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Sustainability of Discrete Manufacturing Processes Based on the Lean Principle: A Case Study

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Abstract: **-**The growing awareness of environmental and social issues in production engineering requires improved control and enhancement of sustainability in discrete manufacturing processes. The research aims to identify challenges in a discrete manufacturing center and to determine optimal solutions to boost productivity. More explicitly, the study has the following purposes: To use the Lean Principle to enhance productivity and performance and tominimize wastage and non-value-added activities by enabling an atmosphere that simplifies organizational working culture. The analysis presented in this study is based on a single case study done in a discrete manufacturing company using the Lean PDCA (Plan-Do-Check-Act) methodology. At multiple stages of the investigation, the data-based analysis helped pinpoint the issue's root causes with producing magnetic starters. For process sustainability, the procedure parameters have been measured and optimized. The energy and non-value-added activities related to its production processes were decreased due to the lean principles. A thorough implementation of the recommendations in this study would lead to an up to 138 pieces increase in the products daily. The study offers organizations insight into the relevance and significance of quality principles. Regardless of how these efforts are termed, organizations must consistently engage in sustainability-oriented initiatives to thrive.

Keywords*:* Sustainability, Discrete Manufacturing, Case Study, Lean Approach, PDCA

1. Introduction

In the discrete manufacturing sector, unique units or goods are produced, typically in enormous quantities. A finished product is often created by assembling several parts and components in this form of manufacturing. To create the products, machinery and equipment like assembly lines are frequently used. Automobiles, electronics, furniture, and toys are products created using discrete manufacturing. Contrary to process manufacturing, which entails the continuous manufacture of substances or materials, discrete manufacturing entails the production of physical goods with unique features and qualities. To increase productivity and save costs in the production process, these businesses might often use advanced technologies like automation and robotics.

As a result of the availability of a trained workforce, lower labour costs, and favorable government policies, the Indian discrete manufacturing industry has been expanding quickly in recent years. India is now emerging as a global hub for manufacturing, with many multinational companies setting up their production facilities in the country. This might be attributed to the developmental initiatives launched by the Indian government like "Make in India", "Digital India", and "Skill India" aimed at promoting the manufacturing sector and the country's economy at large. Despite its expansion and potential, India's manufacturing sector still faces obstacles such as a lack of suitable infrastructure, restrictive regulations, and supply chain problems. To overcome these obstacles and make India an attractive location for manufacturing firms, several actions need to be taken. The 2011-drafted National Manufacturing Policy of the Indian Government is now being updated to integrate Industry 4.0. Government and industry-led initiatives are being developed to stimulate and transform India's manufacturing capabilities(1).

Furthermore, to improve India's manufacturing sector, it is essential to transform to more innovative and distinctive business strategies centered around services that will sustain their viability in the long and medium term, generally(1). It is anticipated that the manufacturing sector in India will increase its contribution to GDP to 25% by 2022 if it achieves the sustainable annual growth objective of more than 12% set in FY2018(2). Consequently, India's environmental performance has attracted much attention in sustainable development studies, especially in light of the country's recent increases in GDP and per capita income(3). However, due to the adverse effects on the welfare of society and the environment, the business operations of environmentally sensitive businesses, like the manufacturing sector, are regularly criticized (4). Recent research on environmentally sensitive industries' sustainable practices is scarce, for instance (3,5,6). This article aims to investigate internal process optimization, which is thought to be a crucial component in responding to the manufacturing industries. The implicit contribution of this study pertains to the manufacturing sector in India, as the majority of enterprises operating in this sector are required to comply with mandatory ESG disclosure rules.In order to gain worldwide competitive advantages, it has been thought necessary to employ high-valued approaches to help the manufacturing industry. This study is set to employ LEAN techniques to improve discrete manufacturing procedures by decreasing waste and improving production time. Hence, this translates to the following sub-objectives;

- To use the Lean Principle to enhance productivity and performance, specifically in the discrete manufacturing industry.
- To minimize wastage and non-value-added activities by enabling an atmosphere that simplifies organizational working culture.

Lean management principles seek to improve an organization's effectiveness and efficiency by maximizing customer value and reducing waste. The LEAN principles, initially developed by the Toyota Production System, were created by the Lean Enterprise Institute. The LEAN strategy involves five major guiding principles. First is to understand the customers' needs and then concentrate on providing goods and services to fulfil those needs. The second is to assess all the stages and procedures necessary to deliver the product or service while eliminating waste and enhancing efficiency. The third is to establish a smooth workflow to avoid all possible disruptions. Fourth is to set up pull by only manufacturing goods and services when the client orders. The final principle is continuously seeking ways to streamline procedures and eliminate waste. These five guiding principles of lean management are summarised in Figure 1.

