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Penerapan Pendekatan SMED untuk Mengurangi Waktu Pergantian dalam Proses Pengujian di Perusahaan Listrik Multinasional

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Implementing SMED Approach to Reduce Changeover Time in the Testing Process at an Electrical Multinational Company

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Abstract— *PT. XYZ is a company that produces electrical components, they make a product based on an engineer to order (ETO). PT. XYZ find the changeover time in the testing process is very high and still follow the time in the old factory. The focus of this research is to reduce changeover time and standardize the process. In this research, Single Minute Exchange of Dies (SMED) is a method that used in order to reduce the changeover time. Started by observing the entire changeover process from the process after the panel is tested on Post F to loading a new panel for testing on Post F. Suggested improvement proposals that can be made immediately will be implemented directly in the process. For the internal process, the improvement activities carried out are to make the activities run parallel. Then, for external activities, the improvement activities carried out are to make the activities run in parallel and change the work procedures at post F. Through Five S implementation will improve the speed changeover process. Through this improvement it can reduce the change over time by 54% and increase the number of panels that can be tested to 6 panels per work shift.*

Keywords— ***Electrical Component; SMED; Changeover Time; Five S Methodology; Process Improvement***

Abstrak— PT. XYZ merupakan perusahaan yang memproduksi komponen listrik, mereka membuat produk berdasarkan Engineer-To-Order (ETO). PT. XYZ menemukan waktu pergantian pada proses pengujian sangat tinggi dan masih mengikuti waktu di pabrik lama. Fokus penelitian ini adalah untuk mengurangi waktu pergantian dan menstandardisasi proses. Dalam penelitian ini, Single Minute Exchange of Dies (SMED) merupakan metode yang digunakan untuk mengurangi waktu pergantian. Dimulai dengan mengamati seluruh proses pergantian dari proses setelah panel diuji pada Post F hingga pemuatan panel baru untuk pengujian pada Post F. Usulan perbaikan yang dapat segera dibuat akan diimplementasikan langsung dalam proses. Untuk proses internal, kegiatan perbaikan yang dilakukan adalah membuat kegiatan berjalan paralel. Kemudian, untuk kegiatan eksternal, kegiatan perbaikan yang dilakukan adalah membuat kegiatan berjalan paralel dan mengubah prosedur kerja di post F. Melalui penerapan Five S akan meningkatkan kecepatan proses pergantian. Melalui perbaikan ini dapat mengurangi waktu pergantian sebesar 54% dan meningkatkan jumlah panel yang dapat diuji menjadi 6 panel per shift kerja.

***Kata kunci*— Komponen Listrik; SMED; Waktu Pergantian; Metodologi Lima S; Peningkatan Proses**

I. INTRODUCTION

PT. XYZ, is a multinational company engaged in manufacturing electrical components. PT. XYZ produces software, hardware and service needs related to energy management. The types of manufacturing processes used by PT. XYZ are Engineer-To-Order (ETO). The issue of changeover time faced by PT. XYZ is caused by the calculation of changeover time which still follows the calculation of the former factory. The changeover process occurs after the product testing and will be followed by the product loading process for further testing in the Final Acceptance Test (FAT) area. The whole process is done manually by the operator without the use of machines. The main focus at PT. XYZ is to reduce the time required for the changeover process. The entire changeover process is carried out with the same activities as the previous factory and currently there are adjustments with activities being carried out digitally. The changeover process carried out in the previous factory took 120 minutes. In addition, by looking at the current changeover conditions, the time needed to perform the changeover reaches 140 minutes. The problem with the current changeover process is that it takes an additional 20 minutes. The main focus is resolving the issue at PT. XYZ is how to reduce the time required for the changeover.

The method used to reduce changeover time is a Single Minute Exchange of Dies (SMED). The SMED method is an effective solution to reduce changeover time by converting internal activities into external activities. By applying the SMED method, changeover time can be reduced, and production time becomes more effective. In addition, this method can also reduce production costs and eliminate unnecessary activities during changeover, thereby increasing efficiency in the production process. By completing product repairs on schedule, the company's productivity and profit can increase.

II. RELATED WORKS

Single Minute Exchange of Dies (SMED) is a lean manufacturing method used to transition from producing one type of product to another with a different model. SMED has been proven effective in reducing changeover time. Lean manufacturing, initially developed by Toyota in Japan, has gained immense popularity and serves as a guide for improving production systems. Lean manufacturing is a systematic approach to eliminating waste and optimizing processes by identifying and reducing waste continuously[1]. It includes a range of management strategies and principles aimed at eliminating waste and optimizing activities that enhance product value from the customer's viewpoint[2]. The principles of lean manufacturing are now utilized in multiple industries worldwide, acknowledged as an effective operational framework for minimizing waste, enhancing productivity, and fostering continuous improvement[3]. Many industries have benefited from Lean manufacturing implementation, resulting in better organizational performance[4]–[6]. Companies implement Lean practices to boost productivity and reduce inefficiencies in their operations, fostering an organizational culture focused on continual process and system improvements.

