

## Application and Research of the Chain Type Lifting Device

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**Abstract:** The overall structure design of the chain type lifting device was completed by CAD software. And the device was analyzed with theoretical calculation method. According to the actual working condition, the pressure and deformation ability of the key structure was analyzed. The result showed that the chain meets the load under actual working condition, and it will not affect its normal use. By making a real prototype for experimental, it is proved that the designed lifting device can work normally and meet the practical requirements under the working conditions. It provides a reference for optimizing design in the chain type lifting device and related experiments

### 1. Introduction

In the traditional copper electrolysis process, the use of the starting sheet process is one of the main methods for producing electrolytic copper. Under the conditions of traditional electrolytic production, it becomes more and more urgent to design the equipment related to the production site and improve the efficiency of the production. Currently, researchers domestic and overseas have conducted researches on the electro-copper starting sheet/initial sheet conveying mechanism, for example, Nikola Burasa Et al. <sup>[1]</sup> combined functional sub-modules with other product factors in the process of upgrading the intensive-segment dense transport system, which is a new system to improve the efficiency of the equipment; Researchers such as Guenther Schuh et al. <sup>[2]</sup> modularized the equipment control system to reduce the difficulty of equipment debugging based on the electrolytic copper production process; Eul-Pyo Hong et al. <sup>[3]</sup> presented a module design method that put the physical and functional relationship of product design into the consideration; Li Bingcai et al. <sup>[4]</sup> designed the electrolysis residual PLC transmission control system and evaluated the stability of the system; Guo Nianqin et al. <sup>[5]</sup> improved the copper anode plate dynamic extractor and verified the improvement method by analyzing the simulation results; Cheng Jiawei et al. <sup>[6]</sup> studied the separation problem of copper plate stripping, and solved the problem of unreasonable deflection force by establishing the flexural model simulation, which provided a theoretical reference for the subsequent picking unit.

In this paper, the theoretical calculation method is applied to analyze the lifting distance device. According to the actual working conditions, we studied the force of the chain structure under the specific angle, length and distribution mode of the copper pole piece lifting device. The results show us that the capacity of the loads it bears meets the requirement of the basic condition requirement of the production unit application. According to the physical experiment, it verified that the electrolytic copper initial pole conveying mechanism can work pretty well, which proved that the rationality and validity of the theoretical design, and provides a reference for the performance evaluation of the mechanism in future.

### 2. Model and principle of work

#### 2.1 Principle of work

In this paper, we use the original electrode sheet of electrolytic copper. Generally speaking, the initial pole piece assembled by punching and riveting in a horizontal state. After the transplanting machine converts the initial pole piece into a vertical state, the two chains are lifted all together. The

hook clamps the two ends of the copper rod on the starting piece until the starting piece is lifted to a specific height level, and the starting piece is arranged equidistantly on the storage rack by using a set of row storage module. The planner structure of the starting piece is shown in Figure 1 as follows.

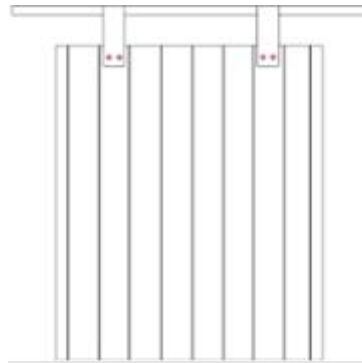


Figure 1 starting sheet

## 2.2 Structure

The lifting range machine can be divided into three modules: lifting module, electric drag, and control and storage row spacing. In this paper, we primarily focus on the lifting module, and we want to improve the row spacing structure shown as Figure 2. The lifting module generally consists of a mechanical frame body, a lifting chain, a lifting sprocket, a tensioning mechanism, a lifting chain hook and the like.

