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Line Balancing with Simulation Approach (ProModel) on SMC Big Volume Lane in HA Export Department at PT. XYZ

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Abstract: This research aims to identify and overcome bottlenecks in production process at PT. XYZ Indonesia, especially in HA Export Department on SMC Big Volume Lane. Bottlenecks were detected in Visual Acc and Housing processes, which resulted in decreased efficiency and productivity. The method used in this study is line balancing with the Pro Model simulation approach, which allows analysis of improvement scenarios without disrupting ongoing operations. Data collected includes process time and machine capacity. Initial simulation results showed significant idle time 15,4%, with accumulation at Raw Material workstation (12.30%), Housing workstation (1.20%), and Visual Acc (1.90%). After the improvements were made, including increasing the Raw Material capacity to 20 pcs, the Housing process to 3 pcs, and Visual Acc to 3 pcs, the bottleneck was successfully eliminated from 15.4% became 0% and the production flow became more stable. This research provides practical solutions to improve efficiency and reduce cycle time, and can be a reference for companies in implementing line balancing and simulation methods to improve productivity in the manufacturing industry.
Keywords: Bottleneck; Line Balancing, ProModel Simulation; Production Efficiency

1. Introduction

In modern manufacturing industries, particularly in automotive and electronics sectors, assembling process of wiring harnesses is one of the critical components that affect the overall product quality and efficiency. A wiring harness is a collection of cables assembled and organized to connect various electrical components. The assembly process involves many manual steps, making line balancing a frequent source of inefficiency. This imbalance leads to bottlenecks, idle time, and reduced output, which in turn increases lead times and production costs.

Simulation has been proven to significantly contribute to optimizing various aspects of manufacturing systems. Vaghefi and Sarhangian [1] demonstrated that simulation can optimize inspection planning in multi-stage systems, decreasing product defect rates. Werker et al. [2] stated that although often used in the medical field, discrete event modeling is highly relevant to the manufacturing sector as it enhances accuracy and efficiency in production processes.

In the context of supply chain systems, Jayant et al. [3] used simulation to design an efficient closed-loop supply network, while Eftonova et al. [4] applied agent-based modeling to understand interactions within complex systems. Bhushan [5] added that simulation is useful in designing resilient systems during emergencies, it is a method that can also be applied in the manufacturing context.

The importance of simulation within the framework of digital manufacturing was emphasized as a tool for production planning and control [6]. The simulation can also be used to optimize energy utilization, supply chain resilience, and predictive maintenance in manufacturing systems [7-9]. In terms of sustainability, Kaur and Kander [10] and Tsiamas and Rahimifard [11] highlighted how simulation helps identify the impact of decisions on operational sustainability and strategic decision-making.

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Advanced technologies have also started to be integrated into simulation, as described by Akter Jahan et al. [12] through the use of graph neural networks in welding processes. In the context of logistics and workflow, the simulation can identify and resolve bottlenecks, as well as improve the overall efficiency of manufacturing processes [13-14]. Butrat and Supsomboon [15] added that simulation can be utilized to optimize resource utilization, resulting in cost efficiency and increased output.

A similar case was found in a study from Muchtar et al. [16], which showed that labor shortage was the main cause of bottlenecks in a food industry. By using improvement scenario simulations, the company successfully increased its production capacity significantly. This research reinforces that simulation is a crucial tool in operational decision-making and capacity planning.

However, despite the many research proving the effectiveness of simulation across various manufacturing sectors, there remains limited research that specifically explores the use of ProModel simulation approach in addressing line balancing issues in the wiring harness assembly process. This presents a research gap that needs to be addressed to help companies design optimal and efficient work sequence.

2. Methodology

This research was conducted at PT. XYZ Indonesia, precisely in HA Export Department at SMC Big Volume Lane. The research time started from collecting field data, initial analysis, to implementing the simulation, which took place during the period of January 2025. This research used a quantitative approach with a discrete-event-based simulation method using ProModel software. This method was chosen to model the production process virtually, identify bottlenecks, and test various improvement scenarios to achieve production line balance. This research was conducted through several stages as follows:

2.1 Identification of the Problems

In this stage, the bottleneck in visual acc and assembly processes in SMC Big Volume Lane production was identified. The key indicators such as cycle time, idle time, utility level, and queue length at each workstation were measured.

