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Reducing Cycle Time by Eliminating Waste in Refrigerator Factory Unloading Process

Nirfison[1]; Rahman Soesilo[2]; Dedy Khaerudin[3]
[1,2]Sekolah Tinggi Teknologi Mutu Muhammadiyah Tangerang - Indonesia
[3]Universitas Bina Bangsa, Serang, Indonesia

ABSTRACT : *The lean approach is often used by manufacturing companies to increase productivity in the production area. In this case PT P, a manufacturing company that produces refrigerators, faces the same problem on the unloading process in the final assembly area. The unloading process is the operation to move the finished product from the production line and store it in the finished goods warehouse. Operators in the unloading area have tasks to unload finished products from conveyors which are connected directly from the assembly line and placing them on pallets. Due to the refrigerator is quite heavy a forklift has to use to move the full pallet to the finished goods warehouse which is located next to the unloading area. Once finished the forklift returns to the unloading area with the empty pallets and places them in the unloading area, to be refilled by the unloading operator. Based on the data taken, the cycle time in the unloading process was recorded to be varied and the highest was 33 seconds, exceeding the takt time that had been determined on the production line, which was 24 seconds. This means that there is waste that occurs in the unloading area. The long and unstable cycle time in the unloading process makes the production line disrupted because the conveyor often stops and causes productivity to drop. For this reason, it is necessary to analyze and improve the process with the Lean concept by reducing the existing waste, so that the cycle time becomes stable and smaller than the takt time.*

KEYWORDS :*Lean, Forklift, Cycle Time, Takt time, Produktivity, Waste*

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I. INTRODUCTION

In the manufacturing industry, productivity is the company's ability to optimize the output of the inputs used. Manufacturing companies are companies that require a process with the use of quite a lot of material and of course this will result in the company having a lot of waste in the process. Lean focuses on identifying and eliminating non-value added activities in design, production (for manufacturing) or operations (for services) and supply chain management that are directly related to customers[1].

Productivity is a comparison between output and input. If the output produced is large with fixed inputs or smaller than before, the company's productivity will increase. The output results are influenced by factors in the production process including defects and waste.

Today, lean manufacturing has been trusted by several Japanese companies as a system that can increase the effectiveness and efficiency of production process activities. To increase the effectiveness and efficiency, the company needs to minimize the presence of waste or non-value added. Waste minimization is one of the principles of lean manufacturing[2]. Lean manufacturing is a systematic approach to identify and minimize waste through continuous and continuous improvement and development, trying to make the flow of production run smoothly to try to attract the attention of consumers in an effort to achieve perfection[3].

Waste minimization is important to get a good value stream. Increased productivity leads to better operations, which in turn helps determine waste and quality problems in the system. Indirect systematic waste management is also a systematic solution to the factors that cause problems in management[3].

PT. P is a company engaged in the household electronic equipment industry, one of which is a refrigerator. This refrigerator is marketed to the domestic market as well as abroad. Every day the products produced are delivered to customers directly from the finished goods warehouse. Given the sizeable volume, production arrangements must be made very efficiently. Constraints in production will directly affect scheduled deliveries to customers every day.

In line with that, the company still wants to continue to maintain existing productivity and continue to improve it with kaizen efforts. However, problems that occur in the unloading process must be repaired first. It is necessary to analyze the area in order to identify the root cause and then take permanent corrective steps.

The problem that occurs is the cycle time in the process of unloading the finished product, sometimes it does not match or exceeds the predetermined takt time[4]. Based on field observations, unloading operators often wait for the forklift to return with empty pallets, so the finished product on the conveyor cannot be unloaded because there are no empty pallets available. This makes the conveyor automatically stop because the finished product is still on the conveyor. The stop of the conveyor in the unloading process causes the assembly production line to also stop because the conveyor is connected to the leading assembly line.

The problem faced by the production line is that the conveyor often stops because there is an operation waiting in the unloading process which causes a fairly high loss time in the production line. For this reason, it is necessary to analyze it by measuring the working time in the process to get the actual cycle time. Then make observations to see the potential waste that occurs during the unloading process.

