Production Process Time Reduction Strategy through SMED Method Implementation

Andi Dwi Wahyu Wibowo[1,*], Taufik Rachmad Fauzy[2], Surjo Hadi[3]
[1,2,3]Program Studi Teknik Industri, Fakultas Teknik Industri, Universitas Yos Soedarso

Email: [1,*]andidwi.w.w@gmail.com, [2]taufikrachmadfauzy@gmail.com, [3]bestsuryo@yahoo.com

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Abstract

The increasingly competitive manufacturing industry demands companies to improve operational efficiency, particularly in the changeover process, which contributes to production downtime. This study aims to analyze the application of the Single Minute Exchange of Dies (SMED) method in reducing setup time in the packaging process to improve production efficiency. The study uses a quantitative approach through direct observation, measuring work time, identifying internal and external setup activities, converting internal activities to external ones, and simplifying non-value-added activities. The results show that the application of SMED can reduce setup time from 265 minutes to 180 minutes, a reduction of 85 minutes (32%). Improvements were made through optimizing the mold installation process, which saved 20 minutes, improving eyemark settings, which reduced the time by 5 minutes, and improving cutter settings, which reduced the duration from 120 minutes to 60 minutes. The research findings prove that the SMED method is effective in increasing the efficiency of the changeover process, reducing production downtime, and increasing productivity in the packaging process. This study provides a practical contribution as a reference for the application of SMED in an effort to improve operational performance in manufacturing industries with similar product changeover characteristics.

Keywords: *Changeover, Operational Efficiency, Productivity, Setup Time, Single Minute Exchange of Dies (SMED).*

1. Introduction

In an increasingly competitive business environment, companies and organizations are expected to optimize their ability to adapt and pursue continuous improvement in order to ensure sustainability and the well-being of all stakeholders. Significant advances in science and technology over the past few decades have provided companies with opportunities to respond more quickly to consumer needs without compromising product quality. Companies or organizations capable of delivering high-quality products with shorter lead times tend to hold a competitive advantage over their peers. Consequently, effective strategies must be implemented to maintain, refine, and enhance company performance across all operational areas. To support the company's growth, various efforts are required, one of which is through improving work performance and productivity. These improvements must be sustained so that waste both in terms of time and material usage can be minimized.

The selection of the Single Minute Exchange of Dies (SMED) method in this study was based on the fact that product changeovers still require a relatively long setup time, with an average duration of approximately 265 minutes. Furthermore, the sequence of activities during the production process in the packaging area is not yet organized in a structured and systematic manner. These conditions have a direct impact on the achievement of OEE (Overall Equipment Effectiveness), which is a tool used to estimate efficiency and effectiveness losses for a specific manufacturing process. The three categories of losses are availability (e.g., downtime), performance (e.g., slow cycle times), and quality: [1]. However, other studies also note that OEE can evaluate the effective performance of a process based on equipment availability, production speed, quality levels, effectiveness, and safety: [2]. This study aims to improve machine performance, as measured by the Overall Equipment Effectiveness (OEE) indicator, by implementing the SMED method as part of a Lean Manufacturing strategy [3].

This research was conducted at a manufacturing company engaged in the Fast-Moving Consumer Goods (FMCG) sector with a focus on the production and marketing of daily necessities, particularly pest control products. As a company that serves market demand with a diverse product variety, the company is required to be able to run the production process efficiently and have high flexibility in product changeovers. The research conducted in the packaging area aims to develop proposals for improving work time as an effort to increase production output through the implementation of the Single Minute Exchange of Dies (SMED) method. Therefore, efforts are needed to reduce setup time so that the product changeover process can take place more quickly and efficiently, thereby increasing the company's productivity and overall operational performance.

This is in line with the opinion that the Single-Minute Exchange of Dies (SMED) methodology is categorized as one of the lean manufacturing tools that has a significant contribution in accelerating the setup and changeover process by reducing the required operational time: [4]. SMED is a system developed to control machine changeover time by focusing on reducing activity duration and eliminating activities that do not provide added value during the changeover process. In addition, this method can be used as a basis for designing a heuristic scheduling model to allocate operator tasks so as to minimize operator idle time and reduce costs arising from downtime during the changeover process: [5]. hus, the implementation of SMED can be accounted for through the various benefits it provides to the company. In general, the application of SMED offers various benefits, including: [6].

