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Applying Lean Six Sigma and SMED to Improve Pre-Assembly Operational Efficiency

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Abstract

In very customized production systems, even long pre-assembly changeovers continue to constrain productivity and on-target delivery. This research explores the extent to which Single Minute Exchange of Dies (SMED) can be embedded within a DMAIC methodology to reduce internal changeover periods throughout an assembly line. Through video analysis and interviews with floor-level employees, we were able to determine and quantify internal changeovers, also isolating non-value-added activity. Root cause analysis suggested operator movement and transport preparation, or better, its elimination through sharing and design, as an area of focus. The important message here is that internal changeovers can be reduced without investing heavily or changing layouts and equipment configurations.

Keywords
Single Minute Exchange of Dies (SMED); Pre-assembly changeover; Lean manufacturing; DMAIC; Setup time reduction

1. Introduction
Productivity is one of the important measures of efficiency in manufacturing, an ongoing stimulant for improvement in each production line (Dhawan 2024). Performance indicators monitor our progress by indicating how effectively we are working towards the achievement of objectives. They emphasize points helping to recognize the effectiveness

of success by indicating aspects of the achievements of the entity (Sujová et al. 2023). From the data available, it is clear that the measurability of productivity remains a subjective matter. Productivity is measurable by its efficiency in terms of the ratio of output to inputs. Also, by measuring the extent to which the final product is of use to the consumers (Dhawan 2024). In each production process, by monitoring productivity, organizations are enabled to detect inefficiencies in processes, improve their utilization of resources, and enhance their competitive advantage. In a production facility, these are usually observed: issues of waste and issues of setup times. The Single Minute Exchange of Dies (SMED) method is highly effective for reducing production setup time across multiple manufacturing contexts. Key strategies include rearranging workspaces, unifying tools, and preparing external elements before machine stoppage (Oliveira and Lima 2023). A previous study demonstrated that applying SMED techniques, including redesigning work procedures and equipment layout, significantly reduces changeover time and enhances production efficiency in automotive manufacturing (Niekurzak et al. 2023).

The research is conducted at a national company engaged in manufacturing electrical panels. The company is required to be able to increase the productivity of its production process on an ongoing basis, as an effort to save production costs, improve quality and competitiveness of the company. One of the problems at the company is often encountered on the production floor is problems related to the main frame production. The product to be studied in this study is the H.2000 W.500 D.900 free standing electrical panel product, while the object of research is the frame that forms the product. Due to the large number of H.2000 W.500 D.900 free standing electrical panel items that must be produced, production preparation activities are often carried out, and this is related to non-added value time.

This study's primary focus is on the assembly division, which oversees producing the electrical panel frame. The division is now dealing with a problem that is causing the time required to build a single electrical panel to grow. This problem is mostly caused by the waste of operator motion generated during manufacturing. Furthermore, components like plint, bolts, and screws are positioned in ways that need unnecessary motion on the part of the operator. In addition, the plastic wrapping of the product forces the operator to open the packaging before utilizing it.

When building a free-standing electrical panel, the goal of the entire section of the production process is to complete the entire production time in parallel, as shown in Figure 1. The assembly region generally aims to build the panel up to the halfway point, focusing on the major components crucial to holding up the rest of the panel's elements before the door, gasket, base, and finally, the roof is placed in their respective positions. This happens due to the third-party powder coating supplier, whose lead time may vary depending on the complexity of the parts to be coated. To minimize delays in the wiring and busbar sections, the assembly is completed in stages, with the final components installed after those sections are finished.

As illustrated in Figure 2, before the assembly process begins, materials such as screws, bolts, and gaskets are supplied by the Supply Chain Department. However, due to the wide range of product variations, the materials provided by SPC often do not match the exact quantities needed for the current assembly task. This discrepancy forces assembly operators to retrieve additional materials independently, resulting in delays and longer pre-assembly times.

