Improvement and Analysis of Dispatching Braking Device

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Abstract

In view of the current dispatching winch brake device there is poor braking effect, noise, poor heat dissipation and other issues. An improved scheme of replacing the block brake with a disc brake is proposed to improve the braking performance. In this paper, the design and calculation of the disc brake device are carried out, and then the kinematic analysis is carried out by ADAMS. The results show the rationality and feasibility of the scheme.

Keywords

Dispatch winch; Disc brakes; Block brakes; Kinematics simulation; ADAMS.

1. Introduction

Scheduling winches are used as lifting machinery equipment to upgrade personnel and materials, dispatch mine cars, and transport equipment in the production and life of coal mines. The braking device is one of the important components of the winch and it also plays an important role in the safety production of the mine. According to statistics, accidents caused by brake failures account for approximately 60% of the entire hoist accident[1]. Therefore, it is imperative to improve the braking performance of the braking device and improve the reliability.

1 Existing brake device

The current scheduling winch mostly uses a block brake, as shown in Figure 1.

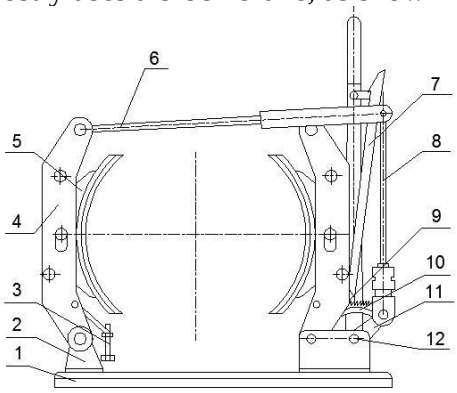


Fig.1 block brake device

1. Base 2. Right bracket 3. Adjust the bolt 4. Brake arm 5. Brake block 6. Pull rod 7. Operation handle 8. link 9. Brake claw 10. Helical plate 11. Arm brake 12. Left bracket

During braking, manual operation is required. It can be seen that the overall structure of the block brake device is complex. In particular, the connecting rod between the two brake arms involves many parts, which results in a long braking time and sensitivity. Poor, low reliability and other issues.

2. Braking device improvements

In order to solve the above problems and considering the compactness and operability of the dispatching winch structure, the improvement plan is as follows: The brake device still uses the human rocker as the power part, and the transmission part is from the liquid tank, the brake master

cylinder and the oil pipe. Composition, the implementation of the part is the use of normally open floating disc brake; it has a fast braking, high reliability, good heat dissipation and so on. The disc brake consists of a brake disc and a friction block. The structure is shown in Figure 2.

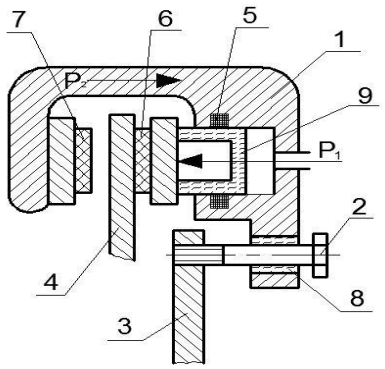


Fig.2 Structure of floating disc brake

1. Clamp body 2. Guide pin 3. Bracket 4. Brake disc 5. Sealing ring 6. Active friction block 7. Fixed friction block 8. Rubber bush 9. Wheel cylinder P1- Hydraulic force P2- Hydraulic reaction force

To prevent additional radial forces and bending moments, the brakes are arranged in pairs, as shown in Figure 3.

