INFLUENCE OF SCREENING BLOCK SUPPORTING WAY ON THE BEHAVIOUR OF A SOLID PARTICLE ON AN OSCILLATING SURFACE

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Abstract: This article shows a study aiming to identify the influence carried out by the supporting way of the working surface in the case of plane oscillating screening device, over the behavior of a solid particle. In order to achieve this, a theoretical study has been conducted by using a simulation program, Working Model 2D, within which two ways of supporting the screening block have been conceived: the working surface supported by tie-rods, and the surface suspended on tie-rods. Following the simulation, a series of physical parameters has been determined: the trajectory followed by the solid particle; the circuit of the solid particle during its movement on the working surface; the acceleration of the solid particle and the reaction force occurred between the solid particle and the working surface. Following the analysis of resulting values it may be noted that the best way to support the working surface, as far as the efficiency of mechanical separation is concerned, according to width and thickness of the solid particle, is obtained in the case where the working surface is supported by tie-rods, since the running time of the working surface is the highest and it is 4.12 seconds, value generating the high average moving speed; the particle's rotation angle is from -2 rad to +4.8 rad, having as a result the amplest possible rotation.

Keywords: block supporting, 2d working model, behavior of a solid particle

1. INTRODUCTION

The separation process of a heterogeneous mixture of solid particles is an important stage in different industries, having as main goal to obtain high-quality products. For this purpose, a series of instruments is used applying different separation methods, but the most used method is the separation according to the dimensions of the solid particle, i.e. according to its width and thickness [1-3]. Within this working method, the running of the solid particles mixture over a perforated surface is observed. In order to make this operation more efficient, the working surface is undergoing several movement processes: plane oscillatory movement, vibrating movement, plane horizontal circular movement or combined etc. [4-7]. The plane oscillatory movement is the most common way to stimulate the working surface, the sieve, movement carried out by an eccentric disk gear. In order to compensate the oscillating motion of the sieve, a series of supporting systems is used, such as tie-rods made of different elastic materials, springs, rubber-coated supporting systems etc. [8].

The supporting system plays a very important role in this process, and this influence has been analyzed analytically by applying different calculation methods [7, 9], experimentally for different types of sieves [10, 11] and stimulating methods, but also by using simulation programs [12-16].

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This article shows a study meant to emphasize the influence carried out by the supporting way of the screening block for the machines used within the mechanical separation process of solid particles heterogeneous mixture according to width and thickness of their components. To do so, a simulation program has been used, Working Model 2D, which analyzed the behavior of the same type of solid particle for the same functional parameters of the machine.

2. EXPERIMENTAL SETUP

The laboratory stand used for the simulation is conceived from a real device showed on Figure 1.

The laboratory stand is used to achieve the mechanical separation of a heterogeneous mixture of solid particles, operation carried out by the alternating oscillatory movement of the working surface. For a more efficient study of the separation process at the experimental stand, the followings may vary [1]:
- screening block rotation angle;
- crank mechanism rotation speed;
- number of sieves.

Fig. 1. Laboratory stand:
1. support stand; 2. vertical tie-rod; 3. screening block; 4. operating unit.

To facilitate the plane movement, the screening block is supported by four vertical tie-rods, made of timber, an elastic material. As mentioned above, this article will analyze the behavior of a solid particle on a working surface (sieve) by using a simulating program. To achieve the simulation, aiming to emphasize the way in which the supporting system of the screening block influences the behavior of the solid particle, the Working Model 2D software has been used. During the simulation process, the dimensional values of the laboratory stand have been considered.

Working Model 2D program is a simulation software that contains various virtual mechanical components such as springs, ropes, engines, etc. These can be combined with different objects in a 2D workspace. After creating the model, the software can simulate the interaction between components. The software is used to simulate the basic physical and dynamic geometric analysis.

