International Journal of Scientific Research in Science, Engineering and Technology
Print ISSN: 2395-1990 | Online ISSN : 2394-4099 (www.ijsrset.com)
doi : https://doi.org/10.32628/IJSRSET23103173

Analysis of Line Balancing Problem for Production of Fuel Tank Mounting Bracket

Ashish Kumar Kaushik[1], Dr. Abhishek Dwivedi[2]
[1]Research scholar, Department of Mechanical Engineering, Integral University, Lucknow, Uttar Pradesh, India
[2]Assistant Professor, Department of Mechanical Engineering, Integral University Lucknow, Uttar Pradesh India

ARTICLEINFO

Article History:

Accepted: 10 June 2023
Published: 24 June 2023

Publication Issue
Volume 10, Issue 3
May-June-2023

Page Number
603-618

ABSTRACT

Assembly line balancing is a manufacturing technique that establishes an expected production rate to create a specific product in a particular period of time. Six Sigma is a profit-maximizing technique achieved by meeting consumer satisfaction. Cycle time reduction has emerged as a crucial aspect of improvement to generate high production and fulfill client demands. In industrial production, assembly lines play a vital role as flow-line production systems. Assembly lines need a significant capital expenditure to build or redesign them, but with good configuration, cost-effective manufacturing is possible. This study aims to increase assembly line productivity with shorter cycle times. The main stage in enhancing an assembly line's overall performance is to create or reconfigure an assembly system, which is made possible by assembly line balance and related operations analysis.

Keywords : Assembly Line, Cycle Time, Workstations, the balance of the Assembly Line, Production And Equipment Cost

I. INTRODUCTION

Assembly line balancing is a manufacturing technique that establishes an expected production rate to create a specific product in a specific amount of time[1][2]. In order to ensure that every line segment in the manufacturing process can be satisfied within the time frame and available production capacity, the assembly line also has to be successfully planned and duties need to be allocated among employees, equipment, and work stations[3]. Assembly line balancing is the process of allocating the appropriate quantity of people or equipment to each task on an assembly line in order to achieve the desired production rate with a minimal or zero optimum time [2][4].

Manufacturing businesses have been much more cognizant of excellent quality during the past ten years. It is anticipated that as technology advance, mass manufacturing will become more efficient and product quality will improve. High expectations from customers also accompany this progress. As a result, the business makes improvements to better serve customers [5]. The process is modified to include a variety of activities, high-quality tools, and quality improvement. India is not falling behind either. The same difficulties are being faced by our industries. Therefore, in order to create a strong and dynamic stake to extend excellent manufacturing practises, we must adapt to and learn from other global companies. A company with a solid improvement system is more likely to overcome obstacles and expand quickly. The improvement might be considered a must-do. The majority of the obstacles are caused by the production process[6]. The issue needs necessary direction or a remedy. Production problems in this case are mostly caused by quality difficulties. Industry today need a manual for efficient issue resolution. Here, quality is at risk above all else, and actions to enhance will undoubtedly help achieve the goals. In order to achieve the necessary quality results, competent guidance is therefore crucial. Companies must compete to advertise luxury goods if they want to thrive in this expanding business. Continuous process improvement will result from a competitive environment. Understanding may be one of the factors causing this circumstance. How can staff be made to comprehend and carry out process improvement, then? Finding the ideal medium to help the implementer successfully complete the project holds the key to the solution. The use of high-quality tools that are integrated with the required methodology and instructions is now the best way to ignite comprehension. Now, the implementer is in charge of driving changes to their processes through a thorough explanation of their problem-solving methods. The overarching goal of all approaches or methodologies is to keep track of the implementer's progress towards the optimal actions for quality improvement. The direction must be given in a methodical, focused, regulated, and timely fashion [7].

II. METHODS AND MATERIAL

This chapter introduces the study's general design, including the techniques used to carry out the task. The study follows the DMAIC is the main approach, with an infusion of the CAPA methodology to investigates the root causes of defect and offer the solution to reduce them [8].

