HIGH FREQUENCY VIBRATING SCREENS IN CLOSED GRINDING CIRCUITS

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ABSTRACT

Optimum performance in a closed grinding circuit is usually low due to the classification device. Today closed grinding circuits using high frequency vibrating screens have proved to be the new option on plant design. This paper discusses benefits, operation factors and control variables in closed grinding circuits with high frequency screens.

KEYWORDS: classification; comminution; mills; screens; high frequency screens.

1. INTRODUCTION

One of the most recent advances in plant design is the use of high frequency vibrating screens in closed grinding circuits. Operating grinding mills in closed circuit with screens as the classification device improves grinding efficiency with reduced unit power consumption, reduced overgrinding of valuable minerals, reduced reagent consumption in flotation, reduced circulating load and increased recovery of valuable minerals. The operation of the classifier has been recognized as the most important factor in the performance of the mill circuit.

Table I show examples of plants were high frequency screens replaced hydrocyclones with results in terms of increased mill throughput and reduced circulating load (1).

Table I. Comparison of Grinding Circuits Closed by Cyclones vs. High Frequency Screens.

Case	Mine	Country	Product	Cyclones versus Screen	New Feed (t/h)	New Feed Gain (%)	Circulating Load (%)	Reduction Circulating Load (%)	% Acumulated Passing 150 Microns		
									Feed	Fines	Coarse
1	Colquijirca Brocal	Peru	Zn/Pb/Cu Ag/Au	Cyclones	138	78	350	-81	36	85	28
				Screens	245		65		42	69	9
2	QISC Apatit	Russia	Phosphate	Cyclones	95	31	430	-69	32	23	72
				Screens	124		135		32	7	65
3	QISC KMAruda	Russia	Fe	Cyclones	120	21	215	-33			
				Screens	145		145				
4	Cerro Lindo	Peru	Cu/Pb/Zn	Cyclones	245	12	144	-25	46	31	85
				Screens	275		108		48	21	75
5	Condestble	Peru	Cu	Cyclones	57	16	243	-49	36	71	21
				Screens	66		124		40	73	13
					Average	31.60	Average	51.4			

Based on these examples an average of 31.6 percent of increased capacity and 51.4 percent of circulating load reduction is demonstrated.

Ongoing development of new circuits designed with screens in place of cyclones will continue to show improvements in energy efficiency with maximized recovery as a better classification device allow an increase in mill capacity with consequent reduction in unit power consumption. Since screens truly places the oversize product that requires further grinding back to the mill and correctly places the undersize product with minimized overgrind to feed flotation or any other concentration process, the consequences are verified with improvements in metallurgical recoveries due to more of the ground ore be presented in the proper size range to flotation or other concentration process (2).

It is well recognized that metallurgical recovery is highest in a certain area of the particle size range with lower recoveries in the coarse sizes and in the extremely fine sizes as Chart I shows. The curve can shift left or right depending of the mineral liberation of the ore.

