In July, Canada’s Centre for Excellence in Mining Innovation (CEMI) announced that the provincial government is supporting mining research with an investment of C$2.24 million from the Ministry of Research and Innovation’s Ontario Research Fund-Research Excellence program (ORF-RE). Laurentian University will be working with CEMI and colleagues at the University of Toronto and Queen’s University in a broad research effort to improve both safety and efficiency in deep mining. CEMI has been instrumental in the design of the research program and will play a lead role in ensuring successful outcomes.

The funding leverages industrial contributions from Vale, Xstrata Nickel and Rio Tinto and will support the work of more than 75 researchers and students in a project called Smart Underground Monitoring and Integrated Technologies (SUMIT) for Deep Mining, with Laurentian University as the lead applicant in the initiative.

SUMIT’s goal is to apply smart engineering principles and technologies to make major advances in the deeper mining operations of the future. Its 14 core projects are focussed on three major challenges of sustainable mining at deeper elevations: Mitigating GeoRisk (for both workers and investors); Rapid Underground Development (more efficient excavation), and Mine Sustainability (better management of energy, materials, and mine waste).

“The kind of research being undertaken by Laurentian and its partners is critically important to the future of the mining industry in Canada and abroad,” said Laurentian University President Dominic Giroux. “There is no question that mines will go deeper in future years as ores are exhausted at current levels. Laurentian will be in the forefront of making that work both safer and more productive.”

Dr Peter Kaiser, Principal Investigator for SUMIT, Chair of Rock Mechanics and Ground Control at Laurentian and President/CEO of CEMI, added, “By leveraging the collective expertise and knowledge at Laurentian, Queen’s University, and the University of Toronto, we will be able to contribute to game-changing knowledge capacity in how the world designs mines and controls mining operations.”

Kaiser explained that in the SUMIT network, participating mines will serve as “living laboratories” so that researchers and innovators can test next generation technologies and make observations in the field to facilitate early-stage innovations in the underground work environment as well as to produce tested solutions.

CEMI develops excellence in mining innovation in the areas of exploration, deep mining, integrated mine engineering, environment and sustainability for the metal mining industry. Its mandate is to deliver innovation to the mineral industry, from idea to implementation, with one of the most experienced R&D leadership teams in the country, and with core competencies in these fields.

Some of the outcomes expected are:

- Ability to detect mine-wide deformation patterns and to better understand stored energy flow patterns in active mines
- Means to detect higher risk geological structures that may pose a risk to investors
- Engineering rationale to systematically design rock support in fault-, slip-, burst-prone mines
- Ground control management techniques to facilitate the implementation of game-changing mechanised excavation technology
- Scientific evidence to implement Ventilation-on-Demand (VOD) as an energy saving change
- Produce 75 person-years of research, leading to significant knowledge and science advances
- Value optimisation and efficiencies in mining operations
- Best practice guidelines emphasising worker health and safety and considering the unique worker environment, helping to ensure the safest worker environment possible
- Knowledge transfer initiatives such as website or wiki-based guidelines and short courses. This knowledge will be made available to universities and mining/engineering firms.

Last November, the Rio Tinto Centre for Underground Mine Construction (RTC-UMC) was established as a division of CEMI, located in Sudbury, Ontario. Rio Tinto will be investing C$10 million over five years to undertake research lead by the centre to speed-up mine development with mechanised excavation technologies including two tunnel boring systems (TBS) and a shaft boring system (SBS).

The RTC-UMC is undertaking research into ground and machine performance. For this purpose, prototype test sites are being instrumented to improve ground characterisation techniques and to develop innovative support systems to facilitate high
Mines of the future will be going deeper, resulting in higher costs for infrastructure, ventilation and energy. How your mine addresses these future challenges will separate your company from the rest of the mining industry.

BESTECH, one of Canada’s leading firms specializing in engineering, automation, software development and energy management has developed NRG1-ECO. NRG1-ECO (Energy Consumption Optimization) is a mine-wide energy management system that can save mining operations millions of dollars in energy costs per year. NRG1-ECO can be applied to automated equipment and processes such as compressors, pumps and ventilation to significantly reduce energy consumption.

NRG1-ECO is currently installed and operating at Vale’s Coleman Mine and Xstrata Nickel’s Fraser Mine, both in Sudbury, Ontario, Canada.

“We worked together with BESTECH on what was needed in the industry and they’ve completed the development of NRG1-ECO’s Ventilation-On-Demand management tool for us,” says Cheryl Allen, Chief Engineer - Ventilation, Vale Mines Mill Technical Services, Canadian Operation.

A mine ventilation system usually operates at peak capacity 100 per cent of the time. NRG1-ECO’s VOD (Ventilation-On-Demand) module enables the mine to actively control the ventilation system’s air flow to when and where it is needed. This allows a mine to reduce its ventilation costs by as much as 30 per cent, which represents significant savings given that ventilation usually represents more than 50 per cent of a mine’s energy costs.

