Research on simulation improvement of a restaurant based on statistical analysis

Jidong Guo[a,b,*], Cuiling Xu[a], Ting Qu[b], Zehao Huang[a], Jianxin Zheng[a], Minglong Gao[a], Ming Wang[a] and Dawei Zhou[a]

[a]School of Industrial Automation, Beijing Institute of Technology, Zhuhai, 519088, China; [b]School of Intelligent Systems Science and Engineering, Jinan University, Zhuhai 519070, China

ABSTRACT

This paper uses the statistics for the school shop to order data collection and data simulations by Flexsim simulation software analysis, found that there exists a problem of the unreasonable operation site, the number of workbench through there on the spot, the analysis of the distance apart, use ECRS four principles of industrial engineering, by engineering methods adjust the job site, The labor intensity of the staff is reduced, and the meal time of the customers is reduced, and the utilization rate of the hearth is improved.

Keywords: Statistical analysis, Flexsim simulation, job site layout, meal time

1. INTRODUCTION

With the vigorous development of economy, the traditional operation method of restaurant is unable to meet the needs of modern society. The improvement of operation method of industrial engineering can improve the efficiency of production and facilitate the growth of consumption.

Restaurants have their own advantages, such as the wide variety of food. However, there are several problems that need to be improved, such as long waiting time and complex workplace. In order to reduce the wastes and improve customer's experience and survive in the market, the running method of Huang Shulang Chicken Pot needs to be improved.

2. OPTIMIZATION BASIS

Huang Shulang Chicken Pot is a pull-type production workshop, Order before processing, need to wait for food processing. This paper collects the data of customer's ordering and dining experiences, and then uses [1] statistical method to test the homogeneity, stability and independence of the collected data. MINITAB [2] quality management software is used for distribution type identification, parameter estimation and goodness-of-fit test. The solid model is analyzed by Flexsim simulation software, which found that the time of finishing the dishes ordered by customer is too long. This kind of problem can be improved by reducing the number of stoves and adjust place of goods.

3. ANALYSIS OF THE BASIS SITUATION

3.1. Impact of data collection

3.1.1. Influence of meal varieties. Shop food variety is more. Different meals at different times. Out of 235 samples, Gai Bo accounted for 208. So, gai Bo was taken as the representative of the study.

3.1.2. Customer service impact. The Chicken Pot is a pull-type production workshop, so customers' payment is taken as the order entry, and the order time is recorded. After ordering, customers go to the window to pick up their food and record the time. The process is shown in Figure 1.

*35189850@qq.com

International Conference on Computer Application and Information Security (ICCAIS 2021), edited by Yingfa Lu, Changbo Cheng, Proc. of SPIE Vol. 12260, 122602E · doi: 10.1117/12.2637620

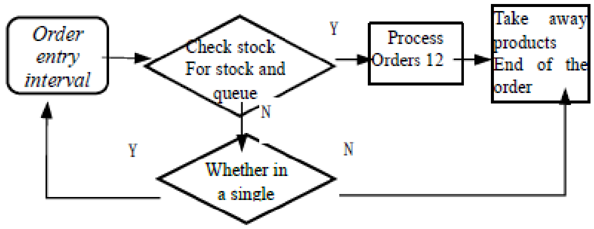


Figure 1. Entity flow chart.

Table 1. First data collection and collation (Part of the content).

First data collection and collation								
Huang Shulang chicken pot simulation class set up data questionnaire (10.31, Thursday, 4:55-6:25, a total of 52 pots)								
Serial number	Order time	Ordering interval/min	Meal time	Meal interval/min	The product takes/min	Type of Pot (Default Chicken Pot)	spicy	note
1	16:57	—	17.01	—	4	Medium	Less	
2	16:58	1	17.11	10	13	Big	Less	potatoes
3	16:59	1	17.02	-9	3	Medium	Less	celery
4	16:59	0	17.05	3	6	Medium	Less	
5	17:10	11	17.17	12	7	Medium	Less	
6	17:13	3	17.18	1	5	Frog pot, small	Medium	
7	17:15	2	17.18	0	3	Small	Less	
8	17:22	7	17.28	10	6	Small	Less	
9	17:28	6	17.35	7	7	Medium	Medium	
10	17:30	2	17.32	3	2	Small	Less	
11	17:32	2	17.37	5	5	Small	Less	
12	17:34	2	17.38	1	4	Small	Less	
13	17:35	1	17.4	2	5	small	Medium	
14	17:36	1	17.41	1	5	Small	Less	
15	17:36	0	17.41	0	5	Small	Less	
16	17:36	0	17.4	1	4	Small	Medium	
17	17:37	1	17.41	1	4	Small	Less	
18	17:37	0	17.44	3	7	Small	Less	
19	17:38	1	17.44	0	6	Small	Less	
20	17:38	0	17.42	-2	4	Small	Less	

