

LATEST DEVELOPMENTS IN INTERPARTICLE
 CRUSHING AND GRINDING EQUIPMENT
 LIBERATION OF DIAMONDS FROM KIMBERLITE
 CASE STUDY AT DE BEERS OAKS MINE, RSA



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1 INTRODUCTION

The liberation of ore is very linked with the downstream process used to recover it. The recovering facility can require from a full liberation of the crystal (DMS) to a simple access to the crystal (chemical reaction). The interparticle compressive grinding creates both liberated grains and deep cracks initiated along the natural boundaries in the rocks. So, the chemical fluid can reach the ore located along the cracks most of the time.

In diamond industry, the physical property used to collect diamonds is the density. So, the type of liberation required is a full separation of the diamond from the matrix. The crushing qualities to achieve such a work are :

- The initiation of particles breakage along natural grain boundaries
- The differential grinding of smooth particles compared with hard particles of the same grain size.
- The good shape of particles. The cubical shape increases the DMS efficiency. Flaky particles sometimes sink or float.

The Inter particle comminution combines these three properties.

2 RHODAX® PROJECT WITH DE BEERS GROUP

2.1 First project (Premier mine, RSA)

The 90's years have seen the development of inter particle crushers and grinders. This new generation of machines led to substantial improvements in crushing and in the down stream processes linked with.

De Beers got interested mainly in HPRC machines and looked at the Rhodax® as a parallel solution. A Rhodax® 600 was installed at Premier Mine in South Africa in 1998 and commissioned in 1999. That Rhodax® was the single one to work in wet process. The machine was not installed for production purposes but for deep test works. From the data collected, De Beers had a better idea of the performances of the crusher and included the results in a statistical empirical model used as a reference for the future projects in the De Beers group.

2.2 Second project (Oaks mine, RSA)

2.2.1 Mine background

The Oaks Mine is a small mine operation located in a remote part of South Africa 16 km south east of Swartwater in the Limpopo Province. The pipe was discovered in 1986 during regional reconnaissance sampling and this was confirmed in 1998 with a detailed sampling and percussion drilling program. In 1990 large drilling as well as diamond drilling was done on the pipe. The kimberlite is intrusive into quartzo-felspathic and amphibolite gneiss of the Limpopo mobile belt with an age of 509 ± 23 Ma.

The Oaks Mine started production in 1999 when the higher grade north lobe ore body was first mined and treated followed by the relevant lower grade south lobe ore body. Production is currently in the region of 350,000 tons per annum with grades varying from 120 to 20 cpht.

2.2.2 Scope of project

The increase in demands of diamonds from the Oaks Mine has brought with it the requirement of increasing the amount of diamonds that was produced. Different scenarios to achieve that requirement were identified. The plant could have increased its head feed call, or improved the efficiency of the plant at that time. A model of the treatment plant was set up by means of using the Limn Diamond Wizard. The recrusher circuit was identified as an area with a potential to increase carats by improving the liberation of locked-up diamonds from the coarse DMS tailings and material from the recrusher stockpile.

The model on diamond wizard indicated a potential revenue gain of 9% if the recrusher circuit product size was reduced to 80% passing 6mm. This can be achieved using an IPC type crusher. The Rhodax® 600 HP from Cullinan Mine was bought to improve the liberation of locked-up diamonds at The Oaks. The improvement in liberation in return would result in an increase in carats recovered. With this increase in carats recovered a potential gain in revenue would also be realised.

The objectives of the project was to:

- Optimise the Rhodax 600 HP crusher (settings, screening sieve).
- Determine the Rhodax® contribution to diamond liberation.
- Investigate the influences of the Rhodax crusher on the downstream processes of the treatment plant.
- Evaluate the possibility of diamond damaged during operation of the crusher.

2.2.3 Recrush flow sheet

Locked-up diamond from the recrusher stockpile, the coarse DMS and the recovery tailings are liberated in the recrusher circuit. The current recrusher circuit consists of the Rhodax® 600 HP crusher and a Nordberg 3ft Symons cone crusher. A diagram of the recrusher circuit arrangement is shown in figure 1 below.