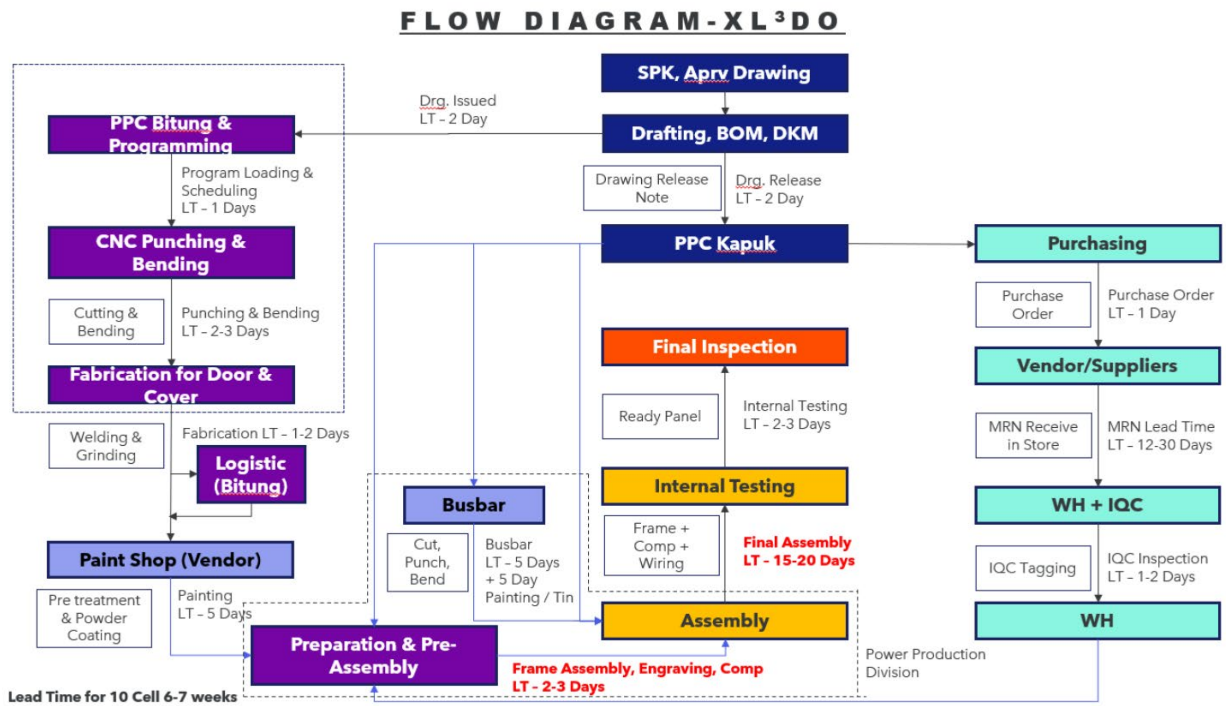

Figure 1. Flow diagram of free-standing electrical panel H.2000 W.500 D.900

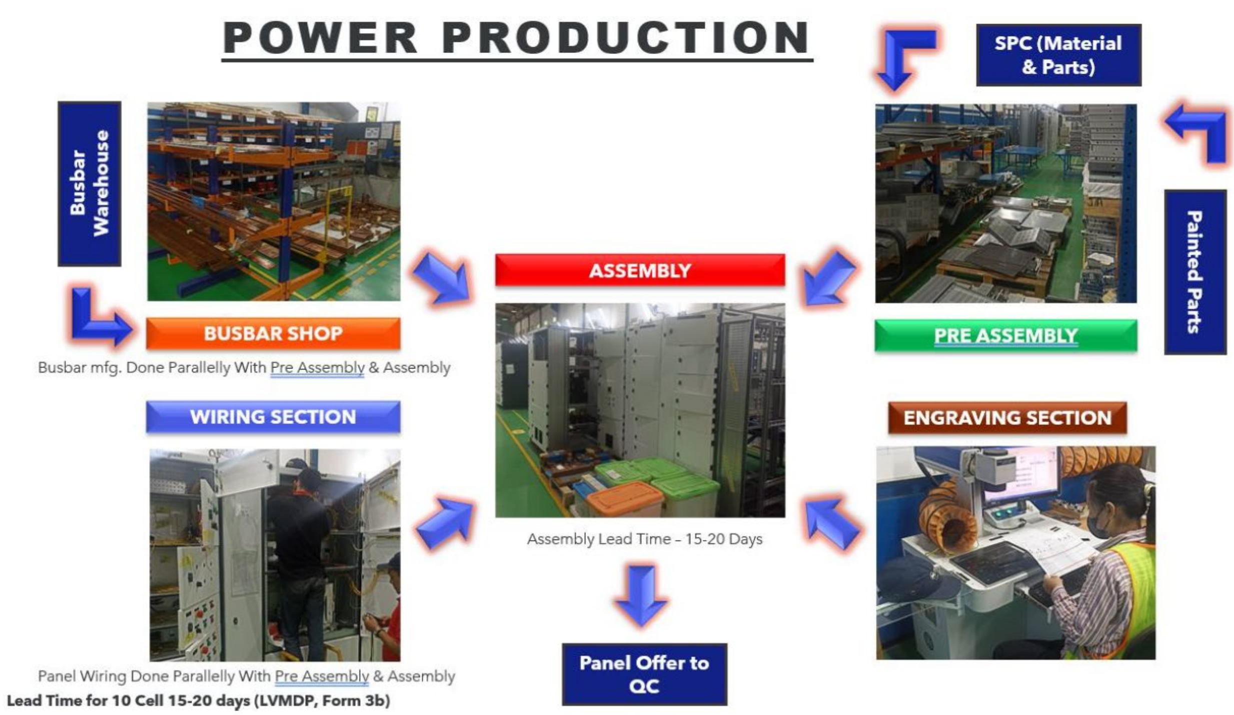

Figure 2. Electrical panel production process

2. Problem Formulation

The assembly of electrical panel production system has yet to be optimized. The issues are proven by the internal setup time, all activities that are done when production stops, that slow down the operator in finishing the required product before deadline. This cause the late shipment of the product and in worst case when the panel hasn't had its wiring, the wiring is done in site with one operator from the company wiring section is sent to do the job at site.

