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A turning over mechanism based on a parallel quadrilateral protection nested

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ABSTRACT: It is difficult for the present turn over nurse caring bed industry to fulfil the patients' requirement of separate turn over nursing care implementation on the upper body and the lower part of the body, nested turn institutions can satisfy the requirement, additionally, it is able to meet the requirement of the cleaning care after the independent turn over, the principle of the mechanism is that when the nurse caring bed turns over to one side, the parallelogram protection agency, the periphery of the bed board frame and the embedded plate move around fixed action at the same time. The solidworks three-dimensional (3D) solid model building, the statics analysis by solidworks nsimulation Xpresee and the dynamics simulation by the solidworks motion was used to calculate the interaction between the moving parts, such as torque, feasibility and inertia, which further verify the rationality of mechanism design and achieved the patients' split nurse caring requirement. Moreover, in order to ensure the size and the turning angle of each member in the structure, comprehensive analysis and calculation was employed; Vector equation analytic method was used to draw the displacement, velocity and the formula of the acceleration, the result matched the analysis of the software.

Keywords: *Turnover, Embedded, Parallelogram mechanism, Force Analysis*

I. INTRODUCTION

Due to the accelerated process of population aging, the number of disabled elderly is growing rapidly, and the people in our country getting old before getting rich, the economic level cannot adapt to the trend of the nurse caring industry, while the high costs of doing separate family nurse caring can be the heavy financial burden of the low-income families. To deal with the disabled elderly nurse caring, especially the elderly paralyzed is an urgent problem to be solved[1], However the current bed nursing agencies are normally applied the traditional single plate which is unable to meet the increasing requirement of patients[2]. It is likely for the patients who lying in bed for a long time to have the wash caring, however, the whole plate turn over will not meet the demand of patients daily cleaning and security. This paper attempts to consider the actual security needs of the patient and starting from the existing deficiency in nursing bed function, to design an embedded turn over mechanism which includes a follow-up protection agency through the parallel parallelogram principle.

