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Study on the Impact Damage Characteristics of the Middle Slot of the Scraper Conveyor

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Abstract. The scraper conveyor is vital for mine production but is susceptible to impact damage from falling coal during shearing. However, scholars have conducted limited research on wear patterns in the middle trough of scraper conveyors. This paper began by modeling and assembling the SGZ630/220 double-chain scraper conveyor. We then used the wear depth of the middle trough as a measurement parameter and employed EDEM software to study the impact wear patterns in the middle trough during coal transport under different working conditions, including lateral incline angle (5°, 0°, -5°), forward incline angle (5°, 0°, -5°), chain spacing (110mm, 320mm, 450mm), and particle size (20mm, 30mm, 40mm). The simulation demonstrated that adjusting the laying angle, reducing chain spacing, and optimizing coal particle size effectively minimize impact damage to the middle trough. These findings hold paramount importance for retrofitting scraper conveyors, enhancing their operational longevity.

Keywords. Scraper conveyor, middle trough impact wear, three-dimensional modeling, EDEM simulation

1. Introduction

Under the dual-carbon goal, the coal industry will move toward the direction of intelligence and unmanned[1].Scraper conveyor is the core equipment of fully mechanized mining face in coal mine[2].It can be seen from Figure 1 that the central trough of scraper conveyor is damaged due to the strong impact of coal, gangue, scraper chain and other factors during operation.

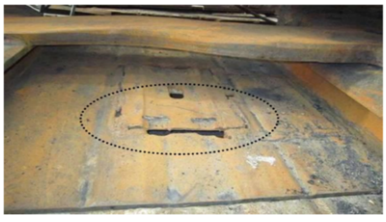

Figure 1. Impact damage of scraper conveyor[3].

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Research on the impact wear of the middle trough of the scraper conveyor has certain guiding significance for improving the reliability of the scraper conveyor. According to the basic theory of tribology, Wang et al. studied the working characteristics and wear failure reasons of the middle groove and scraper chain[4]. Yaralı et al. showed that the gangue content in the coal bulk as well as the increase in the average particle size increases the tool wear[5]. Chen et al. studied the effects of scraper chain speed, laying angle, particle hardness and other parameters on the wear of the middle groove[6]. Yao et al. analyzed the wear of the middle groove before and after the sprocket transformation[7]. Cao et al. carried out finite element analysis on the problems in the middle groove of the scraper conveyor in the process of pulling frame, pushing and shearer walking[8]. Ge et al. conducted impact wear experiments using medium manganese austenitic steel, and the measured data proved that medium manganese austenitic steel has higher impact abrasive wear resistance than martensitic steel[9]. Grincova et al. studied the service life of conveyor belts as well as the reliability of different conveyor belts when subjected to impacts through tests[10].

In theory, the research of many scholars focused on the reliability of the middle groove, stress and failure analysis under different working conditions[11-12]. However, due to the complex working conditions of scraper conveyors, its wear is restricted by various factors such as coal particles, sheet metal quality and working environment, and many scholars have few studies on the impact wear effect mechanism of sheet metal under multiple working conditions, so it is extremely necessary to study the impact wear effect of sheet metal under multiple working conditions.

2. Methods

This section mainly discusses the impact wear law of the middle groove under different working conditions, such as side angle, front angle, chain distance and coal particle size, in the process of conveying coal particles by scraper conveyor.

2.1. Three-dimensional modeling of scraper conveyor

Application of Solidworks 3D modeling software, and according to Shanxi Lingshi Dangling Coal Mine SGZ630/220 (11SJJ02) double chain scraper conveyor manual, combined with relevant coal industry standards, SGZ630/220 scraper conveyor modeling and assembly. For general parts can be directly imported from the software and peripheral model library, and scraper, sprocket, ring chain is the scraper conveyor is the key part of the material, should be based on the relevant specifications of the coal mine industry for the corresponding structural design and calculation.The assembly diagram of the SGZ630/220 series scraper conveyor is shown in Figure 2.

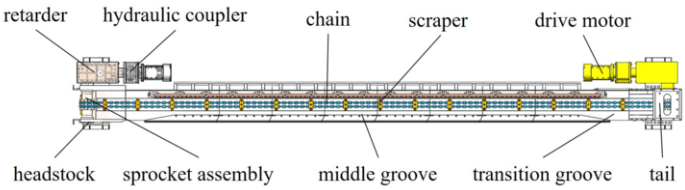


Figure 2. Modeling and assembly of SGZ630/220 series scraper conveyor.

