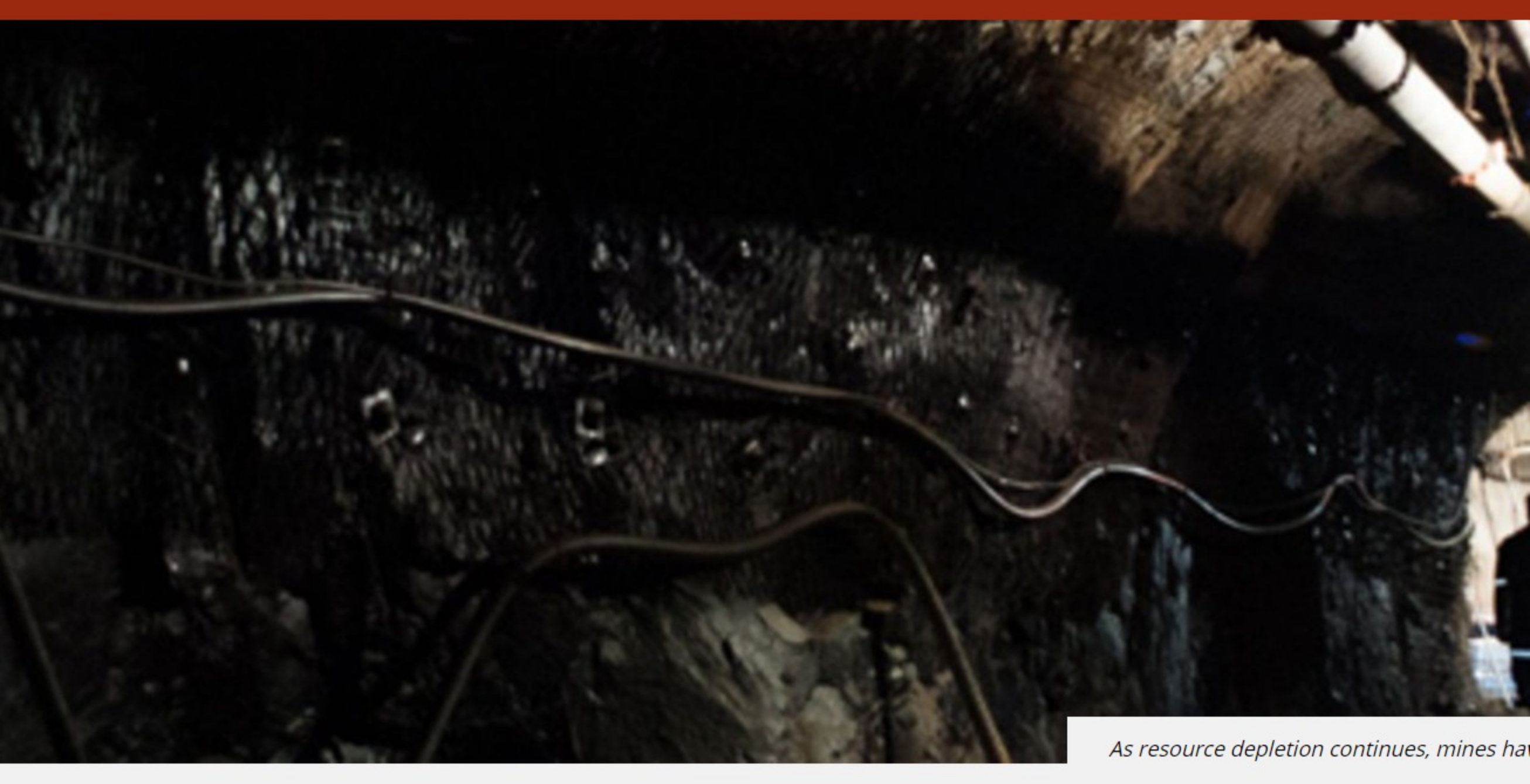
Technology to help miners breathe more easily

Of all the technology required to run an underground mine, there is none more important than the technology allowing workers to breathe



As resource depletion continues, mines ha

Underground Mining > Technology-innovation

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Ventilation does a lot more than just providing the oxygen needed by workers to work and operate safely, however. "Ventilation is for people to be able to breathe, it's for removing contaminants, it's for cooling down the environment," Charles Nyabeze, vice president of business development for the Sudbury-based Centre for Excellence in Mining Innovation (CEMI), says.

Providing cool air has always been a requirement for underground excavation, with compression leading to air temperatures rising. The increasing temperatures at the rock face also cause air temperatures to rise.

"Working in an environment where it's 40°C can be very challenging," Nyabeze says. It slows down productivity, and when machines are introduced, it causes heat to rise even faster.

"The challenge with the heat is not just with the labour force, but it's on the equipment side as well," Pedram Rostami, a Stantec consulting engineer for ventilation systems, says, adding that equipment is specifically designed to work optimally in certain temperatures.

As a result, many particularly deep mines must pre-chill the air before machines and humans can enter, which also eats up energy.

