THE MAGAZINE FOR INDUSTRIAL VEHICLE TECHNOLOGY, DESIGN & ENGINEERING

MINING SPECIAL

Designing cabs for draglines

Super-sized electric drives

How to meet ISO 3450

MINExpo review

Cat 6120B hybrid shovel

Design Challenge: selective loading Saving fuel with efficient cooling

INTERNA' INDUSTRIAL VEHICI

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A new line of safety controllers from Sauer-Danfoss can enable OEMs to achieve elusive international standards such as ISO 13849-1



REWOF

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Being a proud Pit Yakker (native of East Durham), mining equipment has always held a special place in my heart, even if pit ponies were more the order of the day in the small coal mines of North East England. In fact, the first time I ever saw a rigid dump truck in the iron was when a fleet of them were being used to clear Easington Beach after the Thatcher government's decimation of the UK mining industry. (If you're wondering why such a clean-up was necessary, check out the final scene of Get *Carter*, which was filmed there over 20 years previously...)

So the prospect of a first-ever visit to Minexpo this September was incredibly exciting, despite it being held in Las Vegas, which is - to put it mildly - almost certainly my least favourite city. I can't remember the last time I had so much fun at a trade fair and after tagging on a trip to see some of Cat's huge range of machinery in action at its Tinaja Hills facility in Arizona, I came back more eager than ever to get cracking with putting a new issue together - the issue in question being this, our Mining Special. (Check out www.ivtinternational.com for video footage of probably the best machine demo I've ever seen, by the way.)

Unfortunately, once back in real life, reality bit. Several of the vehicles I wanted to explore in much greater depth were still effectively being kept under wraps, despite having been prominently displayed at the show. A massive scoop (of the journalistic, rather than the underground machinery variety) I had picked up after bumping into the managing director of an OEM not previously even remotely involved in mining, when we'd discussed featuring the designs that were still being worked on, bit the dust due to ongoing contractual reasons (but stay tuned). And speaking of newcomers, a potentially revealing interview with GE Mining also fell by the wayside, largely as a result of its acquisition of Industrea not yet having concluded.

Nevertheless, every cloud has a silver lining, and in this case, it has meant that we've been able to break with tradition and compile a pretty comprehensive review of the show's vehicle launches (page 14). And perhaps going to show just how secretive some of these manufacturers can be, I'm delighted to finally be able to include an in-depth feature (page 44) on the new cab that adorns Cat's new shovels and draglines - a mere three years or so after its author, Steve Casey, initially suggested it, due to Bucyrus (as then was) wanting to keep it a secret weapon for as long as possible.

Luckily, there were plenty of exhibitors showcasing electric drive technologies who were only too happy to talk about their products, meaning our annual focus on these products is bigger than ever - both in terms of word count and the size of the equipment in question. So if you want to know what makes some of the largest machines on earth tick, turn to page 50.

One of only two non-specifically mining-related features is our Engines and Emissions article on page 64, which, by looking at efficient cooling systems, concludes our year-long theme of reducing fuel consumption (though of course, I don't expect we'll ever really be finished with that...) And then, the first in a new series suggesting solutions to the hundreds of regulations affecting off-highway equipment looks at ISO 3450 braking requirements, of which the dynamic stopping performance can be a particular problem for dump trucks (see page 60).

Talking of regulations, I'd also recommend a read of our 'insider' feature, which questions the common sense behind Tier 4i. Wanting to reduce nitrogen oxides and particulate matter in diesel exhaust is all well and good, but is Tier 4i's reliance on aftertreatment really the best way to go about it?

Richard Carr, editor, iVT International

Coming up in the March issue of iVT

Bauma Preview • Design Challenge • Volvo PL3005D pipelayer • Cat 336E H hybrid excavator Mobile Hydraulics
 OEM interview – Dobroslav Rak, VP Engineering, Doosan Bobcat

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acu-ity [ah-kyoo-i-tee] *noun* [from Old French, from Latin *acūtus* acute]: keenness of perception: sharpness; acuteness: a quick and penetrating intelligence: in battery monitoring the newest, most accurate, most advanced CAN system to capture true Battery State-of-Charge and Battery Condition intelligence to improve vehicle productivity and provide a battery warranty-witness: only from Curtis.



With plans for the world's largest haul truck, 50-tonne ADTs and several other new models and ranges being backed up by a huge investment in production, Belaz seems to have it all well worked out

Zhodino, Belarus – Belarusian Autoworks (Belaz) used Minexpo 2012 as a platform to announce some ambitious plans for mining truck sales and development over the next two to three years.

Perhaps the biggest news was the official confirmation of its plans to design and bring to market the largest series production haul truck in the world. With a prototype due out in 2013, the development programme for the 420- to 450-tonne truck will continue the trend for increased hauling capacity and the resulting reduction in cost per tonne. The truck will boast 4,600hp, married to a Siemens MMT 500 AC/AC drive system.

With pneumohydraulic suspension and a 4x4 wheel arrangement, the truck will feature two driving and steering axles, and be fitted with eight 59/80 R63 tyres.

In addition, the company's mining truck portfolio will soon provide a solution for each 30 tonnes of payload, with the 2014 release of 2,000hp 170- to 190-tonne models, and 2,700hp 260- to 290-tonne models by 2015.

These will be available with either MTU or Cummins engines, and a complete array of electric drive options in line with the offerings available for trucks of 90 tonnes or larger – in other words, Siemens AC/AC, GE AC/AC or Russian-manufactured AC/AC or AC/DC systems. Belaz-designed and -manufactured wheel motor gears are currently standard on all configurations.

It's haul in hand

75710

A design programme that will offer a configuration for trolley operation of 220and 240-tonne models was also announced, with production of the option being targeted for 2015.

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With its 60- and 90-tonne models in mind, the company's proprietary hydromechanical transmission design is scheduled to go into production in 2014. This will be the latest in a series of initiatives to integrate the design, manufacture and quality control of certain key components within the organisation.

The magic number

This transmission will also be included in another of Belaz's exciting announcements – a 600hp 50- to 52-tonne model topping off a new range of articulated construction and quarry dump trucks. The 6x6 configuration will also be available in 350hp 27-tonne and 400hp 36-tonne sizes, all with engines from world-leading manufacturers. Production is planned to begin, in stages, from 2013-2015.

Questions concerning exactly how the almost mythical 50-tonne capacity had been achieved without affecting stability and other factors were, however, unfortunately sidestepped at the press conference, with the emphasis instead being switched to the plans for larger rigid models.

Development of a full line of underground trucks and LHDs was also announced. The trucks will be offered at ratings of 22, 40, 50 and 60 tonnes, and LHDs at 9 and 16 tonnes.

WHAT'S NEW

BELOW: 220- and 240-tonne trolley models will be in prototype form by 2014

BELARUSIAN AUTOWORKS

Flex your (electric) muscles

Another important announcement at Minexpo concerned Belaz's plans to become the only manufacturer in the world to produce an electric-drive truck offering a 90-tonne hauling capacity. The new model, due to enter production in 2014, will offer quarry operators the flexibility to choose hydromechanical or electric drive, depending on the haul profiles in their operation.

Both versions of the 90-tonne models will be available with MTU or Cummins engines delivering 1,050hp. The electric drive will use a Russian system developed in conjunction with the OEM. The mechanical model will integrate the in-house hydromechanical transmission described to the left.



With 450 tonnes capacity, the eight-wheeled Belaz 75710 is set to be the world's largest series production haul truck

Production will start in 2013, with the full line available by the end of 2015.

These plans will be made possible as a result of a US\$644 million investment that will dramatically boost production capacity, adding to increases initially started in 2011. A 20,000m² facility will be added next year to produce the ultra-class line of 320- to 450-tonne trucks, with additional capacity being generated by moving some 90-tonne truck production to a JV with Russia's SBU.

Global pillage

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On the sales front, Belaz announced its intent to enter major new markets within the next three years, most notably across North America and Brazil, Colombia, Peru and Indonesia. New sales and service organisations to serve those markets are now in the pipeline, with Michigan-based Belaz Trucks Americas already announced as a distributor for North and Latin America.

"Over the next three to five years, Belaz will be recognised as the manufacturer of the most complete line of earthmoving equipment and mining trucks in the world," said Petr Parkhomchyk, general director. "Our line is already strong, but the actions we are announcing will fill product line gaps and provide customers with the ability to choose product capacity and powertrain components to precisely tailor Belaz equipment to their operational and budgetary requirements."



 ABOVE : The 2,700hp 260- to 290-tonne truck, scheduled to enter production in 2015, will fill one of the payload gaps in the portfolio

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RARING TO GO

SAN MAURO, ITALY – Case has unveiled the first three models in its improved wheeled excavator range. The WX148, WX168 and WX188 feature a new fully automatic hydrostatic powershift transmission that is mounted to the rear axle to provide maximum ground clearance. In conjunction with the new heavy-duty ZF axles, this enables travel speeds of 35km/h, while providing a creep function for fine control.

Providing high drawbar pull, the axles feature auto locking for maximum stability when working without stabilisers. Multi-disc wet brakes and axle oil-change intervals of 2,000 hours reduce operating costs while providing powerful braking capabilities.

A three-pump hydraulic system enables the use of multiple excavator functions for continuous movement while digging and grading. With one pump being dedicated to the slew function, the Case Intelligent Swing system is therefore able to offer four swing acceleration and three deceleration settings. This enables the adjustment of the superstructure's swing speeds to suit a variety of worksites while ensuring continuous movement.

The Case Intelligent Hydraulic System governs the extra-powerful system with just one CPU, simplifying diagnostics and improving controllability. The Automatic Powerboost delivers optimum performance for heavy lifting and breakout operations, while providing an automatic power increase in travel mode to ensure speedy movement on the jobsite. Improved orbitrol steering enables effortless manoeuvring.

Superstructure 5 swing 5

WHAT A BIG LUG

CHAMPS SUR YONNE, FRANCE – Nicolas has produced a new version of the world's largest tractor for a mine in Australia. At over 10m long, 3.5m wide and 4.6m high, it has been purpose-built from the ground up, apart from the on-highway truck cab.

With 1,000hp, the tractor has twice the pulling strength of previous models due to its task of hauling lignite sidetipper trailers – each carrying up to 87 tons of coal – in a convoy with an overall towing weight of 535 tons.

Transport distances range from 10 to 40km at gradients of up to 5%, which can be tackled at 10km/h under full load. On straight, flat routes, 50km/h (loaded) and 65km/h (empty) speeds are attainable.



This is all made possible via the 663bkW C27 ACERT engine, in conjunction with the PowerBooster auxiliary drive system. Fitted between trailers, this motorised dolly automatically engages to deliver the necessary driving force when it detects a lack of power on gradients. A further benefit of the feature is the improved cooling performance that enables efficient operation in extreme climatic conditions, such as ambient temperatures of up to 50°C.

A six-speed Allison automatic transmission, tworatio ZF dropbox and axles of 12.5 and 25 tonnes capacity at the front and rear respectively complete the powertrain.

CONSTRUCTION FOCUS 🤝

JIM MANFREDI, MACHINERY OUTLOOK

LIEBHERR'S GOOD 2011 Liebherr's 2011 revenues for construction machinery and mining equipment jumped by €642.4m, or 13.5%, to €5.4bn, or 64.6% of the company's overall revenues.

For the first-ever time, earthmoving and mining division sales data was disclosed separately. In the former, revenues increased by 27.9% to \in 2.06bn. In the latter, sales revenues rose by 26.1% to \in 1.01bn.

Revenues from the mobile cranes division – included in the construction machinery product area – decreased by 4.0%, to \in 1.3bn. The overall turnover in the construction cranes and mixing technology area was \in 577.2m in 2011, an 11.1% increase.

Liebherr has announced an expansion project for a logistics building at its mining excavator production plant in Colmar, France, to cover an area of more than 15,000m². In addition, plans were drawn up to increase the production area to approx 29,000m².

WN STILL CONFIDENT

Wacker Neuson continues to expect double-digit revenue growth for 2012 as a whole, with a forecast of approx €1.1bn. Q1 was a strong period, especially in its core markets of Europe and North America, with revenues of €274.0m – an increase of 29% YoY. The YoY growth in Q2 revenues slowed to 7%, to €284.2m, due to lower demand from Europe.

"By contrast, strong light and compact equipment sales in the Americas pushed revenue in this region up 23% over the previous year's quarter," said Cem Peksaglam, CEO of Wacker Neuson SE.

One event in particular affected business in Europe during the quarter, when in May 2012 the Group began the production of compact equipment in its new R&D facility in Hörsching, Austria. Along with some changes to manufacturing processes, this delayed deliveries and also caused process and logistics costs to rise.

