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# OPTIMIZING EFFICIENCY THROUGH TIME AND MOTION STUDY: UNVEILING CRITICAL BOTTLENECKS FOR ENHANCED PRODUCTIVITY

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**Abstract**
A thorough Time & Motion analysis was conducted in an effort to improve the effectiveness and productivity of operations at Rajshree Engineering. The purpose of this study was to comprehend, measure, and examine the motions and time spent by workers when performing particular jobs. To collect accurate data, traditional procedures and contemporary tracking systems were used
The study yielded insightful results, notably identifying bottleneck operations within the workflow. These bottlenecks, hindering overall productivity, were meticulously pinpointed. Alongside quantitative data on time allocation, the analysis highlighted redundant movements and inefficiencies, offering a detailed understanding of areas requiring improvement. Recommendations stemming from this study ranged from restructuring workflows and retraining staff to potential technology upgrades, all aimed at streamlining operations and maximizing productivity at Rajshree Engineering.
**Keywords**: Time & Motion Analysis, Productivity Enhancement, Bottleneck Identification, Workflow Optimization, Efficiency Improvement.

## I. Introduction

Time and Motion studies, introduced by Frank and Lillian Gilbreth, continue to be invaluable techniques for boosting operational effectiveness. Time studies focus on task durations, setting standards for performance, while Motion studies delve into movement specifics, aiming to trim superfluous actions [9] [15] [17]. This dual approach not only streamlines workflows but also enhances productivity and prioritizes worker welfare by curbing fatigue- inducing motions [5] [7] [12]. These methods, originating in the early 20th century, have evolved to suit contemporary industrial demands, seamlessly integrating with modern technologies to maintain their relevance in optimizing operations and maximizing efficiency [3] [6] [7] [8]. Time and Motion studies have practical uses in diverse industries, such as manufacturing, healthcare, logistics, and services. They refine assembly line processes in manufacturing, improve patient care routines in healthcare, optimize warehouse operations in logistics, and streamline customer service procedures in the service sector. These studies contribute to efficiency enhancements across various sectors without duplicating content. [2] [10] [11] [16]

## II. Literature

These diverse studies on Time and Motion Studies across multiple industries underscore the methodology's versatility and practicality in enhancing operational efficiency. From manufacturing to healthcare, logistics, IT, education, and municipal services, the consistent findings reveal the profound impact of this approach. Across these sectors, the studies consistently demonstrated improvements in identifying bottlenecks, streamlining workflows, optimizing resource allocation, and ultimately enhancing productivity. The research consistently highlighted tangible benefits, such as reduced production time, improved patient care, efficient route planning, enhanced system performance, optimized teaching methods, improved product quality, and cost savings. Moreover, the studies showcased adaptability, as Time and Motion Studies proved effective in varied contexts, from electronics manufacturing to waste collection services, emphasizing their potential for widespread applicability and positive impact across diverse industries.

Sukwon Kim's [1] The study assessed how Time and Motion Studies impact manufacturing. By closely analyzing workflows, it found that integrating these studies reduced production time and boosted overall efficiency. Manufacturers could spot problems, cut waste, and manage resources better. Kim's research showed clear benefits for manufacturing, promoting the use of these studies to streamline operations and stay competitive.

Pedro et al. [2] The research centered on Time and Motion Studies in healthcare, using observation and workflow analysis. It discovered that these studies efficiently pinpointed issues in healthcare processes, leading to better patient care and shorter wait times. This study showcased how Time and Motion Studies can adapt to various sectors, emphasizing their role in refining healthcare operations and improving patient services overall.

Afraz et al. [3] The study delved into merging technology with Time and Motion Studies in logistics, employing wearable sensors and data analytics. Their discoveries showcased enhanced route optimization, quicker deliveries, and boosted worker productivity. This research highlighted how technology-infused Time and Motion Studies greatly enhance logistics by efficiently streamlining operations and amplifying productivity within the industry.

Shruti Guha and Dr. Devendra Varma [4] conducted a study focused on using Time and Motion Studies to refine office workflows. Their findings showed that these studies successfully identified inefficiencies, leading to increased productivity and better resource allocation. This study's significance lies in highlighting how Time and Motion Studies, usually associated with industries, also benefit office settings, emphasizing their role in boosting efficiency and managing resources effectively.

