

## DEM Simulation of Spin Vibration Screening Process

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**Abstract:** This paper focuses on the motion simulation and visualization of the material particles in the operation of the spin vibration screening using DEM (Discrete Element Method). Based on analysis of the simulation results, some conclusions are made which provide the theory basis in order to design the screen parameters reasonably. Finally some experiments are carried out in order to verify the correctness of the simulation.

### Introduction

The research about the movement of materials in vibrating screen is most important to design such machines. For too complex to model the movement especially in spin vibrating screen, in traditional research method it is simplified into a single particle in motion while the interaction between the particles is ignored. This paper introduces DEM into study on the material particles movement of spin screen. Compared to traditional method DEM establishes a more realistic model in which a group of particles are studied and interaction among the material particles and particles, particles and screening machine is put into account. The DEM simulation is carried out with EDEM software system

### Study of Screening Process Simulation

**Vibration System Modeling.** We build vibrating screen model for the simulation in EDEM according to the size and weight of the laboratory vibration system first. It is shown in Figure 1.

**Particle Model.** The basic particles are ball particles in the EDEM system. Irregular particles can be also modeled by filling the wire frame model of irregular particles with ball particles. It is shown in Figure 2.

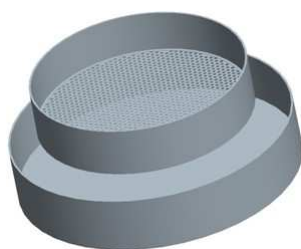


Fig. 1. Vibrating system model

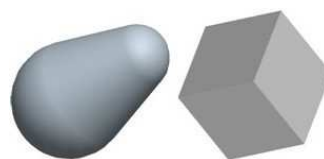


Fig. 2. Particle model

**Simulation of Screening Process.** After analyzing the Dynamics of the spin vibration screen, we know that the movement of spin vibration screen is the circular movement that at the mass center of radius  $X$ , combined with swing movement of certain angle; its synthetic movements are shown in Figure 3.

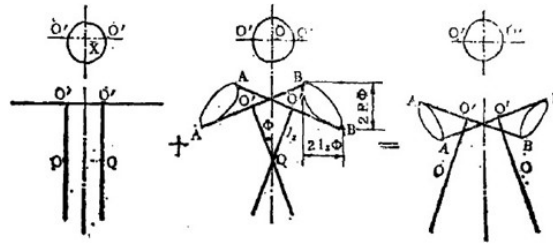


Fig. 3. Movement of screen

Three main factors affect spin vibration screen performance are eccentric angle which determines the mount or erecting force, material thickness and vibration frequency. With different combination of above parameters a group or DEM simulation are carried out to study the impact on the efficiency of spin vibration screen. The parameters and screening efficiency get from simulation result listed in Table 1.

Table 1 Data of simulation

No.	Eccentric Angle ( $^{\circ}$ )	Material Thickness (mm)	Vibration Frequency (Hz)	Screening Efficiency (%)
1	0	12	11	97.54
2	60	14	13	90.55
3	0	13	16	62.81
4	0	16	13	75.77
5	0	13	11	75.55
6	45	8	12	87.14
7	0	11	14	99.70
8	45	14	16	96.71
9	75	16	18	95.34
10	90	20	22	75.43
11	45	12	16	99.78
12	60	12	15	92.83

### Analysis of Simulation Results

**Particles in Different Shapes.** Irregular particles with more ball fillers lead to dramatic increase in simulation time. Therefore, we try to explore probability to adopt simple particles in situation. We carry out simulations with different particle models which are shown in Figure 4.

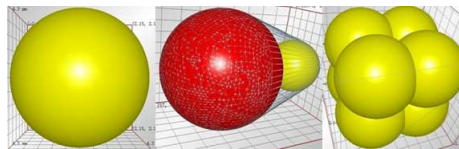


Fig. 4. Different shape of particle model

It can be seen from Table 2, the screening results are not very different among the three groups of particles of different shapes. It indicates that particles of different shapes have a little effect on the result of the simulation. So, using spherical particles instead of complex irregular shapes of the particles for simulating is feasible.

Table 2 Simulation parameter design

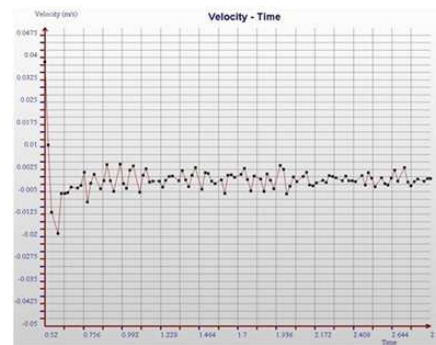
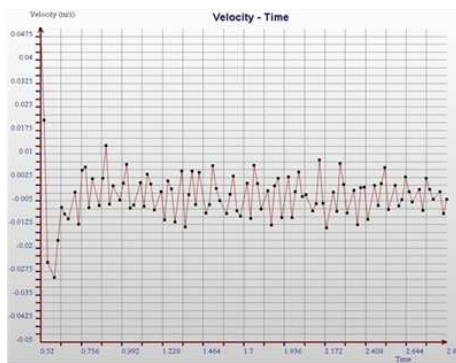
No.	Eccentric Angle (°)	Material Thickness ( mm )	Vibration Frequency ( Hz )	Sieve Efficiency ( % )
sphere	45	14	16	96.71
cone	45	14	16	99.78
cubic	45	14	16	96.44

