The Use of the Jameson Cell to Improve Flotation Circuit Design

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Abstract

Mineral processing plants are facing an urgent need for more efficient technologies to produce saleable concentrate as the ore bodies are becoming more complex. This complexity typically translates in changes to the configuration of existing flotation circuits to be able to maintain productivity. The Jameson Cell is a high performance flotation cell able to recover mineral particles in a wide range of sizes due to a combination of small bubble size and intense mixing ideal for bubble-particle collisions. This paper presents case studies where the Jameson Cell has been successfully retrofitted in brownfield mineral processing plants transforming the existing flotation circuits into more efficient flowsheets.

Biography

Rodrigo Araya is a chemical engineer graduated from Universidad Católica del Norte, Antofagasta, Chile. He obtained a Master of Engineering degree from McGill University in Canada. Following graduation, he worked as a researcher at McGill University in the Mineral Processing Group, studying hydrodynamic properties of industrial flotation machines. He has worked on mineral processing operations including Taseko Gibraltar Mines, Teck Red Dog and Canadian Royalties Nunavik Nickel. Currently he works at Glencore Technology focused on flotation, grinding and atmospheric leaching technologies.

Virginia Lawson has 25 years experience in mineral processing in operations and technical management. Her operational experience covers precious and base metals in Australia and Canada. The last five years have been spent focused on applying her expertise to solving problems in clients' plants around the world. Virginia manages the global Jameson Cell business for Glencore Technology and enjoys using her engineering skills and interacting with people all over the world to help improve their mineral processing performance.

Introduction

The modern society is increasing its demands for metals to produce goods and infrastructure for an always growing population. It has been reported that the extraction of the main commodities has increased by a factor of 1.7, which accelerates the depletion of mineral resources (Calvo et al., 2016). Consequently, new ore bodies around the world are at deeper depths, present lower head grades, complex mineralogy and high variability often complemented with deleterious elements including arsenic, fluorine, and mercury (Huynh et al., 2014). Complex mineralogy often requires fine and ultrafine grinding to liberate valuable mineral particles. For example, Glencore's McArthur River Mine produces a concentrate at a P80 of 7 µm (Pease et al., 2010). Processing plants using conventional flotation technologies and fine/ultrafine particle size typically struggle due to poor hydrodynamics to recover fine liberated particles (Jameson, 2012). This paper proposes the Jameson Cell as a flotation technology to overcome these challenges. Case studies of industrial installations are presented.

Background

Flotation is a process that separates hydrophilic particles from hydrophobic particles by means of air bubbles that rise to the top of a flotation cell to produce a froth layer (Wills & Finch, 2016). Ideally, hydrophilic particles remain in the pulp phase and hydrophobic particles adhere to air bubbles and exit the flotation cell as concentrate; however, in practice there will always be water entrained as it is required to build the froth phase (Ireland et al., 2007). The froth layer is a system in which gas cells are enclosed by water (Weaire & Hutzler, 2001). The water that forms the froth layer is transported from the top of the pulp phase; therefore, the water in the froth has the same composition as the pulp. This transport of water from the pulp to the froth is the start of the transport of unwanted hydrophilic particles from the froth to the concentrate launder (Johnson, 2005). The negative effects of water entrainment depends on particle size. Relatively coarse hydrophilic particles settle more easily in the froth phase, whereas fine fractions (<10 µm) do not settle and are transported much more successfully through the froth (Johnson, 2005). In most cases, relatively deep froths are enough to produce clean concentrates when coarse hydrophilic gangue is present. The use of wash water is typically needed for fine hydrophilic gangue.

