Multi-functional nursing bed lateral function improvement design

Wei Li¹, Li Lu¹b

¹School of Mechanical Engineering, Xijing University, ShaanXi, Xi’an, 710123, China
¹aliwei6512@126.com, b1422387676@qq.com

Abstract. In this paper, a new lateral model -- fixed axis lateral model is proposed based on the functional requirements of the lateral body. Based on the lateral body model, the nested combined turning-over bed frame and its new lateral body mechanism are designed. Through the kinematic analysis of the lateral body mechanism, the relationship between the rotation Angle of the upper body side plate and the displacement of the driving slider is obtained.

1. Introduction

Under the influence of the traditional bed plate structure, this paper analyzes the force when the body is actually on the side from the functional demand of the side, and proposes a new side mode -- fixed axis side mode. According to the demand of auxiliary nursing and turning angle not less than 80°, this paper completed the design of bed frame and actuator[1].

2. Lateral motion analysis

In combination with the movement status of the human body during voluntary lateral movement and the lateral dysfunction of the patients with paralysis, we abstract the object of lateral movement as the shoulder of the human body, and study the trajectory of the lateral movement of the human body by rolling the shoulder with variable curvature on the bed surface[2], as shown in figure 1.

Figure 1. Rolling mode of human body

Figure 2. Side view to the left

lateral curvature change
2.1 lateral rotation mode of fixed axis
According to the movement characteristics of human body when side, a fixed axis side model is proposed, which is composed of left side frame, right side frame and middle frame.

Sideways to the left in the process of this model as shown in figure 2, sideways to the left, the left side of the box began to turn, to specify the location to stop, and the middle box linkage, at a fixed Angle of left side, side of up to 90 °; When the human body returns to lying flat, the left frame and the middle frame are rotated and reset at a fixed Angle. Rotate the left side frame to the horizontal to complete the flow to the left side. The body remains in the v-shaped groove formed by the middle frame and the left frame throughout the lateral movement[3]. Turning to the right works the same way as turning to the left.

2.2 side frame layout
Considering that the supporting force of the bed frame on the human body mainly ACTS on the upper body, buttocks and thighs, the middle side frame is divided into three parts to act on the upper body, buttocks and thighs of the human body independently, as shown in figure 3.

![Figure 3. Schematic drawing of segmented position of the middle turnover frame](image)

1. Upper body roll over frame 2. Hip roll frame 3. Leg roll frame

When side body, side body frame 1, 2, 3 synchronous movement, keep coplanar; When nursing, the side frame of the nursing part is reset, and the other two side frames support the body; The three middle side frames were replaced alternately to complete the whole body auxiliary nursing work[4].

3. Design and analysis of mechanism for lateral function

3.1 principle of side drive mechanism
When the side body mechanism works, as the side frame and the middle frame move independently, two original moving parts are needed. In order to realize the left and right body movement through two motors, the side body transmission mechanism as shown in figure 4 is designed.

![Figure 4. Side drive mechanism diagram](image)
The driving mechanism is driven by two motors and moves reciprocating along the guide rail (10) through the regular control of the active slider (13, 16) to realize the whole lateral process.

Active slider to the right side, the side box (13) has been driven to the right side box right passive slider (13), through the connecting rod (9), leverage (10) and the roller (6) transfer movement to the right side of the frame (4), to achieve the right box flip, flip to the specified Angle, lateral box initiative to move the slider (13) reverse reset at the same time the middle box active slider (16) to the right to promote the middle frame, passive slider (15), make (2) inside the middle and the right side of the box (4) maintain a constant Angle turn to the right, to realize constant rotation Angle of a fixed axle sideways.

