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THE DISTRIBUTION OF ENERGY IN GRINDING CHARGE OF BALL MILLS

PRICHICI Mariana, INDRIE Liliana, GHERGHEL Sabina, ALBU Adina
University of Oradea, Faculty of Management and Technological Engineering,
Faculty of Textiles and Leatherworks,
mprichici@uoradea.ro

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Abstract: This paper presents the distribution of energy in the grinding charge of ball mills as a function of the number of impact between the balls and the grinding material inside the ball mill with different diameters and different values of the rotational speed.

1. Introduction

The number of surges inside the ball mills is difficult to determine not only in an experimental mode but to design it as well. In the impact process, the grinding material is transformed in little pieces by breaking the internal links of the material, which leads to the actual process of grinding causing material to break. Therefore it is essential to determine the force that interacts between the balls during the grinding process inside the mill.

2. Energy distribution for various parameters

The collision between two balls has two main characteristics, effort and deformity. Therefore it is possible to compute the energy distribution from the collision of the entire charge of balls.
The results of a simulated grinding process shows that the distribution of the energy inside the charge of a tubular ball mill is modified by the speed of the mill, the filling ratio, the dimension of the balls and the material of which is made the inner layer if the mill. The global effect of these parameters were studied statistically [Mishra şi Ramajamani, 1992]. The individual effect of some parameters are presented bellow. For the study of the energy distribution inside the mill, we simulate the grinding process on a mill with the diameter 4.75m, filling ratio 45%, and inner layer with steps (60). For 2 rotation speed, 60% and 80% from the critical rotation speed, the energy distribution we obtain the following results:

Mill diameter: 4,75 m
Filling ratio: 45%
Rotation speed: 80% from the critical rotation speed

Average energy [J]	Specific number of collisions per time unit
1	1400
6	1040
12	140
16	114
22	104
26	15,0
32	13,0
36	11,0
42	10,0
46	6,0
52	3,0
56	2,0
62	1,0

Mill diameter: 4,75 m
Filling ratio: 45%
Rotation speed: 60% from the critical rotation speed

Average energy [J]	**Specific number of collisions in time units**
1	10400
6	1000
12	120
16	100
22	14
26	11
32	10
36	4
42	2

Besides the rotation speed of the mill, the diameter of the ball mill, the energy distribution inside the mill is modified by the inner layer and the viscosity of the charge. At laboratory tube mills, with small diameters all the collisions have a small impact energy measured in millijoules. So the impact energy grows with the growing of the mill diameter. Given a filling ratio, with a rotational speed, the grinding material is lift up compress and broken in the first part of the movement and crushed by falling on the second part. The maximum energy is in the A-A zone in [Fig 1].

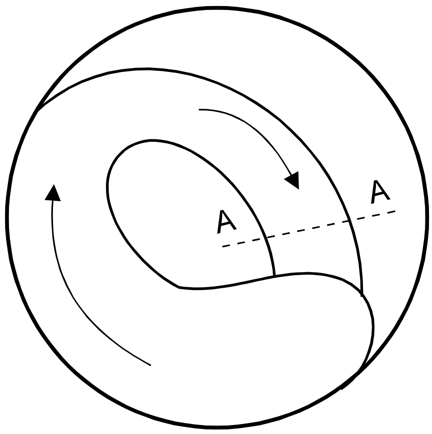

Fig.1. Maximum energy in a tubular ball mill

This energy can reach up to 200 J and the collisions forces up to 1000 N [Mishra şi Rajamani 1992] only that these forces are only 10 – 20 % of the collisions in the mill.
Using the simulation method of the discrete element we can sketch a map of the equal energies inside the mill. We have bellow an example of such a map on a mill with 4.75m diameter.

