

## Reducing the Number of Intermediate Stock by Implementing Just-in-Time and Pulling System

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### Abstract

*In the tire manufacturing process in PT X, there is an area called the Intermediate Area in the Building - Curing area where Work-In-Progress (WIP) materials are temporarily stored before proceeding to the Curing process. The capacity of Intermediate Area is 15000 pcs, and the daily production volume approximately 20000 pcs. As a result, more space in the Intermediate Area is required to accommodate the increasing tire production planning. In this study, Just-In-Time (JIT) & Pull system improvement process is carried out by following the Plan-Do-Check-Act (PDCA) cycle methodology. The implementation of the JIT done by determining standard for the number of intermediate stocks with stopwatch time study, whereas the Pull system implementation done by setting the standard material handling cycle time standard for one cycle. To keep the improvement runs according to the plan, the guidance sheet is made as the reference of the process. These improvements done to achieve the objective which is to reduce the number of stocks in the Intermediate Area by up to 834 pcs per day and reduce the total cycle time from 110 minutes to 90 minutes. This improvement could achieve the objectives that have been set with a ratio of 95% of the specified target. Therefore, the main contribution of this research is to reduce the number of WIP materials in intermediate area and reduce the excessive transportation in the material handling process.*

*Keywords: cycle time, delivery, Just-In-Time (JIT), Pulling System, stocks, Stopwatch Time Study*

### 1. Introduction

In general, the primary goal of a manufacturing industry is to manufacture items profitably and punctually. The manufacturing industry demands a growth and enhancement of the production process to ensure the continued success of the company. Now, businesses must also be more aggressive in their pursuit of the existing market. Many methodologies are implied to reduce the production cost in the company, one of them is by reducing the amount of inventory. Inventory is the collection of any kind of resource that has economic value and is maintained to fulfill the present and future needs of an organization (Nwaiku and Ejechi, 2022). According to research, determining the appropriate inventory level is crucial since inventory ties up money and affects performance (Priniotakis and Argyropoulos, 2018).

Waste is defined as any activity that uses resources but adds no value to the product. Essentially, all waste is closely related to the time dimension. Muda denotes inefficiency, pointlessness, and worthlessness, implying a rejection of esteem expansion (Shedge *et al.*, 2022). According to Jaffar *et al.* (2015), Muda could be classified as 7 types, there are overproduction, defects, unnecessary inventory, inappropriate processing, excessive transportation, waiting, and unnecessary motion. Lean production is used to continuously remove waste from the production process to increase productivity and efficiency. Lean manufacturing is fast growing process to improve the productivity of an industry (Gupta, 2015). Kumar (2014) on his paper with the title "Lean Manufacturing and its Implementation" stated that one of the objectives of lean manufacturing is to reduce stock levels at all manufacturing stages, especially when it comes to works-in-progress between stages. Some of lean manufacturing key techniques are Just-In-Time (JIT) and Pull system. Just-in-Time (JIT) is an inventory management approach of having the exact amount of inventory goods arriving at the exact time when needed

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(Mankazana and Mukwakungu, 2018). On the other hand, a Pull System controls the flow of products by automatically adjusting inventory levels based on actual consumption (Huang *et al.*, 2014).

PT X is a tire manufacturing company that is located in West Java. Its main activity is to produce tires for passenger cars, commercial trucks & buses, light trucks & vans, forklifts, inner tubes and tubes. The manufacturing process consists of Banbury, Extruding, Calender, Cutting, Slitter, Bead, Building, Curing, and ended with tire finishing process. In Building process, the output from the Building process is a WIP materials called Green Tire (GT). These GTs are stored in a custom rack called Daisha. There are two types of Daisha, namely Ring Daisha and Vertical Daisha (Verda). Ring Daisha has the capacity of 12 to 14 GTs while Vertical Daisha has the capacity of 4 GT. After Building process there's a process called doper. Doper is the process to coating the inner part of the GT before GT proceed to curing process. There is also an area known as Intermediate Area where Daisha full of GTs are stored before they proceed to doper process or curing process. The problem raised in this research is related to the increasing production plan. According to the 2023 production plan, the production plan of tire demand will be increasing from June until August as in Figure 1. This increasing production plan will cause the increasing area needed in intermediate area to store the GT.