Data collection methods are carried out through:

1. Observation, namely observing the process carried out in the unloading area of the finished goods warehouse as an object of research, to obtain the necessary data, including the potential waste that occurs.
2. Retrieval of cycle time data directly on the processes carried out in the unloading area.
3. Documentation, namely collecting data in the form of documents, such as the current layout data, a list of work tools used in carrying out activities in the warehouse area, including taking photos to see any changes before and after implementation.
4. Make suggestions for improvement to overcome problems that occur.

II. THEORITICAL BASIS

Productivity

The word productivity was first coined by Quesnay in 1766. In 1883, Littre defined productivity as “the ability to produce.” The definition of productivity has been made by many experts and international bodies. The Organization for European Economic Corporation defines that productivity is the quotient obtained by dividing output by one of the factors of production, namely capital, investment and raw materials.

Drucker [5] suggests the definition of productivity as follows: Productivity is a balance between all factors of production that provide more output through the use of fewer resources. Greenberg [6]defines productivity as the ratio between the totality of expenditure at a certain time divided by the totality of inputs during that period. Then work productivity is also defined as the ratio between output per input. By knowing the value (index) of productivity, it will also be known how efficiently the input sources have been successfully saved[7].

Productivity is also defined as:

1. Comparison of price measures for inputs and outputs.
2. The difference between a set of total expenditures and inputs expressed in general units.

There are four stages in the concept of the productivity cycle, namely: productivity measurement, productivity evaluation, productivity planning, and productivity improvement. Mali [8]also suggested that "productivity is a combination of effectiveness and efficiency". Effectiveness is related to performance in achieving goals and efficiency is related to the use of resources. Productivity is achieved with the greatest possible results, using as few resources as possible.

The relationship between the three is as follows:

$$\text{Produktivity} = \frac{\text{Output obtained}}{\text{Input used}}$$

$$\text{Produktivity} = \frac{\text{The results achieved}}{\text{Source used}}$$

$$\text{Produktivity} = \frac{\text{Effectiveness}}{\text{Efficiency}}$$

Lean Manufacturing is a production streamlining concept originating from Japan. This concept is the concept of adoption of the Toyota production system. The concept of this approach is oriented to the elimination of waste (waste) that occurs in the production system. This waste elimination is carried out so that the production system runs effectively and efficiently[9].

Lean can be defined as a systematic and systematic approach to identify and eliminate waste or non-value-adding activities through radical continuous improvement by way of product flow (materials, work-in-process, output) and information using a pull system from internal and external customers to pursue excellence and perfection[10].

Lean manufacturing is a systematic approach to identify and eliminate waste in the form of non-value added activities through continuous improvement by allowing product flow with a pull system from the customer's point of view with the aim of perfect customer satisfaction[11]. The concept of this approach was pioneered by Taichi Ohno and Shigeo Shingo where the implementation of this concept is based on 5 basic Lean principles:

1. Identifying product value (goods and/or services) based on customer perspective, where customers want superior quality products (goods and/or services), at competitive prices and on time delivery.
2. Identifying the value stream process mapping (equal distribution of processes in the value stream) for each product (goods and/or services). (Note: most of the management of industrial companies in Indonesia only do business process or work process mapping, not product mapping. This is different from the Lean approach.)
3. Eliminate non-value added waste from all activities throughout the value stream process.
4. Organizing so that materials, information, and products flow smoothly and efficiently throughout the value stream process using a pull system.
5. Constantly looking for various improvement tools and techniques to achieve excellence and continuous improvement.

In lean applications, waste or waste must be eliminated. Waste is an activity that has no added value. Therefore, waste must be eliminated because it can cause the production process to be inefficient.

Warehouse

Warehouse is a place or roofed building that is used to stockpile, store and pack goods, with the aim that these goods are protected from damage and loss due to human activities, animals, insects, or due to temperature or weather[12].These activities may include movement, storage and information transfer[12]. In a warehousing system, layout is one of the determining factors for building construction and maintenance costs, material handling costs, storage capacity, land utilization, and equipment utilization[13]. Factors that determine product layout in the warehouse include order picking method, product characteristics, demand trends and space requirements[14].

Warehouse is an activity of managing goods which includes, receiving goods, storing goods according to their requirements, maintaining goods, maintaining the cleanliness of the space where goods are stored, removing goods as needed, taking care of the administration, and being responsible for the management[15]. Broadly speaking, warehouses do not have to be in the factory environment because distribution centers also have warehouses. The explanation of the warehouse in this case will focus on its presence in the factory environment.

