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Study of Time and Value Stream Mapping for Wiring Harness Production

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Abstract:- Several factors have impacted the manufacturing industry, including global competition, declining profit margins, and customer demands for high-quality products and shorter lead times. These requirements can be met with various quality management and industrial engineering strategies, including ISO 9000, Total Quality Management, Kaizen, Timely Production, Enterprise Resource Planning, Business Process Restructuring, and Lean Management. Lean Six Sigma is a new paradigm in this field of manufacturing strategies. This approach is increasingly being adopted in the manufacturing sector to improve productivity and quality, as well as to strengthen the responsibility considerations. A time and work-study are conducted in the paper to improve the quality and productivity of a manufacturing enterprise. Six Sigma DMAIC (Defined-Measure-Analyze-Improvement-Control) is applied to a manufacturing context that identifies, analyzes, and improves several quality and productivity indicators, optimizes operational variables by quantifying and eliminating sources of variation in the process in question. Provides a framework to, improve and maintain performance. The industrial situation has given a challenging task to analyze and identify the requirement of the industry. The process timing for every process has become a chance to view the errors happening in the industry. The errors are recorded and plotted in the form of graphs and data. With the help of the dataset have viewed the errors and identified the errors of improvement. The identified errors are found and improved to increase the productivity and quality of the system for about 49 % of the existing system.

Keywords*: MUDA, Lean Six Sigma, Value Stream Mapping, MURA.*

1. Introduction

This paper studied about ABCD company, and they are the leading manufacturers of Wiring Harness assemblies in Coimbatore producing assemblies like Automobile Wiring Harness, Elevator and Escalator Wiring Harness, Data Cables, Medical Equipment Wiring Harness, Home Appliances Wiring Harness, etc [1],[2]. In this Paper, study of time and a value stream mapping is done to products to have a clear view of the process. The plant has researched to optimize the production system to reduce production time and maintain a positive reputation among internal customers [3],[4].

The "Lean six sigma" methodology has been used to expand this work. The DMAIC Lean Six Sigma architecture utilized in this investigation is depicted in the diagram. The defining stage's mission was to identify work objectives and ranges. This stage entails analyzing the supplier and customer utilizing SIPOC (suppliers, inputs, process, outputs, customers) and collecting VOC for the customer[5]-[7].

The information is eventually combined to form a work charter. Flowcharts and line graphs are broadly speaking used at some point of the size segment to gather information inside the range set within the preceding step and organize the data into hassle factors [8],[9]. To become aware of possible causes and analyze the concern improvement sequence, the evaluation step includes discussion, cause and impact diagrams, and modes of failure and effect analysis (FMEA). At some stage in the improvement section, a development plan is created. System management is part of the managed segment, which guarantees that problems do no longer recur and that operational requirements are met.[10]

2. Objectives

This thorough case study's main goal is to methodically identify and resolve the inefficiencies that currently exist in the inspection and packing department of a fast-paced business that assembles three different kinds of solar cables. This inquiry is specifically focused on the complex problems that the 150sqmm cables provide. These cables have a weight of 1.5 kilogram per meter and a variable length that can range from half to three meters. A comprehensive analysis of the existing operational framework has identified a major workflow bottleneck, primarily originating from the lengthy stickering procedure. This process starts with the batches being arranged, and then stickers with QR codes are applied. The distinct physical characteristics of the cables, which differ in length, diameter, weight, depth, inner diameter, and other dimensions despite their apparent similarity, worsen this bottleneck.

Moreover, the production process is now set up as a batch flow, which makes material handling even more difficult, especially for the Power Cables (150 sq mm). 'Mura,' which denotes an uneven or inconsistent condition, is a result of the uneven techniques used in this batch flow. Furthermore, it was found that a sizable section of the staff lacked the necessary abilities, which eventually led to talk time limits being broken. The problem is exacerbated by ineffective communication between workers, which causes delays in the production process.

The main goal of this study is to put strategic interventions into place with the goal of changing the current batch flow method into a more responsive and agile single-piece flow, given the complex terrain of difficulties. It is anticipated that this shift will result in numerous benefits, such as decreased processing times, shorter changeover times, and fewer talk time violations. The main objective is to increase material handling productivity, remove bottlenecks, and create a more efficient and productive production process that conforms to industry best practices. By implementing these focused efforts, the company hopes to streamline its workflow, increase production, and establish a strong position for itself in the highly competitive solar cable assembly market.

