ISEN 645 : Rochester Gauges Line 35M

GROUP 5

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1. Introduction

Rochester Gauges, LLC is a global corporation based in Dallas, Texas. Their production facilities are located in Dallas, Mexico City, Mexico, Brussels, Belgium, and Shanghai, China. With over 100 years of experience and about 200 patents, they are a global manufacturer of liquid level gauges and sensors. They offer a comprehensive range of fuel/oil, water, and compressed gas level gauges. Rochester gauges can be used in a variety of processes, including welding, stamping, metalworking, and soldering.

The available information about Rochester Gauges and the production line was researched and analyzed using the ideas taught in the ISEN 645 course. It aided in the development of practical models and implementable solutions to meet the objectives. To comprehend the functional decomposition of the production system, the ASIS model was first investigated and traced as an IDEF0 model. This gave us insights into desirable features, and after assessing numerous wastages, we were able to meet our expected benchmarks and develop an optimal cell plan. We've also devised a strategy for implementing the recommended modifications, as well as tips for doing so.

2. Problem Statement

The project's goal is to solve the issues that arise in the 35M production line's manufacturing procedures. Excess productions, bottlenecks, longer lead times, more WIP inventories, and other issues/waste were all visible in the process. But, among all of these issues, a few that caused the most inefficiencies in the process were bottlenecks in the stages, which resulted in high WIP Inventory, and poor workspace organization, which resulted in superfluous motions in the worker's activities. These issues were generally discovered by comparing data from manufacturing processes, such as completion time, cycle time, and visual flow of processes, with video footage of the workers' real activity on the production line.

After identifying all of the issues, the team concentrates on improving the production system by implementing lean approaches such as Kaizen, Poka-Yoke, and Continuous Flow among the workstations and other stages to improve the flow.

3. ASIS Macro Level

IDEF0 Model

Purpose: The purpose of the model is to map the ASIS production process of liquid level gauges on line 35M at Rochester Gauges, LLC to identify ways to improve the existing process.

Viewpoint: The viewpoint is that of a lean engineer so as to identify potential wastes and find ways to mitigate them.

Context: The context of the model is to map the liquid level gauges production process from manufacturing, assembly, calibration, and packaging using different mechanisms and inputs as part of the ASIS model.