Coarse DMS float, material and tailings from the recovery and sort house, in the size ranges (-25 +8 mm) and (-25 +1.15 mm) respectively, are conveyed to a classification screen, which removes the -6mm material. The underflow (-6 +1.15 mm) from the classification screen is conveyed to the coarse tailing paddock. The overflow (-25 +6 mm) is conveyed to a 5 tons recrusher surge bin fitted with a diverter which feed material either into the Rhodax or cone crusher. Material from the recrusher stockpile and oversize from the Rhodax classification screen is also conveyed to the 5 tons bin.

The product from the underflow of the classification screen below the Rhodax with size range (-6 +1.15 mm) is conveyed to a scrubber together with the material from the primary and secondary crushing circuit. The material then passes over a 28 mm Trommel screen. The (+36 -25 mm) from the scrubber is send to the secondary crusher. The -25 mm material enters on to a double deck banana screen with 7 mm VR panels on the top deck and (1.2x12 mm) slot panels on the bottom screen. Thus, are the material split in to two size fractions, one with the size range (-25 +6 mm) for the coarse DMS and the other material is conveyed to the fine DMS with size fraction (-6 +1.15 mm).

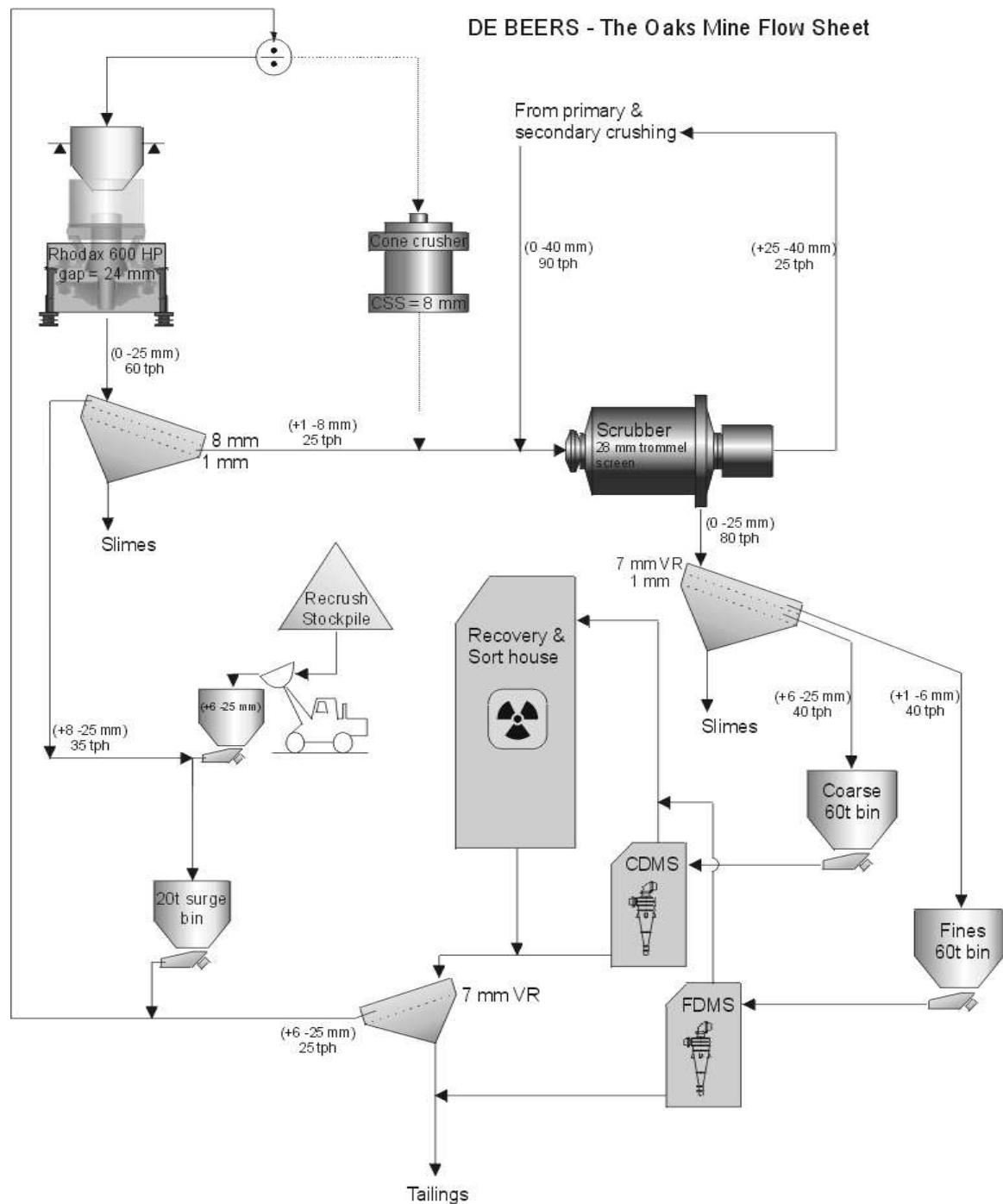


Figure 1 – Simplified flow sheet of the recrusher circuit at the Oaks mine

PROCESS RESULTS AND ANALYSES

2.3 Fresh feed

The fresh feed only coming from the coarse DMS has been sampled and analysed (dry screening).

This material contains kimberlite but also significant amounts of gneiss, breccia, pegmatite (Quartz-Feldspath), and amphibolite (Garnet, Biotite).

