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THE RESULTS OF PROCESS INVESTIGATIONS OF A DOUBLE-FREQUENCY SCREEN

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In the present study the preliminary results of process investigations, being part of the research programme which has been carried out at the Department of Process Equipment, Technical University of Lodz, have been presented. The investigations are aimed at the process examinations of a new double-frequency screen in respect of its usefulness for screening of finely grained loose materials. The main objective of the present study is to demonstrate the results of the process investigations of this screen for various drive configurations in the form of the graphical efficiency – and capacity dependencies.

key words: classification, double-frequency screen, vibrator, rotational frequencies

INTRODUCTION

In the industry of rock raw materials one deals with the screen classification of finely grained materials (Banaszewski, 1990; Wodziński, 1981, 1997; Meinel and Schubert, 1971; Book and Kramer, 1984). It is evident from the preliminary results of the investigations, that the modern construction of a double-frequency screen is an ideal solution to the realisation of the process of fine grain screening (Wodziński, 2008).

A vital field of the industry in which one may utilize the double-frequency screen is processing of minerals. The authors of the present study intend to propose the

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double-frequency screen for the application to the Polish copper industry. The classification of copper ores is a difficult process due to various physicochemical properties of those media and, additionally, due to high process efficiencies with which one deals.

A DOUBLE-FREQUENCY SCREEN

The experimental screen which is the focal point of the study was constructed in the Department of Process Equipment, Technical University of Lodz. The dimensions of the screen are demonstrated in Figure 1. As the most characteristic feature of this construction one may recognise the drive which is composed of two inert vibrators operating at various rotational speeds thereby causing the complex movement of the screen.

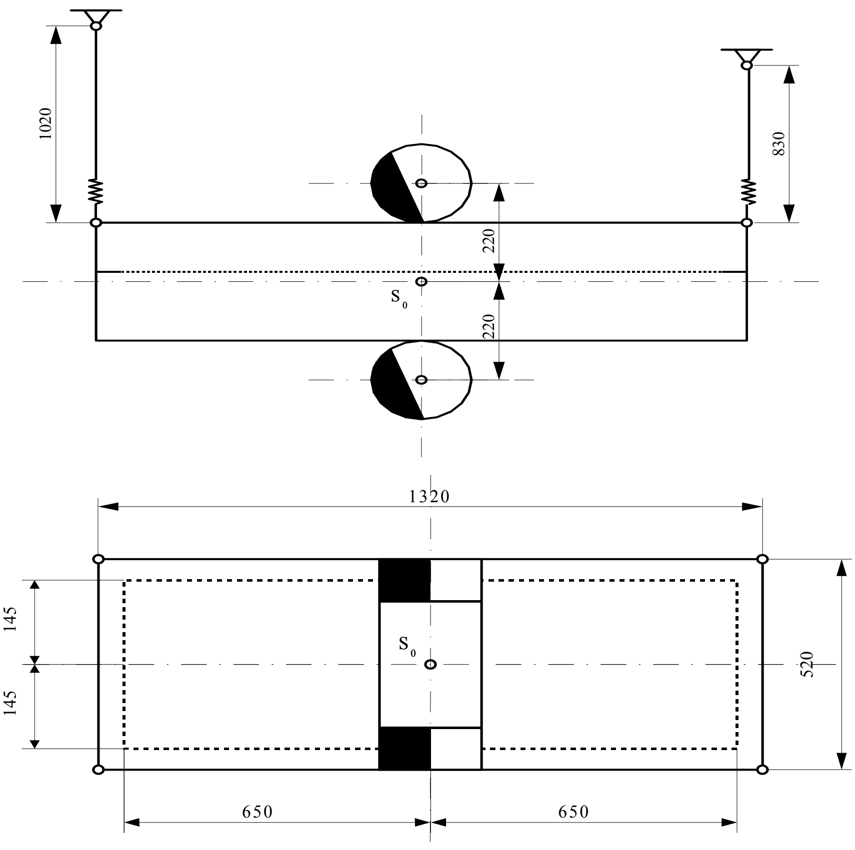

Fig. 1. The basic dimensions of the experimental screen

The construction of the screen allows the regulation (for research needs) of all basic machine operation parameters, in particular such as:

- the inclination of the sieve against the level – α ;
- the arrangement of the engine against the middle part of the sieve – β ;
- the exciting forces generated by the engines – F ;
- the rotational speeds of the engines.

