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The "fish-hook" phenomenon and using separation sharpness parameter in investigation of vibration screen performance

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Abstract

Vibration screens are one of the classifier equipment in industry of mineral processing whose performance should be examined in a given time periods; and the most common way for it is using partition curve and calculating parameters of imperfect factor and cut size. One of the common phenomena in partition curve is fish-hook phenomenon which shows entering fine particles into coarse flow. The purpose of this study is to investigate the cause of occurring fish hook phenomena in double deck vibrating screen of Gol Gohar iron ore mine with the aperture size of the 25 and 12 mm respectively in the first and second deck and also to use separation sharpness parameter in order to evaluate its performance. Both parameters of imperfect factor and separation sharpness conceptually reflect the accuracy of screening operations, but separation sharpness parameter is special for hydrocyclone which is used in the present study by defining its parameters for vibration screen. To increase the accuracy, both parameters are used. Cut size of the first and second decks of this screen was obtained respectively, 28.5 and 10.4 mm. Screen imperfect factor was obtained as 0.13 and 0.14, respectively and separation sharpness as 3.72 and 3.01, respectively. The obtained values for imperfect factor and separation sharpness indicate acceptable performance of the screen under study. Also, consistencies of for imperfect factor and separation sharpness indicate possibility of using separation sharpness parameter in investigating performance of vibration screens. The occurrence of fish hook phenomena is attachment of fine particles to coarse particles and inability of screen in separating them and as a result their transfer to over flow.

Keywords: Vibration screen, fish hook, partition curve, imperfect factor, separation sharpness.

1. Introduction

Mineral processing operations include three main parts of crushing, classification and separation. The classification stage is of importance from different aspects such as reducing energy consumption, suitability of the product for the next phase of the process, suitability of the product for sale and so on. If in the process of crushing, the materials are crushed more than what is suitable, in addition to power dissipation, fines particles are generated that valuable material in it that cannot be recycled at a later stage. Also, if the material is not crushed reason enough in crushing stage and enter phase separation, its valuable content is not released yet and cannot be separated, and thus enters into the waste stream, so investigating performance of this equipment in given periods of time is necessary. Vibration screen is important equipment of this step [1]. In this study, the performance of Vibrating screen with name of SC18 was investigated which is a double-deck vibration screen with aperture size of 25 and 12 mm in the first and second deck. To evaluate performance of classifier equipment such as screening and Classifier and hydrocyclone different methods are used. The most common way to evaluate the performance of the screening is partition curve. Partition curve represents the percentage of ingredients that have been transferred to over flow. Through this curve parameters of cut size and imperfect factor can be calculated for screen [2]. If screening performance of screen is appropriate, fine particles should not be transferred to coarse grain part, but in some cases, the distribution coefficient of these particle is not zero, and this indicates the presence of fine-grained particles in over flow. Since distribution coefficient is not zero,

the screen partition curve is not normal S-shaped. The cause of this phenomenon in hydrocyclones and classifiers is respectively fine particles' following the water and the air flow [3], [4].
Several screening and risk assessment procedures [5-7], some used by chemical process industries are evaluated to determine their appropriateness for focusing on hazard identification and exposure estimation. One of the most widespread is the so-called Environmental Impact Assessment (EIA). This technique is extremely useful but there are also drawbacks. For instance, subjectivity in initial value choices makes model comparison difficult. To overcome some of these problems, Gomez and Herbert [8] set out a methodology to establish an environmental analysis, focusing on the evolution of environmental impacts over time.

2. Research process

2-1 Sampling and analyzing grading

The main objective of sampling in this research is analyzing screens input and output flows. Therefore, the method used is the formula G (1979), for graining which is shown in equation (1) was used [9].

$$M = \frac{20\,fgbd^3}{R^2} \qquad (1)$$

In this relation, *(M)* represents the minimum sample weight in grams, (f) is shape factor, (g) is grading factor, (b) is specific weight of material in gram per cubic centimeter, (d) is the size of the largest particle in centimeter, and (R) is accuracy required. Shape factor value is considered 0.5 for all flows and specific weight of material as 2.7 grams per cubic centimeter. Table 1 shows the values for formula Gy parameters in relation to the area of study and weight required for each flow.

Table 1. The numerical values of the parameters of the formula Gy

Flow name	$d(cm)$	b	g	f	R	M(kg)
Feed	4.5	2.7	0.25	0.5	0.1	61.50
First deck overflow	4.5	2.7	0.25	0.5	0.1	61.50
second deck overflow	2.5	2.7	0.25	0.5	0.05	42.18
second deck underflow	1.2	2.7	0.25	0.5	0.05	4.66

2-2 Screen Analysis

Figure (2) is related to the screen SC18 and curve of balanced graining for input feed flows streams (S18F), First deck Overflow (S18D1O), second deck overflow (S18D2O) and under flow of the second deck (S18D2U).

