

RECENT APPLICATIONS OF THE SPLIT-ONLINE IMAGE ANALYSIS SYSTEM

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ABSTRACT

In the past 18 months, over 25 Split-Online™ systems have been installed in mineral processing plants throughout the world. These operations include copper, gold, zinc, iron and diamond mines. In order to meet the varying requirements of these operations, several enhancements to the Split Image Analysis Software have been made to ensure integrity of the size distribution measurement in a wide range of actual operating conditions and to improve the data transfer to the different DCS or SCADA systems at each site.

For installations where a Split system has been installed on the feed conveyor to a SAG or AG mill, archived data shows a good correlation between the fragmentation distribution of the feed and the resulting performance of the mill. Several sites have implemented control strategies for their mills, which use the Split information as an input whilst others simply use the information as a basis for the manual control of the mill and feed. In both cases the additional information of the fragmentation distribution of the feed has greatly augmented the ability of the operator to gain better control of the grinding circuit.

INTRODUCTION

Split Engineering has developed two image analysis programs for use in the mining industry, Split Desktop™ and Split-Online. Both programs use image analysis techniques and the Split algorithm (Wu and Kemeny, 1992) to convert grey scale images into two-dimensional shapes that represent particles of material. Equal area ellipses are then used to represent each particle within the program and the fragment screen size and volume are estimated from the major and minor axis of these ellipses (Girdner et al., 1996). Split Desktop is used to process still photos (e.g. muckpile photographs) while Split-Online is used to capture images from live video sources (e.g. a camera positioned over a conveyor belt).

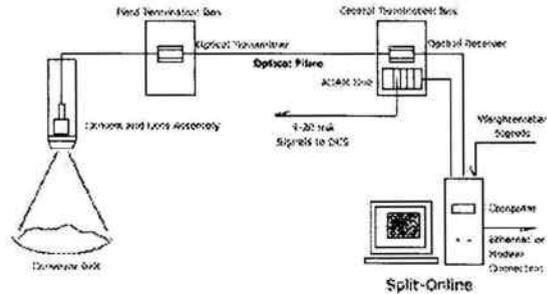


Figure 1 – Split-Online for Conveyors

The software was developed at the University of Arizona, with collaboration from the JKRMC. In early 1998 it was felt that the software was mature enough to market to the mining industry and the commercialisation of the system began. At the time of writing this paper, over 38 systems analysing live video images from 92 cameras have been installed worldwide at 27 mine sites. Some enhancements to the software have been made in that period based on the experience gained from the varying conditions each system must operate under and these will be detailed later in this paper.

SYSTEM ACCURACY

At the time of commissioning a Split-Online™ system at a mine site, a belt cut is performed to validate the system and to determine the fines correction factor that compensates the resulting size distribution for particles smaller than that which can be resolved by the software (Kemeny et al., 1999). The size of these belt cuts depends on the expected size distribution on the belt (Gy, 1976). A large database of comparisons between sieved and Split fragmentation results for various conditions has been gathered over the last 18 months and Figures 2 to 4 show typical results obtained for these belt cuts. Obviously, not all Split results agree so closely to the actual size distribution on the belt but on average the error for each size fraction is less than 10%.

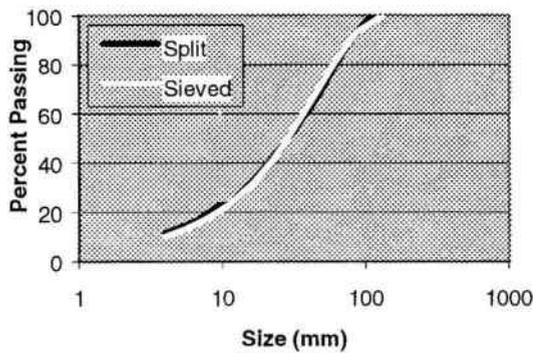


Figure 2 - Typical Split Results (a)

