

Research Article

Application of Man-machine Engineering in Design of Food Machinery

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Abstract: The purpose of this study is to explore the man-machine engineering design of food machinery, thereby designing the humanized food machinery, in order to make people feel comfortable and safe in the process of using. It specifically studies the display device design, console design, operating control design and protective device design. The study elaborates that the display device design should be based on human visual characteristic, according to the best observation method to design; the console design should accord to human size parameter and machine mechanics parameter, sufficiently considering the influence of food machinery upon the person, reasonably choosing various parameter and making person easy to operate, not tired and easy to observe process situation, which builds up a kind of best working environment; the operating control design should sufficiently consider the figure, physiology, psychology, physical strength and ability of operator; the protective device design should accord with the dimensional requirement related to the anthropometric parameters. And then the analysis for the humanized design of food machinery is made, based on which the conclusion has been reached.

Keywords: Food machinery, humanized design, man-machine engineering

INTRODUCTION

Man-machine engineering is a science that applies the physiology, psychology and other related disciplines to research the interaction between human, machine and its working environment. It makes the machine design suitable for the factors of all aspects of human, to create a comfortable and safe environment condition for users, making person not only save both labor and time, but also get higher production efficiency when operating. In its own development process, this discipline has gradually broken the boundaries between the various disciplines and organically combined the related discipline theory, constantly perfecting the basic concept, theoretical system, research methods and technical standards and norms in themselves, thus forming a comprehensive edge discipline of which the study and application range is very wide (Fu, 2002).

The UK is the earliest country to carry out the research on man-machine engineering in the world, but the foundation work of this discipline is actually completed in the United States. So, man-machine engineering has the statement that it is originated in Europe and formed in the United States. Although the origin of this discipline could be traced back to the beginning of the 20th century, it only has 60 years of history as an independent discipline.

Although this discipline starts late in the domestic, its development is rapid. Before liberation there were only a few people engaged in the research on engineering psychology and to the early 60s, there were

also only a few units such as the Chinese Academy of Sciences and Chinese Academy of Military Sciences engaged in the research on individual problem in this discipline and its research scope was only limited to the national defense and military fields, but these researches have laid the groundwork for the development of man-machine engineering in China (Ding, 2005).

With the development of science and technology in our country and opening to the outside world, people have gradually realized the importance of research on man-machine engineering for the development of national economy (Luo *et al.*, 2004). At present, the research and application of this discipline has expanded to the various sectors of the national economy such as the industry and agriculture, transportation, health care and education system, which has promoted the cross and permeation between this discipline and engineering technology and related disciplines, making the man-machine engineering become a noticeable edge discipline in the domestic science and technology forum (Ding, 2005).

Due to the development of food industry and the constant improvement of processing mechanization and degree of automation, the working conditions, production tools, use methods and human labor characteristics have been changed, which requires human to react accurately, act expertly and decide quickly. If it is not familiar with the man-machine engineering, it is impossible to design the reasonable structure of machine (Jiang, 2015). So, it is very important for the design of food machinery to use the

achievements of man-machine engineering to reduce the fatigue of operator, prevent the accidents and improve the safety and work efficiency (Wu, 1994).

The purpose of this study is to explore the man-machine engineering design of food machinery, thereby designing the humanized food machinery, in order to make people feel comfortable and safe in the process of using. At the same time, through the man-machine engineering design of food machinery, it also will necessarily improve the market competitiveness, improving the self-sufficiency rate of food machinery in China.

MATERIALS AND METHODS

With the progress of the age and the improvement of people's appreciation ability of the beauty, it presents higher request to food machinery, that is, the food machinery should not only have high-tech function and good function, but also have a pleasant effect which makes person feel work delightful, decreases tired and pleases the eye. Therefore, the color and material choice of food machinery control the whole feeling which food machinery gives person. The good console design can make the operator quickly identify and can't take place a mistake operation and ensure accuracy and efficiency, comfort and convenience of operation (Su, 2004). The number monitor put inside the normal scope of vision can raise the accuracy and efficiency of recognizing and reading and can also ease the vision tiring for a long time watching.