The PSD is announced to be a (+6 -25 mm). There are 2.2% minus 6 mm. These fines come from the drying of the material before screening analyses. Some clayish particles have a tendency to create fines.

PSD characteristics	Fresh feed
P50 (mm)	10.1
P80 (mm)	14.2
Reject at 25 mm (%)	1.2
Passing at 6 mm (%)	2.2

Figure 2 – Fresh feed PSD analyses

2.4 Test work results

2.4.1 Rhodax versus cone crusher performances

The configuration of the Rhodax is summed up in the table below. The screen sieve size is about 6 mm with a top size at 8 mm. The fresh feed was only coming from the coarse DMS and consequently had an important surface moisture.

Gap (mm)	Speed (rpm)	Phase (%)	Amps (A)	Q _{RX} (tph)	Q _{+1-8mm} (tph)	ES _{RX} (kWh/t)	ES _{+1-8mm} (kWh/t)
26.6	830	65	100	61	22	1.2	3.4

Figure 3 – Settings of the Rhodax with CDMS feed

The PSD analyses were compared to the tertiary cone crusher ones. The cone crusher is running in open circuit with a CSS at 6 mm. The Rhodax® is running in close circuit with a screen sieve size at 6 mm. It is the only way to compare crushers performances as far as the cone crusher cannot run in close circuit at 6 mm.

The main following differences were measured :

- The passing at 6 mm is 80% for the Rhodax and 40% for the cone crusher equipped with a new set of liners.
- The passing at 6 mm drops down to 10% with worn out liners on the cone. With the Rhodax, the PSD is not modified during the life time of the liners.
- The outputs are 26 tph for the cone and 22 tph for the Rhodax. The Rhodax -1mm is screened (about 8 tph) and the cone one has been removed by calculation (4 tph). Hence, the outputs are the same.