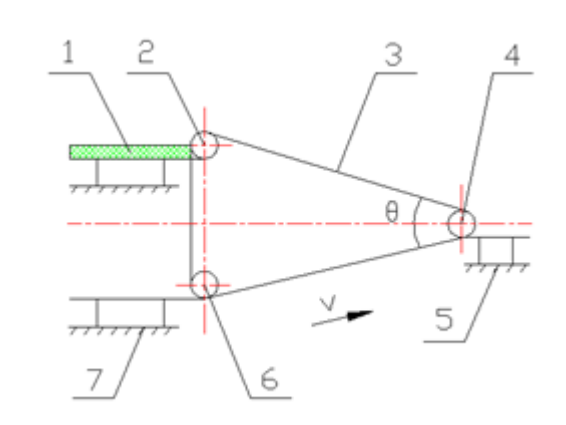


Figure 2 Lifting row structure diagram

1. Storage area; 2. Lifting sprocket; 3. Lifting chain; 4. Power input sprocket; 5. Mechanical frame; 6. Tension sprocket; 7. Mechanical frame

## 3. Structure design and force analysis of lifting row machine

The lifting row machine is an important machine for the cathode copper assembly line. Its choice is essential to the quality of operation and the production cost of the initial processing unit. At present, the commonly used chain transportation method is accepted, and a hook structure is added to the chain to prevent the initial piece from slipping during transportation. On account of failure of the chain plate will be caused by the chain transportation method, and the pin shaft will be broken over long-term application, we will analyze the structural force in the paper.

### 3.1 Structure design of lifting row machine structure

In the process of lifting the row drive, we use the difference in the gear ratio to reduce the power speed output to the intensive device, so the transport speed of the initial piece transported to the intensive device can be reduced to a very intense purpose in this case.

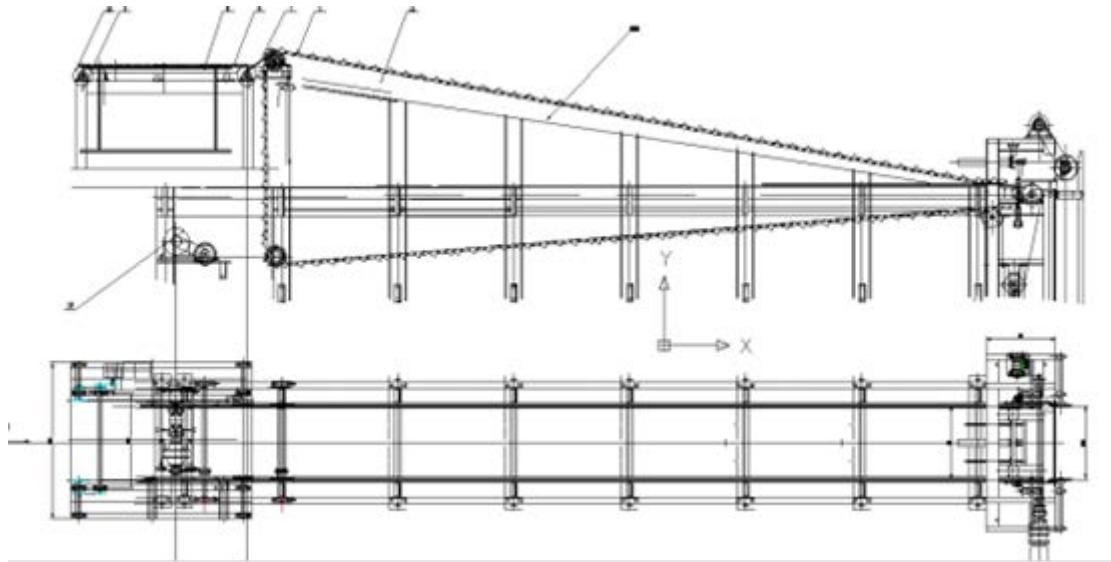


Figure 3 Design of the lifting row machine

According to the general production and the service condition, the horizontal length of the storage transport chain is designed to be 10m, the angle  $\theta$  of the power input chain is  $32^\circ$ , the height difference between the lifting sprocket and the tension sprocket is 4 meters, and the speed of the intensive-row chain is 36/h. The running speed of the chain is 0.5m/h, the motor power is 1.5kW, and the torque is 240N·m.

