The impact of bottom cut-off on diamond mine recovery efficiency

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In the current volatile economic climate, most companies are faced with the challenge of ensuring that resources are mined optimally and at the lowest cost. Failure to find means to ensure profitability, even for a short period of time, could result in the mine facing possible closure. These challenges are more prominent in the high-risk alluvial diamond sector, where resource classification and modelling is a challenge. Moreover, mineralization is not uniform, as large areas can be barren while individual sites can be very rich, which is why alluvial operations are normally high-risk investments. These challenges include process limitations, and the market fluctuations compel better diamond value management.

One possible way to improve the operational margin is to change the bottom cut-off size, thus changing the smallest size of diamonds that the plant can recover, which not only affects the amount of fine diamonds (and revenue) that can be recovered, but can also have positive benefits on the efficient recovery of all other diamond size fractions.

Introduction

The 2008–2009 economic downturn has highlighted the importance of effective mining and processing. Estimates indicate that an increase of 5% in the working cost can severely affect the profitability of a mine.

In the diamond industry, several determinants have been identified that will increase the dollars per ton. These include changing the bottom cut-off, control on diamond damage, increasing plant efficiency, improving diamond liberation, waste control, changing the top cut-off, improved security, and better understanding of the resource. Application of these determinants will assist in driving down the production cost, improving metallurgical processes, and increasing the revenue.

This study will focus on the impact of change of the bottom cut-off with a specific focus on alluvial diamond mining. Data used for the analysis is from Rockwell Diamonds Inc., Jasper Mine. This alluvial deposit comprises extensive flat-lying alluvial sequences. Based on the geological constraints, the general mining strategy involves mining the entire sedimentary unit, including the overlying calcrete. Also, the amount of sand within the unit impacts on carat recovery and the resultant grade. In 2012, a decision was taken to decrease the bottom cut-off at Jasper Mine from 5 mm down to 3 mm, which was aimed at improving processing and diamond recovery. It is important to realize that this change is not only about the physical recovery of smaller sized diamonds, but also the effect that this recovery has on the recovery of other diamond sizes. This study highlights that there is a very real interplay in the process of recovery, also extends from materials handling to utilization of equipment, and physical recovery, by which the inclusion of finer sized material may impede in the recovery of larger sized diamonds.

Change in bottom cut-off

Changing the bottom cut-off size implies changing the smallest size of diamonds that the plant can recover. In order to determine the benefits of a change in bottom cut-off, the size frequency distribution (SFD) is used. An SFD curve shows the cumulative carats recovered; an example is shown in Figure 1 for an alluvial and kimberlite sources. Kimberlites tend to have a large population of finer sized stones, whereas alluvial populations are coarser. As such, making a decision about bottom cut-off is more serious for a kimberlite mine, where there could be a reasonably healthy revenue associated with these finer stones. In terms of alluvials, the finer sized stones are more marginal, particularly when the larger stones are typically of very high quality, and thus, very high value.

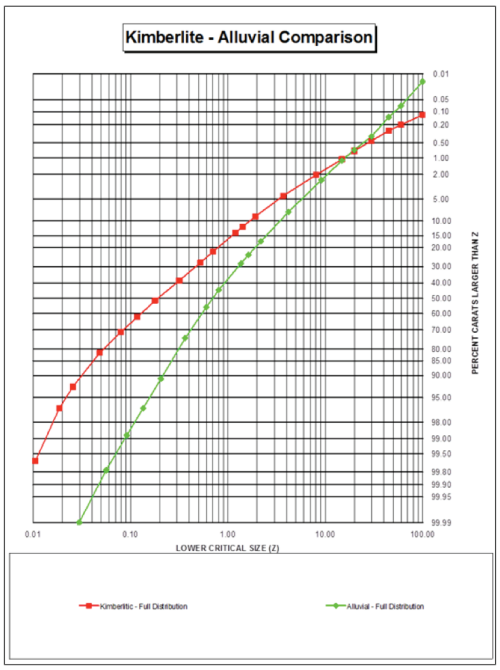

Figure1. SFDs for kimberlite and alluvial deposits

The SFD representation (Figure 1) is a standard tool to determine if there are any changes in the dollar value per carat of recovery as a result of changing the cut-off, and if this has been accompanied by a change in the resource or in the processing efficiency. For this study, Jasper mine changed the bottom cut-off from 5 mm to 3 mm. The SFD representation of the recovered diamond populations was used to visualize if a change had occurred in the recovered population. In particular, the impact on the recovery of diamond sizes larger than 5 mm was of importance.

For purposes of constant money comparison, the 2012 dollar value per carat per sieve class was chosen as a baseline. All production results were re-priced onto the 2012 revenue figures for easy reference and to mitigate the impact of a fluctuating diamond price.

Through the period of change-over from 5 mm to 3 mm, the following aspects were given particular attention;

- Liberation: Ensure that maximum liberation of diamonds from the source is attained through using the bulldozer in the pit to breakdown the conglomerate
- Waste management: The management of waste plays a vital role in the lack of reconciliation between the estimated gravel grade and the actual grade recovered at the plants. One of the major contributors to grade overestimation or underestimation is dilution. Increased dilution in an alluvial deposit lowers the predicted grade significantly. To combat this, the amount of waste rock that reports to the plant should be reduced through stripping. The impact of increased waste is a decrease the efficiency of the concentration process (pans). As expected, this results in poor diamond recovery, leading to revenue loss.
- Dilution was reduced through removal of the overlying calcrete, enhancing the efficiency of the plant. As a result the stripping ratio was increased from 2% to approximately 12%.
- Frequent efficiency testing: Regular boart testing was conducted in order to monitor the recovery process.