3. Methods

3.1 Define Phase: The Lean Six Sigma project initiation involved a thorough understanding of the problem at hand. The Define phase involved drafting the Business Case, Goal Statement, Opportunity Statement, and Project Scope, among other important project documents. To identify the structural elements of the customer's organization, the SIPOC (Supplier, Input, Process, Output, Customer) tool was utilized. During this stage, it was essential to involve consumers and employees by using surveys and interviews to learn about their needs—a process called as "customer's voice." The knowledge acquired was then used to develop workable plans for cutting non-value-added time.

Business Case To reduce the nonvalue added time and increase the productivity rate. Cables contain 3 families with every three types.	**Goal Statement** To reduce the lead time. To reduce manpower costs. To reduce customer complaints.
Opportunity Statement Customer complaints are increased. Ensuring the proper maintenance of the machines. Avoiding errors by implementing poka-yoke	**Project Scope** Modification in the process and material flow. Modification in the inspection method. Implementing an error-proof system. Authority to change the process.

3.2 Measure Phase: In this stage, important metrics for inputs, processes, and outputs were defined. Tables 1 (Input, Process, and Output Measures), Table 2 (Solar Cable Process Time), Table 3 (Cycle Time), and Table 4

(Wastage Time) are among the tables and graphs that were created. Moreover, graphs showing cycle time and waste time were shown in Figures 2 and 3. These quantitative measurements allowed for additional investigation by giving a thorough picture of the process's current status.

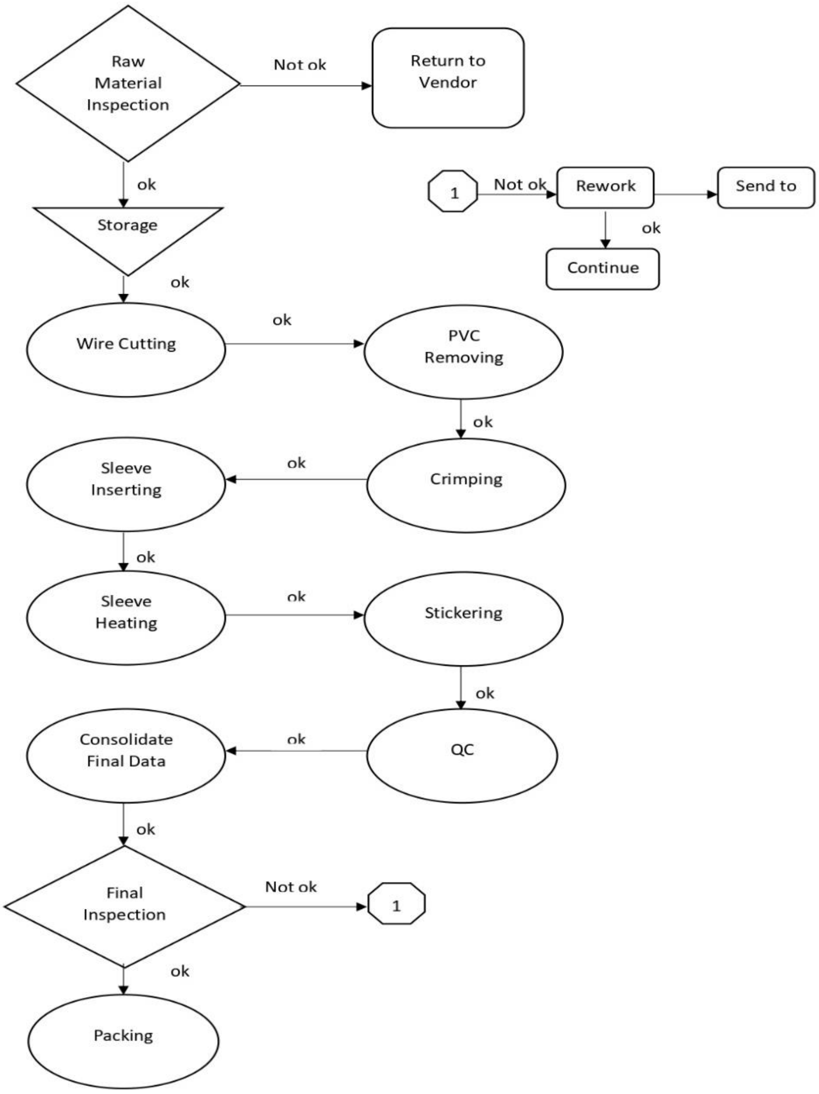

Fig 1 Flow chart

INPUT	PROCESS	OUTPUT
MACHINE OPERATOR	Wire Cutting	Reducing change over time
	PVC Removing	Productivity improvement
	Crimping	Economic growth
	Sleeve inserting	Better process flow
	Sleeve Heating	Better material flow
	Stickering	Improve identify