A highly important parameter characterizing the operation of the double-frequency screen is the speed coefficient defined as follows (Turkiewicz i Banaszewski, 1982):

$$\xi = \frac{\omega_1}{\omega_2} = \frac{n_1}{n_2}. \tag{1}$$

This quantity defines how much the angular velocities (or rotational speeds) of two rotational vibrators are different from one another.

The regulation of the rotational speed of the engines was performed using inverters. The investigations were carried out for combinations of rotational frequencies of both vibrators as it is summarized in Table 1. For both vibrators: an upper and bottom one, the rotation in the right direction, i.e. in accordance with the clockwise direction, was assumed as a positive direction of rotations.

Table 1. Rotational frequencies of vibrators

Vibrator	Vibrator	Vibrator	Vibrator	Vibrator	Vibrator	Vibrator	Vibrator
Upper (ω_1)	Bottom (ω_2)	Upper (ω_1)	Bottom (ω_2)	Upper (ω_1)	Bottom (ω_2)	Upper (ω_1)	Bottom (ω_2)
Right (+)	Right (+)	Right (+)	Left (-)	Left (-)	Right (+)	Left (-)	Left (-)
rot/min		rot/min		rot/min		rot/min	
1500	1500	1500	1500	1500	1500	1500	1500
750	1500	750	1500	750	1500	750	1500
1500	750	1500	750	1500	750	1500	750
1500	1000	1500	1000	1500	1000	1500	1000
1000	1500	1000	1500	1000	1500	1000	1500
1500	500	1500	500	1500	500	1500	500
500	1500	500	1500	500	1500	500	1500

PROCESS INVESTIGATIONS OF A DOUBLE-FREQUENCY SCREEN

Agalite (as a model material of spherical grains), sand (irregular grains) and marble aggregate (sharp-edge grains) were utilized as loose material in the investigations. The shape of grains is presented in Figure 2.

The material had been appropriately prepared beforehand, i.e. screened in laboratory shakers in such a way that half of material mass constituted an upper fraction. In other words grains greater than 0.63 mm and another half constituted the bottom fraction. Further process examinations were carried out on a metal woven sieve of a square opening and sieve mesh side $l = 0.63$ mm (Figure 3).

