Research on the Loading Mode of Shipborne Fluidized Cargo

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Abstract. Shipborne fluidized cargo can easily cause serious accidents such as the center of gravity deviation, leakage, and ship damage due to the moisture content in the transportation process, and the center of gravity shift is often an important factor leading to ship overturning. To reduce this risk, minerals with high density and low moisture content are used as the research objects. Starting from the principle of cargo center of gravity deviation [1], using the EDEM software model, the means of controlling the looseness of material flow, the material flow velocity, the material flow direction, the convergence of materials, and other methods to inhibit the deviation of the cargo center of gravity are proposed, which provides a risk prevention basis for ship management personnel and helps to improve the safety level of shipborne fluidized cargo transportation in China.

Keywords: airborne; fluidized goods; the center of gravity is offset

1 Introduction

This paper mainly studies the transportation risk caused by the influence of easily fluidized cargo loading mode on the offset of the center of gravity. Firstly, EDEM software is used to simulate the compaction degree of easily fluidized cargo, and to quantify the specific parameter standard. Then, the loading process of the conveyor belt and the particle distribution and particle movement state of the goods loaded are analyzed, and the loading operation is improved to improve the compaction degree of the goods according to the experimental simulation. It is concluded that how to load the conveyor belt during the reloading process is more conducive to achieve high pressure compaction.

2 Determination of the Density of Goods

The EDEM model is used to simulate the swaying moment and rolling motion of nickel pulp with different water content and different external excitation. The loading depth of nickel pulp with different water content is set to 121.2mm. In addition to the nickel pulp

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with a water content of 40%, the addition takes into account the nickel pulp with a water content of 50% and 60%, respectively. as Table 1.

Table 1. List of swinging moment amplitude and phase difference results in the slurry chamber of different nickel water content

Excitation amplitude	Excitation cycle	Nickel pulp with different moisture content	Forward amplitude of sloshing moment	Negative amplitude of sloshing moment	Phase difference
		Water content60%	3.39	-3.42	0
10	4	Water content50%	3.58	-3.61	3.00
		Water content40%	3.77	-3.78	26.30
		Water content60%	2.36	-2.38	0
7	4	Water content50%	2.33	-2.35	5.50
		Water content40%	2.67	-2.69	22.0
		Water content60%	4.93	-5.00	5.35
10	1.57	Water content50%	5.52	-5.58	10.70
		Water content40%	4.49	-4.56	42.80

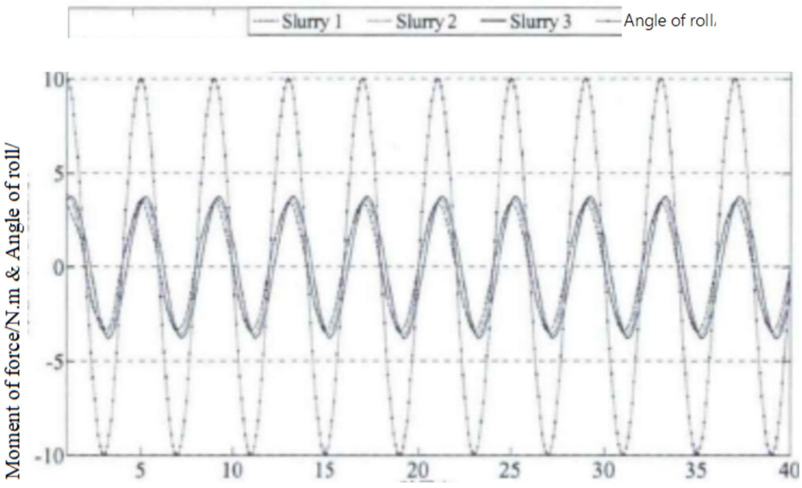

Fig. 1.comparison of θ amp = 10, T=4s different water content

The calculation results are based on the swaying moment and rolling motion of nickel pulp with different water content and different external excitation. Amplitude and phase difference of sloshing moment under different excitation conditions. The sloshing moment in the fluid cargo hold basically changes periodically.as Fig. 1. Under the same excitation period, if the excitation amplitude is increased, the amplitude of the sloshing moment will increase, and the phase difference between the torque and the cargo hold motion will also increase. Based on the calculation results in this section, as Fig. 2. under the same excitation amplitude, increasing the excitation frequency will also increase the amplitude of the sloshing moment and the phase difference. It can be seen from the above that the external excitation amplitude and frequency are the two key factors that affect the amplitude and phase difference of the sloshing moment. In addition, by comparing the swaying moment of nickel pulp with different water content, it can be seen that under the same excitation condition, the amplitude and phase difference of the swaying moment of the fluidized cargo increase basically with the decrease of the water content of nickel pulp. However, when the external excitation amplitude is 10 and the excitation period is 1.57s, the amplitude of slosh moment of slurry 3(40% nickel pulp) is lower than that of the other two types of nickel pulp in either positive or negative direction, and the phase difference of slurry 3 is the largest. In this case, due to the decrease of water content, the fluidity of nickel pulp becomes worse and the amplitude of swaying moment decreases. Compared with the other two excitation conditions, no similar situation appears, it can be seen that the external excitation conditions are the key factors affecting the slosh in the nickel pulp cabin. Under the above three excitation conditions, the phase difference increases with the decrease of the water content of nickel pulp when the swaying moment and the cargo hold motion phase difference are considered separately. In other words, when the water content decreases, the fluidity of nickel pulp becomes worse, and its hysteresis relative to the movement of the cargo hold becomes significant. In addition, according to the comparison of the average amplitude of the positive and negative direction of the swaying moment, it can be seen that there is a positive and negative asymmetry of the swaying moment, but it is not obvious.