The Jameson Cell

The Jameson Cell is a high intensity flotation cell in which pulp and air are brought together in a co-current descending flow in a vertical tube called the downcomer. The pulp is introduced into the downcomer through a slurry lens orifice to produce a high velocity jet that generates violent mixing and fine bubble size. Due to these conditions, a dense foam is produced inside the downcomer where violent collisions between bubbles and particles occur, therefore allowing the collection of hydrophobic mineral particles (Evans et al., 1995). The pulp then discharges into a separation tank, which allows the air bubbles carrying the hydrophobic particles to raise to the top of the cell to form a froth layer, which is consequently collected in the concentrate launders. Figure 1 shows an illustration of the Jameson Cell. The main advantages of the Jameson Cell includes the very rapid collection leading to compact size; self-aspiration of air eliminating the need of a blower or compressor; froth washing to reduce entrainment of unwanted hydrophilic mineral particles. Another great advantage is that the Jameson Cell recirculates a portion of its tails so the volumetric flow rate to the downcomer is constant, therefore, mixing, bubble size, air flow rate and metallurgical performance are constant.

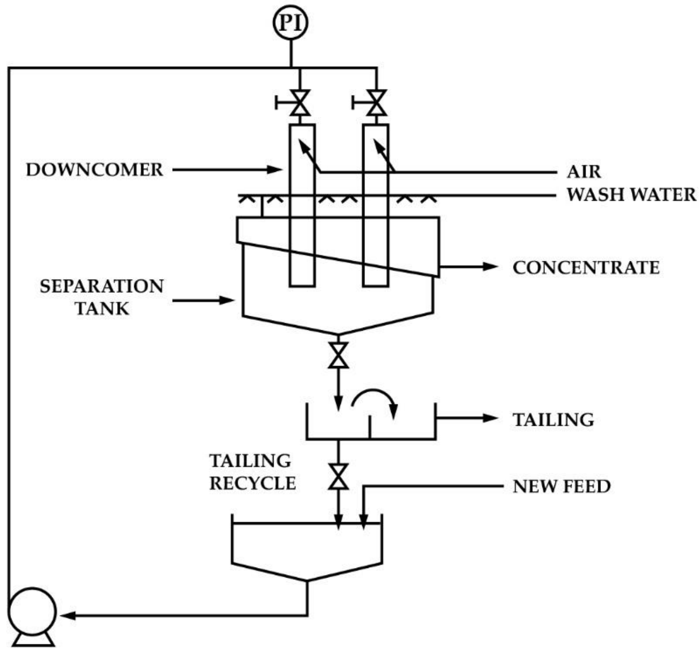

Figure 1 – Illustration of the Jameson Cell

Conventional Cell Cleaning Circuit

Cleaner circuits that use conventional mechanical cells are typically developed based on flotation tests to define the number of cleaning stages required to achieve the desired concentrate grade (Wills & Finch, 2016). There are a number of conventional cleaning circuits that have installed the Jameson Cell at the head of their cleaner circuits for several reasons including, increase cleaning capacity, removal of deleterious elements, increase of final concentrate grade (Bennet et al., 2012; Seaman et al., 2012). These installations serve as industrial demonstrations that the Jameson Cell is equivalent to three stages of cleaning in conventional mechanical cells, therefore implying that more efficient cleaner circuits can be designed with less machines, therefore less footprint and more power efficient.

Improved Cleaner Circuit Design

The proposed cleaner circuit design use the Jameson Cell in two separate duties: cleaner/scalper and recleaner (see Figure 2). The cleaner/scalper Jameson Cell produces a high grade concentrate by recovering the fast floating liberated mineral particles at the head of the cleaner circuit. The tails from the cleaner/scalper proceeds to a bank of mechanical cells as cleaner/scavenger to maximize recovery of a stream now with a lower degree of liberation. The concentrate of the cleaner/scavenger circuit feeds a re-cleaner Jameson Cell that also produces final concentrate. In flowsheets that include regrinding, the performance of the re-cleaner Jameson Cell can be used as a diagnostic tool to determine the grinding power required to liberate the value particles and consequently increase concentrate grade and recovery. Typically in base metals, the Jameson Cell when installed as cleaner/scalper is able to achieve final concentrate grades at unit recoveries ranging from 50 to 70%.

