THE VARIATION OF MASS CENTER AND THE INFLUENCE OF THE GRINDING PROCESS IN BALL MILLS

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Abstract: It is easy to determinate the behaviour of balls in ball mills with small dimensions in the laboratory. When the dimensions of ball mills increases it is very difficult to establish the particularly behaviour of balls in real ball mills. It is very difficult to determine the impact force between the grinding material and the balls or the grinding material and the inside layer of the mill. Therefore we can study and make a numerical analyses of the behaviour of balls, without high costs, without laboratory experiments, and miniaturized ball mills. The parameters that influence the process of grinding are easy to determine. The numerical simulation has a lot of advantages because we applied the law of physics. The measurements of the impact forces between the grinding material and the balls or the grinding material and the mill's body are done using sensors.

1. Introduction

The measurement of the impact forces inside the mill are done using two ways: using integrated circuits sensors for measuring striking forces inside the balls and using sensors inside the inner layer of the mill. Dunn and Martin (1978) inserted acceleration meters inside a command ball and could determine the effort between the balls (they determined the effort using the second law of mechanic). Vermeulen (1984) used electrical sensors inside the inner layer of a mill to determine the striking forces and Yashima and Hashimoto (1988) established the frequency of the surge from measurements on the load of the ball and the grinding material.

In the case where the proportion is small, there is a problem with the fact that the spaces between the balls will not cover entirely, therefore there will be a larger number of collisions between the balls, ending with a reduced grinding process. The same effect will happen in case of a large quantity of grinding material in the mill, overloading the space between the balls. Over time it has been noticed that the best results for grinding are obtained in the case where the superior layer of the grinding material is also the superior layer of the grinding bodies over the entire length of the tube's mill. This situation is obtained only if, the process of accelerating the smoothing of the material is done by increasing the evacuation speed of the material from the mill.

The crushing level and the circulation of the material in the mill depends on a dimensional structure of the grinding bodies, and the best results are obtained apparently by using higher dimensions for the grinding balls.

Practically the problem is more complex than it seems. Through experimental tests, it can lead to finding the maximum flow on which a mill can be used, for an established grinding ratio, stated through a sieve residue, specific surface or through the grading of the material [Mishra&Rajamani, 1992].

Liddel and Moys (1988) made a study about the effect of rotational speed of the mill and the filling ratio on the minimum and maximum value of the energy, and the effective torsion moment was determined using electrical conductivity. The results evidence the difference between the measurement and the existent values.

Rolf and his team (1982) developed a new measuring technique of energy distribution inside a ball mill. This technique used sensors inside the balls. When the impact force upgraded the elasticity limit, an electrical impulse was transmitted into a digital device monitored by a computer.

These types of information are sometimes unreal because of the way they are obtained. The used instruments are not always high tech therefore the results are not always real.

We will study below the discrete element method applied to ball striking inside ball mills and see if we can determine the efficient power of a mill.

2. Segregation effect

The charge behaviour is described by researching the speed and the inner layer of the mill. The speed effect is easy to observe, still we have another thing that influence the behaviour and that is the dimension of the balls. Different dimension of balls inside the mill leads to the segregation effect where some balls remain down in the mill and some are risen by the inner layer of the mill making a primary grinding. The difference between the size and weight of the balls leads to the segregation effect.

The results on a mill with 4.3m diameter, having rectangular inner layers (8 bars) is presented in Figure 1 and 2.

