Production and logistics optimization of packing workshop in sugar enterprises

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Abstract. In the increasingly fierce market competition, sugar enterprises often face the problems of insufficient production capacity and low logistics efficiency. Based on the balance theory of production line, this paper studies the packaging production in the packaging workshop of sugar enterprises, determines the bottle-neck of production in the packaging workshop, and puts forward the corresponding optimization scheme to improve the production process and increase the production efficiency, reduce the probability of material accumulation in production line, so as to improve the production level and logistics level of enterprises, so that enterprises get better production efficiency.

1. Introduction

In recent years, with the improvement of people's living conditions, the domestic demand for sugar has been rising. The profits of sugar industry have attracted a lot of investment, and various sugar factories have sprung up, making the industry more competitive, high-cost and low-efficiency sugar enterprises is doomed to be eliminated by the market.

In the production workshop of sugar enterprises, the packaging workshop has much manual participation and low automation, which is the most labor-intensive area in sugar factories at present. The packaging production line in the packaging workshop mainly consists of manual bag-loading, manual folding and manual sewing, which labor-intensive, low efficiency, difficult management and high cost. [1].

2. Overview of production line balance theory

Production line balance theory refers to the small or even zero time difference between adjacent stations in the production line, uniform operation speed, and no obvious backlog or waiting on the production line[2]. Production line balance means to average all working procedures of the production line, balance the working load and make the working time of each working procedure as close as possible. Production line balance is an important idea of bottleneck theory, also known as "bottleneck improvement". An important concept of line balance is the "beat", which refers to the interval between the continuous completion of the same two products, that is, the average time required to complete the product. Therefore, production line balance is mainly to control the production time.

The balance of production in line production according to a certain tempo and load is an important factor affecting line production. Production line balance is a multi-objective optimization problem, so one or more indicators should be determined according to the actual production needs to evaluate the efficiency of production line balance and the merits of the scheme. The BR(Balance Rate) of production line is an important parameter to measure the Balance of production line. Its formula is as follows:
BR = \sum_{i=1}^{k} \frac{T_i}{k \times CT} \times 100\% \quad (1)

W=1-BR \quad (2)

Type: \(T_i\) — Operation time of station \(i\); \(k\) — The total number of stations; \(CT\) — The operating time of the process with the longest operating time in a production line; \(W\) — Balance loss rate.

3. Details of sugar packing workshop

X Sugar enterprises was selected as the research object. Its packaging workshop was located at the end of the sugar production line, adjacent to the honey refining and separation workshop and the finished product warehouse. The package of finished white sugar was 50kg. The workflows of the packaging workshop are respectively weighing, bagging, folding, stitching, spraying code, emptying, detecting, eliminating, leveling and pressing bags, stacking, and transporting to the warehouse, as shown in figure 1.

First of all, the high sugar storage hopper dumps the bulk sugar formed after the drying process to the weighing machine tray, and determines the parameter value of the weighing machine according to the finished sugar packaging[3]. When the set weight value is reached, the weighing worker closes the sugar outlet and stops feeding, and places the weighing sugar tray on the transmission belt. Then the bagger takes out the empty woven bag from beside him, picks up the tray that flows in front of him and puts the sugar into the empty woven bag. Subsequently, the filled packaging bags are transported to the folding edge station through the vertical bag conveyor, and the folding edge is completed manually by the folding edge workers. After that, it is delivered to the sewing station. The sewing machine is operated by the sewing worker to complete the sewing of the bag mouth. After packaging and sewing the bags, the finished products will be finished by the coding machine operated by the coding worker at the coding station, then manually emptied by the bag emptying worker, and then entered into the metal detection machine and weight detection machine, which will be inspected by special inspectors. After the test is completed, relevant personnel will remove the products containing metal or unqualified weight, transport them out of the packing workshop and deal with them separately. The finished bags that meet the requirements are stacked by palletizing workers after manual leveling and pressing, and finally transported to the finished goods warehouse by porters[4].