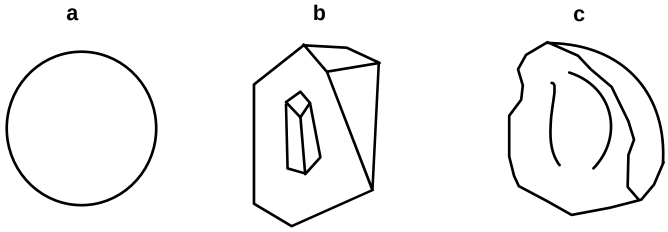

Fig. 2. Shapes of grains of model materials: a) agalite; b) aggregate; c) sand

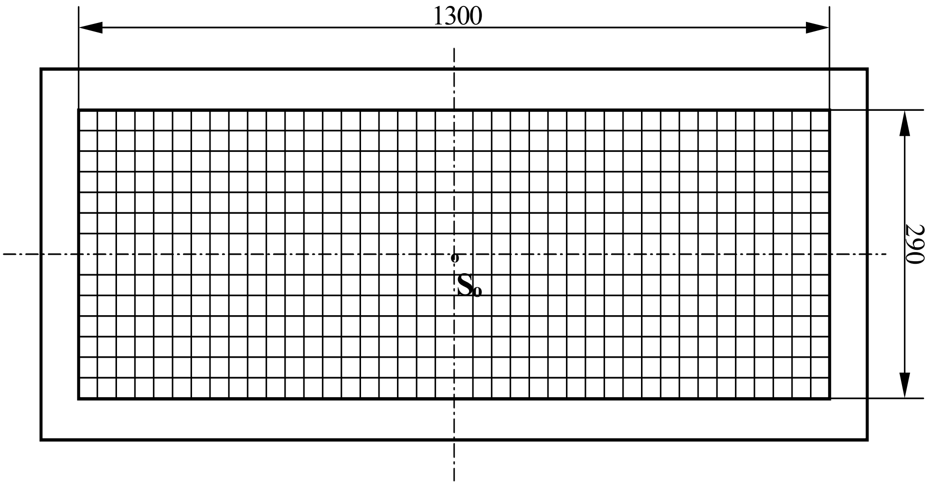

Fig. 3. The dimensions of sieve of the experimental screen

The granulometric composition of the material is summarised in Table 2 provided underneath. For all materials used the granulmetric composition coincided. In Figure 4 the composition of the material is given in the form of the curve of outflow and the curve of the material gathered on the sieve.

Table 2. Granulometric composition of used material

Grain class d [mm]	Percentage of share U [%]		Mass of sand class [kg]	sum [kg]
0.2	11.25	50%	3.38	30
0.4	16.25		4.88	
0.63	22.5		6.75	
0.85	22.5	50%	6.75	
1	16.25		4.88	
2	11.25		3.38	

In the course of the investigations a few tens of series tests were performed. Each cycle of tests consisted of the experimental screening of the material prepared beforehand and its separation into two products, i.e. upper and bottom ones. On completion of screening the following products were weighted, i.e. the products which were above the sieve (m_g) and under the sieve *(m_g)*. The results were summarized in Table 2. Next, both fractions were thoroughly mixed and they were used in a subsequent test cycle. The parameters of work of the screen drive were set for each cycle. Additionally, the mass flow rate of material outflow was regulated through the increase and decrease of the outflow gap in a feeder.

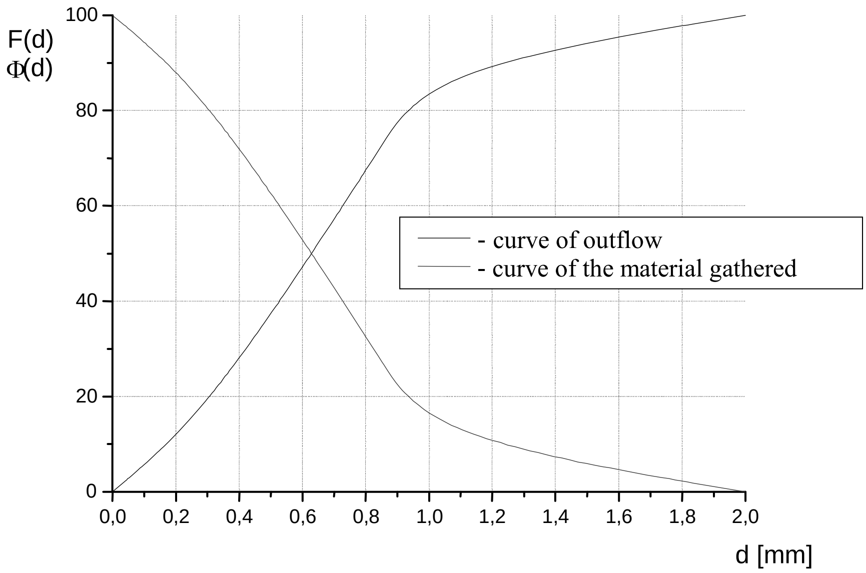

Fig. 4. The characteristics of the materials examined

The results of the research were presented in the graphical form. Each of the graphs was constructed on the basis of three test cycles, corresponding to three different rates of material feeding. The screen capacity was marked on two x-axes. The bottom axis was scaled in [$^{kg}/_{s}$] (mass flow rate of material inflow) whereas the axis of ordinates presents the efficiency of the screen.