BESTECH’s NRG1-ECO technology is attracting world-wide attention from other mining giants, including North America’s fastest growing senior gold producer, Goldcorp Inc. “We looked at two different systems. It seemed BESTECH was offering a complete package from ground up. We’re hoping to go ahead with NRG1-ECO in a two-stage approach. First, have the system up and running on two levels in the Hoyle Pond Mine in Timmins and if that proves to be satisfactory, then we will expand it to the rest of the mine," says Imola Götz, Chief Engineer, Hoyle Pond Mine, Goldcorp.”

Assistance with Energy-Efficiency Grants and Rebate applications is available to mines for both the initial NRG1-ECO site assessment and commissioning to help leverage increased profitability and savings.

“Many types of environmental monitoring sensors can be integrated into the NRG1-ECO control system to monitor various parameters including temperature, relative humidity, carbon monoxide (CO), carbon dioxide (CO2) and nitrogen monoxide (NO). Providing real-time data to support Ventilation-On-Demand.

To find out more information on NRG1-ECO, go to www.NRG1-ECO.com.

NRG1-ECO Web Based HMI
The Web Based HMI allows remote access to standard process control HMI. Shown here is a VFD Fan under cascading closed loop PID control.

NRG1-ECO was developed with an open architecture so that it will work with technology already in use at the mine site. Integration is at the core of NRG1-ECO and its ability to incorporate with new or existing mine technology offers mining operations, old or new, the opportunity to realize significant energy savings.

The NRG1-ECO system can be customized to reflect each mine’s needs and protocols in order to leverage the highest ROI for each mine site.
speed, mechanised tunnel and shaft excavation technologies for underground mines in highly stressed ground and at depth. With the support of Rio Tinto, CEMI will be collaborating with recognised researchers in Canada and around the world.

In 2007 the Deep Mining Research Consortium (DMRC), another Canadian innovation program, completed the first round of projects and began developing new projects based upon a cost model strategy. One completed project focused on Diesels at Depth (2004-2007). Since air density decreases with altitude, fuel/air ratios get richer and diesel engines no longer operate optimally the performance of the engines decreases, producing more toxic emissions.

The effects of operation at great depth are not well known and could include reverse effects due to a leaner fuel/air ratio and possible shortcomings/failures of the engine and its associated control modules and systems. The effect of operation at great depth could vary depending on the type of engine, i.e. naturally aspirated, turbo charged and/or electronically controlled engines.

CANDMET-MMSL conducted field experiments that examined these factors and focused on the effects of increased barometric pressure and intake air density on diesel engine emissions in a deep production mine. The completed project research shows engine performance is consistent with extrapolations from high altitude studies. Increased levels of NOx at depth should be expected, whereas particulates are reduced. Instrumentation for measuring diesel performance at depth is reconfigured.

A second project developed Gelfill as an alternative fill system (2004-2008): A solidifying backfill that can be placed quickly contributes to the stability to deep mining zones. Gelfill holds the promise of good flow characteristics and the ability to set without drainage. This is achieved by controlling additives such as sodium silicate. This DMRC project included a series of laboratory and underground trials to optimise the Gelfill process. A cost-benefit analysis compared Gelfill to hydraulic and paste fill systems for various deep mining scenarios. Encouraged by the early findings, the consortium members decided to proceed with additional trials on the path to implementation.

The Hoist Rope Inspection Automation (2004-2006) program is designed on the premise that maximising the automation of rope inspections would add to hoist time in all types of mines, thereby increasing revenue. High speed, cost-effective cameras and vision system algorithms detect rope defects and measure rope diameter while the hoist rope is moving. Computer-based signal analysis and pattern recognition systems interpret loss of metallic area (LMA) and local faults (LF). Neither of these technologies had been used previously for hoist rope inspection.

An automated wire rope inspection system was developed and successfully replaced the daily, manual hoist rope inspections at Xstrata Copper’s Kidd D Mine in Timmins. Installed in April 2006 following pilot installations at Vale’s Garson mine in Sudbury and BHP Billiton’s Leinster mine in Australia, the computer visioning system performs a 360° inspection of ropes and detects broken wires with the hoist skipping ore at full speed.

The Thin Spray-on Liner (TSL) project is monitoring and addressing all health and safety issues associated with spraying with Isocyanates and is testing and evaluating manual application systems for the TSL.

It has shown that adequate toughness sufficient to prevent tearing and blast damage demands the use of Isocyanates in TSL formation. Adequate coverage given a rough blasted surface and a minimum application thickness of typically 4-6 mm imposes special requirements concerning a) TSL formulation b) application process control. Adhesion failure together with bolt connectivity is required in order to mobilise TSL capacity in the limit of rock failure.

