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Efficiency Improvement in The Electrical Accessories Production Line Using Lean Strategies

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Abstract

This case study objective is to improve efficiency in electrical accessories production line using Lean tools particularly Single Minute Exchange of Die. Single Minute Exchange of Die denotes principles, methodologies employed to minimize equipment setup durations. Single Minute Exchange of die aims to achieve setup times of under ten minutes, specifically a single-digit number of minutes. More internal setup and changeover time. Impacted stake holders in the organization due to the above challenges are Production, Logistics, Finance and Supply chain sectors. This case study focuses on reduction of the changeover time in manufacturing line to satisfy client needs on time. Digital concepts have not touched upon through SMED. This can be adopted for the changeover reduction in the process followed in shopfloor. Through this case study, Lean implementation hourly rate improvement and capacity increased, industrial efficiency improved, change over time reduced, movement waste drastically reduced. All Customer orders were secured within short span of time. Setup time has been optimized to a greater extent in electrical accessories production line.

Keywords: *Efficiency Improvement, Changeover Time, Efficiency, SMED, Cycle Time, Setup Time.*

1. Introduction

Lean manufacturing is the one of the collective method by which the productivity, quality and efficiency of the customer demand and satisfaction the customer lead time gets improved with low material handling cost, labor efforts and without it wastages which are also not value adding activities. Utilization of existing resources and enhancing value addition can also be called for. The value to the material simply means any change in the material - either shape, size, color or reason for its usage or all of these for which the Client is accepting to provide more. In essence, Lean manufacturing is applied to any manufacturing or service industry, large or small. Adoption of lean manufacturing techniques could improve the working culture and give a better environment to serve. To fulfil the Customer need and to be effective, manufacturing industries needs to increase their flexibility in manufacturing multiple variants of products in the industry they are. How ever this multiple variant manufacturing will lead to most significant increase in setup time. In this Thesis the SMED technique, Lean Management Concepts are employed to increase Productivity, operational availability and Overall Efficiencies of the Electrical accessories Product line. Selective industries were taken and case study was conducted and SMED was deployed to minimize the changeover time to multiply productivity and improve efficiency in product line. The internal and external activities were studied in detailed and potential activities were parallelly conducted to reduce cycle time and increase productivity. The efficiency improvement using SMED technique was very well implemented in electrical accessories product lines. It is useful to understand that there are two main types of improvement when using SMED: Human: accomplished by planning and structuring; Technical: accomplished by means of engineering.

Human factors can usually be improved far more quickly and at a lower cost than technological ones, according to experience. To put it another way, the human factors typically yield the fastest results. Steer clear of the temptation to concentrate too much on technical aspects, particularly when working with highly skilled teams. Rather, start with the human aspects [1-5].

2. Literature Review

Equipment setup times are reduced using the Single Minute Exchange of Die (SMED) theory an techniques. The goal of SMED is to reduce setup times, for example, from a double digit (i.e. the traditional setup time) to a single digit (in task terms, essentially a very short time). Although not all setups can be literally reduced to this period of time, between one and nine minutes it is within the realm of the SMED methodology (Shingo, 1985). Prasanna, S. G., Kadam, A. A., Vignesh, S., & Raja, K. A. A. (2025) examined the use of the lean manufacturing concepts in production settings, emphasizing critical techniques such the 5S system, Just-In-Time (JIT) production, Kaizen, Value Stream Mapping (VSM), and Total Productive Maintenance (TPM).And also illustrated how lean principles foster operational excellence and sustained profitability via the analysis of case studies and industry examples. Sunny, A. M. U., (2024) unveiling spatial insights: navigating the parameters of dynamic Geographic Information Systems (GIS) analysis. Mohammad, A., Hamja, A., & Hasle, P. (2024) illustrated Reduction of changeover time through SMED with RACI integration in garment factories. S M Mustaquim. (2024) utilized remote Sensing Data and ArcGIS for Advanced Computational Analysis in Land Surface Temperature Modeling European Lean Educator Conference. Cham: Springer Nature Switzerland, (2023) explained the impact of SMED on Productivity and safety. Selim Molla, Iqtiar Md Siddique, Anamika Ahmed Siddique, Md. Minhajul Abedin (2023). Securing the Future: A Case Study on the Role of TPM Technology in the Domestic Electronics Industry amid the COVID-19 Pandemic. Ullah, M. R., Molla, S., Siddique, I. M., Siddique, A. A., & Abedin, M. M. (2023) done research on Manufacturing Excellence Using Line Balancing & Optimization Tools. Ullah, M. R., Molla, S., Siddique, I. M., Siddique, A. A., & Abedin, M. M. (2023). Optimized the Performance and also conducted a deep dive into Overall Equipment Effectiveness (OEE) for Operational Excellence. Fayshal, M. A., Ullah, M. R., Adnan, H. F., Rahman, S. A., & Siddique (2023), I. M. evaluated multidisciplinary Approaches within an Integrated Framework for Human Health Risk Assessment. Ullah, M. R., Molla,S., Siddique,M.I., Siddique,A.A., Abedin,M.M .(2023). Utilized the Johnson's Algorithm for Enhancing Scheduling Efficiency and Identifying the Best Operation Sequence. Utama, D. M., & Abirfatin, M. (2023) aimed to propose a new framework for evaluating Manufacturing Sustainability based on lean Six Sigma and Sustainable Manufacturing concepts using Sustainable Value Stream Mapping (Sus-VSM). Iqtiar Md Siddique, Anamika Ahmed Siddique, Eric D Smith, Selim Molla. (2023) Assessed the Sustainability of Bitcoin Mining: Comparative Review of Renewable Energy Sources Selim Molla, Md Minhajul Abedin and Iqtiar Md Siddique. (2023) explored the versatility of medical textiles. Rathi, R., Vakharia, A., & Shadab, M. (2022) systematically reviewed the research studies conducted on LSS in the healthcare sector. Yadav, G., & Desai, T. N. (2022) investigated organizational culture's impact on lean methods and operational performance through evidence from Indian manufacturing SMEs. Hardcopf, R., Liu, G. (jason), & Shah, R. (2021) evaluated the role of one critical contextual variable, organizational culture, in realizing operational improvements from lean. Mohan Prasad, M., Dhiyaneswari, J. M., Ridzwanul Jamaan, J., Mythreyan, S., & Sutharsan, S. M. (2020) studied the framework of lean implementation in Indian textile industry. Noman, A. H. M., Das, K., & Andrei, S. (2020) done a modified Approach for Data Retrieval for Identifying Primary Causes of Deaths. Sinha, N., & Matharu, M. (2019) made a comprehensive insight in to lean management Literature review and its trends. Noman, A. H. M. (2018). WHO Data done a modified approach for retrieval (Doctoral dissertation, Lamar University-

