Development of an Innovative Copper Flowsheet at Phu Kham

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Phu Kham Location in Laos

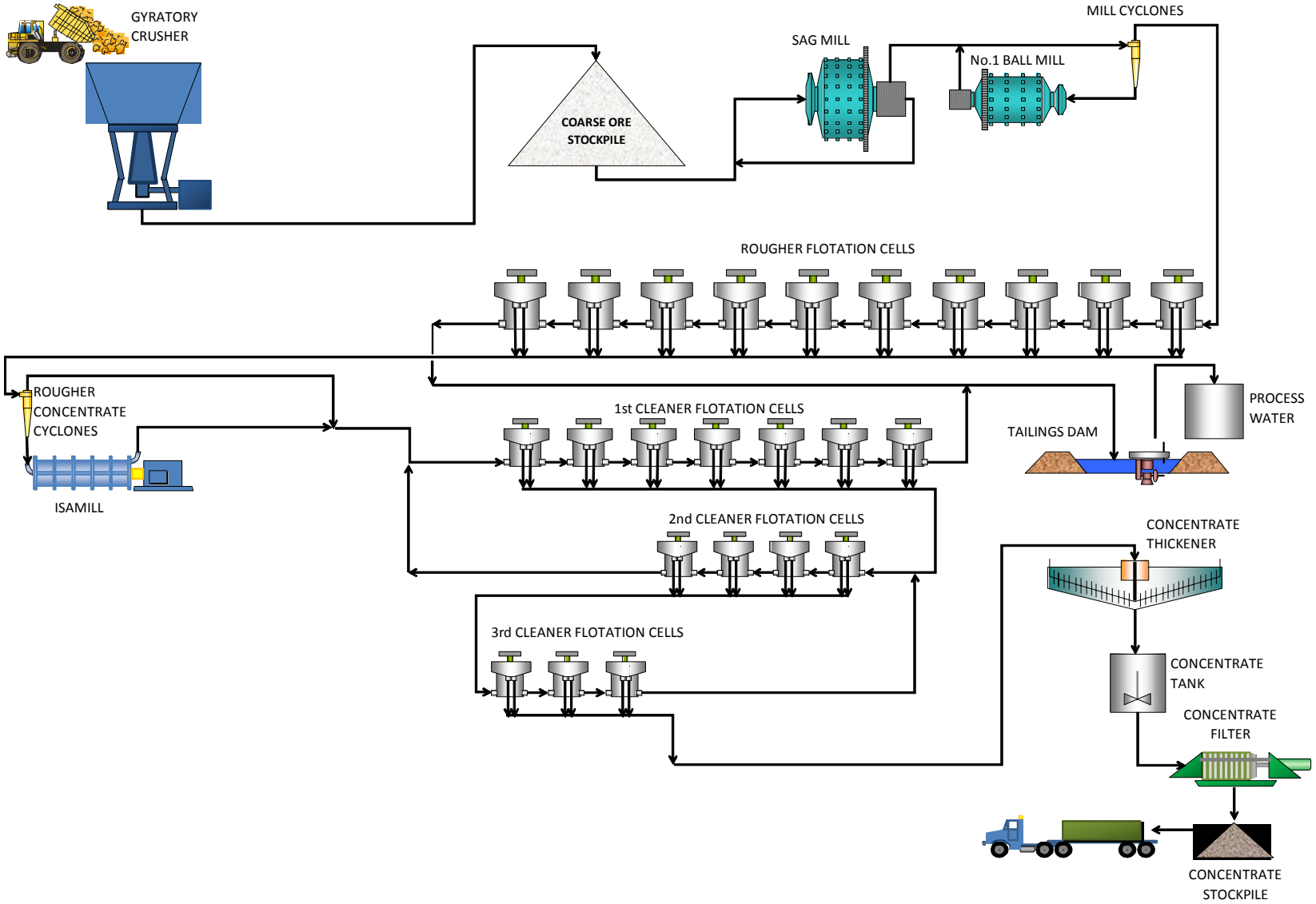
Phu Kham Plant Layout

Phu Kham process plant at night

Plant Layout showing

- Primary Grinding
- Rougher Flotation
- IsaMill Regrinding

Phu Kham Flowsheet



Phu Kham Flowsheet

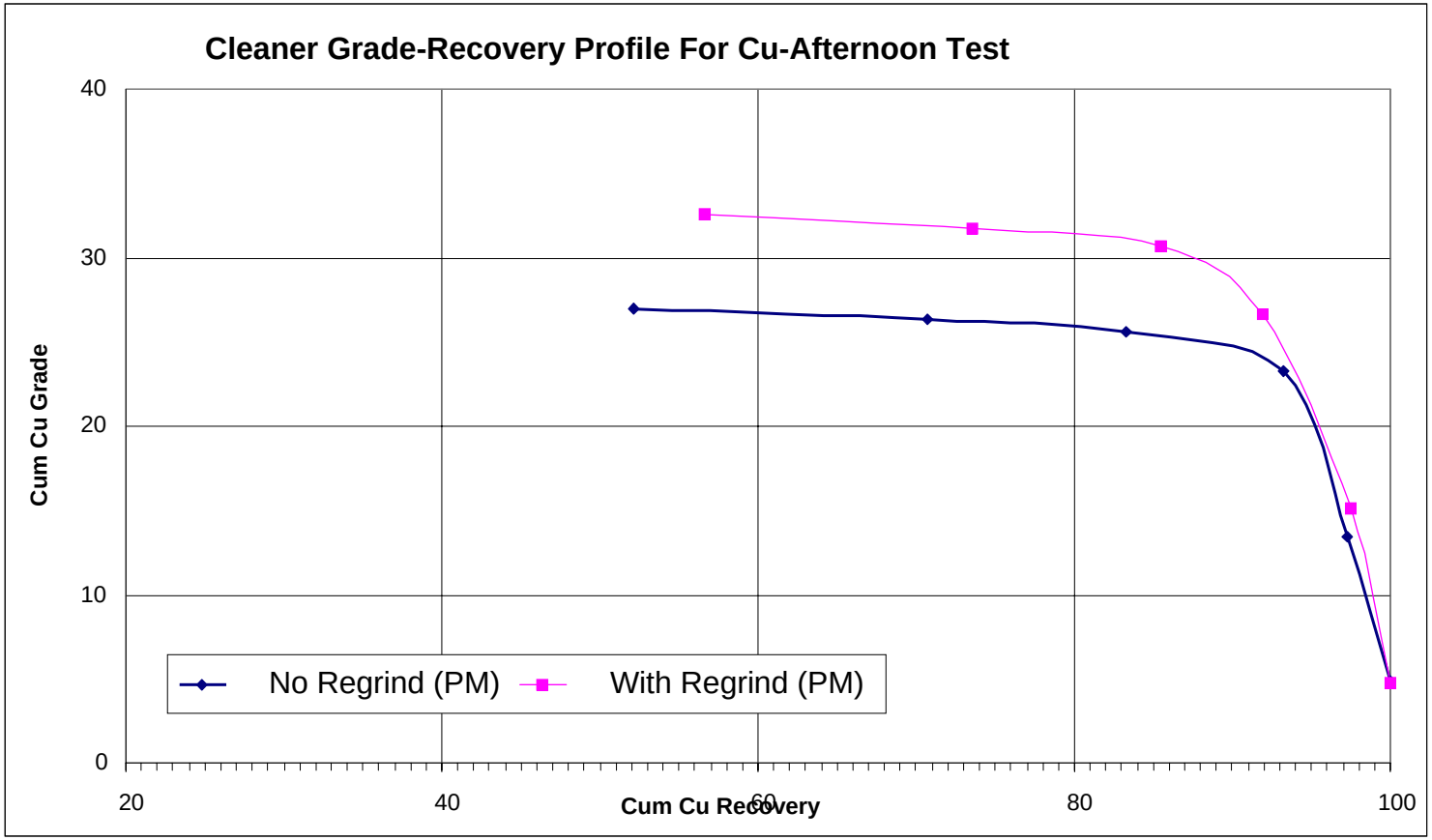
- 12.8 Mt/a of copper-gold bearing ore from the open pit
- Plant Feed Grades are 0.75% Cu and 0.33g/t of Au and 3.8g/t of Ag
- Concentrate quality is +25% Cu, 7 g/t of Au and 60g/t of Ag

