

# Identification of Bottlenecks in Rod Slider Production Using Siemens Tecnomatix Plant Simulation

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## Abstract

The manufacturing industry has long strived to improve production line efficiency by reducing waste and costs while increasing profits. However, issues such as bottlenecks, underutilization of resources, and downtime could have improved overall manufacturing process efficiency. Hence, the present study aims to identify the bottlenecks and their efficiency on the existing rod slider production line. In this study, Tecnomatix Plant Simulation software was used to mimic the production line, where data were obtained utilising qualitative methodologies like interviews with the company's CEO and firsthand observation of the manufacturing line. The present rod slider manufacturing has a bottleneck at CNC turning and milling, reducing production line efficiency by 20%. The suggested solution to optimise the present production line by using in-house processing reveals that the identified bottleneck may be removed or minimised by up to 12%. This increases the production line efficiency from 20% to 92.5%. The findings offer real strategies for enhancing effectiveness and optimising production processes by proactively identifying and resolving bottlenecks using various means.

## 1. Introduction

The company XYZ Sdn Bhd was established in Malaysia on November 25<sup>th</sup>, 2015. The main business activity of the company is to design, manufacture, process, buy, sell, distribute, and deal with machinery, machine tools, engines, tools, supplies, equipment, accessories, and appliances of all types and nature as a principal or an agent. Thus, keeping the company's operations running smoothly and its production at its peak is critical to eliminating non-value-added activities using any method available. Simulation is essential for checking and validating the decision to be applied to the operations to verify that the eliminated activities provide benefit to the company's operations and productivity.

In the era of Industry 4.0, the major goal of most manufacturers is to improve their efficiency and reduce waste. It is critical to employ simulation techniques to analyse and improve processes to achieve these objectives before making changes to actual operations or production line processes. Poor decisions will have a detrimental impact on the company's productivity and, in the worst-case situation, loss (Talapatra *et al.*, 2018). Simulating includes constructing a model that mimics an existing or proposed process. Allows the simulated models to anticipate the results of any modifications made or suggested to the current process. This will provide critical information and a reason to support any adjustments that may be taken to increase productivity and profit for the organization. Simulations may be used to represent a variety of manufacturing processes, including production lines, material handling systems, and supply chains (Law, 2019). Simulation can save time and ensure that any action taken will likely benefit the organization.

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XYZ Sdn Bhd, a prominent player in the manufacturing sector, is currently grappling with significant production challenges that are affecting its overall efficiency. Recent analyses indicate that the company normally faces persistent issues such as production bottlenecks, underutilization of resources, and considerable downtime, which collectively hinder operational performance (Mofolasayo *et al.*, 2022). Notably, the production cycle for rod sliders, a critical component in their product lineup, extends over a cumbersome five-days period, encompassing various stages from raw material handling to final packaging. This extended timeline is primarily attributed to the prolonged hardening treatment phase, which alone consumes three days.

The complexity of the rod slider production process, involving intricate steps like material selection, turning, hardening treatment, and flash chrome plating, underscores the need for a systematic approach to improve productivity (Yemane *et al.*, 2020). Addressing these bottlenecks necessitates not only identifying the root causes but also devising strategies that could involve substantial investments in process redesign and the adoption of advanced technologies (Damiani *et al.*, 2018). Such initiatives might also require reskilling and training of the workforce to adapt to new methodologies.

In light of these challenges, simulation techniques have emerged as a powerful tool for optimizing production and supply chain processes. Prior research has demonstrated the utility of simulation in various contexts, from modelling supply chain performance (Yassine *et al.*, 2019) to traffic and transportation systems (Fedorko *et al.*, 2022). By employing simulation software, companies can create detailed models of their operations, identify inefficiencies, and develop targeted improvement strategies.

In this study, we propose the use of Siemens Tecnomatix Plant Simulation software to address the production issues at XYZ Sdn Bhd. The primary objectives are to: (i) to identify the bottlenecks within this current rod slider production line, and (ii) to propose effective solutions to mitigate these bottlenecks and enhance overall production efficiency. By leveraging this advanced simulation tool, we aim to provide actionable insights that will facilitate a more streamlined and productive manufacturing process.

## 2. Experimental Procedure

### 2.1 Research Design

The research design focused on leveraging simulation to enhance production line efficiency. To gather relevant data, the study employed interviews and observations as primary methods. To boost the performance of XYZ Sdn Bhd, the researcher opted to redesign the facility layout. This study adopted a qualitative approach to thoroughly understand the company's production environment. Utilizing qualitative methods enabled the exploration of the deeper reasons and mechanisms behind human behaviours, experiences, and perspectives, aspects that quantitative methods alone could not fully reveal.

### 2.2 Data Collection

To gather data on the current production line layout, interviews were conducted with supervisors, engineers, and operators involved in the manufacturing process. These interviews take a qualitative approach, aiming to gain in-depth insights into the participants' experiences, perspectives, and expertise regarding the facility layout. During the interviews, respondents described the current production layout, including the arrangement of workstations, equipment, and material flow. This preliminary information serves as a foundation for understanding the existing layout. Additionally, respondents were encouraged to inform any issues or bottlenecks in the current production layout that could impact productivity, workflow efficiency, or safety. This helps pinpoint areas that may need improvement or modification.