WHAT'S NEW

Revenues in the compact equipment segment rose 23% over the previous year. This segment also includes agricultural machinery, which reported a 28% improvement and already accounts for 17% of total group revenue.

Wacker Neuson plans to unite its light and compact equipment product segments under single management to maximise synergies, in particular with regard to international expansion. Martin Lehner will therefore take on responsibility for light equipment at executive board level in addition to his current role as head of compact equipment.

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SANY MIXES ANOTHER Sany Heavy Industry has

acquired Intermix, the world's third-largest manufacturer of truck mixers, for US\$9.78m.

Sany says the acquisition will expand the portfolio of its Putzmeister subsidiary, extend its industry chain and better collaborate with its existing business. Intermix recorded sales revenues of approx US\$12.5m in 2011.

AWPs GIVE TEREX A LIFT

Terex's Q2 2012 revenues hit US\$2.0bn, a 35.2% increase YoY. Excluding the impact of the Demag acquisition, they increased by approx 11%.

The Aerial Work Platforms division saw most growth, with Q2 revenues increasing 24.7% to US\$605.7m YoY as a result of good replacementbased demand in the North American rental channel. The Australian market was also a relatively strong contributor.

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Safety Control Units

WHAT'S NEW

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SEE YOU MUCH LATER, GATOR

MANNHEIM, GERMANY – John Deere has released an electric version of the Gator TE utility vehicle, which now provides an increase of up to 75% in battery life, depending on the application.

With an onboard battery charger under the passenger seat, the vehicle can now be charged from a standard 240V electric socket. Its advanced temperature sensor technology enables the eight lead-acid batteries to be charged more fully than ever before. Then, on sensing the charge cycle is complete, it shuts down automatically. The extra operating time this provides means that one charge should easily last the average user all day. A new, optional, 48V to 12V converter is now available, which means the operator can use a full range of 12V accessories.

A Dana transmission with helical gearing provides ground speeds of up to 25km/h via the separately excited super-quiet 48V DC motor and two-wheel drive system.

The wide wheelbase and low centre of gravity help to ensure high stability, despite its 185mm of ground clearance. Solid one-piece forged axles and a cast aluminium rearaxle housing provide the durability needed to handle extreme conditions.

The new 667kg model runs on low ground-pressure, highflotation turf tyres which help prevent soil compaction. With polypropylene side panels and tailgate, its deluxe cargo box provides an impressive total payload capacity of 410kg. It can tow up to 275kg.

The spacious operator station features adjustable seats, an FNR switch on the dashboard and the option of a four-post safety ROPS or cab protection.

NEW DESIGN AUGERS WELL

GRAND ISLAND, NE, USA – New features on 2013 Case IH Axial-Flow combines include an advanced Luxury cab option with brushed-chrome styling, and improved auger technology to enhance productivity.

Now lowered and featuring more seat travel, the operator's seat now gives more legroom. Air-ride suspension is standard on all 30 Series models, while a semi-active air-suspension seat is optional. A red leather Luxury seat option provides even greater comfort. The codriver's seat opens to reveal a portable electric refrigerator.

A slim, multifunction propulsion handle places all key controls within a finger's reach, while the upgraded right-hand console features simple ergonomic controls



and a slide rail for precise adjustment of the AFS display.

An industry-exclusive pivoting spout option on all High Capacity unloading auger lengths allows the grain stream to be accurately adjusted, via the propulsion handle, rather than having to reposition the tractor/trailer. Electronically controlled, the spout moves the grain stream by 60-90cm, while also providing a spillproof grain-saver feature – when disengaged, the spout automatically pivots upwards to prevent grain loss. This feature also can direct grain straight downwards to reduce wind-blow of light crop types.

AGRICULTURAL FOCUS

JIM MANFREDI, MACHINERY OUTLOOK

CAN YOU SMELL GAS? Valtra is to begin limited serial production of biogas tractors in 2013, becoming the first tractor OEM to do so. The company unveiled its four-cylinder N Series biogas prototype in 2010, followed by a six-cylinder T Series model in late 2011.

The model chosen for limited serial production is the 110hp N101. This dualfuel tractor can run on both transportation grade biogas or natural gas and diesel.

Registering the tractor will require special approval in each market, as common emissions regulations have not yet been agreed for dual-fuel vehicles.

TRACTIVE EFFORT

AGCO has announced a US\$20m investment in its tractor manufacturing facility in Beauvais, France; this is the largest industrial investment project at the facility since 1986.

The 'Beauvais 2' project involves the acquisition and development of a brand-new building on a 4ha site in the Allone industrial zone, less than five minutes from the existing 25ha AGCO factory site at Avenue Blaise Pascal.

The new complex will house the tractor cab production line and boost available floor space by 25%. Production is scheduled to begin there no later than September 2013.

Richard Markwell, président directeur général of AGCO SA, and VP and MD of Massey Ferguson EAME, explained: "As part of our development work on the new 'Beauvais 2' building, we plan to double its area to 10,000m² to provide sufficient room for the cab line and associated components.

"As a result, the space liberated at the current factory in Avenue Blaise Pascal will provide the next stages of Lean Manufacturing implementation, improving logistics flow in order to meet our goals of increased productivity."

CORDOBAN COMBINES CNH is to make further investments in two new plants at its Cordoba facility in Argentina, increasing total investment in fixed assets to €158.3m. The two plants will cover 65,000m².

The OEM will manufacture Class 7 rotary combines as well as a sub-85hp tractor range for special applications, and its Class 8 and 9 combine models, which are already in production at the complex. It will also manufacture T7 and Puma tractors, which range up to 220hp and have a sowing capacity of 80ha/day.

MITAS TOUCHES RUSSIA CNH-Kamaz Industry LLC, the Russian producer of Case IH and New Holland tractors and harvesters, and tyre manufacturer Mitas signed a contract at the Agrosalon agricultural exhibition for the delivery of tyres in 2012 and 2013. ۲

Initially the tyres will be shipped to Kamaz via Italy; then in 2013, tyres will be shipped directly to the CNH Kamaz facility in Naberezhnye Chelny (Tatarstan, Russian Federation).

In December 2011, Rostselmash began fitting Mitas-manufactured tyres to its harvesters and Buhler Versatile tractors. In late 2012, Mitas will undertake deliveries to John Deere in Domodedovo and Claas in Krasnodar.

Mitas has trebled sales in Russia between 2010 and 2012 (forecast). In 2011, sales to Russia amounted to just 2% of the total Mitas' sales, a share that is now likely to grow significantly.

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HANDLING FOCUS

MICHAEL LEU, FORKLIFTACTION.COM

ground during Q1 2013 on

an expansion of its Houston,

Texas, facilities to meet the

growing demand for electric products. Production capacity

will increase by more than

40%, for all electric and IC

to include production of IC

capacities and eventually

of the new Jungheinrich

rider pallet trucks.

TIGHTEN UP

ECR 327/336 series of end

"We plan to build all five

classes of products right here

in Houston," said Kent Eudy,

UniCarriers is consolidating

manufacturing sites in Japan

in a move to trim production

costs by 10-15% by the year ending March 2014.

Its subsidiary, Nissan

Forklift Co, has outsourced

production to a Yokohama

firm since 2001 but will end

the contract in April 2013,

said the Nikkei Report. As

from May 2013, the 7,000

small forklifts it produces

will be built at UniCarriers'

have an annual output of

20.000+ units.

main markets.

OUT OF REACH?

Shiga plant, which will then

UniCarriers bought TCM

August of this year, and plans

Corp and Nissan Forklift in

to integrate the subsidiaries

into the main company early

in 2013. It also intends to cut

shipping costs by expanding

domestic production in the

USA and China, which are its

Negotiations are underway with Cargotec staff who could

be affected by the centralising

of reach stacker and ECH

Szczecinski, Poland. These

are currently assembled at

the Lidhult plant in Sweden,

which is destined to focus on

forklift production in future.

production in Stargard

VP of sales and marketing.

support the manufacturing

This should enable MCFA

forklifts built at the site.

models in 6- to 16-ton

CLARK GOES OFF-ROAD Clark Material Handling has acquired EverGreen Electric Vehicles LLC to complement its existing product lines.

EverGreen has a 2,787m² assembly and production site in Compton, CA, USA. Its products include EVE lowspeed street-legal vehicles, Legacy golf and recreational cars, Hoss commercial and industrial units and Goat off-road vehicles.

"Industrial vehicles ... are a natural complement to our material handling line," said a Clark statement. "We view these ... as incremental sales opportunities, inclusive of vehicles and aftermarket parts, [and] another way in which we attempt to improve the Clark offerings."

TICO'S PLAN OF ATTACH

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Toyota Industries Corp is to acquire Cascade Corp for US\$759m. TICO plans to operate Cascade under its existing name as a wholly owned subsidiary, and retain its executive team. Cascade will exist separately from Toyota Material Handling operations, which "will not receive any competitive preference or advantage as a result of our new ownership", said the supplier.

Tetsuro Toyoda, TICO president, said: "Cascade has a strong reputation for providing customers with the latest technology in materials handling attachments. We've long known Cascade as a reliable and world-class supplier ... and we look forward to better meeting our customers' logistical needs by broadening our lift-truck business."

However, just as *iVT* was about to go to press, a classaction complaint against the bid was filed in Oregon.

HOUSTON, WE HAVE A... Mitsubishi Caterpillar Forklift America intends to break

Global materials handling online: www.forkliftaction.com

GOLDEN RETRIEVER

ANCENIS, FRANCE – Toyota Material Handling Europe has announced limited Gold Edition models of its 7FBMF 2.0- to 5.0-tonne electric counterbalance trucks.

The trucks feature an 'allround' digital multifunctional display with an overspeed alarm and a drive- and liftmotor service hourmeter. A low-maintenance battery cuts running costs, while sideshift makes pallet handling faster and safer.

There are also four option packages that enable further enhancement to suit specific customer needs. The Safety package includes PIN-code access to restrict truck use to authorised drivers only; an emergency shut-off button; and a back-up buzzer for safer reversing. A brand-new feature is the seat belt, which forms part of the Operator Presence Sensing (OPS) function, and prevents the truck from being operated without a properly seated, and secured, driver.

The Comfort package comprises three cabin options: open-sided, steel (enclosed) with heater, and the steel Comfort Cabin, which adds a radio/MP3 player and fabric trim for more comfortable operation in harsh Work rate can be boosted with the Productivity package, which adds a fork-positioner with a sideshift function for simple yet precise pallet handling. The Durability package adds efficient and long-life front LED lights, plus rear combination lights, which are ideal for shift work and busy applications.



A LOAD OFF YOUR MIND

JÄRVENPÄÄ, FINLAND – Designed for greater speed and manoeuvrability, the new six-model Velia ES series of low-level order pickers from Mitsubishi incorporate a number of key developments.

Based on the ergonomic design of OPB20NE models, the 1.0- to 2.0-tonne trucks are available with a choice of load selections, including cantilever and scissor lift, which help reduce operator strain by lifting loads to an ergonomic height of 800mm. Safety has also been

Safety has also been enhanced, with the inclusion of three rising platform models that lift the operator up to a height of 2.5m for safe secondlevel picking.

Said to offer the market's biggest-ever platform, the operator compartment offers an uncluttered walk-through design with a low step height of 105mm and chamfered platform edges for easy access. The entire floor mat acts as an operator-present sensor, enabling the truck to move away as soon as he boards.

Sophisticated electronics enable the tailoring of speed, acceleration and braking settings to suit individual operators and applications. The electric steering system provides automatic speed reduction around curves as well as automatic drive-wheel centring for safer operation.

The Maxius steering wheel brings all controls to within close reach and can be easily operated with one hand. It quickly adjusts to the most ergonomic position.



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DISPLAYS



COBO has completed its range of displays, offering now one of the largest range available in the mobile automation market. From the smallest 2.8" to the top 12.1" size, the common features are industrial design and ratings, high protection degree and reliability, 16bit or 32bit hardware architecture, single or double processor, Linux Operating systems and much more.

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INCLINOMETERS

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UNDERGROUND, OVERGROUND...

...WANDERING FREE AT MINEXPO, *iVT* WAS IN RAPTURES AT THE NUMBER OF EXCITING NEW MACHINES. MAKING GOOD USE OF SIX PAGES, HERE'S OUR ROUND-UP OF (ALMOST) EVERY NEW VEHICLE WE FOUND

■ The 'Caterpillarisation' of Unit Rig haul trucks is now under way, with the launch of two yellow models in the 320- and 240-ton classes.

Work on the former, the **MT5300D AC**, only began in late 2011, with the inclusion of a Cat C175-16 2,750bhp (optional 3,500bhp) engine and Cat 360T AC electric drive system into the proven MT chassis, hydraulics, electrical system and suspension.

