Frontiers in Manufacturing Engineering (FME)

DOI: http://doi.org/10.7508/fme.01.2020.01.04

ISSN: 2329-8227 (Print)
ISSN: 2329-8219 (Online)
CODEN : FMERA8

ARTICLE

BARRIER-FREE DESIGN OF DISABLED PEOPLE' ASSISTANT WORK PLATFORM

Qiulei Du*, Zhiyuan Hou

Special Education College of Changchun University, Changchun 130022, China
****Corresponding Author E-mail: 2908521@qq.com***

ARTICLE DETAILS

Article History:

Received 13 November 2020
Accepted 1 December 2020
Available online 17 December 2020

ABSTRACT

The auxiliary devices used by disabled people, who are currently engaged in art design, painting, drawing and other related work, have caused great inconvenience to use and carriage of disabled people. This paper is aimed at an innovation research on new auxiliary device that plays multiple roles such as a desk, an easel or a drawing table. Based on design of steel 45 frame structure, by ergonomics and color methods, both humanized and innovative design are used to expand individualized design of this product. The comprehensive application of material structure theory meets ergonomic requirements. The final product will be small in size saving space, and easy and flexible to operate. Users can operate it with one hand only by sitting in front of the device, so that it can convert various functions, making its use efficiency obviously improved. Owe to this device, accessibility services between disabled people and environment will help them to better participate in social life with higher quality.

KEYWORDS

Disabled people, work platform, accessibility.

1. INTRODUCTION

With continuous advancement of society and development of higher and newer technology, auxiliary equipment in disabled people's daily life is becoming more and more important. According to surveys, there are about 83 million disabled people in China, more than 60% of whom need to be equipped with assistive devices, and a considerable number of disabled people can contribute to society through assistive devices. The World Health Organization (WHO) has published that, for many people with disabilities, access to assistive devices is necessary and important to development strategy; With none aid, people with disabilities can hardly be educated or able to work, so that poverty will continue to cycle. Premier Li Keqiang once said that we must rely on scientific and technological innovation, focus on big market in disabled-oriented service field, accelerate the transformation of scientific and technological achievements and promote their application, strengthen international exchanges and cooperation, so as to develop more products, and provide better products and services, for the benefit of the disabled.

After investigation, auxiliary equipment currently available for disabled people engaged in art design, painting and cartography-related work has been at a low level, such as desks, easels or drawing tables, which have led to better use of disabled people due to simplification of functions. Inconvenience, handling is even more difficult; for example, the easel and design table used by art students (including disabled art students) need to be interchanged when courses are alternated, and there must be enough space to store each other. This process of handling and sorting is cumbersome, wasteful of manpower and damage to appliance, especially for disabled students, which brings many obstacles. The above phenomenon is a common problem that has existed for a long time until now, and it has not been improved or solved.

According to research and experimental analysis, this project is based on user's needs and user-centered design concept [1], which can be a good substitute for desks, easels and drawing tables, to make up for existing aids' shortcomings. It helps disabled people overcome obstacles in work and study. This paper researches a new type of auxiliary device that combines various functions including desk, easel and drawing table. It is small in size saving much space, and is convenient and flexible to operate. Users can operate with only one hand by sitting in front of it. It converts various functions, and thus its use efficiency is obviously improved. It truly fulfills barrier-free service for the disabled making them better participating in social life with higher quality. Certain conditions have important academic significance, practical value and good market demands.

2. HUMAN AND MACHINE SIZE STUDY

This product is designed to meet needs of people (or people with disabilities), so people should be fully considered in design process. The GB10000-1988 standard has been main basis for product size determination for more than 30 years. With development of the times and continuous improvement of people's living standards, some sizes cannot meet needs of modern product design. In this regard, relevant researchers combined their own professional background, perfected them from different angles, and proposed some constructive methods [2]. The ergonomic performance requirements proposed in overall design, such as telescopic size of platform and rotation angle design, which are all proposed by current users' comfort [3]. In terms of working posture and human body function, measurement standing body

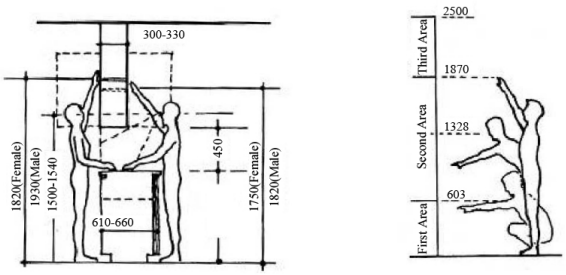

Figure 1: Human body standing activity range measurement.

