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Design of The Flexion Leg Mechanism

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ABSTRACT: turning over nursing bed industry to adopt the traditional electric push rod directly drive the bracket to drive the leg on curved legs and under the bed to realize curved legs function based on the later has a motor driven parallelogram mechanism, parallelogram and fixed bed legs, so that the motor indirectly promote the realization of the bed legs curved legs and lower leg bending function. But both of them have defects, the former cannot guarantee the curved legs keep horizontal plate in the process of movement, the latter mechanism design complexity and the high cost of the electric push rod and a parallelogram linkage combined mechanism, not only can solve the curved legs during the uneven leg problems and can save cost, through 3D modeling and Solidworks nsimulationxpresee、 Solidworks 、Solidworks motion static analysis and dynamic simulation, the calculation of the components between torque and inertial interaction, The rationality and feasibility of the design of the mechanism are verified. Determination of the length and the installation position of the electric push rod The function expression of displacement, velocity and acceleration is obtained by using the vector equation analysis method. The result of the theoretical formula and the analysis of the actual software are completely consistent.

Keywords: Curved legs,linear actuator, Parallelogram mechanism,Force Analysis

I. INTRODUCTION

With the development of society and the improvement of people's living standard, the social and individual citizens pay more and more attention to the medical and rehabilitation care products. Therefore, the function of the corresponding rehabilitation care products is put forward higher requirements. This article referred to the multi-functional electric rehabilitation nursing bed with rehabilitation and care of the two basic functions, part of the curved leg with rising and falling function, the patient's lower limbs, especially the calf for a separate rehabilitation exercise and care. Legs and feet of the blood circulation is related to the health of the body, leg rehabilitation care is also directly related to the patient's overall rehabilitation effect and post-rehabilitation progress, so the rational design of curved leg body to improve the rehabilitation of patients There are benefits. Currently on the market for a wide range of rehabilitation products for lower limbs, there are many rehabilitation products at home and abroad specifically for the rehabilitation of limb development of a variety of equipment, in general terms can be divided into two categories: active rehabilitation equipment and passive rehabilitation Training equipment.

In general, passive rehabilitation training refers to rehabilitation training institutions to drive the limbs of patients with rehabilitation training, passive training is mainly used for the lower limb has lost consciousness can not exercise and only slight movement of patients, or lower extremity without loss of consciousness but not Can take the initiative to exercise the situation, rehabilitation equipment to drive the limbs to do reciprocating motion in order to promote blood circulation, so as to achieve the therapeutic effect. For example, patients with severe paralysis have low or no exercise capacity or exercise capacity, and the patient is not able to perform rehabilitation exercises on their own. Such training requires passive training [1], or early rehabilitation of fractures. Active training refers to the autonomy of patients in rehabilitation care equipment on their own sports training, this training can help users to strengthen muscle training, it is more suitable for patients with limb injury has been restored; for example, elderly rehabilitation training for the elderly is the best May be independent of the elderly to exercise their own, nursing staff just standing on the side to prevent the elderly accidents. Common types of active foot pedal trainers fall into this category. A lot of rehabilitation machinery for the circular trajectory in the actual rehabilitation training, this trajectory can play a better training result, and has been recognized by most people [2].

II. DESIGN METHOD

2.1 curved leg mechanism program design requirements

In this paper, the design of the rehabilitation of nursing-oriented flexion legs for the user orientation of the need for passive rehabilitation of special groups. As the passive rehabilitation training leg-oriented user groups for their own body of the particularity and vulnerability, so early in the design of the need to note the following points:

First, multi-functional rehabilitation care bed size design must meet the human body structure. Legs in the normal work can be better to adapt to the law of movement of the human lower limb and the human body exercise habits, must meet the sitting and lying down when the human lower limb posture requirements, rehabilitation care when the output end of the trajectory and the body must lie flat Curved legs of the same trajectory.

Second, the operation is simple, safe and reliable. As the majority of patients with mobility, not enough to control the ability to exercise in the process of rehabilitation exercise can not maintain the body's balance and timely adjustment of the correct posture, so how to make training easier and safe for patients and their families have special significance , Which includes patients with posture, training methods and so on.

Third, comfort level. As the majority of patients lying in bed for a long time, so the body will be uncomfortable, so when the rehabilitation care is not only meet the objective function of the lower limb movement needs, more comfortable adjustment, relieve lower extremity discomfort .

The role of Multi-functional rehabilitation nursing is to achieve bed rider who sit when the leg can be bent naturally and lying down when the passive rehabilitation training to promote leg blood circulation and prevent muscle atrophy, relieve long-term movement of lower limbs Such as discomfort. In the course of training, the curved bed of the multi-functional rehabilitation nursing bed has close contact with the lower limbs of the patient, so the movement angle of the curved leg and the size of the bed of the curved leg mechanism part need to be determined according to the size of ordinary human lower limbs. It is required that the trajectories of the upper and lower legs should be as close as possible to the trajectory of human legs. The design parameters of the curved bed should meet the requirements of human body structure and human body kinematics to ensure the patients' Rehabilitation training comfort. Therefore, in the specific design of multi-functional rehabilitation nursing bed bent legs and determine the size of the body before the need to explore the human lower limb skeletal structure and their relationship with human lower limb movement. These help us to design and coordination of the human body, safe and reliable curved leg body.