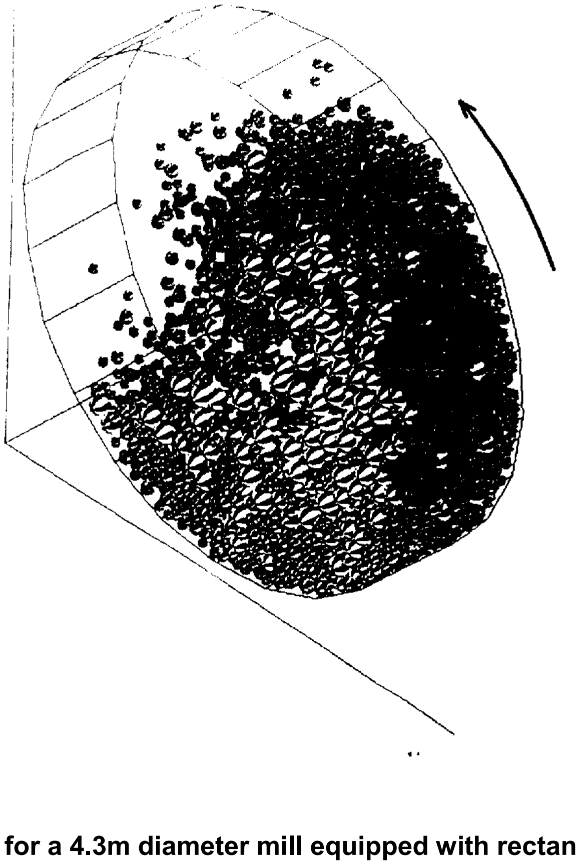


Fig .1. Segregation effect for a 4.3m diameter mill equipped with rectangular inner layers and the rotational speed 60% of the critical rotational speed

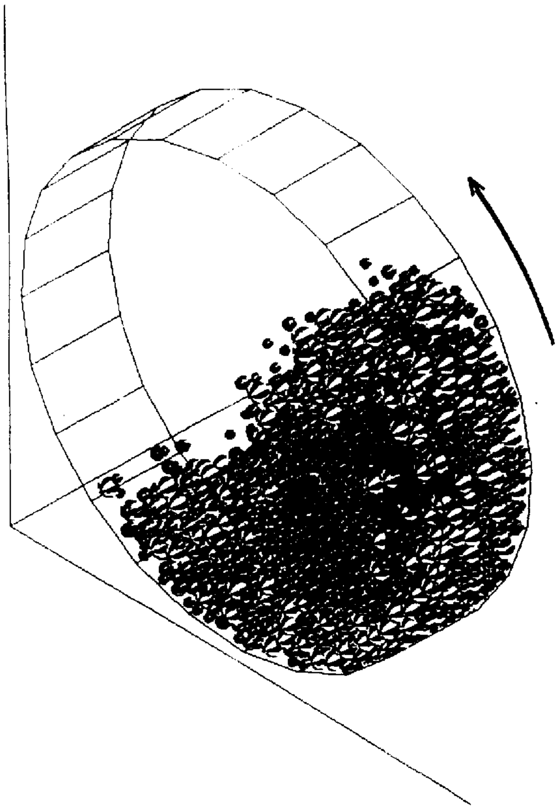


Fig.2. Segregation effect for a 4.3m diameter mill equipped with rectangular inner layers and the rotational speed 80% of the critical rotational speed

In these figures the mill is loaded with 3 different types of balls, 4cm, 2.5cm, 1,25cm. We can see in Fig.1, that small size balls are segregated in the interior of the mill and on a 80% rotational speed of the critical rot. speed, small size balls are centrifuged.

3. Friction effect

The friction coefficient between the superficial layers of the balls has a large effect on the projected power of the tubular ball mill(Liddel , şi Moys ,1988, 11). This effect is observed by studying the general behaviour of the charge inside the mill to different friction coefficients. In tubular ball mills without inner layers, the behaviour of the charge depends on the friction coefficient between the balls and the body of the mill. Still it is interesting to observe the behaviour of the balls inside a 4.75m diameter mill, with rectangular bars as inner layer, a loading coefficient of 45% and using different size balls. At 70% rotational speed of the critical rotational speed of the mill, and 2 different friction coefficients we have the results in Figure 3.

4. Ball charge and grinding material inside the mill

It is known that inside the mill the grinding type is linked to the grinding speed and the filling ratio of the mill. For each filling ratio, the grinding type is modified by the speed of the mill. This variation is presented in tables 1 and 2 and in Fig. 4 and 5 where it is presented the weight center of the charge in a 55cm diameter mill, filling ratio 40%, and rotational speed 60% and 80% from the critical rotational speed of the mill.