The Cat AC drivetrain has logged hundreds of thousands of hours in the field, most notably in its 795F AC mining truck, and now leverages the experience of recent acquisition Electro-Motive Diesel in its design and manufacture. It

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offers high dynamic retarding capacity and dissipates stored energy at shutdown. Fourcorner wet-disc brakes provide highly effective stopping power.

The **MT4400D AC** features a 2,500bhp Caterpillar 3516C HD engine matched with a 240T AC electric drive system with rear wet-disc brakes to provide a solution for mines that do not require Tier 2 compliance.

Engine bay service walkways are popular with maintenance technicians, while the simple hydraulic systems, modular components, grouped service locations and groundaccessible maintenance points reduce downtime further.



■ One of the show highlights, despite frustratingly restricted technical detail, was a sneak preview of Atlas Copco's 3.4m-wide and 3.5m-high

MineTruck MT85.

"This truck is designed to fit the same drift dimensions of 50- to 60-tonne class trucks with one essential difference: it will haul 85 tonnes, which provides a tremendous productivity boost in terms of fewer trucks and more tonnes/kilometres per hour," claimed Ben Thompson,

product manager of Atlas Copco's Underground Rock Excavation Division.

Despite its 14m length, it boasts an impressive turning radius of 44°, largely as a result of the electrohydraulic steering of the rear axle.

The truck is also fast and highly manoeuvrable on ramps and inclines. "This means that fewer cycles need to be made which, in turn, reduces the cost of transport in relation to the amount of material hauled," Thompson added.

MINETRUCK

This gives mining companies a more cost-effective way to haul ore in the mine: "It now makes it more attractive to go for deeper ore bodies by ramp instead of sinking a shaft."

A high degree of options and modularity will enable the MT85 to fulfil a variety of requirements. Three engines (535, 760 and 1,010bhp) are offered, as well as 4WD or 6WD. The dump box can be tipped to the rear and the side, and the tailgate can be hinged at the top or the bottom.



■ With 66-ton capacity – 9% more than the AD55B it has replaced – the **AD60** is the largest of Cat's ADTs.

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Providing 579-600bkW, the Cat C27 engine has been refined for the truck, with new pistons and high-temperature fuel injectors, more durable rocker arm assemblies, a redesigned crankshaft lubrication system, a high-efficiency engine oil cooler and a higher-capacity fuel cooler.

Also new is a remotemounted transmission oil cooler that ensures optimum operating temperature of the seven-speed planetary





The ROPS cab, wide access stairways, traction control and quiet radial retarder grid with optimum visibility to the righthand side greatly benefit the operator. Although the cab interiors now bear a stronger resemblance to the Caterpillarbranded range, there are no plans to adopt a common cab module, due to the different mounting points.

Ed McCord, Cat's product segment manager for Large Mining Trucks, told *iVT* the technology flow goes both ways, however. "They are not interchangeable, but we're finding some good design features in the Unit Rig suspension struts that could be adopted in Cat models."

Komatsu will put the 730E (AC) 200t-class truck, which offers 15% higher speed and simpler maintenance, into full production in 2014. The bolttogether design makes field dis/assembly less complicated, reducing the need for skilled technicians and enabling the truck to be quickly deployed

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into new projects. The new frame and axle housing is said to set new standards for robust design and performance. With an easily removable powertrain module, less time is needed for on-site maintenance. The efficient design, which uses fewer hoses, bearings, pumps and wear components than many competing products,

simplifies training service technicians and completing regular maintenance tasks.

(formerly VHMS), the vehicle's operating information is sent wirelessly to a secure website, where data such as component trends and machine utilisation is made available for analysis in real time, enabling remote diagnosis of machine issues.

The operator compartment benefits from the same comfort features and controls used in Komatsu's larger models. The standard air-ride seats, superb climate control and easy-touse instrument panel with automatic speed control help to keep the operator focused on the road.

■ Sales of Liebherr's T 282 C ultra-class mining truck have grown by almost 60% since 2008, so the follow-up – the T 284 – has a lot to live up to.

Supporting high-capacity tyres, and claimed to offer the highest payload in the industry, this 400-ton-class haul truck features a durable lightweight frame with cast components in strategic areas and hollow box rails with fully welded internal stiffeners. The low empty vehicle weight that this creates ensures the maximum pavload can be carried.

The truck now relies on Liebherr's own electric drive Equipped with Komtrax Plus components, the Litronic Plus AC system, to determine the optimum way to extract power

from the MTU 20V 4000 engine (with options up to 3,000bkW). Combined with the relatively low GVW, this provides more power for acceleration and climbing grades.

Litronic Plus also conserves fuel when the engine is idling. This (and a 4,920-litre fuel tank) has helped Liebherr's other new truck, the **T 264**, to operate for 24 hours without refuelling, depending on use.

The AC drive system delivers up to 3,300kW of dynamic braking, reducing engine loading and fuel consumption.

Sized to match Liebherr's R 996 B and R 9800 hydraulic excavators, the new truck marks the OEM's return to the 240-ton class.



powershift transmission, which features a lock-up



torque converter, as well as an electronically controlled retarding system for optimum safety and productivity. The new cooler further reduces heat load on the engine oil cooler, helping it to function more efficiently. A new heat-shielding

system isolates heat from the turbocharger impeller, exhaust manifolds, and exhaust piping to reduce engine compartment temperatures and provide a cooler environment for any nearby components. Improved ventilated hoods and covers aid effective heat dissipation and assist in passive cooling of component compartments.

The truck forms an ideal match for the new **R3000H**, Cat's largest load-haul-dump with a 22-ton payload (up 16% from the R2900 XTRA it

being no larger).

This is made possible through the use of larger, repositioned lift cylinders with their greater lifting force, and a larger tilt cylinder with much | version is electrically operated, more aggressive digging and I while the Dual Drive model breakout characteristics.

between the solid-steel lift arms, and new bucket stops, add strength and durability to the front linkage.

The LHD is powered by a 409bhp C15 ACERT engine. This, in association with the newly developed Ventilation Reduction Package, which uses engine hardware and software modifications to reduce particulate matter, provides a 42% reduction in ventilation requirements over its predecessor. There is also a welcome 4% reduction in fuel consumption.

replaces, despite its footprint 📲 🗖 Putzmeister has introduced the SPM 4210 Wetkret series of concrete sprayers – three versions have been designed to meet a variety of job site requirements. The standard has a dual operating system The redesigned torque tube 👔 that makes it possible for all of its components to be

operated either electrically or by diesel. The Rotor version uses a rotor pump, which enables the equipment to be used for both wet and dry spraying processes. All three models include an onboard air compressor.

The reinforced spraying arm provides a 10m vertical spraying reach, while the

maximum concrete output of the double-piston pump is 20m³/hr). Easy operation of the spraying arm, regulation of the concrete output, and adjustment of the dosing pump can all be remotely controlled.

The SPM 4210's reinforced turning system and axles will allow it to accommodate the toughest working conditions.





MINEXPO REVIEW

■ With a 296-tonne payload, the **EH5000AC-3** is Hitachi's largest haul truck and the first to feature its Advanced Hitachi AC Drive System, the technology that also powers Japan's bullet trains.

Hitachi claims to be the only company in the industry that designs and manufactures all the components of its drive control system. Now featuring sensors on all four wheels, the latest iteration incorporates two inverters with 200kVA rated capacity per unit, two 920kW wheel motors and a 2,050kVA alternator.

In addition to the slip control for traction (similar to active traction control) and slide control for grip (similar to an ABS system) that were on the previous generation of Hitachi AC trucks, the technology provides the new model with two useful extra features. Pitch control provides far smoother ride control and control of bouncing when stopping, while skid control enables greater stability when cornering in

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slippery conditions. And now, with additional feedback from the drive system, front wheels, steering, suspension and other systems, the slip/slide control functions have been enhanced too. ۲

Electric braking provides 3,750kW of retardation, thereby ensuring a complete halt on grades via the AC wheel motors in conjunction with six Hitachi resistor grid packages.

Power is supplied by a Tier 2 Cummins QSKTTA60-CE 2,850bhp engine, providing a top speed of 56km/h.

Hitachi also introduced the **SkyAngle** camera monitoring system at the show. Developed in conjunction with Clarion, this synthesises images from four wide-angle cameras mounted at each side of the truck to display a bird's-eye view of the surroundings on an in-cab display. Operators can then toggle between zoom and wide-angle displays to provide more comprehensive monitoring of other machinery in the vicinity.



■ Engineered to be a perfect three-pass match with the LH517 and LH621 LHDs, the new **TH551** and **TH663** underground trucks from Sandvik place an emphasis on safety as well as productivity.

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The 51- and 63-tonne trucks – to be made available in mid-2013 and late 2013 respectively – boast 63 safety features to protect the operator, maintenance staff and the truck itself. The 35% larger ROPS/FOPS cab, for instance, includes a four-point retractable seatbelt for the operator and an easy-to-use control system display with a range of colourcoded warnings. Front-frame suspension enhances comfort.

The replacement time of large components, such as the transmission, has been reduced, leading to increased uptime and total tonnes per year hauled. Another productivity benefit comes from the optional onboard jacking system, which allows fast and safe tyre changing, avoiding lengthy downtime that could also potentially block the haulage ramp.

As well as providing high torque and low fuel consumption, the low-particulate Tier 4i diesel engines (models still to be disclosed) can considerably reduce the need for underground ventilation.

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MINEXPO REVIEW



■ Joy Global announced two new rope shovel designs that are scheduled to be placed in mines by Q4 2013.

The **P&H 2650CX** hybrid (right) is a diesel-electric machine designed to blend the high productivity of electric models with the flexibility and mobility of hydraulic excavators. Its articulating hydraulic clamshell delivers a 65-ton payload to four-pass load 240-ton trucks.

P&H expects the new design to deliver a 15% reduction in TCO compared with hydraulic

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excavators. "Fuel consumption will be reduced by as much as 25% through using proven

power regeneration from our electric motor and drive systems technology from our

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P&H Letourneau-Series wheel loaders," said John Koetz, VP product marketing & engineering. "The system will be approximately 50% more efficient than comparable diesel-hydraulic systems."

By decreasing hydraulic routings, onboard fluid and pumps, reliability, efficiency and maintainability should also substantially improve. resulting in increased machine availability.

With a 135-ton payload, the P&H 4800XPC (main image) will become the company's largest electric rope shovel. Designed to three-pass load 400-ton haul trucks, with the potential to move 9,000tph, it offers 20% more productivity than the P&H 4100XPC AC, upon which it is based.

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It also features new patentpending Adaptive Controls technology that offers seven advanced functions to optimise shovel power usage across different phases of the dig cycle. There are also more such as the wider boom and handle, the new dipper with a higher weight-to-payload ratio, and a patent-pending modular counterweight system.



IZ-Kartex revealed that its **EKG-50** electric rope shovel is I now under development, using the NX 7.5 software package. This top-of-the-range 1,550-ton ■ model will feature a 108-ton. 60m³ bucket capacity designed to suit the loading of 280- to ■ 360-ton haul trucks.

Adjustable frequency drive ■ (AFD) technology with a PWM microprocessor-based algorithm will complement the AC drive. With 50Hz, 6kV ∎ voltage and a 2MW main transformer, IGBTs will be used to generate the variable voltage and frequency needed to control motor speed.

Two 1,100kW hoist motors L. robust structures and systems, and three 400kW slew motors will enable a 34-second cycle time. Eaton-Airflex disc brakes, with a floating housing design develop equal torque in either direction of rotation. Travel speed will be 1.1km/h.

■ A new package of upgrades to Atlas Copco's Boomer underground mining and tunnelling rigs was revealed at the show. The rigs can be equipped with up to four booms - providing a coverage area of 16-208m² - and one of the most extensive ranges of high-performance (16-30kW) rock drills on the market.

With the engine being used only to propel the vehicle, and electricity for drilling, this reduces emissions, as does the option of a Tier 4i engine. Biodegradable hydraulic oil is another option.

The operator is at the heart of the upgrades, with a more ergonomic seat now provided. Its flat armrests now feature two multifunctional joysticks, rather than the previous four, although the rig can also be operated from a standing position.

The control system has also been upgraded, with a 15in intuitive touchscreen providing a user-friendly interface. Underground Manager, the latest planning support software, now includes functions that were previously individual products, such as Ore Manager for long-hole drilling and Tunnel Manager for face drilling. It also adds features that were previously not supported, such as blast design and blast simulation.

Other features such as CAD file import/export will provide greater flexibility in areas such as drill plan design. It contains a new drill plan generator, a complete 3D view of the tunnel, smart interpolation of contours and improved logging and reporting functions.

The package will be applied to all new computerised rigs beginning Q2 2013.



Know-How in Motion



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OEMs are seemingly at a post-downturn paradox: their teams are ramping up projects and aggressively pursuing new machine designs, yet those ambitions are being tempered by their current staffing limitations. Sauer-Danfoss experts are ready to help.