It is assumed that the company has all the necessary tools and machinery required for manufacturing the H.2000 W.500 D.900 electrical panel frames but faces operational inefficiencies mainly due to human factors and organizational workflow. The assembly division is primarily responsible for the observed delays in setup time, which impact on overall productivity. The issues are primarily with setup processes, including retrieving materials, preparing tools, and managing operator motion waste. Production floor layout optimization can significantly reduce manufacturing inefficiencies through strategic redesign of workspace, material flow, and operator workflows. Layout redesign could reduce workflow, material handling costs, and labor expenses (Kovács 2019). In a previous study, it was a reported reduction of 3.8% logistics movement, and 11% automated guided vehicle use by optimizing layout designs (Choi et al. 2024). This has been proven in different manufacturing environments, showing steady improvement in measurable outcomes when the layout configuration is addressed with optimization in mind. The principle here is that the prevailing production process is a fixed, repeatable, and predictable effort, with adjustments to the layout allowing an immediate reduction in the production cycle time. The company has set production aims and deadlines, forcing the production staff to attain production efficiency, but this has been threatened by the issues with the setup. It's assumed here that the operators use the skills they have to the fullest, but they use suboptimal procedures.

The study is limited to the pre-assembly process for the manufacture of the H.2000 W.500 D.900 electrical panel frame in the assembly division of the company. The purpose of the study is to zero in on the efficiency of setup and assembly processes in the factory concerned and not the overall processes in general. It also does not involve the stages of wiring, testing, or final assembly processes for the study. The suggestions for improvements from the study would therefore be specific to the factory in which the study was done. Although recommendations to relocate materials closer to the workstations could be made, radical changes in factory floor configuration or the acquisition of large pieces of equipment would not be required. The scope will be centered on workflow re-engineering, or workflow changes, relating to the placement of materials, motions, and workflow optimizations. The project will have a strictly limited time to carry out time studies, analysis, or implementation, restricting potential improvements that could be achieved. No assessment of SMED's overall productivity impact or benefits of post-implementation will be included.

Table 1 highlights literature references an evident trend of companies using structured improvement approaches to overcome productivity gaps, waste, and other inefficiencies in manufacturing processes, led by Lean, Six Sigma, and DMAIC. Historically, previous studies have focused primarily on the Define and Measure phases, with applications of methodolgies such as Value Stream Mapping, SIPOC diagrams, Pareto charts, Time studies, and performance analyses such as Overall Equipment Effectiveness (OEE), Run Time Yield (RTY), and Defects per Million Opportunities (DPMO) (Adeodu et al. 2020; Nurprihatin et al. 2024; Widiwati et al. 2025). For the Analysis stage, various root-cause analyses and solutions such as RCA, or FTA, and statistics-based and correlation analyses have been utilized extensively (Febriana and Hasbullah 2021; Nurprihatin et al. 2023a; Munyaka et al. 2024). The Improve stage, before implementation, has been reflected in SMED analyses, 5S implementations, and FMEA and SOP redesigns for setup reduction, mitigation, and elimination (Nurprihatin et al. 2023b). The Control stage is considered resolved with continuous control and Statistical Process Control (SPC) by various studies, while partial implementations of control have been documented.(Saptaji et al. 2024; Reihana et al. 2024). Based on this background, this current research differentiates itself from previous ones because it focuses on pre-assembling changeovers and systematically incorporates SMED within a DMAIC approach, with particular emphasis on transitioning internal changeovers to external ones. This targeted scope addresses a gap in existing literature, where changeover optimization at the pre-assembly level remains relatively underexplored despite its critical impact on downstream production performance.

Table 1. Related works

No	Author(s)	Research Objective	Define Phase	Measure Phase	Analyze Phase	Improve Phase	Control Phase
1	(Widiwati et al. 2025)	To analyze the performance of the manufacturing operation and to minimize waste	VSM	RTY, Pareto chart, control chart, DPMO	RCA	Recommendation plan	Monitoring
					FMEA	5S, FVSM	
2	(Adeodu et al. 2020)	To optimize the production process by minimizing machine downtime	Pareto Chart	Overall Equpment Effectiveness (OEE)	RCA	Single Minutes Exchange of Die (SMED)	Standard Operation Procedure (SOP)
						5S (Sort, Set in Order, Shine, Standardize, Sustain)	
3	(Munyaka et al. 2024)	To optimize the line manager's activities and reduce wasteful actions	Time Study	Time Study	RCA	Goal setting	Monitoring
					Statistical Process Control, Pareto Chart		
4	(Febriana and Hasbullah 2021)	To increase value added and reduce defect	SIPOC	Statistical Process Control	FTA Diagram, MLR, Correlation Analysis	FMEA	Monitoring
			Pareto Chart				
5	This Paper	To optimize changeover time and recommend operational efficiency	SIPOC	Time Study	RCA	Recommendation plan, Single Minutes Exchange of Die (SMED)	-