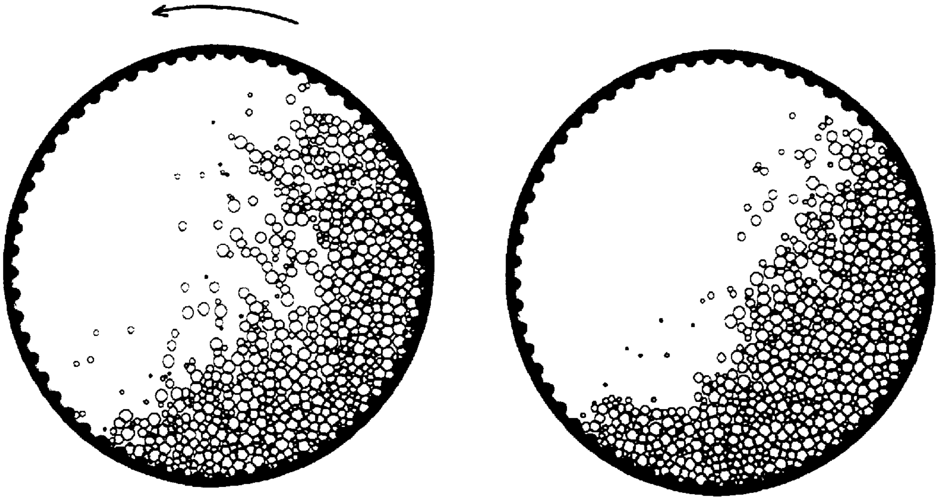


Fig. 3 Charge variation inside the mill
a) for friction coefficient 0.7;
b) for friction coefficient 0.2;

Table 1
Mill diameter: 55 cm
Filling ratio: 40%
Rotational speed: 80% from critical rotational speed

X [cm]	Y [cm]	X [cm]	Y [cm]
33,8	22	34,04	22,85
33.9	21,7	34,05	22,84
33,95	22,05	34,20	22,85
33,85	22,1	34,24	22,82
33,82	22,5	34,25	22,6
34,10	22,05	34,20	23,15
34,12	22,9	34,45	23,18
34,05	22,45	34,55	23,16
34,05	22,44	34,8	22,9

Table 2
Mill diameter: 55 cm
Filling ratio: 40%
Rotational speed: 60% from critical rotational speed

X [cm]	Y [cm]	X [cm]	Y [cm]
34,4	20,4	35,06	21,0
34,7	20,4	35,05	21,40
34,65	21,07	35,055	21,45
34,85	21,0	35,10	21,5
34,85	20,8	35,11	21,55
34,9	21,8	35,11	21,3
34,9	21,4	35,4	21,25
34,95	20,9	35,1	21,2
35,05	20,8	35,3	21,45
35,07	20,9	35,45	21,5

