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THE CONCEPT OF THE SCIENTIFIC STANDPOINT OF THE ROLLING -SCREW SCREEN. PARTIAL AUTOMATION OF THE SCREENING PROCESS

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Abstract. The study presents suggestions of partial automation of the screening process with the use of the rolling-screw screen. The principles of screening using such a screen was also briefly described in the study.

Keywords: *screening, rolling-screw screens, automation*

Introduction

Rolling screens (rolling-screw screens) are machines designed for the realization of granular materials sieve classification processes. It refers, first of all, to fine and very fine-grained granular mixtures, which due to their particle size, cannot be screened using other known sieves. These machines perform a complex, spatial, rotational movement, being so-called "drunken barrel" movement. The screening process of these machines is performed through putting the feed centrally onto the highest located (within sieving layer sets) sieve (of the biggest holes). The above-sieved products X1, X2… are collected through side gutters whilst the below-sieved products Y1, Y2… form the feed for further, lower located sieves (Fig. 1) (Pocwiardowski and Wodzinski 2011a, Pocwiardowski and Korpal 2010, Pocwiardowski 2012, Wodzinski 1997).

During the screening process we deal with a number of parameters, which need both monitoring and controlling. To fulfill these needs the elements of mechatronics registering and supervising these parameters could be introduced.

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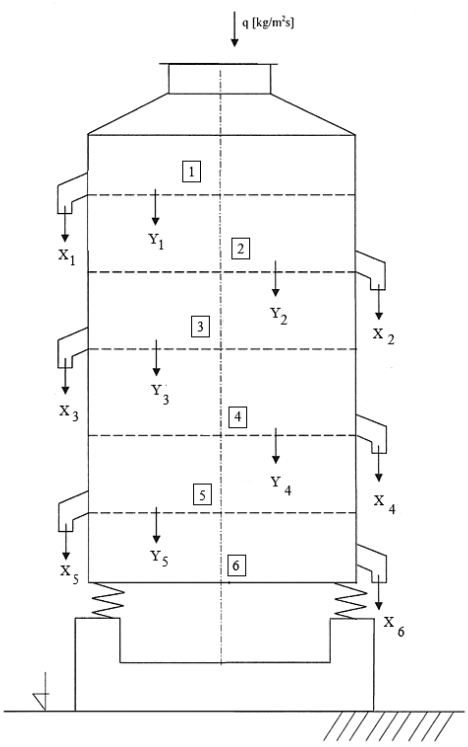

Fig. 1. The diagram of the screening process using a rolling-screw screen

The aim an the scope of the study

The aim of the study is to propose a solution to the screening of granular materials process automation using a rolling-screw screen.

The guidelines on the screening process automation

The project includes the place for screening granular materials of fine and very fine grain-size, which consists of the following:

- gutter feeder (website of VIBRO-EKO-TECH) operating within the influx intensity q within the range from 5 to 50 kg/h. The influx intensity is adjusted by feeding voltage of the electromagnetic vibrator with the use of the inverter. Additionally, the feeder is equipped with an electronic sliding bolt in a place where a charging hopper is,
- a rolling-screw screen consisting of seven sieving panels, which enables to achieve up to eight fractions within one passage (Fig. 2),

Fig. 2. A rolling-screw screen with a fraction receiver (Pocwiardowski and Wodzinski 2011b)

- a sieving fraction receiver (Fig. 2) located on electronic industrial scales (website of RADWAG) enabling monitoring of mass increment of collected fractions,
- an inverter, which is used for switching on and off the screen, as well as for changing the angular speed of motor-vibrators, and adjustment of granular materials influx (Catalog page of inverter MX2 OMRON),
- Bruel&Kjaer SYSTEM PULSE used for the measurement of oscillation amplitude of the screen within three axis plane x,y,z,
- computer PC, which controls the entire process and is connected to the monitoring sensors of the sceening process.

The mechatronics system guidelines

- the control of sieving fractions mass influx, which enables indirectly the monitoring whether the sieves have not been blocked by the materials being screened;
- the measurement of oscillation amplitude within three axis plane x, y, z,
- change of the angular speed of motor-vibrators (the phenomenon of the sieve blockage by the sieving material),
- dosage of the granular materials.

