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Capacity Management and Bottleneck Identification in Green Tea Industry Using Simulation

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ABSTRACT

This study aims to measure production capacity and identify process bottlenecks in green tea processing plants in Bandung. This research method uses Discrete Event Simulation (DES) which starts from the arrival of the picked tea leaves to the final product in the form of dry tea and tea powder after processing. The problem faced by the company is the inability to increase daily production capacity, which results in queues for material processing that will degrade the quality of the product due to being too long in the process. To overcome this, Theory of Constraints (TOC) is used to identify the location of bottlenecks so that production can be completed faster. Validated simulation results indicate a production capacity of only 10 tons per day compared to a historical target of 20–30 tons. The main bottleneck is caused by the rotary mixer, which has a utilization rate of 66.87%, while the tea ball mixer has the longest waiting time, at 802 minutes. Various simulation scenarios show that the addition of machines has a significant impact on the system; in the 30-ton production scenario, the total processing time is reduced from 43.1 hours to 23.25 hours. This study shows that Discrete Event Simulation (DES) supports the TOC methodology to be able to optimize production capacity.

Introduction

The tea industry is one of the backbones of Indonesia's agroindustry which in addition to meeting domestic needs but is also able to penetrate the global tea market. Indonesia ranks eighth as the world's largest tea producer (Divisi Kominfo Kemenko Perekonomian RI, 2022). The demand for tea in the domestic market continues to increase every year. The green tea processing factory in Bandung where this research is carried out plays a dual role as a green tea producer who is actively expanding the market, also acts as a tea research center that aims to promote innovation and international cooperation (Agung et al., 2025). The problems faced today are mainly in the limitation of production capacity, seen in the accumulation of raw materials, delays in the production process and the decline in product quality. This situation can potentially reduce the company's productivity and competitiveness.

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The current condition in the company is that the volume of fresh tea leaves coming to the factory sometimes far exceeds the factory's capacity to process it in one day. So that tea leaves are held back for more than one day to be produced the next day, this situation has the potential to reduce the quality of the final tea product. Based on the Theory of Constraints, this condition causes the performance of the system to continue to be limited by the slowest process (Goldratt & Cox, 2012). Thus, this study will measure actual production capacity, identify congestion, and provide improvement strategies using Discrete Event Simulation (DES) which is implemented using the ProModel application (Muchtar, 2025). The results of the research are expected to provide an overview of alternative solutions to increase production capacity and maintain tea quality.

The problem identified in this green tea processing factory is the frequent accumulation of fresh tea due to delays in the production process. For these conditions, it is necessary to answer three basic questions, namely first, what is the actual production capacity that the company can achieve? Second, are there workstations that have the potential to hinder the flow of production? Third, how can production capacity be increased?

Therefore, the purpose of this study is to determine the actual green tea production capacity, identify congestion locations, and develop production capacity increase solutions using Discrete Event Simulation (DES). The results of the study are expected to provide a comprehensive picture of the current system capacity, machine utilization, and capacity improvement opportunities.

Many studies have used the Discrete Event Simulation (DES) method to study production systems, but most have been done on manufacturing plants, with few addressing agro-industrial processes such as green Previous research has also tended to focus on one aspect, whether identifying bottlenecks or increasing capacity. This study does not combine the two into one unified framework. This research offers something new: combining ProModel-based DES with Theory of Constraints (TOC) to simultaneously identify bottlenecks and evaluate capacity building strategies. This is all done using real-world production data from a green tea processing plant in Bandung. This ensures that the resulting simulation models are truly relevant, realistic, and can be directly used to make better decisions in the agroindustry.

Literature Review

Discrete Event Simulation (DES) is a system modeling method in which changes in the system state only occur at predetermined "discrete events," such as the arrival of raw materials, the start of a process, the completion of a process, machine breakdowns, machine replacements, and so on. DES allows researchers or production managers to represent production process flows realistically by taking into acount process time variability, machine breakdowns/maintenance, queues, and resource constraints such as the number of machines, labor, and work capacity (Zamani, 2023). With DES, we can test various change scenarios such as adding machines, changing work shifts, redistributing loads, and improving processes without having to directly change the actual system, thereby reducing risks and costs.

In practice, the steps for using DES generally include: (1) identifying problems and mapping the processes to be analyzed; (2) collecting input parameter data (process time, machine capacity, waiting time, utilization, labor, and historical data); (3) building simulation models with appropriate software (e.g., ProModel, Arena, FlexSim, or others); (4) verifying and validating the simulation model so that the simulation results approximate real conditions; (5) experimenting or simulating improvement scenarios; and (6) analyzing the results (total production time, machine utilization, bottlenecks, efficiency, and so on). DES is particularly suitable for situations where the production system has many discrete events that occur randomly, and when system performance needs to be optimized or its impact predicted in the event of changes (Santosa et al., 2024).

The advantages of DES include its ability to model systems dynamically, handle uncertainty in process time and material arrival, and its flexibility in quickly testing many alternative scenarios (Hidayat et al., 2024). However, there are also challenges: the need for accurate data for input parameters for the model to be valid; the complexity of the model can be high if the system is large or involves many machines and events; and computation time can be quite long for large-scale simulations or with many variable scenarios. From the explanation above, it is clear thet to achieve the maximum benefits of DES, data calibration, the use of tools/software that support rigorous verification and validation, and the selection of realistic and practical scenarios are often necessary.

ProModel is a simulation software that can be used to perform Discrete Event Simulation (DES), which is ideal for modeling complex production systems, such as raw material flow, machine processes, queues, and

resource utilization (machines, labor) (Harrell et al., 2012). In this study, ProModel was used to build a simulation model based on production flow mapping (EFD), entering parameters such as process time, machine capacity, and labor, then performing verification and validation to ensure that the model reflects real conditions. Once the model is validated, the next step is to conduct experiments by creating several scenarios , for example, adding machines or redistributing workloads to see how these changes affect total production time, machine utilization, and bottleneck identification.