2.2. Model import and basic parameter setting

The middle groove model is simplified and imported into the discrete element EDEM software for the next step of impact wear research, as shown in Figure 3. The research object selects a middle groove and its middle scraper chain. Above the middle groove is a coal drop area of a particle factory moving at the mining speed of a shearer. The coal drop area of the pellet factory is set to be a rectangular coal drop area, the length of the rectangular coal drop area is set to be 900 mm, the width to be 500 mm, the mining height to be 2 m, and the center coordinate is set to be (0,-300,2000). The moving speed of the particle factory is set at 0.15 m/s, and its starting point in the velocity direction is (0,0,0) and ending point is (0,1500,0). The formation speed of impact particles 1, 2 and 3 in the particle factory is set to be 100 kg/s, and the initial speed of the three coal particles is set to be -2 m/s when they are generated, and the negative sign indicates the negative direction along the Z axis. Other parameters are set by the system default. Contact mode of Coal particles The default contact mode between particles in the system is Hertz-Mindlin (no slip) mode. The contact modes of coal particle-geometry model were selected as Hertz-Mindlin (no slip) mode, Archard Wear mode and Relative Wear mode.

Figure 3. Simplified model of the center channel in EDEM software.

2.3. Study on impact wear of middle groove with particle size

In the study on the influence of coal particle size, three kinds of coal particles with different radii, including four basic spheres, are set for impact simulation. The model and structural parameters of impact particles 1, 2 and 3 in EDEM are shown in Figure 4 and Table 1, and the material is set as anthracite. At the same time, other simulation conditions are set as middle double chain, and the middle slot is arranged horizontally.

(a)Impact particle 1 (b)Impact particle 2 (c)Impact particle 3

Figure 4. Impact coal particle model.

Table 1. Structural parameters of impact coal particles 1, 2 and 3 in EDEM

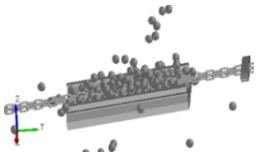
particle number	basic sphere radius	basic sphere centroid coordinates	particle mass
particle 1	40 mm	(0,7,0) (0,-7,0) (7,0,0) (-7,0,0)	0.577167 kg
particle 2	30 mm	(1,6,0) (-1,-6,0) (6,-1,0) (-6,1,0)	0.254179 kg
particle 3	20 mm	(-1,6,0) (1,-6,0) (6,1,0) (-6,-1,0)	0.088320 kg

2.4. Research on impact wear of middle trough caused by dip angle

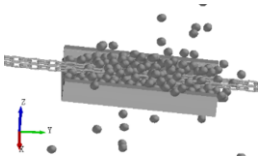
The inclination angle of the scraper conveyor is generally small, within ±10°. Therefore, in the study on the impact of side inclination and front inclination on the impact wear of the middle groove, the simulation parameters are set as 3 angles of 5°, 0° and -5°. The working conditions of side inclination and front inclination of the middle groove are shown in Figure 5. Other simulation conditions are set to medium double chains with a basic sphere radius of 40 mm.

(a)Central trough side inclination 5° tilt mode

(b)Central trough side inclination -5° tilt mode



(c)Central trough dip angle 5° inclined mode

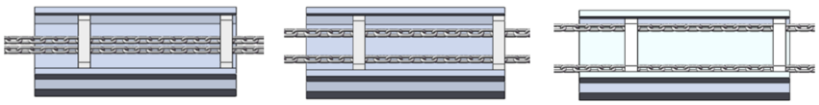


(d)Central trough dip angle -5° inclined mode

Figure 5. Working conditions of side inclination and front inclination of central trough.

2.5. Study on impact wear of middle groove by chain spacing

When studying the influence of chain distance on the impact wear of intermediate groove, three cases of chain distance 110mm, 320mm and 450mm were set respectively. The simplified impact model of the middle trough under the condition of chain distance is shown in Figure 6 below. Other simulation conditions were set as horizontal arrangement of the middle groove, and the basic sphere radius of the particles was 40 mm.



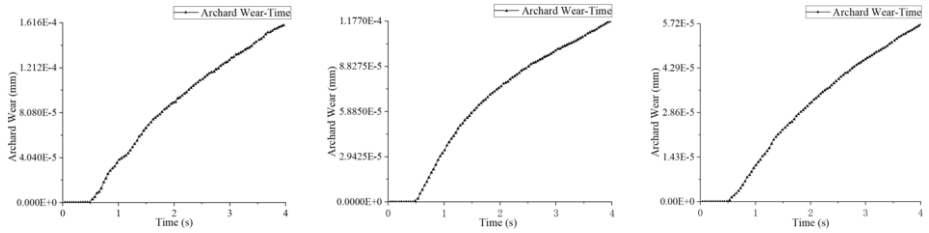
(a)Medium double chain 110 mm (b)Quasi-side double chain 320 mm (c)Side double chain 450 mm

Figure 6. Simplified impact model of middle trough under the condition of chain spacing.

3. Results

3.1. Different particle size conditions

The wear depth curves of the middle groove are shown in Figure 7. It can be seen that at the end of 4 s, the cumulative impact damage depth of the intermediate groove reaches the maximum value, reaching 0.0001616mm when the particle size is 40mm, and decreases successively when the particle size is 30mm and 20mm.