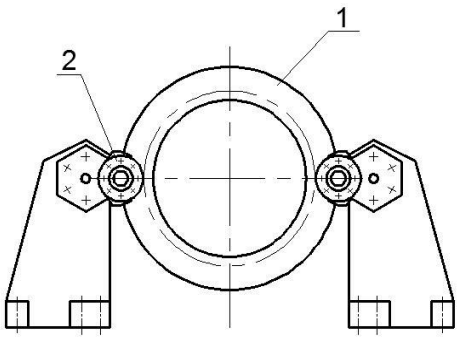


Fig.3 Disc brake layout

1. Brake disc 2. Brakes

2.1 Working principle

The disc brake is a brake caliper body that can move in the axial direction and the wheel cylinder is arranged inside the caliper. Its working process is: When the hydraulic oil enters the wheel cylinder through the oil pipe, under the action of the hydraulic force P1 thrust, the wheel cylinder piston pushes the movable friction block to press the brake disc; when the pressure continues to rise, the brake disc will give the friction block A hydraulic reaction force P2, at this time, under the action of the guide pin, the caliper body moves the fixed friction block and presses the brake disc to achieve braking.

2.2 Brake disc design

It is known that the braking torque of the dispatching winch must not be less than 3 times of the rated static moment when braking [2]。The braking torque should meet:

$$M_Z \geq 3M_j \tag{1}$$

Take JD-1 type dispatch winch as an example, the maximum static tension of the outer wire rope is 10kN [3], The maximum static moment is:

$$M_j = F_{\max} D / 2 \tag{2}$$

In the formula: D —reel diameter, take 224mm[3];

$F_{\max}$—Maximum static tension;

Total axial thrust of the brake$F$:

$$F = \frac{M_Z}{\mu R} \tag{3}$$

In the formula: R—The distance from the center of the disk to the center of rotation of the brake disk, the effective braking radius is set to 274mm[4];

μ—Friction factor, take0.35.

Due to the use of two brake brakes, according to the formula:

$$X = \frac{F}{P} \tag{4}$$

In the formula: P—The thrust of each device, N;

X—Secondary number, take2.

2.3 Brake wheel cylinder design

The relationship between the thrust P produced by the brake wheel cylinder to the friction block and the wheel cylinder diameter dw and the line pressure p is expressed as:

$$d_w = \sqrt{\frac{4P}{\pi p}} \tag{5}$$

In the formula: p—Brake line pressure, Brake oil pressure is generally not exceeded 10～12MPa[5], For disc brakes$p$=10MPa.

The working volume of the i-th wheel cylinder is:

$$V_i = \frac{\pi}{4}\sum_1^n d_{wi}\delta \tag{6}$$

In the formula: d_{wi}—The i-th wheel cylinder piston diameter;

n—Number of pistons in wheel cylinder;

δ—Piston stroke, preliminary design, take δ=3mm.

Total working volume of all wheel cylinders:

$$V = \sum_1^m V_i \tag{7}$$

In the formula:m—Number of wheel cylinders.

2.4 Brake master cylinder design

Determination of diameter d_m

The diameter d_m of the master cylinder is selected in Table 1

Table 1 brake master cylinder diameter size series

Master cylinder diameter d_m	14.5	16	17.5	19	20.5	22	24	26
	28	30	32	35	38	42	46	

Master cylinder working volume

$$V_m = V + V' \tag{8}$$

In the formula:V—The total working volume of all wheel cylinders;

V'—Displacement of the brake hose.

Master cylinder piston stroke S_m is determined by

$$V_m = \frac{\pi}{4} d_m{}^2 S_m \tag{9}$$

3. Kinematic analysis

Create a three-dimensional model of disc brakes in Solidworks, as shown in Figure 4.

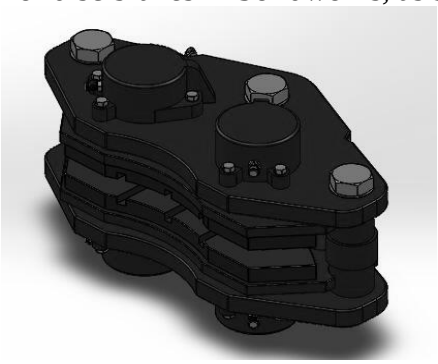


Fig.4 Disc brake three-dimensional model

3.1 Apply restraints and loads

In order to improve the simulation speed and make the result more accurate, this paper only adds constraints to the brake disc and the friction block and applies the load, and the rest simplifies the processing. Import the model into ADAMS. The resulting kinematic model is shown in Figure 5.