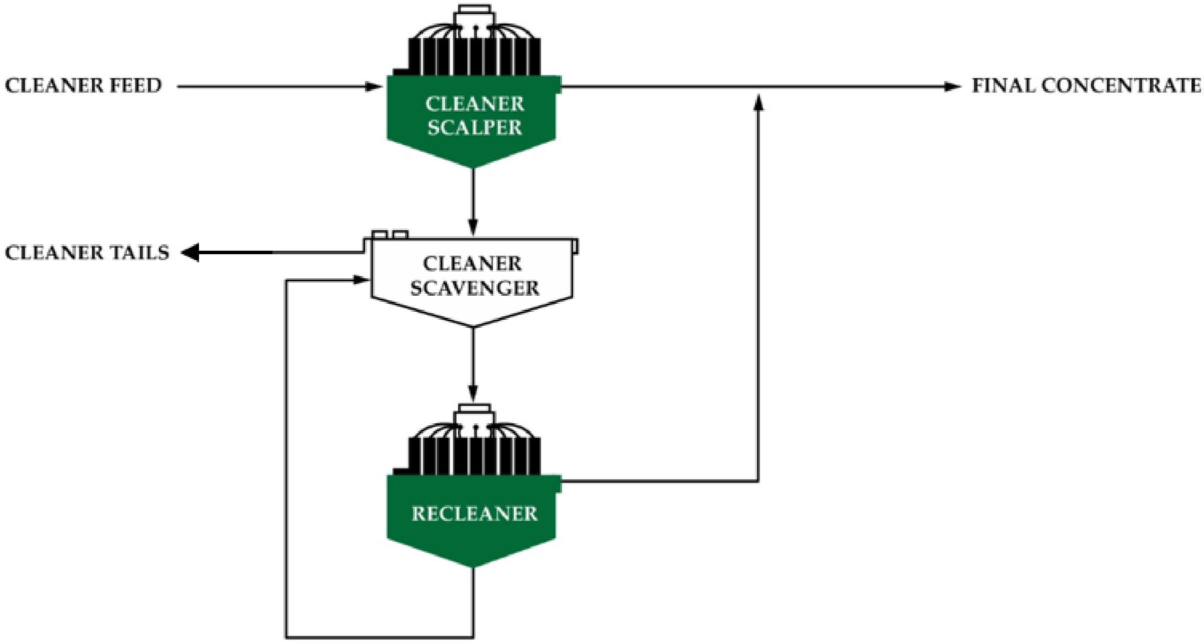

Figure 2 –Cleaner Circuit Design with Jameson Cell as Cleaner/Scalper and Recleaner

Case Study 1: Mount Isa Mines Copper Concentrator

Mount Isa Mines is one of the biggest mining operations in Australia that operates as a subsidiary of Glencore PLC, located near Mount Isa, Queensland. Mount Isa Mines operates two separate mining and processing streams: copper and silver-lead-zinc. The mining and smelting complex produces copper anodes, crude lead bullion (containing silver), and zinc concentrate. The copper operation mine chalcopyrite as the only significant copper mineral that occurs as a replacement deposit in a silica-dolomite host rock. The sulphide gangue consists of pyrite, minor amounts of pyrrhotite and cobaltite. The non-sulphide gangue (NSG) consists of dolomite, chlorite, quartz and talc.

The copper concentrator was built to process chalcopyrite ore and has throughout its history also processed converter slag when mine output allowed, to produce copper concentrate. The concentrator was commissioned in 1973 and by 2015 most of the flotation cells had reached their service life, therefore it was decided to perform an online refurbishment which gave an opportunity to re-design the cleaner circuit. Figure 3 shows the flowsheet before the refurbishment. The cleaner circuit consisted of 33 flotation cells: three 2.5m x 17m column cells, twelve 120 Agitair cleaners, eight 120 Agitair re-cleaners, eight 120 Agitair retreatment and two 100 m^3 Wemco cleaner/scavengers (Lawson et al., 2017).

Figure 4 shows the concentrator flowsheet after the cleaner circuit re-design where it can be seen a dramatic reduction from 33 to 5 flotation cells. The new cleaner circuit consists of one B5400/18 cleaner/scalper Jameson Cell, one B5400/18 recleaner Jameson Cell and three cleaner/scavengers (one B5400/18 Jameson Cell and the two 100 m^3 Wemco). The cleaner/scalper Jameson Cell takes rougher concentrate and produces final concentrate. The cleaner Jameson Cell receives the tails from the cleaner/scalper and the cleaner/scavenger concentrate (Jameson Cell and mechanical cells) to produce final concentrate. The cleaner/scavenger Jameson Cell takes the cleaner Jameson Cell tails plus the reground rougher/scavenger concentrate.