2.2 Data Collection

In this stage, the data collected includes process time at each workstation, machine capacity and workforce, production flow and daily output quantity, and data collected that were carried out through observation, interviews with operators, and production document studies.

2.3 Simulation Modeling

In simulation modeling, an initial model of the production process was created using ProModel based on actual data. Then, the model validation was conducted by comparing simulation results with historical data to ensure model accuracy.

2.3 Simulation Experiment

Identify improvement scenarios, such as redistribution of workload, addition of manpower or machines, and rearrangement of workstations are the activities done during this stage. It was also conducted improvement scenario simulations to evaluate their impact on production line efficiency.

2.4 Analysis of Results and Recommendations

Afterwards, the simulation results of each scenario were analyzed to determine the best solution. Recommendations for improvements in the field implementation also were provided.

3. Results and Discussion

Line Balancing system simulations provide valuable insights into system performance and the interactions between its components. From the simulation results, we can see how lead times, production process efficiency, and resource utilization levels can change with variations in parameters such as lead times, process times, and downtime.

Researchers have collected data on the amount of time used during the production process at each production location on the SMC Big Volume Lane in the HA Export Department and calculated the capacity at each location. Researchers use ProModel to create a line balancing simulation. The following is the initial production data on SMC Big Volume Lane.

Table 1. SMC big volume lane production data

Location	Capacity	Unit	Time Process (Min)	Lead Time (Min)
Raw Material	15	1	0,3	1
Move to Housing	2	1	1	0,3
Housing Process	2	1	0,1	1
Move to Assembling	2	1	1	0,1
Assembling Process	3	1	0,1	1
Move to Visual Acc	3	1	1	0.1
Visual Acc	2	1	0.2	1
Move to Storage	2	1	1	0.2
Storage	13	1	0.5	1

The data were simulated first to find out where the problem occurs, the following is the description of the simulation.

