White Paper

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TITLE: Magnetic Separation Techniques to Improve Grinding Circuit Efficiency – 2014

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Magnetic Separation Techniques to Improve Grinding Circuit Efficiency – 2014

New Trunnion Magnet Technology Provides Significant Cost Savings

By Jose Marin, Eriez Director-Minerals/Materials Processing

Grinding Ball Fragments in the milling circuit impact on two critical areas. One is the crushing circuit where companies have observed damage to crushers, unscheduled downtime and loss of production. The other is the grinding circuit where companies have discovered wear to pumps, sumps, piping, hydrocyclones, mill liners as well as inefficient grinding, power consumption and optimization of mill throughout overall.

After reading this article, the reader will realize why a trunnion magnet offers a significant return on investment with tremendous cost savings.

* The Trunnion Magnet is an enhanced system for the separation and removal of balls and broken ball pieces typically used for ore processing in ball/SAG mill operations. Depending upon mill capacity, ball size and other parameters, Eriez will select and specify the appropriate construction features.

Figures 1 and 2 indicate respectfully the damage a grinding ball did to a cone crusher mantle—and the accelerated wear to a pump impeller as an example of the equipment imparted by recirculating steel scots. This results in costly repairs, often unscheduled downtime and loss of production.

* Figures 1 and 2

Fig. 1. Cone Crusher Mantle damaged by a grinding ball - ultimately resulting in costly repairs, unscheduled downtime and loss of production.

Fig. 2. Accelerated wear to pump impellers, and all other process plant in contact with or impacted by recirculating steel scats.

Here are four applications/circuit locations accompanied by a recommended equipment solution. Each has its own set of challenges, and each is approached in a different manner.

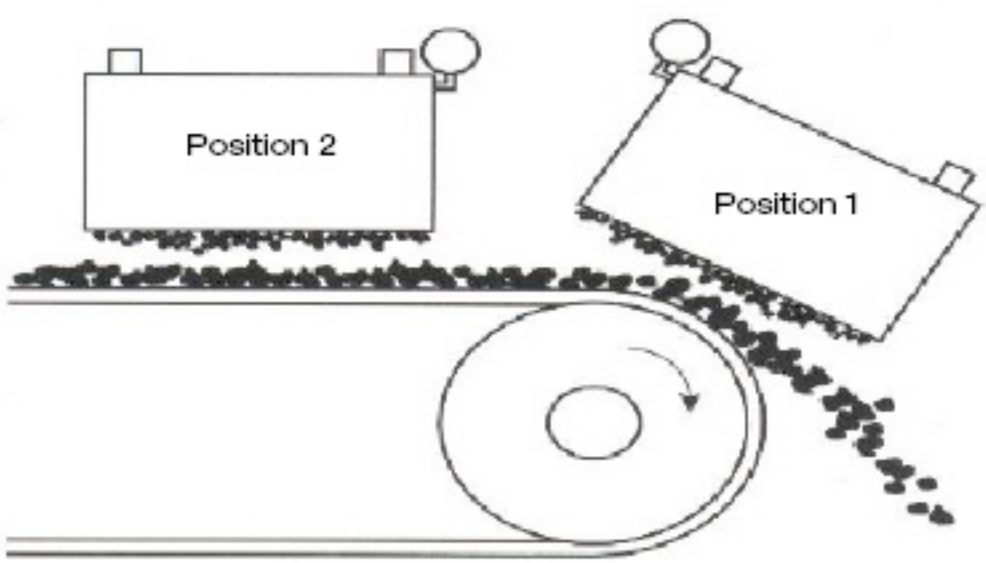
Application/Circuit Location	Technique/Equipment Solution
• Pebble Crusher	– Suspended Electromagnet
• SAG Mill Vibrating Screen Oversize	– Suspended Magnetic Drum
• Ball Mill Discharge	– Trunnion Magnet

Pebble Crusher

Figures 3 and 4 shows the location of a suspended electromagnet over a pebble crusher conveyor.