2.2 human lower limb bone and joint analysis

Choosing a reasonable leg bed size is beneficial to the multifunctional nursing bed to improve the comfort during training and the efficiency of rehabilitation training. The human body through the coordination of various joints to rotate and move to complete their complex body movements, joints are an integral part of the human skeletal tissue structure, if the joint failure, then it means that the corresponding part of the body corresponding to the lack of physical movement.

This article is to discuss the lower limb joint structure and the activities of the various ways and scope. Before discussing the movement of lower extremity joints, familiar yourself with the three special terms that are common in medicine:vertical plane, coronal, and cross-sectional. In medicine from the side of the human body to see, the cross-section is known as vertical plane, seen from the front of the human body is called the coronal plane , the human head to see the direction of the horizontal section called cross-section.

And lower limb joints and by the lower limb basin and free lower extremity joint composed of two parts, which is also called by the pubic syphilis and sacroiliac joints composed of two parts, lower limb joints by the hip, knee and foot joints in three parts, as shown in Figure 2-1. Hip joint is the top of the lower limb joint structure, which is responsible for driving the lower limb and the connection and relative rotation, and it is the entire lower limb joints in the largest joint capacity. Hip is the implementation of the person standing, walking, running, jumping and other activities of the middle of the transmission joints, so it is the most important part of the lower limb joints, while the hip is the most stable and reliable yet flexible and flexible lower limb joints. Hip joint involved in flexion and extension, adduction abduction, external rotation and internal rotation of the three basic movement, some studies show that human motion in general human action, the hip flexion angle is less than or equal to120 degree.

The abduction angle is less than or equal to 20 degree .The external rotation Angle is less than or equal to 20 degree . Normal human gait, marital, coronal and horizontal rotation of the hip joints were about,52 degree,12 degree and 13 degree.

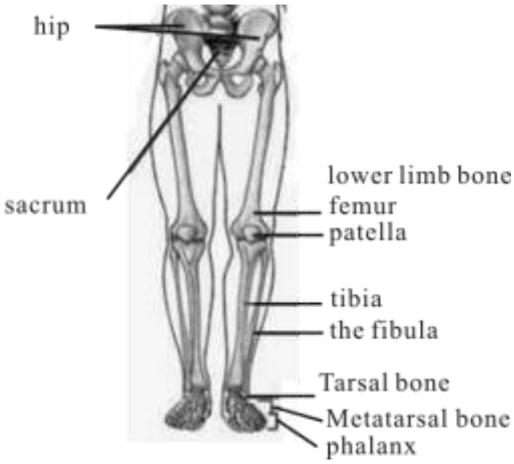

Figure 2-1 human lower limb joint structure diagram

In the sagittal plane, the hip joint is rotated counterclockwise about the horizontal axis called flexion motion, clockwise around the transverse axis, called the extensional motion, as shown in Figure 2-2. The angular range of the human flexion motion is approximately 0 degree~125 degree , and the range of the extension motion rotation angle is approximately 0 degree~15 degree.

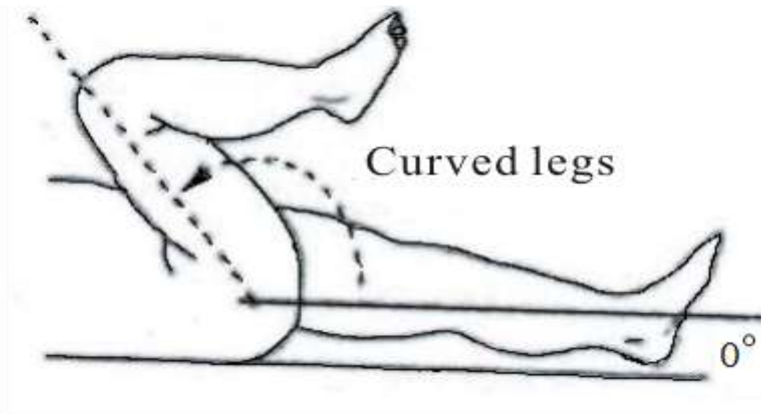

Figure 2-2 bend and stretch diagrammatic sketch of hip joint

The motion angle of the hip joint in the coronal plane is shown in Fig.2-3. The motion angle of the hip joint is about 0 degree~45 degree between the left and the right. The angle of motion of the hip joint in other plane has little effect on rehabilitation training.