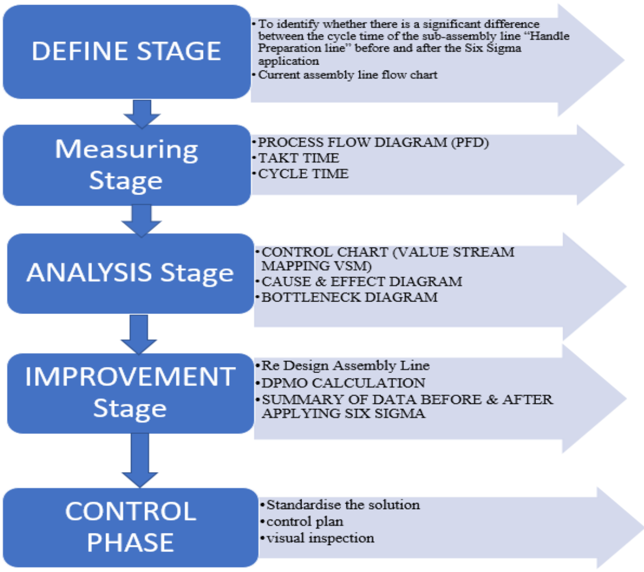
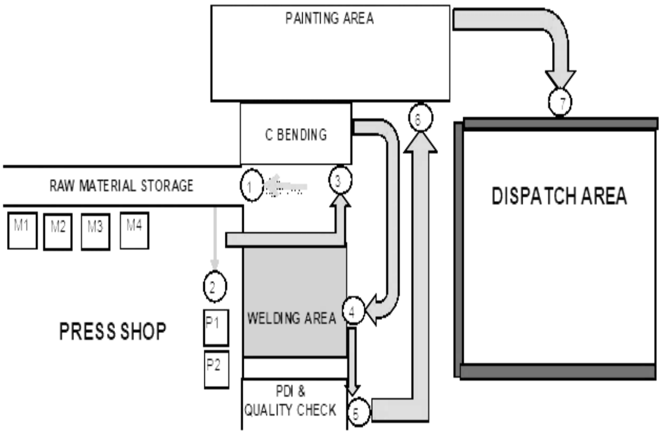


Figure 1. The visual diagram for the Six Sigma DMAIC structure.

A. Define Stage

The first phase of the DMAIC cycle leading to change is "Define". It is assessed and classified how many problems must be resolved altogether. If the project team had a thorough grasp of a particular project, their ability to collaborate would be easier. They will be able to mentally reproduce the simulation of processes because of this. This action also gives the impression that the requirements of the consumers and processes have been grasped. The issue description, scope, and objectives are established in this instance. We choose the most significant and important improvement possibilities at this phase. The approach, scope, focus, and ultimate aim are all mapped out at this phase, and every stakeholders' impact on the issue is also understood. The issue statement must be carefully crafted in order to kick off a DMAIC cycle.



B. Measuring Stage

"Measure" is the second phase of the DMAIC cycle. Current procedural status does not require modification. In any instance, the processes are normalised before the enhancement cycle is used. The identification of the initial triggers for any issues that were identified throughout the defining process is a need. Process maps and flow charts, which give the explanations weighting, are used to do this.

Analyze

The DMAIC cycle's "Analyse" step, which is closely related to the measuring procedure, is the third stage. The data gathered from the second stage is revaluated in order to identify the many potential triggers, allowing for the current step to provide stronger and more reliable data. The major goal of this method is to identify the primary source of chaos and waste using the available data. Pareto charts, fishbone diagrams, and other diagrams are used in the various techniques. To ensure that improvements come from the root causes of the issues, you must identify and test the underlying causes of problems at this phase.

3.1.4 Improvement Stage

'Improve' is the fourth stage of the DMAIC cycle. The project team determines the best course of action during this procedure to minimise waste while also repairing malfunctioning equipment and personnel. The proposed solutions must, however, result in a significant improvement over the data gathered between phases 2 of the study. The DoE is a crucial tool in this process.

C. Control stage

To enhance the system, the processes are evaluated, early data is analysed, and the last corrective action is implemented. The control role's primary responsibility is to efficiently satiate scheme improvements. One of the potential tools being employed in this process is the SPC. Whether or whether the previously controlled process is still under control, the SPC has a duty to warn management in real-time. Some of the nearby Lean approach techniques that may be applied in this process are 5S, Kanban, Kaizen, Poka-Yoke, etc.

Improvement activities

From Figure 3 it can be observed that proposed system is very Haphazard shop floor due to this increase the cycle time, decreases the productivity. After Shop floor clean and gangway made decease the cycle time, increase the productivity and Better look of press shop.

