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# REDUCING WORK IN PROCESS (WIP) USING LINE BALANCING TECHNIQUE IN MANUFACTURING INDUSTRY

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*Abstract*— **For organizations looking to increase productivity and efficiency in the manufacturing sector, reducing Work In Process (WIP) is a crucial goal. The deployment of line-balancing techniques to accomplish this goal is the main topic of this research article. The introduction discusses the negative consequences of WIP, including productivity loss, leads times that are too long, and bottlenecks. The application of lean manufacturing principles, workflow optimization, WIP limits establishment, improved communication and collaboration, prioritization and sequencing of work, identification and removal of bottlenecks, and performance monitoring are just a few of the methods for reducing WIP that are covered. The importance of line balancing in maximizing efficiency, effectiveness, and productivity in manufacturing output is emphasized in the study. The literature review explores the use of work-sharing and line-balancing approaches to increase productivity as well as the advantages of line-balancing in eliminating operational inefficiencies. The procedure for data collection and analysis, which includes calculating cycle time and takt time, is described in the methodology section. To reduce WIP and streamline processes, the suggested methodology advises allocating greater resources to bottleneck stations. The outcomes show how the suggested methodology works to decrease WIP and boost productivity. The paper concludes by comparing the advantages of line balancing in reducing workstations, cycle time, balance delay, idle time, and overall line length. Present. The references provided offer relevant studies on line balancing and assembly line basics. This research contributes valuable insights and practical implications for improving productivity and reducing WIP in the manufacturing industry.**

*Keywords*— **Line Balancing, WIP, Lean Manufacturing, Efficiency, Bottleneck**

## I. INTRODUCTION

Work in Process is a huge problem for the growing industries. Reducing Work in Process (WIP) is a common goal for the organization trying to improve efficiency and productivity. The market has grown more competitive and price concerned. Any business that wants to succeed in the competitive market of today needs to have robust quality processes. In order to offer best-in-class products and services under this circumstance, it is essential to review the manufacturing processes and systems in order to increase operational efficiency. Mass production and full plant utilization have traditionally been the keys to financial success. The drawbacks of the conventional manufacturing process include an excessive consumption of raw resources and increased inventories of finished goods and work-in-progress. This method of manufacturing produced rigid plants that are exceedingly challenging to reorganize. Lean and agile manufacturing techniques have been adopted by businesses to cut inventory, maintain short product lead times, and improve system reliability. [1] [2]

Lean manufacturing focuses on reducing waste and increasing value. Applying Lean tools like Just In Time (JIT), Continuous Flow, and Pull systems can reduce WIP. JIT focuses to produce and deliver goods exactly when they are needed, eliminating excess inventory and WIP. Optimizing Workflow: Focuses your workflows and identifies areas where WIP piles up. Seek opportunities to streamline processes, and eliminate unnecessary steps which are blocking the process. Set Work In Process Limited: Establishing WIP Limited is a technique to control WIP by controlling the amount of work at any given time. By setting limits the team members won't have to take more than they can work. [3][4][5]

Improve Communication and Collaboration: Lack of communication and inefficient collaboration can generate WIP. With proper communication and channels, there won't b much WIP. Prioritize and sequence work: By implementing proper prioritization techniques to ensure that the most important task is done first. Use techniques like Value Stream Mapping or Critical Path Analysis to identify critical processes that need to be addressed first. [6] [7]

Identifying and eliminating Bottlenecks: Bottlenecks are points where the process slows down and work is piled up there. Identifying and eliminating bottlenecks can reduce WIPs.. Monitor and Measuring Performance: Regularly track and monitor Key Performance Indicators (KPIs) related to WIP which are Cycle time, Throughput time, and Lead time. These provide insight into your proper efforts to reduce WIP. Line Balancing Technique: Line Balancing is an IE technique used in production and assembly lines to optimize efficiency, effectiveness and productivity. The goal is to evenly distribute the workload across the stations. It is the technique we will be using to reduce Work In Process. [8] [9] [10]