The advantage of ProModel in this study is its ability to enable scenario analysis without disrupting actual operations, visualize production entity flows, calculate waiting times and queues, and measure the utilization of each machine, by utilizing simulations created using ProModel. The evaluation carried out can reduce project costs because the simulations are not carried out directly in real conditions. In addition, with ProModel, researchers can evaluate various possible scenarios for improving the production system, such as increasing machine capacity, adding machines at certain stations, or changing the production flow layout, and immediately see the impact in real metrics. This is very helpful in formulating improvement strategies based on data and simulations, not just assumptions (L. Aguilar et al., 2024).

Common challenges in using ProModel, which you may also experience, include the need for highly accurate data input (process time, entity arrival distribution, inter-machine waiting time, machine & labor availability), as well as computation time that can be lengthy depending on the complexity of the model and the number of scenarios. In addition, a verification and validation process is required to compare simulation outputs with actual historical production data in order to ensure the credibility of the simulation results. However, when supported by well-managed data and carefully designed scenarios, ProModel can serve as a highly effective tool for conducting analyses such as bottleneck identification and system optimization (Haryadi et al., 2023).

Methodology

This study used a Discrete Event Simulation (DES) approach, with a series of clear steps. First, problems were identified in the field. It includes observations on the green tea production floor to obtain structural data in the form of the location of each process. Then identify operational data in the form of logical flow of the production process from the arrival of fresh tea leaves to the final product produced. Furthermore, numerical data collection in the form of machine capacity and processing time will be used as input for the simulation model. The purpose of collecting all such data is to ensure that the model can accurately reflect the operational situation in the field.

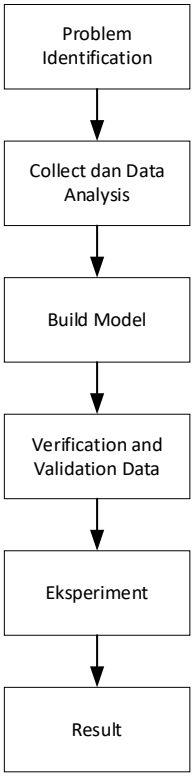


Figure 1. Stages of the Discrete Event Simulation (DES) Method
Source: Simulation Using Promodel Book, 2012

After all the data is collected, the next step is to create a simulation model which begins with creating an Entity Flow Diagram (EFD). After the EFD is validated, it is followed by the development of a simulation model using the ProModel application. A completed model is verified to ensure the logic and process flows in the model can represent actual activity by looking at the statistical outputs of that model. If the output of the model is considered to be equal to the actual condition, then the model is declared valid. Then experiments can be carried out through scenarios on the value of input variables such as increasing the number of machines or changing the configuration of the process to see changes in the response variables. The results of each experiment were demonstrated through performance indicators such as total production time, machine utilization rate, and queue lengths during the production process. The research stages are summarized in Figure 1.

The first step in building a simulation model is to identify the problem. Based on field observations, limitations and idle capacity were found at several points in the process. This condition resulted in long waiting times and caused delays in the next machine. These limitations also had an impact on the length of production time, especially in historical periods when production exceeded daily capacity, which was more than 24 hours.

The second step is data collection, which is obtained through direct observation in the field and interviews with factory managers. The data collected includes: (1) number of workers, (2) number and capacity of machines, (3) factory layout, (4) processing time, and (5) production volume. All of this data is then analyzed and processed to suit the needs of the simulation model.

The third step is to build a simulation model using ProModel software. The elements used in this model include location, entities, arrival, processing, and variables (global). The simulation model must be able to depict a production process flow that resembles real conditions on the production floor.

The fourth step is to verify and validate the simulation model. Verification aims to ensure the logic in the simulation model is similar to the real state of the system, and validation to ensure the model can generate statistical data that reflects the actual state of the system. In model validation, statistical tests such as the Kolmogorov-Smirnov test are used to assess the normality of the data and the Mann-Whitney U test to test for similarity between the data.

The fifth stage is to conduct an experiment. The simulation model is run based on a specific scenario to find the best configuration, the scenario used includes the addition of the number of rotary panners, rotary dryers, and cooling cylinders. This scenario is then run with multiple replications to account for variability and ensure more consistent results. Observable outcomes in each scenario include total production time, machine utilization, and queue conditions at workstations.

In the final stage, a comparative analysis is carried out between the actual production output on the production floor and the proposed scenario. The main factors considered include actual daily production capacity, total processing time, percentage of machine utilization, and queues at a given workstation. These findings provide a basis for assessing the right strategies to increase capacity, either through increasing the number of machines or changing the distribution of workloads. The main goal is to achieve the targeted solution of 20,000-30,000 kg of green tea leaves per day.

To facilitate the simulation model, the Entity Flow Diagram (EFD) depicts the movement of entities from fresh tea leaves to the final product, along with processes, machines, and interconnections between workstations. EFD serves to visually depict the flow of entities in the simulation model, making it easier to trace relationships between processes, identify bottlenecks, and demonstrate the effectiveness of proposed improvement scenarios (Akbar & Haryanti, 2021) Figure 2 presents the Flow Diagram of the Entity of the production system in the Green Tea Processing Factory.

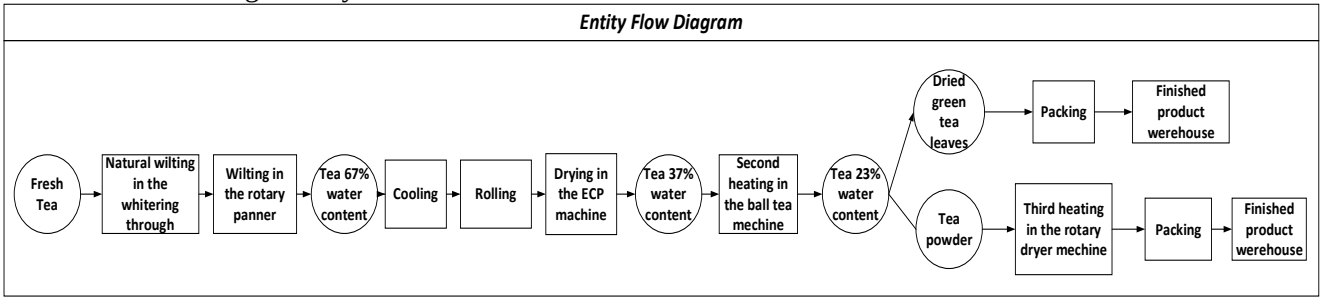


Figure 2. Entity Flow Diagram of Green Tea Production at Green Tea Processing Factory

Source: PPTK Gambung Green Tea Factory, 2025

Result and Discussion

In actual production data, there are several extreme values that are statistically considered different from other values (outliers). The identification results revealed several daily production data with very high values, ranging from 23,930 kg to 29,847 kg, which were detected as outliers based on the standard value test (Z-score). This data exceeded the limits of the normal distribution with an absolute Z-score value of more than 3, thus being categorized as an outlier (Montaño Moreno et al., 2013). Details of the values detected as outliers are shown in Table 1.