3. Methods

The Methodology that is used in this study are as follows:

a. Company Time Study
   Time study is collected from various sources, such as company documentation, company manuals, and other documentation that contain the required data. Moreover, secondary data can also be obtained from various types of literature outside of company documentation, such as research journal, article, and information book that has required information. In the form of literature analysis.

b. Time Study Analysis
   The main data of this study is collected through video analysis and interview methods that are carried out by directly asking with the source related to the object being observed at, with the guidance of the field supervisor. The interview is used more as a validation and verification of video analysis data that is given directly by the company.

c. Interview and Discussion
   Time Study using Interview and discussion is carried out by asking questions and discussing directly.

d. DMAIC Analysis

DMAIC (Define, Measure, Analysis, Improve, Control) analysis is utilized to analyze and solve problems related to the free-standing electrical panel changeover time. However, this analysis doesn't include the control stage due to limited observation and the application of the Improve Phase.

e. Conclusion
From the results obtained, the suggestion and improvements areas of analysis for changeover time of free-standing electrical panel is presented to decrease the total amount of internal time present during pre-assembly.

4. Results and Discussion

Setup time is the accumulation of time that occurs on a machine/equipment when it cannot operate due to other activities that must be carried out, so that at that time it does not produce a product/output, while downtime is the setup time that exceeds the specified time.

To reduce setup time, pre-assembly needs to be done in the shortest possible time using an effective and efficient method. One method that can be used to analyze and improve pre-assembly production is the SMED method as a technique developed in lean manufacturing studies where pre-assembly needs to be done in the shortest time possible.

4.1 Define Phase

At the define phase, the mapping out of the production process is carried out through the Supplier Input Process Output Customer (SIPOC) Diagram to identify which of the activities is needed to optimize. Figure 3 illustrates the stage of production process starts from parts and material preparation (Profile, Bottom cover, Top cover, and other materials) than sort it according to each specification which is set manually by SPC operator.

Based on the time study taken directly in the company, in the period of June to August 2024, the percentage of internal activities currently present in the process is around 15% of total process time, as shown in Figure 4. Although this number may look small, pre-assembly is the first value added activities that is crucial to start other section in the production process

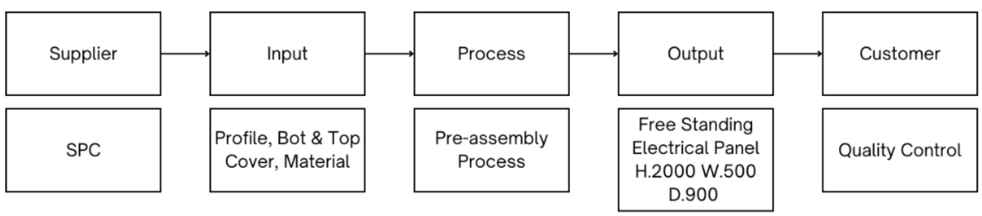

Figure 3. SIPOC diagram

To improve the define phase of this study, Pareto Chart also been utilized to show the priority concern of internal changeover happening in the company. Figure 4 are the Pareto Chart for Define Phase.

