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Enhancing Productivity through Quick Changeovers: A SMED-Based Methodology in Manufacturing Industry

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Abstract

The research focuses on enhancing production capacity in manufacturing industries by applying the Single Minute Exchange of Die (SMED) technique, a method aimed at improving efficiency during assembly changeovers. The objectives are to: (i) identify inefficiencies in the changeover process, (ii) implement techniques to improve efficiency, and (iii) propose productivity enhancements through SMED. Using a combination of qualitative and quantitative methods, the study analyzes assembly line productivity and provides an improvement plan by comparing internal and external operations, optimizing changeover timing, and converting internal operations to external ones. Conducted via a case study of Food & beverage industry, the research demonstrates increased productivity and improved changeover effectiveness on the production line.

Keywords: SMED, Changeover, Productivity, Lean Manufacturing, Efficiency

Introduction

incorporating recent empirical studies would make the introduction much stronger by linking its theoretical ideas to real-life situations in the workplace. The Foucauldian examination of lean as a "technology of power" in UK automotive dealerships offers direct empirical validation of the passage's principal assertion that the implementation of SMED presents social challenges that transcend mere technical procedures. This illustrates how workers resist standardization through narratives of professional autonomy while ultimately being ensnared by lean's exploitation of their quest for recognition. This research contributes to the labour process discourse referenced in the passage by demonstrating that deskilling is not the sole mechanism of control; instead, control is exercised through the inherent subjectivity and "human capital" of workers themselves. Recent empirical research on digitization and SMED complicates and contests the prevailing narrative: a study of German mechanical engineering indicates that skilled workers, presumed to be immune to such influences, experience "de-qualification" and "shrinking spaces of autonomy" due to lean standardization and knowledge digitization. Artisans resist these changes by concealing tools and materials, thereby highlighting the tension between standardization and autonomy and challenging overly optimistic narratives of upskilling. On the other hand, the new "Human-Centric SMED" literature gives a different but important view. It shows through case studies in fashion eyewear that methodology can be intentionally redesigned to meet the needs of workers and ergonomics, resulting in setup reductions while focusing on human subjectivity instead of taking advantage of it. This body of work both supports the passage's criticism by showing that social consequences are important, and it also goes against its dystopian direction by suggesting that different ways of implementing things, especially those based on Industry 5.0 principles, can change power dynamics and outcomes of autonomy. Collectively, these studies convert the introductory inquiry from a hypothetical theoretical assertion into an empirically significant and contentious domain of modern manufacturing transformation.

Objectives and Limits of the Research

This study's objective is to connect the technical and dimensional aspects of SMED by looking into how it works as an integrated manufacturing system. It is a focused ethnographic and operational case study in a manufacturing setting where frequent changeovers are very important for overall equipment effectiveness (OEE) and production throughput. The research is directed by the following interconnected objectives:

(i) To identify the factors contributing to inefficiencies in changeover processes across the production line. A comprehensive analysis will be conducted to identify bottlenecks, delays, and non-value-adding activities that hinder rapid changeovers. This includes examining machine setups, tooling, operator practices, and material handling systems.

(ii) To implement a suitable technique for addressing changeover inefficiencies. The study will employ the SMED methodology as a structured approach to reclassify and optimize setup activities. Time studies, process mapping, and root cause analysis will be conducted to support this implementation.

(iii) To propose targeted improvements aimed at increasing productivity through the application of SMED. Based on the findings, a set of actionable recommendations will be developed. These may include modifications to standard operating procedures (SOPs), equipment upgrades, training programs, or scheduling adjustments—all aligned with lean manufacturing principles. By achieving these objectives, the research aims to demonstrate that the systematic application of SMED not only minimizes downtime but also fosters a culture of continuous improvement within manufacturing operations.

Significance of the Research

By pursuing these objectives, this research contributes a nuanced, technical perspective to lean manufacturing studies. (i) Technical Tools: It embeds a proven operational method (SMED) within critical social science debates on power, labor, and organizational ideology. (ii) Implementation Gap: It treats the "how" of implementation not as a neutral technical challenge but as the core social process determining success or failure. (iii) Holistic Framework: It aims to provide practitioners and scholars with a framework that views productivity gains and human resource management not as separate concerns, but as inextricably linked elements of successful technological change.

Technical Overview

SMED, the core method under study, enhances manufacturing efficiency by rigorously separating and converting internal tasks (done while the machine is stopped) into external ones (prepared while it runs). This enables smaller batches, lower inventory, and faster customer response. Techniques like pre-staging and parallel operations aim to reduce waste and boost OEE. However, this study proceeds from the premise that its socio-technical implementation reveals critical tensions: the method requires worker ingenuity and teamwork to succeed, yet simultaneously seeks to codify and standardize that very knowledge.

