Journal of Engineering and Digital Technology (JEDT)
Vol.12 No.1 January - June 2024

Improvement of Inbound Logistics Process in Coconut Manufacturing Using FlexSim Simulation: A Case Study

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Received: 31 August 2023; Revised: 17 December 2023; Accepted: 20 December 2023
Published online: 28 June 2024

Abstract

This research focuses on improving the inbound logistics process in coconut manufacturing by employing simulation techniques using the FlexSim software tool. Data of the processes were collected and validated to generate the simulation model. Multiple scenarios were proposed, analyzed, and assessed against the key performance metrics, including throughput, work in process (WIP), stay time, and resource utilization. All scenarios were generated depending on the number of work centers for each process. The findings indicated that Scenario 3, Scenario 4, and Scenario 7 offered higher average throughput with 384.73, 384.60, and 384.73 units, respectively, and Scenario 7 provided the most efficient average WIP with 53.01 units and average stay time with 1263.7 seconds. Resource utilization was moderate across all scenarios. It is recommended to adopt strategies similar to Scenario 7 for optimizing inbound logistic case study. Nevertheless, real-world validation is necessary to ensure the implementation. The study contributes valuable insights to decision-makers in the coconut manufacturers. It serves as a basis for future research in logistics optimization, utilizing simulation techniques to enhance manufacturing performance and competitiveness.

Keywords: Coconut manufacturing, FlexSim, Inbound logistics process, Simulation

I. INTRODUCTION

Inbound logistics is an essential part of the production process and plays an important role in the efficient flow of information and resources into the production process. Optimizing inbound logistics for the coconut industry in Thailand, the world's third exporter in 2021 [1], is important to improve cost-effectiveness and competitiveness as well as to meet market demands. Traditional methods for logistics development are limited in capturing complex processes and interactions. However, advances in simulation technology provide powerful tools for comprehensive modeling and analysis of logistics processes.

This study aims to improve inbound logistics management in coconut production using simulation techniques. A case study of a coconut manufacturer located in Southern Thailand. In particular, the FlexSim simulation software tool, which is well-known for its efficiency and ability to model the production process, was applied in this research. Simulating various scenarios supports the overall performance improvement of the production process by providing insight into the performance of the system, identifying potential bottlenecks, and evaluating different strategies.

The study highlighted the potential improvement scenarios for the inbound logistics process of coconut production via simulation-based analysis. The analysis was employed by assessing against key performance indicators such as access, Work-In-Process (WIP), waiting time, and resource utilization, our goal is to optimize the number of work centers for the system. Insights from this study can guide decision-makers in the coconut manufacturer to use insights from data to improve the overall profitability and competitiveness of their manufacturing processes.

This paper is organized as follows: The next section presents a literature review, discussing prior research applying the FlexSim simulation software tool in the manufacturing industry. Subsequently, the methodology section details the simulation model setup, data collection, and the scenarios tested. The results and discussion section reports the simulation outcome analysis and the study findings in the context of coconut manufacturing. Finally, the conclusion summarizes the key insights and outlines future directions for research and implementation.

II. LITERATURE REVIEW

This section presents an overview of various research studies that have utilized the FlexSim simulation software tool which is widely applied to optimize and enhance manufacturing processes across different industries. By utilizing simulation and mathematical techniques, the studies address various challenges, such as bottleneck identification, layout improvement, and efficiency enhancement. Chawla and Singari [2] simulated two-wheeler crankcase cover manufacturing, identifying Scenario 2 as the most effective, optimizing Die-Casting Machines and Vertical Milling Centers. Kumar *et al.* [3] analyzed a complex Flexible Manufacturing System (FMS) using FlexSim, demonstrating its cost-effective and resource-efficient approach. According to Jidong *et al.* [4], the improvement scenario of a furniture production line was suggested and assessed with FlexSim, achieving a 34.7% increase in production balance rate.