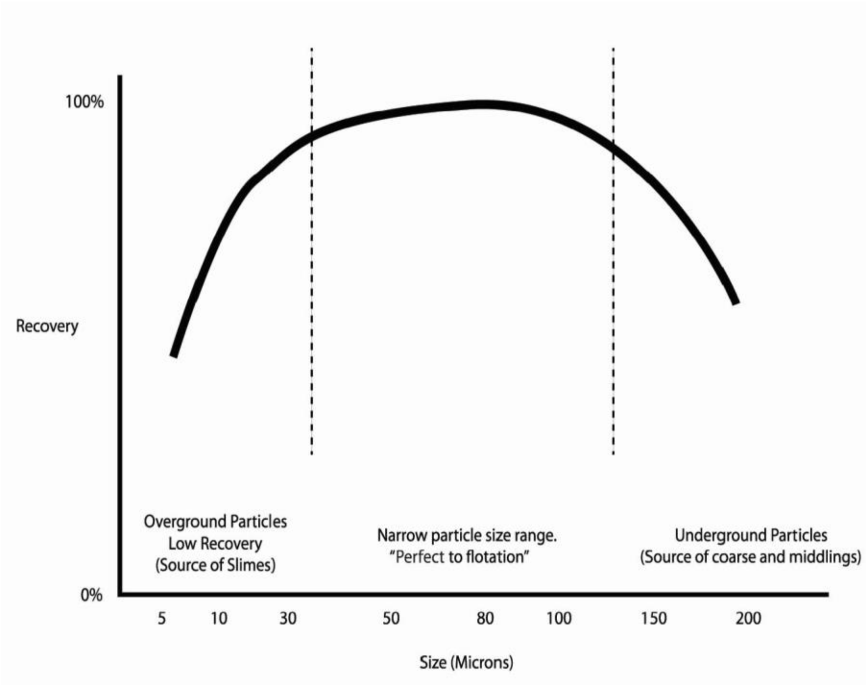

Chart 1. Typical Recovery versus Size.

With improved classification efficiency, the amount of grains in the coarse size range can be practically eliminated and the amount of ultrafine (slimes) material can be substantially reduced [3]. Narrowing the size distribution to flotation allows for a better environment for reagent conditioning. Other subsequent downstream processes also benefit from a sharper size distribution with less ultrafine material.

A large amount of work has been performed to improve the sharpness of classification [4, 5]. This work normally concentrates on the fines returning to the mill with less effort paid to prepare and produce sizing to achieve better plant recoveries. Although reducing the amount of fines returning to the mill is beneficial, the main objective of the classification device is the reduction of coarse material to feed the downstream circuits; sharper classification in the mill circuit can produce a narrow size distribution and increase the percentage of particles in the optimal recovery range.

Breaking the paradigm of high circulating loads with hydrocyclones in closed grinding circuits with screen classification has demonstrated substantial improvements with achievements in better liberation of the valuable minerals and better metallurgical recoveries. In mineral processing plants, maximum valuable mineral recovery and product grade is dependant on proper mineral liberation and optimum size distribution for downstream processes. Today plant capacity, costs in energy and water availability play an important role to determine the adequate technology for the milling and concentrating stages in the plants.

Keeping innovation in mind, if one looks at a plant design, the concept of numerous lines of flotation cells is well accepted; nevertheless the cost and size of the classification device often takes precedence over efficiency; despite the fact that classification is a critical process with major influences on downstream processes like flotation and filtration. The concept of a larger classification device consisting of numerous lines of screens is often not considered even though the benefits have been demonstrated at numerous processing plants.

Plant designers often accept classification devices with low efficiencies even though it is well known that reduced efficiencies result is lower recoveries of valuable minerals. Engineers often favor the old concept of poor classification and high circulating loads rather than moving forward with innovative technology of higher efficiency classification devices [6, 7]. Efficient classification devices have been slowly gaining acceptance with plant designers that focus on increased throughput at lower specific power consumption and better mineral recoveries with more difficult ores. With the recent innovations in fine screen technology the benefits of a high efficient classification have been demonstrated to be practical at several concentrators throughout the world.

This proven concept of efficient classification has demonstrated that additional grinding mills are not always necessary to increase production. An investigation of screen classification may determine that a required feed tonnage for a new project can now be achieved with smaller grinding mills that operate with a lower specific energy consumption. Plant designers should now consider more efficient classification with high frequency screens regardless of the size of the classifier instead of continuing to accept a standard of less efficient hydrocyclone classification because it fits in a smaller box.

2. FACTORS THAT AFFECT WET SCREENING OPERATION

Moving further on the concept of high frequency screens in your grinding circuit is important to understand the factors that affect the operation of screening [8]. These factors are as follows:

2.1. Feed Rate

The capacity of a screening machine is defined (Chart II) as the optimal feed rate to meet the desired product specifications. Feed rate, usually expressed as dry mass flow (t/h), is one of the more critical factors affecting screen performance. The capacity of the screen will determine the number of screening machines required. Exceeding capacity (or over feeding a screen) will result in the misdirection of undersize particles and fluid to the oversize stream as well as a reduction in screen surface life. Depending upon other factors, the optimal feed rate can be exceeded to some extent without a significant decrease in efficiency. The capacity of wet fine screen is best determined by full-scale testing to optimize all factors affecting screen performance.