Material handling can be defined broadly as all material handling in a manufacturing environment. More fully, material handling can be defined as a function to provide 9R, namely material in the right amount, for the right material, in the right condition, in the right place, at the right time, in the right position, in the right sequence, at the right cost and by using the right tools and methods that minimize production cost[16].

There are various warehouses according to the characteristics of the material stored, namely:

1. Raw material storage
   The warehouse will store every material needed or used for the production process. The location of the warehouse is generally located in the factory building, so the company can save on warehouse costs because it does not require a special building to be used as a warehouse.
2. Storage of semi-finished goods
   In the manufacturing industry, we often find that the workpiece must go through several kinds of operations in the process. Such procedures often have to be stopped because from one operation to the next the processing time is not the same. As a result, the goods or materials have to wait until the next operator is ready to work on them.
3. Finished production storage

This warehouse is also called a warehouse with the function of storing finished or finished products. In this warehousing there are durable products and vice versa. And the shape of this warehouse depends on different variations, such as circle, square and others.

III. RESULT AND DISCUSSION

Every production process in the assembly line is connected to each other by conveyors. The conveyor is also connected to the packing section and the unloading section of finished goods in the finished goods storage warehouse. If there is one operation slower than the takt time it will affect the productivity of the entire assembly line. The following is the layout of the assembly production line and finished goods warehouse. Conveyors are depicted in blue.

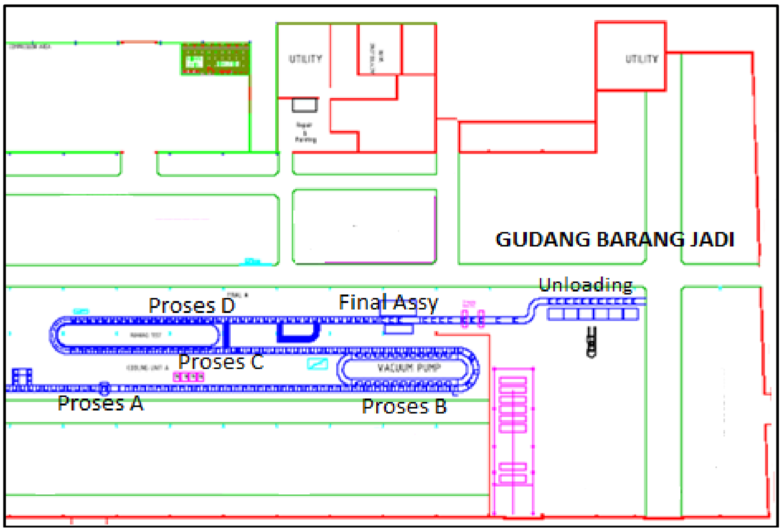
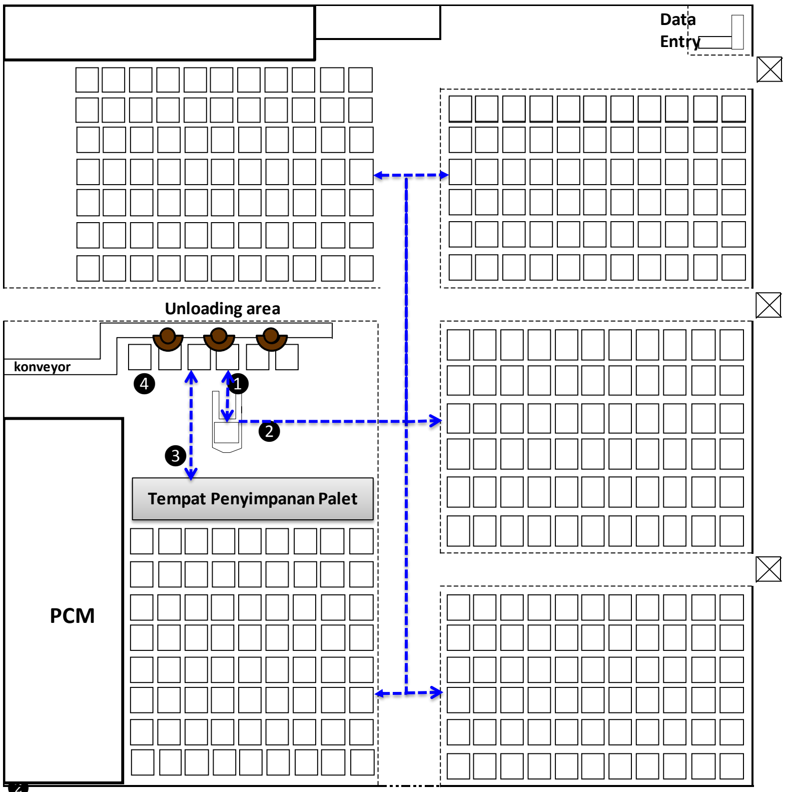


