International Journal of Recent Engineering Science (IJRES),
ISSN: 2349-7157, *Volume 4 Issue 3 May to June 2017*

Analysis of the Pneumatic Braking System Optimization Balancer

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Abstract:

This article describes the structure and working principle of pneumatic balancer emergency braking system, the braking effect of the emergency braking system theoretically calculated and analyzed by finite element software ANSYS line of brake system crash simulation analysis of its structure optimized to improve the braking system in unexpected braking reliability and safety when falling, pneumatic balancer to promote domestic research and to break the foreign monopoly of the pneumatic balancer technology is of great significance happened lifting objects.

Keywords : *pneumatic balancer,braking system, theoretical analysis and calculation,ANSYS finite element simulation,structural optimization*

I. INTRODUCTION

At present, pneumatic balancer has been widely used in mechanical industry for its advantages such as no gravity, high precision and good reliability.In the process of lifting workpieces, the pneumatic balancer uses the working process of the gas pressure in the cylinder and the gravity balance of the hoisting workpiece.

II. BRAKE SYSTEM ANALYSIS AND OPTIMIZATION

Pneumatic balancer in the course of work may be a sudden separation of the workpiece from the hook and lead to a sudden rapid rebound phenomenon, the personal safety of the staff will pose a great threat. In order to avoid the above emergency, a pneumatic brake system is needed.

A. Composition and Working Principle of Braking System

The brake system is composed of two parts: the brake disc(Fig.1) and the fixed frame(Fig.2). Emergency brake disc is mainly composed of upper, middle, chassis, centrifugal block, spring, rotating pin and other components, the centrifugal block can rotate around the rotating pin.


Fig.1 : brake disc Fig.2 fixed stop

Emergency braking system working principle: in normal work, the centrifugal block in the spring tension, in the state of recovery. When the lifting object suddenly falls, the emergency brake disc is driven to produce a large angular acceleration. Under the action of the angular acceleration, the centrifugal block produces a force of inertia along the radial direction. When the inertia force is greater than the spring force, the centrifugal block rotates around the rotating pin and is thrown out. When the centrifugal block is thrown out, the utility model can be quickly stuck in the clamping groove of the fixed stop to realize the emergency braking function.

B. Critical State Analysis of Brake Disc

Firstly, the structure of brake disc is simplified, and the structure diagram of brake disc is obtained (Fig.3). Among them, O is the center of rotation of the brake disc and the OA segment is from the center of rotation of the brake disc to rotate between the center of the centrifugal block distance, AB represents the centrifugal block, in which the centrifugal block C tension spring, and the spring force under the action of centrifugal OB block B with the end of the brake disc contact.

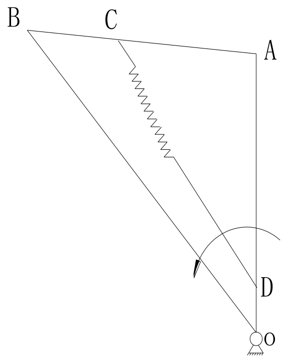

Fig.3 Structure Diagram of Brake Disc

Assuming that the quality of the workpiece is m, the torque generated by the compressed air in the cylinder is:

$$M = mg \cdot R_{drun} \quad (1)$$

Total moment of inertia:

$$J_{\text{total}} = J_{\text{drum}} + J_{\text{screw}} + J_{\text{brake disc}} \quad (2)$$

The calculation :

$$\mathrm{J_{total}} = 8.714 \times 10^{-3} \mathrm{kg \cdot m^2}$$

Under the action of the torque M, the angular acceleration produced by the emergency brake disc is:

$$\alpha = \frac{M}{J_{total}} \quad (3)$$

When the B end of the centrifugal block is separated from the brake disc, the binding force of the brake disc to the B of the centrifugal block is zero. At the same time, the angular velocity of the brake disc is the angular acceleration of the center of gravity of the centrifugal block, and the tangential line acceleration is a. Centrifugal block is selected as the research object, The mass of the centrifugal block is $m_1 = 3.52 \times 10^{-2}$kg, he force (including inertia force) of the centrifugal block is shown in Figure 4, in which the inertia force of the centrifugal block is:$F_{Ie} = m_1 \cdot a$,

$a = \alpha l_0$.