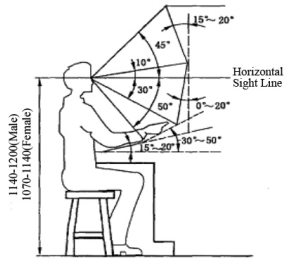

Figure 2: Human body sitting activity range measurement.

activity range is shown in Figure 1. That of sitting human body is shown in Figure 2.

Through actual measurement and data analysis, handling human-machine relationship in system can only be basis on understanding of human's action and posture characteristics. The point of determining working posture is to take most reasonable, least fatigued and efficient posture. Product size parameters combine relevant theories of ergonomics and human factors engineering, and also combine rotation angle of platform, height of cabinet lifting and position of screw-out tray with human to achieve best human-machine relationship. The auxiliary platform size parameters of this design are shown in Table 1.

Table 1: Auxiliary platform size parameters.

Item	Size
Total size	650 mm × 450 mm × 900 mm
Platform telescopic size	(650-1200) mm ×(450-840) mm
Platform rotation angle	0°-75°
Box size	475 mm ×310 mm × 150 mm
Box lifting range	385 mm -560 mm
Screw-out tray	280 mm ×200 mm × 355 mm
Tray rotation angle	0°-270°

3. FUNCTIONAL DESIGN RESEARCH

① Single office platform: meeting basic requirements of writing and reading.

② Drawing platform: Retractable platform surface can be placed with different types of drawing boards. The stable platform can basically meet drawing requirements; platform angle can be adjusted and ergonomics to meet different demands; mobile and easy to move to desired site.

③ Easel: Easel box at the bottom can be moved up and down along slide. When it moves to lowest position, it can be used as a toolbox for drawing, holding color palette, carving knife, etc. Screw-out tray can be rotated by 270 degrees, and pen barrel can be placed when it is unscrewed. Shrinking bucket can be stored after being placed in this tray, which further expands its space.

4. STRUCTURAL DESIGN RESEARCH

4.1 Platform telescopic mechanism

Platform telescopic mechanism adopts a rack and pinion mechanism. Specific structure is as follows:

A coaxial double gear is mounted on motor shaft through a flat key. The double gear meshes with two parallel racks respectively, and rack moves along a guide sleeve mounted on platform back to improve stability of rack movement. Outer ends of the four racks are respectively welded with L-shaped brackets, which can complete telescopic movement of platform along racks to expand desktop's use area [4]. This motor is an innovative point by a motor that simultaneously drives four racks

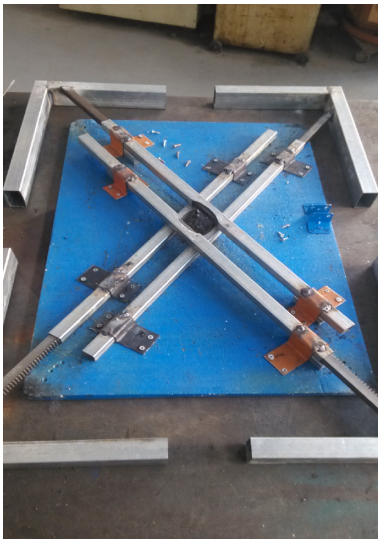

Figure 3: Physical model of platform telescopic mechanism.

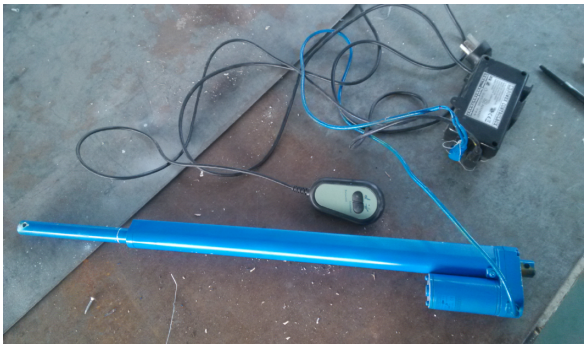

Figure 4: Physical model of screw mechanism.

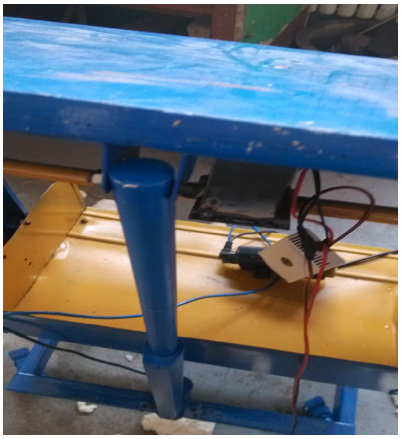

Figure 5: Physical model of platform angle adjustment mechanism.

to move in four directions to complete simultaneous expansion and contraction. The physical model of platform telescopic mechanism is shown in Figure 3.

