Design Studies and Intelligence Engineering
L.C. Jain et al. (Eds.)

doi:10.3233/FAIA231488

Operation Space Optimization Design of Mobile Chinese Food Cart Based on Ergonomics

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Abstract. Based on ergonomics and Chinese eating habits and taking ,this paper takes Beijing mobile food cart as the research object and analyzes mobile food cart workers' job duties and process as well as and the layout of the working space through field trips and interviews to deeply study how to reasonably plan the functional layout of the operation area in the limited space of the dining cart and improve work efficiency so as optimize the people-oriented operation space design of the mobile Chinese food cart. The study aims to give full play to the man-machine efficiency and design a multifunctional, clean and sanitary food cart for the operators of the mobile Chinese food cart, which will enhance the usability and comfort of mobile food carts and provide a valuable reference for other catering trailer' interior space layout design.

Keywords. Mobile Chinese food cart; Operating space; Ergonomics; User-friendly design

1. Introduction

In recent years, China has set up convenient catering trailers, buffet cabinets and other facilities at subway entrance and crowded streets, so that citizens can buy hot meals at any time, which makes people feel the warmth of urban fine management. But how to provide diversified meals to cater for the Chinese people's eating habits such as staple food with a balanced portion of vegetables and meat and make the catering cart easy and handy to use become a major concern.

With the Beijing mobile food cart as the research object, ergonomics as the theoretical basis, and through qualitative and quantitative data analysis, this paper will design the functional layout of the interior space of the cart and carry out further study on how to rationally plan the functional layout in the limited space to enhance its usability and comfort. Therefore, both cart staff and consumers can improve the operation and purchase efficiency, which is committed to promoting a user-friendly design of the operation space in the mobile Chinese food carts.

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2. Research and Analysis of Mobile Carts

Mobile food carts are mobile kitchens set up on the street to prepare and sell food to passers-by. Taking those on the streets of Beijing as examples, there are three common styles (as shown in Figure 1): one is the food trailer, which generally stops near the subway entrance for a long time, mainly selling snacks such as drinks, biscuits, cooked food, etc., and occasionally selling hot food like boiled corns as the seasons change. This kind of food carts is generally operated legally, and the cart is semi-closed. The food sold is relatively sanitary and clean. Only the front part needs to be towed away if the food trailer needs to be repaired. The functional layout of the trailer can be divided into two parts: the sales area and the operation area. The sales area contains commodity display and cashier. There are devices like refrigerator, display rack. The operation area is mainly for machine processing, which is mainly equipped with operation table, microwave oven and so on. The division and functional layout of this kind of carts are unclear and unreasonable. The cart staff are often hurry-scurry and consumers have to queue up for their food.

Another type is a small food trailer, which only appears near the subway entrance or neighborhood during breakfast time. It is operated legally, but its space is limited, and the facility is crude. It does not have its own power and the gas tank is directly exposed outside the vehicle. There are serious security risks.

The third type is hand push food cart. Some vendors will also use tricycles. It is generally illegal, and its devices are poor. It mainly sells traditional and hot food, such as: pancake rolled with crisp fritter, Chinese hamburger, porridge and so on. It is generally all-open, with prepared food and semi-prepared food directly exposed outside. The sanitary conditions is worrying. Due to its illegal operation, the hand push food cart is more flexible and can be moved at any time in order to escape from the regulation enforcement by city inspectors.

Figure 1. Concession Food Trailer, Concession Food Trailer, Hand Push Food Cart.

The problems of the above three mobile catering carts (as shown in Table 1) will be solved and optimized one by one in terms of the spatial function layout and man-machine operation in the design process.

Table 1. Analysis of Status Quo of Existing Mobile Food Carts.

Name	Pros	Cons
Concession food trailer	• Semi-open, tidy&clean	• The spatial function layout is unreasonable. The sales and the meal pickup are in the same area. • The light source design is unreasonable. The light source area is set in the middle of the top of the cart, and the staff is in the shady area during operation. • The hanging cabinets is above the head of the staff, which is easy to cause a sense of depression; • There is no washing area and it is inconvenient to clean the items.
Small food trailer	• Less area occupation; • Food can be cooked on site.	• Small and cramped; • There is no electric box. It uses gas tank and is installed outside the cart, which have security risks. • It is an almost all open operating panel and food is exposed outside. The Food hygiene safety is a great problem. • There is no washing area and it is inconvenient to clean the items.
Hand push food cart	• Flexible and movable	• Poor equipment • The operating panel is all open and food is exposed outside. The Food hygiene safety is a great problem.

