INSTALLATION AND COMMISSIONING OF NEW PRIMARY FANS AT BARRICK’S KANOWNA BELLE MINE, KALGOORLIE, AUSTRALIA

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ABSTRACT

Barrick’s Kanowna Belle gold mine in Kalgoorlie, Western Australia, has reached a depth of 1100 m and further development will take it to 1250 m. A feasibility study undertaken in 2006 identified the mining of E-Block as both technically and commercially feasible. One of the major requirements of mining this block was upgrading the existing primary ventilation fans. These fans consisted of three 450 kW axial fans that provided approximately 490 m$^3$/s of airflow. The feasibility study concluded that an additional 160 m$^3$/s was required for E block. Subsequent study showed that in order to achieve this, two of the existing fans were to be replaced with 2 x 450 kW axial fans in series, each of them, and the other was to be replaced with a 1400 kW axial fan.

The processes of installation and commissioning of these new fans are discussed in this paper.

KEYWORDS: Axial fans; stages; sensors; vibration; shaft alignment; VENTSIM

1. INTRODUCTION

Kanowna Belle is part of Western Australia’s Yilgarn Craton and is located 18 km northeast of Kalgoorlie and 600 km east of Perth as shown in Figure 1. The property has produced 3.3 Moz and has a current reserve of 1.2 Moz. The property became a 100% owned Barrick Gold Corporation asset after the takeover of Placer Dome Inc in 2006.

1 Operating Features at Kanowna Belle Gold Mine

A system of orepasses feed two primary plate feeders at 9620 mRL and 9330 mRL, at the depth of 740 m and 1030 m respectively. The ore is hauled directly to surface in Komatsu Caterpillar 775E rigid body trucks.
Continuous retreat stoping blocks are mined with longhole open stoping using paste for exposable backfill and waste rock for bulk backfill. The average stope size is 27 000 tonnes.

1.2 E-Block Project History

E-Block is an extension of the main orebody and most exploration and resource drilling was carried out during 2001 and 2002. The initial mining of D-Block in 2002/03 encountered stability issues related to pre-mining stress, so mining of E-Block was deferred until mining practices were refined for operating in these highly stressed conditions. A Pre-Feasibility Study was completed in 2003, ending with the decision to defer E-Block pending results from the Deep Exploration programme conducted in 2004.

Since the Pre-Feasibility study, the decline has been extended to allow exploration drilling of F-Block and E-Block East, to fully assess the ore potential at depth. The results of this drilling showed that mineralisation is continuous down dip. There were no intersections to indicate a significant change to orebody yield (tonnes per vertical metre). Indicative orebody yield below E-Block shows no potential to increase production rates at depth (Figure 2). This supported the operating philosophy of progressively developing mining blocks down dip, rather than injecting major capital to develop a shaft and increase production from deep mining below E-Block.

During 2005, underground access and ventilation infrastructure was extended to allow E-Block development to commence production in March 2006. A feasibility study was completed in mid 2006.

2. KANOWNA BELL GOLD MINE

The primary ventilation circuit intake is via the decline and thus been extended to C-Block w D-Block. The airflow is provided by VR5 shafts, as shown in Figure 9380 mR, whereas VR3 and bottom of the mine. VR5 exh Therefore, the East side from 9 by VR3 and VR5.

The existing fans were installed operation. The existing 2800-1 (now FlaktWoods). These fans exhausting ventilation shafts # Hz, 1000 rpm, star connected 4 casing. Figure 3 shows one of the fans.

Fans at VR1 and VR3 were in 1999. A spare fan assembly with a motor, motor couling and casing.

The Kanowna Belle ventilation through-flow' philosophy that immediately exhausted. Levels drive or from a central location located at the extremity of the shafts are located at both ex (Figure 4). Ore is loaded from trucks at a lower level. Design dilution of diesel exhaust emiss

The study concluded that in or of the existing fans were to be them, and would be installed.
D’Angelo and Gardner (2008) described the study of ventilation requirements as part of E-block feasibility study. The study found that the capacity of the existing ventilation system, which consisted of three 450 kW axial fans that providing 490 m³/s, would not be adequate to ventilate mining of E-Block. An additional 160 m³/s needed to be provided. In order to achieve this, two of the existing fans were to be replaced with 2 × 450 kW axial fans in series, each of them, and the other was to be replaced with a 1400 kW axial fan. This paper describes the installation and commissioning of the upgraded primary fans.