Understanding of SMED

SMED (Single-Minute Exchange of Die), created by Shigeo Shingo under the Toyota Production System, reduces setup times to minutes by eliminating waste and simplifying processes. It helps manufacturers respond quickly to market demands by making changeovers faster and more efficient. SMED boosts productivity, reduces downtime, lowers costs and improves resource use. It also encourages continuous improvement and innovation among employees. As explained by Berhe et al. (2023), many industries now use methods like Lean Manufacturing (LM), Lean Six Sigma (LSS), and Total Quality Management (TQM) to cut waste and improve efficiency.

Lean Manufacturing

Lean assembly, based on the Toyota Production System (TPS), improves manufacturing by cutting waste and streamlining production. Developed in post-WWII Japan and formalized by Ohno in 1988, Lean Manufacturing (LM) focuses on small-scale, high-quality production with minimal resources, influencing industries worldwide (Holweg, 2007). LM principles aim to deliver customer value by removing non-essential tasks (So & Sun, 2010). Tools like Kanban and standardized workflows boost productivity and align production with demand, reducing waste and inventory costs (Liker & Choi, 2004). Modern LM uses technologies like IoT, AI, and analytics for real-time monitoring and maintenance (Irgang et al, 2023). Combining Lean with Six Sigma improves quality and reduces waste, while a focus on continuous improvement empowers workers to innovate and solve problems (Maia et al, 2024). These practices make LM essential for today's manufacturing success.

8 Waste of Lean Manufacturing

Lean Manufacturing is a systematic approach to identifying and eliminating waste through continuous improvement, with the goal of delivering value to the customer. Central to this philosophy is the recognition that waste—defined as any activity that does not add value from the customer's perspective—can significantly hinder efficiency, productivity, and profitability.

Lean identifies eight types of waste, commonly referred to using the acronym DOWNTIME, which stands for Defects, Overproduction, Waiting, Non-utilized talent, Transportation, Inventory, Motion, and Extra-processing. Understanding and addressing each form of waste is essential to creating a lean, efficient production system.

Tools of Lean Manufacturing

Lean Manufacturing (LM) uses various tools to improve performance, quality, and reduce

waste. Joshi et al, (2024) helps identify waste and improve workflows. The 5S Methodology Huang et al, (2024), organizes workplaces to boost efficiency and encourage continuous improvement. The Kanban System reduces inventory and lead times by aligning production with demand. Poka- Yoke (Maia et al, 2024) prevents errors and defects, promoting a zero-defect culture. Total Productive Maintenance (TPM) Agustiady & Cudney, (2024) reduces downtime by involving all employees in equipment maintenance. Just-In-Time (JIT) minimizes inventory and overproduction, improving flexibility. Continuous Flow Manufacturing Kempa & Paprocka, (2024) improves workflow by reducing batch sizes. Single-Minute Exchange of Die (SMED) cuts setup times, allowing quick adjustments to market needs.
These tools help eliminate waste, improve processes, and increase customer value, leading to better efficiency and long-term competitiveness.

Lean Assembly
Lean assembly, based on the Toyota Production System (TPS), focuses on improving efficiency, quality, and agility. Developed by Toyota after World War II, it uses methods like Just-In-Time (JIT), Kanban, and continuous improvement (Kaizen) to boost productivity and flexibility. Techniques like Value Stream Mapping (VSM) and standardized work reduce waste and increase value.

Lean assembly has evolved to meet modern challenges, helping industries like automotive, electronics, and aerospace. Advances in automation and robotics have further improved efficiency. Lean assembly continues to be important for businesses looking to stay competitive and successful in a global market.

Continuous Improvement
Continuous improvement is key to success in modern manufacturing, driven by technologies like AI, machine learning, and IoT. These tools provide real-time data, predictive maintenance, and process optimization, improving efficiency and reducing downtime. Industry 4.0, with digital tools like smart factories, enhances communication, agility, and control (Sonnenberg, 2024). Manufacturers need to work together in teams and use agile methods like Scrum and Kanban to prioritize tasks and quickly respond to market changes (Terelak-Tymczyna & Niesterowicz, 2024). AI and IoT help optimize equipment use, cut downtime, and reduce defects, boosting efficiency and profits (Das et al, 2024). Industry 4.0 also improves supply chain collaboration, helping companies meet customer needs and stay competitive (Irgang et al, 2023). Using these technologies and strategies leads to better growth, efficiency, and customer satisfaction in manufacturing.

Production Assembly
Production assembly is essential for manufacturing, focusing on efficiency, accuracy, and flexibility to meet consumer needs and stay competitive. It impacts cost, time-to-market, and product quality. As global pressures grow, manufacturers must optimize their assembly processes to keep up with technological changes.

