Research on the Optimization of Cutlery Recycling Place Based on ProE Software

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Abstract

This research mainly focuses on the cutlery recycling center of the second canteen of zhuhai college of Beijing institute of technology. The cutlery accumulation problem resulted from the large flow of people and the operators' failure to take standard operation during the peak period. Fish bone diagram, 5W1H method and ECRS method were used to analyze the problem from all aspects to understand the core of the problem. For the existing problems, from the perspective of product improvement and personnel operation consciousness specification. Innovate the work table and chopsticks and spoon sorting system, redesign the work table with relevant data in human factors engineering, and use ProE software for modeling and rendering; The implementation of two - handed operations, so that the operators of the operation of the standard; Through the characteristics of different shapes and sizes of chopsticks and spoons, the corresponding sorting boxes of chopsticks and spoons are designed. After the improvement, the staff action time is shortened, the comfort level is improved, so that the work efficiency is improved; It improves the phenomenon of tableware accumulation and improves the dining experience of customers.

Keywords
human factors engineering; two-handed operation; chopsticks and spoon sorting box

1. Instroduction
In order to adapt to the market changes and match the speed of tableware recycling with the flow of people, it is imperative to optimize and improve the recycling process of tableware. There are two peak periods in every dining hall: noon and evening. There are two recycling places on each floor of the dining hall, and each recycling place is equipped with one operator. Operators need to remove, classify and recycle tableware. Due to the current situation, such as the increase of the flow of people in peak period, the variety of tableware and the random operation of operators, the dishware recycling process is not smooth, the tableware is overstocked, the tableware is placed scattered, the utilization rate of personnel and equipment is low, and the labor intensity of operators is high.

This study takes the second dining hall of our school as an example to optimize and improve the recycling place of tableware, improve its recycling efficiency, and further achieve lean recycling management.

2. Research background
The present situation of the tableware recycling place is composed of process, working area and operators. Tableware recycling process can be divided into student process and operator process, and equipment layout is work area layout.

After field investigation and data collection, the overall layout of the working area of the tableware Recycling Office is shown in Figure 1. ① The size of the existing worktable is 2200mm long, 800mm wide and 900mm high. The working table is mainly divided into two parts: one is the tableware placing table, which allows customers to place the tableware; the other is the residue treatment platform, which is composed of two residue ports and two residue recovery barrels. ② The area behind the operator is the place where the tableware is placed, and the processed

tableware is stored in multiple dishware recycling boxes. ③Outside the tableware table is a recycling bin for collecting spoons and chopsticks.

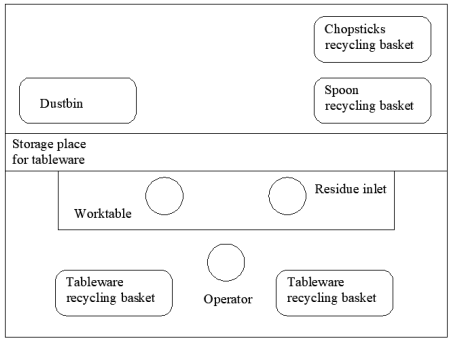

Figure 1: Current situation plan of tableware recycling area

Student customer self-classification process: throw the garbage except food residues into the garbage can → put the tableware and tray on the recycling table → throw the chopsticks and spoon into the designated basket. The specific process is shown in Figure 2.

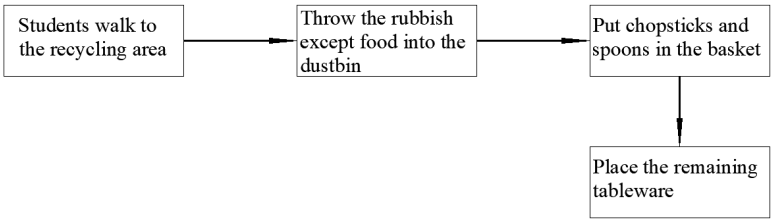

Figure 2: Flow chart of tableware handling by customers

The specific recycling process of operators is as follows:① Disposal of food residue: take the tableware containing the leftover food → move it to the residue mouth and pour out the leftover food → check whether the food is completely cleaned up → put it aside; ② Recycling tray: pick up the tray → move to the residue mouth, pour out the residual food → put aside; ③ Place tableware and tray: arrange the finished tableware and tray together → put all tableware into the recycling basket. The procedure of staff recovery process is shown in Table 1.