Chandra Prakash et al. [5] conducted a study centered on integrating Time and Motion Studies into the construction industry. Their findings emphasized how these studies streamlined processes, minimized project delays, and enhanced safety measures. The study's significance lies in demonstrating the benefits of Time and Motion Studies in the intricate construction landscape, showcasing their capacity to refine operations, improve project management, and fortify safety protocols within the industry.

Abdul Talib Bon et al. [6] applied time and motion study techniques in a rice processing company in Sabah, focusing on the manpower involved. The standard time initially stood at 3.39 hours, which decreased significantly by 5.31% to 3.21 hours after their assessment. They employed Stat Fit and Pro Model software for data analysis and suggested optimizing storage space, cleaning machines, and packaging machinery for enhanced efficiency.

Usman Ghani et al. [7] undertook a study exploring the use of Time and Motion Studies in healthcare service delivery. Their findings showcased these studies as valuable tools for healthcare facilities, resulting in enhanced patient care, reduced wait times, and better resource management. This research was significant for highlighting the practical application of Time and Motion Studies in healthcare, emphasizing their potential to improve service quality and optimize resource allocation in the healthcare sector.

Isaiah K. Kimutai and Dr. Stephen K. Kimutai [8] explored using Time and Motion Studies to optimize transportation logistics. Their study revealed substantial benefits, such as improved route planning, reduced fuel usage, and cost savings in logistics operations. This research showcased the practical application of Time and Motion Studies in transportation management, emphasizing their ability to improve efficiency and cost-effectiveness within the logistics industry..

Yanling Xiao, et al. [9] investigated applying Time and Motion Studies to optimize information technology processes. Their findings highlighted these studies' effectiveness in identifying workflow bottlenecks, leading to enhanced system performance and better resource allocation. This research expanded the scope of Time and Motion Studies into IT processes, showcasing their adaptability and usefulness in optimizing technology-related workflows and improving overall system efficiency.

Nevien Farouk Khourshed, Sahar Sobhy Elbarky, and Sarah Elgamal [10] focused on applying Time and Motion Studies in educational settings. Their findings showcased the potential of these studies to improve classroom efficiency, refine teaching approaches, and enhance student learning outcomes.

This study significantly contributed by exploring a relatively new application of Time and Motion Studies in education, highlighting how this method can be tailored to enhance educational processes for the benefit of both teachers and students.
Dragana Slavic, et al. [11] conducted a study that implemented Time and Motion Studies in the manufacturing of consumer electronics. Their findings emphasized the considerable advantages of these studies, including enhanced production quality, decreased defects, and improved worker safety. This research significantly contributed by demonstrating the tangible benefits of Time and Motion Studies in the electronics manufacturing sector, showcasing their potential to improve product quality, streamline production processes, and enhance workplace safety within this industry.
Saad Abd Ulkareem Hammad and Ali Darub Kassar Al Hiyali [12] conducted a study focusing on applying Time and Motion Studies to enhance municipal waste collection services. Their findings highlighted significant benefits, including the creation of more efficient waste collection routes, cost reduction in operations, and improved environmental sustainability. This study made a substantial contribution by emphasizing the valuable role of Time and Motion Studies in municipal services, showcasing their potential to enhance waste management efficiency and foster sustainability within urban environments.

## III. Methodology

Essential Research Procedure: This study follows a structured approach involving four sequential steps. Firstly, the selection of the specific process or job to be studied is undertaken. Secondly, all pertinent facts associated with the work process are meticulously observed and recorded. Thirdly, a critical examination of each recorded detail is conducted. Finally, the most efficient work process is developed based on the insights gathered from the prior steps [1] [4] [5].

