STM JOURNALS

Journal of
Automobile Engineering and Applications

ISSN: 2455-3360
Volume 11, Issue 2, 2024
May—August
DOI Journal: 10.37591/JoAEA

https://journals.stmjournals.com/joaea

Review JoAEA

Experimental Analysis of Line Balancing Issues in Automotive Fuel Tank Bracket Production

Gopal Chaubey[1,*], Vikash Dwivedi[2]

Abstract

Assembly line balancing is a manufacturing technique aimed at determining the anticipated production rate for manufacturing a specific product within a defined timeframe. Six Sigma, a profit-maximizing method, focuses on achieving consumer satisfaction. Reducing cycle time has become crucial to enhance production rates and meet client expectations. Assembly lines play a pivotal role in industrial production as efficient flow-line systems. Although building or redesigning assembly lines requires significant capital investment, a well-configured assembly line can enable cost-effective manufacturing. This study aims to enhance assembly line productivity by reducing cycle times. Enhancing an assembly line's overall performance hinges on designing or reconfiguring the assembly system, facilitated by assembly line balancing and comprehensive operations analysis.

Keywords: Cycle time, production and equipment cost workstations, Assembly line, the balance of the assembly line

INTRODUCTION

Assembly line balancing is a manufacturing method aimed at determining the anticipated production rate for manufacturing a particular product within a specified time frame [1][2]. To ensure each segment of the manufacturing process meets this timeframe and available production capacity, successful planning and duty allocation among employees, equipment, and workstations are essential [3] [2][4].

Over the past decade, manufacturing businesses have become increasingly focused on delivering excellent quality. With technological advancements, mass production is expected to become more efficient, and product quality is anticipated to improve. This progress is accompanied by high customer expectations, driving businesses to make continuous improvement to better serves their customer [5]. India, too, faces similar challenges. To build a strong and dynamic foundation for excellent manufacturing practices, it is crucial to learn from and adapt to global companies. Improvements is often considered essential, with most obstacles arising from the production process [6]. These issues require appropriate guidance or solutions, as they are primarily driven by quality concerns. Today's industry needs a manual for effective problem-solving, with quality as the top priority. Actions to enhance quality will undoubtedly help achieve the desired outcomes. Therefore, competent guidance is crucial for attaining the necessary quality results. To thrive in this growing industry, companies must vie for market share in luxury goods. A competitive environment fosters continuous process improvement, where comprehension stands out as a crucial factor influencing outcomes [7]. Throughout history, people have invented new things to meet their needs, and if those inventions proved useful,

***Author for Correspondence**
Gopal Chaubey
E-mail: researchpaper033@gmail.com

[1]Student, Department of Mechanical Engineering, B.N. College of Engineering and Technology, Lucknow, India
[2]Assistant Professor, Department of Mechanical Engineering, B.N. College of Engineering and Technology, Lucknow, India

Received Date: July 02, 2024
Accepted Date: July 09, 2024
Published Date: August , 2024

Citation: Gopal Chaubey, Vikash Dwivedi. Experimental Analysis of Line Balancing Issues in Automovite Fuel Tank Bracket Production. Journal of Automobile Engineering and Applications. 2024; 11(2): 25–33p.

they sought to improve them and increase their production speed. Technological advancement was essential to maintain a balance between supply and demand. Therefore, production can be defined as the process of turning raw materials into finished, useful goods. This process integrates various human duties with automation and technology. It involves actions that progressively transform the intermediate product towards its final state. Collectively, these procedures define the assembly line, officially characterized as an industrial setup of humans, tools, and machinery for continuous workpiece flow in large manufacturing processes [1-5].

When designing an assembly line, the manufacturing processes for each component and the finished product are determined. Material movement is kept brief and straightforward, avoiding backtracking or cross-flowing. Work assignments, machine counts, and production rates are set to ensure smooth operations along the line [6-8]. Many modern engine factories and other continuous-process businesses utilize automated assembly lines, comprising machines operated by other machines. Despite its seemingly straightforward definition, assembly line design is a complex subject. The concept was first established over a century ago at the Ford factory in Detroit as a highly efficient method of production. This method remains widely used across various industries in the twenty-first century [9].

