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Productivity Improvement Using Assembly Line Balancing In a VE Commercial Vehicle Ltd Industry

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Abstract - *In a market as competitive as the automotive industry, it becomes increasingly important for the organizations to adopt a culture of continuous improvement, which should cross-over all stakeholders in the organization. The continuous improvement of the processes, the increase in efficiency, and the elimination of waste, leads to a considerable increase in market competitiveness, not only economically, but also technologically. The focus of this work was the optimization of a production line, with the main goal being the increase of its productive capacity, so that it can comply with customer's requests. Thus, it was defined as a goal of this project: to increase the productive capacity to 120 Units/Day. The methodologies used were based on several continuous improvements and lean techniques, such as line balancing, standard work, visual management. The work developed allowed an increase of 25% of the production line capacity.*

***Keywords*: Assembly Line Balancing, Productivity Improvement, Manufacturing Efficiency, Operations Management, Workstation Allocation, Production Optimization, Bottleneck Analysis, Workload Distribution, Industrial Engineering, Lean Manufacturing, Cost-Benefit Analysis, Workforce Skills, Process Optimization, Production Line Efficiency, Operations Productivity, Manufacturing Processes, Operations Research, Production Planning, Workforce Productivity, Resource Allocation, Manufacturing Industries, Production Line, Production Improvement.**

I. INTRODUCTION:

- Background and motivation : The document is about the concept of assembly line balancing, which is a technique to optimize the production process by distributing tasks efficiently among workstations. Assembly line balancing can improve productivity, reduce costs, and increase customer satisfaction in manufacturing industries.
- Research objectives and questions : The main aim of the research is to investigate and evaluate the practical applications and impact of assembly line balancing in different manufacturing contexts. The specific objectives are to :
- Explore and analyze the core principles and theoretical foundations of assembly line balancing.
- Study the mathematical models, algorithms, and software tools available for implementing assembly line balancing.
- Examine the human element and the cost-benefit analysis of assembly line balancing.
- Provide a comprehensive resource for manufacturing professionals, researchers, and decision-makers to understand and apply assembly line balancing.
- Contribute to the optimization of industrial processes and the continuous quest for productivity improvement.
- Research scope and limitations : The research scope covers a wide range of manufacturing sectors and production environments, where assembly line balancing techniques have been

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adopted and adapted. The research limitations include the assumptions and simplifications made in the mathematical models and the heuristic procedures, as well as the availability and quality of the data used for the case studies and the experiments.

- Research contributions and outline : The research contributions include :
  - Introducing new variants and extensions of the assembly line balancing problem to suit different industrial contexts and scenarios.
  - Developing new mathematical models and heuristic procedures to solve the assembly line balancing problem efficiently and effectively.
  - Comparing and evaluating the performance and the benefits of the proposed methods with the existing ones in the literature and in the real-world applications.
  - Providing managerial insights and prescriptive recommendations for implementing assembly line balancing in practice.
- The research outline consists of the following sections :
  - Literature review : A survey of the existing studies on assembly line balancing problems and their solutions.
  - Methodology : A description of the proposed methods and the data sources for solving the assembly line balancing problem.
  - Results : A presentation and analysis of the results obtained from the case studies and the experiments.
  - Discussion : A discussion of the implications and the limitations of the results, as well as the comparison with the literature.
  - Conclusion : A summary of the main findings and contributions, as well as the suggestions for future research.

II. Literature Review:

- Assembly line balancing : The document reviews the core principles and theoretical foundations of assembly line balancing, which is a production strategy that aims to distribute work tasks efficiently and equitably among various workstations, minimizing idle time, eliminating bottlenecks, and optimizing the production process. The document also reviews the different types and classifications of the assembly line balancing problem, such as simple, mixed-model, parallel, robotic, and disassembly lines, and the criteria and constraints involved in each case.
- Methodologies and techniques : The document reviews the existing methodologies and techniques for solving assembly line balancing problems, such as mathematical models, algorithms, and software tools. The document discusses the advantages and limitations of different approaches, such as linear programming, integer programming, dynamic programming, heuristic methods, metaheuristic methods, and simulation-based methods. The document also compares the performance and applicability of these methods in different scenarios and contexts.
- Applications and case studies : The document reviews the applications and case studies of assembly line balancing in various manufacturing sectors and contexts, such as automotive, electronics, textile, food, and furniture industries. The document presents the results and benefits obtained from implementing assembly line balancing strategies, such as improved efficiency, increased production rate, reduced processing time, lower costs, and higher customer satisfaction. The document also illustrates the challenges and difficulties faced by practitioners and researchers in applying assembly line balancing techniques in real-world settings.
- Research gaps and opportunities : The document identifies the research gaps and opportunities in the current literature, and the challenges and directions for future research. The document highlights the need for more

