SELF-CLEARING OF VIBRATING SCREENING SYSTEMS

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ABSTRACT. During the screening process, particles can block the system by becoming trapped in the screening surface which causes a decrease in performance called blinding. This paper studies the forces acting on a blocked particle from the sample and the conditions under which it becomes free again. Self-clearing is the ability of sieves to dislodge blocked particles by no means other than the forces created by the sieving itself. The determinant factors for self-clearing are correctly selected vibration frequency, amplitude and direction, as well as screen slope. The purpose of this work is to investigate the effects of these on the ability to self-clear with forces of friction taken into account. The relationships between particle dimensions and the size of surface openings that permit self-clearing are determined.

Key words: vibrating screening system, self-clearing

САМООЧИСТВАНЕ НА ВИБРАЦИОННИТЕ ПРЕСЕВНИ УРЕДБИ

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РЕЗЮМЕ. В процеса на пресяване така наречените трудни зърна засядат в отворите на ситото и причиняват задръстване, с което понижават производителността. Изследват се силите, действащи върху една заседнала частица от пресявания материал и условията за нейното излизане от това състояние. Самоочистването е свойство на ситото да се освобождава от заседналите трудни зърна без различни помощни средства, а само с помощта на действащите сили. Решаващи фактори за самоочистването на пресевните повърхности са правилно подбраните честота, амплитуда и направление на трептенията и наклон на пресевната повърхност. Целта на тази работа е изследване на влиянието на споменатите фактори върху способността на ситото да се самоочиства при отчитане и на силите на триене. Изведени са зависимости между размерите на частиците и големината на отворите на ситото, осигуряващи самоочистването.

Ключови думи: вибрационни пресевни уредби, самоочистване

Introduction

Screen blinding degrades screening performance and efficiency. It is of particular importance to formulate the exact reasons and identify means to prevent it from occurring.

It is clear from the practice of mining enterprises that the main factors for blinding are the physical properties of material screened (Denev, 1964; Tsvetkov, 1988). The particle-size distribution is particularly important. The larger the "under-size" particle groups and smaller the “limit-size” (or “near-size”) particle groups, the lower the risk of blinding. The general rule is that small particles easily pass through the openings and the screen proves to be large enough for near-limit particles.

High material humidity also contributes to intensified blinding. Finer particles stick together and form larger pieces which cause congestion. Sieving is made difficult not by the humidity itself, but by the water on the surfaces of particles. Water connects particles pulling them together. Increased humidity prevents screening only up to certain limits. Screening beyond these is called wet screening.

Contamination in the feed also creates conditions for blinding of the screen surface. Even in low humidity, loamy impurities form lumps which remain in the material bed and block the openings. Fine dust can also adhere to surface openings and reduce their size.

The shape of the particles and their relative weight are also important. Objects with flat and elongated shapes can cover openings more easily. It is of paramount importance that the shape of the openings be suitable for the shape of the particles. Round holes are recommended for spheres and cubes. Rectangular ones are suitable for flat and elongated particles.

Self-clearing is the ability of sieves to dislodge blocked particles by no means other than forces created by the sieving itself. The determinant factors for self-clearing are correctly selected vibration frequency, amplitude, and direction, as well as screen slope. The purpose of this work is to investigate the effects of these on the ability to self-clear with forces of friction taken into account. This work is a continuation of the quoted study by Pulev (2015).

Analysis

The most common cause of screen blinding is openings blocked by near-sized particles. These are particles with a size d greater than or equal to the size of the holes l (Fig. 1).

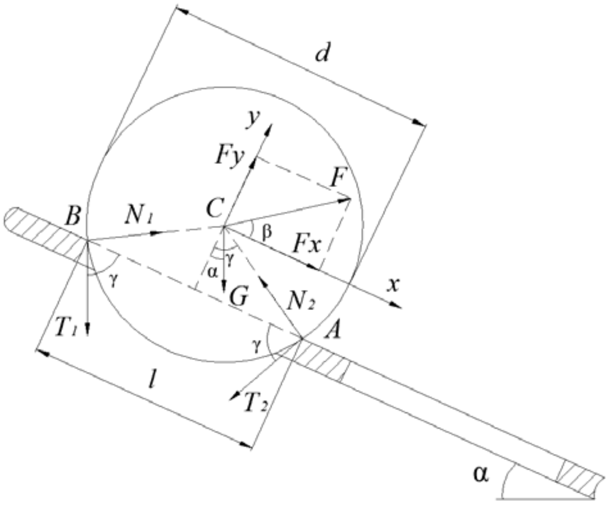

Fig. 1. Diagram of forces acting on a near-sized particle

We investigate a screening surface sloped at an angle α relative to the horizon that performs rectilinear vibrations governed by the law