- Primary Grinding Circuit contains
  - 34 ft × 18 ft (13MW) SAG mill
  - 24 ft × 39 ft (13 MW) ball mill
- Regrinding Circuit contains
  - M10,000 (2.6MW) IsaMill

- Ore has fine locking of copper and gangue minerals
- Ore requires regrinding rougher concentrate to 38 microns to make good quality final copper concentrate

Cleaner Feed Performance

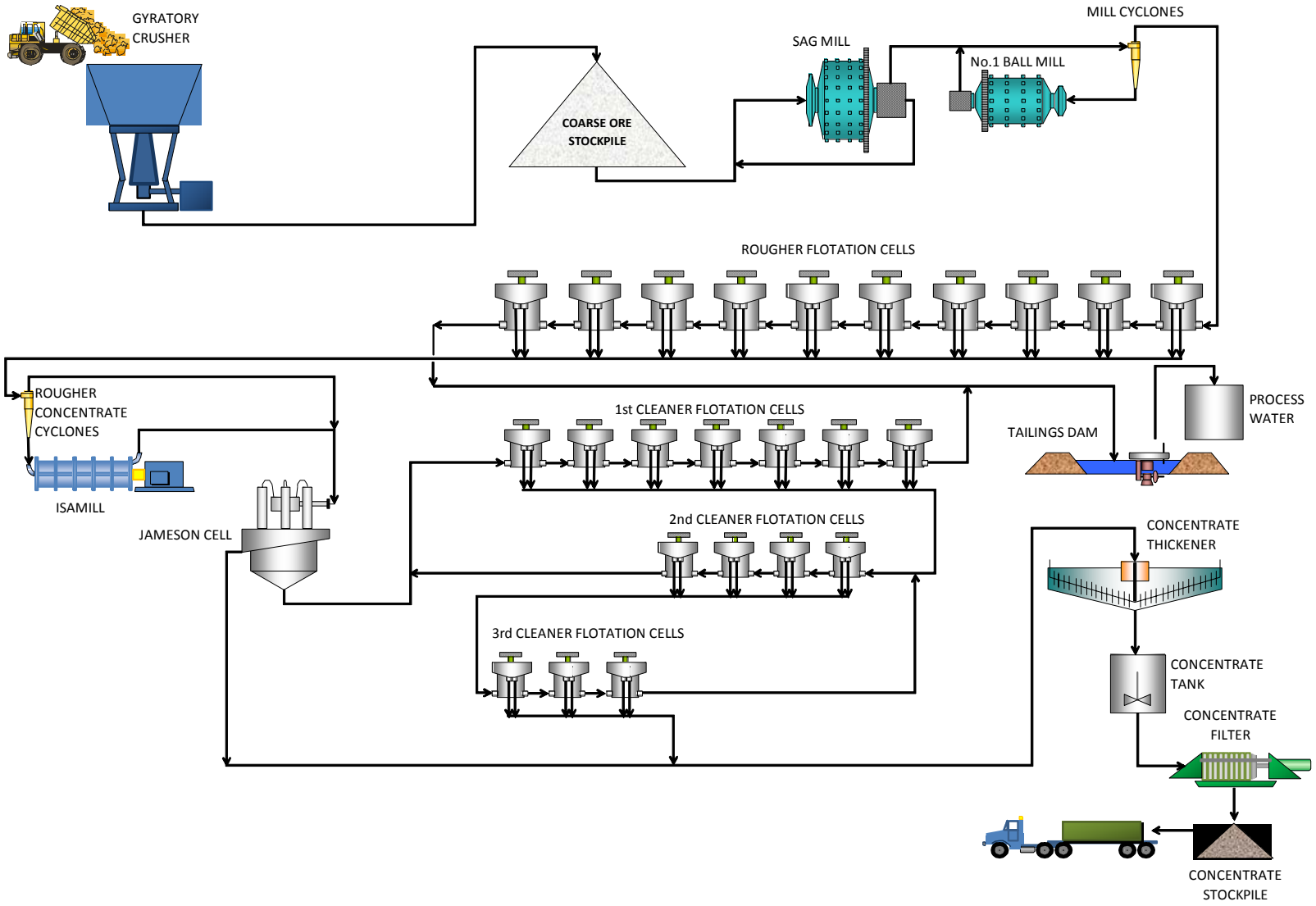
- IsaMill currently grinds from 90 microns to 38 microns
- Cleaner feed performance at 38 microns and 25 microns
- Laboratory Flotation Tests