Table 1: Staff recycling tableware flow chart

Job description	Process series				
	machining	check	carry	wait	store
1. Lean forward and reach for the plate	○	□	→	D	▽
2. Pick up small dishes and other small tableware	●	□	→	D	▽
3. Pour into large dishes such as bowls or plates	●	□	→	D	▽
4. Clean up the food residue of the big meal plate	●	□	→	D	▽
5. Put the tableware aside	○	□	→	D	▽
6. Dispose of food waste on the tray	●	□	→	D	▽
7. Arrange tableware and tray	●	□	→	D	▽
8. Bend down to place the plate	○	□	→	D	▽
Total	5	0	3	0	0

The above process program analysis chart is the normal operation of operators, but in the investigation of dishware recycling process, it is found that students and operators operate improperly, which leads to the increase of actual operation time.

3. Problem analysis

According to the current situation of the above-mentioned tableware recycling place, through brainstorming discussion, the fishbone diagram of tableware stacking in dining hall is drawn, as shown in Figure 3, the reason for the slow recycling process of tableware during peak period was found.

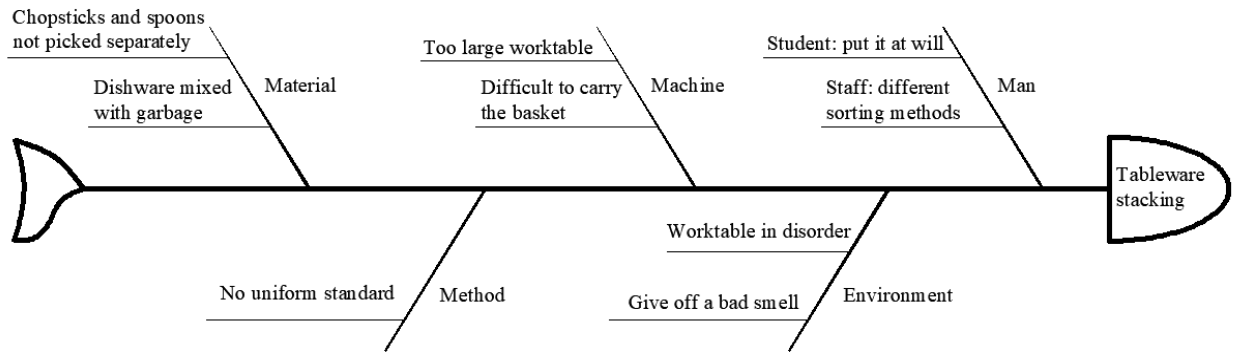

Figure 3: Fish bone diagram of tableware stacking

(1) The unreasonable design of working area and tools of tableware recycling results in low work efficiency and high work intensity of workers, which is easy to form tableware accumulation. In the process of carrying tableware, it causes waste and reduces efficiency.

(2) Students' operation process is not standardized, resulting in uneven classification of chopsticks and spoons. The lack of operation standards leads to the diversity of operation methods and different efficiency.

The problems existing in the recycling area of tableware are analyzed by ECRS principles [1].

Table 2: ECRS analysis table

Principle	Existing problems	Problem analysis
Eliminate	The distance between the storage box and the working table is too large	The unnecessary actions such as bending which makes the operators feel tired
Simplify	The working table is too large and the length exceeds the maximum working range of human body standing	It is unnecessary for the operator to lean forward greatly in the work

After the ECRS principle analysis, the working table is too large, the design is unreasonable, and the length of the working table exceeds the maximum working range of the labor force; the weight of the storage box for installing the tableware increases in the process of increasing the number of tableware, which leads to the difficulty of handling; the distance between the storage box and the working table surface is too large, so that the manual needs to bend down to put the tableware in the tableware storage box on the ground, so as to make the operation time At the same time, it makes the operators easily feel tired and do harm to the body.