The Jameson Cell units were sized based on the surface area required to remove 5 $t/h/m^2$ and not residence time as is the conventional approach. The Jameson Cell can also be simulated from laboratory flotation tests. Figure 5 shows the comparison of the grade/recovery curve created with the laboratory flotation test and the curve produce with the industrial Jameson Cell after commissioning at Mount Isa Copper Concentrator.

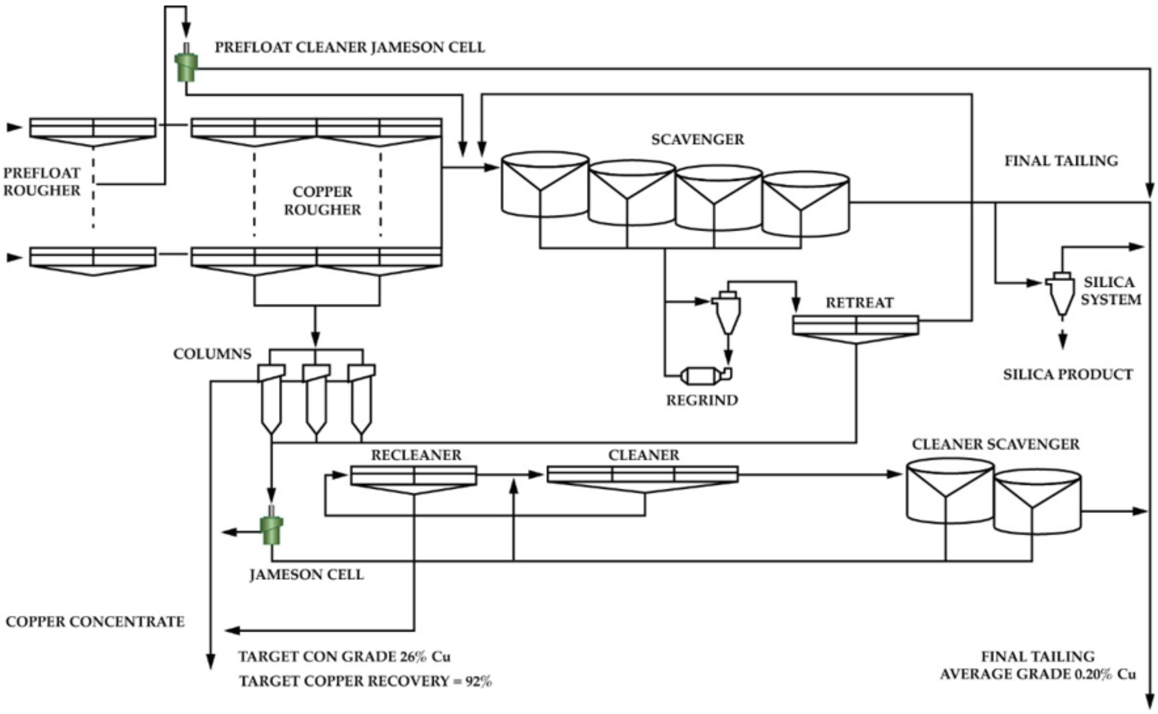

Figure 3 – Mount Isa Concentrator flowsheet before the refurbishment

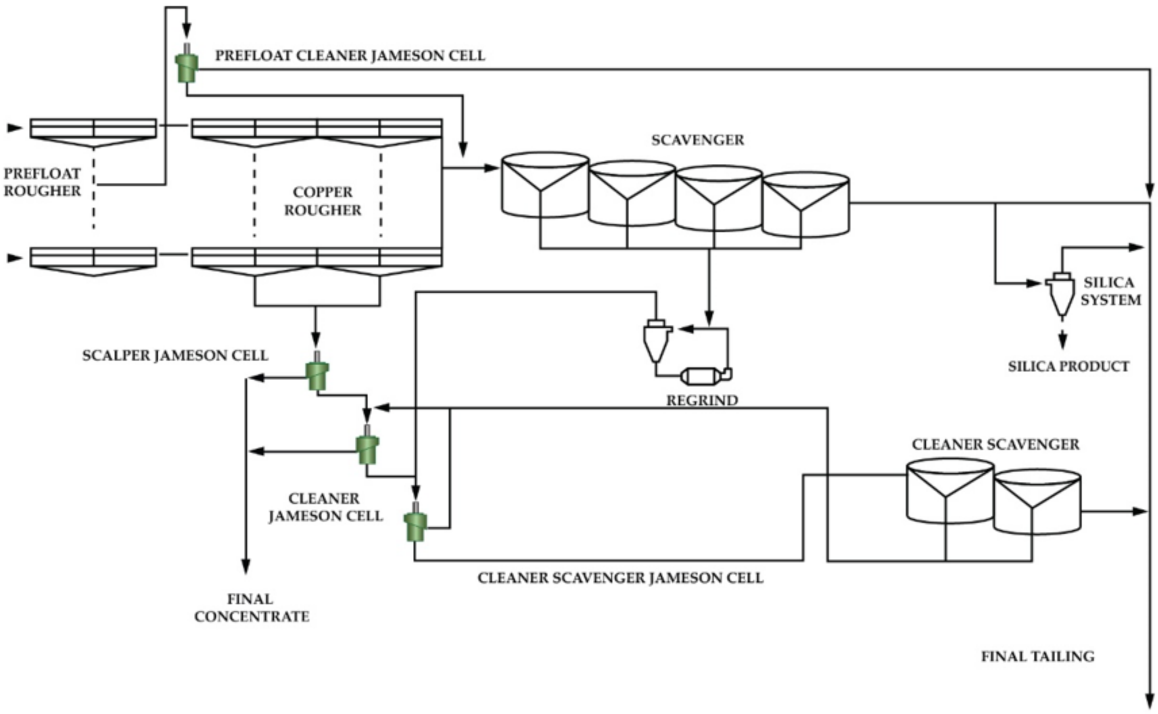

Figure 4 – Mount Isa concentrator flowsheet after the installation of Jameson Cells

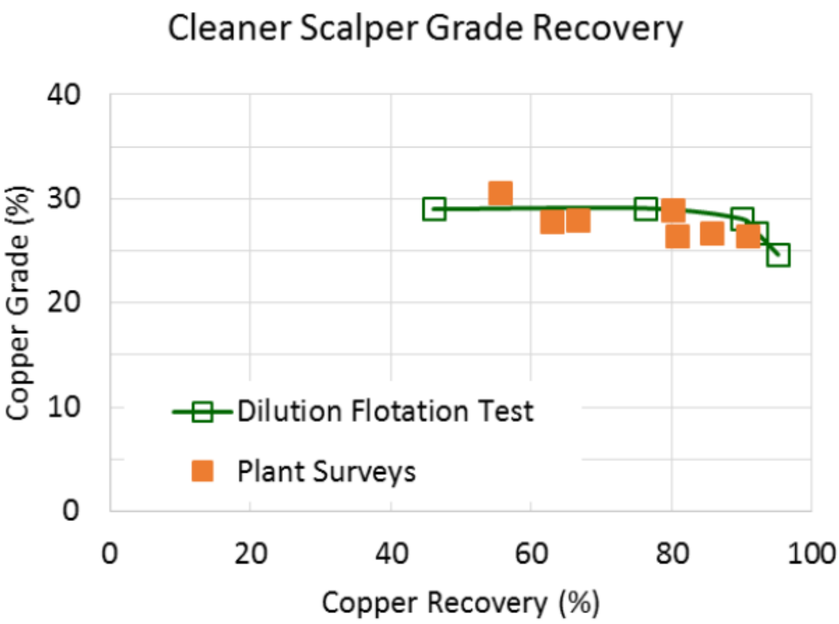

Figure 5 – Comparison between dilution cleaning test and industrial Jameson Cells at Mount Isa copper concentrator