New Phu Kham Flowsheet

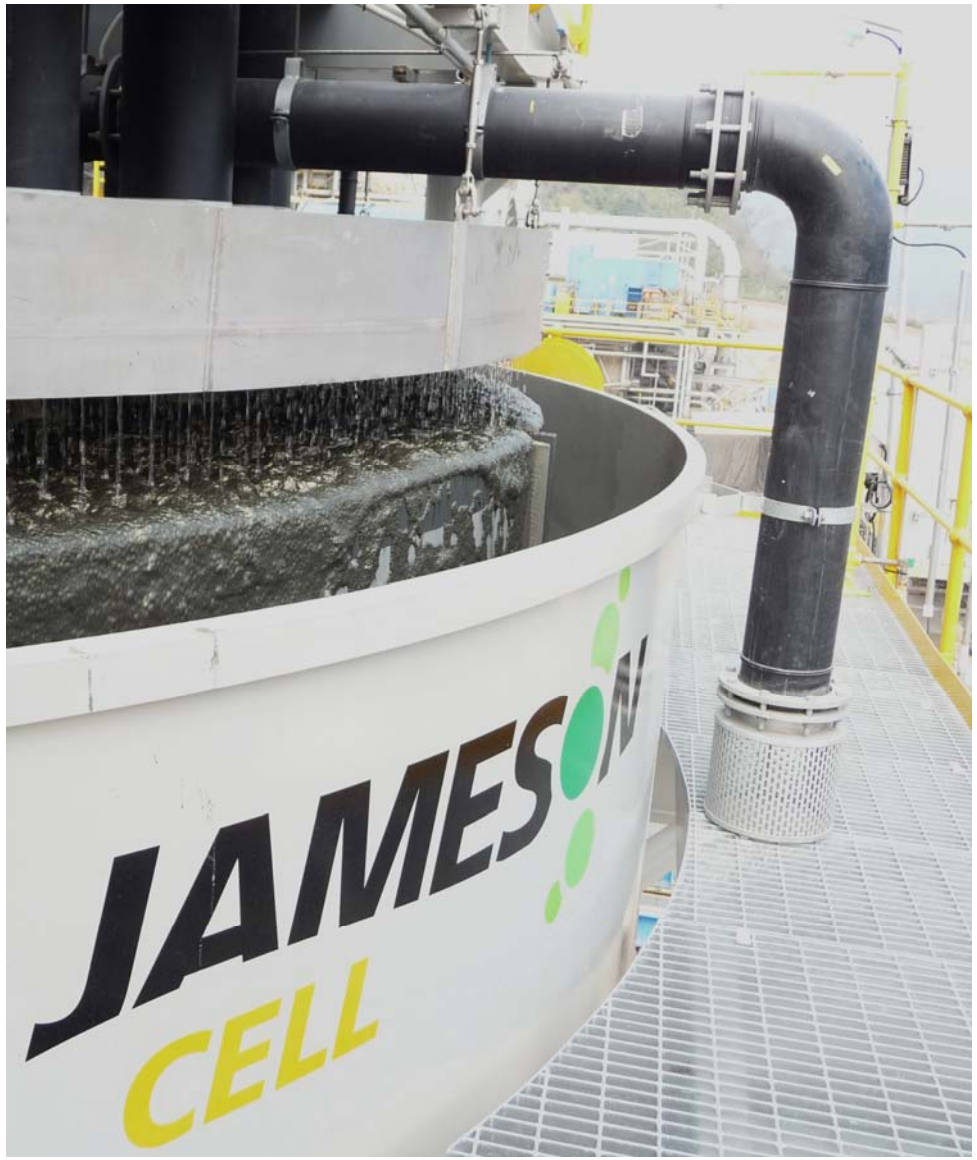
- Cleaning Circuit was overloaded at times
- Fine grinding to improve concentrate quality, slowed flotation rate and increase frothing issues in the cleaner circuit, decreasing the performance of the cleaner circuit
- Jameson Cell with froth washing was installed at the head of the cleaner circuit to increase cleaning capacity
- This new circuit allowed final concentrate to be produced from the IsaMill regrind product in one flotation cell and remove more than half the load from the existing cleaning circuit