Display device design: The soul of food machinery manipulation is the display control device, which is specially used to express the performance parameters of machine and equipment, operation status, work instructions and other relevant information. In the man-

machine system, the information exchange between human and machine mainly depends on the display device. No matter what display device, wants to attain to provide accurate, quick and convenient vision information, of which the design should accord to human vision characteristic and conducts according to the best observation fashion of person (Xia, 2006). Raising the accuracy and efficiency of recognizing and reading, the better vision distance of display device and person is in the scope of 560~750 mm, which can ease the vision tiring for a long time watching and be easy to observe for operator and can attain quick and accurate control when delivering the information to person. So the foreign food machinery equipment attaches great importance to the design of display device. Such as the RV-O rotating bottler placer produced by Slark Company in France, of which the display control device is set to the right side of the machine to facilitate the operation. Since there is no appropriate place on the mainframe, it adopts steel pipe to hang the display control box, just in the best region of human eye vision, a reasonable position height and it is also easy for right hand to press button and the instrument and buttons on panel also use different colors, forming the better visual effect.

Display device should be arranged based on the structure characteristics of machine. If the machine is higher, it could be arranged on the appropriate position of vertical wall; if the machine is lower, it is arranged on the vertical wall directly, which will make the operation and identification all inconvenient. The mainframe of the EZ bread machine produced by business type joint-stock company in Japan is not high, so the display device is placed on the outstanding part of vertical wall, of which the panel forms a 30° incline with the vertical wall, which makes workers easy to recognize and makes control operation do not need to bend over. The manipulation and the displayed coding and arrangement are also consistent, which makes

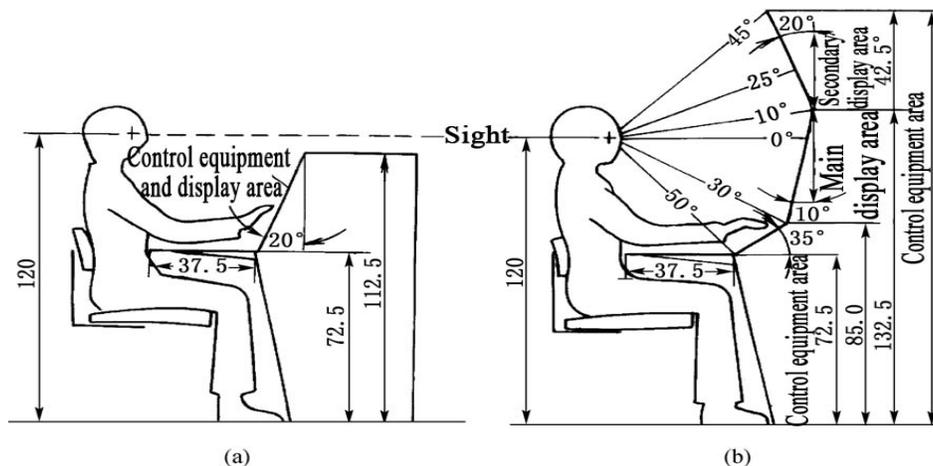


Fig. 1: Console of sitting position; (a): Console of low desktop for sitting position; (b): Console of high desktop for sitting position

people easy to establish a profound memory, shortening the reaction time and improving the working efficiency. The automatic paper packaging machine of Japanese Chinese steamed bread also adopts this kind of arrangement (Wu, 1994).

Console design: In console design, the key is that the arrangement of the console and monitor should be located in the normal scope of operation space, ensuring that the operator could well observe the necessary monitor, operate all the controllers and provide comfortable operation posture for long-term operation. Sometimes, the console also has operation area at the side before operator, certainly all these districts have to be within the area of seeing and reaching. Therefore, the design of console height and work zone should accord to the person's size parameter and machine mechanics parameter, sufficiently considering the influence of food machinery upon the person, reasonably choosing various parameter and making person easy to operate, not tired and easy to observe process situation, which builds up a kind of best working environment.

Console of low desktop for sitting position: When operator sits to monitor the front fixed or moving target object and must observe the display and operating controller according to the changes of object, the console meeting the functional requirements should be designed in accordance with the Fig. 1a.

Firstly, the height of console should lower below the visual horizontal line of human body of sitting position, in order to make sure the line of sight of operator can reach the console front; secondly, the required display and controller should be set on the panel of 20° slant; thirdly, According to these two points to determine other sizes of console (Ding, 2005).