Case Study 2: CSA Cobar

CSA Mine is an underground copper mine owned by Cobar Management Proprietary Limited (CMPL), a wholly owned subsidiary of Glencore PLC. It is located 14 km north of Cobar in New South Wales. The main copper species processed are chalcopyrite and cubanite. It is a high grade copper mine with head grades varying from 5 to 8%. The large variations in feed grade often overwhelmed the flotation process leading to the need to by-pass rougher concentrate directly to final concentrate. In addition to this challenge, the last stage of cleaning that consisted of Denver cells installed in 1965 that needed to be replaced. A plant upgrade project was requested with the ultimate goal of increasing the concentrate grade from 28% Cu at 96% overall recovery to 30% without compromising the overall copper recovery. The flotation circuit before the plant upgrade consisted of two banks of five 500 ft^3 Wemco Cells roughers, two banks of ten 1.8 m^3 Denver Cells as first cleaners, two banks of five 1.8 m^3 as second cleaners. The rougher and cleaner tails were sent to three 30 m^3 Outotec Cells.

Figure 6 shows the flowsheet of the new flotation circuit. The cleaner circuit was re-designed to increase the concentrate grade and to eliminate the need to by-pass the rougher concentrate to final concentrate, therefore making it easier to operate. A cleaner/scalper E4232/10 Jameson Cell was added to produce final concentrate. The second cleaners (ten 1.8 m3 Denver Cells) were replaced with only one E1732/4 Jameson Cell. Figure 7 shows the characteristic grade vs. recovery curves for the cleaner/scalper and re-cleaner Jameson Cell at CSA Mines. It can be seen that the cleaner/scalper is removing most of the mass of copper as final concentrate with unit recoveries greater than 80%, due to collecting the fast-floating-liberated mineral particles. On the other hand, the more challenging grade/recovery curve of the re-cleaner Jameson Cell clearly indicates that it is recovering a greater number of composite particles (Huynh et al., 2014). This new cleaner circuit was capable of producing the target grade and recovery, 30% Cu and 96%, respectively.