New Phu Kham Flowsheet



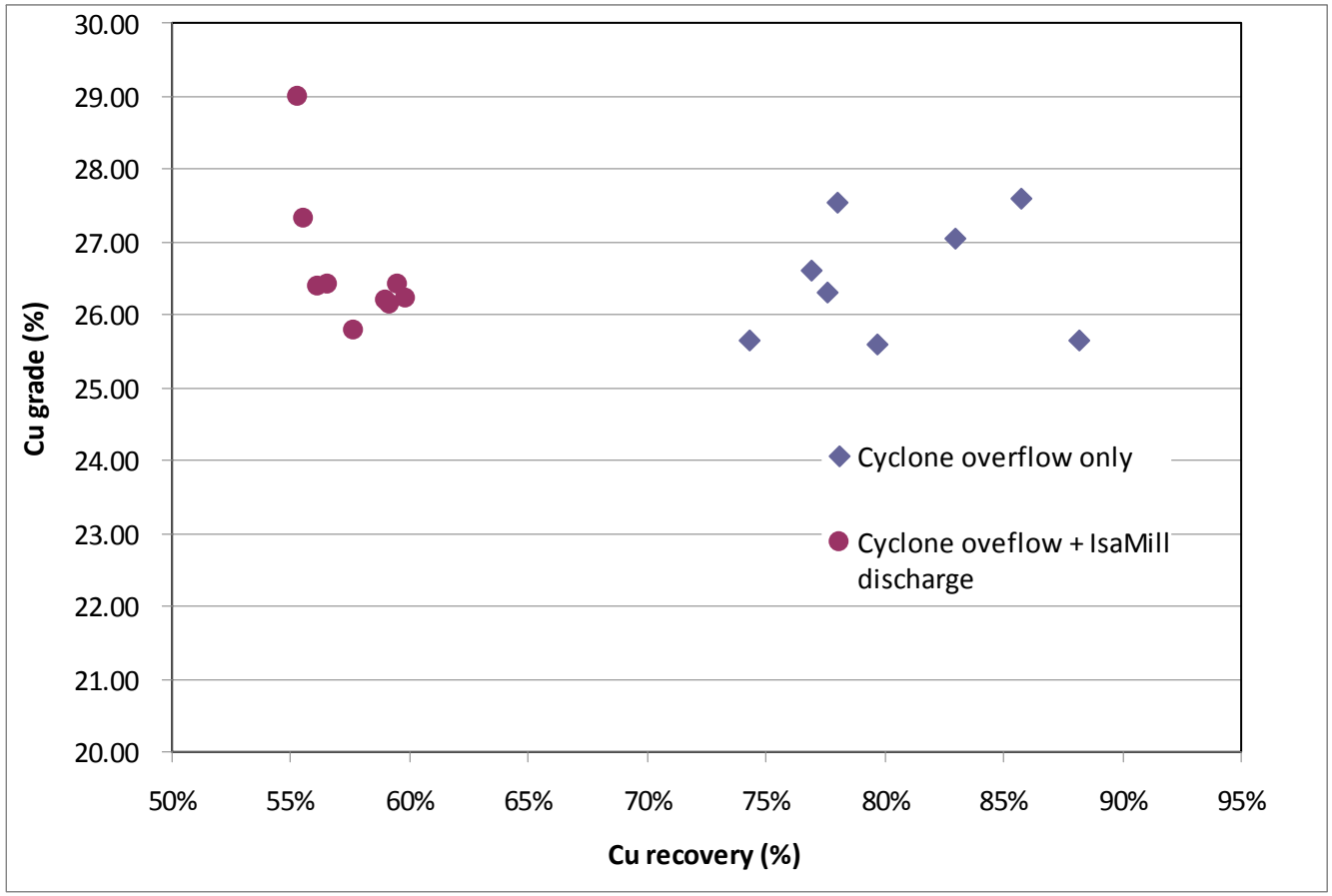
Layout of IsaMill and Jameson Cell

Jameson Cell Flotation at Phu Kham

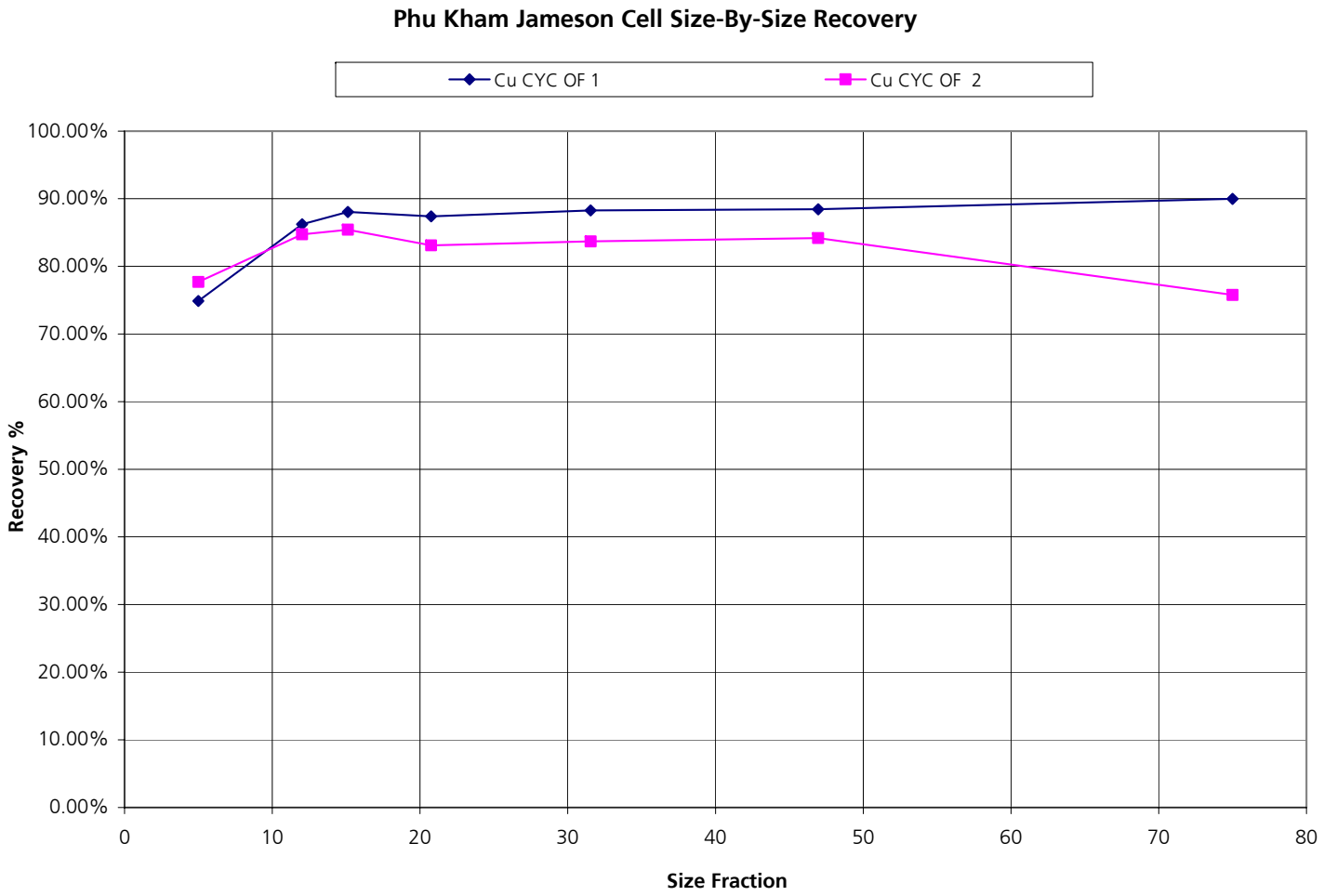


Phu Kham Jameson Cell
Grade-Recovery Curve Performance

- IsaMill Cyclone Overflow P80=20 microns
- IsaMill Discharge P80=38 microns
- Feed (Rougher Conc) Grade = 3-5% Cu



