RESEARCH ON OPTIMIZATION OF NIPPER MECHANISM ON CM500 COMBERS USING ADAMS

ADAMS KULLANARAK CM500 PENYE MAKINELERİNDE KISKAÇ MEKANİZMASI OPTİMİZASYONU ÜZERİNE ARAŞTIRMA

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ABSTRACT

Comber is one of the important equipments on cotton yarn spinning. In this paper, the research on optimization of nipper mechanism on CM500 series Combers was discussed using ADAMS software. First, the nipper mechanisms moving characteristics of CM500 Combers was analyzed and the models of displacement, velocity, acceleration of nipper balance shaft were given. Then, the optimization of nipper system was discussed by using ADAMS software, and corresponding optimal crank radius was addressed. The simulation results show that vibrations of nipper are decreased significantly by optimization. The results obtained in this paper provide a theoretical support for product design.

Keywords: Comber; Nipper mechanism; Optimization; ADAMS; Simulation.

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1. INTRODUCTION

Comber is one of the most important equipments on cotton yarn spinning, in which the short fiber, neps and impurities could be removed and cotton fibers can be straightened and parallel [1]. Therefore, the researches on comber have been attracting more and more attentions recently, and many interesting results have been established [2-8]. Especially, with the constant requirements of high-quality yarn, the combing process become more and more important on yarn spinning and the speed of combers is also more and more quickly. However, with the increasing of comber speed, the noised vibration becomes more and more serious and takes unfavorable influence on carding. Therefore, the noised vibration is the most key factors influencing the comber speed [1]. Nipper mechanism is one of the most important components of comber. It has been found that the middle shaft system of headstock and nipper mechanism is the main components to produce the noised vibration [2]. Therefore, it is important to optimize the dynamic balance of the headstock middle shaft system and nipper mechanism in order to improve the performance of comber.

For nipper mechanism, the movement of balance shaft is the main factor producing noised vibration. ADAMS is one of most important software in analyzing mechanical movement [9]. Motivated by all these research works, this paper attempts to investigate the optimization of nipper mechanism on CM500 series Combers. The nipper mechanisms moving characteristics on CM500 Combers has been analyzed and the models of displacement, velocity, acceleration of nipper balance shaft have been given. Then, the optimization of nipper balance shaft has been discussed by using ADAMS software, and corresponding optimal crank radius has been presented.

2. MOVEMENT MODELS OF NIPPER BALANCE SHAFT
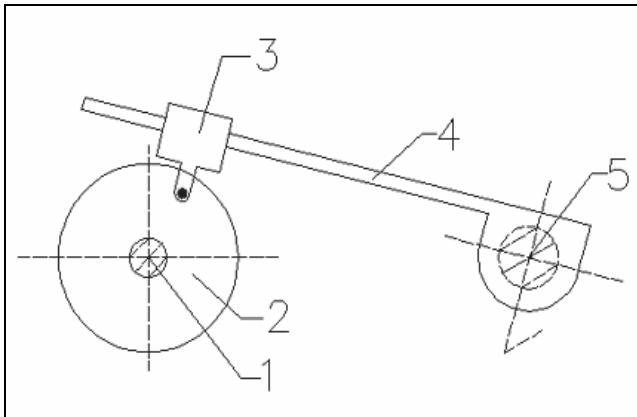
1 Axis of cylinder, 2 Flange, 3 Sliding sleeve, 4 Sliding bar,
5 Balance shaft
Figure 1. The diagram of nipper driving mechanisms
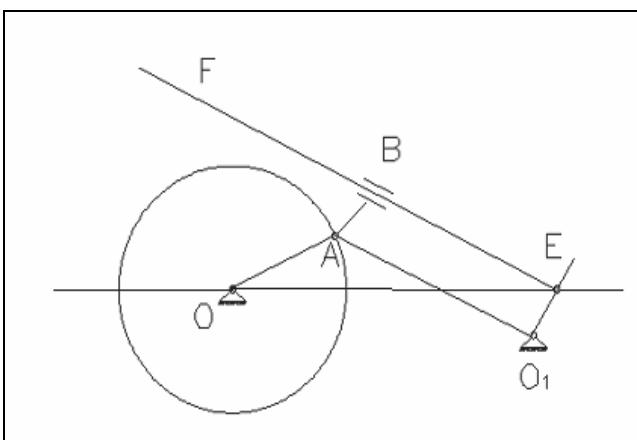
Figure 2. The geometric structure of nipper driving mechanisms
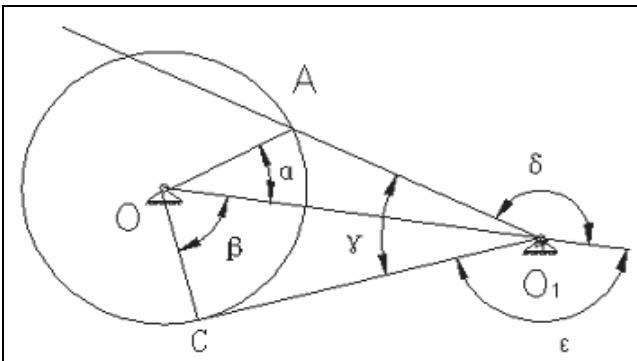
Figure 3. The simplified geometric structure of nipper driving mechanisms

The nipper driving mechanisms is shown in Figure.1. When the flange rotates a round with the driving of cylinder, the nipper balance shaft swings one time through sliding sleeve and sliding bar. Corresponding geometric structure of nipper driving is shown in Figure.2. For easy to analyze, the simplified geometric structure is shown in Figure.3. In the following, the models of displacement, velocity, acceleration of nipper balance shaft will be given according to the moving characteristics of nipper.