In order to identify the way in which the supporting system of the working surface modifies the behavior of a solid particle, the influence carried out by the positioning (Figure 2) of the tie-rods has been considered:
a) separator’s working surface is supported by the four vertical tie-rods;
b) separator’s working surface is suspended on the four vertical tie-rods.

For the simulation, a particle of any shape has been chosen, thus trying to respect the fact that in reality there is no ideal shape of particles.

The model subject to simulation has the following features:
- the working surface has a length of 1 m;
- the tilt angle of the working surface against the horizontal plane is 7 degrees;

- the eccentric disk of the crank mechanism is 8 mm;
- the angular rotation of the motor running the crank mechanism is 20.9 rad/sec;
- the solid particle has the following features: density of 4000 kg/m^3, corresponding to a rock, mass of the particle 0.001 kg, sphericity is 0.63.

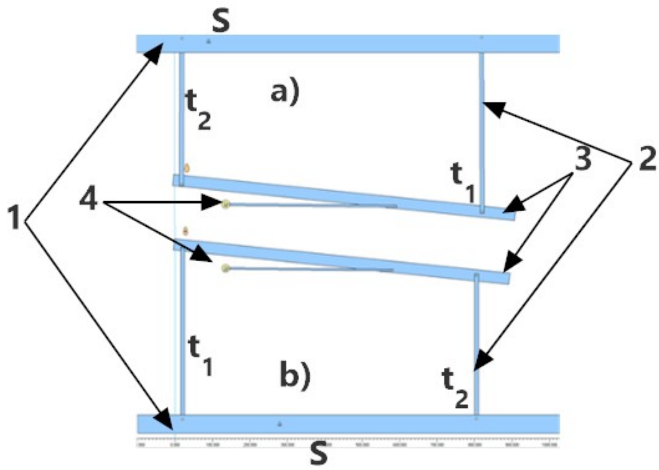

Fig. 2. Methods used for the analysis:
a) separator's working surface is supported by the four vertical tie-rods; b) separator's working surface is suspended on the four vertical tie-rods;
1 - support; 2 - vertical tie-rods; 3 - working surface; 4 - engine; S - support; t_1 and t_2 - vertical tie-rods.

The model designed and developed by using the Working Model 2D program is a 2D model of laboratory equipment presented in Figure 1, stand corresponding module of the separator that have the working surfaces suspended on the four tie-rods. In order to create the second model has changed the position of the supporting plane S and the position of the two tie-rods, to get the same inclination of the work surface. For both models work starting position was the same solid particle

The Working Model 2D software has the possibility to visualize certain parameters and show a vector presentation (Figure 3). This may help us to understand better what happens during this process. Within this analysis, the working methodology showed on Figure 4 has been observed. Following the simulation, the obtained values can be exported, making thus possible comparative graphical representation.

