The Design and Test Study of Low-Noise Double-Pitch Silent Conveyor Chain

Wencheng Wang

Department of Mechanical Engineering, Chengde Petroleum College, Chengde 067000, Hebei, China

Abstract

In order to reduce the impact noise of conveyor chain, a new kind of double-pitch silent chain was proposed. The structure of double-pitch silent chain plate was designed; the main design parameters were given. Its engagement process was analyzed, and the compared test about noise between double-pitch silent conveyor chain and double-pitch roller conveyor chain has been done, and the results shown that under the same condition, compared with double-pitch roller conveyor chain, when the rotating speed is equal to 300 rpm, the double-pitch silent conveyor chain's noise reduced 4.3 dB ,and the higher of the rotating speed, the larger of the amount of noise reduction, and meanwhile the variance of noise measure value of double-pitch silent conveyor chain is only 0.104,compare with double-pitch roller conveyor chain reduced by 73%. So it can be seen that the noise of double-pitch conveyor chain is lower than double-pitch roller chain and the noise fluctuation is more stable.

Keywords

Double-pitch silent chain; Structure design; Engagement process; Noise test.

1. Introduction

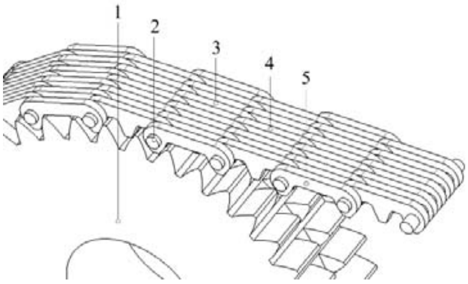
As the equipment of transporting goods and materials, chain conveyors are widely used in the fields of mechanical processing, agriculture and chemistry, etc. Double pitch roller chains are the most widely used conveyor chains. In the process of transportation, due to the polygon effect and engagement impact, loud noises are generated, which influences the conveyor's environmental friendliness [1]. Standard silent chains posses the advantages of high speed, heavy load and low noise. But, the weight of its unit length is too heavy, which makes it unable to significantly improve the noise problem caused by the engagement impact.

Domestic and foreign scholars performed a great number of researches on the vibration and noise control of chain transmission systems. Fawcett and Nichol found that lubricating oil of the proper viscosity can reduce the impact load of the chain sprocket [2]. By means of correct setup of the guiding device, the tension device and damper, the vibration and noise of the system can be effectively controlled [3]. Xiaolun Liu reduced the engagement impact and realized the goal of noise reduction by changing the structure and material of the chain roller [5-6].Meng Fanzhong, Wang Yong *et al* and their teams performed a lot of researches on silent chains. Their researches indicated that the vibration and noise can be effectively reduced by changing the meshing mechanism of the chain drive system [7-8]. Their research results are of great guiding significance to the production of domestic Hy-Vo silent chain.

Based on the silent chain meshing principle, this paper designed the structure of double-pitch silent chain, provided the main design parameters and analyzed its meshing process. Besides, using the closed force flow test bench, comparison test was performed on the noises of double-pitch silent chains and double-pitch roller chains in order to verify the design rationality of double-pitch silent chain. The test results indicate that compared with double-pitch roller chains, double-pitch silent chain's noise problem is significantly improved.

2. Structure Design of Chain Plate

The design of double-pitch silent chain aim to reduce the vibration noise caused by the engagement impact of double-pitch roller chain in the operation process of chain conveyors and to improve its environmental friendliness. As shown in Figure 1, the drive system of double-pitch silent chains is mainly composed of the double-pitch silent chain and the involute sprockets. And the double-pitch silent chains are assembled by the chain plate, the fence plate, the reinforcing plate and the cylindrical pin. The chain plate, the fence plate and the cylindrical pin are in clearance fit. The reinforcing plate and the cylindrical pin are in interference fit and riveted together.



1-involute sprocket 2- cylindrical pin 3-chain plate 4-fence plate 5-reinforceing plate

Fig.1 Schematic diagram of double-pitch silent chain system.

Figure 2 is the sketch of the structure parameters of the chain plate. It has three teeth. Among them, the lateral teeth 1 and 3 are the working teeth; they make contacts with the involute sprockets to transmit the power. Tooth 2 is the anti-friction tooth. It makes contact with the lead rail to play the roles of increasing the contact area, reducing the tooth top wear of chain plate and supporting. The main design parameters of the chain plate include the hole center distance P_0, the tooth profile angle 2α, apothem f, the distance from the crotch to the hole center h and the protruding length δ, etc. Formulas (1) to (5) give the relations between the main design parameters.

