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Implementation of lean techniques to reduce mudas in smart tone horn assembly

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Abstract

In today's competitive manufacturing environment, companies are constantly looking for ways to improve in their production process. A new redesigned assembly line is proposed for bottleneck problems for continuous flow type horn assembly line. We present the improvement of the production rate and balance loss ratio of the manual assembly line. In order to improve the production rate, four different methodologies were proposed and the best one is chosen based on the output.

Keywords: Lean Thinking, Productivity improvement, Value Stream Mapping.

Introduction:

A horn is a sound-making device that can be equipped for motor vehicles, buses, bicycles, trains, trams, and other types of vehicles. The sound made usually resembles a "honk" (older vehicles) or a "beep" (modern vehicles). The driver uses the horn to warn others of the vehicle's approach or presence or to call attention to some hazard. Motor vehicles, ships, and trains are required by law in some countries to have horns. Like trams, trolley cars, and streetcars, bicycles are also legally required to have an audible warning device in many areas, but not universally, and not always a horn. In the horn assembly, a number of components are involved. A core principle in lean methodology is the removal of waste within an operation. And in any business, one of the heaviest drains on profitability is waste. Lean waste can come in the form of time, material, and labor. But it may also be related to the utilization of skill- sets as well as poor planning. In lean manufacturing, there are seven types of waste. In general, customers are not willing to pay for these activities because they do not benefit from them. The lean management and continuous improvement philosophy (Kaizen) attempts to decrease as much waste as possible. Our main objective is elimination of these seven kinds of waste which can help companies reduce costs, increase employee engagement and customer happiness, and increase profits.

Literature Review:

Lean and agile manufacturing plays a vital role to uplift the production process by lowering manufacturing cost minimal inventory and reducing the cycle time between the processes (C. Hemalatha et. al., 2021). Continuous improvement in the assembly sector can take two different approaches, depending on the investment that one wants or can make, and the depth of the actions that one intends to implement (P. Dias et. al. 2019). Value stream mapping helps in the implementation of new production management concepts - in particular in SMEs (D. Klimecka-Tatar et. al. 2022). The combination of VSM and Computer simulation have a significant effect on decreasing lead time and waste in the color industry (J. M. Rohani et. al. 2015). VSM used seven tools and concluded that this approach was not only limited to automobile industry but can also be applied for different industries as well (P. Hines et. al.1997). Among all of the methods, VSM extension supports the production planners to choose supportive Smart manufacturing Solutions (N. L. Martin els. 2020). As part of managing the internal environment, senior managers offer support and encouragement. Internal management is a key success factor for companies adopting green practices. (Tharun J et. al. 2022) Event based framework approach helps to tackle the problem of a heterogeneous and incomplete data landscape in the digitalization of value stream mapping

(T. Teriete et. al. 2022). The most advantageous aspect of using VSM is that it establishes the possibilities for future advancements (S. M. Zahraee et. al. 2020). The Digital Value Stream Mapping concept is intended to improve the original Lean Value stream method by adding a practical way to assess "digital improvement," which is said to have been overlooked in the original VSM approach (D. Arey et. al. 2021).

Methodology:

From the literature survey mentioned above, smart tone horn assembly line can be balanced by two methods

1. Traditional method of line balancing

2. Value stream mapping (VSM)

Line balancing was done by these two methods to produce 1350 horns. The results of these methods were compared and analyzed by arena software.

TRADITIONAL METHOD OF LINE BALANCING

The traditional method of line balancing is to reduce the number of workstations by combining the workstations in a way that will reduce the WIP time. Work In Process (WIP) Work In Progress (WIP), goods in process, or in-process inventory are a company's partially finished goods waiting for completion and eventual sale or the value of these items. These items are either just being fabricated or waiting for further processing in a queue or buffer storage. **Table 1** shows work in progress time is the amount of time the part needs to be waited before operation.

Table 1. WIP-Current

Process no	Process name	Process Time In Secs	Current WIP time in sec
1	Spool holder riveting	16	0
2	Terminal base diode point plate and point holder assembly	10	16
3	Terminal riveting and tuning screwinserting	26	0
4	Diaphragm assembly Riveting & height measuring	14	9
5	Gasket assembly pre crimpling & final crimpling	23	5
6	Air gap measuring and adjusting	29	0
7	Pre tuning and mounting bracket assembly	17	0
8	Horn tuning and testing	10	13
9	Measurement of tuning range and sealant application	23	0
Total Time		168	43
Total Lead Time		211 sec	

WIP time of 43 sec is non-value-added time.