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MINEXPO REVIEW



■ Liebherr introduced a face shovel version of its 353-tonne **R 9400** mining excavator, with production-tailored kinematics and a mining-optimised 22m³ bucket shape to provide the highest crowd and breakout forces, as well as being ideally suited for loading 150-ton haul trucks.

Every attachment cylinder has been fitted with Liebherr's Electronic Damping System to ensure controlled endcushioning for fast, smooth motions. During boom lowering, pump flow is diverted by the energy-management system to enable other cylinders to operate unimpeded.

It is available in a 1,675bhp Tier 2 Cummins QSK50 dieselpowered version, while an electric-drive configuration provides an efficient alternative for cold climates. A powered 45° stairway fitted with handrails provides access to the superstructure, where a drop-down flap gives efficient access to the main servicing features. However, fuel, engine and hydraulic oil, grease and windscreen wash are refilled from ground level.

In the small class, Liebherr introduced the 757hp 130-tonne **R 9150**, with 8m³ bucket and a heavy-duty fatigue-resistant undercarriage, which will soon replace the R 984 C. When less power is required, Eco-Mode can be selected via the monitor panel to reduce engine load and fuel consumption.

The grease and fuel tanks have been sized to considerably extend the service intervals, while one-side service access simplifies the process. The robust sliding ladder and large catwalk give effortless access to major service points. In other news, Dr Jörg

Lukowski, executive VP (sales and aftersales) revealed that Liebherr was looking closely at developing a product in the 200-ton class to enable it to offer the most complete hydraulic excavator range on the market – of which it had an almost 20% share in 2011.

■ As well as the **6120B H FS** hybrid shovel, featured on page 40, Cat launched the **6030B FS** at the show. Building on the performance of its Bucyrus 6030 FS predecessor, it retains the 33-ton payload and approx weight of 316 tons, but now incorporates several Cat components.

The displayed machine featured two Cat C27 engines producing 1,530bhp, although there is a full line of diesel and electric-drive options. Available in backhoe and front shovel configurations, it now features Cat C95 GET with a hammerless design for simplified installation.

To aid bucket guidance and assist in applying forces, the TriPower shovel kinematics have also been retained, along with the advanced hydraulics control, independent oil cooling, intuitive onboard electronics and durable structures.

Access walkways and hand rails have been redesigned to enhance the safety of operators and technicians. The primary improvements however, relate to the cab, which you can read more about in our exclusive article on page 44.



■ Putzmeister's new Mixkret 4 low-profile concrete mixer provides a concrete transport capacity of 4m³, and includes a liquid additive tank for the transporting and transferring of additives to the shotcrete equipment.

Its 176hp turbocharged Cat ACERT engine provides high motive and climbing power, as well as the ability to work at high altitudes as a result of the Automatic Altitude Compensation system. It comes with a catalyst as standard, helping minimise ventilation requirements.

Heavy-duty planetary axles, both of them steered and powered, ensure excellent mobility in narrow tunnels, with an external turning radius of 6,631mm. The rear axle oscillates to provide greater shock absorption across the maximum load area when crossing uneven terrain.

The hydrostatic ICVD transmission with stepless variable gear motor ensures the ideal torque-to-speed ratio, while an automatic speed-control system enables the truck to descend grades, fully loaded, at the maximum safe speed.

Combined with the hydrostatic holding system used to lower the speed on slopes, curves and crosssections, the hydraulically driven multidisc wet brakes can reduce operation costs.

A heavy-duty ancillary transmission gives the drum high load and rotation capacity, while the cab is mounted in the same direction as the truck, which, with the night-vision camera at the rear, greatly enhances visibility and manoeuvrability.

Atlas Copco released the
 latest model in its range of
 multidirectional ANFO
 ammonium nitrate/fuel oil
 explosive) charging trucks,
 which was acquired with the
 underground products division
 of GIA early this year.

The **Chargetec UV2** has a high-speed charging capacity of 130kg/min with high density. The single-boom truck can be fitted with one or two vessels for optimised charging of a full drill pattern with fixed carrier positioning. The ANOL CC charging vessels are available in volumes of 300, 500, 750 or 1,000 litres.

The heavy-duty carrier has articulated frame steering and 4WD, providing high flexibility and manoeuvrability, even in narrow drifts. It is available in diesel or electric versions.

A FOPS-II approved canopy or cabin protects the operator, who is issued with a comfy seat with armrests. A passenger seat is also standard; both seats are equipped with a two-point safety belt.



MINEXPO REVIEW

Cat's MD5150 track drill is a customer-inspired design for the drilling of holes up to 6in in diameter. Holding six rods and accommodating multiple lengths and diameters of drill steel, its innovative carousel rod changer can dramatically reduce setup time. Weighing less, and holding more rods, than linear models, it is able to reach farther and drill deeper

a (102.5ft) while maintaining high stability.

With less than half the moving parts of competitive models, its simple reliable design is easily serviceable by the owner. An automated lube system eliminates the need to schedule manual greasing every two hours.

A boom-mounted camera provides a constant view of

the boom while working inside the walk-in service station, which also provides easy access to the major service points.

Its 285bhp Tier 3 Cat C11 is matched with a biggestin-class air compressor to optimise airflow, while an oversized high-efficiency cooling system further improves performance. Atlas Copco's Pit Viper 311 wide-range rotary blasthole drill is the first release of the all-new Pit Viper 310 series. Although similar to the Pit Viper 351 with its single-pass drilling, it has the capacity to drill holes even deeper, to a maximum depth of 125ft. Offering 9- to 12.25in hole diameters, it fills in the gap between that machine and the Pit Viper 270.

"One of the things we're most excited about on the PV-310 series project is our new cab," said lain Peebles, engineering project manager.

"Now you have a fully adjustable chair with joystick and cab controls. We've also elevated the cab above the deck to give the operator a better view. We've tried to improve operator visibility around the machine, with larger windows and mirrors placed so that the operator can see what's going on at ground level and to the front of the machine."

There are Tier 4i and Tier 2 engine options available, while a patent-pending automatic hydraulic clutch option has been designed to decrease



fuel consumption during nondrilling operations.

A multipass version, known as the Pit Viper 316, is under development as a replacement for the DM-M3, enabling drilling to 295ft using a five-rod carousel with a 50ft drill pipe.



■ The MineCat **UT99C** was designed from the ground up to handle extreme underground environments. The entire vehicle can be split into two halves for transport in cages, eliminating the need to cut the heavy-duty frame with torches.

Meeting Tier 3, MSHA and CANMET requirements, the utility truck is powered by a Cummins QSB3.3 engine, matched to a Dana T12000 powershift transmission and heavy-duty axles featuring SAHR wet-disc brakes.

Unlike the 12V powerpack that is often used on converted pickup trucks, the UT99C is equipped with an open-centre hydraulic pump that supplies power to the brake system.

Highly customisable, it can be fitted with a wide range of equipment including a crane and telescopic aerial boom.





1,300 lb load capacity on land, or 1,000 lb on water.

Its fuel-injected 31hp Kohler petrol engine powers a directdrive triple-differential Admiral steering transmission, feeding even torque (AWD) to the eight 25in tyres. All eight heavy-duty axles are connected to the tranny's output shafts with heavy-series final drive chains. An optional chain lube system automatically lubricates them all via a pressurised pump and distribution block, during a five-second period every 15 minutes.

A claimed industry first, the multiposition handlebar steering enables adjustment of the driving position to suit every operator.

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ECOMIX II, the new generation of ZF mixer transmissions, has been greatly improved compared to the previous models. In addition to weight and installation space savings, the new ECOMIX II is tougher, quieter, more flexible at installation, allows easier maintenance and is fitted with life-time oil lubrication – to name just a few of the advantages.



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TAUTONA LHD



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Gary Major & Ed Wagner

Previously in charge of in-house ID at JCB, Gary is now director of ID at LiuGong R&D. Ed is LiuGong's director of testing and deputy chief engineer of advanced technologies. He has previously held several roles at CNH Construction Equipment

The TauTona LHD is a concept study for a low-profile, electricdrive underground load haul dumper for use in deep mines. With a brief to explore ideas to improve machine productivity, the focus has been on designing the loader end to be a more efficient tool for use in a confined and often hostile environment.

Based on telescopic monoboom geometry, the loader end consists of a one-stage extension that gives the LHD a competitive loadover height and incorporates a swivel joint to enable the ruggedised shovel to be 'steered' into restricted spaces. Once fine-tuned to optimise shovel positioning, laser calibration would enable a swift return-to-dig cycle. To enhance reach even further, the shovel itself can be biased to the left or right by activating a powered side-shift mechanism. The all-electric heavy-duty driveline is designed to accommodate

The all-electric heavy-duty driveline is designed to accommodate high-torque loading applications and high-speed tramming. With zero emissions, the TauTona contributes to keeping operating costs down by lowering airborne particulate matter (thereby meeting environmental ventilation/filtering requirements) as well as reducing the risk of underground fire and explosion.

The cab is designed around an asymmetric footprint to maximise the available space envelope and features all-round visibility through a super-strong laminate of graphene and Corning's Gorilla Glass. Built-in CIPS (cave-in protection system) is incorporated into the steel structure. During normal operation, the machine CPU continually sends

During normal operation, the machine CPU continually sends a ULF radio signal through the mine, indicating its exact position. In the event of an emergency, the break of signal and subsequent 'handshake' to the main tracking computer would alert the onsite rescue team to the problem and provide the exact threedimensional position of the machine when the signal was lost.

Meanwhile, the TauTona LHD automatically shuts down all external functions and puts itself into 'lifeboat mode'. The fully pressurised cab then acts as a safety cell with several days of survival provisions, and the main batteries switch to trickle mode to run the machine's onboard air-filtration system. garym@liugong.com / edward@liugong.com / http://en.liugong.com LIUGONG





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GROUNDHOG LOADER



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Pope Design

Jon Pope has designed heavy equipment for over 14 years. He has worked for a variety of off-highway OEMs, whether as an independent design consultant or employed by Teague

A loader mounted on a turntable is not a new idea – the first time I saw one was as a kid back in the early 70s, when I was given a Kingsize Matchbox replica of a Hatra loader that featured this sort of layout. The difference with my Groundhog Loader concept is that the loader arms are articulated. This allows the loader assembly to rotate 90° to either side and then extend out – now the loader can dig and load rock 180° from one side to the other.

The cab rotates 360° so that the operator always has visibility of the work area being excavated, no matter in which direction the loader is digging.

A static counterweight located in the middle of the chassis, and one mounted to the loader turntable, help to maintain the machine's stability while reaching and digging to either side. A large side-shifting counterweight mounted under the chassis also helps keep the Groundhog stable. When the loader digs and reaches to the left, the counterweight shifts outboard to the right, and vice versa when the machine digs and reaches to the right.

The rotating loader assembly and articulating loader arms on the Groundhog Loader also give the machine a loading versatility underground not seen on other machines. The Groundhog Loader can pull up parallel to a hopper or haul truck, rotate the loader arm assembly 90°, and use the articulating loader arms to reach out to properly centre-load the hopper or haul truck dump bed. In addition, because the cab can rotate 360°, the Groundhog Loader can load forwards or to either side of the machine. This could allow for great flexibility in terms of how the mine is set up. *www.pope-design.net / jpope@pope-design.net*





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TOP: Buckets can move vertically for greater selectivity of material

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LEFT: Conveyor belt angle adjusts according to cab position

THE EXCAVEYOR



Kevin Wilson

A graduate of the Reilly programme at Notre Dame, Kevin is a freelance machine designer specialising in the conceptual visualisation of mechanisms, vehicles and industrial environments

Designed for underground mining, particularly of soft rock, the Excaveyor has a relatively low height compared with traditional excavators. A diesel-electric hybrid, its business end consists of a cluster of rotating buckets, which are oriented at 90° to the regular position on a typical loader. These spin rather like the brushes on a street sweeper as the machine moves towards the load. When an individual bucket reaches a certain point along its circular path, its contents are then transferred to an adjustable angled conveyor belt that takes the raw material and transfers it to another vehicle or container for further processing.

The cab/cockpit slides forwards and backwards to enable the conveyor belt to adjust to various angles as needed, while a set of hydraulic ripper claws at the rear of the machine help break up tough surfaces. The bucket cluster can also move horizontally and vertically as it rotates, to enable greater selectivity. If the machine was used for ferrous ore mining, the buckets could be magnetised, providing an easy way to separate out dirt from the actual ore.

