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ANALYSIS OF TRANSFER STATIONS OF BELT CONVEYORS WITH HELP OF DISCRETE ELEMENT METHOD (DEM) IN THE MINING INDUSTRY

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Abstract: *This article reports about the application of the Discrete Element Method (DEM) for an analysis of the "rock box"-transfer stations, which is widely used in the mining industry..*

Key words: *Transfer Stations, Discrete Element Method (DEM), Simulation, Mining, Belt Conveyors*

1 INTRODUCTION

Steady growing demand on row materials in emergency markets boosts a development and improvement of bulk material equipment in mining industry. Belt conveyors and their elements remain most popular mining equipment due to its very high productivity. Transfer stations are widely used for belt conveyors, where a bulk material is transported over long distances and/or complex mine or nature terrains. In the mining industry heavy and hard bulk materials (e.g. crushed rock or similar) must be transported very often. In this case a carefully designed transfer station essentially contributes for a long life time of a conveyor belt. The behavior of a bulk material flow in a transfer station is very complex and cannot be described sufficiently by an analytical model. The analysis of alternative designs of a transfer station can be aided by using a numerical simulation based on the Discrete Element Method (DEM) before a transfer station is ever built.

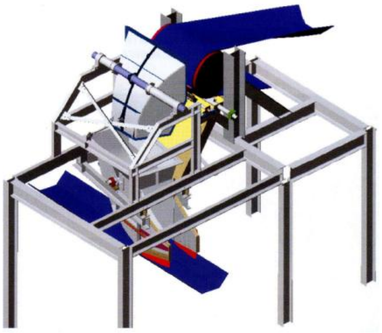
DEM was developed in the 70th of the twenty century by Cundall for geo- and rock mechanics and is widely used now for simulation of material handling equipment [1]. From many numerical methods the DEM-method is the most representative one to describe a complex dynamic behavior of the discrete and discontinuous processes, which is e.g. the transportation of bulk materials.

Transfer stations and feeding points remain one of the most important and challenging units of belt conveyor systems, because a poor designed transfer station may cause:

- Build-ups and plugs in transfer stations resulting in high downtime of production
- Dust, noise and spillages around the conveyor system
- Essential wear or destruction of a conveyor belt, transfer station elements and idlers
- Belt misalignment due to not a central loading

Following transfer station types are widely used in the mining industry: Impact Wall, Rock Box, Hood-Spoon-system and Grizzly Fingers (Table 1).

Table. 1 *Typical transfer station designs used in the mining industry*

Impact wall	**Rock box**
 *Source: RWE, Germany*	
Hood – spoon system	**Grizzly fingers**
 *Source: Gulf Conveyor Systems Pty Ldt., Australia*	 *Source: Jadco Manufacturing Inc., USA*

All types of the above mentioned transfer chutes have advantages and disadvantages and should be applied depending on bulk material properties, conveying parameters, site conditions etc. This article focuses on the Rock Box type.

2 DESIGN CONSIDERATION FOR TWO ROCK BOXES

One existing and one alternative transfer stations with a different geometry and position of the rock box were considered in the two simulations. The simulation models were generated on the base of the CAD drawings offered by one mining company. They are shown by Fig. 1. The models are named after the Existing Rock Box (ERB) and the Alternative Rock Box (ARB).

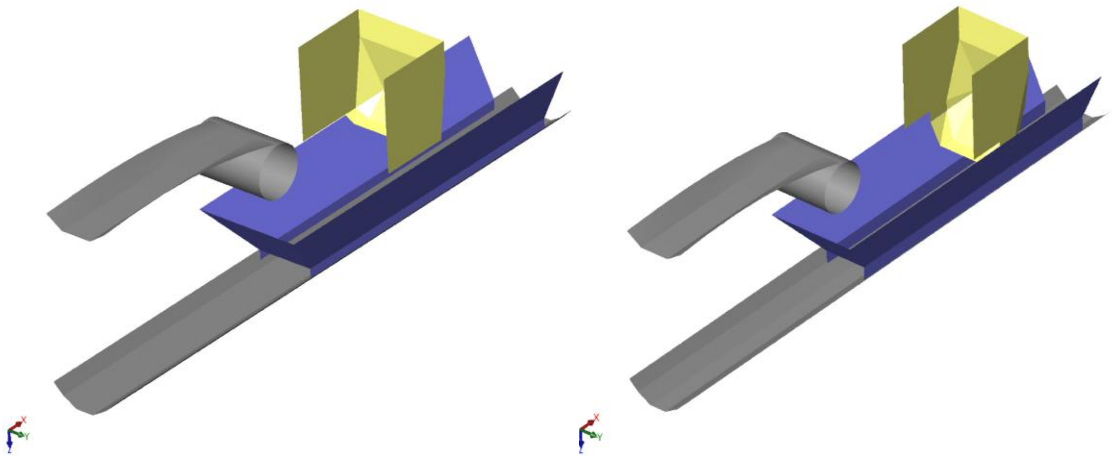


Figure 1 *3D simulation models of the transfer chute geometry*

The bulk material rock was simulated with the following particle size distribution:

- Approx. 40% of total mass: 110 mm < dK < 150 mm
- Approx. 60% of total mass: 37 mm < dK < 74 mm

The simulation parameters were chosen after the analysis of the given rock sample. The following operational parameters were considered in the simulation models.