Table 1: Shop floor

Operation	Problem	Counter measure	Result
Shops of small presses	Haphazard shop floor	Shop floor clean and gangway made	Better look of press shop

Before KAIZEN	After KAIZEN
	

Figure 3: Shop floor clean and gangway made by using KAIZEN

From Figure 4 it can be observed that proposed system is very Haphazard way of storing dies. No clear identification& Traceability due to this increase the cycle time, decreases the productivity. After Improved the way of storing dies Due identification provided on board and location fixed of dies in rack decease the cycle time, increase the productivity and Easy Identification & Traceability.

Table 2: Improved the way of storing dies

Operation	Problem	Counter measure	Result
Storage of Dies	Haphazard way of storing dies. No clear identification& Traceability	Due identification provided on board and location fixed of dies in rack	Easy Identification & Traceability. Improved 5 S

Before KAIZEN	After KAIZEN
	

Figure 4: Easy Identification & Traceability Improved by using KAIZEN

From Figure 5 it can be observed that the proposed system is very Storage system does not exist due to this increase the cycle time, decreases the productivity. After Improved in the Racks and Bins provided decease the cycle time, increase the productivity and delivery improved & inventory control.

Table 3: Improved the Storage system of Racks and Bins provided

<table>
<tr><th>Operation</th><th>Problem</th><th colspan="2">Counter measure</th><th>Result</th></tr>
<tr><td>KANBAN</td><td>Storage system does not exist</td><td colspan="2">Racks and Bins provided</td><td>Delivery improved & Inventory control.</td></tr>
<tr><td>Before KAIZEN</td><td colspan="4">After KAIZEN</td></tr>
<tr><td>No Kanban & storage system</td><td colspan="2"></td><td colspan="2"></td></tr>
</table>

Figure 5: Delivery improved & Inventory control by using KAIZEN

From Figure 6 it can be observed that the proposed system is setting getting disturbed due to more packing plates due to vibrations during operation due to this increase the cycle time, decreases the productivity. After Improved in the clamping block introduced instead of packing plates decease the cycle time, increase the productivity and Due to vibration die setting disturbance eliminated.

Table 4: Improved the Clamping block introduced instead of packing plates.

Operation	**Problem**	**Counter measure**	**Result**
Die clamping on machine	Setting getting disturbed due to more packing plates due to vibrations during operation	Clamping block introduced instead of packing plates.	Due to vibration die setting disturbance eliminated

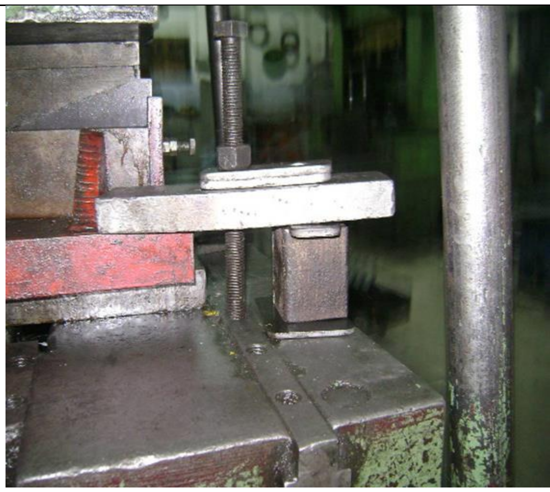
Before KAIZEN	After KAIZEN
	

Figure 6: Clamping block introduced instead of packing plates by using KAIZEN

From Figure 7 it can be observed that the proposed system is Notch angle 60 deg observed 45 deg due to this increase the cycle time, decreases the productivity. After Improved in the die angle has been modified 30 deg to 48 deg decease the cycle time, increase the productivity and Notch angle problem eliminated.

Table 5: Improved the Die angle

Operation	Problem	Counter measure	Result
Notching process	Notch angle 60 deg observed 45 deg	Die angle has been modified 30 deg to 48 deg.	Notch angle problem eliminated.

Before KAIZEN	After KAIZEN	
		

Figure 7: Improved the Die angle by using KAIZEN

Table 6: Improved in the Support plate

Operation	**Problem**	**Counter measure**	**Result**
Cowl mtg bkt welding	Due to welding distortion dim 34.5 mm not controlled	Support plate added	Dim 34.5 mm controlled

Before KAIZEN	**After KAIZEN**
	

Figure 8: Improved in the Support plate by using KAIZEN

From Figure 8 it can be observed that the proposed system is Due to welding distortion dim 34.5 mm not controlled due to this increase the cycle time, decreases the productivity. After Improved in the Support plate added decease the cycle time, increase the productivity and Dim 34.5 mm controlled.