In addition to interviews, observational methods were also employed to provide a comprehensive view of the company's manufacturing process. Data collection for facility layout optimization included time studies and production layout identification. Time studies were utilised systematically observing and recording the time taken to complete tasks, providing data on task efficiency. Production line layout identification involved visually mapping the arrangement of workstations, equipment, and material flow within the facility. These observations help identify inefficiencies, bottlenecks, safety hazards, and ergonomic concerns. The collected data acts as the basis for analysing and improving the facility layout, with the goal of enhancing productivity and workflow efficiency.

Data collection was conducted to gather the necessary information for running simulations using Siemens Tecnomatix Plant Simulation software. Key data includes a list of all processes involved, distances between processes, and the size of workstations for the simulation. Additionally, for the time study, data such as task descriptions, the number of cycles, time measurements, task elements, operator characteristics, and environmental factors were collected. These data elements are crucial for accurately simulating and optimizing production processes using the simulation software, as well as for effective production scheduling.

### 2.3 Data Analysis

Data analysis in Siemens Tecnomatix simulation software involves key steps to extract insights from simulation results. After developing and running the simulation model, data was analysed to understand system performance and identify areas for improvement.

Data analysis focuses on identifying bottlenecks by examining processes, workstations, or resources with high utilization or long cycle times. Sensitivity analysis evaluates the impact of varying parameters on system performance, supporting optimization under different conditions. Visualization techniques, such as charts and graphs, are crucial for interpreting and communicating findings.

The analysis ensures the model runs smoothly, with output validated against real-world data or benchmarks. Tecnomatix helps identify bottlenecks and idle times, guiding solutions to minimize or eliminate them for improved system performance. The suggested solutions were assessed again using the same simulation before being pitched to the company.

### 3. Results and Discussion

#### 3.1 Observation and Time Study

Table 1 provides a detailed analysis of XYZ Sdn Bhd's process flow, based on observations of the current production process. The study identified that rod sliders are manufactured through eight distinct procedures. The table also notes the number of operators needed for each procedure. Additionally, the time required for each procedure, measured in minutes, was carefully recorded and included in the table, with the exception of the hardness treatment process, which takes three days and is outsourced.

**Table 1** Current process flow of the rod sliders

Operation	Process	No. of operator	Setup time (min)	Process time (min)	Cycle time (min)
1	CNC turning	1	10	10	60
2	CNC milling	1	5	5	30
3	Hardening treatment	1	20	20	3 days
4	Grinding	1	5	5	30
5	Flash chrome plating	1	10	10	180
6	Quality control check	1	2	2	15
7	Packaging	1	2	2	15

A crucial observation is made in the flash chrome plating process, which has a much higher cycle time of 180 minutes than other procedures, indicating that it is one of the most time-consuming. Furthermore, the quality control and packing process is notable for its efficient parallel work with a single operator and deficient cycle time. The table's primary goal is clear: it is a strategic tool for assessing production flow, identifying improvement possibilities, optimising scheduling, tracking performance indicators, and improving communication among team members. Finally, it enables decision-makers to make rational recommendations to improve production efficiency and overall operational performance.

#### 3.2 Current Production Line Analysis using Tecnomatix Plant Simulation

To examine the existing process flow of the rod slider, a simulation was developed using Siemens Tecnomatix Plant simulation software, which included CNC machines, hardening treatment, flash chrome plating, and inspection and packing. Fig. 1 depicts the sequential flow of operations and the incorporation of statistical aspects, giving a clear picture of the simulated production procedure. This integration of visual representations not only adds a layer of realism to the simulation but also enhances the overall engagement and interest of the users. By aligning the station module with its real-world counterpart through detailed and accurate graphics, the model creates an immersive experience, allowing users to witness a seamless transition between virtual simulation and the physical manufacturing environment.

The extensive simulation report included crucial variables including blocked time, waiting time, and working time, allowing for a thorough review of the manufacturing processes. A thorough study of the resource data in Fig. 2 revealed the processes with the highest values in each category. Notably, the flash chrome plating process had the greatest working percentage (81.06%), suggesting that it used up a large share of the available time resources. This indicated that in terms of working time, this process dominated the whole production cycle.

