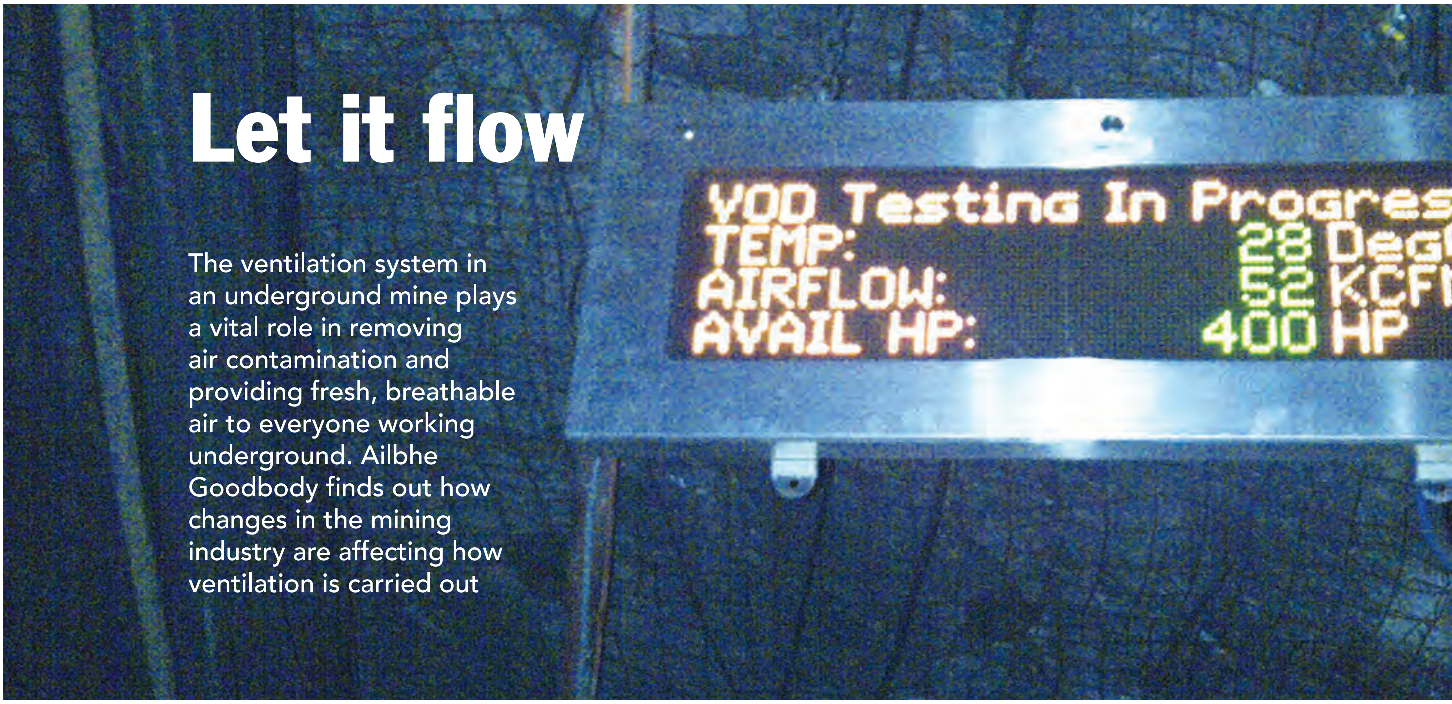
Let it flow

The ventilation system in an underground mine plays a vital role in removing air contamination and providing fresh, breathable air to everyone working underground. Ailbhe Goodbody finds out how changes in the mining industry are affecting how ventilation is carried out



Ventilation-on-demand (VOD) can significantly improve the energy efficiency of a ventilation system
Photo: Maestro Digital Mine

Ventilation dilutes the harmful components that are found in a mine to an allowable regulatory level – these contaminants can include:

- Gases that come from the strata rock (such as methane, CO_2, H_2S, SO_2 and radon);
- CO and NO_2 that are generated by diesel-operated underground equipment;
- Clearance of blasting gases to allow the miners to return to the mine face; and
- Oxygen depletion in areas of the mine with poor air circulation.

Dr Pedram Rostami, mining engineer at Stantec, says: "The contaminants could be both heat and gases, which decrease the quality of the underground air and could be hazardous to health if not ventilated appropriately."