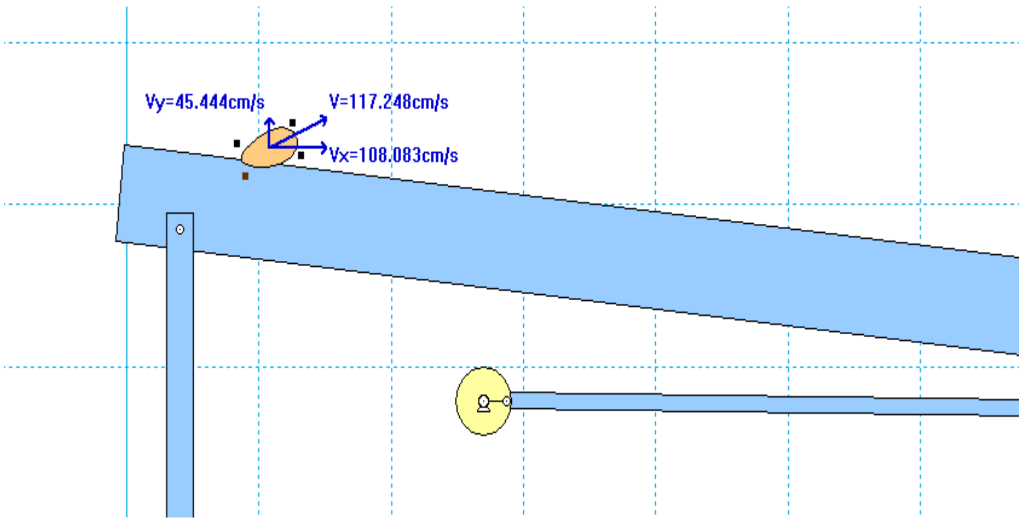

Fig. 3. Vector presentation of solid particle's moving speed.

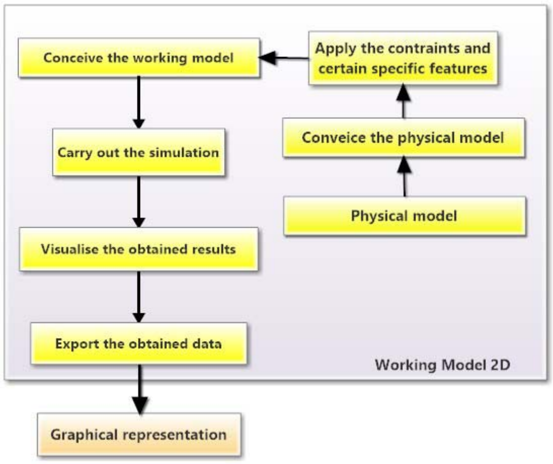

Fig. 4. Working methodology within the analysis.

3. OBTAINED RESULTS

In order to find the difference between these two methods to support the work surface, in Figure 5 it is shown the movement made by the work surface following a point at the bottom of this area.

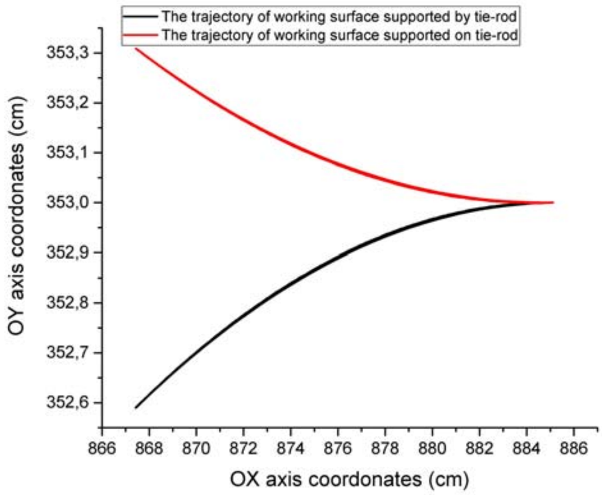

Fig. 5. Trajectory of working surface.

From the movement of the work surface performed analysis it is found that this execute a similar curvilinear motion, but "in a mirror" position, with a common point trajectory at one end.

Following the simulation, a number of parameters used to visualize the behavior of particles on a surface solid swing plane were identified using 2D Working Model Software. A graphic representation was realized for each analyzed parameter, respectively:
- movement of the solid particle on the plane surface, tracking how many times the solid particle touches the working surface and its rotation (Figure 6 and Figure 7);
- variation of solid particle's moving speed on the working surface and its angular speed (Figure 9 and Figure 10);
- variation of solid particle's acceleration, but also of angular acceleration (Figure 11);