Table 1. Outlier Value of Production Quantity Data.

No	Fresh Tea (kg)	Standardize 1	ABS Standardize	Outlier
682	23930	3.086512949	3.08651295	OUTLIER
683	24432	3.196738512	3.19673851	OUTLIER
684	24432	3.196738512	3.19673851	OUTLIER
685	24587	3.230772302	3.2307723	OUTLIER
686	29847	4.385725419	4.38572542	OUTLIER

Source: Historical Production Volume Data for 2024–2025 At PPTK Gambung Green Tea Factory, 2025.

Next, the statistical calculation results were compared between data with and without outliers. The comparison was made with the aim of seeing the extent to which outlier values affect the average, standard deviation, and median production. The results showed that the average production with added outlier values was 9,873.10 kg with a standard deviation of 4,554.30 kg, and for statistical results without outliers, the average decreased to 9,758.77 kg with a standard deviation of 4,366.00 kg. Median production was almost balanced in the range of 9,436 – 9,490 kg. A complete comparison between the two data conditions is shown in Table 2.

Table 2. Statistical Calculation Results for Production Data With and Without Outliers.

Data	Average production (kg)	Standard Deviation (kg)	Median (kg)
Outlier	9,873.10	4,554.30	9,490
Without Outliers	9,758.77	4,366.00	9,436

Source: Historical Production Volume Data for 2024–2025 At PPTK Gambung Green Tea Factory, 2025.

Although outliers affect the mean and standard deviation, these values are still used in the analysis to reflect the varying production outputs of real-world conditions. Extreme production volumes can still occur at certain times so it was decided to include them in the simulation model. Therefore the arrival rate of fresh tea is set between 5,000 kg to 30,000 kg, this is to cover production under normal conditions and peak loads. Next is the implementation stage of creating a simulation model using ProModel 2016.

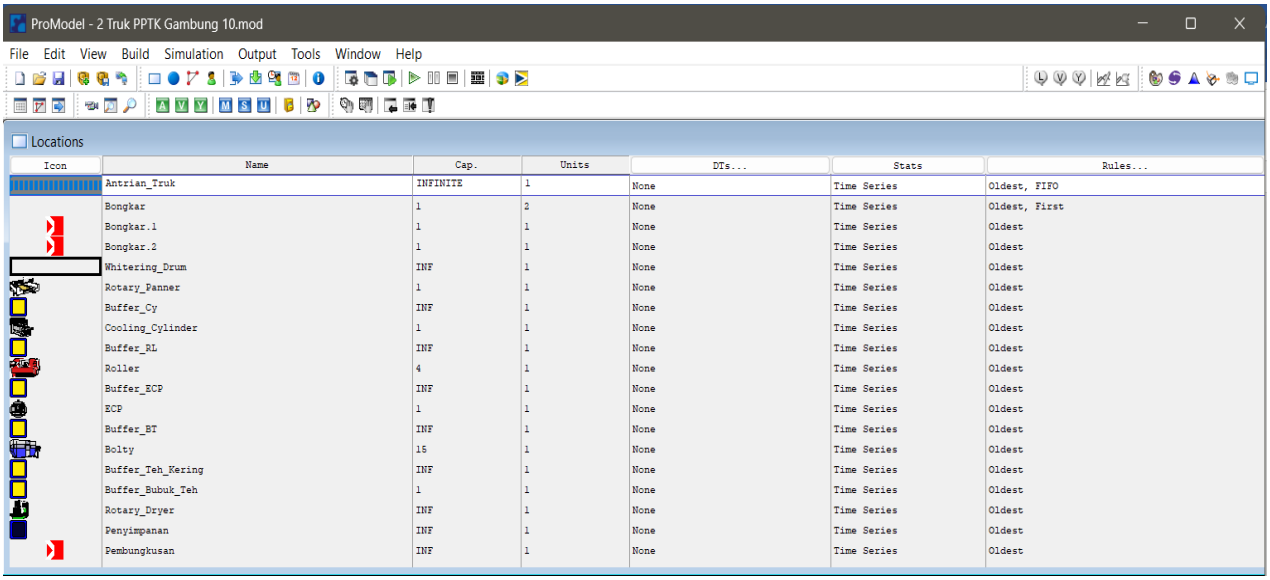
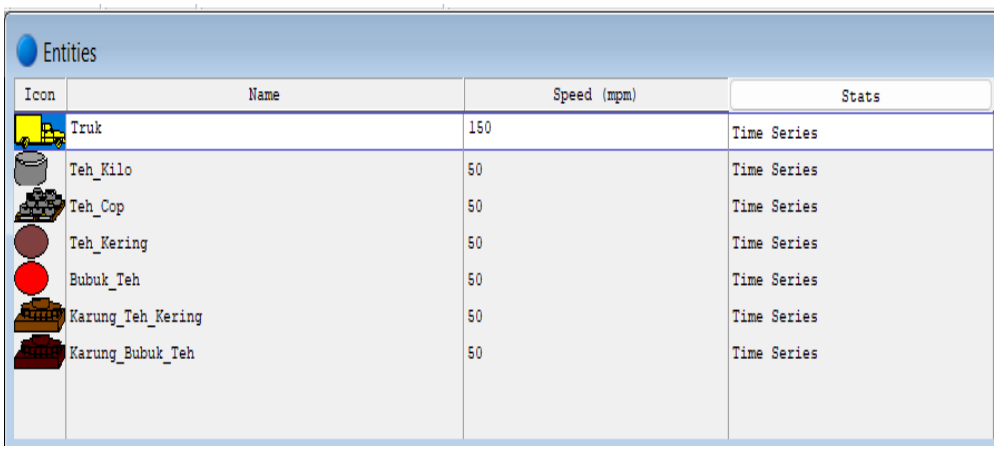