The second function of underground mine ventilation is to keep the temperature within a safe operating zone for the workers. Ventilation can be used for either heating or cooling, depending on the requirement of the particular mine.

As mineral-extraction technology evolves, different approaches to ventilation have become necessary. Evolving mining methods introduce diverse contaminants and obstacles for ventilation that require unique approaches.

"A worst-case scenario for a mining business would be for it to be rendered operationally unsafe during extreme peaks in temperature," explains Pieter Jordaan, key account manager, mining at Aggreko.

"Above-ground temperatures in places such as Australia and South Africa often reach more than 45°C, which can put health, safety and productivity at mines in jeopardy. Controlling and regulating temperatures underground, as well as extracting moisture and contaminants, go a long way to ensuring that miners' welfare and productivity are preserved when the boundaries of underground mining exploration are pushed."

DEEPER MINES

Mining companies have started to excavate deeper underground as shallower reserves are in increasingly short supply. However, deep and ultra-deep mining incurs more technological challenges, not least ventilation – as we go deeper, mines get hotter, so more ventilation is needed to keep them cool so that people and equipment can work in reasonable conditions.

Jordaan says: "As companies push the boundaries of mining exploration, by excavating deeper and in more remote locations, temperature control and ventilation take on an ever-increasing level of importance."

Worker heat stress begins to be a major factor as mines get deeper, which impacts the amount of time that a miner can work in the hot area. At some point, the mine may have to consider more or larger fresh-air or return-air raises in order

Walking out of the portal during a ventilation survey
Photo: SRK Consulting

to get more airflow underground. Cooling systems may have to be considered, which impacts both CAPEX and OPEX. As a result, ventilation is a major cost for deep underground mines.

Another consideration is friction. The moving of air over longer distances causes this friction, which also generates heat and so must either be cooled or extracted away from the working faces.

"Air is a compressible gas, so as the mines go deeper, the weight of the air itself causes it to compress and so heat up, in a process called auto-compression," notes Kim Trapani, ventilation engineer at Stantec.

"So, the main challenge with deeper mines is that more air needs to be forced underground compared with shallower mines to provide the same volume, and this air could need to be cooled down at surface or underground to ensure that the mine remains within working temperatures."

The development or construction of vertical infrastructure for deeper mining blocks has become very expensive. Greater development costs have yielded smaller shafts, which ultimately restrict the capacity of the ventilation system. This has resulted in the requirement for greater efficiency with respect to the operation of the ventilation system and the distribution of airflow through the working areas.

Michael Gribbons, vice-president – sales and marketing at Maestro Digital Mine, says: "Energy becomes a very important factor, as the resistance in the airways increases as the mines become deeper. The mines will have to install underground booster fans in order to circulate the air throughout the mine."

Increases in distance require more electrical or mechanical equipment to access these farther regions but also to cool the natural rise in rock temperatures and the heat generated from the presence of more equipment.

Jordaan comments: "A larger workforce goes hand in hand with deeper mining too, generating more heat and requiring cooler, cleaner air. Also, the presence of gas must be addressed. Gases can be combustible and therefore present a fire risk, particularly in the case of coal mines."

Deeper mines have also brought a greater emphasis on the develop-

"As mineral-extraction technology evolves, different approaches to ventilation have become necessary"

A Stantec twin intake fan and heater installation in Canada

“The benefits of improving a ventilation system’s energy efficiency are both financial and environmental”

ment of accurate ventilation models so that there is a greater chance of success when the system is constructed. A spokesperson for Mine Ventilation Services, a new division of SRK Consulting, says: “The use of ventilation modelling promotes a closer relationship between the ventilation engineers and production planning engineers so that limitations to the ventilation system due to depth can be anticipated by the production planning engineers and any modifications to the overall mine design can be incorporated early in the planning cycle. This can relate to areas such as equipment selection (diesel or battery), sump locations, timing of re-entry into backfilled areas, cycle time modifications and general level layouts.”

Christian Lanas, global business development at Accutron Instruments, adds: “As mines get deeper and technology improves, we’re going to see more and more automation.

“These efforts towards increased automation make the workplace safer, lower costs and conserve energy. This can be a difficult process, but through easy-to-install, reliable and integrated technology we can slowly retrofit older mines to new industry-gold standards.”