- Data Collection Methods: The research necessitates the collection of data related to various facets of the work process, including the time duration, movements or distances involved in each process, and the production volume within specific time frames. To gather this information, several methods are employed:
- Systematic Observation: Researchers observe the entire work process within the industry, selecting specific processes or jobs for in-depth study. They meticulously record all occurrences from the process initiation to its completion.
- Stopwatch Time Study: This method involves measuring the time required for a particular process, aiming to identify the most time-efficient techniques. Utilizing snapback stopwatch equipment ensures precise and swift data recording, directly inputting element times onto the study sheet [13] [14] [16].
- Process Chart: Employed to illustrate handling, inspection, operations, storage, and delays within the work process, process charts use symbols to depict each step of the process flow from initiation to completion.
- Data Analysis: Post data collection, a comprehensive analysis ensues. Every work process, documented through systematic observation and process charts, undergoes thorough examination. Statistical tools like Stat Fit and Pro Model software generate charts and graphs aiding in critically assessing each recorded detail. This scrutiny enables the identification of non-productive segments and time-consuming elements within the work process.

The data obtained from the stopwatch time study is shown in the Table 1

**Table 1. Compiled data obtained from time study in Chassis Assembly Line**

| S. No. | Station Name | Cycle Time (Min.) | | |
|---|---|---|---|---|
| | | 01 | 02 | 03 |
| 1 | Drilling & Reaming | 10.4 | 17.45 | 11 |
| 2 | Riveting | 17.31 | 10.43 | 13.09 |
| 3 | Boxing | 31.4 | 18.92 | 20.02 |
| 4 | Boggie Assembly | 20.25 | 17 | 16.37 |
| 5 | Assembly 01 | 25.5 | 15.03 | 17.21 |
| 6 | Torqueing 01 | 25.24 | 20.34 | 22.23 |
| 7 | Torqueing 02 | 20.48 | 20.32 | 23.51 |
| 9 | PDI | 15.01 | 26.2 | 24.13 |
| 10 | Painting | 26 | 14 | 23.08 |
| 11 | Offline Assembly 02 (Lift Axle Assembly) | 42.3 | 29.58 | 31.42 |
| 12 | Offline Assembly 02 (Lift Axle Frame Assembly) | 44.79 | 53.43 | 35.22 |

The primary data collection method, videography, was selected for its capacity to visually document the manufacturing or assembly process, capturing activities at various stations acrossdifferent frames. This method facilitates precise observation and time measurement for specifictasks, enabling a detailed assessment of movements, delays, and interactions within the workflow. The collected video graphic data is presented in the provided table, categorizing stations and showcasing cycle times for each station across three frames (Frame 01, Frame 02,and Frame 03). Cycle time denotes the total duration for task completion at each station. Analysis of this data unveiled notable disparities in cycle times among stations and frames, indicating varying time requirements for different tasks. Understanding these variations is pivotal for optimizing workflow and enhancing overall efficiency.

**Table 2. Compiled data obtained from time study in Front Axle Assembly Line**

| Sn.No. | Type of Axle | | | | | | |
|---|---|---|---|---|---|---|---|
| | Station Name | Cycle Time (Sec.) | | | | | |
| | | 01 | 02 | 03 | 04 | 05 | 06 |
| 1 | Washing | 180 | 180 | 180 | NIL | NIL | 180 |
| 2 | Knuckle Sub Assembly | 69 | 69 | 69 | NIL | NIL | 69 |
| 3 | Hub Bolt Pressing | 165 | 165 | 165 | NIL | NIL | 165 |
| 4 | Knuckle Assembly in Axle Beam | 189 | 189 | 189 | NIL | NIL | 189 |
| 5 | Hub Race Pressing | 79.2 | 79.2 | 79.2 | 79.2 | 79.2 | 79.2 |
| 6 | Bearing Greasing | 6 | 6 | 6 | 6 | 6 | 6 |
| 7 | Hub Greasing | 26.4 | 26.4 | 26.4 | 26.4 | 26.4 | 26.4 |
| 8 | Hub Oil Seal Pressing | 135 | 135 | 135 | 135 | 135 | 135 |
| 9 | Hub Rotor Assembly | 1.2 | 1.2 | 1.2 | 1.2 | 1.2 | 1.2 |
| 10 | Axle Drop on Conveyor | 67.2 | 22.2 | 25.2 | 135 | 94.2 | 64.8 |
| 11 | Arm Assembly and Grease Nipple Fitment | 107.4 | 105.6 | 142.2 | NIL | NIL | 322.8 |
| 12 | Tie Road Assembly | 126.6 | 108.6 | 113.4 | NIL | NIL | 241.2 |
| 13 | Dust Cover Assembly | 187.8 | 185.2 | 186.2 | 188.2 | 187.6 | NIL |
| 14 | Brake Assembly & Tightening | 488.2 | 420.6 | 435.6 | 725.4 | 787.8 | 761.4 |
| 15 | Hub Fitting and Tightening | 280.8 | 379.2 | 229.8 | 2692.2 | 349.8 | 446.4 |
| 16 | Drum Fitment | 70.2 | 75.6 | 21.8 | 117 | 32.4 | NIL |
| 17 | Cap Greasing and Fitment | 121.8 | 192.5 | 168.6 | 168.6 | 173.4 | 567.6 |
| 18 | Axle Greasing | 119.4 | 62.4 | 63.6 | NIL | NIL | 52.8 |
| 19 | Painting | 150 | 150 | 150 | 150 | 150 | 150 |