3.2. Data collection and processing

3.2.1. The data collection. This paper determines the peak period. 5 data collection times, each collection time ≥90 minutes, total data more than 8 hours. Data collection and sorting Table 1.

3.2.2. The data processing. (1) Order interval homogeneity test.

Make access interval pivot tables, draw histograms, as shown in Figure 2 [3].

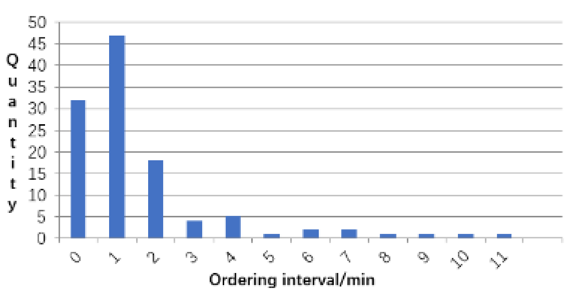


Figure 2. Order distance distribution histogram.

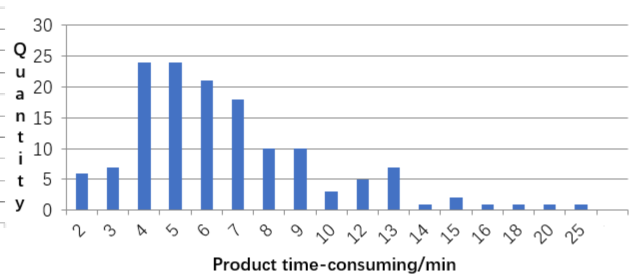


Figure 3. Product processing time histogram.

According to Figure 2, the time between sequences is approximately exponential. Since all the data samples collected were ≥30, the interval was considered to be approximately normal distribution.

(2) Product processing time-consuming homogeneity test

The product processing time into a pivot table, Figure 3, the product processing time approximately obey exponential distribution. The product times are normally distributed.

(3) Stationery test of order interval

Will be five times survey data collected by sorting interval grouping, as shown in Table 2 [4].

Table 2. Mean value of order intervals and Average product time.

Date	Mean ordering interval	Average product time
October 31st	1.72min	6.57min
November first	1.46min	7.28min
November fifth	1.91min	5.74min
November tenth	1.94min	6.71min
November twelfth	2.48min	6.03min

From (1), the mean difference was 1.02min. The sorting time fluctuates near the mean, so it is considered that the sorting interval is stable.

(4) Product processing time-consuming stationarity test

The processing time data collected from sorted out and grouped, as shown in Table 2. The difference of mean value was 1.54min. The time - consuming interval is stationary.

(5) Order interval independence test

The data has no impact and is said to be independent [5]. The time interval between orders collected by the survey is organized into a scatter plot, as shown in Figure 4.

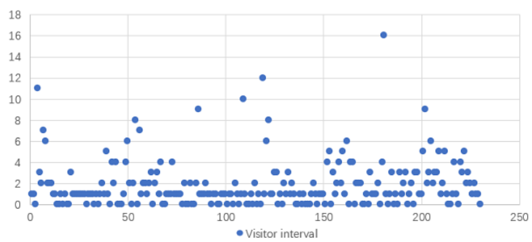


Figure 4. Scatter diagram of order intervals.