Table. 2 *Operational parameter of the simulation models*

Case	Drawing	Volumetic flow	Belt velocity	Belt Troughing Angle	Material Surcharge Angle	Transition Distance	Material Density
1	ERB	20.000 t/h	≈7,6 m/s	35°	12°	≈3,8 m	1,9 t/m³
2	ARB	20.000 t/h	≈7,6 m/s	35°	12°	≈3,8 m	1,9 t/m³

3 RESULTS OF DEM-SIMULATION

Figure 2 shows the steady state situation of the material flow of the two transfer stations.

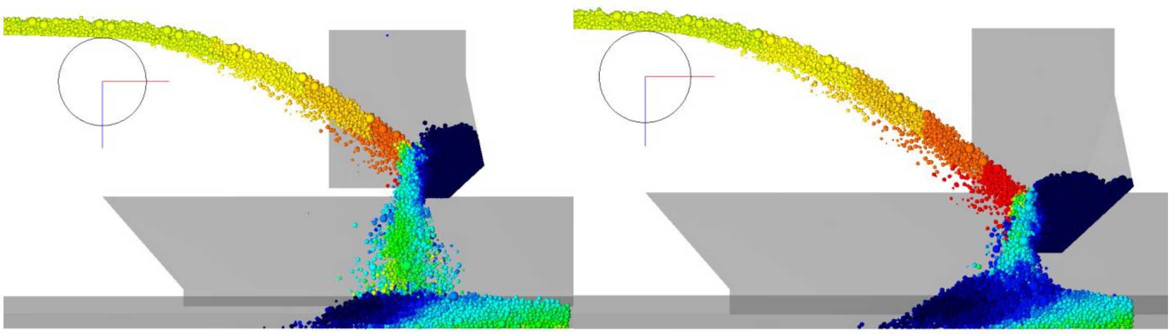


Figure 2 *Simulated material flow. Particle colour: Particle velocity: 0 ▇▇▇ >10m/s*

Due to the narrower wide of the chute in the configuration ARB, the material builds up higher on the receiving belt. Regarding also the lower position of the rock box in this configuration hardly any accelerating distance for the down falling of particles can be recognised.