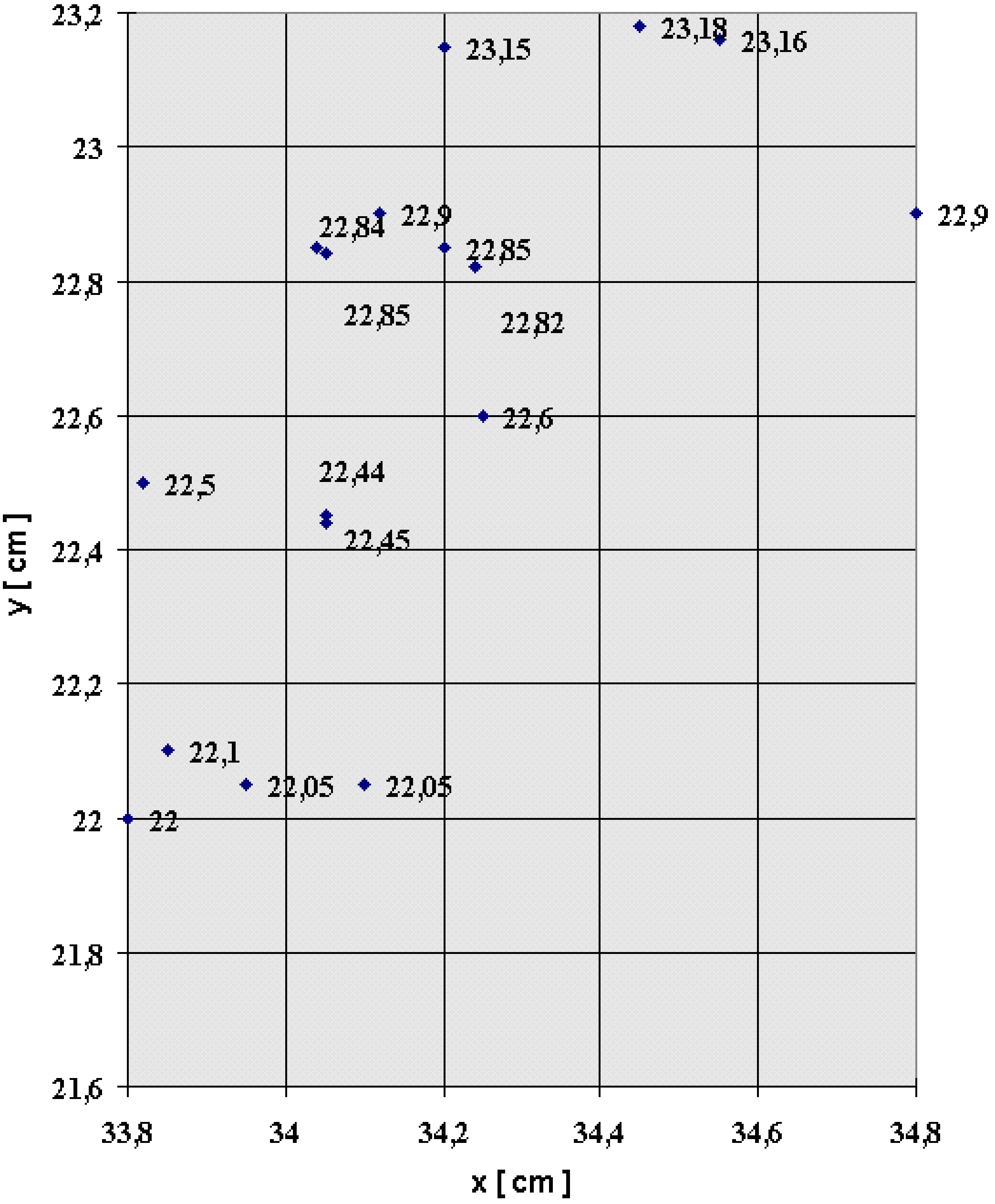
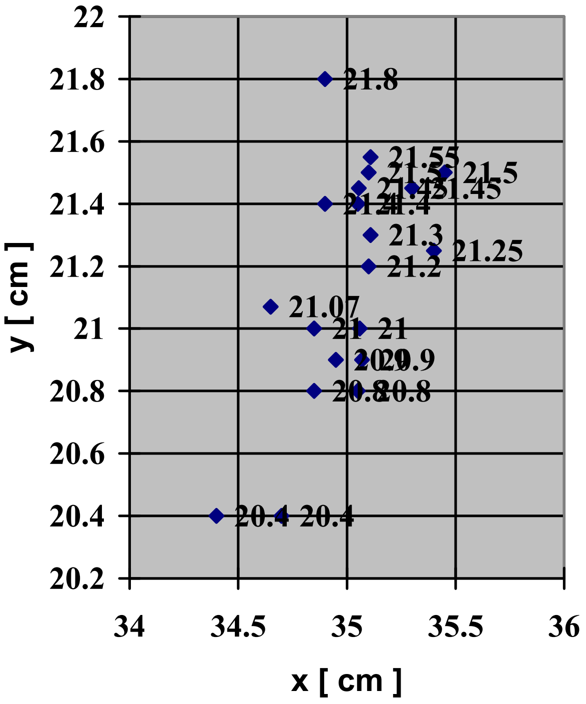


Fig. 4. Weight center coordinates of the ball charge of a 55cm diamter mill, a filling ratio of 40% and a rotational speed of 60 % from the critical one

The origin of the axis system is chosen do the center of the circle that represents the tube of the mill has the coordinates x=D/2 , y=D/2 .

Fig.5 Weight center coordinates of the ball charge of a 55cm diamter mill, a filling ratio of 40% and a rotational speed of 60 % from the critical one



On a contraclockwise movement of the mill the center of the charge weight is modifying ascendant on the left while the rotational speed grows from 60% to 80% of the critical rotational speed.

Fig. 2.5 can be translated to sow the numerical variation of the ball striking in the mill. The modifying of the gravity centers of the charge is due to the dilatation and contraction of the charge. The dilatation process shows locally due to the grinding process of the material.

5. References

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