A basic assembly line consists of several workstations arranged in a straight line, connected by material handling equipment. The component is processed according to a set of tasks performed at each station over a predetermined amount of time, known as cycle time. The process time is the duration needed to complete a task at each workstation. The assembly line's cycle time is determined by a targeted production rate, which ensures timely manufacturing of the required final product quantity [10][11]. To maintain a specific output rate, the total processing time at each station must not exceed the cycle time. Idle time occurs if the total processing time at a station is less than the cycle time. One of the key challenges in establishing an assembly line is organizing the tasks to be completed. Tasks are distributed across workstations based on precedence relationships and constraints to maximize one or more goals.

METHODOLOGY

This chapter outlines the study's overall designing and the technique employed to execute the research. The primary approach used is DMAIC, complemented by the CAPA methodology. This combined approach investigates root causes of defects and provides solutions to reduce them [8].

Improvement activities

Figure 1 shows that the proposed system initially results in a very haphazard shop floor, leading to increased cycle time and decreased productivity. However, after cleaning the shop floor and creating organized gangways, cycle time decreases, productivity increases, and the press shop has a more orderly appearance (Table 1).

Table 1. Company Shop floors.

Production Operation	**Shop floor Problem before KAIZEN used**	**Operation Counter measure**	**Improve in Result**
Shops of small presses	Shop floor Problem is Haphazard shop floor	Gangway made and Shop floor clean	**Improve in Result:** Better look of press shop by using the KAIZEN method

Table 2. The method of storing dies has been enhanced.

Production Operation	**Storing Dies Problem before KAIZEN used**	**Operation Counter measure**	**Improve in Result**
Storage of Dies	Dies are stored haphazardly, with no clear identification or traceability.	Clear identification has been provided on the board, and the location of dies in the rack has been fixed.	Improve in Result: Easy Identification & Traceability. Improved 5 S by using the KAIZEN method

Condition Before KAIZEN **Condition After KAIZEN**

Figure 1. The shop floor was cleaned and a gangway was established through the implementation of KAIZEN principles.

Condition Before KAIZEN **Condition After KAIZEN**

Figure 2. Easy traceability and identification have been improved using the KAIZEN method.

Table 3. The storage system of racks and bins has been improved.

Production Operation	**Racks and Bins Problem before KAIZEN used**	**Operation Counter measure**	**Improve in Result**
KANBAN	Storage system does not exist	Racks and Bins provided	Delivery improved & Inventory control by using the KAIZEN method.

Table 4. Delivery and inventory control have improved through the use of the KAIZEN method.

Production Operation	**Delivery and inventory Problem before KAIZEN used**	**Operation Counter measure**	**Improve in Result**
Die clamping on machine	The settings are getting disturbed due to the vibrations during operation, caused by an excess of packing plates.	A clamping block has been introduced as a replacement for packing plates.	The disturbance in die setting due to vibration has been eliminated by using the KAIZEN method.

Table 5. The die angle has been improved.

Production Operation	**Die Angle Problem before KAIZEN used**	**Operation Counter measure**	**Improve in Result**
Notching process	Notch angle 60 deg observed 45 deg	Die angle has been modified 30 deg to 48 deg.	Notch angle problem Eliminated by using the KAIZEN method.

Condition when No Kanban & storage system

Condition Before KAIZEN **Condition After KAIZEN**

Figure 3. Delivery and inventory control have been enhanced through the application of KAIZEN principles.

Condition Before KAIZEN **Condition After KAIZEN**

Figure 4. The introduction of clamping blocks instead of packing plates was implemented through the KAIZEN method.

Condition Before KAIZEN **Condition After KAIZEN**

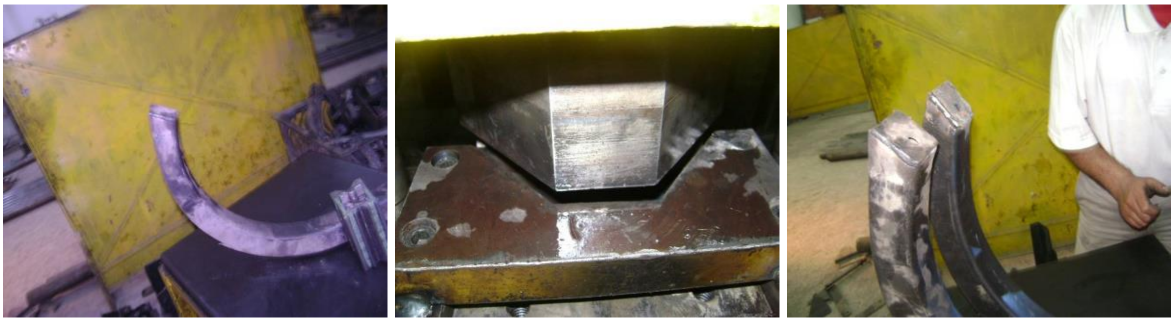

Figure 5. The die angle has been optimized through the application of KAIZEN principles.

