Optimizing the Fabric Flows during the Warehouse Receiving Process: A Simulation Study in Sri Lankan Fabric Industry

S.M.A.V.S. Tennakoon
Department of Industrial Management
Faculty of Applied Sciences
Wayamba University of Sri Lanka
Kuliyapitiya, Sri Lanka
30190.vstennakoon@gmail.com

S.A.K.M. Perera
Department of Industrial Management
Faculty of Applied Sciences
Wayamba University of Sri Lanka
Kuliyapitiya, Sri Lanka

M.A.D.D.I.D. Sarathchandra
Department of Industrial Management
Faculty of Applied Sciences
Wayamba University of Sri Lanka
Kuliyapitiya, Sri Lanka

E.A.D.D.D. Edirisinghe
Department of Industrial Management
Faculty of Applied Sciences
Wayamba University of Sri Lanka
Kuliyapitiya, Sri Lanka

M.G.S. Dilanthi
Department of Industrial Management
Faculty of Applied Sciences
Wayamba University of Sri Lanka
Kuliyapitiya, Sri Lanka

***Abstract*—Sri Lanka has made significant contributions to the global fabric manufacturing industry, particularly in terms of quality production, diversification, and sustainability. One critical aspect of the fabric industry is the warehouse receiving process, which involves the inspection, sorting, and storage of incoming greige flows into the warehouses. Nevertheless, the optimization of the warehouse receiving process remains a relatively unexplored area of research. Accordingly, this study was undertaken to reduce work in progress and optimize the warehouse receiving process of a highly reputable fabric manufacturing company in Sri Lanka. The selected warehouse suffered from significant work in progress and long waiting queues, posing major drawbacks. The existing system had only one data entry counter, a team for carrying and storing greiges enabling the system to behave as an integration of a single server queuing system. This system was observed for four working shifts within two consecutive days and analyzed using Rockwell Arena software version 16 by utilizing a sample comprising 273 observations for each parameter. It was identified that 93 greiges work in progress and lengthy waiting queues were the major issues. Recommendations were defined under three possible improvements. They were increasing the resources at the data entry counter, eliminating temporary storing areas, and disaggregating the existing team into more empowered teams. Among the defined recommendations, a model with improvements except adding another data entry counter was the economically feasible model. The optimized model resulted in reducing work in progress up to 59 greiges. Thus, eliminating temporary waiting areas and optimal use of the staff was the conclusion for reducing the work in progress. Additionally, it recommends conducting further longitudinal analysis to obtain optimal results and refine the proposed strategies.**

***Keywords*—Arena, queuing simulation, greige, waiting time, work in progress**

I. Introduction

Greige, regularly known as fabric, is a combination of natural and synthetic fibers or threads made through a common process that includes weaving, sewing, holding, felting, and turfing. Greige or fabrics are commonly used in an assortment of items, including clothing, domestic furniture, and industrial materials [1]. Greige materials are made in large amounts and conveyed to textile mills around the world to encourage preparing for the reason of creating a tremendous range of garments [2]. This allows for more enhanced productivity in material fabricating as textile manufacturing firms can focus on coloring, printing, and wrapping up instead of beginning from scratch with raw materials [3]. In general, the greige manufacturing industry is a significant portion of the textile industry [4].

Commitment of Sri Lanka on the Greige manufacturing industry: Sri Lanka has made noteworthy commitments to the worldwide greige manufacturing industry, especially in terms of quality production, diversification, employment generation, trade profit, and sustainability. The industry in Sri Lanka is known for creating high-quality fabrics that meet worldwide standards and has contributed intensely to modern innovation and production processes [5]. Generally, Sri Lanka's greige manufacturing industry is a crucial contributor to the worldwide textile industry and has made a difference in promoting economic development, employment, and sustainability within the nation.

A. Greige Flows in Warehouse Receiving Processes of the Selected Organization

The selected organization is one popular Greige manufacturer in Sri Lanka. It manufactures Greige textiles in large quantities and then delivers them to the textile and garment manufacturers worldwide including the local apparel manufacturing giants. This allows for greater efficiency in textile manufacturing as the firms can focus on dyeing, printing, and finishing rather than starting from scratch with raw materials. Therefore, the organization provides its products worldwide for producing high-quality fabrics that meet international standards and has invested heavily in modern technology and production processes.