**Analysis Sieve of the Material State of Motion.** What the instantaneous speed of the screening is that the average speed of all particles on the surface through the sieve at the same time. Therefore, we can count several groups of different material parameters of the speed through the sieve in order to analyze the results. The selected parameters are listed in Table 3.

Table 3 Simulation parameter design

No.	Eccentric Angle (°)	Material Thickness ( mm )	Vibration Frequenc ( Hz )	Screening Efficiency ( % )
a	45	14	16	96.71
b	0	16	13	75.77

It can be seen from the two compared tables, the figures are superior to b in both the maximum speed through the sieve and its fluctuant range. From the Table 3 we can know, increase the speed through the sieve is one of the efficiency ways to improve screening.

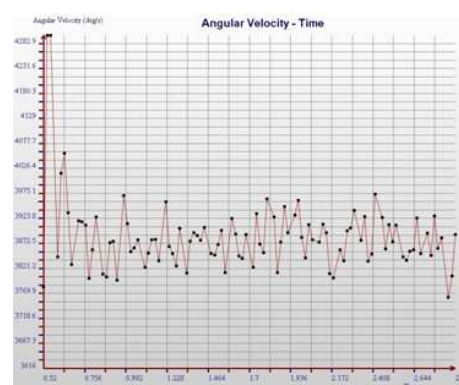
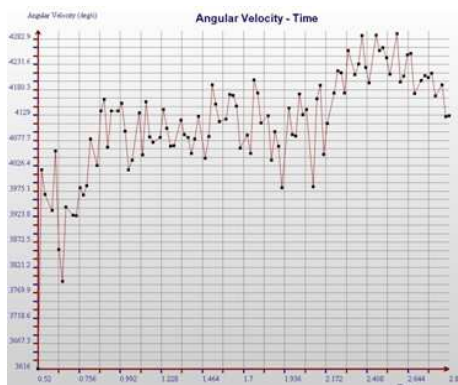


(a) Velocity through screen of plan a

(b) Velocity through screen of plan b

Fig. 6. Velocity through screen varying with time

From the preceding analysis we can know that, when the spin vibration screen works, the trajectory of the material from the screen surface of the center to the edge at the rotation spread. Therefore, we take the average angular velocity in the screen surface as the material conveying speed do analysis.



(a) Delivery speed of plan a

(b) Delivery speed of plan b

Fig. 6. Delivery speed varying with time

As is seen from the Figure 6, it is different with linear vibration screen, conveying speed is treated as a constant in the spin vibration screen in most of the literature does not apply. In addition, with the conveying speed increasing, the processing capacity of the screening machine is enhanced.

Study the central of the screen surface as the object, analyzing the state of material motion that in the region of “a” program, the results are shown in Figure 7.

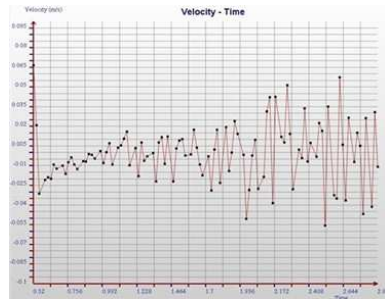


Fig. 7. Partial velocity through the screen



Fig. 8. Partial delivery speed

In the diagram we can see that the material speed near the center of the screen surface and conveying speed through the screen are much higher than its overall speed and conveying speed through the screen; but the changes of the local speed through the screen near the center and the local conveying speed are instability. This makes the material particles in the middle of the screen surface are less than in the edge of the screen surface. It is not only conducive to sieve fine-grained materials, but also good to the large size of the particles away from the screen surface area through the screening center; therefore avoiding to reduce the screening efficiency because of the excessive concentrate of the material in the middle of the screen surface.

**Analysis the Plugging Holes.** In order to analyze the Plugging hole of Spin vibration screen and find out factors that have effect on the phenomenon, as well as the correlation between them, we take a set of data, Eccentric block angle=  $60^\circ$ , Material layer=14mm, Vibration frequency=13Hz, to simulate the process with the different friction coefficient(0.2 and 0.4) between the particles and screen and visualize the plugging hole. From Fig.9, we can make a conclusion that with other conditions unchanged, it didn't make a remarkable improvement to reduce the friction coefficient for plugging hole. So, the friction coefficient has a limited effect on the plugging hole for Spin vibration screen other than with Line vibrating screen.