Other studies focused on logistics and layout optimization. Liu *et al.* [5] applied 3D modeling technology to logistics engineering, enhancing transportation efficiency. Wang *et al.* [6] optimized logistics distribution centers, showcasing the suitability of the FlexSim for system analysis. Kumar and Narayan [7] optimized the Upvc windows manufacturing layout, resulting in improved product quality and productivity. Similarly, Liu and Lin [8] transformed China's coastal manufacturing industry, achieving production line balance in Company Z. The experimental results indicated the effectiveness of FlexSim simulation.

Simulation proved effective in goods and services provision organizations [9], printing machine product quality improvement [10], and tapioca powder packaging enhancement [11]. The simulation also provided several benefits in both the production and inventory stages. For instance, Lucinski and Iwanov [12] evaluated manufacturing system flexibility, while Medan [13] reduced production costs and implementation time. Zhang [14] balanced an automobile coating production line, while Krynke [15] assessed the production flow scenarios' impact. Poloczek and Oleksiak [16] optimized the steel industry's production process, and Asante *et al.* [17] used FlexSim to model and simulate a fruit pack house, identifying idle resources and bottlenecks, leading to adjustments that improved overall fruit cold chain performance.

Additionally, studies focused on traditional practices, such as shea nut processing [18] and production logistics in enterprises [19]. According to Yuan and Zhang [20] applied optimization methods to JKL's cooler manufacturing system, leading to significant improvements.

These literature reviews offer valuable insights into the extensive applicability and effectiveness of the FlexSim simulation software tool for optimizing manufacturing processes. The findings emphasize the potential of simulation-based approaches in cost-effective process optimization and informed decision-making for manufacturing enterprises, leading to enhanced productivity, product quality, and resource utilization. The knowledge gained from these studies forms the basis for our current research, which aims to enhance the inbound logistics process in the coconut manufacturing industry. By leveraging FlexSim's capabilities, this research aims to improve overall efficiency and competitiveness in the coconut manufacturing sector.

III. RESEARCH METHODOLOGY

This section provides an overview of the inbound logistics process in coconut manufacturing using the FlexSim simulation software tool and a case study of coconut manufacturing. The analysis included the following detailed steps:

Step 1: Data Collection. The first phase involved collecting detailed data related to the inbound logistics process of coconut manufacturing. The information includes incoming coconut, shipping times, loading and inspection times, stock levels, and other errors. Accurate and detailed data collection is essential for effective simulation analysis.

Step 2: Model Development. In this step, the simulation model is created using the FlexSim software tool. The software tool provides a user-friendly interface that allows the creation and customization of the models.

Step 3: Model Verification. This includes comparing the model output with real-world data and running tests to make sure that the model can represent the system.

Step 4: Creating Scenarios. Different improvement scenarios are proposed to simulate various operation options in the inbound logistics process.

Step 5: Performance Evaluation. Analyze the efficiency of the inbound logistics process using simulation models and designed scenarios. Measure and compare the key performance indicators as mentioned in topic 1. In addition, the details related to the coconut manufacturer case study and the simulation modeling are explained as follows:

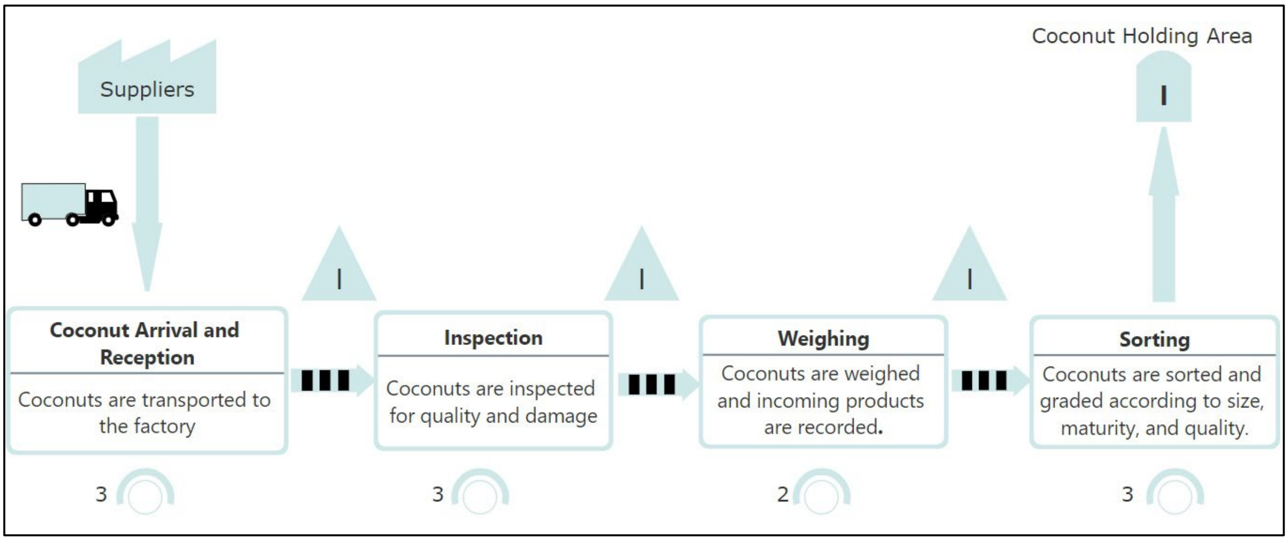

Figure 1: Inbound logistics process of coconut manufacturing case study

A. Inbound Logistics Process of Coconut Manufacturing: A Case Study

The case study coconut manufacturer is located in Prachuap Khiri Khan province. Based on the current operational data, one of the critical problems is inbound logistics. Therefore, this research aims to address this issue by studying the entire inbound logistic process, starting from coconut receiving to coconut preparation (before production) process as shown in Figure 1.

The operational process of the study is as follows:

1. Coconut Arrival and Reception: Coconuts are transported from suppliers and farms to the factory. Coconuts will be collected from reception on arrival.

2. Inspection: The coconut quality inspection includes inspecting the condition of the coconuts, checking for damage or rot, and making sure they meet the appropriate standards for processing.

3. Weighing: Coconut is weighed and incoming products are recorded. This information is essential for inventory control and tracking of incoming coconuts.

4. Sorting: After inspection, coconuts are sorted and graded according to size, maturity, and quality. The separated coconuts were used for different purposes for different final products.

5. Storage in the holding area: The extracted coconuts are temporarily stored in the storage area near the factory. This provides better organizing and makes it easier for the next process.

The inbound process of the factory consists of 11 employees (an employee per workstation) to operate each process. The present operation process has 3 workstations for reception, 3 workstations for inspection, 2 workstations for weighing, and 3 workstations for sorting. For the current issue, a high average WIP occurred (65.26 units per runtime). There were bottlenecks in the production process, leading to production inefficiencies and slowdowns. Hence, the production process lacked smoothness and effectiveness as it should have been. The potential root causes of the problems might be the factory constraints and/or the limitation of production lines balancing, i.e., the number of employees or workstations cannot be increased or decreased. Consequently, optimizing the number of employees in each workstation based on production line balancing principles becomes a challenge in finding the most optimal approach.

B. The Simulation Modeling Using FlexSim Simulation Software tool

The simulation model was carried out via the FlexSim running simulator version 2019. The inbound logistics process of the coconut manufacture was analyzed regarding the collected data related to the process movement and employees' operations. The unit of operation time for the model was set in seconds. The statistical validation for the parameter setting of the simulation model was applied by the ExpertFit Function as depicted in Figure 2 [21].

Figure 2 shows the example of validation for operation time of sorting process that use in this research. The three best distribution models that were carried out for the automated dataset. The best one of the analyses has been selected to set in the model.

All parameters used in this model were carried out in Table 1.

Table 1: Operation time setting (seconds)

Process	Values
Reception	Weibull (0.642, 3.653, 2.000)
Inspection	Weibull (5.368, 4.428, 2.000)
Weighting	Beta (6.735, 13.320, 0.834, 0.872)
Sorting	Johnson SB (14.690, 25.369, -0.033, 0.688)

Relative Evaluation of Candidate Models

Model	Relative Score	Parameters	
1-Johnson SB	94.35	Lower endpoint	14.69083
		Upper endpoint	25.36942
		Shape#1	-0.03392
		Shape#2	0.68842
2-Beta	92.74	Lower endpoint	14.84969
		Upper endpoint	25.16281
		Shape#1	1.18306
		Shape#2	1.13087
3-Rayleigh(E)	87.90	Location	14.22095
		Scale	6.55783

32 models are defined with scores between 0.00 and 94.35

Absolute Evaluation informative of Model 1 -Johnson SB

Evaluation: Good

Suggestion: Additional evaluations using Comparisons Tab might be informative.

