Optimizing Crushing Plant Performance using a Dynamic Simulation

By

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SAMEVATTING

Optimisering van 'n Vergruisingsaanleg deur die gebruik van 'n Dinamiese Simulasie

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Die primêre vergruisingsaanleg by Premier diamantmyn is gesimuleer om bedryfskostes en diamantherwinning te verbeter. As gevolg van fluktuasies in die voer was dit nodig om 'n dinamiese simulasie te doen. Die toepasbaarheid van 'n meerdoelige simulator, Siman 4, vir 'n metallurgiese proses is bepaal. Weens die beperkings van 'n diskrete dinamiese simulator is die strome materiaal verdeel in entiteite (1 ton, 10 ton blokke material) elk met sy eie attribute. In die lig hiervan moes die sifmodel, wat gebasseer is op die model van Karra, en die brekermodel wat gebasseer is op die Simon-Whiten model, wiskundig gemanipuleer word om die grootte distribusie met net twee attribute te beskryf. Hierdie modelle is getoets deur dit met die aanlegdata te vergelyk. Na sorgvuldige evaluering is die model gebruik om alternatiewe bedryfstoestande te voorspel. Dit het behels verskillende sifopening groottes, gaping groottes vir die brekers, tonnemaat en bedryfspraktyke vir die wissel transportband. Die sukses van hierdie metode van simulasie toon dat dit ook gebruik kan word om ander metallurgiese aanlae te simuleer. Dit beteken dat mynmaatskappye wat alreeds meerdoelige simulators gebruik, dit ook vir die simulasie van hul metallurgiese aanlae kan gebruik.

SUMMARY

Summary Optimizing Crushing Plant Performance using a Dynamic Simulation

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The primary crushing circuit at Premier Diamond Mine was simulated to improve operating costs and diamond recovery. Due to surges in certain feed streams a dynamic simulation was done. The applicability of the general-purpose simulator, Siman 4, for simulating a metallurgical plant is evaluated in this work. Due to the constraints of a discrete dynamic simulation the streams of material had to be divided into streams of entities (1 ton, 10 ton blocks of material) each with its own attributes. Because of these constraints the screen model, which is based on the model of Karra, and the crusher model, which is based on the Simon-Whiten model, had to be mathematically manipulated to allow the size distributions to be described by two attributes. These adjusted models were tested by comparing them with the plant data. After satisfactory validation of the plant model, it was used to predict alternatives plant operations. This included different screen aperture sizes, closed side settings for the crushers, tonnages and operating practices for the shuttle conveyor. The success of this method of simulation indicates that it could be used to simulate other metallurgical plants. This means that mining companies that have already invested in general-purpose simulators can use them to simulate their metallurgical operations.

List of symbols

α	=	Constant obtained using a best-fit routine available within Siman, used in the probability density function.
a	=	Value obtained from the numbers theory, used to determine the pseudo-random number sequence, the value being 1607.
A, B C, D E, F.	=	Basic capacity factors used in the model of Karra, which take into account the size distribution, wet or dry screening and the screen's operating characteristics.
β	=	Constant obtained using a best-fit routine available within Siman, used in the probability density function.
b	=	The starting number in the pseudo-random number sequence set equal to x_0.
C_i	=	The percentage of material in the size range, i, reporting to the over size.
C_iu	=	The percentage of material in the size range, i, reporting to the under size.
Cu	=	The percentage of material reporting to the under size for all the size ranges.
C(x)	=	Fraction of material at size x selected to be broken during the nipping period of the crushing cycle.
d	=	Wire-diameter.
d_{avg}	=	The average size for the material entering the screen.
d_{50}	=	The size range were 50% of the material will report to the over size.
e_i	=	Expected frequency.
G	=	Fraction of fines produced during the crushing.
h	=	Aperture size of the screen.
ht	=	Effective aperture size, the aperture size that the particles being classified see.
k_1	=	Largest particle that can pass through the crusher without any chance of breakage.
k_2	=	Largest particle that can pass through the crusher during the fully open part of the crushing cycle.

K, k_3, n_1, n_2 = Parameters for the crushing model, unique to specific crusher. Determined using the optimization subroutine in Microsim.

m = Value obtained from the numbers theory, used to determine the pseudo-random number sequence, the value being 1607.

combined.

Multi = Conversion factor for variations in the feed to the screen.

o_i = Observed frequency.

Q = Percentage oversize in the feed to the screen.

R = Percentage half size in the feed to the screen.

T_o = The standardized delay time between the arrival of entities to the screen.

$T_{immediate}$ = The instantaneous delay time between the arrival of entities to the screen.

Θ = Inclination of the screen with the horizontal.

U = Material bulk density of the feed to the screen (kg/m^3).

χ^2 = Parameter used to compare sets of data in the null hypothesis set (chi-square).

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