But in mines located in more frigid areas, such as in northern Canada and Russia, keeping the mines warm enough to work effectively is also necessary.

Space limitations are also a difficulty in designing ventilation systems, Remy Bourcier, Minetek's chief engineering officer, says.

"The age-old issue is, if you make a bigger tunnel for more flow, it's going to cost the mine a lot more to dig out a lot more dirt than necessary," he says. "The question is, how big do you make it? It has to be big enough to get your truck and equipment in and out, as well as providing compliant air to flow to the rock face."

An increase in production rates is also making it harder for mining companies to install adequate ventilation systems, Geritt Goodman, the branch chief of the Pittsburgh Mining Research Division of the National Institute for Occupational Safety and Health (NIOSH), says.

Production of underground mines has increased significantly due to innovative mining equipment, leading underground mines to produce more than a million tonnes of resources every year across the world, Goodman says. As resource depletion continues, mines have had to go deeper to find resources.

"These new challenges have not only increased airflow and pressure requirements, but have also created more complex mine gas management, air conditioning, and dust and silica mitigation, all of which may aggravate existing ventilation concerns," he says.

He also expects that regulators will tighten air-quality rules in the future to maintain worker health and safety.

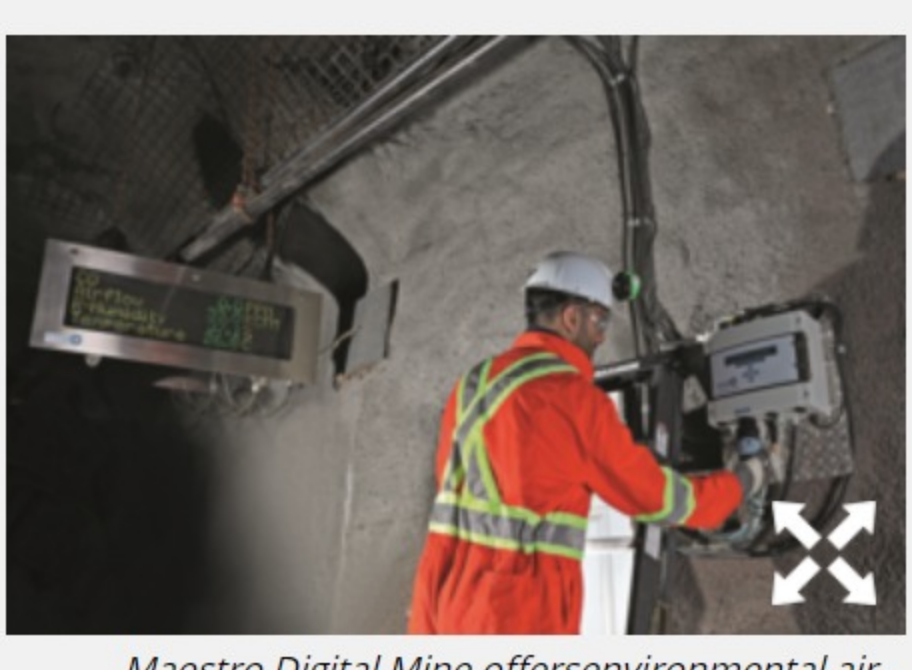
Canadian mines are already under pressure to improve air quality for their workers, due to a recent court case which found a mine liable for the lung cancer death of one of its workers, Maestro Digital Mine VP Michael Gribbons says.

New technologies

Traditionally, over the last century, miners have been using compressed air to keep operational areas cool. Now, mines are depending on large refrigeration systems, coupled with large industrial fans, to move the cool air throughout the mines.

Though the basic method of providing cooler air to warmer mining environments has remained essentially the same, different technologies are allowing mining companies to maximise their returns and also monitor the equipment better.

One such tool is the Maestro Vigilante AQS, an environmental air-quality monitoring station for underground mining operations, Gribbons says.



Maestro Digital Mine offersenvironmental air-quality monitoring stations for underground mining operations

Development of this technology emanated from research undertaken in Sudbury in 2010, he adds.

In 2010, CEMI led a C$8.5 million (US$6.2 million) project, to which the Canadian government contributed C$4.25 million. Research focused on the impact of emissions from mining equipment, and the overall quality of the air in ventilation-on-demand scenarios.

"The goal was to reduce the mine's energy footprint by controlling the amount of air to different locations," he says. "The project ultimately provided data to support ventilation controls at many of the mines within the basin."

Building on these developments, Maestro launched the Vigilante AQS, which uses sensors to measure barometric pressure and temperature to assure accuracy at all levels, even in situations of high heat and intense pressure. "All the sensors on the market were designed for use in surface applications and not meant for measurement at depth," Gribbons says.

The Vigilante machine also employs new, VoIP-like (Voice over Internet Protocol) technology, known as Industrial Internet of Things (IIoT), to transfer data directly to the industrial network.

The machine eliminates the need for a programmable logic controller (PLC), and enables the data it collects to be transmitted via IIoT.

