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Research on vertical standard cabinet design based on ergonomic

Peiyao Zhang[1,*], Hongchang Niu[2]

[1]*Shanxi Yinhe Electronic Equipment Factory, Taiyuan, Shanxi, 430000, China*
[2]*Henan Huaqi Tiancheng Intelligent Manufacturing Co., Ltd, Xingxiang, Henan, 453000, China*
[*]*Corresponding author*

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Abstract: Product design mainly studies the relationship between human-machine environment. Ergonomics is the exposition of the relative relationship between products and the human body. The product and human body work in a unified and coordinated manner to maximize the effectiveness of the product and human body under working conditions. This article introduces the system, structure, layout of standard vertical cabinets, as well as people's use in vertical cabinets, 3D model drawing of vertical cabinets, assembly drawings, and other work. The human-machine software JCAK is used to analyze people's usage status in the environment, while JACK is used to handle human hands. The simulation of envelope range and reachable range can match the actual effect.

1. Introduction

In the initial stage of product design and project establishment, designers will consider the relationship between products and people for a long time, and the application degree of human body to the product. Through the establishment of product and human body virtualization model, they will intuitively feel and understand the practicality and flexibility of products and human body at the early stage of the project.

Standard vertical cabinets are widely used in existing products, mainly for equipment maintenance, vehicle modification and so on. A standard vertical cabinet houses devices and standard equipment chassis. The material is mainly alloy steel such as Q235, and the steel plate is bent and welded to form the main part of the product. Based on the above human-machine analysis, which does not meet the standards, the cabinet design can be improved, mainly focusing on the wiring harness bundling problem at the back of the cabinet, rather than human-machine comfort.

2. The environment determines the binding nature of man and machine

The standard vertical cabinet is used in the environment such as equipment assembly. In the front of the vertical cabinet, the device is picked up and placed by the handles on both sides of the device. The standing size of the adult human body and the specific situation in which the hands move the device become the design points. There are many cable routing paths in the rear of the vertical cabinet[1]. For cabinet design, how to make reasonable use of the cable trough is one of the key points in the design. Most of the cable routing in the man-machine environment requires manual wiring. Figure 1 shows the impact of the human body on the environment of the cabinet under the surface of a specific cabinet. Through the analysis of the impact diagram, we can achieve the expectation of the cabinet entity and better prepare for the subsequent three-dimensional design.