- Combining process 1 and process 2 will reduce the WIP time of 16 seconds.
- Combining process 7 and process 8 will reduce the WIP time of 13 seconds to 5 seconds.

Implementing the method will eliminate the WIP time of 24 seconds. Total, it will reduce the WIP time form 43 seconds to 19 seconds. It will also reduce the manpower from 13 to 11.The lead time is 211 sec for manufacturing 1150 horns per shift.

Table 2 Show the WIP Future implementing method and lead time will reduce to considerable amount in seconds.

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Table 2. WIP-Future

Process no	Process name	Process time in sec	Future WIP time in sec
1	Spool holder riveting & terminal base diode point plate and point holder assembly	26	0
2	Terminal riveting and tuning screwinserting	26	0
3	Diaphragm assembly riveting & height measuring	14	9
4	Gasket assembly pre crimpling & final crimpling	23	5
5	Air gap measuring and adjusting	29	0
6	Pre tuning and mounting bracketassembly & Horn tuning and testing	17	5
7	Measurement of tuning range and sealant application	23	0
Total time		**168**	**19**
Total Lead Time		**181 sec**	

By implementing the method, the lead time will reduce to 181 seconds. With a lead time of 181 seconds, it has capacity to produce 1350 horns per shift. The main disadvantages of this method are that the size of the horn testing station will be increased, and the workers will find it too hard to perform the operations.

Value Stream Mapping (VSM)

Value stream mapping is a method of lean manufacturing which uses symbols, metrics and arrows to show and improve the flow of inventory and information required to produce a product or service which is delivered to a consumer. It is a visual representation which enables one to determine where the waste occurs.

Value stream maps are utilized to assess current manufacturing processes and create ideal and future state processes. It used as a tool which enables a company to map the process flow that helps in identifying various factors like:

- Value added time (time taken for producing the product),
- Non-Value-added time (time taken which do not contribute to the production of end product),
- Cycle time (time required to perform a process) and
- Changeover time (time required to change tool and programming etc.).

This helps in identifying and eliminating mudas (wastes), thereby implementing lean principles. After identifying the non-value-added steps in the current state, a future state value stream map is developed which acts as blueprint for lean activities. The future state value stream map often represents a significant change compared to the way the company currently operates.

The future state value stream map often represents a significant change compared to the way the company currently operates. The value stream map team thus develops a step-by-step implementation strategy to make the Future state a reality.

The key elements of the value stream map are shown:

- The Customer and his requirements.
- Process steps.
- Process Metrics.
- Inventory.
- Supplier with material flows.
- Information and Physical flows.
- Total lead time and Takt time

Takt time= Total available production time / Average customer demand.

Current Takt time = (27000/1150) = 23 seconds.

Future Takt time = (27000/1350) = 20 seconds

Future Takt time = (20*0.90) = 18 seconds

Table 3 show the Process Table Current and future TAKT time with manpower.

Table 3. Process Table - Current

S.no	Process operations	Process time	WIP time	TAKT time		Man power
				Current	Future	
1	Spool holder riveting	16	0	23	18	1
2	Terminal base diodepoint plate and point holder assembly	10	16	23	18	1
3	Terminal riveting and tuning screw inserting	26	0	23	18	1
4	Diaphragm assemblyRiveting & height measuring	14	9	23	18	1
5	Gasket assembly precrimpling and final Crimpling.	23	5	23	18	1
6	Air gap measuring andadjusting.	29	0	23	18	1
7	Pre tuning and mounting bracket assembly	17	0	23	18	1
8	Horn tuning and testing	10	13	23	18	1
9	Measurement of tuning range and sealant application	23	0	23	18	5

Figures 1&2 show the Current Process chart and Current Pareto Chart with appropriate numerical values.