Industry 4.0 technologies like robotics, AI, and IoT improve productivity, flexibility, and sustainability. However, challenges such as supply chain issues, skill gaps, and environmental concerns remain (Bednarski et al, 2024). Geopolitical problems and natural disasters add complexity, stressing the need for better risk management.

Collaboration between businesses, universities, and governments helps drive innovation in areas like supply chain optimization and sustainable manufacturing. By embracing technology and working together, manufacturers can improve assembly processes, boost efficiency, and stay competitive for long-term growth.

Single Minute Exchange-Die (SMED)

Single Minute Exchange of Die (SMED), created by Shigeo Shingo in the Toyota Production System (TPS), focuses on reducing changeover times to improve efficiency and responsiveness to market demands (McIntosh, 2000). It separates tasks into internal (done when production stops) and external (done while production continues). By moving internal tasks to external, manufacturers reduce downtime and improve equipment effectiveness (OEE). SMED uses techniques like standardization, parallelization, and automation to speed up setups, with visual aids like color-coded checklists to help workers (Marsden & Shahtout, 2024). Technologies like automation, RFID, and real-time monitoring improve accuracy and reduce errors (Liker & Choi, 2004). Industry 4.0 tools such as AI, IoT, and robotics further enhance SMED's efficiency and flexibility (Da Silva & Godinho Filho, 2019) (Mendes Monteiro et al, 2023). SMED is also applied in sectors like healthcare and services to improve processes.

Changeovers

In SMED, the key to successful implementation lies in understanding what a changeover entails. A changeover involves re-setting equipment, tooling, and processes to transition from manufacturing one product to another. Faster changeovers minimize downtime, enhancing productivity and supporting higher Overall Equipment Effectiveness (OEE). Changeover processes are a focal point within lean manufacturing, aimed at eliminating waste and optimizing operations. Utilizing lean principles, such as 5S, visual management, and continuous improvement, helps streamline changeover times. Additionally, technological advancements like advanced robotics, predictive maintenance systems, and digital twin simulations play a significant role in reducing setup times and minimizing unplanned downtime.

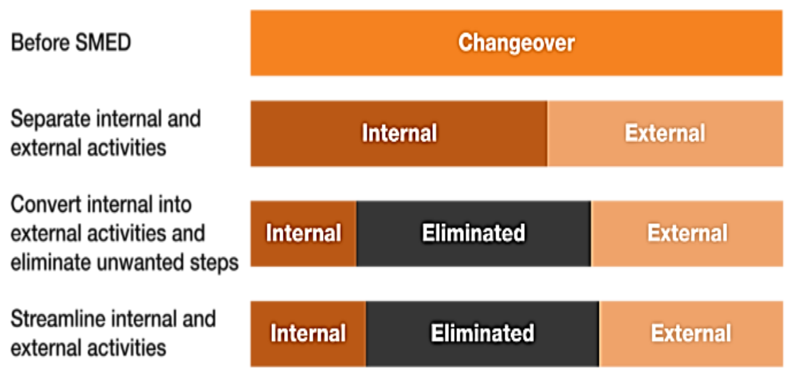

Figure 1: Internal vs External Changeovers

Based on the figure 1.1 above, changeovers are categorized into internal and external tasks. Internal tasks involve equipment downtime, such as adjustments, calibrations, and component replacement, which significantly contribute to changeover time and are the focus for optimization. SMED focuses on minimizing internal setup tasks to reduce downtime and improve operational effectiveness (Braglia et al, 2023). External tasks, on the other hand, can be performed while equipment operates, such as material preparation or tool staging. By converting internal tasks into external tasks, manufacturers can significantly reduce changeover times and improve OEE. Optimal changeovers involve a combination of standardization, quick-change tooling, visual management, and automation. These approaches help minimize downtime and enhance overall manufacturing efficiency, making internal and external changeovers critical areas for maintaining competitiveness in the market.

Applications of SMED

The primary application of SMED in manufacturing is the reduction of changeover time. By optimizing the setup process, manufacturers can significantly decrease the time required to switch between different products or production runs. This reduction enables enhanced productivity, faster response to customer demands, and the ability to efficiently accommodate smaller batch sizes (Sousa et al, 2018). Additionally, SMED fosters more flexible manufacturing. Reduced setup times allow manufacturers to respond quickly to fluctuating market demands and introduce new products or variants. This flexibility enables the optimal utilization of production resources, allowing manufacturers to meet differentiated customer requirements and adapt to market fluctuations. Furthermore, SMED helps minimize waste associated with setup processes, such as material handling and unnecessary steps, which reduces costs and promotes a more sustainable, cost-efficient manufacturing environment.

A systematic review, as outlined by Petrosino et al. (2001), entails the rigorous identification, synthesis, and evaluation of both quantitative and qualitative evidence to generate well-founded responses to specific research questions. Unlike traditional narrative reviews, systematic reviews adopt standardized methods for article selection and data analysis, thereby minimizing bias and enhancing the reliability of findings (Mallet et al., 2012).

