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SIMULATION OF THE GRANULAR FLOW OF GRINDING MEDIA, INSIDE A BALL MILL

Robert Kostek, Bogdan Landowski

University of Technology and Life Sciences,
Faculty of Mechanical Engineering
ul. Kaliskiego 7, 85-796 Bydgoszcz, Poland
e-mail: robertkostek@o2.pl, e-mail: lbogdan@utp.edu.pl

Abstract

The ball mills are often applied in mineral processing, they are e.g. an important part of the cement industry. A key factor, which influences the milling process, is the granular flow of grinding media. The flow determines: energy consumption, time of milling and capacity; thus there is a need to describe the phenomenon. The discrete element method - DEM is a computational method, which allows to simulation of the granular flow, thus it has been applied in this article. The received results of simulation have been compared with experimental results.

***Keywords** : DEM, ball mill*

1. Introduction

The ball mills are widely used machines. They are mainly used to powder minerals, that is their typical application. The powdering takes place between balls, due to normal and tangent forces. The forces determine interaction between the balls, thus they have an influence on the granular flow of the grinding media. In the considered case, the interaction between the balls has been described with Coulomb friction, and restitution coefficient.

At the stage of conception and designing, various: shapes of liners, values of speed and fill levels can be considered. That gives an opportunity to analyse, the dynamics of grinding balls, acting forces and power consumption, at the very beginning stage. This is the reason why the discrete element method, has been applied in mineral processing [1, 2, 3, 4].

The basic concept of the discrete element methods (DEM) is to model the bodies with large assemblages of particles (discrete elements), which is a very general and practical approach. The discrete elements can represent: atoms, groups of atoms, grains of sand, stones or FEM primitives. That approach gives an opportunity to model: gases, fluids and solids, thus DEM is used to solve a wide range of engineering and scientific problems [5]. Motion of the discrete elements, which is described by the second order ordinary differential equations, is computed, and finally the motion is presented as a movie and analysed [1, 2, 5, 6, 7].

2. The granular flow of grinding balls inside a ball mill

As it has been mentioned above - shape of liners, values of speed and fill levels influence the milling process. Liners are designed in the way, that impedes rolling balls on the liners, and makes an easier lifting the grinding balls. The values of speed of the mills *n* are in the range from n=0,55n_{kr} to n=0,85n_{kr}, but the typical value is n=0,75n_{kr} (e.g. [8]). The critical speed n_{kr} is reached when centripetal acceleration of any liner, is equal to the gravity acceleration. While the fill levels are in the range from 0,3 to 0,55 - which is the maximum value.