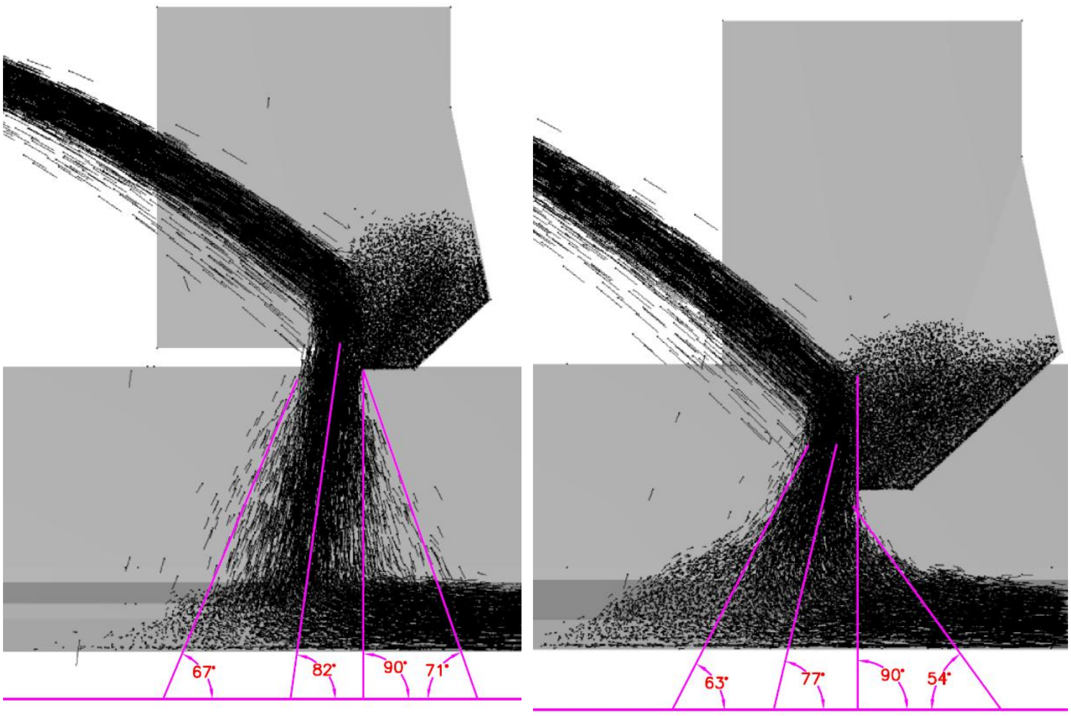


Figure 3 *Particle velocity vectors and impact direction on the receiving belt*

The material which flows down the rock box is generally directed against the conveying direction of the receiving belt. Fig. 3 shows this even clearer via the vectors of the particle velocity.

The steady state condition can be not only recognised by the observation of the material flow but also by the analysis of the acting forces on the rock box. Fig. 4 shows the forces due to the particle impact on the rock box in transport direction (x-direction). After a certain time nearly constant values of both forces are measured.

Although the particles hit the "ARB"- rock box with a higher velocity, lower impact forces in x-direction could be measured. This is caused by the higher particle velocity component in z-direction due to the increased distance from the drum.

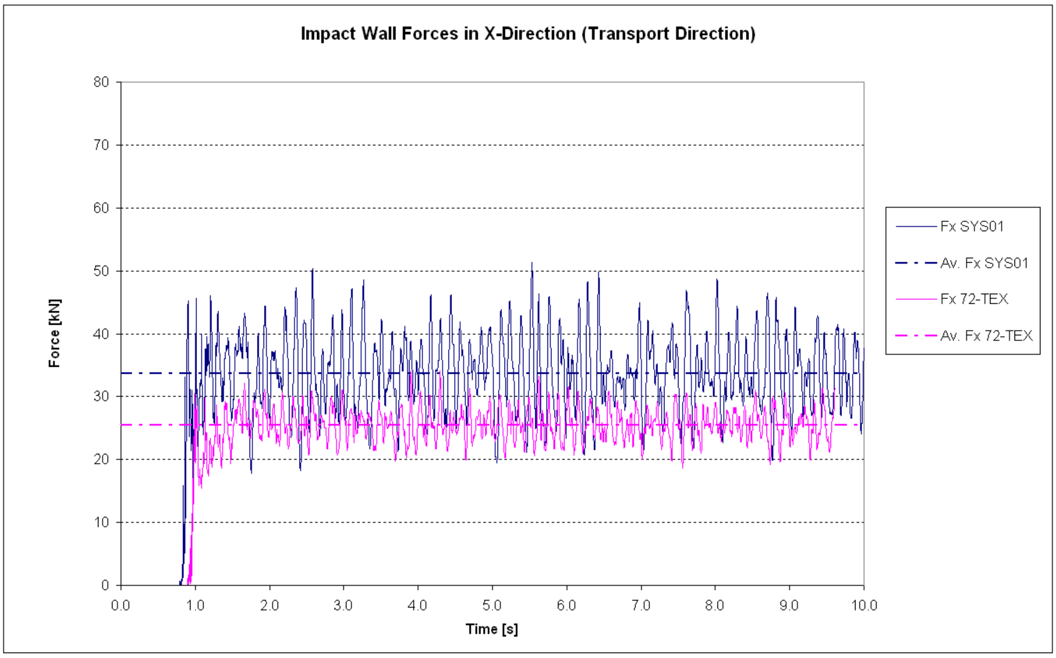


Figure 4 *Forces on the rock box caused by the particle impact (x-direction)*

The forces on the rock box acting in gravity direction (z-direction) are mainly influenced by the weight of the stored bulk solid on the rock box. Fig. 5 shows that the "ARB" rock box is loaded with a smaller force in gravity direction. A measurement of the stored bulk solid mass in steady state condition results in a weight difference of 1030 kg between the two rock box designs. The reason for this is the much more narrow design of the "ARB" rock box.