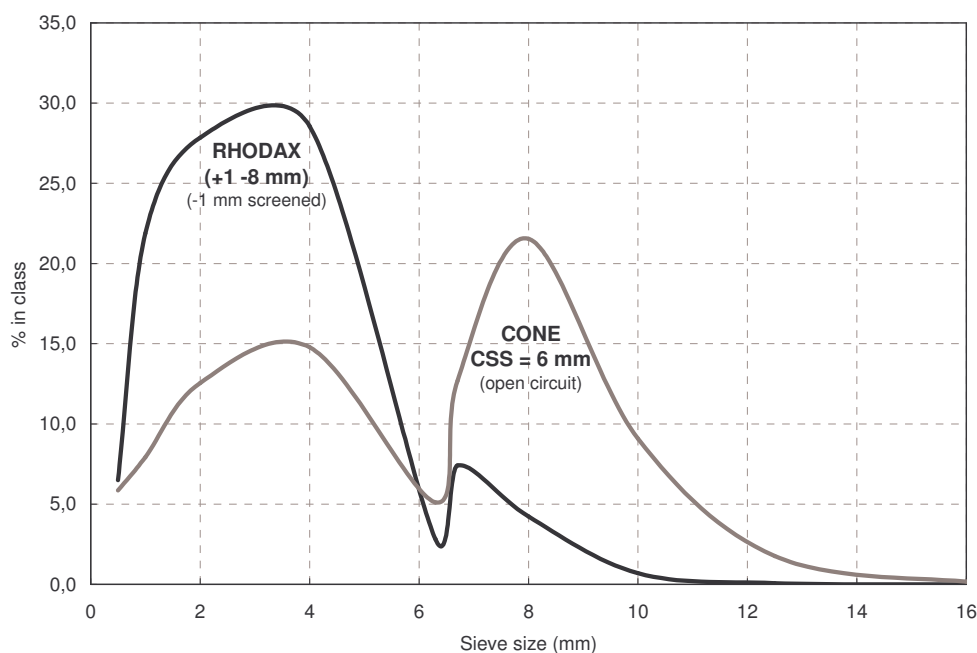
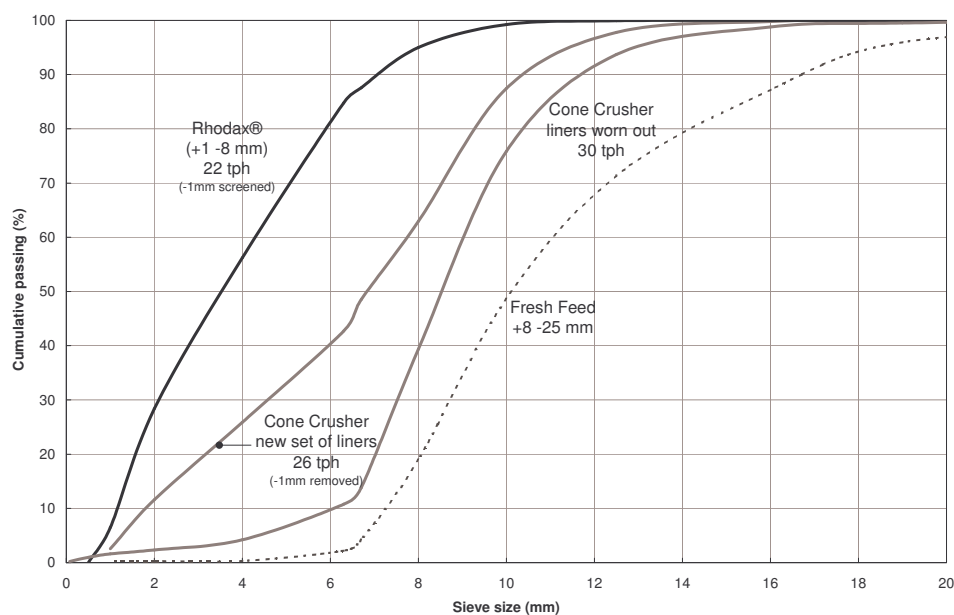


Figure 4 – Rhodax versus cone crusher PSD

2.4.2 Consequences on the downstream circuit

The figure 4 above also shows a peak at 30% at sieve class of 4 mm for the Rhodax compared with 15% for the cone crusher. As the outputs are nearly the same, the Rhodax fines production is twice the cone one.

The -1 mm cannot be sampled for the Rhodax but some mass balance indicate that the production of this fraction is at least twice the cone one.

The downstream circuit, composed with a Fine DMS and a Coarse DMS, is not receiving the same PSD and feed rate. The efficiency of both units is no more optimised when the Rhodax is running. The parameters to optimise are :

- The sieve size of the banana screen, which split the flow rate in two.
- The settings of the X-Ray machines. Overflowing these machines leads to a poor efficiency and therefore to a poor recovery of diamonds. For instance, it is obvious that the 4 mm fraction X-Ray machine has to be set in another way to treat twice the production of a cone crusher.

2.4.3 Diamond recovery

The figure 5 below shows the average data distribution of diamonds (from 1 mm to 9 mm) during the first six months and the last six ones. Only the cone crusher was running the first semester. The second semester, the Rhodax ran for 600 hours of about 3000.