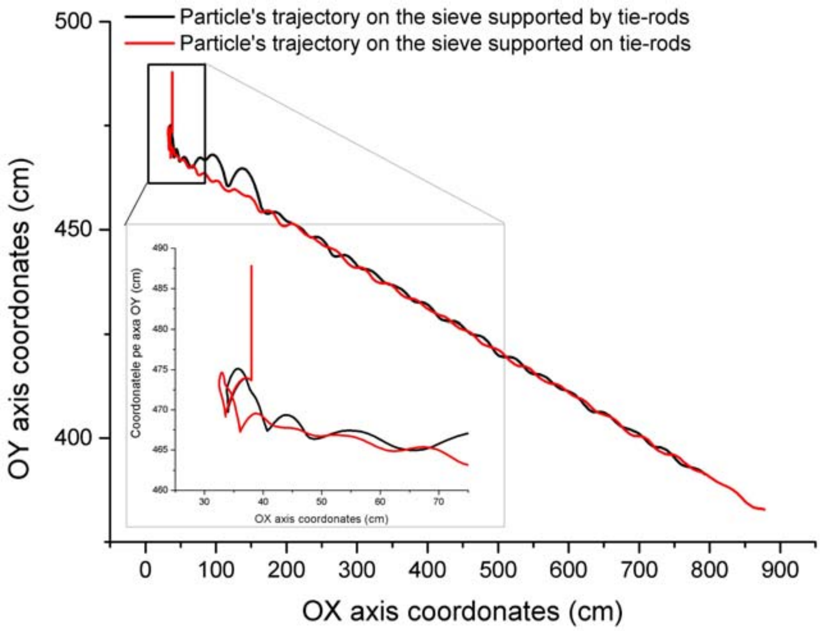

Fig. 6. Particle’s trajectory on a plane oscillating surface.

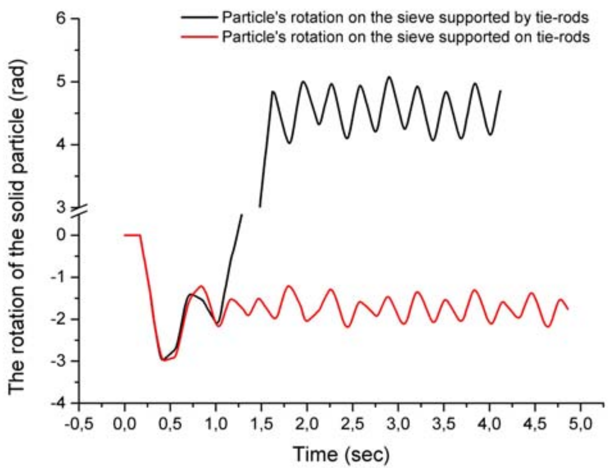

Fig. 7. Graphical representation of variations of solid particle’s rotation.

Following the analysis of the solid particle’s trajectory (Figure 5), it proves that between the two supporting methods there are differences of behaviors. For the sieve supported by tie-rods case, the time of running on the working surface by the solid particle is 4.12 seconds, and in the second case is 4.86 seconds, difference that occurs due to solid particles jumps. The biggest particle jump is executed at the beginning of the movement when the work surface is supported by the two tie-rods. During this jump, the solid particle executes a rotation simultaneously. This is highlighted in Figure 6 where solid particle turns from -2 to +4.8 rad, 433 degrees respectively. The + / - sign of this parameter depends on how it is measured relative to a reference point. After 1.75 sec from solid particle movement starting on the work surface it is found that regardless of tie-rods positioning, this angle value fluctuates:
- for the work surface supported by tie-rods the range is between 4 and 5 rad;
- for the work surface suspended on tie-rods the mean value is -1.7 ± 0.46 rad.

Looking at the particle path (Figure 8), only for values on OY axis, it is observed that initially this is the same. After 0.8 seconds it is observed that differentiates two trajectories:
- for the work surface supported by tie-rods the particle execute two jumps followed by a movement in steps;
- for the work surface suspended by tie-rods the particle trajectory shows no large jumps, these being small amplitude.

