ISSN 2616-7433 Vol. 2, Issue 4: 63-65, DOI: 10.25236/FSST.2020.020417

Design of Suspension Control System for Four Motors

Liu Yinhui, Zhao Hang, Fan Hang, Luo Wei

School of Information Engineering, Jilin Engineering Normal University, Changchun 130052, China

ABSRTACT: *The suspension system of multi motor coordinated control can realize the five degree of freedom movement of the controlled object, which has a wide application space. In this paper, the four motor working mode is adopted to realize the control of arbitrary linear motion and circular motion of the suspension system.*

KEYWORDS: *Suspension control; Motor coordination; Curve fitting*

1. Introduction

The suspension system controlled by multi motor can provide technical support and service for dynamic landscape design of stage, shopping mall, theme park, film and television base and has a wide application market.[1] In this paper, the disk is taken as the controlled object, and the four motor mode is adopted to design and realize the control system which can make the linear motion in any direction and the circular motion in any radius in the space.

2. System Structure and Parameters

Assuming that the working environment of the system is a cube space, as shown in Figure 1, the side length of the space is L = 1200mm; the distance from the disk to the top is h = 500mm; the diameter of the disk is D= 200mm; the center of the disk is o point, and the four stepper motors are connected with the disk through ropes (y1, y2, y3,y4), and the included angle from the four connecting points to the center of the disk is 90 °. Figure 1 is a schematic diagram of the disc moving right along the horizontal direction from its initial position.[2] The distance from o point to o' point is x, and the value range of X is 0 ≤ x ≤ 400mm.

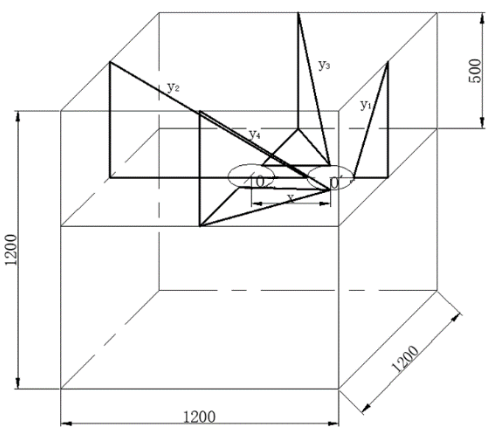

Figure. 1 Schematic diagram of disc moving horizontally to the right

ISSN 2616-7433 Vol. 2, Issue 4: 63-65, DOI: 10.25236/FSST.2020.020417

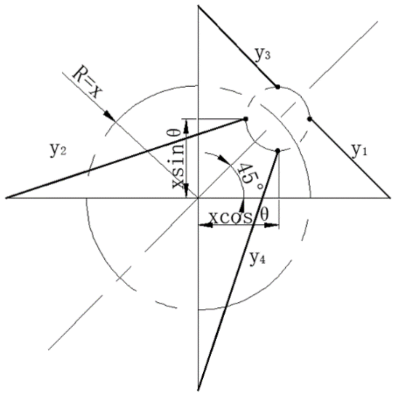

Figure. 2 Schematic diagram of moving position of top view panel

3. Motion Control Algorithm

This part aims to analyze the situation that the disk moves to a certain point along a straight line. In the case shown in Figure 1, the Pythagorean theorem should be used to get the length change rule of the suspension rope (y1, y2, y3, y4) at o 'point, as shown in formula (1) - (4):

$$y_1^2 = h^2 + \left(\frac{L}{2} - \frac{D}{2} - x\right)^2 \tag{1}$$

$$y_2^2 = h^2 + \left(\frac{L}{2} - \frac{D}{2} + x\right)^2 \tag{2}$$

$$y_3^2 = h^2 + x^2 + \left(\frac{L}{2} - \frac{D}{2}\right)^2 \tag{3}$$

$$y_4^2 = h^2 + x^2 + \left(\frac{L}{2} - \frac{D}{2}\right)^2 \tag{4}$$

Then analyze the circular motion of the disc, set the circular radius as X, the angle of the disc stopping at a certain point on the arc as θ, and Figure 2 is the effect picture of looking down on the system. The length change rule of the suspension rope (y1, y2, y3, y4) can be obtained as shown in formula (5) - (8):