2. KANOWNA BELLE MINE VENTILATION SYSTEM

The primary ventilation circuit comprises the decline and six dedicated shafts. Air intake is via the decline and three intake shafts VR2, VR4 and VR6. These shafts have been extended to C-Block with the exception of VR2, which is extended into D-Block. The airflow is provided by exhausting fans on surface at VR1, VR3 and VR5 shafts, as shown in Figure 2. VR1 exhausts the west side of the mine down to 9380 mRL, whereas VR3 and VR5 exhaust the east side. VR3 exhaust from the bottom of the mine. VR5 exhausts down to 9670 mRL where it links with VR3. Therefore, the East side from 9670 mRL down to the bottom of the mine is exhausted by VR3 and VR5.

The existing fans were installed within the confines of an open pit that had ceased operation. The existing 2800-1230-6VP axial flow fans were manufactured by ABB (now Flakt Woods). These fans were installed vertically onto the collars of the exhausting ventilation shafts and were each fitted with a 6-pole, 450 kW, 1000 V, 50 Hz, 1000 rpm, star connected 450 frame electric motor which is located inside the fan casing. Figure 3 shows one of these fans.

Fans at VR1 and VR3 were manufactured and installed about 1996 and VR5 about 1999. A spare fan assembly was maintained on site. The assembly includes impeller, motor, motor cowling and casing.

The Kanowna Belle ventilation system was originally designed with a ‘one-pass through-flow’ philosophy that is air is used once on a level or by an activity and immediately exhausted. Levels are accessed either at the extremity of the footwall drive or from a central location. Air intakes via this access and is exhausted to a shaft located at the extremity of the footwall drive. On a typical level with a central access shafts are located at both extremities, allowing one-pass through-flow ventilation (Figure 4). Ore is loaded from the drawpoints into an orepass and rehandled into tracks at a lower level. Design airflow to the level is 24 m³/s which is adequate for dilution of diesel exhaust emissions from one LHD working on both ends.

3. NEW PRIMARY FANS

The study concluded that in order to achieve additional ventilation requirements, two of the existing fans were to be replaced with 2 × 450 kW axial fans in series, each of them, and would be installed at VR1 and VR3, whereas a new 1400 kW axial fan
would be installed at VR5. The fans at VR1 and VR3 were installed horizontally as shown in Figures 5 and 6. The $2 \times 450$ kW axial fans in series consist of the existing fan assembly (refurbished) paired with a new 450 kW fan assembly. The upgrading sequence was as follows:

1. The spare fan assembly was sent to FlaktWoods to be retrofitted for horizontal installation.
2. This and a new 450 kW fan assembly were then paired in series and installed at VR1 (Figure 5).
3. The existing VR1 fan assembly were then sent to FlaktWoods to be refurbished and retrofitted for horizontal installation.
4. This and a new 450 kW fan assembly were then paired in series and installed at VR3 (Figure 6).
5. The existing VR3 fan assembly was then sent to FlaktWoods to be refurbished and then kept as a spare unit.
6. A new 1400 kW axial fan was installed at VR5 (Figure 7).
7. The existing VR5 fan assembly was then sent to FlaktWoods to be refurbished and then kept as a spare unit.

These works were carried out between January and August 2008.

Figure 2: Primary ventilation layout
installation of the new fans. The timeline of five days and the fact that the fans were operating for 24 hours one of the fans had to be stopped. The motor was designed to improve cooling, but it was found that the problem was with the motor's cooling system. The sensor was soon replaced and the installation was continued.

5.2 VR3 Fans Installation

The lessons from VR1 fans installation were useful. The result, no problems encountered.

However, the installation of the VR3 fans was not without challenges. The power was cut off for 1.5 days due to maintenance work, and 30% of Western Australia's industrial electricity for 6 weeks.

As most of the mining activities were considered significant, the production schedule was affected. The short circuiting of 90 m³/s of air created a shortage of air at the installation site. It was decided to capping VR3 during installation and maintained adequate airflow in the area.

Another identified impact was the commissioning of the new VR fans. The VR3 and VR5 fans act like one large fan with a combination of 900 kW and 450 kW. VENTSIM showed that the air distribution needed to be optimized. The installation process would be monitored continuously until the installation of the new fans was completed.

5.3 VR5 Fan Installation

Installation of the VR5 fan provided a significant improvement. The fan motor is located outside to avoid dust and caused several delays, notably due to the high demand for parts during installation.
installation of the new fans. The installation was completed according to a planned timeline of five days and the fans were commissioned soon after that. After running for 24 hours one of the fans tripped due to motor overheating. FlaxtWoods was consulted and it was then decided to install a blocking plate to re-direct airflow around the motor to improve cooling. However, the problem still existed. Three days later it was found that the problem was simply caused by a faulty temperature sensor. The sensor was soon replaced and the fans have been running smoothly since then.