$$P_0 = 2P_1 \cos 180^\circ / z \tag{1}$$

$$2\alpha = 2\alpha_1 + 360^\circ / z \tag{2}$$

$$h = 0.06P_1 \tag{3}$$

$$f = 0.375P_1 \tag{4}$$

$$\delta = 0.1 \sim 0.3 \text{ mm} \tag{5}$$

In z —the number of small chain

P1 —the standard silent chain pitch

$2\alpha_1$ —the tooth profile angle of the standard

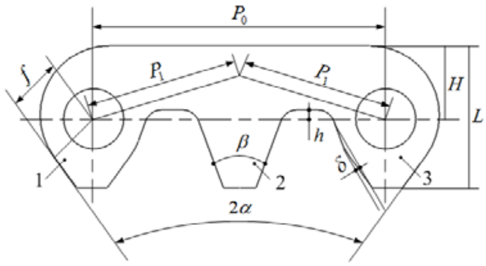


Fig.2 Sketch of the chain plate's structure parameters

3. Analysis of the engagement process

As shown in Figure 2, due to the existence of the protruding length δ in the chain plate structure, at the straightening state, in the double-pitch silent conveyor chain, the inner convex curve working tooth profile of neighboring links bulges the protruding length δ compared with the outer straight working tooth profile. This enables the double-pitch silent chains to have the internal-external compound meshing mechanism in the meshing process with the involute sprockets. Figure 3 shows the internal meshing process of double-pitch silent chain. When double-pitch silent chain mesh with involute sprockets, first, the inner convex curve tooth profile of link 2 contacts with the wheel tooth and mesh with it at point M. With the chain wheeling rolling, the included angle between link 2 and link 1 is increased. During this process, the protruding amount δ is decreased gradually and the contacting point M moves downwards along the tooth profile. When the outer straight tooth profile of link 1 starts to contact the chain wheel's tooth at point N, as shown in Figure 4, at this moment, the inner convex curve tooth profile of link 2 and the outer straight tooth profile of link 1 contact with the sprocket tooth at the same time. The sprocket continues to roll, the inner convex curve tooth profile of link 2 will retract into the outer straight tooth profile of link 1. And, it will break away from the sprocket tooth and realize the transition from internal meshing to external meshing, as shown in Figure 5. When the relative angle between link 1 and link 2 is $4\pi/z$, link 1 will enter into the location state .

The internal-external compound meshing mechanism of double-pitch silent chains decomposes the one-time engagement impact between the outer meshing silent chains and involute sprockets into three stages to accomplish, which greatly reduces the engagement impact in the operation process.

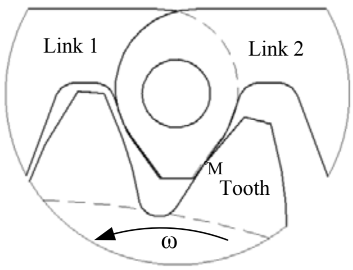


Fig.3 Schematic diagram of the internal meshing stage

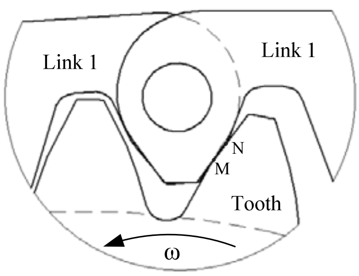


Fig.4 Schematic diagram of the simultaneous meshing stage of internal and external working teeth

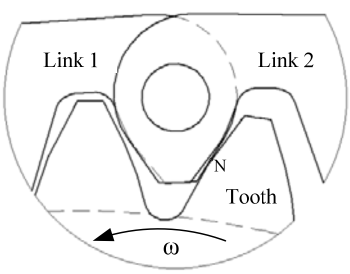
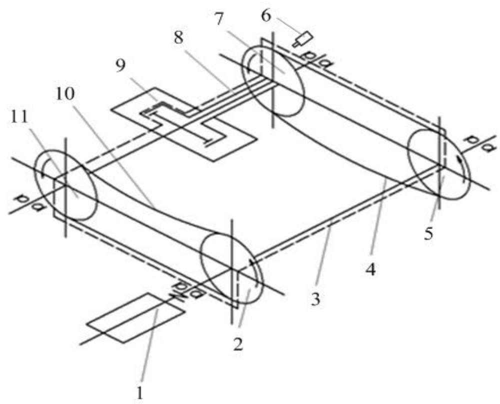


Fig.5 Schematic diagram of the external meshing stage

4. Noise test and analysis

In order to verify the improvement of the noise performance after replacing double-pitch roller chains with double-pitch silent chains, the closed force flow test bench was used to perform noise contrast test on double-pitch silent chain and double-pitch roller chain.

4.1 Test Specifications



1-electric motor 2, 5, 7, 11-chain wheels 4, 10-test chains 3, 9-axis 6-noise measuring instrument 8-loader

Fig.6 noise contrast test bench

The noise contrast test was conducted on the closed force flow test bench. TES-1358 noise measuring instrument was used for data collection, as shown in Figure 6. The test chains were double-pitch silent chains and double-pitch roller chains. The pitch was P_l=15.875 mm. The chain link number was 64. The driving sprocket's tooth number and the driven sprocket's tooth number were both 39. The chain's tight edge tension was 1.5 kN, flooding system lubrication. The noise testing speeds were respectively 300 r/min, 350 r/min, 400 r/min, and 450 r/min. The noise testing point is the tight edge meshing point of the chain drive system.