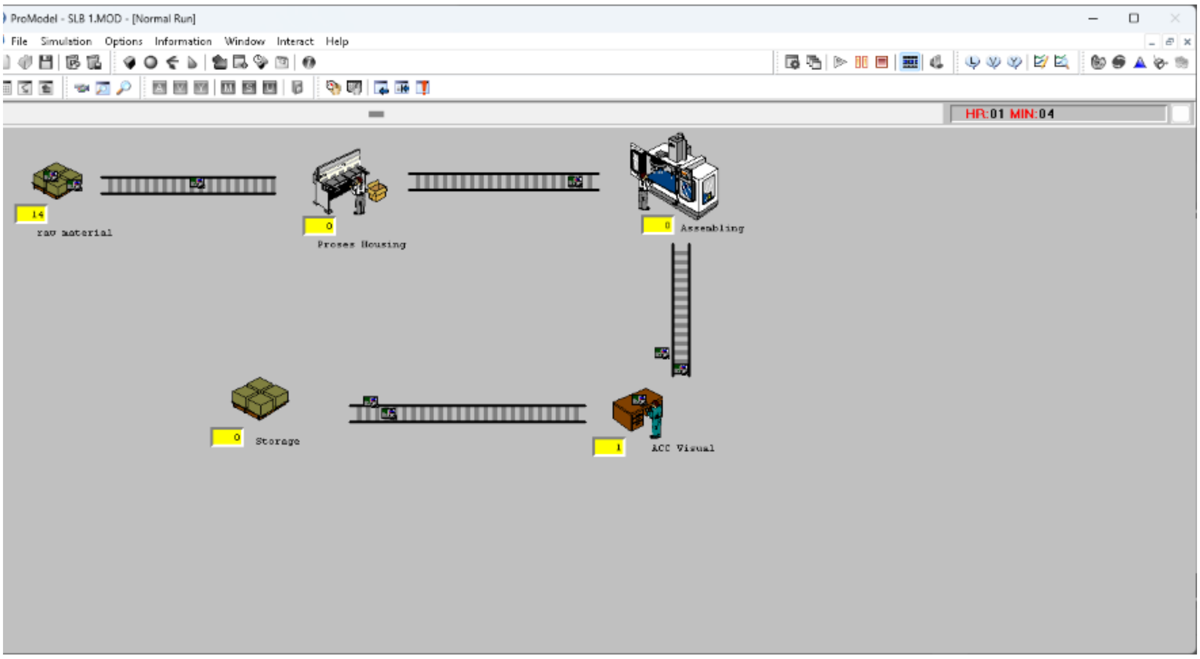

Figure 1. Initial condition simulation of big volume SMC lane

In the first ongoing line balancing simulation, there were accumulated products because the capacity was insufficient in the Big Volume SMC Lane.

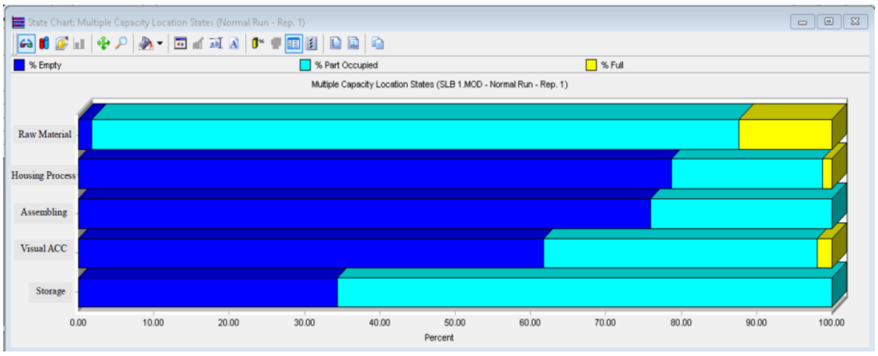

Figure 2. Initial condition simulation results of big volume SMC lane

The initial condition simulation results show that there are still bottlenecks that cause the process flow to be unstable and not run as it should, in this problem there is piled up raw materials as much as 12.30%, Housing process as much as 1.20%, Visual ACC 1.90%. In this initial condition model, it requires a total cost of Rp. 21.100.000. The details are in this following table.

Table 2. Production cost data for SMC big volume lane

Entity	**Need**	**Price**	**Total price**
Operator/Manpower	3	Rp. 3.500.000	Rp. 10.500.000
Pallet Raw Material	1	Rp. 800.000	Rp. 800.000
Hanger	1	Rp. 5.000.000	Rp. 5.000.000
Jig Board & Stand	1	Rp. 4.000.000	Rp. 4.000.000
Pallet Storage	1	Rp. 800.000	Rp. 800.000
Total cost			Rp. 21.100.000

With the existing line balancing problem, it is necessary to make improvements to balance the production process flow. To overcome this problem, researchers provide suggestions in the form of additional capacity at each work station to be more efficient in improving performance in the production process to eliminate bottlenecks. Based on the data obtained and simulations made, there were accumulations at several work stations. Therefore, a simulation was made with the second condition by increasing the capacity at each location or work station. This method was done by training manpower in order to improve their performance. The following is the improvement data taken.

Table 3. Alternative data 1

Location	**Capacity**	**Unit**	**Time Process (Min)**	**Lead Time (Min)**
Raw Material	20	1	0,3	1
Move to Housing	3	1	1	0,3
Housing Process	3	1	0,1	1
Move to Assembling	3	1	1	0,1
Assembling Process	4	1	0,1	1
Move to Visual Acc	4	1	1	0,1
Visual Acc	3	1	0,2	1
Move to Storage	3	1	1	0,2
Storage	15	1	0,5	1

After improving the initial condition, the Capability in the Housing section was increased to 3 pcs, in the Assembling process the capacity was also increased to 4 to balance, while in the Visual Acc section the storage capacity is also increased to 3 pcs to accommodate more products being worked on. The following are the simulation results with conditions almost similar with the initial conditions, with additional capacity at each location.

