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Bottleneck Analysis in Garment Production Process Using Simulation Approach (ProModel)

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Abstract: Garment industry is a labor-intensive manufacturing sector with a complex production flow, highly susceptible to bottlenecks. Unresolved bottlenecks can lead to decreased efficiency, increased waiting times, and reduced productivity. This research aims to analyze bottlenecks in the garment production process using a simulation approach with ProModel software. The research method was carried out using a quantitative-descriptive approach, starting with production system selection, process flow mapping, and simulation model development and testing. The results of the original model simulation show a production output of 1.719 units, with a bottleneck of 3,86% and a cost of USD 38,01. This situation requires improvement, which was achieved through scenario 1, where production capacity at each location was increased, considering a relatively similar cost of USD 41,40. This change reduced the bottleneck to 0,60%, and total production increased to 1.811 units. In scenario 2, with a similar cost, the author recommended further adjustments to the production capacities at the required processes. After conducting the simulation, total production increased to 1.908 units, with a cost of USD 41,42. The simulation using ProModel proved effective in systematically identifying and evaluating bottleneck solutions. This research provides practical recommendations for garment industry management in making data-driven decisions to improve production efficiency.
Keywords: Bottleneck; Garment Industry; Simulation; ProModel; Production Efficiency

1. Introduction

The garment industry is a highly labor-intensive and complex manufacturing sector, with the primary challenge being the imbalance of workload between workstations, which often leads to bottlenecks. These bottlenecks become a serious barrier to meeting production targets and operational efficiency. To address this issue, simulation has proven to be an effective approach for identifying and resolving problems within production systems [1], [2].

According to Vaghefi and Sarhangian [1], simulation can be used to optimize inspection plans in multi-stage manufacturing systems, which directly impacts the reduction of product defects. This enables companies to identify critical points that require more attention. In the field of process planning and efficiency, Werker et al. [2] demonstrate that discrete event simulation can improve accuracy and scheduling precision, which is also relevant for garment production that demands speed and flexibility.

In the supply chain domain, simulation is also used to understand the interaction between system components and design more efficient production networks [3], [4], [5]. Jayant et al. [3] and Bhushan [5] show that through simulation, companies can manage supply chain risks and disruptions, positively impacting production continuity. Furthermore, Shubbar et al. [9] add that the dynamic systems simulation approach contributes to supply chain resilience in uncertain conditions.

In the context of digital manufacturing, Mourtzis et al. [6] emphasize the role of simulation in comprehensive production system planning and control. Integrated information and communication technology with simulation systems allows for more accurate and responsive decision-making. A similar study by Akter Jahan et al. [13] using neural networks and numerical simulation also shows that manufacturing system complexity can be modeled for data-driven decision-making.

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Several studies have specifically focused on bottleneck analysis. Pekarcikova et al. [14] used simulation with the Kanban module to address delays in logistics flow, while Alves et al. [15] studied integrated process simulation in ceramics industry to design more efficient processes. Butrat and Supsomboon [16] applied simulation to optimize resource utilization in the tire industry, which is also related to cost reduction and quality improvement.

Recent research by Muchtar et al. [12] demonstrates a real-world case of applying simulation to address bottlenecks in the food industry at PD. ABC. The simulation results showed that scenario improvements through additional labor were able to eliminate process bottlenecks and significantly increase output.

However, up until now, there has been little research specifically applying ProModel simulation in the garment industry context to identify and resolve bottlenecks in its production flow. As noted by Bongomin et al. [17], bottleneck issues in the garment industry require a suitable simulation approach to optimally enhance production efficiency. Therefore, this research aims to apply ProModel software simulation to analyze and address bottlenecks in the garment production process.

Based on the literature review conducted, the majority of previous studies have focused on the application of simulation in the logistics, assembly, supply chain, or general manufacturing sectors [1-16]. Although some studies have addressed bottleneck analysis in production flow [14], [15], the application of simulation specifically in the garment sector, especially for identifying and reducing bottlenecks using ProModel, is still very limited [17]. Therefore, this study fills that gap by providing an applied study in the garment industry as a new contribution to the literature on production management and industrial engineering.