Figure 1 Layout of Production and Finished Goods Warehouse
(Source: PT. P)

The unloading process which is located at the end of the conveyor, is tasked with unloading the finished product and placing it on a pallet, then it will be stored in the finished goods warehouse using a forklift. The movement of the forklift can be seen in layout 2 below which is marked with a dotted blue line.



Forklift mengambil palet yang sudah penuh barang jadi
Forklift menyimpan palet tersebut ke tempat penyimpanan yang sudah ditentukan
Forklift menuju ke area penyimpanan palet dan mengambil palet kosong
Forklift menaruh palet di area unloading dan mengaturnya sesuai dengan tempat yang ditentukan

Figure 2 Unloading Area Process Layout in Finished Goods Warehouse Before Repair
(Source: PT. P)

The pallets used are specially designed to accommodate refrigerators, which are physically quite large and quite heavy. The pallets are made of thick wood or iron profiles. The dimensions are also larger than most pallets, with a weight ranging from 30 kg to 45 kg. These pallets are heavy enough to be moved by an operator without an assistive device such as a forklift.

*Takt Time*calculation

Takt time is the time standard set for making a certain unit of product. Takt time shows how often a product should be produced in a day to meet the average customer demand. Takt time calculation is done for each process. The available working hours are 2 work shifts, each of which is shift 1 which is 458 minutes and shift 2 is 398 minutes, the total working time is 856 minutes, after deducting rest time. Meanwhile, the average finished product produced in one month is 47,000 sets or 2,136 sets per day with an average working day of 22 days per month. Then the calculation is as follows:

$$Takt\ time = \frac{\text{Available working time}}{\text{The desired quantity}}$$

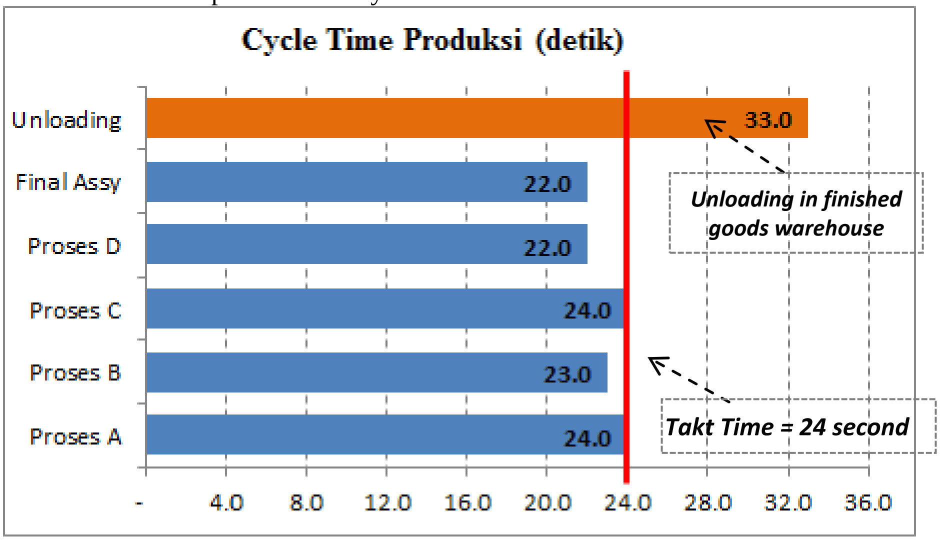
Where :

Working Time : 856 minutes
: 51,360 seconds
Quantity : 47,000 sets/month
: 2,136 sets/day
Working days : 22 days/month

Takt time = 51.360 / 2.136
= 24.0 seconds

Based on the highest cycle time data taken in all assembly line processes (process A, process B, process C, process D and final assembly) as well as the unloading process in the warehouse, it can be seen the comparison of the cycle time to the takt time required in Graph 1 below this.