1. Increased productivity: [7].
2. Elimination of stockouts caused by errors in demand forecasting: [8].
3. Increased work rate and machine production capacity: [9].
4. The error rate in machine setup is minimal and tends to be virtually nonexistent: [9].
5. Improved product quality: [10], [7].
6. Improved safety levels in operational processes: [11], [10], [7], [9].
7. Reduced setup time: [12], [13].
8. Reduction in costs associated with production lot size: [14].
9. Increasing equipment flexibility and effectiveness: [15].
10. Elimination of stockouts caused by errors in demand forecasting: [8].

The implementation of the SMED method depends on the type of production to be analyzed. Various types of case studies involving conventional SMED applications have been presented [16] for example:

1. Utilizing SMED to reduce setup times on an automotive battery assembly line [17].
2. Reducing machine setup times on a turning line using SMED in a bearing manufacturing company [18].
3. Reducing changeover times by implementing SMED in cork stopper production [19].
4. Using SMED to improve machining processes in the metalworking industry [20].
5. Utilizing SMED in a cold profiling process, using a population of five separate profiling equipment [21].

2. Methods

The process of collecting data information in this scientific study was carried out through a question-and-answer method and direct observation at the research location. Data sources in this study are divided into two, namely primary/main data and secondary/supporting data. Data were obtained without intermediaries from the main source through direct observation activities during the product changeover process and the work activities of operators on the line 9 packaging machine. Meanwhile, secondary data were collected through questions and answers and dialogue with workers in the production division at various employee levels, as well as with parties from other relevant departments to complete and enrich the research information. The secondary data were obtained during the implementation of the production process on the use of shrink wrap machines related to the research object.

The results of data processing in this study were obtained through the application of the Single Minute Exchange of Dies approach. In its implementation, the SMED methodology applies the following steps according to [3]:

1. Stage 1: Identify and separate internal and external activities.
   This phase is essentially a step to gather relevant information about the current setup procedure. This step alone can help reduce setup time by 30-50 percent. External setup is an activity that occurs while the machine is operating and is performed early to save time when setting up the machine. Internal setup is an activity that occurs while the machine is idle or on hold and can only be performed after the machine has completed the previous operation. The operator must be able to complete all external setups and be ready to complete internal setups for the next product before the machine finishes processing a product.
2. Stage 2: Change internal settings to external settings.
   This process takes time in both setups, but by increasing or shifting some internal activities to external ones, machine uptime will increase from one product to the other. Most external setup activities are not visible in internal setup time, such as cleaning, product handling, gathering tools and equipment, etc.
3. Stage 3: Reset all aspects of the setup.
   The work environment should be properly organized, placing equipment near the point of use, and ensuring proper functioning of machines and equipment. Adjustments that help minimize internal setup activities should be simplified and practiced, such as using quick-release fasteners and positioning pins, preventing rework of alignments with previously desired settings.
4. Stage 4: Perform parallel preparation activities.
   Standardizing components, parts, and raw materials can improve or even eliminate setup activities. Continuous practice of setup processes can be documented, as it is crucial for workers and engineers to reduce setup time. These principles can be referred to as principles after the resulting ideas are studied and implemented. These principles can then be implemented until improvements can be made.

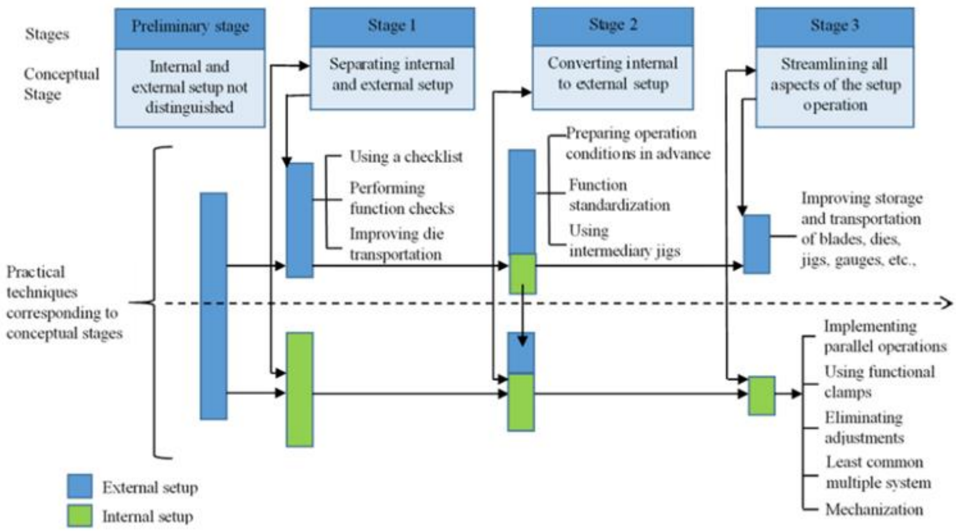

Figure 1. Conceptual stages and practical techniques of SMED [18].