2. Methodology

2.1 Research Approach

This research used a simulation method approach with ProModel software. ProModel was chosen because it is capable of dynamically modeling manufacturing systems, handling discrete systems, and providing visualizations and analyses of system performance such as waiting times, resource utilization, and bottlenecks.

The simulation was conducted to model the production process in the garment industry, then identify bottlenecks based on system performance measurements. Afterward, several improvement scenarios were tested to assess the impact of changes on production system performance.

2.2 Research Stages

This research was conducted through the following stages:

2.2.1 Determine the Production Process

The first step is defining the production system for the simulation. Relevant data such as process times, waiting times, and operation sequences were collected to set up the model.

2.2.2 Process Flow Mapping

A process flow diagram (flowchart) was created to visually represent the production process. During this stage, entities, activities, resources, and production routes were identified to ensure a clear understanding of the system operations.

2.2.3 Build the Simulation Model in ProModel

The flowchart was translated into a simulation model in ProModel. Process data, including process time distribution, arrival rates, and the number of operators or machines, were inputted into the system. Model validation was then performed to ensure accuracy.

2.2.4 Bottleneck Analysis

In this stage, the simulation was run to identify bottlenecks. Areas with the longest waiting times and highest resource utilization were analyzed. The performance was evaluated using indicators such as throughput, utilization, average waiting time, and work in process (WIP).

2.2.5 Scenario Development and Testing

Improvement scenarios were developed and tested. Each scenario was simulated to assess the impact of proposed changes on the system performance.

2.2.6 Evaluation and Recommendations

In this final stage, the performance results of the original and improved scenarios were compared. Based on the findings, recommendations are formulated, focusing on the best scenario for improving the production system.

3. Results and Discussion

In presenting the results of this research, the author has structured them into 3 models, i.e., the Original Model, Model of Scenario 1, and Model of Scenario 2.

3.1 Original Model

The author prepared data on the capacity, time, and costs used during the production process at each production location across the entire garment area. The author used ProModel for the simulation process. The following presents the original production data from the garment factory.

Tabel 1. Original System

Location	Capacity	Unit	Time Process (Min)
Raw Material	200	1	2
Move to Design	1	1	2
Design	17	1	10
Move to Marker and Cutting	1	1	2
Marker and Cutting	60	1	1
Move to Sewing	1	1	2
Sewing	20	1	12
Move to Quality Control	1	1	2
Quality Control	30	1	5
Move to Packing	1	1	2
Packing	20	1	5

The data was used to create a simulation to identify the areas where issues occur. The following figure provides an overview of the simulation.