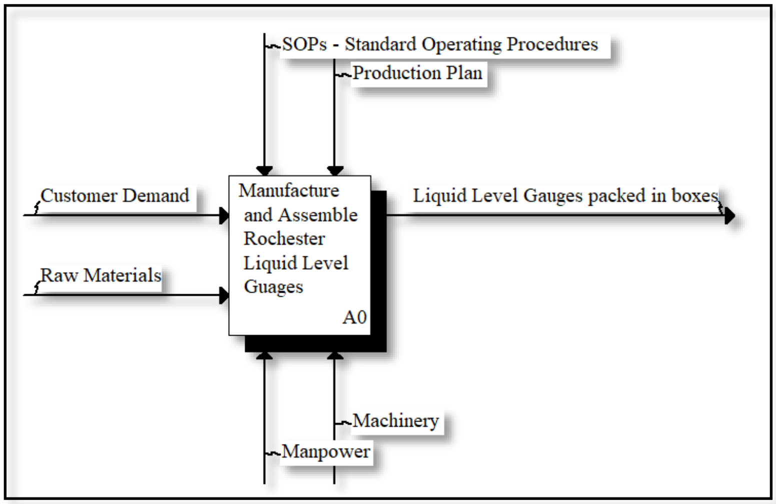

Figure 1: ASIS IDEF0 model of Line 35M

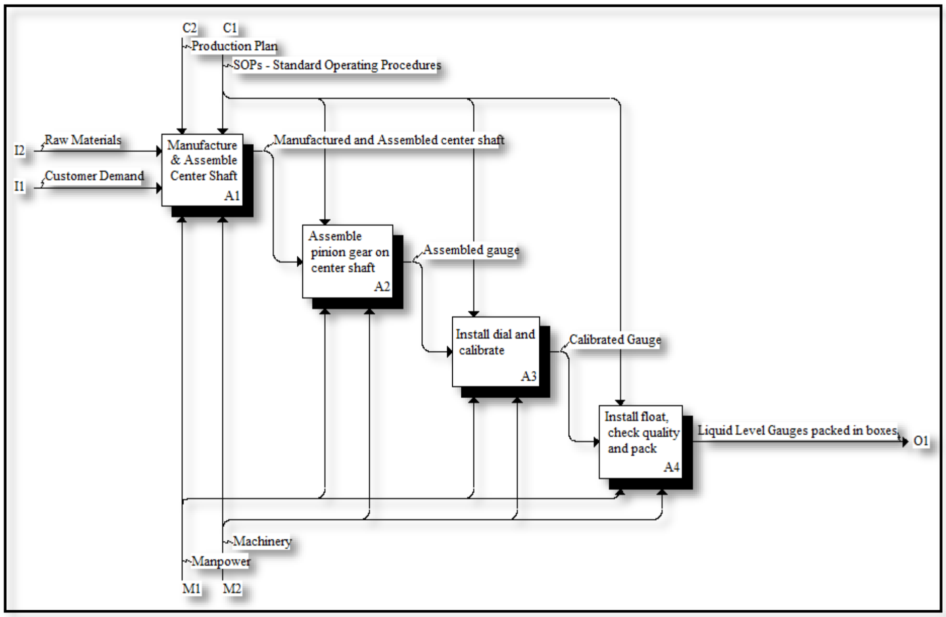

Figure 2: IDEF0 ASIS - A0 level model

4. TOBE Macro Level

IDEF0 Model

Purpose: The purpose of the model is to map the TOBE production process of liquid level gauges on line 35M at Rochester Gauges, LLC to identify ways to improve the existing process. Lean concepts are implemented to optimize the process

Viewpoint: The viewpoint is that of a lean engineer so as to identify potential wastes and find ways to mitigate them.

Context: Context is to produce liquid level gauges on line 35M with the help of certain mechanisms and control. It is an improved version of the ASIS model.