Warehouse management in the selected organization involves daily operations running in the warehouse. Amongst, receiving and organizing the related space, scheduling of respective employees, managing inventory, and fulfilling orders are vital. Thus, effective warehouse management expects to optimize these processes while integrating many operations and working together to improve its performance. Considering the usual practice, the Warehouse receiving process is identified as the first and the most important step in warehouse management. It involves the inspection, sorting, and storage of incoming fabric greige flows in warehouses. Productive and profitable receiving processes are basic for the fabric industry to meet customer demand, reduce lead times, and minimize costs.

- In this warehouse receiving process, it was not monitored hence; any service discipline or labeling system indicating such receiving was not available. Thus, identifying the respective products was very hard. This caused many products to be retained in the warehouse for a long time without further processing.
- Forming of many waiting lines was found in the warehouse. Checking the quality of products manual and the absence of any service disciplines were identified as major causes for the above problems. They laid many barriers to a smooth warehouse operation.
- Accumulation of defects, disposals, and unnecessary amount of inventories at each work station in the warehouse created ineffective space utilization. Thus, low visibility was noted in the selected warehouse receiving process. Thereby, the organization could not identify the moving and non-moving inventories. This caused creating much waste in the warehouse while taking much additional time and labor to find required items among those inventories.
- Moreover, the warehouse operation of the fabric manufacturing industry involves several processes, people, and strategies to ensure its effective performance. But, in the Sri Lankan context, the industry of warehouse management also encounters numerous challenges. Amongst, skills gap among the employees, low visibility in the warehouse, delays in warehouse processes, and accumulation of unnecessary amount of inventories and defectives are vital.

The accessed empirical literature provided evidence for the existence of the above problems in many contexts. Amongst, the following were highlighted.

A warehouse receives manufacturing products or commodities from suppliers and distributes them to wholesalers or customers [6]. The first operation in the warehouse is receiving. This procedure begins with a notice of the arrival of goods. The process of unloading, counting, identifying, quality control, and goods acceptance (incoming inspection) is associated with a particular type and quantity [7]. Planning and controlling in warehouse management have been explored by professionals from both the arts and sciences. Nonetheless, a robust fundamental theory for warehouse design technique is still absent [8]. Each day in the warehouse, this work's receiving, data entry, and storing operations are all conducted simultaneously, and the arrival of greiges, inspecting, unloading, and racking storage are the procedures in the unloading system [9]. The Fabric Greige Flows during the Warehouse Receiving Process have not received significant attention in the existing literature, despite the numerous studies on queuing systems in different contexts.

Nonetheless, there are no solid core theory or simulation studies for warehouse design techniques. Simulation is the process of developing computer models of real or hypothetical systems that are used to run numerical experiments under various situations to acquire a better knowledge of the system [10]. The application of simulation modeling in the manufacturing industry is well-explained by those who emphasized that the majority of applications are for control and production planning analysis.

Therefore, this research aimed to address this gap by carefully investigating the current structure and performance of fabric greige flows during the warehouse receiving process. Accordingly, the objectives of this study were to;

- Model and analyze the receiving and storing of greiges in a finished goods warehouse.
- Examine potential strategies for optimizing the waiting times and wait times of data entry and storing operations in the warehouse.
- Accordingly propose viable solutions to enhance the overall efficiency of warehouse operations.

II. Methodology

A. *Theoretical Model*

Queueing theory is a well-known mathematical method used in operations management for investigating waiting lines and WIPs. Queueing theory is a well-known mathematical method used in operations management for investigating waiting lines and WIPs [11].

Little's rule states that the average length of a queue (L) and the typical length of time a customer spends in a system (W) are inversely related. The average length of the queue (L) can be calculated using the average number of customers in the queueing system (Ls) and (Lq). The rate of arrival for the units to the system is λ. The average amount of time a client spends in a system (W) can also be stated as the sum of their time spent in line (Wq) and their time spent in the queueing system (Ws).

The general model marked by

$$M/M/S:GD/\infty/\infty \tag{1}$$

can be used to define a queueing system that has multiple servers, an unlimited waiting room size assuming that the storing capacity is very large compared to the entities arriving in the system, and an unlimited population. Here, the letter M stands for Markov process, S is the number of servers, and GD is the general discipline, which means that the services are offered on various service disciplines such as FIFO/LIFO, etc. This study is focused on the analysis of the complex queuing system comprising multiple queuing

Nevertheless, theoretically, the basis for the queuing system follows the above assumptions. When a system of queuing system is analyzed, the entire system is an integration of various critical components, Rockwell Arena software provides the simulation platform for analyzing the system virtually with the feature of running the actual system in a simulated environment in a speed manner with utilizing object path simulation, routine path simulation, realistic 2D and 3D animation capabilities, graphical use interfaces built around SIMAN language, common flowchart modules such as ‘Create, Process, Decide, Dispose, Batch, Separate, Assign, and Record’. Create a module to simulate the arrival greiges into the system. The process module represents the core of the system that simulates the steps and major actions done to the arrived entities into the system. The decide module introduces the decision points or conditions in this simulation such as returning criteria in the process of returning the damaged greiges to the QC department. The batch module is used for grouping the greiges and processing them as a batch [12]. Assign module deals with the resource allocation for handling specific greiges or processes based on predefined rules and priorities. The dispose module is used to exist the entities where they have completed their tasks or left the process [14].