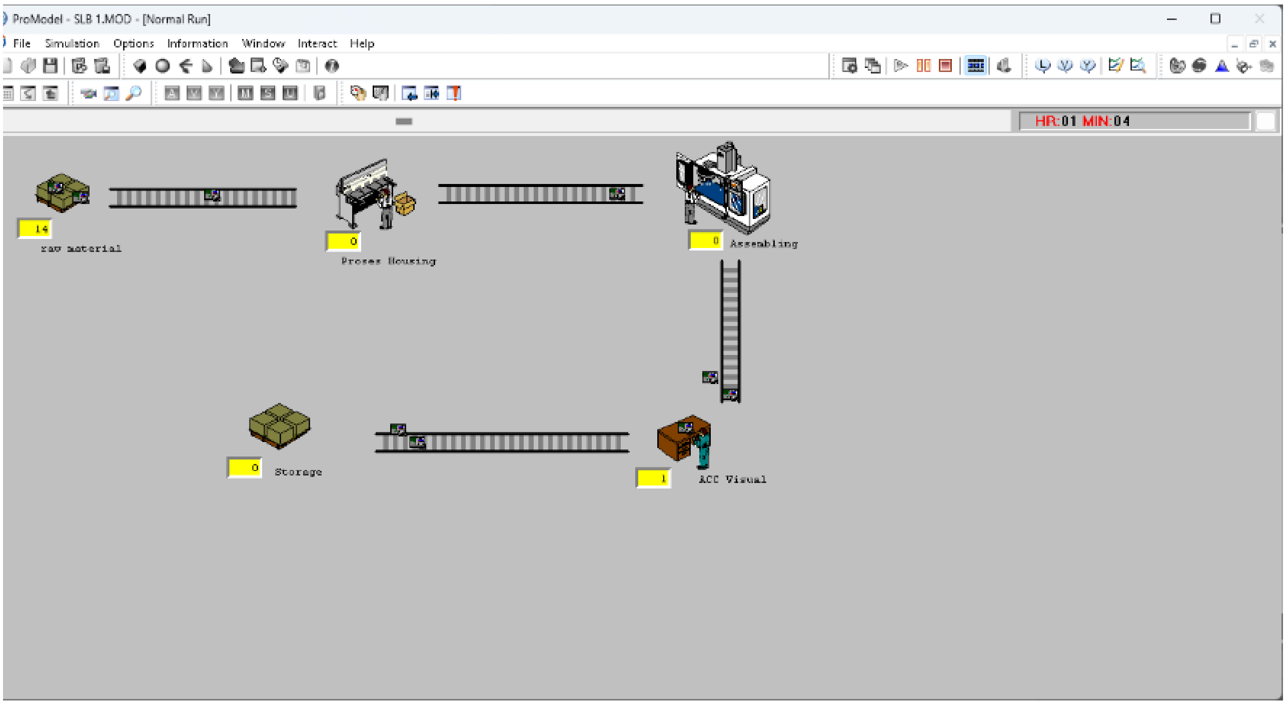

Figure 3. Capacity addition in housing, assembling and visual acc processes

Adding the capacity to the Housing, Assembling, and Visual Acc processes can be an alternative solution to the Line Balancing system simulation on the Big Volume SMC Lane. The following are the simulation results of the second condition or the first alternative after the simulation was carried out.