BETTER ENERGY EFFICIENCY

The benefits of improving a ventilation system’s energy efficiency are both financial and environmental – the reduction in energy use means a reduction in operating costs, and depending on the source of the energy, there could also be benefits in terms of reduction of emission of greenhouse gases.

Lanas says: “Saving energy expenditure on ventilation will translate into huge savings over the course of a year, and incredible savings over the course of a mine’s lifespan, as well as decreasing its environmental footprint.”

There are several steps that can be taken to reduce the amount of energy required to ventilate a mine. Gribbons advises: “The mine will need to measure the airflow and air quality in ‘real time’ to understand the conditions, instead of manually surveying the mine, which can take up to three weeks for large operations.”

Sound planning and system design to improve the overall efficiency of the ventilation system will allow the primary fans to operate in an efficient range while providing effective airflow, resulting in an infrastructure that is constructed and utilised effectively, minimising operating pressures. To improve their energy efficiency, mines should ensure that the ventilation system is operating at its designed specifications, as fans are more efficient when they operate at their designed operating points.

Trapani says: “As with any sector, ensuring that losses are minimised – which is referred to as leakage in ventilation – and that energy is only used when required, through practices such as ventilation-on-demand (VOD), the energy efficiency of the ventilating system can be significantly improved.”

Once the mine can quantify the airflow and quality, it can start turning on and off the auxiliary fans during the blast cycle and also when the miners are not working.

Lanas recommends: “Instead of thinking of mine ventilation as ‘on or off’, it should be thought of ‘how much and when’. Like a light that turns on when someone enters the room, and off when they leave, we need to address ventilation the same way.”

Gribbons says: “This can be either achieved manually or on a scheduled basis from surface. This is the least expensive and can save 15-20% of the energy cost.”

Matching the airflow quantity supplied to the mine for the activities being conducted requires a ventilation management system to be developed.

The SRK spokesperson notes: “This system can be as simple as turning off auxiliary ventilation fans when headings are not in use, or turning down the main fans between shifts or on maintenance shifts; it could also be as complicated as actively tracking all equipment and personnel in the mine and remotely ramping up/down the ventilation system in all areas supporting equipment identified as working in those areas. There is currently a great deal of research and systems trials being conducted like this in the mining industry.”

Adjusting the airflow rate to each level based on the amount and type of equipment in the work area also requires a major CAPEX spend and a reliable communications network. Gribbons says: “This will result in the addition of automated doors and automated airflow regulators. The control method can either be automatic by installing a tracking system or semi-automatic by manually entering the required airflow rate once per shift from surface.”

The SRK spokesperson comments: “Maintaining a close relationship between production and ventilation planning can focus mining activities in smaller mining blocks, instead of being spread throughout a mine. Ventilation demand can rise tremen-

Aggreko's underground temperature control at Peak Mines gold mine in New South Wales, Australia

dously while supporting remnant mining activities through a mine by increasing airflow required to offset leakage, extend haulage routes and isolate stopes. If the production schedule can be modified to maintain mining activities in more localised areas, then the ventilation system can be more effectively and efficiently applied.

The mine can also adjust the total airflow to the mine by adjusting the rotational speed of the primary fans on surface. Gribbons says: "This is a very complex challenge that needs everything to be working properly and maintained perfectly. This is very difficult to achieve. Many attempt to achieve this but very few if any can do this on a continual basis."

Cooling air prior to it going underground by using air coolers, fridge plants and ice plants can also help to make mine ventilation more efficient. This equipment can be installed underground in strategic places to scrub and cool air before recirculation and extraction.

Recycling is also key in making mining more energy-efficient. Jordaan suggests: "Mines should consider practices such as scrubbing the air using underground air cleaners to reuse the same air before it is discarded to the surface. Every cubic metre of air discarded to surface has to be imported again from surface at cost."

It is crucial that the quest for energy efficiency cannot be at the expense of health and safety. The ventilation system must always have the provision of a safe environment for the personnel as its absolute primary goal. It should, however, be noted that through ventilation, overall working conditions are improved, optimising production and leading to financial and environmental benefits.

"When a mine is an unsafe and unclean environment to work in, the likelihood of human error is heightened," says Jordaan. "Better production and reduced risk of costly accidents and injuries are achieved by making a mine a safe and clean space to work.