Beaumont). Yadav, G., Jain, R., & Soni, U. (2018) studied the influence of lean methods on operational performance through an empirical study of Indian process industries. Godina, R., Pimentel, C., Silva, F. J. G., & Matias, J. C. O. (2018) made a structural review of the single minute exchange of die. Kumar, R., Shankar, R., & Thakur, L. S. (2018). researched on implementing sustainable manufacturing practices in Indian manufacturing companies. Das, D., & Kodali, R. (2018) investigated on the Lean production practices and bundles. H.T.S. Caldera, C. Desha, L. Dawes (2017) done a detailed investigation study on the systematic literature review of how the implementation of lean and green initiatives could lead to sustainable business practice. Hasan, M. R., Hossain, M. S., & Rahman, K. P. (2017) investigated the design and construction of a portable charger by using solar cap. Fayshal, M. A., Jarin, T. T., Ullah, M. R., Rahman, S. A., Siddque, A. A., & Siddique, I. M. A (2017) Comprehensive Review of Drain Water Pollution Potential and Environmental Control Strategies in Khulna, Bangladesh. Dora Manoj, Kumar Maneesh & Xavier Gellynck (2016) done a detailed research and case study on the Determinants and barriers to lean implementation in food processing SMEs. Rajesh, R., & Ravi, V. (2015) deployed Lean management practices to improve supply chain performance of leather footwear industry. Patil, S. K., & Laishram, B. (2015) probed the role of lean practices in enabling BIM adoption. Narang, H. K. (2015) categorized a roadmap for implementing lean in the Indian auto component manufacturing sector. Alves, J.R.X., & Alves, J.M. (2015). Studied the Production management model integrating the principles of lean manufacturing and sustainability supported by the cultural transformation of a company. Juthamas Choomlucksanaa et al. (2015) studied the improvement in the productivity of sheet metal stamping subassembly area using the application of lean manufacturing principles. Ramesh, A., & Kodali, R. (2015) laid an application of lean in Indian process industries through Some empirical evidence. Singh, B., & Garg, S. K. (2015) has successfully done a case study on lean approaches in the equipment manufacturing industry. Yadav, G., & Desai, T. N. (2015) studied a impact of lean practices on performance measures in the Indian machine tool industry. Jasti, N. V. K., Sharma, A., & Kodali, R. (2014) illustrated the Human resource management implications of adopting the Toyota lean culture paradigm to India. Shakil, M., Ullah, M. R., & Lutfi, M. (2013) demonstrated the Process flow chart and factor analysis in production of jute mills. Sharma, R. K., Dixit, A. R., & Pandey, P. M. (2013) done A strategic and operational approach to assess the lean performance in radial tyre manufacturing in India through a case study approach. Vinodh, S., Aravindraj, S., & Chintha, S. K. (2013) made a structural model for assessment of lean manufacturing practices. Ramesh, A., & Kodali, R. (2013) laid a framework for assessing lean manufacturing implementation in the Indian automobile industry. Pius Achanga, Esam Shehab, Rajkumar Roy and Geoff Nelder (2012) presented the critical factors that constitute a successful implementation of lean manufacturing within manufacturing SMEs. Dabhade, N., & Karandikar, A. M. (2012) explained the Lean Six Sigma approach for quality monitoring. Bhamu, J., & Sangwan, K. S. (2012). reviewed the LM literature and report these divergent definitions, scopes, objectives, and tools/techniques/methodologies. Achanga, P., Shehab, E., Roy, R., & Nelder, G. (2012) defined a scale to measure the applicability of lean practices in IT support services. The researcher after accomplishing a complete and detailed review of the literature of the current research study summarize the findings and observations of related previous research works [6].