### 3.2 Structure design of transportation chain and force analysis

The chain-type row transfer method has the strengths of good transportation capacity, continuous transportation and high precision for example. Considering the working conditions, objects and machine functions, we choose the transport chain. In the conventional chain design, we added a hook-and-loop structure and the bumps catch the conductive bars on the pole pieces to prevent them from slipping during transportation. The storage and transportation chain design is shown in Figure 4.

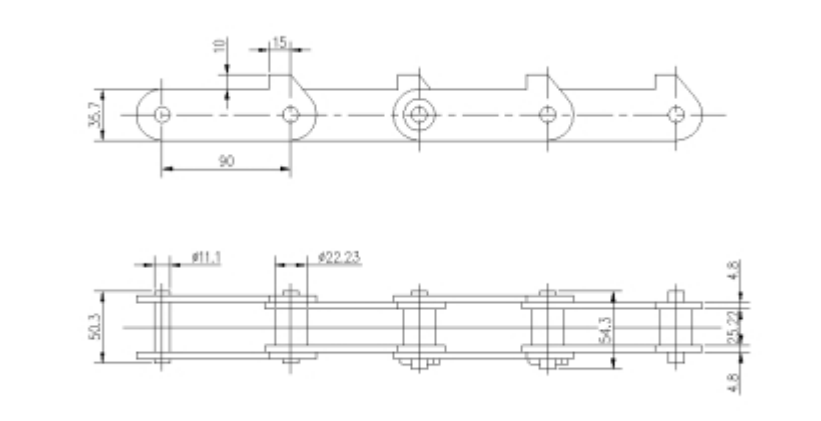


Figure 4 Transportation chain structure design

Considering that the chain between the lifting sprocket and the power input sprocket and the horizontal ground are inclined by  $\theta_1$ , the anode plate has a self-weight of  $G$ . Assuming that the chain moves at a constant speed, the instantaneous acceleration is not put into the consideration, and the force analysis of the chain when the anode plate is suspended is shown in the Figure 5.

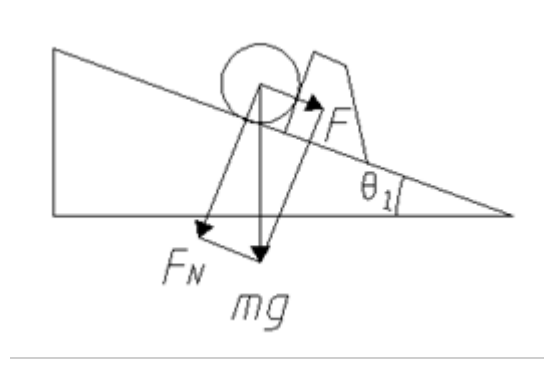


Figure 5 Force analysis of a single initial piece and transport chain

$$F = mg \sin \theta_1 \quad (1)$$

$$F_N = mg \cos \theta_1 \quad (2)$$

The copper initial sheet weight  $m$  discussed in this paper is 5 kg,  $\theta_1$  is  $20^\circ$ , and  $g$  is 10 N/kg. It is calculated that the hook structure of the sprocket is subjected to a pressure of  $F$  of 17 N, and the chain bevel will withstand a positive pressure of  $F_N$  of 47 N. It is known from experience that the positive pressure of the sprocket to withstand this size does not affect its regular use.

When the copper pole piece is evenly placed on the chain between the lifting sprocket and the power input sprocket, the chain will be bent and deformed due to the load. It is assumed that before the copper plate is placed, the tension sprocket adjusts the chain to be straight and has no arc-shaped angle. It is now discussed that the deformation of the chain after being filled with the copper pole piece is discussed.