Ventilation at depth

The VOD project is installing, testing and measuring the efficiency of novel Ventilation on Demand technologies to decrease energy costs and increase productivity. It should increase productivity and decrease the environmental

Rio Tinto is investing C$10 million to undertake research led by the Rio Tinto Centre for Underground Mine Construction to speed-up mine development. Its Argyle underground block-cave project is large and complex, requiring more than 40 km of tunnel development.
the earth is full of treasures. we will help you bring them to the surface.

Becker Mining Systems is a leading global supplier of unique system solutions for the underground mining sector. Our solutions have evolved from our clients’ needs and years of international experience bringing you the most advanced, reliable and efficient systems available. With branches in every key mining region, we partner with our clients to give them the very best. becker-mining.com
impact of energy consumption. The project focuses on two sites: Vale's Coleman and Xstrata Nickel's Nickel Rim South mines. The technical solution at Coleman (for the 153 orebody - 153OB) is provided by BESTECH and at Nickel Rim South Mine by Simsmart Technologies.

The mining methods are very different. The installation of the VOD system was a retrofit to the existing orebody at Coleman 153, and a part of the new mine design at Nickel Rim South. The two test sites thus provide a wide spectrum of VOD implementation.

At this year's CIM Conference in Montreal, Vale's Cheryl L. Allen and BESTECH's Trang Tran presented a paper on Ventilation-on-demand control system's impact on energy savings and air quality. They noted that "increasing energy costs associated with mining have become an issue that must be addressed by industry to ensure sustainable production. As underground mine ventilation systems account for 40% to 50% of a mine's total energy requirement, initiatives to maximise their efficiency have been introduced worldwide.

For primary ventilation, surface fans downcast air via the Coleman shaft and McCreedy East #1 ventilation shaft and underground booster fans exhausting to the mined out workings of Coleman, Levack and adjacent Xstrata mine. The original ventilation system was designed to supply a constant volume of air to levels or areas of the mine which are active; but may or may not have constant mining activity.

153OB is narrow vein and currently mined by cut-and-fill. Air is supplied to the zone via a fresh air raise where it is distributed by booster fan(s) attached to the raise on each level. As the air travels across the football drift to the exhaust raise access it is picked up by auxiliary fans located at each stope access. These auxiliary fans push the air, through ducting, to the working face and back via the access drift to the level football drift where it travels to the exhaust raise and enters through regulated louvers.

The VOD control method, its strategies and impact on energy consumption and flexibility of airflow distribution as commissioned at Coleman Mine was demonstrated as part of an overall energy management control system known as NRG1-ECO®. The VOD uses five control strategies ranging from manual to fully automated operation using air monitoring sensors and activity based asset tagging to adjust the ventilation system by responding to the activity of mine personnel and air quality. The system provides real-time monitoring of all the variables to optimise the control of all connected equipment.

Allen and Tran explain "the system achieves efficiency by having NRG1-ECO adjust fan speed and louver position settings in unison to established ‘set-point’ flows on the levels. The use of ramping techniques ensures stable system responses which mitigate ‘hunting’ following minor ventilation disturbances; which allows the entire system to become more efficient at directing and channelling the air supply to the desired regions.

“The ability to supply air to where it is needed and reduce where it is not required allows any available air to be redirected to additional mining areas; without increasing the total airflow to the mine. This flexibility has potential for increase in mine production.

“The application of VOD technology benefits the environment through the reduction in energy consumption helping to reduce environmental impacts from greenhouse gas emissions. For every kW reduction in energy, Coleman mine is reducing its carbon footprint by 1,577 kg of CO2. The estimated energy savings based on the current VOD configuration at Coleman's 153OB is 3,000,000 kWh which is a reduction of 540 t of CO2/y.”

They conclude that “the business case for implementation of a VOD system is based on energy savings. However, secondary benefits
such as increased productivity, continuous monitoring of workplace environmental conditions, and reduction in mine air heating fuel can be realized. Further expansion of the energy management system could include electronic tag-in/tag-out boards, quick response of employee location in the event of an emergency, and awareness of system efficiency through key performance indicators.

“The future is very bright for ventilation-on-demand,” CEMI R&D Program Director Glenn Lyle told the Sudbury Mining Solutions Journal. “The ability for a mine to be able to effectively and efficiently move air from one area of a mine to another will be a tremendous benefit in terms of energy savings because you don’t have to ventilate to the same levels all the time.”

Another equally important benefit is the ability to increase production by putting the air where it's needed. “Most mines tend to be more ventilation constrained than production constrained,” said Lyle. “If you had ventilation available, you could likely achieve higher production rates.”