* Figures 3 and 4

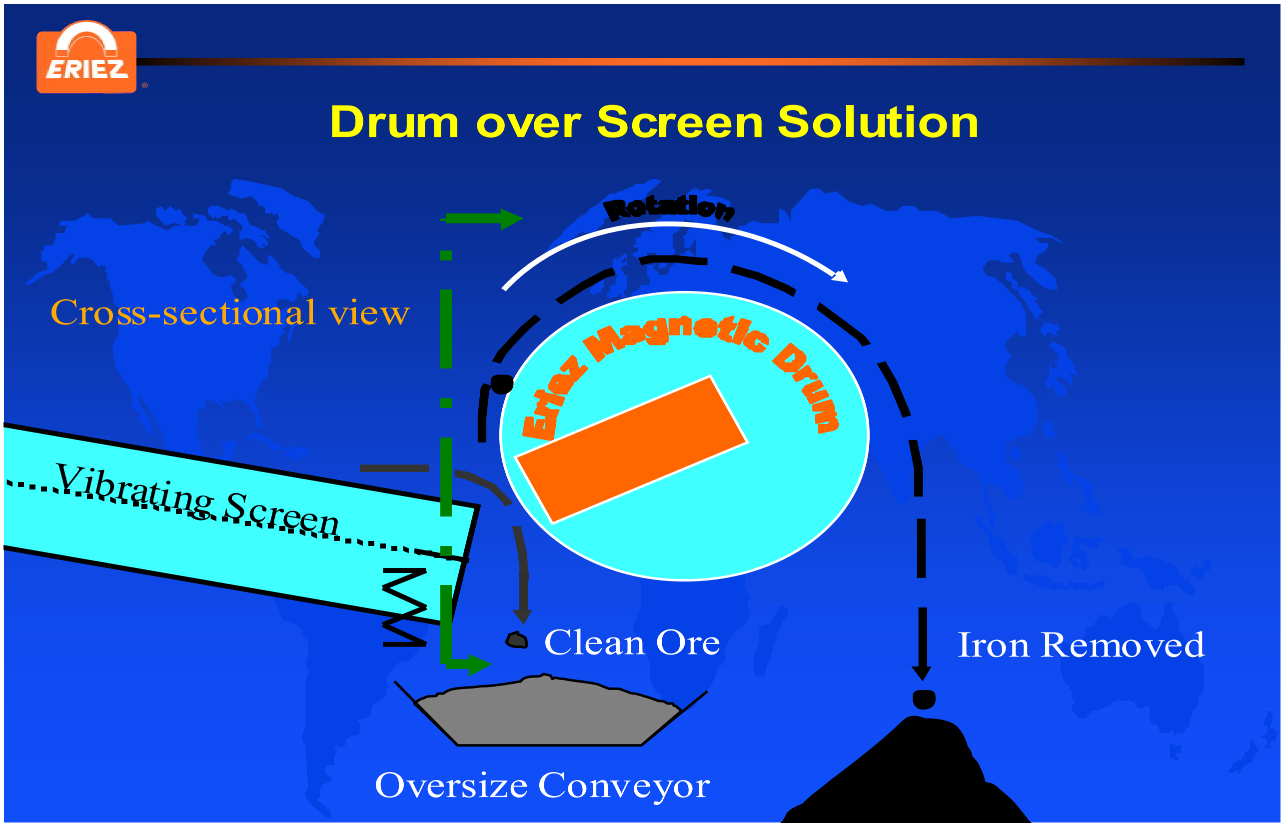
In this application, over the overhead pulley is preferred to the cross belt position (See Figure 5). A magnet width must be utilized to provide the most effective burden width coverage. The smallest size and shape of the tramp (steel scats) to be removed dictates the size of the magnet. Other considerations include the burden depth, belt speed, capacity, as well as clearance to the magnet and specification of a self-cleaning belt.