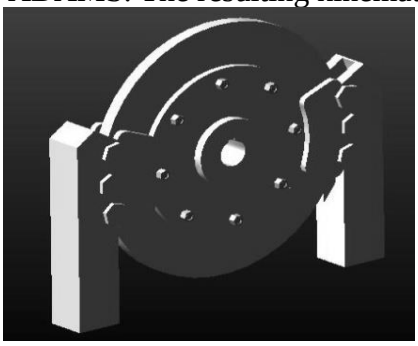


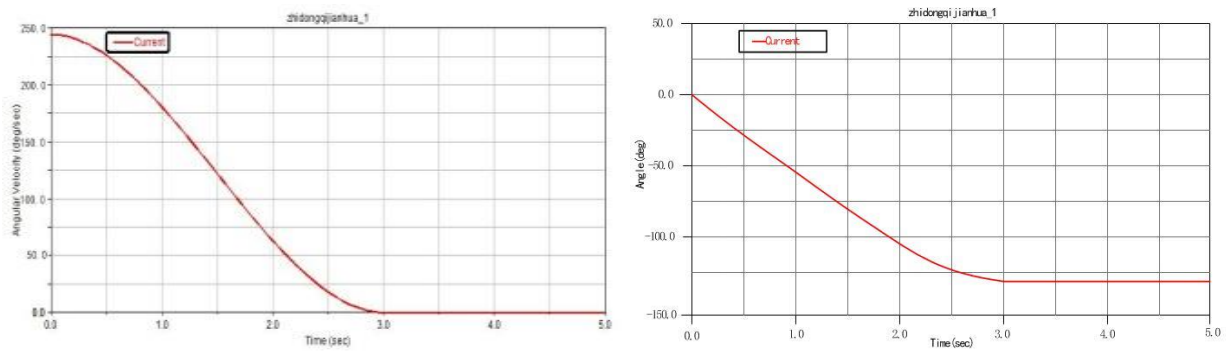
Fig.5 Kinematic model of brake and brake disc

According to the actual work situation, add the rotating pair on the brake disc and add the sliding pair on the ground to the friction block; apply the force perpendicular to the brake disc to the friction block, and add the friction block and the brake disc separately. Contact force, due to the friction between the two, so choose the IMPACT function, the collision index is set to 2.2, the contact stiffness coefficient is the system default value of 1E+5, the damping is generally 0.1%-1% of the contact stiffness coefficient, damping is set to 100, the default value of the invasion depth selection system is 0.01, the dynamic friction coefficient is set to 0.35, the static friction coefficient is set to 0.4, the dynamic friction speed is set to 100, and the static friction speed is set to 0.1[6]。

3.2 Simulation results and analysis

Add a rotary drive to the rotor of the brake disc. The initial speed is set to 240.4rad/s[3], The duration is set to 5s, the number of steps is set to 1000, and the simulation is performed. The result is shown in Figure 6.

From the results, it can be seen that the angular velocity of the brake disc changes from 240.4 rad/s to 0 rad/s after 2.8 s, it is completely braked by the brake; in this process, the angular displacement of the brake disc is 130.2°. From this, it can be seen that the disc brake device has a short braking effect from the start of braking to full braking, and the braking effect is good.



(a) Brake disc angular speed curve (b) Brake disc angular displacement curve

Fig. 6 Simulation results curve

4. Conclusion

Aiming at the problem of poor braking effect and low reliability in scheduling the winch brake device, a modified scheme is proposed in which the disc brake is used instead of the block brake as the execution part and the oil pipe and the master cylinder are used as the transmission part. The relevant parameters of the device are first calculated, then the three-dimensional model of the braking device is established, and finally the model is simulated and analyzed. Through the above studies, it can be found that: 1) The improved scheme can achieve the braking requirements of the dispatching winch; 2) According to the simulation results, the solution is sensitive and the braking effect is good; 3) The transmission part of the scheme has a simple structure and improves the braking. The reliability.

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