To achieve the objective of improving machine performance, this study employed the Single Minute Exchange of Dies (SMED) methodology as the primary improvement approach to reduce setup time during the changeover process. The SMED method focuses on distinguishing setup activities into internal setup, which can only be performed while the machine is stopped, and external setup, which can be completed while the machine is operating. Where feasible, internal activities are converted into external activities to minimize machine downtime and improve production efficiency [22], [23].

The research procedure consisted of direct observation of the changeover process, measurement of setup time for each activity through a time study, identification and classification of internal and external setup activities, conversion of feasible internal activities into external activities, and simplification and standardization of the remaining internal setup tasks [24]. The effectiveness of the proposed improvements was evaluated by comparing setup time before and after SMED implementation to determine the percentage reduction achieved and its impact on production efficiency [25]. This approach has been widely adopted in manufacturing environments because it enables significant reductions in setup and changeover time without requiring substantial capital investment, relying instead on workflow optimization and standardized operating procedures [26], [27].

3. Results and Discussion

The packaging area changeover process is performed every time a SKU is changed to adapt the machine configuration to the characteristics of the next product. This process involves several key activities, namely preparing machine components, replacing formers and holders, setting up the cutter system, adjusting the eyemark, installing the printing machine, and conducting a trial run before the machine is returned to the production operator. All of these activities are carried out sequentially when the machine is stopped, resulting in relatively high setup times and reducing effective production time.

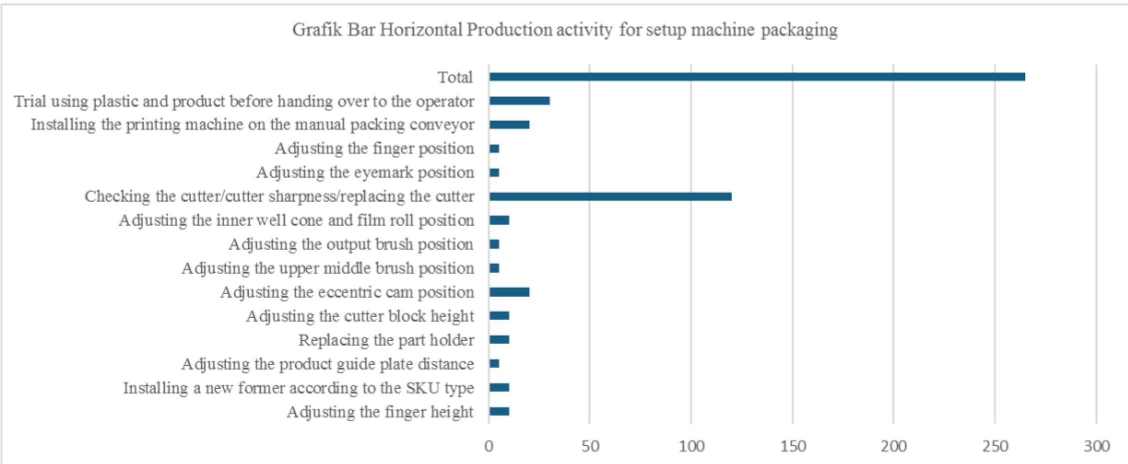

Figure 2. Production activity for packaging machine setup

3.1 Identify Setup Activities Before SMED Implementation

The initial stage of the research was conducted through direct observation of the changeover process on the packing machine. All activities during the product changeover process were observed, documented, and measured using the time study method. The implementation of the SMED method in this research follows four main stages, namely (1) Preliminary Phase, (2) Separating Internal and External Setup, (3) Converting Internal and External Setup, and (4) Streamlining All Aspects of Setup Operations, as shown in Figure 3.