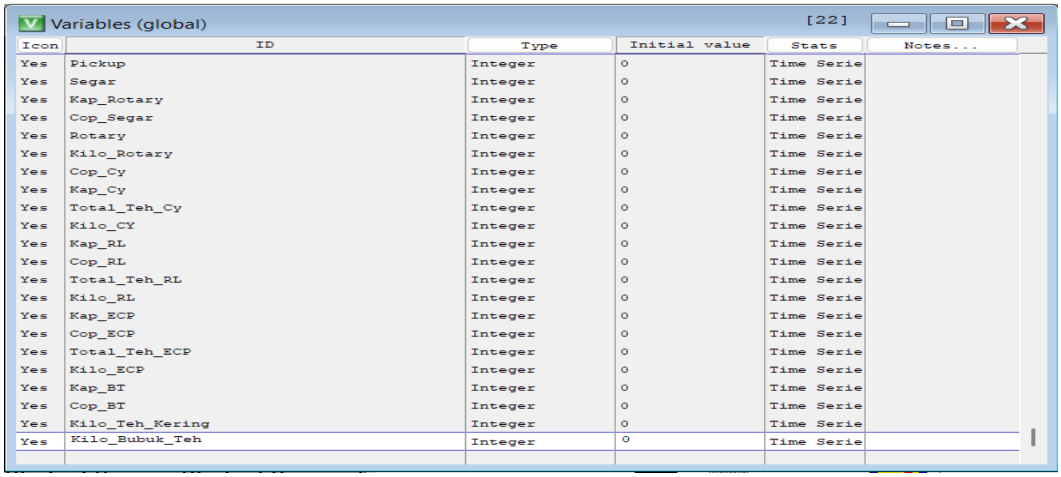
Figure 3. List of Location Names in Promodel
Source: ProModel Software 2016 Version, 2025



Entities

Icon	Name	Speed (mpm)	Stats
	Truk	150	Time Series
	Teh_Kilo	50	Time Series
	Teh_Cop	50	Time Series
	Teh_Kering	50	Time Series
	Bubuk_Teh	50	Time Series
	Karung_Teh_Kering	50	Time Series
	Karung_Bubuk_Teh	50	Time Series

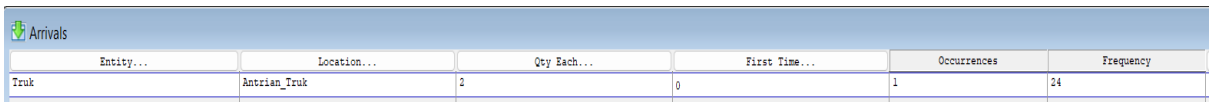
Figure 4. List of Entity Names in ProModel
Source: ProModel Software 2016 Version, 2025



Variables (global) [22]

Icon	ID	Type	Initial value	Stats	Notes...
Yes	Pickup	Integer	0	Time Serie	
Yes	Segar	Integer	0	Time Serie	
Yes	Kap_Rotary	Integer	0	Time Serie	
Yes	Cop_Segar	Integer	0	Time Serie	
Yes	Rotary	Integer	0	Time Serie	
Yes	Kilo_Rotary	Integer	0	Time Serie	
Yes	Cop_Cy	Integer	0	Time Serie	
Yes	Kap_Cy	Integer	0	Time Serie	
Yes	Total_Teh_Cy	Integer	0	Time Serie	
Yes	Kilo_CY	Integer	0	Time Serie	
Yes	Kap_RL	Integer	0	Time Serie	
Yes	Cop_RL	Integer	0	Time Serie	
Yes	Total_Teh_RL	Integer	0	Time Serie	
Yes	Kilo_RL	Integer	0	Time Serie	
Yes	Kap_ECP	Integer	0	Time Serie	
Yes	Cop_ECP	Integer	0	Time Serie	
Yes	Total_Teh_ECP	Integer	0	Time Serie	
Yes	Kilo_ECP	Integer	0	Time Serie	
Yes	Kap_BT	Integer	0	Time Serie	
Yes	Cop_BT	Integer	0	Time Serie	
Yes	Kilo_Teh_Kering	Integer	0	Time Serie	
Yes	Kilo_Bubuk_Teh	Integer	0	Time Serie	

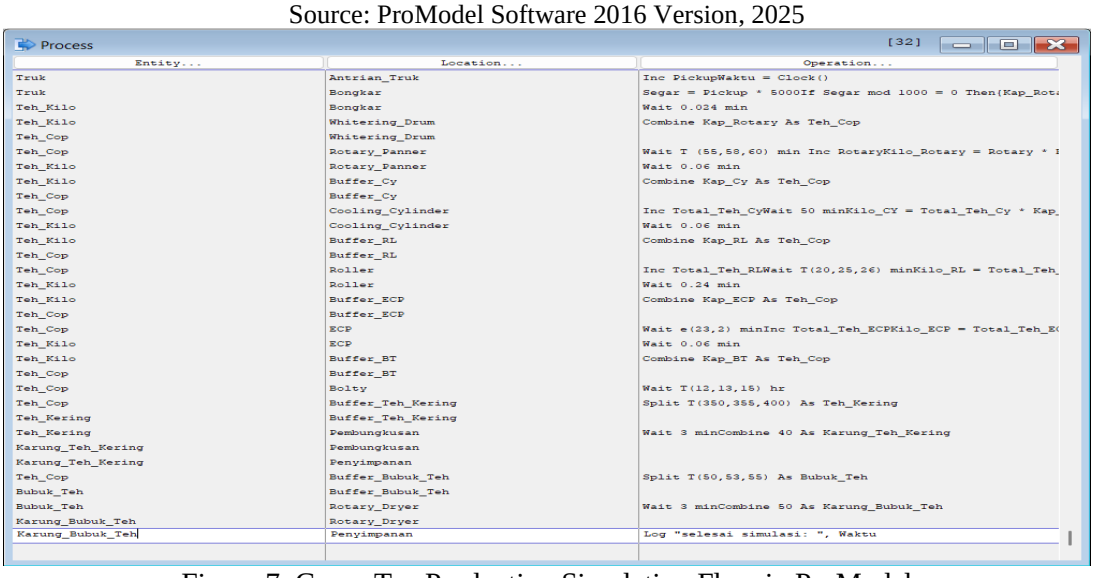
Figure 5. List of Variables (global) Names in ProModel
Source: ProModel Software 2016 Version, 2025