See Help for more information.

Additional Information about Model 1 -Johnson SB

"Error" in the model means

relative to the sample mean 0.00881= 0.04%

Figure 2: The data validation of the sorting operation using ExpertFit function

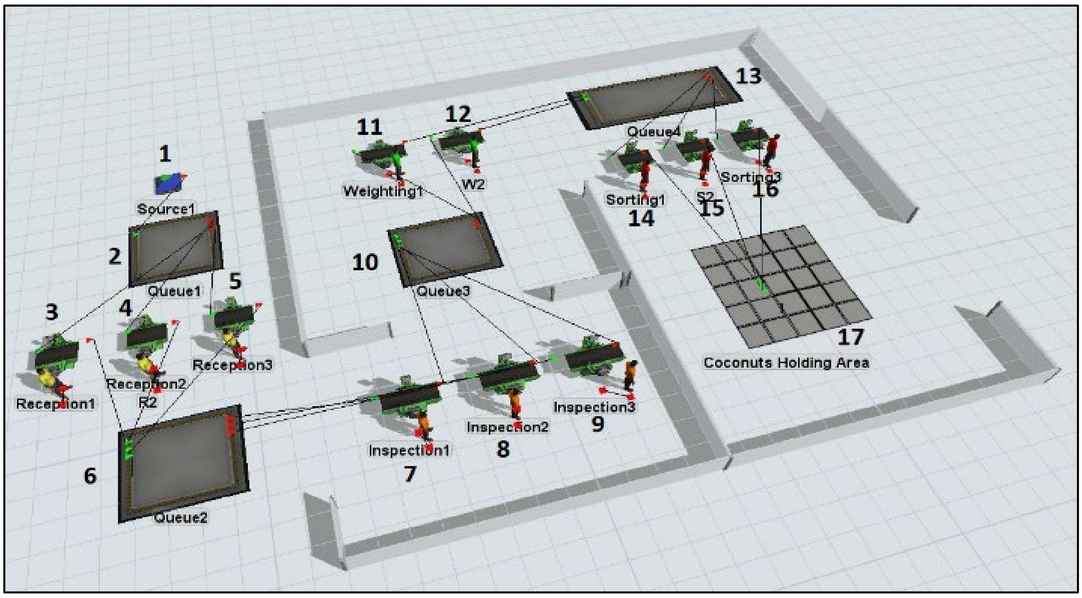

Figure 3: The simulation model of the inbound logistics process of the coconut manufacturer

Table 2: Details of the model

Object	Description
1	Coconut arrival at the manufacturing
2,6,10,13	Waiting queue to be processed for the next operations
3-5	Workstation of coconut reception
7-9	Workstation of coconut inspection
11-12	Workstation of coconut weighting
14-16	Workstation of coconut sorting
17	Coconut holding area to be processed in the next process

The simulation model of inbound logistics coconut manufacturing is illustrated in Figure 3. The details of the model in Figure 3 are described in Table 2.

C. The Model Verification

To validate to simulation model, 30 results of average throughput from the model and the current situation are compared by using a paired t-test hypothesis analysis with an alpha is 0.05. If the p-value is greater than 0.05, it indicates that there is no difference between the current process and the model.

The hypothesis testing is carried out by Minitab 2019 which hypotheses are equations (1) and (2) as follows.

$$H_0: \mu_{actual} = \mu_{model} \quad (1)$$

$$H_1: \mu_{actual} \neq \mu_{model} \quad (2)$$

when μ_{actual} is the average throughput of the current situation and μ_{model} is the average throughput of a model.

As a result, the p-value of this case is 0.077 greater than 0.05. Therefore, this simulation model can represent the actual system of the study [22].