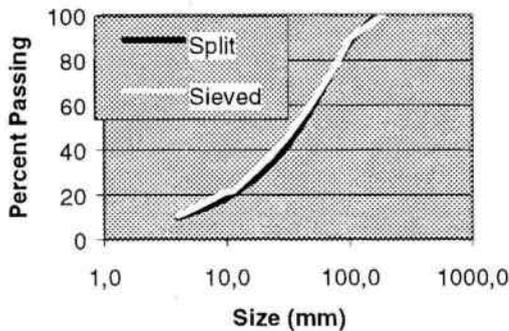


Figure 3 - Typical Split Results (b)

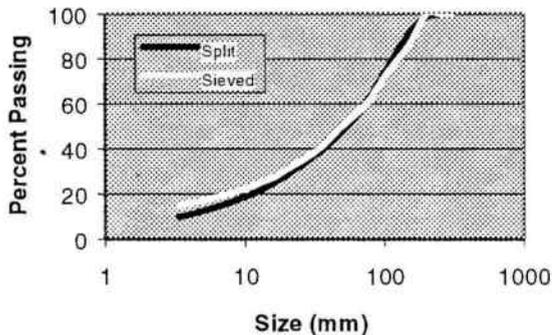


Figure 4 - Typical Split Results (c)

If Split-Online systems are to be used in real time control then there must be total confidence by the site engineers that the system can accurately predict the size distribution of the feed. The results gathered so far have been most encouraging in confirming this assumption.

SOFTWARE ENHANCEMENTS

Fines Recognition

Fine material is a problem for any size analysis system. The combination of the resolution of the frame grabbers used to capture the live video and the image processing

algorithms employed, mean that there is a finite limit to the smallest particles the software can resolve. In extreme cases, such as the image shown in Figure 5, the material appears as a few larger particles on a bed of fines. This is especially problematic for fragment identification algorithms as the most common practice is to find the boundaries of the particles using edge detection methods. This type of approach is most susceptible to misidentifying groupings of fines as large particles and the resulting size calculation can be extremely compromised (Maerz and Zhou, 1999). In addition to conveyor belts at some mining operations, the cases of haul truck material or muck pile images are extremely susceptible to erroneous identification.

The latest Split software includes a new algorithm that re-evaluates the area inside each found particle boundary and labels it as fines if the texture within that particle meets a certain criteria. To save time while running online only the largest, user selected number of particles are reanalysed. Figure 7 shows the results of this algorithm applied to the image in Figure 5.