* Figure 5

SAG Mill Vibrating Screen Deck

By placing a magnetic drum over a vibrating screen (Figure 9,) an installation will realize a number of benefits:



* Figure 9

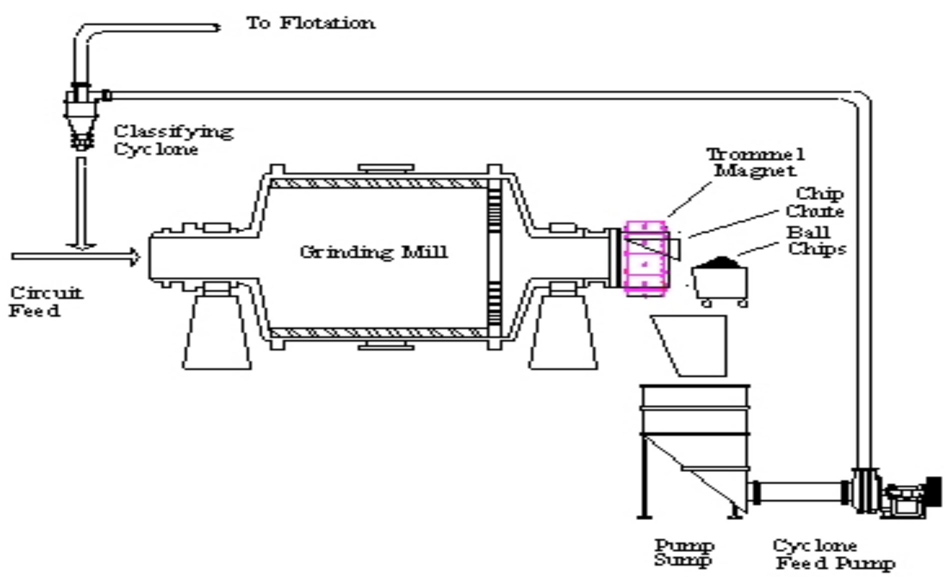
- Provides a relatively slow-moving ore
- Eliminates the dead burden of a conveyor belt, since this is essentially a mono-layer approach. (See Figure 10)
- Agitates material to aid the physical release of entrapped steel scats.
- Able to place magnetic drum close (150 to 250 mm) to discharging ore.
- Effectively remove long rods before they spear and damage the conveyor belt.

* Figure 10

Ball Mill Discharge

Figures 11 and 12 indicate how a trommel screen is replaced by a trunnion magnet system.

The trunnion magnet is mounted at the ball mill discharge point.



* Figure 11

* Figure 12

There are significant advantages and measured improvements when a trunnion magnet is installed (Figure13):

- It eliminates the higher capital cost of a trammel screen and the maintenance it requires.
- It extends pump and hydrocyclone life that has been documented at 250%.
- It increases mill throughput 5 percent.
- It reduces mill power consumption 8%.
- It results in 10% reduction in the mill work index due to more efficient grinding.

* Figure 13

As part of this article, there are two Ball Mill Calculations comparing conventional ball mill power consumption (Hogg & Fuerstenau Model) before tramp steel removal (Figure 14) and after tramp steel removal (Figure 15). These calculations indicate the ball charge is reduced from 678 tons to 585 tons (target ball loading).

CONVENTIONAL BALL MILL POWER ESTIMATION

Hogg & Fuerstenau Model

Remarks Calculates the Total kW prior to the removal of the tramp steel
Note: That the ball charge is 678 tons

Mill Dimensions and Operating Conditions

Diameter ft	Length ft	Mill Speed % Critical	Charge Filling%	Balls Filling%	Interstitial Slurry Filling%I	Lift Angle (º)
2200	36.00	76.00	38.00	37.55	100.00	23.47
	RPM	12.41				

Mill Power kW	
6121	Balls
30	Overfilling
1010	Slurry
7161	Net Total
7.00	% Losses
7700	Gross Total

