COMO ENGINEERS

Laverton Process Plant DFS

Process Description – 1.0Mtpa

Brightstar Resources Limited

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Brightstar Process Description

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1 PROCESS DESCRIPTION

The Laverton process plant has been designed based on processing 1,000,000 tpa of gold ore. The crushing plant is designed to operate on double shift at 75% availability with a throughput of 152 t/h. The design milling rate is 125 t/h based on an availability of 91.3%.

The processing circuit includes the following major equipment areas:

- Crushing
- Screening
- Milling and gravity separation
- Cyclone classification
- Gravity concentration and intensive leaching
- Leaching and adsorption
- Elution circuit and carbon regeneration
- Services and reagents.

1.1 Crushing

The crushing circuit will produce crushed ore with a P_{80} of 12 mm to feed the milling circuit. The crushed ore will be stockpiled, reclaimed with a front-end loader and subsequently fed into to a fine ore bin. All conveyors in the crushing circuit are fixed speed and are equipped with:

- Belt scrapers
- Belt ploughs
- Belt underspeed detection
- Belt drift detection
- Local emergency stop buttons
- Local isolation, and
- Conveyors pull wires.

Walkway access is provided on one side of the conveyor to the head pulleys on the following conveyors:

- Screen feed conveyor
- Fine ore bin feed conveyor
- Secondary and tertiary crusher feed conveyors.

All conveyor transfer chutes are fitted with blocked chute detectors which are interlocked to stop the respective conveyor drive if a chute has a high level.

1.1.1 Primary Crushing

Ore is fed by front-end loader to the ROM bin which is fitted with parallel grizzly scalping bars at 600mm spacing to prevent oversize entering the ROM bin.

The ROM bin is equipped with dump/no dump lights to regulate feeding ore to the bin.

The ROM bin dump point incorporates a concrete pad with integrated tyre bump stop.

Ore is withdrawn from the ROM bin at a controlled rate by a variable speed apron feeder, feeding the vibrating grizzly to remove any undersized material before feeding the oversized to the primary crusher and controlled from the crusher control room.

The primary crusher is a single toggle 32” x 45” or equivalent jaw crusher.

Ore passing through the jaw crusher falls onto the heavy-duty Primary Sacrificial Crusher Discharge Conveyor. This conveyor also receives crushed product from the secondary and tertiary crushers and is fitted with an overhead magnet at the discharge end to remove tramp metal. The Primary Sacrificial Crusher Discharge Conveyor discharges to the Screen Feed Conveyor.

From the primary crusher, crushed ore feeds onto a double deck vibrating screen which sizes the crushed ore into mill feed and secondary/tertiary crusher feeds. The transfer chute onto the screen is designed to ensure even distribution of material across the screen. Additional screening capacity has been allowed in the screen size selection.

The screen undersize (nominally P_{80} of 12 mm crushed product) is fed to the Fine Ore Bin by a product conveyor.

1.1.2 Secondary Crushing

Top-deck oversize from the product screen is fed to the secondary crusher by the secondary crusher feed conveyor. A metal detector is fitted to detect any tramp metal on the conveyor.

The secondary crusher feed can is fitted with a level element transmitter. Ore feed to the crusher feed can is controlled by the primary feeder.

Level control allows choke feeding of the crusher to ensure efficient operation and minimise power and wear.

The secondary crusher has adjustable closed side setting, which can be changed using the vendor supplied hydraulic adjustment pack.

1.1.3 Tertiary Crushing

Bottom-deck oversize from the product screen is fed to the tertiary crusher by the tertiary crusher feed conveyor. A metal detector is fitted to detect any tramp metal on the conveyor.

The tertiary crusher feed can is fitted with a level element transmitter. Ore feed to the crusher feed can is controlled by the primary feeder.

Level control allows choke feeding of the crusher to ensure efficient operation and minimise power and wear.

The tertiary crusher has adjustable closed side setting, which can be changed using the vendor supplied hydraulic adjustment pack.

1.1.4 Fine Ore Storage

The mill feed bin has a live volume of 26m^3, equating to 20 minutes of production.

An overflow chute and level sensor are fitted to the mill feed bin so that when the bin is full, excess ore will flow to the stockpile transfer conveyor and subsequently to the crushed ore stacker for relocation to the emergency stockpile. When the crushers are offline, this crushed ore is reclaimed from the stockpile using the front-end loader and fed into the milling circuit via the mill feed bin.

Crushed ore is withdrawn from the mill feed bin using a belt feeder with a variable speed drive. The speed of the belt feeder is controlled by a process loop to the weightometer located on the mill feed conveyor. The mill feed rate is automatically controlled to the selected mill feed rate.