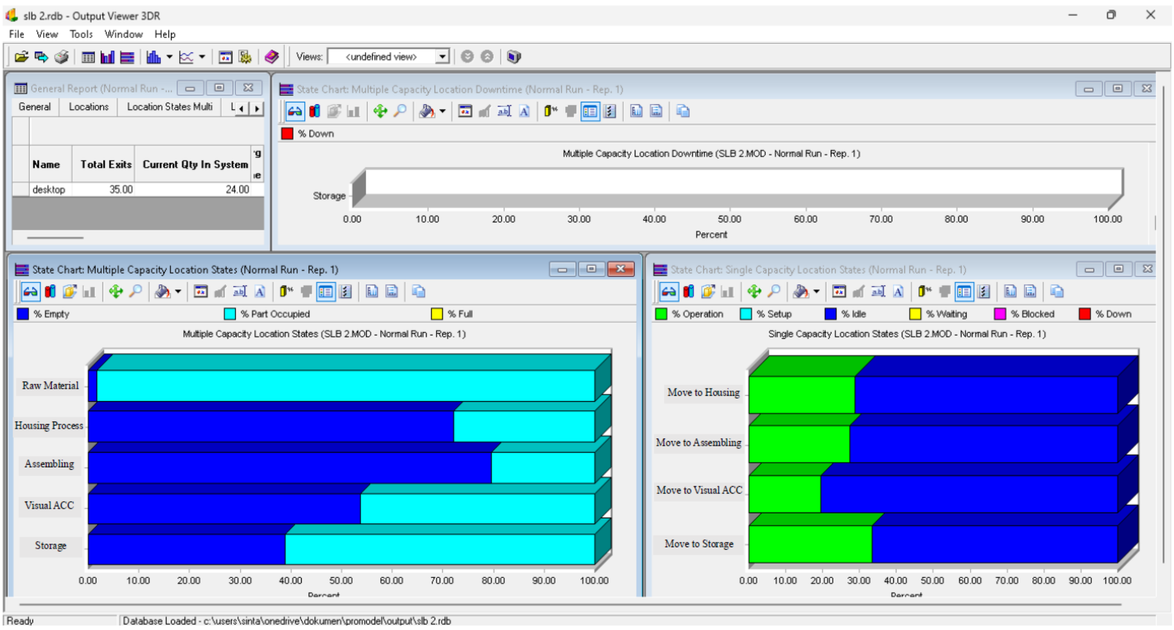

Figure 4. Alternative statistics 1 after testing

After conducting a simulation test of the line balancing system with ProModel on the SMC Big Volume Lane at PT. XYZ Indonesia, we found that the addition of capacity to the Housing, Assembling, and Visual Acc Processes greatly influenced because it could eliminate Bottleneck in the previous process, thus creating a line balancing system that was no longer constrained by Bottleneck. Meanwhile, the production costs for alternative 1 were still the same as the initial model, here are the details.

Table 4. Production cost data for alternative 1

Entity	Need	Price	Total price
Operator/Manpower	3	Rp. 3.500.000	Rp. 10.500.000
Pallet Raw Material	1	Rp. 800.000	Rp. 800.000
Hanger	1	Rp. 5.000.000	Rp. 5.000.000
Jig Board & Stand	1	Rp. 4.000.000	Rp. 4.000.000
Pallet Storage	1	Rp. 800.000	Rp. 800.000
Total cost			Rp. 21.100.000

Although the bottleneck problem has been solved, there was still something that needs to be fixed, the company was faced with increasing product demand from customers. The company must also increase the results of the products made. With the existing capacity, it is certainly not enough to get more output, therefore the other alternatives were planned. The following is another alternative.