3. Design of Mobile Food Cart

3.1. Man-machine Size Design of facilities inside the Mobile Food Carts

According to the area of the open space near the subway entrance, the basic dimensions of the catering cart are: 5*2.4*2.5 meters. How to enable the staff to work effectively and comfortably in the interior limited space of mobile food cart, which requires that all the layout and equipment inside are analyzed and designed strictly according to ergonomics. Areas inside the cramped space that concerning the ergonomics are the operation area, sales area, food storage and display area.

- Operation Table Design

Ergonomic data show that the stand width of women is 66 cm, the male's is 70 cm. However, the basic spatial scope is not only limited by human size and their work area, but also influenced by their psychology. A space suitable for long working hours needs to consider the psychological scale on the basis of the physiological scale (as shown in Figure 2). Therefore, the optimization design of mobile food cart operation space

should take the psychological implication into consideration and enlarge the cramped space through appropriate space processing means and turn the depressed environment into a cheerful one. It is recommended to adjust the width of the operation table to 55cm (as shown in Figure3) given to the fact that the angle between the arms and the body is 5 degrees, so as to make the working environment more comfortable. The width of the washing area and the cooking area is set to 60 cm in consideration of the need to place the induction cooker, the mixing tank and the related tools on the operation table of the mobile food cart. The heating area and packing table, with less operation involved, are set to 36cm in size given to the width of the heating pot and cash register, which is to extend the walkway space for workers (as shown in Figure 4).

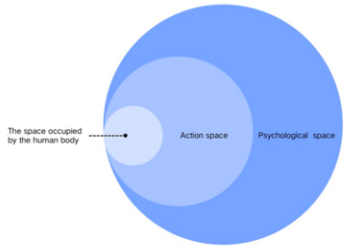

Figure 2. Human Engineering Mental Space Dimensions.

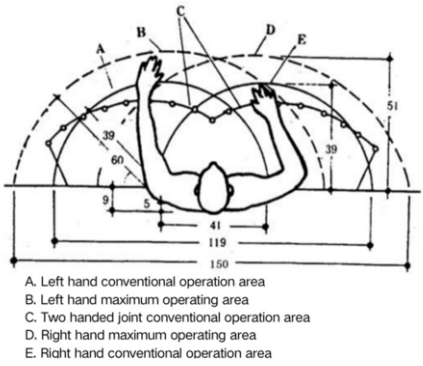

Figure 3. Man-machine Graphic of Main Operation Area.

The height of the operation table and its size are also determined according to the size of the human body . When cutting vegetables and preparing food, people often need to bend over, which can easily lead to fatigue. At present, the height of operation table in some mobile food carts is about 75cm, which is similar to the height of a desk or a dining table, so it may be slightly short for a standing person. For example, if a person's height is 165cm, 75cm is the height from his arms to the table when his arms are straight. But it will be uncomfortable to work with the arms straight all the time while the body is upright. The study found that the upper arm and forearm need to maintain a proper angle when cutting vegetables, so as to give full play to the strength of the body and both hands can also cooperate to finish the task. The height data for most comfortable standing posture is shown in Table 2.

Table 2. Most Comfortable Operating Height (cm).

Height	150	153	155	158	160	164	165	169	170
Most comfortable height	80	81	82.5	84	85	86.9	87.6	89.1	90

Although the most comfortable height can be determined by heights according to the above chart, people of the same height can have differences in the height of their upper and lower bodies. Taking the height difference of 10 cm as an example, the most suitable height difference is usually about 5 cm according to the table. Therefore, the operating height of the mobile food cart takes into account the average height of Chinese male 173. 8cm and female 161cm and is set at 88.35cm (as shown in Figure 5).

- Display Case and Storage Cabinet Design

According to the previous research and analysis, the experience and comfort of taking items vary as the height of the storage cabinet is different. The most comfortable height is about 150 cm, followed by the less comfortable height is 175 cm to 180 cm. The thirld level is 65 cm to 120 cm. If the height is above 185 cm or below 65 cm, the view will be blocked and not very comfortable to operate (as shown in Table 3). Therefore, the food display area should be between 100cm to 175cm of the cabinet so that it is handy for the staff to take food. Area below 100 cm is a locker (as shown in Figure 6) that holds some spare food stock. The space of operation table below 88.35 cm are lockers for storage of inventory. The reason why the operation table and the display area below 100 cm are designed as storage cabinets is that the mobile food cart is a special place for selling food. A certain amount of food stock is bound to accumulate, so sufficient storage space must be ensured.

Table 3. Table of Visual Perception in Different Area.