Videography was utilized to visually capture the manufacturing process at different axle assembly points, providing a comprehensive dataset for analysis. The collected data, detailed in Table 2, categorizes cycle times (measured in seconds) per station, considering axle typesand assembly points. This categorization aids in understanding task durations at each station. Analysis of the data revealed significant variations in cycle times among stations, axle types, and assembly points, indicating diverse task natures within axle manufacturing. While some stations showed consistent cycle times, like 'Knuckle Sub Assembly,' others, notably 'Hub Fitting and Tightening' in Axle-04, displayed substantial discrepancies, suggesting potential issues requiring further investigation and corrective action.

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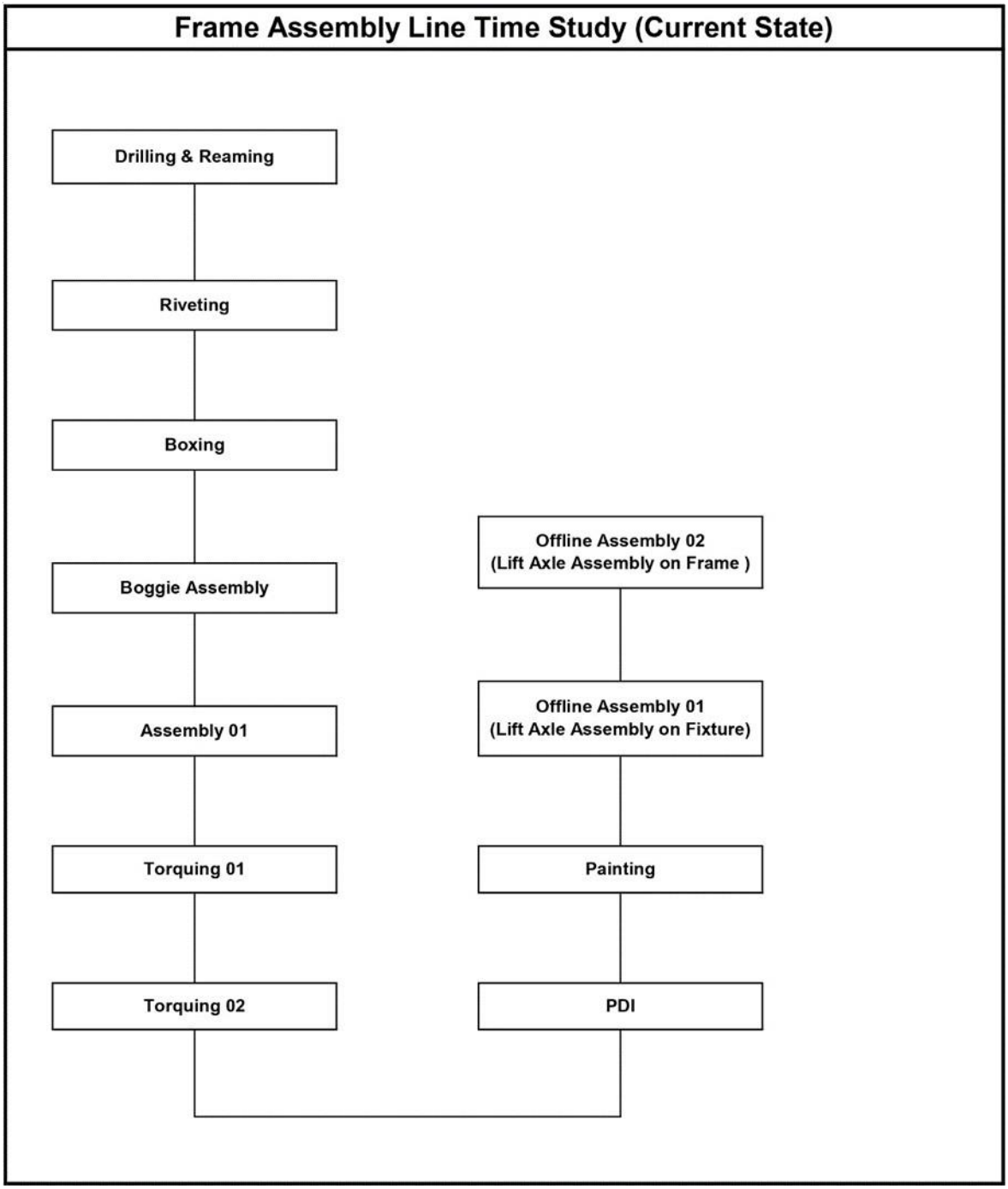