Table 7: Improved in the Slot made & strip welded

Operation	**Problem**	**Counter measure**	**Result**
RUPD side support bkt welding	Not proper seating & alignment during welding	Slot made & strip welded To maintain 40 mm height in fixture	Dimension Control
Before KAIZEN		**After KAIZEN**	

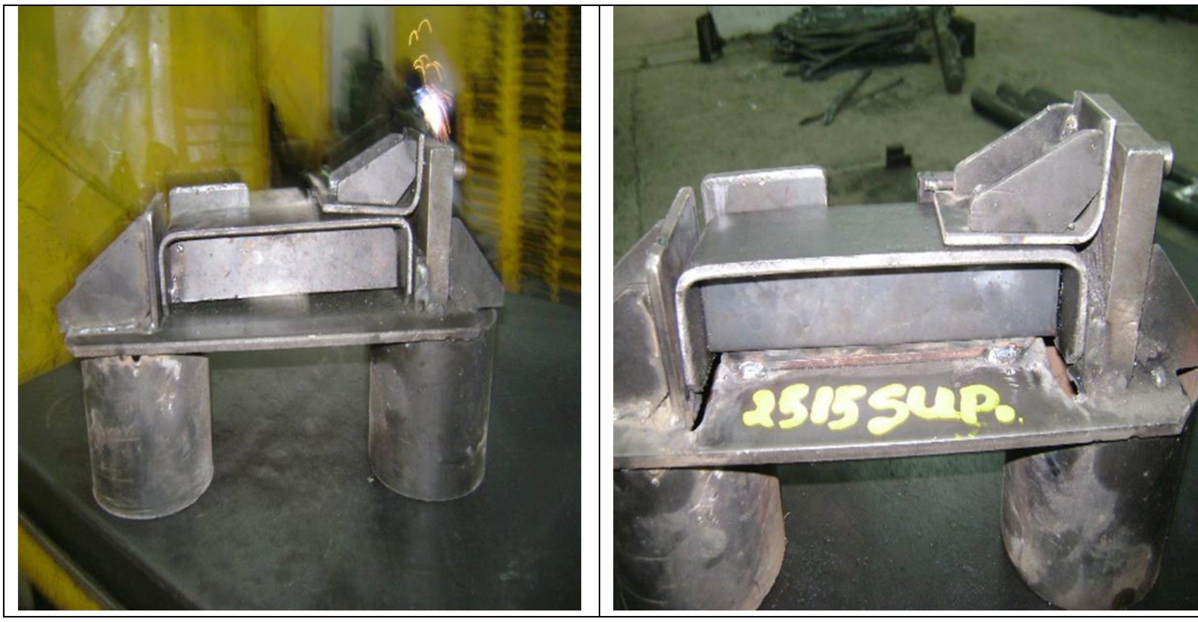


Figure 9: Improved in the Slot made & strip welded by using KAIZEN

From Figure 9 it can be observed that the proposed system is Not proper seating & alignment during welding due to this increase the cycle time, decreases the productivity. After Improved in the Slot made & strip welded to maintain 40.0 mm height in fixture decease the cycle time, increase the productivity and Dimension Control.

Table 8: Improved in the Slot made & strip welded

Operation	**Problem**	**Counter measure**	**Result**
Bush Welding Process of radiator side mounting Bracket	Wrong height bush welded during operation	Fixture has been modified and two new bushes of the required height have been welded	Correct height bush welded (Poka – Yoke)

Before KAIZEN	**After KAIZEN**
	

Figure 10: Improved in the Slot made & strip welded by using KAIZEN

From Figure 10 it can be observed that the proposed system is Wrong height bush welded during operation due to this increase the cycle time, decreases the productivity. After Improved in the Fixture has been modified and two new bushes of the required height have been welded decease the cycle time, increase the productivity and Correct height bush welded (Poka –Yoke)

To prevent the longest cycle times on the assembly line, new hires receive special training. After the training, employees performed their jobs more effectively. To reduce cycle time at this workstation, add more stud welding. Cycle time in this work station decreases after adding a machine. Remove any unused racks to make the space more open. To avoid interfering with the mobility of the personnel doing the assembly, only the necessary parts should be put close by. Some employee groups hold off on making any comments until after the procedures and changes have been developed, responding to criticism when they disagree. This method may be distinct from the employment of observers who only observe and offer recommendations to trained individuals who conduct motion and time studies in collaboration with business engineers. A time study approach was employed by the researcher to observe assembly line operations. Time study calculates the amount of time required to finish a project or task in the most effective way. For the purpose of establishing the new standards time, cumulative time research is made. Together with the CEO, the researcher is tasked with coming up with a plan to set appropriate productivity goals for seasoned employees. In addition, establish productivity targets for training to keep the workforce awake. Additionally, identify superfluous activities to decrease waste and improve consistency of operations. Last but not least, relevant with aims is to shorten cycle time and boost business productivity.