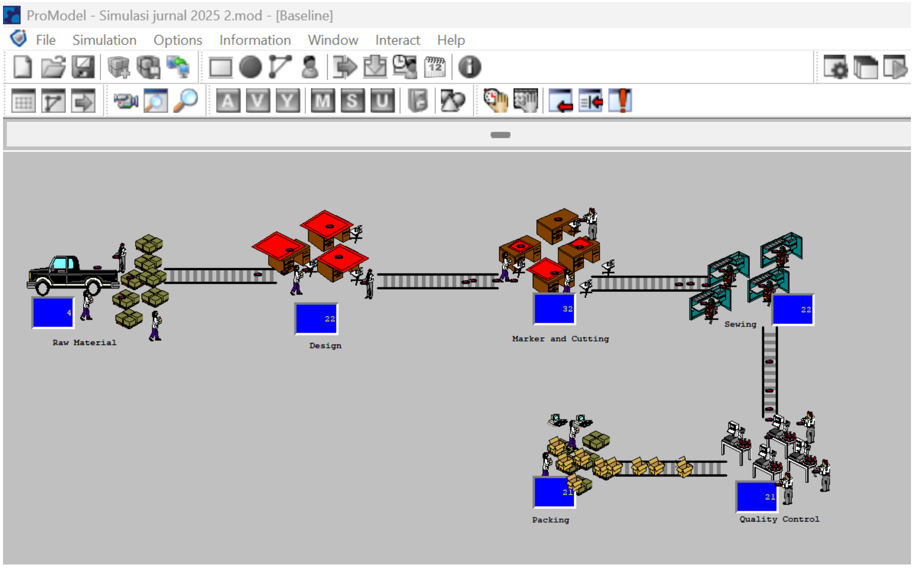

Figure 1. Simulation model of the original condition

In the original simulation, there was still an accumulation of items due to the capacity not aligning with the requirements.

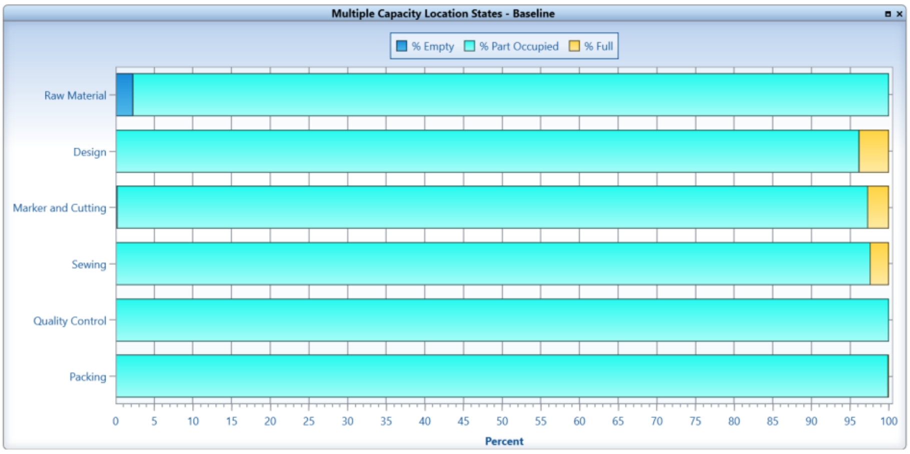

Figure 2. Bottleneck results (design: 3,86%, marker and cutting: 2,73%, sewing: 2,41%)

The results of the original simulation indicated that bottlenecks were still present, causing the process flow to deviate from its optimal state, or leading to accumulations in the Design process (3,86%), Marker and Cutting process (2,73%), and Sewing process (2,41%). This original condition model incurred an average cost per process type per hour of USD 38,01, with the details shown in the figure below, producing a total of 1.719 pieces.

Scoreboard		Scoreboard	
Total Exits	Average Time In System (Min)	Average Time In Operation (Min)	Average Cost
0,00	0,00	0,00	0,00
1.719,00	44,98	20,12	38,01

Figure 3. Productions, times, and costs result in the original model

Based on the results of the original system simulation, improvements are necessary to balance the production process flow that was arranged in Model of scenario 1.

3.2 Model of Scenario 1

To address this issue, the author proposed increasing the capacity of the required processes to enhance efficiency, reduce bottlenecks, and improve production output. The data table for this scenario is as follows.

Tabel 2. System of Scenario 1

Location	Capacity	Unit	Time Process (Min)
Raw Material	200	1	2
Move to Design	1	1	2
Design	27	1	10
Move to Marker and Cutting	1	1	2
Marker and Cutting	60	1	1
Move to Sewing	1	1	2
Sewing	27	1	12
Move to Quality Control	1	1	2
Quality Control	29	1	5
Move to Packing	1	1	2
Packing	21	1	5

After the improvement, the capacity in the Design section was increased to 27, in the Sewing section to 27, in the Quality Control section to 29, and in the Packing section to 21. The result of the simulation is as follows.