Graph 1 Process Cycle Time & Production Takt Time



From the data above, the cycle time for all processes in the production line is still below the takt time, but the cycle time for the unloading process is above the takt time. This means that the process becomes a bottleneck, it needs a deeper analysis to reduce the cycle time.The unloading process consists of two separate but interrelated operations, namely the process that the operator performs when unloading the finished product and placing it on the pallet, then the process carried out by the forklift carrying the filled pallet and storing it in the warehouse and picking up the empty pallet and placing it in the unloading area. The following is the cycle time obtained for each operation

Tabel 1 *Cycle Time* Operator Unloading (detik)

No	Item	Time
1	Ambil produk dari konveyor	15.0
2	Tarik dan geser ke atas palet	29.0
3	Atur posisi produk diatas palet	12.0
Total Cycle Time		56.0

The figure above is the total work done by 1 operator for each finished product placed onto a pallet. If the takt time used is 24 seconds, then the number of operators needed is:

Number of Operators = Total Cycle Time / Takt Time
= 56 / 24
Number of Operators = 2,3 or = 3 operators

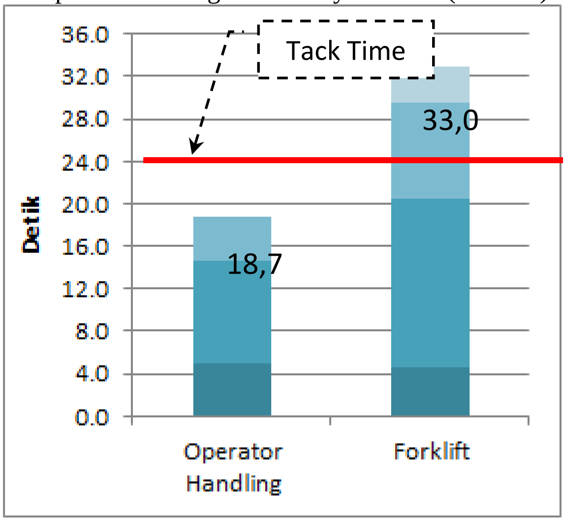
So then the average unloading operator cycle time becomes; 56 seconds divided by 3 operators = 18.7 seconds

Table 2 Forklift Cycle Time (seconds)

No	Item	Time
1	Mengangkat palet yang sudah pernuh terisi barang jadi	3.5
2	Membawa palet ke ke area penympanan di gudang	16.0
3	Mengambil Palet yang kosong	4.5
4	Meletakkan dan menyusun palet kepada tempatnya	9.0
Total Cycle Time		33.0

Then the cycle times of the two operations are combined in a bar graph as follows:

Graph 2 Unloading Process Cycle Time (seconds)



It can be seen that the operation carried out by the operator (3 manpower) had no problems, in contrast to the operation performed by a forklift. When viewed in more detail, the data from the forklift as shown in table 3, there are variations in cycle time in forklift operations. This might happen because it is influenced by the distance of the unloading area with various storage areas as seen in the warehouse layout in the previous graph 2.

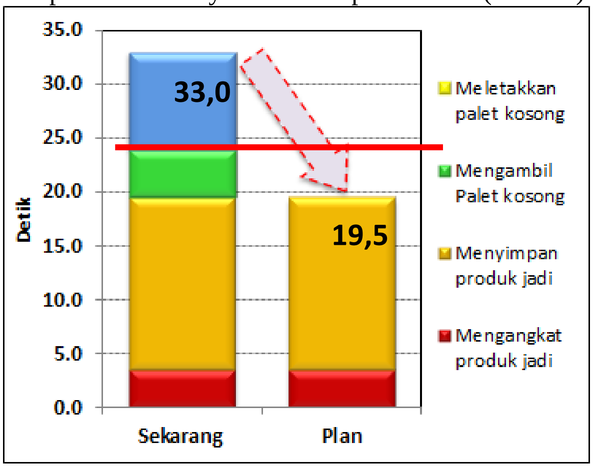
Table 3 Forklift Operation Cycle Time

Data	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
C/T (detik)	28.5	26.0	31.8	24.0	23.0	25.5	23.5	31.0	33.0	29.5	30.0	32.0	23.5	27.5	24.0	26.0	31.5	33.0	28.5	26.0

Repair Step

In this case, the handling of the operator is not a problem, so the priority of improvement will be on the forklift operation. Observations show that the operation of picking up, carrying and placing empty pallets is a waste. If these two operations can be eliminated, the total forklift cycle time can be saved by 13.5 seconds, which means that the total cycle time decreases to 19.5 seconds as shown in graph 3.