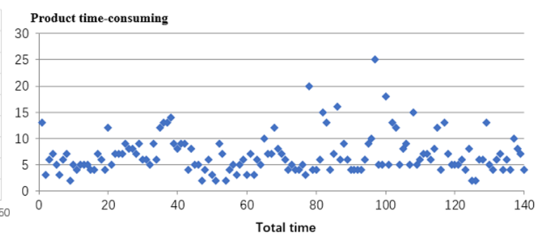


Figure 5. Scatter diagram of product processing time.

Equation (1) is used to obtain the autocorrelation coefficient between interval time and time.

$$x \sim N(\mu, \sigma^2) \tag{1}$$

$$\mathrm{f(x)} = \frac{1}{\sqrt{2\pi}\sigma} \mathrm{e}^{-\frac{(x-\mu)^2}{2\sigma^2}}, x > 0 \tag{2}$$

According to equation (1), the correlation coefficient ρ=0.0716 is obtained. When ρ is close to zero, the data is not correlated and the sorting interval is independent.

(6) Product processing time - consuming independence inspection

The processing time of products was sorted out and made into a scatter plot, as shown in Figure 5.

According to equation (1), the correlation coefficient between processing time and total time is close to zero, and the product processing time is independent. Sample size is 230, ranking interval approximate normal distribution, be determined by Minitab, as shown in Figure 6.

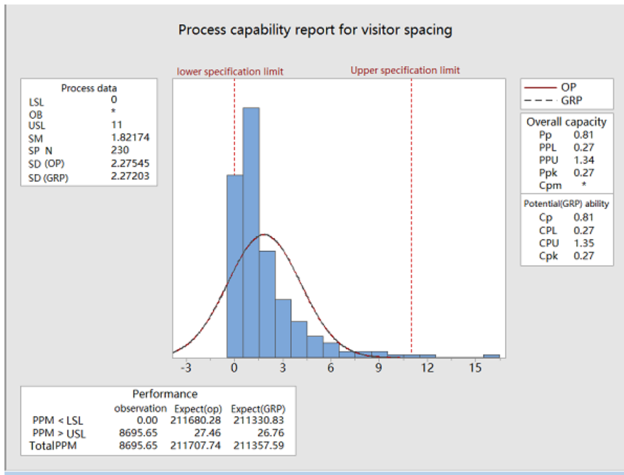


Figure 6. Distribution map of meal interval.

(7) Parameter estimation and goodness of fit test

Parameter estimation was performed for X, and 230 samples were integrated (only n-1 order interval was investigated each time). The sample mean x=1.82, variance 2.28, standard deviation 1.51.

The maximum likelihood estimation method is shown in equation (3):

$$\mu = \frac{\sum_{i=1}^{n} xi}{n}, \sigma^2 = \frac{1}{n}\sum_{i=1}^{n}(xi-\mu)^2 \tag{3}$$

$$x = \frac{\frac{\sum_{i=z}^{n} xi}{n} - \mu}{\sigma / \sqrt{n}} = 1.7263 < Z\frac{\alpha}{2} = 1.96 \tag{4}$$

The mean μ was tested by standard normal distribution, and null hypothesis Ho was set: population mean μ=1.65; Alternative hypothesis H1: μ≠1.65. Because the order interval X approximately follows a normal distribution, it is a two-sided test. n =230, significance level α=0.05, Z*0.025=1.96.

The test statistics are shown in equation (4).

The acceptance domain is (-1.96, 1.96), and the test statistic x ∈ (-1.96, 1.96). μ is in the receiving domain. Conclusion: There is not enough evidence to reject Ho, so μ=1.65.

Variance is tested by chi-square distribution, and null hypothesis Ho: population standard deviation σ=1.45; Alternative hypothesis H1: σ≠1.45. Similarly, n=230, the significance level α=0.1, Z*0.1=1.28. The test statistics are shown in equation (5).

$$x^2 = \frac{(n-1)s^2}{\sigma^2} \sim x^2_{\alpha=0.1}(n-1) \tag{5}$$

$$x = \frac{\frac{\sum_{i=z}^{n} xi}{n} - \mu}{\sigma / \sqrt{n}} = 0.5292 < Z\frac{\alpha}{2} = 1.645 \tag{6}$$

Calculate:

In the accepting domain, σ=1.45.

Namely: the ordering interval x of chicken Pot obeys the normal distribution x ~ N (1.65, 2.1025).