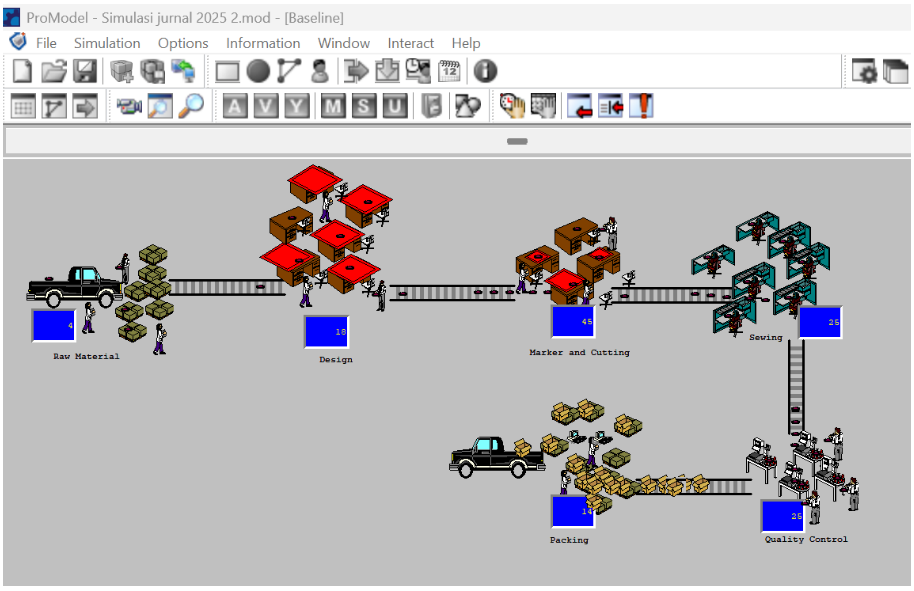

Figure 4. Simulation model of scenario 1

After the capacity was increased in the processes, the result of the simulation is shown as follows.

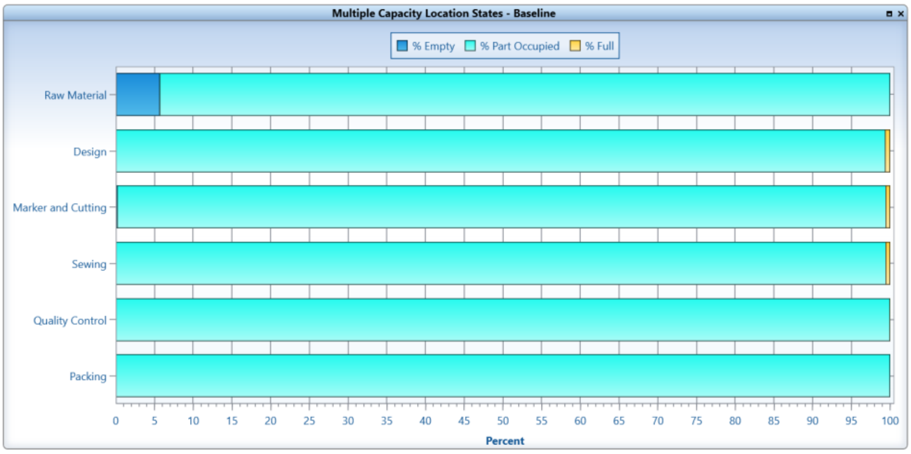

Figure 5. Bottleneck results (design: 0,60%, marker and cutting: 0,51%, sewing: 0,51%)

After simulating Scenario 1, it was found that increasing the capacity in certain processes according to the needs had a significant impact, as it could significantly reduce the bottleneck. In the Design process, the bottleneck was reduced to 0,60%, in the Marker and Cutting process to 0,51%, and in the Sewing process to 0,51%. This Scenario 1 model incurred an average cost per process type per hour of USD 41,40. The total production achieved was 1.811 pieces. The details are as follows.

Scoreboard Scoreboard

Total Exits	Average Time In System (Min)	Average Time In Operation (Min)	Average Cost
0,00	0,00	0,00	0,00
1.811,00	48,64	22,96	41,41

Figure 6. Productions, times, and costs result in the model of scenario 1

Although the bottleneck issue had been reduced, there was still something that needed to be addressed. The improvement was made in Model of scenario 2.