To calculate the efficiency of the screening process the following dependence was used:

$$\eta = \frac{m_d}{m_n \cdot K_d} \tag{2}$$

where: m_d – the mass of the product under the sieve, kg, determined experimentally
m_n – the mass of the material, kg

K_d – the participation of the bottom class in the material – 50%.

Figures 5 – 7 show the course of chosen curves concerning the efficiency and capacity for various settings of the screen drive.

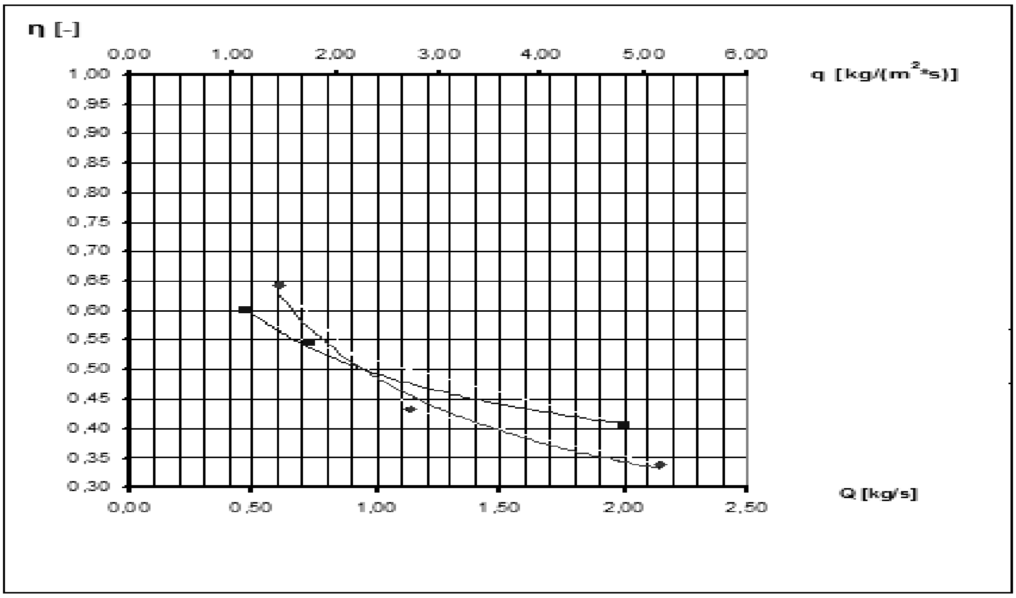

Fig. 5. The results for the following settings: α=15º, β=0º, F=2kN, ω_1 / $\frac{1}{2}$ ω_2