Rockwell Arena software provides both options which are module-based model building and animated-based model. To model a non-stationary time-dependent queueing system with limited resources and solve queueing problems using Arena, researchers must rely on their knowledge and experience in identifying the appropriate and relevant system parameters and making modifications to these system parameters through trial and error [15].

The Fabric Greige Flows amid the warehouse receiving process have not received noteworthy consideration within the existing literature, despite the various considerations on queuing systems in different contexts. Subsequently, this research aimed to address this gap by analyzing the current structure and execution of fabric greige flows during the warehouse receiving process and proposing viable solutions to improve the overall efficiency of warehouse operations. In this study, the primary objective is to model and analyze the receiving and storing of greiges in a finished goods warehouse. The simulation experiments were utilized to examine potential strategies for optimizing the waiting times and wait times of data entry and storing operations within the warehouse while minimizing operating costs.

B. *Data Collection*

The study focused on the finished goods warehouse receiving process of a leading greige manufacturing company in Sri Lanka, with observations limited to two normal working days from 8.00 am to 10.00 pm, encompassing both peak and non-peak hours. Data was collected by recording 321 observations on various types of parameters. Parameters related to service provisions, parameters related to route times, and the parameters related to waiting times of the system are the basic types of variables that have been observed in this study. There were two major service provisions in this system identified as:

- Data entry process
- Storing process.

There were four major routes included in this system identified as:

- R1 - Route time from the corridor area to the data entry area
- R2 - Waiting time (R2) from data entry to the temporary warehouse area
- R3 - Route time from the temporary warehouse area to the storage rack
- R4 - Route time (R4) for returning greiges from the data entry area to the Quality Control (QC) department which is not a major analysis component in this study (in minutes)

Two waiting times were identified within the system as follows:

- Waiting time before the data entry process
- Waiting time before the storing process (in minutes)

Subsequently, data were collected for the following variables through the observations;

i. Number of Rolls
ii. Arrival of number of greiges per each trolly was averaged as 11 greiges.
iii. Inter-arrival time of greiges (in minutes)
iv. Route time (R1) from the corridor area to the data entry Area (in minutes)
v. Route time (R4) for returning greiges from the data entry area to the Quality Control (QC) department (in minutes)
vi. Decision criteria on data entry or moving to Quality control (QC) where the criterion is that 5% of arrived greiges at the warehouse entrance are returned to the QC department
vii. Waiting time before the data entry process (in minutes)
viii. Service provision time for the data entry process (in minutes)
ix. Route time (R2) from data entry to the temporary warehouse (in minutes)
x. Waiting time before the storing process (in minutes)
xi. Route time (R3) from the temporary warehouse area to the storing rack (in minutes)
xii. Service provision time for the Storing process (in minutes).

The following assumptions were made in order to collect and analyze data:

i. Greiges are not moved to the queue until their details are entered.

ii. Unlimited number of arrivals of greiges

iii. Data entry services are provided according to the FIFO (First In - First Out) method.

iv. There are no work shifts among the workers.

v. While the model is running, the employees aren't provided with breaks.

C. Data Analysis

The collected data comprising 321 observations for each variable was processed using SPSS Software version 21 to clean the data and to eliminate any outliers that deviated significantly from the rest of the dataset due to various measurements and unexpected behaviors of the system. After the data cleaning the sample was reduced up to 273 observations for each variable or parameter. The data was then analyzed using Rockwell Arena Student Version 16 software, with its Input Analyzer feature used to examine the data distribution of the observed variables. The results obtained from the input analyzer were utilized to generate Tab. 1.