% Solids in the Mill	76.00
Ore Density ton/m3	270
Slurry Density ton/m3	1.92
Balls Density ton/m3	7.75

Charge Volume m3	Mill Charge Weight Tons: Ball Charge	Mill Charge Weight Tons: Slurry Interstitial	Mill Charge Weight Tons: Slurry Above Balls	Apparent Density ton/m3
147.54	678.00	111.84	3.33	5.376

* Figure 14 (Before Tramp Removal)

CONVENTIONAL BALL MILL POWER ESTIMATION

Hogg & Fuerstenau Model

Remarks Calculates the Total kW after the removal of 93 tons of tramp steel
Note: That the ball charge has been reduced to 585 tons
(target ball loading)

Mill Dimensions and Operating Conditions

Diameter ft	Length ft	Mill Speed % Critical	Charge Filling%	Balls Filling%	Interstitial Slurry Filling%I	Lift Angle (º)
2200	36.00	76.00	32.85	32.40	100.00	23.47
	RPM	12.41				

Mill Power kW	
5767	Balls
33	Overfilling
951	Slurry
6751	Net Total
7.00	% Losses
7259	Gross Total

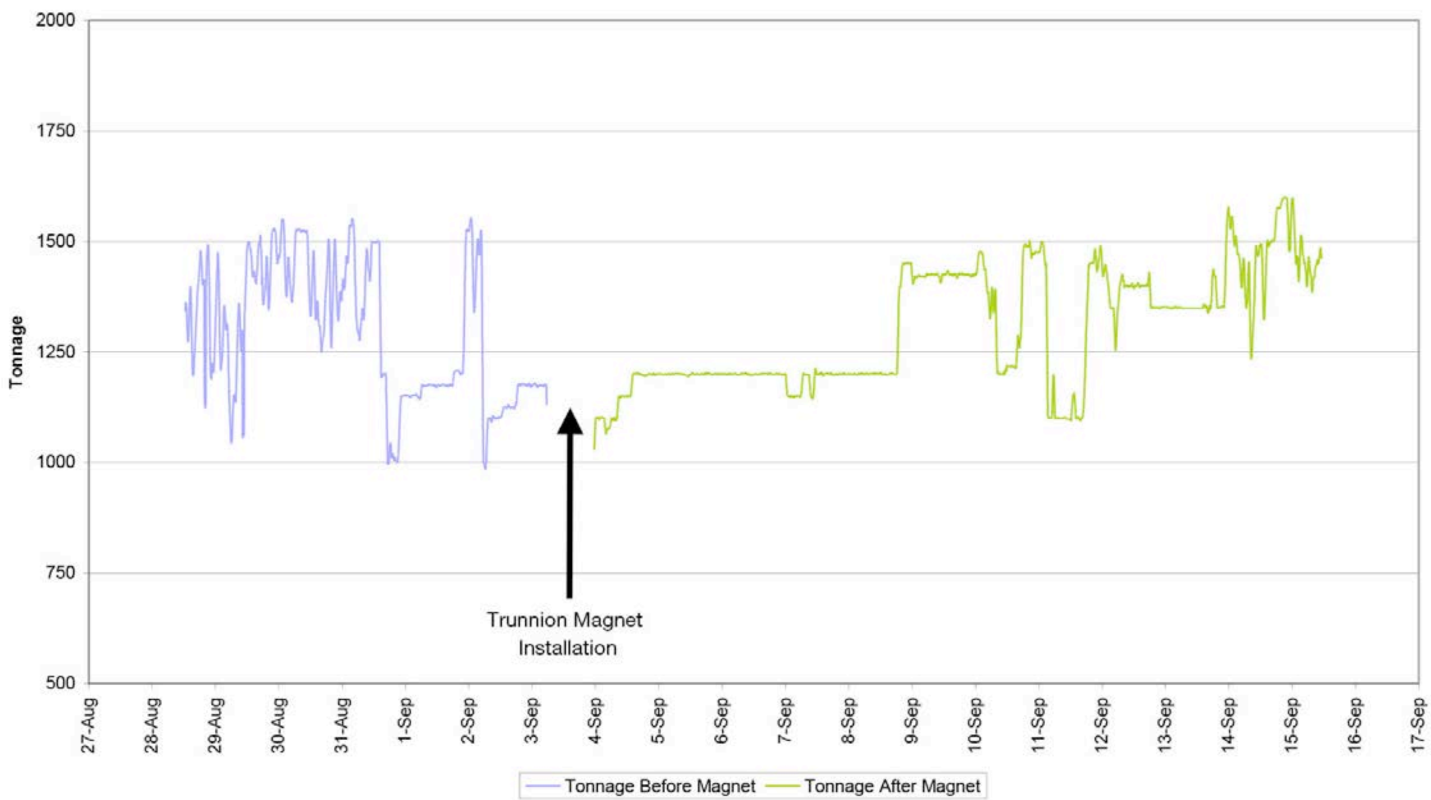
% Solids in the Mill	76.00
Ore Density ton/m3	270
Slurry Density ton/m3	1.92
Balls Density ton/m3	7.75