## II. LITERATURE REVIEW:

"Line Balancing Technique to Improve Productivity Using Work Sharing Method". It focuses on the use of work-sharing strategies and line-balancing techniques as a way to boost productivity in manufacturing environments. The study looks into the role that proper line balancing plays in streamlining operations and achieving effective manufacturing processes. It presents a methodical strategy to divide up work tasks among employees in order to establish a balanced workload and maximize productivity using the work-sharing method. It offers useful implications for practitioners and scholars in the field of operations management by providing insights into different line-balancing procedures and their effect on enhancing productivity. [11]

Enhancement of Productivity by Using Line Balancing in Manufacturing Production examines the effect of line balancing methods on raising productivity in manufacturing environments. It presents a study that looks into the value of line balancing in streamlining operational inefficiencies and improving production processes. It looks at different line-balancing methods and how they might be used to boost productivity. The authors contend that line balancing can lead to increased productivity, shortened cycle times, and improved overall operational performance by efficiently dividing the workload among workers and maintaining an equitable distribution of jobs. For manufacturing professionals and decision-makers seeking to optimize their production systems and boost efficiency, this study provides insightful information and useful recommendations.. [12]

Application of assembly line balancing in the manufacturing industry delves into the utilization of assembly line balancing techniques in the context of the manufacturing industry. The study focuses on the main fields of Industrial Organization & Economy, Logistics, and Management. Through a comprehensive analysis, the paper explores the significance of assembly line balancing in optimizing production processes, improving efficiency, and reducing costs. It investigates various methodologies, algorithms, and tools employed in assembly line balancing, considering factors such as task allocation, worker skill levels, and cycle time. The findings of this research contribute to the understanding of best practices in assembly line balancing and provide practical insights for industry professionals and researchers in the field of industrial organization, logistics, and management. [13]

A Study on Basics of Assembly Line Balancing provides a comprehensive examination of the fundamental concepts and principles related to assembly line balancing. The key components of assembly line balancing, include task allocation, cycle time, workstations, and efficiency measures. It shows the significance of achieving a balanced workload distribution to optimize productivity and minimize production bottlenecks. It highlights different methods and algorithms employed in assembly line balancing, such as the Ranked Positional Weight (RPW) method and Johnson's algorithm. By presenting a thorough understanding of the basics of assembly line balancing, this serves as a valuable resource for researchers and practitioners in the field of industrial engineering and manufacturing, aiding them in making informed decisions to enhance production processes and overall efficiency. [14]

## III. METHODOLOGY

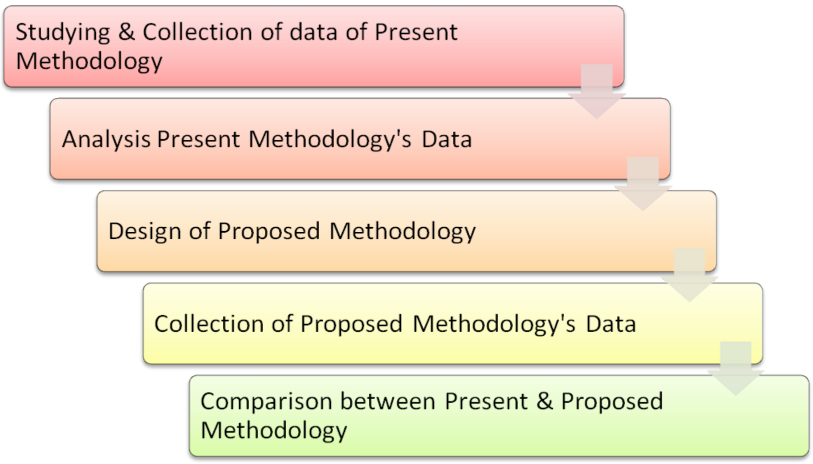



Fig. 1. Methodology

STUDYING AND COLLECTION OF DATA OF PRESENT METHODOLOGY:

Starting study the present study by understanding of all processes involved in it. How each process works and how many workers are working there. After studying the process well, the next step is the collection of data for each process. In the collection of data, the most important step is calculating the Cycle time of each process. [15]

CYCLE TIME: Cycle time refers to the total time it takes to complete one cycle of a specific process or task. It represents the duration starting from the beginning of a process until its completion, including all necessary steps and activities involved. [16]

Calculating cycle time, we also need to note the number of workers allocated to that process.

| ELEMENT | M/C TYPE | Remarks | REQ. WORKER | 1 | 2 | AVG. | Rating factor | Std. Time | Present Methodology Line Balancing |
|---|---|---|---|---|---|---|---|---|---|
| Stitching | Machine | SNL M/C | 6 | 281 | 298 | 274.0 | 100% | 328.8 | 54.80 |
| In line qc inspection | Visual | | 1 | 19 | 11 | 19.4 | 100% | 23.3 | 23.28 |
| Latex pasting | Manual | Foam | 1 | 21 | 22 | 21.6 | 100% | 25.9 | 25.92 |
| Sticker removal | Manual | sticker removal | 1 | 63 | 59 | 62.2 | 100% | 74.6 | 74.64 |
| Air +bladder insertion | Manual+ | Air bladder | 1 | 12 | 14 | 12.2 | 100% | 14.6 | 14.64 |
| Foam pasting (simple) | Manual | Manual | 1 | 32 | 29 | 30.2 | 100% | 36.2 | 36.24 |
| Foam pasting (ring) | Manual | Manual | 1 | 33 | 32 | 31.2 | 100% | 37.4 | 37.44 |
| Air +bladder insertion removal | Manual | Air bladder | 1 | 13 | 16 | 13.0 | 100% | 15.6 | 15.60 |
| Inspection after foam pasting | Manual | | 1 | 39 | 44 | 34.4 | 100% | 41.3 | 41.28 |
| Nozzle & Bladder Insertion | Manual | Needle & Latex | 2 | 42 | 35 | 42.0 | 100% | 50.4 | 47.52 |
| Closing stitches (binding) | Machine | SNL M/C | 1 | 28 | 21 | 24.4 | 100% | 29.3 | 29.28 |
| Final closing | Manual | Manual | 6 | 288 | 281 | 304.8 | 100% | 365.8 | 60.96 |
| Molding | Molding M/c | M/C | 1 | 58 | 59 | 57.6 | 100% | 69.1 | 69.12 |
| Cleaning | Manual | White Petrol | 1 | 16 | 19 | 19.6 | 100% | 23.5 | 23.52 |
| Quality inspection | Visual + | | 1 | 37 | 35 | 37.6 | 100% | 45.1 | 45.12 |

Figure 2 Present Methodology Data

We calculate Line-balancing by dividing Standard time by number of workers in that process. In the last column can be seen that's how we calculated line balancing.

ANALYSIS OF PRESENT METHODOLOGY'S DATA:

After the Collection of the study and collection of the present methodology, the next process is the analysis of the present methodology. For this, we have to calculate Takt Time.

Takt Time: It refers to the maximum amount of time available to produce a product to meet customer demand. Takt time is calculated by dividing the available production time by the customer demand rate. [17]

