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# Optimization Study on Production Line Balancing Based on Logistics Resources System

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**Abstract:** This study mainly focus on: with the modern manufacturing industry stepping into the era of post-industrialization, Chinese modern manufacturing enterprises have to promote technical innovation, adjust industrial structures, perfect Logistics Resources System (LRS), strengthen quality education, enhance Supply Chain Management (SCM) level, fulfill energy saving and waste lowering, uphold stable, sustained and coordinated and scientific development. Facing to the global and economic recovery, this is a very important problem how to solve before us. Utilization of the production line balancing based on LRS integration, the Chinese modern manufacturing industry and logistics industry would put their heads together and find ways to tide over the difficulty and win an advantage over the international competition.

**Key words:** Work flow, logistics resources system, production line balancing

## INTRODUCTION

Along with the unceasing advance and development of science and technology and economy, globalization information network and market have already been formed as well as intensifying technical transformation. It is increasingly intense around the market competition of product innovation. The technical advance and diversified demands make the product life period shorten continuously. Enterprises are faced with the pressure to shorten date of delivery, raise product quality, reduce cost and improve service (Lamming, 1993). About all of these, the modern manufacturing enterprises ought to respond the market change fast and continuously develop the custom-made products that meet users' demands in order to occupy the market. The theory of lean manufacture has greatly improved the traditional way of production and management, quick reaction to the market change.

## THE METHODS OF PRODUCTION LINE BALANCING

How much a barrel filled with water, does not depend on the highest piece of wood board, but rather depends on the shortest piece of wood board, this law we call "bucket principle", we can see from the bucket principle, only all boards are high enough and the barrels can be filled with water, all the wooden planks above the lowest part is meaningless and more than, the larger waste, then the bucket capacity to improve the most effective way is to try raising of the minimum board height. The Production line balancing is one of management practices of industrial engineering; also it is the key to affect the production line efficiently - the most important method of equalization on the production line.

Definition of the production line balancing wall: to show the Value-Added (VA); Non-value Added (NVA) and Opportunity for Improvement (OFI) in one wall via visually diagram.

The analytical purpose of production line balance lies in grasping procedures time, increasing equalization and finding the bottleneck procedure. The improvement solutions are of procedures between long time and short time, as shown from Fig. 1-4.

## IMPROVEMENT OF WORK FLOWS

**Methods research in work flows:** The analysis of program, motion and time in IE is the theoretical basis of developing field management and improving ability and vision.

**Analysis of programs:** The purpose of program analysis should be quite clear. Only we regard it as the most important thing that we should hold a clear one before

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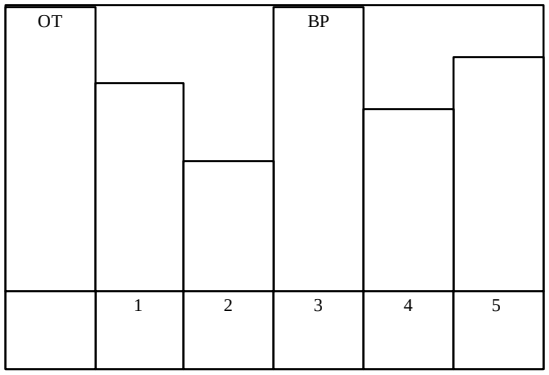


Fig. 1: BP as the initial improvement. OT: Operation time, BP: Bottleneck process, OC: Operation content, OP: Operation persons

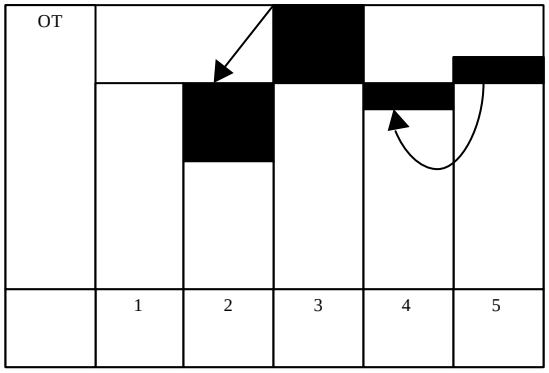


Fig. 2: OC assigned to other processes. OT: Operation time, BP: Bottleneck process, OC: Operation content, OP: Operation persons

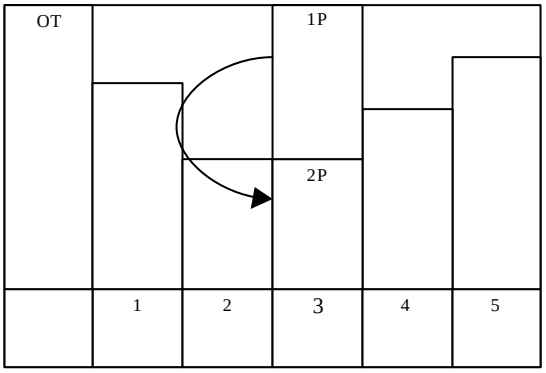


Fig. 3: OP added. OT: Operation time, BP: Bottleneck process, OC: Operation content, OP: Operation persons