Console of high desktop for sitting position: When operator sits to operate and the number of display is also large, it should be designed to be the console of high desktop. Compared with the console of low desktop, its biggest characteristic is to distribute the display and controller by area, as shown in Fig. 1b.

Firstly, it should set the panel of 10° slant within the scope of above the visual horizontal line of operator 10° to below 30°, on which it should set the most important display; secondly, it should set the panel of 20° slant within the scope of above the visual horizontal line of operator 10° to 45°, on which it should set the secondary display; in addition, it should set the panel of 45° slant within the scope of below the visual horizontal line of operator 35° to 50°, on which it should arrange all kinds of controllers; finally, it should determine other sizes of console (Ding, 2005).

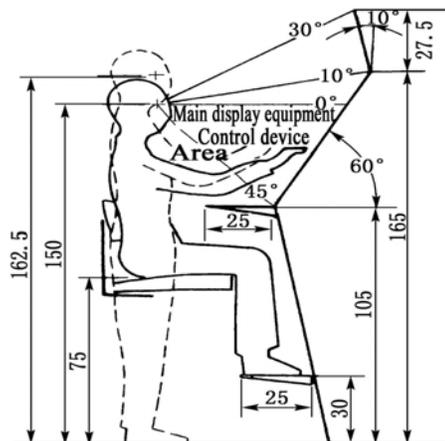


Fig. 2: Console of dual purpose for sitting position and standing position

Console of dual purpose for sitting position and standing position: When operator sometimes needs sitting and sometimes needs standing to operate according to the operation content as stated, it should be designed to be the console of dual purpose for sitting position and standing position. In addition to meeting the requirements of operation content as stated, this type of console could adjust the monotonous operation position as well and contributes to delaying the body fatigue and improving the work efficiency.

The panel configuration of console of dual purpose for sitting position and standing position is shown in Fig. 2. Firstly, it should set the panel of 60° slant within the scope of above the visual horizontal line of operator 10-degree to below 45°, on which it should set the most important display and controller; secondly, it should set the panel of 10° slant within the scope of above the visual horizontal line of operator 10° to 30°, on which it should set the secondary display; finally, it should determine other sizes of console.

When designing what it should pay attention to is that it must take the comfort and convenience of two operating position into account. Due to the overall height of console is based on the human body dimension of standing position, when sitting to operate, it should set the foot rest at the bottom of console, to meet the requirements of higher sitting position operation (Ding, 2005).

Console of standing position: Its configuration is similar to the console of dual purpose for sitting position and standing position, but at the bottom of console it does not set the space putting legs and the foot rest and only sets the space putting feet or vertical sealing plate.

Operating control design: The operating control is a device that transports the person's information to the

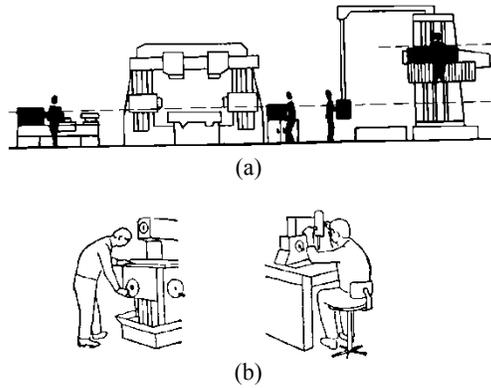


Fig. 3: Relationship of food machinery and human body scale

machine so as to adjust and change the machine status. The type of operating control is a lot. Manual manipulator can be divided into rotary type, mobile type and push button type. Although the type of operating control is a lot, the requirements of man-machine engineering for operating control are consistent. Operating control converts the operator's output signal into the machine's input signal. Therefore, the design of operating control firstly should sufficiently consider the figure, the physiology the mental state, the physical strength and the ability of operator. The size and shape of operating control should adapt to the sport characteristic of the person's hand or feet and the strength scope should be placed in the best scope of human body strength, could not outrun the extreme limit t of human body strength. The important or using frequently operating control should arrange in the space scope where the person's

responding is the most sensitive, the operation is the most convenient and the body could attain, as shown in Fig. 3.