Arrivals

Entity...	Location...	Qty Each...	First Time...	Occurrences	Frequency
Truk	Antrian_Truk	2	0	1	24

Figure 6. Truck Arrival Process Logic in ProModel
Source: ProModel Software 2016 Version, 2025



Process [32]

Entity...	Location...	Operation...
Truk	Antrian_Truk	Inc PickupWaktu = Clock()
Truk	Bongkar	Segar = Pickup * 5000If Segar mod 1000 = 0 Then{Kap_Rot
Teh_Kilo	Bongkar	Wait 0.024 min
Teh_Kilo	Whitering_Drum	Combine Kap_Rotary As Teh_Cop
Teh_Cop	Whitering_Drum	
Teh_Cop	Rotary_Panner	Wait T (55,58,60) min Inc RotaryKilo_Rotary = Rotary * I
Teh_Kilo	Rotary_Panner	Wait 0.06 min
Teh_Kilo	Buffer_Cy	Combine Kap_Cy As Teh_Cop
Teh_Cop	Buffer_Cy	
Teh_Cop	Cooling_Cylinder	Inc Total_Teh_CyWait 50 minKilo_CY = Total_Teh_Cy * Kap_
Teh_Kilo	Cooling_Cylinder	Wait 0.06 min
Teh_Kilo	Buffer_RL	Combine Kap_RL As Teh_Cop
Teh_Cop	Buffer_RL	
Teh_Cop	Roller	Inc Total_Teh_RLWait T(20,25,26) minKilo_RL = Total_Teh_
Teh_Kilo	Roller	Wait 0.24 min
Teh_Kilo	Buffer_ECP	Combine Kap_ECP As Teh_Cop
Teh_Cop	Buffer_ECP	
Teh_Cop	ECP	Wait e(23,2) minInc Total_Teh_ECPKilo_ECP = Total_Teh_E
Teh_Kilo	ECP	Wait 0.06 min
Teh_Kilo	Buffer_BT	Combine Kap_BT As Teh_Cop
Teh_Cop	Buffer_BT	
Teh_Cop	Bolty	Wait T(12,13,15) hr
Teh_Cop	Buffer_Teh_Kering	Split T(350,355,400) As Teh_Kering
Teh_Kering	Buffer_Teh_Kering	
Teh_Kering	Pembungkusan	Wait 3 minCombine 40 As Karung_Teh_Kering
Karung_Teh_Kering	Pembungkusan	
Karung_Teh_Kering	Penyimpanan	
Teh_Cop	Buffer_Bubuk_Teh	Split T(50,53,55) As Bubuk_Teh
Bubuk_Teh	Buffer_Bubuk_Teh	
Bubuk_Teh	Rotary_Dryer	Wait 3 minCombine 50 As Karung_Bubuk_Teh
Karung_Bubuk_Teh	Rotary_Dryer	
Karung_Bubuk_Teh	Penyimpanan	Log "selesai simulasi: ", Waktu

Figure 7. Green Tea Production Simulation Flow in ProModel
Source: ProModel Software 2016 Version, 2025.

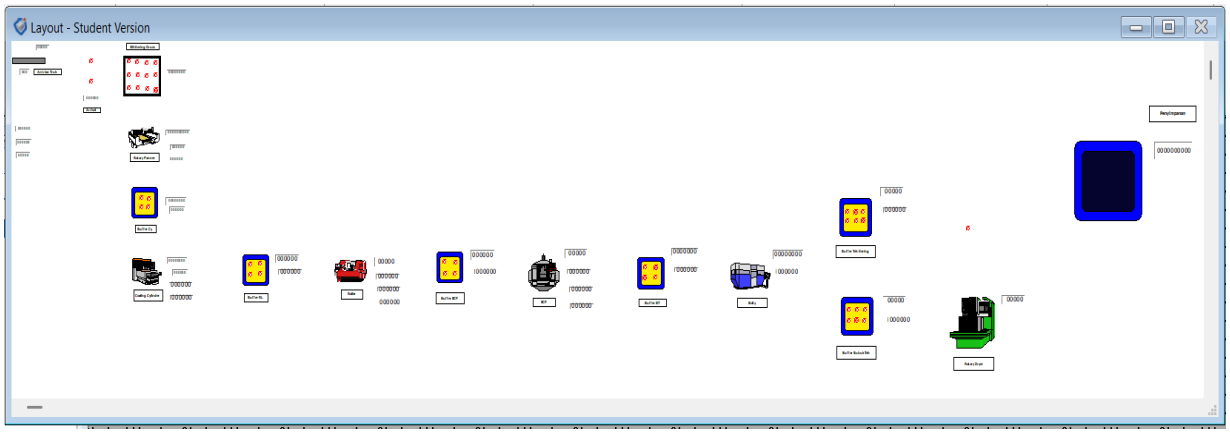


Figure 8. Green Tea Production Process Model Display in ProModel
Source: ProModel Software 2016 Version, 2025.

As a preliminary analysis, the simulation results were compared with actual production data to observe the similarity in output patterns before conducting statistical validation.