Table 1. Input, Process, and Output Measures

S. No	Process	Process Time (per pcs)	No. of pcs/hour

1	Wire Cutting	41.2806	87
2	Stripping	64.853	55
3	PVC Removal, Cable End Crimping	62.11	57
4	Terminal Inserting, Crimping	43.837	82
5	Sleeve Inserting, Sleeve Heating	60.2	60
6	Stickering	33.6041	107
7	QC	549.81	180

Table 2. Solar Cable (700 mm)

Name of process	Cycle time (in hrs)
Wire cutting	0.044
PVC removing	0.0159
Crimping	0.00239
Sleeve inserting	0.0072
Sleeve heating	0.0106
Stickering	0.0049

Table 3. Cycle Time

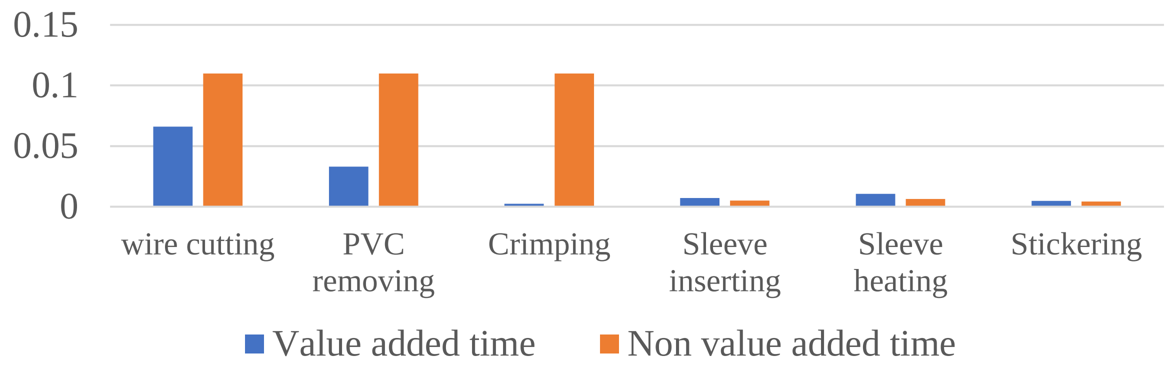

Fig 2 Current state

Name of process	Wastage time
Wire cutting	0.0069
PVC removing	0.0021
Crimping	0.011
Sleeve inserting	0.005
Sleeve heating	0.005
Stickering	0.0045

Table 4. Wastage Time

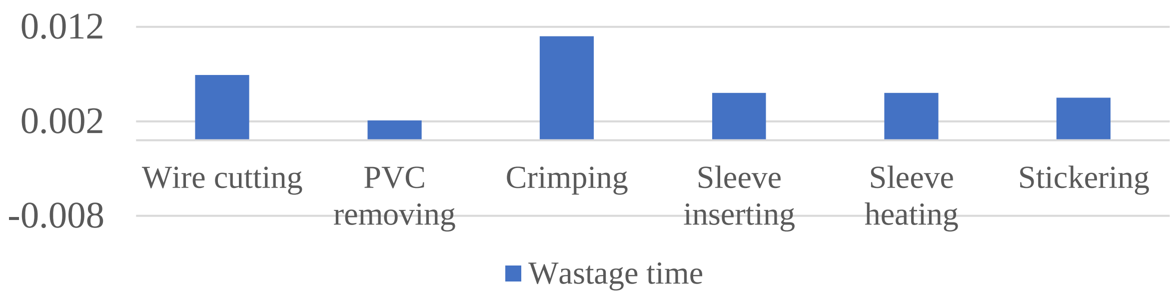

Fig 3 Wastage time

3.3 Analysis Phase: Following the stages of building, verification, and analysis, the analysis phase pinpointed issues and process bottlenecks. Extensive process maps created at the Measure stage were examined closely. Through the use of "process analysis," which included Time Analysis and Value Added Analysis, the process's collective wisdom was harnessed. In order to pinpoint possible problem roots, Cause and Effect Diagrams were used to facilitate structured brainstorming. A thorough Cause and Effect analysis (Figure 6) was also carried out.