The implementation of the mechatronics system

- mass influx is monitored with the use of an industrial scale of RADWAG WPW 60 H5/K with a maximum load 60kg and readout accuracy 20g, and output signal RS 232/RS 485,
- the oscillation amplitude within three axis plane x,y,z is measured with an Bruel&Kjaer Triaxial delta tron accelerometer type 4524-b-001. The signal form a sensor is converted in the Bruel&Kjaer SYSTEM PULSE measuring box connected to the PC via a cable,
- the change of the angular speed of motor-vibrators is done with the use of OMRON inverter OMRON mx2, class 400v, with signal output RS485 ModBus RTU,
- the dosage of the granular materials is done with the use of a gutter feeder connected to OMRON mx2 inverter and equipped with an electro -valve (numerically controlled (I/O)) placed in the charge basket opening,
- the connection to the computer via USB-COM-4S equipped with four ports RS 485, the computer equipped with an USB input and a card system.

Table 1. A sample solution to the implementation of the mechatronics system for a rolling-screw screen

No.	Given parameters	Solution	Apparatus
1	Receivers mass influx	An industrial scales of max. load 60kg with readout accuracy 20g, and output signal RS 232/RS 485.	e.g., RADWAG scales model WPW 60 H5/K
2	oscillation amplitude within three axis plane x,y,z	Accelerometer measuring oscillation amplitude within three axis plane x,y,z w within frequency 0.25–3000 Hz	e.g., Triaxial delta tron accelerometer model 4524-b-001 operated by Bruel&Kjaer SYSTEM PULSE
3	The adjustment of the angular speed of motor-vibrators	Inverter class 400v, with signal capacityRS485 ModBus RTU with a possibility of connecting to PC	e.g., Omron inverter mx2
4	dosage of the granular materials	Gutter feeder (dosing capacity up to 50 kg/h) connected to an inverter and equipped with an electro -valve (numerically controlled (I/O)) placed in the charge basket opening	e.g., Gutter feeder – vibratory Omron inverter mx2 an electro-valve (numerically controlled (I/O))

The description of the system operation – the stages of the process

Initial research

Before commencing the screening process with the use of a rolling-screw screen, the sieving analysis of the researched material should be performed (suggested shaker Fritsch) in order to determine the percentage composition of individual sieving fractions.

The dosage process

The feed is put centrally onto the highest located sieve of the screen pillar (of the biggest sieving holes) with the use of a gutter feeder driven electromagnetically. The change in current frequency causes the change of engine rotation frequency thus the material dosage amount adjustment onto the screen. The feeder gutter is placed on a springy suspension. The gutter is activated by the engine therefore it performs reciprocating motion. The motion makes the granular material shift onto the screen. The charging hopper opening of the feeder is equipped with an electronically controlled electro -valve, which adjusts the dosage with influx intensity q [kg/h]. In case there is a screen running stoppage (messages: SIEVES BLOCKAGE, RECEIVERS CHANGE, SCREENING FINISHED) the computer sends a signal to the electro -valve in order to cut out the granular material influx onto the screen.

The screening process

The granular material dosed onto the rolling-screw screen is directed from sieving panels via side gutters onto the receivers. The receivers are placed on the electronic industrial scales, enabling the monitoring of mass increment of the particular fraction. When the receivers are filled (the mass of the received fraction exceeded the maximum mass of the receiver) a message RECEIVERS CHANGE is displayed, the screen is stopped by the inverter and the electro-valve is closed. After the receivers change the screen turns on again via the inverter controlled by a computer PC. In case there is too large amount of one of the sieving fractions (the receiver mass is too large due to the percentage contents of particular sieving fractions of the researched material) a message SIEVES BLOCKAGE is displayed. The system sends signal to the inverter in order to increase the motor-vibrators rotational speed until the sieve is unblocked (the completion of the process is indirectly noticeable via the particular fractions mass)

The control of the SYSTEM PULSE

The Bruel&Kjaer SYSTEM PULSE analyzer operated by PULSE LabShop program reads the signal from the sensor: Triaxial delta tron accelerometer type 4524-b-001 (Bruel&Kjaer official website). With the use of this sensor the sieving oscillation amplitude within three axis plane x,y,z is recorded. In case of too low or too high amplitude value on particular axis, a message SERVICE is displayed. The deviating amplitude values on particular axis might mean:

- wrong set-up angle of the side motor-vibrators,
- wrongly screwed screen,
- screen resonance occurs.

In each of the above cases the system turns of the screen via the inverter and cuts out the influx of the granular material onto the screen.

The sensor mounting diagram (Fig. 3) on the rolling screen as well as actual measurement of the sieving oscillation amplitude within three axis plane x,y,z (Fig. 4–8) were presented below.