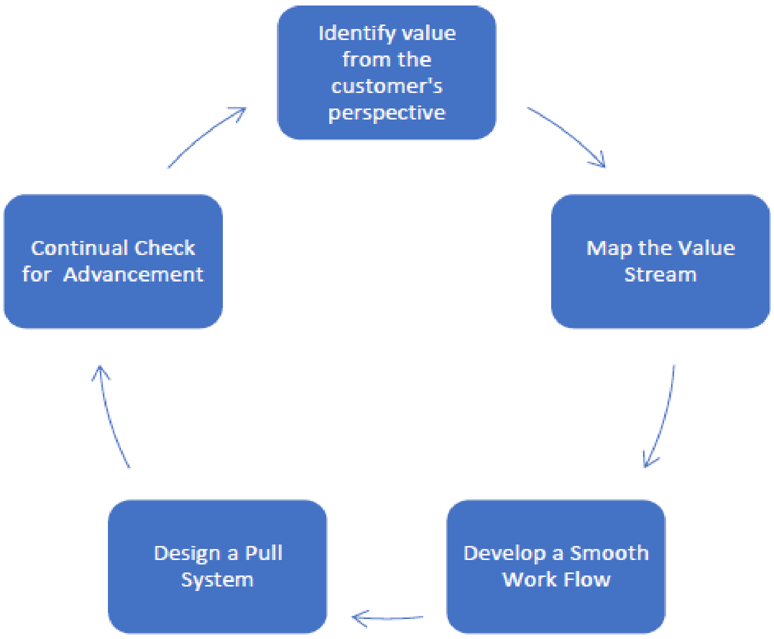

Figure1: Lean Principles

In order to enhance effective material flows, reduce lead times, and minimize time waste, a variety of Lean approaches and technologies can be used (7). The main tools used in this study to investigate waste are; Value Stream Mapping (VSM), Gemba, Spaghetti diagram, Cellular Manufacturing, 2 Bin Kannan System, and the 5s Methodology.

This paper is structured as follows; The study’s objectives are established in the current section of the paper under the subject of introduction. The details of the industry and the process that follows are discussed in section 2. The methodological approach of the study is described in section 3. While section 4 presents results and findings, section 5 discusses the study's conclusion and suggestions for future research.

2. Case Study

2.1 About the Company

The organization is Europe's largest industrial manufacturing company, with branch offices across many countries. Energy, healthcare, infrastructure, and cities are the industries where the company's main divisions are dispersed. These industries reflect the company's core business activity. The corporation is a famous producer of medical testing tools. The company's healthcare branch, representing about 12% of its total sales, is its second-most prosperous business segment after the industrial automation industry. The organization is included in the Euro Stocks 50 stock market index. According to the press statement, the parent company and its subsidiaries employed about 303,000 people across the globe and had a global sale of about €62 billion in 2021.

The company and India have a close partnership and participated in the Smart Cities project from 2015 and beyond. The company and India shared a long-term history traced back to the 18th century when the founder established the first subsidiary in the eastern part of the country. The corporation operates over 20 factories, numerous expertise centers, nearly 15 research and development (R&D) facilities, and a comprehensive sales and service network spread across the region. The company is into the manufacturing of magnetic starters which are used to power electric motors. It also offers power cut-off, under-voltage, and overload protection.

2.2 Products Process Flow

- Wire Cutting Assembly: In this assembly, the wire is twisted, cut, and bent to connect the contactors with relays. This is mainly done initially before the body plate assembly to ensure the continuous flow of the raw materials

- Assembly 1: This is the first assembly station of the starter assembly line. Here, the raw material, like the metallic top cover, is brought, where wire, push button, and sticker containing details of the product and instructions are attached.

- Assembly 2: This is the second assembly station of the starter. Here the relay is attached along with the contactor and wires. After successfully assembling, the top cover is fixed and sent for testing.

- Testing 1: This is the third assembly station of the starter. Here, the test is done to check if the push button is working properly and to visually check if everything is working efficiently.

- Testing 2: The starter received from the Testing 1 Workstation is unloaded here, and the test is done by using a machine where high voltage is passed to check if everything is in working condition, especially if the magnets are working properly. Thereafter it goes to stamping on the starter.

- Assembly 3: The starter received from Testing 1 Workstation is unloaded here; the final label is attached. Also, a cardboard roll is inserted for the safety of the product. The sole reason for doing this is to ensure the safety of the contactor and relay during shipment. Then, it is put inside the plastic cover along with an instruction sheet for final packaging.

- Packing Workstation Assembly: This is the sixth assembly station of the starter. The starter will come for the assembly after successfully completing the Testing 2 Workstation area. The operator will pack the starters inside the carton and will pass it to the taping machine for pasting the tape. After successful packaging, the starter is ready for dispatching and shipment.

3. Methods

The study was conducted in a discrete manufacturing industry in Maharashtra state of India. The methodology adopted is the PDCA (Plan, Do, Check, Act) approach by integrating the Lean tool in each PDCA cycle stage. The PDCA method facilitates persistent process improvement and enables ongoing quality enhancement within a company (11). As this approach comprises numerous activities, it facilitates improving processes by making them more visible and agile (8).

