

SAMENVATTING

Optimiserings van 'n Vergruingsaanleg deur die gebruik van 'n

# Optimizing Crushing Plant Performance

using a

Leier: Prof. R. F. Sauerbrey

using a

Departement: Metaalkunde en Metallurgiese Ingenieurswese

## Dynamic Simulation

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By

diagnosties te gebruik. 'n Simulasieprogram is ontwikkel om die dinamiese

IAN DU PLESSIS

simulasie te gebruik. Die toetsresultate is in 'n meerdeurprogram wat gebruik

in metallurgiese proses te gebruik. Wanneer die program gebruik word, is

is die stroom materiaal wat in 'n sekere tydperk in 'n houer maksimum

aanhou. 'n Simulasieprogram is ontwikkel om die dinamiese

in die houer te gebruik. 'n Simulasieprogram is ontwikkel om die dinamiese

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die houer te gebruik. 'n Simulasieprogram is ontwikkel om die dinamiese

*Submitted in the partial fulfilment of the requirements of the degree*

**MASTER OF ENGINEERING (METALLURGICAL ENGINEERING)**

atommiese bedryfskondisies te gebruik. 'n Simulasieprogram is ontwikkel om

gaping gebruik. 'n Simulasieprogram is ontwikkel om die dinamiese

Die watter 'n faktor gebruik. 'n Simulasieprogram is ontwikkel om die dinamiese

metallurgiese plant te gebruik. 'n Simulasieprogram is ontwikkel om die dinamiese

analise gebruik. 'n Simulasieprogram is ontwikkel om die dinamiese

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## SAMEVATTING

### Optimisering van 'n Vergruisingsaanleg deur die gebruik van 'n

### Summary Optimizing a Grinding Plant using a Dynamic

### Dinamiese Simulasie

*I. du Plessis*

**Leier:** Prof. R. F. Sandenbergh *du Plessis*

**Departement:** Prof. *du Plessis* Materiaalkunde en Metallurgiese Ingenieurswese

Department: Material *du Plessis* Universiteit van Pretoria Metallurgical Engineering

**Graad:** M. Ing (Metallurgie)

Die primêre vergruisingsaanleg by Premier diamantmyn is gesimuleer om bedryfskoste en diamantherwinning te verbeter. As gevolg van fluktuasies in die voer was dit nodig om 'n dinamiese simulatie 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 materiaal) elk met sy eie attribute. In die lig hiervan moes die sifmodel, wat gebaseer is op die model van Karra, en die brekermodel wat gebaseer 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 bedryfstoele 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 simulatie 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 simulatie van hul metallurgiese aanlae kan gebruik.

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 employed general-purpose simulators can use them to simulate their metallurgical operations.

## SUMMARY

### Summary Optimizing Crushing Plant Performance using a Dynamic Simulation

*I. du Plessis*

**Supervisor:** Prof. R. F. Sandenbergh

**Department:** Materials Science and Metallurgical Engineering

University of Pretoria

**Degree:** M. Eng (Metallurgy)

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

- $\alpha, \beta$  = Parameters for the probability density function. Determined 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.
- $A, B$  = 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.
- $C, D$  = 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.
- $E, F$  = 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.
- $\beta$  = 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.
- $C_u$  = 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 where 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.
- $\Theta$  = 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.
- $T_{\text{immediate}}$  = The instantaneous delay time between the arrival of entities to the screen.
- $\Theta$  = Inclination of the screen with the horizontal.
- $U$  = Material bulk density of the feed to the screen ( $\text{kg/m}^3$ ).
- $\chi^2$  = Parameter used to compare sets of data in the null hypothesis set (chi-square).

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## Synopsis

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- My supervisor, Professor R. F. Sandenbergh for his assistance during the course of this project;
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- The people of Premier Diamond mine for their support and help.
- The department of Industrial Engineering at the University of Pretoria and in particular, Professor P. S. Kruger.

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Premier Diamond Mine by maximizing the quality and recovery of the diamonds being produced at as low a cost as possible. In terms of quantifiable quantities the strategy is

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trying Siman's Interaction with the Fortran-Defined Files . . . . . 62

The reason for trying to send as much material as possible to the roll crushers is because these crushers operate the diamonds more efficiently and with less breakage of the diamonds in comparison to a standard cone crusher. The roll crusher works on the principle of breakage due to pressure, which diamonds can handle well, whereas with a standard cone crusher breakage occurs due to impact, which may break diamonds. The good liberation of the diamonds in the roll crusher is due to the disintegration of the kinetic energy that is present within the ore to produce fine particles which are not attached to the diamonds.

The reason for sending as much material as possible to the X-ray plant is to recover the larger diamonds as early as possible to avoid possible breakage during the processing.

The reason for trying to reduce energy consumption is because this relates directly to cost saving.

1.2 The Methodology

Historically simulation has proved to be a way of reproducing a process.

Due to surges in the feed to the plant a dynamic simulation was done. The process