	385.6	534.2	580.4	543.4	506.4	467.8	363.8	297	0	174.3	0	0	537.6	759.4	0	0	0	0	0	0	0	7120.32
overaging	0	0	0	0	0	0	526.3	520	495.1	660.7	392.3	263.2	298.98	459.1	416.6	300.2	415.3	300	179.2	0	0	0	0	0	0	5226.98
stitching 1	0	447.7	623.2	673.96	590.3	540.1	595.3	549.2	467	576.5	334	0	365.4	291.7	378.1	0	284.5	344.9	0	0	0	0	0	0	0	7061.86
stitching 2	0	447.7	623.2	673.96	590.3	540.1	595.3	0	467	576.5	334	0	365.4	291.7	378.1	0	284.5	344.9	0	0	0	0	0	0	0	6512.66

Dec-17

mach.no.	pro/day	pro/day	pro/day	pro/day	pro/day	pro/day	pro/day	pro/day	pro/day	pro/day	pro/day	pro/day	pro/day	pro/day	pro/day	pro/day	pro/day	pro/day	pro/day	pro/day	pro/day	pro/day	pro/day	pro/day	pro/day	
hemming1	988.4	1169.9	0	0	0	971	1031.4	0	0	0	0	0	0	0	0	0	0	0	537.6	856.7	858.6	732.9	0	555.7	671.6	8373.8
hemming2	1112.8	1145.3	953.1	554.4	864.3	939.3	1423.4	1641.8	1128.8	932.9	823.5	1135.8	918.3	1260.6	1142	709.4	1149.8	1002	860	1102.9	1075.4	970	995.7	693.3	874.3	25409.1
overaging	548.3	789.3	823.5	639.9	1010.2	960.9	714.1	873.5	880	685.8	849.9	831.4	761.8	1021.4	850.2	526.7	820	929.3	645.6	824.4	898.9	746.8	898.7	611.7	639.2	19781.5
overaging	627.7	666.1	432	470.3	270	531.9	687.3	700.9	800	612.5	750.9	938.7	706.4	0	830.9	503.3	675.7	823.9	606.1	771.6	827.6	538.2	634.9	527.9	591.7	15526.5
overaging	493.9	0	702	0	0	525.1	476	574.98	580.7	534.12	467.8	665.9	472.8	790.4	591.7	457	596.5	740.3	470.3	703.4	643.8	581	628.4	524.3	354.8	12575.2
stitching 1	0	0	900	885.9	761.5	858.4	0	0	1135.6	759.7	822.8	887.4	1081.8	977.5	820	714	0	1047	821.4	0	0	0	1436.3	683.6	844.8	15437.7
stitching 2	529.4	1005.3	747	603.4	611.7	635.2	1031.4	574.98	0	703.9	656	811.4	721.6	808.4	691.4	620	461.8	874	537.6	716.9	794.6	758.1	728.8	570	723.8	16916.68

Jan-17

mach.no	pro/day	pro/day	pro/day	pro/day	pro/day	pro/day	pro/day	pro/day	pro/day	pro/day	pro/day	pro/day	pro/day	pro/day	pro/day	pro/day	pro/day	pro/day	pro/day	pro/day	pro/day	pro/day	pro/day	pro/day	pro/day	
hemming 1	988.4	1169.9	0	0	0	971	1031.4	0	0	0	0	0	0	0	0	0	0	0	537.6	856.7	858.6	732.9	0	555.7	671.6	8373.8
hemming 2	1112.8	1145.3	953.1	554.4	864.3	939.3	1423.4	1641.8	1128.8	932.9	823.5	1135.8	918.3	1260.6	1142	709.4	1149.8	1002	860	1102.9	1075.4	970	995.7	693.3	500	25034.8
overaging	548.3	789.3	823.5	639.9	1010.2	960.9	714.1	873.5	880	685.8	849.9	831.4	761.8	1021.4	850.2	526.7	820	929.3	645.6	824.4	898.9	746.8	0	0	0	17631.9
overaging	627.7	666.1	432	470.3	270	531.9	687.3	700.9	800	612.5	750.9	938.7	706.4	0	830.9	503.3	675.7	823.9	606.1	771.6	827.6	538.2	634.9	527.9	591.7	15526.5
overaging	493.9	0	702	0	0	525.1	476	574.98	580.7	534.12	467.8	665.9	472.8	790.4	591.7	457	596.5	740.3	470.3	703.4	643.8	581	628.4	524.3	354.8	12575.2
stitching 1	0	0	900	885.9	761.5	858.4	0	0	1135.6	759.7	822.8	887.4	1081.8	977.5	820	714	0	1047	821.4	0	0	0	1436.3	683.6	844.8	15437.7
stitching 2	529.4	1005.3	747	603.4	611.7	635.2	1031.4	574.98	0	703.9	656	811.4	721.6	808.4	691.4	620	461.8	874	537.6	716.9	794.6	758.1	728.8	570	723.8	16916.68