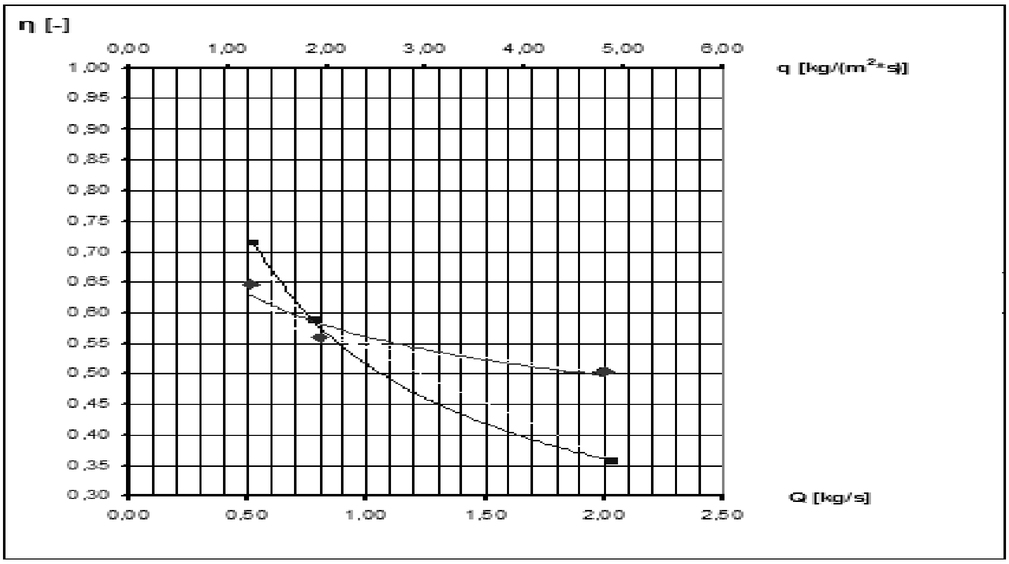

Fig. 6. The results for the following settings: α=15º, β=0º, F=2kN, ω_1 / $\frac{1}{3}$ ω_2

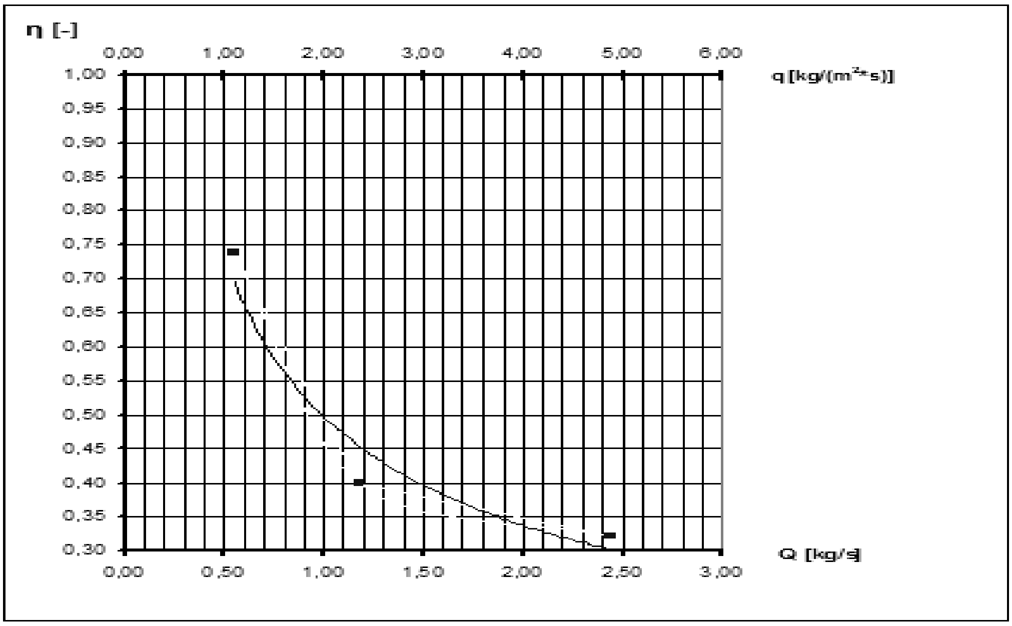

Fig. 7. The results for the following settings: α=15°, β=42,2°, F=2kN, ω_1 / ω_2

It must be underscored that in certain cases the material motion on the sieve was not ensured which took place at the concurrent synchronization, maximal exciting force and the frequency ratio $\omega_1 / {}^{1/}{}_2\omega_2$. Such configuration of the sieve contributed to the generation of torsional vibrations, i.e. the beginning and end of the sieve moved at maximal amplitudes whereas the middle part was almost still. The effect of torsional vibrations was the accumulation of the granular material in the central part of the sieve which, in turn, led to the blocking of the whole process of material flow. In this way, the circulation occurred in the material layer generated, in the course of which the material was flowing on the sides of the sieve down the screen to circa ¼ of its length and, subsequently, was reversed in the direction of the central part of the sieve. The process of screening occurred, however not sufficiently effective.