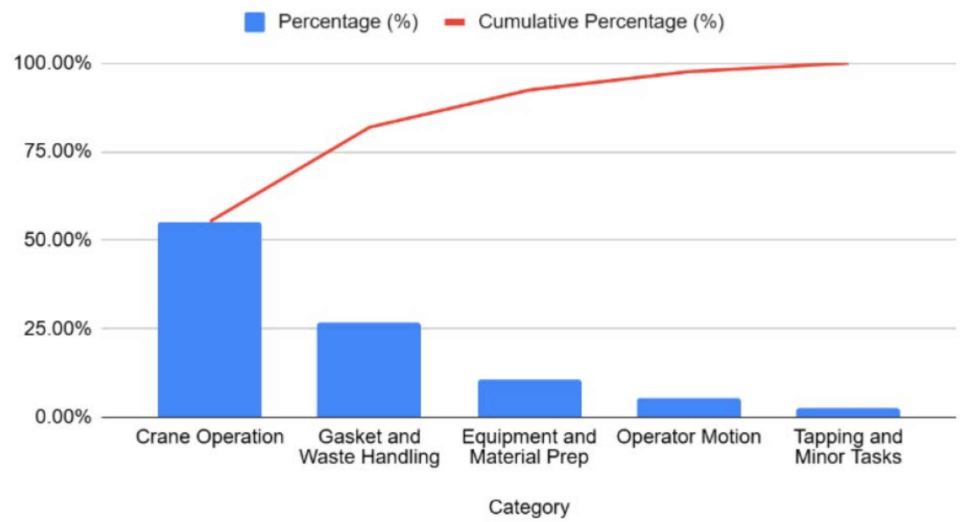

Figure 4. Pareto chart

Table 2. Time study based on category

Step	Changeover Activities	Activities (External or Internal)	Changeover Time (Sample) (seconds)										Average Changeover Time (seconds)
			1	2	3	4	5	6	7	8	9	10	
1	Production preparation	Internal	86	121	90	118	72	123	111	85	85	108	100
2	Operator changes the position of the top cover workpiece	Internal	34	26	24	41	23	38	20	19	24	30	28
3	Tapping top cover	External	34	41	32	38	33	36	34	37	42	35	36
4	Operator changes the position of the bottom cover workpiece	Internal	30	30	28	25	28	30	25	29	27	29	28
5	Tapping bottom cover	External	77	85	102	80	107	107	90	82	85	106	92
6	Bot cover installation	External	186	154	164	153	179	145	150	180	155	184	165
7	Operator picks up bag of couplers	Internal	36	50	49	45	35	40	45	37	35	41	41
8	Operator opens package of couplers	Internal	12	20	18	13	18	14	13	13	12	16	15
9	3-way joint take-up	Internal	44	44	55	46	56	41	50	49	57	58	50
10	Gasket installation top cover	External	340	348	323	348	331	316	290	290	353	292	323
11	Top cover lid installation	External	421	421	445	460	442	410	450	418	475	458	440
12	Equipment changeover between operators	Internal	143	153	146	164	152	139	150	142	148	153	149
13	Main frame assembly	External	800	787	792	802	793	797	793	798	784	786	793
14	Operator changes the position of the main frame	Internal	43	41	43	44	45	44	45	45	41	43	43
15	Operator takes the ladder	Internal	105	110	100	115	110	108	100	106	115	111	108
16	Frame gasket installation	External	1036	1076	1049	1046	1069	1066	1065	1075	1073	1077	1063
17	Operator disposes of gasket waste	Internal	46	50	44	52	51	45	52	53	50	53	50
18	Top cover installation	External	168	174	166	175	178	173	165	168	171	169	171
19	Use of crane for bottom cover installation	Internal	255	262	248	248	260	253	259	255	262	250	255
20	Bottom cover + flint installation	External	213	220	222	220	217	213	214	213	213	216	216
21	Operator moves ladder position	Internal	35	34	36	35	29	36	35	27	27	27	32

Step	Changeover Activities	Activities (External or Internal)	Changeover Time (Sample) (seconds)										Average Changeover Time (seconds)
			1	2	3	4	5	6	7	8	9	10	
22	Mounting side installation	External	345	348	346	346	345	352	344	345	347	344	346
23	Flint cover + upright installation	External	441	439	464	463	451	456	442	441	456	461	451
24	Side and back cover installation	External	853	842	842	846	836	850	834	837	846	853	844

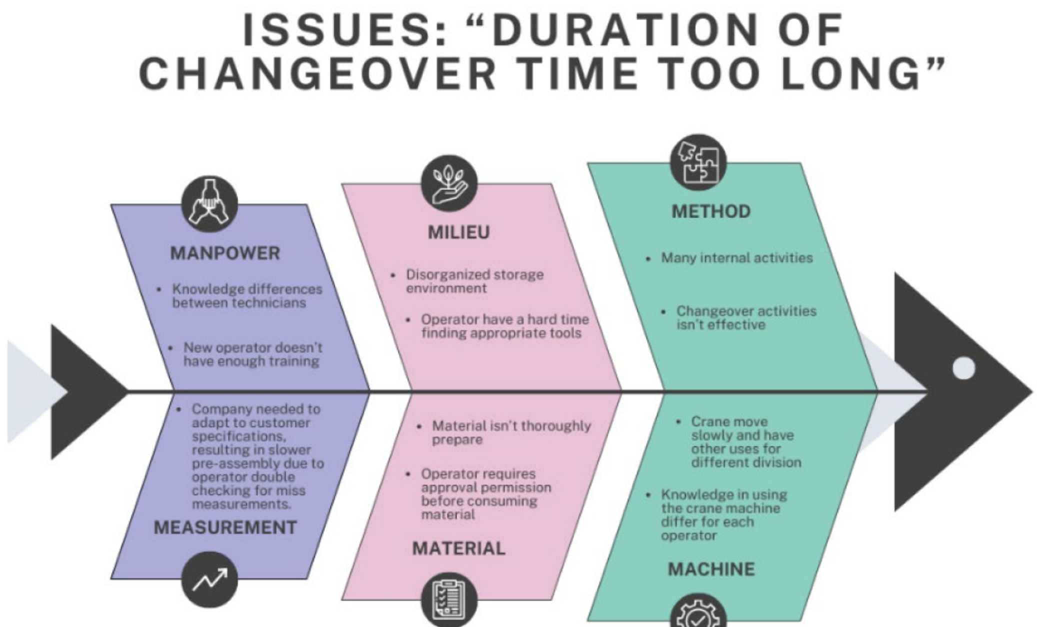

Figure 5. Fishbone diagram

4.2 Measure Phase
The Measure Phase is a measurement stage where the activities carried out are taking measurements, in this case the cycle time of each pre-assembly activity. Table 2 explains the changeover time for each assembly activity based on category.

