

Stability analysis of constrained conveyor chain

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Abstract: The slideway restrained conveyor chain is a new type of chain drive configuration. Reasonable selection of various parameters is conducive to improving the performance of the chain. In this paper, a special case of the conveyor chain as the research object, calculated its stability and found out the influencing factors. The simulation results show that the polygon effect of the chain can be reduced by reducing the length of the link, increasing the radius of the sprocket and decreasing the speed of the active sprocket. It provides some reference for reducing the polygonal effect of chain drive in chute constrained chain.

1. Introduction

The polygon effect in the conveyor chain has always been one of the technical problems to be solved. The polygon effect will have a serious impact on the smooth operation of the conveyor chain[1]. Chain drive will bring obvious technical and economic benefits[2][3]. Wang Guangjian et[4] designed a new type of high-speed conveyor chain, and through simulation methods, the centroid of the chain plate and the center of mass of the pallet have an impact on the stability of the conveyor chain. Zhang Lingling et[5] verified the theoretical analysis of the angular velocity and unevenness of the driven sprocket in the ordinary chain drive through experimental methods. Yang Renmin et[6] solved the equation by the fourth-order R-K method and obtained the real-time motion state of the driven sprocket. Li Yingjie et[7] analyzed the motion characteristics of the conveyor chain from the perspective of kinematics, and analyzed some factors affecting the polygonal effect of chain transmission. Li Shujing et[8] obtained the compensation trajectory of the free pin in the large pitch conveyor chain from both statics and dynamics. In this paper, through a kind of chute-constrained conveyor chain model[9], the displacement difference of the main driven sprocket is calculated, and some factors affecting the displacement difference are found out.

2. Analysis and Calculation

The chain center line of the traditional chain drive conveyor chain and the sprocket indexing circle alternately have the phenomenon of tangency and phase cutting during the movement, which leads to the continuous change of the chain speed and acceleration, and the movement of the chain when the chain continues to appear. It is the polygon effect that exists in ordinary chain drives.

2.1. Slide Constrained Conveyor Chain Configuration

This paper establishes a transport chain model that constrains the links of the chain to a fixed orbit, as shown in Figure 2. The right driving sprocket rotates clockwise at an angular velocity $\omega_1=0.5$ rad/s. The length of each pin is $p=262$, the center of the left and right sprocket is O_2 、 O_1 , and the radius are $r=185$, and the distance between them is D . Thus, the sprocket can accommodate three pins at the same time, and the number of teeth of the sprocket is four. The pin shafts are numbered P1-P12 clockwise from the beginning to the position of the drive sprocket, which is known to be $\angle P_1O_1P_2=90^\circ$. Since the chain has a periodicity during the movement, from the pin P_1 movement to the pin P_2 , it is possible to analyze the motion of one cycle. α_1 is the angle between

P_1O_1 and positive direction of the y-axis and α_2 is the angle between P_2O_1 and positive direction of the x-axis. α_7 is the angle between P_7O_2 and the negative direction of the y-axis and α_8 is the angle between P_8O_2 and negative direction of the x-axis. In this model, α_1 equals α_2 and α_7 equals α_8 .

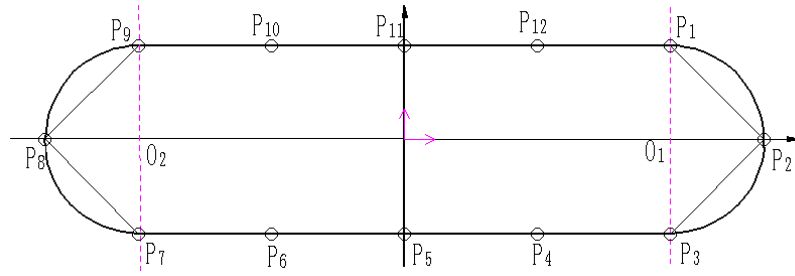


Figure 1 Trajectory constrained chain drive pin position

2.2. Polygon Effect Representation

During the movement, the pin speeds at the left and right sprocket positions vary greatly, which is the polygonal effect of the chain. In order to express the strength of the polygon effect, the displacement changes of the pin shafts of the left and right sprocket in one cycle are calculated respectively. The larger the displacement difference is, the more obvious the polygon effect is, and the more unstable the conveyor chain is. Here is the calculation process.

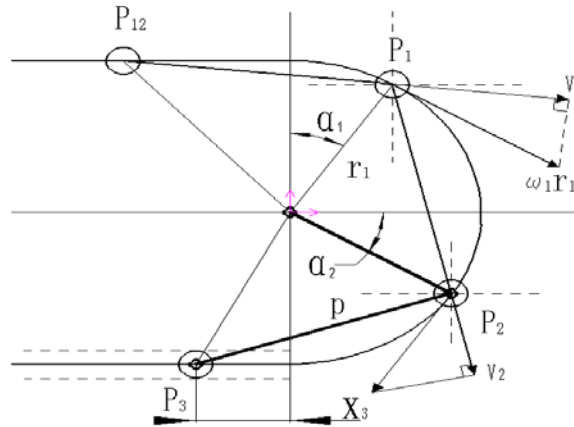


Figure 2 Speed analysis of right chain wheel

From the motion analysis diagram, the pin P_1 is on the upper semicircle of the drive sprocket, its speed

$$v_1 = \omega_1 r_1 \cos \left[\alpha_1 - \arcsin \frac{r - r \cos \alpha_1}{p} \right] \quad \alpha_1 \in [0, \frac{\pi}{2}] \quad (1)$$