Feb-17

mach no.	pro/day	pro/day	pro/day	pro/day	pro/day	pro/day	pro/day	pro/day	pro/day	pro/day	pro/day	pro/day	pro/day	pro/day	pro/day	pro/day	pro/day	pro/day	pro/day	pro/day	pro/day	pro/day	pro/day	pro/day	pro/day	
hemming1	1026.8	993.4	1062.5	1035.6	1204.7	867.1	981.4	1002.8	1031.2	952.4	978	992	851.2	851.2	872	940.8	0	0	0	0	0	0	0	0	0	15643.1
hemming2	496.9	587	903.4	829.5	829.9	955.6	791.6	0	847.8	889.4	854.6	886.5	1161	995.3	752.6	676.5	0	0	0	0	0	0	0	0	0	12457.6
overaging1	707.2	593.2	771.4	840	893.3	923.7	760.6	700.7	857.4	737	723.2	824.1	929	847.4	676.5	663	0	0	0	0	0	0	0	0	0	12447.7
overaging2	0	0	0	711.2	711.2	575.5	887.3	861.8	735.4	781.8	560	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5824.2
overaging3	0	560.3	663.2	607.7	816	801.6	788.1	537.2	922.6	428	608.4	618	656.6	711.3	539.8	582.4	0	0	0	0	0	0	0	0	0	9841.2
stitching 1	545.6	1059	565.8	979	826.1	880	813.1	771.6	1049.7	746.8	660.2	769.2	798	793	933.7	694.4	0	0	0	0	0	0	0	0	0	12885.2
stitching 2	579.4	993.4	846.6	863.4	825.4	585	724.8	724.8	908.7	803.2	524	755	518.8	0	629.4	593.6	0	0	0	0	0	0	0	0	0	10875.5

Mar-17

mach.no	pro/day	pro/day	pro/day	pro/day	pro/day	pro/day	pro/day	pro/day	pro/day	pro/day	pro/day	pro/day	pro/day	pro/day	pro/day	pro/day	pro/day	pro/day	pro/day	pro/day	pro/day	pro/day	pro/day	pro/day	pro/day	
hemming1	0	944	1109.2	1126	1129.6	1376	1163	0	1134	1121.6	746	948.4	1308.4	952.4	1448.9	1036	740	962	1287.6	1554	1036	0	0	0	0	21123.1
hemming2	0	648.1	909	640.8	1099.4	1127.7	606.4	639.4	1151	1223.9	933.4	959	1137.2	735.2	1140.8	815.5	832.5	0	0	0	0	910.2	0	0	0	15509.5
overaging	0	632.5	673.5	648.96	637.52	896.9	1069.7	909.6	1048	968.2	923.2	1025.24	850.3	706.8	870.9	769.6	839.6	791.8	847.2	0	714.1	802.6	0	0	0	16626.22
overaging	0	622	797.2	879.2	834	682.8	857.2	0	695.6	723.6	730	699.2	890.8	584.8	886.3	873.2	814	0	0	0	710.4	0	0	0	0	12280.3
overaging	0	574.2	869.7	840.6	686	825.1	864.2	0	781.2	670.1	784.2	806.4	1134.4	783.7	1326.4	1099.2	828.8	0	976.8	1024.2	817.6	0	0	0	0	15692.8
stitching 1	0	828.5	754.2	720	948.2	1090.2	0	0	0	782.5	768.9	0	771.8	0	0	654.9	777	893.2	854.7	0	936.1	0	0	0	0	10780.2
stitching 2	0	805.7	626.9	761.4	837.6	0	1051.5	987.8	1153.2	1008.6	971.5	1080.9	888.9	918.2	0	700.3	814	821.4	814	1	525.4	669.7	0	0	0	15438