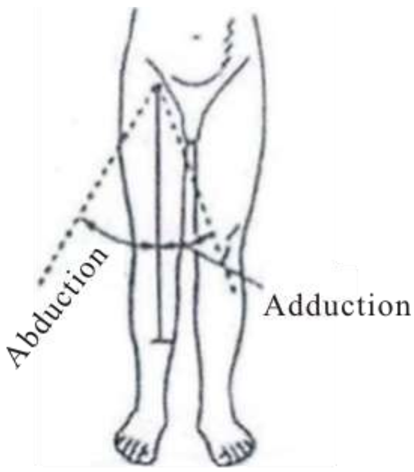

Figure2-1 Left and right movement range of the hip joint

Knee joint is double joint structure composed of Shin strands of joints and patriotic lo femoral joint its movement and hip movement similar to it in three planes can be rotated, so the movement of the knee is more complex. The rotation of the knee in the agitate plane is larger than that of the other planes, as shown in Fig2-4. The maximum degree of flexion of the knee and the hip joint related to different hip position, knee flexion range vary. On the other hand passive and active rotation of the calf flexion range is also different. Under normal circumstances, the scope of rotation of the human knee roughly in 0 degree~135 degree between the left and right.

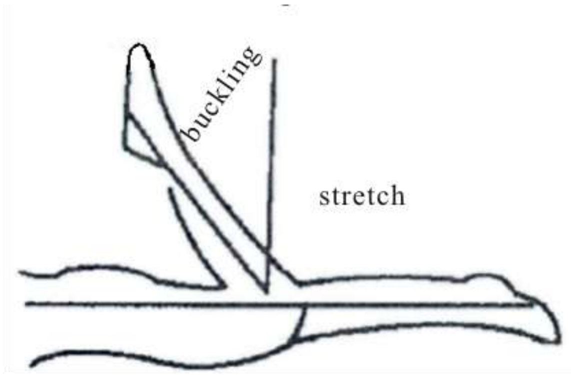

Figure 2-4 knee movement range

Foot joint structure by the ankle joint, tarsal joint, tar so metatarsal joint and metatarsal joints between the four parts, in terms of function can also be referred to as the ankle joint and subtler joint. In the process of lower extremity rehabilitation training, the main force in the leg support points, while the size of an adult's feet compared to the entire lower limb is negligible, so in the process of lower limb rehabilitation training on the impact of the foot is Small, foot joints in the rehabilitation of the activities of the training process is temporarily negligible.

2.3 curved legs of the program selection

Through the above analysis of the human lower limb joints, access to the hip and knee rotation angle data, through analysis and found that patients sitting training although simple, reliable, but the patient can be extended to use flat training Range, patients can be different situations of rehabilitation training, an increase of generalization, especially in the early stages of injury and stroke patients with hemiplegia and other elderly people can not stand, they are difficult to use for a long time or can not use sitting upright to Rehabilitation training. At this time, while lying training has significant advantages over standing, for example, without having to bear the weight of the patient's upper limb, other body parts of the body movement will not affect the training of lower limb leg movement. Taking into account the use of multi-functional rehabilitation care beds for hospitals, homes, nursing homes, etc., should be as small as possible within the scope of the operation and to ensure safe and reliable, can not cause secondary injury to patients. Many patients lying in bed, at the side of the medical staff or relatives to help their rehabilitation training for lower limbs, do not accept the use of rehabilitation training equipment, because patients with training equipment after training not only the lower extremities did not appear to alleviate the more uncomfortable, Would rather choose to replace the artificial care equipment training, rehabilitation training equipment for the lower extremities of the design should pay attention to comfort. In this paper, we will analyze three kinds of institutions which can achieve the training of leg and legs, and finally determine the mechanism to achieve the function of leg flexion by comparing their respective characteristics.

III. Mechanism design

3.1 flat five-legged crank mechanism

Figure3-1 is a three-bar linkage mechanism by the addition of a curved leg structure, the slider slider design is relatively simple to allow space in the case of movement is more convenient, easy to implement, by a regular time fixed Mode to carry out leg flexion exercise to achieve the effect of rehabilitation training, taking into account the multi-functional rehabilitation nursing bed design of the economic reality

