Study on Dynamic Characteristics of Shearer Walking Mechanism

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Abstract

In order to study the dynamic characteristics of shearer walking mechanism, the force balance equation and rigid body dynamic equation of shearer walking wheel were established. The meshing collision simulation model of shearer walking mechanism tooth pin was built on the basis of digital model of walking mechanism. The changing curve of the contact force and the motion state curve of the walking wheel are obtained through simulation. The results show that the average contact force of running wheels is basically 600 kN, and the average traction speed is 0.15 m/s less than the theoretical speed. The periodic fluctuation of contact force curve accords with the actual meshing condition and has good consistency with the change curve of velocity and acceleration.

Keywords

Walking wheel, dynamic characteristics, contact force.

1. Introduction

Shearer is the main working equipment in the mechanized production of coal mining face, which plays an important role in the safe and efficient production of coal mine. With the continuous development of large mining height mining technology, the application of full height mining technology in medium and thick seam mining is more and more widely [1], which puts forward higher requirements for shearer traction performance. At present, the gear pin meshing traction part is the most widely used haulage mode of high-power shearer, and the failure of running wheel is the most common fault form of this haulage mode. The increase of mining height directly leads to the increase of traction load, which requires higher strength and overload performance of the traction part. The reliability of haulage part is an important index which affects the overall performance of shearer and restricts the efficiency of mining face[2]. Relevant scholars[3-6] at home and abroad have done a lot of research work on dynamics analysis, strength analysis and modal analysis of traction part. Compared with other gears in the traction transmission system, the meshing environment of the walking wheel in the walking mechanism is worse and the working conditions are more complex. Therefore, it is very important to study the dynamic characteristics of shearer traction mechanism for shearer design optimization and safety protection.

2. Theoretical Analysis

According to the meshing mechanism of the gear pin of the walking mechanism, the force state of the meshing point is analyzed, and the mechanical state equation is established as follows:

$$\left.\begin{aligned} F_t &= \frac{2T}{d} \\ F_n &= \frac{F_t}{\cos\alpha} \\ F_r &= F_t\tan\alpha \end{aligned}\right\} \quad (1)$$

Formula: Ft is the effective traction force; T is the walking wheel torque; D is the walking wheel indexing circle diameter; Fn is the meshing point normal force; Fr is the radial force; α is the pressure angle.

The driving wheel engages with the driving wheel to obtain the torque input and drives the Shearer to move by engaging with the pin tooth. References, see Fig. 1 is a simplified model of the walking mechanism, and the dynamic equation of the engaging contact of the driving wheel is established:

$$\begin{cases} J_1 \ddot{\theta}_1 + c_1 R_1 (R_1 \dot{\theta}_1 - R_2 \dot{\theta}_2) + k_1 R_1 (R_1\theta_1 - R_2\theta_2) = T_1 \\ J_2 \ddot{\theta}_2 - c_1 R_2 (R_1 \dot{\theta}_1 - R_2 \dot{\theta}_2) - k_1 R_2 (R_1\theta_1 - R_2\theta_2) + c_2 R_2{}^2 \dot{\theta}_2 + k_2 R_2{}^2 \theta_2 = T_2 \end{cases} \quad (2)$$

In the formula: J1 and J2 are the rotational inertia of driving wheel and running wheel respectively; R1 and R2 are the pitch radius of driving wheel and running wheel respectively; T1 and T2 are the torque of driving wheel and running wheel respectively; K1 and C1 are the integrated meshing stiffness and damping of running wheel and driving wheel respectively; K2 and C2 are the integrated meshing stiffness and comprehensive damping of running wheel and pin row respectively. Meshing damping; θ1 and θ2 are driving wheels and running wheels.

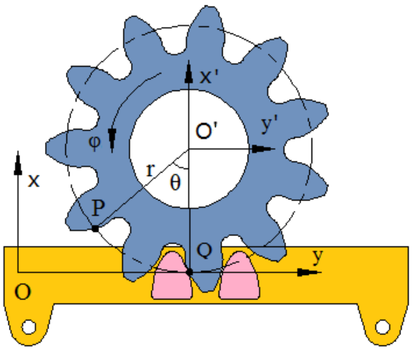

Fig 1. Simplified model of walking mechanism

3. Modeling and Simulation

3.1 System Modeling

he three-dimensional model of walking mechanism is imported into the dynamic simulation software, and the material attributes are defined by setting density, Poisson's ratio and elastic modulus, and the dynamic simulation model of walking mechanism is constructed. During the actual operation of the shearer, the pin row is fixed and the running wheel rolls along the pin row. For easy operation, the model is equivalent to the horizontal movement of the pin and drainage, and the fixed axis rotation of the running wheel. Therefore, the pin row can only move horizontally and restrict the remaining degrees of freedom, adding angular speed drive for the walking wheel and restricting the remaining degrees of freedom. Suppose that the ideal traction speed of the shearer is v=12.5 m/min, and add angular speed drive for the shearer running wheel, add load function according to the ideal load balance condition of the two running wheels, References, see Figure. 2. The contact stiffness coefficient, maximum contact damping, nonlinear force index and friction coefficient are set up based on the contact force equation of pins[7].