CEMI is moving to develop a follow on project from the VOD. The VOD project was seen as Phase I and CEMI is currently scoping the next phase. The goal is to address industry wide issues associated with the implementation of VOD. A new tool developed by Sudbury-based Objectivity links a simulator and a ventilation solver and calculates the demand for ventilation based on the number and location of equipment in the mine at a given time, explained Lyle. This information is then fed into the ventilation solver to determine the airflows required on the various mine levels. The tool will help mining companies make decisions about moving forward with VOD systems.

Andrew Dasys, President of Objectivity, explains that “Objectivity developed the modelling software in order to build a business case for VOD. The software is called VREX - Ventilation Rules Engine. The software uses data from a production model, a long term mine plan or from an RFID feed to determine what the specific air demand is in a mine over time. It then has a number of rules that allocate this demand to a ventilation model. VREX can also perform some optimisation to determine the lowest cost to deliver the air to the designated working areas.

“VREX provides a means of determining detailed air requirements for any number of production scenarios, and then it can determine where capital should be invested and what type of VOD system should be installed to maximise payback. Because we are not in the business of installing VOD systems VREX allows us to create an objective assessment of the levels of savings that VOD can bring to operations while taking into account their specific production profiles.

As part of the VOD project the software also explores how changes to fleet propulsion systems will affect ventilation costs - thus it is possible to determine the benefit of changing all support vehicles from diesel to electric engines and see if there is a direct ventilation cost decrease. Or to determine what affect changing ventilation legislation may have on ventilation cost.

The VREX models and initial data collected at both VOD test sites indicates that there is a significant amount of energy (electrical and gas) costs to be saved when using VOD, however the greater benefit is in creating a safer working environment and in better allocating the air. When viewed at a mine wide level this also provides the opportunity to potentially increase production by moving air from areas where there is no activity and scheduling production activities when there is ‘surplus, air available. Part of the VOD II focus is to determine what the production benefits of better air use can be.”

“If you're going to have VOD, you need to have a good, reliable sensor network because as you're moving quantities of air throughout a mine, you want to know that what you expect to happen is actually happening,” said Lyle. “VOD relies heavily on feedback from sensors installed underground, so there has been a fair number of learnings about making sure the sensors are in the right location, that they’re
SymBot showing loader status properly calibrated and properly maintained.”

Simsmart’s SmartEXEC (Smart Expandable Energy Control) system is purpose built for mining. It challenges existing and new ventilation design and performance through engineering analysis for total system optimisation. Savings can potentially exceed 50%.

SmartEXEC is the new upgraded version of OMVOD (IM, September 2010, pp54-56) that includes optimisation capability of all mine electrical consumers in addition to the ventilation elements. ABB and Simsmart have worked together extensively on this (IM, September 2010, pp54-56).

The SmartEXEC system interfaces with a mine's infrastructure to provide real-time control of existing, expanding, or new ventilation systems. Using Open Connectivity (OPC), the control technology is seamlessly integrated into ventilation design, connecting directly to Process Logic Controllers (PLCs) via existing communication structures. This permits immediate implementation into existing mines by adding VOD control directly to existing infrastructure. Since the system interacts directly with the PLCs, it is not restricted in its integration or control capabilities. This unique ability enables mines in any operational state to reassess their energy needs and find a solution that fits.

Depending upon the mine’s size and production needs, the SmartEXEC system can be commissioned to use either conventional control based on physical measurement and demand; or optionally, mass-flow balance control which calibrates the optimal air flow for a specific area based on depth, temperature, air quality, and demand. While VOD conventional control is standard in the SmartEXEC system, providing true optimisation requires constant airflow balancing and calibration. The optional mass-flow balance control is a unique feature of the SmartEXEC system and provides the highest degree of energy optimisation.

Simsmart works on turnkey projects with its global partners for electrification, fan motors and drives, air flow regulators, air quality and flow instrumentation, automation, communications (voice and data), tracking and installation.

Monitoring progress

Also involved with VOD projects, Kirk Petroski, President & CEO of Symbolicware quotes IBM’s Envisioning the future of mining White Paper, October 2009: “New technologies will make a mine and both its local and remote managers smarter by becoming instrumented, interconnected and intelligent - Assets will be instrumented, interconnected and intelligent, reporting their location, their status and other key metrics remotely and automatically”

His company is an innovator and integrator of standardised information-based technology that enhances the productivity of mobile mining equipment and mining processes. At the core of Symbolicware's solutions is the SymBot™. The SymBot is used in monitoring applications for productivity gains, risk mitigation, energy savings and as a platform for new development projects where real-time data collection is crucial for making better and informed decisions.

It offers bi-directional, store-and-forward, data standardisation and remote configuration capabilities. Data collected is processed and can be analysed on-board for real-time reporting and alerts. Standardised data is also delivered to data management systems for centralised control centres and management reporting.