Table 9 Progress sheet

Kaizen Results		Target / Progress Sheet							
Kaizen Event: K-188		Line Name: M/s. LD JOSHI (P) Ltd							
Improvement Situation		Before	Target	After Kaizen				% Improvement	Remarks
				November					
				26.0	27.0	28.0	29.0		
Improvement in 5 'S' level		Zero	1 'S'	10.0	20.0	20.0	20.0	70%	Bins to be made
Inventory Control		No storage process	Kanban store to be done	10.0	40.0	50.0		100%	
Material Handling Improvement			Packing Imp. & Racks to be made	0.0	10.0	40.0	20.0	70%	Plastic bin & Racks to be made
Customer complaint reduction			50% reduction						Will be monitored in Dec. 07
Space reduction	Space Reduced (Sq. m.)		30%	0.0	10.0	30.0	20.0	60%	2 machines to be shifted in 1st week of Dec. 07
	Space Congestion reduction (%)		30%	0.0	10.0	20.0	50.0	80%	More work bench to be made
Quality	PPM Reduction	3143	To be moniterd in Dec.						To be monitored in Dec. 07
	C of C of critical parts	Nil	100%					80%	Balance C of C will be by 05-Dec-07
	Poka Yoke / Improvement	0.0	10.0	1.0	4.0	2.0	1.0	80%	
Supplier System Improvement			Inventory control						Parts to added in Kanban as identified by the team
			Quality Improvement						Material handling equipment provided to avoid paint related problem

III. RESULTS AND DISCUSSIONS

Assembly line

A vital component of the management and design of an assembly line is assembly line balancing (ALB). The goal of ALB is to divide up the jobs involved in assembly in a way that maximises overall productivity. Simple ALB is an assembly problem when each workstation needs to have a known, predictable cycle time and where work activities need to be completed in a certain, known order. In the **L. D. JOSHI PVT. LTD**. a mixed assembly line has been found to have shearing, piercing, bending, welding, painting, quality check, and dispatch processes performed in a mixed manner. In the present assembly line the process are working in the following steps: Collect the Raw material form store shop after collecting the material form store shop go to next shop for pressing the material after pressing the material go to nest shop for Bending after bending the sheet go for welding after welding the work piece go to next shop for PDI & Quality check after checking the PDI & Quality go to next shop for Panting shop after painting the workpiece go to the final stage for dispatch the product to TATA Motors company. But the above assembly line is a mixed assembly line. This assembly line is taken lot of time to complete the process because the assembly line has arranged in mixed manner. Applying six sigma approach using DMAIC methodology has been introduced as a main approach, further an infusion of CAPA concept has been used to increasing the assembly line productivity by converting the mixed assembly line to 'U' shape assembly line. Priority constraints are the restrictions on the order of work tasks that are required by the product design. Additionally, there should be a predetermined takt time that is constant across all workstations and establishes the output rate of the line. General ALB difficulties exist when there are more elements influencing the assembly line design than the work job sequence and cycle times. These elements may, for instance, be disparities in the workforce's skill sets or the requirement for certain machinery. The ALB issue will thus need to take resources, salaries, and investment expenses into account. ALB must be taken into consideration while planning an assembly line. The goal is to maximise resource utilisation while maintaining a production tempo that meets consumer demand. Each workstation must get an equal amount of work, and priority restrictions and the placement of previously installed, fixed equipment must also be taken into account. The cycle time on each workstation should be the same to ensure the greatest balance possible in the manufacturing line. The ineffective material handling structure, inadequate material storage system, and unclear standard operating procedures are the main shortcomings of the existing assembly technique. This results in operator motions that are redundant and repetitive, such as the removal and replacement of the identical accessories at two successive phases, confusion during assembly, assembly reworks, etc [9][10].

