Supply Preparation of Line Production through Capacity using Simulation Model in Garment Industry

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Abstract

With the rapid development of fashion, it can boost labor-intensive industry players, especially in the garment sector. PT PBT is a garment company that produces make to order. This research will be carried out on jacket products, this is because it is in the old preparation department, causing a lot of waiting time. In addition, line balancing on PpA and Quilting processes is one of the focuses of this study. The purpose of this study is to identify the location of the bottleneck in the production process, in addition to knowing the bottleneck at the work station. The method used in this research is a simulation model. From the simulation results, it is found that two work stations have more than 50% full process so that improvements are made to the second scenario which can increase the total exit by 14%, besides that, it can reduce the average time in the system by 2% and reduce the average time in operation by 13%.

Keyword:
Simulation Model, Garmen Manufacture, labor-intensive industry, production process, Preparation.

1. Introduction
Fashion in Indonesia is currently growing very rapidly. This is in line with the awareness of the Indonesian people about fashion that leads to a lifestyle. With the very rapid development of fashion, it can boost labor-intensive industry players, especially in the garment sector. according to (Rahmah, 2020) Labor-intensive industries are industries that have more human labor than machine labor. The labor-intensive industry in the garment sector has enormous potential in Indonesian exports. Faster market demand accompanied by the development of fashion will be a challenge for the garment industry in Indonesia. PT PBT is a garment company that produces make to order. The products produced are outdoor jackets, t-shirts and pants. In four months the demand for jackets has been increasing. With increasing demand, it is necessary to balance the production line so that production runs according to leadtime. according to (Novianto and Herdiman, 2020) identify problems in the production line, namely the number of bottlenecks that occur on the sewing line which causes the flow of the production process to not run smoothly so that the resulting output is not in accordance with the target. According to (Monte, 2021) simulation model has a purpose for decision making by using various data analysis. This research will be carried out on jacket products, this is because it is in the old preparation department, causing a lot of waiting time. In addition, line balancing on PpA and Quilting processes is one of the focuses of this study. The need for simulation of the preparation department to identify the location of the bottleneck in the production process, in addition to knowing the bottleneck at the work station. then line balancing will be carried out so that the production flow will not be hampered and get maximum output.

2. Literature review
2.1 Simulation Model
Simulation according to (Monte 2021) Simulation is the right tool to use, especially if it is required to conduct experiments in order to find the best comments from system components. The simulation approach often begins with the construction of a real system model. The model must be able to show how the various components in

the system interact with each other so that it truly describes the behavior of the system. According to (Supsomboon 2019) simulation models that are a coherent part of a digital factory solution. With the formation of a simulation model can analyze alternative situations and improve understanding of the behavior of the system. In gold companies in Thailand, simulation is used to increase productivity by minimizing the number of workers and machines in the system. According to (Abd Rahman et al. 2020) simulation can be used as a decision maker in the manufacturing process with the MD-DSS model. According to (jerry Banks and Barry L. Nelson, 2010) A simulation is the imitation of the operation of a real-world process or system over time. Whether done by hand or on a computer, simulation involves the generation of an artificial history of a system and the observation of that artificial history to draw inferences concerning the operating characteristics of the real system.

2.2 Capacity

Production capacity is a level that states the limits of ability, acceptance, storage or output of a unit, facility or output to produce within a certain period of time. Production capacity determines the capital requirements thus affecting a large part of the cost. according to (Yamit 2011) Production capacity is the maximum amount of output that can be produced in a certain time unit. according to (Heizer and Render, n.d.) Production capacity is a breakthrough or number of units which a facility can store, receive or produce within a certain period of time.

3. Methods

This research was conducted on jacket products and carried out in the preparation department which consists of: cutting process, numbering process, distribution center allocation (process), Preparation Assembly (PpA) and Quilting. The structure of this simulation model is as follows:

3.1 Entities

The entities in this research are the fabric to be cut, then the panels resulting from the cutting process and semi-finished products produced from the output of CNC (Quilting) and PpA.

3.2 Activity in simulation

In Figure 1 there is activity in the simulation model.