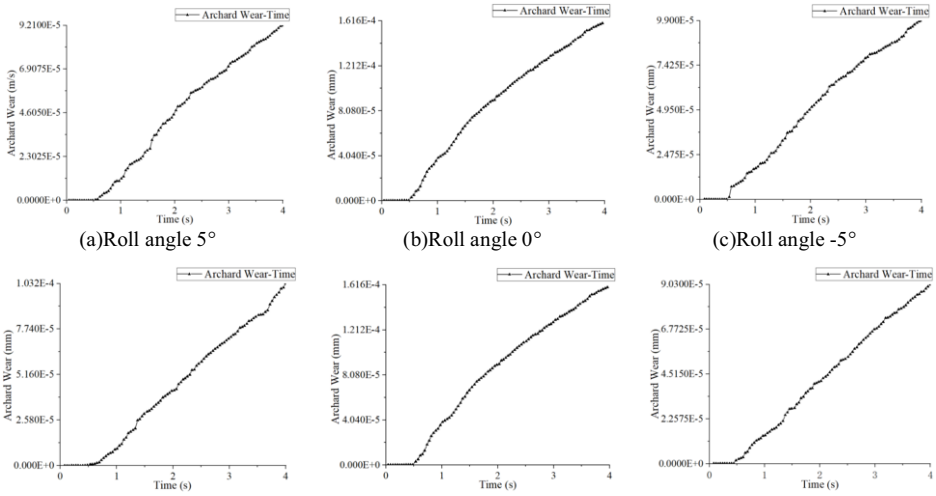


(a)Size 40 mm (b)Size 30 mm (c)Size 20 mm

Figure 7. Simulation results of wear depth of middle groove under particle size condition.

3.2. Condition of different dip angles

The wear depth curves of the middle groove are shown in Figure 8. It can be seen that when the side angle and front angle of the middle groove are 0°, the impact damage depth of the middle groove is the largest, and the cumulative impact damage depth of the middle groove is 0.0001616mm at the end of 4 s.



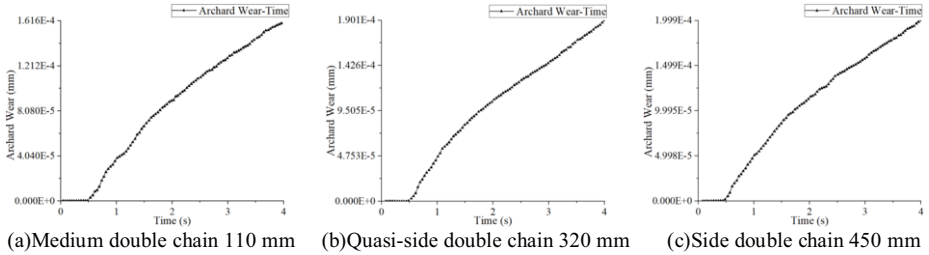
(a)Roll angle 5° (b)Roll angle 0° (c)Roll angle -5°

(d)Front angle 5° (e)Front angle 0° (f)Front angle -5°

Figure 8. Simulation results of the wear depth of mid-groove under the condition of roll and forward roll.

3.3. Different chain spacing conditions

The wear depth curves of the middle groove are shown in Figure 9. It can be seen that when the chain distance is 450mm, the cumulative impact damage depth of the middle groove at the end of 4s reaches the maximum, reaching 0.0001999 mm.



(a)Medium double chain 110 mm (b)Quasi-side double chain 320 mm (c)Side double chain 450 mm

Figure 9. Simulation results of middle groove wear depth under the condition of chain spacing.

4. Discussion

4.1. Different particle size conditions

As the coal with large particle size has relatively large mass, when it falls under the same simulation at the same height, its kinetic energy will be larger when it touches the middle trough, and its impact on the middle trough will be larger. Therefore, the larger the coal particle size is, the greater the impact damage depth of the middle trough will be.

4.2. Condition of different dip angles

The impact damage to the middle trough is mainly caused by the normal force. Under t-he working conditions of the side Angle and front Angle of the middle trough, the normal force will decrease, resulting in the reduction of the impact damage depth of the middle trough.

4.3. Different chain spacing conditions

When the scraper chain of the scraper conveyor adopts different layout, the size of the contact area between the coal particles and the middle trough is different. The larger the chain distance, the larger the contact area between coal particles and the middle trough, and the more obvious the impact damage of coal particles on the middle trough.

5. Summary and conclusions

In this paper, the wear law of impact damage to the middle groove of scraper conveyor is studied. The impact damage of coal particles to the middle groove will be reduced when there is side Angle and front Angle. Under different scraper chain spacing, the larger the scraper chain spacing, the greater the impact damage of coal particles on the middle trough; Under the impact of coal with different particle size on the middle tank, the larger the coal particle size, the greater the impact damage to the middle tank. Conclusion It is of great significance to improve the service life and reliability of the scraper conveyor.

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