Methodology

The methodology section contains a description of the strategy and processes utilised to conduct the project's study. It includes details about the study's design, the methods used to collect and analyse data, and any special techniques or tools that were employed. The research process is interpreted using a flow chart, and the research technique is explained by the study's design. Site visits are then utilised to complete the data collection process in the real manufacturing scenario. The data will next be examined to ascertain the result and study conclusion. This section seeks to demonstrate the validity of the study and to offer enough information so that other researchers can understand and carry out the same research.

Design of Study

The design of a study involves a structured plan for collecting and analyzing data related to the research variables. It is essential for ensuring the accuracy and reliability of the methodology employed in the study. Research can be conducted using two primary methodologies: quantitative and qualitative. Qualitative research focuses on gathering non-numerical data—such as opinions, experiences, and perspectives—to understand theories, first-hand accounts, and concepts. This type of research often employs methods like surveys, interviews, literature reviews, and case studies to gather insights. It aims to explore a deeper understanding and interpretation of data rather than concentrating solely on measurable outcomes. In contrast, quantitative research emphasizes numerical and statistical methods, using mathematical formulas and computational strategies to analyze data. This approach enables the measurement and statistical analysis of variables to identify relationships between them. Quantitative research provides measurable and objective results, offering a more structured approach to understanding data and its implications.

Flow Chart of Research

The overall methodology is depicted in Figure 2, which outlines the actions taken to achieve the research goal. A flow chart will be included in the methodology to serve as a guideline, indicating each stage or action that must be completed in a specific order to carry out the research.

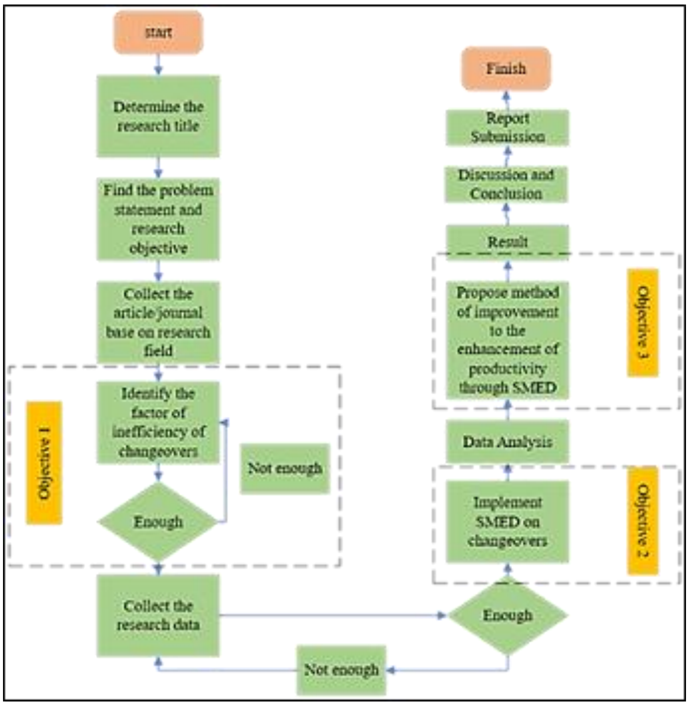

Figure 2: Detailed Process Flow of Research Methodology

Result and Discussion

This section, conducted at Food & beverage industries, a company dealing with food and beverages focused on using the SMED tool to address a specific problem related to changeover activities. Data was collected through real-time observations, cycle time recordings, and interviews with employees. The collected data was analyzed, reorganized, and validated to ensure accuracy and reliability. The study aimed to streamline the production process by reducing changeover times and improving operational efficiency. Additionally, the application of DMAIC and cause-and-effect analysis supported the identification and resolution of issues within the production line. The ultimate goal was to optimize the current production processes for better performance. Long turnaround times are a significant challenge in manufacturing, leading to slow production and increased downtime. This inefficiency hinders the ability to quickly adjust to market demands, causing significant production losses. The study identified prolonged cycle times and ineffective internal and external activities during changeovers as key issues, resulting in longer lead times and bottlenecks in the production process. High cycle times negatively impact overall process efficiency and reduce productivity, making it difficult for manufacturers to meet customer expectations in a timely manner.

Data Collection

This study involves collecting data to analyze the current production line at Zaliza Sdn. Bhd., a small and medium-sized enterprise established in June 2006 that specializes in flavored beverages such as soy milk, tamarind, and honey tamarind. The data, categorized into primary and secondary sources, is analyzed using the Single Minute Exchange of Die (SMED) approach. Ensuring data reliability is critical for addressing the research question, minimizing errors, and supporting sound decision-making. The focus is on examining the cycle time and activities involved in flavor switching, particularly between ordinary and honey tamarind beverages.