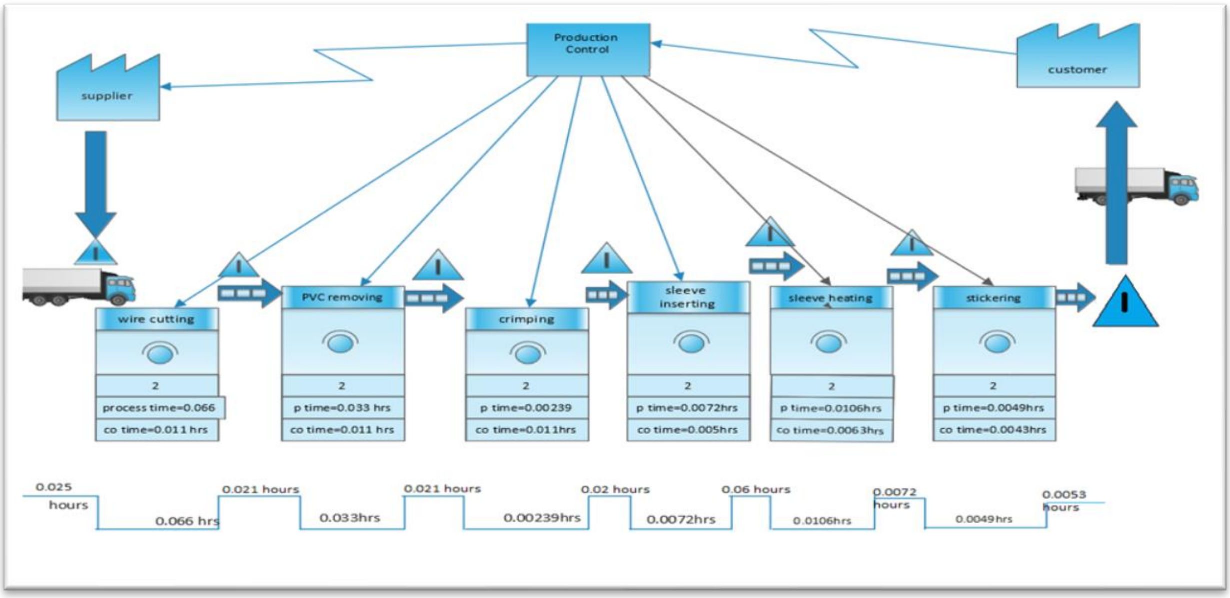

Fig 5. Current State Mapping

From raw material input through shipment, the graphic above represents the entire process flow of the industry. This is a detailed process map that displays how much time each process and worker spend on things that bring value and tasks that don't.

Task Number	Number of operators	Task Description	Value Added-time	NVA Time	Total
1	2	Wire cutting	0.066	456	456.066
2	2	PVC Removing	0.033	48	48.033
3	2	Crimping	0.00293	2	2.00293
4	2	Sleeve Inserting	0.0072	1	1.0072
5	2	Sleeve Heating	0.0106	0.16	0.1706
6	2	Stickering	0.0049	0.5	0.5049

Table 5. Value/non-value added time

The table 5 explains how to calculate value-added and non-value-added time based on the number of operators and the number of employees. After conducting preliminary research, we discovered that non-value-added time accounts for 41% of total time. In the overall procedure, around 41% of the time is wasted. The progress must be visible in the process.

