F. YANG, ZH. TONG, SH.W. ZOU, ZH. Y. LI, Z. J. SHEN

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PELLETIZING ANALYSIS OF CYLINDER PELLETIZER ON MgO-FLUXED PELLETS BY DISCRETE ELEMENT METHOD (DEM)

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Discrete Element Method (DEM) was used to analyze palletization process of MgO-fluxed pellets in cylinder pelletizer. The effects of the charge ratio and rotational speed of the cylinder pelletizer on the behavior of MgO-fluxed pellets were investigated by using the simulation. The simulation results show that under the condition of a certain gradient angle of the cylinder pelletizer (The gradient angle is 3°), the suitable parameters of the cylinder pelletizer are that the charge ratio is 3 % and the rotational speed *N/* critical rotational speed N_C is 0,3.

Key words: blast furnace, pellet, cylinder pelletizer, discrete element method, charge ratio

INTRODUCTION

Due to the disadvantages of low softening temperature, wide softening zone and high expansion rate of acid pellets, the pellet ratio in blast furnace charge in China is generally low, and the ratio of acid pellets in most blast furnaces is less than 20%[1-3]. In the production of pellets, adding fine-grained materials of Cao and MgO (such as limestone or dolomite) to iron concentrate before pelletizing is very beneficial to improve the physical and metallurgical properties of pellets. At the same time, it can also meet the needs of blast furnace slagging and desulfurization[4]. Therefore, it is an inevitable trend to vigorously develop MgO-fluxed pellets in China. Compared with acid pellets, MgO-fluxed pellets have the advantages of higher reduction degree, higher initial softening temperature, narrower softening interval and lower expansion rate. High reduction degree makes good use of gas in blast furnace smelting process, indirect reduction development, can reduce coke ratio. The high initial softening temperature can increase the heat reserve of hearth and improve the physical and chemical properties of slag, which is conducive to the smelting of pig iron with low sulfur and low silicon. The narrow soft melting zone can enhance the permeability of the charge, which is conducive to the smooth running and stable production of the blast furnace. Low expansion rate, can greatly improve its use proportion in the furnace raw material, so as to reduce the environmental pollution caused by the production of sinter[5-8].

The disc pelletizer is mostly used in pelletizing plants in China, which has the advantages of uniform pelletizing, high productivity and low capital construction and production cost. However, the operation of the disc pelletizer is not stable enough, and the parameters such as water volume and feeding volume need to be adjusted manually. The single unit production of cylinder pelletizer is large and the operation is stable. With the increasing output of blast furnace, more and more MgO-fluxed pellets are needed. The production capacity of the disc pelletizer can not meet the needs of large pellet production, so it is necessary to use the cylinder pelletizer to produce MgO-fluxed green pellets. However, the cylinder pelletizer has the disadvantage of uneven pelletizing size. In this paper, the motion law of green ball in cylinder pelletizer was simulated by DEM, and the effects of the charge ratio and rotational speed of the cylinder on pelletizing law are studied.

F. Yang (E-mail yangfu@wust.edu.cn), Zh. Tong, Sh.W. Zou, Zh. Y. Li, Z. J. Shen, Wuhan University of Science and Technology, College of Resources and Environmental Engineering , Wuhan, China.

NUMERICAL MODELING

Figure 1 shows the schematic diagram of a continuous cylinder pelletizer used in the simulation

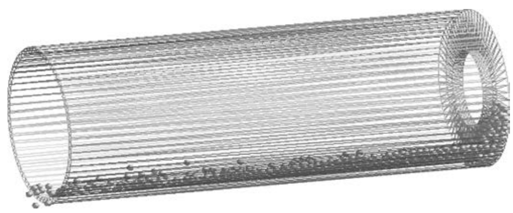

Figure 1 Schematic diagram of cylinder pelletizer used in the simulation

Physical constants and simulation conditions are shown in Table 1.

Table 2 lists the size of cylinder pelletizer. Rotational speed and charge ratio were changed to investigate their effects on the pelletizing behavior. The raw material is fed at the extreme right of the cylinder pelletizer and pellets drop from the extreme left (Figure 1).