Primary Data Collection

The collection of primary data for inventory management, which includes data from direct sources like interviews and surveys, and is recorded in spreadsheets for analysis. It outlines the process flow from extraction of the tamarind, cooking process, to filling bottles using the filling machine and packaging. The floor layout in the warehouse is meticulously planned for optimal organization. Visits to the company provide operational insights into the whole batch process, highlighting the importance of the workflow in the project. Lastly, the changeover time for different activities during the changeover of flavors illustrates the required items and assemblies for production. This is the examples of data in Figures 3, Figure 4 and Table 1 visualizes the whole study process.

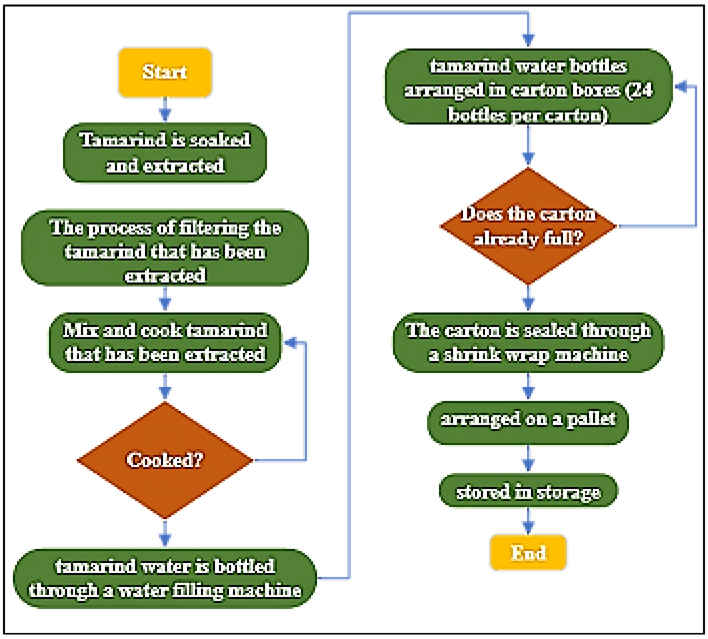

Figure 3: Production Process Flow

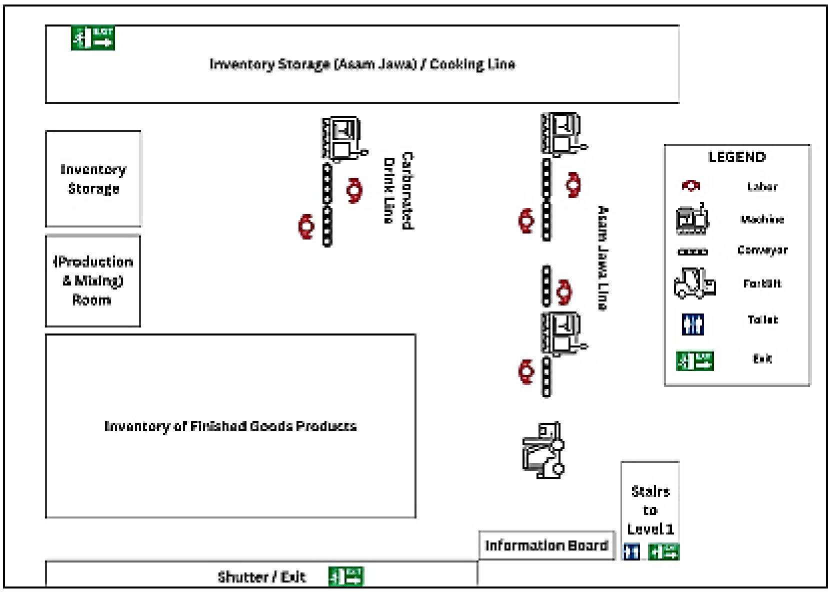

Figure 4: Layout of Production Line

Table 1
Changeover Time for each Activity

no	activities	Duration (s)
1	Bringing bottle caps towards the filling machine	35
2	Switching and bringing different batch of labelled bottles towards the filling machine (per bag)	65
3	Bottles labelling (per bag)	900
4	Filling machine setup	120
5	Bringing carton boxes towards the filling machine	20
6	Setting up raw materials for cooking process	1800

Secondary Data Collection

This study emphasizes the use of secondary data to support research by providing additional insights and identifying key issues in manufacturing. It highlights the classification of manufacturing tasks during transitions into internal (requiring machine stoppage, e.g., tool changes) and external (tasks performed while the machine operates, e.g., material prep) activities, essential for reducing downtime and boosting productivity. During the changeover from preserved plum to honey tamarind drinks, the study identifies internal and external activities, with efforts to convert internal tasks to external ones, as shown in 2, Table 3 and Table 4. This conversion aims to eliminate idle time and reduce waste like waiting and transportation, significantly cutting internal task durations. Streamlining internal activities further optimizes the process. For instance, tasks such as activities 1, 2, and 5 are combined and performed before the changeover, saving time and reducing waiting periods. Increasing the workforce for bottle labeling reduces task time from 15 to 10 minutes per bag. Similarly, pre-scheduling task 6 (raw material setup) resolves its bottleneck nature, allowing seamless batch transitions and minimizing delays. These changes collectively enhance efficiency and reduce overall changeover time.