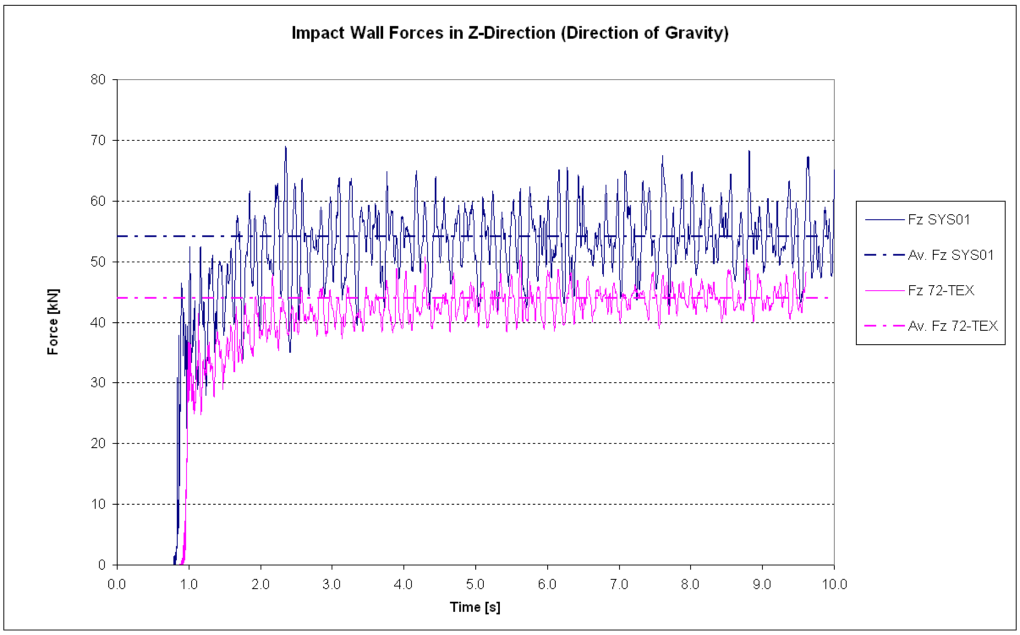


Figure 5 *Forces on the rock box caused by the mass of stored material (z-direction)*

But not only the forces on the rock box could be measured. Also the impact forces on the receiving belt were measured in the simulation. This allows a prediction of belt wear. Fig. 6 shows the measured belt impact forces of the both transfer stations. The transfer chute configuration “ARB” shows clearly less impact forces due to the lower distance of the rock box to the belt.

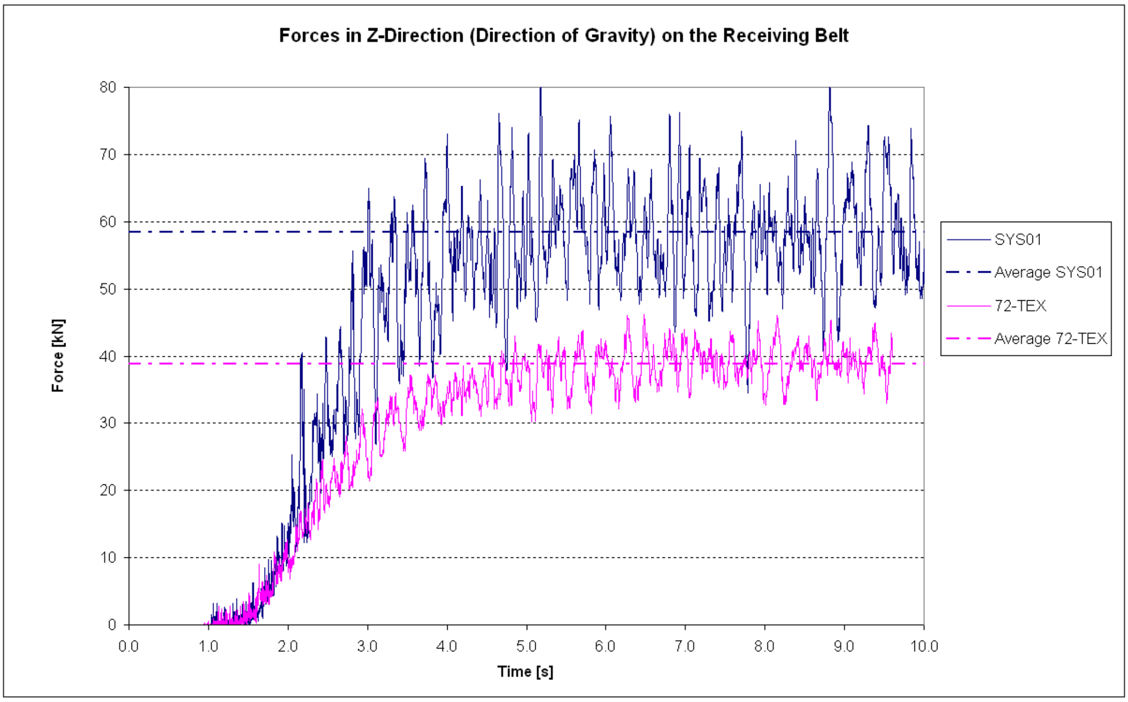


Figure 6 *Impact forces on the receiving belt*

4 CONCLUSIONS

The DEM simulation of two rock boxes showed that by means of the DEM superior design could be identified and the higher wear impact on a belt reduced at the design stage with less cost. Summarizing it can be mentioned, that DEM is a powerful tool, which can be used for the development, design and calculation of conveyors and their elements and for problem solving in conveyor technology.

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