Table 1 **Simulation conditions**

Time step $2{,}05\times10^{-5}$ s			
Contact parameters			
Contact material	Coefficient of restitution	Coefficient of static friction	Coefficient of rolling friction
Pellets-cylinder	0,20	0,50	0,02
Pellet-Pellet	0,23	0,55	0,03
Pellet radius		4 mm	
Pellets density		2 500 kg/m^3	
Pellets Poisson's ratio		0,3	
Pellets shear modulus		1×10^7 Pa	

Table 2 **Condition of cylinder pelletizer**

Radius	250 mm
Length	1 300 mm
Rotational speed N/N_c	0,2 0,3 0,4
Gradient angle	3°
Charge ratio C	2 % 3 % 4 %

Note: N is the rotational speed of cylinder pelletizer, and Nc is critical rotational speed.

SIMULATION RESULTS AND DISCUSSION

Figure 2 shows motion state of pellets simulated by DEM in the cylinder pelletizer at 3 % in charge ratio for different rotational speeds of the cylinder.

It can be clearly seen from Figure 2 that when N/N_c is 0.2, due to the low speed, only a few pellets roll, while the vast majority of pellets do not roll in the cylinder, only slide, and the pellets swing up and down along the cylinder wall as a whole. If the rotating speed is too fast, for example, N/N_c is 0,4, the pellet moves upward close to the cylinder wall, then falls at a steep angle, and the pellet rotates and falls onto the lower material layer. Similarly, there is no rolling. Under this moving state, the pellet cannot be formed. At the same time, it causes violent collision between pellets, resulting in serious damage to pellets and deterioration of balling effect. When N/Nc is 0,3, the pellet moves to the highest point and then starts to fall from the highest point. The upper pellet falls to the surface of the lower material to produce a layered effect. Then the pellet rolls and falls in a fluid shape. In this sport, the pellet grows up.

In order to understand the influence of different charge rates on pellets movement, the movement behavior of pellets in the cylinder pelletizer was simulated when the charge rate was 2 % and 4 % respectively at 0,3 in N/N_c. The simulation results are shown in Figure 3.

As shown in Figure 3, when the charge ratio is too small, the pellets are lifted to a higher position before falling, resulting in serious collisions between pellets. At the same time, the cylinder pelletizer has less loading capacity and lower productivity. When the filling rate is too high, similar to the above, the pellets are lifted to a higher position, the falling distance increases,

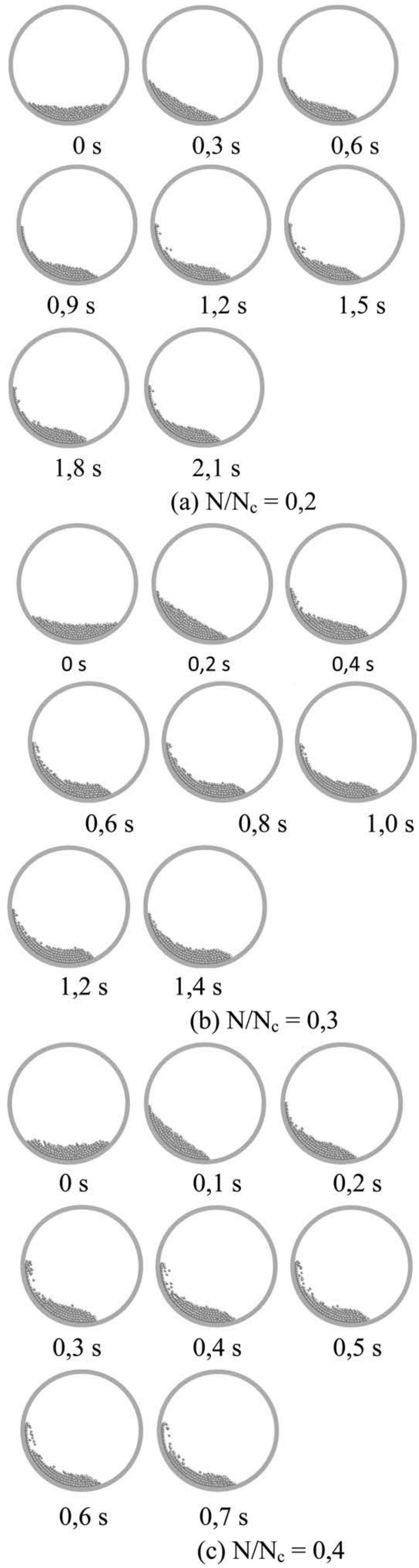

Figure 2 Motion state of pellets at 3 % in charge ratio for different rotational speeds ➤