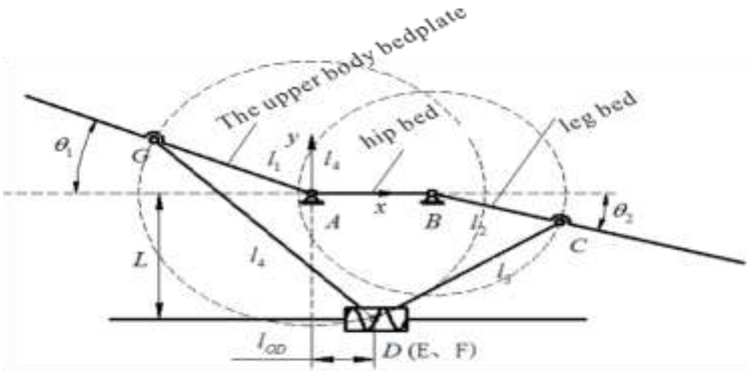

Figure 3-1 flat five-legged crank mechanism

And the principle of the use of lightweight requirements, as well as in the smallest possible space for the power actuator to achieve the functional requirements of the design, in the bottom of the bed space using only a power mechanism to drive the slider movement, and then slide the drive Connecting rod in accordance with the design of a trajectory movement, and ultimately achieve multi-functional nursing bed curved legs function. The planar three-link external slider mechanism has one degree of freedom, so there is definite unique motion for the curved leg movement without any uncertain unknown motion. As the multi-functional rehabilitation nursing bed curved leg angle to meet the requirements of the national standard, so the rod length of BC and CD should be selected to meet the length of the curved leg maximum and minimum angle range requirements. In order to obtain BC, CD rod length and curved leg movement in the process of position angle relationship. The establishment of A as the origin, X axis in the AB coincidence of the coordinate system, respectively, the relation of l_2 and θ_2 , θ_1 and l_1 is:

$$l_1 \sin\theta_1 + l_2 \sin\theta_2 = L$$

*MERGEFORMAT(3−1)

$$(l_{AB} - l_{OD} + l_1 \cos\theta_1)^2 + (L + l_1 \sin\theta_1)^2 = l_2{}^2$$

*MERGEFORMAT(3−2)

By the and we can see that the institutions can reach the maximum and minimum leg angle and l_1、l_2、L , in order to ensure the level of the leg bed can reach the state, that is, to ensure that the corresponding position of θ_1 to 0^0. Therefore, after determining the length of L and l_1, the length of l_2 is a fixed value. According to the latest national standard, multi-functional care bed bed height should be adjustable in the range of 450 ~ 600mm, in order to meet the multi-functional care bed height of not less than $L \le 400$ and to ensure the care bed to install the casters reserved height direction enough space, Must ensure that L mm, in order to ensure that Figure3-1 in the screw nut D slide in the bottom of the bed frame has enough space to install, you need to leave the nut a total height of one-half of its installation space, the program take $L = 400$ mm、$l_1 = 320$ mm when L 、l_1 , the maximum and minimum angle range of the leg is only related to the stroke of the l_2 and lower nut sliders. That is l_1、θ_1、θ_2 are all the function of l_2.
according to

$$l_1 \sin\theta_1 + l_2 \sin\theta_2 = L$$

*MERGEFORMAT(3−3)

$$(l_{AB} - l_{OD} + l_1 \cos\theta_1)^2 + (L + l_1 \sin\theta_1)^2 = l_2{}^2$$

*MERGEFORMAT(3−4)

When $L = 400$ mm，$l_1 = 320$,the solution can be obtained by Matlab $l_{OD} =$，$\theta_2 =$,the initial position, back and legs bent back to the maximum angle can be,The calculation results show that the use of three-bar plus slider mechanism, the slider is driven by the screw-driven rehabilitation program for lower extremity leg flexion, due to the multi-functional rehabilitation care bed height and leg bed length restrictions, The ideal leg flexion angle, if the use of this leg body rehabilitation exercises on the human lower limbs and can not meet the cardiovascular and cerebrovascular patients and severely injured and seriously biased long-term bedridden patients with care requirements. So the use of the curved leg mechanism can not be used in rehabilitation nursing bed. However, in the case of a medical wheelchair having a curved leg function, the leg-crank mechanism can realize the exercise exercise of the leg of the patient at a low cost and the installation space can be saved as much as possible without being strictly limited in height, Enhance its application and different groups of people.

3.2 crank slider crank mechanism

Taking into account the use of three-bar plus the slider mechanism of the curved leg program by the multi-functional care bed height and curved leg bed length limit, resulting in curved leg movement angle range of small phenomenon, is to be used crank crank motion , The leg bed is divided into two to make up and down movement, so as to achieve the purpose of leg training, the body diagram shown in Figure3-2:

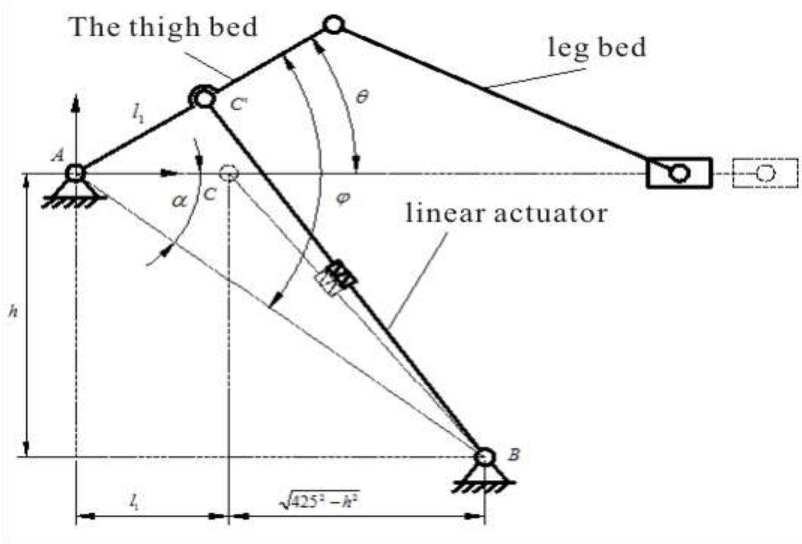

Figure 3-2 crank slider crank mechanism

The advantages of the mechanism is simple and reliable, the use of electric putter alone drive the total bed to drive the thigh leg leg bed movement. Electric push rod with a small space to provide the driving force, easy to install easy to control. The angle of the upper leg is affected by the position of the electric push rod, that is, the maximum leg angle θ and l_1 and h . In the initial position of the flexion movement, that is, when the thigh and the lower leg are in the horizontal position, The angle α between ACand AB satisfies the following relationship:

$$\cos\alpha = \frac{AB^2 + l_1^2 - BC^2}{2ABl_1}$$

*MERGEFORMAT（3-5）

Where: BC is the initial length of the electric putter, the standard length of the electric putter series, select the value of 425mm, the thrust is 250mm.

AB is the distance between the mounting point of the electric actuator and the hinge A, the size of which is related to l_1 and h :

$$AB = \sqrt{h^2 + \left(l_1 + \sqrt{425^2 - h^2}\right)}$$

*MERGEFORMAT（3-6）

In ABC by the cosine theorem available:

$$\cos\varphi = \frac{l_1^{\,2} + AB^2 - BC'^2}{2l_1AB}$$

*MERGEFORMAT（3-7）

$$\theta = \varphi - \alpha = \arccos\left(\frac{AB^2 + l_1^{\,2} - BC^2}{2ABl_1}\right) - \arccos\left(\frac{l_1^{\,2} + AB^2 - BC'^2}{2l_1AB}\right)$$

*MERGEFORMAT（3-8）

In order to obtain a larger angle of the crank, we want θ value close to $\frac{\pi}{2}$, need to figure 5.6 shown in the body size parameter optimization, the first l_1 and h is defined as the overall variable, then the B point and A point in the horizontal direction The projection distance can be expressed as $l_1 + \sqrt{425^2 - h^2}$, solidworks in the definition of the overall variables a and b, respectively, said Figure5.6 l_1 and h of the length of l_1, the greater the length of the putter power arm the greater the same time in order to achieve the desired song Leg angle and moderate power arm length, take the length of the crank l_1 range of variation $200mm \sim 300mm$,in order to ensure the minimum installation height of multi-functional care bed, take the bending range of h 9 $300mm \sim 400mm$, the optimal target for the crank angle of the maximum displacement.

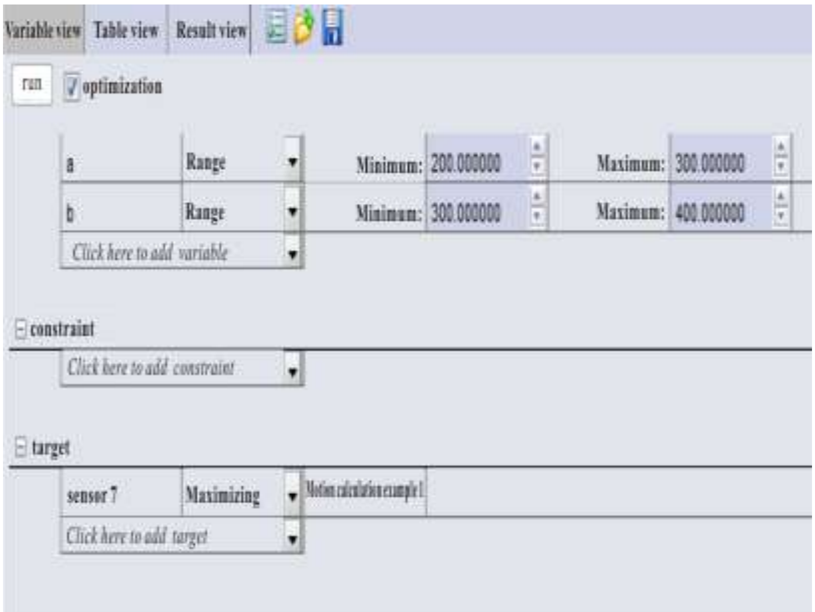

Figure 3-3 parameters based on solidworks optimization settings

By optimizing, the optimal solution of a set of rod length is obtained, that is, when the crank length is $l_1 = 200mm$, $h = 400mm$, the maximum angle of crank is 81 degree.

