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Simulation of the granular flow within an impact crusher

Introduction

The impact crushers are widely used crushing machines. They are mainly used to crush many kinds of materials, whose impact resistance is low, and ultimate compressive strength is bellow 350 MPa. The crushing process takes place in the crushing chamber. A blow bar (hammer) hits a stone, and accelerates one. Next the hit stone hits a breaker plate (anvil, impact plate). The process leads to disintegration of the stone. The stone should be hit and hit perpendicular to the surface, then crushing process is effective. The phenomena like impact [1], energy consumption [2, 3], granular flow of material [4, 5] are coupled with the crushing process and are investigated by researchers.

On the stage of prototyping impact crushers are not perfect. The main problem on the stage is proper shape of a crushing chamber. A crusher must be fitted safely, thus stones can not leave a crusher through inlet. The next issues are shape of the rotor and the breaker plates. Which influence on the crushing process. In addition designers tray to find a solution that guarantee high size reduction and low power consumption. A few examples of the impact crushes are presented in Fig. 1. The designing process can be aided by computer simulation – DEM, then is faster.

Discrete element methods (DEM), are numerical methods used to solve a wide range of engineering and scientific problems. The fundamental assumption in these methods is that material consists of large assemblages of separate, discrete particles. These particles may have different shapes and properties. Interaction phenomena between bodies are simulated with numerical methods. Next, the motion of particles is computed. Finally, the motion of a large number of particles is presented as a movie [5, 7] and analysed. The methods have significant applications in mineral processing. Thus the main aim of the work is to present an application of the DEM on simulation of granular flow within the crushing chamber. The crushed material that flow through the crushing chamber is modelled with a number of particles [4, 5]. The particles represent for instance stones or grains, examples of simulations are presented bellow.

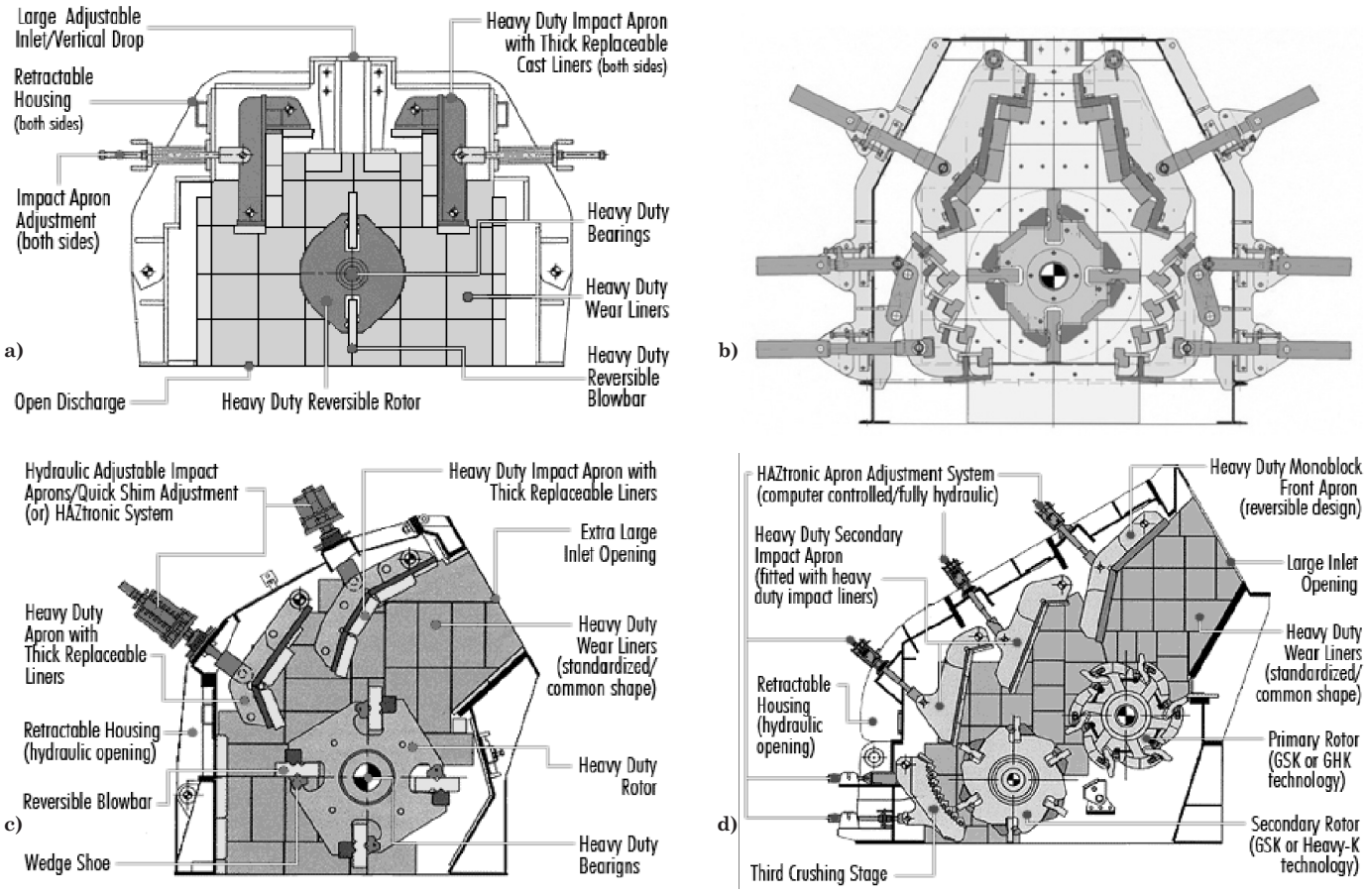

Fig. 1. Examples of impact crushers design [6]

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Granular flow of material through a impact crusher

In the section two granular flows are presented, the first one has been simulated for a large number of small particles, while the second one for a number of bigger particles. Interpretation of the first simulation is simple, thus one is presented as a first.