"Very similar to what VoIP has done to the older PBX (private branch exchange) phone systems, the Vigilante AQS now has done to the PLCs underground," Gribbons says.

Maestro Digital Mine launched Zephyr AQS, which is a lower-cost version of Vigilante, at the latest CIM convention in Montreal, Canada.

Ventilation on demand

Another company has focused on a different way to improve mining ventilation systems: better fans.

Australia-based Minetek has put out a new fan, the high output axial system, which provides reduced energy use, lower noise levels and no fatigue-related issues.

The strength of the fan allows it to provide 50% more air than can be produced from other similarly sized equipment, which improves compliance with air-quality regulations, Minetek's Bourcier says.

Most fans cannot produce enough air to remain compliant when blast operations are occurring, he says. "But because our fan can do 50% more air, we can be assured that the mine is going to be compliant in all stages of the working day."

Having a one-speed fan means there are fewer stoppages in production, he adds.

Minetek's Remy Bourcier next to the company's 1,320mm high output axial

"You're not having to stop production or stop the work whilst you change the fan in and out," he says. "Depending on the mine, sometimes it can take one shift or two shifts to change out a fan, so just that one or two shifts in lost production is very valuable to the mine."

Another benefit of this industrial fan is that it can increase and decrease the amount of air heading to areas of the mine, due to RFID (radio-frequency identification) tags which can identify when trucks have gone in and out and adjust air flow heading into the area, Minetek's Bourcier says. The process is known as 'ventilation on demand'.

It is a hot topic in the cooling and refrigeration sphere.

Several mining actors - among them the Canadian federal government and several mining research bodies, including CEMI - have been enthusiastic about ventilation on demand, a method that would allow mines to only funnel air to areas of the mine that need it. By limiting the amount of air needed, mines would be able to cut down their energy bills and improve productivity.

CEMI's Nyabeze is fervent about the future of ventilation on demand.

Having computers being able to digitally monitor where air is being released in the mine by use of sensors means that ventilation is going where it's needed, he says.

"This is being developed and has been implemented," he adds.

But Maestro Digital Mine's Gribbons says the technology has a long way to go before it can become viable.

"If the sensors are not perfectly maintained, the system does nothing - it's a very complex apparatus," he says. For ventilation on demand to work flawlessly, mining companies need to install complex base sensors.

"These are really hard to maintain, really expensive to integrate." This is why Gribbons believes the technology failed in the past.

NIOSH's Goodman is hopeful that the technology will develop and provide a valuable service to the industry and notes that a number of companies are already beginning to offer these kinds of technologies to mining customers.

"Miner ventilation aspects, such as monitoring systems and ventilation on demand, will benefit with advancement in this field, Goodman says.

Future of air technologies

Another research area in ventilation is using liquid air/nitrogen to cool hot mining operations underground.

"One of the challenges with liquid air/nitrogen is the high pressure," Kim Trapani, senior ventilation engineer at Stantec, says.

"To keep it in liquid form, you need pressurised tanks. But because it needs to be under pressure, this could pose a risk, and-research is being undertaken on how you can safely store and use liquid air/nitrogen underground."

CEMI is currently working on research to use cryogenics as a zero- or low-carbon way to keep mining shafts and underground operations cool. The research organisation has already made some progress on its research and is now in the process of putting together a consortium to commercialise the technology.

"We've done some tests to release liquid air into the natural environment in a controlled way," Nyabeze says. "When you release it, it expands by 100 times."

CEMI is also looking for additional uses of compressed air, he adds.

"We're working on research about how cryogenics can also power equipment, such as machines that run on liquid air," he says. This would in turn mean that the exhaust from these machines would be less harmful to the environment, and fans would not have to be deployed to decontaminate it for mine workers.

The problem in developing future technologies is that the usual providers of critical research are disappearing, NIOSH's Goodman says.

"A trend in this country [US] and around the world has been the loss of critical ventilation competencies and capabilities at universities and at government and commercially supported mining R&D facilities," he says.

NIOSH is doing what it can to fill this gap by providing competitive grants to institutions and companies to encourage more development of mine safety equipment, as well as providing funds for mining engineering graduate students who specialise in ventilation sciences.

Better machinery

One factor which may play the biggest role in improving air quality in underground mines is the electrification of mining equipment.

The bulk of mining equipment in use today is dependent on diesel fuel, which produces harmful exhaust and requires systems to decontaminate the air for human workers labouring underground.

The most straightforward way to improve air quality is to embrace electrification of equipment, Gribbons says.

"There will be some relief with the energy intensity of a mine when full electrification takes place," he says. "Electric motors are far more efficient than internal combustion motors, so the heat that is given off is less, and there are no noxious gas emissions to deal with."

But it will take some time for the industry to replace its diesel equipment.

"It may take another 20 years to fully change the current fleet of equipment, but for those that can afford this technology, it will reduce their demand on ventilation and energy," says Gribbons.