5.2 VR3 Fans Installation

The lessons from VR1 fans installation was taken into VR3 fans installation. As a result, no problems encountered after the fans were commissioned.

However, the installation itself was not without drama. During the installation, the power was cut off for 1.5 days as a result of Varanus island gas plant explosion, which cut 30% of Western Australia’s gas supply for electricity. Kanowna Belle was fortunate to secure the power back within short time as the explosion crippled the state’s industrial electricity for weeks. Some other mines were without power for a week.

As most of mining activities were done on the East side, the shut down of VR3 had a significant impact. Thanks to VENTSIM simulations, the impacts were identified and the production schedule was adjusted accordingly. One of the impacts was shortcircuiting of 90 m³/s of air due to linkage of VR3 and VR5 at 9670 mRL. This created a shortage of air at the bottom of the mine. Shutting down VR5 fan during the installation was not an option, as this would stop production. The solution was capping VR3 during installation. This reduced the shortcircuiting to 11 m³/s and maintained adequate airflow at the bottom of the mine to allow sufficient production rate.

Another identified impact was the potential stalling of the existing VR5 fan after commissioning of the new VR3 fans. Due to the linkage of these shafts at 9670 mRL, VR3 and VR5 fans act like two fans in parallel. The new VR3 fans have a combination of 900 kW motor, double the size of the existing VR5 fan motor, 450 kW. VENTSIM showed that VR5 would not stall, but it was decided to act on the side of caution. It was decided that after VR3 fans were commissioned, the VR5 fan would be monitored continuously and if it showed signs of stalling, one of the stages in VR3 fans would be switched off. VR3 fans would then be running with one stage until the installation of the new VR5 fan is completed. It turned out that this was not necessary. Both new VR3 and existing VR5 fans were running smoothly before the installation of new VR5 fan.

5.3 VR5 Fan Installation

Installation of VR5 fan provided new challenges as the fan type is new and different from previous fans that had been installed at Kanowna Belle. As shown in Figure 7 the fan motor is located outside the casing, whilst with the other fans it is inside. This caused several delays, notably during motor-impeller shaft alignment. The alignment
was the most critical task as shaft misalignment could result in excessive vibration, shaft fatigue, bearing wear and increased power consumption (Calizaya et al., 2000). Nevertheless the installation was completed in three weeks.

One day after commissioning, the fan had to be shut due to excessive vibration of about 5 mm/s. FlaktWoods then proposed to stiffen the structure holding the fan bearings to address this problem. This rectified the problem and vibration was reduced to <2 mm/s.

As with installation of VR3 fans, due to linkage of VR5 and VR3 at 9670 mRL, VR5 had to be capped to reduce shortcircuiting. However, due to the different structure of fan casing, the shaft was just able to be capped partially. This caused greater shortcircuit quantity than that at VR3, about 30 m³/s. However, this was still a significant reduction than that without capping, which was 90 m³/s. Production at the bottom of the mine was able to be maintained, albeit at a less rate than that during VR3 fans installation, due to higher shortcircuit quantity.

Before the commissioning, a VENTSIM simulation was done to identify the impact of the new VR5 fan upon VR3 fans. Since the new fan has a larger motor, 1400 kW, than that of VR3 fans, 900 kW, there was a possibility of stalling VR3 fans during the commissioning due to the linkage of these two shafts at 9670 mRL. The simulation showed that VR3 fans would not stall, but it was decided to shut VR3 fans before starting VR5 fan as a precautionary action. VR3 fans were re-started afterward. Subsequent pressure measurements showed that both fans were running far from stall region. Both fans have been running smoothly since then.

6. DISCUSSION AND CONCLUSIONS

During fan installation, it is essential to ensure that sensors are working properly. False reading can cause unnecessary problems, which subsequently can make things worse. It was fortunate that this did not happen during VR1 fans installation.

With fan with outside motor as in VR5, the alignment of motor-impeller shaft is very critical. Misalignment can result in excessive vibration, bearing wear, shaft fatigue and increased power consumption.

The installation of the VR5 fan was more complicated than VR1 and VR3 due to the different and unfamiliar design. This is a typical issue in such a situation and it led to delay. The Kanowna Belle crew gained a new experience which will be useful in the future.

The advantage of a mine that does not rely on a single exhaust shaft like Kanowna Belle is that the mining activities can still continue when one of the primary fans is being replaced. A ventilation network simulation using popular software like VENTSIM should be done to identify the impact of shaft shut down upon production.
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CONCLUSIONS

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REFERENCES