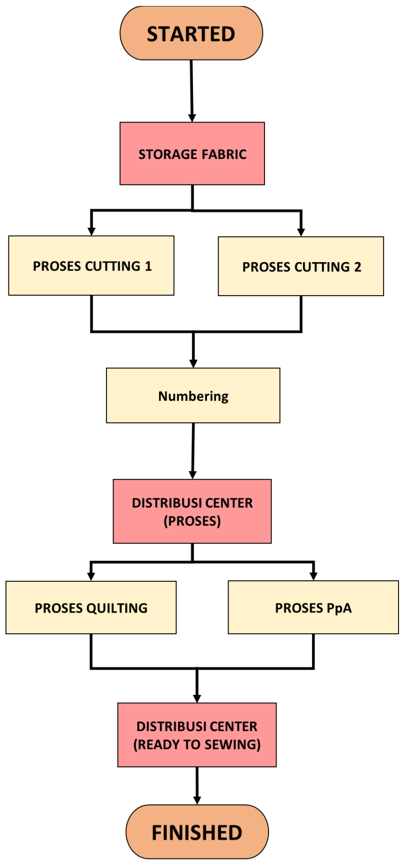

Figure 1. Activity in model simulation

3.3 Data Collection

The data used are in table 1. and there are fitting results for each process.

Table 1. Result of data fitting

Process	Data Fitting Results
Process cutting 1	Uniform(11,47)
Process cutting 2	Uniform(18,29)
Process numbering	Uniform(5,25)
Process DC	Expo(38,24.7)
Process PpA	Uniform(5,20)
Process Quilting	Uniform(71,110)

According to (Jung et al. 2020) Although data accuracy is an important part of simulation, only collecting accurate data in a labor-intensive industry such as the garment industry is of limited utility. In particular, it is very difficult to collect realtime data that changes frequently at garment production sites and then apply it to simulation.

3.4 Stages of making a model simulation

In making the simulation model, the following stages are carried out:

1) Identify each process in the system
2) Perform data collection based on processing time
3) Making models according to real conditions
4) Verify and validate the simulation model
5) Creating scenarios for real conditions with simulation models

4. Results and Discussion

4.1 Building a simulation model in the current state

In the construction of the simulation model, in this study using software promodel 16. Where the construction of the simulation model aims to identify bottleneck problems that exist in the preparation department. In this study, the production process was carried out with 12 working hours in one day for 5 days. Here in Figure 2 there is a layout in the software model.