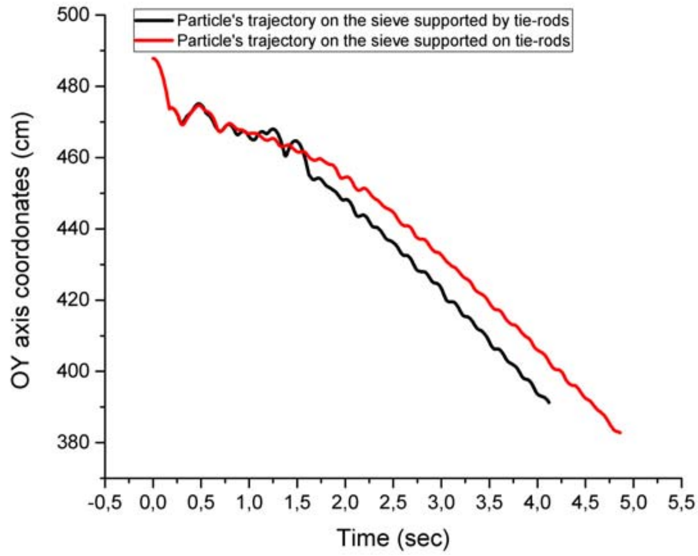

Fig. 8. Variation in time of solid particle trajectory.

Following the comparative analysis of the graphical representation of the linear moving speed of the solid particle (Figure 9) on a plane oscillating surface, it shows that before a time of 0.32 sec the particle has the same speed. For a greater time value a differentiation in this parameter value occurs, namely:
- for the work surface supported by tie-rods, speed value increases, especially when solid particle execute the two jumps (between 0.8 sec and 1.69 sec) from 47.7 cm/sec to 205 cm/sec, then growth presents a curvilinear trend with more fluctuations corresponding to contact moments of the solid particle with work surface;
- for the work surface suspended by tie-rods, solid particle speed presents a curvilinear increase with more fluctuations than the first case.

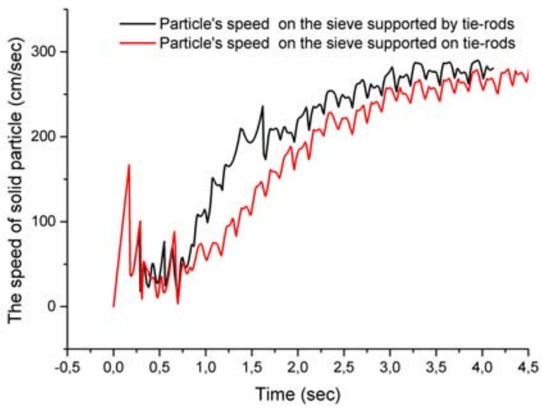

Fig. 9. Solid particle's moving speed.

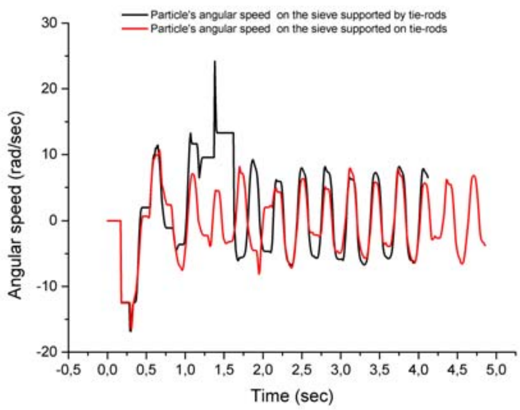

Fig. 10. Solid particle's angular speed.

As far the angular speed is concerned (Figure 10), the highest values are obtained for the model in which the working surface is supported by the four tie-rods. Regarding the change in angular velocity (Figure 10), it is found that we have the same shape of plotting excepting 0.8 - 1.69 seconds interval in which, for the work surface supported by tie-rods, it is obtained a maximum value of 24.2 rad/sec due to the rotation of solid particle. The analysis of this parameter also finds that values are higher than those for the second event.