Jameson Cell Size by Size Recovery on IsaMill Cyclone Overflow Stream

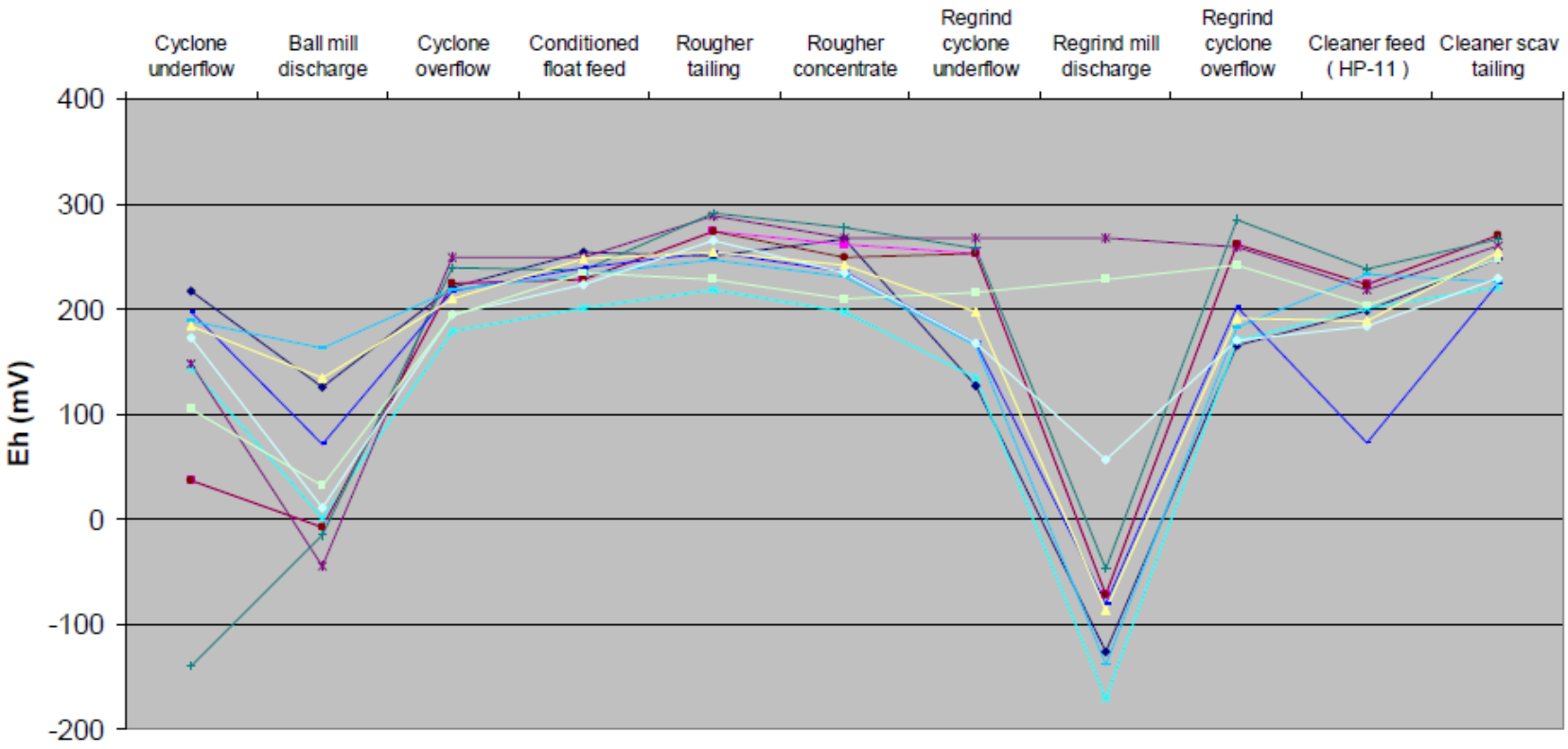


New Cleaning Circuit Results

- Jameson Cell was initially commissioned on the regrind cyclone overflow
- Cyclone Overflow was fine (P80=20 microns) and well liberated
- Jameson Cell produced 25.5% to 27.5% Cu grade at 75% to 90% Cu recovery on this stream
- Jameson Cell produced high recovery in all size fractions for this stream

- Jameson Cell then treated cyclone overflow plus IsaMill discharge
- Jameson Cell still produced high grade copper concentrate at 26% to 29% Cu grade at 55% to 60% copper recovery
- The recovery of the coarser size fraction was lower due to the locking and lower liberation in the size fractions