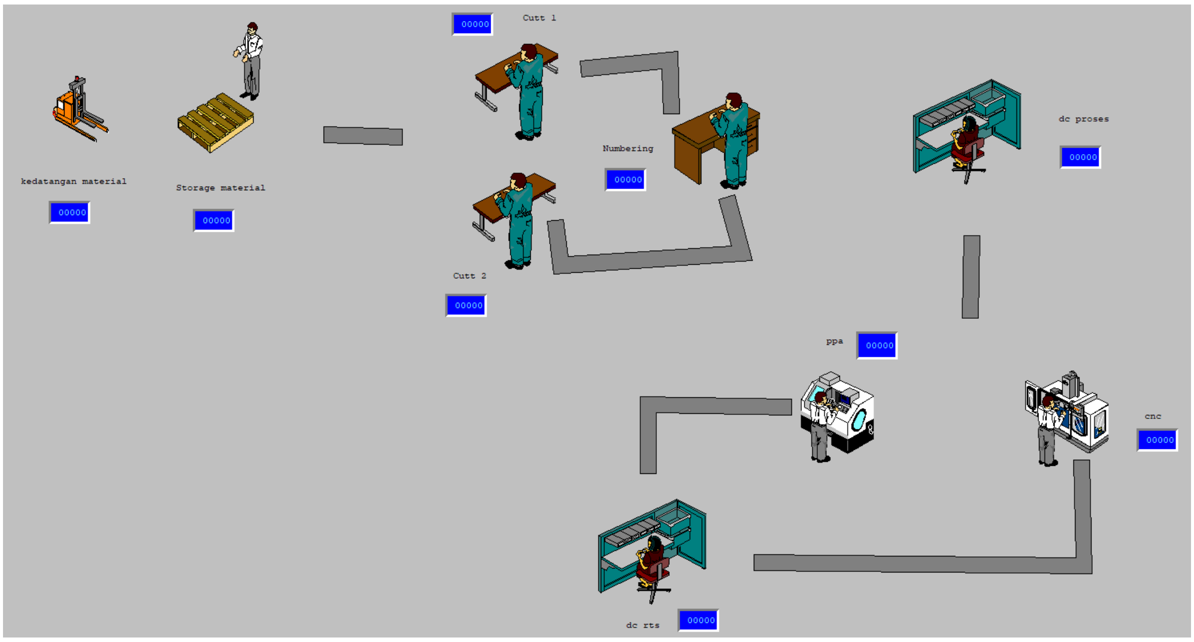

Figure 2. Layout on software promodel

After running on the Promodel 16 software, the total exit results were 284 with an average in the system of 1504.04 min while the average in operation was 605.01 min. contained in table 2 the results of multiple capacity location.

Table 2. Results of multiple capacity location with real conditions

	Cut1	Cut2	Numbering	PpA	CNC (Quilting)
Idle %	2.53	1.47	1.05	4.89	1.27
Process %	78.52	48.08	21.94	95.11	13.58
Full Process %	18.95	50.45	77.01		85.15

4.2 Building a simulation model with random number generation

In the process of building a simulation model with random numbers, the data used are the results of fitting the data with the Promodel 16 software. The results of fitting the data are presented in table 3.

Table 3. Result of data fitting

Process	Data Fitting Results
Process cutting 1	Uniform(12,41)
Process cutting 2	Uniform(18,29)
Process numbering	Uniform(7,24)
Process DC proses	Uniform(8,118)
Process PpA	Uniform(6,20)
Process Quilting	Uniform(73,110)

Based on the results of fitting the data, run the simulation model with the same layout as the current condition. The total exit result is 283 with an average in the system of 1507.88 min while the average in operation is 589.89 min. contained in table 4 the results of multiple capacity locations with random numbers.

Table 4. Multiple capacity location results with random number generation

	Cut1	Cut2	Numbering	PpA	CNC (Quilting)
Idle %	2.35	1.61	1.82	35.72	1.77
Process %	59.62	72.50	22.80	64.28	14.74
Full Process %	38.03	25.89	75.38		83.49

(Sime et al. 2019) To carry out the line balancing process efficiently, a good observation of the entire system is required. However, the fast rate at which the entire process takes place, the higher number of system variables, and the stochastic nature of these variables make it very difficult for humans to observe the actual manufacturing system. In addition, it is also very difficult to solve the line balance problem manually considering all the variables that affect system performance. In the simulation model run results, there are 2 work stations that have a full process of more than 50%, namely the numbering work station with a full process of 77%, besides that the CNC work station also has a full capacity result of 83%, so it can be identified that there will be a bottleneck. at 2 work stations that have a full process rate of more than 50%.

4.3 Perform verification and validation tests on simulation models with current conditions and random number generation

At the verification and validation testing stage, the simulation carried out a test with 2 samples of Kolmogorov-Smirnov test. The test results are presented in table 5.

Table 5. Kolmogorov-Smirnov . test results

Process	Test result
Process cutting 1	0.998
Process cutting 2	0.952

Process numbering	0.799
Process DC	0.388
Process PpA	0.998
Process Quilting	0.998

In this test carried out with 5 work stations, the results showed that sig a > 0.05, meaning that in each work station there was no difference between the real condition data and the simulation data.

4.4 Creating scenarios in a simulation model

In the simulation model, there are two work stations that are the focus because they have a full process exceeding 50% so that a bottleneck will occur at the work station. From the results of the simulation model, two scenarios will be created to reduce the full process level and to increase the total exit on the system.

4.4.1 First Scenario

In the first scenario, it is done by adding work stations to the numbering process and the CNC process because in that process a bottle neck will occur, causing delays in the production process. After running the promodel software, the result is a total exit of 262 with an average in the system of 1516.53 min while the average in operation is 407.31 min. contained in table 4.6 the results of the first multiple capacity location scenario.

Tabel 6. The results of the first multiple capacity location scenario

	Cut1	Cut2	Numbering	Numbering 2	PpA	CNC 1 (Quilting)	CNC 2 (Quilting)
Idle %	3.58	2.44	1.04	1.67	1.57	22.63	30.65
Process %	45.95	70.48	21.45	15.81	32.89	61.18	68.71
Full Process %	36.94	27.07	77.51	82.03	65.54	16.18	0.64

From the results of the first multiple capacity location scenario, the total exit is 8% smaller than the simulation and the average time in the system is 2% smaller than the simulation. Meanwhile, the average time in operation in the first scenario is 31% greater than the simulation.