TABLE I. PROBABILITY DISTRIBUTIONS OF OBSERVED VARIABLES

Variable	Distribution
Number of rolls	3.5+26*BETA(2.33,2.42)
Inter arrival time of greiges (mins)	TRIA(0.4, 22.5, 45)
Waiting time before data entry process (mins)	TRIA(5, 18.2, 21)
Data entry process service provision time (mins)	WEIB(6.58, 3.48)
Waiting time before storing process (mins)	NORM(6.55, 1.49)
Storing process service provision time (mins)	TRIA(1, 15.3, 21)
R1	1+2*BETA(1.58, 0.48)
R2	TRIA(1, 2.51, 3.23)
R3	TRIA(2, 5.44, 6)
R4	TRIA(5, 13.2, 14)

Number of rolls per each lot of arriving to the system has followed a Beta distribution where the alpha parameter is 2.33 and beta parameter 2.42 suggesting that the distribution is negatively skewed. In addition to that, mean value of number of greiges arriving was 11 per trolly. This mean value for number of greiges arrival has been considered in further system analysis of this study. Inter arrival time of greiges which a primary parameter in the queuing system has obtained a triangular distribution with the minimum possible value is 24 seconds and, maximum possible value is 45 minutes suggesting that the inter-arrival time of greiges cannot exceed 45 minutes and most likely value is 22.5 minutes considering that most common or expected time between arrivals is 22.5 minutes.

Greiges are waited at the corridor of the warehouse before scanning following a triangular distribution where the minimum waiting time before the data entry process is 5 minutes, most likely waiting time is 15.2 minutes and waiting time cannot exceed 21 minutes. Route time from the corridor to the data entry area has followed a Beta distribution where the alpha parameter is 1.58 and the beta parameter 0.79 suggesting that the distribution is positively skewed. Route time of moving returning greiges to the QC department has followed triangular distribution with the minimum possible value is 5 minutes, and maximum possible value is 14 minutes suggesting that the inter-arrival time of greiges cannot exceed 14 minutes and most likely value is 13.2 minutes considering that most common or expected time between arrivals is 13.2 minutes.

Service provision time for the data entry process has followed a Weibull distribution with the shape parameter 6.78 minutes suggesting the distribution is positively skewed and the scale parameter is 3.68 minutes suggesting that a moderate amount of variability in the service provision time for the data entry process. Route time from the data entry area to the temporary warehouse area has followed a triangular distribution with the minimum possible value is 60 seconds and, the maximum possible value being 3.23 minutes suggesting that the inter-arrival time of greiges cannot exceed 3.23 minutes and most likely value is 2.51 minutes considering that most common or expected time between arrivals is 2.51 minutes.

Greiges are waited at the temporary warehouse area before moving into racks and the waiting time has followed a normal distribution with a mean of 6.55 and a standard deviation of 1.49 minutes indicating that the waiting time may be 6.55 ± 1.49 minutes. Storing process service provision time has obtained a triangular distribution with the minimum possible value is 60 seconds, and the maximum possible value is 6 minutes suggesting that the inter-arrival time of greiges cannot exceed 6 minutes and the most likely value is 5.44 minutes considering that the most common or expected time between arrivals is 5.44 minutes.

Further analysis was conducted using the Arena model and animated model features by utilizing various modules such as 'Create, Process, Decide, Dispose of, Batch, Separate, Assign, and Record'.

D. Model Development

The selected warehouse suffered from significant work in progress and long waiting queues, posing major drawbacks. The existing system had only one data entry counter, a team for carrying and storing greiges enabling the system to behave as an integration of single server queuing systems with the parameters of unlimited population size and limited waiting room capacity. To address these issues, three possible improvements were identified and categorized as recommendations. They were increasing the resources at the data entry counter or introducing multiple data entry counters, eliminating temporary storing areas, and disaggregating the existing team into more empowered teams. However, the implementation of multiple data entry counters with more ERP system logins incurs an additional expense for the company. This is because warehouse operations are considered non-value-added services, and management aims to minimize investment in functions associated with the warehouse. Given the constraints imposed by the budget and organizational resources, this particular study was undertaken for building and simulating basic models using Rockwell Arena software version 16. When analyzing the system, the study has utilized both animated and module-based development models to enhance the internal validity of the system as the outcomes are highly influenced by the parameters and limitations that are provided by the software.

III. Results

A. Existing System

The existing system had only one data entry counter, a team for carrying and storing greiges enabling the system to behave as an integration of single server queuing systems with the parameters of unlimited population size and limited waiting room capacity. The greiges are delivered to the warehouse and temporarily stored in a corridor. Subsequently, they are transferred to the warehouse door, though internal decisions may necessitate the return of certain greiges to the Quality Checking department. Upon their return, these greiges are temporarily stored again before undergoing the data entry process. The data entry process entails scanning details of each greige and attaching stickers with relevant information. Upon completion of this process, all greiges that have undergone data entry are transferred to a temporary location and stored until they are ready for use in the manufacturing process. It is important to note that the decision to immediately move some greiges into the rack is dependent on various factors. Proper storage of the greiges in the rack is a critical step in the manufacturing process and can significantly enhance their utility and effectiveness. Fig. 2 indicates the physical movement of greiges within the existing system.