II. DESIGN METHOD

2.1 The design process is follow the actions in the Figure 2-1.

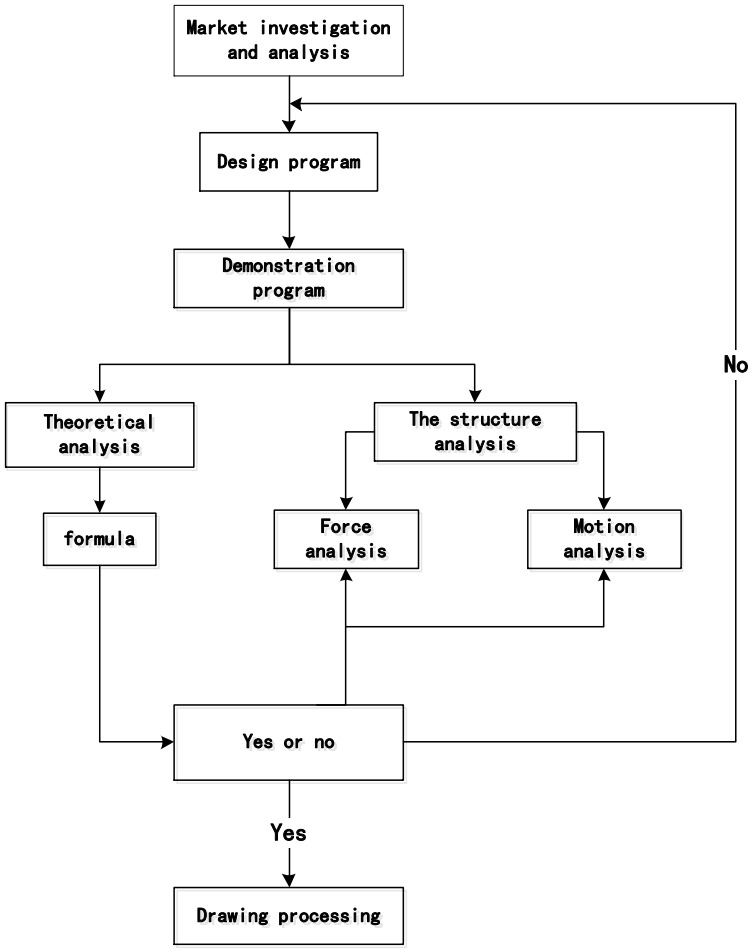


Fig. 2- 1Design of flow-process diagram

III. MECHANISM DESIGN

According to the human body actually turning requirements and meet the functional demands, the first step is to design the bed frame of nested turn structures and calculate the feasibility of movement and then design the follow-up protection agencies and calculate the feasibility of movement.

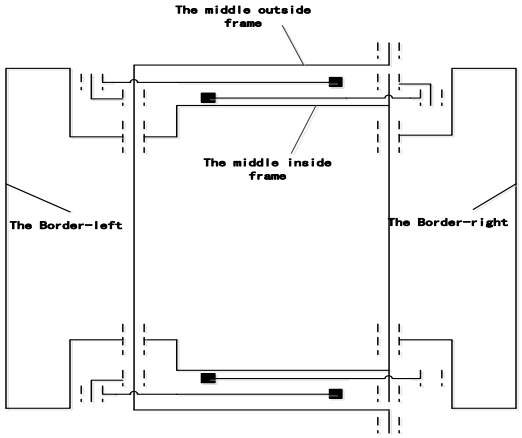


Figure 3-1 Schematic diagram of the middle frame with a protective mechanism of connection

3.1 The turnover frame design

According to turnover function requirements, the middle frame cane turn to left and right at the same time, therefore the nested design is employed[3]. The middle frame consists of two layers of nested, internal and external, as shown in figure (3-2). When turn to the left, the external frame's turn to the left and the follow the internal frame which roll to the left, as shown in figure (3-3); When turn on the right, the internal roll to the fight and the external frame keep still, as shown in figure (3-4).