4.4.2 Second Scenario

In the second scenario, it is done by adding work stations to the PpA process because in that process a bottle neck will occur, causing delays in the production process. After running the promodel software, the result is that the total exit is 330 with an average in the system of 1478.02 min, while the average in operation is 513.63 min. contained in table 7. the results of the second multiple capacity location scenario.

Table 7. Results of the second scenario multiple capacity location

	Cut1	Cut2	Numbering	Numbering 2	PpA	PpA 2	CNC 1 (Quilting)	CNC 2 (Quilting)
Idle %	3.11	2.04	1.04	1.67	83.16	18.65	22.18	16.14
Process %	50.58	75.24	20.90	14.92	16.46	81,35	56.09	66.35
Full Process %	46.31	22.72	78.05	83.41			21.73	17.51

From the results of multiple capacity location in the second scenario, the total exit is 14% larger than the simulation and the average time in the system is 2% smaller than the simulation. Meanwhile, the average time in operation in the second scenario is 13% smaller than the simulation.

4.4.3 Summary scenario and simulasi model

At this stage combine the results of the simulation model and the scenarios that have been made.

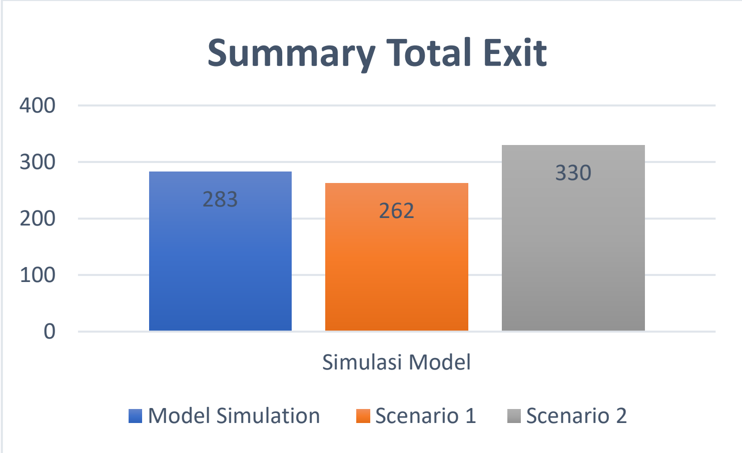

Figure 3. Summary of Total Exit

From the total exit results obtained, the simulation model achieved a total of 283 which is not too far from the real condition. The difference between the simulation model and scenario 1 is that the total exit decreases by 21 from the total exit, meaning that adding a work station to CNC and Numbering cannot increase output, where the PpA work station becomes the center of the bottleneck because the flow from the numbering process is very large. In addition, the difference between the simulation model and scenario 2 experienced an increase in the total exit of 47 from the total exit of the simulation model. The increase was followed by the addition of work stations in the PpA process.

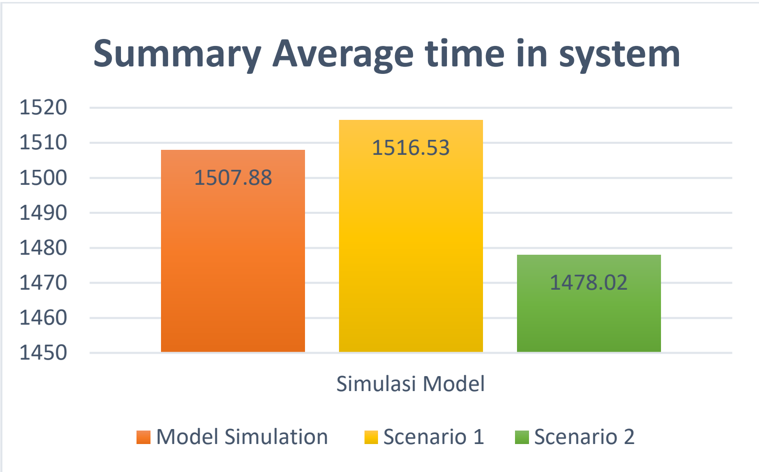

Figure 4. Summary of the average time in the system

From the results of the average time in the system, the difference between scenario 1 and the simulation model is obtained. Where the difference in the average time in the system is 8.65 minutes. From this difference, the average time in the system in scenario 1 is considered to be longer than the simulation model. In addition, the average time difference in the system in scenario 2 is 29.86 minutes. From the difference in the average time in the system, the flowtime of the process is 29.86 minutes faster than the simulation model. With faster time in the system, it means that with the same availability, the scenario can result in greater product/production output.