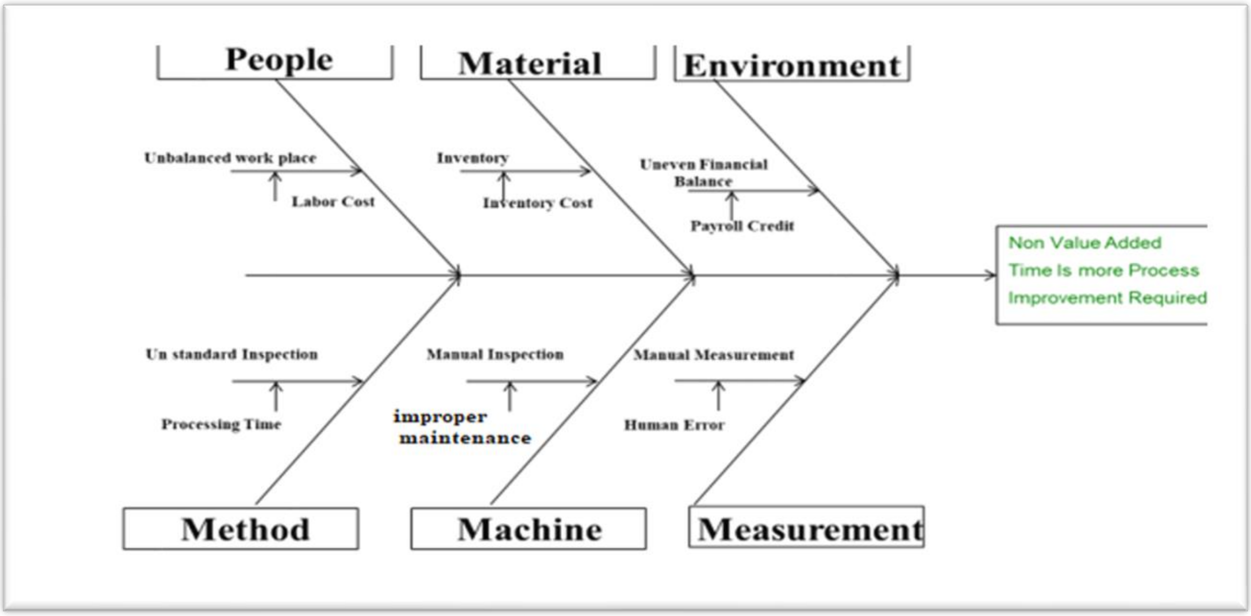

Fig 6. Cause and effect analysis

3.4 Improve Phase: Improving value-added time and decreasing non-value-added time were the main goals of the Improve phase. Single-piece flow replaced batch flow, and optimization was made to the heating, packaging, crimping, cutting, and visual inspection processes. Diagrams were used to show the future condition, and the use of SMED (Single-Minute Exchange of Die) was emphasized (Figure 7). Table 6 shows the efficiency benefits by breaking down the value and non-value-added time after the change.

Task Number	Num. of operator	Task Description	Value-added time	Non-value-added time	Total time
1	2	Wire cutting	0.066	0.011	0.077
2	2	PVC removing	0.033	0.011	0.044
3	2	Crimping	0.00239	0.01	0.01239
4	2	Sleeve inserting	0.0072	0.05	0.0572
5	2	Sleeve heating	0.0106	0.0063	0.0169
6	2	Stickering	0.0059	0.0043	0.0102

Table 6. Value and Nonvalue-added time

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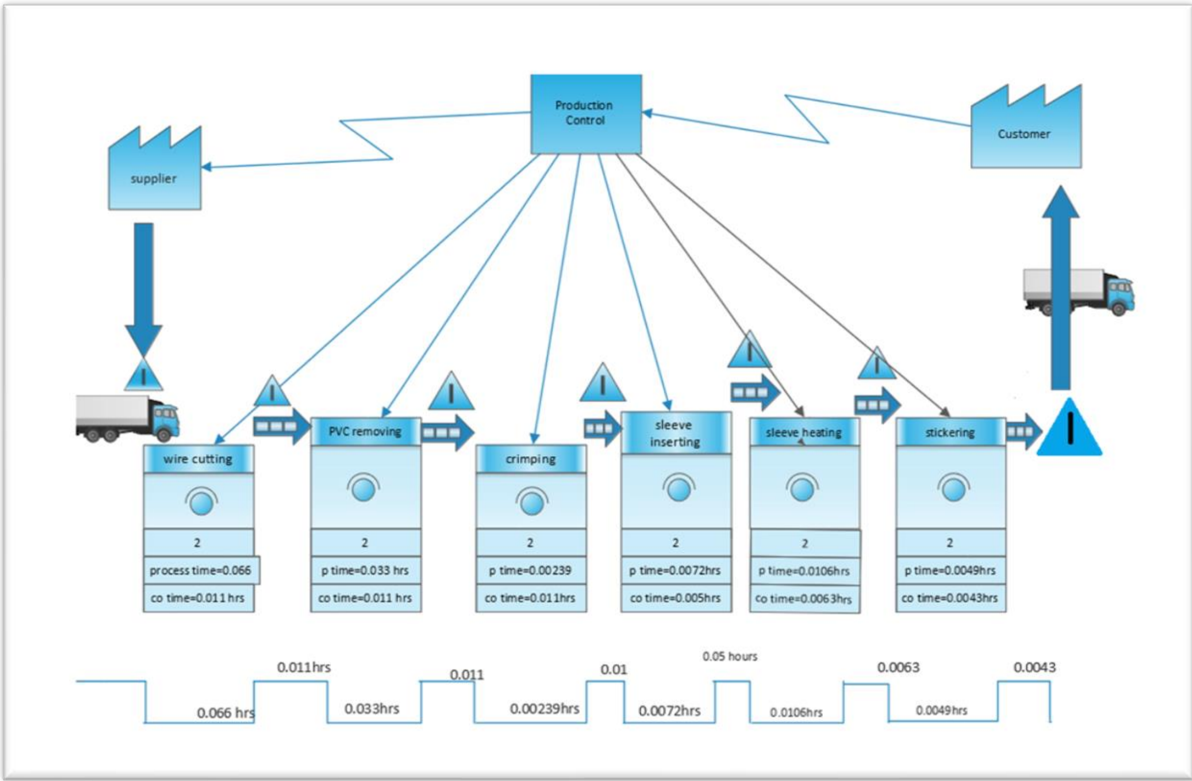