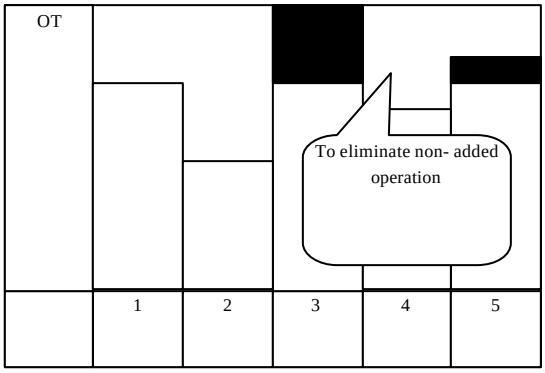


Fig. 4: Operation improvement, OT: Operation time, BP: Bottleneck process, OC: Operation content, OP: Operation persons

beginning to work, can we clear up the waste and unreasonable things in production, then raise the production efficiency. Thus, processing, inspection, interruption and removal of any working procedure are not reasonable because of its existence. The standard of measurement is that whether the value is reasonable.

**Analysis of motion:** Motion analysis, by studying various human beings' operational actions, is to identify and improve ineffective actions or waste phenomenon and ultimately increase operation efficiency. There are scientific evidences and guides in production management and improvement because of it and IE combination. This situation is the base of scientific management (Wang, 2005).

- **Analysis of visual motion:** The observer directly watches and analyses field operation, prepares to improve motion problems if existing. The advantage lies in improving bottleneck procedures and increasing work efficiency; the disadvantage in difficulty of time measurement and detailed movement changes.
- **Analysis of dynamic factors:** This is divided into 18 kinds of the smallest unit including the human being's brain action.
- **Analysis of image:** It is precise to determine and study for working time and motion factors through videos. This is the most accurate one.

**Measurement of work flows:** The measurement of work flows is a kind of important and analytical method for work ways and means through work time. The great goal

of IE from the beginning is to improve productivity, its standard being time. Work time can effectively reflect the work methods of superiority and inferiority, the work efficiency of highness and lowness.

**Analysis of time:** It divides somewhat work into fractions of work elements or work units. The operator prepares to observe records and analyze their time value (Cui, 2005). This is a good way to study and improve work methods, conditions and environment. The purpose of time analysis is:

- To found problems and waste during the improvement
- To evaluate and compare with the working methods of superiority and inferiority during study
- To set standard time for the existing methods standardized

**Setting of standard time:** It is work time that satisfies quality requirements using work methods standardized and reasonable labor intensity and speed under the normal operation conditions. It has 5 factors (Nahmial, 2003).

- **Normal work conditions:** The status of tools and environment come up to working requirements and conditions, such as women carry the weight of not more than 4.5 kg
- **Proficient degree:** The operator should understand the processes, machines and tools on the basis of a little more than medium level.
- **Work methods:** It is a kind of regulated method of working standards
- **Labor intensity and speed:** They are suitable for most operators' strength and speed.
- **Quality standards:** Its basic principles are completed by operators' self and mutual inspection.

## CASE ANALYSIS

**Analysis of the measurement of work flows:** Firstly, we will use time analysis of IE methods to measure time and elements for product lines by a stopwatch and camera. The purpose is to improve working passing successive time analysis, using time as measurement, quantizing working. During the test, the time unit is appointed 20 sec. Taking the case of gluing the bottom, it is shown in Table 1:

Table 1: Measurement of gluing the bottom

| Working unit | T (sec) | Working unit | T (sec) |
|---|---|---|---|
| **Station 1 Total: 189s** | | | |
| 1. Fetch the glue gun | 2 | 5. Fill glue in the rear | 8 |
| 2. Go to the position | 2 | 6. Return the gun back, fetch parts | 5 |
| 3. Fill glue at the bottom of the rear | 165 | 7. Install parts | 5 |
| 4. Move to the rear | 2 | | |
| **Station 2 Total: 174s** | | | |
| Working unit | T (sec) | Working unit | T (sec) |
| 1. Fetch the glue gun | 2 | 3. Fill glue at the bottom of the front | 167 |
| 2. Go to the position | 2 | 4. Return the gun back | 3 |
| **Station 3 Total: 139s** | | | |
| Working unit | T (sec) | Working unit | T (sec) |
| 1. Fetch the glue gun | 2 | 5. Fill glue in the front wheel hub on the left | 40 |
| 2. Go to the position | 3 | 6. Return the gun back, fetch parts | 6 |
| 3. Fill glue in the rear wheel hub on the left | 65 | 7. Return to the position back | 4 |
| 4. To the next station | 4 | 8. Install parts | 15 |
| **Station 4 Total: 136s** | | | |
| Working unit | T (sec) | Working unit | T (sec) |
| 1. Fetch parts | 2 | 5. Fill glue in the rear wheel hub on the right | 65 |
| 2. Go to the position | 3 | 6. To the next station | 4 |
| 3. Install parts | 10 | 7. Fill glue in the front wheel hub on the right | 44 |
| 4. Fetch the glue gun and return to the car | 5 | 8. Return the gun back | 3 |
| **Station 5, 6 Total: 175s** | | | |
| Working unit | T (sec) | Working unit | T (sec) |
| 1. Fetch the gummed paper | 2 | 4. Enter into the body | 2 |
| 2. Go to the position | 4 | 5. Cementing for the front floor | 50 |
| 3. Cementing for the front wheel house | 115 | 6. Throw away the gummed paper | 2 |
| **Station 7, 8 Total: 133s** | | | |
| Working unit | T (sec) | Working unit | T (sec) |
| 1. Fetch the glue gun, Go to the position | 6 | 4. Fetch the glue brush | 2 |
| 2. Fill glue | 4 | 5. Cementing for the rear wheel house | 115 |
| 3. Return the glue gun back | 2 | 6. Return the glue brush back | 4 |
| **Station 9, 10 Total: 98s** | | | |
| Working unit | T (sec) | Working unit | T (sec) |
| 1. Fetch the gummed paper | 2 | 3. Cementing for the rear | 90 |
| 2. Go to the position | 4 | 4. Throw away the gummed paper | 2 |

Table 1: Continue

| Working unit | T (sec) | Working unit | T (sec) |
|---|---|---|---|
| **Station 11 Total: 188s** | | | |
| Working unit | T (sec) | Working unit | T (sec) |
| 1. Fetch the gummed paper | 2 | 3. Cementing for the front bottom | 180 |
| 2. Go to the position | 4 | 4. Throw away the gummed paper | 2 |
| **Station 12 Total: 158s** | | | |
| Working unit | T (sec) | Working unit | T (sec) |
| 1. Fetch the gummed paper | 2 | 3. Cementing for the central section bottom | 150 |
| 2. Go to the position | 4 | 4. Throw away the gummed paper | 2 |
| Station 13, 14 Total: 118s | | | |
| Working unit | T (sec) | Working unit | T (sec) |
| 1. Fetch the gummed paper | 2 | 3. Cementing for the rear bottom on the left or the right | 110 |
| 2. Go to the position | 4 | 4. Throw away the gummed paper | 2 |

$$PBR = \Sigma WTS/(WP \times P) \quad (1)$$

$$PLR = 1\text{-}PBR \quad (2)$$

PBR : Production balance ratio
WTS : Working time of station
WP : Working period
P : Person
PLR : Production lost rate

$$PBR = (189 + 174 + .... + 118)/(189 \times 14) = 76\%$$
$$PLR = 24\%$$

**Analysis of situation:** It means that there is a great waste and low efficiency while PBR between 60-70%, in another word, 30-40% of working time being no value. 70-80% of PBR is a very big management and technology problem while production in the state of low level management; 80-85% represents management staffs with due diligence; and more than 85% indicates that management and IE technique in a higher state.

PLR was serious and working division unbalancing from the view of working time and PBR. The processing motions are divided into "operations", "movement", "inspection" and "standstill" on principle of value creation (Yang, 2005). In the way of workflow analysis, it is to analyze processing, handling, inspection and waiting longitudinally and find out the station of long timing and waiting. In the way of horizontal analysis, the personnel as research objects are assigned whether reasonable or not, taking a long time. Finally, we'd better make out the unbalancing state compared with conditions. Thus, we adopt sharing-working by the combination of staffs-add and working improvement. The situation analysis is shown in Table 2.