The crushed ore is transferred from the mill feed bin via the belt feeder to the mill feed conveyor. The mill feed conveyor is fitted with a walkway to one side and a dual idler weightometer linked to the belt feeder VSD via a PLC to control the mill feed rate setpoint.

Ball mill grinding media addition is from the crushed ore stockpile via the FEL.

A lime silo and feeder are located above the mill feed conveyor. Bulk lime is delivered to site and pneumatically transferred to the lime silo. The lime is fed by a variable speed screw feeder onto the mill feed conveyor at a rate controlled by a pH loop in the first leach tank.

1.2 Milling and Classification

The milling circuit comprises a single stage 2,600kW ball mill, fitted with rubber liners, discharge trommel and operating in closed circuit with cyclone classification. The mill discharge density is controlled by water addition to the mill feed chute, regulated using a flowmeter and flow control valve. The mill discharge slurry flows through the trommel screen into the mill discharge hopper fitted with a level indicator. The slurry level in the mill discharge hopper is controlled by a level control loop to the VSD on the Cyclone Feed Pump motor.

The mill discharge slurry is pumped to a cluster of 10" cyclones for classification to oversize (product which is at the P_{80} of 106µm for the leach circuit) and coarse undersize. Operation of the cyclones is monitored by a slurry flowmeter and pressure transmitter. The cyclone feed density is regulated by water addition to the mill discharge hopper using a flowmeter and flow control valve.

A fraction of the cyclone underflow slurry (~20 to 40%) is diverted from a splitter box to a horizontal vibrating Gravity Concentrator Feed Screen. The rest of the cyclone underflow will gravitate back to the ball mill feed chute.

The milling area is equipped with a manually operated sump pump that pumps into the mill discharge hopper.

1.3 Gravity Circuit and Intensive Leach

A fraction of the cyclone underflow slurry is diverted from a splitter box to a horizontal vibrating Gravity Concentrator Feed Screen. Dilution water for the gravity screen feed is added to the feed line before the screens. Oversize from the screens (nominally +2 mm) is directed to the mill feed chute. Undersize from the Gravity Concentrator Feed screens (nominally -2 mm) flows into a 30" batch centrifugal concentrator.

The concentrator maintains a fluidised bed using raw water added at a constant flow rate which is controlled by a flowmeter and flow control valve. The concentrator and feed screen can be bypassed if required for maintenance or operational purposes (during dump cycles).

The gravity concentrator is operated semi-continuously by a local PLC. Concentrate from the batch centrifugal concentrator is periodically discharged to a secure hopper feeding the gravity leach unit.

Tailings from the gravity concentrator and the gravity screen oversize are discharged into the mill feed chute.

Gold from the centrifugal concentrator is stored in the Concentrate Collection Cone to be treated in the intensive leach reactor. The intensive leach reactor dissolves gold recovered in the gravity concentrator by using a high concentration cyanide/caustic solution with added LeachAid. After leaching the gold, solids are allowed to settle, and the clarified solution is then transferred to a loaded solution tank for recovery by dedicated electrowinning cell. The barren solid is transferred the mill discharge hopper.

The Intensive Leach area is equipped with a manually operated sump pump that pumps into the mill discharge hopper.

1.4 Leaching and Adsorption

The cyclone overflow from the milling circuit is fed to the first of two leach tanks. The feed can be diverted into the second leach tank if the first tank is offline for maintenance.

The leach and adsorption circuit will comprise of two leach tanks and six adsorption tanks, each with live volumes of 632m^3. A pH probe is installed in the first leach tank and controls the lime addition rate to the milling circuit.

Cyanide is added to the first leach tank, with the option to divert it to tank 2 at a set rate controlled using a flowmeter and flow control valve.

Air is added to each of the leach tank sparges at a rate manually controlled using an adjustable pressure control valve. The air addition rate is adjusted manually to target the required dissolved oxygen levels as manually measured using a portable oxygen probe in the first leach tank.

Carbon is added to the adsorption tanks to collect the gold from solution and is pumped counter current to the direction of slurry flow using slurry airlifts. Carbon concentration in the adsorption tanks will typically be 15-20g/L, providing 9.5 to 12.6t per tank and allowing for 4t movement. The granular activated carbon adsorbs the dissolved gold from solution as it travels counter current to the slurry flow. Carbon is retained within each tank by mechanically agitated cylindrical wedge wire inter-tank screens as the slurry flows by gravity through the screens and overflow launders.

