Frontiers in Business, Economics and Management
ISSN: 2766-824X | Vol. 19, No. 2, 2025

Research on the Balance Optimization of Glass Production Line Based on Flexsim

Yifan Jiang *

School of Economics and Management, Southwest Petroleum University, Chengdu 610500, China
* **Corresponding author**: 1062782878@qq.com

Abstract: In response to global manufacturing competition for manufacturing excellence, this study applies lean production principles to optimize the assembly line of the glass product in Company Z, a glass manufacturer. Through time study, process flow analysis, both-hands operation optimization, and Flexsim simulation, the research achieves an 86.19% line balancing rate, reduces cycle time to 63.76 minutes, and implements 6S management for enhanced on-site organization. The findings validate the effectiveness of lean methodologies in resolving production imbalances.

Keywords: Optimization of production line; 0-1 integer programming; Flexsim simulation.

1. Introduction

In China's economic structure, manufacturing forms a key link in the real economy, and it is the cornerstone of a country's hard power which reflects a country's economic development level and level to a certain extent. After the reform and opening up, China's manufacturing technology has made great progress, from the simple-based production workshop to the modern factory dominated by intelligent technology, constantly improving quality and efficiency. Against the background of the rapid and premature decline of the proportion of manufacturing industry in Chinas national economy, facing the increasingly fierce competition in the industry, many enterprises hope to find a way to improve productivity quickly and effectively. Concepts such as "Made in China2025" and the Industrial Internet have emerged as the times require, and more and more Chinese enterprises have begun to transform and upgrade, moving towards globalization and diversification.

This paper takes the optimization of Z company's laminated glass processing production line as the research object, analyzes the existing problems and their causes, and traditional industrial engineering methods and constructs mathematical models to balance and optimize, and then uses Flexsim software to build and simulate the production line before and after the improvement of the production line, compares the simulation results of the two, and verifies the rationality and scientificity of the optimization scheme, so as to achieve the purpose of improving productivity, meeting market demand and competitiveness.

The significance of this research lies in its theoretical and practical contributions. Theoretically, it integrates lean production principles with integer programming and simulation techniques to validate the applicability of these methods in production line balancing. Practically, the proposed optimizations can help Z Company reduce costs, improve productivity, and enhance market competitiveness. Additionally, the findings of this study can serve as a reference for other similar enterprises facing similar production line balancing challenges.

2. Literatute Review

2.1. Lean Production and Production Line Balancing

Lean production is a methodology that focuses on the elimination of waste in all its forms, including overproduction, waiting, transportation, processing, inventory, motion, and defects. Production line balancing, on the other hand, is a technique used to ensure that the workload is evenly distributed across all workstations in a production line, thereby maximizing efficiency and minimizing bottlenecks.

The integration of lean production principles with production line balancing has been extensively studied in the literature. For instance, research has shown that the application of lean tools such as value stream mapping (VSM), 5S management, and continuous flow can significantly improve production line efficiency. Furthermore, the use of simulation software like Flexsim has become increasingly popular for modeling and optimizing production lines in lean environments.

2.2. Recent Studies on Lean Production and Assembly Line Balancing

Recent studies have focused on the application of lean production principles to address assembly line balancing problems. For example, Yu et al. (2010) introduced a method for using lean production theory to solve assembly line balancing (ALB) problems. The study utilized fishbone charts to analyze constraints impacting assembly line balancing in a reducer manufacturing company and applied lean tools such as 5S activities, standard operating time development, continuous flow, and teamwork to improve the original assembly line. The results indicated that workload became more balanced, and productivity improved significantly.

Similarly, Dong et al. (2013) studied the application of lean production in the production line improvement of a Carlisle tire company. The researchers employed 5W2H, ECRS, and economic analysis methods to optimize the production process. The findings confirmed the feasibility and effectiveness of lean production in practical applications, demonstrating improvements in production efficiency and waste reduction.

2.3. Case Studies of Lean Production in Manufacturing Industry

Numerous case studies have illustrated the successful application of lean production in various manufacturing industries. In the automotive sector, lean production has been instrumental in reducing waste and improving quality. For example, Toyota's TPS has been a global benchmark for lean production, with practices such as just-in-time (JIT) production and jidoka (autonomation) being widely adopted.

In the electronics industry, lean production has helped manufacturers respond to rapidly changing market demands. For instance, the application of single-minute exchange of die (SMED) techniques has enabled faster equipment changeovers, facilitating flexible production of multiple product variants in small batches.

2.4. Research Methodologies in Lean Production and Production Line Optimization

Research methodologies in this field are diverse and often involve a combination of qualitative and quantitative approaches. Qualitative methods such as literature reviews, case studies, and expert interviews are commonly used to explore the theoretical underpinnings and practical applications of lean production. Quantitative methods, on the other hand, involve the use of statistical tools, simulation software, and mathematical models to analyze and optimize production line performance.

For example, simulation software like Flexsim has been extensively used to model and optimize production lines. The software allows researchers to experiment with different production scenarios, evaluate the impact of various lean tools and techniques, and identify optimal solutions for production line balancing.

2.5. Evaluation of Lean Production Implementation

The evaluation of lean production implementation is crucial for assessing the effectiveness of lean initiatives and identifying areas for improvement. Various performance metrics have been proposed in the literature, including the degree of leanness (DOL), which measures the extent to which lean practices have been implemented in an organization.