An essential tool for vertical integration in the lean process is the GEMBA walk. The data collection was carried out in the field following the GEMBA walk to obtain first-hand information on the company's process. It ensures that all organizational levels stay in contact with "the Gemba," the front line where the real value is created (9). All phases of the factory's manufacturing process, from the purchase of wire and the metallic top cover to the last shipping, were timed and measured at the core and within them. All the information acquired enabled the generation of a Value Stream Mapping (VSM). The following 5 phases were carried out;

a) Implementing the "value stream mapping" (VSM) and swim lanes to identify and eliminate non-value-added activities (MUDAs) after multiple GEMBAS.

b) Conducted motion study (MOST) analysis to research and track the efficiency and quality of labour workers to cut down repetitive tasks, hence reducing NVA tasks and unnecessary stress: To identify and eliminate the waste in the existing procedure.

c) Performed root cause analysis and designed cellular manufacturing layout to match the demand, where line balancing was done on every workstation to maintain the optimized flow of materials.

d) Employed the 5S techniques in the workplace to organize raw materials and finished products to improve efficiency.

e) Implemented Kanban card system in the workforce stations to reduce work in process inventory and maximize efficiency.

4. Results

4.1 Plan

The first phase plan consists of meetings and discussions with the upper hierarchy to discuss the project flow on how to achieve the targets. This included immense brainstorming and performing root cause analysis and why-why analysis, which resulted in us focusing on developing the manufacturing line to reduce/eliminate the probable waste.

4.2 Do

The second phase of the approach was "Do". The initial step to be performed is to prepare a Value Stream Mapping, study the existing layout and begin with the application of 5S and Visual Kanban to examine the current status. In addition, it not only helped to improve the manufacturing line of one product but also the other product-making processes can be benefited. It also improved the productivity of all the stakeholders involved in the system.

The next stage was to create a better configuration that allowed for faster product flow within the plant. The senior hierarchy and the plant's stakeholders must be engaged before implementing changes. The necessary adjustments are present in the new layout. In the existing layout, if we draw a spaghetti diagram, we see a lot of to and fro and excess unnecessary movements between the flow. Not only the raw materials are appropriately kept but also the finished products are kept scattered. The line is also not correctly managed; hence, the material flow is also done in a haphazard way, leading to motion waste. Line balancing is also not maintained, hence giving rise to a lot of Work-in-Process (WIP) bins before particular processes, and hence many bins are required. Particularly, we face the same motion waste and unutilized space. The contractors/relay/raw materials bins are kept anywhere. Thus, this brings us to introduce a cellular manufacturing layout to arrange the workstation as required with proper line balancing.

The next step was to perform the "Maynard Operation Sequence Technique" (MOST). MOST is a predetermined motion time system used primarily in industrial settings to set the standard time a worker should perform a task. It helped to identify and eliminate the non-value-added task of the operator. In contrast to other techniques, MOST alleviates the difficulties of analysis and lessens the workload associated with handling a significant volume of data (12). To determine this, activity is divided into several motion components, each given a numerical time value in time measurement units (TMUs), where 100,000 TMUs are equal to one hour. The standard time is then calculated by adding all the motion element times and allowances.

a) "Basic MOST, Mini MOST, and Maxi MOST" are the two variants of MOST that are most frequently utilized. The amount of focus used by each method varies; Basic MOST records motions at the level of tens of TMUs, whereas Mini MOST and Maxi MOST, respectively, employ individual TMUs and hundreds of TMUs. This enables various applications—Mini MOST is frequently used for short, repetitive cycles (less than a minute), and Maxi MOST for more extended, non-repetitive activities (more than several minutes). Between them is Basic Most, which can be utilized precisely for tasks that take between a minute and ten minutes to complete.

b) The Industrial Engineer can measure work in a practical, efficient, and affordable manner thanks to Basic MOST.

c) MOST is a potent analytical tool that boosts productivity, enhances processes, makes planning easier, determines workloads, estimates labour costs, boosts safety, and makes the most available resources. MOST can be used for any task for which a technique can be specified and detailed.

d) Because it applies to all industries, MOST has been adopted as the norm by thousands of businesses.

e) As MOST is a system for measuring work, it focuses on the movement of items. It has been noted that things move in constant, repeated patterns, such as reaching, grasping, moving, and positioning. In general, there are two ways to move objects: Either lifting them upward and transporting them efficiently across space or moving them while maintaining contact with another surface.

f) As an illustration, a transmission case can be pushed across the top of a workbench or picked up and carried from one end to the other. A different M.O.S.T. sequence model is employed for each type of maneuver, which results in a unique sequence of occurrences.

g) Hence, three M.O.S.T. sequences are required to describe manual operations and a fourth sequence is required to measure the movements of objects when using manual cranes.

- The "General Move Sequence" (for the unrestricted movement of an item in the air).
- The Controlled Move Sequence (for an object's movement when it is constrained by a surface or continues in contact with it).
- The "Tool Use Sequence" (in order to use standard hand tools).

Thus, after completely examining the scenario by the above methods, the NVAs that are identified are as follows:

- Raw materials and finished products are scattered.
- Motion waste due to improper positioning of the line.
- High WIP bins/materials (stack) due to bottleneck and constraints.
- Material movement is high.

