A Commercialized Dry Gravity Concentrator for Gold Applications

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ABSTRACT

A commercialized dry gravity concentrator is operating on an alluvial gold deposit in the Boludo Mining District, State of Sonora, Mexico. The technology base of the process is the Rotary Air Concentrator (a dry circular air jig) that recovers gold from the desert sand resource. An overview of the Mexican operation and the dry concentration technology is presented. Application of the dry technology to pretreatment of heap leach feeds and other heavy minerals is a possibility.

INTRODUCTION

Efficient dry gravity concentration at commercial scale has been an elusive target for gold miners. Numerous systems have been envisioned and tried, only to fail because of issues such as recovery efficiency, throughput capacity, and equipment robustness. The success of a small dry plant designed and operated in the early 1990s by Keith Piggott and his partners in northern Queensland Australia[1], led to a patented redesign and larger plant which is now operating successfully in northern Mexico. Mineral Ventures, LLC., located in Sparks NV, has an exclusive license to apply the dry concentrating technology. On January 5, 2000, Mineral Ventures contracted with the author and others, to visit the Minera Secotec SA operation in Mexico to observe the mine and its concentrating technology in operation, and to meet with Keith Piggott who continues to manage the day to day operation of the plant. This paper presents a brief overview of the operation, and, in particular, the successful application of the dry concentration technology.

OPERATIONS OVERVIEW

The process plant is mobile which allows mining excavation of feed in front of the plant and discharge of tailings behind the plant. Therefore, the plant moves forward to the mining face with the plant tailings redeposited onto mined ground behind the plant. Mining is accomplished by tracked back-hoe excavators which discharge feed directly onto the plant grizzly (see Photograph 1).

Photograph 1. Mobile Dry Process Plant with Tracked Back-Hoe Excavator

A process flowsheet for the dry plant is presented in Figure 1. The simple plant is comprised of four unit operations: grizzly screen, vibrating screen, primary air jig units, and a cleaner air jig unit. The process results in a minus 2 mm black sand concentrate and a coarser plus 2 mm screen concentrate. Both, of which are transported to a conventional wet cleanup plant. Vibrating screen oversize and primary concentrator tailing products are discharged from the plant. Photograph 2 shows the grizzly and plant feed conveyor. Photograph 3 shows the enclosed dry plant (Keith Piggott in

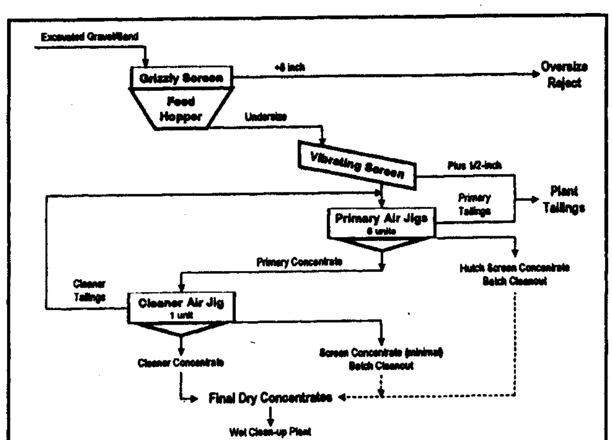


Figure 1. Dry Plant Process Flowsheet

[1] Mining Magazine, Air Separation: a viable technology, May 1993, p. 251 – 253.

foreground), while a closer view of the plant wheels/tires, providing scale comparison, is shown in Photograph 4.

PROCESSING THE MINED GRAVEL/SAND

Minus 8 inch gravel/sand (from grizzly, see Photograph 5) is fed to a vibrating screen which results in minus ½ inch primary concentrator feed. The mining rate is varied so as to result in a nominal 180 yds^3/hr of feed to the six primary concentrator air jigs (about 30 yds^3/hr to each jig). Feeding the grizzly creates a fugitive dust problem in the desert environment as shown in Photograph 6.

The minus ½ inch jig feed is distributed in a rotary splitter (see Photograph 7); hence by two chutes onto the central distribution cone at each of the six primary (air jig) concentrators. Revolving bars level and distribute the material, at a constant depth of about 25 mm (1 inch), over the jig hutch screen to an outer diameter of nearly 5 meters (about 16 ft.) These same revolving and angled bars facilitate movement

Photograph 2. Grizzly and Plant Feed Conveyor

Photograph 3. Enclosed Dry Process Plant and Tailing Conveyors

Photograph 4. Plant Close-Up

Photograph 5. Grizzly/Hopper with Apron Feeder

Photograph 6. Excavation and Feeding

Photograph 7. Rotating Feed Splitter

Photograph 8. Primary Air Jig with Feed Chutes

Photograph 9. Primary Air Jig Surface with Revolving Bars and Tailing Launder

of the feed across the jig bed and hutch screen to the outer edge of the jig where an annular launder accepts the material (now tailings) for discharge out of the plant. Photographs 8 and 9, show the distribution, revolving bars, and tailing launder at the air jig surface. The consistent bed depth, facilitated by the revolving bars, can be credited with control of the bed back pressure; thus ensuring that there is no blow-by of the pulsing air in areas where the jig bed is thin, and corresponding bed "dead spots" are eliminated.