Lean manufacturing aims to detect and remove waste throughout all phases of a product's production cycle[7]. A manufacturing system with minimal changeover times can reduce lot sizes and provide several benefits, such as lower costs, faster production, enhanced productivity, shorter lead times, streamlined process flows, a greater range of lot sizes, reduced inventory, and diminished waste[8]. Changeover involves all activities and time required to transition from the last production to the subsequent production under normal circumstances. The duration of changeover activities plays a vital role in this strategy[9]. Changeover activities that do not contribute value to the final product are regarded as waste because they raise production costs. Therefore, these activities must be minimized or eliminated[10]. Improving changeover times, achieving supporting milestones, and performing these tasks in a precise and standardized manner are crucial for the firm's productivity[11].

According to Shingo, SMED involves a series of technical methods that enable the changeover process to be completed in less than 10 minutes, reflecting the term "single minute" or single-digit minutes[12]. The SMED system reduces changeover time through its two main components: internal and external activities. The proposed shift of activities from internal to external during the changeover process led to a reduction in CNC machine changeover time[13]. SMED enables swift production changes. Internal operations are those that must be conducted when the machine is halted, whereas external operations can occur while the machine is operational[14]. Implementing SMED can reduce changeover time by 18% to 33% in a case study conducted in a plastic company[15]. The SMED methodology reduces setup time by 45%, but it requires a systematic reorganization of work, along with training and new methods for conducting operations[16].

Implementing the 5S methodology aids in reducing operational lead times. The goal of 5S is to identify waste and abnormalities immediately, ensuring that anything unnecessary in the workplace is removed, thereby making waste visible[17]. The 5S methodology assists in minimizing non-value-adding activities, boosting productivity, and enhancing quality, and it has been applied in the design of efficient facilities[18]. Currently, the majority of businesses employ 5S not just for cleaning, organizing, and managing operations, but also to minimize downtime and non-value-added activities in manufacturing[19]. The 5S aims to reduce the number of movements required by a worker during operations[20]. However, the utilization of lean tools and methodologies might be restricted in manufacturing settings characterized by fluctuating demand, a diverse product range, low volumes, and varying order processing durations[21]. According to [22], the SMED concept is used to optimize activities and reduce changeover time, while the 5S concept is applied to support SMED, eliminating waste in the work area. By applying the SMED concept, they managed to decrease changeover time by 18%.

III. RESEARCH METHOD

DMAIC is a Six Sigma method that ensures the customer's voice is integral throughout the process. Six Sigma aims to improve quality, targeting 3.4 defects per million opportunities (DPMO) for every product transaction (goods and/or services), aligning with the goal of zero defects[23]. Six Sigma emphasizes rigorous quality control, continuous process improvement, and fostering a culture of precision and accountability to achieve the highest standards in production and service delivery. The DMAIC procedure, which is a fundamental problem-solving approach in Lean Six Sigma, is centered on resolving identified issues[24]. DMAIC contains five stages: Define, Measure, Analyze, Improve, and Control[25], [26]. Previous literature has validated the use of DMAIC as an improvement methodology[27]–[30].

In this study, the DMAIC procedure is employed as the main method due to its structured process for enhancing systems, from problem identification to establishing a standard operating procedure (SOP) for sustaining future improvements. This research aims to determine the standard time and operator work methods during the changeover process using the DMAIC methodology. The research flow is detailed in Figure 1.