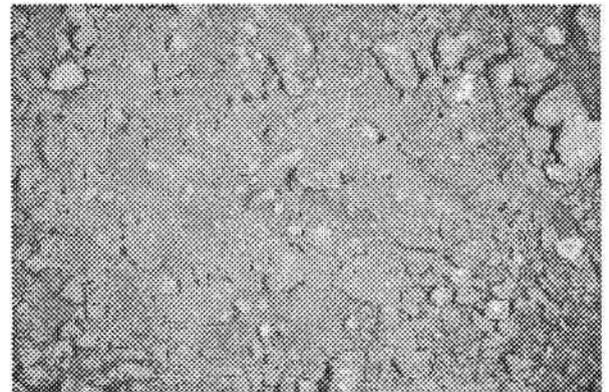


Figure 5 - Image Before Processing

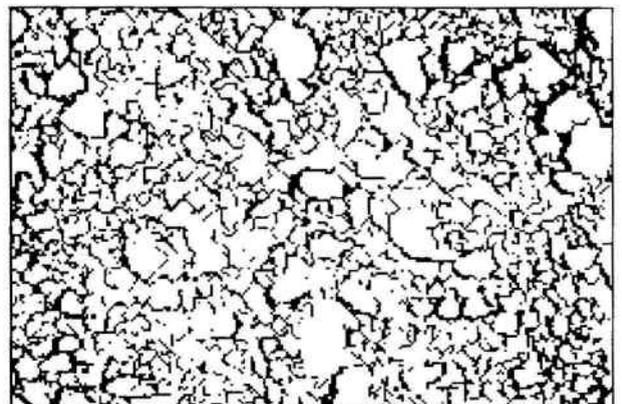


Figure 6 - Delineated Image

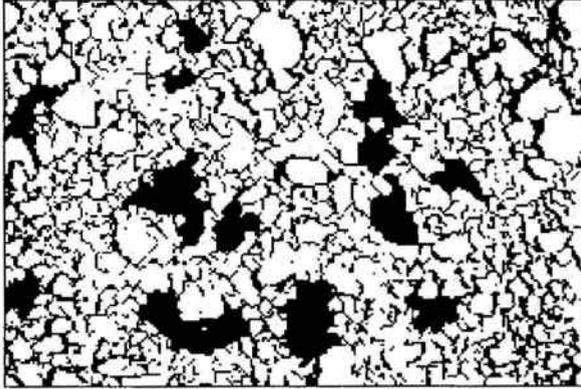


Figure 7 – Delineated Image after Fines Recognition

Windowing

Having a large area of conveyor belt in the image adversely affects the fragmentation results, so it is sometimes necessary to window in to the largest possible rectangular area containing only rock. This means that, depending on the orientation of the conveyor belt, the new left and right coordinates, or top and bottom coordinates, which define the transition from conveyor belt to rock, need to be detected. To find these new coordinates, the fact that in the image, the area of the conveyor belt is relatively smooth in comparison to the area of rock is used. Therefore, the standard deviation computed along a single image column or row containing only conveyor belt pixels will be lower than if computed along a single column or row containing only rock pixels.

In order to find the new left and right coordinates, the standard deviation along each image column is computed. This produces a one-dimensional plot, which is then smoothed to reduce the effects of noise. Using this data, the new left coordinate is determined by starting at the position of maximum value and searching towards the left until finding a value less than some threshold or until reaching the image edge. Starting at the same maximum value and searching towards the right determines the new right coordinate. The threshold is computed using the minimum and maximum of the plot values, so it changes to deal with the contrast differences from image to image. The procedure to find the new top and bottom coordinates is the same, except that the standard deviation along each image row is computed.

This new feature is especially useful on low tonnage belts where a small change in loading can expose significant areas of belt. This frequently occurs on belts that are being loaded with plate feeders. Figure 8 shows a binary image from a belt which has a lower

than normal tonnage on it. The auto-windowing algorithm in the software is able to identify the belt in the image by the process described above and the resulting binary is presented in Figure 9. Figure 10 shows the difference in the resulting size distributions from the two images. As expected, the image with the empty belt on the edges has been represented as coarser since Split identified the belt as larger particles. If Split were allowed to process during long periods of low tonnage this would represent a significant error in the predicted fragmentation.

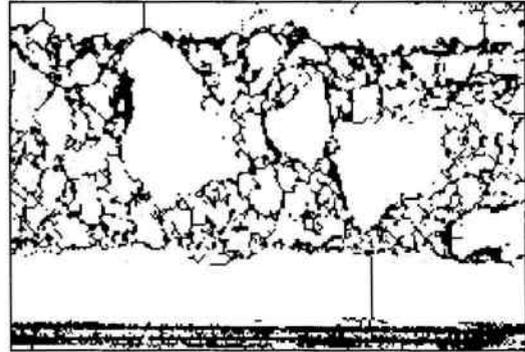


Figure 8: Binary Image with Empty Belt



Figure 9: Image after windowing

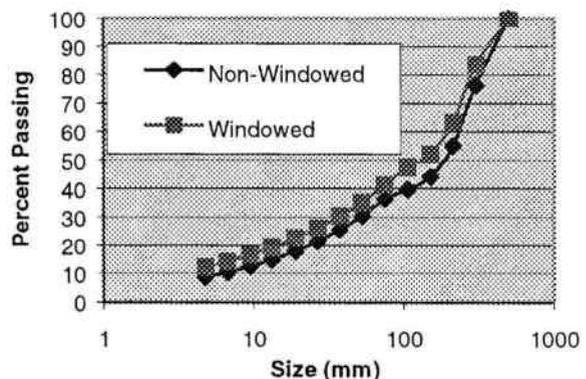


Figure 10: Difference in Size distribution

THE USE OF SPLIT IN MINE TO MILL OPTIMISATION PROJECTS

Introduction

The use of Split-Online together with modelling and simulation of blasting, crushing, milling and classification has allowed the JKMRC to explore the interactions between Mine and Mill and to indicate changes which have the potential to improve company profitability. Case histories such as that illustrated in Valery (2001), as well as growing experience in the field show that it is possible to improve the overall economic performance of mines by utilising these tools.