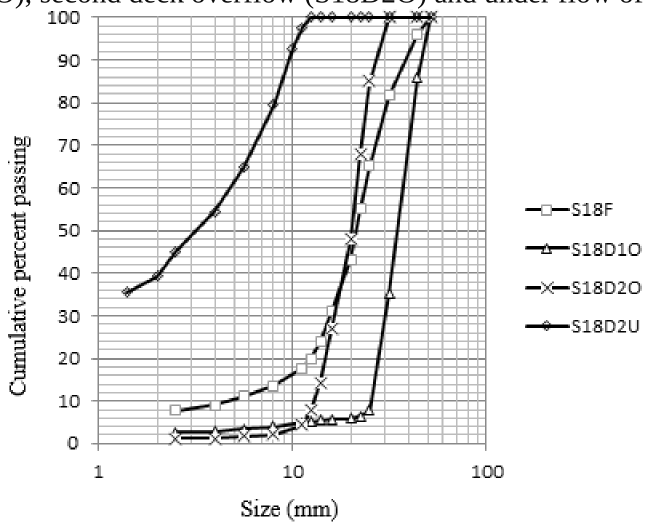


Figure 1- curve of graining flows of screen SC18

In this research, due to comprehensively of the resin Ramlr function compared to other functions, this graining function is used to show the graining distribution.

2-3 Drawing partition curve

Percentage of feed material that is transferred to the remaining part on screen is called distribution coefficient. By drawing distribution coefficient variations relative to the average diameter of each part of the graining, partition curve is obtained that is also called efficiency curve. This ideal and real partition curved are shown in figure (2).

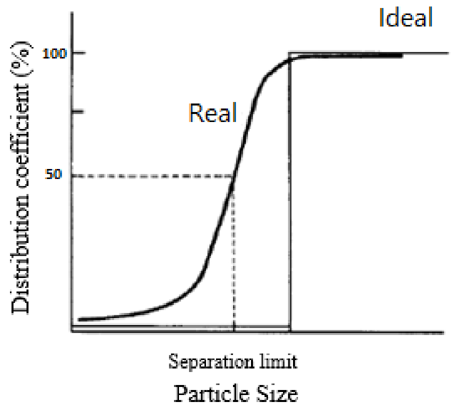
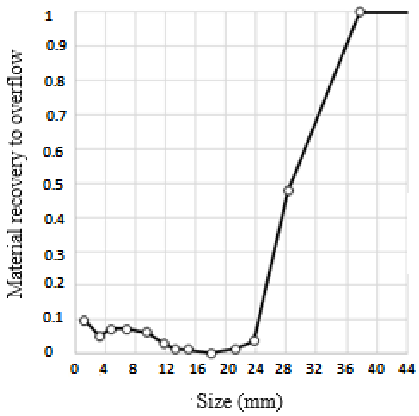
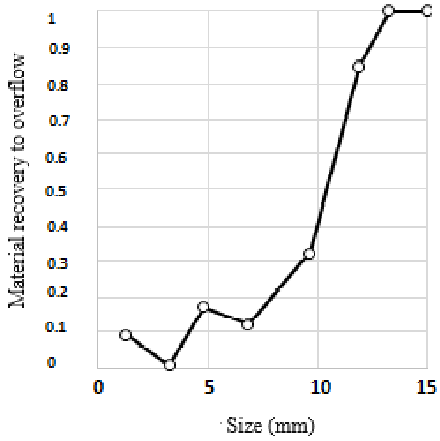


Figure 2. Ideal and real distribution curves [4]

In this research, according to dimensional analysis of flows, partition curves were plotted for each of the classes of the screen. Figures (3) and (4) respectively show the performance curves of first and second decks of screen SC18.



Figures 3- Partition curve of first deck of screen



Figures 4- Partition curve of second deck of screen

3. Results and discussion

3-1 Cut size

In fact, the separation is located at a point of the Trump curve where distribution coefficient is 50%. Grains with this size, has identical probability of being in the remaining part of the screen or the part crossed from screen.
After drawing partition curves, cut size was obtained in mm for first and second deck of SC18 screen as respectively 28.5 and 10.4

3-2 Imperfect factor

Considering distribution coefficient curve, the curve coefficient of imperfect can be extracted. The imperfect factor rate represents closeness or f farness of the real performance of curve from its ideal state. In ideal state imperfect factor is equal to zero, and the more curve is out of the ideal state, this number becomes greater.
Imperfect factor equation is as follows [9].

$$I = \frac{d_{75} - d_{25}}{2 \times d_{50}} \quad (2)$$

Where I represents imperfect factor of curve and d_{75} d_{25} ، d_{50} are diameter of the particles whose probability of being in remaining part of up wailing is respectively 75, 25 and 50 percent. For each deck of screen under study, the mentioned parameters are calculated and shown in Table 2.