(8) Parameter estimation and fitting Optimization Test of Product processing time

Integrating the sample data, sample mean x=6.57, variance 3.65, standard deviation 1.91.

The maximum likelihood estimation method is shown in Equation (3).Ho: population mean μ=6.5; H1: μ≠6.5. Similarly n=235, the significance level α=0.1, Z0.05=1.645.

The test statistics are shown in equation (6). x ∈(-1.645, 1.645). If μ is in the receiving domain, μ=6.5.Similarly, Ho: σ=1.9; H1: σ≠1.9. n=235, α=0.1, Z0.1=1.28.

The test statistics are shown in equation (5). In the acceptance domain, σ=1.9, the processing time of follows the normal distribution x ~ N (1.65, 3.61).

4. FLEXSIM SIMULATION MODELING ANALYSIS

4.1. Entity model analysis

The ordering and picking time are taken as the beginning and end of the order, and the parameter values are set according to the verified ordering interval and product processing time distribution [6]. Set parameter values in the generator and processor, as shown in Figures 7 and 8.

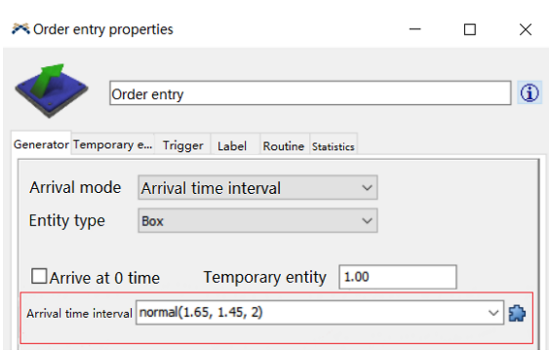


Figure 7. Parameter setting of generator.

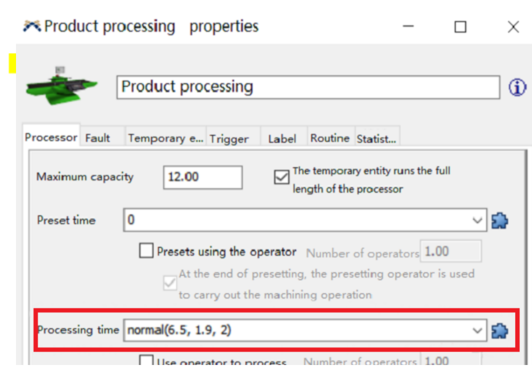


Figure 8. Processing parameter settings.

4.2. The analysis of running data

Table 3. Flexsim simulation data sheet (Part of the content).

Serial number	Generator order input/ pieces	Absorber order output / pieces	Average customer waiting time /min	Largest work-in-process / pieces	Average work in process / pieces
1	47	42	6.66113	7	3.45677
2	48	43	6.652813	7	3.482
3	48	45	6.682224	7	3.4957
4	50	45	6.682224	7	3.49423
5	51	45	6.682224	7	3.52236
6	59	54	6.933841	9	4.338257
7	52	45	6.682224	7	3.55233
8	52	46	6.69348	8	3.57574
9	52	47	6.689761	8	3.5897
10	54	49	6.623614	7	3.594796

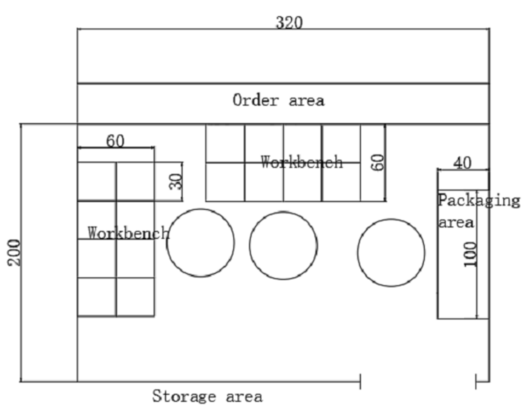
11	55	49	6.623614	7	3.6388
12	55	50	6.62424	7	3.644756
13	56	53	6.56147	7	3.66794
14	57	55	6.536614	7	3.648785
15	58	55	6.536614	7	3.6976
16	59	55	6.536614	7	3.6
17	61	56	6.571186	7	3.625386
18	61	57	6.584561	7	3.639445
19	62	58	6.596167	7	3.652676
20	63	60	6.55873	7	3.649542
21	64	60	6.55873	7	3.64828
22	64	61	6.57277	7	3.644522
23	64	61	6.57277	7	3.644522
24	67	61	6.57277	7	3.636985
25	67	62	6.594169	7	3.65999
26	69	63	6.599359	7	3.67999
Total	1377	1495	172.1839	186	94.481102
Average	57.5	52.96153846	6.622458192	-	-
Take four decimal places	57.5	52.9615	6.6224	-	-