Graph 3 Forklift Cycle Time Improvements (seconds)



1. Eliminate the use of pallets

In order to reduce forklift cycle time, the use of pallets must be eliminated. The removal of pallets does not affect the quality of the product. The function of the pallet is only as a medium for product transportation which is only used in the finished goods warehouse and is not carried during product delivery. Because the pallet will be removed, the product transfer method will be carried out directly by clamping the finished product in the unloading area and moving it to the storage area.

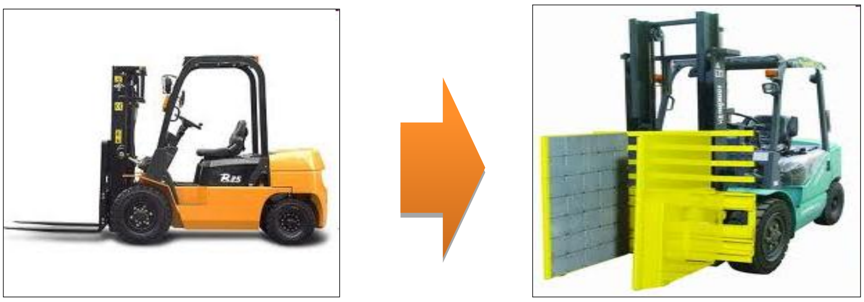


Figure 3 Fork Type Forklift (left) and Pinch Type Forklift (right)

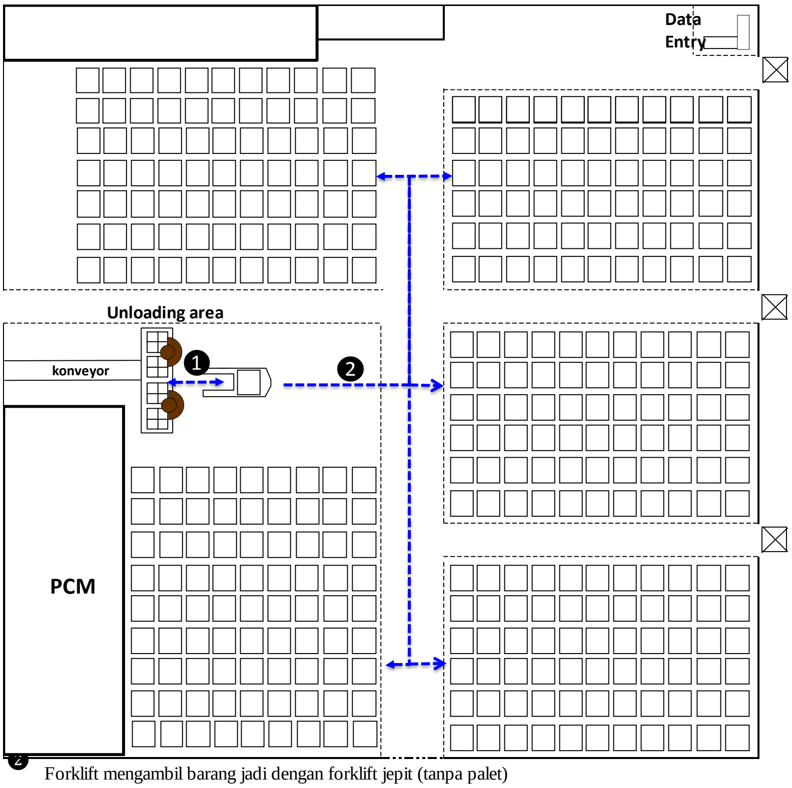
The forklift needs to be modified so that it can directly lift the finished product by clamping. The carriage, namely the front part of the forklift, must be modified and its construction changed, which originally had two fork blades in a horizontal position, replaced with two iron plates whose surface was covered with rubber, which were placed vertically on the left and right sides, as shown in Figure 3.