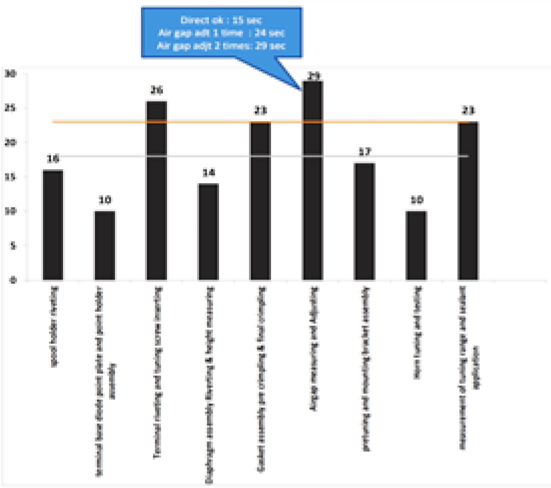

Fig 1. Current Process Chart

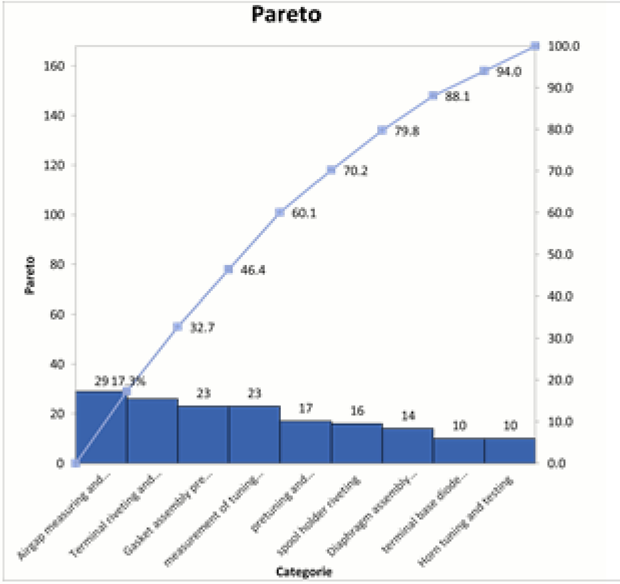

Fig 2. Current Pareto Chart

Figure 3 show the Value Stream Mapping Layout Before Implementation with cycle time

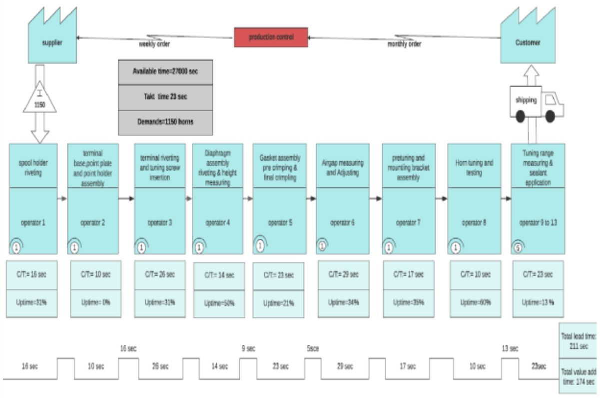

Fig 3. Value Stream Mapping Layout Before Implementation.

Problem identification in VSM

There are four processes that have cycle times greater than that of TAKT Time. They are,

- Terminal riveting and tuning screw inserting.
- Air gap measuring and adjusting.
- Gasket assembly pre crimpling & final crimpling.
- Measurement of tuning range and sealant application.

Tables 4 & **5** show the ECRS principle and process table in the future. The elemental time was reduced in the following way

Table 4. ECRS Table

Operation	Element	Method
Eliminate	Process number =3; Element =5; Double green button is pressed by both hands and work piece in right hand is swapped to left hand.	4 sec can be eliminated by usage of proximity sensors
	Process number =6; Element=3; Press the double green button.	3 sec can be eliminated by usage of proximity sensors
	Process number =6; Element 8,10; Using the right hand rotate the rod so air gap will reduce.	Element 8=3 sec and 10=2 sec can be eliminated by operating the machine using foot
	Operate the machine using right hand.	
	Process number =5; Element= 8; Press double green button using both hands.	The element 8=3 sec can be eliminated by using sensor.
	Process number =2; Element=1; Housing is taken in right hand and it changed to left hand.	Interchanging the side can eliminate this element.
Combine	Process number =3; Element= 3,4; Previous workpiece is removed by right hand. Work piece in left hand is fixed in fixture.	For the elements 3=3 sec & 4=4 sec by combining both the process we can reduce 3 sec in the cycle time.
	Process number =3; Element= 7,8; Tuning screw is inserted on screwing machine by right hand. Riveted work piece is inserted in the screwing machine by left hand	For the elements 7=2 sec & 8=4 sec by combining both the process we can reduce 2 sec in the cycle time.
	Process number =6; Element= 5,6; Put the mounting washer using right hand. Place it in the conveyer using left hand	Combine the element 5=3sec and 6=2sec so the time can be reduced to 2 sec
	Process number =5; Element= 5,6,7; Remove the horn placed in pre- crimpling using right hand. Place the new assembly horn in the pre-crimpling machine using left hand. Then remove the horn placed in final crimpling using L hand and place it in conveyer	Combining pre crimpling and final crimpling in a single machine can reduce element time to 5 sec
	process number=4; Element =3,4; 2 SHIM (ss) is taken in right hand and placed over it. Washer is placed over it using left hand	Combing the element 3 and 4 will reduce the element time from 5 sec to 2 sec
Rearrange	Process number=9; Element=1 to 19; 1. Measure the tuning range 2. Paint the blue ink and apply thread locker 3. Paint black ink over the diaphragm 4. Imprint batch code 5. Test the horn and apply green sticker	This process is done by 5 workers and the times taken are 3.06, 5.32, 5.06, 3.15 and 7.23 seconds. After the action analysis of these processes, we found the above processes can be done by 3 persons. It will not become the new bottleneck processes. It is done by combining the operation 2 and operation 3 and also operation 4 and operation 5.
Simplify	Process number=9; element=20; Push the empty tray towards the 1st operator.	Use of gravity conveyer to pass the tray to initial position.
	process number=6; Element=1; Horn is taken form conveyer using left hand and changed to right hand.	Element can be simplified by interchanging the side.