Charge Volume m3	Mill Charge Weight Tons: Ball Charge	Mill Charge Weight Tons: Slurry Interstitial	Mill Charge Weight Tons: Slurry Above Balls	Apparent Density ton/m3
127.55	575.00	96.50	3.34	5.369

* Figure 15 (After Tramp Removal)

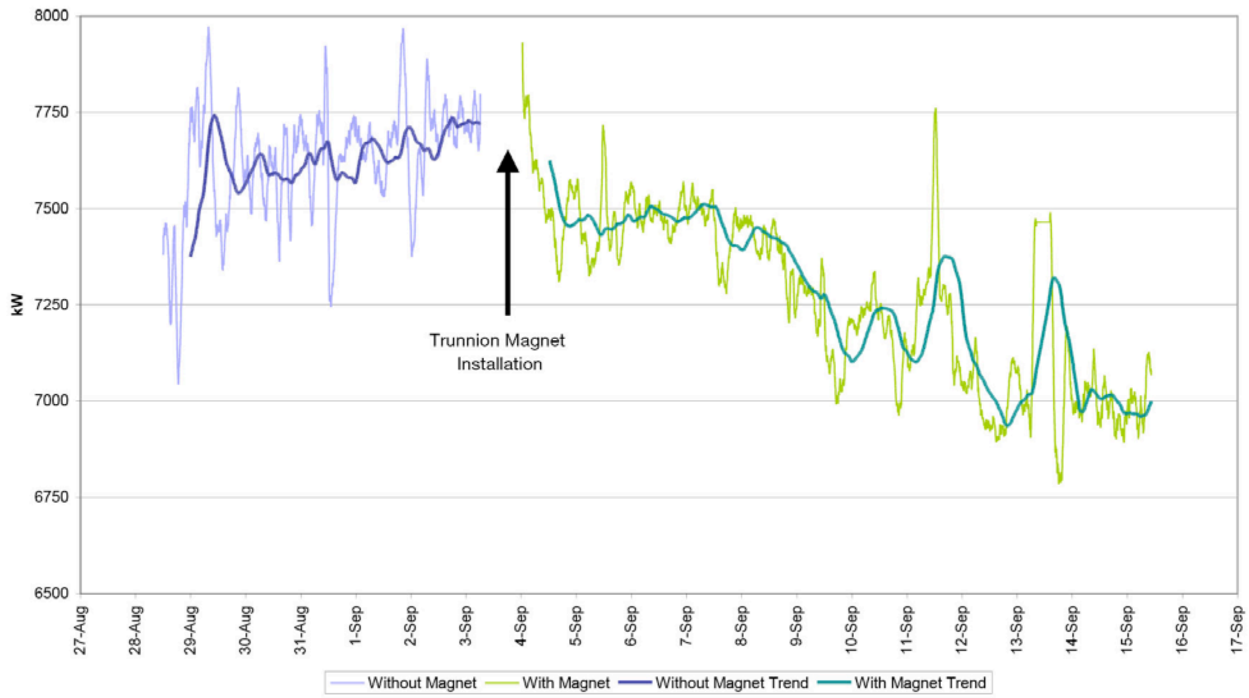
Three other figures 16, 17 and 18 indicate how ball mill tonnage is consistently greater after the trunnion magnet is installed, while energy savings also occurs. In addition, the mill work index dropped impressively.

