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Investigation of iron ore material behavior in semi-autogenous grinding mill. Part II. Comparative analysis of iron ore material in semi-autogenous grinding mill with different lifters shapes.

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Abstract: *In the presented paper attention is paid to simulation of lifter bodies with different shapes (spherical and spherical-tetrahedron shape). The simulation is made with software working on the discrete elements method - EDEM Software. For the behavior of the particles is used iron ore material. Analysis of the results is made.*

Keywords: lifters, SAG mill, simulation, grinding.

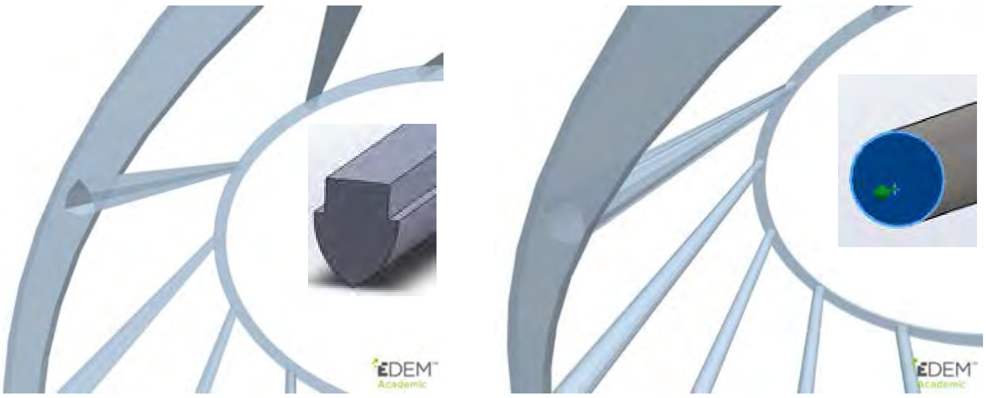
1 Introduction

Mostly Mills are used in a various technological continuous processes in metallurgy, mining, cement and other industries. Typically, SAG mills works with lifters, made of rubber or metal. SAG mills works also with spherical grinding

bodies. The grinding bodies are made of materials meeting the requirements of BDS, EN, ISO, requirements about the cleanness of the material, etc., such as steels, alloys of steel, porcelain, ceramics, etc [1-4].
In today's operating conditions, besides technological, constructive and economic requirements, attention is also paid to ecology, energy efficiency, operational reliability as well as human factor.
The objective of this paper is to compare iron ore material in semi-autonomous grinding mill behavior in different lifter shapes.

2 Simulation preparation

The comparative analysis is made with the same software, used in part I. Grinding with innovative lifter shape of "Investigation of iron ore material behavior in semi-autogenous grinding mill".
Almost the same methodology from part I is used, but instead of the innovative lifter shape, another type is used. The original one from laboratory mill is cylindrical lifters type. The differences are shown on fig. 1. All other tasks and properties remains the same: material for milling, equipment material, and rpm's of the mill, dimensions (Length and diameter), number of lifters and number of particles, model for calculation, simulation time and grid. The CAD model is based on 3 main parts – shell of the mill (drum), hoods and lifers. This type of modelling helps for fast change of parts for investigation of their role in the process [5-11].
Another advantage of the used software is the function for relative wear recording of geometry, based on the mesh of the 3D objects and the identified contact with particles. The calculation is based on relative velocity and connected between particles and equipment forces of the produced from the software particles [12].