D. Scenarios of the experiment

To optimize the number of workstations (employees), multiple scenarios were generated in the experimenter function in FlexSim based on four objectives: a) average throughput, b) average work in process, c) average stay times, and d) average utilization of the workstation. The assumption for the experiment is that each employee has similar abilities to work in each process. This research proposes 7 scenarios using the trial-error method that represents the number of workstations for each process based on the constraints and limitations of the manufacturer mentioned in the previous section. The details are demonstrated in Table 3.

Table 3: Number of workstations for all scenarios in the FlexSim simulation experimenter

Process	Scenario						
	1	2	3	4	5	6	7
Reception	3	2	2	2	1	1	1
Inspection	3	3	3	4	4	4	4
Weighting	2	3	4	3	3	2	4
Sorting	3	3	2	2	3	4	2

Table 3 illustrates the number of workstations for each process for each scenario. Scenario 1 is the current process. The others represented the alternative approaches to assigning employees (or workstations) to each process. For example, scenario 1 represented the production line consisting of 3 workstations for reception, 3 workstations for inspection, 2 workstations for weighting, and 3 workstations for sorting.

IV. RESULTS AND DISCUSSION

In this section, the performance of the model was investigated. Thirty replications were conducted and evaluated with four key performance indicators. Computational time was four hours (08.00 AM to 12.00 AM as a real-case study). The experimental results were designated as the 90% confidence interval for the studied phenomenon [23]. The experimental results are reported as follows.

A. Results Analysis

1) Throughput: The throughput analysis provides valuable insights into the system's process capacity and efficiency. The experimental results are illustrated in Figure 4 and Table 4.

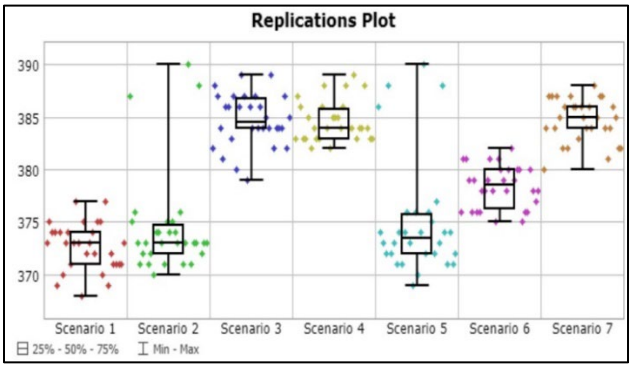

Figure 4: Replication plot of average throughput

Table 4: The experimental summarize of average throughput (units)

Scenario	Mean (90% Confidence)	Sample Std Dev	Min	Max
1	372.63	2.25	368	377
2	374.53	4.93	370	390
3	384.73	2.49	379	389
4	384.60	1.89	382	389
5	375.03	5.52	369	390
6	378.40	1.99	375	382
7	384.73	2.07	380	388

Among the tested seven scenarios, Scenario 3 and Scenario 7 exhibited the highest mean throughput values of 384.73 units, followed by Scenario 4 with 384.60 units. Therefore, these three scenarios have the potential to achieve higher production rates compared to the other scenarios. On the other hand, Scenario 1 demonstrated the lowest mean throughput of 372.63 units, indicating a comparatively lower processing rate.

2) Work in process: WIP analysis (in Figure 5 and Table 5) provides insights into the level of congestion and inventory of the system.

Scenario 1 had the highest mean WIP of 65.26 units, indicating a higher accumulation of materials in the process.

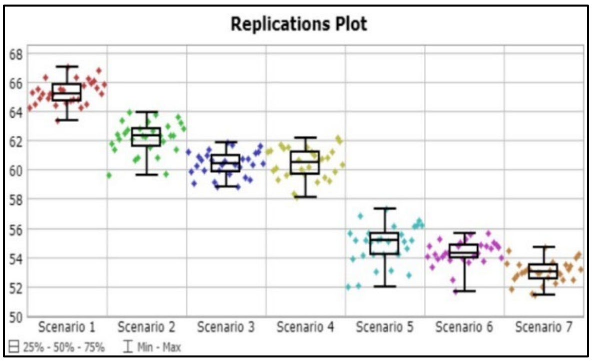

Figure 5: Replication plot of average WIP

Table 5: The experimental summarize of average WIP (units)