$$\eta = h\sin\omega t\,.$$

The amplitude and frequency are denoted by h and ω, respectivley, and the angle β determines the direction of vibrations . Fig. 1 presents a blocked particle that has covered the screen opening, modelled as a completely rigid body with a spherical shape and mass m . A coordinate system Cxy is introduced with the x axis parallel to the screening surface. The active forces acting on the particle are the force of gravity

$$G = mg$$

and the periodically changing inertia force

$$F = mh\omega^2 \sin\omega t$$

with components

$$G_x = mg\sin\alpha$$
$$G_y = mg\cos\alpha$$
$$F_y = mh\,\omega^2 \sin\omega t.\sin\beta$$
$$F_x = mh\,\omega^2 \sin\omega t.\cos\beta\,.$$

The normal forces with which the screen acts on the particle at the ponints of contact with the screen surface A and B are denoted by N_1 and N_2 . Sliding friction forces of type

$$T_1 = \mu N_1 \text{ and } T_2 = \mu N_2$$

are applied at the same points. The coefficient of friction between the particle and the screen is μ . The border state in which the particle separates from the screen in the positive direction of the y axis is examined. It is assumed that separation is possible at the maximum value of the inertia $(\sin\omega t = 1)$;
then

$$F_y = mh\omega^2\sin\beta \tag{2.1}$$
$$F_x = mh\omega^2\cos\beta\,.$$

As there are no external causes, it is considered there is no possibility for the particle to rotate around its center O . The conditions for equilibrium of this setup are:

$$F_x + G_x + (N_1 - N_2)\sin\gamma + (T_1 - T_2)\cos\gamma = 0$$
$$F_y - G_y + (N_1 + N_2)\cos\gamma - (T_1 + T_2)\sin\gamma = 0$$

Following transformations, the expression below is derived:

$$2N_1 = \frac{F_x + G_x}{\sin\gamma + \mu\cos\gamma} + \frac{G_y \quad F_y}{\cos\gamma - \mu\sin\gamma}\,. \tag{2.2}$$

From Fig. 1, the following holds for the geometric dimensions:

$$\cos\gamma = \frac{\sqrt{d^2 - l^2}}{d}\,,\ \sin\gamma = \frac{l}{d}\,.$$

The concept of relative particle size is introduced. It is denoted by

$$a = \frac{d}{l}$$

and represents the ratio between particle size and sceen opening size. The size of the particle is relative. The following equations then hold:

$$\cos\gamma = \frac{\sqrt{a^2 - 1}}{a}\,,\ \sin\gamma = \frac{1}{a}\,. \tag{2.3}$$

It is considered that the release of the particle will occur when the particle does not exert pressure on the screening surface, i.e.

$$N_1 = 0 \tag{2.4}$$

After taking into account conditions (2.1) to (2.4), we can derive the expression for the relative particle size

$$a = \sqrt{1 + \left(\frac{g(\cos\alpha + \mu\sin\alpha) - h\omega^2(\sin\beta - \mu\cos\beta)}{g(\sin\alpha - \mu\cos\alpha) + h\omega^2(\cos\beta + \mu\sin\beta)}\right)^2} \tag{2.5}$$

The relative particle size determined by (2.5) gives an idea of the ability of the screen to self-clear. At values close to 1, particles fall deep into the openings, block them, and release becomes harder. As values become greater than 1, the particle center of gravity is more distant from the surface and the probability of self-clearing increases.

Numerical experiment and discussion

The analysis of (2.5) shows that the the following four factors influence self-clearing:

– vibration frequency ω ;

– vibration amplitude h ;

– vibration direction determined by angle β ;

– screen slope α .

To investigate their impact, charts (see Fig. 2, 3, 4, and 5) have been plotted using (2.6) with the following parameters set at:

$$h = 2\ mm,\ \omega = 400\ s^{-1},\ \alpha = 9^\circ,$$
$$\beta = 15^\circ,\ \mu = 0{,}2.$$

Fig. 2 shows changes of relative particle size against an amplitude variation from 1 to 10 mm. It can be seen that self-clearing improves as amplitude increases. The reason is that a larger inertial force pulls near-sized particles out from the openings more easily.

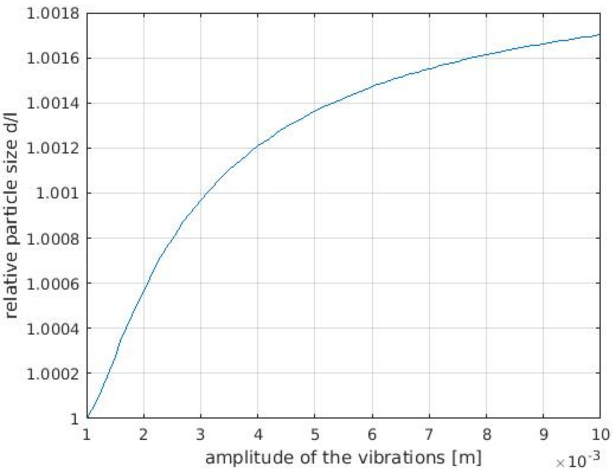

Fig. 2. Influence of vibration amplitude on self-clearing ability

Figure 3 illustrates relative particle size against a vibration frequency varying from 50 to 250 s^{1}. As can be seen, high vibratoin frequency adversely affects self-clearing.