Setting time parameters as peak, through random traffic, 26 times Flexsim simulation run, the operation data statistics in Table 3. Table 3 shows that the peak with an average of 57.5 order entry, 53 order output. Take food the average waiting time is 6.52 minutes, maximum wip for 9.

5. IMPROVEMENT MEASURES

5.1. The causes of the problem

Through the simulation, it is find that too many customer order from the oven, panic when peak of processed foods, repeatedly feeding. By reducing the number of stoves, adjust the venue layout to solve.



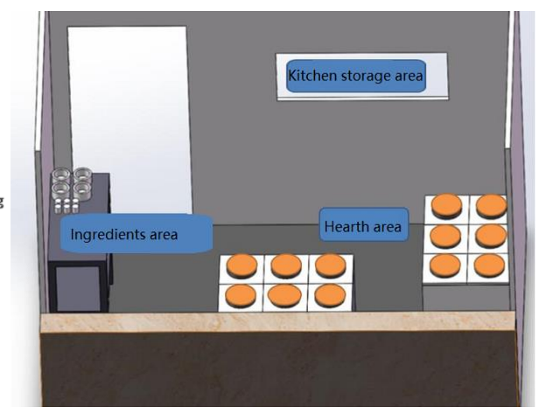


Figure 9. Two-dimensional diagram of site layout. Figure 10. 3D diagram of job site layout.

5.2. The reduction of the number of stoves

Workshop plane is shown in Figure 9, the stereo is shown in Figure 10. Job site with 12 stoves. Peak is shown in Figure 13, processing, use stove number of nine, the maximum utilization rate of 75%.

5.3. The adjustment oft the site layout

From Figure 10, the stove in the processing area is composed of two rows of three columns, employees is unsafe when they are using the oven. Function [7] analysis the external and internal cooking. Design operation area, ideal site 2d Figure 11, 3D front and side view Figure 12.

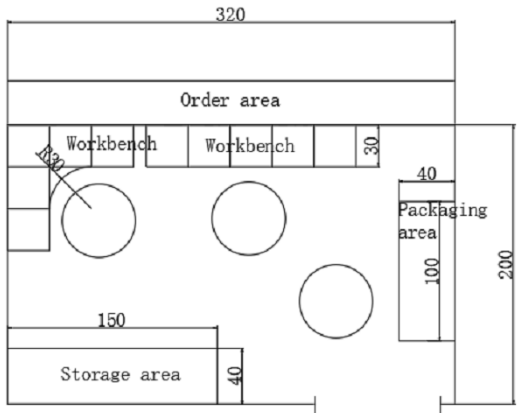


Figure 11. Ideal two dimensional site plan.

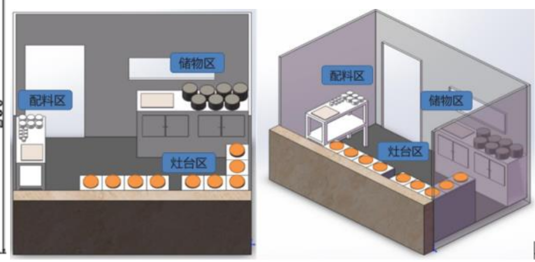


Figure 12. 3D diagram of ideal field layout.

Figures 11 and 12 show the improved model. [8] Through the analysis of the process, improve the before and after the cooking process, drawing in Figure 13. The number of employees with action to reduce and arm movements reduced 30 cm, to improve the safety in production. In the operating area set the material storage area, raw materials and walking distance from the reduced 2.9m.

