KNELSON CONCENTRATORS EXTREME GRAVITY

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Abstract

The concept of Extreme Gravity is the latest in a series of innovations that has seen a re-introduction of gravity recovery systems into the milling operations of most gold mines. Traditionally, most gold milling circuits are designed around flotation and cyanidation requirements, with the gravity circuit being fit in where possible. Extreme Gravity takes the novel approach of optimizing the circuit, in order to maximize recovery by gravity. In some cases gravity systems can achieve high enough recoveries to eliminate the need for chemical systems such as cyanidation or flotation.

There are many advantages of such a system including low capital cost, reduced permitting, improved cash flows and much reduced environmental issues.

There are a number of plants currently in operation which utilize this new methodology. The Muzhievo project has been an example of a recent turn key success achieving recoveries from 85-90%. The details of this project are examined as a case study.

Introduction

Extreme Gravity, in the simplest terms, is the aggressive use of the latest gravity recovery technology.

The definition of what is and is not gravity recoverable in gold mills has changed over the years as the technology has improved. As the recoverable particle sizes become smaller and the required density differential closes, gravity can now begin to shift from a partial solution to a total solution. A number of circuits are already in use in which gravity systems are the sole means of recovery.

As a general rule, there is no statistical correlation between the percentage of gravity recoverable gold and the grade of any given deposit although the percentage of gravity recoverable gold will decrease as the overall grade decreases in a given deposit. Utilizing a standard release analysis test, grades as low as 1.0 gram per tonne have been found amenable to the “Extreme Gravity” approach. In places where cyanide use is limited or environmental laws are prohibitive, the Extreme Gravity approach will be even more attractive.

The benefits of Extreme Gravity include, low capital cost, short project lead time, improved cash flow, no use of cyanide or other chemicals. In addition small plants can be modular and easily moved between locations.

Evolution of Enhanced Gravity

The industry perception of gravity systems has changed significantly in recent years. Gravity technology had been decreasing in popularity for a number of years when Knelson Concentrators were first introduced on a large scale in 1986. At this time it was difficult to find initial acceptance in any form as people felt it was unproven and had not distinguished itself from older technologies.

Once the technology had gamed some form of acceptance most of the installations were retro-fit, where the new gravity circuit would be squeezed into an existing installation. These circuits provided clear benefit but certainly did not explore the limits of gravity technology.

With the acceptance of the Knelson Concentrator, new projects began to be developed with a gravity circuit engineered from the outset. These circuits eliminated some of the shortcomings of the initial retrofit installations but still left the gravity circuit at the mercy of the other unit operations.

The final step of gravity circuit evolution begins with a question. What if the gravity circuit is not installed as an afterthought? What happens when we employ the latest technology, in an aggressive fashion to create an efficient and optimized gravity recovery environment?

General Concepts

As gravity technology advances, our ability to target difficult particles improves, The use of the latest technology will push the limits of what is possible. Recent advances include new concentrating cone designs, new PLC control algorithms, better feed preparation, optimized crushing and nesting of circuits.

New Cone *Designs*

Cone designs have been steadily advancing as the test work database expands and mathematical modeling improves. In 1998 the new G5 cone was launched (Pyper, J, 1998). This unit reduces water consumption by up to 60% while improving recoveries in most cases. As the understanding of the system improves, the ability to target fine particles through improved cone geometry also improves. Side by side test work between G4 and G5 in a number of different applications has shown the large improvement in fines recovery (Table 1).

Table 1 G4 and G5 Comparison

Application	Cone Type	Mass Yield Comparison	Recovery (%)	Recovery % Increase in G5
1 Standard Au	G4	100	20	
	G5	16.6	46	230 %
2 Russia (Pt,Pd)	G4	100	25	
	G5	60	34	136 %

A comparison of The G4 and G5 cones for both standard Au and a Pt,Pd applications. In each case water consumption was reduced by approximately 50% while recoveries increased substantially as shown.

New cone designs are continually evolving and a new cone design, the G6, is currently undergoing test work in a gold application. This cone specifically targets applications with very fine feeds such as flotation concentrates while again, reducing the water consumption.