The operating control of JWM-22 meat grinder produced by Youjin machinery joint-stock company in Korea is designed better. Under general circumstance, the breaking and opening of equipment all adopt two buttons, so when opening circuit it must first identify clearly. However, this machine only adopts a largish rotary knob installed on a vertical wall where the height is moderate, it is also easier for touch to recognize and it is better to act as location instruction adjustment, which simplifies the working procedure. The shell of this machine is sand finish of stainless steel, accompanied by the black plastic rotary knob, which appears to be concise and decent (Wu, 1994).

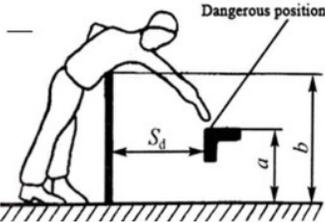
The design of operating control still needs to consider enduring nature, revolve speed, external appearance and energy consuming (Qiu, 2005). The operating control is an important constituent part in man-machine system, of which the design whether proper, relates to the normal safety movement of the whole system (Zhan, 1999).

Protective device design: Protective device that exclusively provides a safe protection by the object obstacle and includes machine hull, cover, screen, door, lid, close type device and others is a constituent part of food machinery. The protective device could be used alone, as well as be used through uniting with allied lock device together. If used alone, only when closed, can it have a protection function; if used through uniting with allied lock device together, no matter what positions, it could have a protection function.

Table 1: Safe distance of free oscillation of upper limbs S_d mm

Upper limbs			
From	To	Safe distance S_d	Graphical representation
Metacarpophalangeal joint	Fingertip	≥ 120	
Wrist joint	Fingertip	≥ 225	
Elbow joint	Fingertip	≥ 510	
Shoulder joint	Fingertip	≥ 820	

Table 2: Safe distance of exploration and overstep of upper limbs S_d mm

b									
a	2400	2200	2000	1800	1600	1400	1200	1000	800
2400	-	50	50	50	50	50	50	50	50
2200	-	150	250	300	350	350	400	400	400
2000	-	-	250	400	600	650	800	800	800
1800			500	850	850	950	1050	1050	
1600			400	850	850	950	1250	1250	
1400			100	750	850	950	1350	1350	
1200			-	400	850	950	1350	1350	
1000			-	200	850	950	1350	1350	
800			-	-	500	850	1250	1250	
600			-	-	-	450	1150	1150	
400			-	-	-	100	1150	1150	
200			-	-	-	-	1050	1050	

a: Danger zone height calculated from the ground; b: Edge height; S_d : Horizontal safe distance of edge away from the danger area

The structure and layout of protective device should design reasonably, so that each part of human body can not directly enter the danger zone (Ding, 2005). Protective device design should accord with the dimensional requirement related to the anthropometric parameters, such as the safe distance of free oscillation of upper limbs (Table 1) and the one of exploration and overstep of upper limbs (Table 2).

RESULTS AND DISCUSSION

The humanized design is highly advocated in today's society. Only designers diligently pay close attention to people and humanity, it can touch people with the design that is full of humanitarian spirit. Applying the man-machine engineering in the design of food machinery is an important embodiment of humanized design. As a chirping kettle, if changing the whistle into a harmonic whistle, it does not make person panicky for sharp whistle when the water is boiling and of course it also maximally reduces the noise harm to people. The scissors that are assembled in contrast to the conventional direction bring convenience for people used to use the left hand. The focal point of these designs lies in making more people in the society feel the warmth of the world, the love of humanity and the harmony of people and things. The rapid development of high-technology is gradually changing all aspects of human production and life. While showing the great conquest strength and incomparable intelligence and wisdom of human, it also brings person new troubles and worries and that is loneliness of human feelings, alienation and emotional imbalance. So in high-tech society, people inevitably pursue the balance of high-tech and high emotion and the technology is more advance, the desire of balance is more intense (Jiang, 2007).

The profession of food machinery is similar to other professions, requesting people fully consider various factors including physiological and mental factors in development design of food machinery, making the operation simple, labor-saving and accurate

and making the work environment comfortable and safe and making work efficiency and work quality of the man-machine system attain superior (Ding, 2005).