2.1 Problem Statement

As the Electrical accessories product line faced challenges, There was a higher manufacturing cost, bigger lot sizes and there was a delayed responsiveness to Customer demand, Inventory levels were very high and there were longer startups and changeover process was non standardized. Here the above challenges have affected the below sectors of organization: Production, Logistics, Finance and supply chain. This study is mainly focused on optimizing the change over time to meet Customer demand on time without any delivery failures [7-12].

2.2 Objective of Study

Objective of study is to Case study on the electrical accessories production line using lean tools and main aim to reduce the changeover time and in turn improving productivity and to meet the Customer demand on time without any delivery failures [13-20].

3. Methodology

The processes and procedures of collecting and analyzing data on a study topic is known as research methodology. It refers to the practice of how researchers set up their study so it will accomplish what they intended with the study tools available to them. These principles will help you know what the research methodology is, but you must know why choosing the ideal technique is important. The research helps the researchers to frame hypothesis depend on the suggested observations. The researcher can quickly respond to any inquiries regarding the research. It helps researchers decide which is the best research design, sampling approach and data collection and analysis method to use. A sound research methodology not only helps a researcher to know for sure that what they found is valid, accurate and free of biases and errors but is essential for the researcher to make certain. This also ensures that to conduct the research is done properly and ethically. A good research methodology ensures arranging of research by the researchers. While undertaking a research study, the researcher has to consider some crucial aspects which includes framing the detailed research design and objectives; Setting the sampling design; Developing the tool for collecting the data (Questionnaire or Schedule of Observation sheet), Reviewing the available literature to discover any knowledge gaps and to analyze and interpret the research study findings. It is advisable to check for the statistical requirement if the study is data-driven nature or if the statistical outcomes are required, quantitative research is the best option. Qualitative research is best suited for research study that can be analyzed using people's views and perceptions. Sample size is commonly determined and used based on the examination of the feasibility of a research methodology. The methodologies have been adopted to reduce the setup time in order to improve efficiency and productivity improvement. Non value added activities to be listed and reduction plan to be made to improve value added activities. This Case study uses Qualitative such as observational technique and also Quantitative tools such as Experiments, analysis of secondary data [21].

3.1 Adoption of Single Minute Exchange of Dies in Electrical Accessories Production Line

The Single Minute Exchange of Dies (SMED), as described by Shingo, posits that a changeover—the switch from manufacturing one product variant to the next—should be completed in a single-digit time frame, specifically under 10 minutes. The methodologies developed to achieve changeovers within these short timeframes were then implemented in manufacturing sectors to minimize downtime between batches, employing various tools and techniques. According to current practices, a key step in SMED is distinguishing between internal and external activities by analyzing the process, optimizing changeover steps, and providing ongoing training. The expected results of profitability will be reflected in increase in a product output having an economic benefit. While reducing the changeover time further will also result in completely new Non Value added achievements like more ergonomic conditions, standardization, teamwork and workload is expected as well [22-30].

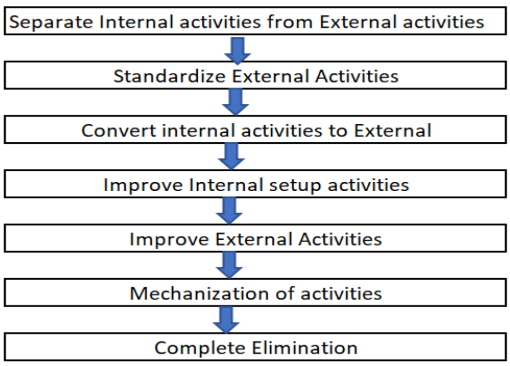

Figure 1 Setup Changeover Time Reduction Steps

Source: Process and Time Study Conducted in The Case Study Industry

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According to Figure-1, seven steps to reduce changeover time: change from previous product to last one to next product first good part [31-37].

3.2 Examination and Understanding of Outcomes

From the study conducted in one of the leading electrical accessories manufacturing Industry in Chennai. The basic constraints and Challenges faced in the Various Products lines in this Electrical industry are: There were more internal movements in RCCB feeder line, Setup time was more and line efficiency was less. There were more operator movement in all the electrical accessories line. In this article Author had overcome the above constraints and challenges one by one and using SMED tools and the solution was arrived out to reduce Manufacturing costs, to reduce lot sizes, and to meet Customer demand on time, low inventory levels and reduce longer startups [38-46].

3.3 Optimizing Movement in RCCB Feeder by Relayout through Spaghetti, LADM

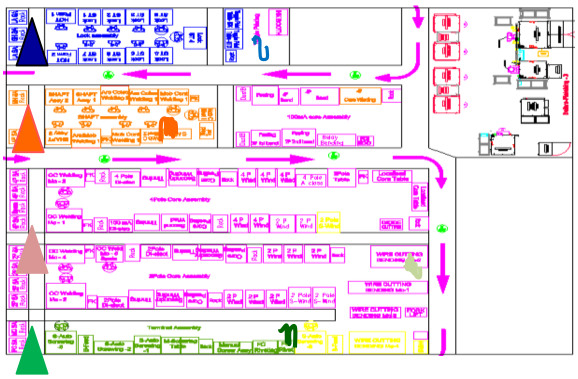

Figure 2 LADM Concept
Source: Concept Arrived Out in The Case Study Industry

Spaghetti, LADM concept for layout redesign is represented using Feeder in Figure 2. We numerated all Changeover steps to create proper order and get desirable number of spare steps ensuring standard and efficient process. Some of their activities will be reduced but some also will be externalized for applying lean principles before production starts. Each of Gemba walks, brainstorm and any regular meeting has collated data up to this point and with proper solution and improvements in action.