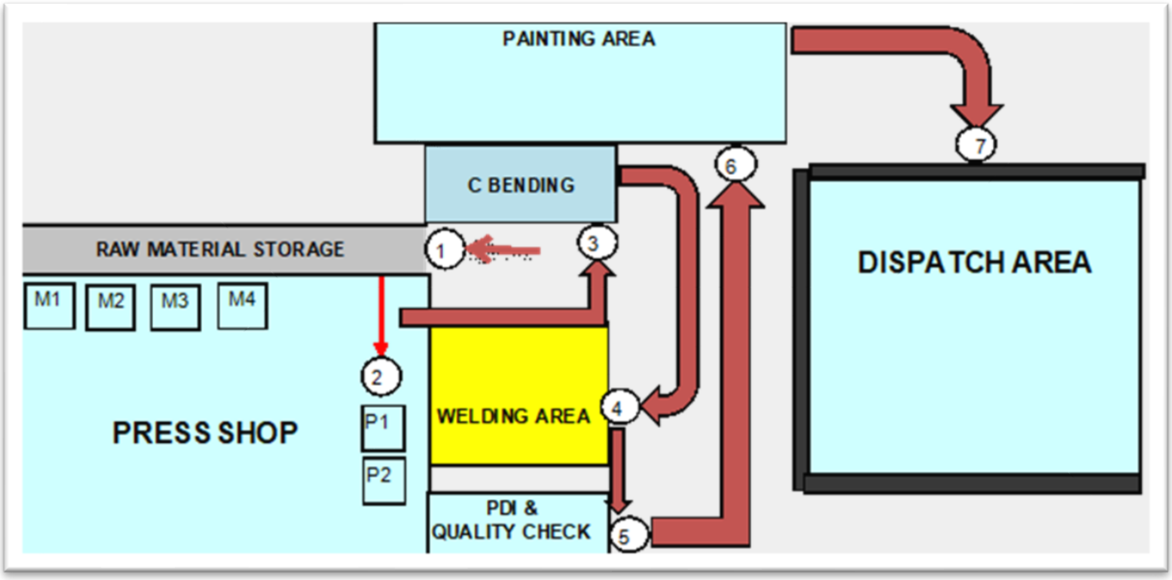


Figure 11: Old assembly line

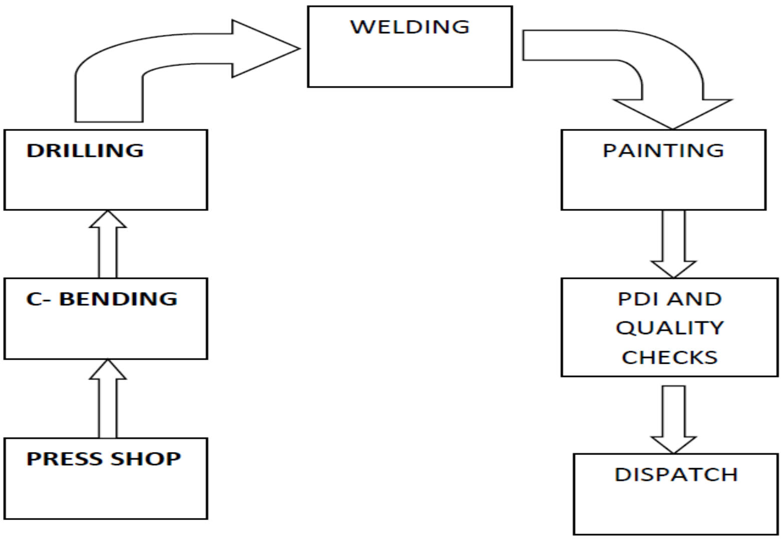


Figure 12: New assembly line (U Shaped assembly line)

Bending during welding

To prevent the bending and distortion during welding process following fixture has been introduced to the welding shop. This has two support plate for prevention of miss location and distortion the workpiece. By introducing these features to improve the welding quality and increase the productivity the product.