According to 5W1H analysis method, the process problems of students and operators were analyzed [2], see table 3.

According to the analysis of human factors of operators, according to the 5W1H analysis method, the operators did not have a clear operation standard and the students did not put in according to the standard process, which led to the decline of work efficiency and high work intensity.

Table 3: 5W1H analysis table

	present situation	Problem analysis
Object (What)	The operation of students and operators is not standard	No obvious sign
Reason (Why)	Slow recycling of tableware	The work efficiency of operators is low, and the customer operation process is not standardized
Place (Where)	The design of working area of tableware recycling is unreasonable	The size of worktable is too large

Time and procedure（When）	During the peak period, the work load of the tableware Recycling Office is heavy, resulting in accumulation.	During the peak period, the staff's action is not standard, and no one is on duty at night after the peak period, which leads to serious accumulation and affects the working environment
Operators（Who）	The working efficiency of operators is low and the work intensity is high	The size of worktable is too large
Method（How）	The action is not standardized, there is no unified operation method, and the customers put in at will.	There are no operation standards for operators, and customers do not follow the process.

4. Solution

4.1 Overall idea of optimization and improvement

In view of the problems caused by various types of tableware, transportation difficulties, worktable layout, human factors and other problems, the improvement is carried out from the following aspects.

(1) By using the innovative design and optimization of the products, the inconvenient recycling of tableware and the low transportation efficiency are improved, and the collection time of tableware is shortened.

(2) Considering the influence of human factors, through the clear recycling process and the establishment of post operation standards, reduce unnecessary time loss and improve staff work efficiency.

4.2 Facility optimization design (model)

4.2.1 Design of chopsticks and spoon sorting basket

The present situation is to set up a chopsticks recycling basket and a spoon recycling basket, chopsticks and spoons are put in separately by students themselves. However, due to the unclear identification and some students did not sort by themselves, the workload of tableware recycling personnel increased. On this basis, this study designed a simple structure of chopsticks, spoon sorting box, as shown in figure 4 and figure 5.

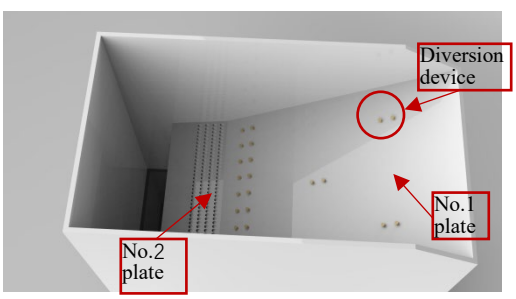

Figure 4: Internal sorting mechanism of sorting box

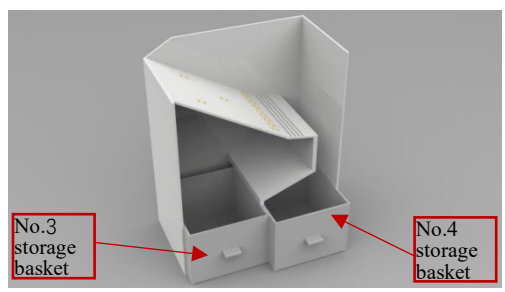

Figure 5: Drawer type recycling basket inside sorting box

Put the tableware at the entrance of sorting box, and the tableware slides down along the No.1 board, which is guided by the small cylindrical convex guiding device on the No.1 board, so that the chopsticks can slide vertically along the No.1 board to the No.2 board; there is an angle of 160 degrees between the No.2 board and the No.1 board, so the chopsticks can enter the No.3 storage basket through the holes on the No The hole will slide down from the surface of No. 2 plate and fall into No. 4 storage basket. As a result, chopsticks and spoons will fall into different baskets, playing the role of sorting. The overall appearance of the sorting box is shown in Figure 6.