3.3 Model of Scenario 2

The author contended that the production seemed to still have the potential for improvement, with relatively the same cost considerations. Therefore, the author proposed to create another scenario. The following is the scenario that was developed.

Tabel 3. System of Scenario 2

Location	Capacity	Unit	Time Process (Min)
Raw Material	200	1	2
Move to Design	1	1	2
Design	27	1	10
Move to Marker and Cutting	1	1	2
Marker and Cutting	50	1	1
Move to Sewing	1	1	2
Sewing	30	1	12
Move to Quality Control	1	1	2
Quality Control	31	1	5
Move to Packing	1	1	2
Packing	22	1	5

After the improvement, the capacity in the Design section was increased to 27, the capacity in the Marker and Cutting process was adjusted to 50, in the Sewing section to 30, in the Quality Control section to 31, and in the Packing section to 22. The result of the simulation is as follows.

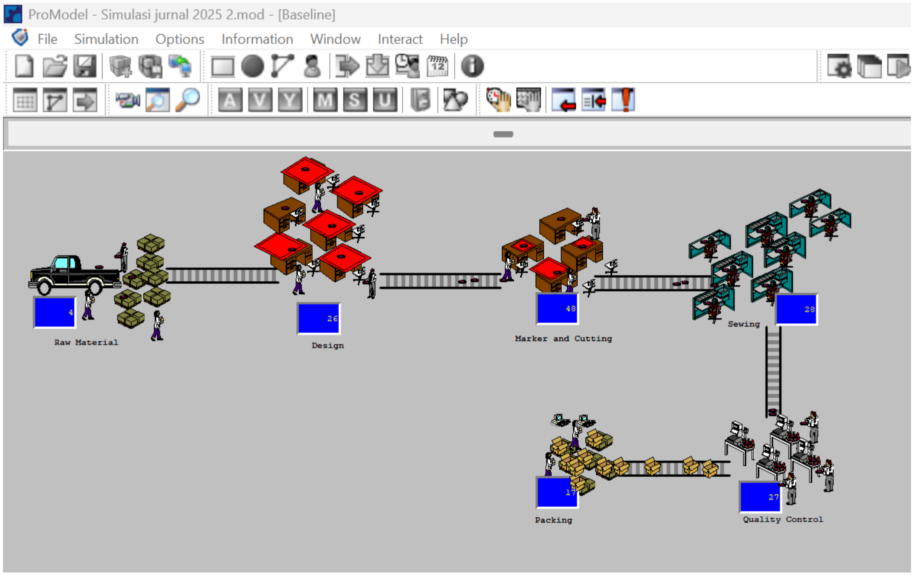

Figure 7. Simulation model of scenario 2

After the capacity was increased in the processes, the result of the simulation is shown as follows.

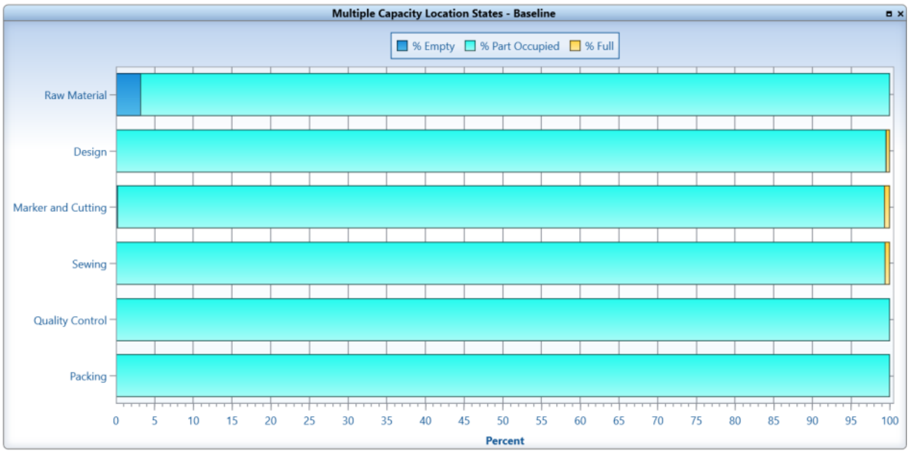

Figure 8. Bottleneck results (design: 0,48%, marker and cutting: 0,70%, sewing: 0,60%)