**Fig. 1. Flow Chart (Chassis Assembly Line)**

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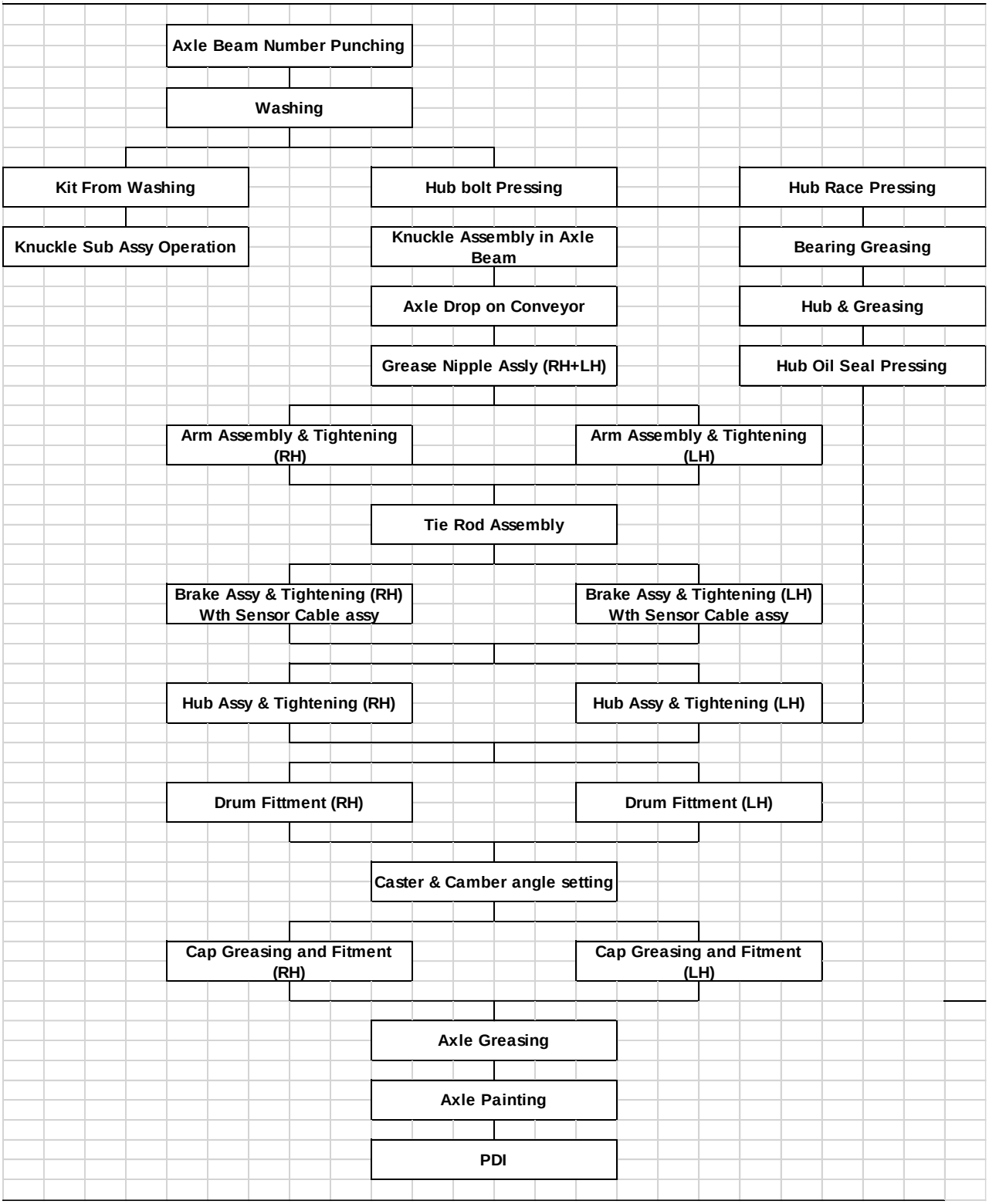