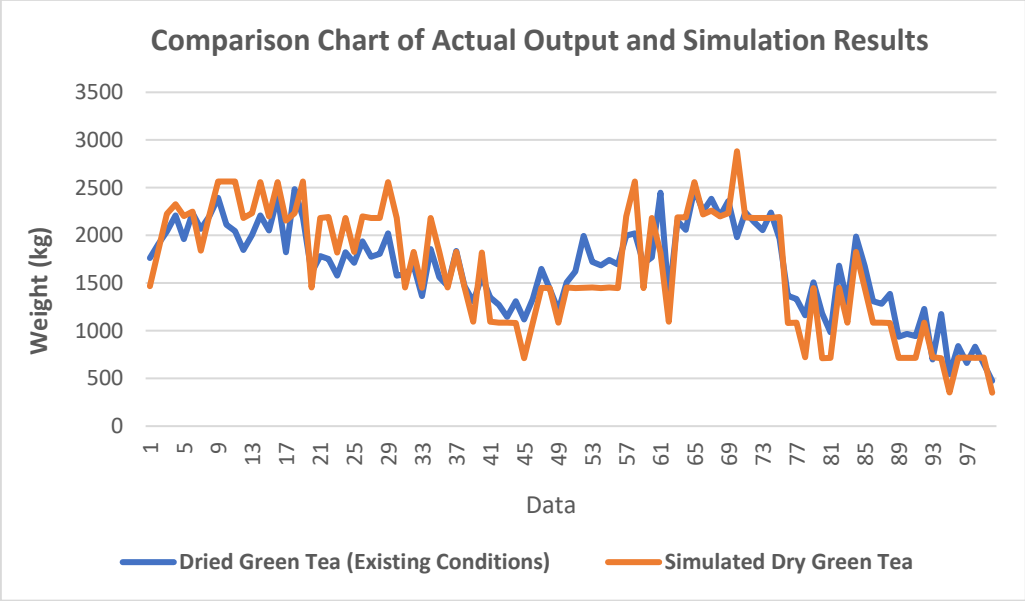


Figure 9. Comparison Chart of Actual Output and Simulation Result.
Source: Ms. Excel Software 365 Version, 2025

One-Sample Kolmogorov-Smirnov Test

			Unstandardized Residual
N			100
Normal Parameters[a,b]	Mean		.0000000
	Std. Deviation		264.31176759
Most Extreme Differences	Absolute		.080
	Positive		.080
	Negative		-.060
Test Statistic			.080
Asymp. Sig. (2-tailed)[c]			.117
Monte Carlo Sig. (2-tailed)[d]	Sig.		.117
	99% Confidence Interval	Lower Bound	.109
		Upper Bound	.125

a. Test distribution is Normal.
b. Calculated from data.
c. Lilliefors Significance Correction.
d. Lilliefors' method based on 10000 Monte Carlo samples with starting seed 2000000.

Figure 10. Results of data normality test using the Kolmogorov–Smirnov Test method.
Source: IBM SPSS Software, 2025

Test Statistics[a]

	Berat Teh Kering
Mann-Whitney U	4884.000
Wilcoxon W	9934.000
Z	-.283
Asymp. Sig. (2-tailed)	.777

a. Grouping Variable: Aktual dan Simulasi

Figure 11. Results of data homogeneity test using the Mann–Whitney U Test method.
Source: IBM SPSS Software, 2025

The Kolmogorov-Smirnov Test (KS) is used to assess whether or not the data is normally distributed, while the Mann-Whitney U Test is used to assess whether there is a significant difference between the actual system output and the simulated results. This nonparametric test was chosen because it does not require strict distribution assumptions and is suitable for comparing real and simulated data. If the significance value of the value is greater than 0.05 for both tests then the data is considered to be normally distributed and there is no significant difference between the actual output and the simulation. This confirms that the simulation model is able to adequately represent the actual production system. The statistical output results of the simulation model under existing conditions are shown in Table 3.

Table 3. Statistical Calculation Results for Production Data With and Without Outliers.

Truck	Load (Tons)	Total Simulation Time (minutes)	Time Conversion (hours)
1	5	1190.63	19.8
2	10	1436.31	23.9
3	15	1776.63	29.7
4	20	2064.17	34.4
5	25	2348.74	39.3
6	30	2585.19	43.1

Source: ProModel Software 2016 Version, 2025.

The results show that total simulation time increases with higher production loads, exceeding the 24-hour production cycle at maximum capacity. This shows that the current production system in the green tea processing factory cannot handle peak loads in one working day, leading to potential queues and process delays as well as degradation of product quality.

The results of the simulation regarding the utilization rate of production machinery are shown in the line diagram in Figure 12. The diagram shows the comparison of utilization rates for each scenario of 5,000 – 30,000 kg of fresh tea leaves.

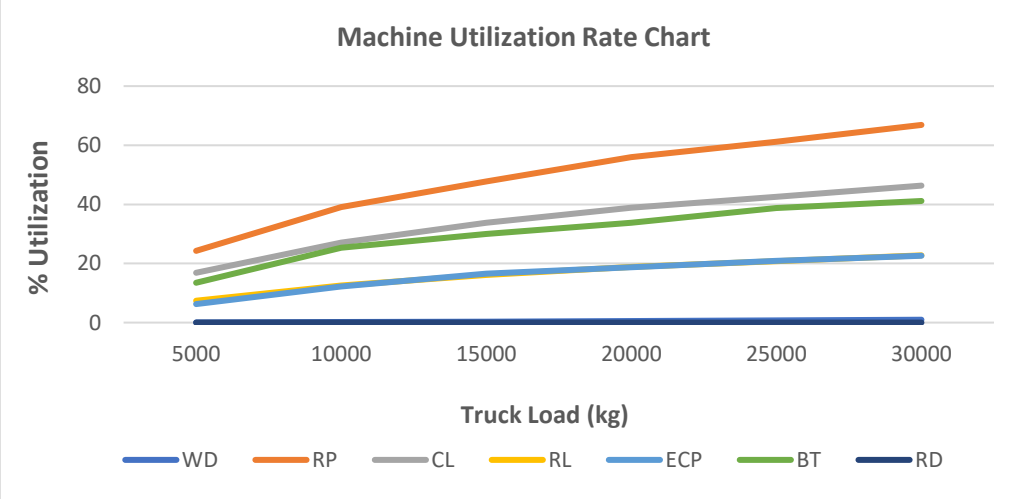


Figure 12. Actual Machine Utilization Percentage in ProModel
Source: Ms. Excel Software 365 Version, 2025