The food machinery is a high-tech product, of which the structure is very complicated and usually has a lot of buttons and control plank. People usually think that mastering its operation is very difficult and needing very high technique level and thereby influencing its usage (Jiang, 2013). In consideration of the man-machine factors in design, the humanize control panel should be adopted, which can draw near the distance of person and machine, if considering the design of operation panel from the point of view of person's cognition, it is easy for operator to learn, understand and do a reaction. As a machinery of processing food, in addition to having a high technique, it should infuse deep sensitive cognition into the product. Do not forget giving more concerns and more popular and convenient operation method to operator in design, which makes the product hommization and gives operator with affinity (Jiang, 2014). For example, in the noisy environment, the distinguishing ability of eye to the warm color descends, but the distinguishing ability to the cold color (particularly green) raises on the contrary, which should cause a value in the design of indicating and control device of food machinery. Only hard study in the cognition design of a man-machine interface, endowing thoughtfulness and affection in design process, can raise the friendliness of the product interface and the market competition ability of the product.

The workbench and the operation panel of food machinery are to be provided for person to operate, so their size, position and high should all accord with the size of "average person". For example, the size, position and shape of hand handle in the door of Japanese product all consider the man-machine factors and the diameter much took to be suitable for the size (4~5 cm) that the Asian hand holds and the position of hand handle is in the center partial to the next position in the door, which is as far as possible to make the wrist keep natural state and keep the hand and the small arm

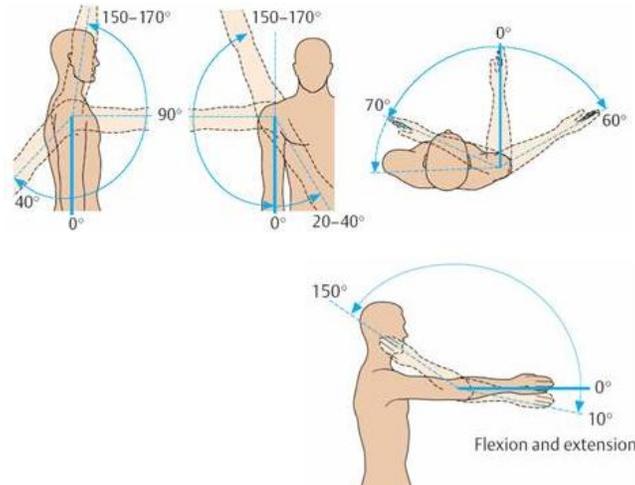


Fig. 4: Range of activity of human arm and hand

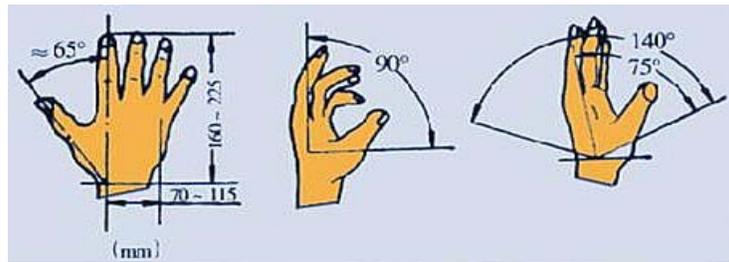


Fig. 5: Structure and range of activity of hand

in a line. The operation panel is a main interface for man-machine interaction, where person conducts the careful operation of information-based control type, so its position, tilt angle, upper show, the size and position of control device all should make the person observe and operate in a comfortable, accurate and efficient working condition, as shown in Fig. 4 and 5.

CONCLUSION

So far, the man-machine engineering is still an emerging edge discipline in China and our country starts to research it until the mid 1980s. Now in our country the man-machine engineering design of food machinery is just beginning, so man-machine engineering has not been well applied in the design of food machinery products, which causes the use, operation and maintenance of some equipment to be inconvenient and even some equipment making workers being in an extremely unsafe operation environment. So well applying the man-machine engineering in the design of food machinery has been extremely urgent.

It is the future direction of our country's food machinery design to combine with the design theory principle of man-machine engineering to design the food machinery products. Of course, it should also

consider the characteristics and design principles of food machinery, namely, strong adaptability, durability, high efficiency, light weight, easy to move, easy to dismount parts, easy to clean, security and reliability, simple operation and good appearance.

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