Variable view | Table view | Result view

Case 11 has been sccessfully run and the designed example quality is high
The current full generation is the optinal solution

		current	initial	optimization	iteration 1	iteration 2	iteration 3
a		200.000000	299.992371	200.000000	300.000000	200.000000	300.000000
b		400.000000	380.000305	400.000000	400.000000	400.000000	300.000000
sensor 7	Maximizing	81.36643radian	49.26952radian	81.36643radian	49.37153radian	81.36643radian	51.20925radian

iteration 4	iteration 5	iteration 6	iteration 7	iteration 8	iteration 9
200.000000	300.000000	200.000000	250.000000	250.000000	250.000000
300.000000	350.000000	350.000000	400.000000	300.000000	350.000000
77.70861radian	49.72514radian	77.51978radian	60.71977radian	61.34005radian	60.12843radian

Figure 3-4 based on solidworks optimization results

Figure 3- 4 shows the crank angle displacement and the amount of electric putter elongation curve, the figure can be seen from the crank and the angle and the extension of the motorized extension of the approximate function of a linear relationship. Because of the electric push and the speed of the pole in the range of 50mm / s, the load on the leg bed is smaller, so we will not discuss the acceleration and the supporting reaction force of the electric push rod.

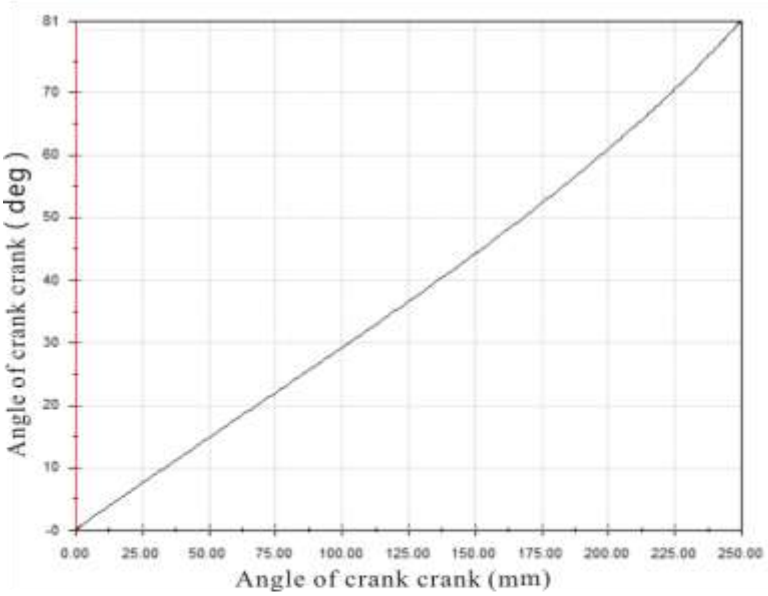

Figure 3-5 crank angle displacement and the amount of electric putter elongation curve

3.3 Based on the parallelogram mechanism of the crank leg

Due to the height limitation of the multi-functional rehabilitation nursing bed, the three-connecting rod plus the slider-crank mechanism can not meet the maximum and minimum crank angle required in the initial design of the curved leg, and the crank-crank type leg mechanism It can not solve the problem that the three-bar linkage mechanism can not meet the maximum and minimum crank angle, but the crank-cranked leg-crank mechanism can not achieve the downward flexion movement, and the parallelogram mode flexion-leg mechanism can not only meet the mechanism upward- Under the movement of the requirements and can achieve a wide range of angular motion. The mechanism diagram is shown in Figure 3-6, the figure ABCD constitute a parallelogram, EF is an electric putter, the mechanism can achieve both up and down movement function, and the mechanism in the process of moving up and down the foot bed board Always keep the horizontal state, the transmission mechanism not only cleverly avoid the multi-functional rehabilitation care bed due to height restrictions caused by the angle of the lower crank angle is too small problem, and is very easy to do in the leg down to the extreme position, leg The upper part of the bed board and the upper part of the bed at an angle close to the human body and natural sitting when the lower limbs and upper body into almost the same angle, so the curved leg body not only to meet the patient up, down Qu legs function, the patient can also achieve the effect of natural sitting.