Height above the ground	State and posture	Comfort	View
Less than 65cm	Squat down and reach out for something	Not very comfortable	Blocked
65-120cm	Stand up and reach out for something	Good	Clear
150cm	Stand up and reach out for something	Very good	Clear
175-180cm	Stand up and stretch the arm to take items	Good	Clear
More than 185cm	Stand up and take thing on a stool	Uncomfortable	Blocked

3.2. Mobile Food Cart Internal Space Functional Layout Design

The interior space of the mobile food car is narrow, so the features of its spatial function layout are mainly based on convenience, functional utility, comfort, and ventilation.

- Convenience

The main function of the mobile food cart is to make and sell food, and it needs to finish this process efficiently and quickly in the morning peak when the traffic volume is the largest, so the design of the operation table is very important. The layout of the mobile food cart operation table adopts a L-shape (as shown in Figure 4), and the cooking and washing areas that are most complicated to operate are arranged at the innermost part of the cart. There are separated from the walkway and does not interfere with each other. It make the operation table relatively independent. When several people work inside the cart at the same time, it can effectively prevent crowding and collision.

- Functional Utility

The main cooking area shall include the disinfection storage area, the washing area, the heating area and the cooking area. This functional area distribution is common in mobile food vehicles and is a compact arrangement of integral operating stations (as shown in Figure 4). From left to right, the worktop contains a washing area, a cooking area and a heating area. The washing area is located on the far left of the operator table, next to the refrigerator, to facilitate the continuity of the staff's whole working process. The general process is to take food ingredients from the refrigerator, wash them in the washing area, and then cook them in the cooking area. The cooking area is also provided with a mixing tank, which is used to collect the seasoning used in making meals, so that the operation table is neat, clean and regular.

The design of the washing area avoids the disadvantage that there is no washing function inside the existing mobile food cart. Since no water pipe is arranged at the parking position, a clean water bucket and a waste water bucket are arranged below the washing area of the operating table (as shown in Figure 5) . Just below the washing tank is the waste water tank. The waste water flows into the waste water tank after use by extracting the water from the clean water tank next to it. The two buckets are equipped with wheels underneath for easy towing to the washing room in the subway to store clean water and dump waste water to clean the waste water bucket. The water pipe connector on the bucket can be opened, and the diameter is 10cm. Generally, staff can put their arms into the bucket or use brushes to clean it. A small disinfection cabinet is arranged below the cooking area for disinfection, cleaning and storage of cooking utensils.

The heating area is mainly used for heating porridge, bean and stir-fried food. According to the survey, office workers are more inclined to choose Chinese breakfasts, such as porridge, steamed buns, steamed buns, soy milk, etc., while for lunch and dinner, they prefer hot food with meat and vegetables. Therefore, there are three heating pots in the heating area, which can be flexibly used according to the needs of three meals to meet the different tastes and nutritional combinations of customers. Below the heating table are two trash bins for collecting garbage. The garbage can is yellow, mainly to highlight its usage in the color, and the staff can see the garbage can at a glance when they need to throw garbage during the peak time, so as to improve work efficiency. There are two heating cabinets beside the heating pot, one for heating steamed buns and the other for heating baked sausages. The transparent glass cover used in both heating cabinets is easy to show food to consumers and enhance their desire to buy. The heating area is next to the sales area, and the 165cm wide sales window is mainly used for cash collection and food pickup, which can disperse the crowd and improve the purchasing efficiency (as shown in Figure 5).

Opposite the selling area is the storage area and the display area (as shown in Figure 6). From left to right, there are refrigerators, display cabinets and beverage display freezers, which has a large space for storing food.

- Comfort

In terms of comfort, apart from the problem of operation layout and dimensions as described above, the light source is also unreasonable because it is located in the middle of the top of the car. This lighting method can only play the basic role. The interior facilities and functional layout of the mobile food cart are set along the cart wall, which makes the light source located behind the operator's head. No matter which area the operator is in, he will stand on his own light. Furthermore, his shadow will be cast on the operation table and the whole operating process was performed in his own shadow. This indoor lighting environment is like reading and writing with your back to the light, which makes people feel very uncomfortable and affects the operation of the staff. Therefore, the optimized design of mobile food cart will make it more comfortable by setting the light belts in three area on the top of the cart (as shown in Figure 4). One is above the washing area and the cooking area. Another one is above the sales area and the commodity display area. These lighting area are all above the front of the staff, providing a comfortable and bright light source.

- Ventilation

Although there are windows in the existing mobile food cart, it is not well ventilated. The window at the head of the car is smaller. Basically, the sales window serves as the only one air vent, and the interior of the cart will be stuffy in bad weather. Besides, cooking food will also produce fumes. To solve this problem, one solution is to enlarge the size of the sales window. Another one is to install an exhaust fan and a ventilator in the middle of the cart top, which is also the main ventilation equipment (as shown in Figure 5).