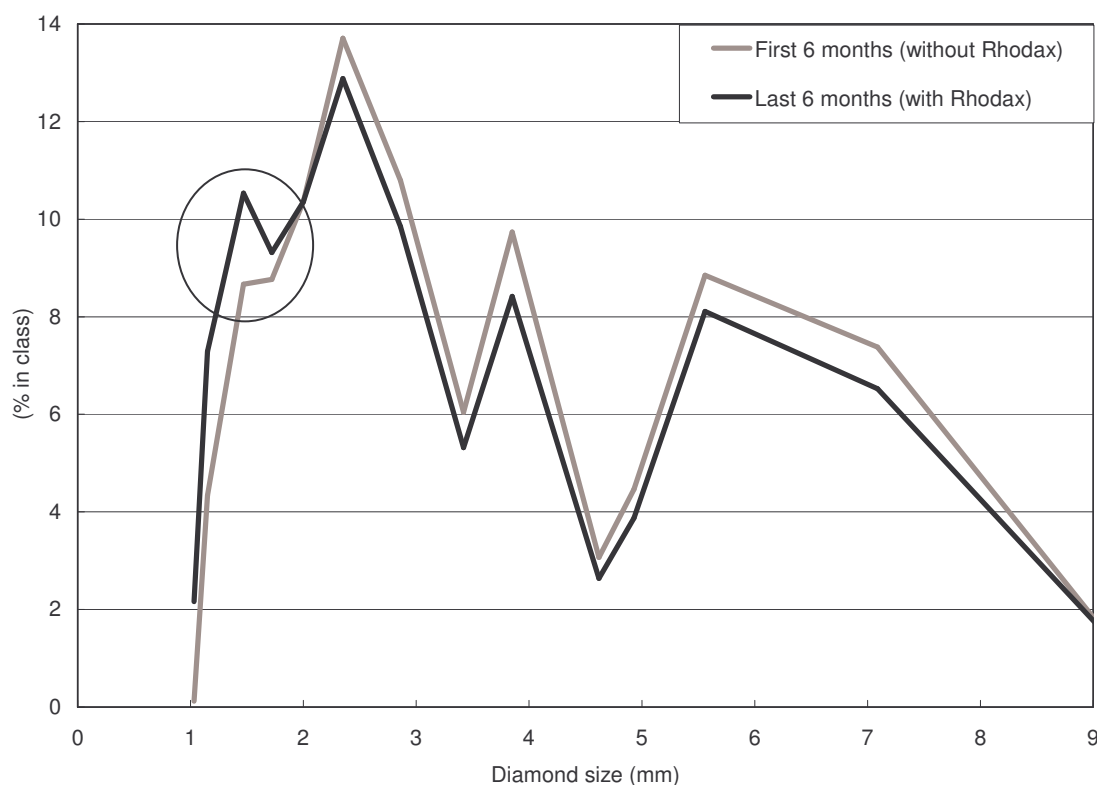


Figure 5 – Diamond recovery chart in 2004

Although the Rhodax ran for 20% of the time during the last 6 months, the diamond recovery trend for that period of time shows an increase in small diamonds fraction recovery (<1.72 mm, +6DS). Otherwise, the space between the two trends is due to a different grade for the ore body since this space remains constant for almost all diamond sizes. Therefore, there is obviously a better recovery of small diamonds given by the use of the Rhodax®.

3 CONCLUSIONS AND PERSPECTIVES

After a first period of test works at Premier mine, the Rhodax® 600 HP was put in production at the Oaks mine.

The machine was inserted in a current flow sheet. The full potential of the machine is not exploited. Its main advantage is the high reduction ratio, which could have been up to 15 with the size of this machine. It is only 4 in the present recrusher circuit. Nevertheless, the following improvements were measured :

- Increase of the head feed input
- 50% increase of slimes and fines tailings production
- increase in diamonds recovery, mainly in small fractions (<1.7 mm)
- 50% increase of (+1 –6 mm) production

That work is still in progress and the next aims concern :

- the optimisation of the DMS and sort house,
- the increase of the recrusher circuit reliability,
- the optimisation of the Rhodax® (wear liners, screening sieve size, feed size, wet or dry process, way to drive the machine...)
- the evaluation of the percentage of broken diamonds produced by the Rhodax®

The first step of the Rhodax® project showed great interest and perspectives. The second phase should demonstrate the possibility to apply this technology to wider application fields and bigger mines.

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