Ball Mill Tonnage



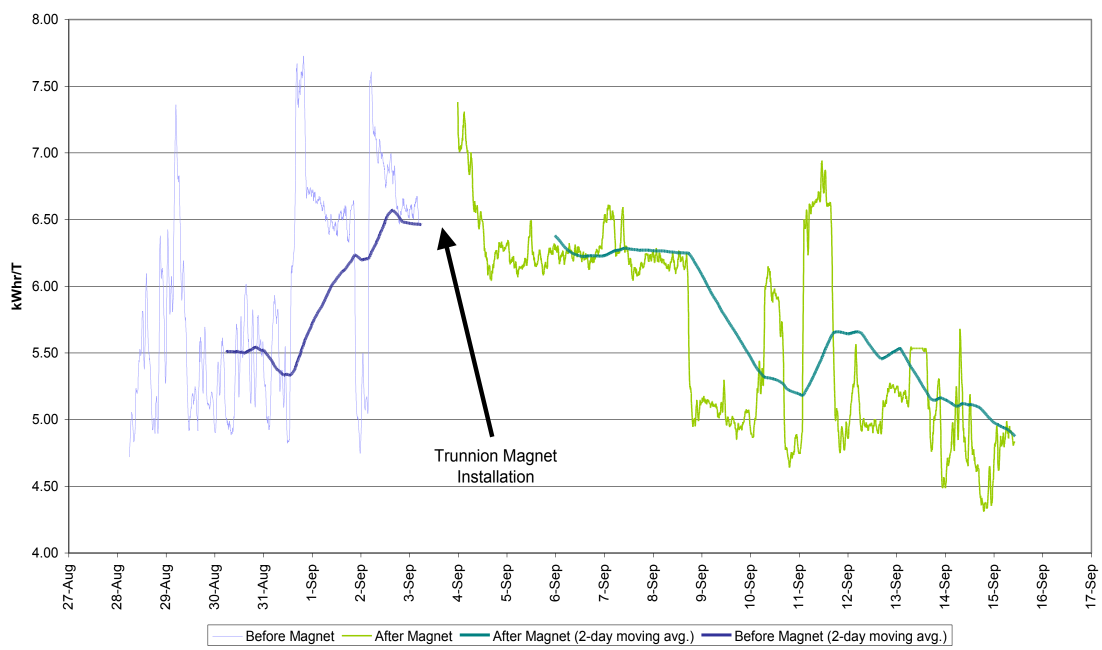
* Figure 16

Ball Mill Total kW



* Figure 17

Ball Mill Index in kWhr/T



* Figure 18

At the Kemess Mine, the effect of a trunnion magnet system on the ball mill was significant. The total mill feed remained essentially unchanged averaging approximately 1300 TPH. However, the total mill power consumption dropped 8% from an average of 7600 kW to 7000 kW. The mill work index dropped 10 percent from an average of 5.5 kW-hr/T to 5.0 kW-hr/T.

Conclusions

This represents a current view of the effects of grinding ball fragments in the milling circuit and the impact on the crushing and grinding circuit. The performance of a trunnion magnet should be compared to the existing operations especially if cost savings and output need improvement. Retro-fitting a ball mill with a trunnion magnet is easy to accomplish, particularly when the benefits are weighed against the cost. There are approximately 150 installations of trunnion magnets around the globe.