4.2 Platform angle adjustment mechanism

This platform angle adjustment mechanism adopts a screw mechanism, and specific working principle is as follows:

The whole platform is connected to rotating shaft by welding, which is mounted on whole bracket, and upper end of screw is connected with platform back. When screw motor is working, telescopic rod of screw mechanism moves up and down, and platform is rotated along rotating shaft to realize t desktop flipping 0°-75°, which is able to realize continuous angle change to meet users' requirements [5]. The physical model of screw mechanism is shown in Figure 4, and physical model of platform angle adjustment mechanism is shown in Figure 5.

4.3 Box up and down moving mechanism

The up-and-down moving mechanism of box adopts a slide device. When box reaches highest position, it can be used as a common table box, box moves down slide to achieve two height adjustments; when it reaches lowest position, it can be used as an easel, where toolbox is used to expand used space. The physical model of box moving up and down is shown in Figure 6.

Figure 6: Physical model of box moving up and down.

Figure 7: Physical model of screw-out tray mechanism.

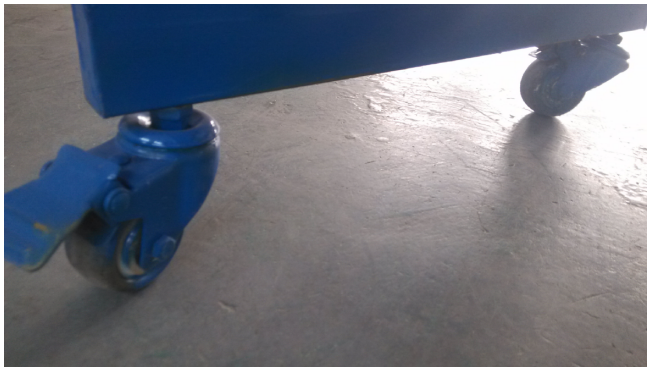

Figure 8: Physical model of auxiliary platform moving mechanism.

4.4 Screw-out tray mechanism

A fixed short shaft is mounted under cabinet, and tray can be rotated or rotated along tshaft, and rotation angle is 0°-270°. The physical model of screw-out tray mechanism is shown in Figure 7.

4.5 Auxiliary platform moving mechanism

Self-locking direction wheel is installed on four feet of auxiliary platform to facilitate overall movement. The physical model of auxiliary platform moving mechanism is shown in Figure 8.

5. RELATED DESING CALCULATION

① Motor selection [6]

a. Motor type of platform telescopic mechanism: DS-37RS3530

n=5 r/min, p=24 w

Gear m =1.5, z=30, Index circle d=45 mm

v=11.8 mm/s

L-frame expansion speed is v=11.8 mm/s

b. Motor type of platform angle adjustment mechanism: 28BYJ-48

Rotation angle 0-75° t=450/2 × sin75°=3.9 s

② Teeth and tooth gap matching

Rack: width×height=15 mm ×15 mm; Gear sleeve: width×height=17 mm ×17 mm.

③ Axis strength check

Force analysis of platform shaft is shown in Figure 9:

D=20 mm; Force of shaft is F=300 N

$\sigma = \frac{F}{A}$, $A = \frac{\pi d^2}{4}$

$\sigma = 45$, Allowable stress of steel 45 is $\sigma = \frac{F}{A} = \frac{4 \times F}{\pi d^2} = 0.955$, $MPa < [\sigma]$

It can be known that: It is reasonable to choose steel 45.

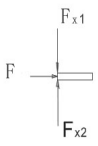

Figure 9: Force analysis of the platform shaft.

④ Other parts check

a. Connecting bolt M7×2

M7 bolt is made of steel 45 and has a maximum tensile force of 300 N when platform is rotated.

$\sigma = \frac{F}{A}$, $A = \frac{\pi d^2}{4}$

d=7, $\sigma = \frac{F}{2A} = \frac{2 \times F}{\pi d^2} = 3.898$, $MPa < [\sigma]$

Therefore, M7 bolt is reasonable.

b. Connecting shaft bolt M12×2

M12 bolt material is initially selected from steel 45 and received a maximum shear force of 280 N when platform was rotated.