In Figure.3, points O and O_1 are the axis of cylinder and nipper balance shaft respectively, A is the contact point between sliding bar and flange, and OA is crank radius. The coordinate can be established by choosing O as origin and OO_1 as x-axis. α is the angle between OA and x-axis, β is the angle between the front-end of balance shaft OC and x-axis, δ and ε are the angles between x-axis and OA and OC respectively, γ is the angle between OA and OC. Then, we can get the following equations.

$$\alpha + \beta = 9 \times i \tag{1}$$

$$\cos \beta = \frac{r}{L} \tag{2}$$

$$\gamma + \beta + \delta = 270 \tag{3}$$

$$\overrightarrow{OA} + \overrightarrow{AO_1} = \overrightarrow{OO_1} \tag{4}$$

Here, $i = 0, 1, \cdots, 40$ is the indexing.

Then, according to equations(1), (2) and (4), we have

$$\tan \delta = \frac{-r \sin \alpha}{L - r \cos \alpha} \tag{5}$$

Here, $r = OA$ is the crank radius and $L = OO_1$.

Then, according to equations (3), (4) and (5), we have

$$\gamma = 270 - \beta - \arctan \frac{-r \sin \alpha}{L - r \cos \alpha} \tag{6}$$

Then, according to equation (6), we have

$$\omega_1 = \frac{r(r - L \cos \alpha)}{L^2 + r^2 - 2rL \cos \alpha} \times \omega \tag{7}$$

After differential operations on each side of equation (7), we have

$$a = \frac{rL(r^2 - L^2) \sin \alpha}{(L^2 + r^2 - 2rL \cos \alpha)^2} \times \omega^2 \tag{8}$$

Here, ω_1 and ω are the angular velocity of nipper balance shaft and cylinder respectively, a is the angular acceleration of nipper balance shaft.

3. THE OPTIMIZATION OF NIPPER SYSTEM

### 3.3.1 The simulation model of nipper system
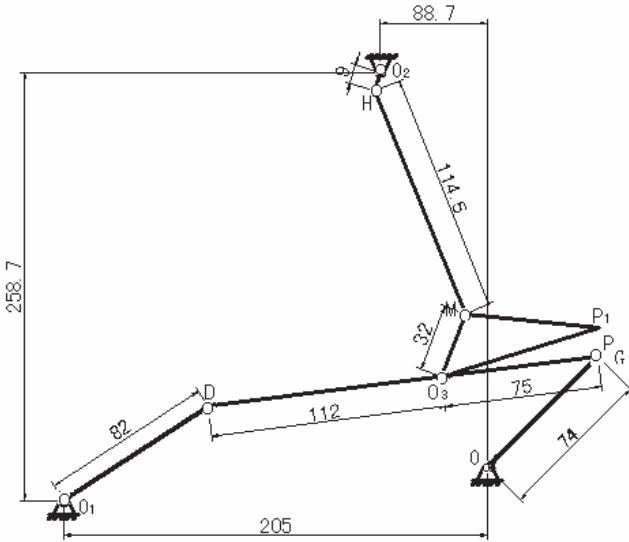
**Figure 4.** The nipper driving diagram
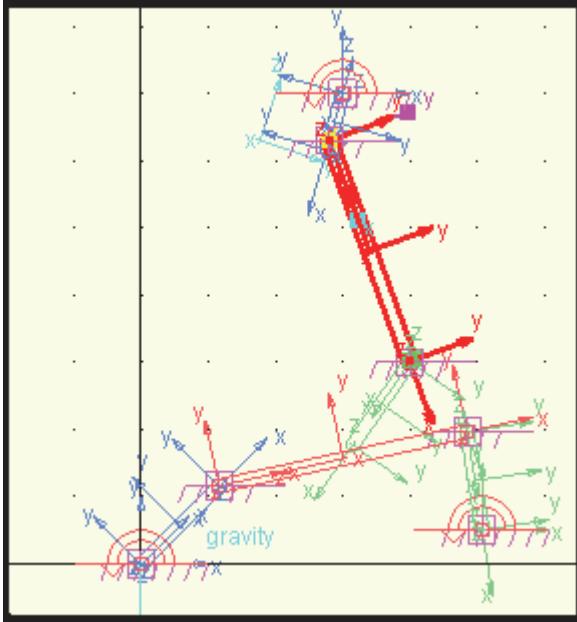
Figure 5. The simulation model of nipper driving system

The movement process of nipper is shown in Figure.4. The upper nipper is fixed on nipper balance shaft DG, and the lower nipper O_3MP_1 do opening-closing movements following with the backward and forward swing of upper nipper. Then, the simulation model of nipper system can be presented in Figure.5 by using ADAMS software.