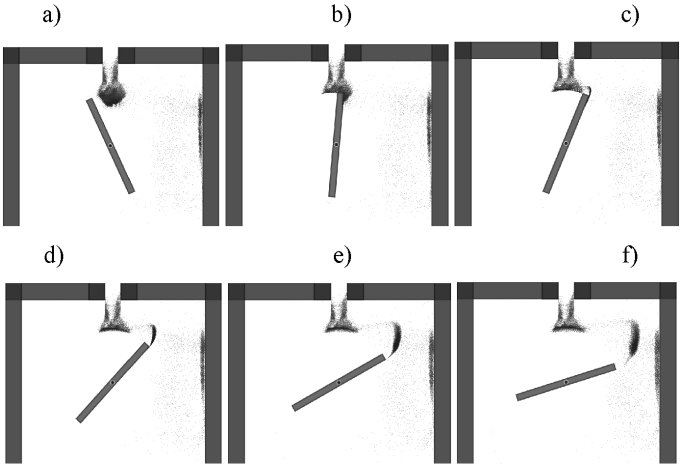

Fig. 2. Stages of forming stream of particles, due to impact of blow bar

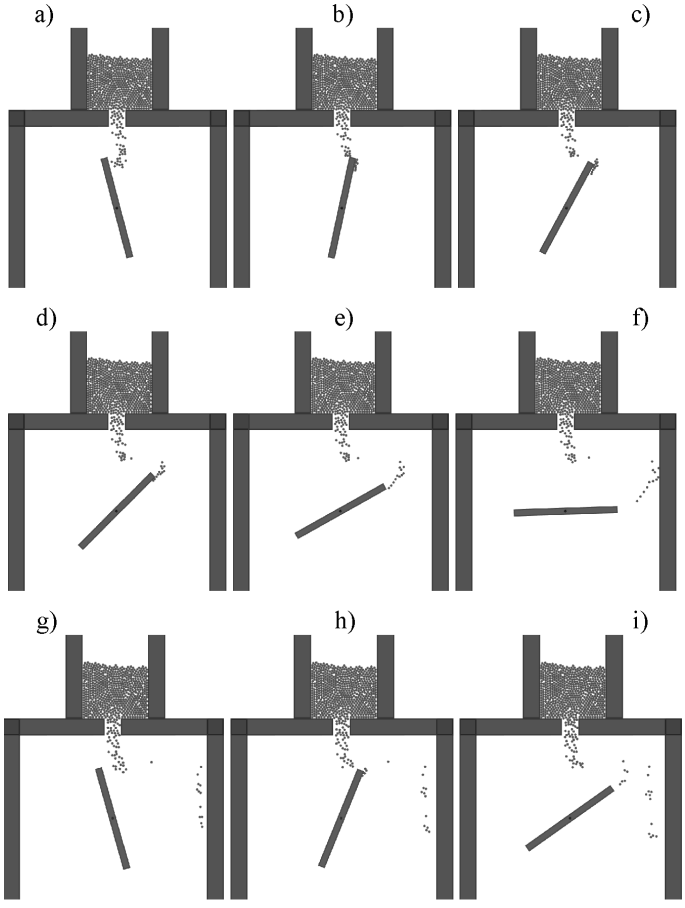

Fig. 3. Flow of crushed material in the impact crusher

The material falls down on the rotor (Fig. 2a). Next the particles interact with the blow bar, and form the stream (Figs. 2b-e), that reaches the breaker plate (Fig. 2f). Finally the particles hit the plate and fall down. The next stream of particles can hit them during falling down. This simulation shows process of granular flow that is clear, because of large number of the particles. The simulation provides information about the stream forming, trajectory of particles and their velocity. Thus designers can modify geometry of the blow bars and breaker plates.

The second granular flow has been simulated for bigger particles, thus their number is smaller, and consequently interpretation is more difficult. This kind of the granular flow, inspite of its deterministic nature, can be considered as a random process. On the top of the simulated crusher is located a container with particles. The particles flow through the gape and fall down (Fig. 3a). The flow on the top of the crusher can be treated as a separate problem, and has been studied before [5]. Next the particles are hit by the blow bar and form the stream (Figs. 3b-d). The received stream is not as clear as the one received previously (Fig. 2), because number of particles is smaller. Nevertheless the nature of the process is the same. Finally the particles hit breaker plate (Fig. 3f). The next formed stream of the particles can interact with the previous one (Figs. 3h,i). The simulation reflect the nature of material flow within crushing chamber, thus can be useful in understanding the crushing process.

Conclusions

The presented simulations show granular flows of the crushed material within the impact crusher. The flows have been simulated as deterministic phenomena with DEM. The stages of the flows have been visualised and interpreted. DEM is very useful tool on mineral processing, because of difficulties coupled with the experimental investigations. That helps in understanding flow of the crushed material, designing impact crushers and virtual experiments. It has been showed that DEM provides valid information, which can be used by designers and scientist. Summarising DEM is proper tool for modification of the impact crushers.

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