Symbolicware’s intelligent monitoring system provides a solution to the industry’s ever increasing need for real-time monitoring. Monitoring and data applications delivered through the SymBot include engine monitoring, automated pre-operation checklist, automated production statistics, dynamic load weighing, emissions monitoring, location tracking, proximity detection, traffic control, tyre pressure and temperature monitoring, custom data applications. To date the SymBot has been integrated with OEM vehicles including Caterpillar, Atlas Copco and MTI, and as a standalone third party system can be integrated with any OEM. Industry adopters of Symbolicware’s technology include Vale, Xstrata Nickel, Baffinland Iron Mines and Peregrine Diamonds. Symbolicware has recently entered the US market by partnering with TEC Systems Group, an electrical, engineering, automation and software company that that has serviced Fortune 500 industrial companies since 1984.

SymBot projects include:

- An open information management platform for underground mobile equipment
- Sensor network and data collection for VOD
- An integrated open Wi-Fi®/ZigBee® sensor network for process automation underground
- SymBot as a critical component for remote mine exploration, development and operations in the far north.

INVEST IN PROJECT NEWS

Published every two weeks, IM Project News is crammed with valuable information incorporating the latest news on projects within that fortnight.

It is specifically about projects (not speculative exploration reports) featuring operations embarking on scoping studies or those further advanced to feasibility and feasibility.

Beyond that, we look at projects in development, publishing regular updates as they get closer to production. We also detail expansion projects at existing mines.

At any one time there can be 8,000 drilling projects underway, 1,500 reserve-definition studies, 800 feasibility studies and 400 mines under construction.

So, to keep up with projects getting close to completion and learn about key project personnel, subscribe now to IM Project News.

Contact: emma@im-mining.com
+44 1442 87 08 29
Annual subscription is only £260, $410 or €315

FOR A FREE TRIAL!
Narrow vein solution

Now available in 880 mm (35”) width : Get only what you want!

The new miniLoader® L110 (L130NE)
- Tramming capacity 1,000 kg
- Standard bucket volume 0.5m³ (width 880 mm)
- Breakout force 2,500 kg
- Operating weight 4,000 kg
- Radius external 3.520 mm : internal 2.200 mm
- Max vehicle speed loaded 6.5 km/h
- Standard engine electrical power 30 kW
- Tires 7.5R15 Xmines D2

Selective mining has never reached such precision.

The success of our miniloader L130, has inspired our customers and pushed us to a further challenge, the L110 (130NE). The strong experience acquired and the full Cad/Cam design allowed us to narrow our machine and keep the same stability, ergonomy and comfort. In fact, except the width, the only thing we have reduced is your waste.

Contact us for more information.
DEEP MINING

At the recent 2011 Australian Mine Ventilation Conference, Mark Ogle from Tahmoor coal mine pointed out that “booster fans are relatively rare in Australian coal mines. However, as mines become progressively deeper it is likely that such fans will be increasingly adopted as a method to sustain or improve the ventilation of underground workings. The reasons why booster fans may be an attractive alternative include:

- Increased cost of sinking additional ventilation shafts with greater seam depths
- Environmental objections to shaft sinking projects
- Increasing urbanisation limiting availability of potential ventilation shaft sites.

“Tahmoor Colliery recently implemented a major ventilation upgrade, which involved installing significantly larger surface fans on an existing shaft. However, the two major ventilation splits underground were not well balanced, meaning the higher-resistance split (containing the longwall face) could not receive the full benefit of the higher pressure and quantity delivered by the new fans.

“Extensive ventilation modelling was carried out to evaluate various potential solutions and the recommended option was the installation of a booster fan or fans.

“Proposals were sought from recognised fan manufacturers and various alternative arrangements were tendered. Ultimately the choice was between one large centrifugal fan and a set (three or four) smaller ‘auxiliary-like’ fans in parallel. The successful tender was for a single centrifugal, an arrangement very similar to the booster fans that have been operating effectively at Westcliff Colliery for a number of years.”

The latest SwedVent underground ventilation fans and ducting systems from GIA Industries are being installed in six Russian mines including the Apatit and Olcon mines in Murmansk; the Mayskoe mine in Eastern Russia; Alrosa mine in Udachnaya; and the Magadan Lunoe and Ducat silver mines.

Four 2AVH224 fan systems have been delivered to the Apatit mine, each delivering 145 m³/s down the shaft of Russia’s largest underground phosphate operation. The fan station has been installed inside a pre-heated building to blow air at not less than +2° into the mine.

A similar fan house and pre-heated building has also been constructed at Olcon, Olenogorsk in Murmansk housing four SwedVent 2AVH224 fans.

