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Increasing Productivity Using Define, Measure, Analyze, Improve, Control (DMAIC) at PT. XYZ (a Case in Indonesian Company)

Adji Candra Kurniawan [a1*], Fiki Rohmatul Maula [b2], Nur Layli Rachmawati [c3]

[a] Department of Logistics Engineering, Universitas pertamina, South Jakarta, Indonesia
[1]adjick@universitaspertamina.ac.id*
* corresponding author

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ABSTRACT

The productivity level of PT. XYZ is still below the target, especially in the batch area. This condition is proved by the Overall Equipment Effectiveness (OEE) value is about 58% based on January and February data. Taking this into account, it is necessary to conduct further research to determine the causes. This study aims to increase productivity in the raw material warehouse and pre-batch areas. To solve this problem we use a six-sigma with DMAIC method because these methods can determine the root cause of the problem and provide appropriate recommendations for improvement systematically. The results show that the application of the kanban system in the pre-batch area and reuse of rack in the pre-batch area can increase the average OEE batch value from 58% to 64%. The increase in productivity tn the raw material warehouse and pre-batch area affects Adherence to Plan (ATP) value from 86% to 91,15%.

INTRODUCTION

PT. XYZ is a multinational company whose mission is to create reliable resources and be able to serve customers through good operations and optimizing the utilization of existing assets. It produces various types of protective paints- such as a Marine Protective Coating (MPC) and coil. In 2021 PT. XYZ has a focus to increasing the productivity of Fix Manufacturing Cost (FMC) by 8%. In achieving this mission, the company set several Key Performance Indicators (KPI), including increasing the Overall Equipment Effectiveness (OEE) value from 54.78% to more than 65%, reducing energy use by 5%, Adherence to Plan value (ATP) of more than 95% and automation of production equipment and machinery by 60%. In carrying out the production process, PT. XYZ applies a production system in the form of Make to Stock (MTS) and Make to Order (MTO), in which the company is more dominant in implementing the MTO production system. The following is the flow of the production process where is divided into two, namely the batch area and the filling area.

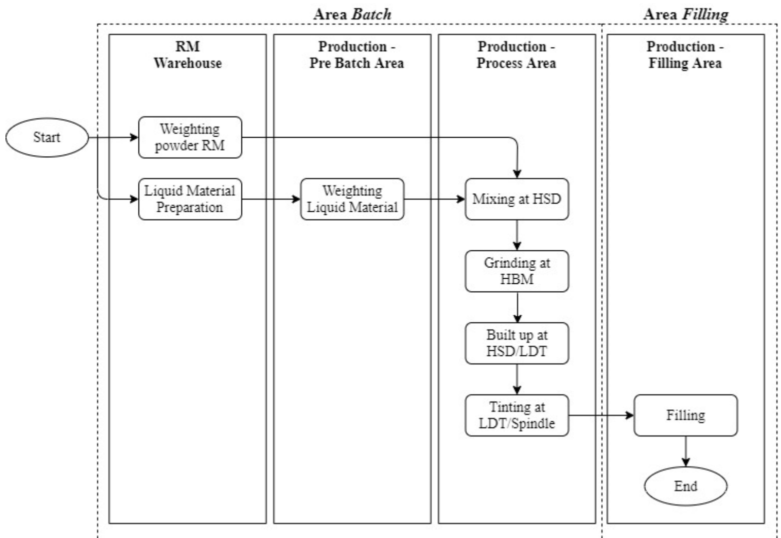

Figure 1. Production Process Flow at PT. XYZ

This research focus to improve productivity level in the batch area because that area gain the lowest productivity, about 54.72%. It is certainly influenced by several factors. Figure 2 shows the root causes of low productivity using a fish bone diagram.