4.3 Analyze Phase
The analysis stage is the stage of analyzing assembly activities. This is done to understand the root causes of the problem at hand. To find out the real root of the problem, it is necessary to analyze using a fishbone diagram as shown in Figure 5.

Analysis of Machine
The crane used in the assembly process is a multi-purpose resource, which creates delays due to shared usage with other divisions, such as quality control and packaging. Moreover, the type of crane that the company uses is hoist crane which moves slowly but precise in movement, as shown in Figure 6. The results in frequent scheduling conflicts, slowing down the pre-assembly process. Furthermore, only skilled operators are authorized to use the crane, which can create bottlenecks if qualified operators are occupied with other tasks.

The study also highlights how machine-sharing practices can also impact on the production schedules as well as the flow of work. Obviously, there is a need for experienced people, and that is where an opportunity exists, which is to elevate crane operating competency to increase the number of people who possess and utilize that skill. When we address all this, it will enable the assembly team to work on its own schedule rather than have to rely on outside scheduling. On a final note, addressing this will reduce the overall lead times.

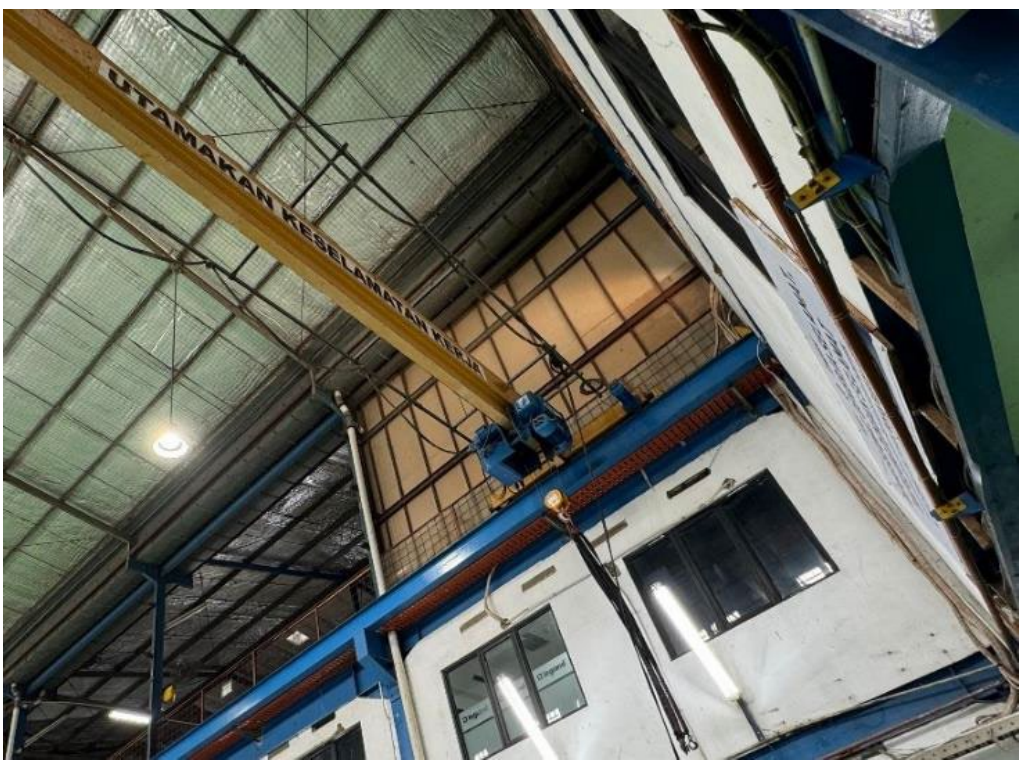

Figure 6. Hoist crane machine

Analysis on Man
In assembly line production, experience becomes a key factor in setup times. Trainees are usually slower than accomplished operators, and there is a difference in pace that results in inefficiency during setup procedures. Trainees require additional supervision, particularly on vital steps, reducing streamlined processes in favor of dedicated operators. Trainee projects may benefit from special training to increase production.

This would also help to ensure uniformity of production output within the crew and remove the "hinge" function of having a few very knowledgeable individuals on board. A better training process would help to ensure uniform setup times and enable productivity gains through handoffs. Assigning trainees to trainers would also enable them to learn faster and result in quicker and more satisfactory completion of setups.