Table 1 Before and After Benefits

Sl No	Particulars	BEFORE	AFTER	Improvements
		Time(Sec)		
1	WH KANBAN Signal Collecting Time	433	308	29%
2	RCCB to WH	520	420	19%
3	Matrial Pick Time	1492	1092	27%
4	WH to RCCB	545	420	23%
5	WH-Matrial Deliver Time	1985	1235	38%
6	No of Trip/Shift	5	6	Additional 1 Trip
	Number of Water Spiders Available	2	1	50%
	Total Cycle Time (Sec) (2+3+4+5)	2271.00	3167.00	39%
	Total Cycle Time (min) (2+3+4+5)	37.85	52.78	
	Total Cycle Time (Hrs) (2+3+4+5)	0.63	0.88	
	Total Lead Time (Sec) (1+2+3+4+5)	12437.50	20850.00	68%
	Total Lead Time (min) (1+2+3+4+5)	207.29	347.50	
	Total Lead Time (Hrs) (1+2+3+4+5)	3.45	5.79	
	Previous Water Spider Utilization	48.32%	81.00%	

Source: Data Collected and Time Study Conducted in The Case Study Industry

Table 1 represents the before and after benefits of SMED change over time reduction in the shop floor. After layout change, warehouse Kanban signal collecting time has been significantly reduced by 29% and location movement time from Warehouse to RCCB and viceversa has been reduced by 23%. Based on the water movement route optimization, number of trips of loading material has been reduced from 2 trips to 1 trip. Utilization has been improved from 48.32% to 81%.

Table 2 Distance Travelled in The Product Line

Part Travel distance Reduced
- ✓ Toggle : 24 Mtr
- ✓ Screwing : 4.8 Mtr
- ✓ Riveting : 5.5 Mtr
- ✓ Core assay : 23 Mtr

SA Travel distance Reduced
- ✓ Lock : 8.5 Mtr
- ✓ Shaft : 10.2 Mtr
- ✓ Terminal : 17.5 Mtr
- ✓ Core : 8.7 Mtr

Source: Data Collected and Measurement Study Conducted in The Case Study Industry

A careful and detailed observation of the present layout and load summary paves an improvement in the layout structure with minimal material handling distance and cost, which results in the reduction in the part and subassembly travel distance and time (Toggle: 24 meters; Screwing: 4.8 meters; Riveting:

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5.5 meters; Core assembly: 23 meters). Six sigma was used to reduce the variation for Pad printing machine changeover from 26 to 12.3 min in fig.4 and line changing over time from 28 to 8 min, shown in Table 2.

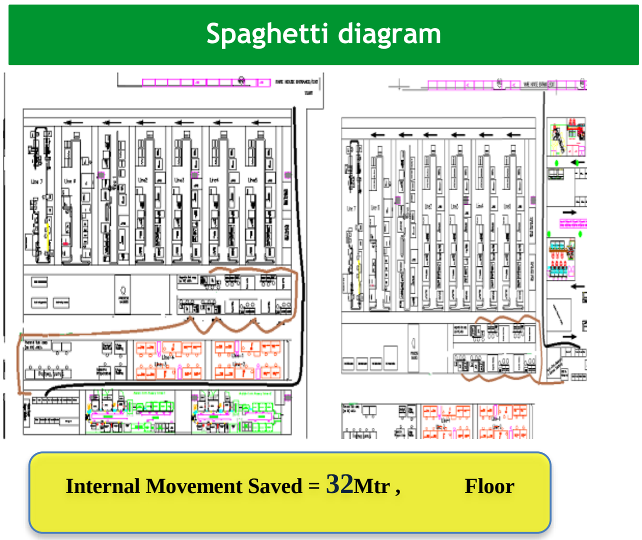

Figure 3 **Spaghetti Diagram**
Source: Data Collected and Study Conducted in The Case Study Industry

Figure 3 represents how Setup time is minimized and improves line efficiency in MCB product line. Using Spaghetti diagram redundancies are identified in the work flow of the MCB manufacturing process and various opportunities were identified to expedite the workflow. By optimizing the material movement route for loading and unloading materials 32 meters of internal movement was saved to reach the material loading point.17% of floor generation, i.e., overall 920 sqft has been saved by removing unnecessary movements and bottlenecks. The flow optimization has been drastically optimized and reduced by removing not relevant and unnecessary movements inside and outside the product line. By means of using the spaghetti diagram the bottle necks are identified in the work flow of the Electrical accessories manufacturing line. After identifying the redundancies, the improvement plan was made along with cross functional team members. Overall area has been saved by 17% and opportunities of deploying new project space in the defined area.