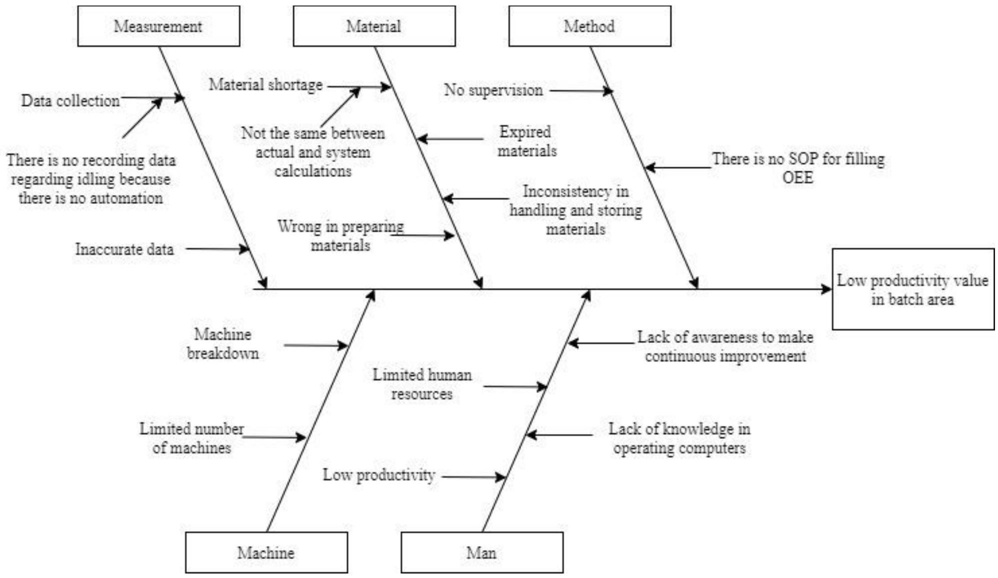

Figure 2. Fishbone Diagram Low Productivity Value in Batch Area

The low productivity value in the batch area will certainly have several impacts for the company, one of which is the existence of unfulfilled demand (backlog) and the failure to achieve the Adherence to Plan (ATP) value targeted by the company. Currently, the company's targeted ATP value is 95%, while the company's ATP achievement only 89.4%.

Based on the explanation above, the purpose of this research is to increase productivity in the raw material warehouse and pre-batch areas. To achieve this goal, continuous process improvement will be carried out. The method that will be used in carrying out continuous improvement is to use six-sigma with DMAIC. (***Explain the reasons for using this method)***

There have been many previous research that have used this method in solving problems regarding productivity, research that conducted by Owais et al., which has succeeded in increasing the productivity of the company and reducing the rejection rate [1], research conducted by Chandel & Kumar that who have succeeded in reducing the rejection rate and rework rate [2], and many more.

Explain the differences with previous research that has been done or synthesize the results of previous research that can support this research

METHOD

The approach used in this research is a DMAIC method. DMAIC method is one of the six sigma concepts. Six sigma is a quantitative approach that can be used to improve product and process quality [3]. The DMAIC method there are consisting of five stages define, measure, analyze, improve, and control. Several previous studies that used the DMAIC systematic method in improving quality were research conducted by K. Srinivasan, et al. [4], Amir Azizi [5], Y. Tri Prasetyo and F. [6], A. Rozak, et al. [7], M.S. Hervian and C. Soekardi [8], M. Owais, et al. [1], N. Mandahawi, et al. [9], K.C Ng, et al. [10], A. Chiarini [11], A. Rahman dan S. Perdana [12]. The following is an explanation for each of these stages carried out in this study.

Define phase

At this phase, identification of problems will be carried out, prioritizing and selecting projects to be carried out in this research [13]. The final result in this phase is a project charter, which is a document that becomes a guideline in working on projects in this research. Several previous studies that used project charters at the define stage in the quality improvement process using DMAIC, namely

Srinivasan et al., in their research at a leading shock absorber manufacturing company with the aim of reducing defects in the leading shock absorber. [4] and Prashar in his research that examines the problem of assembling a helicopter cooling fan with the goal is to reduce the Cost Of Poor Quality (COPQ) [14].

Measure phase

At this stage, measurements are made of the actual condition based on the process that will be the object of observation in improving quality. At this stage also carried out data collection and processing. Based on the results of data processing, it can be used as a basis in determining the current condition or performance. In carrying out measurements in this phase is Overall Equipment Effectiveness (OEE) method will be used, where the OEE value is one of the productivity measurement factors used by companies. OEE is used to carry out a comprehensive measurement to identify the productivity level of a machine, by taking a thorough measurement it will be easier to find out which areas or machines need to be increased productivity [15]. In determining productivity using the OEE value, three measurement matrices are calculated, there are availability rate, performance rate and quality rate [16]. The following is a formula for each OEE measurement matrix. The result of measuring the OEE value is a percentage that can show the level of effectiveness of the use of all equipment. [5].

a. Availability Rate

$$\text{Availability rate (\%)} = \frac{\text{operating time}}{\text{loading time}} \tag{1}$$

b. Performance Rate

$$\text{Performance rate (\%)} = \frac{\text{net operating time}}{\text{operating time}} \tag{2}$$

c. Quality Rate

$$\text{Quality rate (\%)} = \frac{\text{processed amount-defect amount}}{\text{processed amount}} \tag{3}$$

d. OEE

$$\text{OEE (\%)} = \text{Availability} \times \text{Performance} \times \text{Quality} \tag{4}$$

Several previous studies using the OEE method in the measuring stage include Veroya in his research which aims to propose a conceptual framework to reduce bottlenecks [6], Hervian & Soekardi in their research to reduce bottleneck processes in blister machines [8], Azizi in a study that aims to evaluate production productivity by continuously improving equipment efficiency and process control [5]. The result of measuring the OEE value is a presentation that can show the level of effectiveness of the use of all equipment.