Advanced PLC control

With the evolution of complex gravity systems the need for complex control has become apparent. The new Knelson ICS 2.0 utilizes multipoint flow optimization to target higher recovery in specific applications. Next generation control projects at Knelson Concentrators will utilize continual optimization algorithms for the Knelson Concentrator while integrating control of items such as variable apex cyclones. Tests to date have shown recovery increases of up to 50%.

Crushing

By optimizing crushing for gravity concentration, recoveries can be substantially increased over conventional circuits. This employs the use of tension rather than compression when fracturing particles in the crushing unit operation. Examples of crushers which provide tension fracturing include impact and high pressure rolls crushers. This must be examined in each case. Additional ways of optimizing crushing include by-pass of crusher tines directly into the Knelson Concentrator in circuits where a standard mill is used. This minimizes gold smearing and lock-up.

Table 2 is an example of test work performed on a gold bearing ore. In each case the sample was ground to the same passing size. Even at a much finer grind the rod mill failed to match the liberation characteristics of the impact mill.

Table 2 Grind Optimization - Knelson Concentrators Lab Tests

Test	micron p80	Grind Method	Head av (g/t)	Recovery av (%)
151 A-B	300	Rod Mill	6.3 g/t	28.8
151 C-E	450	Impact Mill	6.5 g/t	54.1

Table 2 gives a summary of test work performed in the Knelson Concentrators Research and Testing Center. Note that even at a finer grind the rod mill failed to liberate gold particles as effectively as the impact mill.

Feed Preparation

Proper feed preparation and arrangement is critical to the success of a Knelson Extreme Gravity circuit. Careful use of cyclone technology and screening can increase the overall performance of enhanced gravity devices. Detailed analysis has shown cyclones to be very effective at concentrating gold particles, even into the finest ranges, By taking advantage of a potential recovery in excess of 99% to the underflow for gold particles larger than 25 microns (Laplante 2000a), gold particles can be retained in the circuit while less dense particles are rejected. Gold particles which are retained can be subjected to multiple passes through a gravity recovery device to ensure the chance of capture is maximized. By targeting the high recoveries of the cyclone and the high upgrade ratios of the Knelson Concentrator, even the finest liberated gold can be recovered into a relatively small mass of concentrate for final processing.

Carefully designed screening is also an important aspect for Extreme Gravity circuits. Considerable work by Dr. Andre Laplante has shown benefits to screening prior to gravity recovery (Laplante, 2000 a&b). By eliminating barren oversize or unliberated material from the Knelson Concentrator feed, the concentrate grade and recovery can be improved significantly. New cone designs targeted specifically at fine feeds benefit substantially from careful screening practice.

Muzbievo Project

An example of the successful implementation of the Extreme Gravity concept is the Muzhievo project in far Western Ukraine (Grodowski, M, and Van Kleek, D,M, 2000).

Intertech Corporation, the Knelson Concentrators representatives for the CIS were approached regarding the project in early 1999. The Muzhievo project had many features which made it an extremely difficult undertaking. Firstly, it was in an environmentally sensitive area and thus there would be no use of either cyanidation or flotation allowed. Secondly, due to upcoming elections, the project had to be completed and in operation by September of the same year.

A preliminary study was undertaken and it quickly became apparent to the client that a Knelson Extreme Gravity approach was their best option. With the decision to go ahead with the project it was concluded that Intertech would provide the project design and management while Knelson would provide the recovery technology as well as technical and process support. General operational targets included a minimum recovery of 80% while treating at least 20 tonnes per hour.

To provide the desired recovery guarantee a more detailed lab analysis was performed on the proposed circuit (Pariy, A, 1999). Once this series of tests had been completed it was agreed an 80% recovery minimum guarantee would be given to the client based on a predominant gold distribution of 40-70 microns.

Table 3 Laboratory Work

Sample #	Head (g/t)	Recovery (%)
1	**25.5**	**80.3**
2	**6.7**	**78.6**
3	**8.5**	**83**

Table 3 shows recoveries generated for three different blended ore types. Lab tests included grind size versus recovery analysis. Recovery at each grind level is added to achieve a composite recovery indicative of final circuit recovery.

Muzhievo Circuit Flowsheet

The final flowsheet was generated to maximize cost benefit (figure 1). In this case lab work showed that a standard crushing circuit would be adequate. Important points include the bypass of crusher tines straight to the gravity circuit, the treatment of primary cyclone underflow, efficient screening in primary underflow, careful treatment of fines in a secondary cyclone circuit and utilization of a back-up concentrator which can be used in place of either of the two production concentrators.