Fig. 1. Animated model for the existing system

In summary, the exiting process includes the following steps that coincide with the observed variables:

i. Greiges arrival

ii. Deciding whether to return greiges to Quality Checking or forward them to the Warehouse

iii. Moving greiges to the data entry location

iv. Waiting for greiges to be scanned

v. Conducting the data entry process

vi. Moving the data-entered greiges to a temporary warehouse area

vii. Deciding which greiges should be moved to the rack first and which should wait where the system has analyzed assuming that the deciding criteria is FIFO

viii. Moving selected greiges near the rack using a forklift

ix. Storing the greiges in the rack.

The existing system had only one data entry counter, a team for carrying and storing greiges enabling the system to behave as an integration of single server queuing systems with the parameters of unlimited population size and limited waiting room capacity which is indicated by Fig 1.

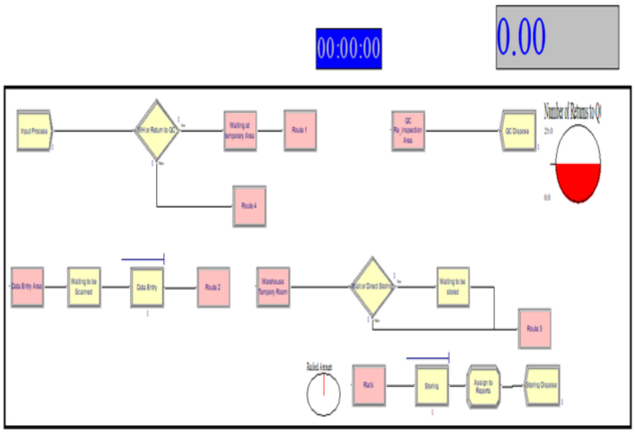

Fig. 2. Arena model for the existing system

The major issue with the existing is the higher amount of WIP indicating that the existing system has 93 WIP values indicating that 93*11 = 1023 greiges are still been processed which could result in increased honeycombing and losses of greige lots. More greiges are being waited at the data entry counter which is 24 lots of greiges and queue length at the storing process is 45 lots of greiges indicating that the system is inefficient. Data entry service provision time comprising of one person is 12 minutes per lot of greiges. To reduce WIP, the following models have been proposed under the basic three recommendation criteria.

B. Proposed Models

1) Proposed Models 01: Adding New Data Entry Counter

The study proposed to add a new data entry counter to the existing system as indicated in Fig. 3 to enhance the efficiency of the data entry process and to enhance the system efficiency. The new counter is expected to provide the same level of service as the current data entry machine. However, a financial analysis has determined that allocating another computer with an ERP system login would not be beneficial for the company. Thus, instead of implementing a completely new system, integrating the new data entry counter into the current system is recommended. This approach would result in a reduction of costs while still achieving the desired increase in efficiency. In summary, the proposed model entails the addition of a new data entry counter with the same service provision rate as the current machine to the existing system. A financial analysis has determined that allocating another computer with an ERP system login would be financially inefficient; therefore, the study recommended integrating the new counter into the current system to reduce costs while enhancing efficiency.

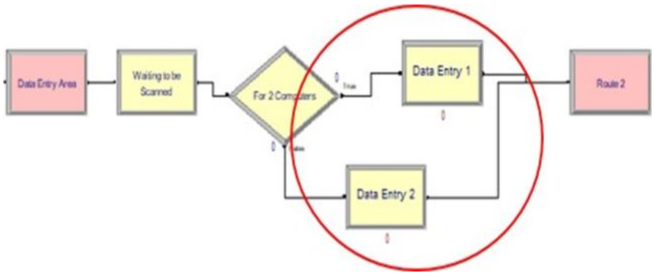

Fig. 3. Arena model with added new data entry counter

WIP has been reduced up to 61 lots of greiges where 61*11= 671 number of greiges are still been processed which still could result in increased honeycombing and losses of greige lots. More greiges are being waited at the two data entry counters which are 6 lots of greiges and 5 lots of greiges with the waiting times at each data entry counter being 1.51 and 1.38 minutes respectively. Meanwhile, queue length at the storing process has increased up to 49 lots of greiges compared to the existing system indicating that the system is inefficient. Data entry service provision time comprising of two persons with two ERP logins is 10.5 minutes per lot of greiges.