$$y_1^2 = h^2 + (xsin\theta)^2 + \left(\frac{L}{2} - \frac{D}{2} - xcos\theta\right)^2 \tag{5}$$

$$y_2^2 = h^2 + (xsin\theta)^2 + \left(\frac{L}{2} - \frac{D}{2} + xcos\theta\right)^2 \tag{6}$$

$$y_3^2 = h^2 + (xcos\theta)^2 + \left(\frac{L}{2} - \frac{D}{2} - xsin\theta\right)^2 \tag{7}$$

$$y_4^2 = h^2 + (xcos\theta)^2 + \left(\frac{L}{2} - \frac{D}{2} + xsin\theta\right)^2 \tag{8}$$

Therefore, when the space height h, radius x and angle θ are known, the straight line and circular motion in any plane can be realized by formula (5) - (8). Among them, if h is a constant, action can be realized at a certain height; if θ is a constant, linear motion can be realized; if x is a constant, circular motion can be realized.

The parameters of the stepping motor used in the system are: step angle α = 1.8 °, shaft radius r, four suspension ropes fixed on the motor shaft, with the forward and reverse rotation of the motor, the rope extends or shortens, when the change rule of formula (5) - (8) is converted to the motion rule of the motor, the formula (9) is adopted.

ISSN 2616-7433 Vol. 2, Issue 4: 63-65, DOI: 10.25236/FSST.2020.020417

$$step_n = \frac{360°}{\alpha} \times \frac{y_n}{2 \times \pi \times R} \tag{9}$$

4. Control Circuit

The system uses four HBS57 stepping motor drivers, their power supply voltage is DC24V, rated current 4A, rated output torque 2.2N · m, rated speed 1000r / m; the model of four stepping motors is 57HS8244A4; the controller uses STM32F407 development board; the input and output equipment uses 7 " TFTLCD.

In terms of hardware connection, the A + / A-pin of HBS57 stepping motor driver is connected with the A-phase winding of 57HS8244A4 stepping motor, and the B + / B-terminal is connected with the B-phase winding of 57HS8244A4 stepping motor; the PLU pin of each HBS57 stepping motor driver is connected with the PWM output pin of STM32F407 development board, and the DIR and ENA pins of each HBS57 stepping motor driver are respectively connected to STM32F407 on Digital I / O pin .[3]

In terms of software design, the controller obtains the motion requirements through the 7 " TFTLCD touch screen, h, X and θ through conversion, the motion equation of each rope through (5) - (8), the rotation steps of each motor through formula (9), and finally the 57HS8244A4 motor is driven by the PLU pin of the HBS57 stepping motor driver.

5. Experimental Results

Considering that the performance of four motors and four ropes is not completely consistent, and there will be deviation when the system works, the appropriate correction is made through the actual test. At the height of H = 500mm, the circular motion of the disc is made with different radii. The measured error data is shown in Table 1.

Table 1 Error Statistics of Circular Motion When h = 500mm

radius x(mm)	10	20	30	40	50	100	150	250	350
deviation e(mm)	0.07	0.27	0.71	1.25	1.81	7.23	15.82	43.56	82.25

$$\triangle y = 0.006x^2 + 0.0115x - 0.2542 \tag{9}$$

Using MATLAB to do curve fitting, using the second-order polynomial form, the deviation variation rule between radius X and rope length y is obtained by formula (9) .the corrected error is limited within 20 mm.

References

[1] Li Hui, Liu Xingqiao, Li Jing, Sun Feifei (2014). Summary of Multi-Motor Synchronization and Coordination System Control Strategy. Electric Machines & Control Application, vol.41, no.4, pp.6-11.

[2] Chen Zulin, Shen Ying, Wu Jing (2020). Design of stepping motor motion control system based on STM32 and FPGA. Journal of Fuzhou University (Natural Science Edition)., vol.48, no.1, pp.27-33.

[3] Peng Lifang, Peng Jianhua, Meng Pengxiang (2020). Design of Control System with Stepper Motor Driving Seed-metering Device Based on PLC. Journal of Agricultural Mechanization Research, vol.42, no.2, pp.183-188.