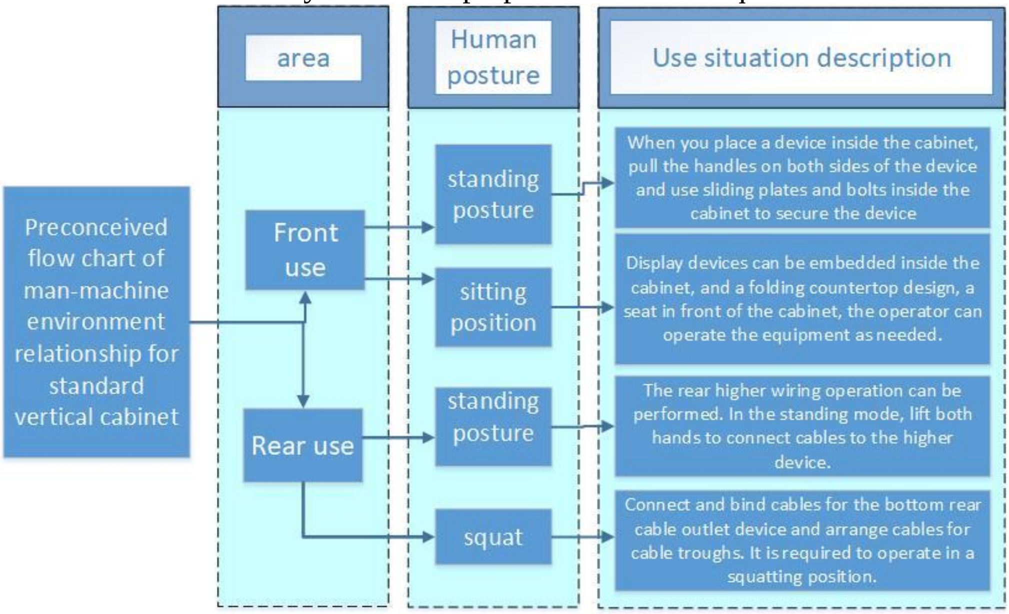

Figure 1: Uses the envisioned flowchart

3. Establishment of three-dimensional model of standard vertical cabinet

The standard vertical cabinet structure is mainly composed of the bottom plate, the middle outer beam, the inner beam, the reinforcement bar, and the upper plate[2]. The exterior has a left and right decorative mask, and a heat dissipation port is evenly distributed in the mask. As shown in Figure 1, Figure 2-A is the 3D model diagram, and Figure 2-B is the product rendering effect diagram. The built-in structure components can be seen in the view. The standard cabinet height is 1600mm, the length and width are 550mm and 650mm respectively, and the ergonomic simulation analysis can be performed based on the specific size[3].

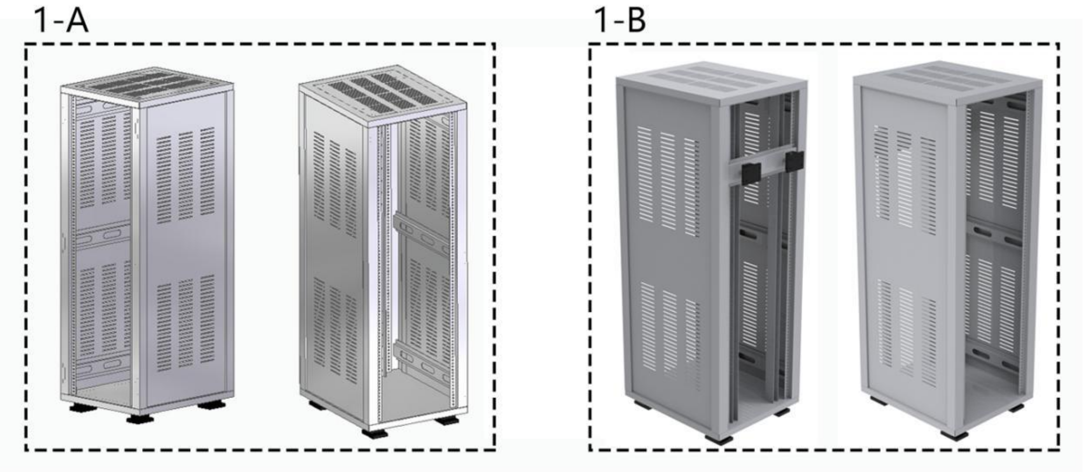

Figure 2: Cabinet 3D modeling and effect diagram

3.1 Establishment of product man-machine usage model

Based on the standard cabinet shown in Figure 3, it can be assumed that the cabinet is equipped with a display screen, a countertop and a series of reinforcement devices. The height of the workbench is 750mm, the height of the seat cushion is 520mm, which is ergonomic. The seat is placed on the workbench about 100mm, and the relative position is fixed, as shown in Figure 3. The relative position of the cabinet and the seat is schematic diagram.

Figure 3: Relative positions of cabinets and seats

4. Use jcak software for man-machine simulation

The 3D model of the relative position of the cabinet and the seat is translated into the step format in the engineering software, and the step file is imported into the jack software to solve the human-machine relationship[4]. The human body model used is the average height and weight model of Chinese people, the height is 173.8cm, the weight is about 65kg, and the human body model is male.

