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GRAINED MATERIAL CLASSIFICATION ON A DOUBLE FREQUENCY SCREEN

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The present study demonstrates the results of research carried out at the Department of Process Equipment, Technical University of Lodz, devoted to double-frequency screens. Process investigations were aimed at determination of efficiency and capacity of an experimental screen on a semi-commercial scale. The project assumptions of an industrial machine were presented.

keywords: screening, screen, sub-sieve, grained material, grain classes

1. INTRODUCTION

Construction of well performing industrial screen is a challenging and difficult task. Our present investigations were aimed to determine efficiency and capacity of a semi-commercial screen. The tests were carried out using an experimental stand (Wodziński, 1997) (Fig. 1), which consisted of charging hopper 1, a riddle with a sieve 2, an upper driving vibrator 3 of rotational speed ω_1, bottom driving vibrator 4 of rotational speed ω_2, spring suspension 5 mounted at the lifting construction and a

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container for above-screen product 6 and under-screen product 7.

The screen has a possibility of vibrator set-up change from 0 to 380 mm in respect of the centre (Fig. 2). A change of the vibrator spacing causes a change of oscillation path angle of screen β.

In the course of process investigations three different configurations were applied:

– vibrators arranged one under another in the centre of the riddle, β=0° (Fig. 2a)
– vibrators spaced in respect of the centre by 110 mm, β=27,5° (Fig. 2b)
– vibrators spaced in respect of the centre by 380 mm, β=61° (Fig. 2c).

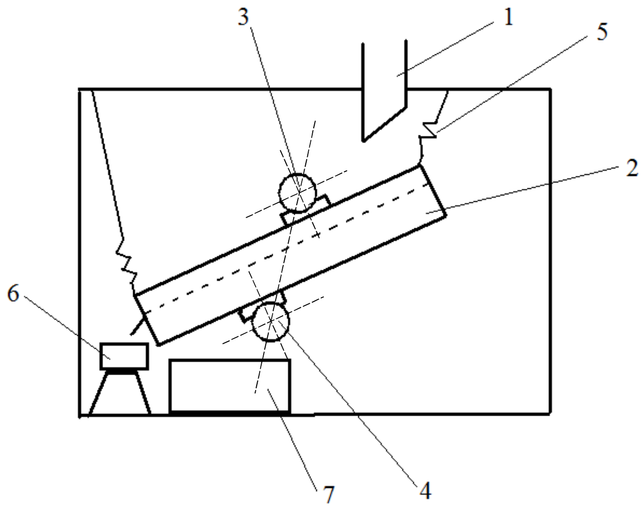


Fig. 1. Experimental screen

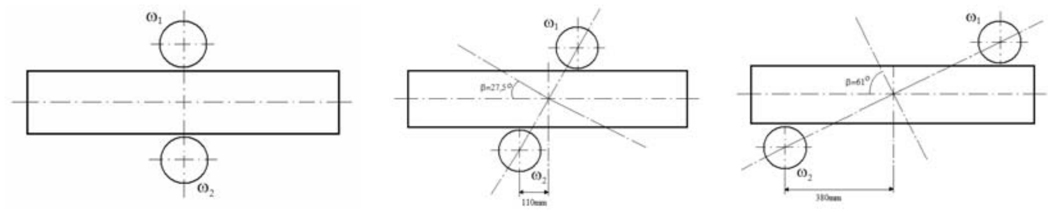
The experimental stand is equipped with an inverter being the system of vibrators' control. The inverter allows for the change of current frequency which makes it possible to attain various rotational speeds of vibrators. This enables to change the direction of vibrators' shafts rotation. The control panel contains two separate regulators for the upper and bottom engine. The maximum rotational speed possible to be obtained using the control panel is equal to 1500 rpm.

In the course of investigations the speed and direction of only one vibrator were altered. This was the bottom vibrator (ω_2). On the other hand, the upper engine (ω_1) was set on the maximum rotational speed and was not subjected to any modifications.