"Scientific research and common practice show that heat exhaustion is far less likely to occur if ventilation and refrigeration achieves air cooling power greater than 250W/m^2 at an underground work site. In the event of an extraordinary rise in surface temperature, where existing equipment is unable to reliably produce the increased cooling or ventilation, underground miners face possible shut-downs unless they have a backup plan in place."

As well as mining staff, machinery and equipment are more efficient when operating in favourable conditions and have a reduced risk of overheating.

RESEARCH AND DEVELOPMENT

The companies working in mine ventilation are constantly reviewing, developing and upgrading their mechanical and electrical equipment to make mining more efficient and safe.

For example, Stantec's ventilation R&D focuses on ventilation solutions that have a low operating cost and are simple to maintain, while adhering to ventilation regulation requirements. Dr Rostami comments: "In our experience, most mines want systems that can support: automation for ventilation on demand; refuge stations for health and safety; and deep mine cooling."

Lanas says: "Reducing the overall power demand for mines is extremely important. Energy costs are going up while environmental concerns and demands are increasing. The more we can control and reduce our electrical demands, the better. Our products offer integrated technology that is easy to install and reliable."

The SRK spokesperson states: "At SRK Consulting we constantly strive to develop ventilation systems that will effectively and efficiently support mining activities. We regularly conduct full pressure/quantity ventilation surveys of mines so that accurate ventilation models can be developed on which plans for future mining blocks can be designed.

"Ventilation modelling is a key component to the design process and looking at methods by which we can elevate the accuracy of the ventilation models will greatly influence the design of infrastructure. This allows for shafts to be correctly dimensioned, fans to be more accurately specified, and the operation of the ventilation system to be more closely aligned with reality."

Machinery and electrical equipment are used to cool and clean air but they expel heat and fumes as well. Jordaan says: "We constantly find ways to make equipment more productive by reducing the overall impact to the environment, such as addressing levels of CO and CO_2 emission rates generated by mechanical machinery.

"Another focus is the extraction of noxious gases naturally present in some rock types. We research the amount of explosives required to break rock to calculate the volume of nitrous fumes generated as a result."

He adds that various factors must be researched from the rock type to the level of moisture in the mine when determining a ventilation plan for a specific mine.

"Different types of rock have different heat characteristics and temperatures, which vary dependent on depth," explains Jordaan. "The

"When a mine is an unsafe and unclean environment to work in, the likelihood of human error is heightened"

more insight into these variables we have, the better we can determine the ventilation requirements of a mine. Additionally, factors such as the evacuated space of a mine, the number of humans underground generating heat and requiring air and cooling as well as the levels of moisture present in the underground rock will impact the level of ventilation required.

As mine exploration goes deeper underground and into more remote locations, we are constantly analysing and developing unique ventilation requirements to keep sites safe and productive."

The SRK spokesperson notes: "Our customers do not want to promote efficiency or energy savings above health and safety. Our customers want both: an efficient ventilation system with a robust design that will allow for safe operation with continually changing conditions."

Gribbons also cautions: "Mining

"The management must understand the benefits of ventilation in terms of productivity, worker health and safety, risk management and energy savings"

Recent projects

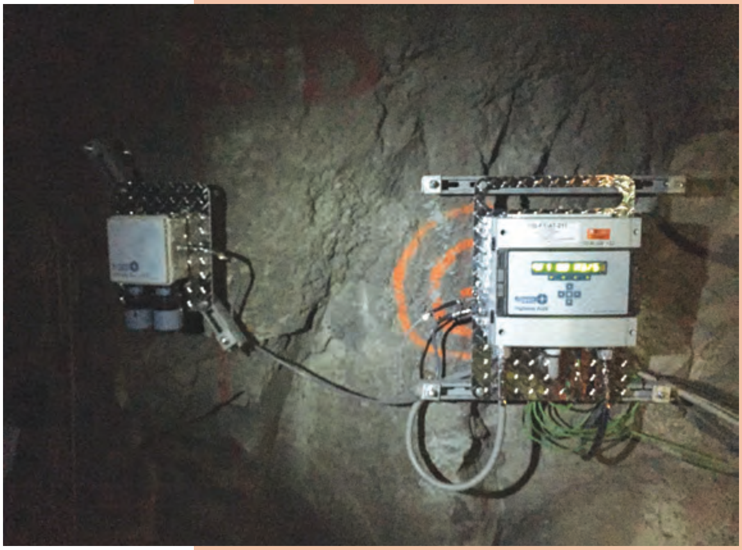
Mining Magazine spoke to several providers of ventilation technology about their recent ventilation installations in the mining industry.

