A world-class operation

Every now and again, you come across a real gem of a mine that isn’t just about the commodity, but rather the entire mine, and the manner in which it is managed and operated. Petra’s Finsch diamond mine is such a mine. **BY TONY STONE**

**THE FINSch DIAMOND** mine is pure synergy, a team effort between the mine, Sandvik – its primary mechanisation and automation provider – and other state-of-the-art technology service providers – such as Schneider Electric and Bentley – in an integrated system that literally runs like clockwork.

Located 165 km northwest of Kimberley, in the Northern Province, the mine is South Africa’s second largest diamond mine by production, after De Beers’ Venetia diamond mine. With mine safety as the number one priority, Pieter Boshoff, technical services manager at Petra Diamonds, is a stickler for safety. Looking at Finsch’s safety record, it’s quite impressive. ISO14001:2004 and OHSAS 18001:2007 accredited, its trophy cabinet is testimony to this, as is its November 2014 Northern Cape Mine Managers Association award for underground safety. Finsch is a major resource, with 51.3 Mct, including 28.0 Mct in reserves and 2.0 Mct in tailings. Its innovative infrastructure, modern plant, and quality management process provide the framework for its excellent, multi-award winning safety and environmental record, as well as its strong social responsibility programme.

The mine’s ‘block cave’ and ‘sub level cave’ mining methods achieved a high-volume, low-cost 2014 production of 1.89 Mctpa, with a revenue stream of US$183.7 million. Expansion plans will see a run-of-mine production increase to 2.0 Mctpa, from the 2018 fiscal year.

**Surface to underground**
MIning at Finsch began on a small scale, after Allister Fincham and William Schwabel, two prospectors looking for asbestos, stumbled upon the find in 1960. When De Beers took over, in October 1964, they mined the 118 million year old volcanic pipe as an open pit operation. This went on until September 1990, when this mining method was terminated, at which point the pit had a surface area of 55 ha and a depth of 423 m. From then onwards, the mine’s operations moved underground.

**ABOVE** The Finsch diamond mine
**BELOW** Deon Stander, safety manager and the Finsch diamond mine, demonstrating the Res-q-pack
This is where things get interesting. Two methods of underground mining are being used at Finsch today – block caving and sub level caving, in a mechanised and automated operation.

Geology
To contextualise these mining methods, an understanding of Finsch’s geology is necessary. A classic diamondiferous kimberlite pipe, it is hosted by banded ironstones at the surface and, beneath that, dolomites and limestones of the Griqualand West Sequence of the Transvaal Supergroup. The pipe, originally 17.9 ha on the surface, is a group II kimberlite intrusion, consisting of weathered kimberlite (yellow ground) to a depth of around 100 m with unweathered material (blue ground) beneath that. The main pipe tapers to 3.7ha, and the precursor to 1.5ha, at 880m. There are a total of eight different kimberlite facies, each with unique characteristics and different grades. Of these, two facies (F1 and F8) make up the majority of the main pipe. Grade quality increases with depth, with a concomitant decrease in waste dilution.

Operations centre
In moving underground, with the initial development of Block 4 as a mechanised and automated mining operation, and to maximise production efficiencies, the creation of a purpose-built operations centre was necessary. Also, and not forgetting that Finsch’s objective was to develop a state-of-the-art mining operation, an intuitive operator interface, with simplified configuration for ease of maintenance and operation, was an absolute must. After a careful selection process to identify a SCADA solution that would provide the necessary high operability and scalability, as well as superior connectivity, Schneider’s CitectSCADA’s easy configuration tools and user-friendly screens were selected, and they were implemented without incurring delays. For example, the advanced technology, especially in the use of ‘blown fibre’ – ultra-lightweight single bundle optic fibres passed through preinstalled tubes using only airflow – exemplifies the sophistication of this installation. In addition, this particular type of fibre optics allows expansion without disrupting operations. And, of key importance, CitectSCADA’s built-in redundancy and system stability were key factors in the purchase decision. Ensuring safety and reliability for the mine’s operations, the CitectSCADA system has dual redundant server pairs. The system is used to monitor and control processes throughout the mining operation, including rock breaking, ore management, access control, production control, dispatch, and CCTV, to deliver a total, low-risk solution that dramatically minimises downtime, lowers life-cycle costs, and provides crucial information in real time. A high capacity (1 GB/second) Ethernet LAN handles the vast flow of data within the operations. Four 62-inch plasma screens provide an overview of the production status and progress. Two are used for the autonomous operation, while the other two are used for the other mine operations. A fifth screen provides real-time coverage of the autonomous operations underground.

In planning the centre, one of the primary risks identified was the possibility of production downtime. This was, and is, avoided with the support of a professional team of service experts. It’s their number one priority. For the mine, reliability and performance are non-negotiable.