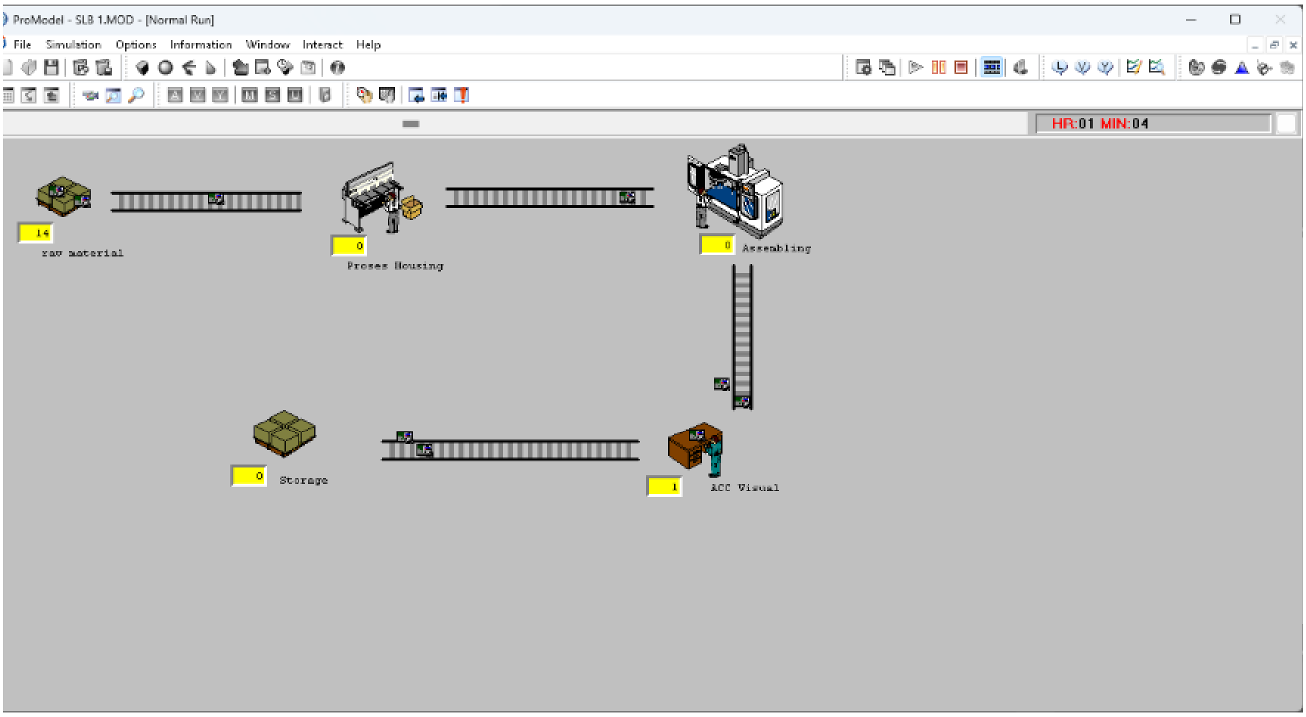

Figure 5. Addition of manpower in the assembling process

The increasing amount of manpower in the Assembling process was made because the process affects the output results that were worked on. The following is a description of the simulation that was made with the same work location and only added 1 manpower to the Assembling process so that the capacity in the Assembling process also increased.

Table 5. Alternative data 2

Location	Capacity	Unit	Time Process (Min)	Lead Time (Min)
Raw Material	20	1	0.3	1
Move to Housing	3	1	1	0,3
Housing Process	3	1	0,1	1
Move to Assembling	3	1	1	0,1
Assembling Process	8	1	0,1	1
Move to Visual Acc	8	1	1	0,1
Visual Acc	3	1	0,2	1
Move to Storage	3	1	1	0,2
Storage	15	1	0.5	1

Then, here are the results after conducting a simulation using ProModel by increasing the amount of Manpower in the Assembling process.