The Excaveyor has the additional advantage of being able to load and unload simultaneously without needing to reverse out or change its orientation relative to the load or other vehicles. wilsonme2@gmail.com



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ANTIS LOADER

Jouko Polojärvi

Jouko Polojärvi works for Elomatic R&D Services, a team of industrial designers, art designers, ergonomics and usability experts serving several Finnish off-highway vehicle manufacturers

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The Mantis is a bug-like remote-controlled loader designed to simply and efficiently clear tunnels of rock debris, selectively loading it into a truck to the rear via a series of conveyor belts.

The starting point for our concept was to create a flexible system that accommodates different working modes in response to the surrounding conditions, rapidly clearing rocks from the tunnel and enabling the next blasting to take place within a minimum cycle time. The Mantis is therefore a vehicle used for drilling, loading and scaling, with independent belt units that haul material away from the tunnel. It is controlled automatically via cameras and sensors or by using a remote control, either close to the vehicle or from a distant control room.

The Mantis uses pneumatic hammers to chop the blasted rock into smaller pieces, before moving and selecting rocks for loading. This work is carried out by a pair of jaws that transfers rocks onto a conveyor belt. This consists of independently moving remote-controlled belt elements, which can be used in a traditional conveyor belt mode, where material selection occurs manually somewhere along the line. Alternatively, one element could be equipped with a dividing module to separate different materials, carrying the ore, for example, to place A, and the spoil to place B.

The belt elements are able to operate in vehicle mode as well. Each element can be assigned to different locations, depending on the material they are loading. www.youtube.com/user/ElomaticOY / jouko.polojarvi@elomatic.com

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ON THE WEB For much more detailed explanations and extra images of most of these concepts, visit: www.iVTinternational.com





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Alberto Seco

Alberto has been involved in design projects from mobile phones to heavy equipment. After working for an Italian design consultancy and as an industrial designer, he now works in the Colour & Trim area for the auto industry

In opencast mining, bottom-dump buckets designed with curved shapes to improve material flow are used on front shovels for removing overburden, while smaller, customised excavators are used for mining coal seams. Customisation consists of high-capacity deep bottom-dump buckets and a curved boom that avoids the added height of a truck's coal body while improving side visibility.

However, bucket design seems to be a limitation in carrying out both duties with the same machine. The 400HY CFS (Coal Front Shovel) concept consists of a 75-tonne excavator that could be used for removing overburden as well as mining the coal seam, simplifying the task of reaching, selectively transferring and loading the raw material. The main innovation is an extendable quick coupler that enables the operator to change buckets or implements without leaving the cab, as it includes an automatic coupling for the hydraulic oil. Different buckets can therefore be quickly attached according to different uses: • Heavy-duty bottom-dump buckets for removing overburden. V-shaped blade

and wear-resistant replaceable components provide the ideal solution for poorly blasted or difficult to penetrate material; • Bottom-dump buckets for coal seam duties such as the extraction of coal

From the seam, cleaning/classification and loading of coal. Coupling points provide a bigger angle of bucket movement for better seam mining;

• High-capacity forward-dump buckets also provide more manoeuvrability, making them more suitable for coal extraction. Their lighter weight and higher capacity enable higher performance, while the extendable quick coupler enables other implements to be mounted with different coupling pins.

To avoid the added height of coal bodies and improve side visibility, the operator station has been moved higher and forwards, the boom has been perforated and the RHS bonnet grilled to minimise obscuration zones. www.behance.net/albertoseco / albsec@euskalnet.net





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CANbus Joystick | WM-580

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CASE STUDY

When this year's Forbes and Thomson Reuters Innovation lists were revealed, I was a little taken aback at how poorly represented the off-highway industry was. Yet while many familiar OEMs were notable by their absence, standing proud at number 84 on the former was Atlas Copco, a company that has been off my radar for most of my time at *iVT* because of what seemed to me to be its much heavier emphasis on tools and static machinery rather than actual off-highway vehicles.

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However, I'd already been planning a feature on the company, after being intrigued by three incredible new drilling rig concepts – the ROC X series – on display at its booth at Intermat this year (brief descriptions of each appear as captions in the following

Atlas Copco

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pages). So when I called Alex Liebert, its Industrial Design Competence Center manager to discuss these, we started off by chatting about Atlas Copco's emphasis on innovation, as evidenced by its motto: 'There's always a better way'.

"I was also surprised at the lack of mobile machinery manufacturers on those lists," he began. "We're all in the same market, so the same thinking should apply – you have to put your customer first, learn what they need, and then innovate to solve those problems. Innovation is the advantage that customers get from us – that's why they buy our products."

Funnily enough, one of Atlas Copco's main innovations could be the 'Innovate With Us' page on its website, which actively encourages MAIN IMAGE: The ROC Xone was first seen at the 2010 World Expo in Shanghai, China – the other two concepts debuted at Intermat 2012

BELOW: Alex Liebert, Atlas Copco's Industrial Design Competence Center manager



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CASE STUDY

designers, customers and back-yard inventors alike to submit ideas and partner up for the development of new features or machines. At the time of writing, however, it had only been live for two weeks or so, and therefore far too early to judge whether any potentially industrychanging ideas have flooded in.

Crowded house

The company would be well placed to handle any deluge though – its industrial design centre has grown from just one to 25 designers in the past eight years. "The operator is inside our product in a really tough environment, so there has been a great focus on protecting operators so they feel more comfortable," Alex explains. "Our engineers realised early on that the complexity of these products is so huge, that it's natural to involve different competencies in the process, and we are one of those.

"When I started at Atlas Copco in 2004, it was a smaller company with fewer products. Now the portfolio for each of the different business lines has grown, and we also have increased through acquisition, so we now have 30 brands.

"We're like an internal consultant, telling everyone what we can do, why, and what the advantages will be – we see the maturity of Atlas Copco to use design to utilise the advantages most."

Speaking of acquisitions, I was surprised to learn that since Dynapac joined the family in 2007, no attempts to increase component commonality between these very different brands have been made – in fact, Alex's team has worked hard to exaggerate those aspects that makes each different.

"Atlas Copco products have one main competitor underground, two sometimes, but for Dynapac there might be 30, or even 50 in certain markets. So it's a totally different situation, and we have to face that with different brand appearances.

"After the acquisition, we made a design strategy project to see what the design language of Dynapac was, and how we could improve it over time. We found that the colour red was very often used on very complex and technical elements, so we came up with a new design language to enhance that, calling it 'Red Element'. If you compare the latest machines



The Xone can also tram to a work site in virtual silence without churning up the ground, using extrawide stealth tracks for greater manoeuvrability and low ground pressure. These quad-tracks are like feet that adjust to the ground, automatically raising the 'toe' at the front to climb over

obstacles





to those before 2007, they're much more powerful-looking, although we prefer not to use the word 'styling' – it's 'design language'. Styling suggests we come in late, after the engineers have handled the entire project and we just add colour and graphics, but we try to be there from the start to make sure that we really enhance certain aspects of the appearance so that we can best display brand values and functionality features, etc."

That said, I decide to risk his wrath by asking if 'styling' carries the same importance for Atlas Copco vehicles that rarely see daylight as it does for the more well-known Dynapac road construction equipment, for instance.

"Most of the reason for the growth of our design centre is due to the fact it's so important for underground machines," he claims. "The person buying them may not be the user, but a corporation that is more interested in the features and service contract, etc. But when we tell somebody we're a market leader and we have the best product, it's vital that its appearance backs that up. Over time, operators will destroy our product - it will look horrible after a couple of years in the mine, but it would look even worse if they didn't like it from the start! If they climb in a machine and like it,

then they take care of it and become more productive because they know they are safe, comfortable and can be more focused on their task."

Motive power

Back above ground, we return to the subject of innovation when I ask about the motivation for displaying the three ROC X concepts at Intermat.

"In our industry, new products can revolutionise the business - they can suddenly make an operation work totally differently, switching from one kind of technique to another," Alex states. "It's nice to work in a company with these long-term perspective projects where you work on innovation that needs to reach the market maybe in 10 or 15 years at the earliest - but the problem is, how do we tell customers we're actually doing this? They typically have to wait until three or four incremental updates reach the market before there's such a breakthrough.

"So, with the ROC X models we can show that we have these kind of solutions without revealing our actual development plans. These concepts all use currently available technology – we could actually make them today if we wanted. But although we will manufacture something like these in

CASE STUDY

QUIET REVOLUTION

Although cabs are conspicuous by their absence on two of the three concepts, I was still keen to pick Alex's brains on a few related topics. He'd already mentioned the recently released Rig Control System (RCS), which provides an interface similar to that of modern iPads and tablet interfaces, helping operators intuitively find what they're looking for without needing to head into the office for the information they require, before talking about how today's machines must change to adapt to the user, rather than vice versa. "When we started with computers, we had to learn the computer's way, but now when our children pick up a computer, they can do what they want to because the interfaces have been adjusted to the mindset of the users. So you shouldn't have to change to become an operator – the machine should work with your feedback and your thoughts and ideas."

I'd recently heard a comment about how increasingly quiet cabs could make voice control a more viable method of activating functions – could that be a possibility for Atlas Copco machines? "I think audio is really important," he responds, "but it's not just controlling by voice. Quieter cabs also allow you to receive information by audio, especially when you need to make the operator aware of an incident, etc. You don't need to force people to look at the screen all the time – if you have, for example, the right software on your smartphone, you can use audio cues to know at what speed you're running, the distance you've made... you can choose to focus on what information comes in. A lot of data in our rigs is not crucial – you don't need to know about it all the time – so you could choose whether or not to focus on the sound – that's something we will have to explore more in the future."

the future, they will look different and work different – but still offer breakthrough advantages."

It's all in response to 'unarticulated needs', he continues: "We really know what operators are doing and what they need. But we don't just listen to what they tell us, we also watch them and see what they do in reality. We can't tell what we have learnt from them because it's secret – they don't know themselves, but it will make their day!"

Although Alex admits that some of the ideas in these concepts could well be seen in Atlas Copco's next generation of surface drills, he's coy about revealing exactly which. But it's notable that two of the machines are autonomous – so now that we're becoming more and more accustomed to autonomous haul trucks, will the technology really kick in with drill rigs soon too?

"Yes, definitely, given certain scenarios that we see developing," he replies. "As mines become more mature, the level of sophistication demanded both from the operators and the machines increases all the time. At the same time, when mines want higher performance from their machinery – and also due to safety aspects – it becomes increasingly

"ALTHOUGH WE WILL MANUFACTURE SOMETHING LIKE THESE IN THE FUTURE, THEY WILL LOOK DIFFERENT AND WORK DIFFERENT – BUT STILL OFFER BREAKTHROUGH ADVANTAGES"

difficult to attract employees. The iPad Generation rarely wants to go out of its comfort zone – they'll ask 'Why can't we be on the surface and operate this product instead?' So we have to create products that can work autonomously, with people only needed for supervision.

"As you shift complexity, the products can become more efficient, too. Our Scoop Tram is an example – there's an innovation we call 'Foot Box' which 'bends' the transmission around the operator so he can sit in a comfortable position. So with no cabin, we no longer need the up box and the drop box, meaning the driveline is much more efficient."

When two worlds collide

What's also interesting about these concepts is the way they take some commonly seen technologies from underground mining machinery and transfer them to surface machines to make something quite unusual. Take the traction technology, for instance – why does the ROC Xtwo use wheels, in contrast to the almost exclusively tracked surface rigs around today?

"We typically work in very harsh environments where rubber tyres just can't cope," Alex says. "We looked at forestry machines, which have really big, wide wheels – often they have to climb over rocks and logs so they have chains round the tyres to protect them and provide a lifespan as long as that of tracks. So we're not just using the rubber tyre; it's protected with these chains and therefore we think it will work in the harsh environment."

And what about the quad-track arrangement of the Xone and Xthree – why aren't any other surface rigs using those at the moment? "I think it's a very traditional focus that you add tracks to get the counterweight and stability you need when drilling, but we applied different thinking. We have seen in other industries that quad tracks make sense."

I remember being astonished when I first saw the dual-drill arrangement of the Xone, before putting it into context after recalling that many


RIGHT: The semi-

it is easy to use

regardless of terrain.

the mirrors or just try to destroy products," Alex complains. "So you can

the next morning to continue working or it

is sent on to the next

customer.

autonomous ROC Xthree's adaptable size and foldable

design make it the ideal

rental machine for a variety

of tasks in the construction market. It fits in a standard

10ft container, enabling it

underground machines operate with four booms. So why has it taken so long to transfer this idea?

"We can really see this taking off because it makes a lot of sense," Alex states. "When you go underground, everything gets more expensive so high productivity becomes extraimportant. The shorter cycles from multiple booms help to reduce costs, but the fact that it is much cheaper to be on the surface is a main reason why it hasn't transferred over yet.

"Another is that to get the same performance from each drill would require a much bigger engine, but by thinking differently - that you only need hydraulics for the drills you can accommodate that."