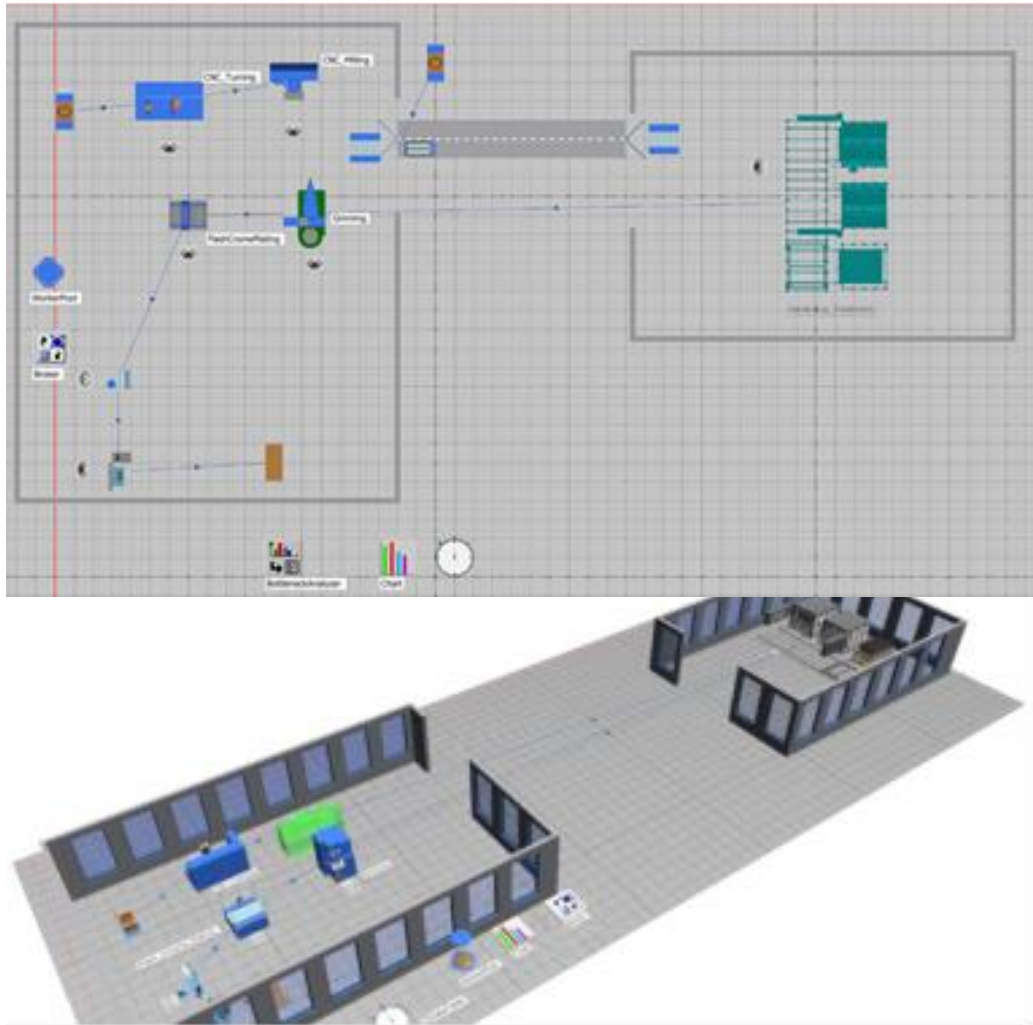


Fig. 1 The process flow of the rod slider production process

**Resource Statistics - Resource Statistics**

Object	Working	Set-up	Waiting	Blocked	Powering up/down	Failed	Stopped	Paused	Unplanned	Portion
RawMaterials	0.00%	0.00%	0.00%	100.00%	0.00%	0.00%	0.00%	0.00%	0.00%	
CNC_Turning	12.50%	0.69%	0.01%	75.44%	0.00%	11.35%	0.00%	0.00%	0.00%	
CNC_Milling	4.17%	0.35%	7.36%	79.42%	0.00%	8.70%	0.00%	0.00%	0.00%	
Flash_Chrome_Plating	0.00%	0.00%	91.25%	0.00%	0.00%	8.75%	0.00%	0.00%	0.00%	
Grinning	0.00%	0.00%	89.66%	0.00%	0.00%	10.34%	0.00%	0.00%	0.00%	
Quality_Control	0.00%	0.00%	100.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	
Packaging	0.00%	0.00%	100.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	
Customer	0.00%	0.00%	100.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	
HardeningTreatment	81.06%	1.39%	7.77%	0.00%	0.00%	9.78%	0.00%	0.00%	0.00%	

Fig. 2 Resource statistics of current rod slider production

**3.2.1 Working Time**

Fig. 3 shows the working time analysis of current rod slider production. Working time is a crucial statistic for evaluating process efficiency. It is defined as the amount of time that passes between the occurrence of a system’s stated input condition and the conclusion of a designated activity. The hardening treatment process has the highest functioning percentage in the current process flow (81.20%). In detail, the total working hours for hardening treatment process came to 19 hours and 2 minutes.