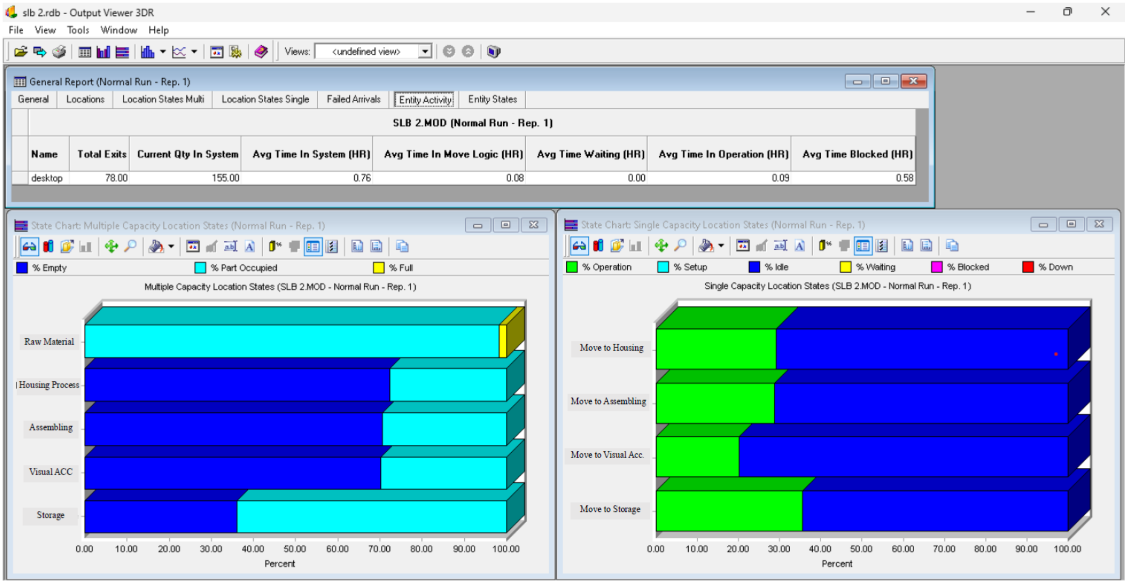

Figure 6. Alternative statistics 2 after testing

After conducting the simulation test of the line balancing system with ProModel on the second alternative in SMC Big Volume Lane at PT. XYZ Indonesia, it was found that the addition of manpower in the Assembling Process can provide significant results. The total output increases from the 35 pcs in 1 hour of process to 78 pcs in 1 hour of process. This second alternative model required an additional cost of Rp. 3.500.000, so that the total cost required increased to Rp. 24.600.000. The cost details are as follows:

Table 6. Production cost data for alternative 2

Entity	Need	Price	Total price
Operator/Manpower	4	Rp. 3.500.000	Rp. 14.000.000
Pallet Raw Material	1	Rp. 800.000	Rp. 800.000
Hanger	1	Rp. 5.000.000	Rp. 5.000.000
Jig Board & Stand	1	Rp. 4.000.000	Rp. 4.000.000
Pallet Storage	1	Rp. 800.000	Rp. 800.000
Total cost			Rp. 24.600.000

From the several simulation models that have been created, the following is a summary of the simulation results using ProModel.

Table 7. Simulation Result *Summary*

Resume	Early Model	Alternative 1	Alternative 2
Bottleneck	15.40%	0.00%	0.04%
Cost	Rp. 21.100.000	Rp. 21.100.000	Rp. 24.600.000
Production (Total Exit)	35 Pcs/Hour	35 Pcs/Hour	78 Pcs/Hour

In the initial model, the problem that occurs in the SMC Big Volume Lane with a total exit of 35 pcs/hour was bottleneck that reached 15.40%. It required repairs so that there was no more accumulation. The purpose of alternative 1 was to eliminate the bottleneck by increasing production capacity at each location so that the bottleneck becomes 0% or no more bottlenecks were found, yet the total exit displayed was still the same, which was 35 pcs/hour. Another challenge faced by the company was the increasing demand from customers and it required increased production with the existing capacity, this was not enough to solve the problem.

Afterwards, the second alternative was made to solve the existing problem. In this second alternative, it is suggested that the company add operators to the assembling section because it can affect the productivity level of the HA Export production line. After the simulation, the total exit obtained increased to 78 pcs/hour, which means that production results increased by more than doubled. It only increases the company's cost by Rp. 3.500.000 to pay for an additional operator, from the total cost Rp. 21.100.000 to Rp. 24.600.000.

4. Conclusion

The final simulation designed on ProModel successfully overcome bottlenecks that occur in the production process at PT XYZ Indonesia, especially in the HA Export Department on the SMC Big Volume Lane. The bottlenecks were detected at the Raw Material workstation, Housing process, and Visual Acc, which resulted in decreased efficiency and productivity. By using a ProModel-based simulation method, this research was able to model the production process virtually. It allows in-depth analysis of the production flow and identification of points that experience the accumulations. This research proposes increasing capacity at each workstation that experiences bottlenecks.

The addition of capacity and manpower proved an effectivity in eliminating bottlenecks, so that the production flow became more stable and efficient. The simulation results showed that after the improvement, the bottleneck in the production process was successfully overcome, with reduced waiting time and increased output. Production increased from 35 pcs/hour to 78 pcs/hour after the implementation of the second alternative. This research recommends that the company continue to monitor and evaluate the production process periodically. In addition, the company is advised to consider further capacity additions and training for the workforce to deal with the increasing demand for products.

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