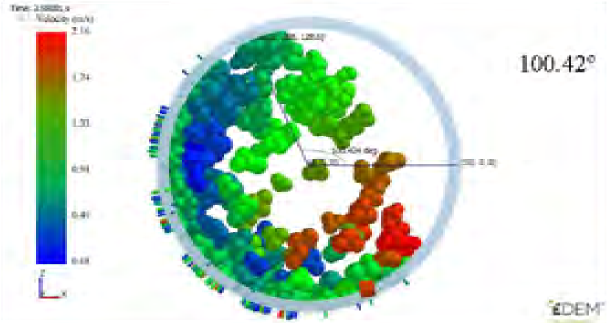
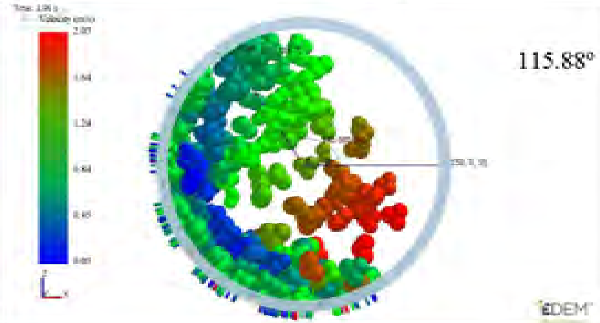
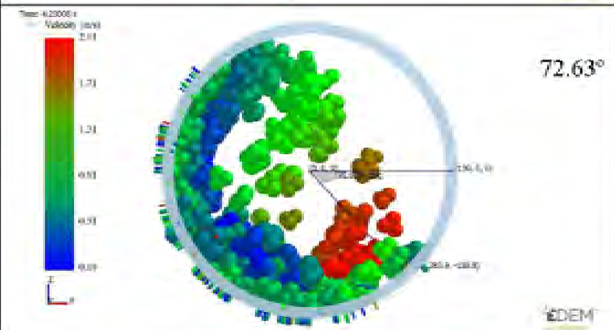
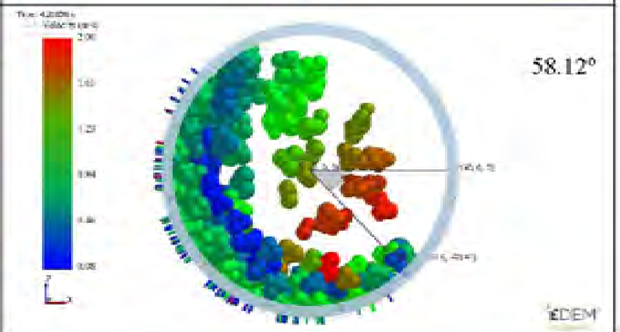
a) Innovative lifter shape b) standard lifter shape

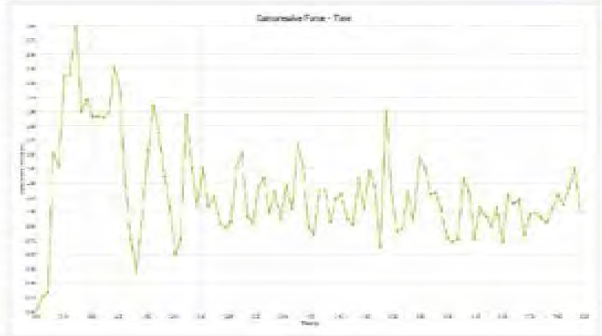
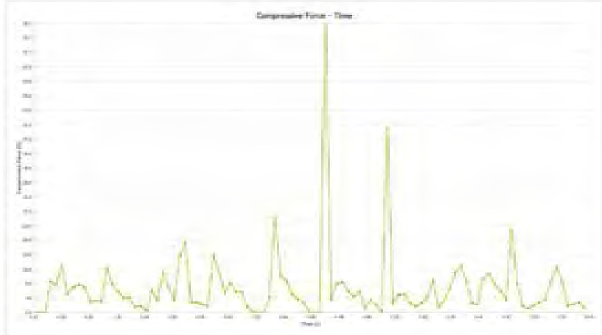
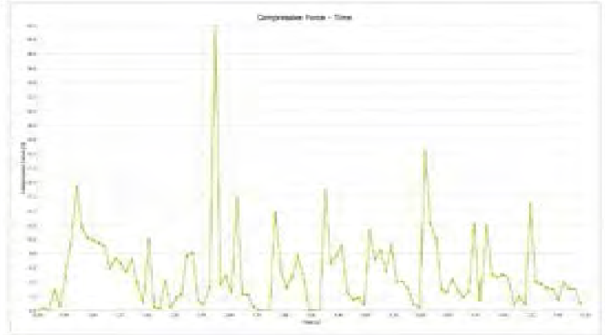
Fig. 1. Differences of lifter shapes.

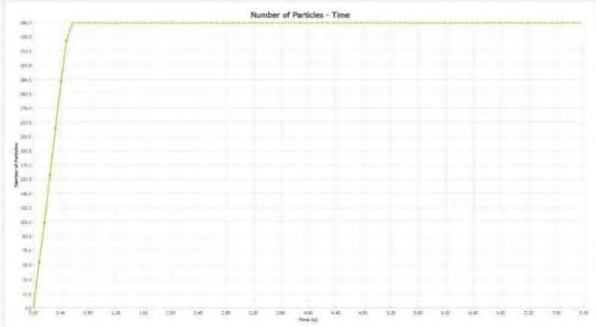
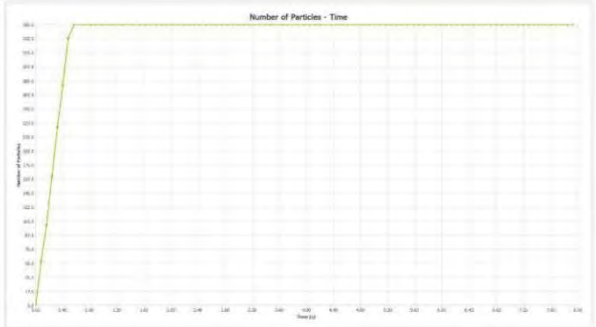
4. Comparative analysis of the obtained results