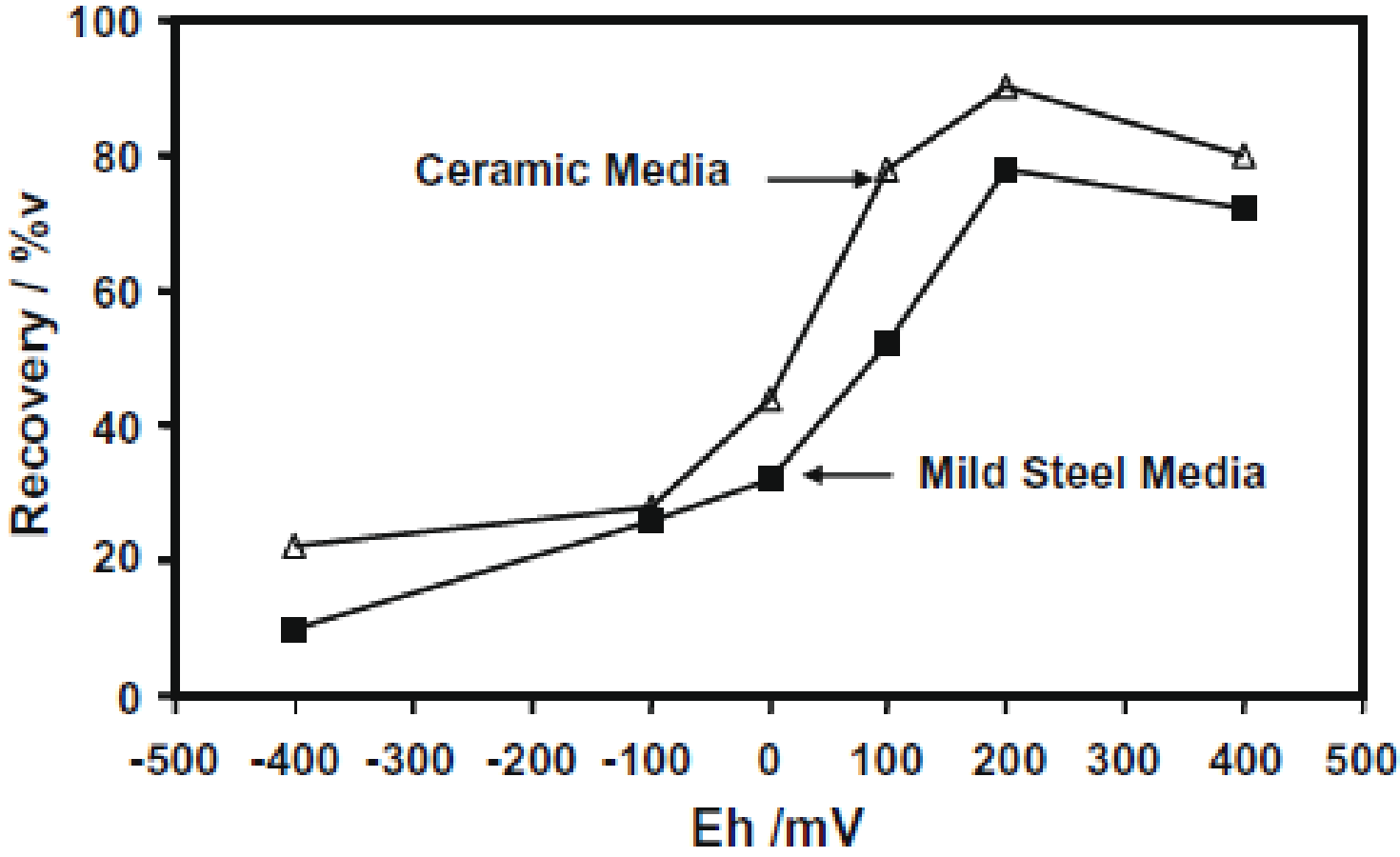
Redox Measurements in Plant



Low Eh reduces the copper mineral flotation performance

Impact of Inert Grinding - Chalcopyrite

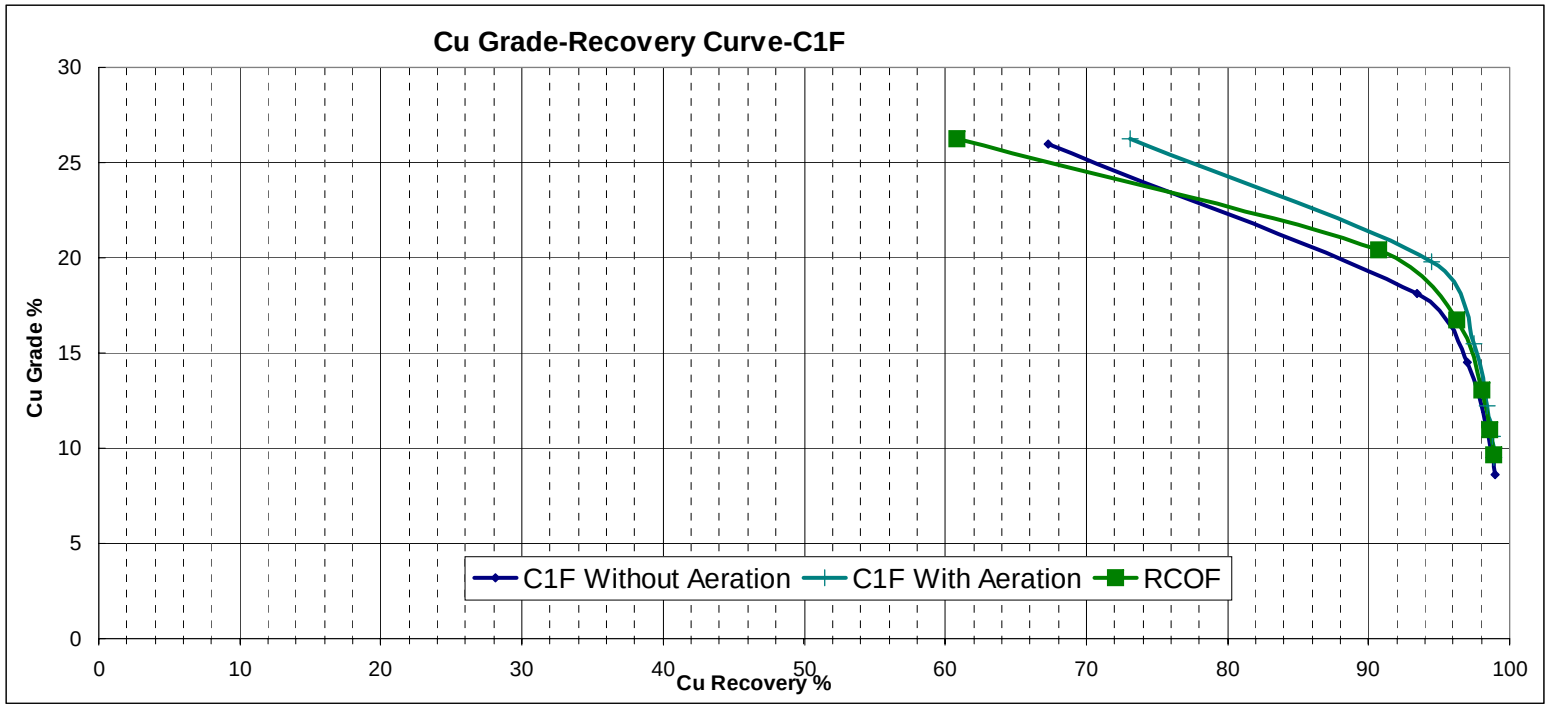
The Effect of Eh – Mt Isa Cu Ore



The critical importance of the grinding environment on fine particle recovery in flotation - Stephen Grano - 2009