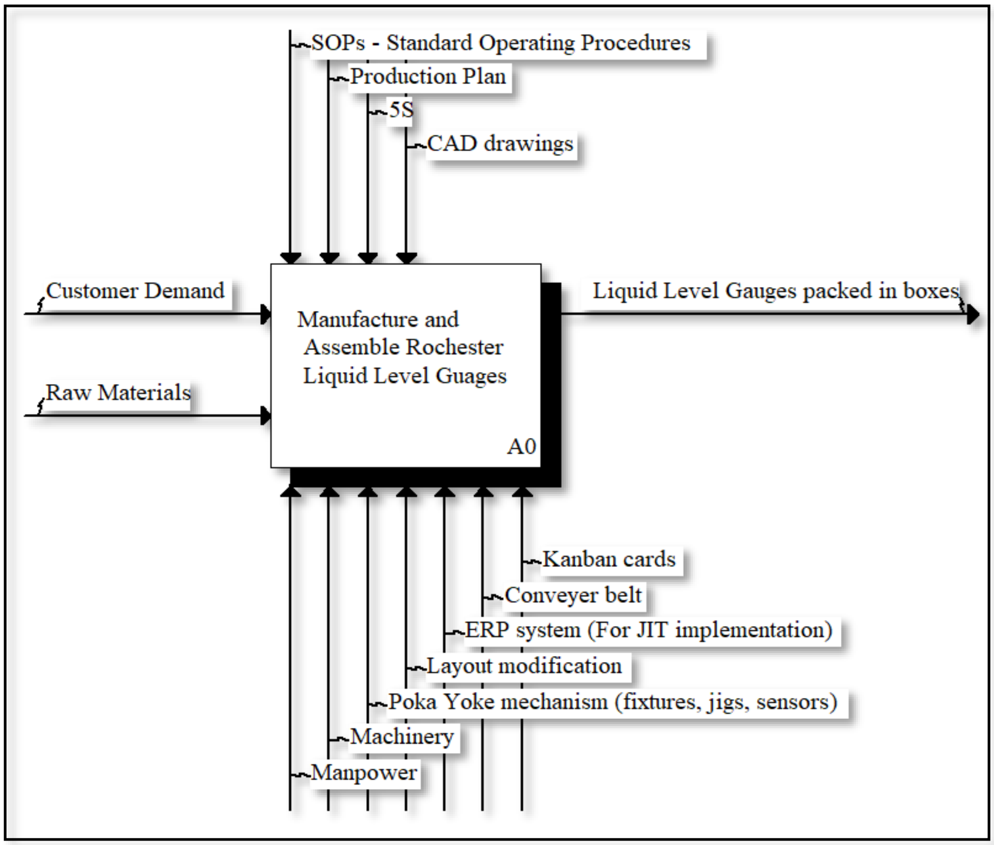

Figure 3: TOBE IDEF0 model

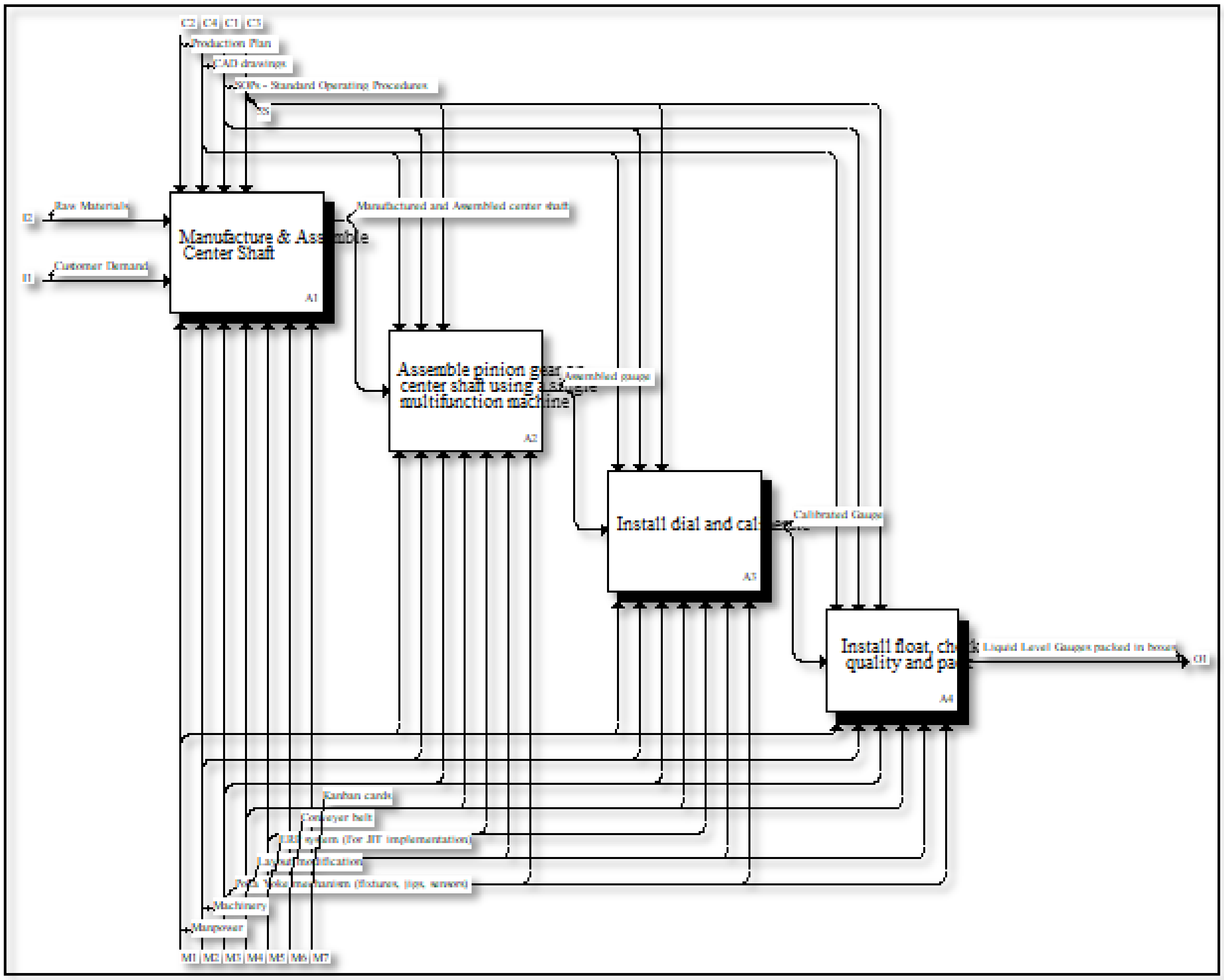

Figure 4: IDEF0: TOBE - A0 level model

5. TOBE Micro Level

5.1: 5S Methodology

A production system that uses the 5S methodology is one in which everything and everyone has their place. The 5S concept is derived from five Japanese words: Seiri, Seiton, Seiso, Seiketsu, and Shitsuke, which translate to:

- Sort entails removing anything that isn't required.
- Straighten entails organizing whatever is left after sorting.
- Shine entails cleaning and evaluating the work environment.
- Standardization of the process entails tailoring the process to adhere to a set of guidelines in order to produce consistent outcomes each time it is run.
- Sustain, i.e. continue to use the 5S framework that has been put in place.