Aggreko worked with an intermediate mining company in Australia that was experiencing wet bulb temperatures in excess of 30°C at its gold mine located in the Cobar mining district, approximately 600km northwest of Sydney in New South Wales, Australia.

The high temperatures in the mine meant that miners working underground were working for reduced periods. The high temperatures posed a significant health-and-safety risk and negatively affected productivity. Operations were 1.2km underground and air shafts at the mine measured 11km in length, so the mine's operators needed a way to chill the air in the fresh air decline and reduce the ambient wet bulb temperature.

Jordaan comments: "We worked closely with the customer and provided a 1,800kWr (600 refrigeration tonne) scalable cooling solution comprising bulk air coolers connected to the mine's fresh air decline, along with chillers located in the return air risers. The package exceeded all QHSE [Quality, health, safety, environment] requirements, which ensured mining operations at the required temperatures."

Maestro Digital Mine has supplied over 70 mines with ventilation-monitoring equipment. Gribbons says: "Very few mines track the savings of a ventilation system but those that do, such as Vale's Totten mine [in Sudbury, Canada], a user of Maestro equipment, have confirmed that manual ventilation controls have saved 25% of the total energy bill of the mine. They have predicted a 50% saving with automated ventilation controls. The full paper on the second component will be published in one year."



Maestro Digital Mine has supplied over 70 mines with ventilation-monitoring equipment

Many of Maestro's clients are also using the equipment to visualise the environmental conditions in real time. "This allows the mine to return to the face quicker and safer," explains Gribbons. "This by far is the most attractive reason since it deals with production and worker safety at the same time. If a miner has an extra 30 minutes at the face per shift, it could result in several more buckets of ore being extracted for each stope."

He tells *MM* that the main challenge for Maestro in some cases has been getting data up reliably from the underground workings. Gribbons says: "This is a general infrastructure challenge; however, over the past five years, this has become less important since most C-Suite level persons understand that data to the underground workings is a requirement for permanent productivity improvements."

The company's second main challenge is building the confidence of management to really relate to the mining companies' internal culture. Gribbons comments: "The management must understand the benefits of ventilation in terms of productivity, worker health and safety, risk management and potential energy savings."

The third challenge is maintaining anything underground. "It is difficult," says Gribbons. "Digital systems, such as Maestro's, offer full diagnostic functions through MaestroLink software to reach out to all of our equipment. The software examines all the diagnostic bits in real time and self-diagnoses the majority of the potential issues to keep the system operating reliably."

Meanwhile, the ventilation division of **SRK Consulting** has been involved with many mining operations this past year, ranging from active mine-expansion projects in Colombia to greenfield mine designs in Minnesota and Nebraska, US. The SRK spokesperson states: "Each mine has its own level of individuality and presents a unique assortment of challenges."

Some of **Stantec**'s recent challenges include: a mine where it provided the air required despite a restricted shaft width; an especially challenging project where it needed to prevent air from recirculating throughout the mine while having limited air intake and exhaust throughout the mine; and a mine in a warm region where the climate and working conditions resulted in high temperatures underground. Dr Rostami says: "Stantec required that the air be cooled through refrigeration to maintain allowable working temperatures."

clients are not interested in research and development like academics are. Mines are looking for proven end-to-end solutions to their everyday problems.

"Conventional R&D has for the most part only resulted in further questions and very little commercialisation. Mines have been down this path for decades and the productivity curve has not been improved."

In contrast, he says that mining clients are asking for simple, ease-of-install solutions that can start from OPEX budgets and then quickly scaled to full CAPEX budgets once proven. Gribbons notes: "Solutions that can be integrated quickly without the necessity to cut across layers in the company or a multitude of internal departments are often considered first."

The mines need to illustrate a return on investment for a major CAPEX spend, and they require proof from mines that are already using the equipment and willing to speak about their experiences.

Gribbons says: "The 'star wars' solution that some 'ventilation on demand' software companies promised oversold and under-delivered. This has been a major setback to the mine ventilation segment. Mines have been soured on the amount of effort it takes to keep them running vs. the payback based on energy savings."

A Stantec intake fan installation in Canada