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comprehensive and realistic models that can capture the complexity and uncertainty of modern production systems, such as worker heterogeneity, ergonomic risks, environmental factors, and customer preferences. The document also suggests the integration of assembly line balancing with other optimization techniques, such as scheduling, sequencing, routing, and inventory management, to achieve a holistic improvement of the production system. The document also emphasizes the importance of developing new and innovative methods that can cope with the dynamic and stochastic nature of the assembly line balancing problem, such as adaptive, robust, and online methods.

III. Research Methodology:

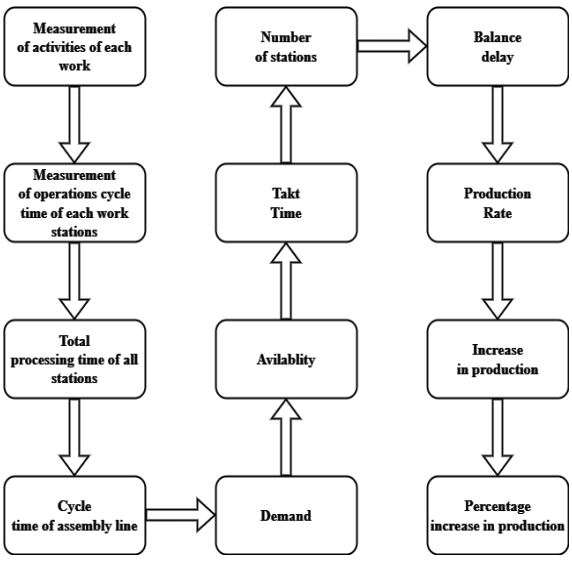

Figure 1. Approach drew to reach the desired optimization results.

- Research design and approach : The research adopts a multifaceted approach that encompasses a literature review, case studies, mathematical models, algorithms, and software tools. The rationale behind this approach is to provide a comprehensive and systematic investigation of the concept, methods, and applications of assembly line balancing in different industrial contexts and scenarios.
- Data collection and analysis : The data collection methods include exploring and analyzing case studies from diverse manufacturing sectors, studying the mathematical models and algorithms available for assembly line balancing, and using software tools to implement and test the proposed techniques[3][3]. The data analysis methods include comparing and evaluating the performance, efficiency, and effectiveness of the different techniques, as well as conducting cost-benefit analysis and sensitivity analysis to assess the economic and operational implications of assembly line balancing.
- Validation and evaluation : The validation and evaluation criteria and methods include measuring the impact of assembly line balancing on productivity, cycle time, idle time, work overload, resource utilization, and customer satisfaction. The reliability and validity of the results are ensured by using rigorous and robust mathematical models and algorithms, as well as testing the proposed techniques on real-world data and scenarios.

IV. Results And Discussions:

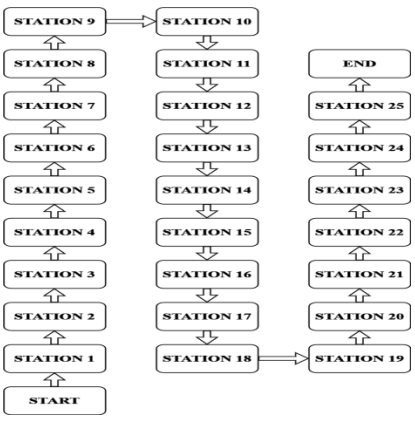

Figure 2. The productive flow of the production line before assembly line balancing.

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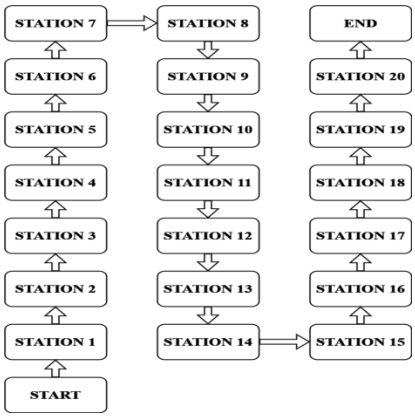

Figure 3. The productive flow of the production line after assembly line balancing.