The manufacturing system in question has an unorganized work environment, and 5S approach can be implemented in each of the system's workstations. All of the tools and materials needed to do the duties assigned to each workstation should be organized in separate marked trays and stored close to the machines to save the worker time from having to go to another workstation to get them. For example, the worker at the first workstation repeatedly moves to bring severed cables from another location, increasing overall time and decreasing efficiency. Second, the workstations are congested and unorganized, with waste materials and trolleys strewn about, interfering with the tasks being carried out. When raw materials are brought to workstation 1, the trolley that is left there gets in the way of the material movement, which is undesirable. As a result, workstation organization is vital to the 5S methodology's success. After identifying and removing all waste products from each workstation, the following step is to arrange the machinery, as well as the associated tools and tackles, in the order of the procedures involved. The next stage is to clean and check the workplace to confirm that the first two phases have been followed correctly, and after that, the process and workplace design should be standardized by documenting each method and creating a standard layout for the workplace. Finally, it is vital that all of the procedures taken thus far are maintained over time, and periodic inspections should be conducted to assure this.

5.2: Line Balancing

Line balancing is a production approach that involves matching the production rate to the takt time by balancing operator and machine time. It is critical to guarantee that machine cycle time is less than or equal to takt time in order to meet customer demand. The entire cycle duration in the current situation is 174.2 seconds, which should be decreased to 108 seconds. Furthermore, all four workstations should have the same cycle time so that no single workstation becomes a bottleneck, and the manufacturing process runs smoothly.

Each process' takt time is provided, as well as stopwatch readings for the primary processes. The actual time is estimated by averaging the stopwatch readings, and for the missing data, an approximate actual time is assumed. The bottleneck processes with the highest percentage

variation are determined based on the comparison. The many methods for reducing cycle time to meet the takt time are identified.
1. Material flow optimization: Moving an operator to carry a load is a time-consuming process that generates motion and transportation waste. The use of advanced material handling techniques, such as the installation of conveyor belts within workstations, can significantly minimize this time. The belts will ensure that the material flows smoothly without the operator having to move.
2. Use of automated procedures: At each workstation, a multifunctional machine can be installed that can be used to complete a list of processes. The use of automation will aid in the reduction of cycle time and the elimination of manual labor, hence enhancing cycle time while minimizing investment costs.

We can completely balance the production line to meet the takt time using the various strategies outlined above, resulting in a continuous flow in the manufacturing process. Because each workstation has only one operator, line balancing is used to balance the operators.

5.3: Six Sigma

Alongside creating a single-piece workflow, it's also critical to ensure that the process is statistically under control, and that if there are any outliers, corrective actions are made to keep the system lean. We used the Lean six sigma process to control process variation for this. When a process is six sigma, 99.9997 percent of the observations fall inside these control limits. This equates to 3.4 dpmo (defects per million opportunities).

The system will be lean if you plan for six sigma. When looking at the existing process, it appears that there is a lot of variation in the process, which leads to product rejection or rework. To combat this, the team decided to create a process flow diagram that encompassed all of the processes and operations. A joint group meeting was held to better comprehend the issue. To move forward, the DMAIC (Define, Measure, Analyze, Improve, Control) technique was adopted.

During the Define phase, the team examined the current situation, identified areas for improvement, and set a goal of lowering the rejection rate to 5%. A 'Project Charter' was created based on the facts, goal, improvement opportunities, and estimated course of action. We measured all of the potential data in the Measure phase. Following the Measure phase, the Analyze phase looked at each process to see if there were any outliers or non-conforming events. During the Analyze phase, it was discovered that the majority of the process variance was caused by human errors, such as inexperienced workers and machine errors.