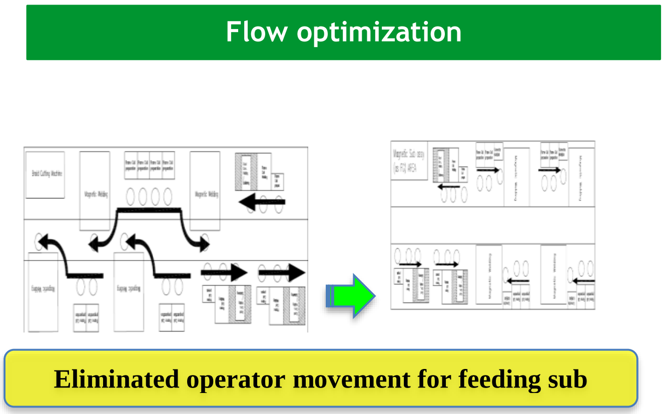

Figure 4 **Flow Optimization**
Source: Flow Optimization Done in The Case Study Industry

Based on Figure 4, it becomes fairly straightforward to identify where bottlenecks are occurring and hindering progress. This highlights a primary reason for utilizing Kanban boards in this case study: to visualize the flow of work within the system. By monitoring this flow, teams can understand their capacity, recognize when issues arise, and thus concentrate on restoring the flow. Lean metrics hold significant value when integrated with a Kanban system—this approach not only allows for quicker and more dependable value delivery but also fosters ongoing process improvement. Overall material movement flow has been optimized to reduce time to a greater extent. This will increase efficiency and productivity of a line and to meet customer order on time without any delay. Earlier operator movement for feeding subassembly was more and lead to lot of stoppages and pulled down the efficiency of the production line. Operator movement has been drastically reduced by optimizing the work flow and movement of people and material in the production assembly line. Figure 5 represents the SMED and changeover time reduction benefits gained in MCB Magnetic welding lines. External and internal movement was studied throughout the process. Electrode collecting time was more during the study and by means of creating the nomenclature of the electrode and electrode storage 100 secs has been reduced per setting. By means of having automatic water evacuation the frequent closing and opening of

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water line for electrode cooling has been minimized. And by using master setting block, time taken for setting the electrode was reduced. With the above action Change over time has been reduced by 130 seconds, due to which the output and efficiency of the line has been increased by 15%.

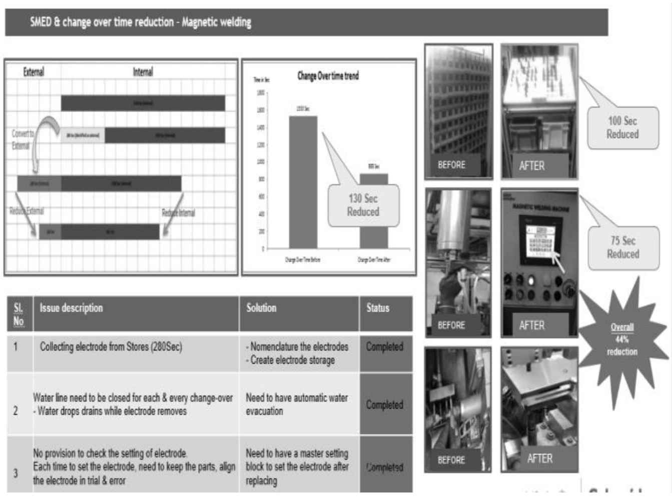

Figure 5 **SMED and Change Over Time Reduction**
Source: Data Collected and Time Study Conducted in The Case Study Industry

3.4 Magnetic Welding Process- Setup time reduction by 17%

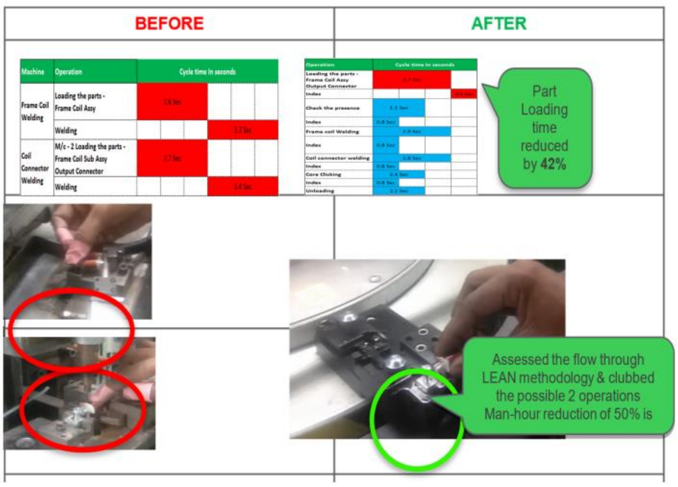

Figure 6 **Reduction of Setup Time**
Source: Data Collected and Time Study Conducted in The Case Study Industry

Figure 6 represents how setup time was reduced in MCB Magnetic welding process by optimizing the operations. By assessing the flow through lean methodology and combining the frame coil welding and coil connection welding operations, the manpower has been reduced by 50% per station and the direct labor productivity has been increased by 10%. With all constraints addressed through SMED Tools Capacity has been increased predominantly and the manufacturing cost reduction evidenced, Hourly rate improved to meet customer orders on time and overall industrial and line efficiency has been improved by 8% in the plant.