The next step from the research framework is analyzing the current condition of the related area. In the current condition, the total space available can accommodate 15,000 pcs GT. It is known that the ratio of the number of Verda and ring Daisha is 3:2. Therefore, Intermediate Area could accommodate the total of 2,250 Verda and 500 ring Daisha with the total area available is 2923 m<sup>2</sup>. This intermediate area could accommodate GT as much as about 65,000 GT. As in the forecasted production plan, the quantity of GT production will be increasing up to 68,000 in August. It means, in a day, the daily production plan will be in the amount of 20,000 pcs GT for June until August. This condition is depicted in Figure 2.

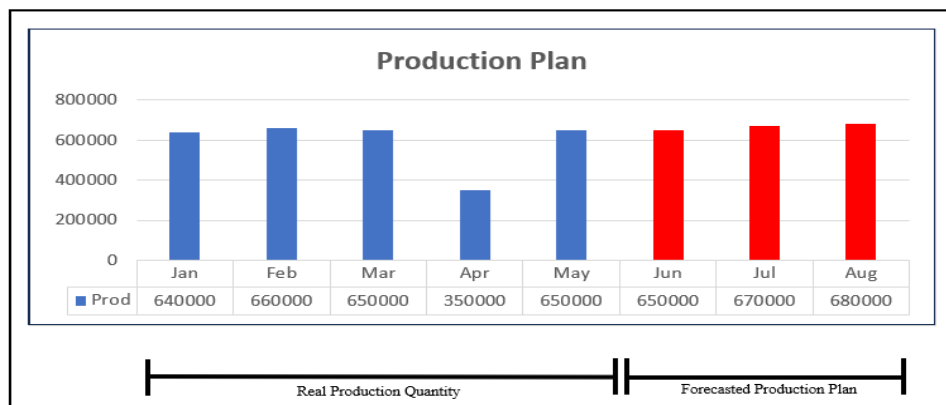


Figure 1. 2023 Production plan

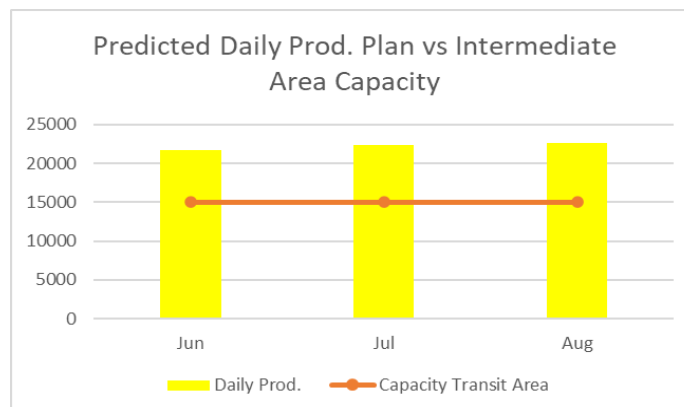


Figure 2. Predicted production plan vs. intermediate area capacity

On the other hand, the cycle time for 1 cycle of delivery process is calculated through stopwatch time study and it counts that the cycle time is 110 minutes for 1 cycle of delivery process.

Responding to the increasing production plan, the company therefore intended to optimize the use of Intermediate Areas and Daisha so that the increase in the number of productions does not have an impact on adding Daisha units and using a larger Intermediate Area. According to the step in research framework, the next thing to do is determine the target setting. The target is to reduce the number of GT in the Intermediate Area by 10% from the current condition. This target will be achieved gradually from June until August as explains in Figure 3.

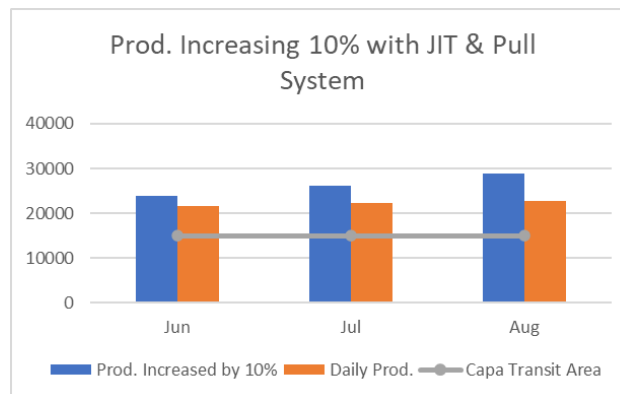


Figure 3. Target setting

After the target setting is determined, the next step is doing the root-cause analysis. This root-cause analysis done using the fishbone diagram. After that, the next step is to identify the potential solution for the problem and to reach the target. These solutions then will be eliminated by specific requirements to determine the selected countermeasure, continued with the improvement plan implementation and analyze the result of the improvement. Then the result comparison with the target is gathered, to make sure whether the Improvement meets the target or not. After that, the standardization and next action for the project is determined. To achieve this target, the implementation of JIT & Pull system is held according to the PDCA cycle methodology. Furthermore, the making of Guidance sheet is made to keep the flow runs according to the plan.