4.1 Front standing and sitting posture simulation and fatigue analysis

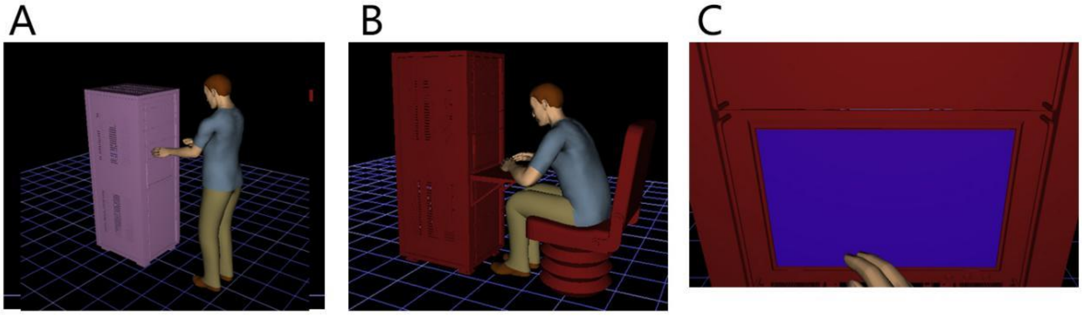

Figure 4: Operation diagram and eye observation diagram of the front cabinet

There is a display device in the front of the cabinet. Figure 4-A. shows the axial view of the standing posture of the human body, and it can be seen that the height of the cabinet is slightly lower than that of the human body, and the human arm can be slightly raised to grasp the handles on both sides of the device and place the device. Figure 4-B shows the rear axial view of the human sitting posture. There is a certain space in the front of the cabinet. Figure 4-C shows the human sitting position and the observation view of the human eyes. It can be seen that the human body can easily see the panoramic view of the display screen under comfortable conditions[5].

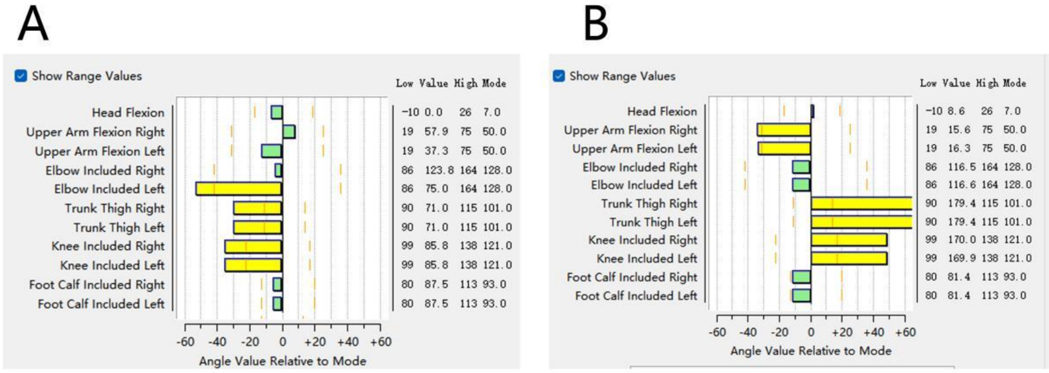

Figure 5: Simulation of sitting/standing posture at the front of the cabinet

Figure 5-A is a simulated column diagram of the comfort level of the front standing posture. It can be seen from the diagram that Elbow included left,left elbow, Trunk Thigh L/R ,left and right thigh, and Knee lncluded L/R ,left and right knee joint, all exceeded the load. Figure 5-B is a simulated column chart of sitting comfort. It can be seen from the chart that the comfort of the left and right arms, left and right thighs and left and right knee joints all exceed the load.

4.2 Spatial simulation and fatigue analysis of the rear hand

The rear space of the cabinet is the cable space, and the cable speed of many devices passes through the rear space of the cabinet. To make use of the small rear space, the human body mostly squatts in the rear space, and most cables are gathered from the bottom of the cabinet for binding. The rear of the cabinet is provided with two human body working positions through jack for observation and comfort simulation[6].