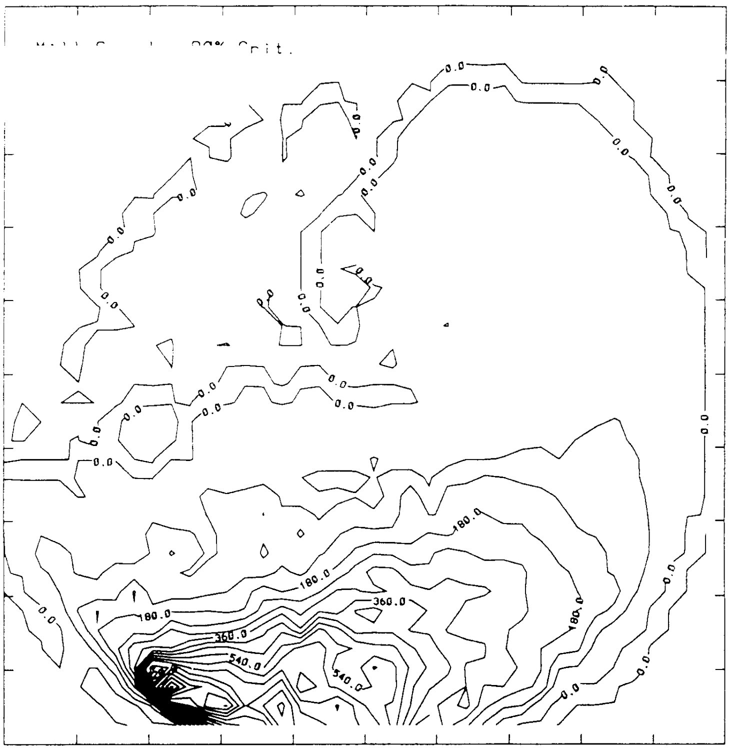

Fig. 2. Equal energy lines inside a ball mill with 4.75m diameter

The corresponding energy values can reach up to 200 joules and the striking forces up to values of 1000N order [Mishra şi Rajamani 1992] but these striking forces represents only 10 - 20 % from the striking inside the mill.

Using the simulation method using discrete element, we can drive a map of the equal energy lines inside a tubular ball mill [Fig. 3]

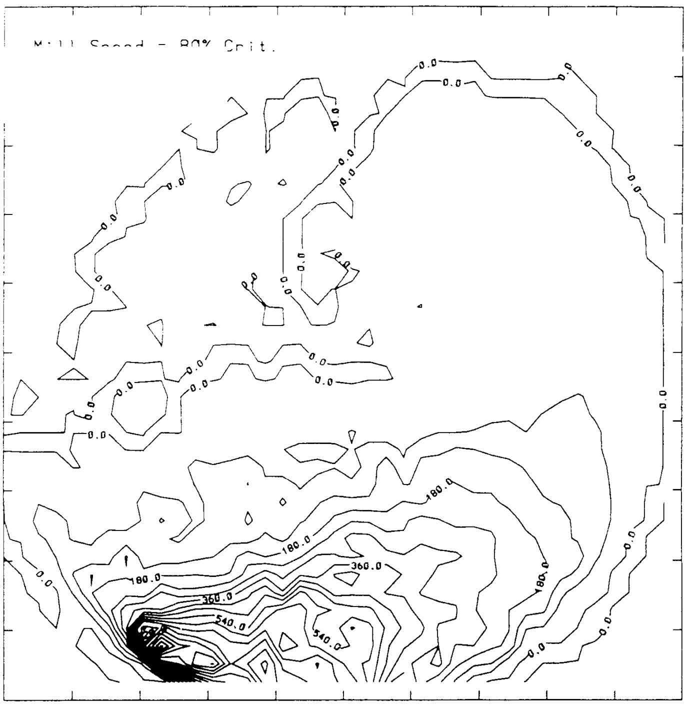

Fig. 3. Equal energy lines inside a mill having 4.75 diameter

Average value of the height in the falling process of the grinding material and the balls inside the mill is another indicator of the intensity of the grinding. By simulation in a 4.75m diameter mill on two rotational speeds 60 – 80 % of the critical rotational speed we get:

Mill diameter: 4,75 m
Rotation speed : 80% from the critical rotation speed

Height in the falling process [CM]	Specific number of collisions in time unit
10	10000
30	1900
50	1250
70	1100
90	1050
110	100
130	16
150	15,5
170	15
190	13
210	11,5
230	10,5
250	10,1
270	10,4
290	10,5
320	10
340	7
360	5
380	4
400	2

Mill diameter: 4,75 m
Rotation speed: 60% from the critical rotation speed

Height in the falling process [CM]	Specific number of collisions in time unit
10	1900
30	170
50	120
70	105
90	18
110	13
130	11
150	8
170	5
190	1
210	1
230	0,8
250	0,8
270	0,5
380	1
400	3

By studying these results we can tell that on a small rotational speed the value of the height in the falling process is also small. By increasing the height, we increase the impact energy. Hence the rotational speed influences directly the energy in the mill. Studying the distribution of the height in the falling process, we can control the collisions by adjusting the weight of the balls. Since 1958, Rose and Sullivan noticed the influence of a large diameter ball on the efficiency of the collisions.

3. Conclusions

The simulation method using the discrete element is useful in studying the processes inside the mill, during the collisions. This type of information is hard to get in an experimental way. So they can be studied better in real situations with large diameter ball mills.

Analysing the behaviour of the balls we notice:

- The behaviour of the charge is influenced by some factors. To different rotational speeds the larger balls tend to remain in the center of the mill.
-The filling ration inside the mill is modified during one rotation
-to a certain rotational speed the grinding ratio is modified by the friction coefficient.
-The energy distribution and the falling height inside the mill are important features which show the behaviour of the charge inside the mill. The fact that the collisions with big intensity are few indicates the cascade movement of the balls. A part of the necessary energy is obtained from pressure inside the mill.

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