## 2. Methods

In this study, the research method used is following the PDCA Cycle, which the steps are Plan, Do, Check, Action. PDCA is chosen as the method because according to Isniah, Debora and Purba (2020), PDCA is sufficient under the surrounding that support kaizen and sustainable development, the process's carried out repeatedly, the new solutions can be explored to solve the number of problems and improve solutions while testing with control implementation. In the current condition of the observation area, the surrounding is a kaizen supported area and sufficient for a sustainable development. The research framework of this study follows the steps in Figure 4.

### Plan

The first phase of PDCA cycle is Plan. In this phase, the problem background of the project is defined (Wani, Chin and Muhammad, 2019). The step started with problem identification, continue with current condition analysis, then setting the research target. After setting the target, the gap between the current condition and the target setting is exposed. Root-cause analysis is held to identify the root-cause of the problem. In this research, Fish bone diagram is utilized. Fish bone diagram or cause and effect diagram is a problem-solving tool that investigates and analyzes all of the potential or real causes that result in a single effect in a systematic manner. On the other hand, it is an effective tool that enables the organization's management to investigate the possible causes of a problem (Neyestani, 2017). Based on the root-cause identified, the potential improvement plan is developed and proposed, according to

Bazrkar and Iranzadeh (2017) on their research, 5 criteria to selecting and ranking Six Sigma and Lean Six Sigma project are project cost, cost of poor quality, project duration, customer satisfaction, and increasing sigma level. The criteria describe by Bazrkar and Iranzadeh (2017) then adjusted according to the usage of this project. The last step in the “Plan” phase is finalize the improvement plan using the 5W1H method.