Studies have shown that the implementation of lean production can lead to significant improvements in operational efficiency, quality, and cost-effectiveness. For instance, research has demonstrated that successful implementation of lean production can result in operational efficiency improvements of 20%-50% and quality cost reductions of 20%-40%.

3. Methodology

3.1. Determine the Operation Time of The Process

This article uses the production operation measurement technique to measure the standard working hours. Before the formal measurement, we fully considered the actual operation of the production line and the appropriate measurement technique. After completing the measurement, we applied the allowance factor and the comparison coefficient to correct the measurement results, resulting in the final standard working time. The specific process as follows: determine the measurement method, divide the operation elements, determine the number of observations, collect and organize data, calculate the normal time, determine the allowance time, and the standard time.

3.2. Two-Handed Operation Analysis

When the production line is running normally, the bottleneck process is often at full capacity. Due to the time it takes, which is much longer than other processes, efficiency of the entire production line is reduced. Therefore, optimizing the bottleneck process is the top priority.

3.3. Construct a 0-1 Integer Programming Model

After the introduction of the model assumptions, the constraints, the relevant parameters, and the decision variables, it is necessary to construct the production line balancing optimization model for product. The model construction idea is as follows: First, determine the objective function; second, abstract the various constraints that the model should satisfy; third, construct the production line integer programming model for the first type and the second type of glass products.

4. Results

The data collected and collated in advance was entered into the lingo software, and the following results were obtained:

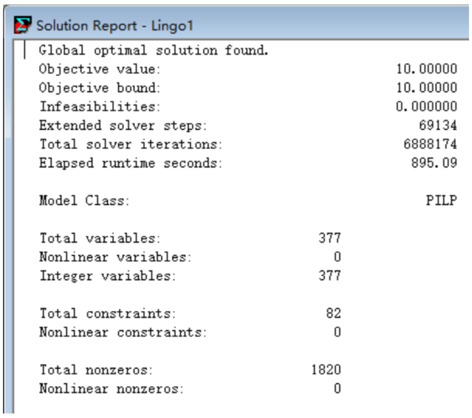

Figure 1. Solution to the First Type

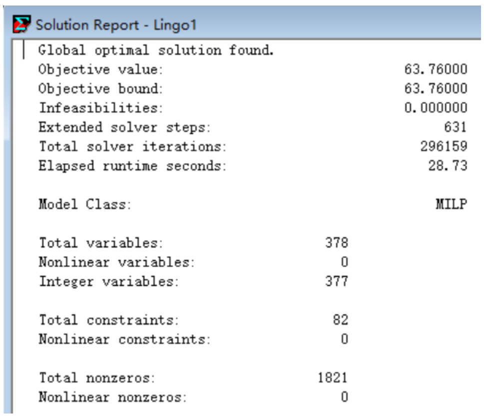

Figure 2. Solution to the Second Type

5. Discussion

5.1. Current Situation Analysis

The initial analysis revealed significant imbalances in this production line. The bottleneck process, specifically the lamination process, had a significantly longer cycle time than other processes, leading to high idle times and overall inefficiency. The overall line balance rate was only 56.7%, indicating a need for optimization.

5.2. Bottleneck Process Optimization

Through two-handed operation analysis, several inefficient movements in the lamination process were identified and eliminated. The optimized process reduced the cycle time from 74.98 minutes to 66.79 minutes, significantly improving line efficiency.

5.3. Task Reassignment Optimization

Based on the 0-1 integer programming models, task reassignments were proposed to balance the workload across workstations. The Type I model resulted in a reduction in workstation count from 13 to 10, with a balanced cycle time of 63.76 minutes. The Type II model also achieved a balanced cycle time but required more workstations.

5.4. Field Management Optimization

The implementation of 6S management improved workplace organization, reduced search times, and enhanced overall productivity. The 6S team was responsible for enforcing standards, conducting regular audits, and providing training to employees.

5.5. Effect Evaluation

Simulation results showed that the optimized production line configurations significantly improved line balancing. The balance rate increased to 86.61%, and the smoothing index decreased to 11.99. The reduced cycle time and workstation count translated into lower costs and higher productivity for Z Company.

6. Conclusion

This study successfully optimized the production line balancing for the glass product in Z Company through a combination of lean production principles, integer programming models, and simulation techniques. The proposed optimizations significantly improved line efficiency, reduced costs, and enhanced overall competitiveness for Z Company. The findings of this study contribute to the existing literature and provide valuable insights for other similar enterprises seeking to optimize their production lines.

References

[1] Kusarj.Implementation of the lean concept and simulations in smes- a case study [j]. International journal of simulation modelling, 2022, 21(1): 77-88.

[2] Campos G, Huayhua M, Chavarri L, RIbaez C. Lean Manufacturing Production Management Model using the Johnson Method Approach to Reduce Delivery Delays for Printing Production Lines in the Digital Graphic Design Industry [J]. IOPConference Series: Materials Science and Engineering, 2020, (1): 12-20.

[3] Canonico P, De Nito E, Esposito V, et al. Visualizing knowledge for decision-making in Lean Production Development settings. Insights from the automotive industry [J]. Management decision, 2022, (4): 28-36.

[4] Li Ke. Research on the optimization of the production line balance rate of Company H based on 0-1 integer programming [J]. Internalustion Engine and Accessories, 2018(24): 143-144.

[5] Zhang Sining, Wang Ze, Ma Dali. Simulation Optimization of Shirt Assembly Line Based on Improved Ant Colony Algorithm in Flexsim [J]. Journal of Textile Research, 2021, 42(03): 155-160.