Analyze phase

At this stage, the cause of the variability will be determined. The measurement results in the measurement phase will be used to determine cause and effect relationships in a process to understand the causes of variability. The tools used in this research are Failure Mode & Effect Analysis (FMEA). FMEA is a tool that can be used to prioritize various sources that have the potential to cause variability, errors, errors or defects in a product or process. FMEA itself has 3 criteria in conducting an assessment [17], there are:

a. Severity

Severity is an assessment of the severity of a failure. The following is a table description of each failure described using a scale of 1-10.

Table 1. Severity Rating Description [17]

Value	Description
1	Negligible severity
2	Mild severity, so that the consequences are mild and repairs can be made during regular maintenance
3	
4	Moderate severity, which means the failure is still within tolerance limits. Usually, there will be downtime in a short time
5	
6	
7	High severity, where the perceived failure is outside the tolerance limit. Usually, it will cause downtime which causes expensive expenses
8	
9	Potential safety problems, which means that the danger caused by the failure is very fatal
10	

b. Occurrence
Occurrence is the frequency of how often the event or failure occurs. The following is a table description of each occurrence rating using a scale of 1-10.

Table 2. Occurrence Rating Description [17]

Value	Description	Failure Rate
1	It is unlikely that this cause resulted in the failure mode	1 in 1.000.000
2	A rare failure	1 in 20.000
3		1 in 4.000
4	Possible failure	1 in 1.000
5		1 in 400
6		1 in 80
7	A very likely failure	1 in 40
8		1 in 20
9	It is almost certain that failure will always occur	1 in 8
10		1 in 2

c. Detection
Detection is an assessment of how well a machine's ability to detect failures occurs. The following is a table description of each detection value which is described using a scale of 1-10.

Table 3. Detection Rating Description [17]

Value	Description	Failure Rate
1	A very effective prevention method for the detection system. So there is no chance that the cause of failure will occur	1in 1.000.000
2	The probability of a failure occurring is low	1 in 20.000
3		1 in 4.000
4	The possible causes of failure to occur are moderate. Existing prevention methods or	1 in 1.000
5		1 in 400

Value	Description	Failure Rate
6	detection systems still allow sometimes the cause to reoccur	1 in 80
7	The possibility that the cause of the failure was still high	1 in 40
8		1 in 20
9	The probability of the failure to occur is very high	1 in 8
10	Existing prevention methods for detection systems are not effective. So that failure will always happen	1 in 2

The three scores from each potential source of severity, occurrence, and detection are multiplied to obtain the Risk Priority Number (RPN). The following is the equation used in calculating the RPN.

$$RPN = Severity \times Occurence \times Detection \qquad (5)$$

Several studies that have used this method in conducting analysis include research conducted by Shieddieque to identify product nonconformities, measuring initial conditions and analyzing the causes of problems, and determining possible corrective actions [18], research conducted by Girmanova et al., which aims to ensure product quality [19], and research conducted by Fitriana et al., which aims to improve production quality for Yamalube bottle products [20].

Improve phase

This stage is the stage where the researcher moves on to creative thinking, where the team makes specific changes that can be made in the process as well as other things that can be done to have the desired impact on a process. This phase aims to get an increase in quality.

Control phase

In the DMAIC method, the control stage is the last stage. Control has the aim of reviewing whether there is an advantage in the improvement process, if so, the improvement will be applied to other similar processes in a business process [20]. At the control stage in this study, control chart tools will be used. In this study, the Shewhart chart / Individual Moving Range (I-MR) chart will be used. The I-MR control chart consists of an Individual chart (x-chart) and a Moving Range chart (MR-chart). The following are some of the formulas used to determine the Upper Control Limit (UCL), center line, and Lower Control Limit (LCL).

a. Individual chart (x-chart), the following are some of the formulas used to measure UCL, center line, and LCL [1].

$$UCL = \bar{x} + 3\frac{\overline{MR}}{d_2} \qquad (6)$$

$$LCL = \bar{x} - 3\frac{\overline{MR}}{d_2} \qquad (7)$$

$$Center\ Line = \bar{x} \qquad (8)$$

b. Moving range chart (MR-chart), the following are some formulas used to measure UCL, center line, and LCL [1].

$$\overline{MR}_i = |x_i - x_{i-1}| \quad (9)$$

$$UCL = D_4\overline{MR} \quad (10)$$

$$LCL = D_3\overline{MR} \quad (11)$$

$$Center\ Line = \overline{MR} \quad (12)$$

Information:
$\overline{MR}$ = moving range
$\overline{x}$ = sample mean
x = sampel

The following research uses control charts as tools in the improve stage, namely research conducted by Hervian & Soekardi in their research that uses control charts to control the improvement process that has been carried out to reduce process bottlenecks [8].