2) Proposed Model 02: Elimination of Temporary Storage of Greiges in the Warehouse Following the Data Entry

A new data entry counter is included in this proposed model, which processes data at the same rate as the existing data entry machine. It is determined, however, that allocating another computer with an ERP system login would not be financially beneficial to the company. Furthermore, the temporary storage of greiges in the warehouse following data entry is eliminated, and they are forwarded directly to the storing racks as indicated by Fig. 4. This eliminates the need for intermediate storage while also lowering the risk of errors and damage during the transfer of greiges from temporary storage to the storing racks. As a result, the new model simplifies data entry and improves operational efficiency.

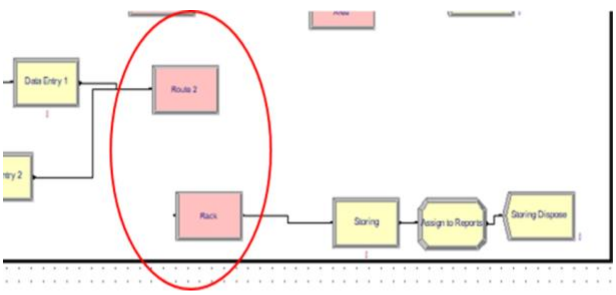

Fig. 4. Arena model with new data entry counter and eliminated temporary storage area

WIP has been reduced compared to the existing up to 79 lots of greiges where 79*11 = 869 number of greiges are still been processed which still could result in increased honeycombing and losses of greige lots. More greiges are being waited at the two data entry counters which are 7.56 lots of greiges and 6.44 lots of greiges with the waiting times at each data entry counter being 1.32 and 1.37 minutes respectively. Meanwhile, queue length at the storing process has increased up to 51 lots of greiges compared to the existing system indicating that the system is inefficient. Data entry service provision time comprising of two persons with two ERP logins is 4.48 minutes per a lot of greiges assuming that both employees in the data entry counter have the same working capabilities and same working conditions.

3) Proposed Models 03: Enhancing the Efficiency of the Data entry Process and Disaggregation of the existing team into separate teams without adding a new data entry counter to the existing system

The installation of a new data entry counter is not feasible due to financial limitations. It is planned to divide the current team of employees into two primary teams with more additional facilities such as two forklifts for each team for the job of storing greiges to reduce WIP as indicated by Fig. 5. and Fig. 6. Among defined recommendations, a model with all other three improvements except adding another data entry counter was the economically feasible model.

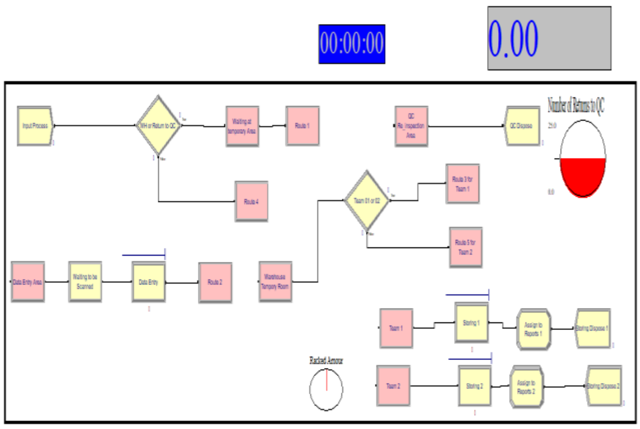

Fig. 5. Arena model with all recommendations except adding new data entry counter

Fig. 6. Indicates the animated view of proposed model 03 where the WIPs have been reduced and intermediate temporary storage areas which includes moving the data-entered greiges to a temporary warehouse area and deciding which greiges should be moved to the rack first and which should wait have been eliminated those results in less hair combing.

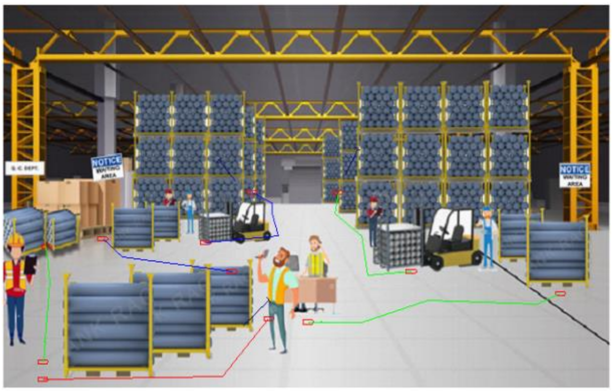

Fig. 6. Animated model with all recommendations except adding new data entry counter

WIP has been reduced compared to the existing up to 79 lots of greiges where 59*11 = 649 number of greiges are still been processed which still could result in increased honeycombing and losses of greige lots. Number of greige lots being waited at the data entry counter is 18 and queue length at the storing process has decreased to 31 lots of greiges compared to the existing system indicating that the system is an efficient system prioritizing the objective of reduced WIP. Data entry service provision time is 10.44 minutes per lot of greiges where this provision time is a lower value compared to the existing system.

