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INVESTIGATION OF THE ROLLING SCREEN***

1. Description of the device — rolling screen

Rolling screens are machines designed for the realisation of the processes of granular materials sieve classification. The point here is about fine and very fine-grained granular mixtures which, because of their particle size, cannot be screened on sieves of other known screens. These machines perform a complex, spatial rotational movement, being the so-called “drunken barrel” movement. As we know, the main resistance of the screening lies on the side of the layer, not of the sieve.

The rolling screen, on which studies were conducted, is equipped with the drive which involves two rotary motovibrators, operating in the conditions of the mutual counter-current self-synchronisation. This system is presented in the Figure 1.

Axes of these motovibrators are inclined to the level (to the plane of the sieve) at the angle of γ . The presented drive system forces complex oscillations of the riddle (a set of sieving panels) which can be viewed as consisting of two elementary oscillating movements. The first one is a vertical oscillating movement with the amplitude of A_v , and the second movement consists of torsional oscillations with the angular amplitude of A_s , or linear one A_{sl} [1].

2. The aim of the studies

The aim is to verify the hypothesis that the use of vertical oscillations, with the optimum choice of remaining screening parameters, will enable the significant increase in the effectiveness of the screening process.

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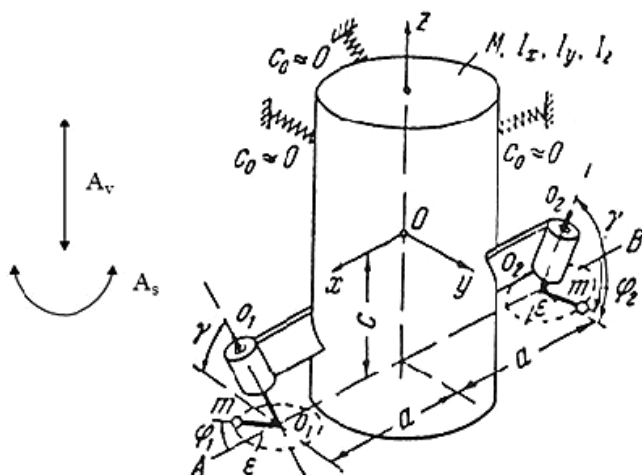


Fig. 1. A rolling screen driven by two synchronised rotary motovibrators

3. Materials and methods

The studied material was limestone (aggregate) provided by EGM Sp. z o.o. Limestone Mine “Wierzbica” in the amount of 50 kg. The material was characterised by the humidity of 0.136%. Humidity was determined by means of a moisture balance. Markings were repeated 10 times. The sieve analysis of the material for the study was conducted by means of the Fritsch Analysette 3 laboratory screen. The analysis was done with the settings of the oscillation amplitude of 2 mm in 5 min. Results are presented in the Table 1.

TABLE 1

The sieve analysis of the studied material conducted on the laboratory screen

A side of the sieve's aperture, [mm]	Class, [mm]	Mass of the material on a sieve, [g]	Percentage of fraction, [%]
1.6	> 1.6	13.90	6.95
0.8	0.8–1.6	47.70	23.85
0.4	0.4–0.8	63.80	31.90
0.2	0.2–0.4	48.00	24.00
0.1	0.1–0.2	23.40	11.70
–	< 0.1	3.20	1.60
TOTAL		200.00	100.00

Screening studies were conducted on the rolling screen equipped with two side motovibrators with the possibility to change their position in relation to the vertical axis of the screen. Motovibrators are characterised by the constant rotary speed of 1500 rpm. A set of woven sieves was used for the studies.

Studies were conducted with the settings of the motovibrators' angle in relation to the vertical axis of the screen 20, 30, 45, 50°. The angle of 20° for the studies with a rolling movement without vertical oscillations and 30, 45, 50° for the studies with a rolling movement with vertical oscillations (30° — for the average amplitude of oscillations, 45° — for the optimum amplitude of oscillations and 50° — for the high amplitude of oscillations).