RESULTS AND DISCUSSIONS

In this section, the results and analysis of the research will be explained. The object of observation that will be examined in this research is productivity in the raw material warehouse and pre-batch areas. The following are the results of data processing in this study.

Define

At this stage, a project charter will be generated, where the project charter is a document that contains a description of a project. Before determining the project charter, it is necessary to have information about the problems that can be used as the basis for preparing the project charter.

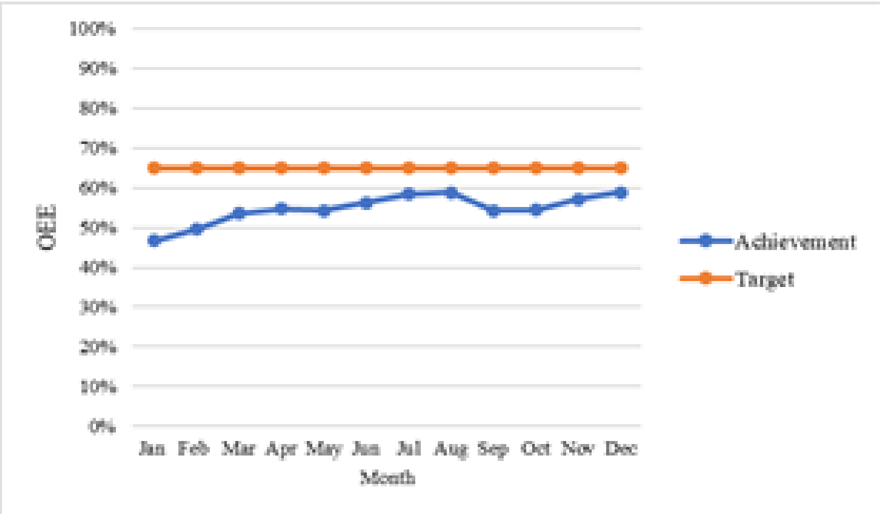

Figure 3. OEE Batch Average Value in 2020

The image above is a visualization of the OEE value in the batch area. Based on the figure, it can be clearly seen that the achievement of the OEE value in the batch area is still fluctuating, where the average batch OEE value in 2020 only reached 54.72% from 65%. So based on these problems, the project charter that has been defined in this study is as follows.

Project Title : Increase Productivity in Raw Material Warehouse and Pre-Batch Area

Problem Statements:
what :
The low value of the company's productivity has not reached the company's target limit.

Why :
The amount of waste in material handling that occurs in the raw material warehouse and pre-batch areas.

Impact :
- High batch cycle time
- High backlog due to low productivity

Project Scope : AkzoNobel Indonesia
Site : MPY-Cikarang Site
Organization : Production
Process : RM Warehouse & Pre-Batch

Project Resources :
1. Site Manager
2. Prod. Manager
3. Contnuous Improvement Engineer
4. Spv. RM Warehouse
5. Spv. Production

CI Project Leader : Fiki Rohmatul Maula

Goal Statements:
Increasing the OEE value of the batch area from 54.72% to 65% by reducing waste activities in the raw material warehouse and pre-batch by implementing the kanban system starting in March 2021.

Assumptions:
- No additional manpower
- Demand for each batch is considered average
- Requests during this period are normal
- Defective products are assumed to be repairable (rework)

Critical Success Factor (CFS):
- Increased OEE value in the batch area
- Increased ATP value

Metrics
Primary Metrics : OEE
Secondary Metrics : Productivity
Prject est. duration : 2 Months

Figure 4. Project Charter Research

In preparing the project charter, the stages carried out in this research are arranged a project overview with the site manager and CI engineer, determining the project approach, and project approval by the site manager, CI engineer, and supervisor.

Measure

At this stage, measurements will be made using the Overall Equipment Effectiveness (OEE) method for January and February 2021. Before calculating the OEE, the availability rate, performance rate, and quality rate are calculated first. The following is an explanation of each of these components.

a. Availability rate

Availability rate is a ratio that shows the use of available time in machine or equipment operation. The results of the calculation of the availability rate value in this study can be seen in the following table.

Table 4. Recapitulation Availability Rate per Week

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Week	***Availability Rate*** **(%)**
1	72%
2	75%
3	79%
4	76%
5	78%
6	82%
7	82%
8	78%
9	81%

b. Performance rate

Performance rate is a ratio that shows the value of the number of products that can be produced during production time. The results of the calculation of the performance rate in this study can be seen in the following table.

Table 5. Recapitulation Performance Rate per Week

Change the table presentation according to the template in this journal
(table format is in accordance with the journal template)

Week	***Availability Rate*** **(%)**
1	90%
2	72%
3	81%
4	80%
5	72%
6	71%
7	67%
8	83%
9	79%

c. Quality rate
In calculating the quality rate in this study, the defect products in the company are failed products that can be reprocessed (rework). So that in calculating the quality rate value in this study the defect product is considered 0. There is a defect, but it can always be repaired so that in the end there is no defect. The results of the calculation of the quality rate value in this study can be seen in the following table.