When calculating the pin, the model can be converted into a crank slider mechanism. The pin is on the straight slide, and the distance from the lower cut point is recorded as shown in Figure 2.

$$x_3 = \sqrt{p^2 - (r_1 - r_1 \sin \alpha_2)^2} - r_1 \cos \alpha_2 = \left(\frac{\cos^2 \alpha_2}{2} + \sin \alpha_2 - \frac{\sqrt{2}}{2} \cos \alpha_2 \right) p \quad (2)$$

The speeds v_4 , v_5 , and v_6 of the pins P_4 , P_5 , and P_6 are equal to the speed v_3 of the pin P_3 , and the distance from the pin P_6 to the lower left point is x_6 , so

$$x_6 = D - 3p - x_3 \quad (5)$$

As shown in Figure 3, in the triangle $P_6O_2P_7$

$$\alpha_7 = \arccos \frac{r^2 + r^2 + x_6^2 - p^2}{2r_2 \sqrt{r_2^2 + x_6^2}} - \arctan \frac{x_6}{r_2} \quad (6)$$

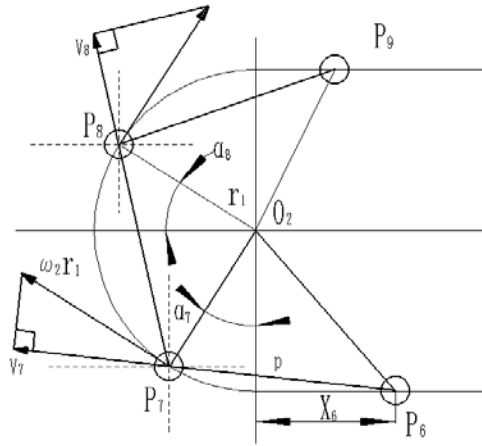


Figure 3 Left sprocket speed analysis

Pin P_8 on the upper half of the left sprocket, so

$$v_8 = \omega_2 r_2 \cos \left[\alpha_8 + \arcsin \frac{r_2 \cos \alpha_8 - r_2 \sin \alpha_7}{p} \right] \quad (7)$$

Based on the equations (1) and (9), the displacement difference can be further solved.

$$s_1 - s_8 = \int v_1 dt - \int v_8 dt = \sum_{t=0}^n \omega_1 r_1 \cos \left[\omega_1 t - \arcsin \frac{r - r \cos(\alpha'_1 + \omega_1 t)}{p} \right] t - \sum_{t=0}^n \omega_2 r_2 \cos \left[\omega_2 t + \arcsin \frac{r_2 \cos \omega_2 t - r_2 \sin(\frac{\pi}{2} + 2 \arcsin \frac{p}{2r} + \omega_2 t)}{p} \right] t \quad (n \in (0, 2 \arcsin \frac{p}{2r})) \quad (8)$$

2.3 The Influence of Different Factors on the Stability of the Conveyor Chain

It can be seen from the analysis that the factors affecting the polygon effect are r , p , etc., and the effects of the polygon effect are analyzed one by one below. Firstly, the influence of the link p on the polygon effect is analyzed. For the convenience of calculation, it is assumed that the angular velocities of the left and right sprocket are equal. It is assumed that after changing the link size p , the initial position of the pin is always at the upper right tangent point, and the initial position of the pin is at the left chain. At the midpoint of the wheel, the motion in a period $[0, 2 \arcsin(p/2r)]$ is analyzed, and all conditions except the center distance are equal. The displacement difference in the case where the link p is 222, 242, 262, 282, and 302 using matlab is as shown in FIG. 5. It can be seen from the figure that the larger the link p is, the larger the displacement difference is, that is, the more obvious the polygon effect is. Under the same conditions, the analysis of ω is 0.3, 0.4, 0.5, 0.6, 0.7, respectively. It can be seen from the figure that the larger the angular velocity, the more obvious the polygonal effect.

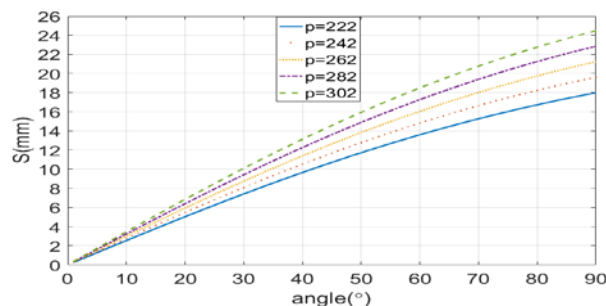


Figure 4 Effect of link length p on displacement difference

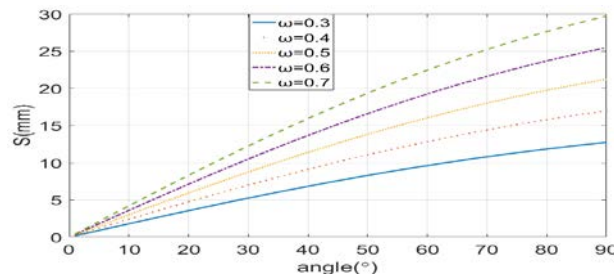


Figure 5 Effect of angular velocity on displacement difference

3. Conclusion

Through the analysis of the motion of the glide-constrained conveyor chain in special cases, a calculation method for measuring stability is obtained, and the stability is related to factors such as r and p . Under suitable conditions, the chain length can be reduced or the sprocket radius can be increased, and the driving sprocket rotation speed can be reduced to reduce the polygon effect in the chain transmission, thereby improving the stability of the conveyor chain during the movement.

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