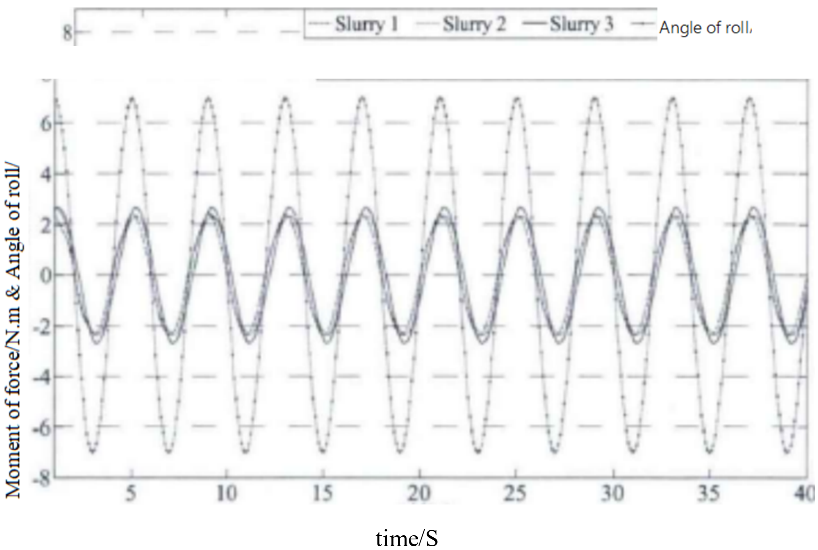

Fig. 2.comparison of θ amp = 7, T=4s different water content

3 The Principle of the Shift of the Center of Gravity of the Cargo

Cargo center of gravity shift is an issue of great concern to practitioners in the liquid cargo transportation industry, and the control of cargo center of gravity shift is crucial to safe transportation [2]. According to the above EDEM model simulation, the density of the cargo in this experiment was obtained. In order to avoid the reduction of the density of the cargo during loading, which would lead to the deviation of the cargo center of gravity, the method of controlling the loading mode of the cargo was adopted to achieve the purpose of effectively controlling the deviation of the center of gravity. For ship loading, there are two ways of loading cargo commonly used in practice: grab bucket and belt conveyor. The gravity center deviation of goods on the belt conveyor is mainly caused by the following four reasons: too fast flow rate, too dispersed materials, large Angle impact, and relative movement when falling on the receiving belt conveyor [3].

4 Control the Looseness of the Material Flow

Loose material type can cause many serious problems, such as blockage, deviation of the center of gravity of goods, serious wear, etc., and the lack of material flow convergence is the main reason for these problems. Through discrete element simulation [4], it is possible to observe the material flow behavior at any position inside the equipment to determine whether the material type is too loose and then decide how to optimize the design.

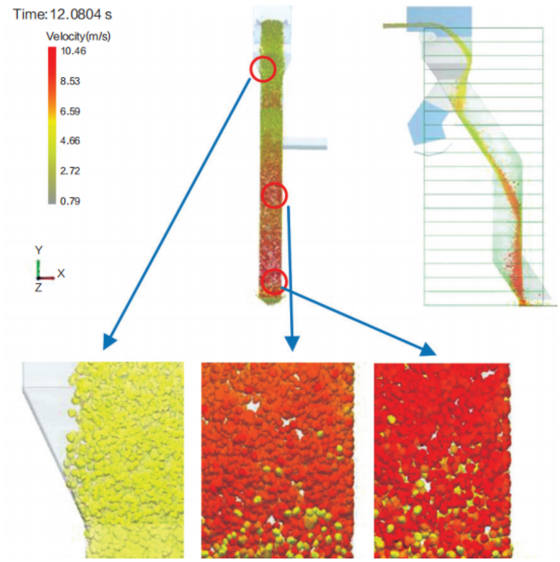

Fig. 3. Uniform distribution of material flow

Fig. 3 shows a shipboard with a drop of about 10m, and it can be seen from the three locally enlarged drawings that the overall material flow is very evenly dispersed inside the blanking pipe, and it is in a state of almost no convergence. Especially at the corresponding impact point, the dispersion of the material flow causes the center of gravity to shift, and the clogging and wear of the goods is much greater than that of the convergent material flow.