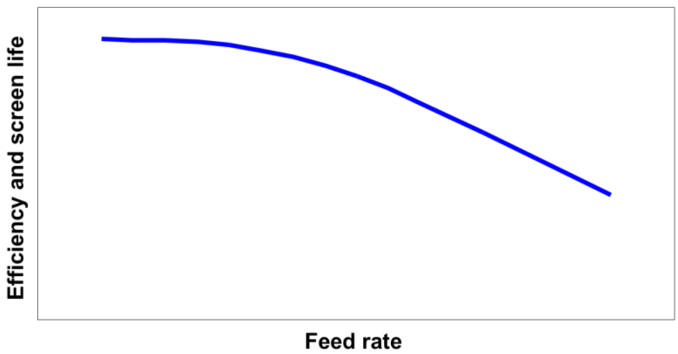

Chart 2. Effect of Feed Rate.

2.2. Feed Density

Undersize particles are transported through the screen openings by the fluid and therefore, the volume fraction of fluid will affect screen efficiency. Screening efficiency will increase with decreasing feed density (Figure II). From a practical standpoint, a screen feed density of roughly 20% solids by volume has been found to be a reasonable compromise, independent of dry solids specific gravity. To maximize undersize efficiency (the correct placement of undersize), the screen feed slurry could be even low, perhaps as low as 10 to 15% solids by volume. It has also been shown that it is usually more beneficial to add water to the screen feed slurry than to add the same amount of water directly to the screen surfaces with spray nozzles.

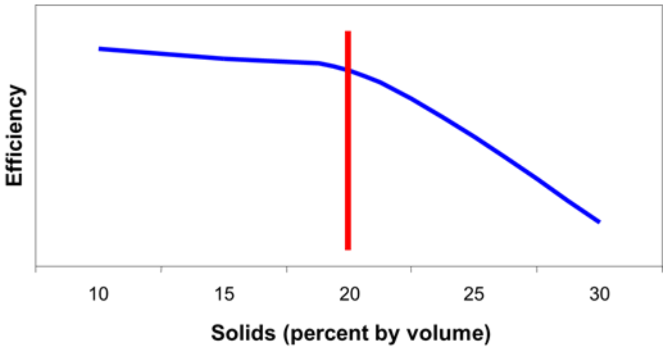

Chart 3. Effect of Feed Density.

2.3. Feed Size Distribution

The size distribution of the material fed to a screen is one of the more important factors affecting (Figure III) both capacity and performance of a wet screening machine. The oversize particles must conveyed off the screen and capacity usually decreases as the amount of oversize increases. Another important factor is the amount of near-size material in the screen feed. Near-size material is defined as the particles that are 2 mesh-size equivalents larger and smaller than the screen opening. Near-size, oversize material inhibits the ability of the undersize material to get through the screen openings and, in some cases, can cause some plugging problems. Selection of screen media is quite important when dealing with significant amounts of near-size material.

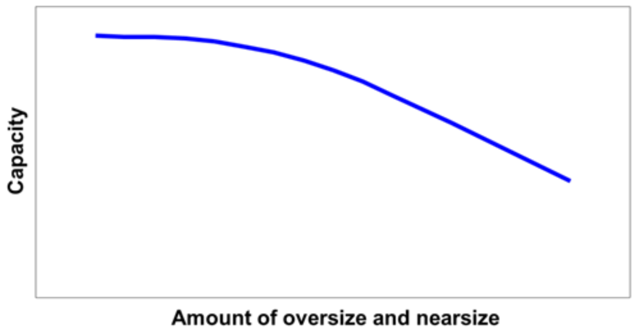

Chart 4. Effect of Feed Density.

2.4. Screen Opening and Open Area

The larger the screen opening aperture, the greater is the machine capacity. Conversely, as the desired separation size decreases, so does machine capacity. For example, say that full-scale tests determine that machine capacity is 100 t/h with a 250 micron (60 mesh) screen opening. Machine capacity could drop to 20 to 40 percent with a 150 micron (100 mesh) openings. At a given size, the open area of a particular screen surface also affects capacity. To increase screen panel life, it may be desirable to use a more robust screen cloth with lower open area. However, doing so will result in a lower machine capacity.