4. Conclusion

With the development of the society, the utilization rate of the mobile food cart in the street is growing, and it requires a more reasonable layout of the mobile food cart's internal operation space and a user-friendly design. In the process of constructing the operation space, we should make full use of the theoretical research results of ergonomics and arrange the relevant equipment appropriately. This paper expects to finally get a functionally diverse, sanitary and convenient design of mobile food carts that optimizes the operation and purchase process from the spatial function layout. It also gives full play to the man-machine efficiency and provides a handy and cozy working environment for mobile food cart staff.

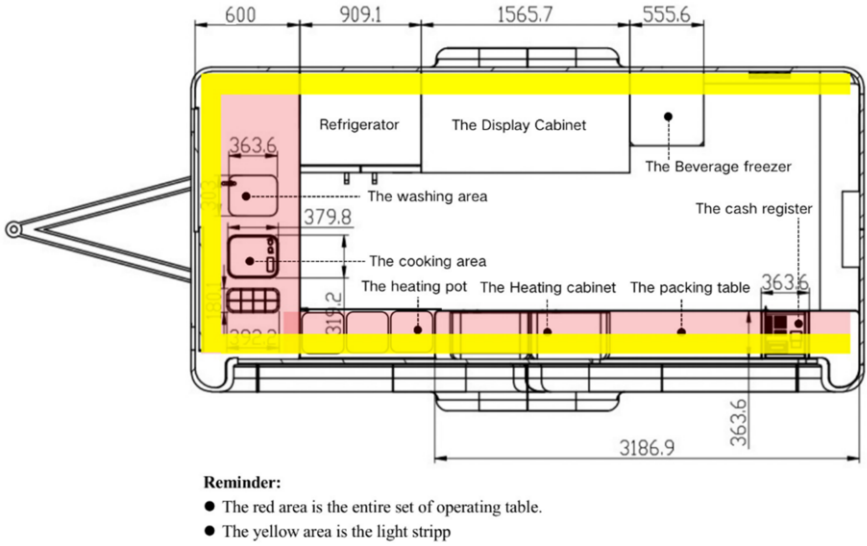

Figure 4. Dimension Figure of Operation Table inside the Mobile Food Cart.

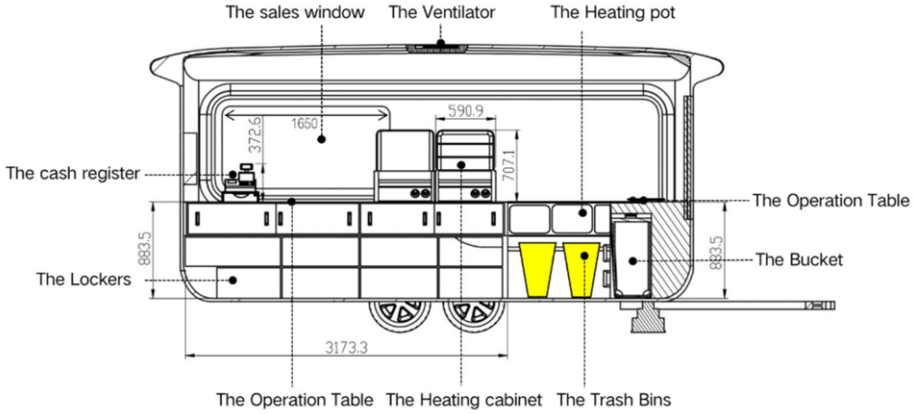

Figure 5. Mobile Food Cart Operation Table Height Figure.

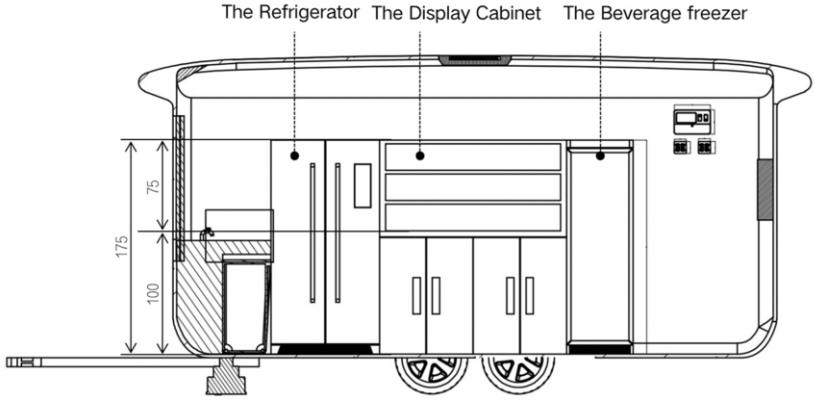

Figure 6. Mobile Food Cart Display Cabinet Dimension Figure.

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