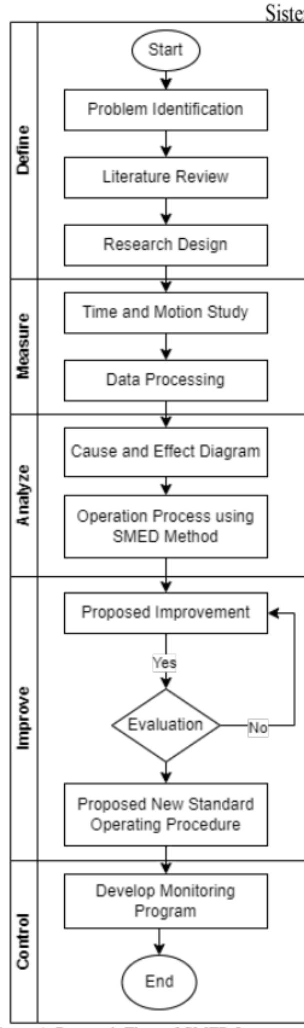

Figure 1. Research Flow of SMED Improvement

During the Define stage, problems occurring in the production line will be identified, relevant literature will be gathered from many references, and suitable research methods will be developed. In the Measure stage, data will be collected through time and motion studies and then processed. During the Analyze stage, the root cause of the problem will be identified using a cause and effect/fishbone diagram, leveraging initial findings. Once the root cause is identified, the operation process using SMED will be constructed. In the Improve stage, aspects for improvement implementation will be considered, and the proposed improvements will be evaluated by comparing performance indicators before and after SMED implementation. Once the improved process is evaluated, a new SOP will be prepared. In the Control stage, to maintain the sustainability of the improvement program, a monitoring system will be developed.

IV. Result and Discussion

The lack of effectiveness in the changeover process in Post F is due to the process taking a long time. The solution to this problem is to use Single Minute Exchange of Dies (SMED). SMED is a lean method designed to address issues in the changeover process. The first step is to measure the changeover time in Post F under the current conditions. In this stage, all data and the duration of each activity will be recorded. Table 1 lists 37 activities in the changeover process, with an average changeover time of 140 minutes. The total work hours amount to 11 hours.

TABLE I
CHANGEOVER PROCESS BEFORE IMPROVEMENT

No.	Elements	*Time (Minutes)*	*Internal/ External*
1	Turn off tool (contact resistant) and remove tool to the tool station	1	Internal
2	Release couple wire for hipot	3	Internal
3	Fill up FISS document	3	Internal
4	Input fill up test report on server (BOX)	20	Internal
5	Update LDS	10	Internal
6	To find available/dedicated space on FAT area (also to find panel moving path)	10	External
7	To dear area from other goods	5	External
8	Retum to post F	2	External
9	Remove stair & open fence rear door of post F	1,5	External
10	To find and take panel hand lifting tools to panel at post F electrical area	5	External
11	Insert hand lifting tools to panel 1	1	Internal
12	Move panel 1 to FAT area	5	Internal
13	To put the panel 1 on its area	2	Internal
14	Retum to post F	1	Internal
15	Insert hand lifting tools to panel 2	1	Internal
16	Move panel 2 to FAT area	5	Internal
17	To put the panel 2 on its area	2	Internal
18	Go to post F mechanical area / WIP	2	Internal
19	Find oanel that ready for test	5	External
20	Insert hand lifting tools to new panel 1	1	Internal
21	Move the new panel 1 to post F electrical	3	Internal
22	To put the new panel 1 on its area at post F electrical	1	Internal
23	Retum to post F mechanical area	1	Internal
24	Insert hand lifting tools to new panel 2	1	Internal
25	Move the new panel 2 to post F electrical	2	Internal
26	To put the new panel 2 on its area at post F electrical	1	Internal
27	Return the hand lifting tools to its station	2	Internal
28	Close and lock fence rear door of post F electrical	1,5	Internal
29	Prepare for panel doc. (FIIS)	10	Internal
30	Printout panel document	5	Internal
31	Drawing and specification checking to panels (SLD)	19	Internal
32	Couple wire for hipot between 2 panels (3 phase)	3	Internal
33	Connect grounding wire from source to panels	1	Internal
34	Open lower door panel 1 & panel 2	1	Internal
35	Connect CT polarity check tool primary cable leads to lower CB pole bushing and cable connection busbar	1	Internal
36	Plug in male test block on CT test block terminal	1	Internal
37	Connect CT polarity check tool secondary cable leads to test block	1	Internal
	Total time (minutes)	140	

For SMED implementation, the repetitive movement and layout of object placement are wastes that cause the changeover process to take a long time, as movement is a process that consumes time. To reduce changeover time, improvements are needed. Proposed improvements are as follows:

Make Activities Run Parallel: During data input for both tested and to-be-tested panels, adequate servers and computers are needed to maximize the process. Based on Table 1, the problem occurs in external activities no. 5 (LDS update) and no. 29 (preparation for panel doc. (FIIS)). Currently, only one computer is used for updating LDS and preparing panel doc. (FIIS) for two panels during each changeover process. The proposed improvement is to maximize the use of all computers in Post F. Since Post F has two computers, operator B can handle LDS update activities and preparation of panel doc. (FIIS), while operator A performs other activities. Implementing this proposal can reduce the external time for the activities "update LDS, prepare panel doc. (FIIS), and print out document" to 16 minutes.