Plugging a gap

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Interestingly, none of the concepts use an IC engine – the primary motive force would be supplied from an onsite electric powerplant, in much the same way as many of today's shovels and draglines. Should that setup not be available, the advances in fuel cell or battery technologies over the next 10-15 years would make a back-up internal electric system viable.

Along with further developments in vibration and noise damping, this would also make the machines much quieter, with electric being used for every function save drilling, where hydraulics - which Alex says are 25 times or so more efficient - would still be employed.

Although no new drilling methods are envisaged - Coprod, DTH and top

hammer could be used on each there is talk of an ultra silencer. "We have silencers already today, with an open sheave where you can see the work drill, but we've a couple of ideas to improve that. Making sure we seal off the connection between the hole and sheave is where we can improve the dust collection system further."

However, a development on the Xthree, and applicable to the others, will be of great interest to operators a built-in drill-bit grinder that does away with a laborious manual task. "It's strange – we make a nice cabin to keep them safe and warm, but they have to stand outside the rig, which is kicking out noise and dust, to grind a fresh drill bit before repositioning.

This concept enables you to keep the drill bit on the drill string – you can sharpen it while you are driving

Designed for tough drilling on challenging terrain, the ROC Xtwo's large wheels enable guick repositioning and easy navigation. Designed with road construction firmly in mind, it's ideal for blast work on a rocky hillside which often requires the drill rig to be attached to a winch - so a much safer option is to have the operator standing to the side with a remote control unit.

The rig can also adapt its ground clearance, with the independent wheel positioning and automatic ground clearance and escalating systems enabling each wheel to lift itself up over an obstacle. By providing turn-on-the-spot functionality, these enable the traditional undercarriage and superstructure to be dispensed with: "The turntable is a big problem to include in the rig – you effectively add a hinge in the middle that creates lots of problems, forcing you to divide your components, but this makes it more compact," says Alex. Once in position, wheel hub jacks act just like outriggers, reducing the effects of the suspension in the tyre by providing a firm connection to the rock.

At the end of the shift, the Xtwo can flatten itself as much as possible for easy, space-efficient loading and transport it even climbs unaided into the box of a mine truck.

> to the next hole and then promptly start drilling with the new bit."

Twice as nice

That will certainly help productivity, which could already be doubled on the Xone due to its extra boom. Alex also forecasts a similar productivity gain from the greater manoeuvrability of the Xtwo, and as for the Xthree: "There is nothing around today where you can rent a simple product that arrives in mint condition, so that would actually create a new market."

Alex is coy about predicting which derivation might enter production first, but believes that all three meet needs that current rigs do not: "Each rig targets a different customer," he says. "There's an equally big need for them all, so you could easily be featuring one in iVT 2022!" iVT



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Just when we all thought that the trend for designing hybrid excavators that may, or may not ever enter production was well and truly over, Minexpo was the stage for the surprise announcements of two new hybrid shovels.

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The reason for the development of one of them, Caterpillar's 6120B H FS hydraulic shovel (the letters stand for hybrid face shovel) is simple: 'lowering our customers' total cost of ownership is the driving force behind the development and integration of hybrid technology on an ultra-class hydraulic mining shovel'.

That seems straightforward – but how exactly might one accomplish this feat with this behemoth?

Back in the game

Having been out of the hydraulic shovel business for some years, Cat kicked things off in the early part of 2010 by announcing that it planned to re-enter the industry with the development of five models, with production to be carried out at its facility in Aurora, Illinois, USA.

This was a fairly straightforward approach, bearing in mind the time needed to design the machine and components, test them on the bench as much as possible, and follow up with field evaluation and so on. However, with Caterpillar seeing some long-term opportunities, things started to get interesting as the company soon started making some important acquisitions – the most notable being of the Bucyrus Corporation of South Milwaukee, Wisconsin USA.

This company actually predates Caterpillar but is well known for a variety of complementary mine site products such as wire rope shovels. But of more significance is the fact The Cat 6120B H FS is the industry's first hybrid hydraulic shovel





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that Bucyrus had recently purchased a portion of the Terex mining business – which included the well-known O&K hydraulic mining excavators. These used a standard configuration of two engines and parallel hydraulic systems, which enabled operation with just one engine; the capability to run solely off the electrical grid if a mine is so equipped; and the basic design feature of the TriPower boom linkage – a special feature offering more effective filling of the bucket at a reduced power requirement.

In fact the initial development of this hybrid ultra-class mining shovel had originated with Bucyrus – to then be completed by Caterpillar and to be fully supported with the expertise and input of its new product development approach.

Most importantly for the new Caterpillar Global Mining group, there would be an actual existing product to work from – while the development of a nice line of shovels could perhaps be accomplished that much sooner.

But certainly, from a product standpoint, the surprise news was how quickly the Bucyrus name was retired and all products branded as Cat – without doubt a significant decision that was a shock to some but carefully thought through ahead of time.

Filling a need

Claimed to offer similar levels of productivity to electric rope shovels, the new hydraulic shovel will fill the need for a safe, cost-efficient and highly mobile ultra-class shovel for short-term mining operations, nonelectrified sites and areas where the power grid has limitations, as well as greenfield developments.

Once put into operation at a mine, this type of machine rarely leaves. Its predicted life expectancy is around 15 years – which, given typical 24hour operation and 90% availability, would be in excess of 100,000 hours.

And, of course, they cannot be delivered in one piece as they are far too large. Therefore they are sent in individual pieces - frequently to quite remote locations - and assembled on site. Some specific characteristics of the 6120B H FS include the fact that it consists of 19 specific modules the power module, for example, consists of two engine skids - which not only allows a more structured approach in putting it together but enables their complete change-out if service requirements suggest that this is the best approach to keeping a machine in operation.

And though, even with these improvements it still takes around six weeks for field assembly, special efforts have been made to ensure that



TOP AND ABOVE: The Cat 6120B H FS prototype pictured at the Design Validation Center in South Milwaukee, WI

welding and grinding are not necessary. Should conditions and requirements change, this overall approach offers greater opportunity for actually disassembling a machine and moving it to another location. Examples that come to mind include the ability to use such a productive machine in the early days of a small mine, where mining over the full lifetime of the machine itself might not normally be justified and it would - and could - be moved to another location; or just a desire to go after higher-value material and wanting to move the 'best' machine to the newly identified location - perhaps suggestive of those high-value offshore drilling rigs that need to be wherever the action is to justify their purchase.

Big and beautiful

Two aspects of this new machine warranting further clarification are its size and its drive and operational technology – in other words, the 'hybrid' aspect. Being the largest hydraulic mining shovel in the world – Caterpillar describes it as 'ultra-class' – its relationship to the ultra-class haul trucks that will be queuing up to be served three or four helpings of material from the various sizes of shovels that will be fitted is clear. And with an operating weight of approximately 1,400 tons

and engine output of about 4,500hp (3,360kW), the shovel will efficiently handle dipper sizes of 46-65m³, depending on material density.

The hydraulic shovel also has selective digging capabilities that rope shovels do not, as hydraulics enable applying strong bucket forces through a wide range of heights.

Of course, scooping up the material and filling these trucks with as few passes (usually three or four) as possible is the primary task of the machine. Ultra-class buckets are custom designed for the material, loading conditions and hauling conditions of a particular mine, so one can only expect Caterpillar to further optimise these conditions for maximising productivity and lowering costs.

Usually at this point in writing about such a product, there would typically be further and detailed discussion of the specific features and enhancements the machine provides, usually over the previous iteration - however, not much of this is currently known. What we do know about the hybrid integration aspect is that it is electrical in nature and supported by an extensive bank of ultracapacitors; and that energy is regenerated from both the swing deceleration of the machine as well as when lowering the bucket; with a 25% saving being claimed.

That stored energy then helps power the hydraulic system when the machine requires peak power, such as during the digging portion of the cycle. The hybrid technology features long-life components and design for ease of service, as do the other systems within the shovel.

"We use bi-directional flow to achieve extra savings," says Joe Helfrich, Cat's product manager for

THE STRONGEST LINK

For face-loading procedures, purchasers of Caterpillar's hydraulic shovels will now benefit from the TriPower linkage system that has been a main – and patented – feature of the Terex predecessor for around 25 years. And Caterpillar has made it quite clear that this is to be the standard geometry for all of its products in its newly expanded mining portfolio.

Based around linkage plates at each of the cylinder mounting points, this system provides a fundamental kinematic advantage through the full range of bucket travel and operation. In the initial loading stage it keeps the bucket horizontal as it is pushed into the material to be collected. Then,



once the shovel has been filled, a second kinematic advantage is that the bucket remains level as it is raised to be dumped into the waiting haul truck alongside.

There are additional kinetic benefits in play. The design allows for adjustable pivot points, which results in engaging only the set of hydraulic cylinders that support the particular movement, meaning the cylinders can therefore be smaller, resulting in less energy being required – which in turn provides a quicker cycle time to position the bucket for dumping.

Machine operators who have used this noteworthy system before will be pleased it remains available on the Caterpillar products, as will those mine operators who appreciate the enhanced productivity it offers.

And for those engineers and others in the Caterpillar organisation now exposed to its benefits and availability, perhaps we'll see its usage passed along to other products that are either currently used or being developed for that important partnership between the shovel and haul device?

With an operating weight of 1,400 tons and engine output of about 4,500hp (3,360kW) the shovel will efficiently handle dipper sizes of 46-65m³

BELOW: Two large ultracapacitor banks

store and release energy,

considerably reducing

surface extraction machinery. "The engine effectively becomes a gen set, which feeds the electric motors that power the hydraulic pumps. When the attachment lowers, the hydraulic fluid would usually be dissipated in the form of heat, but instead the pumps turn backwards making the motors generators."

In addition to those fuel savings, the Cat 6120B H FS enhances safety. The state-of-the-art operator's cab offers industry leading visibility, dual egress, no-trip floor, and a traineraccessible emergency stop button. Likewise, the modular design of the machine incorporates a physical block between the hydraulic and engine modules, eliminating the potential for a hydraulic fluid leak to spray on the engines.

The fact that it is an electricalbased hybrid technology is also of some interest as Caterpillar has only just brought out the 336E H, a more traditional excavator product that adopts a hydraulic hybrid system based around an accumulator. Cat found this to be more effective for operation after having started out evaluating both types of systems – though electrical has been identified as best suited for mining shovels.

The two means of regeneration is also notable in that many available hybrid machines have only one method for input, such as the swing function of the boom or the braking power of a highly mobile vehicle. This limitation in power input contribution is certainly far more simple in terms of the systems that must be fitted and managed as would be the case with the 6120.

Finally, the 25% fuel saving per ton presented is quite intriguing in that one would normally need to have a baseline to compare against. But, among all the discussion of new technology, accelerated product development and the considerable investment needed to bring such a monstrous machine to production, there is no actual baseline per se. There is not a 'standard' equivalent that can be hybridised, as has been routine as this technology becomes more readily available for off-highway equipment. What we have here is a machine of only one flavour - either one is completely accepting of the fully integrated aspect of a hybrid or one will just not be a purchaser of such a machine.

So, just as Caterpillar has boldly formed a comprehensive mining group – have a look at mining.cat. com for a better understanding – and made its intentions known by integrating all the companies and products into the Cat family and colours, it now has emphatically made it clear that, when it comes to hydraulic mining shovels, the new standard is a completely new product type.

For the customer, the total cost of ownership is lowered as promised – and, for the competition, the bar has been raised. **IVT**



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Tipping the scales at over 1,361 and 7,257 tonnes respectively, Cat's 7495 electric mining shovel and 8750 walking dragline are not only two of the largest machines on the planet, but two of the largest vehicles to have ever moved over the surface of the Earth. These are industrial vehicles on a titanic scale, deceptively toy-like when seen from a distance, yet astonishingly immense once up close and personal, especially when in the operator's cab.

Each is designed to do a very specific surface-mining job. In the case of the electric mining shovel, it is to remove, every 30 seconds or so, up to 109 tonnes of overburden, oil sands, coal or minerals in a single pass, rotate to the side, and deposit the load in the back of a haul truck. After a few more passes, and with its bed full, the haul truck moves off to be replaced by another that has been waiting in the wings. When necessary, the shovel operator will activate the tracks, drive the machine to a slightly new position, and continue digging. And that is pretty much it, day and night, week after week and month after month.

The value of a single shovel's output – the eventual value of the material it removes – often exceeds US\$160,000 per hour or US\$2,666 per minute. Sliced even further, that is US\$44 per second, a figure giving new meaning to the phrase 'every second counts'.