Barren carbon is added to the last adsorption tank and is successively moved up the tank train using slurry airlifts, as the carbon loads with gold.

The loaded carbon is recovered from the first adsorption tank by recessed impellor pump to the horizontal vibrating Loaded Carbon Screen, where it is washed by sprays and then flows to the acid wash circuit.

The tailings slurry flow from the last adsorption tank will gravitate to a horizontal vibrating Carbon Safety Screen. This screen will collect carbon if there is a leaking inter-tank screen. The undersize from the carbon safety screen will flow to the Tailings Hopper. Allowance has been included to feed the carbon safety screen from either adsorption tank number 5 or 6, for periods when one tank is offline.

The leach and adsorption area are equipped with a manually operated sump pump.

1.5 Elution and Goldroom

The elution circuit is a 4.0 tonne pressure Zadra circuit. The circuit includes separate acid wash and elution columns, electrowinning cells, thermal heater and a carbon regeneration kiln. The elution process is automated by a PLC system.

Slurry with loaded carbon from Adsorption Tank number 1 is transferred to the loaded carbon screen by a recessed impellor pump.

The loaded carbon screen recovers and washes the loaded carbon, while the underflow gravitates back to Adsorption Tank number 1.

1.5.1 Acid Wash

The loaded carbon on the screen is washed and gravitates into the acid wash column.

Once the acid wash column is full, the drain valve is closed and a mixture of raw water and hydrochloric acid (to a concentration of 3% HCl) is pumped up through the column before discharging to the tailings hopper.

After one bed volume of dilute acid has been pumped through the column, the carbon bed is then flushed with four bed volumes of raw water to remove residual acid and increase pH. The spent acid solution and rinse solution are sent to the tailings hopper.

After completing the acid washing and rinsing, the column is pressurised, and the carbon is hydraulically pressure transferred to the elution column.

The acid wash bund is equipped with a manually operated sump pump discharging to the Carbon Safety Screen.

1.5.2 Elution

Once full of carbon, the elution column is drained of excess water before being pressurised and placed in a closed loop with the eluate tank, elution heater, heat exchangers and electrowinning cells.

To recover gold, a caustic/cyanide solution is pumped from the eluate tank and pre-heated up to 90 ºC by passing through the reclaim heat exchanger. The solution is then further heated to 140 ºC in the direct fired heater.

To prevent boiling, the pressure of the system is maintained above the vapour pressure of water at 140 ºC.

The hot, pressurised solution is pumped through the elution column via screens at the base of the column. The hot caustic eluate causes the gold and silver to release from the carbon back into solution as cyanide complexes.

The solution then exits the column at the top via tube screens and flows through the hot side of the reclaim heat exchanger to lower the temperature of the eluate below boiling point. Prior to discharge to atmospheric pressure, the solution passes through a trim heat exchanger and then enters a flash pot to safely release steam.

The gold-bearing solution flows to the electrowinning cells where the precious metals are plated onto the cathodes.

The barren solution discharging the electrowinning cells gravitates back to the eluate tank. This cycle is repeated for up to 12 hours or until the barren eluate concentration target is reached.

Barren eluate from the elution circuit is returned to the first leach tank in a controlled manner.

Fresh eluate is prepared by filling the tank with potable water and adding cyanide and caustic.

After carbon stripping and electrowinning is completed, the elution column is rinsed with water to cool the carbon and remove excess caustic.

The elution column is then re-pressurised with raw water and the now barren carbon is transferred to the regeneration kiln feed hopper.

The elution area is equipped with a manually operated sump pump discharging to the leach tank number 2.

1.5.3 Carbon Regeneration

The barren carbon from the elution column is hydraulically transferred to the regeneration kiln feed hopper across a static dewatering screen. The wastewater from the underflow is gravity fed to the tailings hopper.

Once the regeneration kiln feed hopper is full, carbon is added to the kiln at a controlled rate using the VSD on the kiln screw feeder. Water entering the kiln with the wet carbon creates a reducing atmosphere and prevents burning of the carbon.

Carbon is heated to 650-750 ºC in the horizontal regeneration kiln, with the temperature regulated by a burner control loop. The high temperature removes volatiles (diesel, oils, grease etc.) and regenerates the carbon surface to near its new adsorption capability.

The regenerated carbon discharges from the kiln into a quench tank and is then pressure transferred to the barren carbon dewatering/sizing screen above the last adsorption tank.

The barren carbon dewatering screen is a static sieve bend screen, which is used to dewater the carbon before it enters the adsorption circuit. The underflow from the dewatering screen is sent to the Carbon Safety Screen.