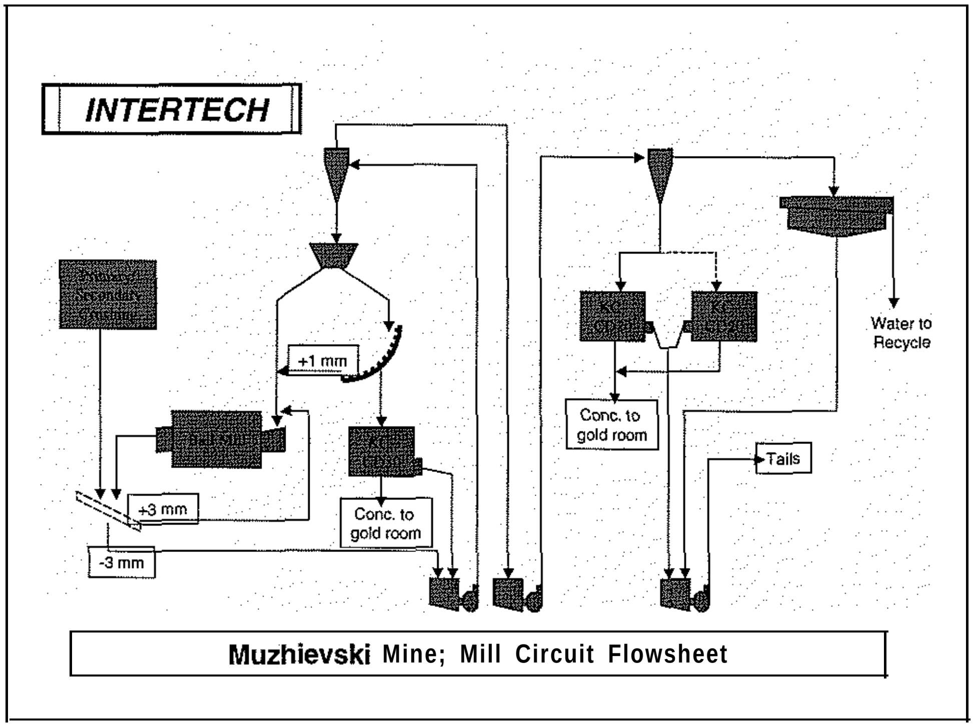

Figure 1 Muzhievo Flowsheet

Muzhievo Results

The project site was picked on April 26" 1999 and the final acceptance protocol after full startup and commissioning was signed September 24th of 1999. This is a total of just under five months for all engineering, design, procurement, construction and startup. Even during commissioning the mill achieved above the 80% recovery guarantee while throughputs ranged from 20-25 tonnes per hour. Historical data now shows recoveries averaging between 85 and 90% while further optimization is hoped to brings this to a long term average of 90%. Currently, the Knelson Concentrator in the primary cyclone circuit achieves approximately 60-65% of the total recovery while the secondary cyclone underflow Knelson Concentrator recovers the remaining 20-25%.

Other Knelson Concentrators Extreme Gravity Projects

Table 4 shows a list Knelson Extreme Gravity operations, The first five projects were a collaboration of Knelson Concentrators Canada and Knelson Concentrators Russia while the last project listed was designed by Intertech Corporation.

Table 4 Extreme Gravity projects in the CIS

Year	Deposit	tph	Head (g/t)	Recovery (%)
97-98	Molodezhnoe	15	21-24	92-94
97-98	Bogatyr	15	4	80
97-00	Kedrovskoe	15	7-8	70-80
95	Biler	15	26	88
96-00	Kedrovskoe	15	11.5	86-90
99-00	Muzhievski	20-25	10	85-90

Table 4 gives a list of Extreme Gravity plants, all of which operated successfully at the recoveries indicated.

Conclusion

As environmental legislation becomes more restrictive, permitting more difficult and commodities prices languish, innovative new operating strategies are needed in order to remain profitable.

There are many new problems being faced by the mining industry today that will only be overcome with new ideas and modes of operation. The concept of Extreme Gravity provides a potential solution for gold deposits with amenability to gravity concentration.

References

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