Sl. No.	Activity Description	Sequence Model														Total TMU	Frequency	Grand TMU	Time in Minutes	Time in secs	
	Operator 1																				11.235
1	Sit on the chair with adjustment	A	1	B	10	G	0	A	0	B	0	P	0	A	0	11	0.0016667	0.18333333	0.00	0.0066	
2	Grasp 10X packing carton & PLACE on table	A	3	B	0	G	3	A	1	B	0	P	1	A	0	8	0.1	8	0.00	0.288	
3	Grasp the carton from table	A	1	B	0	G	1	A	0	B	0.0	P	0	A	0	2	1	20	0.01	0.72	
4	Rotate for correct position & place it on the work table (Check that notch should	A	0	B	0	G	1	A	0	B	0	P	0	T	1	2	1	20	0.01	0.72	
5	Push both hands towards each other to open carton	A	0	B	0	G	0	M	1	X	0	I	0	A	0	1	1	10	0.01	0.36	
6	Rotate carton and GRASP the side flap PUSH it with pressure inside.	A	0	B	0	G	1	M	1	X	0	I	1	A	0	3	1	30	0.02	1.08	
7	GRASP the upper flap PUSH it with pressure & Align it to one point < 10cm apart.	A	0	B	0	G	1	M	1	X	0	I	1	A	0	3	1	30	0.02	1.08	
8	SEAT the flap	A	0	B	0	G	0	M	1	X	0	I	0	A	0	1	1	10	0.01	0.36	
9	Place the carton on table with open end up within reach.	A	0	B	0	G	1	A	1	B	0	P	1	A	0	3	1	30	0.02	1.08	
10	GRASP the open end side flap PUSH outwards	A	0	B	0	G	0	M	3	X	0	I	0	A	0	3	1	30	0.02	1.08	
11	Grasp the contactor from the bin	A	1	B	0	G	1	A	1	B	0	P	0	A	0	3	1	30	0.02	1.08	
12	Visually check the contactor	A	0	B	0	G	0	A	0	B	0	P	0	T	1	1	1	10	0.01	0.36	
13	Place the contactor in the carton with adjustment	A	0	B	0	G	0	A	1	B	0	P	1	A	0	2	1	20	0.01	0.72	
14	PLACE IT UNDER SCANNER	A	0	B	0	G	0	A	1	B	0	P	3	A	0	4	1	40	0.02	1.44	
15	SCAN THE UNPACKED CONTACTOR PROCESS TIME AND ALIGN FOR SCANNING(1	A	0	B	0	G	0	M	0	X	1.39	I	1	A		2.39	1	23.9	0.01	0.8604	

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Figure 2: Cyclic Activity of One Workstation after MOST study

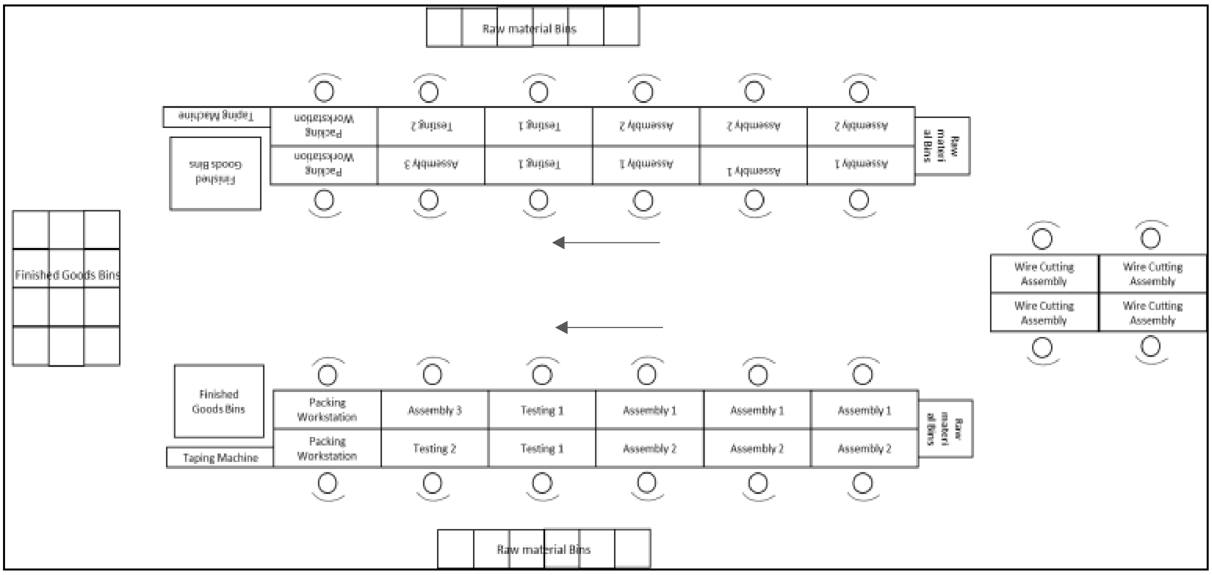

Figure 3: Initial Layout

4.3 Check

In the “check” phase, the first approach was to have multiple GEMBAS, i.e., continuously visiting the shop floor to track the flow and identify the NVAs by applying lean management tools like VSM, spaghetti diagram, and swim lanes. After a successful conclusion in the “do” phase, as discussed, we identified motion and inventory waste as the only MUDAs to be eliminated/reduced. An Excel checklist was also circulated to the employees via a Google form, where the results were plotted in the graph to identify their intensity. The low-hanging fruits were targeted first to solve the issues. The next problem follows based on the majority of votes given into the specific problem.