Table 6. The support plate has been improved.

Production Operation	**Support Plate Problem before KAIZEN used**	**Operation Counter measure**	**Improve in Result**
Cowl mtg bkt welding	Due to welding distortion dim 34.5 mm not controlled	Support plate added	Dim 34.5 mm Controlled by using the KAIZEN method

Condition Before KAIZEN **Condition After KAIZEN**

Figure 6. Support plate has been enhanced using the KAIZEN method.

Table 7. The slot has been improved and the strip welded.

Production Operation	**Slot made & strip welded Problem before KAIZEN used**	**Operation Counter measure**	**Improve in Result**
RUPD side support bkt welding	Not proper alignments and not proper seating during welding	Slot made & strip welded To maintain 40 mm heights in fixture	Dimension Control by using the KAIZEN method

Condition Before KAIZEN **Condition After KAIZEN**

Figure 7. The slot has been improved and the strip welded through the application of KAIZEN principles.

Table 8. Improvements have been made to the slot and strip welding.

Production Operation	**Slot made & strip welded Problem before KAIZEN used**	**Operation Counter measure**	**Improve in Result**
Bush Welding Process of radiator side mounting Bracket	Wrong height bush welded during operation before using the KAIZEN method	The fixture has been modified, with two new bushes of the required height welded in place.	Correct height bush welded (Poka –Yoke) by using the KAIZEN method

To reduce the longest cycle times on the assembly line, new hires receive specialized training. Following training, employees demonstrated improved job performance. Increasing stud welding at this workstation was implemented to reduce cycle time, which subsequently decreased after the addition of a new machine. Unused racks were removed to create a more open workspace. To ensure assembly personnel's mobility is not hindered, only necessary parts are kept nearby. Some employee groups refrain from commenting until procedures and changes are fully developed, responding to critiques afterward. This approach is distinct from observer roles that only provide recommendations, as trained individuals collaborate with business engineers to conduct motion and time studies (Tables 2-8). The researcher employed a time study method to monitor assembly line operations, identifying the most efficient times for task completion and setting new standards. Collaborating with the CEO, the researcher is tasked with setting appropriate productivity goals for experienced employees and training initiatives to maintain workforce alertness. Additionally, identifying and reducing unnecessary activities aims to minimize waste and enhance operational consistency, ultimately aiming to shorten cycle times and boost overall business productivity (Figures 2-8).

Figure 8. The slot and strip welding have been improved using KAIZEN principles.

RESULTS AND DISCUSSIONS

Assembly Line

The management and design of an assembly line hinge on assembly line balancing (ALB), which aims to optimize overall productivity through efficient distribution of assembly tasks. In a simple ALB scenario, each workstation operates with a known, predictable cycle time and follows a specific order of work activities. Currently, the assembly line follows these steps: raw material collection from the store, material pressing, bending, welding, PDI and quality check, painting, and final dispatch to TATA Motors. However, this assembly line operates as a mixed assembly line, which often prolongs process completion due to its non-sequential arrangement.

To enhance productivity, the six-sigma approach's use DMAIC methodology has been implemented, complemented by the CAPA concept, to transform the mixed assembly line into a 'U' shape assembly line. Priority constraints dictate the required sequence of work tasks as per product design, with a constant takt time established across all workstations to maintain line output. Challenges in ALB arise from factors beyond job sequence and cycle times, such as workforce skill disparities and machinery requirements, which impact resource allocation and investment costs during line planning.

Effective ALB aims to maximize resource utilization while meeting consumer demand with consistent production tempo. Ensuring equal workload distribution across workstations, adhering to priority constraints, and accommodating fixed equipment placement are critical for achieving optimal line balance. Existing assembly technique shortcomings include ineffective material handling, inadequate material storage systems, and unclear standard operating.

Bending During Welding

To prevent distortion and bending during the welding processes, a new fixture has been implemented in the welding shops. This fixture includes two supports plates designed to prevent misalignment and distortion of the workpiece. These enhancements aim to improve welding quality and enhance productivity of the products (Figure 9).