Provide Dedicated Area for Ready-to-Test Panels: Based on Table 2, another problem occurs in external activity no. 19 (finding a panel that is ready for testing). The problem is that when loading a new panel, the operator must first find a panel that is ready to test in the production area. Because there is no dedicated area for ready-to-test panels, the operator has to walk a significant distance, taking 5 minutes to find the panel. The proposed improvement is for the production area to provide a dedicated area for ready-to-test panels so that the operator at Post F can easily load them. If this is implemented, it can reduce the changeover time by 2 minutes.

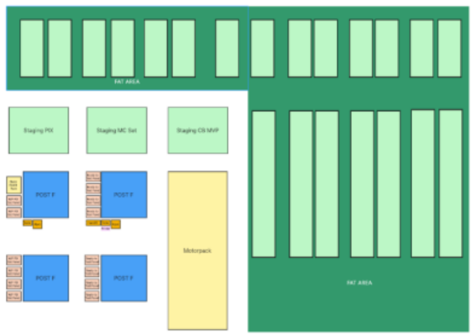

Figure 2. Current Layout of Changeover Process

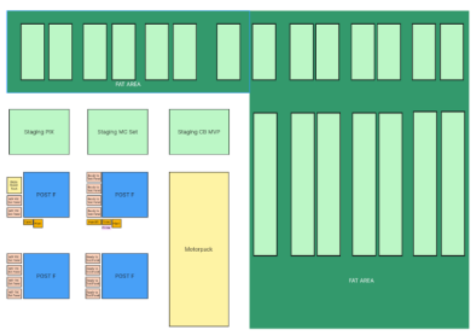

Figure 3. New Layout of Changeover Process

New Layout for Changeover Process: The proposed improvements above will impact the layout of the changeover process. This layout change aims to maximize and refine the changeover process. Figure 2 exhibits the existing layout of the changeover process. Figure 3 illustrates the new layout, highlighting the relocation of the printer from the FAT area to the Post F area.

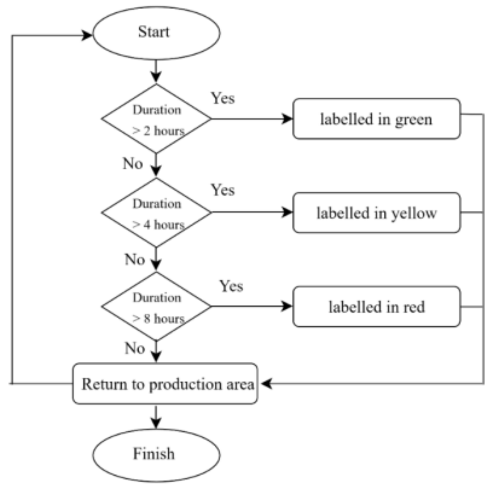

Figure 4. Seiri Plant Activity

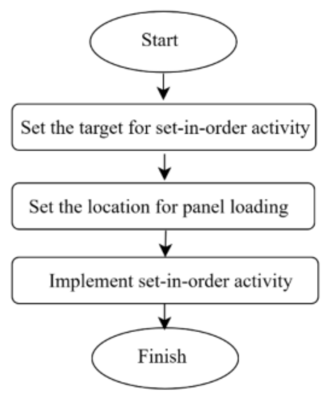

Figure 5. Sort in Order Plant Activity

In addition, 5S is also implemented. For Seiri (Sort), the operator needs to separate the types of panels that require fast, medium, or long testing times in the FAT area so that the operator can easily place the panels according to the duration of the test. The Seiri activity is shown in Figure 4.

For Seiton (Set In Order), the operator needs to place the panels in the correct area. To make this easier, area marking is required so that the operator will place the items in the correct area. The Seiton activity is shown in Figure 5.

The Seiso (Shine) activity involves cleaning the machines and the FAT area. All equipment for FAT testing must be placed in its designated location so that the panel loading area remains clear. This activity is shown in Figure 6.

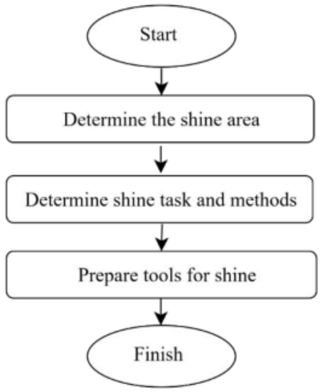

Figure 6. Seiso Plant Activity

For Seiketsu (Standardize), the results of the implementation of Seiri, Seiton, and Seiso will be meaningless without actions that support their ongoing practice. Some actions to support this implementation are as follows:

Standard for Seiri: After sorting the panels according to the duration of the test, each panel will be marked with a sticker in one of three different colors. An explanation of each sticker is provided in Table 2

TABLE II
STICKER STRATEGY

Tag Code	Criteria
Green sticker	Panels are identified as Panels with fast testing times. So that the Panel is placed in the front area of the FAT.
Yellow sticker	The Panel is identified as a Panel with moderate testing time. So that the Panel is placed in the middle area of the FAT.
Red sticker	Panels are identified as Panels with long testing times. So that the Panel is placed in the back area of the FAT

Standard for Seiton: Panel placement in the FAT area must be according to the designated area. The plan for panel placement is shown in Figure 7, with the explanation of the color of each area corresponding to the explanation of the color of the stickers in Table 2.