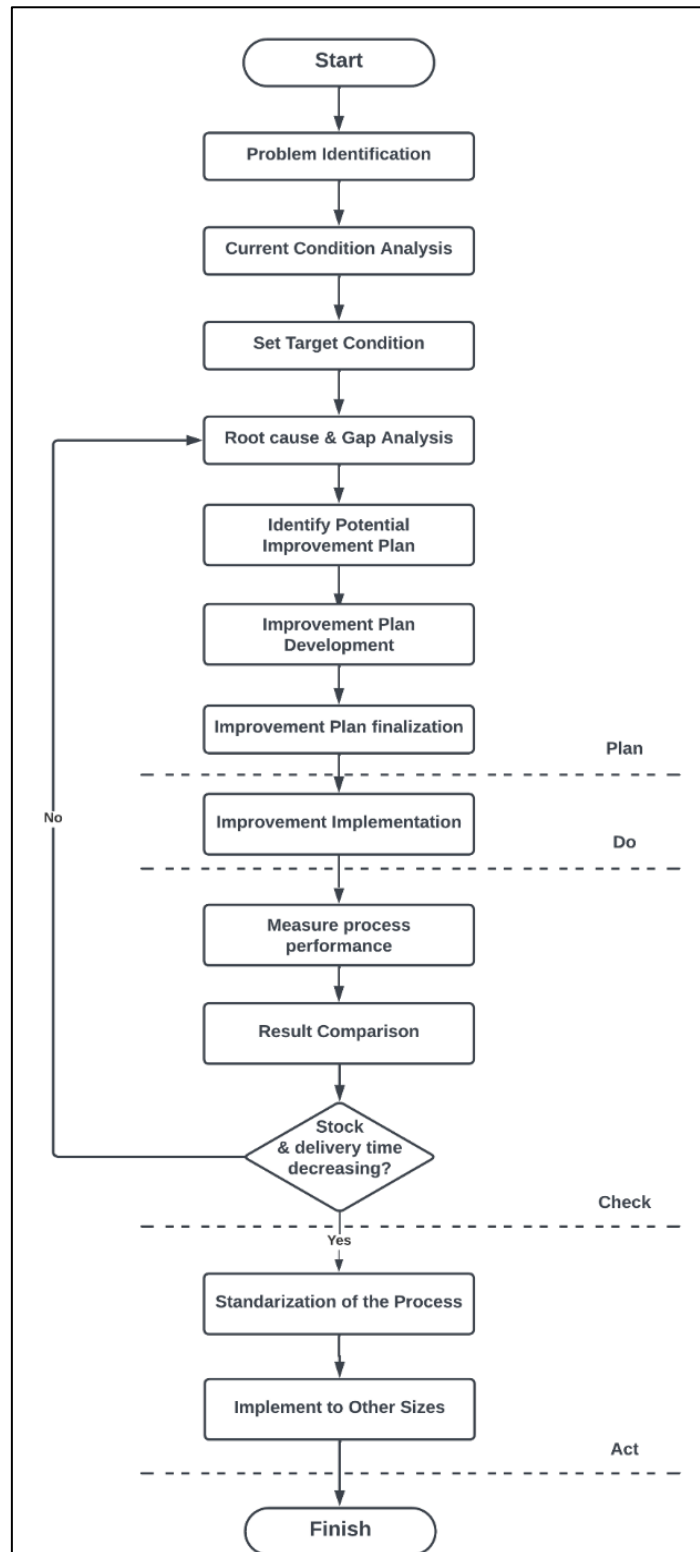


Figure 4. Research framework

### **Do**

In the “Do” phase, the improvement plan that already chosen is implemented. The standard for JIT & Pulling system is determined. The standard is made by calculating the cycle time of the material handling process in Building – Curing area & the waiting time in the doper process. This cycle time calculating by doing the time study. Time study is a structures process of directly observing and measuring human work using a timing device to establish the time required for completion of the work by a qualified worker when working at a defined level of performance (Shahriar, 2019). This cycle time then converted into the number of GT requires for the JIT and Pull system standard. Transfer guidance sheet is made as a guidance for the transfer operator to deliver the GT so the process will keep in accordance to the standard determined before.

### **Check**

Monitoring the project implementation is done to encounter any problem regarding the improvement project as the implementation of “Check” phase. The primary goal of the "Check" phase is to compare the actual results to the expected outcomes defined in the "Plan" phase and determine whether the process changes have resulted in the desired improvements. Therefore, process performance measurement is done through monitoring the number of GT stock daily and delivery cycle time for 1 cycle of material handling process. The result from monitoring process then compared to the objectives of the research, to determine whether improvements can be implemented further or not.

### **Action**

The fourth and final step in the PDCA cycle is the "Act" phase. The results and insights gained from the "Check" phase are used in this phase to make adjustments and improvements to the process being analyzed. The main goal of the "Act" phase is to implement changes that have been identified as necessary based on the previous phases' analysis. Process standardization of the improvement is made and ready to implement horizontally for the same type of stock. The process standardization is made by developing a flowchart. A flowchart is a diagrammatic representation of a series of symbols that describe the sequence of steps in an operation or process (Neyestani, 2017).

## **3. Result & Discussion**

According to the research framework, the root cause of the problem identified with the fish-bone diagram. The root-cause analysis observes through Man, machine, material, and method aspect as explains in Figure 5. In Figure 5, as explained before in problem identification, the problem is that there is a lack of space for the future production plan. Therefore, this problem breakdown into four aspects which are man, machine, material, and method. To know the root-cause in each aspect, direct observation and searching for information through related parties within the company through direct employees and company data is carried out.

For the machine aspect, the production timings on Building and Curing machines are different. This can be seen in the daily production data that the building section could produce more GT than Curing section produce tires in a shift time. From the data, it is known that there's a difference within Building and Curing machines. For the Man aspect, based on field observation through time study, it is known that the current transfer operator doesn't deliver GT as much as it should be as in the time study calculation. This could happen because in fact, there's no work instruction for the transfer operator in doing the responsibilities. Another aspect is regarding the method, the delivery method is accumulated the GT in the transit area, whilst there is some GT type could be delivered directly to curing machine.

The next step of the research framework is to initiate, develop, and determine the countermeasure based on the root-cause identified in the fish-bone diagram. The root-cause identified in the fish-bone diagram is then overcome with a proposed JIT & Pull system and Transfer guidance sheet. JIT & Pull System proposed because it has been proven from several previous studies that can reduce the number of inventory and increase the material handling performance.