In the course of investigations the following machine operation parameters were changed:

– intensity of feed inflow
– rotational speed of bottom vibrator (4 variants were investigated: $\omega_2 = \omega_{max}$, $\omega_2 = 2/3, \cdot \omega_{max}$, $\omega_2 = 1/2 \cdot \omega_{max}$ and $\omega_2 = 1/3 \cdot \omega_{max}$)
– the rotation direction of the bottom vibrator (to the right or to the left)

- the exciting force of the upper vibrator (3 variants were examined: $F_1 = F_{max}$, $F_1 = 50\%\ F_{max}$ and $F_1 = 25\%\ F_{max}$)
- electro-vibrators arrangement in respect of the centre (β=0°, β=27,5° and β=61°).



a b c

Fig. 2. Vibration engines layout

2. PROCESS INVESTIGATION

Loose material utilized for investigations was as follows: agalite (a model material of spherical grains), sand (irregular grains) and marble aggregate (sharp-edged grains). The material had been prepared beforehand, i.e. it had been screened in laboratory shakers, so the half of feed mass was the upper fraction and the other half was the bottom fraction. The granulometric composition was the same for all materials applied.

Screening efficiency (η) and screening capacities (Q and q) were calculated according to the following formulas (Banaszewski, 1990; Sztaba, 1993; Dietrych 1962):

- screening efficiency

$$\eta = \frac{m_d}{m_n \cdot K_d} \quad [\text{ - }] \tag{1}$$

- screening capacity

$$Q = \frac{m_n}{t_1} \qquad [\text{ kg/s }] \tag{2}$$

$$q = \frac{m_n}{t_1 \cdot S} \qquad [\text{ kg/m}^2\cdot\text{s }] \tag{3}$$

$$S = B \cdot L \qquad [\text{ m}^2\text{ }] \tag{4}$$

where

m_d – mass of bottom product [kg]

m_n – mass of feed = 30 kg
K_d – bottom class fraction in feed = 50%
t_1 – the time of material pouring out [s]
L – the length of screen's sub-sieve = 1.325 m
B – width of screen's sub-sieve = 0.295 m
S – surface of screen's sub-sieve = 0.39 m^2.

The results of investigations are presented in the form of efficiency–capacity dependences. The example diagrams 3 - 8 allow to assess how the ratio of rotational speeds of driving vibrators changes influence the process of screening.