4.2 Test Results Analysis

Before conducting the noise testing, the background noise of the testing environment was 69.2 dB. When the difference between the noise testing value at the chain's tight edge meshing point and the background noise is bigger than 10 dB, the influence of the background noise on the testing value can be ignored.[10]

According to the specifications, the noise value at the meshing point of the chain transmission system at different rolling speeds were tested and the data was processed. The noise changing curve of the chain drive system under different rolling speed conditions were obtained, as shown in Figure7 and 8.

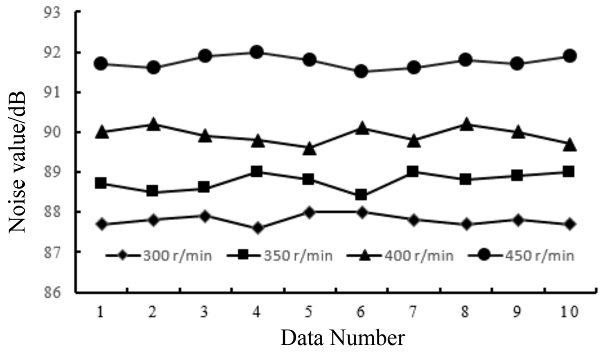


Fig.7 noise changing curve of the double-pitch silent chains transmission system

By comparing Figure 7 and 8, it can be discovered that the noise of the two testing chains' drive systems are both increased with the rolling speed increasing. But, the difference is that the testing noise of the double-pitch silent chain system increased the amounts of 0.97dB, 1.36dB and 1.82dB respectively when the speed increased every 50r/min from 300 r/min; the corresponding increasing amount of the testing noise of double-pitch roller chain system were respectively 1.7 dB, 2.07 dB, and 2.54 dB. From this we can see that with the increasing of the rolling speed, the increase range of the testing noise of double-pitch silent chain drive system is obviously lower than that of the double-pitch roller chain drive system.

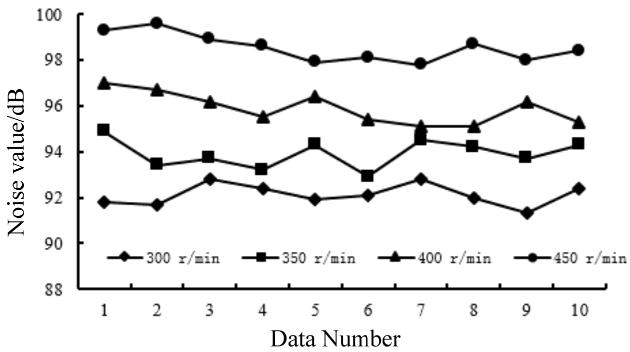


Fig.8 noise changing curve of the double-pitch roller chains transmission system

When the testing speed was 300 r/min, the expected value of the testing noise of the double-pitch silent chain drive system was 87.7 dB and the variance value was 0.104. The expected value of the testing noise of the double-pitch roller chain drive system was 92.1 dB and the variance value was 0.384. It can be seen that when the testing speed was 300 r/min, compared with double-pitch roller chain drive system, the noise of double-pitch silent chain drive system was decreased by 4.3dB and the noise fluctuate was decreased by 73%. Besides, the higher the rolling speed, the bigger the decrease amounts of their noise testing are.

The main reason why the noise performance of double-pitch silent chain is better than that of double-pitch roller chain is that the meshing pattern of double-pitch silent chain with involute sprockets is internal-external compound meshing; the engagement impact generated in its operation process is obviously lower than the direct collision of double-pitch roller chain with the chain sprockets. Reduction of the engagement impact is the main reason why the noise generated by double-pitch silent chain conveyor system is lower than double-pitch roller chain conveyor system.

5. Conclusion

The structure of double-pitch silent chain was designed and the main design parameters were given. Its meshing process was analyzed. The internal-external compound meshing mechanism of double-pitch silent chain with involute sprockets is the main reason why its noise performance is better than that of double-pitch roller chain drive system. Under different rolling speed conditions, the contrast testing was performed on its noise performance. The result shows that the noise of double-pitch silent chain conveyor system is 4.3dB lower than that of double-pitch roller chain conveyor system when the speed is 300r/min. And, with the rolling speed increasing, the noise reduction effect is more and more obvious. At the same time, the variance of the noise testing value of double-pitch silent chain drive system is 0.104 which is 73% lower than that of double-pitch roller chain drive system; the noise fluctuate is significantly decreased. It can be seen that the noise performance of double-pitch silent chain is obviously better than that of double-pitch roller chain.

Acknowledgments

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