May-17

mach no.	pro/day	pro/day	pro/day	pro/day	pro/day	pro/day	pro/day	pro/day	pro/day	pro/day	pro/day	pro/day	pro/day	pro/day	pro/day	pro/day	pro/day	pro/day	pro/day	pro/day	pro/day	pro/day	pro/day	pro/day	pro/day	
hemmimg	0	0	0	0	589.6	896.9	1016.96	0	1015.8	1166	992.5	992.2	901.12	0	1304.3	1400	1414.6	1449.1	1421.8	1337.7	1109.18	1059.88	358.1	1133.4	1167.7	20726.84
hemmimg	0	0	0	0	0	672	694.4	0	1055.8	1031	983.8	876.4	854.6	480.16	910.4	0	0	861.2	672.2	747.6	991.56	1026.6	1200	1324	1112.3	15494.02
overaging1	0	0	0	0	548.66	525.8	685.44	0	0	921.2	669.9	470.3	782.5	592.3	856.8	951.25	541.24	743.5	446.9	650.8	1091.14	965.86	955.62	786.2	548.4	13733.81
overaging2	0	0	0	0	548.66	525.8	685.44	0	754.8	732.9	763.5	524.82	730.4	447.24	770.5	893	551.4	913	890.4	933.5	838.4	809.02	1076	971.4	975	15335.18
overaging3	0	0	0	0	441.26	0	0	0	0	832.9	0	539.4	684.2	863.32	548.04	112.4	500.2	652.6	605.7	624.8	797.16	788.62	0	0	548.4	8539
stiching 1	0	0	0	0	589.6	896.9	1016.96	0	0	980.8	742.5	597.5	0	560.08	638.86	747.6	804.3	710.4	445.7	390.2	929.04	784.24	927.98	864.9	557	13184.56
stiching 2	0	0	0	0	0	672	120.4	0	567.1	667.8	619.5	565.1	623.94	0	1016.3	825.76	485.2	894.5	707.7	947.7	772.16	609.06	821.88	1052.9	941.7	12910.7

Appendix VII: Data collection of statistical package for social science (SPSS) for questioner

	Name	Type	Width	Decimals	Label	Values	Missing	Columns	Align	Measure	Role
1	gender	String	8	0	gender	{1, male}...	None	4	Left	Nominal	Input
2	age	Numeric	8	0	age	{1, 18-24}...	None	4	Left	Ordinal	Input
3	edulev	Numeric	7	0	educational l...	{1, primary}...	None	5	Left	Ordinal	Input
4	workexp	Numeric	8	0	Work experi...	{1, Less tha...	None	8	Left	Ordinal	Input
5	joppos	String	8	0	job position	{1, beaming ...	None	9	Left	Ordinal	Input
6	workenv1	Numeric	8	0	The machin...	{1, Strongly ...	None	8	Right	Scale	Input
7	workenv2	Numeric	8	0	You receive ...	{1, Strongly ...	None	8	Right	Scale	Input
8	workenv3	Numeric	8	0	The workpla...	{1, Strongly ...	None	8	Right	Scale	Input
9	workenv4	Numeric	8	0	You have ac...	{1, Strongly ...	None	8	Right	Scale	Input
10	skiandtra1	Numeric	8	0	You receive...	{1, Strongly ...	None	8	Right	Scale	Input
11	skiandtra2	Numeric	8	0	You underst...	{1, Strongly ...	None	8	Right	Scale	Input
12	skiandtra3	Numeric	8	0	You have op...	{1, Strongly ...	None	8	Right	Scale	Input
13	skiandtra4	Numeric	8	0	You can tro...	{1, Strongly ...	None	8	Right	Scale	Input
14	worproandpr1	Numeric	8	0	You can me...	{1, yes}...	None	5	Right	Scale	Input
15	worproandpr2	Numeric	8	0	Work instru...	{1, yes}...	None	6	Right	Scale	Input
16	worproandpr3	Numeric	8	0	Materials (y...	{1, yes}...	None	4	Right	Scale	Input
17	worproandpr4	Numeric	8	0	The workflo...	{1, yes}...	None	5	Right	Scale	Input
18	perfoandqu1	Numeric	8	0	You consist...	{1, yes}...	None	4	Right	Scale	Input
19	perfoandqu2	Numeric	8	0	You rarely ...	{1, yes}...	None	4	Right	Scale	Input
20	perfoandqu3	Numeric	8	0	Your supervi...	{1, yes}...	None	4	Right	Scale	Input
21	perfoandqu4	Numeric	8	0	You feel co...	{1, yes}...	None	4	Right	Scale	Input
22	sahealmot1	Numeric	8	0	You use per...	{1, yes}...	None	4	Right	Scale	Input
23	sahealmot2	Numeric	8	0	You feel saf...	{1, yes}...	None	5	Right	Scale	Input
24	sahealmot3	Numeric	8	0	The work en...	{1, yes}...	None	4	Right	Scale	Input
25	sahealmot4	Numeric	8	0	You feel mot...	{1, yes}...	None	3	Right	Scale	Input
26	sahealmot5	Numeric	8	0	You feel sati...	{1, yes}...	None	5	Right	Scale	Input
27	simumod1	Numeric	8	0	What specifi...	{1, open-end...	None	5	Right	Scale	Input
28	simumod2	Numeric	8	0	How confide...	{1, Very con...	None	4	Right	Scale	Input