Figure 9. Support plates have been added to prevent workpiece misalignment and distortion.

Hole Mismatch

In assembly line for CNG mounting brackets includes several processes like quality check, welding, shearing, bending, piercing, painting, and dispatch, originally performed in a mixed sequence. The order of these tasks is now determined by priority constraints based on product design requirements (Figure 10).

A significant issue identified in the production of CNG mounting brackets was the misalignment of holes between the outer and inner plates after radius forming. Following a detailed process analysis, it was recommended to use a drill machine to create 13 mm diameter holes after radius bending. This solution effectively improved product quality, reduced rejection rates, and ultimately enhanced production efficiency for CNG mounting brackets.

Material Handling Equipment

Over the past two decades, Malaysia has seen rapid growth in its small, medium, and large automotive sectors, driven by increasing consumer demand both locally and internationally. To maintain competitiveness, most businesses in this sector adopt advanced manufacturing techniques such as Kanban, Six Sigma, Toyota Production System, Kaizen, Just-in-Time (JIT), Lean Manufacturing, among others. Achieving world-class manufacturing status necessitates an efficient material handling system that supports operations to achieve goals like on-time delivery, efficient production and high quality.

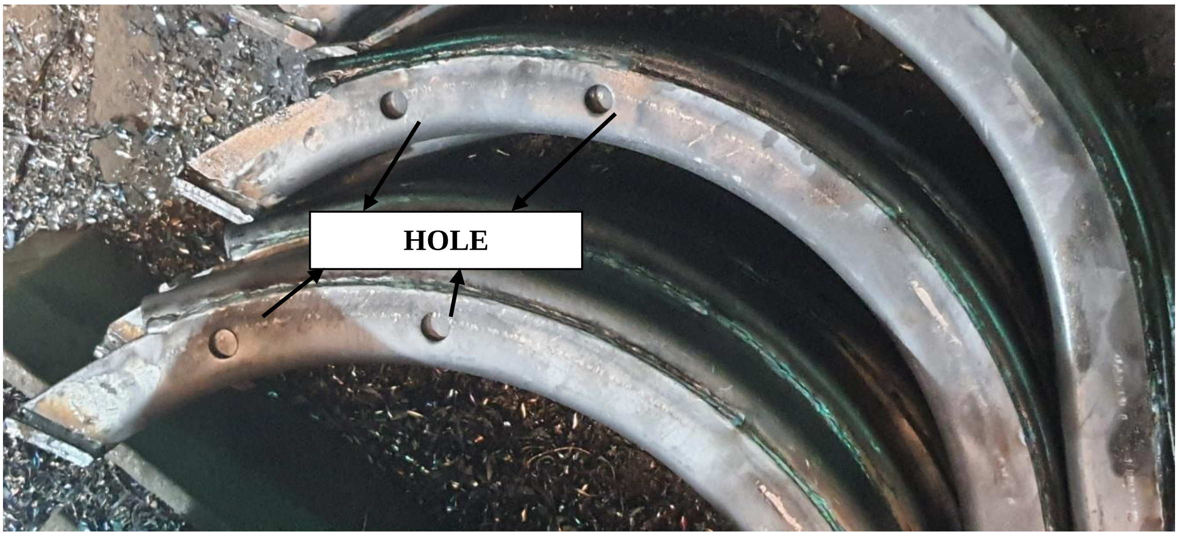

Figure 10. To prevent the distortion during welding process.

An observation at a local automotive manufacturing facility in Shah Alam revealed that their current materials storage methods, utilizing bulk storage like wires mesh and trolley in a JIT automobile assembly line, lacked standardized procedures. To enhance efficiency, the implementation of standard poly-boxes and a gravity flow rack system for material handling tasks was proposed. Computer simulations compared these changes with actual performance, showing an 18.18% decrease in space utilization and a significant 74% reduction in inventory levels (Figure 11).

Figure 11. Material handling equipment.

CONCLUSIONS

The study aimed to explore strategies to improve productivity in assembly line operations within the manufacturing sector. In today's manufacturing environment, companies prioritize both customer satisfaction and profitability, which are crucial components of a strong business strategy. Through simple process adjustments, the objective was to reduce cycle times, thereby enhancing process flow and operational efficiency. Cycle time is a key metric for evaluating manufacturing processes and equipment performance. Additionally, Activity-Based Layout (ABL) emerged as a valuable approach for boosting productivity.

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.