When the medical staff finished the nursing work, the active slider of the middle frame (16) and the active slider of the side frame (13) moved in the opposite direction to restore the bedridden person to lying flat at a constant Angle, and the active slider of the side frame (13) moved to the middle position to achieve the right frame (4) reset. During the reset process of intermediate frame (2, 3) and side frame (1, 4), the pressure spring pushes the corresponding passive slider into contact with the active slider, and drives the lever reset tension spring to provide the reset tension, so that the intermediate frame and measuring frame keep in contact with the corresponding supporting lever end roller, ensuring the continuous, stable and reliable reset of intermediate frame and side frame. The same principle applies to turning to the left[5].

3.2 kinematic analysis of side mechanism

The transmission mechanism of the middle outer frame of the side mechanism is a combination of the crank slider mechanism and the rotating guide rod mechanism. The principle of driving the upper body side plate to turn over is to split it into two independent mechanisms for kinematic analysis, and the kinematic relationship between the two mechanisms is established through the middle outer frame lever (20). Set up a rectangular coordinate system for the middle outer frame transmission mechanism[6], as shown in figure 5.

![Figure 5. Establishment of driving mechanism coordinates](image)

Where $\theta_1$ and $\theta_2$ are the state Angle of the middle outer frame and the middle outer frame lever respectively, $\alpha$ is the fixed included Angle of the middle outer frame lever, and $x$ is the position of the slider on the guide rail.

$$L_4 = AB, \theta_1 + \phi = \frac{\pi}{2}, \theta_2 + \theta_3 + \alpha = \frac{3\pi}{2}$$

The combination mechanism is divided into two loops ABCDA and DEFGD, as follows:

$$AB + BC + CD = AD$$

Establish the vector loop equations:

$$\begin{cases} L_4 \cos \theta_1 + R_1 \cos \phi - L_3 \sin \theta_2 = L_4 \\ L_4 \sin \theta_1 + R_1 \sin \phi - L_3 \cos \theta_2 = -L_2 \end{cases}$$

By vector equation:

$$DE + EF = DG + GF$$
From the vector loop equations:

\[
\begin{aligned}
-L_6 \cos \theta_1 + L_8 \cos \theta_4 &= x \\
L_6 \sin \theta_3 + L_8 \sin \theta_4 &= L_7
\end{aligned}
\]  

(2)

According to equations (1) and (2), the relationship between the state angle \(\theta_1\) of the middle outer frame and the position \(x\) of the active slider of the middle frame can be solved:

\[
x = \sqrt{L_8^2 - \left[ L_7 + L_6 \cos \left( \alpha + \arctan \frac{1}{\tan \theta_1} - k \right) \right]^2} + L_6 \sin \left( \alpha + \arctan \frac{1}{\tan \theta_1} - k \right)
\]

(3)

Of which:

\[k = \arcsin \frac{\tan \theta_1 \left( L_4 - R_i \sin \theta_1 \right) + L_5 - R_i \cos \theta_1}{L_5 \sqrt{1 + \tan^2 \theta_1}}\]

3.3 Turning motion analysis of middle frame and side frame with constant included Angle

According to the schematic diagram of the left frame transmission mechanism shown in figure 6, the vector loop equation of the left frame is established, and the relationship between the state Angle of the left frame and the position of the slider can be solved.

In the process of turning over with a constant included Angle, the included Angle between the side frame and the corresponding frame should be kept constant, as shown in figure 7 when turning over on the left side

Both satisfy: \(\theta_1 + \theta_2 + \gamma = \pi\)

(4).

Formula (4) represents the motion constraint relationship between the active slider of the auxiliary side frame and the intermediate frame, providing conditions for motion control.

4. Summary

In this paper, a fixed-axis lateral mode is proposed according to the rolling lateral mode of variable curvature of human body, and a new type of nested combined bed frame lateral mechanism using this mode is designed. In the process of siding in a fixed-axis rotation mode, the bedrider is always located in the v-shaped space formed by the middle bed plate and the upper body side plate. The middle bed plate and the left and right boards of the upper body have a good supporting effect on the human body, which avoids the relative sliding between the human back and the middle bed plate when turning over and improves the siding comfort.

References

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