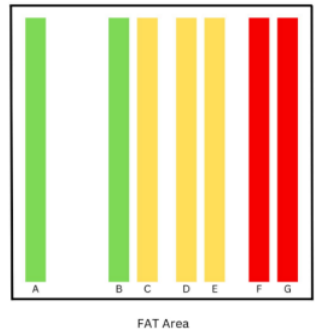

Figure 7. Panel Placing Plan

Standard for Seiso: Cleaning procedures should be prescribed to maintain hygiene. Therefore, a schedule needs to be developed so that the operator knows what needs to be cleaned and when to clean the area.

After the four stages above are applied, the next stage is the Shitsuke (Sustain) stage. At this stage, the operator will repeatedly apply the previous steps until the application of 5S becomes a habit. In this case, the leader must also perform operator control once a month. Previously, an audit program to control the 5S application had never been created.

By using Arena Simulation, we can simulate the results of improvements in Post F to maximize the number of panels that can be tested in one shift (11 hours of work). The time of each activity is entered into the process to see optimal results. All data used for the Arena Simulation is sourced from time and motion studies.

In this simulation, the estimated time for the changeover process before improvement is 140 minutes. With 140 minutes for each changeover process and a total of 11 hours of work, the estimated number of panels that can be tested in one shift is four panels, as presented in Figure 8. After improvements, the activities in the changeover process have been adjusted to 34 activities. As presented in Figure 9, with the same working time of 11 hours, the estimated number of panels that can be tested increases from four panels to six panels in one work shift.

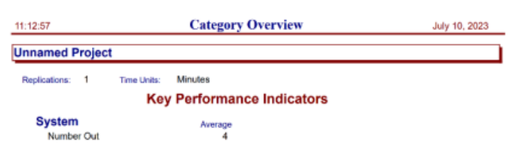

Figure 8. System Output Before Improvement

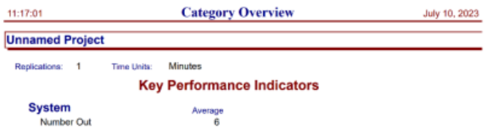

Figure 9. System Output Before Improvement

In Table 3, it can be seen that the changeover process after implementing the SMED process takes 63 minutes, resulting in a 54% reduction in changeover time. At this stage, the changeover time is based on the internal activities' time, as external activities do not affect downtime. Table 3 explains the internal and external times before and after improvement. The table shows that the improvement process reduces internal elements by 2 minutes and external elements by 40 minutes, which translates to a 5% reduction for internal elements and a 54% reduction for external elements.

TABLE III
CHANGEOVER PROCESS BEFORE & AFTER IMPROVEMENT

Activities	Before (Minutes)	After (Minutes)	Reduction (Minutes)	Reduction (Percent)
Changeover	140	63	77	54%
Internal	66	63	2	5%
External	74	34	40	54%

TABLE IV
MOTION STUDY BEFORE AND AFTER IMPROVEMENT

Operator	Before SMED		After SMED	
	Activities	Travel distance (m)	Activities	Travel distance (m)
Operator A	16	196	13	174
Operator B	10	165	12	172

After the improvement process is implemented, the motion in the changeover process also changes. This is influenced by the number of activities carried out by operators and the changes in the layout of Post F. This is explained in Table 4.

V. CONCLUSION

To address the issues in Post F, the Single Minute Exchange of Dies (SMED) methodology was introduced to reduce the 140-minute changeover process. The approach involves segregating internal and external activities. Additionally, a new method for panel loading from Post F to the FAT area was proposed, with plans to implement the 5S methodology in the FAT area. This improvement aims to reduce the average loading time from 10 minutes to 3 minutes. Upon applying the SMED and 5S methods, the changeover time is projected to decrease by 77 minutes (54%). Moreover, the number of panels that can be tested at Post F has increased from 4 panels per work shift to 6 panels per work shift. Furthermore, the availability of the changeover process has risen from 79% to 90%.

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