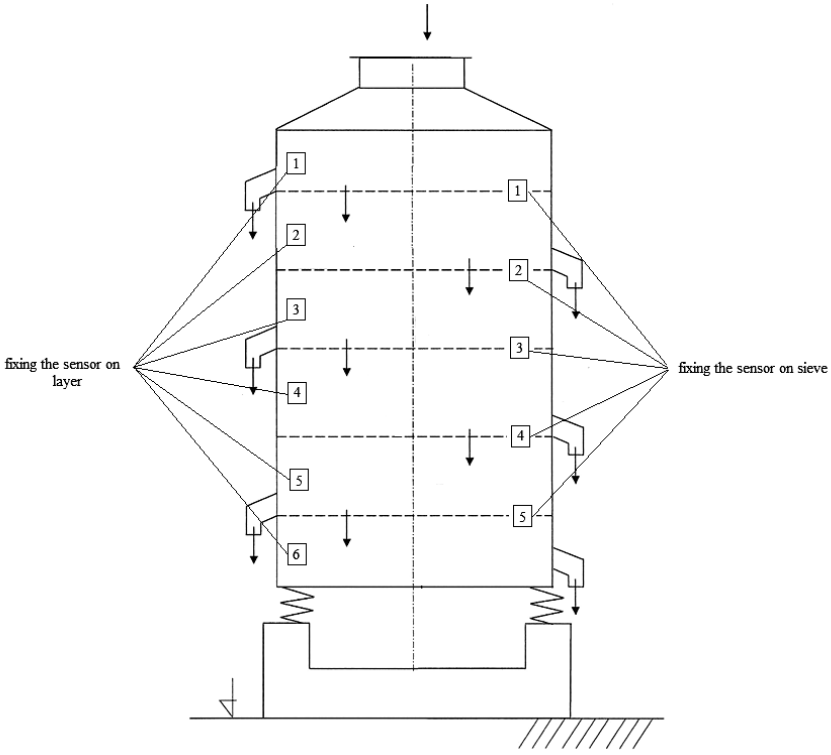

Fig. 3. The sensor (accelerometer) mounting diagram on a rolling scree

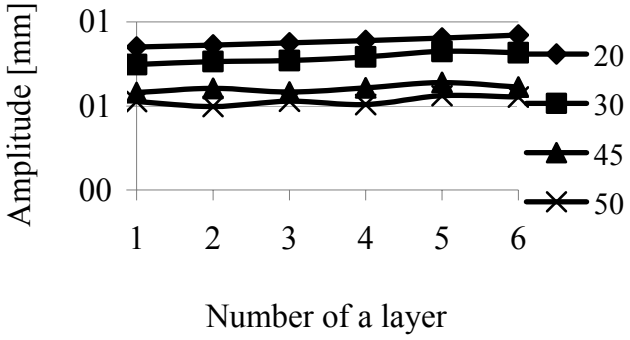

Fig. 4. Layer oscillation amplitude within X axis in the screen with various inclination angles of the motor-vibrators

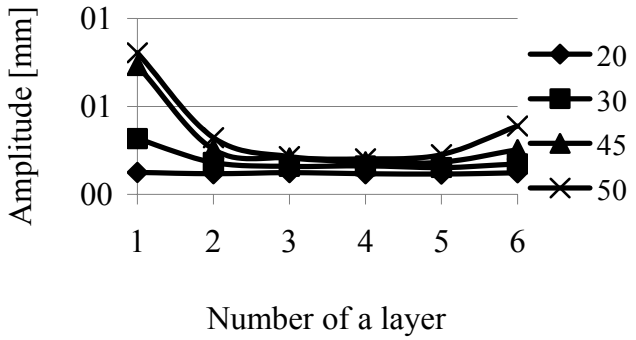

Fig. 5. Layer oscillation amplitude within Y axis in the screen with various inclination angles of the motor-vibrators

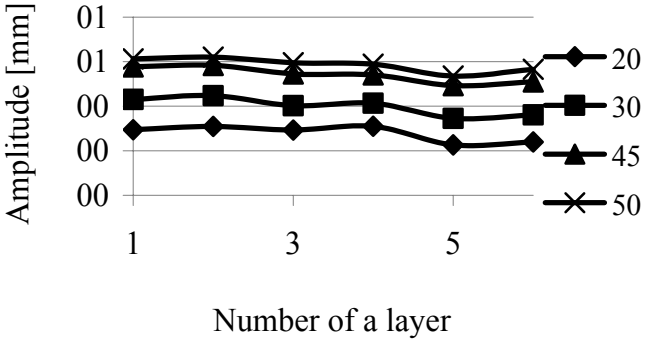

Fig. 6. Layer oscillation amplitude within X axis in the screen with various inclination angles of the motor-vibrators