**Fig. 2. Flow Chart (Front Axle Assembly Line)**

## IV. Results and Discussion

4.1 Chassis Assembly -

Upon scrutinizing the time allocations for each operation, it becomes apparent that the"Boxing Assembly Station" stands out as the bottleneck within this assembly process.This specific operation requires the longest duration (31.40 minutes) compared to other stages. A bottleneck operation

represents a pivotal stage in the workflow that consumes the most time, impeding the smooth flow of the overall process.
The prolonged duration at the Boxing Assembly Station might significantly impact the efficiency of the entire process, potentially leading to delays and decreasedproductivity. To enhance the overall workflow, addressing this bottleneck operation becomes imperative. Implementing strategies such as refining the workflow, optimizing processes, reallocating resources, and enhancing work methodologies specifically at the Boxing Assembly Station can mitigate the prolonged duration and alleviate the bottleneck's adverse impact on productivity. Additionally, it's noteworthy that the operation of "Painting and Assembly 1," which takes 26 and 25.24 minutes, respectively, contributes significantly to the bottleneck and requires careful attention for process optimization.

4.2 Front Axle Assembly –

The key bottleneck operations within this manufacturing or assembly process are identified as "Brake Assembly & Tightening LH" and "Brake Assembly & TighteningRH," each requiring 6.33 minutes. Resolving this bottleneck is pivotal for bolstering the overall production efficiency. To address this constraint, several strategies could be implemented, including parallel processing, automation, adherence to lean principles, workforce training, tool optimization, scheduling enhancements, continuous improvement initiatives, stringent quality control measures, supply chainstreamlining, and considering outsourcing options, as previously discussed.
Moreover, it's noteworthy that the operations involving "Cap Greasing and Fitment," consuming 4.74 minutes, and "Tie Rod Assembly," necessitating 4.016 minutes, also significantly contribute to the bottleneck. These stages warrant thoroughevaluation and integration into the improvement strategies to streamline the overall workflow and optimize production efficiency.

## V. Conclusion

The analysis of Chassis and Front Axle Assembly processes highlights significant bottlenecks impacting productivity. Addressing the Boxing Assembly Station's prolonged duration and optimizing Painting and Assembly 1 stages in Chassis Assembly are vital for workflow enhancement. In Front Axle Assembly, addressing bottlenecks at Brake Assembly & Tightening LH/RH and streamlining Cap Greasing and Fitment, along with Tie Rod Assembly, is crucial. Implementing parallel processing, automation, lean principles, and workforce training are key strategies to improve efficiency. Emphasizing continuous improvement, quality control, optimized scheduling, supply chain streamlining, and considering outsourcing contribute to a holistic plan for enhanced brake assembly efficiency, reduced delays, and heightened productivity.
Implementing a multifaceted approach is imperative to address the identified bottlenecks in the brake assembly process. Strategies such as parallel processing to enable simultaneous operations, automation for enhanced consistency, and lean principles for waste elimination are pivotal. Equally essential is comprehensive worker training, tool optimization, and structured scheduling to optimize resources and prevent congestion. Fostering a culture of continuous improvement and stringent quality control measures are paramount for sustained efficiency. Additionally, streamlining the supply chain and considering outsourcing options, where feasible, contribute to a comprehensive enhancement plan. The amalgamation of these strategies represents a holistic approach towards optimizing the brake assembly process, ensuring improved efficiency, reduced delays, and enhanced overall productivity.

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