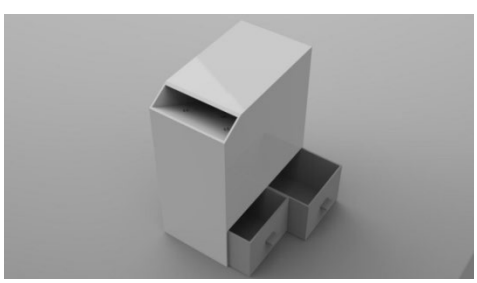

Figure 6: Overall drawing of sorting box

Figure 7: Tableware recycling box with wheels

4.2.2 Design of the roller for the recycling basket of tableware

After the tableware recycling basket is full, the tableware recycling personnel shall carry the basket to the temporary storage area and take the empty basket back. Long term bending down to carry heavy objects leads to the increase of carrying time and overload of human waist muscles, which is not in line with human factors engineering. Therefore, on the basis of the original basket structure, this study designed a more convenient transportation tableware recycling basket by installing rollers at the bottom four corners of the basket, as shown in Figure 7.

4.2.3 Setting of worktable

In view of the problem that the worktable is too large, which leads to the redundant action of bending and reaching out, the size parameters of worktable are improved. Among them, the width and other parameters are directly used with the current parameter values, mainly from human factors engineering and innovation.

(1) Human factors engineering. According to the body size indicator, the forearm length, upper arm length, hand length, shoulder width, standing elbow height, chest thickness and other dimensions of women aged 18-55 in the first 50 percentile were selected to redesign the workbench [3].

Table 4: Relevant dimensions for women with first percentile 50

Project	Size/mm	Size correction/mm	Overall size/mm
Upper arm length	285	0	285
Forearm length	214	0	214
Hand length	171	0	171
Shoulder width	351	0	351
Standing elbow height	960	+16	976
Chest thickness	199	0	199

After calculation, the maximum range of arm movement is 606mm.

The center of the maximum range of arm movement of the operator is as follows:

Horizontal direction: shoulder width (351 mm) reduced by 50 mm inward

Vertical direction: chest thickness = 99.5mm

Table height = standing elbow height = 976mm

(2) Innovation and improvement. According to the size of the existing worktable (2200mm long and 800mm wide), and the setting of the maximum working range of the above-mentioned operators, the original worktable is designed.

The maximum working range of the standing arm of the operator is made into a horizontal plane. The maximum working range is connected to the edge of the table with four ramps. The height difference between the edge of the table and the maximum working range makes the tableware slide to the maximum working range of the standing arm of the operator due to its own gravity when the tableware is placed on the workbench, thus avoiding the action of the operator to bend down and pull the tableware, reducing the work intensity of the operator and improving the work efficiency, as shown in Figure 8.

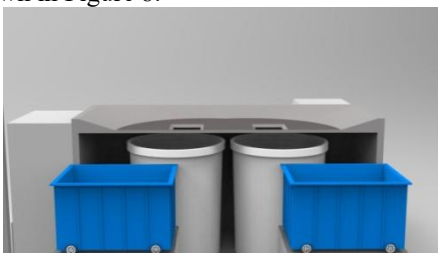

Figure 8: Improved working table

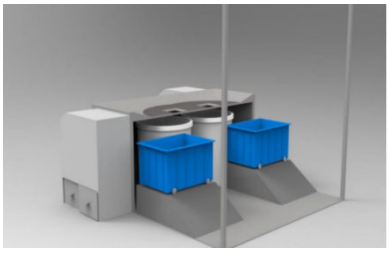

Figure 9: Overall drawing of improved tableware recycling area

By setting up steps with slopes on both sides of the operator and cooperating with the roller collecting box, the height of tableware placement can be increased and unnecessary actions such as bending of operators can be reduced, as shown in Figure 9. At the same time, in the process of tableware handling, the convenience of roller collecting box is used to reduce the handling time and intensity of operators, and greatly reduce the workload of operators [4].

