

# Optimization of Production Line Balance Based on The IE Method

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**Abstract:** As a part of the manufacturing industry, automotive parts manufacturing enterprises optimize their production line is of great significance to reduce production costs and improve the production efficiency of enterprises [1]. In this paper, we take the condenser production line of WF company as the research object, and we found that the production line has problems of low productivity and imbalance of the production line through investigation. We improve the balance of the production line based on the IE method, and finally help WF company to improve the production capacity and product quality, so that the balance rate of the condenser production line reaches a good level, and at the same time, it also provides a practical case of production line optimization for the whole manufacturing industry.

**Keywords:** Industrial engineering; line balancing; improvement; condenser.

## 1. Introduction

With the booming development of new energy vehicles in China, the demand for new energy vehicles from Chinese urban residents is increasing day by day, which drives the booming development of China's auto parts industry. Taking the automobile industry as a guide, China's auto parts manufacturing industry has made great progress in terms of industrial scale, technical level, and industry chain collaboration. At the same time, China's manufacturing industry is also in a severely competitive environment, enterprises want to continue to develop and grow, and must find a way to effectively reduce production costs, but also can continue to meet customer demand for the key strategy, however, the balance of the production line to a certain extent limits the increase in production capacity [2]. IE method that is, Industrial Engineering (Industrial Engineering) The core of the IE method is to comprehensively evaluate the enterprise from four levels: human, machine, flow, and environment, to achieve optimal resource allocation and process optimization. Based on this, this paper takes the condenser production line of WF company as the research object and applies the relevant methods of IE (Industrial Engineering) to solve the problems existing in the production line of the enterprise. The goal is to improve the balance rate of the production line, reduce the cost for the enterprise, and improve production efficiency. In this way, WF can enhance its competitiveness in the increasingly changing market environment improve the economic efficiency of the enterprise, and at the same time provide a certain reference for other related manufacturing enterprises.

## 2. WF Company Condenser Production Line Status and Problem Analysis

### 2.1. Current Situation of The Production Line

WF company was founded in 2008 and is an auto parts manufacturing enterprise located in Weihai, Shandong

Province. The company mainly produces condensers, oil coolers, intercoolers, radiators, evaporators, and other products, this paper takes the condenser production line of the enterprise as the research object. Through further understanding of the condenser production line of WF Company, it is found that the production line has the problems of unbalanced material distribution, low production volume, and chaotic on-site management, which leads to the market orders not being completed on time. Facing these problems, WF company urgently needs to improve the status quo of its production line, improve the balance rate of the production line through reasonable optimization, and then enhance the capacity and efficiency of the whole enterprise.

The condenser production process can be subdivided into 10 processes, the production line has a U-shaped layout, using a stopwatch timing method for each process of operation determination, the workers may be affected by rest, physiological needs, fatigue, and other factors in the work process, so according to the relaxation standards set by the company, take 10% relaxation rate. According to the standard time  $T = t(1 + r)$ , where  $t$  is the observation time,  $r$  is the relaxation rate. The standard working hours before improvement are shown in Table 1.