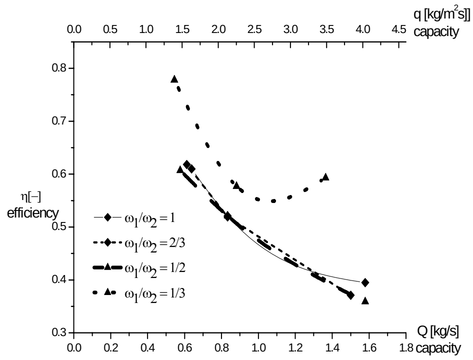


Fig. 3. Results for setting
$\beta = 0°$, $\alpha = 20°$, $F = 2$ kN

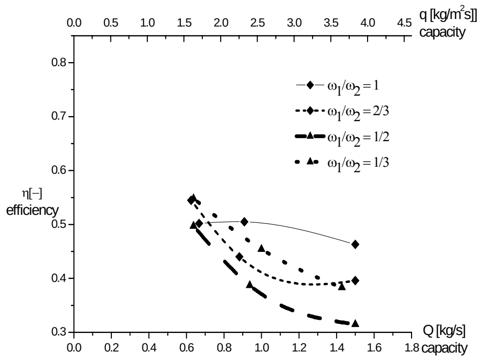


Fig. 4. Results for setting
$\beta = 0°$, $\alpha = 20°$, F=1 kN

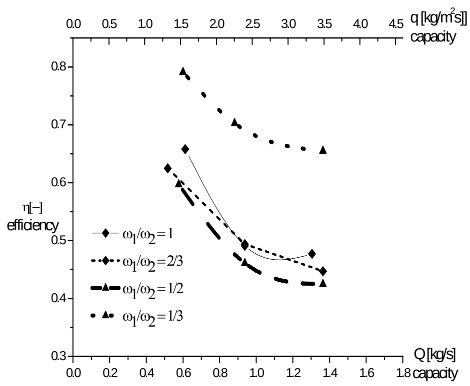


Fig. 5. Results for setting
$\beta = 0°$, $\alpha = 20°$, $F = 0.5$ kN

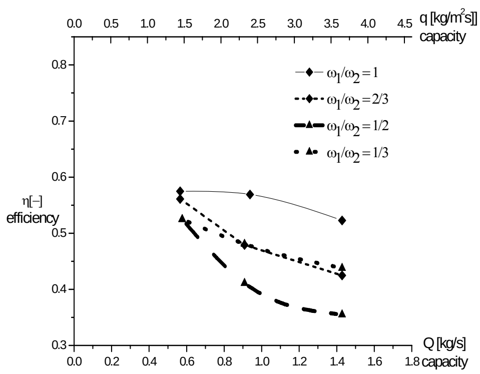


Fig. 6. Results for setting
$\beta = 27{,}5°$, $\alpha = 20°$, F=1 kN

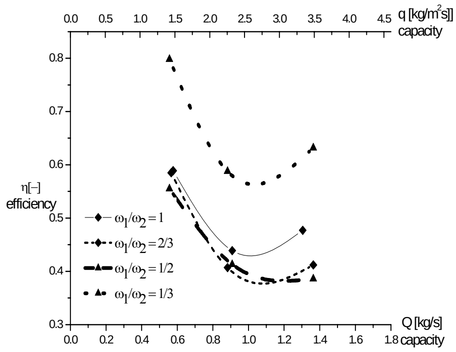


Fig. 7. The results for the following settings
$\beta = 27.5°$, $\alpha = 20°$, $F = 0.5$ kN

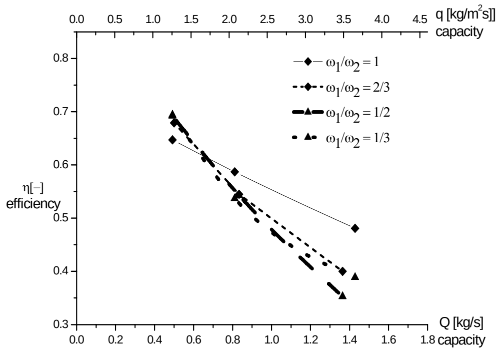


Fig. 8. Results for setting
$\beta = 61°$, $\alpha = 20°$, $F = 2$ kN

3. DEFINING PROJECT ASSUMPTIONS

The analysis of the obtained investigation results allowed to define the range of optimal operation parameters of a double screen (Table 1), which will shorten and simplify the subsequent stage of work being the screen investigation on an industrial scale.

Table. 1. The most beneficial operation parameters of a double-screen

Inclination angle of a sieve	Engine spacing	Exciting forces	Angular velocity (ω_1/ω_2 ratio)
20°	0	1/4	1/3
	0	1/4	-1/3
	1/3	1/4	1/3
	1/3	1/4	-1/3
	max	1/4	1/3
	max	1/4	-1/3

Optimization of the drive operation is carried out through the regulation of the vibrators rotational frequency, their exciting force and mutual location as well as the direction of rotations. Based on the examination, it may be stated that:

– countercurrent synchronization of vibrators is better from the process point of view
– application of vibrators of considerable power is not economically justified
– location of vibrators with regard to the mass centre does not affect the process

– screen drive system allows to obtain a 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 intensive loosening of material on the sieve
– condition of proper operation of the screen is to ensure the rigidity of the sieve on the plane of vibration trajectories.

The phenomenon of driving vibrators self-synchronization (Modrzewski and Wodziński, 2009) enables to simplify the construction of the screen because it is not necessary to apply any devices which would trigger the synchronization. Self-synchronization is a durable phenomenon. In the course of the measurements the motion once appeared in trajectories, depends exclusively upon the configuration of the driving system.

The 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 in industry.

4. INDUSTRIAL DOUBLE FREQUENCY SCREEN

Based on the investigations discussed in the present study the project assumptions for construction of a double frequency screen devoted to a sand mine in Inowlodz (Mikrosil Company, Poland) were prepared. The machine is characterized by a screen inclination angle $\alpha = 18^{\circ}$ in respect of the level. The angle of screen paths is $\beta = 0^{\circ}$. The screen is equipped with a 3-deck riddle in which there are mounted screens of the hole size of, $l_1 = 2.4$ mm, $l_2 = 1.5$ mm and $l_3 = 0.7$ mm. Screen size is: length $L = 4.0$ m, width $B = 1.5$ m.

For the drive of the machine, an axial rotational and modular vibrator of static moment from 100 to 210 Nm (from 10 to 21 kGm) was applied. This is the main vibrator located between the second and third screen deck. An electrovibrator (an unbalanced engine) being the second rotational vibrator, is located above the riddle. This is an electrovibrator of nominal rotations of 1460 min^{-1} and characterized by the operation moment equal to 900 kGm and the static moment equal to 450 kGm.