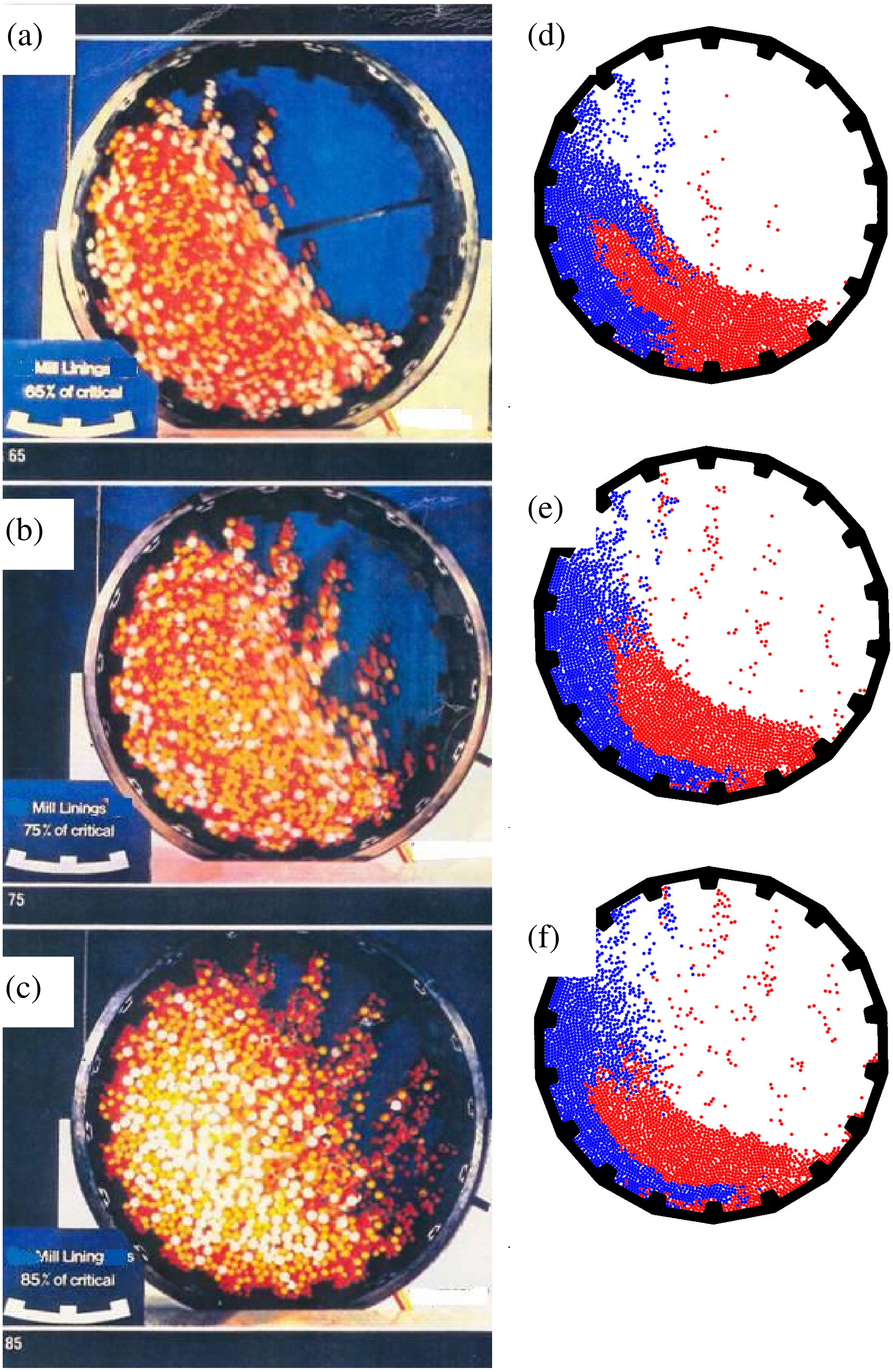

Fig. 1 Comparison of the experimental results (a-c) [9] with the results of simulation (d-f), for the following speeds: n=0,65 n_{kr} (a,d), n=0,75 n_{kr} (b,e), n=0,85 n_{kr} (c,f)

Some experimental results have been published on Internet [9], which gives an opportunity to compare them with the results of simulation (Fig.1). The simulation has been computed for 3702 particles, and the following values of parameters have been adopted to perform the simulation: the restitution coefficient C_R=0,05 and coefficient of Coulomb friction μ=0,5. In spite of the fact that, the values of the parameters have not been published on the web site [9], the computational results show good agreement with the experimental results. The number of balls falling down seems to be bigger in the experiment, but it results from the fact that: the simulated model is two-dimensional, while experiment was three-dimensional, moreover the particles used in experiment are bigger than these in the simulation. The presented results show good agreement with the results of simulations, which have been published previously in literature as well [4,10]. The considered granular flow of grinding media, inside a ball mill has been simulated with program algoodo [11].

3. Summary

The presented results show granular flow of the grinding media, inside the ball mill, for three values of speed. The computational results have been received with DEM, and have been validated against the experimental results. The comparison shows good agreement between them, which suggests that the study should be continued. It shows that, DEM provides valid information, which can be used by the designers. Summarising DEM is a useful tool in future modification of the ball mils.

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