4.3 Improvement of human factors

The students have no clear consciousness about how to place the tableware after dinner, mainly according to their own behavior habits. Therefore, according to the tableware recycling point on the second floor, make a set of clear and appropriate flow chart for students. Paste in the conspicuous position of the tableware recycling place to inform and urge the students to put the plate according to the specified process.

According to the principle of two-handed operation [5], the post standard for canteen operators is formulated, which is shown in Table 5.

Table 5: Post operation standard

Number of work stations	1	Working posture	Stand
MOD number	44	Net operating time	5.676s
Action program			
Serial number	left hand		right hand
1	Reach for the plate		Reach for the big bowl
2	Move in front of body		Move to the residue port and pour out the residue
3	Reach for the dish		Turn over the residue
4	Move to residue port		Reach out and grab the plate
5	Turn over the residue		Reach out and grab the plate
6	Move to the big bowl		Move to residue port
7	Place in large bowl		Turn over the residue
8	Reach for the big bowl		Move to the right basket
9	Move to the left basket		Place
10	Place		Free

5. Improvement results

5.1 Design and optimization of worktable and recovery device

Using human factors engineering knowledge and relevant human body size, the innovation and optimization of the worktable. Set up the maximum working range of operators in standing posture, cancel the unnecessary action of bending down to pull the plate, improve the efficiency of operators and reduce the waist load of operators.

Add wheels to the tableware collection box and set up steps with slope on both sides of the operator, so that the operator does not have to bend down to put the plate on the collection box on the ground, but directly put his hand on the collection box on both sides of himself to cancel the bending action. When carrying the collected tableware, due to the convenience of the basket with wheels, the time and intensity of carrying can be saved.

At the same time, the use of chopsticks and spoons sorting basket to improve the recycling of chopsticks and spoons, realize the automatic sorting of chopsticks and spoons, avoid the phenomenon of mixed packing of chopsticks and spoons due to students' non-standard delivery, and eliminate unnecessary work such as secondary sorting of chopsticks and spoons by operators, which wastes time and increases workload.

5.2 Comparison of processing time of single plate by operators

According to the improved post operation standard, the action factor analysis table (Table 5) of operators after improvement was worked out. The time of handling a single tableware by the improved operators is 5.676 s.

Table 6: Analysis table of operators after improvement

NO.	Left hand movement	Symbol mark	Right hand movement	Symbol mark	MOD analysis/mod
1	Reach for the plate	M4G1	Reach for the big bowl	M4G1	5
2	Move in front of body	M4P0	Move to the residue port and pour out the residue	M4P0	4
3	Reach for the dish	M2G3	Turn over the residue	C4	7
4	Move to residue port	M4P0	Reach out and grab the plate	M2P0	4
5	Turn over the residue	C4	Reach out and grab the plate	M2G1	4
6	Move to the big bowl	M2P0	Move to residue port	M2P0	2
7	Place in large bowl	M2P0	Turn over the residue	C4	4
8	Reach for the big bowl	M2G3	Move to the right basket	M2P0	5

9	Move to the left basket	M2P0	Place	M3P0	3
10	Place	M3P0	Free	BD	3
Total					44

According to the comparison of the time required for full staff to handle a single plate before and after the improvement (Table 6), it can be concluded that after the improvement, the processing time of a single plate is reduced from 7S to 5.676s, and the work efficiency is increased by 19.2%.

5.3 Flexsim simulation was used to compare the data before and after improvement

Flexsim simulation is used to compare the data before and after the improvement. Through the improvement and innovation of worktable and work area and the setting of operation standards, the time for operators to process tableware after improvement is obtained, which is used as a variable parameter to simulate the improved system again with Flexsim software [6]. The comparison of simulation results before and after improvement is shown in Table 7.