Fig 7. Future state

3.5 Control Phase: Creating the groundwork for ongoing improvements, the Control phase represented the DMAIC process's apex. The themes of value, flow, pull, and perfection were all highlighted, along with lean principles. Critical process parameters were continuously monitored thanks to the implementation of a control plan, and documentation was facilitated by the use of tools like control charts.

4. Results

The extensive application of Lean Six Sigma techniques produced revolutionary outcomes in a number of the cable manufacturing process's dimensions, including:

4.1 **Reduction in Non-Value-Added Time:** A significant 26.66% reduction in total production time was the project's main objective. This accomplishment is especially notable because it required a deliberate switch from batch flow to single-piece flow and careful use of lean concepts. Beyond just saving time, this reduction has a direct influence on total productivity, cost-effectiveness, and operational efficiency.

4.2 **Manpower Optimization:** The discovery of two inventory positions and their subsequent removal was one of the most notable results. This resulted in the effective use of workspace in addition to a noticeable decrease in labor expenditures. The project's all-encompassing strategy demonstrated a dedication to resource stewardship and operational excellence by optimizing human resources in addition to increasing efficiency.

4.3 **Increased Production Rate:** A major accomplishment was the noticeable rise in the total production rate. The integration of Lean concepts with the shift to a single-piece flow paradigm created a domino effect that promoted increased production. The initiative has had a good influence on the organization's ability to meet customer requests and market expectations, as seen by the higher production rate.

5. Discussion

5.1 **Proliferation of Efficiency Gains:** The project's commitment to promoting operational efficiency is demonstrated by the transition to single-piece flow and the thoughtful application of Lean techniques like SMED. This methodology not only optimized the production procedure but also established the foundation for long-term enhancements in productivity. More in-depth discussion of particular efficiency indicators and their impact on the overall competitiveness of the company might be had.

5.2 **Improving Customer Satisfaction:** Improving customer satisfaction through value stream optimization was the project's central goal. An enhanced customer experience is the result of a streamlined procedure, shorter lead times, and better response to client requests. Potential routes for ongoing improvement of customer satisfaction metrics, market perception, and particular client input might all be covered in more detail in future discussions.

5.3 **Fostering an Environment of Ongoing Improvement**: The Control Phase emphasizes an organizational culture dedicated to continual growth, which is in line with Lean concepts. The conversation might center on how the company intends to institutionalize this culture, encouraging a growth-oriented, adaptable, and innovative way of thinking. This debate can be enhanced by providing insights into training initiatives, staff engagement, and feedback systems.

5.4 **Reflection on Challenges and Lessons Learned:** Examining the difficulties experienced in putting Lean Six Sigma into practice and the lessons that were subsequently learnt yields important information for internal evaluation as well as external distribution. This conversation can shed light on the organization's flexibility, the effectiveness of change management techniques, and provide useful advice for other sectors starting process improvement projects of a similar nature.

To sum up, the findings and conversations highlight the significant influence that Lean Six Sigma techniques have on the cable production process. In addition to producing measurable results, the project laid the groundwork for a culture of continuous excellence, operational effectiveness, and customer-centricity.

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