After performing root cause analysis, we identified the actual cause, i.e., the WIP inventory of the raw material was high, the stack was also high in between the workstations, creating a huge number of bins in use, and the assembly line was scattered, which brings us to the solution of introducing cellular manufacturing layout which would properly arrange the workstation as per the requirement with proper line balancing.

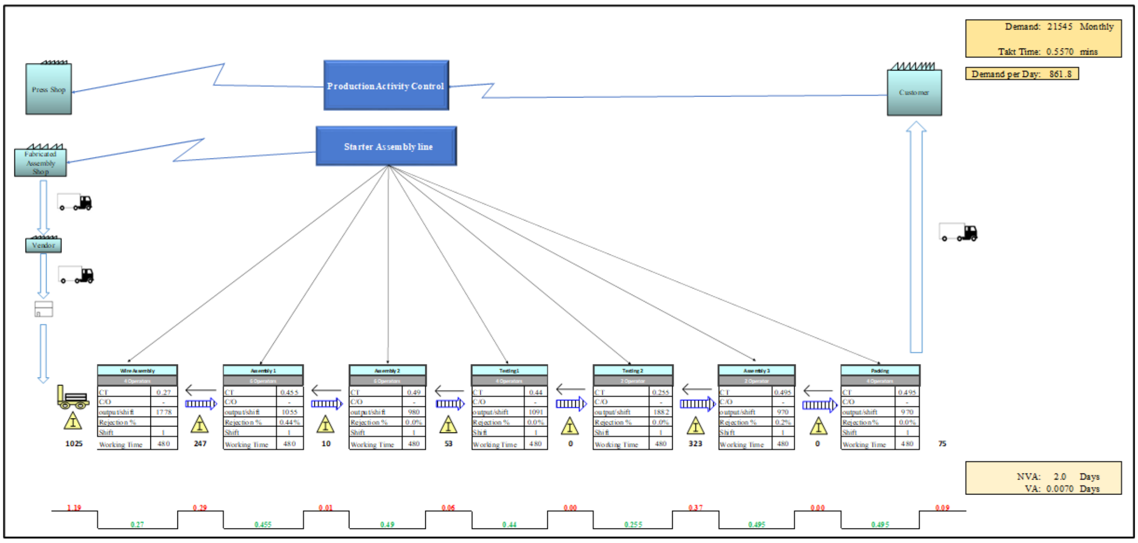

Figure 4: VSM of the current state

4..3.1 Cellular Manufacturing

Cellular manufacturing refers to using a specific set of tools or production techniques to process a collection of related pieces (13). It is conventional for work areas to be laid out in a horseshoe or U shape to allow employees to move swiftly from one technique to another and pass parts between each other. "Cells" normally concentrate on producing particular models in "component families," although they can be changed to produce a wide range of goods as needed. Although it is frequently the case to maximize product throughput with the least amount of floor space, work cells must not be arranged in a U-shaped design. Along with making Work Cells that match letters, notably S, T, W, X, and V, it's further typical to create circles, polygons, rectangles, and other shapes. The requirements of the product will ultimately decide the cell's layout. While designing a new work cell, the goal is to expeditiously and effectively move apart across each phase. In the subsequent stage, the configuration of the work cell is influenced by manual and equipment cycle time along with "Takt Time" to decide cell staffing. Other issues with cell production include equipment redundancy, equipment quantity, cure times, and the versatility of cells to handle a variety of materials. Staff members frequently switch between two or more stations to perform the duties necessary to satisfy the product demand rate when work cells are designed effectively. The utilization of manufacturing cells integrates the implementation of various previously described Lean concepts. The POUS, QAS, JIT, Kanban, and facility layout, to mention a few. By placing all VA actions in the most efficient order, the goal of cell design is to identify and eliminate as much NVA duration and activity from the current procedure as is feasible. To design and deploy a cell successfully, there are five essential stages to follow:

1. Group products: To create a cell, we must first comprehend our product groups. To do this, we must first create a list of all the items and then list all the steps in the process that are necessary for each product. Creating a simple matrix with product kinds on one axis and process stages on the other is typically the simplest solution. After checking off any procedures required for each product, it is straightforward to identify and arrange products by the respective process phases. Once our items have been organized into groups, we may set up certain cells to produce or put together each group's products.

2. Calculate the takt time: The demand rate for each product must now be determined or measured after the products have been grouped. The demand rate measures how quickly our customer demands that we create our thing or offer our service. The demand rate, commonly expressed as units per hour/activities per day, is estimated as the labour time available divided by the total quantity of units sold. Designing a cell must start with understanding the customer's demand rate. The demand rate needs to be somewhat constant for cells to function optimally. If the demand rate is irregular or unpredictable, consider incorporating a visual control supermarket into the cell design.