New updated SOPs with visual representation were provided during the Improve phase to make it easier for workers to grasp. Workers were also provided new training materials, and evaluations were done to check their comprehension. Another feature that was supposed to be included was the use of sensors to assist workers in determining the order of operations. In addition, jigs and fixtures were installed at each workstation to ensure that errors were not made. Poka-Yoke is another name for this technique. It was suggested that old machinery be replaced with new automated multipurpose machines to reduce machine errors. These changes were made in order to obtain a six-sigma procedure.

The final Control phase is critical in ensuring that these improvements are implemented in daily life. It is critical as it guarantees that change is implemented and improvements are maintained rather than returning to the same initial approach, which can be destructive to the business. As previously indicated, we used the DMAIC technique to achieve six-sigma process control. Another method is DMADV, which stands for Design, Measure, Analyze, Design, and Validate. This method is utilized when a new product or organization is being developed with the goal of achieving a six-sigma process from the start. Since we have to improve the existing process this method cannot be implemented on the production line.

5.4: Waste Table

Table 1: Waste Table

Type of Waste	Needs from the ASIS model	Ways to Eliminate wastes (TOBE model)
Defects	Poor quality of product as a result of faulty quality inspections due to unavailability of WS4 operator	Using the Poka-Yoke technique to do quality checks after each workstation, which will eliminate defects by a greater percentage.
Inventory	Due to overproduction at WS1 and slower production at WS2, there is excess WIP inventory between WS1 and WS2.	When manufacturing at WS1 is required, Kanban Card Signaling is used to facilitate production at WS2.
	Due to a lack of personnel, the WS3 operator moves frequently to transfer finished goods from WS2 to WS3.	Adding a transfer tray to transfer finished goods from one workstation to the next
	The delivery route for raw materials is blocked by unorganized inventory or finished goods from WS4.	Using 5S to keep your workstation in order
Overproduction	Increased WIP inventory at WS2 due to excess production	Kanban cards will be added to the WS1 finished goods inventory, signaling when WS1 should resume production. This will reduce the excess WIP inventory at WS2 and, as a result, the time spent waiting on WS3 and WS4.
Transporting	Due to a shortfall at WS1, raw materials were acquired from another production line (late delivery)	Using an ERP system to ensure that raw materials are delivered on time to workstations.

	At WS2, an operator transports components in blue containers from one production line to the next.	Organizing the workspace with 5S principles and ensuring proper storage of raw materials and components at workstations
	Due to a material shortage, the WS1 operator moves to another manufacturing line to pick up material.	Using an ERP system to keep track of raw materials efficiently
	Movement of WS2 operator to support activities at WS1, WS4 and delivery personnel	Using Value Stream Mapping approaches to assure correct material and process flow, hence reducing random motions and disturbances.
Unnecessary Motion	WS3 operator relocated to support WS2 and WS4 activities (due to absence of operators, supporting other tasks because of improper distribution of tasks)	The Line Balancing approach can be used to properly allocate work to each worker, allowing them to fulfill their assigned responsibilities and, as a result, eliminating their absence from workstations.
	Movement of WS4 operator to support storage activities of finished goods	Using Kanban cards to signal the movement of finished goods to the storage area, which will free up space at WS4 and allow for uninterrupted production.
	Due to late delivery of wire/shaft for cutting at WS1, lead time has increased	By having real-time inventory level data and using it to place orders or trigger delivery at the production line in a timely manner, better equipped ERP software can assist reduce this problem.
Waiting	Due to the reduced output rate at WS2, there is an excessive amount of waiting time at WS3.	The use of the 5S approach to properly allocate resources and raw materials for several workstations. This will reduce the number of extra movements made by WS2 operators, allowing them to concentrate solely on WS2 operations.
	After WS4, waiting for finished goods to be collected and stored in the warehouse.	By appropriately structuring station 4's workspace and informing inventory management via ERP for the pickup of finished goods, the 5S technique and ERP system can assist overcome this issue.
	Due to the absence of an operator on many occasions, WS4 packaging and quality control activities were delayed.	The Line Balancing approach can be used to properly allocate work to each worker, allowing them to accomplish their jobs and, as a result, eliminating their absence from workstations.

5.5: 8-step process

We implemented the 8-step process strategy to identify problems and optimize the RG 35M Production line.