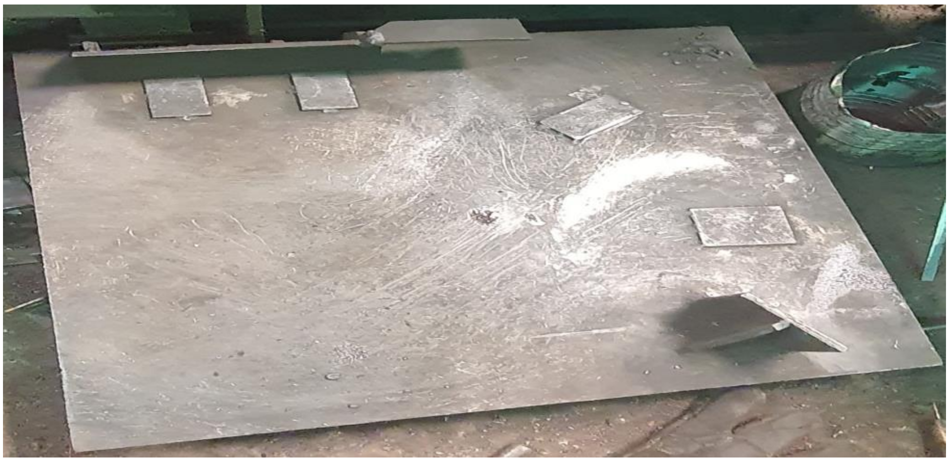


Figure 13: Support plate for prevention of miss location and distortion the workpiece

(a)

Figure 14: To prevent the distortion during welding process

Hole mismatch

In the L. D. JOSHI PVT. LTD. a mixed assembly line has been found to have shearing, piercing, bending, welding, painting, quality check, and dispatch processes performed in a mixed manner. Priority constraints are the restrictions on the order of work tasks that are required by the product design. The core problem regarding CNG mounting bracket was found mismatch hole of outer plate and inner plate after radius forming. After study whole process we suggested to drill hole of 13 mm dia. After radius bending by using drill machine. This strategy improves the quality of the product and reduced the number of rejections. In short it increases the production of CNG mounting bracket.

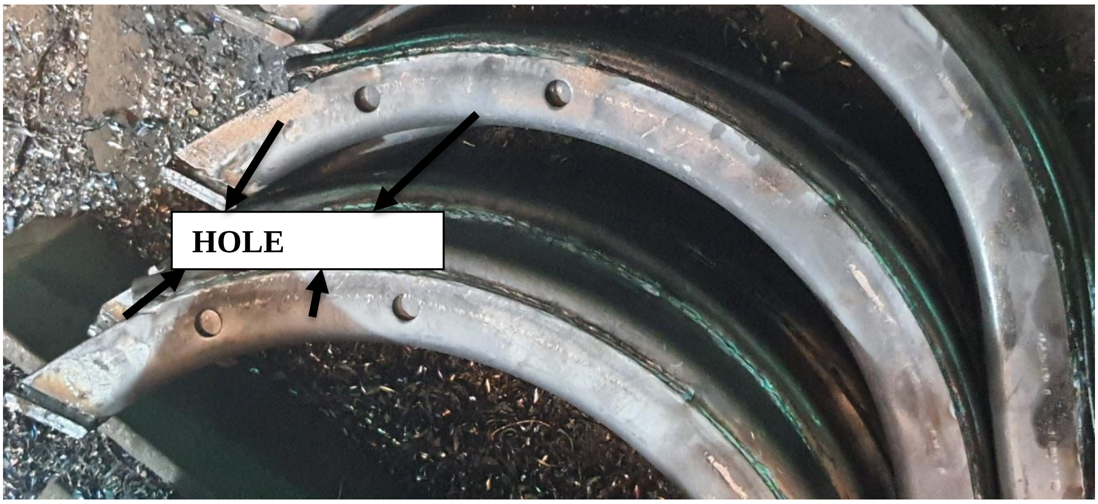


Figure 15: Piercing hole after forming by introducing drilling machine

Material handling equipment

The unplanned delivery time and variable part count of the prior material supply system were the major causes of waste and time delays. The supervisor arbitrarily decided how many components were needed for the assembly line since the pieces would otherwise pile up on the floor, taking up unnecessary space. Previously, the delivery procedure for each component of the door foamer line took more than two hours. Following the establishment of the train system, pickup and delivery tasks were assigned to certain employees. Despite the picking time being constant, the subsystems allowed team members to more readily identify the parts that need reloading. As a result, the load time was significantly decreased. In the beginning of implementation, a system was created for supervisors to track the train timetable, which allowed them get ready before the train arrived.