Scenario	Mean (90% Confidence)	Sample Std Dev	Min	Max
1	65.26	0.82	63	67
2	62.16	1.09	60	64
3	60.37	0.84	59	62
4	60.40	1.04	58	62
5	54.86	1.33	52	57
6	54.30	0.84	52	56
7	53.01	0.79	51	55

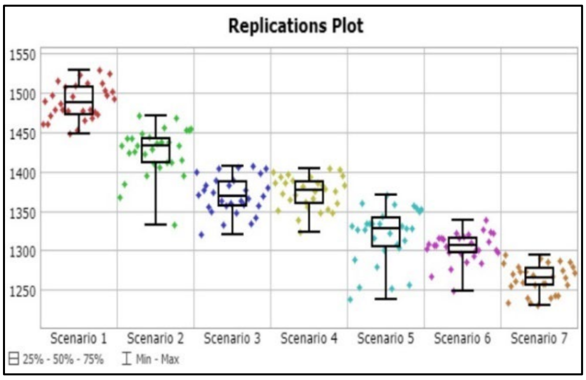

Figure 6: Replication plot of average stay time

Table 6: The experimental summarize of average stay time (seconds)

Scenario	Mean (90% Confidence)	Sample Std Dev	Min	Max
1	1489.00	22.20	1449	1529
2	1425.90	30.00	1332	1471
3	1370.50	23.30	1321	1407
4	1373.90	20.40	1323	1405
5	1319.40	34.90	1238	1371
6	1304.10	18.70	1248	1339
7	1263.70	18.30	1231	1295

In contrast, Scenario 7 demonstrated the lowest mean WIP of 53.01 units, suggesting a less congested system. The WIP values of all scenarios fell within relatively narrow confidence intervals, indicating robustness in the results.

3) Stay Time: In Figure 6 and Table 6, stay time analysis represents the average time a unit spends in the system (in seconds) and indicates the overall efficiency and flow of units.

Scenario 1 exhibited the highest mean stay time of 1489.0 seconds, indicating that units spent more time in the system. Conversely, Scenario 7 had the lowest mean stay time of 1263.7 seconds, implying a more efficient flow of units through the system.

4) Utilization: Utilization analysis reflects the effective utilization of resources and facilities within each scenario. All scenarios resulted in Figure 7 and Table 7.

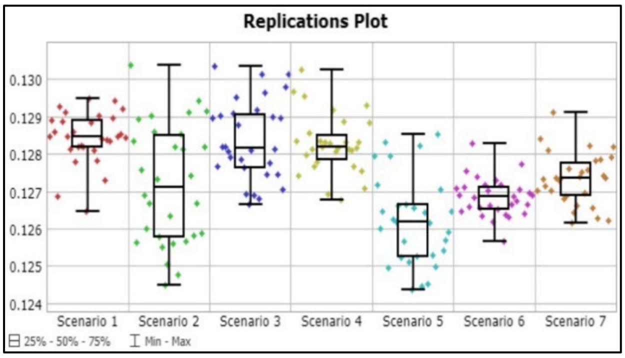

Figure 7: Replication plot of average utilization

Table 7: The experimental summarize of average utilization

Scenario	Mean (90% Confidence)	Sample Std Dev	Min	Max
1	0.1284	0.0007	0.1265	0.1295
2	0.1272	0.0016	0.1245	0.1304
3	0.1284	0.0011	0.1266	0.1304
4	0.1283	0.0008	0.1268	0.1302
5	0.1262	0.0012	0.1244	0.1285
6	0.1268	0.0005	0.1257	0.1283
7	0.1273	0.0007	0.1262	0.1291

All scenarios demonstrated moderate utilization levels, with mean values ranging from 0.126 to 0.128. Scenario 1 had the highest mean utilization of 0.1284, while Scenario 5 had the lowest mean utilization of 0.1262.

B. Discussion

The results obtained from the simulation study offer valuable insights into the performance of different scenarios in the inbound logistics process for coconut manufacturing. Scenarios 3, 4, and 7 demonstrated the highest throughput, indicating their potential as efficient approaches with higher production rates. However, Scenario 1 had the lowest throughput, suggesting a need for further investigation to identify and address possible bottlenecks.