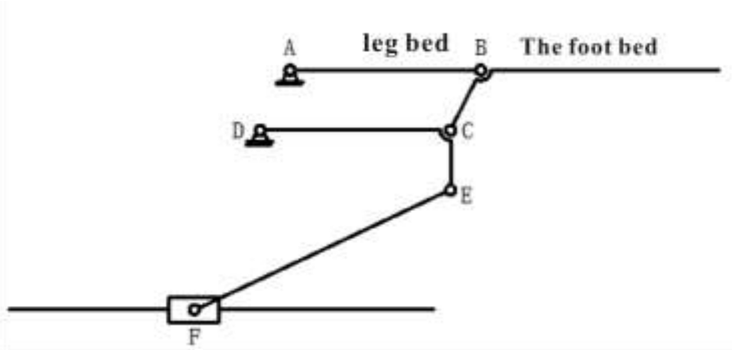

Figure 3-6 parallelogram leg body diagram

In order to obtain the electric push rod length and movement with the leg bed, foot bed position angle relationship is shown in Figure 3-6 institutions kinematics analysis, the establishment of Figure 3-7 shown in Cartesian coordinate system:

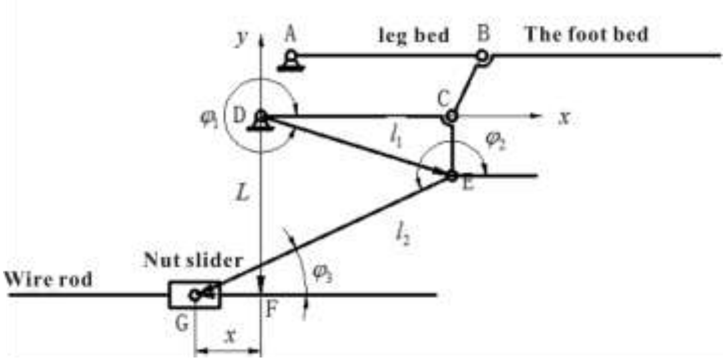

Figure 3 -7 curvature of the body coordinate system

1. Location analysis

As shown in Figure 5 11, the closed vector equation of the mechanism is:

$$\vec{l_1}+\vec{l_2}=\vec{L}+\vec{x}$$

*MERGEFORMAT（3-9）

Rewritten into a plural form:

$$l_1e^{i\varphi_1}+l_2e^{i\varphi_2}=Le^{i\frac{3\pi}{2}}+xe^{i\pi}$$

*MERGEFORMAT（3-10）

Respectively, take real and imaginary parts were:

$$l_1(\cos\varphi_1+i\sin\varphi_1)+l_2(\cos\varphi_2+i\sin\varphi_2)=-Li-x$$

*MERGEFORMAT（3-11）

Equivalent from the real part can be obtained:

$$-x=l_1\cos\varphi_1+l_2\cos\varphi_2$$

*MERGEFORMAT（3-12）

Equivalent from the imaginary parts available:

$$-L = l_1 \sin\varphi_1 + l_2 \sin\varphi_2$$

*MERGEFORMAT（3-13）

When the body size is determined, and there are three unknowns and two independent equations, the use of matlab can be a φ_1 with x changes in the relationship, as the relationship between φ_1 with x is an implicit function, and the explicit function relation is quite complex. In order to reflect the relationship between φ_1 with x more intuitively, when the parameters of the mechanism are determined, Curve, where it is no longer manifested.

3.4 Kinematics simulation of flexion leg mechanism based on parallelogram mechanism

When the leg deck length. . . Mm, the foot bed is. . . Mm, AB = 112mm, CE = 100mm, EG = 472mm, L = 300mm, the curves of the upward crank angle displacement and the linear displacement of the nut slide are shown in Figure 3-8:

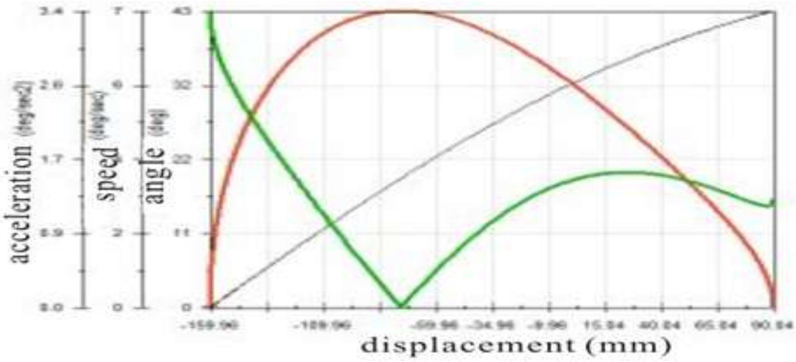

Figure 3-8 results of the crank leg simulation

Figure 3-8 for the slider to 25mm / s movement, leg bed frame angular displacement, angular velocity, angular acceleration and linear relationship between the slider. The black line is the relationship between the angular displacement of the leg bed and the horizontal displacement of the slider. The red curve and the green curve are the curves of the angular velocity and the angular acceleration of the leg bed with the displacement of the slider, respectively. , The position of the slider in the coordinate system shown in Fig. 3-8 is -159.95 mm. When the displacement of the slider is 250 mm, the position of the slider in the coordinate system shown in Fig. The angle of the upper leg of the leg bed is about. The angular velocity of the slider increases gradually from -159.95 to -75.24mm during the movement of the upper curve leg and reaches about 7 degrees per second at -75.24mm. , And the angular acceleration reaches the minimum value of 0 at this time. The angular acceleration is always positive and the maximum value is 3.4 degrees / sq. only in the whole upper leg, so the good leg smoothness is obtained during the whole upper leg bending process.