Highland Gold’s Mayskoe mine is one of the country’s largest known undeveloped gold deposits. Two AVH180 fan systems delivering 130 m³/s were delivered in September 2010 for the underground operation. And two AVH160 fan systems have been ordered by the Magadan Lunoe underground mine in North East Russia's Omsukchan district.

A further two AVH224S, each delivering 104 m³/s have been delivered to Magadan’s Ducat silver mine. Meanwhile at the Alro sa Udachnaya mine, a 3AVH125 fan with a duct diameter of 1,400 mm has been installed at the portal during the driving of the 1.8 km shaft.

The recently introduced new generation of SwedVent fans features improved silencer design to provide noise reductions of at least 3 dB(A) for the full range of fan motors rated between 10 and 500 kW to achieve 75 – 85 dB(A) at 7 m. The improved sound damping is due to a specially designed silencer filled with processed mineral wool to reduce high frequency sounds.

The ventilation system features advanced impeller design incorporating a large hub, short blades and, accurately measured spacing between the blades to give the fan an enhanced ability to counteract high pressure systems. The dynamically balanced impeller rotates in purpose-designed guide vanes to eliminate turbulence.

Individually adjustable aluminium blades allow the same fan to be used for a number of different ventilation conditions by adjusting the blade angle. For example, a 1,250 mm diameter fan can be set to deliver 16–44 m³/s. The range of SwedVent fans is available in 630-2,240 mm diameters with capacities of 1.5–200 m³/s.

Heat stress

In deep mines, workers can be exposed to very high ambient air temperatures as a result of high rock temperatures, auto-compression of the ventilation air and heat generated by the mining machinery. While several solutions are available to combat heat, the cost/benefit of each must be investigated carefully.

Conventional means of heat control, including significant increases in the volume of ventilation to remove the heat or the commissioning of large refrigeration plants to cool the air can be very expensive. This could result in rich deep reserves being left un-mined.

DMRC determined that “the economic benefits from a better understanding of the heat exposure issues and how they impact on ventilation system design are likely to be significant.” The objective of this project is to provide a Heat Stress Index along with a Code of Practice that may be applied in most Canadian deep mines. As well as define further studies heat stress management and heat control. To date the following tasks have been completed:

- Base case measurement of body temperature (energy expended) by mining task (including rescue activity) for underground workers under “hot” conditions
- Laboratory simulation study of mining tasks, measuring associated heat loss while accounting for a) physiological characteristics and b) clothing
- Early findings contributing to heat stress management at Vale-Inco.

This project is expected to deliver (over ~ five years):

- Identification of those individuals particularly at risk of suffering from heat stress
- Best practices designed to combat heat stress including work habits, mining strategies and dress code
- Innovative personalised body coolers.

South African BBE is a group specialising in mine ventilation, refrigeration and cooling. BBE provides a comprehensive service from
Conceptual investigations, through technical feasibility studies, to preparation of detailed engineering design specifications and project execution and management. It recently completed a R3-million EPCM contract to design an underground cooling circuit at Palabora Mining Co’s (PMC) copper mine in Phalaborwa, Limpopo Province. BBE’s design makes provision for two refrigeration machines to provide cooling to current workings and mine development.

The underground cooling circuit comprises two 1.5 MW Bulk Air Coolers (BAC), ± 3.0 MW of cooling coils, chilled and warm water dams, two 3.5 MW refrigeration machines and a 9 MW condenser spray chamber. The refrigeration duty not used for the BACs will be used for cooling coils. The circuit will be located underground on the Production Level, some 1,200 m below surface.

BBE’s lead engineer on this project, Marle Hooman, says refrigeration systems are not often located underground at this depth, which is quite shallow compared to other mines. “However, at PMC high ambient conditions are experienced throughout the year and the surface virgin rock temperature as well as the geothermal gradient of the rock is high,” explains Hooman. “Trade-off comparisons were conducted prior to this work to arrive at the most favourable refrigeration system. We made our decision based on achieving the best efficiencies and lowest operating costs, as well as a variety of practical advantages.”

Construction of the second BAC, condenser spray chamber, dams and the first refrigeration machine were expected to be completed by November 2011.

BBE has worked with PMC on ventilation and cooling studies since 2004, including various studies on ventilation layout and mine planning using the BBE Group’s proprietary VUMA-network (a simulation of steady-state environmental conditions encountered in underground mines). More recently, BEE has been involved in an EPCM project for PMC’s headgear cooling system.

**DPM management**

The presentations made at MDEC 2010 conference and diesel workshop are now posted on the website: http://www.mdec.ca/2010/ (thanks to Dr Mahe Gangal). The following is just some of the important news from that.

Vale employs over 800 diesel-powered units at its mines in the Sudbury basin. The company is exploring the use of alternative power (e.g. electricity, fuel cells) but diesel-powered vehicles will continue to be a very important component of underground mining for many years to come. So Vale is lessening diesel’s undesirable features such as noxious substances in its exhaust.