3.3.2 The optimization of nipper balance shaft

By using ADAMS software, the simulation of the force of teeth coincidence point P before optimization is shown in Figure.6, and the termination time is 5.0s. In the following,

the optimization for the force of point P will be discussed by using ADAMS/View Module. During optimization, the crank radius O_1D is chosen as design variable, the minimum value of the force of point P is chosen as optimization objective. After optimization, the force simulation of point P is shown in Figure.7.
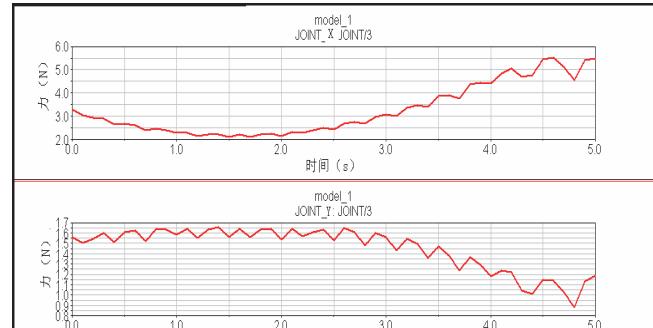

(a) From 0° to 43.94°
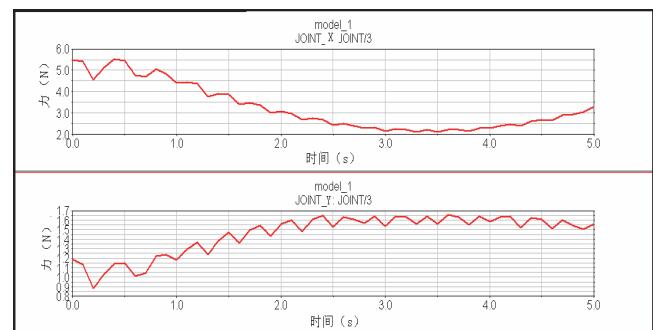
(b) From 43.94° to 0°

Figure 6. The force of teeth coincidence point P before optimization
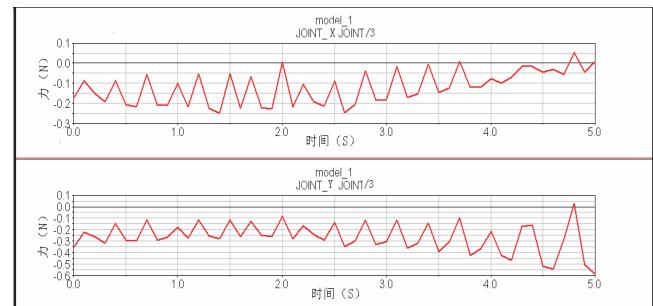
(a) From 0° to 36.41°
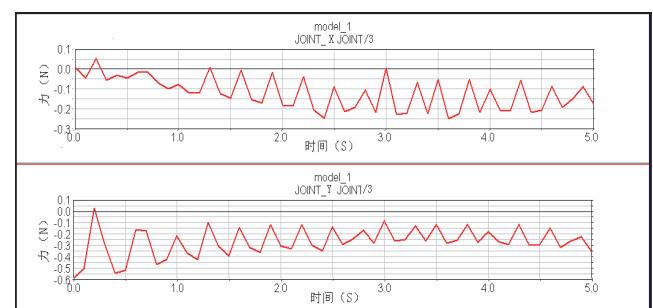
(b) From 36.41° to 0°

Figure 7. The force of teeth coincidence point P after optimization

Table1. The force components of P

The force of P (N)	Before optimization	After optimization
F_x (min)	0.89	-0.25
F_x (max)	1.65	0.05
F_x (av.)	1.45	0.01
F_y (min)	2.11	-0.59
F_y (max)	5.52	0.03
F_y (av.)	3.27	0.02

The amplitude of the force of point P is shown in Table 1. It is shown that the amplitude decreases obviously after optimization. The dynamical performance of nipper system is shown in Table 2. It is shown that the amplitude of angular displacement, angular velocity and angular acceleration of nipper system all decreases obviously after optimization. That is, the vibrations of nipper system are decreased significantly after optimization, which verifies the effectiveness of optimization.

4. CONCLUSIONS

In this paper, the optimization of nipper system of CM500 series Combers has been investigated by using ADAMS software. The models of displacement, velocity, acceleration of nipper balance shaft have been given according to moving characteristics of nipper system. Then, the optimization of nipper system has been discussed using ADAMS software, and corresponding optimal crank radius has been given. Finally, the simulation results have been given and the effectiveness of optimization has been verified. The results obtained in this paper provide a theoretical support for product design.

Table2. The dynamical performance of nipper system

	Crank radius	Angular displacement (max)	Angular velocity		Angular acceleration	
			max	min	max	min
Before optimization	77.5mm	43.94°	21.8	-9.95	896.11	-893.41
After optimization	65.5mm	36.41°	16.78	-8.75	637.3	-642.29

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