Table 6. Recapitulation Quality Rate per Week

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Week	***Availability Rate*** **(%)**
1	100%
2	100%
3	100%
4	100%
5	100%
6	100%
7	100%
8	100%
9	100%

d. OEE
Based on the results of the calculation of the availability rate, performance rate, and quality rate, the OEE value can be known. The calculation of the OEE value is done by multiplying the three components. This is a recapitulation table of batch OEE values for January and February 2021.

Table 7. Recapitulation OEE Value per Week

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Week	**Target**	**Achievement**
1	65%	61%
2	65%	53%
3	65%	62%
4	65%	58%
5	65%	55%

6	65%	57%
7	65%	54%
8	65%	63%
9	65%	62%

Based on the results of these calculations, it can be seen the trend of batch OEE values in the following figure.

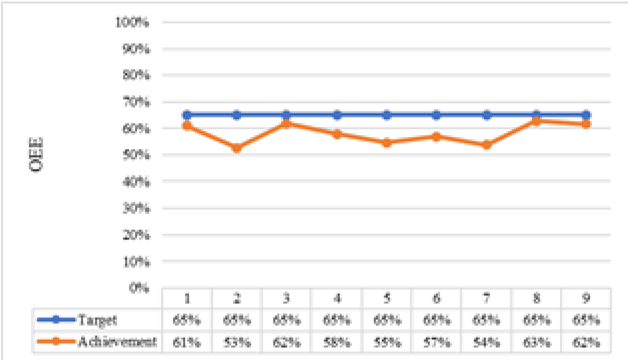

Figure 5. Trend of OEE Value per Week

Based on the picture above, it is found that the achievement of OEE batch values for January and February 2021 has an average of 58%. So it can be said that the achievement of the current batch of OEE is still far from the company's target. For this reason, it is necessary to carry out further analysis on which machine has the lowest OEE value. This will certainly make it easier to determine which processes need improvement.

Analyze

At this stage, FMEA tools will be used. Due to the limited time in conducting research, the focus of improvement will only be on machines that have the lowest OEE value. The following is an OEE breakdown table for each machine.

Table 8. OEE Breakdown per Machine

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Machine	OEE Average
HSD 2	39%
HSD 7	43%
HSD 6	49%
HSD 9	60%
HSD 5	62%
HSD 1	62%
HSD 8	64%
HSD 4	68%
HSD 10	69%
HSD 3	70%

Based on Table 8, the root of causes will be focused on the low OEE value on the HSD 2 machine. Next, the step and failure mode process are determined which causes the low OEE value on the HSD 2 machine. Based on the results of interviews and discussions with related parties, there are 6 process step that related to the low OEE value of the HSD 2 machine. The list of these process step can be seen in the following table.

Table 9. Process Step that Affect The Low OEE Value in HSD 2

No	*Process Step*
1	Raw material preparation
2	Weighing of raw materials
3	Material racking
4	Material transfer to the staging area
5	Production
6	Product replacement machine cleaning

Based on the 6 steps of the process, 8 potential failures, and 9 potential causes that cause low OEE values are obtained. To find out the potential for the most problematic failures, an assessment of the RPN for each failure is carried out by weighting the values of severity, occurrence, and detection. In carrying out the weighting, this is done by filling out a questionnaire with sampling using non-probability sampling with a non-random method. The respondents in this study are CI engineers, warehouse supervisors, and operators.

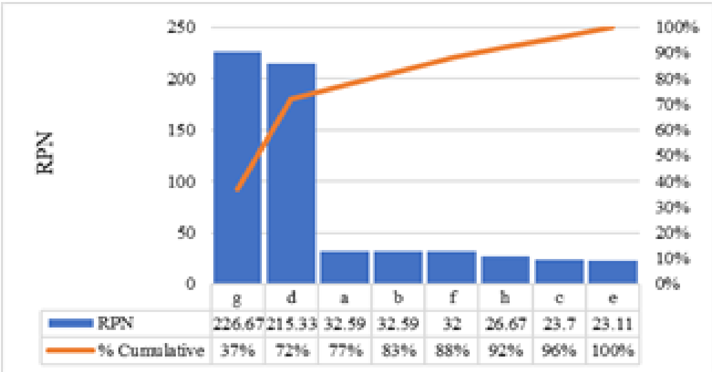

Figure 6. Pareto Chart the RPN Value

Here are the detailed of potential failure that are used to calculate the RPN value in Figure 6:

a. Expired Material
b. Raw material weighing error
c. Limited storage
d. Machine breakdown
e. Diluted product (defect)
f. Waiting for raw materials from RM warehouse
g. Mixed color with the previous product