Takt time = Available Production Time / Customer Demand

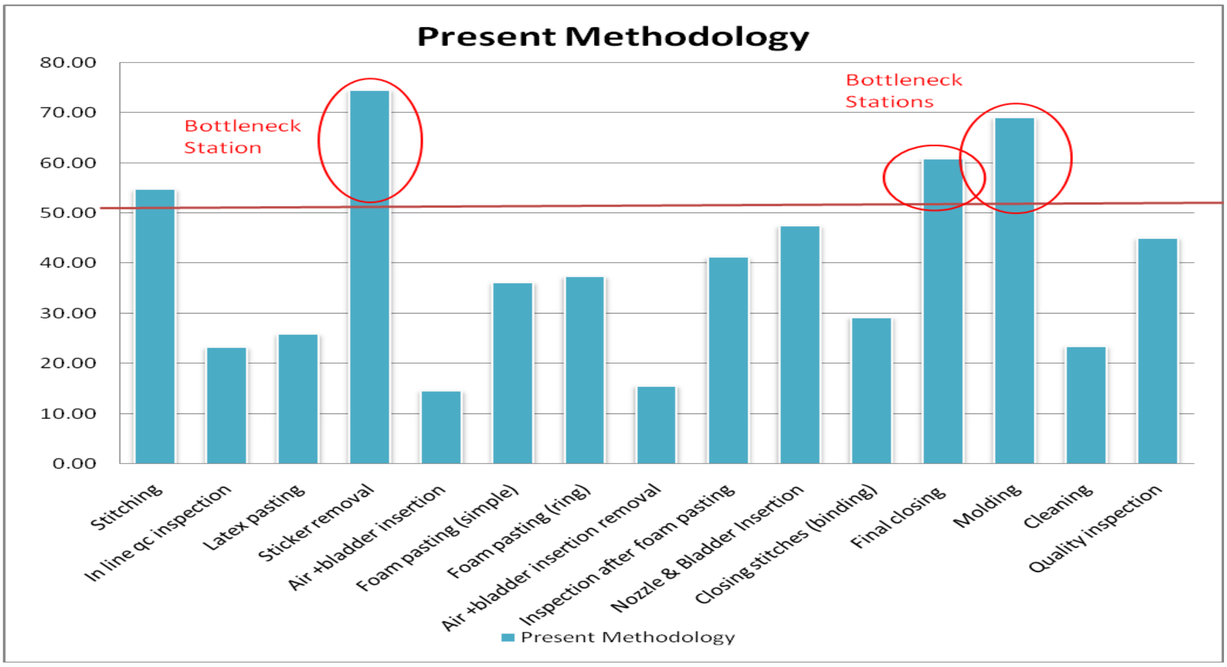
Available Production Time: It refers to the total amount of time available for production within a given period. It is typically measured in minutes or hours and represents the working hours minus any planned breaks, downtime, or non-productive periods.

Customer Demand: It represents the rate at which customers require or demand the product. It is often expressed as the number of units or products needed within a specific time frame, such as per day or hour.

| | |
|---|---|
| **Available Time (sec)** | **28800** |
| **Production Target** | **480** |
| **Takt Time @ 100%** | **60.0** |
| **Takt Time @ 80%** | **48** |

Table 1 Production Target and Available Time

If we do an analysis what how our every process works and how much time it takes to complete one unit. The below graph shows how much time it takes:




Graph 1 Present Methodology Data with Bottleneck Stations

The red line shows that it is our takt time which is 51 seconds. The processes which take more time than 51 seconds will generate Work In Process (WIP) at those stations. The next stations after bottleneck stations will be our starving stations.

DESIGN OF PROPOSED METHODOLOGY:
In this step, we are allocating more resources at each station so we can reduce the takt time of which station and process to reduce Work In Process (WIP) and bottlenecks. It will not only reduce our WIPs but will also streamline our processes. [18]