The analysis of WIP revealed that Scenario 1 had the highest mean WIP, indicating a higher level of congestion and potentially excessive inventory. In contrast, Scenario 7 exhibited the lowest mean WIP, implying a more streamlined and efficient flow of materials through the system. This finding highlights the importance of managing WIP to optimize the manufacturing process.

For stay time analysis, scenario 1 had the highest mean stay time. This indicated that units spent more time in the system in this scenario. On the other hand, scenario 7 had the lowest mean stay time, suggesting a more efficient flow of units through the system. Efficient stay times are crucial in improving overall production efficiency and reducing lead times.

The analysis of resource utilization indicated that all scenarios showed moderate utilization levels, with no significant deviations. This finding suggests that resource allocation across different scenarios is relatively balanced, but further optimization opportunities may exist to improve overall resource efficiency.

In conclusion, the simulation results provide valuable insights into the performance of different scenarios for the inbound logistics process in coconut manufacturing. Scenario 7 was a potentially efficient approach, with lower WIP, minimum stay time, and moderate utilization. However, further optimization and real-world validation are necessary to confirm the findings' implementation. The research outcomes support decision-making in enhancing the inbound logistics process and optimizing manufacturing operations for improving performance and competitiveness in the coconut industry.

Overall, this research provides a foundation for future studies in inbound logistics and/or coconut manufacturing optimization by demonstrating the implementation of the simulation model and evidencing its benefit in the area. This can serve as a basis for implementing efficient inbound logistics strategies in other industries as well. However, it is essential to consider other factors such as cost analysis and sustainability implications when making decisions based on the simulation results.

V. CONCLUSION

This research focuses on improving inbound logistics in coconut manufacturing through the FlexSim simulation software tool. The analysis of various improvement scenarios revealed that Scenario 3, Scenario 4, and Scenario 7 offered higher throughput. Scenario 7 demonstrated the lowest work in process and stay time, indicating its efficiency. Resource utilization was found to be moderate across all scenarios. The study recommends adopting strategies similar to those in Scenario 7 to enhance the inbound logistics process. However, real-world validation is essential to confirm the implementation of the findings. Overall, the research provides valuable insights for coconut manufacturers and serves as a stepping stone for future studies in logistics optimization. By leveraging simulation techniques, manufacturers can make data-driven decisions to improve overall manufacturing performance and competitiveness in the market.

ACKNOWLEDGEMENT

This research was funded and supported by the Rajamangala University of Technology Rattanakosin, Project No. A1/2562

REFERENCES

[1] A. J. G. Simoes and C. A. Hidalgo, "Fresh/Dried Coconuts," The Observatory of Economic Complexity (OEC), Rep. HS: 080110, Aug. 2023. [Online]. Available: https://oec.world/en/profile/hs/freshdried-coconuts

[2] S. Chawla and R. M. Singari, "Modelling and simulation of crankcase cover manufacturing in the automobile industry," *J. Sci. Ind. Res.*, vol. 82, pp. 597–602, Jun. 2023.

[3] B. Santhosh Kumar, V. Mahesh, and B. Satish Kumar, "Modeling and analysis of flexible manufacturing system with FlexSim," *Int. J. Comput. Eng. Res.*, vol. 5, no. 10, pp. 1–6, Oct. 2015.

[4] G. Jidong *et al.*, "Improvement of a furniture production line based on Flexsim" *in Proc. Int. Conf. Ind. Eng. and Operations Manage.*, Harbin, China, Jul. 2021, pp. 133–143.

[5] D. Liu, Y. Pan, and L. Li, "Logistics engineering simulation using computer 3D modeling technology," *J. Phys.: Conf. Ser.*, vol. 2143, 2021, Art. no. 012018. doi: 10.1088/1742-6596/2143/1/012018.

[6] S. Wang, S. Wang, and N. Zhang, "FlexSim-based simulation and optimization of green logistics distribution center," in *Proc. 14th Int. Conf. Comput. Model. and Simul.*, Chongqing, China, Jun. 2022, pp. 76–82.