Geospatial data system
Bentley Systems were contracted to develop an integrated geospatial data management system to better enable Finsch to manage their geospatial data, which is stored in multiple databases across the five departments, previously functioning in isolation. Data redundancy is now a thing of the past. On top of this, the mine also co-manages the mining town of Lime Acres, for which the GIS-based system captures data and bills residents for water and electricity usage. Survey and plan data
are captured and digitised. The mapping feature digitally represents the mining lifecycle, town, and residential layout. The publishing feature makes the geo-spatial mining and town information accessible to the whole mining group. For billings, the database interrogates the human resources system and automatically sends invoices to residents.

**Block caving**

Moving underground, block caving is a hard rock mining method that undermines an ore body, allowing it to progressively collapse under its own weight. As a mining method, it is a safe and proven method, which provides access to higher volumes of ore than other methods. So, how does it work?

With mechanisation and automation in mind, block cave mining involves an elaborate, thoughtful, and practically designed pre-construction process. First, access and ventilation shafts must be sunk to a level below the ore. In this instance, Finsch’s main shaft is down to its current depth of 825 m. After this, two rim tunnels circling the pipe are developed; the top rim tunnel is used for the ‘undercut’ layer, and the bottom for the ‘production’ layer.

Finsch was quite smart in its design, and developed a service tunnel, connected to the spiral decline tunnel, with oil bays, stores, service bays, wash bays, and offices off to the one side of the haulage rim tunnel. The service tunnel is linked, via connecting tunnels, to the rim tunnel. A series of horizontal tunnels, known as haulage tunnels, from one side of the production rim tunnel to the other, are dug using the traditional drill and blasted method. Between, and connecting, the haulage tunnels, a series of ‘raise’ tunnels are dug in an angular, almost roundish shape, to accommodate the LHDs (load, haul, dump), each with a slight rise in the middle to prevent water accumulation.

The small quantities of water runoff into the haulage tunnels are handled by due processes. Within each raise tunnel, a funnel-like cavity is drilled and blasted upward, beneath the undercut level. The mouths of these funnels abut one another, forming a continuous plane of funnel mouths where they contact the undercut.

Once all the raises, funnels, and undercut are constructed, the main ore body is ready for blasting to shatter it into small pieces. Once the blasting is completed, the undercut debris collapses and funnels through into the raises, where LHDs collect the ore, taking same to load points where the ore is transferred to fully automated (driverless) dump trucks that take the ore to the underground gyratory crusher. As the funnels empty, the ‘roof’ above the undercut, now without support, collapses and drops away, feeding more material into the funnels. This process progresses until the ore body is exhausted.

On occasion, a funnel will become blocked by a large boulder; secondary blasting is used to remove the problem. The pattern of blasting and ore removal is carefully managed by the control room to ensure that the ‘roof’ collapses in a level, or balanced, manner.

Finsch’s objective in mining this way is to extend its life-of-mine to sustain its current production profile and increase run-of-mine throughput to 3.5 Mtpa. Production is currently taking place in Block 4, at 630 m, while the development of the sub level caving mining (SLC) method is taking place between 700 m and 780 m.

A dedicated conveyor for ore-handling – to transfer SLC ore to existing infrastructure at 650m – will be ready in the 2016 fiscal year. Once the Block 4 has been fully mined, it will be decommissioned. First production from Block 5’s SLC will take place later this year, with production ramping up to 3.5 Mtpa by 2018.

**Sub level caving**

Tunnels, or drifts, up to 130 m long, are drill and blasted through the orebody. Walls and ceilings are reinforced with bolts, netting, and spray-on concrete. Once the drifts are ready, a set of holes, 40 m to 55 m deep, are drilled through the orebody in a semi-circular or fan-shaped pattern. Each fan cut consists...
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of a set of eight drill holes, and each set is between 3 m and 3.2 m apart. In a 130 m long drift, about 40 fan cuts are drilled, with fan cut 40 closest to the haulage tunnel. The drift is then blasted and cleared used LHDs in a sequence from 1 to 40.

Ore is taken to load points, where it is transferred to fully automated (driverless) dump trucks that take the ore to the underground gyratory crusher. Large ore boulders are either disintegrated using explosives or moved to a holding point for later disintegration.

The performance of SLC is highly dependent on the extraction sequencing and the discipline in following the sequencing of the drill and blast process and, then, the draw control.

Phase 1 of the SLC development – the rim tunnel – is complete. Tunnelling through orebody is in progress, contributing undiluted ore. Excavation of 1400 m, out of the 1600 m of conveyor tunnels, has been completed. Civil work and structural installation has commenced on the conveyor belt system and the crusher excavation is well advanced. First production is planned for mid-2015, with a ramp up, over four years, achieving full production by 2019.

Wrapping up

If anything, the Finsch mine is an example of modern mining sophistication. It is a case study that exemplifies the complete change in culture that is required to mechanise and automate a mine, but it is one that has transformed the entire Finsch mine into an integrated, highly-productive operation. It has and will continue to deliver excellence.

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1 A Sandvik TH550 haul truck. These machines are fully automated
2 Walls and ceilings are reinforced with bolts, netting, and spray-on concrete
3 The Atlas Copco M4C drill used to do the fan cuts
4 A Sandvik LHD (loader, hauler, dumper)