$\sigma = \frac{F}{A}$, $A = \frac{\pi d^2}{4}$

d=12, $\sigma = \frac{F}{2A} = \frac{2 \times F}{\pi d^2} = 1.238$, $MPa < [\sigma]$

Therefore, M12 bolt is reasonable.

6. COLOR RESEARCH

Influence of color on people is objective. People's psychological perception of color will directly affect their working state. The use of color to adjust environmental factors does not require additional operating costs, and will not consume resources, and it is directly affected by people's mentality through human line of sight [7]. Color design of this product is considered from following color perspectives:

① Hue

When people observe warm colors, there will be psychologically obvious excitement and aggressive emotions; when observing a cool color, psychologically obvious emotions of calmness and backwardness will appear; while observing neutral color makes people feel neither cold nor warm, which brings them moderate psychological feelings [8]. This product uses yellow of neutral color, and blue of cool color, bring a little excitement to peace.

② Lightness

Brightness refers to a color's degree of lightness and darkness, and bright colors give people a sense of stability and security. In color visual communication design, expansion and contraction of color is also often used to change visual balance of color area relationship and increase visual comfort [9]. The difference between yellow and blue brightness is large, and they are a pair of contrasting colors, which can bring people a bright visual experience and thus a positive emotion to people in complicated work.

③ Security color

Safe color conveys meaning of security messages [10]. China's current safe color national standard GB50034-2004 in color characterization of safety color includes four colors, namely red, blue, yellow and green. Rules are as follows: Blue - indicates instructions that require people to comply with regulations [11]. Yellow - means to remind people to pay attention. Devices related to warning should be indicated in yellow. In view of the above reasons, color design of this auxiliary platform mainly adopts large area with blue and small with yellow, so that people will get certain warnings when using this auxiliary platform.

7. CONCLUSIONS

Research and development of new products should meet reasonable structural design. On this basis, focus is on innovative design of size and function according to core concept, human-oriented design. When considering this product's structural and functional design, which combines human and machine problem of auxiliary platform, designer considers simple operation of product to convert functions of different modes to each other and adapt to users' needs. Corresponding changes in order to achieve a high degree of unity in structure, function and shape, thus making this product more humane. The designed auxiliary work platform for the disabled can meet the needs of people's work, study, painting, art design and so on. It provides a barrier-free working platform for them in the true sense.

ACKNOWLEDGMENT

This paper was supported by 2018 Project of Jilin Education Science Thirteenth Five-Year Plan, Research on Accessibility Design of Auxiliary Work Platform for Disabled People (Project NO.: JJKH20180944KJ), one of stage research achievements.

REFERENCES

[1] Huang, W.L.and Shi, D.M. 2014. Product Innovation Design for User-Oriented Demands. Mechanical Design, 31(11), 18-24.

[2] Li, F.X. and Sun, J. 2015. Research on Corrections and Reconstruction Methods of Human Body Size in Ergonomics. Mechanical Design, 32(04), 126-130.

[3] Chen, Z.B. 2010. Industrial Product Model Design. Beijing: Mechanical Industry Press.

[4] Changchun University. 2012. Multi-functional Folding Combination Table and Chair: China, ZL2012 2 0053696.0.

[5] Du, Q.L. and Wang, Y. 2016. Innovative Design of Entertainment-Fitness Rubik's Cube Chairs and Tables Based on Ergonomics. Journal of Residuals Science & Technology, 13(07), 282.1-282.7.

[6] Electrical Engineering Manual Editorial Board, 1996. Mechanical engineering handbook. Mechanical Industry Press.

[7] Ding, Y.L. 2011. Ergonomics. Beijing: Beijing University of Technology Press.

[8] Gao, W., Baig, A.Q., Ali, H., Sajjad, W. and Farahani, M.R. 2017. Margin Based Ontology Sparse Vector Learning Algorithm and Applied in Biology Science. Saudi Journal of Biological Sciences, 24(1), 132-138.

[9] Nie, Y., Luo, F. and Lin, Q. 2018. Dietary Nutrition and Gut Microflora: A Promising Target for Treating Diseases. Trends in Food Science & Technology, 75, 72-80.

[10] Du, Q.L., Jiang, X.W. and Pan, L.A. 2014. Research of Sled Motorcycle Model Design. Swiss: Trans Tech Publications Ltd, 852, 529-532.

[11] Wang, G., Wang, F., Shen, F., Jiang, T., Chen, Z. and Hu, P. 2020. Experimental and Optical Performances of a Solar CPV Device Using a Linear Fresnel Reflector Concentrator. Renewable Energy, 146, 2351-2361.