Study on the Application of Industrial Engineering Methods on Production Line Balancing Problem in T Company

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Abstract. This paper uses Man-Machine process analysis to improve the works performance in T company, besides, the 5W1H technique and the principles of ECRS theory are applied to restructure and optimize the work process as well as the layout of the company. Furthermore, movement based on the single piece of flow way is imported to reduce the WIP and increase the turnover rate of funds. All this approaches achieve a significant enhancement of the production capacity,   production efficiency and balance rate.

1. Introduction

The balance of the production line is a technical means and method of averaging all the processes of production and adjusting the operating load so that the operating times are as close as possible. The purpose is to eliminate the unbalanced efficiency loss and excess production. by means of improving the efficiency of the operator and equipment , reducing the hourly consumption of single products and reducing the work in process between working procedure, Production line balancing technology can achieve the improvement of production efficiency and lay the foundation for scientific management[1,2].

Nowadays, with the deepening of the impact of industrial engineering, more and more enterprises began to pay attention to the strength of industrial engineering, there have been many on the application of industrial engineering technology to solve practical problems in the production of research work, and a lot of practice has proved the practicality and effectiveness of industrial engineering methods. Though, more and more companies are applying industrial engineering methods to improve the performance of their plant, Industrial engineering in China's application of the proportion of enterprises is not ideal, More industrial engineering methods in the enterprise application examples will bring great help to our manufacturing enterprises to improve the management level and create more benefits[3].

2. Problem Description

The T company is currently producing more varieties of small quantities. According to the product structure, its product divided into three categories: pallet type, sleeve type and adjustable type. We select the tube plus workshop as a case study. Because some of the equipment is relatively large and the value is higher, so the tube production is divided into two sections, the front stage with a single process group, and the latter part of the use of linear pipeline layout. The total number of processes in the tube plus production line is 15. The Summary of production hours for pipe section is showed in table1. According to table1, we can see that the bottleneck of the production line is the 9th process, namely, protecting welded bracket bottom cover. The production line balance rate is as followed [4,5]:

$$\text{Production line balance rate} = \frac{\sum each\ working\ hour}{bottlneck\ working\ our \times number\ of\ processes} \times 100\%$$

$$= \frac{234s}{33s \times 15} \times 100\% = 47.27\%$$

Table 1. Summary of production hours for pipe plus section

Serial number	Process name	Machine name	Single work hours
1	Pipe cut	Automatic cutting machine	12
2	Initial cleaning	Automatic cleaning machine	3
3	Fine chamfering	CNC lathe	32
4	Word rolling	Word Rolling machine	8
5	Shrinkage	Shrink machine	15
6	Convex welding	Convex welder	8
7	Press the bottom cover	Capping machine	7
8	Press the bracket	Press bracket machine	15
9	Protecting welded bracket bottom cover	Robot welding machine	33
10	Protecting welding plate	Protection welding machine	23
11	Spot welding spring plate	Manual spot welding	12
12	Protecting welding spring plate	Protection welding machine	22
13	Clean the slag	Manual	22
14	Leaks detection	Leak machine	16
15	Cleaning and drying	Automatic cleaning machine	6

3. Improvement and Optimization

According to customer needs, the production line's cycle time is 23.96s, and there are two processes which work ours is beyond the cycle time. That is the 3th Fine chamfering process and the 9th protecting welded bracket bottom cover process.

3.1 Analysis of Man - Machine Operation

Take the 9th process as case, through man-machine joint operation analysis, we learned the utilization of personnel is only 30.3%, and the machine is 69.69%. The leisure capacity analysis shows that the operator can operate 3 sets of machines at the same time. So our Improvement program is accordingly made as follows: the original single table to double table, the robot through the programming control alternately welded two parts, the machine utilization rate increased to 100%, processing a product cycle time from 33 s to 23 s, to improve efficiency 30.3%, to improve the post-cycle time also reached less than or equal to the requirements of the cycle time. After the improvement plan was established, the man-machine joint operation analysis was performed on the 9th process, as showed in figure1.

3.2 Production Line Balance Optimization

In the process of balance optimization of the production line, the priority of the production process is determined first, then the production process is optimized according to the beat time and ECRS principle and the production line station is determined. The production line balance rate is maximized in accordance with the beat time. The scheduling scheme determines the line layout. After the operation of improvement all processes can meet customer rhythm requirements. After the internal operations of each process are refined, the pipeline is balanced according to the job order and the operating time, and the station is divided according to the ECRS principle.

Refinement of the work process After the division of the station, in line with the requirements of the rhythm of a production line staff configuration only 4 people, the maximum cycle time of the production line is 24.6 s.

$$\text{Production line balance rate} = \frac{\sum each\ working\ hour}{bottlneck\ working\ our \times number\ of\ processes} \times 100\%$$

$$= \frac{96.3s}{24.6s \times 4} \times 100\% = 97.86\%$$

Machine	Robot welding machine		Department		Team	Date
Process name	Protecting welded bracket bottom cover		Tube plus shop		IE	2016.6.20
Work time	Man	24	Leisure time	Man	22	Total time
	Machine	46		Machine	0	46
Utilization	Man	52.17%	Machine		100.00%	
Time/s	Man		Machine			Time/s
11	Waiting for the machine to finish		The protective door is open and the robot starts welding the work piece on the B table			22
6	Remove the finished product on the A work piece, visual welding quality; qualified products into the finished product turnover, the defective goods into the repair box					
6	Remove the blank from the transfer car, put it on the A work piece table positioning, start the switch		Welding finished, gun recovery			1
6	Remove the finished product on the B work piece, visual welding quality; qualified products into the finished product turnover, the defective goods into the repair box		The protective door is open and the robot starts welding the work piece on the A table			22
6	Remove the blank from the transfer car, put it on the B work piece table positioning, start the switch					
11	Waiting for the machine to finish		Welding finished, gun recovery			1
6	Remove the finished product on the A work piece, visual welding quality; qualified products into the finished product turnover, the defective goods into the repair box		The protective door is open and the robot starts welding the work piece on the B table			22
6	Remove the blank from the transfer car, put it on the A work piece table positioning, start the switch					
11	Waiting for the machine to finish		Welding finished, gun recovery			1

Fig1. Man-Machine joint operation analysis

4. Analysis on the Improvement of Production Line Balance

According to the actual situation of enterprises, reorganize the tube plus production process and improve the bottleneck process, shorten the cycle time to meet the customer rhythm requirements. Through the re-layout of the production line, the production of a basic realization of the single stream, handling waste greatly reduced. It is important to improve the efficiency of the work and improve the balance of the production line after the process steps are refined and re-scheduled. Comparison of production line improvement of the relevant data is showed in table2.

Table2 Comparison of production line improvement

	Number of Direct operator	Maximum cycle time/s	Hourly output/pcs	Unit capacity/pcs	Line balance rate/%	Work in progress/pcs
Before improvement	6	33	109	18.2	47.27	1200
After improvement	4	24.6	146.3	36.6	97.86	15

5. Conclusion

This paper studies the application of industrial engineering methods in T company, through the training of industrial engineering theory and carrying out related improvement activities, all staff of the company have a better understanding of industrial engineering, and they are more willing to take part in the progress, which is very important for the company in the future.

There are still many factors and methods to be considered in the improvement progress, such as action analysis, Layout analysis, PTS method in the production line balance process are worth doing further research.

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