Object	Portion	Count	Sum	Mean Value	Standard Deviation
RawMaterials	0.00%	0	0.0000	0.0000	0.0000
CNC_Turning	8.93%	40	1:06:00:00.0000	45:00.0000	0.0000
CNC_Milling	2.98%	40	10:00:00.0000	15:00.0000	0.0000
Flash_Chrome_Plating	32.74%	40	4:14:00:00.0000	2:45:00.0000	0.0000
Grinning	2.98%	40	10:00:00.0000	15:00.0000	0.0000
Quality_Control	2.98%	40	10:00:00.0000	15:00.0000	0.0000
Packaging	2.98%	40	10:00:00.0000	15:00.0000	0.0000
Customer	0.00%	40	0.0000	0.0000	0.0000

Fig. 3 Working time analysis of current rod slider production

### 3.2.2 Waiting Time

Fig.4 depicts a visual representation of the waiting time distribution for the current process flow. It provides a thorough understanding of the temporal dynamics and challenges connected with each unique process. Waiting time in manufacturing refers to the time it takes for a work item, such as a document, to be processed further. This temporal gap may occur as a result of a person or machine required for the process to operate at full capacity. The existing process flow displays a significant presence of waiting time throughout the process. Quality Control and packaging process are the two processes with the longest wait durations (4 days 23 hours and 43 minutes).

Object	Portion	Count	Sum	Mean Value	Standard Deviation
RawMaterials	0.00%	0	0.0000	0.0000	0.0000
CNC_Turning	0.00%	1	10.9266	10.9266	0.0000
CNC_Milling	1.47%	2	1:46:02.6586	53:01.3293	34:33.5602
Flash_Chrome_Plating	87.60%	24	09:07:27.0468	2:04:33:43.5234	1:07:45:59.7074
Grinning	89.90%	24	11:52:29.0080	2:05:56:14.5040	1:04:28:27.4895
Quality_Control	99.76%	24	23:43:00.0000	2:11:51:30.0000	1:13:24:28.0937
Packaging	99.76%	24	23:43:00.0000	2:11:51:30.0000	1:13:48:33.4199
Customer	100.00%	25	00:00:00.0000	2:12:00:00.0000	1:14:00:34.6688
HardeningTreatment	1.55%	1	1:51:55.4677	1:51:55.4677	0.0000

Fig. 4 Waiting time analysis of current rod slider production

### 3.2.3 Blocked Time

Fig. 5 shows the results of the blocked time analysis for the current process flow, providing useful insights into the situations where activities are delayed due to downstream unpreparedness. Blocked time arises when an activity remains idle due to the inability of the next downstream action to accept it. The current process flow analysis reveals that the processes with the largest percentages of blocked time are CNC milling, and turning, with 87.37%, and 86.37%, respectively. This investigation leads to a more detailed understanding of the factors impacting operational flow and allows for more informed decision-making for improved process efficiency.

Object	Portion	Count	Sum	Mean Value	Standard Deviation
RawMaterials	100.00%	4	5:00:00:00.0000	1:06:00:00.0000	1:13:16:56.5542
CNC_Turning	86.78%	24	08:07:53.5825	2:04:03:56.7913	1:02:19:10.9049
CNC_Milling	87.37%	24	08:50:53.2558	2:04:25:26.6279	1:02:53:19.0043
Flash_Chrome_Plating	0.00%	0	0.0000	0.0000	0.0000
Grinning	0.00%	0	0.0000	0.0000	0.0000
Quality_Control	0.00%	0	0.0000	0.0000	0.0000
Packaging	0.00%	0	0.0000	0.0000	0.0000
Customer	0.00%	0	0.0000	0.0000	0.0000
HardeningTreatment	0.00%	0	0.0000	0.0000	0.0000

Fig. 5 Blocked time analysis of current rod slider production

In summary, the comprehensive simulation report delved into crucial parameters such as blocked time, waiting time, and working time, revealing insights into the dynamics of the production processes. The flash chrome plating process emerged as a major contributor to working time (81.06%), indicating its pivotal role in the production cycle, while quality control and packaging processes exhibited prolonged waiting times, signalling potential bottlenecks. The hardening treatment process demonstrated high functionality, completing tasks efficiently. The waiting time analysis highlighted delays in quality control and packaging, while the investigation into blocked time pinpointed CNC milling and turning (100%), as potential bottleneck areas. Overall, the current efficiency of the rod slider production is 20% ( $8 \text{ units} \div 40 \text{ units} \times 100\%$ ). There is potential for increased overall productivity.

### 3.3 Potential Solution for Productivity Improvement

Table 1 demonstrates a significant difference in processing times across different stages of the manufacturing process. Certain procedures, such as packaging, clearly require a relatively short period, lasting only 15 minutes. In contrast, more time-consuming operations, such as the hardening process, take three days to complete. Recognizing the potential for increased efficiency and effectiveness within the rod slider's production process flow, process improvement initiatives are critical. The goal of these enhancements is to reduce and eliminate various types of waste, with a special emphasis on areas such as waiting time reduction. This strategic approach not only streamlines operations, but also adds to an optimized workflow, resulting in a more efficient operation (Druetto *et al.*, 2023).

#### 3.3.1 Solution 1 – Rearrange the Process Flow

As part of an initiative to enhance the efficiency of the production process flow, parallel processes were introduced by rearranging the existing workflow (Mengistu, 2019). A bottleneck in the CNC turning operation was identified through research analysis, indicating a potential slowdown in the overall production cycle. To address this bottleneck, parallel processes were implemented using Siemens Tecnomatix simulation as shown in Fig.6. By introducing parallel CNC turning operations, the production line was effectively able to handle multiple tasks simultaneously, reducing the wait times associated with the bottleneck. This rearrangement aimed not only to alleviate the strain on the CNC turning process but also contributed to a more streamlined and expedited production flow.