3. Chart current work sequence: The next step is to map out our present workflow for each product. Typically, a time observation chart is used to record each process component. Keep track of the time it takes to finish each step in the task sequence. In order to break down work activities and get them reconstructed as a fresh and continuous sequence, this time observation method is a crucial supplement.

4. Combine work and balance process: Once we have accurately documented times for each step in the work sequence to achieve the appropriate output or demand rate for the client, we can combine some task components and weigh the advantages and downsides. Element groups are used to calculate a duration shorter or equal to the demand rate. Each step in the work sequence, for instance, must be finished in 10 minutes or less if the estimated demand rate for a particular product is 10 minutes per unit. Our work product flow will be more continuous and seamless the closer we get each component to 10 minutes. Balance of work sequences is not a perfect science. However, we will be able to identify substantial disturbances in workflow caused by uneven work element times after analyzing our time observation chart.

5. Create a new cell work sequence: We are now prepared to establish a brand-new work cell sequence after completing steps 1-4. This stage involves creating a workflow structure that incorporates all. To finish the job sequence, resources, including equipment and labour, are needed. The major objectives are to minimize material handling, fully use staff during peak demand periods, and streamline the flow of material by consolidating key processes. In essence, we want to connect each component of the job and create a smooth flow. The task components will determine how we order these, but choosing one of the proven effective cell arrangements works best. The U-cell and S-cell designs are the most typical.

So, in our proposed layout, we organized the process in each cell, and every workstation is properly balanced to make a single-piece flow-based/cellular manufacturing layout. Eliminating the NVA tasks after rigorous motion study (MOST) has also improved the bottleneck and constraints. WIP bins are nearly negligible as the output of each process is handed over to each process instantaneously. Raw materials and finished products are also kept handy in the process to ease access. 5s can be maintained easily. Hence, an easy flow has also helped us to save space by 35% from the other 2 layouts, reducing around 7% balancing loss. Not only this, but we also managed to reduce the handling time.

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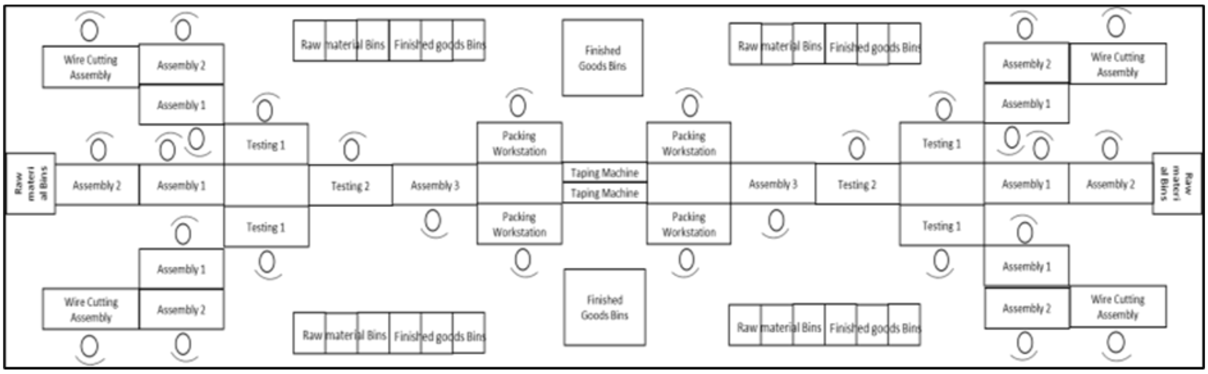


Figure 5: Cellular Manufacturing Layout

4.3.2 Implications from the Layout Comparison

After vividly comparing the dimensions between the two layouts, i.e., the existing layout and the proposed layout in ZWCad software, we found that Space would be optimized by approximately 35%.

Furthermore, there would be a rigorous reduction In Balancing Loss by approx. 7% from the previous layout. This data has been duly taken by observing real-time the stack inventory piled up between every workstation within 1 hour. Thus, we compared the results and got the value before and after the proposed layout. To achieve this, we implemented a Kanban card system in the workforce stations to reduce work in process inventory and maximize efficiency. It is a 2-bin Kanban system that uses 2 bins for managing the inventory. It is a technique that offers several advantages, including decreased stack inventory or increased operator satisfaction. Simply put, it is a "method of managing inventory that employs two actual bins, typically for small but essential parts such as fasteners and class C components" (10). It is a straight pull system in which two spinning containers provide the pieces. The technique is merely based on giving employees two plastic storage bins filled with inventory, which they can use to fill orders or supply supplies to various departments. The number of products in the bins will depend on how quickly they are utilized individually. The employees take what they need from one bin until it is empty, at which point they switch to the second bin while simultaneously placing an order to restock the first bin with what they need. The first bin must be replenished with a predetermined quantity of goods, so there is little chance of running out of supplies (which could slow down production). Additionally, there has been an impressive increase in output per shift by 16%, which ultimately touches the company-targeted takt time. There has been a massive reduction of Material Movement, which has been applicable to line balancing, where every workstation has almost the same output. Also, the movement is also less, which ultimately reduces the motion waste. Figure 10 illustrates the Value Stream Mapping of the future state.