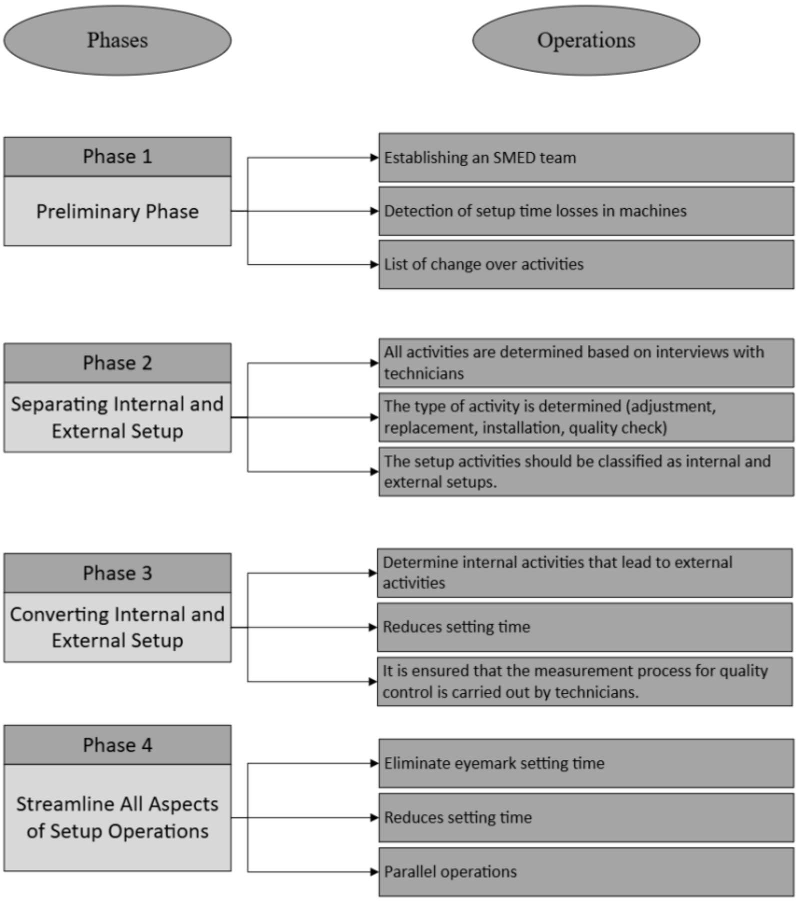

Figure 3. The implementation flow of the SMED method in the packing machine changeover process adapted [18].

Based on these stages, the research began by identifying all setup activities that occurred during the changeover process. Observations revealed 14 activities with a total setup time of 265 minutes, as presented in Table 1.

Table 1 Packing machine replacement activities before SMED

No.	Activity	Time (Minutes)
1	Adjusting the finger height	10
2	Installing a new former according to the SKU type	10
3	Adjusting the product guide plate distance	5
4	Replacing the part holder	10
5	Adjusting the cutter block height	10
6	Adjusting the eccentric cam position	20
7	Adjusting the upper middle brush position	5
8	Adjusting the output brush position	5
9	Adjusting the inner well cone and film roll position	10
10	Checking the cutter/cutter sharpness/replacing the cutter	120
11	Adjusting the eyemark position	5
12	Adjusting the finger position	5
13	Installing the printing machine on the manual packing conveyor	20
14	Trial using plastic and product before handing over to the operator	30
	Total	265

The total setup time of 265 minutes indicates that the changeover process remains inefficient. This duration results in increased machine downtime, reducing effective production time and potentially lowering the productivity of the packing line. Observations also indicate that most activities are still carried out while the machine is stopped (internal setup), so there is still considerable opportunity to improve efficiency. This condition indicates that the changeover process has not implemented the principle of separating internal and external setup activities as recommended in the SMED methodology.

3.2 Classification of Internal and External Activities

The next step was to classify all setup activities into internal and external. Internal activities are tasks that can only be performed when the machine is stopped, while external activities can be performed while the machine is still running [3]. Initially, all activities were categorized as internal setup. Through discussions with operators and observations of the workflow, an opportunity was identified to convert the activity of installing the printing machine on the manual packing conveyor into an external setup activity. This change resulted in a 20-minute reduction in setup time.

These results indicate that separating internal and external setup activities directly contributes to reducing machine downtime. By moving activities that do not depend on machine stoppages to the stage before the changeover process, downtime can be reduced without requiring machine design changes or additional investment. This finding aligns with research [24] and [25], which states that converting internal activities to external ones is a key step in improving changeover process efficiency.