Table 5. Process Table - Future

*S.no	Process operations	Process time	IP time	TAKT time		Manpower		
				Current	Future			
1	Spool holder riveting	16	0	23	18	1		
2	Terminal base diode point plate and point holder assembly	9	0	23	18	1		
3	Terminal riveting and tuning screw inserting	18	9	23	18	1		
4	Diaphragm assembly riverting & height measuring	11	0	23	18	1		
5	Gasket assembly pre crimpling & final crimpling.	18	7	23	18	1		
6	Airgap measuring and adjusting.	21	3	23	18	1		
7	Pre tuning and mounting bracketas-sembly	17	0	23	18	1		
8	Horn tuning and test-ing	10	0	23	]]18	1		
9	Measurement of tun-ingrange and sealant application	19	9	23	18	3		

Figures 4 & 5 show the Future Process Chart and Future Pareto Chart with appropriate numerical values.

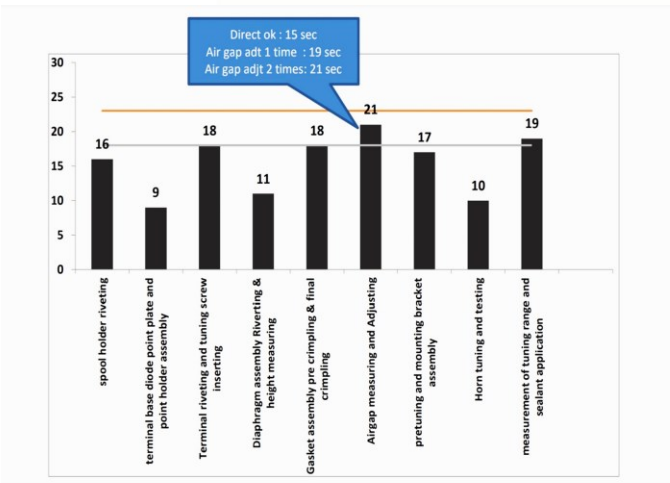

Fig 4. Future Process Chart

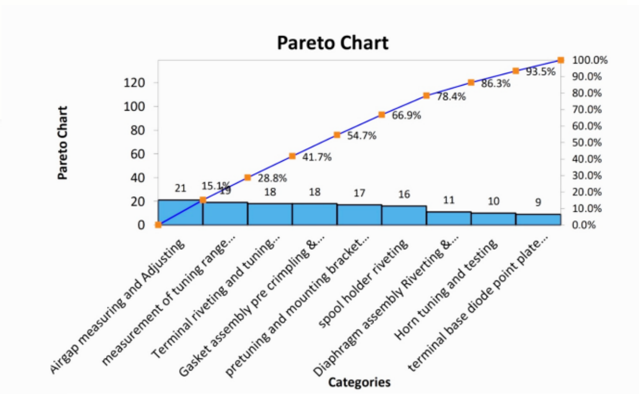

Fig 5. Future Pareto Chart

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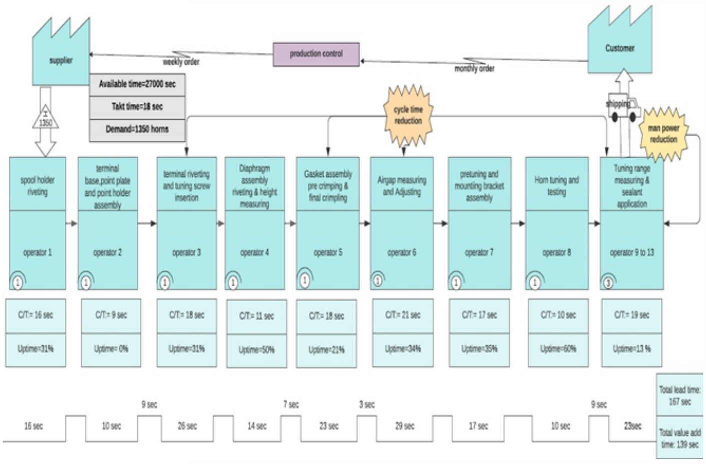

Fig 6. Value Stream Mapping Layout After Implementation

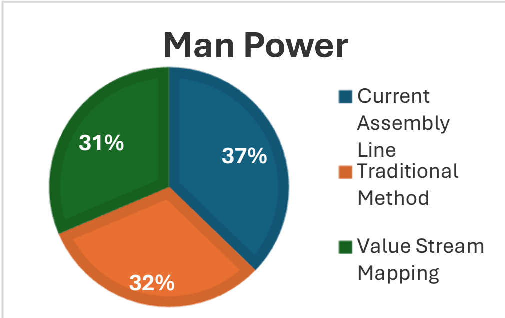

Fig 7. Pie Chart Representation of Manpower

Comparison of four solutions with current assembly line

Here the comparison between the different processes, manpower, lead time, and cycle time are discussed in the **Table 6**, **Figures 7,8,9** respectively to get accurate results regarding the most optimized process to be implemented in the horn industry.

Table 6. Comparison of Four Solutions with Current Assembly Line

Category	Cycle time	WIP time	Lead time	Work-stations	Manpower