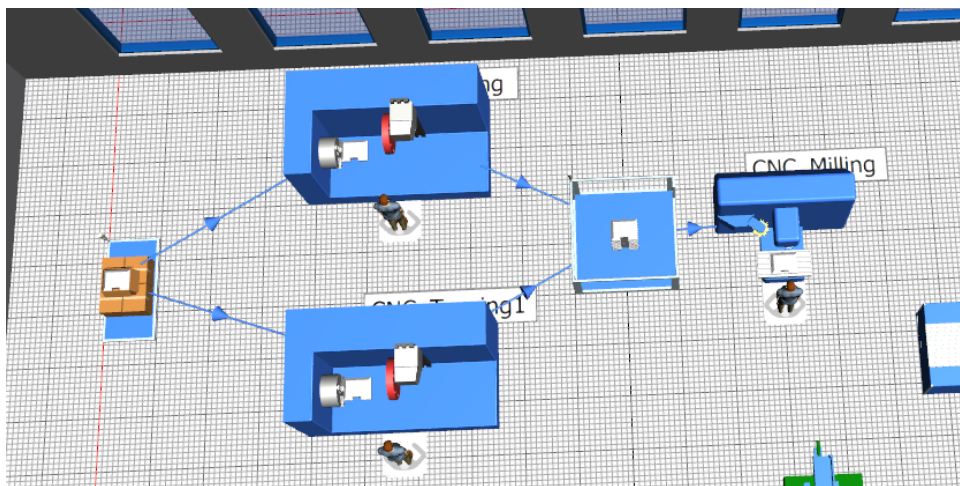


Fig. 6 Introducing parallel processing in the CNC turning process

#### 3.3.2 Solution 2 – Change from Outsourced to In-house Production

In order to improve operational efficiency and reduce downtime in the hardening treatment process, a strategic project has been launched to transition from outsourcing to an in-house production for hardening treatment process based on simulation techniques. Recognising the inherent delays associated with outsourcing, particularly the regular occurrence of waiting periods of up to three days, the researchers hope to eliminate high wait times by using simulation and internalisation of the heat treatment process, thereby significantly shortening the production schedule. This shift offers not just a more agile and responsive operational structure, but also more control over quality assurance and process optimization (Arimoto, 2021). The decision to internalize the hardening treatment process in-house through simulation demonstrates a commitment to fostering a more streamlined and efficient approach. The hardening treatment process is generally done on steel at temperatures ranging from 480 to 680 °C, with holding times ranging from one to two hours (Yilmaz *et al.*, 2021). Fig. 7 shows the process changed from outsourcing to in-house processing.

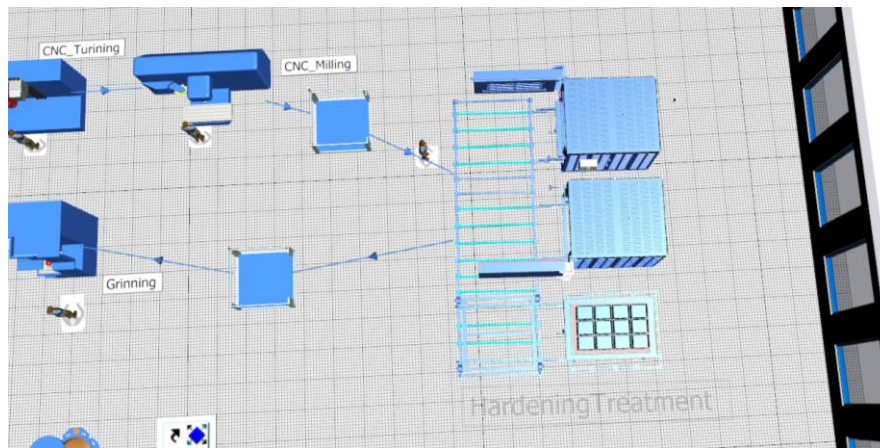


Fig. 7 Hardening treatment process changed from outsourcing to in-house production

### 3.3.3 Solution 3 – Add Buffer Station

The present process flow study shows a bottleneck, causing obstructions in the CNC turning and milling processes due to the longer process time. Two buffer stations, each with a capacity of 20, were added after the CNC turning and milling to mitigate the effects of the slow hardening treatment process. Optimal buffer allocations can considerably increase system throughput by reducing unpredictability and interruptions in manufacturing or service processes. Organisations can reduce waiting times and bottlenecks by deliberately placing buffers along the flow path, resulting in a smoother and more efficient manufacturing or service delivery process (Amjath *et al.*, 2023). Figure 8 depicts the integration of the new buffers into the production process.