4. Packaging line beat-time and bottleneck identification

According to the work flow chart of the packaging workshop shown in figure 1, the packaging production line has 11 processes corresponding to 11 stations. The specific stations and personnel requirements are shown in table 1.
Table 1. Packing workshop position and personnel requirements

| NO. | Job content    | The number of people |
|-----|----------------|----------------------|
| 1   | weighing       | 4                    |
| 2   | bagging        | 8                    |
| 3   | hem            | 8                    |
| 4   | stitching       | 8                    |
| 5   | Spurt the code | 6                    |
| 6   | Pour the bag   | 4                    |
| 7   | detection      | 4                    |
| 8   | remove         | 6                    |
| 9   | flatten        | 8                    |
| 10  | pallet         | 12                   |
| 11  | Transport to warehouse | 10                  |

In order to calculate the working time of each station in the sugar packaging production line of X Sugar enterprises, the workshop manager and staff were first investigated and interviewed to understand the general working hours. Then with the aid of surveillance video monitoring room packaging workshop production, the administrative department for packing workshop production line for three consecutive days of real-time video is analyzed, according to the video to determine the workshop each station to complete a location process of working time, three working days will be the results averaged (accurate to seconds), get process operation time as shown in table 2.

Table 2. Packaging workshop process schedule

| NO.  | Job content         | Number of processing / package | The observation time /s | Average |
|------|---------------------|--------------------------------|-------------------------|---------|
| 1    | weighing            | 1                              | 5.61                    | 5.40    |
| 2    | bagging             | 1                              | 7.82                    | 7.44    |
| 3    | hem                 | 1                              | 6.72                    | 6.85    |
| 4    | stitching            | 1                              | 5.75                    | 5.35    |
| 5    | Spurt the code      | 1                              | 4.56                    | 4.85    |
| 6    | Pour the bag        | 1                              | 2.25                    | 3.19    |
| 7    | detection           | 1                              | 7.63                    | 7.60    |
| 8    | remove              | 1                              | 4.87                    | 5.52    |
| 9    | flatten             | 1                              | 5.63                    | 5.28    |
| 10   | pallet              | 1                              | 8.83                    | 8.81    |
| 11   | Transport to warehouse | 1                             | 6.69                    | 5.76    |
|      | Total               | 1                              | 66.78                   |         |

In order to verify the balance of the sugar packaging line, the balance rate and balance loss rate of the production line were used to investigate the balance of the production line in the packaging workshop. According to the formula (1)(2):\( BR = \frac{66.78}{11\times8.81} \times 100\% = 68.91\%, W = 1 - BR = 31.09\% \). In general, the balance loss rate should be controlled between 5%-15%, and more than 15% indicates poor balance of the production line. The calculation of balance rate of the production line also proves that there is imbalance in the packaging production line[5].
In production management, production beat is the key concept of lean production. Production beat, also known as line speed for short, is the index that controls production speed. Clear production rhythm, can command the entire enterprises each production process, to ensure that each process in accordance with the unified speed of production and processing of parts, semi-finished products, finished products, so as to achieve production balance and synchronization. The calculation formula of production beat is as follows:

\[ p = \frac{F}{Q} = \frac{F_0\eta}{Q} \]  

Type:  
- \( F \) — Scheduled effective working time;  
- \( Q \) — Product output during the planned period;  
- \( F_0 \) — Planned total working time;  
- \( \eta \) — Effective time utilization coefficient (effective time utilization ratio).

The sugar production line of X Sugar enterprises implements an 8-hour working system with three shifts, working 24 hours a day. From the beginning of November of the same year to the end of April of the next year, the working day is 181 days, the annual working time is 4,344 hours, and the working efficiency is 95.35%. The 18/19 pressing season is planned to produce about 128,000 tons of sugar, 2.56 enterprisesion packets of packaging line per year and 14,144 packets per day.

Firstly, the production beat time is calculated, which can be obtained by formula (3), Packaging line production beat = \((24\times3600\times95.35\%) /14144\)=5.82s.

Compare the working time and production beat of the packaging production line in Table 1, as shown in figure 2. As can be seen from figure 2, the working time of Procedure 2, 3, 7 and 10 is more than the production beat time, which should be analyzed as the bottleneck procedure.