Table 2
Classification of Activities

Internalvs External Activities Before SMED Implementation				
no	Activities	Duration (S)	Internal	External
1	Bringing bottle caps towards the filling machine	35	35	-
2	Switching and bringing different batch of labelled bottles towards the filling machine	65	65	-
3	Bottle labeling (per bag)	900	-	900
4	Filling machine setup	120	120	-
5	Bringing carton boxes towards the filling machine	20	-	20
6	Setting up raw materials for cooking process	1800	1800	-
	total	2940	2020	920

Table 3
Converting Internal to External

Converting Internal to External				
no	Activities	Duration (S)	Internal	External
1	Bringing bottle caps towards the filling machine	35	-	35
2	Switching and bringing different batch of labelled bottles towards the filling machine	65	-	65
3	Bottle labelling (per bag)	900	-	900
4	Filling machine setup	120	120	-
5	Bringing carton boxes towards the filling machine	20	-	20
6	Setting up raw materials for cooking process	1800	-	1800
	total	2940	120	2820

Table 4
Streamlining Activities

Internal Vs External Activities after SMED Implementation				
no	Activities	Duration (S)	Internal	External
1	Bringing carton boxes, labelled bottles and bottle caps towards the filling machine	90	-	90
2	Bottle labeling (per bag)	600	-	600
3	Filling machine setup	120	120	-
4	Setting up raw materials for cooking process	1200	-	1200
	total	2010	120	1890

Data Analysis

In this data analysis section, we delve into the challenges related to the lack of efficiency during changeover. We employ a cause-and-effect diagram as shown in Figure 5, categorizing issues into man, material, method, and machine. Following that, the why-why analysis method helps pinpoint critical factors and root causes, facilitating the identification of necessary actions. Additionally, we utilize graphs and attribute statistical process control to measure and analyze collected data, ensuring efficient production monitoring and eliminating unnecessary processes.

Cause and Effect Diagram

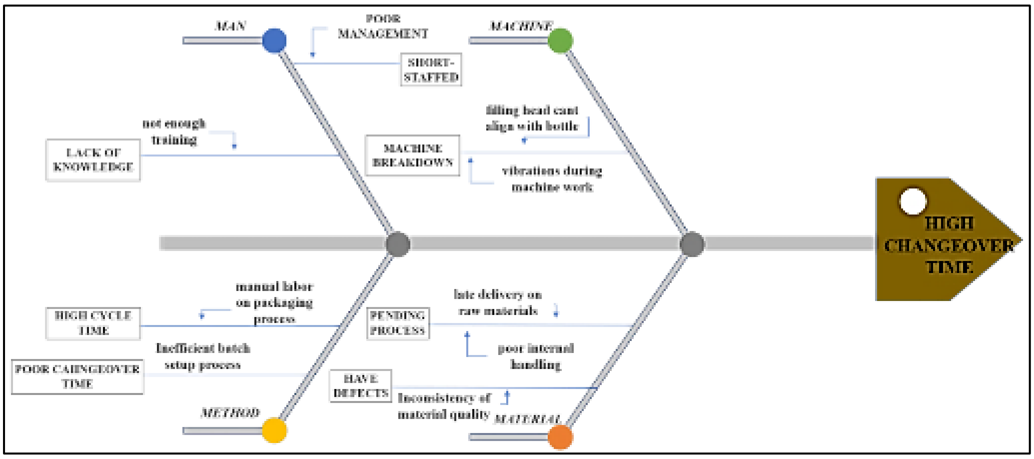

Figure 5: Cause and Effect Diagram

The method that is suitable to list or identify causes is by using a Cause and Effect diagram. The Cause and Effect diagram addresses the root problem using the 4M which are Man, Machine, Method, and Material principles as shown in Figure 5. Thus, after identifying it, the next step is to analyze the root cause.

Why-Why Analysis

Table 5 illustrates the Why-Why analysis for lack of efficiency during changeovers of preserved plum flavor to honey tamarind flavor for the production line.

