Influence of Material Characteristics of Hoppers on Particle Flow Behavior

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Abstract: In the previous study, different structures of hoppers were proposed. And the dust suppression performance of hoppers were evaluated. In this paper, different materials of hoppers were selected.And influence of different material on particle behaviors were studied based on the discrete element method (DEM). Results shows that the wall material with low collision recovery coefficient for the hopper has positive effect on suppressing dust diffusion.and the wall material with high static friction coefficient showed little effect on the particle flow state through the hopper.

1. Introduction

In the previous research ,in order to access the particle behavior of different hoppers[1-2], different structures of hoppers were designed, and the discrete element method was used via the software package EDEM to evaluate the particle behaviors. The hopper shown in Figure 1 is the same as the one used in ports. Unlike the common hopper, a deflection cone as shown in Figure 4 was set in the hopper to change the flow of materials. Besides,In recent years, researchers and some companies focus on the study of particle behavior and dust suppression [5-7].

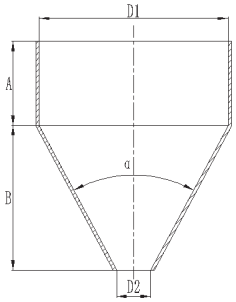


Fig. 1. The hopper

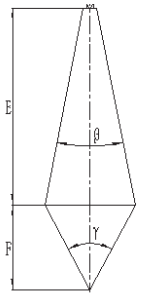
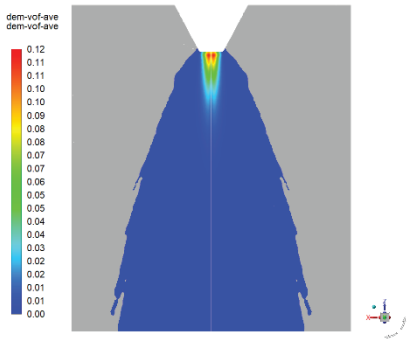
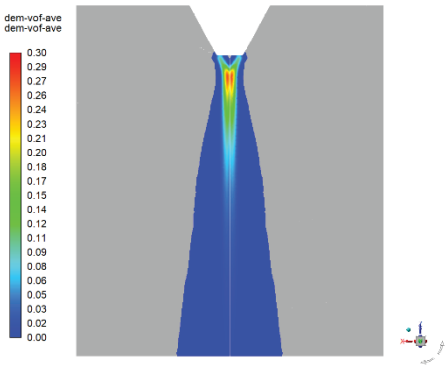


Fig. 2. The deflection cone

Results shows that structure of the hopper greatly affected the particle behavior. After adding the deflection cone in the hopper, the trajectory of particle material can be effectively restrained and the dust diffusion can be reduced. The annular channel formed by the deflection cone and the inner wall of the hopper has a guiding effect on the particle movement as shown in Figure 3.



(a)the hopper without the deflection cone



(b)the hopper with the deflection cone

Fig. 3. The percentage of dust particle for different hoppers

Based on previous study, different materials of hoppers were selected to investigate particle flow behavior in this paper. For different materials, different recovery coefficient and different static friction coefficient were chosen as main factors and influence on the particle behavior were studied based on the discrete element method (DEM).

2. Simulation setting

Different materials can be selected as the inner wall of dust suppression hopper. Therefore, it is necessary to study influence of different materials on the particle flow of the hopper. In this research, it is assumed that two kinds of wall materials have different collision recovery coefficients or static friction coefficients compared with the original materials.

1) Different impact recovery coefficient material: impact recovery coefficient of material A is 0.72, impact recovery coefficient of material B is 0.1

2) Different static friction coefficient material: static friction coefficient of material A is 0.2, and static friction coefficient of material B is 0.01.

The hopper without the deflection cone was selected in this study. The material flow rate of 100 mm dust suppression hopper was 10 t/h.

Calculation domain of the hopper was set as a cylinder under the outlet of the hopper with 600mm in height and 600mm in diameter as shown in Figure 4. During the simulation, Hertz-Mindlin non-slip model was adopted.

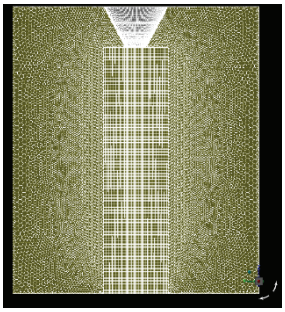


Fig. 4. Calculation domain setting

3 Results and Discussion

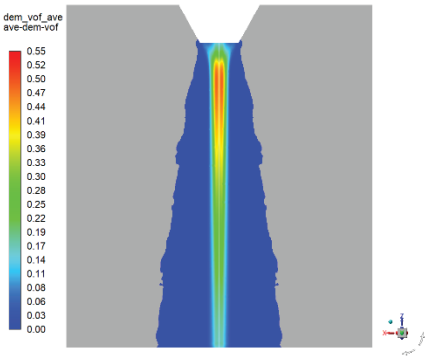
The particle motion results of materials with different impact recovery coefficients are shown in Fig.5. and the simulation demonstrates that particle motion difference between collision recovery coefficients was obvious.