The process of screening will be conducted under dry or wet conditions applying water spray (Wolff, 1979). A charging–water hopper should be located under the screen for collecting the finest product (under-screen product) whereas above-screen products from all screen decks should be collected by chutes mounted to the lifting construction. The height of screening product collection points over hardened bed should make it possible to install there typical ribbon conveyors dedicated to collection of screening products. The integral equipment of the screen is the control panel comprising drive control elements (inverters, contactors, safety devices, etc.).

The double-frequency screen is a multi-variant machine, which means that it may be constructed in various construction versions. The scheme of a prototype screen is presented in Fig. 9. Vibrating mass of the screen WH3–1.5x4.0 is equal to 4500 kg. The whole installation is presented schematically in Fig. 10.

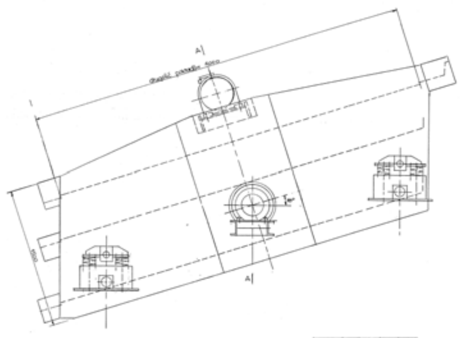


Fig. 9. Double frequency screen WH3-1.5 x 4.0

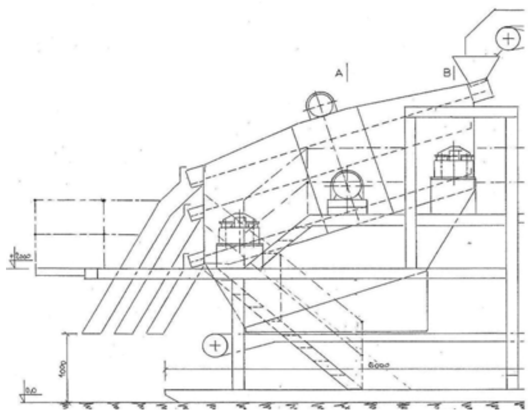


Fig. 10. Double frequency screen installation

5. 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 a given granular material. This screen is a universal screen based on the experience gained so far on 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.

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REFERENCES

BANASZEWSKI T., 1990. *Przesiewacze*, Wydawnictwo „Śląsk”, Katowice

WODZIŃSKI P.,1997. *Przesiewnie i przesiewacze*, Wydawnictwo Politechniki Łódzkiej, Łódź

SZTABA K., 1993. *Przesiewanie*, Śląskie Wydawnictwo Techniczne, Katowice

DIETRYCH J., 1962. *Teoria i budowa przesiewaczy*, Wydawnictwo Górniczo – Hutnicze, Katowice

WOLFF K., 1979. *Systemsiebboden fur Siebmaschinnen*, Aufbereitungs Technik, Essen

MODRZEWSKI R., WODZIŃSKI P., 2010. *The results of process investigations of a double-frequency screen*, Physicochem. Probl. Miner. Process., 44, 169-178

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Niniejsza praca prezentuje wyniki programu badawczego prowadzonego w Katedrze Aparatury Procesowej Politechniki Łódzkiej, poświęconego przesiewaczom dwuczęstościowym. Badania procesowe miały na celu określenie sprawności i wydajności przesiewacza doświadczalnego w skali półtechnicznej. Do napędu przesiewacza stosowane są dwa wibratory rotacyjne o jednakowych lub niejednakowych momentach statycznych. Jak sama nazwa wskazuje jest to przesiewacz, który charakteryzuje się dwiema różnymi prędkościami obrotowymi tych wibratorów napędowych. Konstrukcja przesiewacza umożliwia regulację wszystkich podstawowych parametrów pracy maszyny, w szczególności takich jak: nachylenie rzeszota względem poziomu, ustawienie silników względem środka rzeszota, siły wymuszające wytwarzane przez silniki oraz prędkości obrotowe tych silników.

Głównym celem niniejszego opracowania jest przedstawienie wyników badań procesowych tego przesiewacza dla różnych konfiguracji napędu, w postaci graficznych zależności sprawnościowo-wydajnościowych. Na ich podstawie zostały opracowane założenia projektowe maszyny przemysłowej

słowa kluczowe: przesiewanie, przesiewacz, sito, materiał ziarnisty, klasy ziarnowe