Gold and heavy minerals are concentrated in the air jig much like beneficiation occurs in wet jigs. Low pressure air is pulsed into the hutch area below a wedge-bar screen having 2 mm openings. The pulse is generated by a revolving slot mechanism internal to the hutch. Steel shot, nominally 3 mm dia., is layered to a depth of about 10 mm over the hutch screen creating what is referred to in wet jigs as ragging. The following Figures 2 through 5 show a progression of the jigging mechanism wherein the jig bed is alternatively dilated and settled (constricted) by the pulsing air. In dilation, the lighter particles are lifted higher than the heavier particles and during constriction the heavy particles tend to settle faster than the lighter particles. The end result is that gold and heavy minerals migrate downward through the bed and ragging to the hutch screen. The finer of these

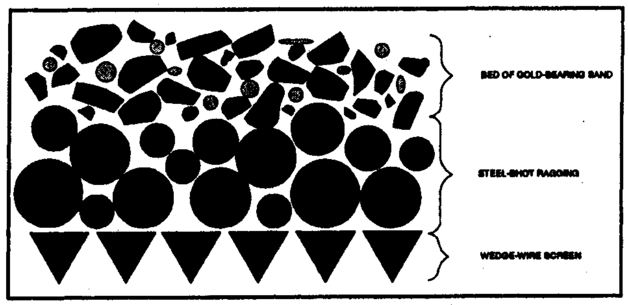


Figure 2. Jig Mechanism Showing Feed, Ragging, and Hutch Screen

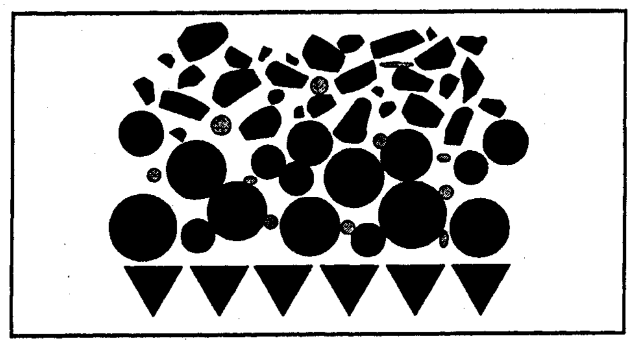


Figure 3. Dilation of Jig Bed Over Hutch Screen

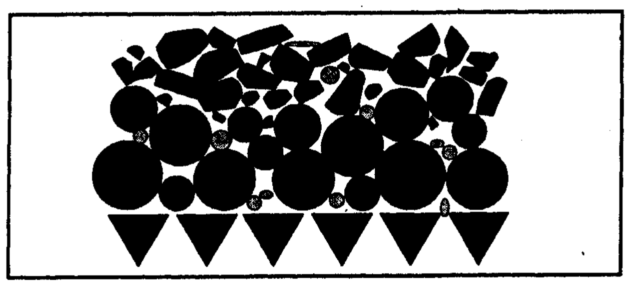


Figure 4. Settled Constriction of Jig Bed Over Hutch Screen

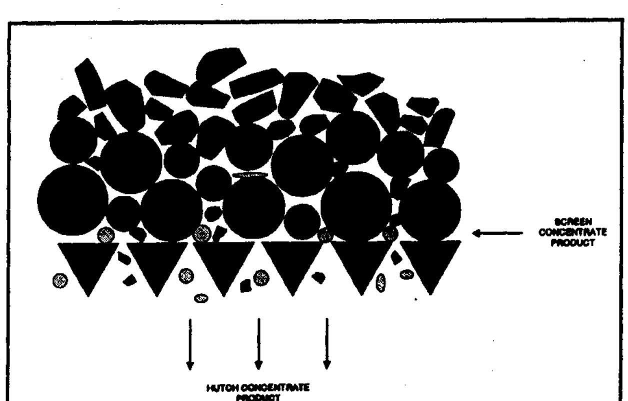
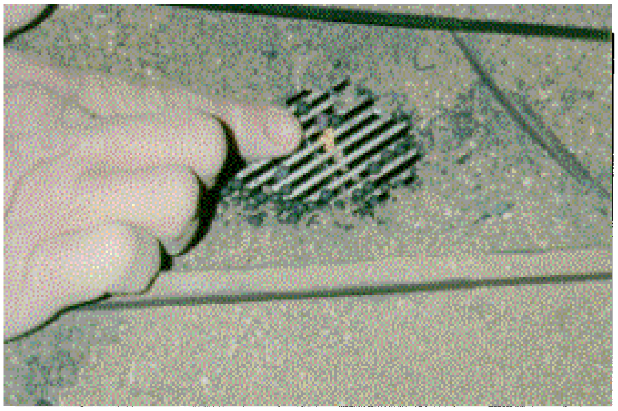
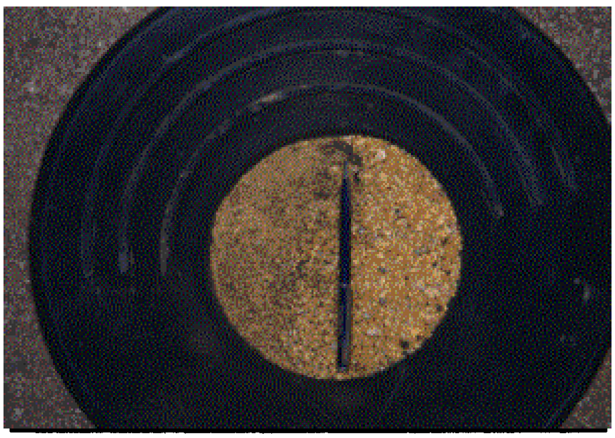


Figure 5. Jig Bed and Ragging with Screen and Hutch Concentrate Products



Photograph 10. Opened Jig Bed with Ragging and Coarse Gold



Photograph 11. Free Gold Concentrate from Clean-Up Plant

heavy particles (those smaller than 2 mm) pass through the screen into the hutch and out of the jig as concentrate. The coarser heavy particles accumulate on the screen, which is manually cleaned at appropriate intervals, and the product forwarded to final wet cleanup. Photograph 10 shows the jig bed opened to show both the steel shot and a piece of coarse (plus 2 mm) gold on the hutch screen surface.

Primary concentrate product from the air jig hutch is transported by conveyor and chutes to the single cleaner concentrator that is similar to the primary concentrator jig units. Adjusting the bed depth, bar rotation speed, and air flow (pulse frequency and pressure) compensates for the finer and heavier character of the material treated in cleaner stage.

The conventional wet cleanup plant uses a magnetic separator and Knudsen bowl (a type of batch centrifugal concentrator) to produce the final upgrading. Photograph 11 shows free gold concentrate produced in the cleanup plant.