To be compared the obtained results and to be analyzed, a comparative table with data from the two types of lifters was produced.
It is clear from table 1, row 1 that the angle of separation of innovative lifter shape is 100.42º instead of 115.88º, angle of falling (row 2) 72.63 instead of 58.12. In that case, where for zero angle is set the middle right part of the mill, the bigger angle means that the particles separates 15.46 º earlier than the innovative lifter shape. This gives opportunity to be reduced the rotational speed of the drum mill when using the innovative lifter shape. That will cause less energy consumption for the same desired angle of separation.
Row 3 on the table shows the average compressive force. Innovative lifter peak of diagram is 2.85N, another peak shows 2N at the middle of the simulation, where particles falls on lifter. The next diagram of the older lifter records peak of 2.71N and in the middle of the simulation, when particles falls on lifter, the compressive force is 1.7N.
Row 4 shows the maximum compressive force of manual selected particles of the innovative lifter with peak value of 79.7N, in the middle of the simulation, another peak shows 51.8N. The standard used lifter in the mill records values of 43.1N, in the middle of the simulation 23.7N. For the time of the simulation, the innovative lifter records bigger compressive force values. If this experiment is able to be produced in the real laboratory mill, probably for the same time, the innovative shape will give smaller size distribution of the material. This can reduce the time for milling to achieve needed particle size after the process.
On the table, row 5 shows the same number of particles also the same time for generation in the simulation.
Row 6 shows average velocity of the manually selected particles. Particles in innovative lifter environment achieves velocity of 1.57 m/s instead of standard used laboratory lifter with velocity of 0.91 m/s with same rotational speed of the drum mill.
The recorded relative wear of the lifters shows increased wear of the innovative lifter type, which was expected due to the geometry of the lifter. Fig 2 shows the obtained results of innovative lifter relative wear. During the simulations the normal cumulative contact energy increases and at the end shows 1.73 J.
Fig 3 shows the results, obtained from the standard used lifter in the laboratory mill, on which basis this simulation was modelled. At the end of the simulation, the normal cumulative contact energy for the standard lifter is 0.8 J.
Methods and means for different hardening and better wear resistant are in investigation for the innovative lifter shape. The aim is to be increased wear resistance of the shape especially of the edge of this lifter [13-15].

Table 1. Comparison of different lifter types.

No	Parameters	Lifters	
		Innovative shape	Standard laboratory shape
1	Angle of separation Θ [Degree°]	 100.42°	 115.88°
2	Angle of falling Θ [Degree°]	 72.63°	 58.12°

3	Average compressive force [N]		
4	Maximum compressive force of manual selected particles [N]		

<table>
<tr><td>5</td><td>Number of particles</td><td>
</td><td>
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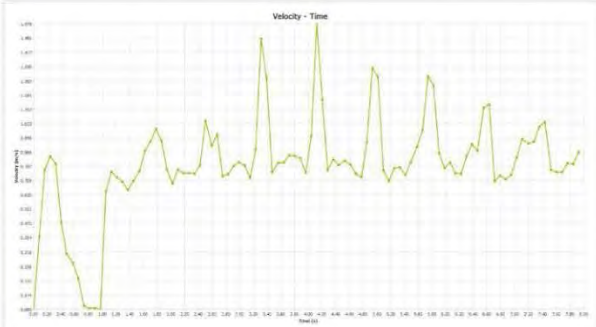
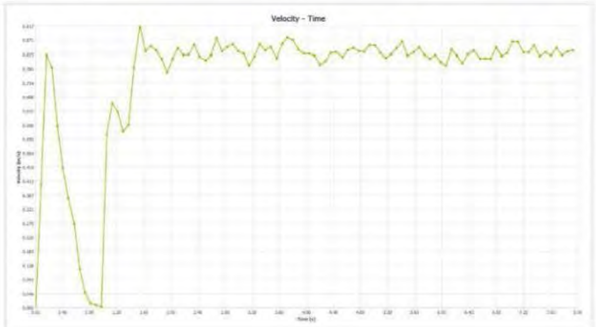
<tr><td>6</td><td>Velocity of manual selected particles [m/s]</td><td>
</td><td>
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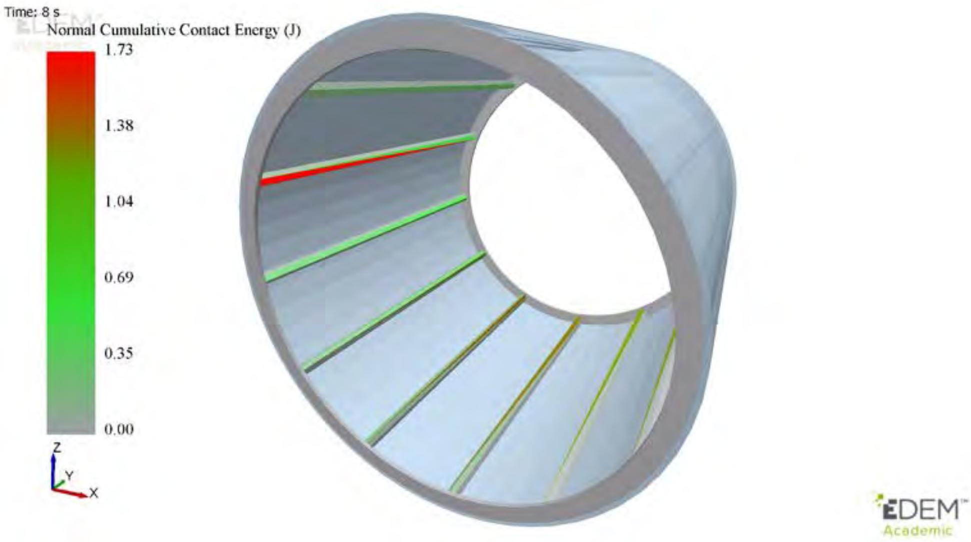