Based on the pareto chart, narrowing of the failure mode can be done. Figure 6 shows that the biggest type of failure that affects the low OEE value of the HSD 2 machine, there are:

a. Waiting for raw materials from RM warehouse, with an RPN value of 226,67
b. Limited storage, with an RPN value of 215,33
c. Material shortage, with an RPN value of 32,59

The three types of failure are then re-analyzed to find out the potential causes of the failure. The following are potential causes that cause the three failures.

a. Schedules that are not in line between RM warehouse and production.
b. The duration of material transfer to the stagging area.
c. Inconsistency in handling and storing materials.
d. The amount of stock that is not the same between the actual and the system because there is no routine recording in doing stock calculations manually.

Improve

At this stage, an improvement solution will be determined based on the root problems that have been obtained at the analyze stage. From the three root problems that have been obtained in the analyze stage, several recommendations for improvement have been proposed in this study. The recommendations are as follows.

a. Implementation of the Kanban System in the raw material warehouse and pre-batch area.
The results of the analysis using FMEA have explained one of the root causes of the low OEE value of the HSD 2 machine, there is a schedule that is not in line between the material prepared by the raw material warehouse and the material requested by the production. That can cause will lead to the high processing time required to get one product due to downtime logistics. The flow of the production process at PT. XYZ runs with a pull system, where the production schedule issued by PPIC is a request at the time. For this reason, in actual conditions, changes in the production schedule often occur which causes asynchrony between the production schedule and the prepared materials. With these problems, the continuous improvement that can be done is to implement a kanban system in the raw material and pre-batch warehouse area. The reason for implementing the kanban system in carrying out this improvement process is that the kanban system is one of the methods that has been widely applied as a material flow control scheme for just-in-time manufacturing systems [21]. As explained in the previous chapter, the production system is often used by PT. XYZ is MTO. In addition, using the kanban system will also avoid the use of complex information and is a simple and effective method to be applied to the MTO production system [22]. Therefore, by running the kanban system in the raw material warehouse and pre-batch area, it is hoped that it will be able to control the production process so that schedule alignment is achieved between the prepared materials and what will be produced. This will make it easier for the production team and warehouse team to monitor ATP (Adherence to Plan) performance. The implementation of this kanban system will also ensure that all products that have to be prepared and manufactured are ATP compliant.

Figure 7. Installation of Kanban System

b. Added "Raw Material Preparation Adherence" system
This system is designed to audit the existing Kanban system. With this system, problems that occur during the preparation of raw materials will be easily detected. This system is run by the warehouse supervisor and monitored by the CI engineer.

RAW MATERIAL PREPARATION ADHERENCE

Machine	Product	Batch Number	Batch	Finished	Remarks
HSD 1	PHB915/5LT	11400		Yes	
HSD 1	CLU65Y/20LT	4300		Yes	
HSD 1	CLU65Y/20LT	4400		Yes	
HSD 1	CLU65Y/20LT	4500		Yes	
HSD 1	LAB000/20LT	215200		Yes	
HSD 1	LAB000/20LT	215100		Yes	
HSD 1	LAB000/20LT	604300		Yes	d Lanjut shift 2
HSD 1	PHE017/20LT	300300		Yes	
HSD 2	HTA097/20LT	205100		Yes	
HSD 2	CPA312/4LT	502700			Tunggu pot
HSD 2	EAA904/5LT	700700			tunggu pot
HSD 2	EGA230/20LT	503000		Yes	
HSD 8	EGO639/20LT	505200		Yes	
HSD 8	CPA097/5LT	503900		Yes	

Batch Completed	20	100%

22-Apr | 23-Apr | 24-Apr | 25-Apr | 26-Apr | 27-Apr | 28-Apr | 29-Apr | 30-Apr | Report

Figure 8. Raw Material Preparation Adherence System

c. Reused of unused rack in the pre-batch area to support the Kanban System
The results of the FMEA calculations in the previous sub-chapters are the root cause of the low OEE value, especially on the HSD 2 machine, there is a high processing time in searching for the required material. Often the material that has been weighed is placed in any empty place. This happens because of a shortage of racks so that it will cause inconsistency in handling and storing materials, especially materials that have been weighed. Whereas in actual conditions, in the pre-batch area there are racks that are not used properly. Therefore, this research proposes an improvement by reusing the rack in the pre-batch area to support the kanban system.
This is due to the limitations of the existing rack in the warehouse, causing the warehouse to be unable to accommodate all the materials on the shelves. With these problems, there are often inconsistencies in the storage and handling of materials, especially for materials that have been weighed. This of course will cause a high waiting time because it often takes a long time to pick up the material. In addition, material storage on the warehouse floor will also narrow the forklift path to perform maneuvers. This of course will be very dangerous because it will increase the risk of work safety in the warehouse. Therefore, the reuse of unused racks in pre-batch areas will reduce work safety risks, increase warehouse utility, and reduce material search time.