[7] U. S. Kumar and Y. S. Narayan, "Productivity improvement in a windows manufacturing layout using Flexsim simulation software," *Int. J. Res. Advent Technol.*, vol. 3, no. 9, pp. 86–90, Sep. 2015.

[8] W. Liu and J. Lin, "Research on simulation and optimization of production line based on FlexSim," *Forest Chemical Rev.*, no. July-August 2022, pp. 1969–1985, May 2022.

[9] N. Ononiwu, M. Macharia, and M. Al-Ali, "Application of discrete event simulation in industrial sectors: A case study," *Int. J. Adv. Eng. Manage. Sci.*, vol. 2, no. 10, pp. 1751–1757, Oct. 2016.

[10] D. A. Pathak, "Improvement of manufacturing process by simulation technique: A case study," *Int. J. Adv. Sci. Technol.*, vol. 4, no. 4, pp. 54–60, Jan. 2012.

[11] N. Samattapapong, "Productivity improvement of tapioca packing process through simulation modeling analysis," in *Proc. 5th Int. Conf. Ind. Eng. and Appl.*, Singapore, Singapore, Apr. 2018, pp. 453–457.

[12] S. Luscinski and V. Iwanov, "A simulation study of industry 4.0 factories based on the ontology on flexibility with using FlexSim software," *Manage. Prod. Eng. Rev.*, vol. 11, no. 3, pp. 74–83, Sep. 2020.

[13] N. Medan, "Modelling and simulating a technological flow using the FlexSim application," *Scientific Bull. Ser. C: Fascicle Mechanics, Tribology, Mach. Manuf. Technol.*, vol. 35, pp. 62–66, 2021.

[14] K. Zhang, "Logistics simulation and optimization design of car coating production line based on FlexSim," *Sci. J. Intell. Syst. Res.*, vol. 3, no. 7, pp. 1–7, 2021.

[15] M. Krynke, "Manufacturing capacity management by using modern simulation tools," *Syst. Saf.: Human – Tech. Facility – Environ.*, vol. 3, no. 1, pp. 129–138, May 2021.

[16] R. Poloczek and B. Oleksiak, "Modeling and simulating production process with the use of the FlexSim method," *Metalurgija*, vol. 62, no. 3-4, pp. 484–487, 2023.

[17] A. A. Asante, M. Yin, C. K. Abbew, and D. Nyumuteye, "Optimizing the operational process of a cold chain fruit pack house," *Afr. J. Eng. Res.*, vol. 7 no. 3, pp. 64–73, 2019.

[18] N. A. Hassan, A. I. Arogundade, U. B. Iyenagbe, and D. I. Musa, "Simulation and analyses of shea nuts (Vitallaria paradoxa) processing plant using FlexSim©," *J. Future Sustainability*, vol. 3, no. 2, pp. 67–74, 2023.

[19] H. Min and Q. Yang, "Study on modeling and simulation of production logistics system based on FlexSim," *Academic J. Manuf. Eng.*, vol. 16, no. 2, pp. 149–156, 2018.

[20] J. Yuan and R. Zhang, "Analysis and optimization of bottlenecks via simulation," in *Proc. IEEE Int. Conf. Ind. Eng. and Eng. Manage.*, Bangkok, Thailand, Dec. 2018, pp. 1879–1883.

[21] N. Samattapapong, “An efficiency Improvement in warehouse operation using simulation analysis,” *IOP Conf. Ser.: Mater. Sci. and Eng.,* vol. 273, 2017, Art. no. 012013, doi: 10.1088/1757-899X/245/1/012013.

[22] N. Samattapapong, V. D. Cadenet, and P. Thongman, “Production sequence using simulation techniques: Case study of mineral production plants for dairy cow,” in *Proc. 11th Annu. Int. Conf. Ind. Eng. and Oper. Manage.*, Singapore, Singapore, Mar. 2021, pp. 650–659.

[23] M. Krynke, “Personnel management on the production line using the FlexSim simulation environment,” *Manuf. Technol.*, vol. 21, no. 5, pp. 657–667, 2021.