4. Benefits out of this Case Study

The capacity was increased from 6900 to 9000 nos and manufacturing cost was reduced by 15% and the Hourly rate has been improved by 25.7%. From 36% to 44%, industrial and line efficiency has been improved. Customer service level increased from 92% to 100%. And all the stake holders Production, Finance, logistics and Supply chain are fully satisfied with the Pain areas addressed and solutions recommended.

4.1 Learning from this Case study

Realistic ideas were arrived out through cross functional team Gemba brainstorming session and this was very helpful during implementation and Operator feedback and involvement was excellent. SMED Concepts were learnt. CFT team assumed a systematic approach and there was a good collaborative approach and team effort and time study concept was well implemented during this case study.

4.2 Limitations and Further Scope of Study

Research study conducted on Electrical accessories product line but the same can be applied to all types of manufacturing and service industries too. The concept of lean strategies and SMED concepts can be very well implemented and executed in all type of product lines. SMED Concepts can be applied to all type of internal and external changeover reduction to reduce cycle time in all type of industries and will yield efficiency improvement and productivity improvement. SMED can be applied to any type of manufacturing industries and applying to reduce changeover time and increasing productivity. Digital concepts can be adopted for the changeover reduction in the process followed in shopfloor. Main and subline processes can be covered and optimizing the internal and external movements of the process steps. Parallel operations can be simultaneously done by reducing the separate operations to reduce cycle time and improve productivity.

5. Results and Discussion

The current case study carried the detailed insight of Single minute exchange of die concept and its deployment in electrical accessories product line and efficiency improvement by changeover reduction. The overall Setup time reduced by 15% and Productivity has been improved by 8 to 12%. Customer service level has been increased from 92% to 100%. Proposed case study can focus more on digital concepts of SMED and its impacting factor on improving productivity and efficiency improvement.

Conclusion

This case study was considered as best practice and implemented across similar product group in the organization clusters. Through this case study, Lean implementation hourly rate improvement and capacity increased, industrial efficiency improved, change over time reduced, movement waste drastically reduced and all Customer orders were secured within short span of time. This case study results in a wider understanding and application of SMED tools and collaborative team work with all Cross functional team members. This best practice has been implemented across the globe in the corresponding and relevant product lines. This SMED concept yielded good results and benefits to the organization and improved productivity to a greater extent. All the relevant team members were given training and SOP was made for future training and standardization purpose.

Statements and Declarations

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- The authors have no relevant financial or non-financial interests to disclose.
- The authors have no competing interests to declare that are relevant to the content
- All authors certify that they have no affiliations with or involvement in any organization or entity with any financial interest or non-financial interest in the subject matter or materials discussed in this manuscript.
- The authors have no financial or proprietary interests in any material discussed in this article.

References

[1]. Achanga, P., Shehab, E., Roy, R., & Nelder, G. (2006). Critical success factors for lean implementation within SMEs. Journal of Manufacturing Technology Management, 17(4), 460–471. doi:10.1108/17410380610662889

[2]. Alves, J. R. X., & Alves, J. M. (2015). Production management model integrating the principles of lean manufacturing and sustainability supported by the cultural transformation of a company. International Journal of Production Research, 53(17), 5320–5333. doi:10.1080/00207543.2015.1033032

[3]. Bhamu, J., & Sangwan, K. S. (2012). Lean manufacturing: Literature review and research issues. International Journal of Operations & Production Management, 34(7), 876–940. https://doi.org/10.1108/IJOPM-08-2012-0315

[4]. Choomlucksana, J., Ongsaranakorn, M., & Suksabai, P. (2015). Improving the productivity of sheet metal stamping subassembly area using the application of lean manufacturing principles. Procedia Manufacturing, 2, 102–107. doi:10.1016/j.promfg.2015.07.090

[5]. Comprehensive Review of Drain Water Pollution Potential and Environmental Control Strategies in Khulna, Bangladesh.

Journal of Water Resources and Pollution Studies 8 (3), 44-53 Available at: https://matjournals.co.in/index.php/JoWRPS/article/view/4333.

[6]. Dabhade, N., & Karandikar, A. M. (2012). Lean Six Sigma approach for quality monitoring: A case study of an Indian tyre manufacturing company. International Journal of Productivity and Performance Management, 61(2), 169–184. https://doi.org/10.1108/17410401211194666

[7]. Das, D., & Kodali, R. (2018). Lean production practices and bundles: A comparative analysis. Journal of Manufacturing Technology Management, 29(4), 660–688. https://doi.org/10.1108/JMTM-01-2018-0010

[8]. Dora Manoj, Kumar Maneesh & Xavier Gellynck (2016) "Determinants and barriers to lean implementation in food processing SMEs – a multiple case analysis", Production Planning & Control, 27:1, pp. 1-23 Geographic Information Systems (GIS) analysis. International Journal of Science and technology

[9]. Eswaramoorthi, M (2011), "A survey on lean practices in Indian machine tool industries", The International Journal of Advanced Manufacturing Technology, Vol. 52 Nos 9/12, 1091-1101.