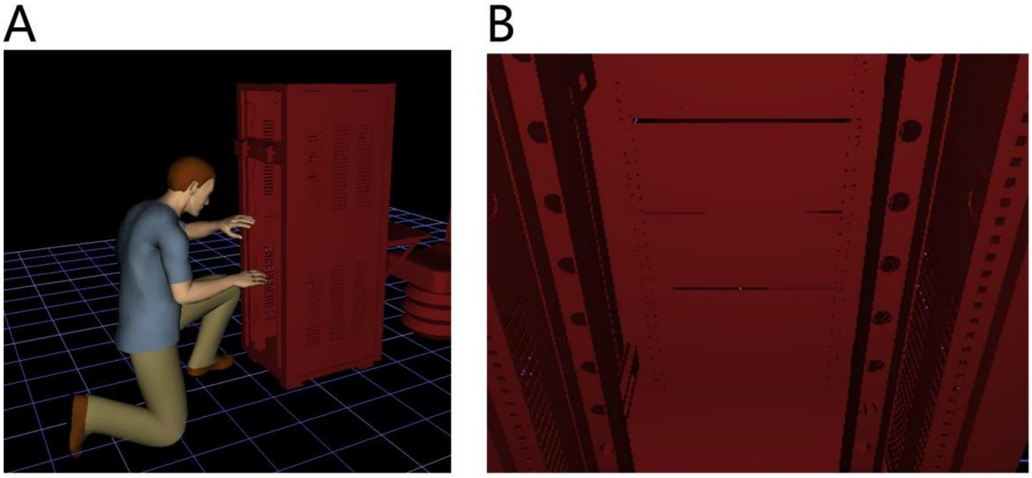

Figure 6: Operation view of the half-squat position at the rear of the cabinet

As shown in Figure 6-A, the human body can comfortably operate the rear cabinet in the semi-squatting mode. Figure 6-B shows the observation figure of the semi-squatting human eye. Figure 7-A shows the operation diagram of the kneeling position at the back of the human body. It can be seen that the human body can work more comfortably in the kneeling position at the back of the cabinet. Figure 7-B shows the eye observation view.

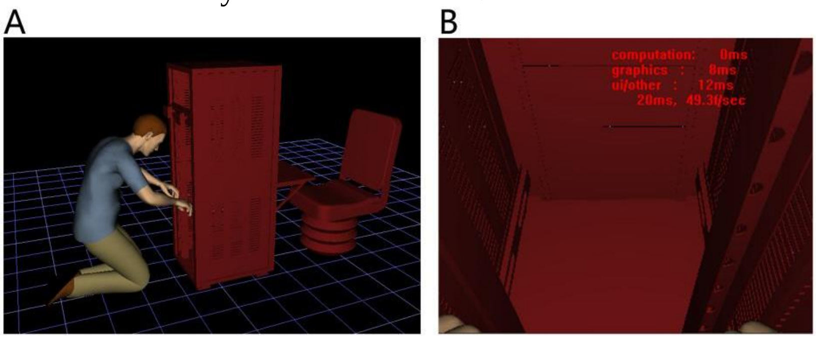

Figure 7: Operation view of the rear of the cabinet in the kneeling position

Based on the two operating views of the human body at the rear of the cabinet in jack software, comfort simulation was carried out in jack software, and the simulation conclusion was obtained in the column diagram. Figure 8-A shows the semi-squat type. From the diagram, it can be seen that the left/right thigh, left/right knee joint and left/right foot all reached the comfort standard value and exceeded the load. As shown in Figure 8-B, when the human body is kneeling, the force on the joints of all parts of the human body is overloaded except that the comfort value of the head reaches the standard value.