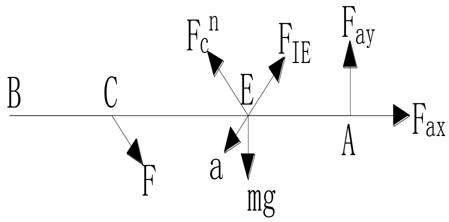

Fig.4 Centrifugal Force

The geometry of the centrifugal block is shown in figure 5:

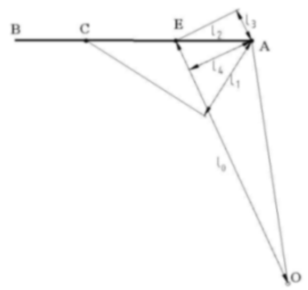

Fig.5 Geometric Relationship of Centrifugal Force

For the moment of the centrifugal block A, according to D'Alembert principle column equilibrium equation can be got:

$$\sum M_A = F_{\text{elastic}} l_1 + g m_1 l_2 - F_{Ie} l_3$$

$$-F_e^n l_4 = 0 \quad (4)$$

Which, , $F_e^n = m_1 \omega^2 l_0$, $F_{elastic} = 4N$, $l_0 = 44mm$, $l_1 = 4mm$, $l_2 = 5.25mm$, $l_3 = 1.5mm$, $l_4 = 5mm$, $\alpha = 0$, (Basic uniform motion at work) Formula 4 critical $\omega = 120.3 rad/s$, The maximum speed of the object is raised by the pneumatic balancer V= 1.5m/s,

The angular velocity of the brake disc is equivalent to 25rad/s, its value is far less than 120.3rad/s, so the lifting objects in normal speed range, the brake disc will not play a role in braking, braking only at the time of the accident.

C. *Brake Disc Braking time Analysis*

During the operation of the emergency brake disc, when the centrifugal block is thrown out during the time Δ_t interval of the emergency brake disc to realize the braking function, the air pressure of the cylinder is unchanged, and the brake disc generates angular α acceleration instantly and remains unchanged.

$$\omega = \Delta_t \times a \quad (5)$$

In formula (4), get the value of Δ_t,

The relationship between the braking time Δ_t and the weight of the lifting object m is shown in figure 6.

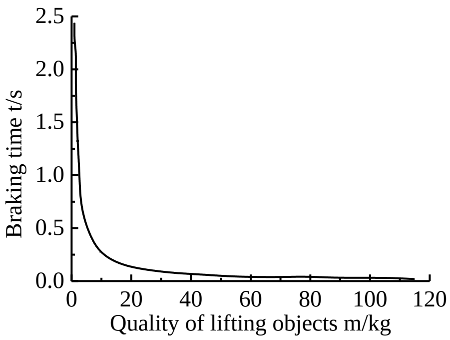

Fig.6 Braking System Braking Time

It can be seen from the analysis that the braking time is short and the braking performance is good and reliable.

D. Brake Disc Braking Distance Analysis

After the lifting of heavy objects, lifting hook distance of h,

$$h = \frac{1}{2}\alpha\Delta_t^2 R_{drum} \quad (6)$$

The lifting distance of the hook can be inversely proportional to the weight of the lifting object by the formula, and the relationship diagram is shown in figure, as shown in figure 7.

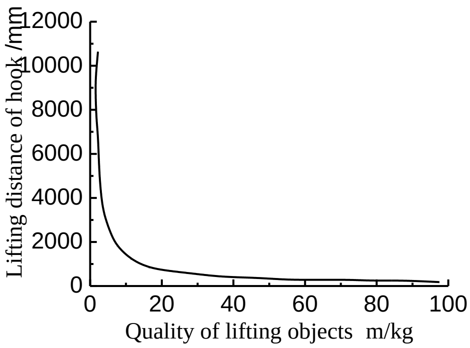

Fig.7Lifting Distance of Hook

The analysis shows that the braking distance of the emergency braking system is short and the braking performance is good and reliable.

1) Transient Analysis of Brake Disc

When the centrifugal block is thrown, the speed is relatively fast, and the impact force of the fixed retaining frame is relatively large.

The linear velocity V_1 before the impact of the centrifugal block is related to the angular acceleration of the brake disc and the braking time Δ_t.

$$V_1 = \alpha\Delta_t R_{drum} \quad (7)$$

The α、Δ_t respectively, into the formula, the value of V_1.

The linear velocity V_1 before the impact of the centrifugal block to the fixing frame is related to the mass m of the lifting object,as fig.8 shows.