3. PLANT OPERATIONAL CONTROL SYSTEM

Based on the screen factors described above a control procedure for a grinding-classification circuit closed by high frequency screens should be designed in part per control loops for the water/mineral balance with an automatic weight scale in the conveyor belt that feeds the mill and a flow meter set to the new ore fed for the determined dilution ratio. The mill discharge pulp percent solids could then be diluted to the proper percent solids (20% with respect to volume) with a control loop between a density meter and a water flow meter. This diluted pulp is then sent by a variable speed pump to the flow distribution system that evenly feeds high frequency screens to generate a separation with an approximate 50/50 weight split of the dry solids to produce a circulating load around 100% (weight ratio of coarse/fine products). The control schematic based on the water/mineral balance proposed can better stabilize and control the capacity of the grinding circuit.

The control system described above will have the following characteristic: The data from the flow and density meters will record the weight of ore that feeds the screens maintaining a stable system. If for any reason the product size distribution coming from the crushing circuit the control system registers a noticeable variation in the circulating load, then it offsets the tonnage by varying the speed of the conveyor belt and adjusting the weight of fresh feed ore entering the circuit and thus, in this manner, maintain the balance with a circulating load in a predetermined and stable range.

This control system proposed is different than the traditional grinding-classification control, where the size distribution product fed to flotation or size classification is registered and controlled by an online analyzer. Variations in particle size are corrected with a direct control loop to the variable speed conveyor belt and by an automatic weight scale that makes minor adjustments to the fresh ore entering the grinding system maintaining in balance the loops related to water/mineral that enters the grinding mill - pulp density and water to feed the classification. It closes the circuit and the objective is to maintain stable the circulating load.

4. OTHER CONSIDERATIONS

4.1. Ball Mill – Grinding Media Size Distribution

The mill charge may need to be adjusted to balance for the decrease of circulating load and increase of new feed tonnage. The ball size distribution inside of the mill is dependent on the top size to be ground and from the size distribution of the ore fed to the mill. The low efficiency of the hydrocyclones allowing coarse particles to flotation or downstream concentration processes and finer particles returning to the mill can be replaced by high frequency screens to allow for efficient classification that does not allow coarser particles to downstream processes and reduces the fines in the circulating load to the mill. It may be necessary to review the ball size distribution inside the mill. Changing of the ball size distribution can be performed immediately by completely unloading the mill then replacing with an adjusted load, but this is often not practical. Since you have to stop the ball mill to perform such work and it is a sudden cost increase in grinding media. It is wise to adjust the ball size distribution by adapting the new charge while monitoring the effects without stopping the operation.

4.2. Flotation and Downstream Operations

After upgrading the grinding/classification circuit with screens the operator should keep in mind that the grinding product will have less specific surface area. This product with less specific surface area reduces the reagent consumption in the downstream flotation processes. Another major benefit that screen size classification offers is consistent control over the top size with a tighter size distribution of the particles that leave the grinding circuit. For example, copper flotation circuits often have poor recovery of particles coarser than 70 mesh [9]. A screen can be used to reduce or practically eliminate the amount of particles coarser than 70 mesh that leave the grinding circuit when closed by hydrocyclones. Plant operators should look at all unit operations to take full advantage of the improvements that screens offers since a sharper classification will be now fed to thickening and filtration units. The optimal size distribution for flotation feed from a screen classifaction might differ from a previously determined optimal size distribution based on hydrocyclone classification. Therefore, a thorough study of the particle size liberation is recommended.

5. CONCLUSIONS

The history and advancement of grinding and classification technology during the last century has been a slow process compared to other sciences. The comminution process continues to be the most energy intensive operation in most mineral processing operations. Studies conducted by researchers through the years have demonstrated that the largest potential improvement in the comminution process could be achieved by improved classification. Today, with the increasing cost of energy and the rising value of metals and minerals, the benefits of improved classification through the use of Derrick high frequency screens is now a practical reality.

The commercial-scale replacement of hydrocyclones with Derrick high frequency screens in closed grinding circuits has demonstrated significant metallurgical and economic benefits, including increased production rates and lower power consumption. Downstream unit operations such as flotation and dewatering also benefit due to a reduction in overgrinding and specific surface area, resulting in improved product grade, recovery and reduced dewatering costs.

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