Fig. 4 shows how screen surface slope affects self-clearing. The angle α varies from 0 to 40º. Increases in slope only sightly imporove self-clearing because they reduce the gravity component $G_y = mg \cos \alpha$. At the same time, steep slope increases material movement speed and can negatively affect screening efficiency.

Fig. 5 illustrates the influence of vibration direction determined by the angle β . The anble varies from 0 to 40º. At smaller angles, self-clearing is weak, but the magnitude of the horizontal component F_x of the inertial force is large. This leads to improved transport of material over the screen surface. Increasing β causes an increase in the vertical component of the inertial force and improvements in self-clearing, but it can adversely affect the vibration stability of individual particles.

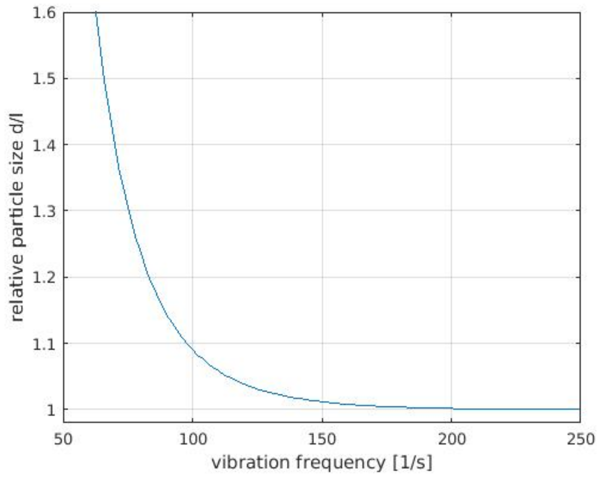

Fig. 3. Influence of vibration frequency on self-clearing ability

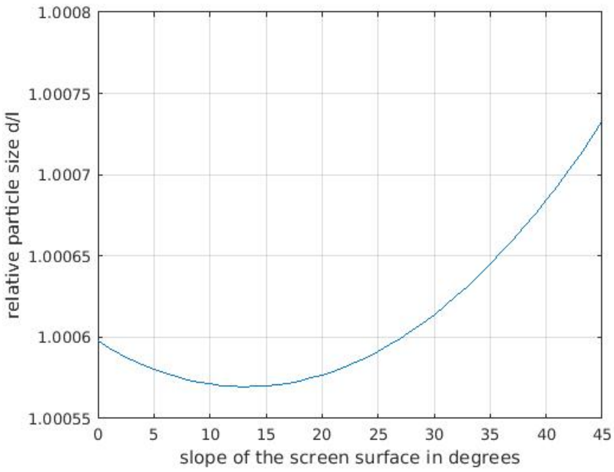

Fig. 4. Influence of screen slope on self-clearing ability

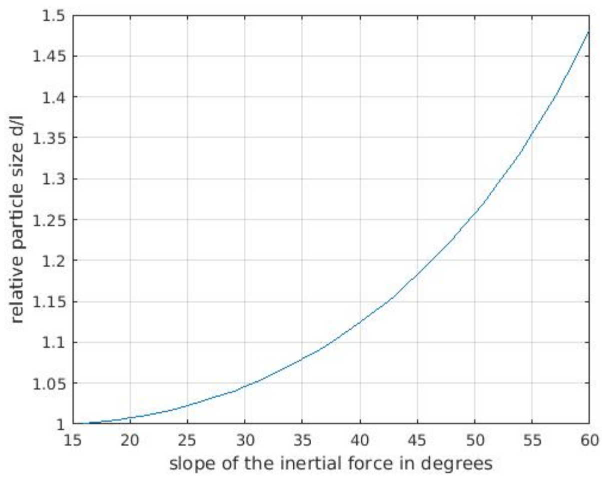

Fig. 5. Influence of vibration direction on self-clearing ability

Conclusion

The ability of the screen to self-clear is an extremely important for increasing the performance and efficiency of vibrating screening systems. It is a complex dependency on the parameters of the vibration and on the slope of the screening surface. The deduced formula (2.5) and its analysis can be used to correctly select the amplitude, frequency and direction of oscillation, as well as screen slope. The results of this study can aid technologists in mining enterprises.

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