After simulating Scenario 2, it was found that increasing the capacity in certain processes according to the needs had a significant impact, as it can significantly reduce the bottleneck. In the Design process, the bottleneck was reduced to 0,48%, in the Marker and Cutting process to 0,70%, and in the Sewing process to 0,60%. This Scenario 2 model incurred an average cost per process type per hour of USD 41,42. The details are shown in the figure below, with a total production of 1.908 pieces.

Total Exits	Average Time In System (Min)	Average Time In Operation (Min)	Average Cost
0,00	0,00	0,00	0,00
1.908,00	45,11	22,77	41,42

Figure 9. Productions, times, and costs result in the model of scenario 2

From the various simulation models that were created, the following is a summary of the results using ProModel.

Tabel 4. Simulation results resume

Resume	Original Model	Scenario 1	Scenario 2
Highest Bottleneck	3,86%	0.60%	0,70%
Cost (USD)	38,01	41,40	41,42
Production (Total Exit)	1.719	1.811	1.908

4. Conclusion

In the original model, the garment production process showed a total exit of 1.719 pieces with a bottleneck of 3,86%, indicating the need for improvements to prevent excessive accumulation of the items. Therefore, the purpose of Scenario 1 was to eliminate or reduce this bottleneck by increasing the production capacity at each location, while keeping the cost relatively close at USD 41,40. As a result, the bottleneck was reduced to 0,60%, and the total exit or total production reached 1.811 pieces. However, the challenge faced by every company is to optimize its production as best as possible to meet customer demand. For this reason, the author proposed Scenario 2 to further increase production, maintaining the cost at a similar level. In Scenario 2, the author recommended further adjustments to production capacity in the required processes. After the simulation, the total exit increased to 1.908 pieces, with a cost very close to USD 41,42.

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Reference

[1] A. Vaghefi and V. Sarhangian, "Contribution of simulation to the optimization of inspection plans for multi-stage manufacturing systems," *Computers & Industrial Engineering*, vol. 57, no. 4, pp. 1226–1234, Nov. 2009, doi: https://doi.org/10.1016/j.cie.2009.06.001.

[2] G. Werker, A. Sauré, J. French, and S. Shechter, "The use of discrete-event simulation modelling to improve radiation therapy planning processes," *Radiotherapy and Oncology*, vol. 92, no. 1, pp. 76–82, Jul. 2009, doi: https://doi.org/10.1016/j.radonc.2009.03.012.

[3] A. Jayant, P. Gupta, and S. K. Garg, "Reverse logistics network design for spent batteries: a simulation study," *International Journal of Logistics Systems and Management*, vol. 18, no. 3, p. 343, 2014, doi: https://doi.org/10.1504/ijlsm.2014.062820.

[4] T. Eftonova, M. Kiran, and M. Stannett, "Long-term Macroeconomic Dynamics of Competition in the Russian Economy using Agent- based Modelling," *International Journal of System Dynamics Applications*, vol. 6, no. 1, pp. 1–20, Jan. 2017, doi: https://doi.org/10.4018/ijsda.2017010101.

[5] S. Bhushan, "System Dynamics Base-Model of Humanitarian Supply Chain (HSCM) in Disaster Prone Eco-Communities of India," *International Journal of System Dynamics Applications*, vol. 6, no. 3, pp. 20–37, Jul. 2017, doi: https://doi.org/10.4018/ijsda.2017070102.