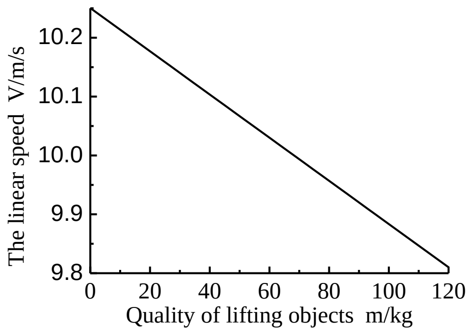

Fig.8 The Linear Velocity of the Centrifugal Block Impacting the Fixing Frame

As can be seen from figure 8, the linear velocity of the centrifugal block decreases with the increase of the weight of the lifting object, but it is basically constant,$V_1 = 10\text{m/s}$.

Results show: $\sigma_{max} = 600\text{N/mm}^2 > [\sigma]$,$[\sigma] = 530\text{N/mm}^2$(Material 45 steel), The impact strength of the centrifugal block on the brake disc can not meet the requirement of strength, so the structure of the brake disc is improved, and two pin shafts are added at both ends of the centrifugal block, and the model is shown in Figure 10.

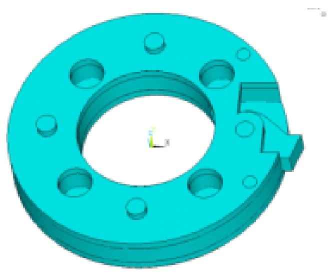

Fig.9 Brake Disc Simulation Model

Torque, load and boundary conditions are analyzed and the results are shown in figure 11.

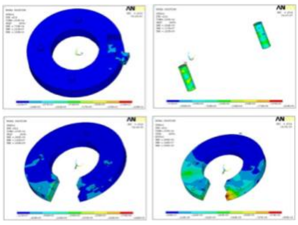

Fig.10 Simulation Results Analysis

According to the analysis results, we can see that the improved brake disc$\sigma_{max} = 397\mathrm{N/mm}^2 < [\sigma]$, brake system strength to meet the use requirements.

2) *The Experimental Results are Verified*

The processing of real braking system as shown in Figure 12, for their experiments as shown in Figure 13, the real simulation of hoisting object crash, we can see that the pneumatic balancer in the object falling to instantaneous emergency braking action, the strength to meet the use requirements, and good braking effect.

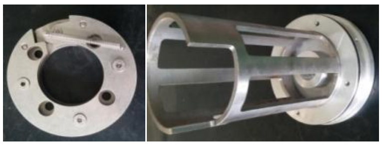

Fig.13: Experimental Drawing

III. CONCLUSIONS

(1) In this paper, the structure and working principle of the pneumatic brake system are analyzed in detail, which lays a theoretical foundation for further study of the centrifugal block braking system.

(2) In this paper, based on the finite element analysis software ANSYS, the transient analysis of the brake disc is carried out, and the structure of the brake disc is optimized according to the analysis results, which improves the reliability and safety of the brake system.

(3) In this paper, the results of theoretical analysis and software simulation are verified by real experiments.

(4) The research content of this paper is of great significance to promote the research of pneumatic balancer in China and to break the monopoly of pneumatic balancer abroad.

REFERENCE

[1] Yang Zhiyong, Han Jianmin, Li Weijing, Chen Yue, Wang Jinhua.hot brake disc during braking - mechanical coupled simulation [J]. Mechanical Engineering, 2010,02: 88-92.

[2] Hu Wenjie Chen Liang.optimization car disc brakes iSIGHT based multidisciplinary design [J]. Agricultural Machinery, 2010,05: 17-20.

[3] Wang Tingyi, LvPengmin, LanJiguang, Li Yujie, Meng Tie.drum brake kinetics simulation [J]. Chinese Journal of Highway, 2010,06: 115-120.

[4] Yuan Wei. Drum brake temperature computing model and its application [D]. Chang'an University, 2003.

[5] Yang Longbao.based ANSYS Workbench automotive disc brake performance analysis [D]. Guangxi University, 2013.

[6] AnYing.Brake flexible multibody simulation analysis [D]. Jilin University, 2006.

[7] MengXingbao.based brake friction heat ANSYS analysis [D]. Yanbian University, 2014.

[8] Liu Changliang. Drum brakes and brake performance optimization dynamics analysis [D]. Jilin University, 2011.

[9] Shi Jinzhu, Zhang Hongxin, HaoYingjie, Liu Gaojun, ZhangGuisen.Keys based drum brake force [J].Qingdao University (Engineering and Technology), 2014,04: 79-82.