Table 2. Parameters d_{75} و d_{25} ، d_{50}, (nominal and real) and defect coefficients of screens under study

Screen name	$d_{25}(mm)$	$d_{75}(mm)$	$d_{50}(mm)$ real	$d_{50}(mm)$ nominal	I
First deck	26	33.5	28.5	25	0.13
Second deck	8.5	11.4	10.4	12	0.14

3-3 Separation sharpness

Sharpness (accuracy) shows goodness or performance screen in separating fine and coarse grains from each other. In order to obtain this parameter, in this study, retrieving relation for the hydrocyclones is used. This model has been described in equation (4) [10].

$$R_i = R_f + (1 - R_f) \times \left[1 - \exp(-0.693(\mathrm{x}_i / d_{50c})^m)\right] \quad (3)$$

In this relation:

R_i : Recovery of solid to under flow of cyclone (recovery of material to over flow in the screen) for the deck with Ith size.

R_f : Recovery of the liquid to the under flow of cyclone (due to dryness of screen process, this parameter is considered as zero).

The size of the particle size specification for my class.

x_i : Size of particles for the deck with ith size.

d_{50c} : The modified cut size (on the same screen as the primary cut size)

m: Sharpness of separation

According to the above description of the parameters definition, the recovery relation can be used for investigating separation sharpness of the screens as the relation (4).

$$R_i = 1 - \exp(-0.693(\mathrm{x}_i / d_{50c})^m) \quad (4)$$

Figures (5) and (6) respectively show fitness of plate curve the first and second deck of the screen SC18.

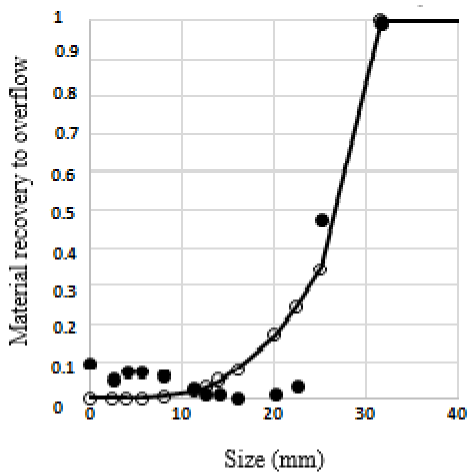


Figure 5. Fitness of Plate Curve for first-deck of screen SC18

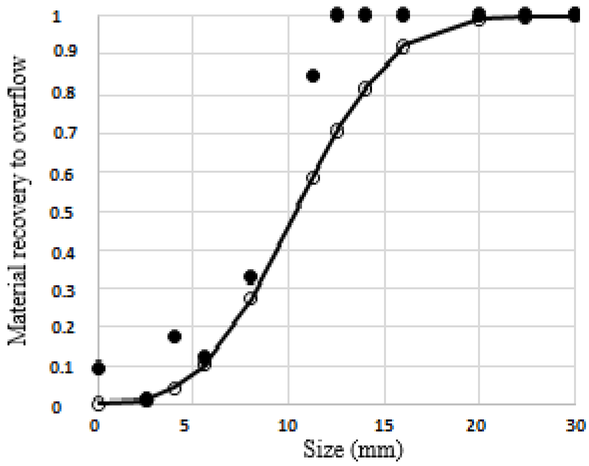


Figure 6. Fitness of Plate Curve for second -deck of screen SC18

In this research for each deck , due to specified parameters of d_{50} and x_i using fitness by least squares method, separation sharpness parameter was obtained whose result for the first and second decks of screen SC18 is respectively, 3.72 and 3.01.

3-1 Phenomenon of fish hook

In case of screen studied, as can be seen in Figures 4 and 5, very fine particles distribution coefficient is not zero and the presence of these material in over flow can be seen. The cause of this phenomenon in screens studied is attachment of very fine particles to the coarse particles and inability of screen to isolate these particles and thus the transport of these particles to the up screen.

Conclusion

According to the values obtained for the imperfect factor and cut size, performance of the screen under study is appropriate and acceptable. Appropriateness and compliance of separation sharpness parameters with imperfect factor obtained indicates possibility of using this parameter for investigating performance of vibration screens. Also, the cause of the phenomenon of fish hooks is attachment of very fine particles to coarse particles and their transfer it to the over flow.

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