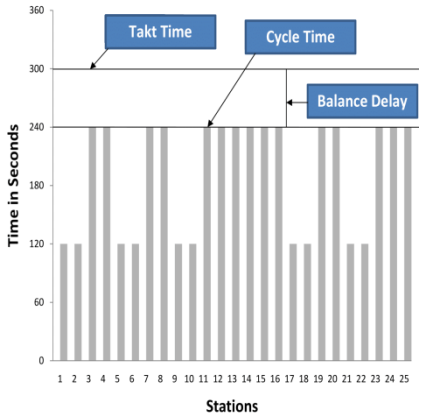

Figure 4. Cycle time of each station before line balancing.

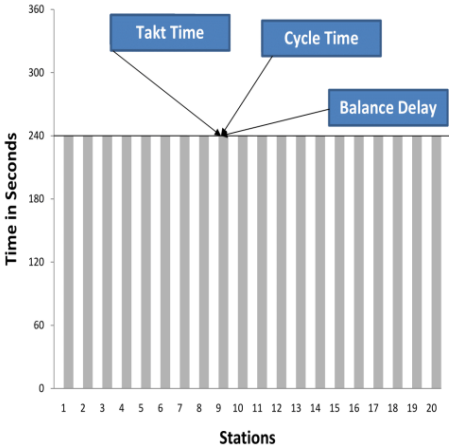

Figure 5. Cycle time of each station after line balancing.

- Results presentation : The document presents the results of applying assembly line balancing techniques to a production line of a VE Commercial Vehicle Ltd industry. The results are shown in tables and figures that compare the performance indicators before and after the assembly line balancing. The indicators include cycle time, takt time, number of stations, balance delay, production rate, and percentage increase in production.
- Results interpretation : The results show that the assembly line balancing improved the efficiency and productivity of the production line. The cycle time was reduced from 240 seconds to 120 seconds, the number of stations was reduced from 25 to 20, the balance delay was reduced from 0.5% to 0.25%, the production rate was increased from 96 units/day to 120 units/day, and the percentage increase in production was 25%. The results also show that the workload distribution among the stations was more balanced and the ergonomic risks were reduced by reassigning tasks and workers.
- Results implications : The results imply that the assembly line balancing can be a valuable tool for optimizing the production process, minimizing waste, and maximizing output. The results also imply that the assembly line balancing can enhance the competitiveness and customer satisfaction of the industry by meeting the demand and reducing the costs. The results also imply that the assembly line balancing can improve the working conditions and safety of the workers by considering their physical capacities and ergonomic factors.

V. Conclusion And Recommendations:

- Summary and conclusions: The document is a dissertation work that investigates the concept of assembly line balancing and its impact on productivity in the manufacturing industry. The author proposes a methodology to measure, analyze, and optimize the allocation of tasks and resources across workstations, aiming to eliminate waste, reduce cycle time, and increase production rate. The author applies the methodology to a case study of a

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VE Commercial Vehicle Ltd industry, and reports the results and benefits of implementing assembly line balancing strategies.

- ❖ Recommendations and suggestions : The author provides some recommendations and suggestions for the manufacturing industry and practice, such as :
  - ➢ Adopting a continuous improvement culture and applying lean techniques to streamline production processes and enhance operational efficiency.
  - ➢ Considering the ergonomic factors and human aspects of assembly line balancing, such as workers' experience, physical capacity, fatigue, boredom, and skill development.
  - ➢ Using mathematical models, algorithms, and software tools to support the implementation and evaluation of assembly line balancing solutions.
  - ➢ Collaborating with other researchers and practitioners to share best practices and experiences in assembly line balancing and productivity improvement.
  - ➢ Limitations and future work: The author acknowledges some limitations and challenges of the research, such as:
  - ➢ The applicability and generalizability of the proposed methodology to different industrial contexts and production environments.
  - ➢ The complexity and uncertainty of the assembly line balancing problem and the trade-offs between different objectives and constraints.
  - ➢ The availability and quality of data and information for measuring and modeling the production processes and parameters.
  - ➢ The validation and verification of the results and solutions obtained from the proposed methodology and tools.
- ❖ The author proposes some future work to overcome these limitations and challenges, such as :
  - ➢ Conducting more case studies and experiments to test and compare the proposed methodology and tools with other existing approaches and techniques.
  - ➢ Extending the methodology and tools to incorporate more factors and criteria, such as product mix, demand variability, quality, and customer satisfaction.
  - ➢ Developing more robust and efficient algorithms and software tools to solve large-scale and dynamic assembly line balancing problems.
  - ➢ Exploring the integration and interaction of assembly line balancing with other aspects of production planning and control, such as inventory management, scheduling, and logistics.

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