Current assembly line	168	43	211	9	13
Traditionalmethod	168	19	181	7	11
Value StreamMapping	139	28	167	9	11

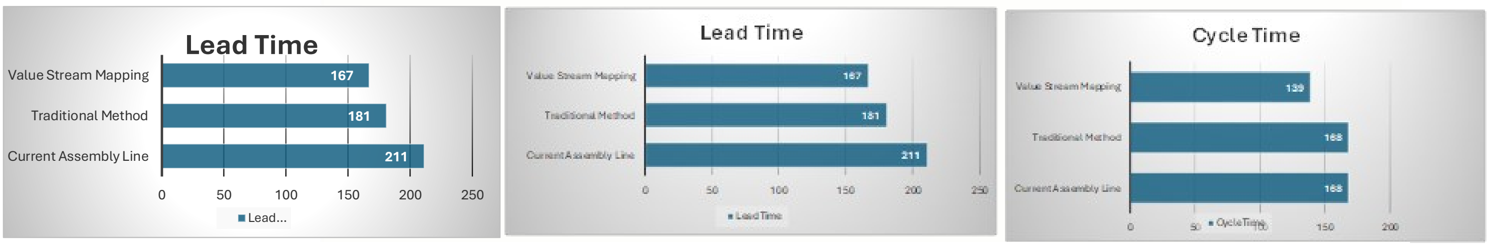

Fig 8. Comparison between the Lead time

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Results:

From the above table and chart, by comparing the two methodologies, it was proven that adapting Value Stream Mapping (VSM) has higher benefits compared to all other methods in smart tone horn assembly line. By implementing this process, time-consuming activities in the assembly line can be reduced. This process not only improves horn production in the assembly line and human intervention is also minimized. If the system is modified and used in assembly line leads to less consumption of time. Combining these two processes reduces the labor cost.

Conclusions:

In this globalizing era, lean thinking and high productivity are essential for the successful operations of manufacturing firms. Manufacturing firms are in search of various means and ways to reduce resource wastage to enhance operation efficiency and productivity. Even though many articles discuss theories of work-study techniques, few of them deal with the application a implementation of work-study. Even though the proposals and solutions developed in this project are about productivity enhancement in a horn company, the methodology adopted for the problem identification and solution development can be customized to other assembly line-based manufacturing firms to improve operation efficiency and productivity

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