(a) collision recovery coefficient of 0.72

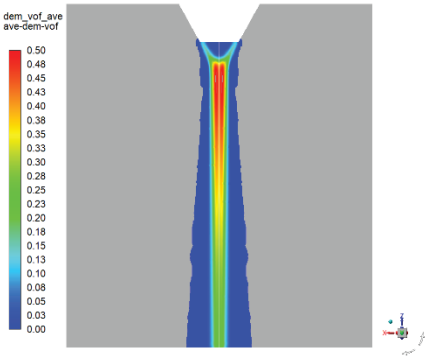
(b) collision recovery coefficient of 0.1

Fig. 5. Particle motionof materials with different static friction coefficients

In order to carry out further evaluation, particle volume fractions of materials with different collision recovery coefficients were shown in Fig.6 and Fig.7 and it shows that the wall material with low collision recovery coefficient has obvious effect on suppressing dust diffusion, because the low collision recovery coefficient can weaken the rebound of particles falling behind the wall, so that the particles can form a more consistent wall-attached flow, and thus it generated a beam closure effect on the material flow.



(a) collision recovery coefficient of 0.72



(b) collision recovery coefficient of 0.1

Fig. 6. Particle volume fractions of materials with different collision recovery coefficients

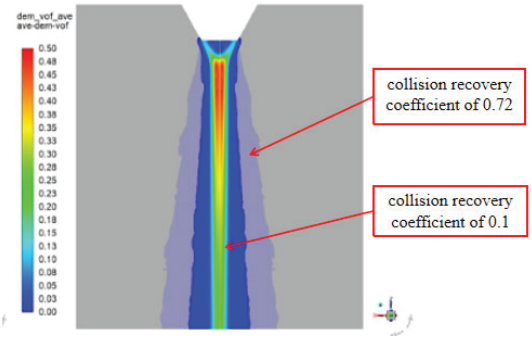


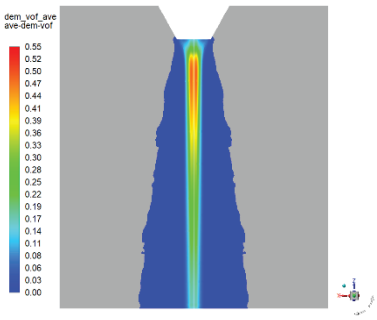
Fig. 7. Particle diffusion range of materials with different collision recovery coefficients

Besides, different static friction coefficients of materials were taken into consideration.and the simulation results of materials with different static friction coefficients are shown in the Fig. 8. and it shows that particle motion difference between two static coefficients was little. For further evaluation, particle volume fractions of materials with different collision recovery coefficients was shown in Fig.9 and Fig.10 and it is shown that the similar trend to the particle motion occurred. In this case, hopper materials of the static friction coefficients has little effect on the particle flow state, and the particle volume fractions range for material with a higher static friction coefficient was just slightly larger under low friction coefficient.

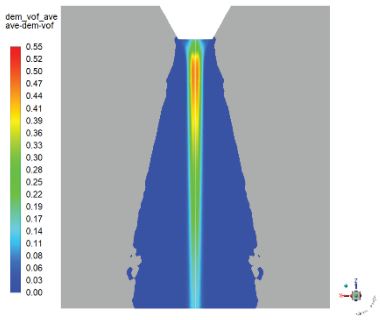
(a) static friction coefficient of 0.2

(b) static friction coefficient of 0.01

Fig. 8. Particle motion state of materials with different static friction coefficient



(a)static friction coefficient of 0.2



(b)static friction coefficient of 0.01

Fig. 9. Particle volume fraction distribution of materials with different static friction coefficients

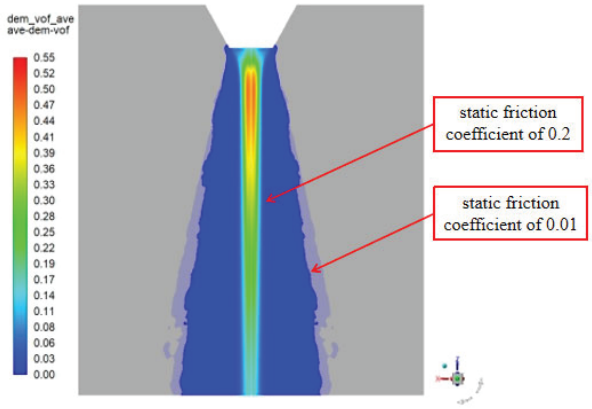


Fig. 10. Particle diffusion range of different static friction coefficient materials

3. Summary

In the previous study, different structures of hoppers were proposed and performance on particle flow were evaluated. In this paper, influence of material of hopper on particle flow behaviors were studied. And the dust suppression performance of hoppers were evaluated. In this paper, different materials of hoppers were selected and influence of different material characteristic on the particle behavior were studied based on the discrete element method (DEM). it reveals that low collision recovery coefficient of the hopper has positive effect on suppressing dust diffusion.and the wall material with high static friction coefficient showed little effect on the particle flow state through the hopper. In future, more factors that may affect particle flow behaviors of hoppers will be taken into account and provide further instruction for hopper design.

References

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