Figure 9. Reused Unused Rack in Pre-Batch Area

Control

After implementing the recommendations for improvement, the thing that must be done is to observe the changes that occur with these improvements. In conducting monitoring, a statistical tool is used in this research is the control chart.

The first stage in performing statistical tests using the control chart is to perform a normality test. The normality test used in this study is the Kolmogorov-Smirnov using Minitab software. The following are the results of the normality test of the data before and after the improvements.

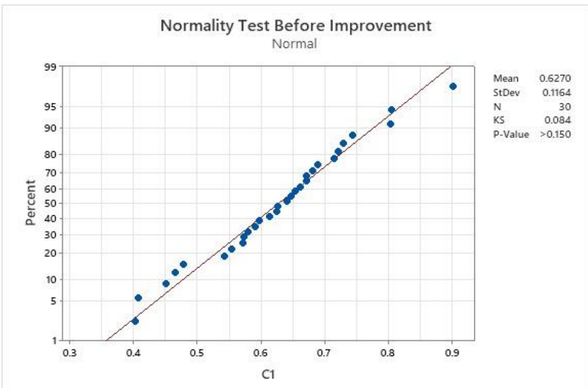

Figure 10. Normality Test Berfore Improvement

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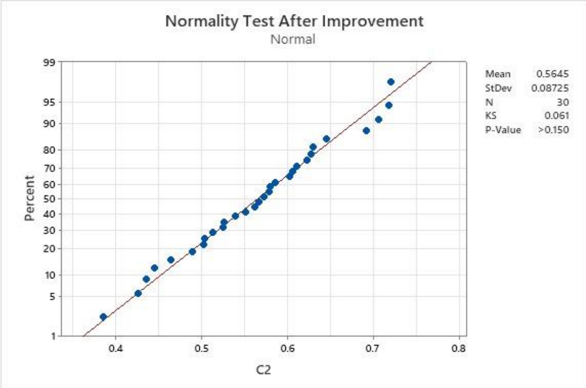

Figure 11. Normality Test After Improvement

Based on the results of the data processing, it can be concluded that the data after and before the improvement follows a normal distribution, with a p-value more than alpha. After testing for normality, the next step is to test the hypothesis using paired t-test. The following is the hypothesis used in conducting statistical analysis in this study.

H_0 = The improvements made have no impact on the average OEE
H_1 = The improvements made have impact on the average OEE

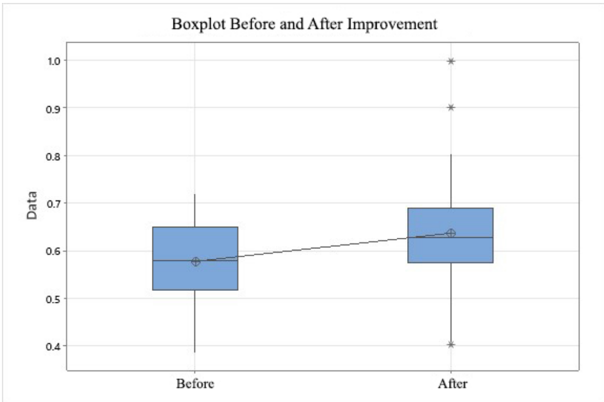

Figure 12. Boxplot Before and After Improvement

Based on the results of data processing using paired t-test, the p-value is 0,035. So it can be said that the improvements made have provided a significant change to the increase in the average OEE value. The next thing to do at the control stage is monitoring. Process monitoring in this study was carried out using a control chart. In this study, control will be carried out using the Individual Moving Range (I-MR) chart, which consists of an individual chart (x-chart) and a moving range chart (MR-chart).

Figure 13. Control chart After Improvement

Based on Figure 13, there are no indications out of control for each of the I and MR chart. So, it can be concluded that the process does not detect any assignable causes. Assignable causes are sources of variability that arise due to errors that make the process out of control. So, based on the chart above, it can be said that the process that has been improved is within the control limits and the average process is running stable.

Discussion will broadly be based on the Critical Success Factor (CFS) that has been determined in the project charter. The predetermined CFS is increasing the value of OEE and the value of ATP.

a. Analysis of achievement of OEE value

As contained in the project charter of this research, one of the CSFs determined is the achievement of the OEE value. The following is a comparison chart of the average OEE values for the HSD 2 machine before and after improvement.