Rina, Syamsudin and Hidayat (2021) in their journal proved that the implementation of JIT in Raw Material system could increase the efficiency of raw material cost. (Halim *et al.*, 2015) in their publication stated that the improve in JIT process could reduce the inventory level and also reduce the space utilization. On a study conducted by Azim (2018), the JIT system design can reduce inventory quantity, minimize the inventory costs, reduce requirements of large inventory spaces and also provide efficient communications in the production. On this study also, pull system is proven able to reduce inventory costs, reduce work in process (WIP), increase storage space with proper arrangement, eliminate over-production instead maintaining fixed production quantities and created an efficient communication throughout the production stream.

These improvements were then weighed with the prioritization matrix to choose the most suitable improvement for the problem. This prioritization matrix values the improvement plans based on the criteria determined before, each improvement plan then weight and the improvement plan with the highest value will be implemented in the project trial. The chosen improvement plan then explains with the 5W1H method as in Table 1 and Table 2.

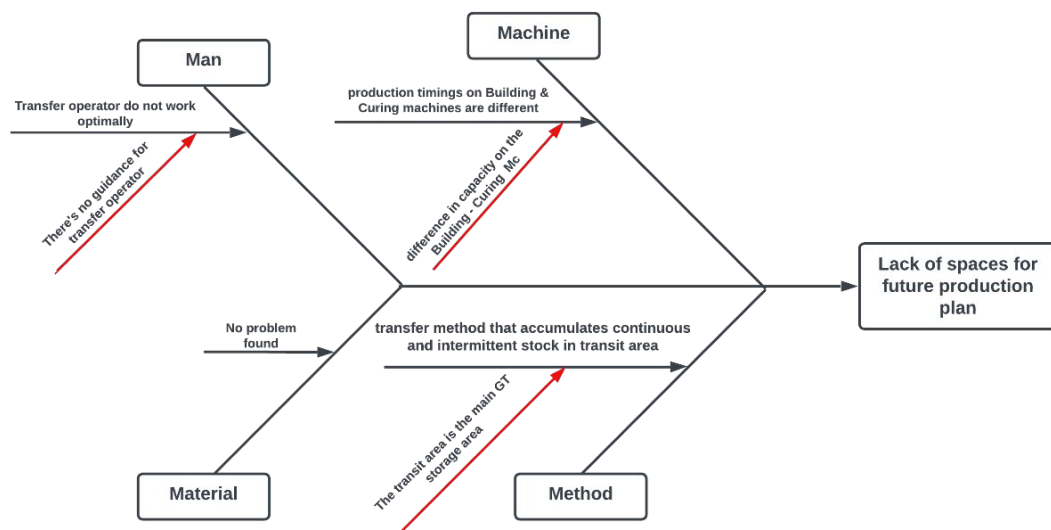


Figure 5. Fish-bone diagram

Table 1. JIT & pull system 5W1H explanation

No.	What	How	Why	Where	When	Who	How Much	Target
1	Intermediate Area is the main GT storage area	Calculate the cycle time for each process Calculate JIT & Pull System Standard Trial implementation in one tire size Monitoring the number of stock & delivery time daily Evaluation	Decrease the continuous supply type stock in Intermediate Area	Building - Curing Area	April - June, 2023	PC Department, Production Building Department, Production Curing Department.	Rp0	Decreasing the number of continuous supply type stock as much as 30% of the current number of stocks.
2	Difference capacity between Building and Curing machine	Implement to other continuous supply type stock						

To implement JIT & Pull system, the calculation of the standard is done by doing the cycle time of Building delivery time, doper waiting time, and curing delivery time. The calculation was done by conducting the stopwatch time study in the Building and Curing production line, and the doper process cycle time. This delivery time then becomes the standard cycle time for 1 cycle of material handling process. Then converting it to the number of GT as the GT on delivery standard as in Table 3. For stock in machine, the total stock in machine consists of stocks in front of machine (8 Daisha) and stocks being processed by curing machine (2 Daisha). The total number of stocks in machine is 40 GTs, it is explained in Table 4. The minimum GT stock for JIT & Pull System is 52 pcs GT and the maximum GT stock for JIT & Pull System is 208 GT as in Table 5.