[10]. Eroglu, C., & Hofer, C. (2011). Lean, Leaner, Too Lean? The Inventory-Performance Link Revisited. Journal of Operations Management, 29, 356-369. http://dx.doi.org/10.1016/j.jom.2010.05.002

[11]. Fayshal, M. A., Ullah, M. R., Fairooz Adnan, H. M., Rahman, S. M. A., & Md Siddique, I. (2023). Evaluating multidisciplinary approaches within an integrated framework for Human Health Risk Assessment. Journal of Environmental Engineering and Studies, 8(3), 30–41. doi:10.46610/joees.2023.v08i03.004

[12]. Godina, R., Pimentel, C., Silva, F. J. G., & Matias, J. C. O. (2018). A structural literature review of the single minute exchange of die: The latest trends. Procedia Manufacturing, 17, 783–790. doi:10.1016/j.promfg.2018.10.129

[13]. Hardcopf, R., Liu, G. (jason), & Shah, R. (2021). Lean production and operational performance: The influence of organizational culture. International Journal of Production Economics, 235(108060), 108060. doi:10.1016/j. ijpe.2021.108060

[14]. Identifying Primary Causes of Deaths. ACET Journal of Computer Education and Research, 14(1), 1-13.

[15]. Jasti, N. V. K., Sharma, A., & Kodali, R. (2014). Human resource management implications of adopting the Toyota lean culture paradigm to India. The International Journal of Human Resource Management, 25(21), 3037–3059. https://doi.org/10.1080/09585192.2014.919952

[16]. Kumar, R., Shankar, R., & Thakur, L. S. (2018). Implementing sustainable manufacturing practices in Indian manufacturing companies. Journal of Manufacturing Technology Management, 29(3), 474–497. https://doi.org/10.1108/JMTM-04-2017-0076 MATHEMATICS: ICMSM 2024, Coimbatore, India. doi:10.1063/5.0275696

[17]. Lyonnet, B., Pillet, M. and Pralus, M. (2010) 'Optimisation de la taille de la série, illustration par un cas industriel', Paper presented at the 8th international congress of Industrial engineering. June 10-12, 2010, Tarbes, France.

[18]. Mohammad, A., Hamja, A., & Hasle, P. (2024). Reduction of changeover time through SMED with RACI integration in garment factories. International Journal of Lean Six Sigma, 15(2), 201–219. doi:10.1108/ijlss-10-2021-0176

[19]. Mohan Prasad, M., Dhiyaneswari, J. M., Ridzwanul Jamaan, J., Mythreyan, S., &

Sutharsan, S. M. (2020). A framework for lean manufacturing implementation in Indian textile industry. Materials Today: Proceedings, 33, 2986–2995. doi:10.1016/j.matpr.2020.02.979

[20]. Narang, H. K. (2015). A roadmap for implementing lean in the Indian auto component manufacturing sector: A comparative analysis of the ISM and UNIDO models. International Journal of Productivity and Performance Management, 64(8), 1091–1112. https://doi.org/10.1108/IJPPM-12-2013-0205

[21]. Nordin, J. D., Solberg, L. I., & Parker, E. D. (2010). Adolescent primary care visit patterns. Annals of Family Medicine, 8(6), 511–516. doi:10.1370/afm.1188

[22]. Patil, S. K., & Laishram, B. (2015). Probing the role of lean practices in enabling BIM adoption: Evidence from two Indian cases. Journal of Construction Engineering and Management, 141(9), 05015006. https://doi.org/10.1061/(ASCE)CO.1943-7862.0000999 Performance: A Deep Dive into Overall Equipment Effectiveness (OEE) for Operational Excellence. Journal of Industrial Mechanics, 8(3), 26-40.

[23]. Prasanna, S. G., Kadam, A. A., Vignesh, S., & Raja, K. A. A. (2025). Implementing lean manufacturing principles to enhance efficiency, streamline operations, and reduce waste in production processes for improved profitability. AIP Conference Proceedings, 3306, 030070. Presented

[24]. Rahman, M. S., Anower, M. S., Hasan, M. R., Hossain, M. B., & Haque, M. I. (2017). Design and numerical analysis of highly sensitive Au-MoS2-graphene based hybrid surface plasmon resonance biosensor. Optics Communications, 396, 36–43. doi:10.1016/j.optcom.2017.03.035

[25]. Rajesh, R., & Ravi, V. (2015). Lean management practices to improve supply chain performance of leather footwear industry. 2015 International Conference on Industrial Engineering and Operations Management. IEEE. https://ieeexplore.ieee.org/document/7093829

[26]. Ramesh, A., & Kodali, R. (2013). A framework for assessing lean manufacturing implementation in the Indian automobile industry. International Journal of Business Excellence, 6(5), 501–525. https://doi.org/10.1504/IJBEX.2013.054296

[27]. Ramesh, A., & Kodali, R. (2015). Application of lean in Indian process industries: Some empirical evidence. Journal of Manufacturing Technology Management, 26(1), 38–62. https://doi.org/10.1108/JMTM-02-2013-0013

[28]. Rathi, R., Vakharia, A., & Shadab, M. (2022). Lean six sigma in the healthcare sector: A systematic literature review. Materials Today: Proceedings, 50, 773–781. doi:10.1016/j.matpr.2021.05.534 Research Archive, 11(2), 1976–1985. doi:10.30574/ijsra.2024.11.2.0690

[29]. Samuel, D., Found, P., & Williams, S.J. (2015). How did the publication of the book The Machine That Changed the World change management thinking? Exploring 25 years of lean literature. International Journal of Operations & Production Management, 35(10), 1386-1407. https://doi.org/10.1108/IJOPM-12-2013-0555

[30]. Selim Molla, Md Minhajul Abedin and Iqtiar Md Siddique. (2023). Exploring the versatility of medical textiles: Applications in implantable and non-implantable medical textile. World Journal of Advanced Research and Reviews, 2024, 21(01), 603–615. DOI: 10.30574/wjarr.2024.21.1.0058.