THE POSSIBILITIES OF APPLICATIONS OF DOUBLE-FREQUENCY SCREENS

To the advantages of double-frequency screens one may account:

- the simplicity of construction with a number of configurations of the driving system which are not encountered in the other machines of this type,
- the possibility of using of the components typical of other screens such as, for instance, sieves, spring suspensions, main frames, mounting mechanisms of

sieves, sieves alone, rotational vibrations and other elements tested in the industrial practice,

- quite high efficiency: for the tested range of material inflow rate (0,5 – 2,5 kg/m^{2}s), the efficiency of the process exceeded 50% in the vast majority of cases, even for such a difficult material for screening as marble aggregate.

In the Ore Enrichment Plants of the KGHM "Polish CopperCo., the granulometric classification of crude ore on the sieves, prior to the process of grinding of this ore, is carried out. The screening of crude ore is performed with an insufficient efficiency due to the fact that the existing screens are supplied with the flux of ore of too high mass flow rate. On screen beds one may observe a too thick granular layer which does not allow the efficacious separation of the bottom class from the upper one. The modernization of the copper ore screen classification may be obtained thanks to the double-frequency screen application and the increase of screen beds in this machine which will allow the quicker separation of the thicker classes from the material.

It is widely accepted that big machines, i.e. screens operating in the extractive and processing industry should be driven using non-balanced shafts, located directly on the sides of screens. Such a constructional solution is realistic also in the case of a double-frequency screen.

As it may be seen, a double-frequency screen is a universal screen encompassing the experience which has been gained so far regarding the structure and exploitation of screening machines. Furthermore, this screen is characterized by a uniform distribution of the oscillating masses which does not take place in the case of the constructions which have been known up to the present moment.

CONCLUSIONS

The main feature of the double-frequency screen is the possibility of free configuration of the inertia drive and, thus the possibility of its compliance with the requirements set by the process of screening of the concrete granular material. The optimization of operation of the drive is carried out through the regulation of the vibrators rotational frequency, their exciting force and mutual location and the direction of rotations.

As a criterion of the device operation quality evaluation the screen efficiency and mass capacity were assumed. These parameters have a significant meaning from the point of view of the process economy. The process investigations constitute the only way to achieve the aim which is the optimization of the drive system due to the fact that even the appropriate operation of the mechanical systems does not mean the ensuring of the sufficiently good screening conditions.

Based on the preliminary examination it may be stated that:

- the countercurrent synchronization of vibrators is better from the process point of view;
- smaller inclination of the sieve ensures better screening conditions;
- the application of vibrators of considerable power is not economically justified;
- the location of vibrators with regard to the mass centre does not affect the process.

The analysis of the results of the investigations makes one draw a number of more general conclusions which are as follows:

- screen drive system allows one to obtain the complex sieve motion which, in turn, enables to attain high screening efficiency;
- double-frequency screen should be assigned to the screening of finely grained materials and those which are screened with difficulty due to the fact that the machine brings about the intensive loosening of material on the sieve;
- condition of the proper operation of the screen is to ensure the rigidity of the sieve on the plane of vibration trajectories;
- phenomenon of driving vibrators self-synchronization enables to simplify the construction of the screen because it is not necessary to apply any devices which would trigger the synchronization. As it is reported, self-synchronization is a durable phenomenon; in the course of the measurements the motion once started occurred in trajectories which depended exclusively upon the configuration of the driving system;
- construction of the line-elliptic screen allows the application of all known construction elements of the screening machines which makes it easier to apply this screen practically to industry.

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W niniejszej pracy zaprezentowano wstępne wyniki badań procesowych, będących częścią programu badawczego, jaki jest prowadzony w Katedrze Aparatury Procesowej Politechniki Łódzkiej. Prace te mają na celu przebadanie procesowe nowego przesiewacza doświadczalnego – dwuczęstościowego, pod kątem jego przydatności do przesiewania drobno uziarnionych materiałów sypkich. Głównym celem niniejszego opracowania jest przedstawienie wyników badań procesowych tego przesiewacza dla różnych konfiguracji napędu, w postaci graficznych zależności sprawnościowo-wydajnościowych.

słowa kluczowe: klasyfikacja, sita wibracyjne, częstotliwość rotacji, wibrator