- Create Urgency: Determine the problem's need and urgency.
- Form a Strong Coalition: Collaborate with Teams to Solve the Problem
- Develop a Vision for Change: Develop a strategy for learning the manufacturing process.
- Communicate the Vision Ensure that front-line employees understand the change's mission and vision.
- Remove Obstacles Work on Non Value Added activities and Necessary but Non Value Added activities
- Build on the Change Concentrate on the source of the problem.
- Anchor Changes in Institutional Culture Sustain the modifications.

We considered time stamps for 25 sub processes based on the available Work-Time Study data and the Yamazumi chart. We looked at some data and used a stopwatch and available production line video to compute the time stamps of the remaining six subprocesses. With the data aggregated, we calculated the current Total Cycle Time to be 37.7 seconds each WS and hope to lower it to 27 seconds.

Before beginning with the process optimization, we examined two approaches. -

Based on the various losses found in the manufacturing system, we believe that rebuilding the cell is the optimal micro-level design for optimization.

The layout design solves the problem of longer cycle times while also increasing the efficiency of both space and labor for the D35M line. This entails applying lean techniques to enhance Rochester Gauges. If implemented appropriately, the micro-level design enlists a step-by-step technique on how we can consider the D35M line to meet needed takt time with a cycle time less than takt time.

Table 2: 8 Step Process

1	**Arranging the work cell**
2	**Cleanup the neighboring area/workspace**
3	**Add a table between Workstation 2 and 3**
4	**Add a worker**
5	**Additional cart or table requirement**
6	**Machine setup**
7	**Start production of parts after training the workers on best practices**
8	**Ensure proper lighting on workstations to reduce defects/rework**

An additional worker should be employed, or one of the present worker should be moved to another line. This worker's responsibilities will include transporting raw materials to the assigned workstation and aiding other workers as needed to save processing time. This person may also be entrusted with manufacturing shipment boxes. To carry out our intended cell structure, we will require additional carts and tables. The dimensions of the offered tables should be such that they do not obstruct any worker's mobility while also requiring him or her to take extra steps.

SOPs (Standard Operating Procedures) are an essential component of any organizational operation. Having SOPs for all levels assists a company in adhering to regular work practices in order to function properly. Rochester Gauges must develop SOPs at each level. It is vital for the company to have solid documentation that may be used as a reference by future engineers/workers. Furthermore, we may employ data-driven tools to assist managers in making data-driven decisions.

Improper lighting near the workstations has been proved by human ergonomics to have a negative impact on worker morale. As a result, we should strive toward enhancing the brightness of the workspace in order to boost worker morale and create a more vibrant ambiance. According to research, there are numerous industrial sites in Japan where the approach of changing the table color is quite common. Workers can readily and rapidly identify goods and tools as a result of these procedures. If changing the colors isn't an option, we may get the same effect with colored table mats. Another significant advantage of using a tablecloth is that it does not slip.

6. Implementation Plan

The manufacturing system in question has an unorganized work environment, and 5S approach should be implemented in each of the system's workstations. As a result, workstation organization is vital to the 5S methodology's success. After identifying and removing all waste products from each workstation, the next step is to arrange the machinery, as well as the associated tools in the order of the procedures involved. Furthermore,we need to clean and check the workplace to confirm that the first two phases have been followed correctly, and after that, the process and workplace design should be standardized by documenting each method and creating a standard layout for the workplace.

Line balancing is a production approach that involves matching the production rate to the takt time by balancing operator and machine time. Methods for reducing cycle time to meet the takt time, such as Material flow optimization and Use of automated procedures are identified and should be implemented. These strategies can completely balance the production line to meet the takt time, resulting in a continuous flow in the manufacturing process. Because each workstation has only one operator, line balancing should be used to balance the operators.

By using the Six Sigma process, it is critical to ensure that the process is under control and find the outliers in the process. For this a six sigma control limit was used corresponding to 3.4 dpmo (defects per million opportunities). The DMAIC – Define, Measure, Analyse, Improve, Control technique was adopted to identify areas for improvement and lower the rejection rate to 5%.

The 8 step process strategy should be implemented to identify problems and optimize the RG 35M Production line that will result in reduction of Total Cycle Time from 37.7 seconds for each WS to 27 seconds. Appropriate implementation of the 8 step process can help in achieving the desired takt time with a cycle time less than takt time. Enforcement of SOPs and implementation of data-driven tools can aid consistent work practices and assist managers in taking data-driven decisions.