The integration of the data generated by a Split-Online system with the mine and mill control systems provides an opportunity to develop on-line process control strategies. It also allows the optimisation of the mining, crushing and milling processes based on real time size distribution information.

Split Truck Systems

Mine to mill optimisation requires that the characteristics of the Run of Mine ore are known. One of the most difficult of these to quantify is fragmentation due to blasting. Split-Online can be used to measure this by processing images from the trays of trucks as the ore is being tipped into the crusher. When these data are correlated with dispatch information they can give a measure of the effect rock mass characteristics and blasting practices have on fragmentation.

Getting reliable information from images taken from trucks can be more problematic than from conveyor belts mainly due to the lack of control over lighting. Structures over the crusher can cast shadows, which cause errors in the delineation of particles. It can also be difficult to get adequate and even lighting. The results shown in Figure 11 do however show some encouraging preliminary results from a truck installation after processing 545 trucks that were hauling ore from 3 separate areas of the pit. The graph shows some definite clustering of the 80 % passing size (P80) for three individual areas of the pit. These results correlated well with the site knowledge that the ore being excavated from Bench 640 was a softer area of the ore body. This area of the pit had been blasted with a higher than normal powder factor due to the development of a ramp. This would have also contributed to the finer size distribution. The differences in blast-induced

fragmentation can subsequently have a marked downstream effect in the processing of the ore.

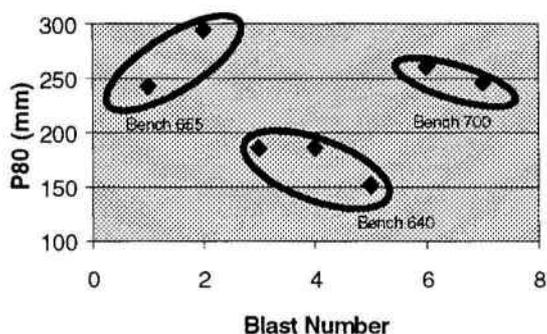


Figure 11 – Results from Split-Online for Trucks

Measuring the Effects on Crushing and Grinding Circuits

It is well known but sometimes ill quantified that the size distribution of the feed to crushers and mills has a direct impact on throughput. The ability to continuously monitor the feed size distribution allows a quantitative relationship to be determined and to use these data in control.

Figure 12 shows the relationship between P80, throughput and specific power for a large SAG mill with a Split-Online system installed (Hart, 2000). The trends clearly show that as the P80 increases, throughput decreases and specific power increases. For a large operation these changes equate to large losses in production and increased cost in grinding.

As can be seen from Figure 12, the data generated by Split-Online can be used by mill operators to manually choose different feeders to maximise throughput as a short-term measure. Ideally however, this data can be incorporated into a real-time control strategy to ensure that optimal conditions for maximum productivity are always met.

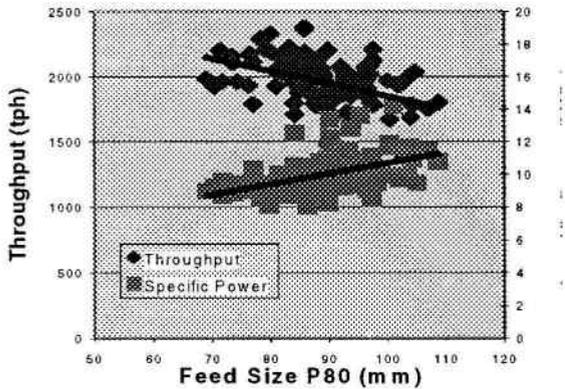


Figure 12 – Mill performance

CONCLUSIONS

The data generated by Split-Online systems are routinely used by the JKMRC in its Mine to Mill projects and are now of a reliability where they can be used in control strategies to improve process performance. Advances in the image processing algorithms allow the software to adapt itself to a variety of situations where the image is not ideal or where areas of fines can be misrepresented as large rocks. This ensures that the most accurate measurement of size distribution is always reported.

ACKNOWLEDGEMENTS

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