Machine name description: 1. WD (Whitering through)
2. RP (Rotary Panner)
3. CL (Cooling Cylinder)
4. RL (Roller)
5. ECP (Exhaust Change Pressure)
6. BT (Ball Tea)
7. RD (Rotary Dryer)

The graph in Figure 12 shows that machine utilization increases at higher production loads. Rotary Panner (RP) consistently shows the highest utilization, exceeding 65% at a capacity of 30,000 kg. this indicates that the Rotary Panner is the main congestion point in the system. The process on the RP machine requires a longer processing time compared to the machine before and after which results in the accumulation of work-in-process on the previous machine. In addition, the Rotary Panner serves as a critical stage that directly affects the flow to the next process, delays at this point impact the entire system. Other engines showed relatively lower and more stable utilization which indicated that the machines were not operating at full capacity.

Improvement experiments are carried out by adding machines to increase production capacity and reduce processing times that exceed 24-hour cycles. Since excessive production time occurs at load levels between 15,000 and 30,000 kg, experiments are focused only on this load range. This analysis also evaluates changes in machine utilization after the increase in the number of machines. The results of this experiment are presented in Table 4.

Table 4. Table of Experimental Results for Machine Addition

Selected Experiment Number	Fresh Tea Weight (Tons)	Machine Addition Scenario	Number of Machines Added	Change in Machine Utilization	Change in Processing Time	
					Minutes	Hours
2	15	Whitering through	-	0.20	1371.89	22.86
		Rotary Panner	1	31.01		
		Cooling Cylinder	1	21.49		
		Roller	-	20.92		
		ECP	-	22.80		
		Ball tea	-	41.72		
		Rotary Dryer	-	0.00		
4	20	Whitering through	-	0.24	1384.53	23.08
		Rotary Panner	2	27.46		
		Cooling Cylinder	2	19.06		
		Roller	4	13.95		
		ECP	-	28.82		
		Ball tea	-	52.46		
		Rotary Dryer	-	0.00		
4	25	Whitering through	-	0.29	1311.84	21.86
		Rotary Panner	3	27.56		
		Cooling Cylinder	3	19.08		
		Roller	8	13.32		
		ECP	1	19.73		
		Ball tea	10	43.85		
		Rotary Dryer	-	0.00		
5	30	Whitering through	-	0.41	1395.85	23.26
		Rotary Panner	3	31.04		
		Cooling Cylinder	3	21.22		
		Roller	8	14.84		
		ECP	1	22.30		

	Ball tea	10	49.65
	Rotary Dryer	-	0.00

Source: ProModel Software 2016 Version, 2025

The simulation results show that adding machines to several critical workstations such as Rotary Panner, Cooling Cylinder, Roller, ECP, and Ball tea can significantly improve production time efficiency. Although the production load is increasing but the green tea processing time can be maintained in a 24-hour cycle, indicating that the increased capacity effectively reduces the system bottleneck. These findings confirm that the addition of targeted machines at congested stations can improve overall system performance without requiring increased capacity across all processes.

The addition of machines also affects the utilization rate of each workstation. The results showed that utilization distribution became more balanced after capacity expansion, showing an increase in workload distribution and a reduction in pressure on machines that were previously constrained. A comparison of engine utilization before and after the upgrade is presented in figures 13 to 16.

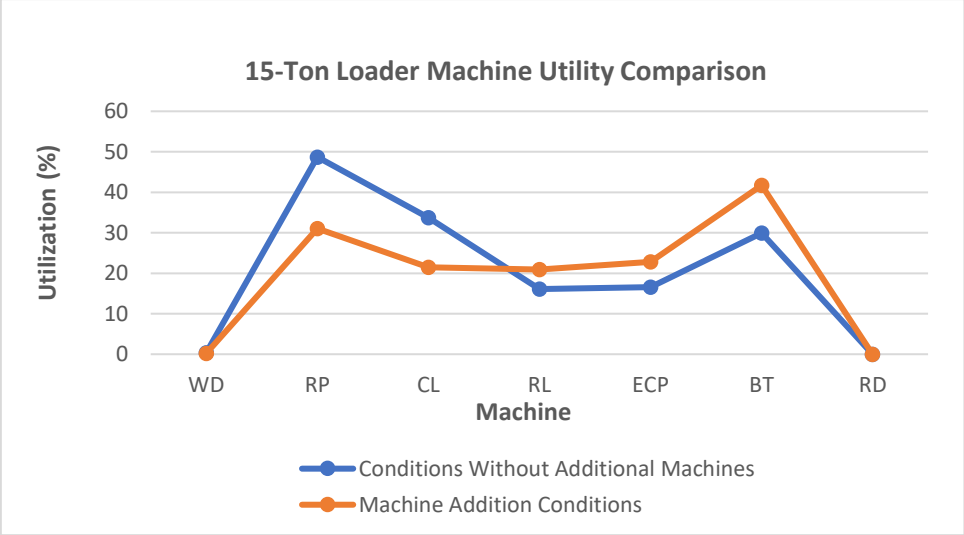


Figure 13. Comparison of Machine Utilization Rates Before and After Adding Machines at a 15-Ton Capacity.