Fig. 2. Relative wear of innovative lifter shape.

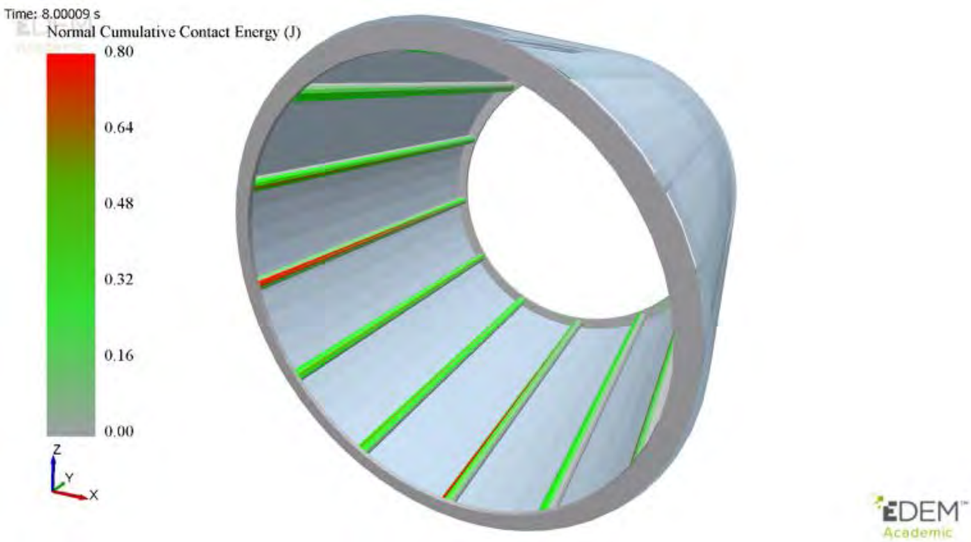

Fig. 3. Relative wear of standard laboratory mill lifter shape.

Conclusion

The comparative analysis between the two simulations shows that they are obtained with same factors and parameters, except one – the lifter shape. Two lifter shapes are investigated (innovative and standard, used in laboratory mill). The standard lifter advantages is that is more wear resistant, than the innovative one. New technologies and nano technologies in hardening and wear resistance can help to improve this disadvantage of the new innovative lifter shape.

Other data such as angle of separation, compressive forces, velocities, etc. shows better results in this simulations for the new innovative shape.

This results can lead to reducing time for grinding, reducing rotational speed of mills, and this will brings to energy efficiency of the whole process of grinding, which is one big energy consumption all over the planet.

Acknowledgement

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Исследование поведение железорудного материала в полу-автогенной мельнице.
Часть II. Сравнительный анализ железорудного материала в полуавтономной мельнице с лифтеров различной формы.

Николай Стоименов, Никола Съботинков

Резюме

В представленной статье обращено внимание на моделирование тел лифтеров различной формы (сферической и сферически-тетраэдрической формы). Моделирование производится с помощью программного обеспечения, работающего по методу дискретных элементов - EDEM Software. Для поведения частиц используется железорудный материал. Проведен анализ результатов.