The way the forklift operates has changed, previously the product was lifted with a pallet from below, now it has been changed by clamping the product from the side as shown in Figure 4 below. From the trials carried out by renting a special type of forklift, there was no problem in terms of product quality because the construction of the product packing was still safe to withstand the pressure load from the forklift clamp, no damage was found. In addition, a pressure sensor will be installed on the forklift, to limit the maximum clamping pressure that can be applied to the product.

Figure 4 Forklift Pins Carrying Finished Products

2.Change the layout of the unloading process

The layout or layout of the unloading area is also changed according to changes in the removal of pallets. The layout of the unloading area is made simpler and the use of the area can be reduced as shown in Figure 5 below.



Forklift mengambil barang jadi dengan forklift jepit (tanpa palet)
Forklift menyimpan palet tersebut ke tempat penyimpanan yang sudah ditentukan

Figure 5 Layout of the Unloading Process in the Finished Goods Warehouse After Repair
(Source: PT. P)

1. Decrease Unloading Process Cycle Time

Layout changes and the omission of pallets also have an impact on the operations performed by operators in the unloading area. Cycle time also decreases as shown in the table below.

Table 4. Cycle Time Operator Unloading After Repair (seconds)

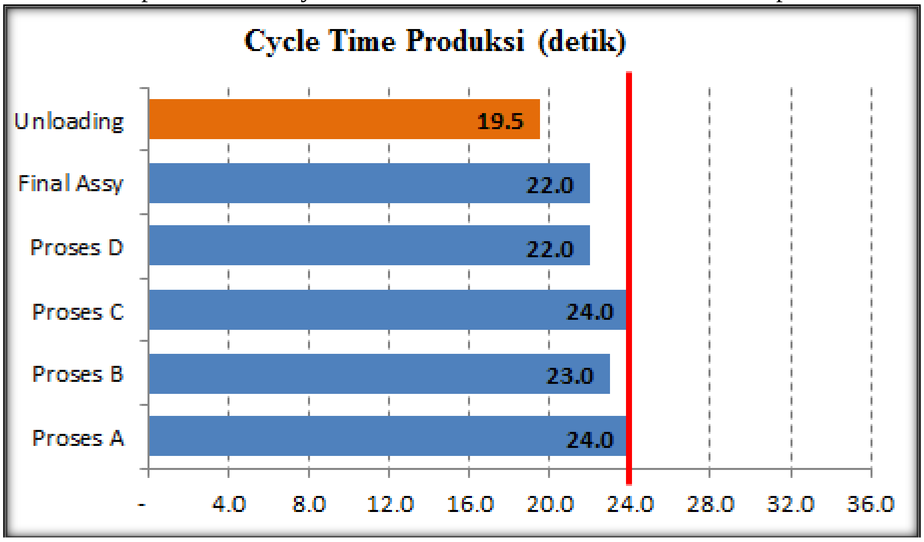
No	Item	Time
1	Ambil produk dari konveyor	15.0
2	Tarik dan geser ke atas platform	25.0
3	~~Atur posisi produk diatas palet~~	0.0
Total Cycle Time		40.0

The number of operators required is:

Number of Operators = Total Cycle Time / Takt Time
= 40 / 24
Number of Operators = 1.7 or = 2 operators

Cycle time after repair will be obtained as follows:

Graph 4 Process Cycle Time & Production Takt Time After Repair



IV. CONCLUSION

From the research conducted, there are several important points to conclude as follows:

1. There is waste that occurs in the unloading process, where unloading operators sometimes wait more for the arrival of empty pallets carried by forklifts. Forklift operations that cause waste are the operations of taking and placing empty pallets in the unloading area.
2. With the idea of eliminating the use of pallets, the waste that occurs can be reduced. Cycle time on forklift operations can be reduced from 33.0 seconds per product to 19.5 seconds.
3. In addition to reducing the cycle time in the unloading process to 19.5 seconds, 1 operator in the unloading process can be reduced, related to eliminating the use of pallets.

In this study it is limited, not looking at it from a financial perspective. However, if this repair is carried out, it is necessary to take into account the investment that must be made to modify the forklift and the payback period for this investment.Forklift operators must be thoroughly trained and re-certified to operate clamp-type forklifts to eliminate operator error, because their operation will be different from previous forklifts.Before actually implementing it, even though there were no quality problems with the product during the trial, further research was still carried out with a wider variety of models.

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