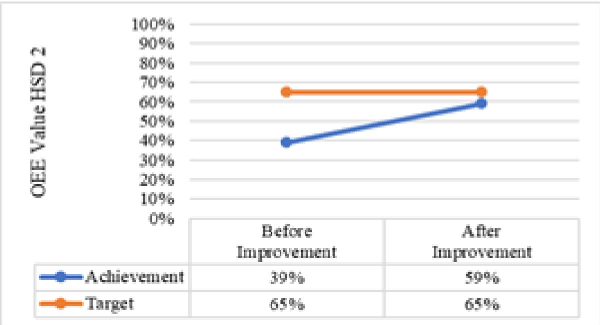

Figure 14. Comparison OEE Value HSD 2 Before and After Improvement

the OEE value after improvement increased from 39% to 59%. In addition to the average increase in the OEE value of the HSD 2 machine, the average batch OEE value as a whole also increased. The following is a comparison graph of the average OEE value of the batch before and after the improvement.

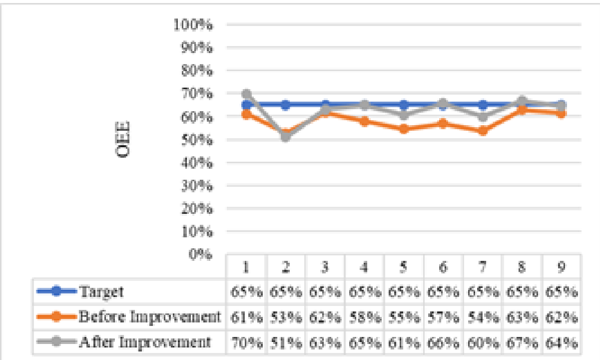

Figure 15. Comparison OEE Batch Value Before and After Improvement

It can be seen in the Figure 15 that almost every week we have succeeded in achieving the targets set by the company. However, the overall average OEE score only reached a 64% for the 2-month measurement period. In addition, the resulting graph after the improvement is also still very fluctuative. This may be due to a lack of consistency in the implementation of improvements because in practice the parties involved still require monitoring and adjustment for a long time.

b. Analysis of the achievement of Adherence to Plan (ATP) value

In addition to the OEE value, the ATP value is also one of the CSFs in this study contained in the project charter. Therefore, this study will also explain the effect of the process improvement on the ATP value. The following is a comparison graph of the average ATP value before improvement (January-February) and after improvement (March-April).

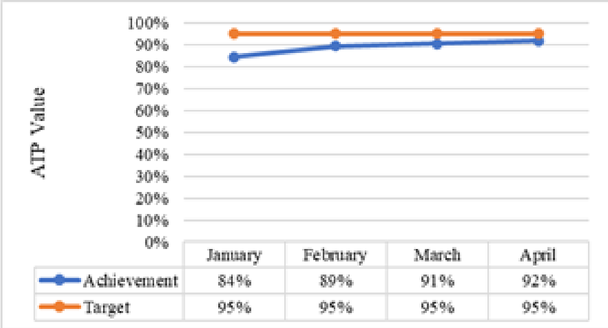

Figure 16. Average ATP Value Before and After Improvement

It can be seen in the Figure 16 that the trend of ATP value from January to April continues to increase. So, it can be said that the improvement process that has been implemented can have a good effect on increasing the accuracy of production.

The results of the study demonstrated an increase in the two response variables. OEE and ATP have increased following the implementation of enhancements. The six sigma approach based on the DMAIC principle is deemed successful in practice [22]. This research also demonstrates that the implementation of Kanban can contribute to the desired improvement. Several studies have demonstrated that the implementation of Kanban within the Six Sigma framework improves the quality of completed projects [23]–[25].

There is no discussion in this article

Explain the discussion by justifying research results referring to previous theories and research

CONCLUSION

This study aims to increase productivity in the raw material warehouse and pre-batch areas by using the DMAIC integrated method. Based on the results of data processing, it is known that the problem that is the focus of the company in making improvements is the low OEE value in the batch area, which in January and February 2021 the trend of achieving the OEE value fluctuates every week and has never reached the target set by the company. The achievement of the OEE value in the batch area in January and February 2021 only reached 58%, which is still very far from the company's target of 65%. After further analysis using FMEA and Pareto charts, the root causes of the problems that often occur are due to schedules that are not in line between the production team and the warehouse, the length of time moving materials to the staging area due to inconsistencies in material handling and storage, as well as material shortages due to the unequal amount of stock between the system and the actual.

So based on the root cause of the problem, in this research, a recommendation for improvement is given in the form of implementing the kanban system in the pre-batch area and reused unused rack in the pre-batch area to support the kanban system. Based on the results of the control using the control chart, it was found that the recommendations for improvement that had been implemented gave a good effect in increasing productivity. This is because the process that is run is stable and demonstrates increased performance in the process. It can be seen based on the results of data processing that there is an increase in the average OEE value which was originally only 58% to 64%. In addition, the increase in productivity also influences the average value of ATP, which was originally 86.9% to 91.15%.

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The references marked in yellow are not in the contents of the article. Please adjust

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