Table 2 indicates the overall summary of each major performance indicator for the existing system and the proposed models obtained by simulation using Rockwell Arena software version 16 in order to logically compare the proposed alternatives for arriving at better solutions by utilizing a sample comprising 273 observations for each parameter.

TABLE II. COMPARISONS OF THE RESULTS OF THE EXISTING AND PROPOSED MODELS

Obtained parameter	**Existing system**	**Proposed model 01**	**Proposed model 02**	**Proposed model 03**
WIP (Lots of greiges)	93	61	79	59
Service time at data entry (mins)	12	10.61	4.48	10.44
Waiting time at data entry process (mins)	5.04	1.51 1.38	1.32 1.37	5.59
Waiting time at the storing (mins)	7.57	9.59	3.46	6.06
Queue length at data entry	24	6 5	7.56 6.44	18
Queue length at storing	45	49	51	31

When evaluating the proposed models against the performance parameters of the existing system based on several key performance metrics, each proposed model has demonstrated unique strengths and areas for further improvements leading to the selection of the best alternative among them contingent on specific operational goals and constraints. Proposed model 03 has demonstrated the lowest WIP, implying an efficient system of management. Enhanced throughput and reduced honeycombing which are advantageous for cost control as warehouse is a non-value-added function is indicated by reduced WIP. Proposed model 02 excelled in terms of service time at data entry, suggesting swift processing of greiges upon entry. This is beneficial for expediting the initial stages of workflow and the lowest waiting time at the storing process indicating efficient storage operations. Proposed model 01 showcased a substantially reduced waiting time at the data entry and the lowest queue length at the data entry. These enhanced parameters are crucial for minimizing delays at the data entry ensuring efficient utilization of resources. Subsequently, the choice among these proposed alternative models should align with the the objective of the study that reducing WIP and waiting times resulted in the proposed models 01 and 03 being slightly similar in terms of reduced WIP. However, a financial analysis from the company management which is not included in this research has determined that allocating another computer with an ERP system login would not be financially beneficial for the company.

IV. CONCLUSION

This study was undertaken to reduce work in progress and optimize the warehouse receiving process of a highly reputable fabric manufacturing company in Sri Lanka. It was identified that 93 lot of greiges work in progress and lengthy waiting queues were the major issues. Recommendations were defined under three possible improvements. They were increasing the resources at the data entry counter, eliminating temporary storing areas, and disaggregating the existing team into more empowered teams while providing more resources.

When considering the objective of reducing WIP proposed models 01 and 03 are slightly similar in terms of reduced WIP (59 – 61) and both options are better options for implementation. However, a financial analysis from the company management which is not included in this research has determined that allocating another computer with an ERP system login would not be financially beneficial for the company. Taking the financial feasibility into consideration proposed model 03 that has been recommended to enhance the efficiency of the data entry process and disaggregating the existing team into separate teams with additional facilities and empowered employees without adding a new data entry counter is the best alternative. This optimized model resulted in reducing work in progress up to 59 lots of greiges. Thus, eliminating temporary waiting areas and optimal use of the staff was the conclusion for reducing the work in progress. Since most of the fabric manufacturing companies are encountering a similar warehouse receiving process and storing procedures, the findings in this research are applicable to the fabric industry context in Sri Lanka.

The simulation with the limited edition has driven limited solutions such as limited simulation periods, limited number of input entries to the system, and limited programming and animation restrictions. The study can further be expanded toward improving the warehouse performance further minimizing the WIP and waiting times using five why analysis. Thus, the respective root causes can be identified and accordingly, the cause and effect analysis can be continued to find potential suggestions

Moreover, it is recommended that more observation of the activities occurring in this system is needed in future research. Therefore, it would be possible to determine the real situations with greater accuracy if it were possible to predict or calculate the likelihood of occurring and, at the same time, identify the best course of action for completely resolving any issues that may arise within the system. Future studies could optimize the rate of staff utilization and take into account not only waiting time but also the utilization rate for each counter. This research can be further investigated using options such as warehouse layout design towards storage facilities and business process reengineering. Additionally, it recommends conducting further longitudinal analysis and exploring further warehouse optimization techniques and feasibility analysis to obtain optimal results and refine the proposed strategies.