DEEP (Diesel Emissions Evaluation Program – www.deep.org) has shown that reducing emissions of DPM from diesel vehicle exhausts is not a simple task. Older diesel engines, particularly heavy-duty engines, are the primary generators of DPM. Newer engines, which are electronically controlled, are better, but many of these engines cannot reliably meet proposed DPM levels. Engine maintenance is an essential component to having diesels perform while limiting deleterious emissions, but maintenance will not by itself be able to reach very low DPM specifications. Alternative fuels, such as biodiesel, can assist in lowering DPM emissions, but will achieve no more than 30-50% reduction.

The best technology for achieving dramatic reductions in DPM emissions is diesel particulate filter (DPF) systems, according to Vale’s J.S. Stachulak and Doug O’Connor. They reported on extensive tests conducted under the auspices of DEEP at Vale’s Stobie mine from 2000-2006. “While many of the DPFs tested there showed good performance for extended periods of time, the main challenge remaining to be overcome in implementing DPF system technology on underground vehicles is to eliminate the human parameter from their operation.”

“With the experience gained from the DEEP testing at Stobie, Vale is well positioned and committed to continue its evaluation of DPFs for the underground environment. More than 50 manufacturers worldwide offer DPFs capable of filtering DPM, but this number was reduced significantly by application of several service and performance criteria. In selecting units for testing, consideration was given to the expected DPF reliability, along with its technical and operational viability under the duty cycle of the vehicle. The technical support of the DPF manufacturer and the experience attained...
Rail-Veyor unloading elsewhere in a particular DPF’s use was also considered. Tests of two identical MANN+HUMMEL SMF-AR DPFs on two quite different light duty diesel vehicles at Vale’s Creighton mine “demonstrated that this system can successfully address soot emissions control for light duty vehicles with differing soot emission levels, exhaust temperatures and duty cycles.” This DPF system is “capable of adapting to and thus working in different operating modes: if needed the active electrical regeneration takes place; if not the system regenerates passively (without electrical heating). In all cases the dosage of the FBC is moderated to optimise performance against cost.

“Other than the obvious benefits of clean exhaust and no downtime during operation, the system is compact, demonstrably robust, and has long (500–800 hours) service intervals.” The SMF-AR DPF system consists of a pleated sintered metal particulate filter surrounded for part of its length by an electric heating element, a controllable FBC dosing system, and a control unit with self-adaptive control software. They conclude that “the advanced technology of the system is applicable in the mining industry and fulfills the expectations of diesel particle filtration for light duty vehicles. In particular it is effective in exhaust soot reduction, regenerates automatically with no effect on operating cycle, is tolerant of engine variations and of changing operating cycles, is compact, robust and uses on-board vehicle electric power.”

IM reported in November 2010 (p4) on Rypos HDPF filters on diesel equipment underground at the Detroit salt mine. Kevin Morris presented Biodiesel Test at Kinross Gold Paracatu Mine. “Analysing the performance of the CAT 3508 diesel engine, which is used in the 777C haul trucks, as per the dynamometer test, it was demonstrated that biodiesel did not significantly alter the power output for mixtures with percentages of 5 to 50%. For higher percentage mixtures, Caterpillar noted a reduction in the power. Caterpillar considers power loses below of 3% to be acceptable. However, for losses in the range of greater than 3% Caterpillar considers these to be problematic.

He noted the important reduction in gas emissions in diesel exhaust:
- Unburnt hydro carbons 14%
- Carbon Monoxide 9%
- Particulates 8%

He also noted biodiesel’s increase in “fuel lubricating properties due to its low viscosity” and “ability to degrade in cases of fuel spills.” But against this he explained “biodiesel can cause deposits that build up on the membranes of the fuel filters resulting in a rapid clogging – the problem worsening when the concentration of biodiesel increases.” Biodiesel also produced a 2% increase in NOX. “Pure biodiesel is 5 to 7% less efficient than regular fuel.”

“The fibres in the filter membrane are hygroscopic, and attract water. The attraction between the filter and water is greater than the attraction between water and diesel. As the water continues being attracted by the filter, water drops form and increase of size until they cannot pass through the membrane and fall into the reservoir, where they are drained.

“The ability of the fuel filter to work is based on the attraction between the filter membrane and the water being greater than the attraction of diesel and water. When the Biodiesels is added, it significantly increases the attraction with the water. Hence, the water will pass through the filter and will not be separate, rendering the filter effectively useless.”

Underground transport
In July the Government of Canada, through Sustainable Development Technology Canada (SDTC), announced investments in clean technology projects in Ontario. One of these is C$1.5 million to Rail-Veyor Technologies Global for a rail haulage system. This technology offers interesting benefits in saving ventilation energy because of its low emissions and low profile attributes.