Back in the dry plant, two tailing streams are exited to the rear of the plant and onto the previously mined area. Photograph 12 shows the plant discharge conveyors; the

Photograph 12. Dry Plant Discharge Conveyors

coarser stack is plus ½ inch vibrating screen product, while the finer stack is primary concentrator tailing material.

DRY CONCENTRATOR PERFORMANCE

The ratio of concentration through two stages of dry concentration with the plant operating on Boludo alluvium material in is the range of 400 – 600 to 1. The Boludo alluvium is known to be a low-grade resource containing a wide range of gold particle size, depending on location. As of November 1999, it is reported that the operation had recovered on average US$ 1.37 in gold value per cubic yard of processed bank material over more than two years of operation (US$ 300/oz basis). A portion of the recovered gold that was observed in the final cleanup plant was finer than 100 mesh, nominally minus 150 µm. Recovery of gold by size fraction has not been quantified. The operation is reported to be profitable.

Fugitive dust is always an issue in dry processing of ores and materials, and the Minera Secotec SA operation is no exception. Dust is air-entrained at the grizzly, inside the plant at transfer points and at the concentrator surface, and at the tailing conveyor discharge behind the plant. It appears that it should be possible to eliminate the majority of the dust issues by design shrouding, pressure differential engineering, bag houses, and minimization of transfer points through value engineering. These considered improvements are consistent with standard engineering techniques as practiced in the United States and Canada to meet hygiene and environmental standards.

OPPORTUNITIES

There are obviously a number of plausible applications for dry gravity concentration. In addition to gold, this technology has potential application for dry recovery of a variety of concentrates including tin, tungsten, iron, and titanium based minerals, garnet, barite, and for coal cleaning. There could be industrial mineral applications such as glass sand beneficiation. Related to the gold industry, it is postulated that recovering free gold from heap leach feed in certain circumstances could reduce the leach cycle time while increasing recovery without the expense of both water addition/mixing and then dewatering prior to heap construction.

ACKNOWLEDGEMENTS

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