REFERENCES

[1] U. N. H. M. M. I. M. A. U. Maeen Md. Khairul Akter, "Textile-apparel manufacturing and material waste management in the circular economy: A conceptual model to achieve sustainable development goal (SDG) 12 for Bangladesh," ELSEVIER, p. 12, 2022.

[2] A. Sayed, "raw-materials-used-in-textile-industries," 2015. [Online]. Available: https://textileapex.blogspot.com/2015/09/raw-materials-used-in-textile-industries.html.

[3] Farah Maria Drumond Chequer, Gisele Augusto Rodrigues de Oliveira, Elisa Raquel Anastácio Ferraz, Juliano Carvalho Cardoso, Maria Valnice Boldrin Zanoni and Danielle Palma de Oliveira, "Dyeing Process and Environmental Impact," 2013. [Online]. Available: https://www.intechopen.com/chapters/41411.

[4] R. Dheerasinghe, "Garment Industry in Sri Lanka: Challenges, Prospects, and Strategies," Sri Lanka Journal Online, p. 40, 2000.

[5] International Trade Administration, "country-commercial-guides/sri-lanka-textiles," 2022. [Online]. Available: https://www.trade.gov/country-commercial-guides/sri-lanka-textiles.

[6] J. Gu, M. Goetschalckx and L. F. McGinnis, "Research on warehouse operation: A comprehensive review," European Journal of Operational Research, pp. 1-21, 2007.

[7] J. Karasek, "An Overview of Warehouse Optimization," International Journal of Advances in Telecommunications, Electrotechnics, Signals and Systems, vol. 2, p. 111 – 117, 2013.

[8] J. Gu, M. Goetschalckx and L. F. McGinnis, "Research on warehouse operation: A comprehensive review," European Journal of Operational Research, vol. 177, no. 1, pp. 1-21, 2007.

[9] A. M. Law, Simulation Modeling and Analysis, New York: McGraw-Hill Education, 2013.

[10] Y. C. LIiong and C. . S. Loo, "A Simulation Study of WAarehouse Loading and Unloading System Using Arena".

[11] C. Y. Liong and C. S. Loo, "A Simulation Study of Loading and Unloading Systems Using Arena," Journal of Quality Measurement and Analysis, vol. 2, no. 5, pp. 45-56, 2009.

[12] W. D. Kelton, R. P. Sadowski, and D. A. Sadowski, Simulation With Arena, New York: McGraw Hill, 2014.

[13] "Dynamic facility layout problem based on open queuing network theory," European Journal of Operational Research, vol. 259, no. 2, pp. 538-553, 2017.

[14] M. M. K. Akter, U. N. Haq, M. M. Islam, and M. A. Uddin, "Textile-apparel manufacturing and material waste management in the circular economy: A conceptual model to achieve sustainable development goal (SDG) 12 for Bangladesh," Cleaner Environmental Systems, vol. 4, p. 13, 2022.

[15] K. Farhana, A. S. F. Mahamude and . M. T. Mica, "The Scenario of Textile Industry in Malaysia: A Review for Potentiality," Mater Circ Econ, p. 20, 2022.

[16] F. M. D. Chequer, G. Oliveira, E. Ferraz, J. C. Cardoso, M. Zanoni, and D. P. Oliveira, "Textile Dyes: Dyeing Process and Environmental Impact," 2013. [Online]. Available: https://api.semanticscholar.org/CorpusID:56383845. [Accessed 24 08 2023].

[17] R. Dheerasinghe, "Garment Industry in Sri Lanka Challenges, Prospects and Strategies," Sri Lanka Journals Online, p. 40, 2009.

[18] J. Wijayasiri and J. Dissanayake, "The Ending of the Multi-Fibre Agreement and Innovation in the Sri Lankan Textile and Clothing Industry," OECD Journal: General Papers, vol. 4, pp. 157-188, 2008.

[19] J. Smith, "Introduction to Queueing Networks: Theory ∩ Practice," Springer, 2018.

[20] S. A. Ahmad, K. W. Ng, S. H. Airdzaman, M. C. Ang and S. B. Suliano, "Improving Queuing System with Limited Resources Using TRIZ and Arena Simulation," Preprints, p. 17, 2018.

[21] A. Yassine, B. Khalid, and E. Said, "Supply Chain Modeling and Simulation using ARENA®a Case Study," International Journal of Advanced Computer Science and Applications, vol. 10, no. 3, p. 8, 2019.