The electrically powered Rail-Veyor system operates remotely through a control centre and incorporates a light rail track with a series of interconnected two-wheel cars capable of continuous movement. The cars travel at speeds of up to 12m/s or 32km/h as they climb grades of 20% and negotiate complex turns within a 30 m radius. The open trough formed by all the rail cars can unload and transport any ore. The cars are connected to allow for articulated movement along curves and for dumping.

A unique drive system consisting of two stationary drive stations and sensors fully automate the system and provide the forward thrust. Speed is controlled by an inverter, which allows for both forward and reverse movement. The system is able to start loaded cars from any position on the track.

Vale-Inco is installing a Rail-Veyor material handling system at the 114 Orebody adjacent to its Copper Cliff mine. The Rail-Veyor is a cross between a railroad and a conveyor system that is propelled by conventional truck tyres at drive stations located at intervals along the track. The tyres provide the forward thrust by turning against the cars’ side plates.

Vale is driving twin ramps into the orebody, one dedicated to the Rail-Veyor, the other to bring in people, supplies and equipment. The installation will demonstrate the technology.
BETTER DRILLING BY DESIGN

At Cubex we believe in using our experience in designing In-The-Hole drills to solve problems encountered by our customers; like the challenges encountered at the world’s highest grade uranium mine.

The solution we provided enables Wassara water hammer drilling on a compact boom-equipped carrier allowing for faster setup and safer operation.

What can we do for you?

www.cubex.net
underground and test an integrated loading system. The material will be hauled to surface, dumped and trucked to Vale’s Clarabelle Mill, but could also be transported directly to the mill via the Rail-Veyor at some point in the future. There is a 37.52" gauge Rail-Veyor test track at Vale’s Frood-Stobie site in Sudbury. It is equipped with a loading, dumping and reinversion loop to demonstrate the technology’s capabilities, “but that kind of structure would only be possible in a fairly fixed type of installation,” said Peter Golde, Chief Mine Engineer - Research and Development, Vale-Inco. The test track is a 750 m loop carrying 53 Rail-Veyor cars.

He explains the mine “will need to load the Rail-Veyor when we’re doing development work and extending our ramp systems and production areas, so we’re looking at something that is portable, mobile and compact, in other words, a continuous loading system at the front end of the process that will grab the broken muck with some sort of conveyor system and feed the train.”

Vale is currently testing several loading and crushing technologies at the test track. It hopes to minimise the amount of oversize material by controlling the fragmentation. Work on this is being done by Mirarco. The objective is to achieve a total target of 5% of material larger than 458 mm.

Caterpillar is developing a new product for underground. This goes back to work originally started by DBT, which was taken over by Bucyrus and is now part of Caterpillar. It has
been tested at El Teniente in Chile over several years. The company says block cave mines can improve production by generating a continuous haulage stream from the drawpoints by using the RockFlow™ Feeder and RockFlow Mover. The product is ready to market and the first industrial application will be in 2013 in a copper mine in Chile. The system offers:

- Significant cost reduction
- High level of automation of the mining process, taking miners out of the process
- High grade safety and is environmentally friendly
- No diesel fumes/heat for less ventilation effort.

The RockFlow Feeder takes the rock from the drawpoints and the Mover is the main conveyor that they feed onto. They are protected by international patents/patent applications.

**Drill advances**

Peterstow Aquapower has completed over 35 trials on its closed-loop hydraulic rock drill, which uses a fraction of the energy of pneumatic drills (*IM*, December 2010, pp22-25). Peterstow opened its state-of-the-art manufacturing facility in Swaziland last year to produce the drills, which were described by Ian Cockerill, Chairman of Petmin and former Gold Fields CEO, as “a game-changing technology”.

The company is now fully operational, having recruited and trained a strong production, management and project co-ordination team. It says “the ambitious claims have been proven through trials with mining companies. Cockerill has since joined Peterstow as a non-executive Director.”

“Our environmental claims have been borne out” says Executive Director Alan Barrows. “In deep-level mines our drills use around 5% of the energy of pneumatic drills, sometimes far less. But the real result has been its productivity. Our drill speeds far exceed pneumatic drills. In side by side trials at 3,500 m [depth], pneumatics took 13 minutes to drill a 1.2 m hole. Peterstow’s drill took two minutes.”

Industry has long been enthusiastic, but switching to a completely new method of mining is a big decision and needs more than bold claims. Peterstow has spent the last year proving these claims in mining environments.

“Long-term trials in an operating environment are nearly complete and results are extremely positive. Once we’re established in a few mines we expect we will have to rapidly ramp up production to meet orders. That won’t be long now” says Barrows. *IM*