Concerning the solid particle's acceleration (Figure 11), the highest value of this parameter has been obtained for the first case, with an average value of 980.665 cm/sec^2, and for the second case an average value of 811.29 cm/sec^2 has been obtained. For solid particle acceleration (Fig. 9), the highest value of this parameter was calculated for both studied cases and corresponding to the initial solid particle falling. Thanks to two solid particle jumps occurring in the first case, it appears that after 1.38 seconds solid particle acceleration reaches a value of 10890 cm/s^2 then after 1.62 seconds reaching a value of 9270 cm/s^2. For the rest of the time interval particle acceleration shows a downward trend with many fluctuations.

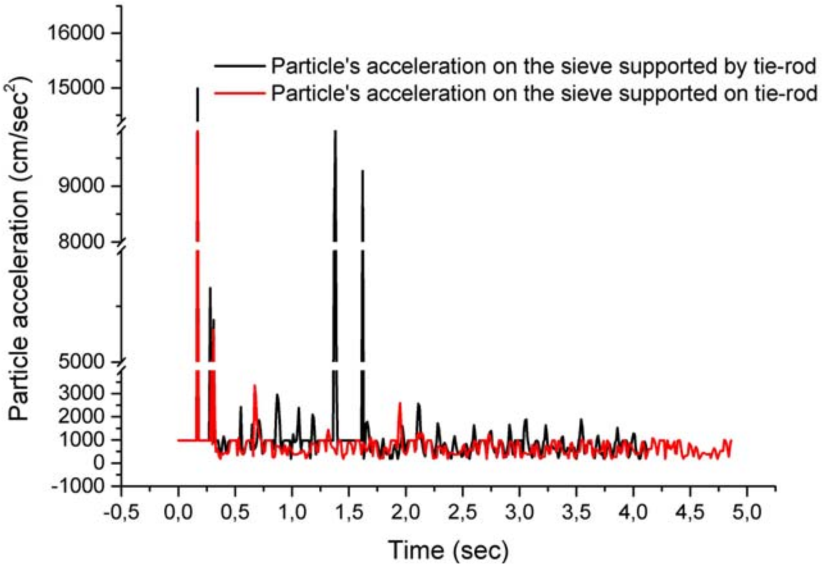

Fig. 9. Solid particle's acceleration.

4. CONCLUSIONS

After analyzing the results obtained during the simulation process, the following conclusions can be reached:
- In order to obtain higher quality products, a separation process is required to eliminate the impurities;
- The most used method of mechanical separation of a heterogeneous mixture is the separation on sieves, procedure implying the use of surface with holes and executing different movements;
- In order to understand this process, different methods are used, among which the simulation of this operation;
- For the simulation, a real stand has been used, as well as the Working Model 2D software that it was created a 2D model for real stand;
- Within the simulation process, two working methods have been used, aiming to find out the influence carried out by the supporting way of the working surface on the behavior of a solid particle;
- Following the simulation, it shows that:
  - The shortest time of displacement of a solid particle on a plane oscillating surface is achieved on a surface supported by tie-rods, due to the trajectory, this having a negative impact on the efficiency of the mechanical separation process;
  - Concerning the rotation of the particle on the working surface, it proves that the highest value is obtained on a surface supported by tie-rods this helping to achieve a most uniform contact between particle and working surface;
  - Regarding this solid particle behavior it appears that the first model generates a movement much larger on the work surface, obtaining even a rotation thereof, which leads to better contact for all particle surfaces to work surface.
  - For this experimental group due to the short time of the particle running on the working surface, the average moving speed of the solid particle on the surface suspended on tie-rods is higher compared to the other variant, thus having a negative influence on the separation process;
  - In the analysis case for solid particle's acceleration the difference between two values is due to the way how the contact between the solid particle and working surface is made.

REFERENCES

[1] Bontas, O., Nedeff, V., Mosnegutu, E.F., Panainte, M., Tirtoacă Irimia, O., Behaviour of solid particles on a flat oscillating surface, Environmental Engineering and Management Journal, vol. 12, no. 1, 2014, p. 17-22.