29	simumod3	Numeric	8	0	Do you think...	{1, Yes}...	None	4	Right	Scale	Input
30	simumod4	Numeric	8	0	Would you s...	{1, Yes}...	None	5	Right	Scale	Input
31	simumod5	Numeric	8	0	What challe...	{1, working ...	None	17	Right	Scale	Input
32	simumod6	Numeric	8	0	What improv...	{1, Access ...	None	8	Right	Scale	Input
33	impro1	Numeric	8	0	How often d...	{1, Very freq...	None	8	Right	Scale	Input
34	impro2	Numeric	8	0	How do you ...	{1, Very neg...	None	8	Right	Scale	Input
35	improv3	Numeric	8	0	What factor...	{1, Product ...	None	8	Right	Scale	Input

Appendix VIII: Simulation modeling result

9:29:28AM **Category Overview** January 27, 2026

Values Across All Replications

factor influence the operator performance on jute bag manufacturing

Replications: 25 Time Units: Hours

Process

Time per Entity

VA Time Per Entity	Average	Half Width	Minimum Average	Maximum Average	Minimum Value	Maximum Value
beaming	745.40	79.69	381.46	1222.58	4.8748	1594.85

Wait Time Per Entity	Average	Half Width	Minimum Average	Maximum Average	Minimum Value	Maximum Value
beaming	2366.84	268.57	1298.05	4164.71	0.00	8033.18

Total Time Per Entity	Average	Half Width	Minimum Average	Maximum Average	Minimum Value	Maximum Value
beaming	3112.23	339.57	1679.51	5387.29	156.85	8550.73

Accumulated Time

Accum VA Time	Average	Half Width	Minimum Average	Maximum Average
beaming	5340.19	641.25	2288.79	8558.03
finished jute bag	0.00	0.00	0.00	0.00
hemming	0.00	0.00	0.00	0.00
over aging	0.00	0.00	0.00	0.00
stitching	0.00	0.00	0.00	0.00
weaving	0.00	0.00	0.00	0.00

Replications: 25 Time Units: Hours

Process

Time per Entity

VA Time Per Entity	Average	Half Width	Minimum Average	Maximum Average	Minimum Value	Maximum Value
beaming	745.40	79.69	381.46	1222.58	4.8748	1594.85

Wait Time Per Entity	Average	Half Width	Minimum Average	Maximum Average	Minimum Value	Maximum Value
beaming	2366.84	268.57	1298.05	4164.71	0.00	8033.18

Total Time Per Entity	Average	Half Width	Minimum Average	Maximum Average	Minimum Value	Maximum Value
beaming	3112.23	339.57	1679.51	5387.29	156.85	8550.73

Accumulated Time

Accum VA Time	Average	Half Width	Minimum Average	Maximum Average
beaming	5340.19	641.25	2288.79	8558.03
finished jute bag	0.00	0.00	0.00	0.00
hemming	0.00	0.00	0.00	0.00
over aging	0.00	0.00	0.00	0.00
stitching	0.00	0.00	0.00	0.00
weaving	0.00	0.00	0.00	0.00

Queue Detail Summary

Time

	Waiting Time
beaming.Queue	2133.12

Cost

	Waiting Cost
beaming.Queue	0.00

Other

	Number Waiting
beaming.Queue	2.87
finished jute bag.Queue	0.00
hemming.Queue	0.00
over aging.Queue	0.00
stitching.Queue	0.00
weaving.Queue	3.13

Appendix ix: jute bag manufacturing annual budget 2016/2017 E.C productivity performance reports for machine capacity of availability

No.	Performance measurement	2016/2017 annual year jute bag production performance		
		Planned	performed	%
1	Design production capacity(pcs /hour)	430	326.57	75.95
2	Attainable production capacity(pcs/hour)	409	326.57	79.94
3	design production capacity/%)	90	75.95	84.93
4	Attainable production capacity (%/	95	75.95	7 9.94

Appendix x: jute bag manufacturing annual budget 2016/2017 E.C productivity performance reports for annual year weaving machine usability report

Machine list	Machine downtime per hour							Machine workable time per hour
	Mechanical	Power interruption	Beaming change	Lack of raw material	employee	electrical	total	Normal time