Table 7: Data comparison before and after simulation

	Maximum accumulation of worktable / piece	Maximum waiting time/**s**	Average waiting time/**s**
Before improvement	8	55.83073	10.621835
After improvement	6	28.47073	3.571728

Compared with the simulation results before the improvement, the maximum stacking amount of worktable is reduced from 8 to 6, the longest waiting time is reduced from 55.83s to 28.47s, the average waiting time is reduced from 10.62s to 3.57s, and the average waiting time is reduced to 33.6% of the original. The efficiency of the whole process of tableware recycling is improved, and the phenomenon of tableware stacking is greatly alleviated.

6. Summary

The results of this paper show that traditional IE combined with operations research and lingo can solve the furniture production problem of cluster type very well [14]. The traditional IE method is used to solve the bottleneck process problem, which reduces the total production line time of workshop 1 by 78S. Operations research combined with lingo solves the production line balance problem, making the production line balance rate reach more than 86% [15], which provides a theoretical reference for solving furniture production problems.

In this study, 5W1H, ECRs and other analytical methods were used to analyze the situation of tableware stacking in the recycling place. Using human factors engineering and mechanical structure innovation, the recycling table and recycling equipment were designed and improved.

(1) On the basis of reducing unnecessary actions such as bending, the working efficiency of staff is greatly improved, and the accumulation of tableware in peak period is reduced; through the application of human factors engineering, the degree of injury to waist muscles caused by staff bending for a long time is reduced, the workload of employees is reduced, and the employees' sense of identity with the company is improved.

(2) Through the innovative design of mechanical structure,the maximum stacking amount of worktable is reduced from 8 to 6, the longest waiting time is reduced from 55.83s to 28.47s, the average waiting time is reduced from 10.62s to 3.57s, and the average waiting time is reduced to 33.6% of the original, improve the recycling rate of tableware and reduce the workload of the staff to a certain extent.

The mechanical innovation involved in this study has good popularization. The sorting and recycling basket can be applied to all kinds of canteens, restaurants, and company canteens to improve the sorting speed of chopsticks and spoons; the convenient transportation recycling basket can be applied to the shelves of supermarkets and enterprise warehouses, which can reduce the secondary handling of personnel and reduce the workload. And the design is simple mechanical structure, low processing cost, high economy.

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Biographies

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Huang Langcheng is a student studying industrial engineering at Beijing Institute of Technology (BIT) Zhuhai College. I learned basic knowledge of science and engineering and related knowledge of industrial engineering in school, and has won the third prize of the National Industrial Engineering Application Case Competition in the scientific research competition, and the second prize and excellent award of the Industrial Engineering Innovation Competition of Guangdong Province and Guangdong-Hong Kong-Macao Greater Bay Area.. I participated in industrial engineering competitions in and out of school and got good results. During my internship in a Japanese-funded enterprise, I applied the theoretical knowledge of industrial engineering to the actual production process.

Ou Jianhai, a student majoring in Industrial Engineering from Beijing Institute of Technology, Zhuhai in 2017, is the first Excellent Student of Industrial Engineering in Guangdong Province. He has published conference papers in the 25th International Conference on Industrial Engineering and Engineering Management, and published academic papers as the first author. He has participated in projects that have won utility model patents, Guangdong Provincial College Students Innovation and Entrepreneurship Project, and won national and provincial discipline competition awards for many times. At present, he is working in Shenzhen Kangguan Technology Group as an IE engineer.

Bie Xiwen , graduated from Beijing Institute of Technology Zhuhai Institute of Industrial Engineering major in 2017, is the outstanding graduate of Industrial Automation College of 2021. She has won many honorary titles such as "Excellent Student" and "Excellent League Member" in the school evaluation, and has won the school-level scholarship for many times. She has won the third prize of the National Industrial Engineering Application Case Competition in the scientific research competition, and the second prize and excellent award of the Industrial Engineering Innovation Competition of Guangdong Province and Guangdong-Hong Kong-Macao Greater Bay Area.

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