In the current system, there are two different kind of delivery process, Transfer building operator takes stock from building is carried to transit area, and the transfer operator takes back the empty Daisha to building machine. On the other hand, the transfer curing operator will take Daisha from transit area to the doper machine and take the Daisha from doper machine to Curing machine, after that, the transfer operator delivering back the empty Daisha to the transit area. Figure 6 depicts the current transfer system concePT

Table 2. Transfer guidance sheet 5W1H explanation

No.	What	How	Why	Where	When	Who	How Much	Target
1	No guidance for transfer operator	Make the guidance for transfer target in a day Share the guidance to production department	Transfer operator could work effectively	Building - Curing Area	April - June, 2023	PC Department, Production Building Department, Production Curing Department.	Rp0	Optimize material handling process in Building - Curing area

Table 3. JIT & pull system (stock on delivery)

	Delivery Time Bld	Doper Waiting Time	Delivery Time Crg	Total
Minute	19.04	30.10	29.52	78.66
+ Loss Allowance (20%)	23.8	37.6	36.9	98.3
Pcs GT	2.68	4.23	4.15	12

Table 4. JIT & pull system (stock in machine)

	Daisha	GT	Total
Verda in front of M/C	8	32	40
Using Stock	2	8	

Table 5. Total stock standard for JIT & pull system

	Daisha	GT
Maximum Stock/ MC (pcs)	13	52
PA00 4 Crg MC (pcs)	52	208

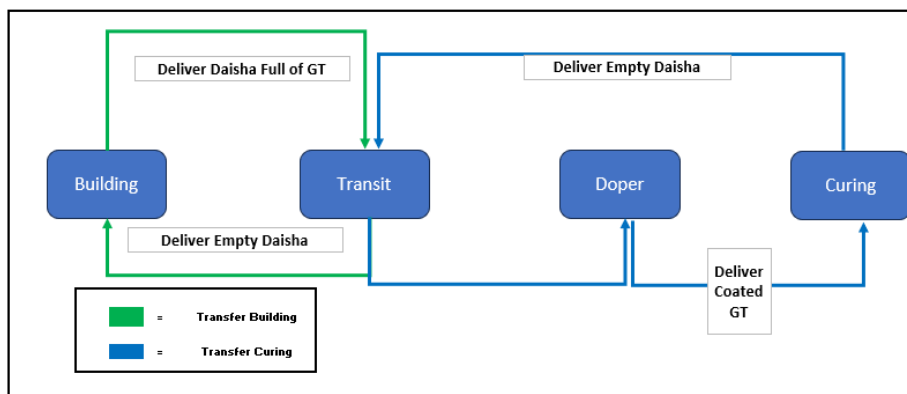


Figure 6. Current transfer system concept

In the pulling system, stock from building pulled directly to doper process and the empty Daisha delivered back to building machine. This improvement would reduce the material handling process cycle time because no waiting time is spent in the Intermediate Area. Figure 7 depicts the scheme of pulling system improvement plan.

The improvement implementation is then carried out directly in the field by doing the trial in one of product style (PA00). Since the improvement is to change the delivery transfer process flow, then there's not much cost required for the implementation, only requires paint as a marker for the Daisha used as a trial. Nevertheless, very strong communication with the related parties is needed to make the flow run smoothly. After that the improvement performance measurement is held by monitoring the flow process. Figure 8 shows the result from stock monitoring within 1 month of JIT & Pull System implementation. The flow monitoring process recorded hourly in a day and divided into two categories, namely the normal and abnormal flow. In normal flow, the total stock is within the minimum and maximum standard of number of GT in the JIT & Pull system. Whereas the abnormal condition of the JIT & Pull system implementation occurred when the number GT stock below the minimum standard (52 GT) or over the maximum standard (208 GT) in the JIT & Pulling system standard.

On the other hand, monitoring process for cycle time is held by doing stopwatch time study to measure the performance of delivery system. As in the calculation of pull system minimum and maximum standard, 1 cycle of delivery process for product style PA00 supposed to be between the minimum and maximum cycle time delivery standard which is between 78 and 98 minutes for 1 cycle. Monitoring process according to delivery cycle time described in Figure 9.