Small, medium, and big automotive sectors have expanded quickly and internationally in Malaysia during the past 20 years in response to rising consumer demand. Most businesses regularly employ cutting-edge manufacturing techniques like Kaizen, Toyota Production System, Six Sigma, Just-in-Time (JIT), Lean Manufacturing, Kanban, and others in order to grow their market share and remain competitive. An efficient material handling system is required to support production operations in order to attain world-class manufacturing status, which includes on-time delivery, high quality, and high production efficiency. Based on observation, it was discovered that the present material storage method employed was bulk storage known as wire mesh and trolley at a JIT automobile assembly line of a local automotive manufacturing in Shah Alam.

Additionally, no standards or procedures were used in the material handling operations. By incorporating new standard poly-boxes and a gravity flow rack system for material handling tasks, the current material handling system will be enhanced. The findings of the computer simulation were contrasted with the line's actual performance. While space utilisation decreased by 18.18%, the inventory level was able to be lowered by 74%.

(a)

(b)

(c)

(d)

Table 2: Improved the way of storing dies

IV. CONCLUSIONS

The purpose of the research work was to explore how productivity can be improved in an assembly line in the manufacturing industry. In modern manufacturing, production companies are more concerned about customer satisfaction, while ensuring great profits which is most certainly a good business model. By making simple changes to the process, it can reduce the time taken for each work sequence to improve the process flow and speed up the process flow which can help to improve the process of operation. For the calculation, cycle time is a key indicator of a process in the manufacturing industry and equipment performance. Additionally, ALB was found to be a successful method to improve productivity. By re-allocating work tasks between operators, a reduced takt time could be achieved.

V. REFERENCES

[1]. A. Adeppa, "A Study on Basics of Assembly Line Balancing," Int. J. Emerg. Technol. (Special Issue NCRIET, vol. 6, no. 2, pp. 294–297, 2015.

[2]. E. Álvarez-Miranda and J. Pereira, "On the complexity of assembly line balancing problems," Comput. Oper. Res., vol. 108, pp. 182–186, 2019, doi: 10.1016/j.cor.2019.04.005.

[3]. A. T. Bon and S. N. A. Samsudin, "Productivity improvement in assembly line by reduction cycle time using time study at automotive manufacturer," Proc. Int. Conf. Ind. Eng. Oper. Manag., vol. 2018-March, pp. 284–291, 2018.

[4]. R. RashmiSarmah, "a Review on Assembly Line Balancing.," Int. J. Adv. Res., vol. 7, no. 9, pp. 465–470, 2019, doi: 10.21474/ijar01/9685.

[5]. A. Adeodu, M. G. Kanakana-Katumba, and M. Rendani, "Implementation of lean six sigma for production process optimization in a paper production company," J. Ind. Eng. Manag., vol. 14, no. 3, pp. 661–680, 2021, doi: 10.3926/jiem.3479.

[6]. R. Titmarsh, F. Assad, and R. Harrison, "Contributions of lean six sigma to sustainable manufacturing requirements: An industry 4.0 perspective," Procedia CIRP, vol. 90, no. March, pp. 589–593, 2020, doi: 10.1016/j.procir.2020.02.044.

[7]. N. A. B. HARUN, "Integration of Dmaic Methodology and Capa Concept for Quality Improvement in Semiconductor Industry," p. 24, 2017.

[8]. G. C. P. Condé, P. C. Oprime, M. L. Pimenta, J. L. Sordan, and C. R. Bueno, "Defect reduction using Lean Six Sigma and DMAIC," Int. Conf. Qual. Eng. Manag., no. August, pp. 779–804, 2022.

[9]. P. I. of a M. A. Yerasi, “Productivity Improvement Of A Manual Assembly Line,” no. August, p. 88, 2011.

[10]. Z. Soufi, P. David, and Z. Yahouni, “A methodology for the selection of Material Handling Equipment in manufacturing systems,” IFAC-PapersOnLine, vol. 54, no. 1, pp. 122–127, 2021, doi: 10.1016/j.ifacol.2021.08.193.

Cite this article as :

Ashish Kumar Kaushik, Dr. Abhishek Dwivedi, "Analysis of Line Balancing Problem for Production of Fuel Tank Mounting Bracket ", International Journal of Scientific Research in Science, Engineering and Technology (IJSRSET), Online ISSN : 2394-4099, Print ISSN : 2395-1990, Volume 10 Issue 3, pp. 603-618, May-June 2023. Available at doi : https://doi.org/10.32628/IJSRSET23103173
Journal URL : https://ijsrset.com/IJSRSET23103173