Figure 3-2Picture of real Nursing bed frame

Figure 3-3 Picture of real Nursing bed frame Turning to the left

Figure 3-4 Picture of real Nursing bed frame turning to the right

3.1.1 figure of the turn over member

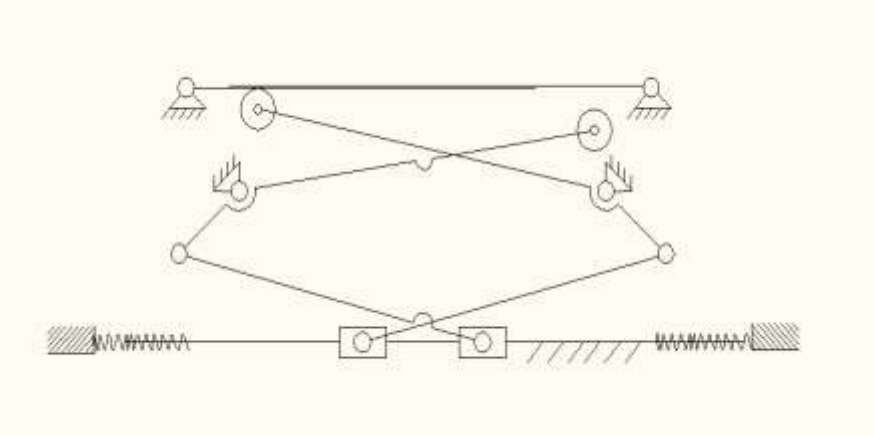


Figure 3-5 Left and right turning mechanism

3.1.2 Single side of the turn over body figure, as shown in figure

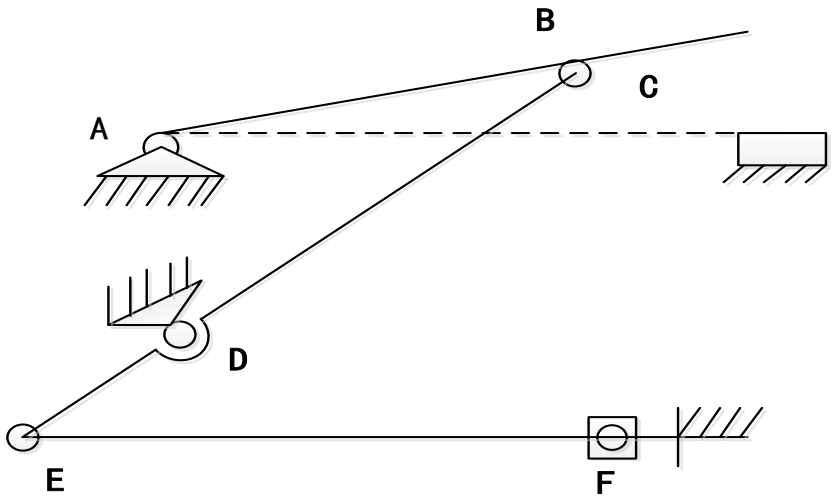


Figure 3-6 Unilateral turn over mechanism

3.1.3 Schematic diagram of mechanism as shown in figure 3-6

F=3n-2pl-ph (1)

F=3*4-2*5-1 (2)

F=1 (3)

n：moving link pl：lower pair p_h：higher pair F：degree of freedom

The driving partonly have one sliding block F and the degree of freedom is F=1，thus this mechanism motion has the only certainty

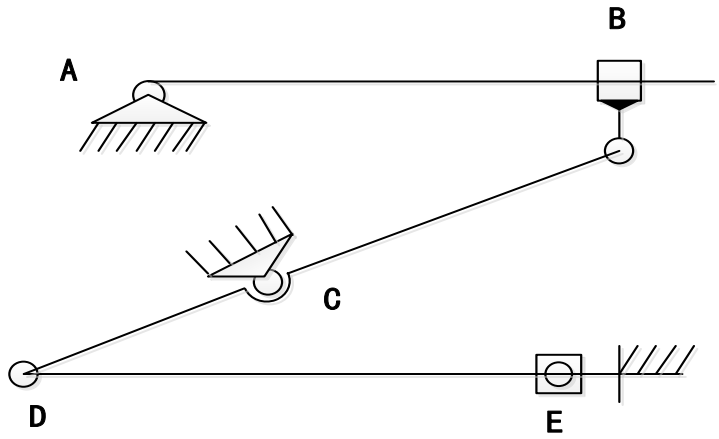


Figure 3-7 Lower pair replace the higher pair

F=3n-2pl (4)

F=3*5-2*7 (5)

F=1 (6)

n：moving link p_l：lower pair F: degree of freedom

The result from the lower pairs replace the higher pairs calculation to degrees of freedom that is the same to the results from organization diagram. That illustrate the uniqueness of movement of the organization is correct .

IV. MATHEMATICAL MODELING

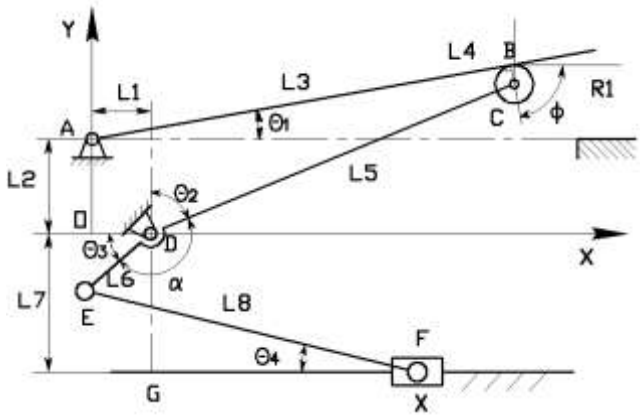


Figure 3-8 Rotation angle calculation simplified mechanism

The θ_1 、 θ_2 is the working angle of the middle external frame and the lever of the external frame, α is the fixed angle of the middle external frame, x is the location of sliding block on the guide rail.