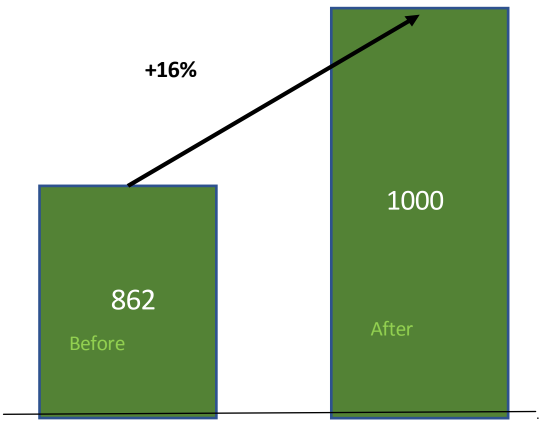


Figure 6: Output/Shift

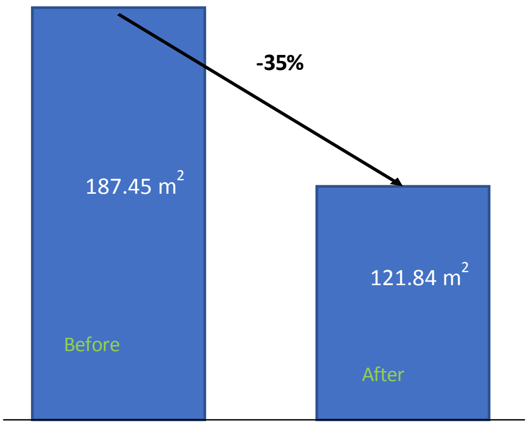
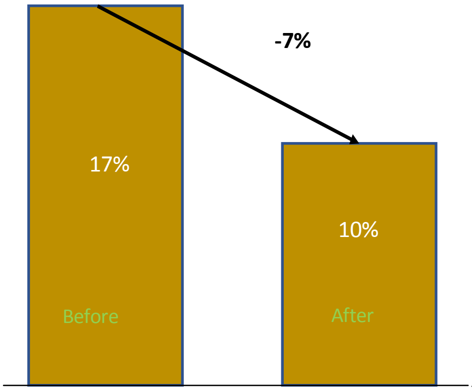