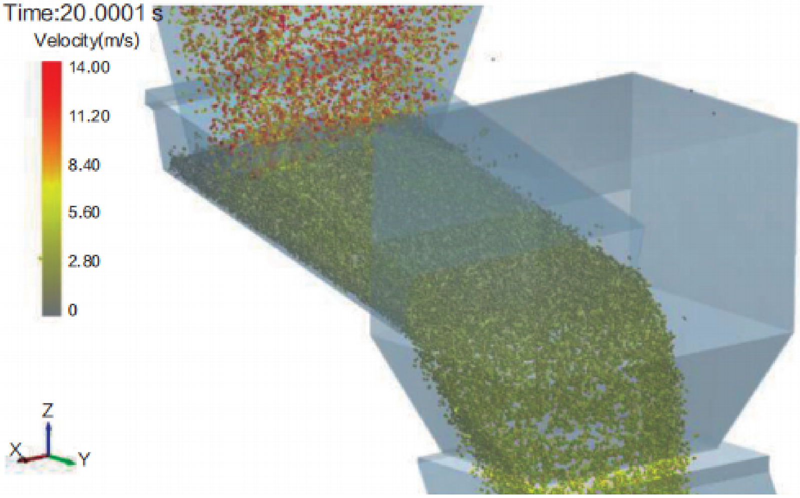

Fig. 4. Loose distribution of material flow

Fig. 4 is a local material pattern diagram of the ship behind certain equipment, from which it can be seen that the material is very scattered. According to the color of the legend, the material speed on both sides is almost reduced to about 1 m/s. In the case of materials with high humidity, it is very likely that chronic compaction will be formed, which will eventually lead to clogging or insufficient throughput.

5 Control the flow Rate of Materials

The flow of materials inside the ship requires good design to control it, especially the control of speed [5]. Traditional design methods cannot accurately calculate the velocity of the material flow at each part. If the material flow is too fast, the impact wear will be multiplied, and the life of the equipment will be severely reduced. However, with the discrete element simulation software EDEM, it is easy to monitor the velocity curve of the material flow in Fig. 3, so as to carry out targeted optimization design.

Fig. 5 shows the velocity profile of the material in a roller screen ship. The ordinate of the curve on the right corresponds to the onboard height of the roller screen in the figure on the left [6]. It can be seen that the speed of the material flow before contacting the roller screen is between 6m/s and 7m/s, and the speed is reasonable; The speed is 12m/s before the feed spoon, which is slightly faster and requires deceleration. After the deceleration section of the arc of the feeding spoon, the material speed loaded into the receiving belt conveyor is reduced to about 7m/s, which avoids the excessive impact damage to the belt conveyor and the deviation of the center of gravity of the goods.

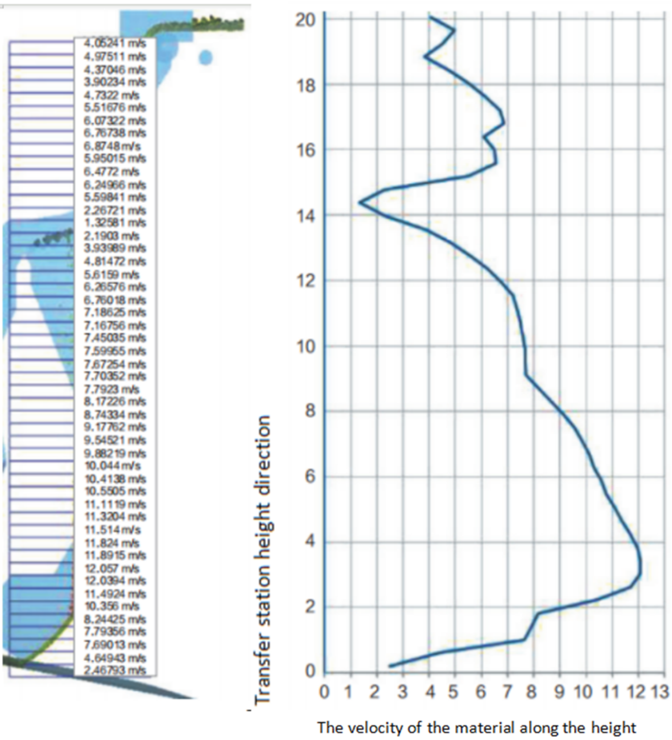

Fig. 5. Material flow velocity curve

6 Control the Direction of Material Flow

Whether the material glides close to the wall of the blanking pipe is an important indicator to judge the design of the entire transfer system. If the material is in free fall for a long time, or if the material is washed away and not re-converged, it will lead to common engineering problems, such as the shift of the center of gravity of the goods, blockage, rapid wear, and mistracking [7].