As far as the walking dragline is concerned, its primary function is to remove overburden, and then replace it after the minerals have been removed (often by an electric mining shovel). A walking dragline literally walks, albeit slowly, to its operating position on two side 'shoes' that move in parallel about massive side-mounted cams. The dragline rotates, as well as changes direction, during a pause in a walk, by lifting the shoes and spinning about the plate-like circular tub beneath its enormous 'house' and the centre of gravity of the whole machine.

The entire vehicle easily exceeds the dimensions of an entire city block. The Cat 8750 can dig down to depths of 66.7m and dump a single load of 129m³ at a height of more than 50m. Just like the electric mining shovel, a dragline is designed to operate around the clock, year after year, keeping in tow a reel of thick electric cable that runs through the mine and is linked to a power grid.

Getting better with age

These vehicles are the product of more than 130 years of rich history, innovation and engineering prowess by a company that built the machines instrumental in the construction of the Panama Canal. Bucyrus, founded in 1880 in Bucyrus, Ohio, joined the Cat family in 2011, making Cat the largest full-service mine vehicle provider in the world.

Shortly before the acquisition, Bucyrus had undertaken development of an entirely new cab for installation on its largest electric mining shovels and draglines. It was intended to be an operator-centric cab, one meeting the functional needs of the operator during actual work as well as the more



DATA MINING TO ENSURE THE NEW CAB FOR ITS SHOVELS AND DRAGLINES WAS TRULY 'OPERATOR-CENTRIC', CATERPILLAR'S DESIGN TEAM CONDUCTED 83 INTERVIEWS ON 50 MACHINES WORLDWIDE, GATHERING FASCINATING INSIGHTS INTO THE NEEDS OF THE PEOPLE WHO 'LIVE' IN THEM



CASE STUDY

'habitation' or comfort-orientated needs associated with operating a complex machine over a long shift in a harsh and remote operating environment. The cab also needed to address the somewhat different requirements of draglines and shovels, as well as integrate state-of-the-art technology and design.

So, with an operatorcentric cab in their sights, the cab engineering group and product planners in South Milwaukee, Wisconsin, USA enlisted the expertise of Santa Barbara, California-based Ergonomic Systems Design, and Formation Design Group of Atlanta, Georgia. The two research and design consultancies have worked together for over 20 years, engaged in the development of numerous industrial vehicles, aircraft interiors, medical devices and other products.

The team quickly set about devising and implementing an extensive worldwide research plan to determine and define the new cab. This was followed by intensive design activities and evaluation and testing with operators.

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Operator-centric field research

The keystone of the undertaking was a plan to visit mine sites, to see and board as many existing machines as possible, and interview a considerable number of individual operators as they went about their work.

The first stop in this multinational trek was in the Canadian oil sands north of Fort McMurray, Alberta. Electric mining shovels are used extensively in the region both for the removal of overburden and the extraction of oil sands. Arrangements were made ahead of time to meet up with a number of major mine owners. One, sometimes two, team members were transported, often dozens of miles, out to the electric shovels.

The operator would cease digging for less than a minute in preparation for boarding. We visitors quickly approached the shovel and tugged on a hanging rope to pull down the retracted stairway. Once on board,



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ABOVE: The importance of a comfortable trainer's seat was stressed early on, as was the need for plenty of storage space the stairway was raised as quickly as possible and digging was resumed. The climb continued, three storeys up, to the cab.

Aside from the sheer size of the machine, the first thing one realises after boarding a working electric mining shovel is that there is a great deal of motion in all axes. There may be in excess of 3,000,000 lb of mass under your feet, but it nonetheless spins, decelerates, lurches, jerks and vibrates as it engages the high wall, lifts and fills the bucket, rotates towards the haul truck, and releases

the load out of the bottom of the bucket. A touch of motion sickness is not uncommon for a first-time visitor to an electric mining shovel. You also find yourself looking for things to hold on to! ۲

Our technique was to let the operators continue to dig while we peppered them with questions covering all conceivable aspects of the machine: visibility and lighting, push button locations and joystick forces, display design and camera locations, radios and communication links, and seat comfort and ride

quality. All answers and other comments were written down, and particularly insightful observations on the part of the operator were explored and discussed. We also made an inventory of everything that was inside the cab. As well as all control, display and communication gear, this typically included a coffee pot, microwave oven, portable radios, helmets and safety gear, coats, tools, documents, seats and chairs, window cleaning equipment, vacuum cleaner, brooms and much, much more.

Each to their own

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It is important to understand that, when employing an operator-centric approach to design, the designer, not the operator, still does the designing. Operators are trained to operate, and designers and engineers are trained to design and engineer.

The operator, however, based on his or her extensive experience with the product, is in an excellent position to point out strengths and weaknesses to the designer, identify features that work well and those that do not, and discern needs and requirements that can be the inspiration for new and improved designs.

During our interviews, for example, a number of skilled shovel

operators who also conduct training noted the importance of addressing the requirements of the trainer, not just the operator. This eventually led to a number of cab features that directly support real-world training, including the trainer and observer seats and a separate emergency stop switch accessible by the trainer.

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Operators of different makes and models of shovels and draglines were interviewed, although most of them were operators of vehicles previously manufactured by Bucyrus or Marion, a company acquired by Bucyrus in 1997. Our interviews lasted anywhere from one to four hours and depended somewhat on the availability of







TOP AND BOTTOM: Visibility improvements on the shovel and dragline (green) relative to previous model (blue)

ABOVE: Watching out for the power cable when in propel mode is a vital part of shovel operation – superb visibility is therefore essential transportation in particularly distant corners of some mines. Personal safety was also of importance and of particular concern when attempting to board or leave a shovel with haul trucks moving about nearby.

Although some shovel activities involve a single individual working alone, many times they are assisted by a tender in a dozer whose job is to keep the working floor flat and clear of debris for access by the shovel as well as arriving haul trucks. The tender might also monitor and position the power cable during travel manoeuvres, as well as operate the shovel when the main operator takes a break for a meal. Most surface mines usually operate on 12-hour shifts, with shift changes in the morning and evening.

From the Alberta oil sands, the research team moved on to Wyoming and the Powder River Basin, a region supplying about 40% of all power plant coal consumed in the USA.

Once again, shovels were visited and operators interviewed. Visits to various draglines and their operators were made here as well. But unlike shovels, draglines typically have an anteroom behind the cab. Although their designs and layouts can differ considerably, anterooms are usually about the size of a large travel trailer and can contain cooking facilities, dining tables, refrigerators and considerable additional storage.

And, again unlike shovels, draglines may frequently be staffed with a number of individuals who are employed as tenders, as well as maintaining equipment inside the massive 'house'.

After moving on to Queensland, Australia, and two weeks visiting various mines (primarily coking coal) in the vicinity of Moranbah and Emerald in the outback, the team eventually racked up a total of 83 (3 women, 80 men) operator interviews on 50 machines in the USA, Canada and Australia. Taken together, the interviewed operators represented a collective machine operation experience of upwards of one million hours, an impressive number by any measure.

Electronic research outreach

Despite our interest in understanding all markets, it was recognised that not all markets around the world could be visited by the research team. Accordingly, shovel and dragline operators worldwide were sent an electronic questionnaire to further extend the research outreach.

A total of 66 machine surveys containing complete descriptive and photographic records of cab interiors and exteriors were received from



ABOVE: The rather cramped toilet doesn't quite share the same feeling of luxury and space as the cab

BELOW: Optimum window and pillar placement and sizing was achieved after numerous studies had been carried out

A VIEW FROM THE OPERATOR

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iVT's editor recently had the pleasure of clambering around this new cab, not just as a self-contained unit exhibited at Minexpo, but on an actual 7495 electric rope shovel at Caterpillar's training facility in Tinaja Hills, Arizona, USA.

Having climbed up the 44 steps to the cab on a very warm day indeed, while musing on the possibility of simplifying access with a Stairmaster, a luxurious seat was a welcome sight in itself.

Sitting across from me in the operator's chair was demo instructor Jim Shanklin, who left me in no doubt as to how much he loved the new, bigger design.

"The seat is comfortable, and it handles like a champ," was his succinct appraisal. "I grew up using traditionally positioned controls, but the kids nowadays like to run them right here," he said, deftly drawing them together in front of his stomach. "You can just about set them up any way you like, and the armrests' indents to rest your forearms in are really comfortable too. "The older machines just didn't have this level of visibility. Now it's incredible – you can see round the sides, to the back and straight down to the ground," he enthused, lifting up the grate and angling it to brace his feet against. "There's good lighting, and the electric shades come in really handy too, when you're working all night and the sun suddenly pops up over the horizon.

"What I love about it is that it's super quiet," he continued. "It's not exactly soundproof, but those doors are heavy – so for all the noise that's going on back there, it's pretty amazing!"

He also highlighted the refrigerator and microwave as bonuses, which means he no longer has to bring a sandwich toaster to work(!) From my point of view, I was highly impressed, but couldn't quite shake the feeling that some of that space – and more pertinently, luxuriousness – should have been allocated to the rather poky downstairs toilet (see left)...

mines in Asia, Africa, North America, South America and Europe.

Shovel and dragline operators can be surprisingly devoted to their unusual machines and take great pleasure in providing detailed information when an interest is expressed. Whereas oriental carpets and curtains might hang from the walls of a dragline cab in North Africa – and rice cookers often take the place of a microwave oven in cabs in Mongolia and China – there were certainly more similarities than differences in regards to operator requirements for the next-generation cab and control system.

The results from this expedition proved to be invaluable, and were added to the eyewitness data that was collected during the team's actual mine visits.

Design development

More than 1,000 user comments and observations were computer analysed to identify important themes and, ultimately, design objectives. This information, taken together with the team's personal observations and ideas, resulted in a cab specification that would serve as a roadmap to development.

Initially, particular attention was paid to the basic size, structure and layout of the cab. Numerous layout, as well as styling, concepts were developed using 3D computer models. The final design incorporated an operator-forward arrangement, trainer's station, observer's station, an entry door on the side, and a second entry door at the rear – the latter serving as the entrance from the anteroom in the case of a dragline. Another reason for having the back door was that it provided a straight-on path to facilitate moving a stretcher into and out of the cab in the case of a medical emergency; an issue we had occasionally heard about during our interviews.

Storage, cabinets and counter tops lined the central fore-aft aisle, providing an efficient and functional arrangement for the cab as a whole. Particular attention was given to ensuring that all of the gear that had been previously inventoried in the 50 visited machines could be stowed within the new layout.

Seating comfort, ride quality, fatigue reduction, communication, remote viewing and camera systems, emergency systems, noise, ingress and egress, control adjustability, glare control, operator reach zones and hand holds are just a few of the topics addressed during the cab design phase.

Visibility was deemed to be of particular importance, so numerous visibility studies were therefore performed for optimal window and pillar placement and sizing – the result being notable improvements



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in the upward views of the boom, downward views of the ground, and views out of the side – something of particular importance with a shovel that is constantly co-ordinating its movements with the comings and goings of haul trucks. Designing the operator's station was a major undertaking in its own right. Special emphasis was given to having a fully adjustable seating and armrest system to accommodate the full range of operators as they ran controls while experiencing a considerable amount of motion.

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Touchscreen control systems have been employed extensively due to the large number of elements requiring control as well as the design flexibility that is provided by touchscreens. For example, not only do shovel and dragline controls operate somewhat differently, but individual mines can have preferred control-response mapping. The use of touchscreens was therefore important in meeting these and other control and display reconfiguration needs without the need to have entirely different sets of hardware.

Military human factors interface design specifications were used in the design of touchscreen control and display elements to help ensure operability in a rugged and moving environment. Custom, patented joystick controllers were developed and incorporated into the fully



ABOVE: Future operators evaluate the cab design mock-up in Wisconsin as the author listens in

adjustable and supporting armrests. Camera views from inside the 'house' as well as all around the vehicle are provided by displays mounted above the front cab window, along with a rearview mirror that provides the operator with a view of the cab behind him or her without the need to turn around.

Prior to the construction and extensive field testing of the final cab in mines, two-dozen shovel and dragline operators from all around the world were brought to South Milwaukee for a week-long test and evaluation of the new cab concept.

These miners systematically evaluated all aspects of the cab, helped in the selection of seating and other elements benefiting from their final input, and by comparing the new design with the one it has replaced, helped to quantify the improvements of the new cab.

The new, super cab has met with great success since its introduction, and is now in operation on dozens of new machines all around the world. The product is a testament to the value of an operator-centric approach to design. **IVT**





ELECTRIC SHADYLAND

WE HAVEN'T GIVEN ELECTRIC DRIVES IN MINING AS MUCH COVERAGE AS WE SHOULD AT *iVT*. SO WITH APOLOGIES TO JIMI HENDRIX, HERE'S OUR ATTEMPT TO HELP APPLICATIONS IN UNDERGROUND, AS WELL AS SURFACE, VEHICLES EMERGE FROM THE SHADOWS

A change is as good as a rest, they say, and *iVT International*'s annual Electric Drives feature is no exception. For many years, this has typically focused on the 'obvious' applications – usually lift-trucks, in other words. Then we started looking at areas where these systems have begun replacing certain hydraulic functions, and last year at how they could soon even be replacing entire drivelines. Now, with Minexpo just a pleasant memory, it's an ideal time to get on to the real heavyweight

systems, and see what benefits they are delivering to mining vehicles.