![Figure 2. Comparison of working time and production beat of each process in packaging production line](image)

5. Optimization scheme design and evaluation

As can be seen from the previous article, the bottleneck processes of X Sugar Refinery are Processes 2, 3, 7 and 10, which are mainly caused by unreasonable station setting and long operation time of some processes. Therefore, the optimization of packaging line working procedure is mainly to reduce the working time of bottleneck working procedure by adjusting the working position and working procedure[6].

(1) Optimization of process 2
For process 2, main is to take the bag of this process was improved, the location by the original distance far empty bag temporarily kept changing the position, a new set of empty bags cases located on both sides of the station, the distance is about 1.5 m in the workstation, make bagging workers do not have to spend a lot of time for lack of empty bags to take bag, after calculation, improved through this method, the process of takt time shortened to 5.62 s.

(2) Optimization of process 3
For process 3, consider increasing the 1 folding workers to achieve 9 ruffled the number of employees and the workers of the location can be divided into 3 groups each group corresponds to one side of the bags in addition to the pincer-like device for folding operation, and actively organize skills improve workers' proficiency, improved through this method, the process of takt time shortened to 5.73 s.

(3) Optimization of process 7
For process 7, consider increasing the four inspection personnel to achieve 8 people detect the number of employees and to increase the metal detection machine, weight each one machine, makes the detection speed is improved, and because the problems at the same time of detection can be nonconforming product from the production line and therefore consider 7 and 8 to merge, through calculation, after the improved through this method, the process of takt time shortened to 5.51 s.

(4) Optimization of Procedure 10
For process 10, considering increasing the number of stacking forklift trucks to 6, the efficiency of stacking is improved with the help of stacking forklift trucks[8], which is economical. After the improvement of this method, the beat time of this process is shortened to 5.72s.

To sum up, by setting the corresponding optimization scheme for procedure 2, procedure 3, Procedure 7 and Procedure 10, and combining procedure 7 and procedure 8, the lead time of each bottleneck procedure is shortened. The working position and working time of the final packaging line are shown in table 3.

### Table 3. Improved packaging workshop process schedule

| NO. | Job content               | Number of processing / package | The observation time /s | Average |
|-----|---------------------------|--------------------------------|-------------------------|---------|
| 1   | weighing                  | 1                              | 5.61                    | 5.40    |
| 2   | bagging                   | 1                              | 7.82                    | 6.25    |
| 3   | hem                       | 1                              | 6.72                    | 8.35    |
| 4   | stitching                 | 1                              | 5.75                    | 5.92    |
| 5   | Spurt the code            | 1                              | 4.56                    | 5.12    |
| 6   | Pour the bag              | 1                              | 2.25                    | 3.17    |
| 7   | Detection and remove      | 1                              | 7.63                    | 6.87    |
| 8   | flatten                   | 1                              | 5.63                    | 4.75    |
| 9   | pallet                    | 1                              | 8.83                    | 8.37    |
| 10  | Transport to warehouse    | 1                              | 6.69                    | 5.37    |
|     | Total                     | 1                              | 52.91                   |         |

After calculation, Optimized BR=52.91/10/5.92=89.38%, W =1-89.38%=10.62%, it can be seen that the production balance rate of the optimized packaging production line is improved, and the production rhythm of each process is more coordinated, which can effectively promote the benign production of the production line.
6. Conclusions
This article mainly studies the sugar enterprise packing workshop production and the physical distribution optimization question. Through the analysis of the production situation in the packaging workshop of the case enterprise x sugar enterprise, the problems existing in the packaging workshop were studied. Through the determination of each working procedure time in the packaging workshop and combining with the theory of production line balance, the bottleneck working procedure of the production line in the packaging workshop is identified and analyzed, and the corresponding improvement measures are put forward, in order to improve the balance of production line in packaging workshop of x Sugar Enterprise. The optimized result shows that the production balance of the improved packing workshop is good, the production rhythm is more coordinated, the probability of material accumulation in the production line is reduced, and the production of the enterprise can be effectively promoted.

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