The tensioning wheel and the power input wheel are simplified as two fulcrums of A and B. Evenly, the  $n$  copper initial pole pieces are evenly distributed to the chain, the distance between A and B is  $L$ , and the sectional deformation angle of the chain after force is  $\alpha$ . Figure 6 is a schematic diagram of force analysis of a chain under uniform load conditions.

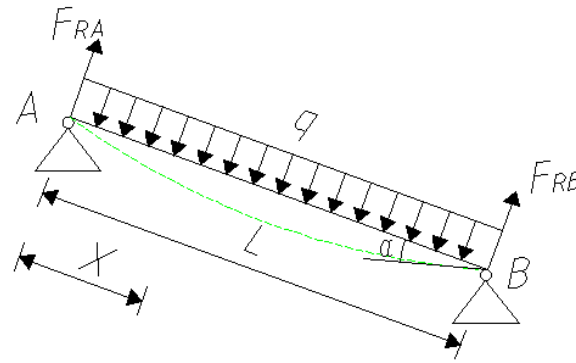


Figure 6 Schematic diagram of force analysis of the chain under even-distributed load conditions

The chain is subjected to a total pressure of  $F_{\text{total}}$  :

$$F_{\text{total}} = qL = nF_n \quad (3)$$

The binding force of the chain at the ends A and B is:

$$F_{RA} = F_{RB} = \frac{qL}{2} \quad (4)$$

The bending moment equation is:

$$M = \frac{1}{2}qxL - \frac{1}{2}qx^2 \quad (5)$$

The angle equation is:

$$\alpha = \int \frac{M}{EI} dx + C \quad (6)$$

The curve equation is:

$$\omega = \int \alpha dx + D \quad (7)$$

We know from the formula (2) ~ (7), and the constraining force  $F_R$  of the two sprocket wheels A and B is  $\frac{nmg}{2}$  N. The angle and deflection of the chain after and before deformation

$\alpha = \frac{nmgx^2}{4EI} - \frac{nmgx^3}{6EI} + C$ . While C and D are constants, E is the modulus of elasticity. I is the moment of inertia of the chain section, and E and I depends on the material and structure of the chain. Since the deflection of the A and B fulcrums is equal to 0, D is 0. If the corner angle is 0, at the midpoint of the horizontal span  $x = \frac{L \cos \theta_1}{2}$ , then C is  $\frac{nmgL^2}{16} \left( \frac{\cos^3 \theta_1}{3} - \frac{\cos^2 \theta_2}{2} \right)$ .

#### 4. Electrolytic copper initial sample experiment

The electrolytic copper initial pole lifting device we studied in this subject is designed and modified on the traditional lifting device. The device primarily includes the following parts: mechanical frame body, lifting chain, lifting sprocket, tensioning mechanism, lifting chain hook, bearing and bearing pedestal, etc. In the theory, when the tensioning sprocket is installed, the intensive copper pole pieces are evenly arranged on the chain, and there is no occurrence of the initial piece scattering and the chain warping deformation.

According to the design scheme, the prototype has a motor power of 1.5KW, a torque of 240N.m, a voltage of 380V, a theoretical speed of the intensive row chain of 36m/h, and a chain running speed of 0.5m/h. The experimental results show that the electrolytic copper initial pole lifting device can work normally, the conveying effect is more stable and no missing part occurs so far.



Figure 7. Prototype operation test

#### 5. Conclusion

In conclusion, the theoretical analysis method is used to study the lifting row device. The pressure of the chain protruding structure is analyzed respectively, and the ability of the chain deformation between the sprocket and the power input sprocket is improved. The results show that: (1) The chain can withstand the load under actual work conditions, and the deformation range is within the allowable value range; (2) Through theoretical analysis and calculation, the angle equation and deflection equation of the inclined chain subjected to even-distributed load are obtained. In future, it provides a theoretical basis for analyzing the deformation of long chains.

According to the prototype operation test, it proved that the designed lifting distance device

works regularly, the copper initial pole piece does not slip and the contact between the starting piece and the chain is not deformed, which reached the requirement under the regular working condition.

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