[6] D. Mourtzis, N. Papakostas, D. Mavrikios, S. Makris, and K. Alexopoulos, “The role of simulation in digital manufacturing: applications and outlook,” *International Journal of Computer Integrated Manufacturing*, vol. 28, no. 1, pp. 3–24, Sep. 2013, doi: https://doi.org/10.1080/0951192x.2013.800234.

[7] V. Ngunzi, F. Njoka, and R. Kinyua, “Modeling, simulation and performance evaluation of a PVT system for the Kenyan manufacturing sector,” *Heliyon*, vol. 9, no. 8, p. e18823, Aug. 2023, doi: https://doi.org/10.1016/j.heliyon.2023.e18823.

[8] Y. Li, Y. He, R. Liao, Xin Xiao Zheng, and W. Dai, “Integrated predictive maintenance approach for multistate manufacturing system considering geometric and non-geometric defects of products,” vol. 228, pp. 108793–108793, Aug. 2022, doi: https://doi.org/10.1016/j.ress.2022.108793.

[9] H. T. Shubbar, F. Tahir, and T. Al-Ansari, “Bridging Qatar’s food demand and self-sufficiency: A system dynamics simulation of the energy–water–food nexus,” Sustainable Production and Consumption, Feb. 2024, doi: https://doi.org/10.1016/j.spc.2024.02.017.

[10] G. Kaur and R. G. Kander, “Supply Chain Simulation of Manufacturing Shirts Using System Dynamics for Sustainability,” *Sustainability*, vol. 15, no. 21, pp. 15353–15353, Oct. 2023, doi: https://doi.org/10.3390/su152115353.

[11] K. Tsiamas and S. Rahimifard, “A simulation-based decision support system to improve the resilience of the food supply chain,” *International Journal of Computer Integrated Manufacturing*, vol. 34, no. 9, pp. 996–1010, Aug. 2021, doi: https://doi.org/10.1080/0951192x.2021.1946859.

[12] D. Muchtar, F. Herdiansyah, and I. Gumelar, “Simulasi Proses Produksi Kerupuk Kulit Dorokdok PD ABC Sukaregang–Garut,” Jurnal Teknologika, vol. 14, no. 1, pp. 80–90, May 2024, doi: https://doi.org/10.51132/teknologika.v14i1.364.

[13] S. Akter Jahan, M. Al Hasan, and H. El-Mounayri, “A framework for graph-base neural network using numerical simulation of metal powder bed fusion for correlating process parameters and defect generation,” *Manufacturing Letters*, vol. 33, pp. 765–775, Sep. 2022, doi: https://doi.org/10.1016/j.mfglet.2022.07.095.

[14] M. Pekarcikova, P. Trebuna, M. Kliment, and M. Dic, “Solution of Bottlenecks in the Logistics Flow by Applying the Kanban Module in the Tecnomatix Plant Simulation Software,” *Sustainability*, vol. 13, no. 14, p. 7989, Jul. 2021, doi: https://doi.org/10.3390/su13147989.

[15] C. L. Alves *et al.*, “Integrated process simulation of porcelain stoneware manufacturing using flowsheet simulation,” *Cirp Journal of Manufacturing Science and Technology*, vol. 33, pp. 473–487, May 2021, doi: https://doi.org/10.1016/j.cirpj.2021.04.011.

[16] A. Butrat and S. Supsomboon, “A Plant Simulation approach for optimal resource utilization: A case study in the tire manufacturing industry,” *Advances in Production Engineering & Management*, vol. 17, no. 2, pp. 243–255, Aug. 2022, doi: https://doi.org/10.14743/apem2022.2.434.

[17] O. Bongomin, J. I. Mwasiagi, E. O. Nganyi, and I. Nibikora, “Simulation metamodeling approach to complex design of garment assembly lines,” *PLOS ONE*, vol. 15, no. 9, p. e0239410, Sep. 2020, doi: https://doi.org/10.1371/journal.pone.0239410.