3.3 Simplification and Standardization of Setup Activities

After the activity conversion process was completed, the next step was to simplify activities still classified as internal setup. Evaluation results showed that eyemark setting activities could be performed concurrently with the machine start-up process, eliminating it as a separate activity. Furthermore, procedural changes were made to the cutter sharpness checking activity, replacing the inspection process with direct cutter replacement based on previous operating conditions using a high-speed machine. This change reduced the activity time from 120 minutes to 60 minutes.

The 50% reduction in cutter time demonstrates that standardizing work procedures has a greater impact than simply transferring internal activities to external ones. Observations revealed that cutter sharpness checking is time-consuming and often does not result in different decisions because components generally wear out after use in high-speed production processes. Therefore, direct component replacement is a more efficient alternative while reducing process variation. These findings indicate that the largest source of waste in the changeover process comes from non-value-added inspection activities.

3.4 Evaluation of SMED Implementation Results

After all, SMED stages were implemented, the number of setup activities was reduced from 14 activities to 12 activities with the total changeover time decreasing from 265 minutes to 180 minutes, as shown in Table 2.

Table 2. Transition activities on the packing machine after SMED

No.	Activity	Time (Minutes)
1	Adjusting the finger height	10
2	Installing a new former according to the SKU type	10
3	Adjusting the product guide plate distance	5
4	Replacing the part holder	10
5	Adjusting the cutter block height	10
6	Adjusting the eccentric cam position	20

No.	**Activity**	**Time (Minutes)**
7	Adjusting the upper middle brush position	5
8	Adjusting the output brush position	5
9	Adjusting the inner well cone and film roll position	10
10	Replacing and adjusting the cutter height	60
11	Adjusting the finger position	5
12	Trial using plastic and products before handing over to the operator	30
	Total	180

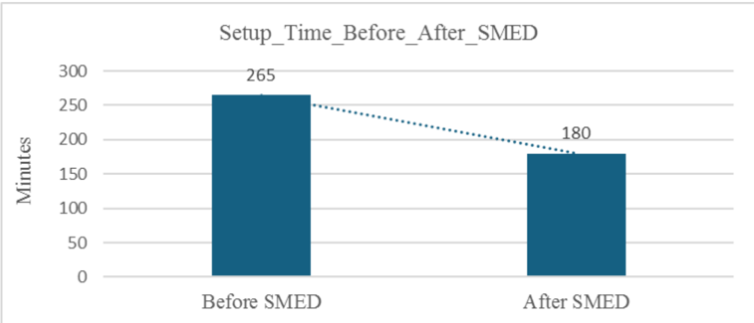

Figure 4 Setup time before and after SMED

Based on Table 2 and Figure 4, the implementation of the Single Minute Exchange of Dies (SMED) method successfully reduced the total setup time from 265 minutes to 180 minutes, resulting in a time savings of 85 minutes or 32%. This reduction indicates that the implementation of SMED is effective in reducing machine downtime by converting internal activities to external setups, eliminating non-value-added activities, and simplifying work procedures. These results indicate that improved work methods can increase the efficiency of the changeover process without requiring investment in new equipment.

This finding is in line with studies [24], [26], and [28] which reported that the application of SMED was able to reduce setup time by separating internal and external setup activities and standardizing operational activities. However, this study showed that the largest contribution of time savings came from the optimization of cutter activities, so that identifying activities with the longest duration is an important factor in determining improvement priorities. From a practical perspective, a 32% reduction in setup time provides additional machine operating time that can be used to increase production capacity and the company's flexibility in dealing with changes in product demand.

4. Conclusion

This study demonstrates that the Single Minute Exchange of Dies (SMED) method effectively improves changeover process efficiency in the packaging area. SMED implementation successfully reduced setup time from 265 minutes to 180 minutes, resulting in a time savings of 85 minutes, or 32%. This time reduction was achieved through converting internal activities to external setups, eliminating non-value-added activities, and simplifying work procedures. The results demonstrate that optimizing work methods can improve process efficiency without requiring investment in new equipment, making it an effective improvement alternative for manufacturing companies, particularly in the Fast-Moving Consumer Goods (FMCG) industry, which has a high changeover frequency.

This study has limitations because the SMED implementation was only conducted on a single packaging line and focused on reducing setup time. Therefore, further research is recommended to apply the SMED method to different production lines or processes and evaluate its impact on a broader range of operational performance indicators, such as productivity, machine utilization, and process efficiency, so that the benefits of SMED implementation can be assessed more comprehensively.

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