The conducted studies were done with the material efficiency Q (Tab. 2).

TABLE 2
The studied material dosing flow

The angle of motovibrators inclination, [°]	The diameter of the dispenser nozzle, [mm]	Dosing flow, [kg/h]
20/30/45/50	7,25	19±1,72

Deviation of the dosing flow is caused by different settings of motovibrators and thus different amplitude of the dispenser oscillations.

4. Screening results

Studies of the screen operation were conducted with the material with the humidity of 0.136%. Dumping (sieving efficiency) of subsequent fractions was examined. For this purpose, before the beginning of screening, empty receivers were weighed to, after the time $t_1 = 0.5$ h, $t_2 = 1$ h, $t_3 = 1.5$ h and $t_4 = 2$ h, enable determining the amount of the material distributed in separate receivers of fractions (buckets). On this basis sieving efficiency was obtained during operation of the rolling screen. Sieving efficiency (sifting) was compared to the amount of the dosed material (feed). The material separation was performed with 4 settings of motovibrators angle: 20, 30, 45 and 50° and dosing flow $Q = 19 \pm 1.72$ kg/h. The yield curves, which are presented below (Fig. 2), were obtained.

During sieving, the purity of the obtained fractions was checked by means of the sieve analysis in the Fritsch analyser. The analysis was performed after $t_1 = 0.5$ h, $t_2 = 1$ h, $t_3 = 1.5$ h and $t_4 = 2$ h of the screen operation.

5. Discussion of results

In connection with the place where force inducing the movement of the screen (location of the panel with motovibrators) is applied, the highest values of the vibrations amplitude

are obtained in the first (sieve 0.1 mm) and the last (sieve 1.6 mm) grid plate. The confirmation of this phenomenon is in sieving efficiency, when the soonest the fractions < 0.1 mm and > 1.6 mm appear in the receivers. On the basis of the sieve analysis, it is known that the share of these fractions is the smallest in the studied material, hence the change of the force application place (location of motovibrators) can cause the increase in the sieves efficiency and thus in the sieving process. Because of the significant share of the fractions 0.2–0.4, 0.4–0.8 and 0.8–1.6 mm (over 70%), the location of the plate with motovibrators between plates with sieves corresponding to those fractions could increase the sieves efficiency and thus the sieving process.

During the studies, the behaviour of the rolling screen for dosing flow $Q = 19 \pm 1.72$ kg/h with four settings of the angle of side motovibrators inclination was tested. The screen worked the most efficiently, with regard to sifting, at the angle of motovibrators inclination of 20° (Fig. 2). The screen must be weighed down with some quantity of the material in order to work properly.

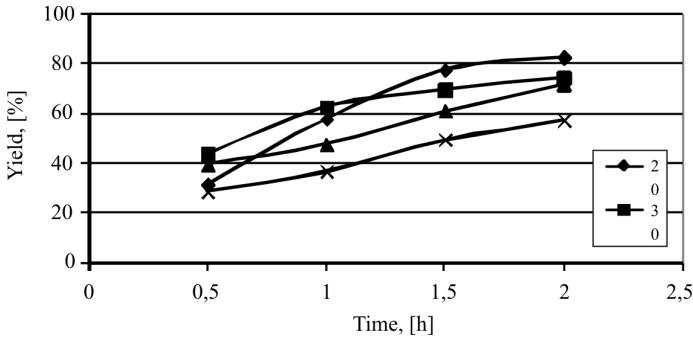


Fig. 2. The comparison of the yield at different angle of motovibrators inclination for the feed Q

TABLE 3
The comparison of dosing flow and sifting efficiency straight line equations

Screening parameters (the angle of the motovibrators inclination and dosing flow)	Dosing flow equation, [kg/h]	R2	Sifting efficiency equation, [kg/h]	R2
20° Q	$Q(20)=21,54t$	1	$W_{20Q2}=21,865t-8,183$	0,9964
30° Q	$Q(3)=19,20t$	1	$W_{30Q2}=16,292t-4,129$	0,9994
45° Q	$Q(45)=17,78t$	1	$W_{45Q2}=14,806t-5,034$	0,9829
50° Q	$Q(50)=18,00t$	1	$W_{50Q2}=12,208t-4,435$	0,9849

Where: time [h]; R^2 — determination coefficient of equation of the straight line;
 Q_i — dosing flow; W_i — sifting efficiency.