[2] Casandroiu, T., Buciuman, V. F., Moise, V., Theoretical aspects regarding the relative motion of seeds on an inclined vibrating plane surface, Journal of Engineering Studies and Research, vol. 19, no. 3, 2013, p. 17-26.
[3] Bontas, O., Nedeff, V., Mosnegutu, E., Panainte, M., Study of factors influencing the solid particles on a flat inclined surface, Journal of Engineering Studies and Research, vol. 18, no. 1, 2012, p. 39-46.
[4] Bontaş, O., Nedeff, V., Moşneguţu, E.F., Panainte, M., Tirtoaca O., Studies regarding the behavior of solid particles on a flat oscilating surface, Oproteh 2013, Constructive and Technological Design Optimization in the Machines Building Field: The X-th International Conference, Bacău, May 23-25, 2013, Conference Proceedings Abstracts.
[5] Voicu, G., Stoica, D., Constantin, G.A., Carp-Ciocârdia, C., Ştefan, E.M., Influence of the granular mixture particles sizes and oscillation frequency on the separation process at the conical sieves with oscillating movement, Journal of Engineering Studies and Research, vol. 20, no. 4, 2014, p. 81-86.
[6] Stoica, D., Voicu, G., Ungureanu, N., Voicu, P., Carp-Ciocardia, C., Influence of oscillations amplitude of sieve on the screening process for a conical sieve with oscillatory circular motion, Journal of Engineering Studies and Research, vol. 17, no. 1, 2011, p. 83-89.
[7] Marin, C., Ene, G., Mathematical Model for the Study of the Dynamical Behaviour of the Case's Elements from the Structure of the vibrating screens, Romanian Review precision mechanics, optics & mechatronics, no. 25, 2004.
[8] Moşneguţu, E., Nedeff, V., Bontaş, O., Bârsan, N., Chiţimuş, A.D., Possibilities to determining the solid particle trajectories on an oscillating separation screen, Journal of Engineering Studies and Research, vol. 20, no. 3, 2014, p. 63-70.
[9] Baragetti, S., Villa, F., A dynamic optimization theoretical method for heavy loaded vibrating screens, Nonlinear Dyn, vol. 78, no. 1, 2014, p. 609-627.
[10] Kostas, T., Some basic factors affecting scree performance in horizontal vibrating screens, The European Journal of Mineral Processing and Environmental Protection, vol 1, 2001, p. 42-54.
[11] Brîndeu, L., Ilea, R., Dynamics of the displacements by vibrations on plane sieves, Annals of the faculty of engineering Hunedoara, vol. 1, 2004, p. 9-14.
[12] Chen, Y., Tong X., Modeling screening efficiency with vibrational parameters based on DEM 3D simulation, Mining Science and Technology, vol. 20, 2010, p. 0615–0620.
[13] Axinti, G., Axinti, S., Study about dynamic behavior of suspended sieve to machine of sorted self-propelled KT 45/18/13, The annals of "Dunarea de jos", University of Galati Fascicle XIV Mechanical engineering, 2006, p. 50 – 54.
[14] Dinu, I., Ungureanu, M., Ungureanu, N., Banica, M., Computer Model For Sieves' Vibrations Analysis, Using an Algorithm Based on the False-Position Method, American Journal of Applied Sciences, vol. 6, no. 1, 2009, p. 48-56.
[15] Dong, K.J., Yu, A.B., Brake, I., DEM simulation of particle flow on a multi-deck banana screen, Minerals Engineering, vol. 22, 2009, p. 910–920.
[16] Moşnegutu, E., Nedeff, V., Panainte- Lehăduş, M., Bontaş, O., Barsan, N., Tomozei, C., Chiţimus, D., Studies and research concerning the displacement of solid particle on an oscillatory flat surface, Applied Mechanics and Materials, vol. 659, 2014, p. 521-526.