For a ship with a small drop, it can be seen from the design structure that the material is thrown out to the final loading of the receiving belt conveyor, and there is almost no free fall. The material flow direction, material type, and speed are completely controlled, so that the design can greatly avoid the generation of the center of gravity of the cargo. Even if the coal transportation system with a high drop occurs and a large induced wind is generated, the center of gravity of the cargo will not be lifted up because the material is close to the wall, to truly inhibit the deviation of the center of gravity of the cargo from the source [8], as shown in Fig. 6.

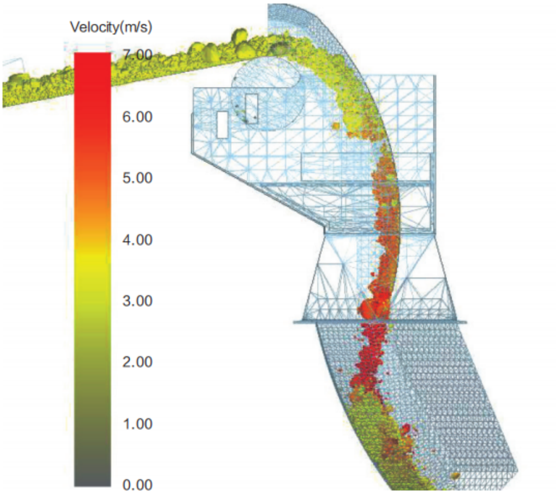

Fig. 6. Material flow trajectory diagram

7 Means of Controlling the Convergence of Materials

It is very important whether the material is aggregated in the ship. A shipboard design that allows materials to converge is a good design, because the converged material type directly reduces the risk of clogging, cargo center of gravity shift, and spilling, and also reduces wear and tear on the equipment, so it is particularly important to keep the material converging at the top inlet of the ship. After passing through the end of the feed belt conveyor and the drum, the material flow can be converged by the deflector or directly by the structure of the equipment. A common way is to add a convergent arc deflector, as shown in Fig. 7. The material follows the deflector through the designed trajectory and slides down to the designed landing point. This method is effective and cost-effective, and can perfectly control the behavior of the material flow inside the ship [9].

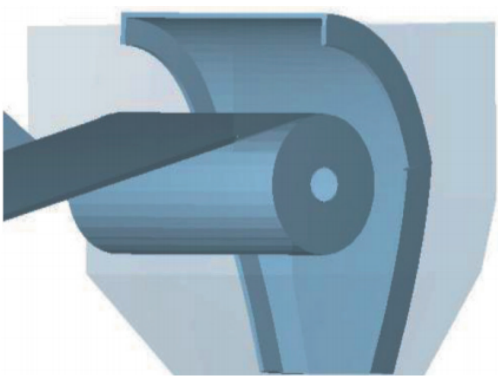

Fig. 7. Convergent arc deflector

8 Other Methods to Suppress the Shift of the Center of Gravity of the Cargo

There are a number of methods to analyze the suppression of the shift of the center of gravity of the cargo. For example, by analyzing the velocity of the particles in the material flow from the beginning of loading on the belt conveyor to the range of 2 m of being transported, it is easy to determine the range of the shift of the center of gravity of the load at the receiving belt conveyor. In addition, there are more design methods to suppress the shift of the center of gravity of the cargo, such as designing a feeding spoon with a large belly and a small mouth to disturb the induced wind, so that it forms a gyration at the exit to reduce the amount of air that is carried out as much as possible. Relying on simulation, it is also possible to reduce the induced wind by reducing the pipe diameter of the blanking pipe.

9 Conclusion

Based on the experimental results, it is concluded that the center of gravity shift is a crucial factor when considering the loading mode of fluidized cargo on board. Through comprehensive analysis, this paper shows that it is an effective method to improve the cargo compactness and control the center of gravity shift of the ship from the methods of controlling the looseness of the material flow, the material flow speed, the material flow direction, the material convergence, and other methods to inhibit the deviation of the center of gravity of the cargo.

The effect of cargo loading patterns on the shift of the center of gravity is significant. Improper loading can cause the goods to move during transportation, which in turn can cause the center of gravity to shift. This offset will not only affect the stability of the ship, but may also cause safety accidents such as cargo leakage and fire. The stability of the ship is also an important factor affecting the shift of the center of gravity, and the ship with insufficient stability is prone to tilt during transportation, resulting in the shift of the center of gravity of the cargo. The stability of a ship is affected by a variety of factors, such as the hull structure, the type and quantity of cargo on board, and so on. Therefore, when transporting fluidized cargo, in addition to the ship with sufficient load capacity, the way the cargo is loaded is also a crucial factor.

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