The y -intercept in the sifting efficiency W_i equations ($y = ax + b$) corresponds to the amount of the material which remains in the screen during its operation.

On the basis of the sieve analysis of the obtained fractions, despite a good sifting efficiency, the separated material in the screen with motovibrators set at the angle of 20° contains significant amounts of the remaining fractions. It attests to the low screening efficiency with these settings of the rolling screen.

However, sifting at the angles other than 20° as a result of the sieve analysis attests to a high separation effectiveness because the obtained fractions contain small ($> 2.5\%$) amounts of other fractions (Fig. 4).

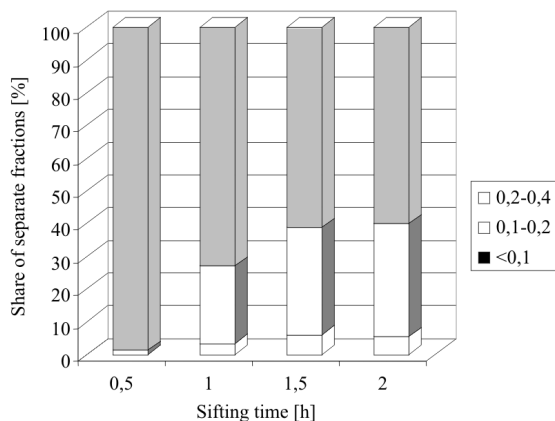


Fig. 3. The sieve analysis of the separated material on a sieve with the hole diameter of 0.2 mm with the angle of motovibrators of 20° and dosing flow Q

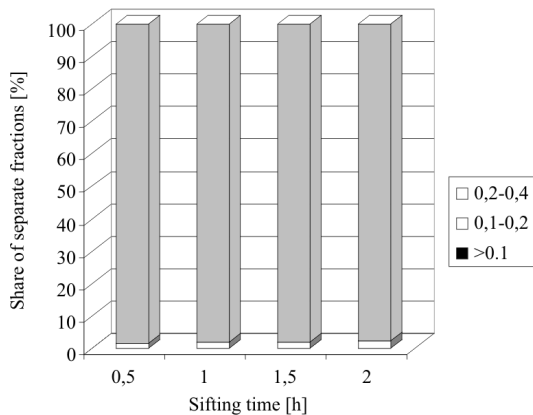


Fig. 4. The sieve analysis of the separated material on a sieve with the hole diameter of 0.2 mm with the angle of motovibrators of 45° and dosing flow Q

6. Conclusions

On the basis of the conducted studies it was stated that:

- 1) The sieve analysis of the obtained fractions enables to evaluate the separation effectiveness of the material. The rolling screen with motovibrators set at the angle of 45° provides the well-separated material. The share of other than the main fraction is very small, and is the smallest when the feed is dosed with the efficiency $Q = 17.78$ kg/h.
- 2) The optimum parameter of the screen operation is the angle of motovibrators inclination of 45° at the dosing flow of 17.78 kg/h and with the use of the dispenser with the diameter nozzle $d = 7.25$ mm.
- 3) Vertical oscillations increase the sieves efficiency. At the optimum parameters for the studied material, the obtained fractions are characterised by other fractions' share below 2.5%.
- 4) The screening efficiency will probably increase when the source of vertical oscillations is on the panel with the sieve separating the fraction with the largest share in the screened material.

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