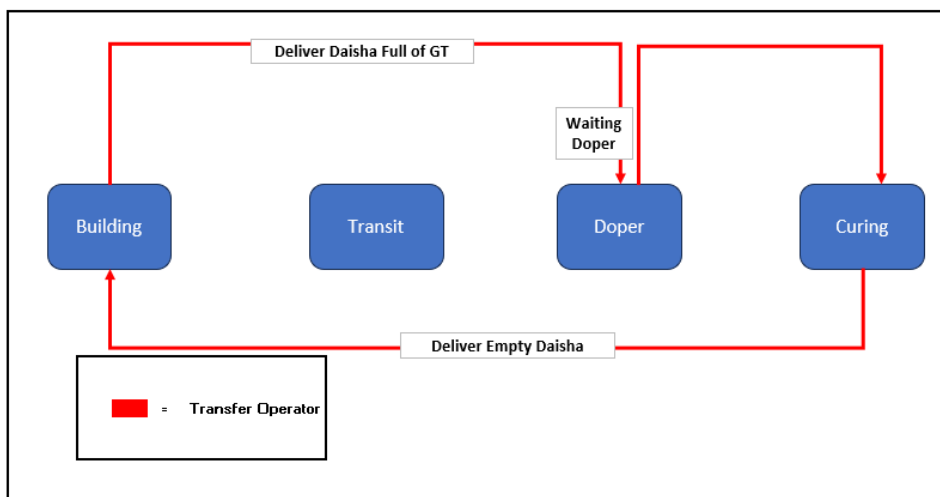


Figure 7. Pulling system concept

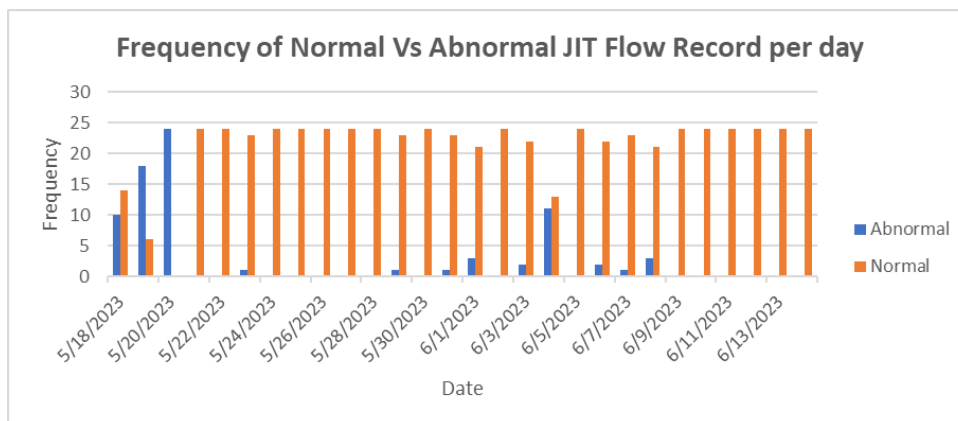


Figure 8. Daily stock monitoring data (normal vs abnormal)



The next step is to compare the result with the target setting and the situation before the improvement. The number of stocks reduced in Intermediate Area has the benefit of increasing the production quantity according to the reduced amount of stock in Intermediate Area. From the improvement that has been implemented, in average of 834 GT reduced from Intermediate Area in a day as in Figure 10. Therefore, the daily production could increase as much as 834 GT. This could happen because the number of GT stocks which were originally stored in the Intermediate Area are directly delivered to the machines. This caused space for other GT stocks available, and the production process could increase accordingly.

The implementation of JIT & Pull system has given significance to the utilization of the area due to the decreasing number of WIP material in intermediate area. The detail of the reduction of the intermediate area usage can be seen in Figure 11. In the figure, the result of the improvement plan is shown in the actual calculation in June, whereas, in July and August is the estimated reduction of area utilization. A further explanation of the total area is shown in Table 6.