[31]. Shakil, M., Ullah, M. R., & Lutfi, M. (2013). Process flow chart and factor analysis in production of jute mills. Journal of Industrial and Intelligent Information Vol, 1(4).

[32]. Shankar, R., & Tiwari, M. K. (2014). A scale to measure the applicability of lean practices in IT support services. Journal of Manufacturing Technology Management, 25(3), 289–308. https://doi.org/10.1108/JMTM-03-2013-0022

[33]. Sharma, R. K., Dixit, A. R., & Pandey, P. M. (2013). A strategic and operational approach to assess the lean performance in radial tyre manufacturing in India: A case based study. Journal of Manufacturing Technology Management, 24(3), 361–385. https://doi.org/10.1108/17410381311318701

[34]. Singh, B., & Garg, S. K. (2015). A case study on lean approaches in the equipment manufacturing industry. International Journal of Productivity and Quality Management, 16(4), 406–423. https://doi.org/10.1504/IJPQM.2015.070857

[35]. Sinha, N., & Matharu, M. (2019). A comprehensive insight into Lean management: Literature review and trends. Journal of Industrial Engineering and Management, 12(2), 302. doi:10.3926/jiem.2885

[36]. Sunny, M. A. U. (2024). Unveiling spatial insights: navigating the parameters of dynamic Geographic Information Systems (GIS) analysis. International Journal of Science and Research Archive, 11(2), 1976–1985. doi:10.30574/ijsra.2024.11.2.0690

[37]. Urban, W., & Rogowska, P. (2018). The Case Study of Bottlenecks Identification for Practical Implementation to the Theory of Constraints. Multidisciplinary Aspects of Production Engineering, 1(1), 399 405. https://doi.org/10.2478/mape-2018-0051

[38]. Utama, D. M., & Abirfatin, M. (2023). Sustainable Lean Six-sigma: A new framework for improve sustainable manufacturing performance. Cleaner Engineering and Technology, 17(100700), 100700. doi: 10.1016/j.clet.2023.100700

[39]. Ullah, M. R., Molla,S., Siddique,M.I., Siddique,A.A., Abedin,M.M.(2023). Utilization of Johnson's Algorithm for Enhancing Scheduling Efficiency and Identifying the Best Operation Sequence: An llustrative Scenario. Journal of Recent Activities in Production. e-ISSN: 2581-9771Volume-8, Issue-3 (September-December,2023). https://doi.org/10.46610/JoRAP.2023.v08i03.002

[40]. Ullah, M. R., Molla, S., Md Siddique, I., Ahmed Siddique, A., & Abedin, M. M. (2023). Manufacturing excellence using line balancing & optimization tools: A simulation-based deep framework. Journal of Modern Thermodynamics in Mechanical System, 5(3), 8–22. doi:10.46610/jmtms.2023.v05i03.002

[41]. Vinodh, S., Aravindraj, S., & Chintha, S. K. (2013). A structural model for assessment of lean manufacturing practices. International Journal of Production Research, 51(19), 5822–5835. https://doi.org/10.1080/00207543.2013.802581

[42]. Wamanrao Chandurkar, P., Rajput, D., Kakde, M., Chandurkar, P., & Raichurkar, P. P. (2018). Enhancing Efficiency and Productivity of Garment Industry by Using Different Techniques. In International Journal on Textile Engineering and Processes (Vol. 4). https://www.researchgate.net/publication/326478992

[43]. Yadav, G., & Desai, T. N. (2015). Impact of lean practices on performance measures in the Indian machine tool industry. Journal of Manufacturing Technology Management, 26(8), 1023–1051. https://doi.org/10.1108/JMTM-04-2014-0040

[44]. Yadav, G., & Desai, T. N. (2022). Organizational culture's impact on lean methods and operational performance: Evidence from Indian manufacturing SMEs.

Journal of Manufacturing Technology Management, 33(2), 317–341. https://doi.org/10.1108/JMTM-06-2020-0253

[45]. Yadav, V., Jain, R., Mittal, M.L., Panwar, A., & Sharma, M.K. (2019). An appraisal on barriers to implement lean in SMEs. Journal of Manufacturing Technology Management, 30(1), 195-212. https://doi.org/10.1108/JMTM-12-2017-0262

[46]. Zahraee, S. M. (2016). A survey on lean manufacturing implementation in a selected manufacturing industry in Iran. International Journal of Lean Six Sigma, 7(2), 136-148. http://doi.org/10.1108/IJLSS-03-2015-0010