Weave 1	75.80	16.5	81.50	500.00	39.50	6.75	1659.30	3140.70
Weave 2	30.25	25.5	109.00	500.00	76.50	0.00	1720.25	3079.75
Weave 3	43.10	24.5	100.10	500.00	69.50	0.00	1657.70	3142.30
Weave 4	46.85	19.5	95.00	500.00	0.00	5.75	1692.85	3107.15
Weave 5	52.50	16.5	106.75	500.00	141.00	0.00	1683.25	3116.75
Weave 6	16.00	29.5	70.50	500.00	71.50	0.50	1462.00	3338.00
Weave 7	26.70	25.5	66.50	500.00	135.50	0.00	1685.95	3114.05
Weave 8	16.75	16.5	93.00	500.00	48.00	3.50	1633.25	3166.75
Weave 9	35.00	36.5	80.50	500.00	73.00	17.50	1667.00	3133.00
Weave 10	26.5	26.5	69.50	500.00	32.00	2.75	1550.25	3249.75
weave 11	29.00	29.5	74.60	500.00	51.50	3.00	1575.85	3224.15
Weave 12	42.90	36.5	71.75	500.00	35.00	3.00	1555.15	3244.85
Weave 13	344.40	18	95.00	500.00	151.00	2.00	1752.15	3047.85
Weave 14	22.15	26.5	72.50	500.00	38.00	0.00	1412.65	3387.35
Weave 15	13.00	19.8	105.00	500.00	111.00	0.00	1549.80	3250.20
Weave 16	36.50	58	72.10	500.00	81.50	2.00	1566.35	3233.65
Weave 17	1238.75	16.5	39.00	500.00	26.00	0.00	2476.50	2323.50
Weave 18	58.25	26.5	57.00	500.00	120.50	13.50	1666.25	3133.75
Weave 19	31.90	16.5	65.00	500.00	135.50	87.00	1634.90	3165.10
Weave 20	67.50	26.5	82.50	500.00	75.50	135.25	1720.00	3080.00

total	2253.8	511.3	1606.8	10000	1512	282.5	33321.4	62678.6
average	112.69	25.565	80.34	500	75.6	14.125	1666.07	3133.93

Appendix xi: weaving machine performance in case of the annual plan of the jute bag manufacturing for weaving machine performance 2016/2017 annual report

No.	Machine list	Weaving machine availability in annual performance plan in (%)		
		planned(hr)	performed(hr)	%
1	weave 1	4800.00	3140.70	65.43
2	weave 2	4800.00	3079.75	64.16
3	weave 3	4800.00	3142.30	65.46
4	weave 4	4800.00	3107.15	64.73
5	weave 5	4800.00	3116.75	64.93
6	weave 6	4800.00	3338.00	69.54
7	weave 7	4800.00	3114.05	64.88
8	weave 8	4800.00	3166.75	65.97
9	weave 9	4800.00	3133.00	65.27
10	weave 10	4800.00	3249.75	67.70
11	weave 11	4800.00	3224.15	67.17
12	weave 12	4800.00	3244.85	67.60
13	weave 13	4800.00	3047.85	63.50
14	weave 14	4800.00	3387.35	70.57
15	weave 15	4800.00	3250.20	67.71
16	weave 16	4800.00	3233.65	67.37
17	weave 17	4800.00	2323.50	48.41
18	weave 18	4800.00	3133.75	65.29

19	weave 19	4800.00	3165.10	65.94
20	weave 20	4800.00	3080.00	64.17
total sum		96000.00	62678.60	65.29
average		4800.00	3133.93	65.29

College of Technology and Built Environment

School of Mechanical and Industrial Engineering

Date: - September 30, 2025

DATA COLLECTION REQUEST FORM

To: Horizon plantation coffee processing and warehousing plc

Mr./Mrs. Senunet Reza Menbesha

is a BSc/MSc/PhD student in our School at College of Technology and Built Environment, Addis Ababa University. At this moment he/she is doing his/her thesis/project/term paper entitled;

" modeling and simulation factor influencing operator performance of fiber bag manufacturing, case study horizon plantation coffee processing plc ware house

In order to successfully complete his/her paper, the student wants to obtain information from your factory/industry/organization.

The school strongly appreciates for any sort of assistance you provide to our student related to his/her thesis/project/term paper. In addition, we would like to inform you that the data is required and will be used only for educational purpose.

Thank you in advance for your kind cooperation.

Dr. Abdulkadir Aman

Head of the School of Mechanical and Industrial Engineering

College Technology and Built Environment

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CamScanner