It can be seen from Fig. 3-9 that the maximum angle that the lower leg can reach when the slider is moving at 40mm / s is 400mm in the process of the lower leg and the leg of the lower leg The angular acceleration of the lower leg is about 12.049 degrees / second at about -310mm, and the angular velocity at the beginning of the next curve is about 12.049 degrees / second, and the angular velocity at the displacement is Acceleration reduced to 0, in the diaphragm continued to increase the process of the next leg to 4.113 degrees / sq.

The angular acceleration of the leg bed is always positive in the process of the lower leg, and the maximum angular acceleration appears at the beginning of the movement. Since the acceleration has a sudden change only at the initial position and the ending position, A flexible shock is present, and since the maximum angular acceleration is only 6 degrees / sq, and the stepper motor has an acceleration and deceleration process during the start and braking phases, good motion comfort can still be obtained.

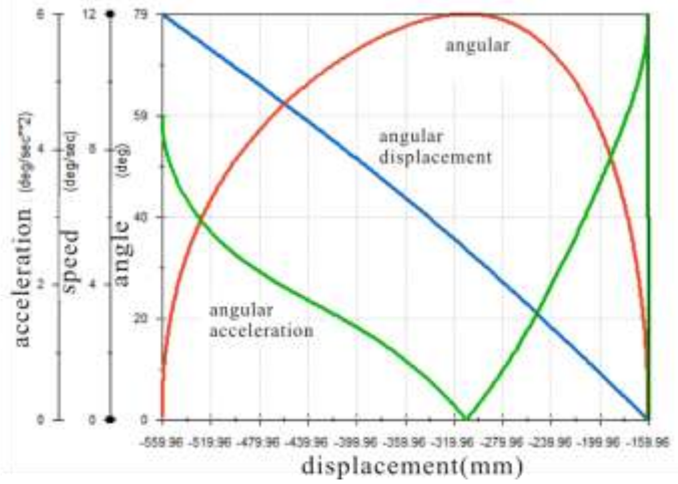

Fig. 3-9 Curve of kinematics of the lower curve

IV. CONCLUSION

4.1 Summary of this chapter

In this chapter, based on the design requirements of human body mechanism and kinematics, simple operation, safe, reliable and comfortable feeling, this paper analyzes the basic joint structure of the human lower limb and the **movement** of the lower limb joint. Function and angular range of motion of each joint. And the motion range and design requirements of each joint are taken as the design basis. The three-link plus slider-crank mechanism, the crank-cranked-leg mechanism and the parallelogram-based mechanism are proposed. The kinematics analysis of the three-bar linkage plus crank-crank mechanism is carried out. The lengths of the rods in the three-bar linkage plus the slider mechanism are determined. The maximum and minimum lengths of the rods under given length are calculated. Leg angle. The kinematic analysis of the crank-crank-crank mechanism shows that the maximal angle of the upper crank-leg varies with the position of the electric actuator. Through the solidworks design example, the position of the electric push rod on the leg bed and the bottom bed frame is taken as the design variable. Under the condition that the initial length and the maximum stroke of the electric push rod are the same, And the crank-leg crank mechanism is optimized and the installation position of the electric actuator is finally determined. The kinematic analysis and simulation of the parallelogram-based flexion-leg mechanism is carried out. The motion characteristics and the maximum angle that the leg bed can reach when using the different length of the crank-connecting rod EF are analyzed. The length of the affected legs on the leg leg can reach the maximum angle and the impact of the next curved leg is not. And finally determine the design parameters so that both the upper and lower legs can reach the desired angle of the crank. By analyzing and comparing, it can be seen that the three-bar linkage with the crank mechanism of the slider mechanism can easily realize the function of the flexion leg and can effectively utilize the internal space of the multi-functional rehabilitation nursing bed, and provide the other mechanical structure of the rehabilitation bed More effective space, while low production costs can also save a lot of capital, but due to the high degree of multi-functional care bed constraints, it is difficult to obtain the desired maximum and minimum leg angle. Crank slider crank mechanism can achieve the actual initial setting of the crank angle, but the fatal flaw is not able to achieve the function of the curved leg down, and therefore does not apply. Based on the analysis and comparison of the advantages and disadvantages of the two front leg mechanisms, this paper presents a flexion leg mechanism based on the parallelogram mechanism, which combines the three-link plus the slider-crank mechanism The advantages of the leg-slide mechanism are not only to meet the designed crank angle but also to realize the upward and downward curve legs and to keep the foot bed level in the whole course of the bending motion. So the final quadrilateral-based curved leg mechanism as a multi-functional rehabilitation nursing bed curved leg design.

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