Source: ProModel Software 2016 Version, 2025

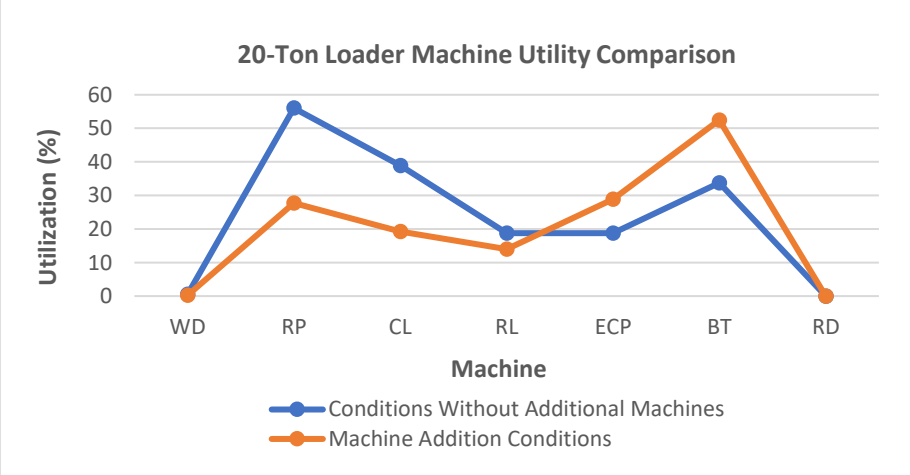


Figure 14. Comparison of Machine Utilization Rates Before and After Adding Machines at a 20-Ton Capacity

Source: ProModel Software 2016 Version, 2025

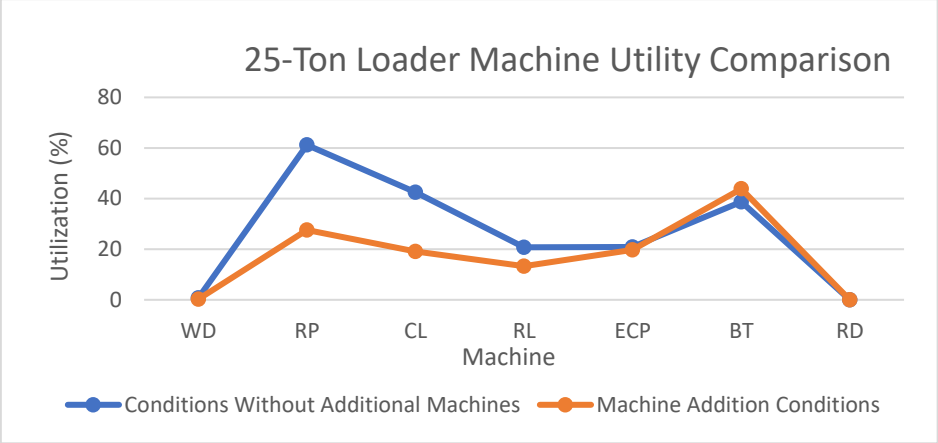


Figure 15. Comparison of Machine Utilization Rates Before and After Adding Machines at a 25-Ton Capacity

Source: ProModel Software 2016 Version, 2025

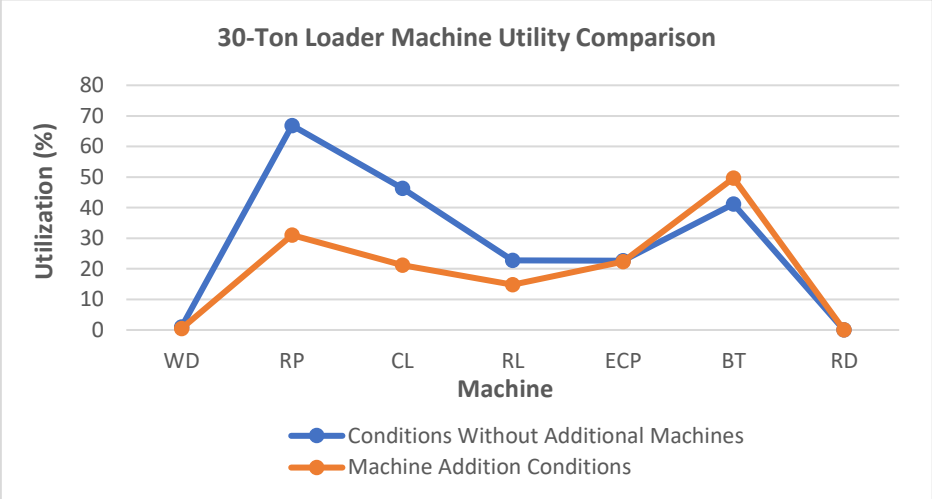


Figure 16. Comparison of Machine Utilization Rates Before and After Adding Machines at a 30-Ton Capacity

Source: ProModel Software 2016 Version, 2025

The results of the utility comparison in Figures 13 to 16 show that the addition of the machine directly decreases the utility level. Without the addition of the machine, the utility value becomes higher and indicates an imbalance of workload, especially in the Rotary Panner (RP), Cooling Cylinder (CL), and Ball tea machines which have the highest utility. After the addition of utility machines, it decreases and is more evenly distributed, so that the workload between machines can be distributed better.

As load capacity increases especially from 15,000 to 30,000 kg, utility without additional machinery continues to increase, demonstrating the limitations of the capacity of the machine to bear more loads. However, with the addition of machines, the increase in load capacity was not followed by a significant surge in utility and the production system became more stable. The strategy of adding machines is proven to reduce the potential for congestion, improve the balance of performance between machines, and support the increase in production capacity with more efficient machine utilization.

Conclusion

This study identified bottlenecks in the production process at the green tea processing factory in Bandung and evaluated several alternative solutions using the Discrete Event Simulation (DES) approach. The findings show that the current production capacity has not reached the optimal level. At the 30,000 kg production target, the total time needed for completion exceeds 40 hours, making it difficult to achieve the production level of 20,000-30,000 kg per day as the company targets. Rotary panners are indicated as the main cause of congestion, followed by tea ball machines and cooling cylinders, which contribute to prolonged queues and uneven distribution of workloads across the production floor.

Further simulation experiments showed that increasing the number of machines at critical workstations could significantly improve system performance. For example, in the 30,000 kg production scenario, the total processing time can be reduced from 43.1 hours to about 23.26 hours. These results suggest that the combination of machine number reduction and better workload distribution can increase production capacity and operational efficiency and potentially achieve targeted daily production levels.

Thus, this study highlights the importance of a strategy to increase the number of machines as a means of boosting production capacity. However, it should be noted that applying the simulation results requires further analysis and adjustment to actual operational conditions to ensure a more sound implementation. For future research, the developed model will be applied to another tea factory in West Bandung Regency to test whether it can be used directly under different conditions or if further adjustments are needed to suit the specific characteristics and operational conditions of each factory.

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