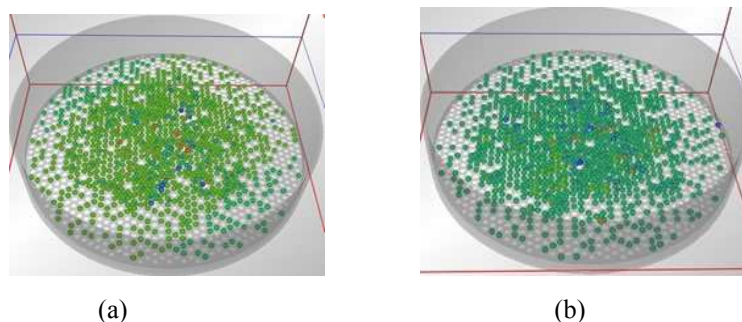


Fig. 9(a) Plugging hole under the condition of friction coefficient 0.4; (b) Plugging hole under the condition of friction coefficient 0.2

During the Spin vibration screen's process of the separation, the changed eccentric block angle will modify the excitation force, as well as cone swing angle. In order to approach the improvement on the screening efficiency through increasing the screen inclination of line vibration screen, an analysis on the plugging hole is made based on the modified swing angle.

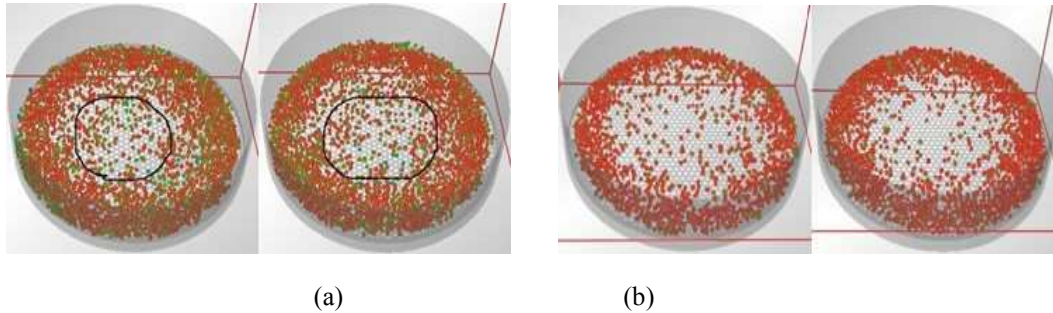


Fig. 10. Plugging hole under the conditions of different eccentric block angle  
 (a) Eccentric block angle:  $45^\circ$  (b) Eccentric block angle:  $0^\circ$

Plugging hole under the conditions of different eccentric block angle is shown in Fig.10; it has a remarkable improvement when eccentric block angle dropped off. The reason for this is following: Firstly, with the eccentric keep decreasing, the spin vibration screen's cone swing angle became larger, as well as the excitation force and vibration amplitude. Then the more powerful force and vibration cause a fiercer movement of the materials. During the move of the materials from the center to the edge, the particles located at the edge suffered an attack from the interior particles and at last, that attack strengthened the ability of the particles to get rid of the screen hole, which improved the screen efficiency.

We can realize that as time keep escapin, the phenomenon of plugging hole dispread, which testifies strengthening vibration frequency can reduce the chance of plugging hole. But if the vibration frequency beyond certain extent, the frequency of collision would increase, which would reduce the screen efficiency. At the same time, the time that the screen contacts with particles also increase and that accelerates the wear of the screen, which will reduce the life of the machine.

### Laboratory Experiment

In order to verify that the DEM simulation result is reasonable a vibration bench is designed, which is shown in Fig 11. The vibration motor is placed upright and the vibration sieve is put on the top.

DEM simulation data of the screening efficiency and experimental values are shown in Table 4, we can see, the simulation values and the experimental ones are close to each other. It performs that the experimental value is smaller than the simulation value.



Fig. 11. The experiment equipment



Table 4 Screening efficiency simulation value and experiment data

Angle(°)	Material Thickness (mm)	Vibration frequency (Hz)	Simulation value (%)	Experiment value (%)
0	11	14	94.49	92.13
45	14	16	96.71	93.37
45	8	12	87.14	83.64

## Conclusion

- (1) In the simulation, particle models which have different shapes result in minor difference in screening efficiency, therefore using sphere particles in simulation is reasonable;
- (2) Based on the analysis of the motion state of particles, It can be seen that to improve screening efficiency, the speed of the material through the sieve should increased firstly; At the same time, the convey speed of materials should be increased appropriately, this makes the particles convey to the edge at the time of through the sieve, avoiding the phenomena of plugging screen caused by most of the particles focusing on the center of the sieve surface and increase the probability that larger particles through the sieve;
- (3) After analysis to the plugging holes phenomenon, it shows that factors, which have important effects on the plugging holes phenomenon, include eccentric angle and vibration frequency, while the friction factor between particles and the screening surface has little effect. Through observation we can find that plugging hole phenomenon are mostly located in the center of the screen surface, while reducing the eccentric angle and increasing vibration frequency appropriately could reduce the occurrence of plugging hole phenomenon.

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