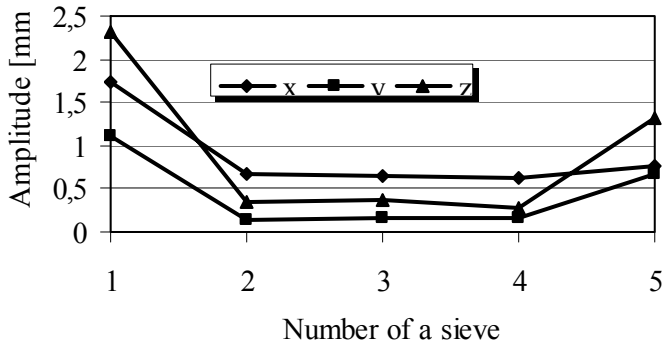

Fig. 7. Sieves oscillation amplitude within X, Y, Z axis with the motor-vibrators inclination angle of 20º

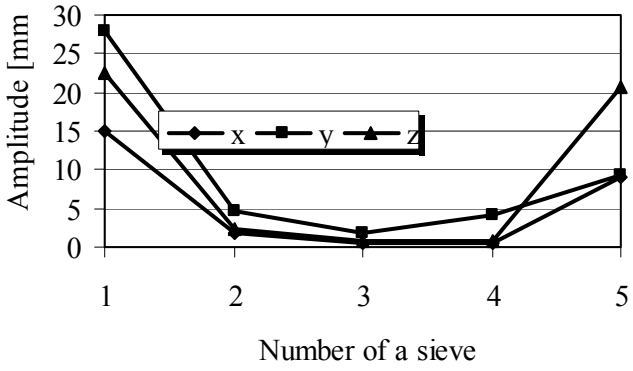

Fig. 8. Sieves oscillation amplitude within X , Y , Z axis
with the motor-vibrators inclination angle of 45º

The mechatronics system diagram was presented below in Fig. 9.

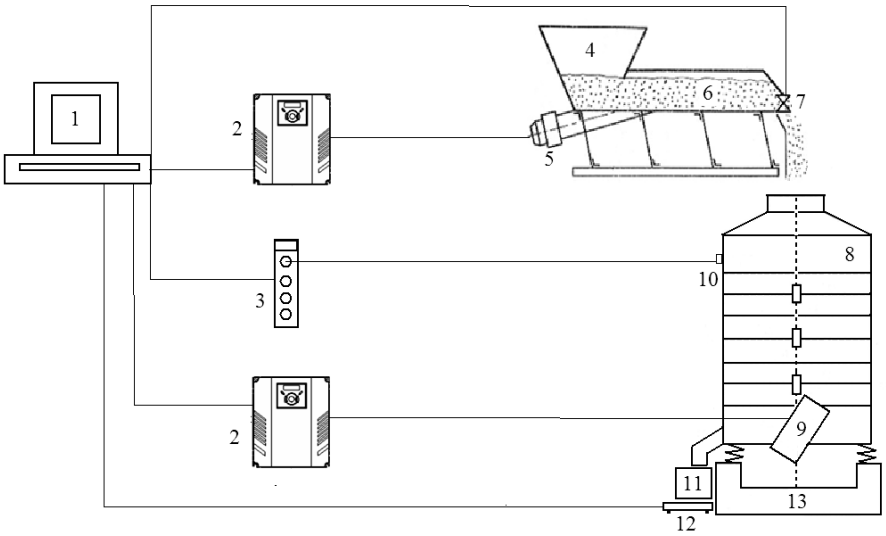

Fig. 9. The mechatronics system diagram
1 – computer, 2 – inverter, 3 – SYSTEM PULSE box, 4 – gutter feeder – vibratory,
5 – feeder engine, 6 – gutter feeder on a springy suspension, 7 – feeder electro-valve,
8 – rolling-screw screen, 9 – side motor-vibrators, 10 – accelerometer, 11 – receiver,
12 – industrial scales, 13 – screen base.

Conclusions

1. The mechatronics system allows controlling most of the screening processes via the computer panel.

2. The application of this solution enables early reaction to the problems arousing during the process.
3. The set of the sensors enables the visualization of particular parameters of the process.
4. The screening process automation enables process run reports making.
5. The above research standpoint is to be made in order to test its possibility.

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