Setting of operation personnel and standard time:

$$PT = TSPH/Q \quad (3)$$

PT : Production tap
TSPH : Total seconds per hour
Q : Job per hour (JPH)

Table 2: Analysis of situation

| Station | Description |
|---|---|
| 1 | The bottleneck, longest timing, big intensity, to adjust |
| 2 | The big intensity, long-time succession in affecting quality, to adjust |
| 3, 4 | The key one will affect commenting if imperfect, to avoid the condition of amounts of work and lack of time |
| 5, 6 | The small intensity, little time fluctuation, to choice skilled workers controlling glue and inspection time, to adjust motion difficulty |
| 7, 8 | The small intensity, to choice skilled workers controlling glue time |
| 9. 10 | The lower intensity and work loads, one of unbalancing factors, waiting phenomenon, to adjust largely |
| 11 | The big work loads and movement areas, easy to bring about tiredness, to adjust largely |
| 12 | The less work contents, one of unbalancing factors, to adjust |
| 13, 14 | The less work contents, one of unbalancing factors, waiting phenomenon, to adjust |

$$PT = 3600/29 = 124 \text{ sec}$$

$$95\% \text{ OWE} = (\Sigma WP/95\%)/PT \quad (4)$$

$$75\% \text{ OWUR} = (\Sigma VAT/75\%)/PT \quad (5)$$

OWE : Object working efficiency
OWUR : Object working utilization rate
VAT : Value-added time

$$95\% \text{ OWE} = 2117/124 = 17 \text{ (persons)}$$

$$75\% \text{ OWUR} = 2656/124 = 21 \text{ (persons)}$$

Thus, the result is 17 or 21 working persons. Assumption of 17 working persons, OWE is 95%.

$$AWUR = \Sigma VAT/(PT * P) \quad (6)$$

AWUR : Actual working utilization rate

$$UR = 1911/(124 * 17) = 90\% (>> 75\%)$$

The 17 is final working persons:

$$ST = PT * 95\% \quad (7)$$

ST : Standard time

ST = 124 * 95% = 118 (s)

Working time will be controlled in 118s and be arranged in distribution averagely according while the adjustment is doing according to 95% of 124s PT (Feng, 1995).

**Project improvement:** To investigate the balancing degree of every station, improve and standardize them. The major of improvement in production working is begun by the balancing state. The purpose of research in working methods, working distributions and frock fixtures is to find out more reasonable methods and be standardized in order that managers realize the overview and discover production scheme problems. The improvement opinions are brought up divided into 3 parts according to the program motion and time analysis in order to get improvement projects (Leck, 2004).

**Filling glue for the bottom:** It consists of the station 1 and 2. There are 2 stations time that far exceed the production lines PT and standard time because of the station 1 being of bottleneck. Thus, it will add 1 person and assign the working content to the 3rd party. The working layout must be changed in order to avoid interference and the first part is the station 1, 2 and 5 after improvement. Anything else, there is also the production efficiency, utilization rate, PT and VAT besides concrete changes.

**Filling glue and cementing for the 2 sides of wheel hubs:** It was made up of the station 3, 4, 5, 6, 7, 8, 9 and 10 before improvement. Owing to the specialty, it will add 2 persons for the correspondent station of both sides after consideration. The working sequence of the station 3 was unreasonable in order to waste. It will be made the station 3, 4, 6, 7, 8, 9, 10 and 11 after improving according to the economic principle of action.

**Cementing for the bottom:** It was made up of 4 stations before improvement. There are 2 stations time that far exceed the production lines PT and standard time, the job of 2 front sides of the floor is moved to the bottom. Thus, 2 persons are added and the working content is reassigned during improvement. The total principal of cementing for the bottom is divided into 3 parts, the same as filling glue. But it is finished by 2 persons. For example, it will add 2 persons in the position of the front bottom and middle, expand the working area and counterbalance the workload in the rear, finishing by the station 12, 13, 14, 15, 16 and 17. The working layout must be changed.

## CONCLUSION

Through the practice of production line balancing, now we can conclude the optimization analysis of production processes management in a sentence. That is the methods that flattening all the processes of producing and adjusting the operating burthen to make every work time as similar as possible. And it also is the most important method of production process and work standard. Although it is just a simple sentence and a simple technical method, but it is the comprehensive application and understanding of LRP knowledge (Xiao and Dang, 2002).

The paper will draw the concept of production line balancing out from the barrel principle and make embedded discussion about the relationship between production line balancing and IE and lean production. The method analysis of IE is the based method of improving the production line balancing. The advanced management philosophy impels and improves the implementation of production line balancing. Because that the particularity of the paint shop makes its adjustment of production lines have its own characteristics, the paper also makes detailed analysis of the process analysis, work analysis, economic principle of motion, time analysis of IE. Besides, it also makes exposition of steps of implying production line balancing from both theory and practice. Including work test, status analysis, established projects improvement by using improvement methods; standardize the operation and finally using PDCA cycle to attain the purpose of continuous improvement.

From the start of the first step to the last, we always use scientific ways and means and apply the theory to reality production activities. As the saying goes, the sparrow may be small but it has all the vital organs.

## ACKNOWLEDGMENT

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