$$L_4 = \overline{AB},\ \theta_1 + \varphi = \frac{\pi}{2},\ \theta_2 + \theta_3 + \alpha = \frac{3\pi}{2} \quad (7)$$

Split into two loop combination mechanism which is ABCDA and DEFGD

According to:

$$\overrightarrow{AB} + \overrightarrow{BC} + \overrightarrow{CD} = \overrightarrow{AD} \quad (8)$$

Establish the Vector loop equation:

$$\begin{cases} L_4 \cos\theta_1 + R_1 \cos\phi - L_5 \sin\theta_2 = L_1 \\ L_4 \sin\theta_1 - R_1 \sin\phi - L_5 \cos\theta_2 = -L_2 \end{cases} \quad (9)$$

According to Vector equation:

$$\overrightarrow{DE} + \overrightarrow{EF} = \overrightarrow{DG} + \overrightarrow{GF} \quad (10)$$

Establish the Vector loop equation:

$$\begin{cases} -L_6 \cos\theta_3 + L_8 \cos\theta_4 = x \\ L_6 \sin\theta_3 + L_8 \sin\theta_4 = L_7 \end{cases} \quad (11)$$

Due to **Error! Reference source not found.**the equations**Error! Reference source not found.**, the relationship between working angle θ_1 of the middle frame and the location of the sliding block x

$$x = \sqrt{L_8^2 - \left[L_7 + L_6 \cos\left(\alpha + \arctan\frac{1}{\tan\theta_1} - k \right) \right]^2} + L_6 \sin\left(\alpha + \arctan\frac{1}{\tan\theta_1} - k \right) \quad (12)$$

$$k = \arcsin\frac{\tan\theta_1 (L_1 - R_1 \sin\theta_1) + L_2 - R_1 \cos\theta_1}{L_5 \sqrt{1 + \tan^2\theta_1}} \quad (13)$$

The middle frame and side frame constant angle turn motion analysis

3.1.4 Stress analysis and checking

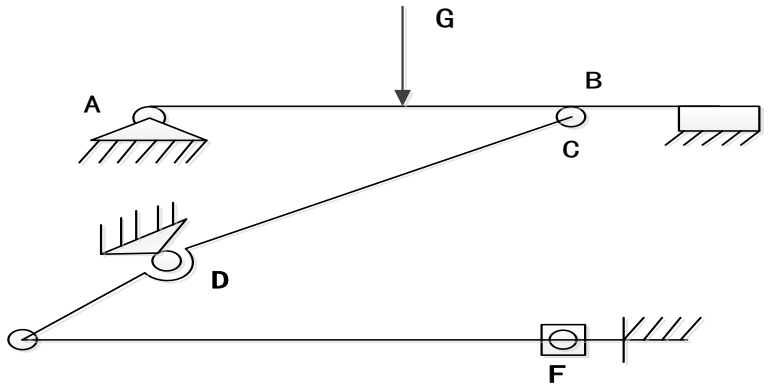


Figure 3-9 Simplified mechanism of gravity calculation

According to the body of the body to turn over ninety percent of the population[4], the selected body weight of 75kg, G=750N, concentrated in the middle, because the torque in the process of roll over continually decrease, thus as long as the initial state agencies can keep the deformation, satisfy the strength requirement, therefore in the later movement it won't appear the strength problem. The original length of the stick is 300mm, then the force bearing point is located in the middle 150mm far from supporting point.

$$M = GL \quad (14)$$

$$M = 750N * 0.15\text{m} \quad (15)$$

$$M = 112.5Nm \quad (16)$$

According to solidworks nsimulationXpresee mechanical deformation figure 3-10、3-11、3-12