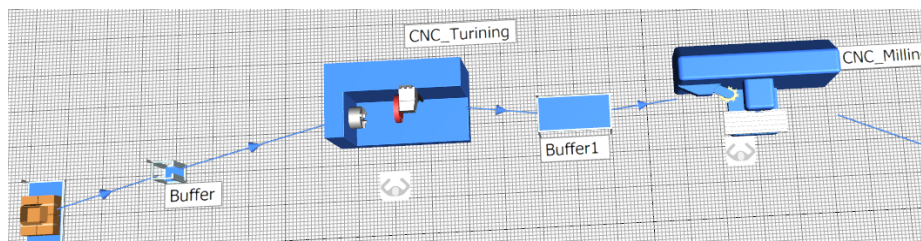


Fig. 8 Buffer stations added in production line

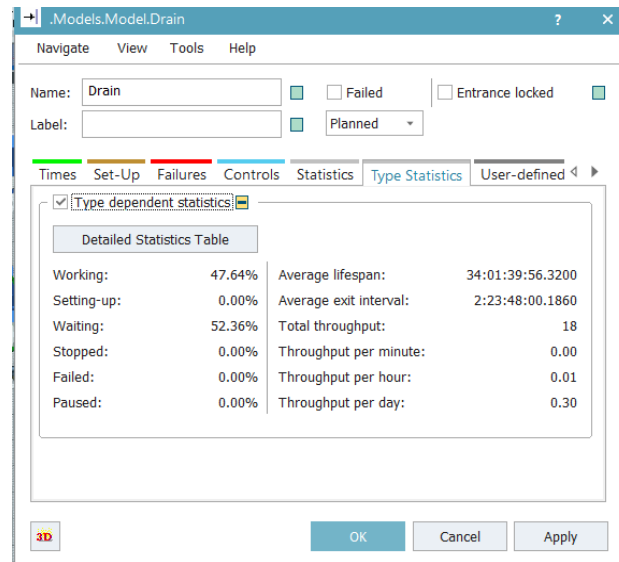
### 3.4 Potential Solution Validity – Comparison Analysis

In order to improve the performance of the existing processes, a comparison was made by introducing a buffer and making all processes in-house. The objective of the simulations was to compare the performance of the existing processes and improve them. The performance measures included working time, waiting time and blocked time. The comparison analysis between current and proposed solution to improve the productivity is presented below.

Table 2 shows that the process that have long working had improved after implement the improvement but the waiting time and blocked time is increased. According to the analysis, the total throughput has climbed from 8 units to 18 units. This represents an improvement of 10 units which mean the production process has resulted in an increased productivity efficiency rate of 45%. Fig. 9 depicts a detailed analysis of throughput statistics and illustrates these conclusions.

Table 2 Comparison analysis between before and after implementing parallel processing

Variable	Station	Percentage (%)		Percentage changes (%)
		Before	After	
Working time	Hardening treatment	81.06	75.00	-6.06
Waiting time	Grinding	89.90	96.06	+6.16
	Quality control check	99.76	99.62	+0.14
	Packaging	99.76	99.69	+0.07
Blocked time	CNC turning	86.78	98.85	+12.07
	CNC milling	87.37	99.69	+12.32

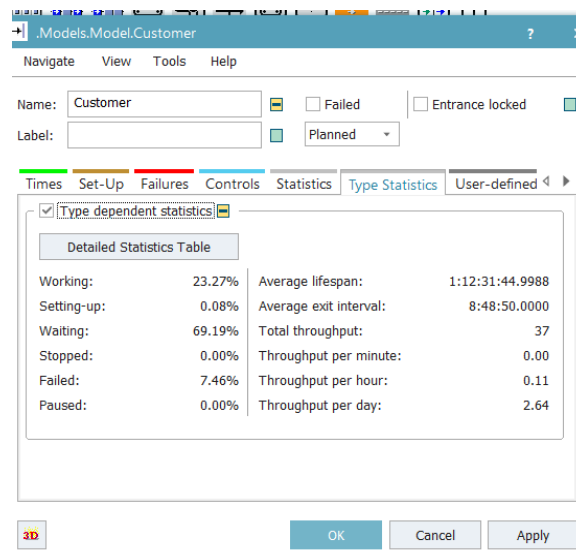


**Fig. 9** Throughput analysis after implement parallel processing

Meanwhile, Table 3 shows the comparison analysis before and after the improvement of implemented in-house processing of hardening treatment process. It shows that all the process that have long working, waiting and blocking time had improved and lower after implement the improvement. According to the analysis, the throughput per unit has climbed to 8 units from 37 units. This represents a significant improvement of 29 units. Furthermore, the in-house production process had increased overall efficiency which was 92.5%, and ensuring more responsive and agile manufacturing system. Fig. 10 depicts a detailed analysis of throughput statistics and illustrates these conclusions.