Table 5

Why-Why Analysis

	problem	why 1	why 2	why 3	why 4	why 5	root cause
Machine	machine breakdown	filling head can't align with bottle	insufficient bottle on conveyor	Bottles are not fed consistently.	Conveyor belt is not calibrated.	-	Inadequate maintenance protocols.
		vibrations during process causing disruption	machine is not maintenance properly	there is not enough engineer to do maintenance	not enough people apply for the position	-	Poor machine condition due to overuse and lack of preventive maintenance.
Method	high cycle time	Production processes take longer than expected, delaying output.	Inefficient setup time between batches.	Complex batch scheduling process.	Poor coordination between teams for handovers.	No standard procedure for quick setup.	Lack of streamlined batch setup processes.

	inefficient batch setup process	Batch setup issues affect production timelines.	Lack of tools for proper calibration.	Tools are misplaced or not maintained.	Lack of ownership for setup activities.	-	Absence of structured pre-batch preparation processes, tool management systems, and accountability frameworks.
				Missing or broken equipment during setup.	Delayed reporting of issues to the maintenance team.	No checklist for batch readiness.	Absence of a structured pre-batch preparation checklist.
Material	pending batch process	Certain batches remain incomplete, delaying production.	Delayed input material delivery.	Supplier shipment delays.	No buffer stock maintained for critical materials.	Poor inventory management.	Lack of robust supply chain management.
	have defects on material upon arrival	Faulty raw materials affect production quality.	Materials not inspected at the supplier's end.	Suppliers do not follow quality checks.	No quality agreement in place with the supplier.	Lack of supplier quality audits.	Weak supplier quality assurance mechanisms.
Man	lack of knowledge	not familiar to new equipment (filling machine)	not enough training on the process	the company has limited resources to send training		-	Insufficient investment in employee training programs.
	short-staffed	difficult to hire new staff	low wages and benefits	limited budget	company focused on minimizing costs	budget constraints preventing the company from offering competitive wages and attracting sufficient staff	Ineffective recruitment and workforce management strategy.

Measure Collected Data by Graph

Figures 6, Figure 7 and Figure 8 shown the difference between before and after SMED implementation in terms of changeover time. As shown, the difference of total value for internal and external activities before and after SMED implementation is significantly lower because of streamlined internal activities during the changeover.