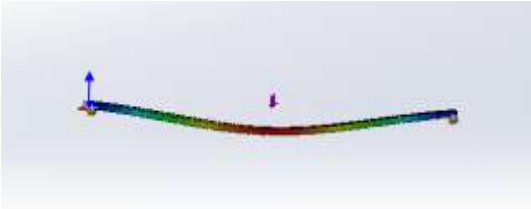
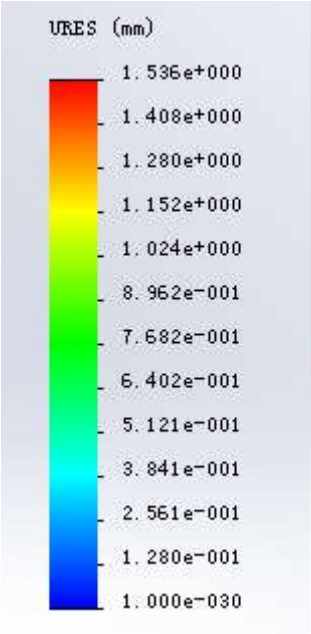


Figure3-10 Stress deformation diagram



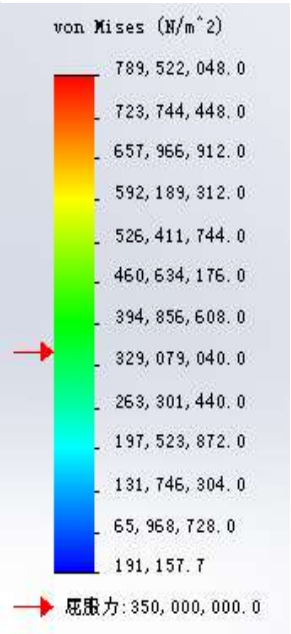


Figure3-11 Stress diagram Figure3-12 Strain diagram

Through querying the cold draw steel of 45# tape,we could know this tape of steel would lose the efficacy within the scope of HRC55.By the mechanical deformation diagram known,the defamation is in the failure range outside .So the experiment meet the requirements.

3.1.4 Follow-up protection agencies design

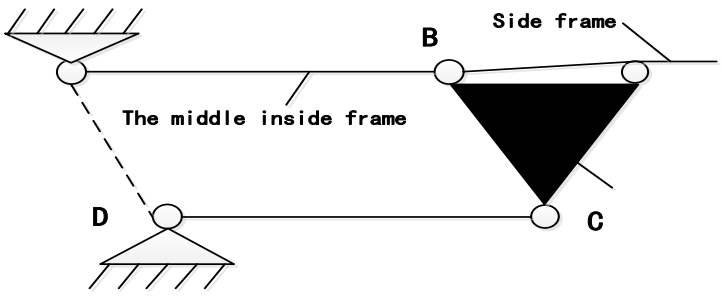


Figure3-13 Follow-up protection mechanism

Calculate the degree of freedom:

F=3n-2pl-ph (17)

$$F=3*4-2*5-1 \quad (18)$$

$$F=1 \quad (19)$$

F: degree of freedom n：moving link pl：lower pair ph：higher pair

Because of the degree of freedom F=1 and the number of the moving link is the same, so the movement is determined.

V. CONCLUSION

As a result of the turn over body movement has the only certainty, follow-up protection agencies movement also has the only certainty, additionally, and the protection agency is moved follow the turn over institutions, thus when the turn over institutions are moving, protection agency can follow the movement and protect of the patient.

(1) According to the principle of reaction on the surface of the vertical effect, nested bed frame and side frame and follow-up protection agencies through a constant Angle to prevent dislocation in the process of human body in turn over process and safety problems

(2) According to the compound turn pattern and bed frame connections in this paper, a servo turns over institutions was established, through motion analysis it is concluded that the relationship between the two;

(3) From the security of turn over nursing care, bed frame of servo mechanism has been put forward, to protect the patients in the nursing care process from the dangerous of the random arm place

(4) Determine the connection between turn over frame, use horizontal follow-up mechanism to eliminate the clearance between the relative motion between the bed frame, improve the security of turning over.

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