| ELEMENT | M/C TYPE | Remarks | REQ. WORKER | 1 | 2 | AVG. | Rating factor | Std. Time | Proposed Methodology |
|---|---|---|---|---|---|---|---|---|---|
| Stitching | Machine | SNL M/C | 6 | 281 | 298 | 274.0 | 100% | 328.8 | 46.97 |
| In line qc inspection | Visual | | 1 | 19 | 11 | 19.4 | 100% | 23.3 | 23.28 |
| Latex pasting | Manual | Foam | 1 | 21 | 22 | 21.6 | 100% | 25.9 | 25.92 |
| Sticker removal | Manual | sticker removal | 1 | 63 | 59 | 62.2 | 100% | 74.6 | 37.32 |
| Air +bladder insertion | Manual+ | Air bladder | 1 | 12 | 14 | 12.2 | 100% | 14.6 | 14.64 |
| Foam pasting (simple) | Manual | Manual | 1 | 32 | 29 | 30.2 | 100% | 36.2 | 36.24 |
| Foam pasting (ring) | Manual | Manual | 1 | 33 | 32 | 31.2 | 100% | 37.4 | 37.44 |
| Air +bladder insertion removal | Manual | Air bladder | 1 | 13 | 16 | 13.0 | 100% | 15.6 | 15.60 |
| Inspection after foam pasting | Manual | | 1 | 39 | 44 | 34.4 | 100% | 41.3 | 41.28 |
| Nozzle & Bladder Insertion | Manual | Needle & Latex | 2 | 42 | 35 | 42.0 | 100% | 50.4 | 47.52 |
| Closing stitches (binding) | Machine | SNL M/C | 1 | 28 | 21 | 24.4 | 100% | 29.3 | 29.28 |
| Final closing | Manual | Manual | 6 | 288 | 281 | 304.8 | 100% | 365.8 | 52.25 |
| Molding | Molding M/c | M/C | 1 | 58 | 59 | 57.6 | 100% | 69.1 | 34.56 |
| Cleaning | Manual | White Petrol | 1 | 16 | 19 | 19.6 | 100% | 23.5 | 23.52 |
| Quality inspection | Visual + | | 1 | 37 | 35 | 37.6 | 100% | 45.1 | 45.12 |
| TOTAL | | | 26 | | | SAM (sec) | | 1226 | |

Figure 1 Proposed Methodology Data

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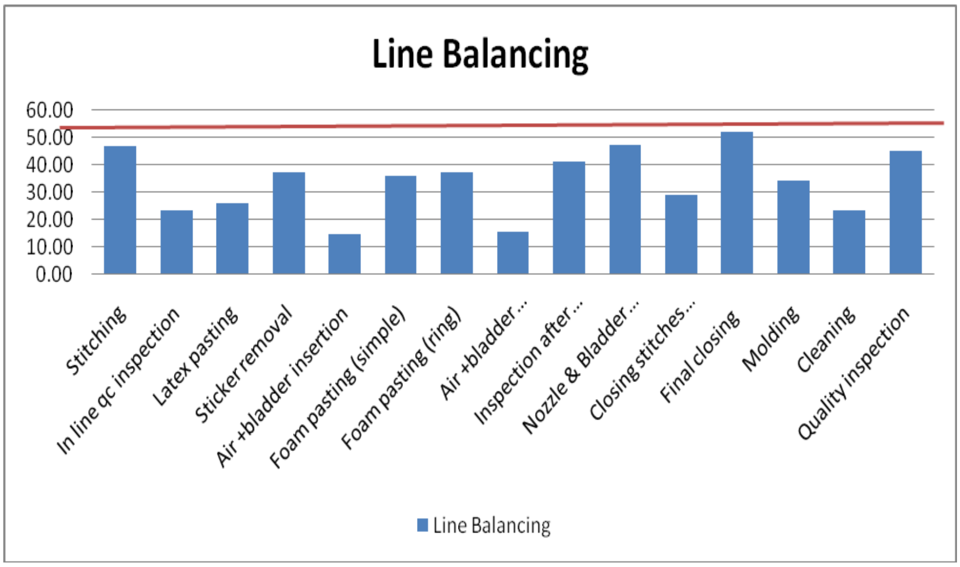
COLLECTION OF RESULTS OF PROPOSED METHODOLOGY:

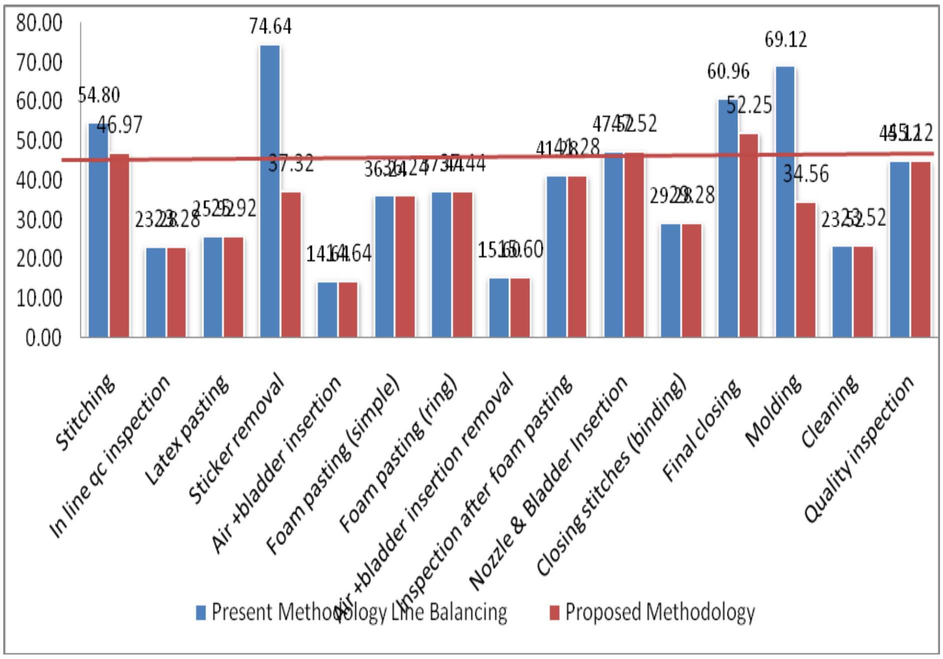
After adding more resources at bottleneck stations we get the result which is an essence. Adding resources not only balances the lines but also will reduce WIP and increase efficiency. If after increasing allocation at bottleneck stations the WIP doesn't reduce then the next thing is to do a method study to reduce waste from the process. The below graph can show that every process will end within 51 seconds. [19]




Graph 2 Line Balancing based on Proposed Methodology Data

COMPARISON OF PRESENT & PROPOSED METHODOLOGY

We can see that in the comparison graph the difference between the present methodology and the proposed methodology. When we draw a line of the takt time we can see the proposed model is well below the line which will help us in reducing WIP in the bottleneck stations of the present model. [20][21]




Graph 3 Comparison Graph between Present and Proposed Methodology

## IV. RESULT

It presents a study that looks into the value of line balancing in streamlining operational inefficiencies and improving production processes. It looks at different line-balancing methods and how they might be used to boost productivity. The authors contend that line balancing can lead to increased productivity, shortened cycle times, and improved overall operational performance by efficiently dividing the workload among workers and maintaining an equitable distribution of jobs. For manufacturing professionals and decision-makers seeking to optimize their production systems and boost efficiency, this study provides insightful information and useful recommendations.

## V. DISCUSSION

The findings of this study demonstrate how crucial line balancing techniques are for lowering WIP and improving production procedures. Line balancing decreases the number of workstations needed for a particular cycle and shortens the cycle time for a given number of workstations by evenly spreading the workload across stations. This has a number of advantages, including a lessened balance delay, less downtime, and a shorter total queue.

The use of line balancing procedures results in increased output, increased operational effectiveness, and simplified workflows. The suggested methodology successfully decreased WIP and made sure that each process could be finished within the takt time by addressing bottleneck stations and assigning more resources. As a result, the production system became more synchronized and effective.

BENEFITS OF LINE BALANCING

The benefits of line balancing can be classified into two categories as represented here. –

i. Minimizing the number of workstations for a given cycle.
ii. Minimizing the cycle time for a given number of numbers of workstations.
iii. Minimizing the balance delay (or) maximizing the balancing efficiency.
iv. Minimizing the total idle time.
v. Minimizing the overall facility or line length.

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