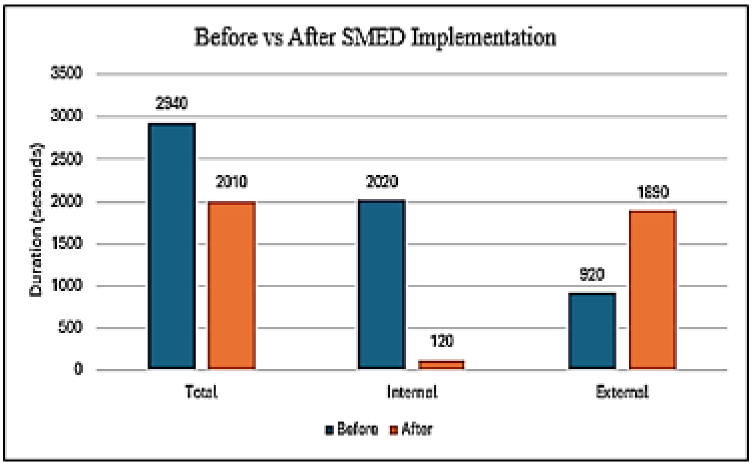

Figure 6: Whole Changeover Process

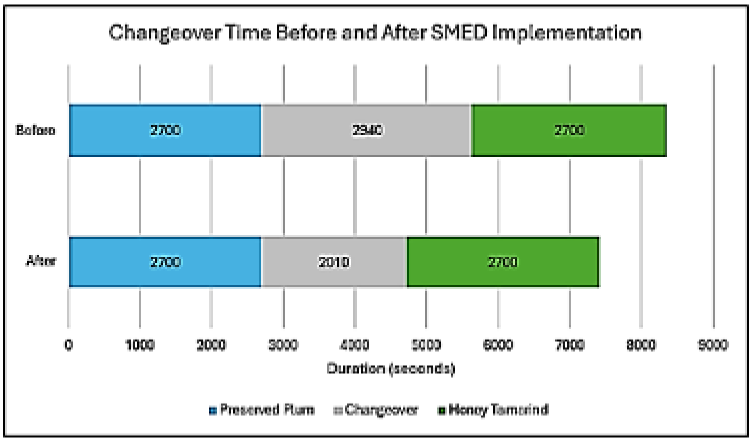

Figure 7: Total Changeover Time

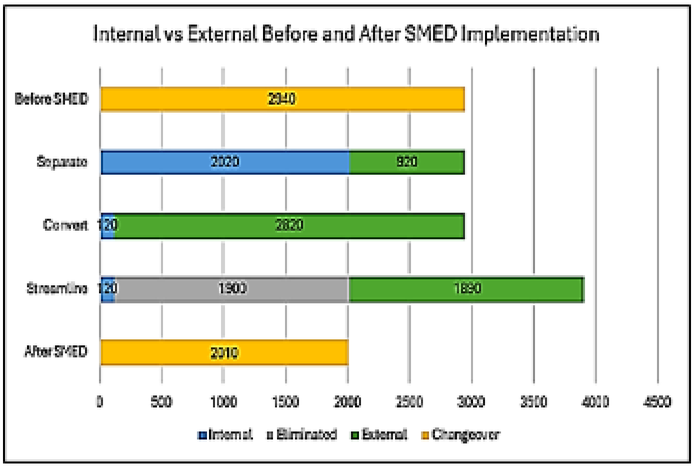

Figure 8: Changeover Time in Process Flow

Process Improvement

The Table 6 suggests improvements for machines through training and maintenance awareness, for methods by standardize batch setup procedures and cross-train staff, for materials through implement quality checks and collaborative supply chain tools, and for man by developing training curriculum and focus on employee retention.

Table 6
Improvement Proposal

:actor	**Root Cause**	**mprovement Proposal**
Machine	Inadequate maintenance protocols	· Establish Preventive Maintenance Schedules · Enhance Training for Maintenance Teams · Implement Predictive Maintenance Tools
Method	Lack of streamlined batch setup processes	· Standardize Batch Setup Procedures · Invest in Automation · Cross-Train Staff
	Absence of structured pre-batch preparation	· Pre-Batch Checklists · Assign Batch Setup Responsibility · Optimize Tool Organization
Material	Lack of robust supply chain management	· Supplier Performance Audits · Inventory Buffer Zones · Collaborative Supply Chain Tools
	Weak supplier quality assurance mechanisms	· Implement Incoming Quality Checks · Supplier Quality Agreements · Supplier Training Programs
Man	Insufficient investment in employee training programs	· Develop Training Curriculum · Use E-Learning Platforms · Conduct Knowledge Audits
	Ineffective recruitment and workforce management strategy	· Streamline Hiring Processes · Focus on Employee Retention · Use Workforce Analytics

Control Method after Applying Proposal

The Table 7 outlines the control method in order to sustain the implementing improvement with training and checks through appropriate action. This improvement monitored using records, checklists, and audits.

Table 7
Control Method

Factor	Proposed improvement	Control Method
Machine	Preventive Maintenance Schedules, Maintenance Team Training, Predictive Maintenance Tools	Track schedules, audit records, and use IoT alerts for proactive failure notifications.
Methods	Standardized Setup Procedures, Pre-Batch Checklists, Tool Organization, Automation, Staff Training	Monitor setup times with KPIs, digitize checklists, review task assignments, and audit tools regularly.
Material	Supplier Audits, Quality Checks, Inventory Buffers, Collaborative Tools, Supplier Training	Use analytics for demand forecasting, supplier scorecards, ERP for real-time flow, and automate quality checks.
Man	Training Programs, E-Learning, Hiring Optimization, Retention Strategies, Workforce Analytic	Track training via LMS, audit skills annually, monitor hiring metrics, and use feedback to refine programs.

Conclusion

The implementation of Single-Minute Exchange of Die (SMED) has proven to be a powerful strategy for improving efficiency, reducing downtime, and enhancing responsiveness in production environments. Originating from the Toyota Production System and developed by Shigeo Shingo, SMED's core principle—transforming internal setup activities into external ones—has enabled companies to streamline changeovers, minimize waste, and boost Overall Equipment Effectiveness (OEE).

This research focused on analysing and improving the changeover process within a food and beverage manufacturing environment. Through structured observation, data collection, and root cause analysis, the study identified key inefficiencies linked to prolonged internal activities, inadequate training, inconsistent material quality, and unoptimized workflows. The application of the SMED methodology led to a significant reduction in changeover time—from 2,940 seconds to 2,010 seconds—by reclassifying and streamlining tasks.

Moreover, tools such as Value Stream Mapping, Cause-and-Effect diagrams, and Why-Why analysis played a pivotal role in diagnosing performance gaps. Complementary Lean Manufacturing practices like 5S, Total Productive Maintenance (TPM), and continuous improvement frameworks helped build a foundation for sustainable progress.

Challenges such as workforce limitations, equipment maintenance gaps, and supplier quality issues were addressed with targeted solutions including training programs, preventive maintenance scheduling, standardized batch setup procedures, and improved inventory control. By applying these solutions, the organization not only improved its operational flow but also developed a culture of continuous improvement and cross-functional collaboration.

In conclusion, SMED is not merely a tool to reduce setup time—it is a catalyst for broader organizational transformation. When combined with Lean Manufacturing principles and supported by digital tools and engaged personnel, SMED enables companies to increase productivity, reduce waste, and enhance flexibility. This positions manufacturers to better meet dynamic market demands and sustain competitive advantage in an increasingly challenging industrial landscape.

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