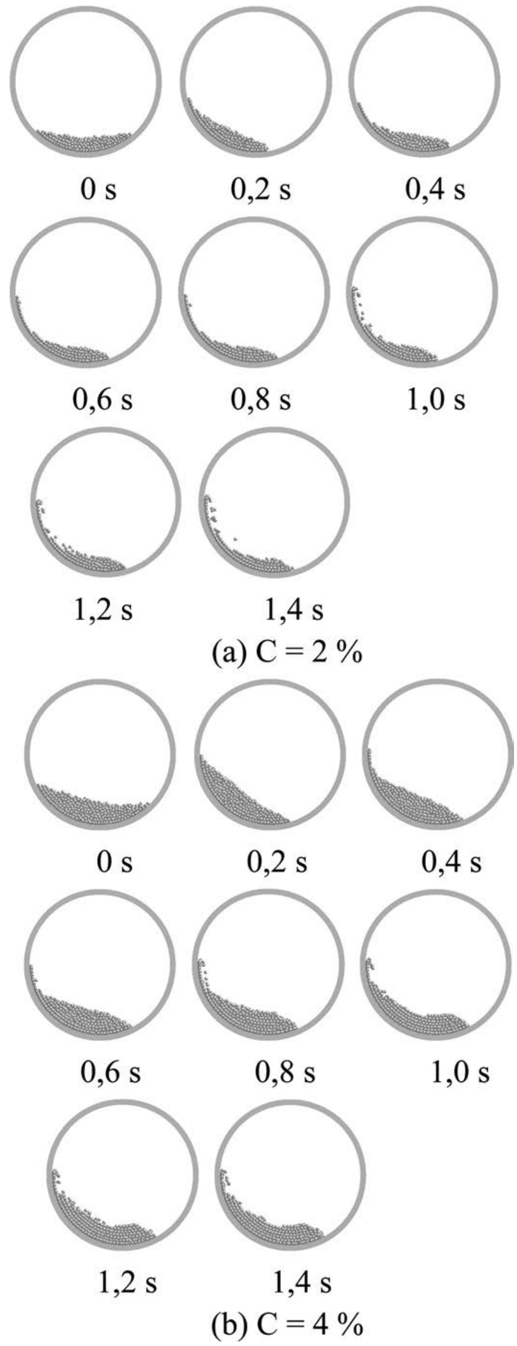

Figure 3 Motion state of pellets at 0,3 in N/Nc for different charge ratio

the pellets are accelerated, so that the pellets have a higher speed, and violent collisions occur between the pellets or with the cylinder wall.

In order to investigate the behavior of pellets, impact energy and rotational kinetic energie of pellets are calculated by using DEM, and they are shown in Figure 4. The impact energy, E_i, and rotational kinetic energy, E_r, are given by following equations, respectively:

$$E_i = \sum_{i=1}^{n} \frac{1}{2} m v N^2 \tag{1}$$

$$E_r = \frac{1}{2} I \omega^2 \tag{2}$$

Where m, n and v_N , are mass of pellet, frequency of collision, relative velocity in the normal component of pellet to colliding pellet, respectively. I and ω are moment of inertia and rotational speed, respectively.

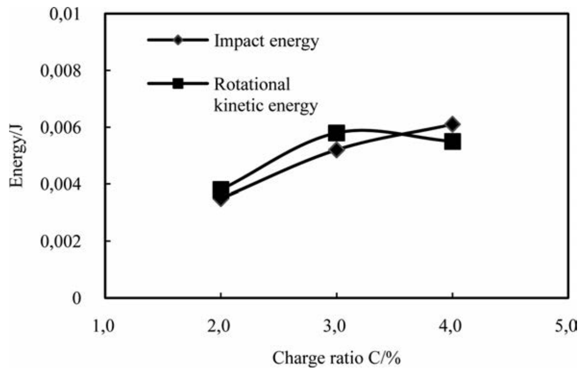

Figure 4 Effect of the charge ratio on impact energy and rotational kinetic energy at 0,3 in N/N_c

It can be seen from Figure 4 that the impact energy increases with the increase of the charge ratio, while the rotational kinetic energy increases first and then decreases with the increase of the charge ratio. When charge ratio is 3 %, the rotational kinetic energy reaches the maximum. When the charge ratio is too large, such as 4 %, the impact energy is dominant.

CONCLUSIONS

The cylinder pelletizer needs a suitable rotational speed. Too slow or too fast are unfavorable to pelletizing. The optimum rotation speed, N/N_c is 0,3.

The cylinder pelletizer also needs a suitable charge ratio. The charge ratio is too small, resulting in low production. If charge ratio is too high, it breaks the rolling of pellets. The appropriate charge ratio is 3 %.

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Note: The responsible translator for English language is F. Yang, Wuhan, China