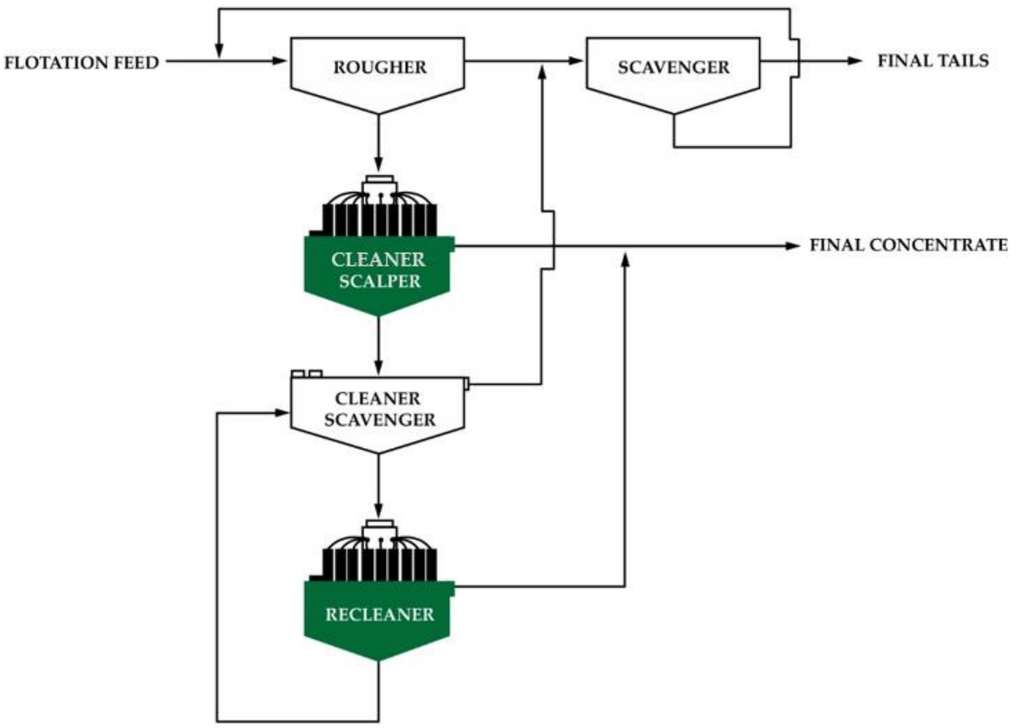

Figure 6 – Flowsheet at CSA Mines with the New Cleaner Circuit Design

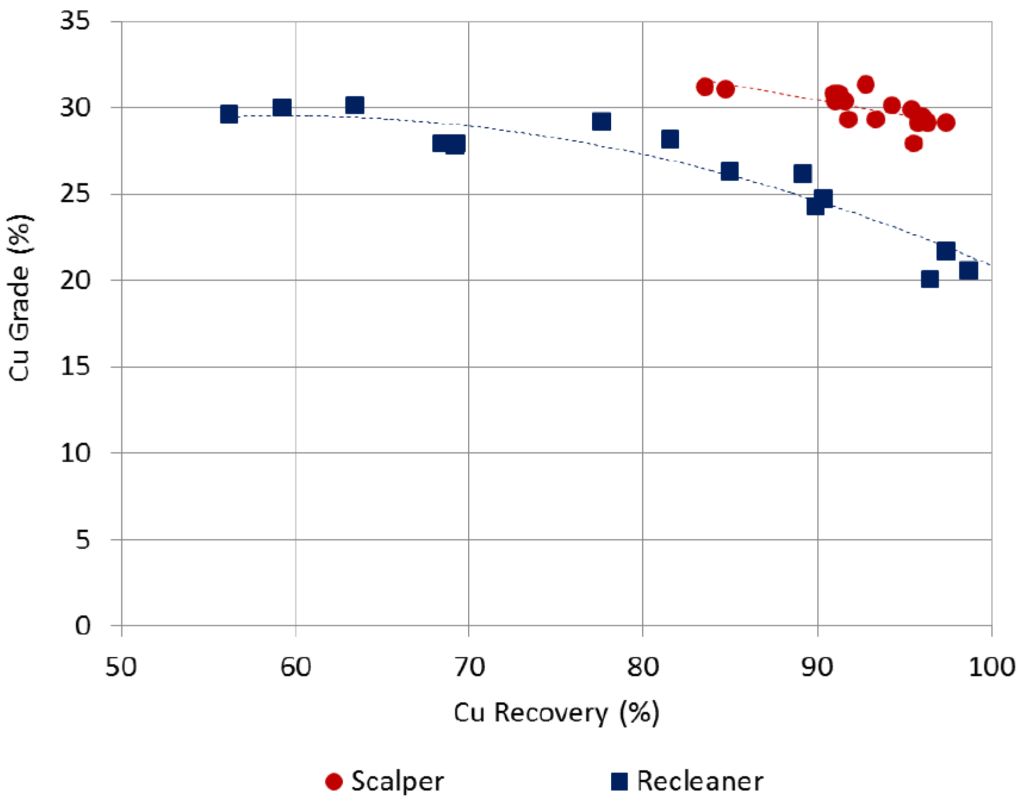

Figure 7 – Grade vs. Recovery Curve of the Two Jameson Cells at CSA Mines

Conclusions

Depletion of world's mineral resources is causing the need to process more complex ore bodies. This challenge is forcing mineral processing plants to adopt more efficient flotation circuits and flotation technologies. An improved cleaner circuit designed was proposed. This circuit is able to achieve ultimate metallurgical targets, great stability in the face of feed variations, reduced plant footprint, and a more robust operation. The Jameson Cell represents a key element in this improved cleaner circuit due to its exceptional metallurgical performance. Case studies were presented in which conventional cleaner circuits were re-designed to implement in industrial scale the improved cleaner circuit with exceptional results. The Mount Isa Mines Copper Concentrator was upgraded resulting in a reduction from 33 flotation cells in the cleaner circuit to only 5 flotation cells without compromising overall concentrate grades and recoveries (Lawson et al., 2017). CSA Mines was able to improve its already spectacular targets from 28% Cu grade at 96% overall recovery to 30% Cu grade at 96% recovery (Huynh et al., 2014).

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