Huang Shulang chicken cooker work flow chart (after improvement)

Name: work flow of cooking chicken Pot

Start: Receive the order

End: Customers pick up their food

tatistical			
Project	Times	Time /s	Distance/cm
Proces ○	5	5.5	
Check □	1		
Carry →	5	10.5	390
Waiting D	1	1	
Storage ▽	1	5	

Job description	Distance/cm	time /s	Process series					Note	Improvement points			
			Proces	Check	Carry	等待	储存		Process	Check	Carry	简化
1 Accept an order		1	○	□	→	D	▽					
2 Move to the back kitchen	100	2	○	□	→	D	▽					
3 Take the cooker		2	●	□	→	D	▽					
4 Return to the front desk	100	2	○	□	→	D	▽					
5 Place the cooker	30	0.5	●	□	→	D	▽					
6 Start the stove		1	●	□	→	D	▽					
7 Get the ingredient	30	0.5	○	□	→	D	▽					
8 Add ingredient		1	●	□	→	D	▽					
9 Cooking			○	■	→	D	▽					
10 turn off the stove		1	●	□	→	D	▽					
11 Take out the cooker	30	1	○	□	→	D	▽					
12 Move to workbench	100	5	○	□	→	D	▽					
13 Customers pick up meals		5	○	□	→	D	▽					

Figure 13. Improved cooking flow chart.

6. SUMMARY OF IMPROVEMENT EFFECT

Call a different random flow before and after the simulation model, after collecting operation data to improve the simulation run data, such as Table 4. Improved after operation data simulation results, compared with the status quo mapped the improvement effect comparison table as shown in Table 5.

Table 4. Simulation running data after improvement.

Serial number	Time/min	Average treatment time after improvement /min	Input	Output
1	2700	6.509	1501	1496
2	2800	6.500	1560	1557
3	2900	6.501	1616	1611
4	3000	6.485	1682	1679
5	3100	6.477	1744	1741
6	3200	6.481	1800	1759
7	3300	6.476	1858	1855
8	3400	6.717	1917	1913
9	3500	6.461	1983	1980
10	3600	6.464	2037	2034
Average	/	6.507	1770	1763

Table 5. Comparison of improvement results.

	Content	Original Status	After the Adjustment	The Improvement effect
The Reduction of the number of stoves	Number of working in the kitchen	12	9	3 stoves reduced
	Stove utilization rate	75%	100%	A 25% increase in
The adjustment oft the site layout	Arm movement distance	60cm	30cm	30 cm shortened
	Feeding back and forth	6.8m	3.9m	By 2.9 m
	Average waiting time per customer	6.65Min	6.507Min	8.82 s shortened

7. PROMOTION AND APPLICATION

Through on-site research and analysis, this paper uses simulation software to simulate the current situation of the store, finds out the existing problems, and uses the ECRS in IE and the principle of action economy to improve the store. The utilization rate of the stove has been increased by 25%, and the labor intensity of employees has decreased. The average wait time for customers was shortened by 8.82s.

REFERENCES

[1] Zhang R T. 2018 Statistics [M] *China Statistics Press*.

[2] Sheng J J, Chen K L, Zhou Y Q. 2010 Quality management analysis based on MINITAB [J] *Value engineering* 29 (2) 129-130.

[3] Huang G R, Ye Z J.1996 Environmental Testing of Electronic Products, 24.

[4] Guan H S, Zhou D.2016 Research on the Effectiveness of Stationary Test Method [J] *Journal of university of south China* 17 (1) 63-68.
[5] Luo F Y. 2020 Teaching Thinking of "The basic Idea of Independence Test and its Preliminary Application" [J] *Chinese Mathematics Education* (3) 14-19.
[6] Li X Y, Liu J T. 2017 Fast food restaurant Simulation Model based on Flexsim [J] V*alue Enginee ring* (82).
[7] Wu G J, Liao M, Zhao Y X. 2019 Optimization of manual sorting process of express delivery based on MOD analysis. *Logistics Engineering and Management* 01-15.
[8] Jin X L, Lin G Z. 2015 Process optimization based on process Program analysis. *Industrial Design* 12-20.