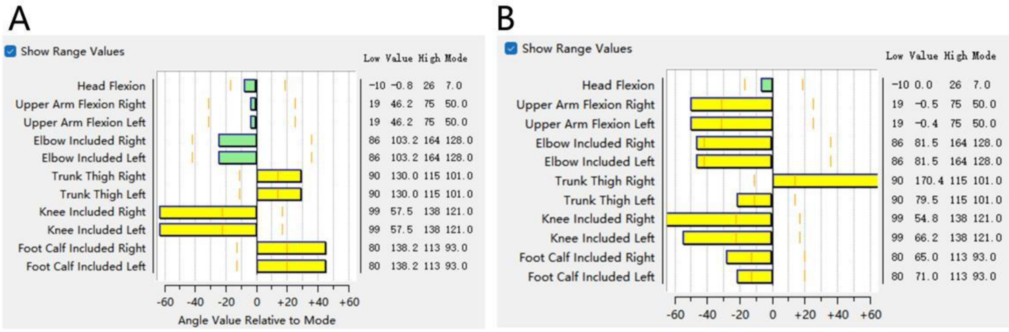

Figure 8: Simulation of the semi-squatting/kneeling position at the front of the cabinet

From the above analysis, it can be seen that the front and back of the cabinet work, the load value of all parts of the human body exceed the standard, if you want to achieve a comfortable degree in the work area, it is the link that needs to be considered in the man-machine design of the cabinet, and it is the part that needs to be worked on in the future cabinet design.

5. Design improvement of vertical cabinet based on man-machine constraints

The above analysis based on human-machine interaction does not meet the standards, which has led to improvements in the cabinet design. The main problem is that the wiring harness at the back of the cabinet is messy, making installation and handling inconvenient. The cable harnesses are concentrated at the bottom of the cabinet for unified output. You can add a cable harnesses output baffle at the bottom to facilitate output of different cable harnesses. As shown in Figure 9.

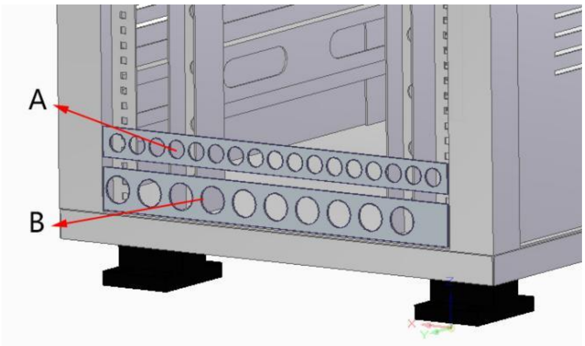

Figure 9: Improved cable harness outlet at the cabinet bottom

The outlet of the cable harness at the bottom cabinet is improved. Figure 9-A shows a 3mm baffle plate with 20mm openings on the right for the 20mm cable harness to pass through. Figure 9-B indicates a 30mm baffle plate with 30mm openings for the 30mm cable to pass through.

6. Conclusion

Based on relevant knowledge of ergonomics, this paper conducts three-dimensional digital modeling of standard vertical cabinets, man-machine operation analysis of relevant parts, joint freedom analysis, and comfort analysis of each posture of the human body, forming the construction of relevant man-machine system. Based on man-machine relationship construction, the product related structural parts are improved, and finally a new product is formed which is more in line with man-machine operation.

References

[1] Obeidat M S, Saaydeh D. Optimizing learning comfort: ergonomic influences on children's transition to online education[J]. Ergonomics, 2024: 1-13.

[2] Irving C , Culverhouse I .Human factors integration with clinical investigations.[J]. Journal of medical engineering & technology, 2024, 47(8):1-7.

[3] Obeidat S M, Saaydeh D .Optimizing learning comfort: ergonomic influences on children's transition to online education.[J]. Ergonomics, 2024,11(3):11-13.

[4] Rauf B W P, Ayaz H .Occupational Health and Neuroergonomics: The Future of Wearable Neurotechnologies at the Workplace.[J]. Journal of occupational and environmental medicine, 2024, 66(6):456-460.

[5] Michel R .Better ergonomics, on and off the truck[J]. Modern Materials Handling, 2024,79(6):12-14.

[6] Sardar K S, Lee C S . An ergonomic evaluation using a deep learning approach for assessing postural risks in a virtual reality-based smart manufacturing context. [J]. Ergonomics, 2024, 10(2):11-14.