Analysis on Method

From the analysis, a considerable amount of time has been utilized internally while the production process has been held. A considerable amount of time, around 899 seconds, has been taken internally. The prolonged time taken internally indicates inefficiencies that should have been optimized by performing activities externally. Completion of preparations for production externally would enhance a smoother flow of setup.

Figure 7. Assembly process for bottom cover installation

As it exists today, there are many stops and restarts in this process, extending the entire process in total. As an example, they must stop so they can call in the crane to raise the mainframe, which aids them in setting in the low cover of their electrical panel, as seen in Figure 7. By delegating their work differently, this process might become smoother, thus productivity increases. A more optimized way of this process might help in integrating setup and production smoothly, so they can perform their duties without any interference. Reducing internal setup time allows them to adhere to the philosophy of eliminating waste.

Analysis on Material

Lack of material availability before assembly makes the process slower since the operators are forced to walk away from their stations to fetch the missing materials. Lack of coordinated resupply makes the process slower. The current solution offered by the company involves passing on the materials wrapped in packaging to the operators to manually open. Figure 8 shows how unnecessary, additional movement creeps into a system.

It would be a proactive approach for the inventory, thereby reducing the activity of the operators and making it easier to set up. By eliminating the activities that do not provide value to the process of creating something, such as the retrieval of material, the time consumed for setup can be reduced. It will create a smooth process of assembly through a consistent and reliable supply of material.

Figure 8. Package couplers

Analysis of Environment (Milieu)

Currently, storage of tools and materials in the region is messy, as indicated in Figure 9. As a result, setups take longer because the involved operators must look for what they need. Organized storage of materials and tools will significantly reduce setup times.

Figure 9. Operator toolbox

Workspace optimization is a parallel application of lean manufacturing concepts, such as the 5S method. The very essence of 5S is built upon arranging and purging in order to have a clutter-free and efficient environment. Establishing standardized storage locations for frequently used tools and materials would eliminate the time wasted in searching. Additionally, clear labeling and structured layouts could contribute to better overall workspace management. This reorganization would facilitate a faster and more efficient pre-assembly process, reduce setup times and enhance productivity.

Analysis of Measurement

Measurements, in this case, are layout (blueprint drawing) that plays a crucial role in determining the measurement of main frame. Even though in this study a fixed size free-standing electrical panel H.2000 W.500 D.900 the company needs to adapt to the customer specification. Therefore, a free-standing panel with a height of 2175 cm is still categorized as free-standing electrical panel H.2000 W.500 D.900. With this issue pre-assembly has taken a slower time due to operator double checking any missed measurement given by the drafting team.

4.4 Improve Phase

At the improvement stage recommendations for improvement will be made using the SMED method to reduce mold change time.

1. Step 1
   This is done by using several useful approaches to reveal the real operating conditions on the production floor. Based on the Define and Measure Phase. There are 34 setup activities with a duration of 5680 seconds/setting.
2. Step 2
   Changing internal settings to external settings, double-checking each operation to see if there are any incorrect steps that are assumed to be internal settings, looking for ways to change the steps to external settings.

Table 3 presents a structured classification of pre-assembly changeover activities and highlights the application of the SMED principle to distinguish between internal and external setup tasks. Based on the analysis, it can be noted that a major chunk of the changeover time comes from tasks that were previously categorized as internal, such as preparatory production, movement of materials, removing or obtaining equipment, and operator movement, which altogether result in unnecessary production downtime. To understand SMED effectively, a major aspect involves moving such internal procedures to external ones when the machine is operating by effectively preparing equipment, materials, and machines just before the machine shuts down (Oliveira and Lima 2023). Specific gains include pre-staging of couplers and joints, packaging with advanced openings, equipment assignment before changeovers, and relocation of ladders and waste containers near to working. However, some activities must inherently remain internal because of their limitations or reasons related to safety considerations, thereby proving that not all activities will be made external, such as moving other products or changing the bottom cover with a crane. Based on the table, it can be explained that with smart activity categorization and minor changes, a significant reduction is seen in internal processing, increasing pre-assembly productivity without any renovation or major investment that fits lean principles (Adeodu et al. 2020; Oliveira and Lima 2023).

Table 3. Changeover activities

Step	**Changeover Activities**	**Average Changeover Time (seconds)**	**Current Activity Classification**	**Improved Activity Classification**	**Changes**
1	Production preparation	100	Internal	External	Ensure all tools/materials are prepared near the operator workstation.
2	Operator changes the position of the top cover workpiece	28	Internal	Internal	Consider standardized workstations to reduce the need for repositioning.
4	Operator changes the position of the bottom cover workpiece	28	Internal	Internal	
7	Operator picks up bag of couplers	41	Internal	External	Place couplers closer to the setup area or at the workstation beforehand.
8	Operator opens package of couplers	15	Internal	External	Pre-open and stage couplers prior to setup by putting it in an open box.
9	3-way joint take-up	50	Internal	External	Pre-position 3-way joints in a ready-access area near the setup location.