### 2.2. Production Line Balancing Analysis

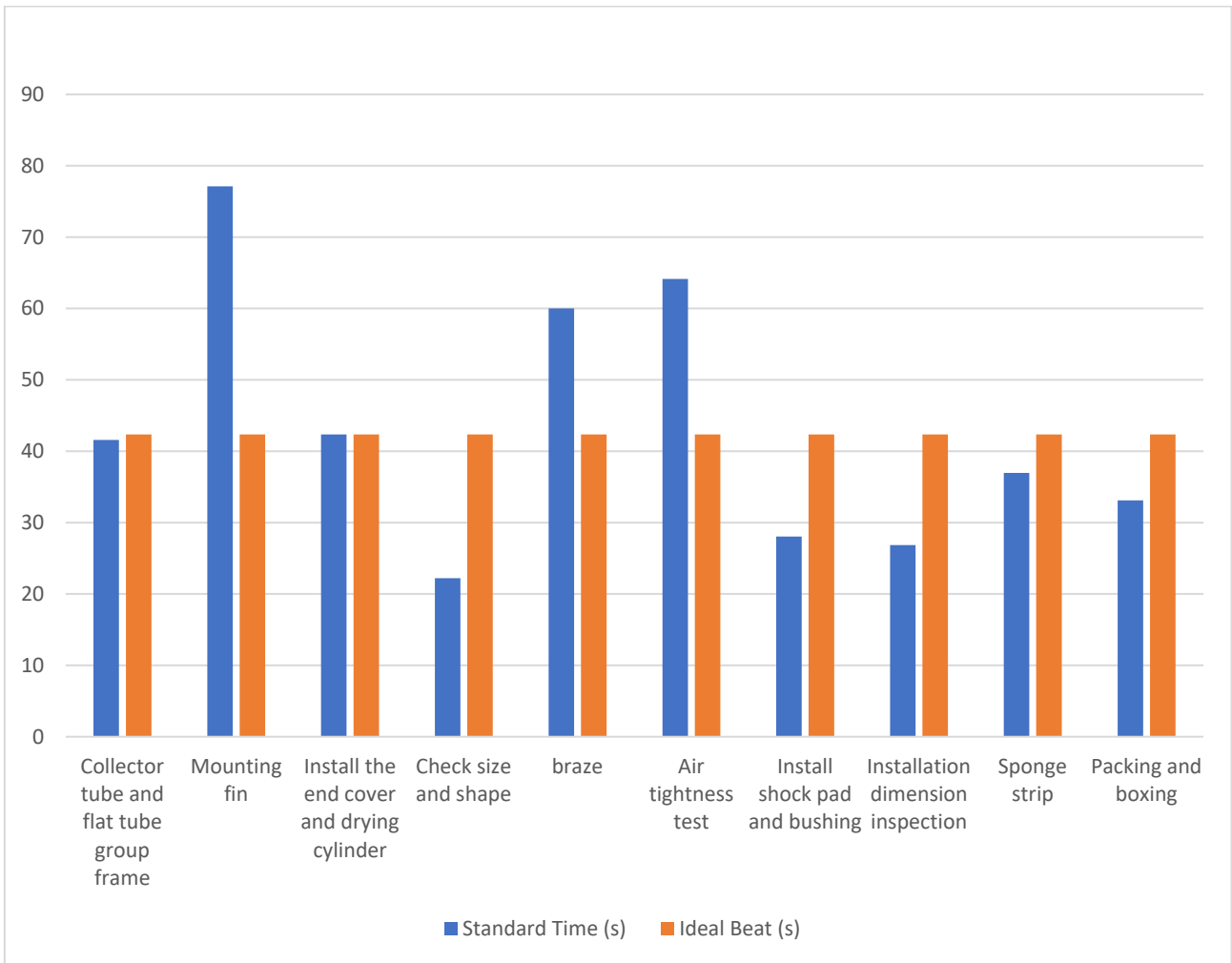
Production line balance is a method to make the operation time as similar as possible by digging the bottleneck process, optimizing the production flow, and improving the key process [3]. This paper adopts the industrial engineering analysis method to investigate and analyze the production site, and finds that there are problems of insufficient productivity and production line imbalance, which are analyzed as follows:

(1) Insufficient productivity. the average daily market demand for condensers in WF company is 680 pieces, and the daily working time of the workshop is calculated according to the legal time of 8 hours. Then the ideal production beat is:

$$8 \times 60 \times 60 \div 680 = 42.35s$$

**Table 1.** Production process schedule before optimization

Work process	Observation time (s)	Relaxation rate	Standard time (s)
Collector tube and flat tube group frame	37.8	10%	41.58
Mounting fin	70.1	10%	77.11
Install the end cover and drying cylinder	38.5	10%	42.35
Check size and shape	20.2	10%	22.22
braze	60.0	0%	60.0
Air tightness test	58.3	10%	64.13
Install shock pad and bushing	25.5	10%	28.05
Installation dimension inspection	24.2	10%	26.84
Sponge strip	33.6	10%	36.96
Packing and boxing	30.1	10%	33.11