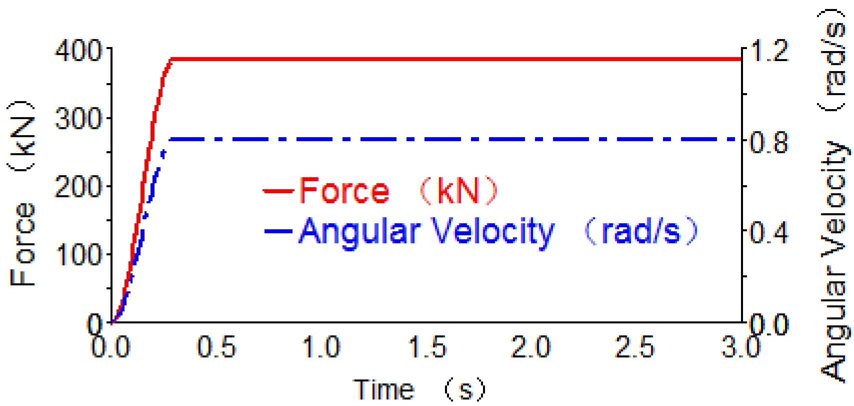

Fig 2. Drive loading function

3.2 Simulation Analysis

The curve of contact force of the wheel under ideal working condition is obtained through simulation and analysis, References, see Figure. 3. The average contact force of the traveling wheel is basically maintained at 600kN, which provides a theoretical basis for the strength analysis of the travelling wheel. The contact force fluctuates regularly, which is consistent with the actual situation of the periodic meshing of gear teeth. The analysis of the fluctuation provides a theoretical reference for the study of gear meshing. By adjusting the design parameters of the running wheel, the meshing quality of the tooth pin can be improved, which provides a basis for optimal design of running wheel.

Through simulation, the curve of wheel movement state under ideal working condition is obtained, References, see Figure. 4. The average velocity of the traveling wheel is 0.15m/s, which is less than the theoretical value 0.208m/s. This phenomenon is mainly due to the engagement gap and contact friction in the actual running process. The fluctuation trend of velocity and acceleration curve is basically consistent with that of contact force curve. It is of great significance to analyze the abrupt change of velocity curve for studying vibration and noise of shearer's running part.

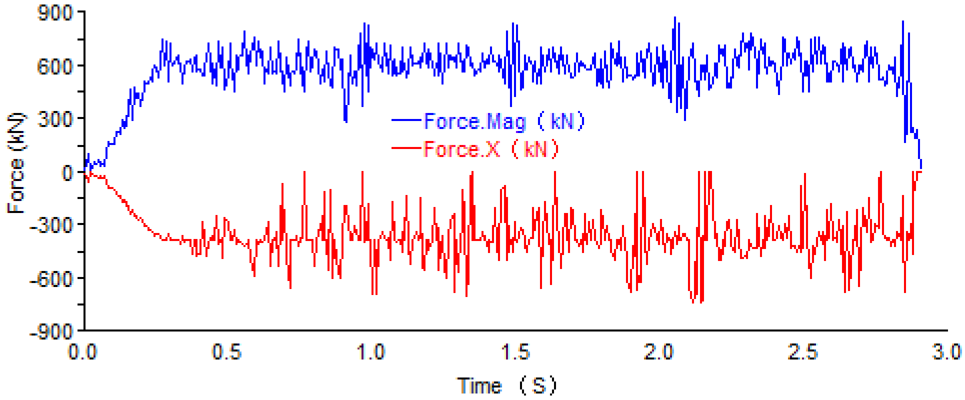

Fig. 3 Curve of contact force of walking wheel

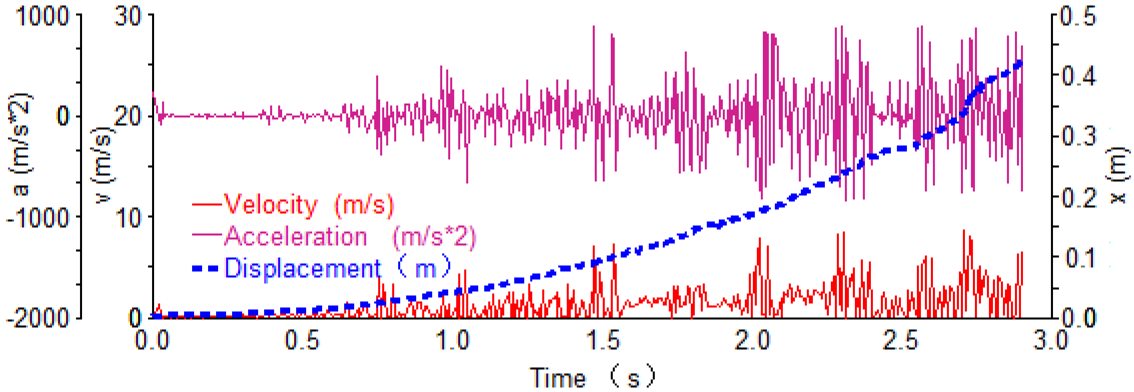

Fig 4. Motion curve of walking wheel

4. Conclusion

Taking the shearer running mechanism as the research object, the statics balance equation and rigid body dynamic equation of the running wheel are established, which provides the theoretical basis for the dynamic characteristic analysis of the walking mechanism. The three-dimensional digital model of the walking mechanism is established, and the meshing and collision simulation model of the tooth pin is established based on the contact force equation of the tooth pin. The contact force curve of the running wheel is obtained by simulation, which provides a theoretical reference for the optimization design and strength analysis of the running wheel. Through the analysis of the motion state curve, it is found that the actual average traction speed is less than the theoretical value, and the change trend of speed and acceleration is basically consistent with the contact force. By obtaining the instantaneous movement state of the walking wheel, it can provide reference for the movement monitoring and fault warning of the shearer.

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