Step	Changeover Activities	Average Changeover Time (seconds)	Current Activity Classification	Improved Activity Classification	Changes
12	Equipment changeover between operators	149	Internal	External	Prepare and assign equipment before the setup process starts to avoid changeover delays.
15	Operator takes the ladder	108	Internal	External	Pre-position the ladder at the work area before the setup begins.
17	Operator disposes of gasket waste	50	Internal	External	Prepare a waste bin nearby for quick disposal or handle waste management during non-setup time.
19	Use of crane for bottom cover installation	255	Internal	Internal	Method of installation needed to change to assemble each part from bottom up.
21	Operator moves ladder position	32	Internal	External	Pre-position the ladder before setting up or assign a second person to handle ladder positioning if feasible.

4.5 Control Phase
The time limits of this study make it possible for us only to present recommendations and stop the DMAIC analysis at the improvement phase without entering the Control Phase.

5. Conclusion
The analysis and improvements are indicative of operational inefficiencies hitting production performance hard. Through the application of SMED, we were able to identify areas that needed improvement, such as the internal setup time, materials handling, and the working environment. More importantly, it should be noted that improving assembly by remodeling setup activities from internal into external activities reduces non-value-added activity in pre-assembly.

Lean methodologies, such as 5S or process standardization, maintain focus on organization and efficiency. Activities such as pre-stage processing, intelligent toolbox optimization, focus on minimizing unnecessary movement on the part of operators, while optimizing setup time. Overcoming human resource issues through training and mentorship will assist operators in handling more complicated setups, further minimizing wait times for the assembly line.

Thus, this paper promotes learning experience in identifying and mitigating the ineffectiveness in the production process by analyzing it in a structured way. The result obtained from the SMED method, or the lean process verifies the success gained in making the processes more efficient. The learning obtained from the project can benefit the firm as well as the learning obtained can form a firm foundation in similar areas of the business being addressed.

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Biographies

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Filscha Nurprihatin holds a position in the Department of Industrial Engineering at Sampoerna University in South Jakarta, Indonesia, while pursuing his PhD in Industrial Engineering. His current research interests include supply chain management, decision support systems, multiple criteria decision making, optimization in logistics, insurance, and service operations, business improvement, and automation. His published works include those in esteemed Scopus-indexed journals and proceedings of international conferences, where he concentrated on using analytical techniques for practical purposes in industry and the services sector. His work aims at transforming theoretical findings of academia into applications, where these applications relate to the selection of suppliers, performance evaluation, satisfaction of customers, environmentally sustainable supply chains, and decision-making in the operation of organizations. On a broader scale, in addition to theoretical works, he also pursues other avenues of applied research that focus on using engineering analytics for decision-making in industry and other applications for the benefit of society as a whole and for industry, in particular. His other areas of research interest include decision-making using data, methods of continuous improvement, and incorporating engineering analytics in management decisions.

Kadek Ayu Alda Verena is associated with the Department of Industrial Engineering at Sampoerna University in South Jakarta, Indonesia. Her research interest areas include operations management, lean manufacturing, and productivity analysis in industrial systems. She was involved in projects concerning improving processes, optimizing changeovers, and applying structured problem-solving methodologies such as DMAIC and SMED. Her research helps identify non-value-added activities in an operation, providing recommendations that increase operational efficiency.

Ali Vaezi is on the faculty in the Department of Logistics and Supply Chain Management at Trent University in Canada. His main areas of research interest include supply chain strategy, logistics optimization, and the development of state-of-the-art decision-support models with a focus on complex, uncertain environments. He integrates analytical modeling with quantitative methods and data-driven approaches, enabling better network design, improved network performance, and enhanced resilience. His work often stands at the junction between supply chain analytics, sustainability, and risk management, dealing with contemporary challenges faced by organizations, such as disruption, environmental footprint, and the requirement of coordinated strategies across multi-tier supply networks. His findings have been either published or are forthcoming in international, peer-reviewed journals and conference proceedings, reflecting both theoretical and practical contributions to the field of supply chain and operations management. In addition to his research work, he teaches and supervises undergraduate and graduate students in how to translate theoretical models into industry-ready solutions. His general academic interests involve issues related to sustainable supply chain management, performance measurement, and the use of analytics to support managerial decisions for effective supply chain networking.

Devi Yurisca Bernanda is part of the Department of Digital Business at Universitas Bunda Mulia in North Jakarta, Indonesia. Her specialization lies at the heart of digital transformation, including business processes optimization and analytics-driven decision-making. She conducted research and projects on digital business models, operational analytics, and technology-based performance improvement. Her research emphasizes the use of digital tools and information systems in enhancing organizational effectiveness and supporting strategic decisions. More generally, her interests are in innovating business processes, managing digital operations, and using analytics to compete in rapidly changing markets.