Category	Item	Scores					Remarks
		0	1	2	3	4	
Sort (Organization)	Unnecessary equipment, tools, and furnishings, among other things, are absent.						Responsibilities of the shop floor workers
	A distinction exists between what is required for the day and what is not required.						
	Water, oil, chemical, and machine hazards are not present.						
	Unnecessary things are not displayed on walls, bulletin boards, or other surfaces.						
Set in Order (Orderliness)	Aisles, workstations, and equipment locations are well marked.						
	After using an item, it is quickly put away.						
	A place for everything and everything in its place at the end of the day						
	The proper locations for goods are clearly labeled for easy understanding.						
Shine (Cleanliness)	At the end of the day, all lines, labels, signs, and other items are clean and intact.						
	At the end of the day, all equipment is clean and free of dirt, oil, and grease.						
	Dirt, oil, and grease are not present on the floors, walls, stairwells, or other surfaces.						
	Cleaning supplies are clearly labeled and readily available.						
Standardize (Adherence)	Every piece of information that is required is readily available in the form of drawings or references.						
	Keep track of the first three categories.						
	In the assembly area, all quantities and restrictions are marked.						
Sustain (Self Discipline)	How many workers have received 5S training?						Responsibilities of Line Manager or Floor Supervisor
	How many times was daily 5S conducted in the previous week/month?						
	Are personal belongings neatly stored ?						
	Are activity boards used and reviewed regularly?						

Figure 5: 5S Audit Table

Score	Type	Criteria
0	Poor	Activities not conducted at all
1	Below Average	Activities conducted between 0-30% that could adversely affect the process.
2	Average	Activities implemented between 31-60% giving average results that need improvement.
3	Good	Activities implemented between 61-90% in a systematic way but can further be improved.
4	Excellent	Activities implemented between 91-100% in a systematic way.

Figure 6: 5S Score Criteria

7. Recommendations

The strategies, approaches, and tools indicated above have been planned to be applied in order to make the current system lean. We have listed the techniques and methodologies below in order of priority of deployment, based on the existing operation of the RG line35 functioning.

Priority One:

- Line Balancing (Cycle Time Optimization) - Line balancing ensures that just one component flows at a time and that there are no wait times. It finds the bottleneck and makes decisions to improve it so that the cycle time and takt time are in sync.
- 5S Methodology - The 5S workstation management strategy will assist employees and instill trust in them. As a result, it should be implemented as soon as possible.
- 8 step process- This is a critical activity. It is the foundation for VSM (Value Stream Mapping). It aids in the comprehension of the current system and the application of lean tools to make the system lean.

Priority Two:

- Kanban — After applying 5S, Poka Yoke, Line Balancing, and an 8-step process, the Kanban method can be used. The thought process is identical to that of the six sigma method.
- Six Sigma — Controlling process variation necessitates the use of the six-sigma process. Because of the high priority approaches listed, we have given it a low priority. The existing system will improve once the high priority approaches are implemented. Then we must comprehend the process and determine whether or not six-sigma should be implemented. As a result, it should be implanted at a later time.

8. Conclusions

The benefits of lean engineering are numerous for both customers and companies. The time it takes to receive an order has been lowered from months or weeks to hours. Returns due to defective products are eliminated rather than scrutinized because of built-in quality. The cost and space required for inventory storage are minimized, allowing the company to focus its efforts on producing better results.

Since products are made after an order is placed, it gives customers a lot of customization possibilities, allowing them to pick and choose which product elements to combine. By lowering manufacturing overheads, lean manufacturing also helps to lower pricing.

Increase in assembly production was achieved by minimizing wastes caused by undesired worker mobility by implementing lean approaches. The implementation of 5S resulted in less unnecessary movement of workers and components, maintaining constant safety. Six Sigma process was used, resulting in proper workstation organization and storage of raw materials and final goods. Effectively monitoring of raw materials was possible by using a new ERP system that provided real-time inventory level data for both raw materials and completed goods. A solid linear flow of processes was recommended, thanks to line balancing, which helped in reducing overproduction at WS1 and underproduction at WS2.

Kanban cards would make it easier to keep track of current WIP inventories in real time. Using the Poka-Yoke method, elimination of faults at the source and prevention of subsequent problems was possible. Lean manufacturing is a bi-winning solution since it provides the consumer with a higher-value product while using far fewer resources to get there.

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