**Figure 1.** Production balance analysis diagram

As can be seen from Figure 1, the beat of WF's condenser production line is higher than the ideal beat on the whole, a phenomenon that indicates that the existing capacity of the production line cannot meet the customer's needs. Especially in the second process of installing fins, the time used is much higher than the ideal beat, which is the bottleneck process and seriously affects the efficiency of the production line.

(2) Production line imbalance. An important indicator to measure whether the production line is balanced is the production line balance rate, the higher the production balance rate, that is, the production line of each process the

more similar time, the more balanced the operating load, the smaller the loss. The formula is as follows:

$$P = \frac{\sum_{i=1}^N T_i}{CT \times N} \quad (1)$$

where  $T_i$  denotes the operating time of a single process,  $CT$  denotes the operating time of a bottleneck process, and  $N$  denotes the total number of processes in the production line. Production line balance loss rate (d) corresponds to the production line balance rate and represents the lost balance rate, that is, the ratio of the total production time that the

product waits for idle time on the production line. It is calculated as follows:

$$d = 1 - P \quad (2)$$

We based on the data in Table 1, brought into the formula (1) to get the balance rate of the production line before the optimization is 56.1%, and according to formula (2) to get the balance of the loss rate (d) is 43.9%. When the balance rate of the production line is between 50% and 60%, it is usually considered that the production line does not have a sense of scientific management, and the production line is barely running and belongs to the rough production management; when the balance rate of the production line is between 60% and 70%, the production line can run; when the balance rate of the production line is 70% to 85%, it means that the production line is running well, and the production line control is carried out under the principle of scientific management; the balance rate of more than 85% of the production line belongs to the excellent range<sup>[4]</sup>. The balance rate of the condenser production line of WF company is only 56.1%, which indicates that the management of the condenser production line of the company is very chaotic and lacks the guidance of scientific management concepts. From the scene, the machine operation of the production line is not balanced, and there is a waste of time such as waiting and carrying; the phenomenon of piling up of items and idle personnel on the scene; the high rate of defective products, which makes it impossible to finish the work on time, and so on. All these show that the condenser production line of WF Company lacks the guidance of scientific management concepts.

### 3. Improvement of Production Line Balance Based on IE Methods

#### 3.1. Bottleneck Process Improvement

From Table 1, we can see that the installation of fins in process 2 is the bottleneck process in the whole production process. We use the 5W1H questioning method to analyze the questioning and find that the reason for the long processing time of this process is that the installation of fins are installed by the workers purely by hand, the number of installations is large and some of the employees are not skillful in the operation, and the degree of cooperation among the employees is low, and the difference in the operation time is large. To optimize this problem, a set of action standards for installation was formulated, employees could refer to this standard, and employees could choose the position according to their own habitual hands, to improve the degree of cooperation between employees under the standard level. Through optimization, the standard time of the process was controlled at about 40.3s, which meets the standard under the ideal production tempo. Next is the gas-tightness test, on the site we found that workers need to observe the helium checker for a long time to record the data, which will lead to employee fatigue and easily cause work errors, and the current helium checker can not keep up with the market demand, the optimization method is to buy a new machine if the funds

allow, which can solve the current problem. The last step is brazing, this step is the cooperation between the machine and the workers to complete, the waste of time mainly appears in the workers in the conveyor belt to place the product do not take into account the machine operation time, resulting in the product on the conveyor belt of the backlog, so according to the machine operation time to reasonably arrange the number of products on the conveyor belt.