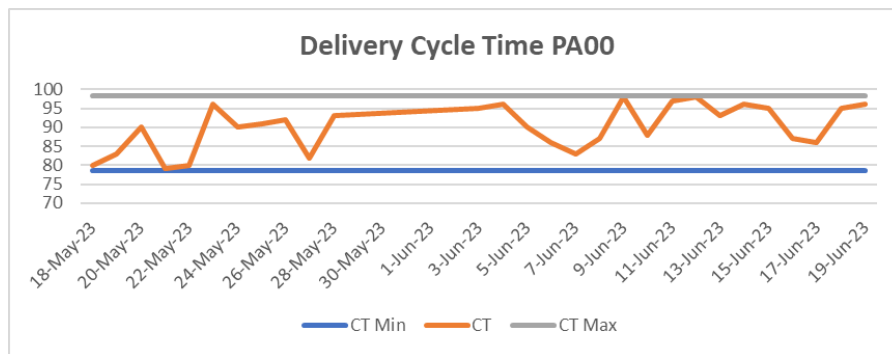


Figure 9. Cycle time monitoring data

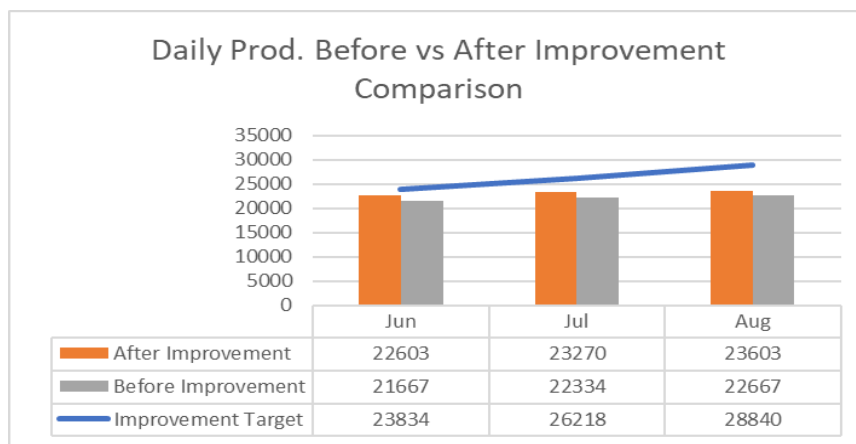


Figure 10. Result comparison (daily production plan)

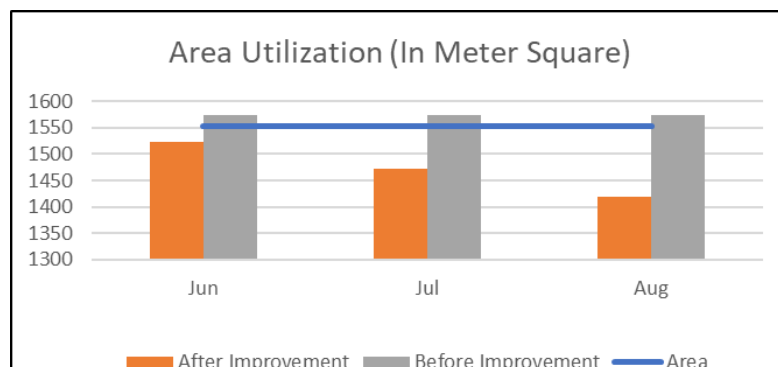


Figure 11. Result comparison (area utilization)

The cycle time of GT delivery process is recorded daily. The result of the cycle time delivery process depicted in Figure 12. Based on the graphic, the time needed for 1 delivery cycle decreases into 90 minutes for 1 cycle when before the implementation of JIT & Pull system, the delivery cycle time is in the duration of 110 minutes.

After monitoring and standardizing the improvement process, the evaluation of the improvement is done to assess how well the project achieves its objectives. The evaluation also determines the next steps that can be taken to improve the process so that the improvement results can be closer to the target. Lastly, this new standard is finalized and will proceed to implemented to other product style to have a better result.

Table 6. Detail data of area utilization

	Jun	Jul	Aug
Area	1552	1552	1552
After Improvement	1523	1471	1419
Before Improvement	1575	1575	1575

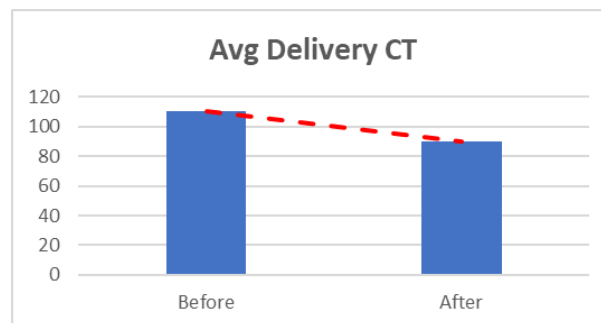


Figure 12. Result comparison (material handling cycle time)

#### 4. Conclusion

To conclude, the implementation of JIT & Pulling system could optimize the inventory management in Building – Curing area. This can be seen from the achievement of the objectives of the study. reduce the number of stocks as much as 834 pcs GT causing the reduced use of intermediate area as much as 52 m<sup>2</sup>, impacted on the increasing of production volume. JIT & Pulling system also optimizes the inventory system because it reduces the delivery cycle time from 110 minutes to 90 minutes underscores the enhanced efficiency of the material handling process in Building – Curing area.

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