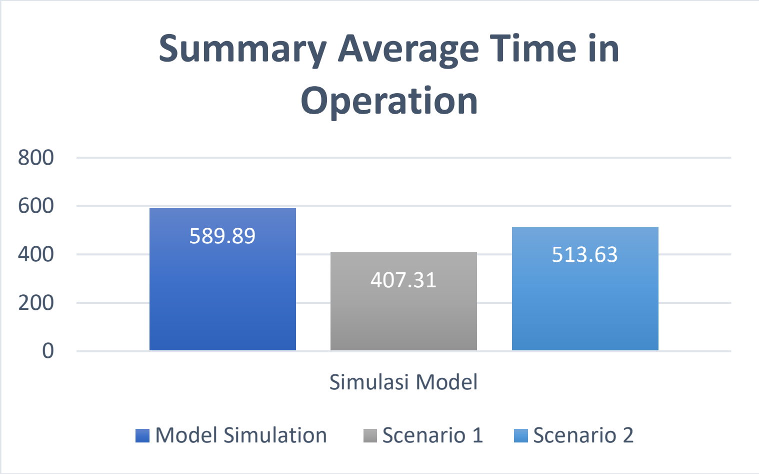

Figure 5. Summary Average time in operation

The results obtained at the average time in operation there is a difference from the simulation model with scenario 1 there is a difference of 182.58 minutes. From this difference, we get a very high reduction in the average operating time. Compared to the difference between the simulation model and scenario 2, there is a difference of 76.26 minutes. From the average time in operation, it means that the smaller the operation, the less waste there is in each work process. According to (B et al. 2021) the increase in operating capacity can be done by increasing the number of machines or by the number of workers. So the scenario created is to increase the number of machines and the number of workers so that capacity can be increased and can reduce or eliminate bottlenecks at work stations. According to (Yemane 2021) on the basis of the time required for each operation, the reasons for line balancing are that: Maximum output, avoiding congestion, smooth flow of work (production), less supervision and effort. The main objective of this research is to increase productivity.

5. Conclusion

In the simulation model, it can be seen that there are bottlenecks, there are two work stations, namely the numbering process and CNC (quilting) so that improvements are made to the system by increasing the number of machines and the number of people at the work station. In summary, the total exit difference between the simulation model and scenario 2 is higher than the simulation model with scenario 2 by 68. Meanwhile, in the summary of the average time in the system, the difference between the simulation model and scenario 2 is smaller than the difference between the simulation model and scenario 1, the value is 38 51 minutes. And the summary of the average time in operation the difference between the simulation model and scenario 1 is smaller than the difference between the simulation model and scenario 2, the value is 182.58 minutes. So the researchers chose scenario 2 as a system improvement because it can produce a total exit of 14% greater than the real condition, besides that it can reduce the average time on the system by 2% smaller than the real condition and at the average time of operation by 13%. smaller than the real condition. This means that scenario 2 can increase output and reduce the average time in the system and the average time in operation.

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Biographies

Bagus Trilaksono is a postgraduate student in Industrial Engineering at Sebelas Maret University, Indonesia. I became a student in 2020. I am currently working for the largest garment company in Indonesia. I am interested in research in the field of manufacturing systems, ergonomics, smart manufacturing and data analytics.

Pringgo Widyo Laksono is an associate professor in Industrial Engineering. Since 2005, He joined as researcher at Production System Laboratory, Faculty of Engineering, Universitas Sebelas Maret, Indonesia. He was received degree Doctor of Engineering from Gifu University, Japan, in 2021. His research interests are automation and production development systems engineering, human-machine interaction, intelligent machine, human factors engineering, robotics, and control system engineering. Currently, Dr. Eng. Pringgo Widyo Laksono is conducting research in Human-Automation Interaction based on bio-signal.