#### 3.2. Improvement of Production Line Layout

As the company's production line is based on the product processing process as the center of the layout, the work area is divided into chaotic, which is easy to causes the operator to go back and forth, part of the process of waiting and handling time is longer, thus affecting the production line of balanced production. This situation should be used for partition management, employees involved in the process of production as much as possible to focus, while the combined installation of shock-absorbing pads and bushings and dimensional inspection of the two processes, which can effectively reduce the number of operators walking back and forth, handling, conveyor belt between the distance between the work in progress set up as much as the possible distribution of uniformity so that the balance of the production line has been improved.

#### 3.3. Implementation of 6S Management

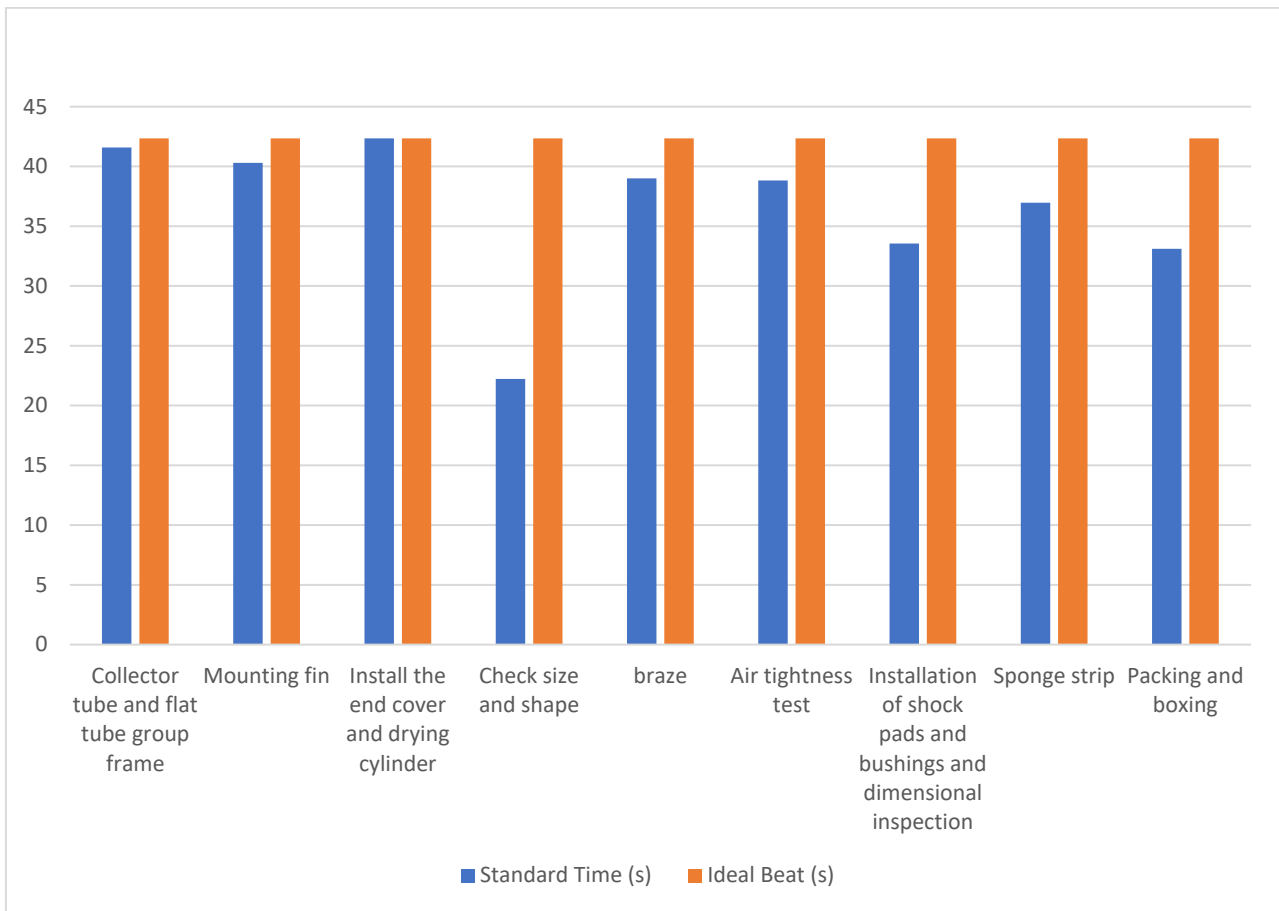
6S management content mainly includes organizing, reorganizing, cleaning, cleaning, literacy, and safety, it is the standardization of the production site people, site, things, methods, etc., to create a clear and concise working environment, the production site of a variety of production factors in a reasonable and efficient management [5]. The first step is to differentiate the utility of items within the production site, retaining the necessary items and clearing excess raw materials, production tools, etc. from the production site. The second is to categorize and locate various items within the workplace to ensure that each item has its own exclusive storage space. This meticulous management not only enhances the tidiness of the work environment but also allows everyone to see where the materials they need are located. Such a visual management strategy is key to achieving an efficient and organized work environment. Then it's all about cleaning up the production site and keeping it tidy. Finally, it is necessary to improve the professional quality of the staff and cultivate their good working attitude, thus making the staff consciously comply with the relevant rules and regulations of the company, and in the case of ensuring safety, letting them maintain a positive and active working condition, to create a harmonious and relaxed working atmosphere and enhance the staff's sense of collective honor.