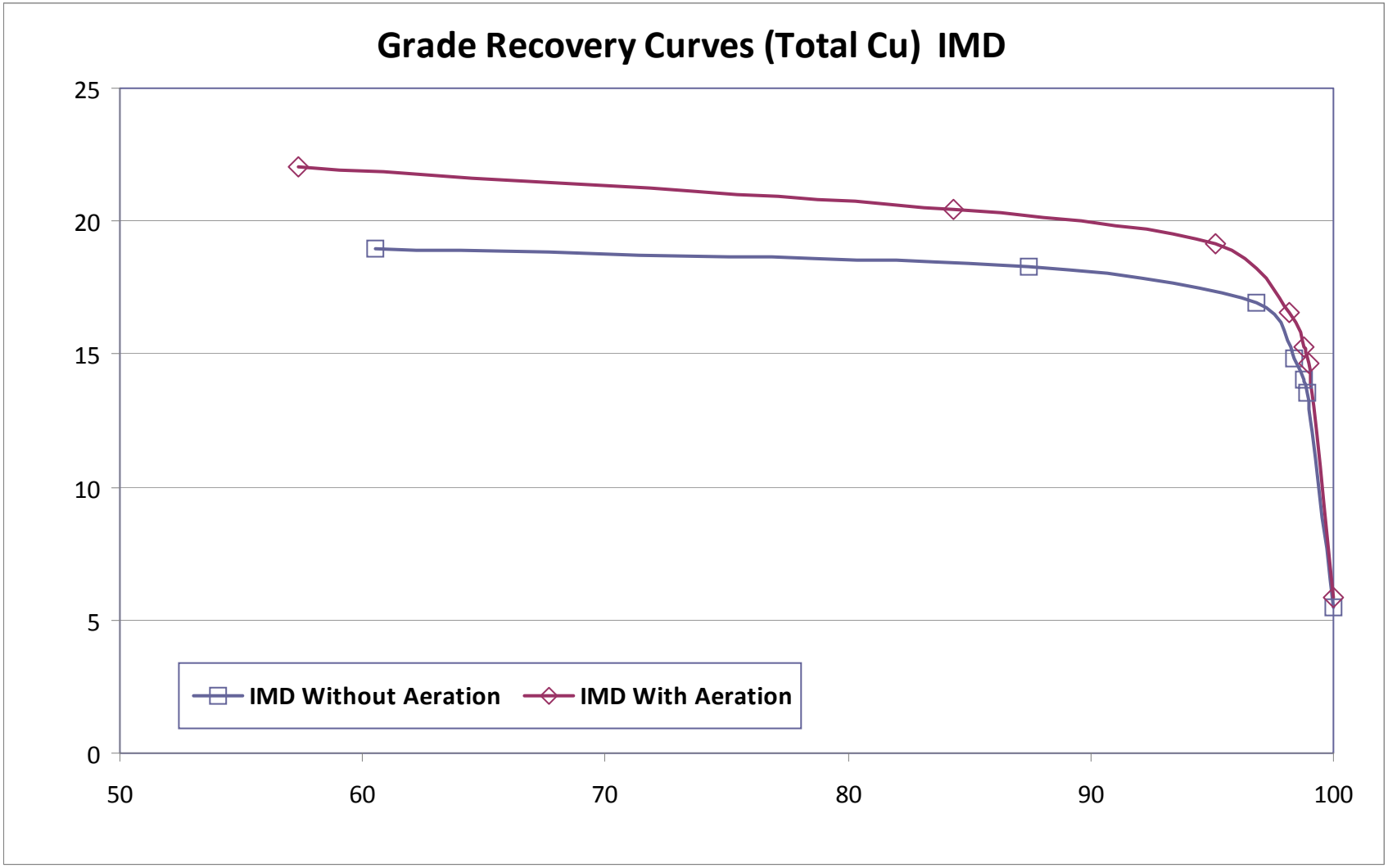
Cleaner Feed Performance

The Effect of Aeration in Laboratory Float

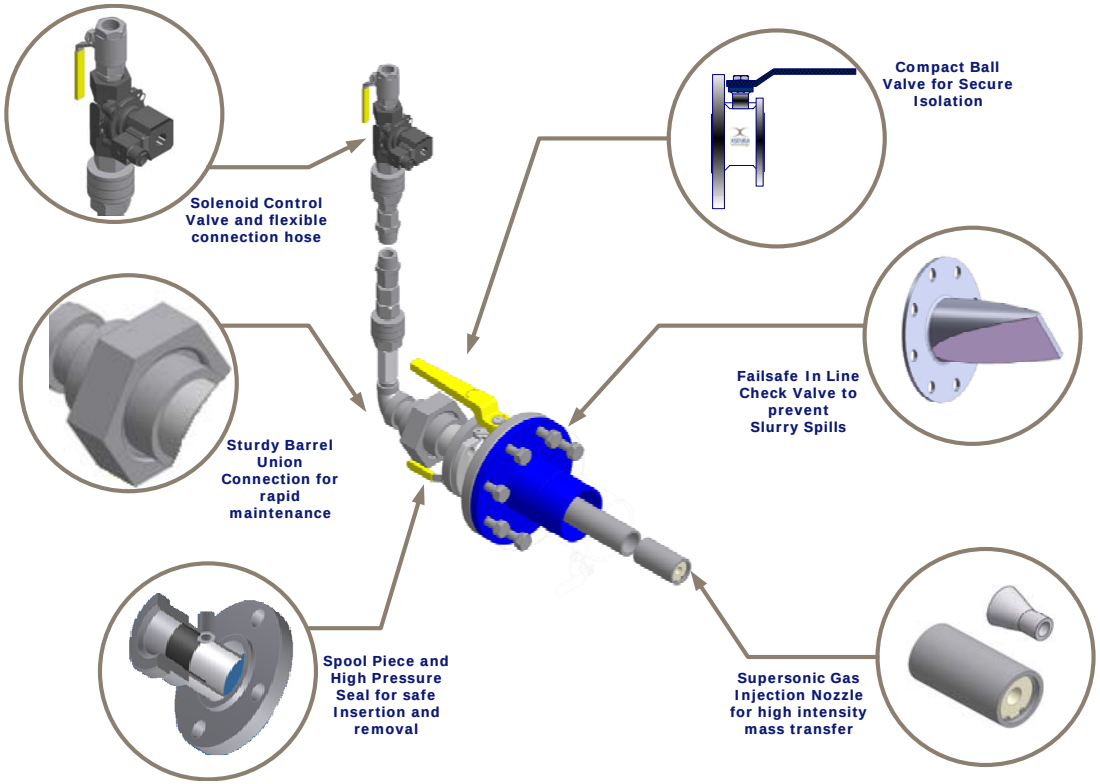


IsaMill Discharge Performance

The Effect of Aeration in Laboratory Float

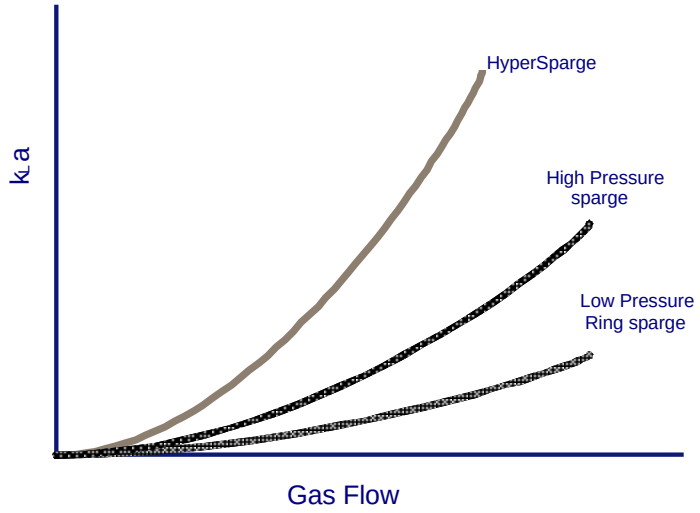


HYPERSPARGE
Supersonic Gas Injection



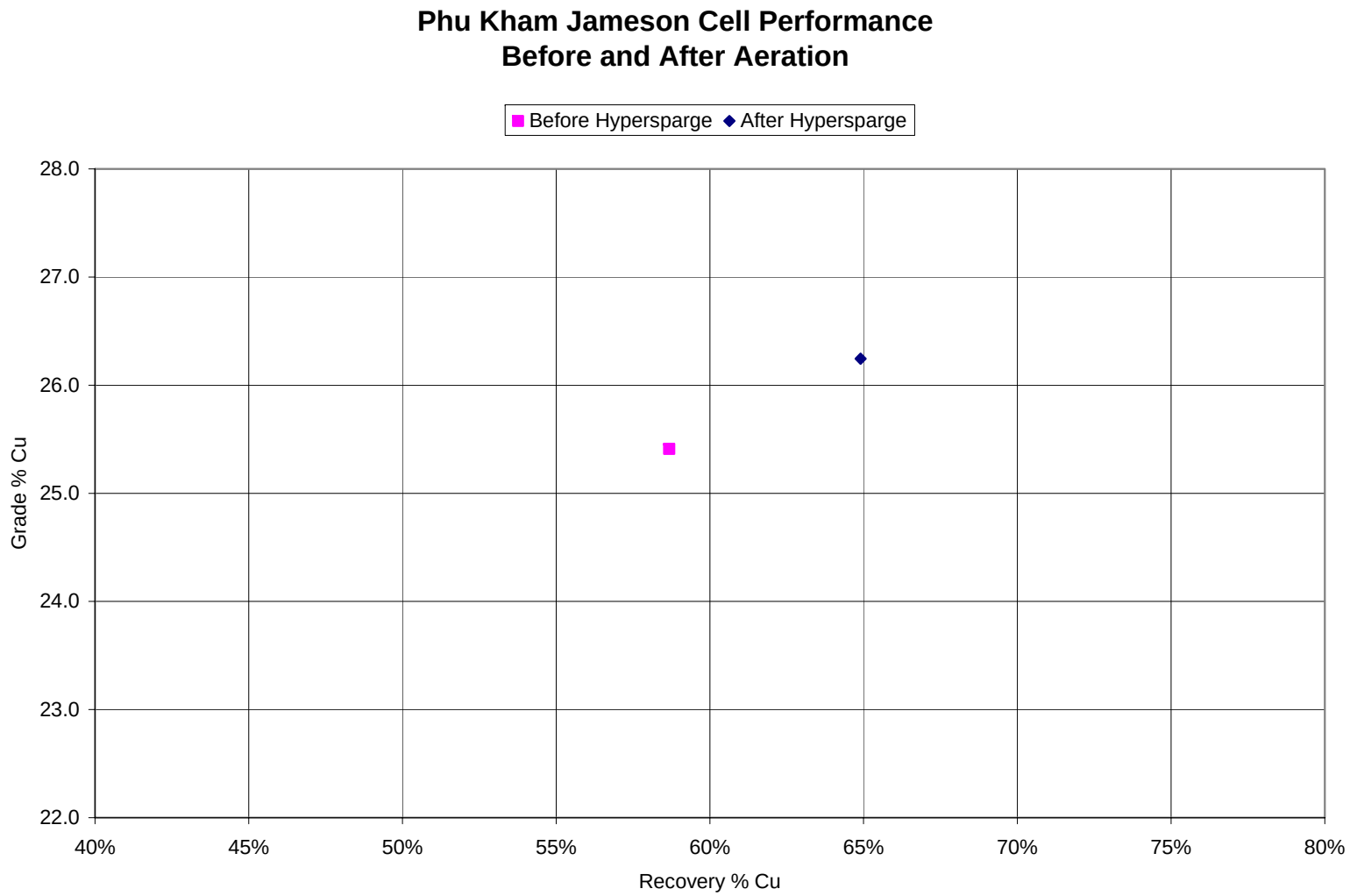
Fine Bubble Generation

Able to generate much finer bubbles for fast gas transfer rates



HyperSparge installed in IsaMill Discharge line

Phu Kham – Effect of Aeration Plant Surveys



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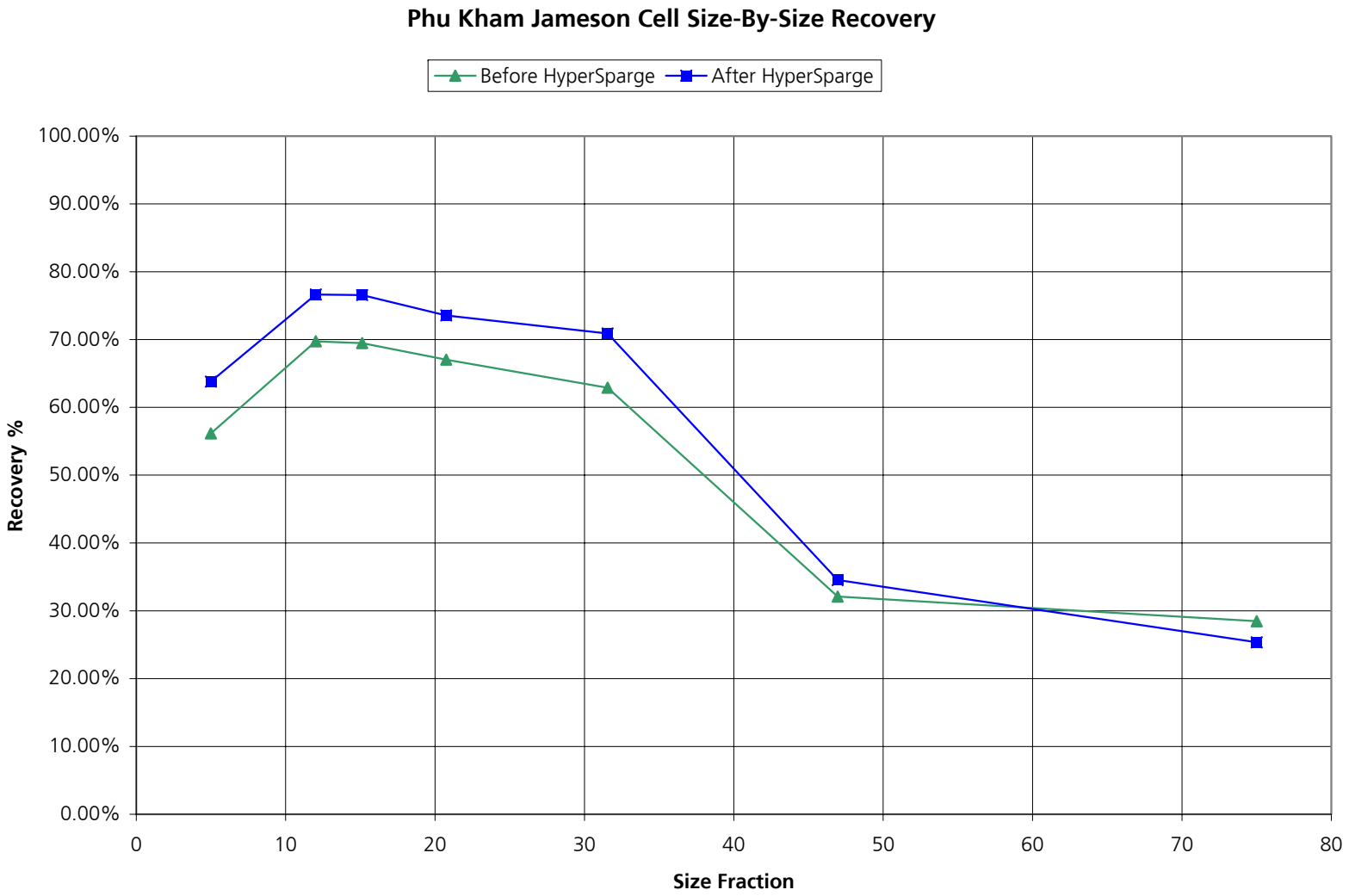

Summary

- IsaMill regrinds rougher concentrate to 38 micron to improve the final copper concentrate quality

- Cleaner feed performance at 38 microns is 25-28% Cu in final concentrate
- and regrinding 25 microns can produce +30% Cu in final concentrate

- Jameson Cell installation was an innovative flowsheet change to removed load from cleaning circuit and increased plant capacity and decrease cleaner circuit frothing issues

- Aeration of Cleaner feed has improve performance and fines recovery and selectivity

- Jameson Cell has allowed the IsaMill to operate at Increase power to improve the circuit performance.