Figure 7: Space Saving



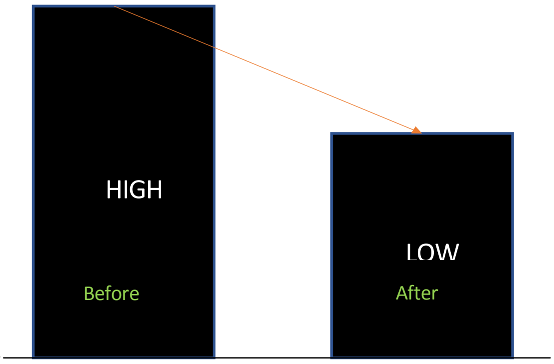


Figure 8: Balancing Loss **Figure 9: Material Movement**

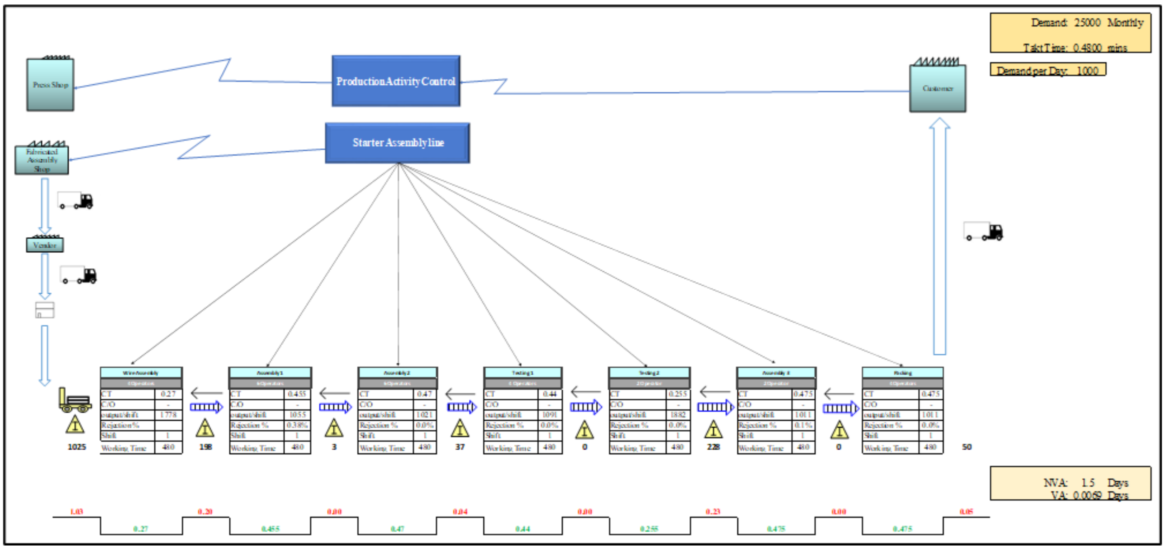


Figure 10: VSM of future state

4.3.3 Implications from the VSM Comparison

Line balancing will control the WIP bins/material as most of the workstation cycle time is similar. There will be minimal stack inventory between the processes, thus causing fewer bins to be used or reducing the overproduction of WIP products. Single-piece flow is maintained in the layout as workstations are placed consecutively in a series, where a continuous material will flow until its packaging. The increased number of operators/workstations has also improved the bottleneck and constraints. Since the takt time got high due to a surge in the market demand, it was necessary to add an extra machine due to less efficiency of its cycle time than expected. Also, this helped in balancing the manufacturing line of the product.

Raw materials and finished products are also kept handy in the process/workstations to ease access, reducing motion waste, as operators do not need to run for the material. Rather, they can get it through close proximity. 5s can also be maintained easily. As we observed that the raw materials were kept scattered and far away from the workstation, we set raw materials and finished goods in proximity to the workstation in order to reduce the movements of the material. Thus, this helped to reduce the motion waste as bins are kept nearby, as shown in the proposed layout design in accordance with mitigation and improvement. Also, every 30 minutes, cleaning the floor has been mandatory and emptying the dustbin after a definite period of time would definitely shine the place. Thus, the 3rd "S" can be followed. To maintain the 5th "S", the check sheet/audit must be duly filled by the employee, operators and the associated stakeholders to get vivid feedback on maintaining the decorum, ultimately improving the ergonomics. Thus, in Figure 11, we can see a reduction of NVA by 25%, which ultimately improved the process efficiency.

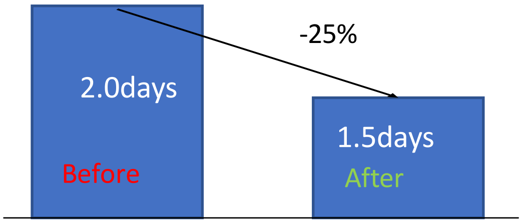


Figure 11: NVA(Days) of Current vs Future State

4.4 Act

In this phase, the project has been rolled on, and there has been a release purchase order for additional infrastructure required to fulfill the proposed assembly line. The future scope has been mentioned for improvements where the loopholes cannot be fulfilled due to constraints.

Currently, the whole manufacturing sector is moving towards automation and digitization. The pace at which technological advancement is taking place is so rapid that what we implement today might not be relevant in the coming times. In these ever-changing times, it is absolutely necessary that we grow at the same rate and make improvements to our model to stay ahead of our competitors. With these thoughts in mind, we have a few suggestions that could be implemented to improve the efficiency and responsiveness of our model:

- A wire Cutting, bending, and stripping Machine can be installed to automate the process, which can reduce the cost of the present three operators as well as reduce the takt time.

- Proper supply of bins can reduce any damage to body cover or finished goods, as can be seen in the assembly line. The finished products are kept haywire causing internal damage in the packaging as well as the product.

- Digitalization or the creation of a live dashboard can provide real-time data to achieve their target production volume and actual production volume for that month/quarter, where monitoring this can pave the way for the scope of improvement as well as improve the tracking system.

Creation of an admin panel and providing the R&D department with the same so that if any new product is developed, it can be readily added to the database without the need for the database team to update it at their need. The data entered through the screen can update the master tables with new entries. Creation of a live dashboard that will give real-time data on different products, their target production volume, and actual production volume for that month/quarter.

5. Discussion

The obtained results demonstrate the considerable ability of the proposed framework to increase productivity in the discrete manufacturing industry. This results in time savings for the entire starters-making process, as it identifies the areas where issues such as waiting time, motion waste, line balancing, and stack inventory are evident. This study demonstrates that the Lean manufacturing approach may be used and implemented in any discrete manufacturing sector. By adopting this technique used in this study, organizations can develop a culture of continuous improvement and become more successful, efficient, and customer-focused.

A thorough implementation of the recommendations would lead to an up to 138 pieces increase in the products daily. The company's remarks on its work are highly positive. As a result of its success, the Company has notified us that they intend to test out our recommendations in their operations. Furthermore, the effectiveness of Lean tools and techniques on organizational performance is demonstrated in this work. These findings offer the discrete manufacturing industries a better knowledge of the link between the efficiency of industrial operations and the Lean approach.

Some limitations were observed during the GEMBA walk due to the absence of technologically advanced tools. Hence the long-term data could not be accurately obtained, as discussed in Section 4.4. Therefore, future researchers can replicate this study at a more technologically advanced facility to obtain longer-time records. Despite much research on the subject, more is needed regarding how sustainability affects other factors linked to a company's performance, reputation, and trust (14). Therefore, other sustainability strategies that apply to other environmentally sensitive businesses can be investigated in future studies.

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