The regeneration area is equipped with a manually operated sump pump that can be directed to the carbon safety screen or the carbon dewatering screen.

1.5.4 Gold Room

Gold is recovered as sludge from the electrowinning cathodes and after drying is smelted into doré bars.

The loaded cathodes from the electrowinning cells are periodically removed and gold sludge washed from the stainless-steel mesh using a high-pressure washer. The sludge is pumped to the gold sludge filter press, from where the sludge cake is recovered and dried in the drying oven. The drying oven is positioned beneath an extraction hood which vents external to the goldroom.

After drying, the gold sludge is mixed with fluxes and smelted in the diesel fired tilting Barring Furnace at ~1100 ºC. The Barring Furnace is positioned beneath an extraction hood which vents external to the goldroom. Once the contents of the barring furnace are fully molten, it will have separated into two phases: reduced metal and slag. The molten contents are then poured into moulds, the heavier metal (gold) remaining in the base of these moulds and the slag flowing over the top.

1.6 Tailings

Tailings slurry from the Carbon Safety Screen will flow into the Tailings Hopper by gravity and then be pumped to the Tailings Thickener by the duty/standby tailings pumps. The slurry level in the tails hopper is maintained constant by a level control loop to the VSD on the Tails Pump motors.

Flocculant will also be added to the thickener to increase the solids settling rate of the tailings. The thickener overflow water will be gravity fed to the Thickener Overflow Tank and then pumped to the process water pond for reuse in the process plant. The thickener underflow will be pumped to the in-pit tailings storage facility via the thickener underflow pumps.

Return water will be recovered from the TSF central decant using a Decant Return Pump.

The tailings area in the process plant is equipped with a manually operated sump pump.

1.7 Reagents

1.7.1 Quicklime

Quicklime will be delivered to site in bulk and pneumatically transferred to the 75m^3 lime silo, located over the mill feed conveyor. Lime is dosed from the lime silo by the lime silo rotary valve into the lime silo discharge screw feeder and drops onto the mill feed conveyor. The lime feed rate is controlled via a variable speed drive in a control loop to the leach tank pH meter.

1.7.2 Cyanide

Liquid sodium cyanide (~30% w/w) will be delivered by road train and transferred to a holding tank fitted with a level indicator. Cyanide solution is pumped to the leach circuit using dosing pumps which are interlocked to LL level in the tank to prevent the pumps running dry. The cyanide area is equipped with a manually operated area sump pump.

1.7.3 Diesel

Diesel fuel for the elution circuit, barring furnace and kiln will be pumped from a day-tank which will be filled from the site diesel fuel supply system.

1.7.4 Elution, Acacia, and Goldroom Reagents

Liquid sodium hydroxide (~50% w/w) will be delivered in IBCs. The sodium hydroxide storage area is equipped with a manually operated area sump pump.

Hydrochloric acid (~32% w/w) will be delivered by road tanker to the hydrochloric acid storage tank. The hydrochloric storage area is equipped with a manually operated area sump pump.

Flux reagents for gold smelting will be delivered in powder form in 25 kg bags, including silica sand, sodium nitrate, soda ash and borax.

LeachAid will be delivered in 20 kg buckets for use in the intensive leach reactor.

1.8 Services

1.8.1 Compressed Air

Duty and standby rotary screw compressors with 22kW electric drives will provide compressed air to the main air receiver and service the general plant including the workshop. This circuit will also provide compressed air to the leach slurry.

The main plant air receiver will also supply the instrument air dryer and instrument air receiver. Instrument air will be supplied to the process plant and laboratory.

1.8.2 Raw Water

Raw water will be distributed throughout the plant by a duty pump from the raw water tank which is fitted with a level indicator.

The fire water pump skid will be equipped with a backup diesel pump and supplied with water from the raw water tank.

1.8.3 Process Water

Process water will be distributed throughout the plant by a duty pump and standby from the process water pond which is fitted with a level indicator. The process water is distributed to the milling and leaching areas and for general hosing. Process water will be sourced from a combination of raw water and tailings dam return water.

1.8.4 Potable and Safety Shower Water System

Supply of the potable water treatment package is outside the battery limit. The potable water will be produced by a reverse osmosis system and transferred to the potable water tank fitted with a level indicator.

A water pump will service the process plant, laboratory, workshop and offices. A separate dedicated pump will supply the safety shower ring main. Pressure for the safety showers is maintained by a pressure sustaining valve on the return line into the tank. The safety shower circuit is equipped with a backup diesel pump in the event of power failure.