**Table 3** Comparison analysis between before and after implementing in-house production

Variable	Station	Percentage (%)		Percentage changes (%)
		Before	After	
Working time	Hardening treatment	81.06	75.00	-6.06
Waiting time	Grinding	89.90	96.06	+6.16
	Quality control check	99.76	99.62	+0.14
	Packaging	99.76	99.69	+0.07
Blocked time	CNC turning	86.78	98.85	+12.07
	CNC milling	87.37	99.69	+12.32



**Fig. 10** Throughput analysis after implementing in-house production

### 3.5 Improved Process Flow

In response to the recognised challenge of moving from parallel processing or changing from outsourcing to in-house processing. Recognising the need for a comprehensive solution, the researcher developed a new and enhanced simulation that accurately duplicates the whole production procedure, as seen in Fig.11. On top of that, the researcher intends to simplify operations and gain more control over the manufacturing cycle by bringing outsourced procedures in-house. The in-house production process strategy was consistent with the larger aim of optimising the production process, boosting total efficiency by 92.5%, and assuring a more responsive and agile manufacturing system, as seen in Fig. 12.

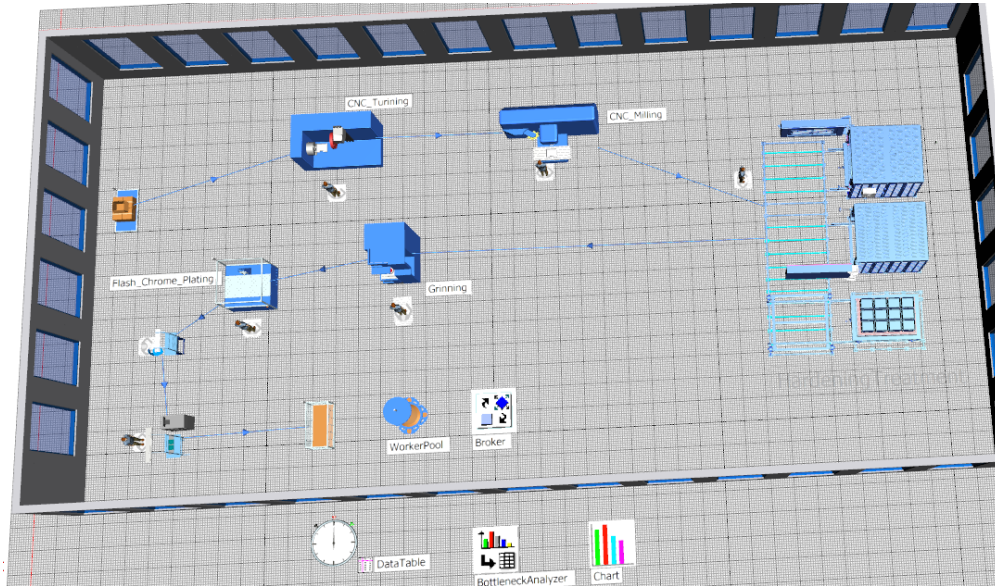


Fig. 11 Improved production layout for the rod slider production

#### Resource Statistics - Resource Statistics

Object	Working	Set-up	Waiting	Blocked	Powering up/down	Failed	Stopped	Paused	Unplanned	Portion
RawMaterials	0.00%	0.00%	100.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	
CNC_Turning	8.33%	0.14%	81.78%	0.00%	0.00%	9.75%	0.00%	0.00%	0.00%	
CNC_Milling	4.17%	0.07%	69.96%	15.97%	0.00%	9.83%	0.00%	0.00%	0.00%	
Flash_Chrome_Plating	25.00%	0.14%	65.10%	0.00%	0.00%	9.76%	0.00%	0.00%	0.00%	
Grinning	4.17%	0.07%	68.49%	17.65%	0.00%	9.62%	0.00%	0.00%	0.00%	
Quality_Control	2.08%	0.03%	97.89%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	
Packaging	2.08%	0.03%	97.89%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	
Customer	0.00%	0.00%	100.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	
HardeningTreatment	16.67%	0.28%	67.96%	5.57%	0.00%	9.52%	0.00%	0.00%	0.00%	
Buffer	0.00%	0.00%	100.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	
Buffer1	0.00%	0.00%	100.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	

Fig. 12 After improvement implementation analysis

### 3.6 Discussion

The analysis of XYZ Sdn Bhd’s production line using Siemens Tecnomatix Plant simulation revealed key insights into bottlenecks. The flash chrome plating process had the highest work percentage, indicating potential resource usage issues. On the other hand, processes such as grinding, quality control, and packaging experienced long waiting times, highlighting areas for efficiency improvements. CNC turning and milling showed significant blocked time, pointing to downstream readiness challenges.

The analysis also showed the hardening treatment process excelled with an 81.20% functionality rate, while quality control and packaging faced substantial delays. CNC milling and turning had high blocked times, reflecting delays due to downstream unpreparedness. This analysis provides a clear view of temporal dynamics and process challenges, offering a roadmap for strategic improvements to enhance overall efficiency and competitiveness at XYZ Sdn Bhd. A significant bottleneck observed is the waiting time in CNC turning and milling, caused by the longest processing time in the hardening process. In response, switching from outsourcing to in-house hardening treatment based on simulation approaches. This modification seeks to substantially

minimise manufacturing delays, which were previously as long as three days owing to outsourcing. However, there are additional elements to consider before implementing the suggested solution, such as cost, equipment, expertise/manpower, and so on. Bringing the process in-house resulted in a far more efficient workflow and better-quality control. To address the slow-pace hardening treatment, 20-unit buffer stations are strategically placed before the CNC turning and milling operations. These buffers keep the process stable, preventing undue pressure and delays.