### 4. Improved Production Line Balance Optimization Effect Analysis

As a result of the improvements, the production line process times have been adjusted as follows:

**Table 2.** Optimized production process schedule

Work process	Observation time (s)	Relaxation rate	Standard time (s)
Collector tube and flat tube group frame	37.8	10%	41.58
Mounting fin	36.6	10%	40.3
Install the end cover and drying cylinder	38.5	10%	42.35
Check size and shape	20.2	10%	22.22
braze	39.0	0%	39.0
Air tightness test	35.3	10%	38.83
Installation of shock pads and bushings and dimensional inspection	30.5	10%	33.55
Sponge strip	33.6	10%	36.96
Packing and boxing	30.1	10%	33.11



**Figure 2.** Optimized production balance analysis

From Table 2 and Fig. 2, we can see that the optimized processes are reduced to 9, and at the same time, the standard operation time of each process has been reduced to below the ideal beat, which means that the production line can finish the product production within the specified time, and the production capacity of the optimized production line can meet the market demand, which is also in line with our optimization principle. Through equations (1) and (2), we can get the balance rate and balance loss rate of the improved production line are 86.03% and 13.97% respectively, and the balance rate of the production line has been increased by 29.93%, which shows that the improved production line has reached a more ideal balance state.

## 5. Conclusion

This paper takes the condenser production line of WF

company as the research object, takes improving the balance rate of the production line as the goal, and applies IE theory and method to optimize the production line. By optimizing and improving the bottleneck process, workshop layout, and on-site management, the balance rate and production capacity of the production line have been greatly improved, which lays a good foundation for the company's future development, and at the same time provides a practicable case of production line optimization for the whole manufacturing industry.

## References

- [1] Amir Nourmohammadi, Hamidreza Eskandari & Masood Fathi. Design of stochastic assembly lines considering line balancing and part feeding with supermarkets. *Engineering Optimization*, 2019, (1),63-83.
- [2] Syahputri K, Sari R M, Anizar, et al. Improving Assembly Line

- Balancing Using Moodie Young Methods on Dump Truck Production[J]. IOP Conference Series: Materials Science and Engineering, 2018,288:012090.
- [3] Johnson R V. Assembly line balancing algorithms: Computation comparisons[J]. The International Journal of Production Research, 1981, 19(3): 277-287.
- [4] ZHAO Tingting. Research on the improvement of production line balance based on the IE method[J]. Journal of Qingdao University (Engineering and Technology Edition), 2021, 36(03): 88-92.
- [5] Zhong Qiupeng. Research on the improvement of the S product production line of X company based on lean production [D]. Nanchang University,2022.