The impact of a decrease in the bottom cut-off to 3 mm, taking into consideration the above-mentioned changes, resulted in:

- An expected decrease in the dollar value per carat from US$1970 to US$1617 as the throughput of finer material increased. Although there is a 17% decrease in dollars per carat, the total revenue per ton has increased slightly from US$10.50 per m^3 to US$10.74 per m^3.
- A decrease in the in average stone size of 6%.
- An increase in grade from 0.53 carats per hundred m^3 ($cphm^3$) to 0.66 $cphm^3$.

Figures 2 and 3 shows the SFD and the grade–size plot for the period when the plant was running at a 5 mm cut-off and at 3 mm. Both distributions have been truncated at 5 mm in order to make the comparison easier. The salient feature observed is that production during the 5 mm period is slightly coarser that for the 3 mm test period at sieve classes above 5+ carat. At 10+ carat size, 39% of the carats are in the 5 mm test period and 35% in the 3 mm period. There is less variation in the lower sieve classes.

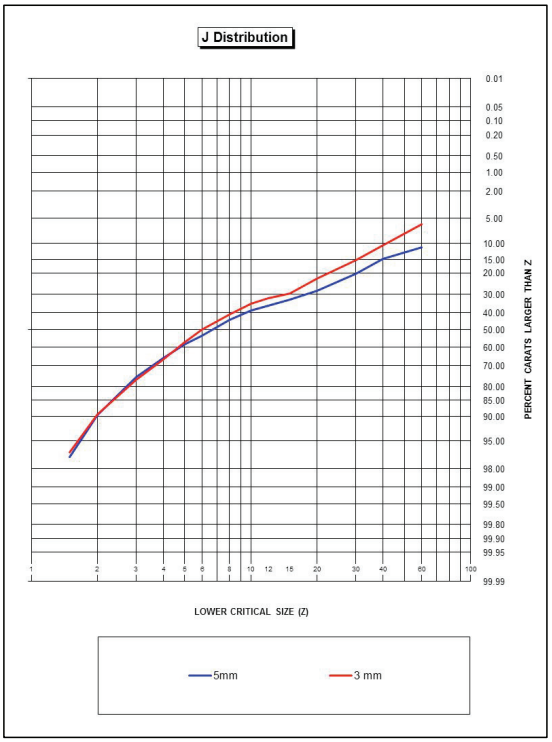

Figure 2. SFD for Jasper mine, 5 mm cut-off and 3 mm cut-off

The primary concern in the interpretation of these two populations is that of resource, in that material physically processed during each period was from different areas of the pit. This is particularly critical in alluvial diamond processing, where considerable variability is often evident. Also, improved waste control was put into place, which also would be beneficial to processing and recovery. As a result, there is an increase in the number of stones recovered across all sieve classes. Although there is a 4% decline in the 10+ carat sieve class based on the SFD, the grade–size plot (Figure 3) indicates that there is generally an increase in the number of stone recovered for the 3 mm cut-off period. Minor variations in the sieve classes below 10+ carat are observed between the two periods, a preferred outcome.

Overall, the 5 mm bottom cut-off scenario provided a period of more stability in processing and more consistent recoveries. This has not been indicated only in this test, but also in current production, where the plant has gone back to a 5 mm bottom cut-off and has continued to show these positive results.

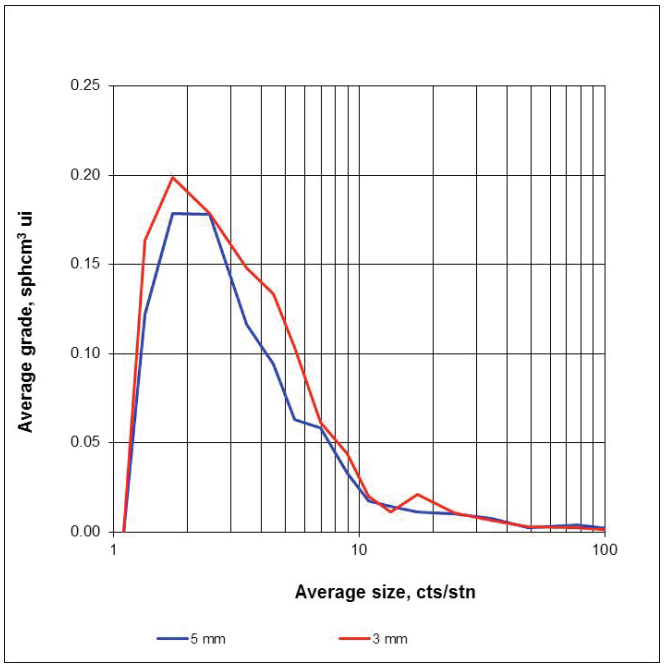

Figure 3. Grade–size plots for 5 mm cut-off period and 3 mm period.

Summary and conclusions

This study has tested the hypothesis that changing the bottom cut-off size on the plant can have a very real impact upon the recovery of all diamond sizes, particularly the coarser stones. There is evidence to suggest that a higher bottom cut-off can enable more stable production, leading to an easier processing environment that can be controlled and maintained such that recovery efficiency is improved. However, it is noted that simply changing the bottom cut-off is not a 'silver bullet' for effective processing, but should rather be viewed as one tool as part of an overall diamond value management strategy. This type of approach is particularly useful in alluvial processing, as it is a priority to protect the coarser stones through the processing chain.

References

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