This approach boosted daily throughput from 0.2 to 2 units, reflecting a significant improvement of 1.8 units per hour. The overall throughput has grown from one to ten units, demonstrating the efficiency advantages gained by the recommended strategies.

#### 4. Conclusion

In conclusion, this study has effectively met its primary objectives. First, it assessed the efficiency of the rod slider production line at XYZ Sdn Bhd using Siemens Tecnomatix Plant simulation, providing a comprehensive analysis of the production process. By documenting and analysing seven distinct processes, the study established a detailed baseline for evaluating operational efficiency. The research also successfully identified key bottlenecks within the production line. The simulation highlighted extended waiting times in grinding, quality control, and packaging, along with significant delays in the hardening treatment process. This insight allowed for a nuanced understanding of the production disruptions affecting workflow. Furthermore, the study proposed effective solutions to address these bottlenecks. The introduction of process flow changes and strategic buffers, as indicated by the simulation, demonstrated substantial improvements in production efficiency by reducing waiting and blocked times. Overall, the study achieved its goals by thoroughly evaluating the production line's efficiency, pinpointing critical bottlenecks, and recommending enhancements. The use of Siemens Tecnomatix Plant simulation was pivotal in achieving these outcomes. This research provides actionable insights for optimizing production processes and enhancing operational effectiveness at XYZ Sdn Bhd.

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#### Conflict of Interest

Authors declare that there is no conflict of interests regarding the publication of the paper.

#### Author Contribution

*The authors confirm contribution to the paper as follows: **study conception and design:** Tee Boon Long, Mohamad Ali Selimin; **data collection:** Tee Boon Long; **analysis and interpretation of results:** Tee Boon Long, Mohamad Ali Selimin; **draft manuscript preparation:** Tee Boon Long, Mohamad Ali Selimin. All authors reviewed the results and approved the final version of the manuscript.*

#### References

- Amjath, M., Kerbache, L., Smith, J. M., & Elomri, A. (2023). Optimisation of buffer allocations in manufacturing systems: a study on intra and outbound logistics systems using finite queueing networks. *Applied Sciences*, 13(17), 9525. <https://doi.org/10.3390/app13179525>
- Arimoto, K. (2021). A Brief Review on Validation for Heat Treatment Simulation. HT2021, 71-80. <https://doi.org/10.31399/asm.cp.ht2021p0071>
- Damiani, L., Demartini, M., Giribone, P., Maggiani, M., Revetria, R., & Tonelli, F. (2018). Simulation and digital twin based design of a production line: A case study. In Proceedings of the International MultiConference of Engineers and Computer Scientists (Vol. 2).
- Druetto, Alessandro, Erica Pastore, and Elena Renner (2023). Parallel batching with multi-size jobs and incompatible job families. *Top* 31.2, 440-458. <https://doi.org/10.1007/s11750-022-00644-2>
- Fedorko, G., Molnár, V., Strohmandl, J., Horváthová, P., Strnad, D., & Cech, V. (2022). Research on Using the Tecnomatix Plant Simulation for Simulation and Visualization of Traffic Processes at the Traffic Node. *Applied Sciences*, 12(23), 12131. <https://doi.org/10.3390/app122312131>
- Law, A. M. (2019). How to build valid and credible simulation models. 2019 Winter Simulation Conference (WSC), National Harbor, MD, USA, 2019, 1402-1414, <https://doi.org/10.1109/WSC40007.2019.9004789>
- Manaye, M. (2019). Line balancing techniques for productivity improvement. *International Journal of Mechanical and Industrial Technology*, 7(1), 89-104.
- Mofolasayo, A., Young, S., Martinez, P., & Ahmad, R. (2022). How to adapt lean practices in SMEs to support Industry 4.0 in manufacturing. *Procedia Computer Science*, 200, 934-943. <https://doi.org/10.1016/j.procs.2022.01.291>

- Talapatra, S., Tarannum, R., & Shefa, J. (2018). Simulation modeling for productivity improvement of a production line: A case study. *Proceedings of the International Conference on Industrial Engineering and Operations Management*, 3175–3186.
- Yassine, A., Khalid, B., & Said, E. (2019). Supply Chain Modeling and Simulation using SIMAN ARENA a Case Study. *International Journal of Advanced Computer Science and Applications*, 10(3), 223-230.
- Yemane, A., Gebremicheal, G., Meraha, T., & Hailemicheal, M. (2020). Productivity improvement through line balancing by using simulation modeling. *Journal of Optimization in Industrial Engineering*, 13(1), 153-165. <https://doi.org/10.22094/JOIE.2019.567816.1565>
- Yılmaz, M. S., Özer, G., Öter, Z. Ç., & Ertuğrul, O. (2021). Effects of hot isostatic pressing and heat treatments on structural and corrosion properties of direct metal laser sintered parts. *Rapid Prototyping Journal*, 27(5), 1059-1067. <https://doi.org/10.1108/RPJ-10-2020-0245>