All-electric solutions based around an engine-driven generator supplying individual wheel-drives are a popular choice in this sector. Hydrostatic motors may provide a higher torque density than electrical machines, but electric motors will compensate for that by typically operating at a much higher speed.

Switched reluctance technology developed by Nidec SR Drives ably meets the requirements for these types of system, offering a wide constant power speed range (CPSR), as well as high efficiency and a rugged construction.

One of the key advantages of LeTourneau's wheeled loaders (now acquired by P&H/Joy Global) is the electrical drive system that optimises energy conservation by improving fuel efficiency, which in turn extends diesel engine life up to 40% versus conventional mechanical drive loaders. The SR drive system allows for bi-directional power flow and



GE's Invertex 200T electric drive system features a motorised wheel with bolton rims for easier and more reliable mounting. With 16 IGBT modules rather than 28, reduced component count increases reliability ۲

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PCFP25





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CLOCKWISE FROM TOP LEFT: SR technology prominently displayed on the LeTourneau L-2350 at Minexpo; LeTourneau's traction system based on individual wheel motors and gearbox; FIGURE 1: Typical SR hub-drive system for an off-highway vehicle application; typical heavy-duty SR traction motor rotor and stator assembly

recaptures all braking energy for use during the standard loading cycle.

LeTourneau wheeled loaders had traditionally adopted electrical transmission systems using brushed DC traction motors powered from conventional diesel engine-driven synchronous alternators. Although this original approach performed well, the OEM wanted to update the electrical systems with more efficient and robust brushless motors and generators and soon settled upon Nidec's SR technology, launching the first new product in 2002.

Since then, LeTourneau's whole range of large wheeled loaders has been converted to SR traction motors and SR generators with engine powers ranging from 1,000-3,000bhp. These SR-powered loaders have been well received by the end-users, who have experienced highly reliable operation, higher productivity and considerably reduced fuel consumption.

An SR machine operates purely on magnetic attraction between salient poles on both rotor and stator. This means the SR rotor does not rely on any magnets, conductors or windings and therefore offers a simple yet very rugged and cost-effective construction.

Similarly, the stator windings are concentrated around individual poles with no overlaps or long end-turn overhangs: a construction that is both electrically and mechanically robust. The losses within an SR machine are concentrated in the stator and therefore easy to dissipate.

Figure 1 (above) shows a typical SR hub-drive system for an off-highway vehicle application. Note that the CPSR (from base speed upwards) is about 10:1, eliminating the need for any ratio changes within the transmission. In this case, the hub gearbox is a planetary system with a fixed ratio of 50:1.

The SR machine is totally sealed from the environment, and in this case is liquid cooled using standard water-ethylene-glycol antifreeze. Oil cooling could also be adopted, however, depending on the available infrastructure.

Only one quadrant of operation is shown in this diagram. The drive system will, however, operate across all four quadrants, namely, forward and reverse, motoring and braking, displaying symmetrical torque characteristics in each quadrant.

The full SR system provides highly dynamic control of torque, thereby enabling effective traction controls that permit each wheel to deliver maximum tractive effort. The systems can operate equally well as generators, and as such are often used to implement the enginedriven generator system.

This type of electrical transmission configuration has been used on very

ELECTRIC DRIVES

large off-highway equipment for many years. In the past, this has been driven more by the difficulties associated with large conventional transmissions than for concerns surrounding fuel efficiency. However, increasing pressure from fuel costs and emissions regulations is now migrating these techniques to smaller vehicles.

High voltage, low maintenance

Caterpillar says its 795 was the first mining truck to incorporate an AC electric drive system single-sourced from one manufacturer. This highvoltage system operates at relatively low current for lower heat generation and longer component life.

The rear-mounted generator provides for a better chassis weight balance and is connected to the Cat C175-16 diesel engine via an isolated driveshaft, which makes generator





ABOVE: Drive system layout on the Cat 795F AC pictured top: 1) C175-16 diesel engine, 2) control power inverter cabinet, 3) variable speed blower, 4) alternator/generator, 5) radial grid, 6) cooling air duct, 7) driveshaft, 8) wheel motors



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ELECTRIC DRIVES

alignment simple. The generator is a three-phase, two-bearing design with a brushless excitation system that provides longer maintenance intervals than brush-type systems.

The AC power is rectified to a nominal 2,600V to form the DC link, which supplies power to the inverter, where Mitsubishi Electric IGBTs convert the DC signal to threephase AC to drive the traction motors and control the rim pull, direction and speed of the truck. Motor output drives the wheels through a doublereduction final drive. The low-current, high-voltage motor is mounted to the rear axle and is trolley capable.

During retarding, the wheel motors become generators, with power being fed back through the DC link to the contactor and chopper circuits and then exhausted through the radial grid. An AC fan blows air across the grid to dissipate the power and control retarding speed.



Sitting well back on the deck, the radial design grid gives the operator excellent visibility to the right side. Rated at 4.75MW (6,365hp), the grid is claimed to offer the highest retarding power in the industry, providing superb control of the truck in long retarding applications. LEFT: Cutaway view of the Invertex 200T, as seen at Minexpo

BELOW: The Invertex 200T provides more support for communications interfaces to reduce maintenance and lifecycle costs Built into the software is a grid thermal calculator that constantly monitors power to the grid. When the dynamic retarding capability is exceeded, the mechanical brakes are blended in automatically, for as long as necessary. As the brake blending is smooth and seamless, the operator is alerted to take corrective action if this continues.

Whenever servicing or rebuilding is required, the engine, generator, motors, inverter, grid and final drives can be removed independently.

Packing a punch

GE Mining's Invertex 200T AC electric drive system has been designed for optimal weight and durability and provides a claimed best-in-class mix of increased (+8%) payload, top-end speed, and retarding speed (+50%) for the 200-ton mining truck class. Delivering greater (+27%) stall gradeability and retarding speed

WHY GETTING TROLLIED COULD BE THE BEST OPTION

A diesel-electric haul truck's drive system typically consists of two electric drive-motors, integrated through gears into the rear wheels, an electric generator and a powerful diesel engine. This makes the idea of a trolley assist system, which substitutes diesel fuel with cheaper and more ecological electric energy, easily realised. Instead of generating electricity from the diesel engine and the electric generator on the truck, the electric energy is sourced directly from a dedicated substation and transmitted via an overhead catenary to the truck's electric drive and motors.

The benefits of trolley assist include increased production capacity with fewer trucks; lower truck maintenance costs – especially on the diesel engine; increased availability and decreased lifecycle costs for the engine, due to fewer operating hours; and reduced noise and diesel emissions.

Siemens can supply, install and commission all the required components. On the truck side, this includes the two pantographs and the mechanical structure holding them, and the switchgear/circuit breakers that connect the power from the overhead wire to the truck's drive system. The roadside trolley consists of substations to supply the DC current to the line, and the line itself, which includes posts, wire and auxiliary equipment, such as the weight that tensions the contact wire of the line. The truck trolley system is most cost-effective on ramps of 6-10°, where most energy is required, though it is also very beneficial to put trolley lines on both uphill and downhill hauls to recover the braking energy.

It should also be borne in mind that there is a relatively high initial cost for the infrastructure and that the trolley line requires maintenance throughout its life. The truck pantographs can also be damaged through operator error, while the trucks themselves feature more complex electrical systems,



Haul truck fitted with pantographs for trolley assist operations



Drawing power from a substation reduces demands on the diesel engine

which require maintenance. Trolley assist can also be harder on tyres, due to the higher running speeds, while operators need to be trained to stay underneath the trolley lines.

Going downhill fast

Trolley systems for most mining haul trucks are installed for uphill hauls, as the energy is wasted in the grid resistors during the downhill haul. However, the system could be designed in such a way that it improves the overall line receptivity of the DC power system by transferring the braking energy to the AC side, and regenerating it, via the transformer, to the AC medium-voltage distribution network. This energy could be used by other loads in the mine or used by the utility grid.

This system can be easily achieved by replacing the uncontrolled diode bridge rectifier with an active rectifier to transform the traditional unidirectional substation into a reversible one. The key benefits expected from reversible substations are:

 Regeneration of the braking energy at all times, while maintaining priority to the natural exchange of energy between trucks;

• Reduction/elimination of the braking resistors, and thereby reduction of the truck mass and heat release;

• Regulation of the output DC voltage to make the DC overhead line voltage



Trolley lines are most effective on grades of 6-10°

independent of AC line fluctuations;Reductions in the levels of harmonics and improvement of the power factor on the AC side.

Based on mine-specific system parameters such as haul cycle distances, grade, production requirements and the price of diesel and electricity, it is possible to predict investment costs, energy costs and maintenance costs as well as production values and payback time (i.e. return on investment).

Ultimately, the cost savings from trolley assist occur when hauling the same amount of material while using fewer trucks or by hauling more payload using the same number of trucks.

A 300-ton loaded truck going down the ramp will regenerate approximately 3MW into the grid, or 1.3MW when empty. Calculations as well as feasibility studies have shown that a trolley system achieves payback in two to four years.



with increased pavload and higher top speeds, it is now available on Komatsu's 730E AC mining truck launched at Minexpo (see p15).

The system features improved control algorithms and optimised integration. With a single inverter per wheel providing independent wheel-motor performance, size and weight can be reduced and the cabling simplified. The drive system's contactorless retarding utilises quad chopper control that results in minimised maintenance and improved lifecycle costs.

The Invertex 200T wheel motor has also been completely redesigned to optimise weight and durability, and has successfully completed highly accelerated life test (HALT) and extensive field validation.

The new design also incorporates bolted flange rims and an improved lubrication system with an advanced sealing arrangement for increased truck availability.

At the core of the drive system is the Invertex II AC Control Software System, which niftily combines the propulsion system controller (PSC) and truck control interface (TCI) into a single state-of-the-art drive system controller (DSC). This

streamlined CPU simplifies truck data access, event management and software configurations, all in one compact control panel with a single entry point for troubleshooting. The redesigned IP54-rated control cabinet maximises maintenance accessibility and prevents dust and moisture from entering.

2011, IZ-Kartex's EKG-32R is designed for loading 190-240t trucks. With a working weight of 1,050 tons, it features an AC electric drive with frequency modulation to improve energy efficiency, cut power consumption and facilitate servicing of electric drive components

channels, including CAN, Ethernet and USB, deliver high-speed data downloads and optimal third-party connectivity. The Windows-based wPTU Toolbox puts a complete array of real-time diagnostic and statistical tools in the operator's hands.

Multiple communication

PLUG AND PLAY?

Researchers at Aalto University in Finland have been working on a way to cut the amount of fuel consumed by mining, construction, agricultural and materials handling machinery in half.

The researchers have added an electric power transmission system into the test machines, which become hybrids with both IC and electric engines, and capture energy that would otherwise be lost by the machine, and use it instead of diesel. Researchers are now analysing the work cycles of different types of machinery to find out which work tasks best allow energy to be captured – deceleration and lowering a load are typical examples.

The technology enables short-term energy storage, making it possible to store energy for later use during

a peak in power demand. The electric transmission generates other benefits such as better operator comfort, controllability, efficiency and more freedom in the machine layout.

The goal is to reduce fuel consumption and CO₂ emissions. Another benefit of hybridisation is that it can lead to other reduced operational costs. With electric power transmission, the machines may even be connected to normal wall sockets. Electricity from the power grid is very cost-efficient and creates no local emissions, so plugging in a machine may usually be the best option. And the benefits do not stop here: the machines are even able to release stored electrical energy back into the grid.

The future is likely to make fuel cells available, too, says Professor Jussi Suomela, who is in charge of the project at the university's HybLab research network.

ELECTRIC DRIVES

"We looked at every component of the system to find ways to make the system lighter, more efficient and easier to maintain," says Lori Kieklak, general manager of Mining Equipment for GE Mining.

"By integrating the controllers into one unit, it was possible to reduce control panel size and the number of parts, simplify downloads and thereby increase reliability."

More than a couple of benefits

Parker Hannifin's Hybrid Electric Business Unit launched its new EHP (electrohydraulic pump) system at Minexpo. The EHP system combines a high-efficiency permanent magnet AC (PMAC) motor/generator and high-performance mobile inverter with a Parker hydraulic motor, and offers notable design and performance benefits for mining machinery and equipment applications.

At its core is a mobile inverter that provides real-time speed/torque commands and enables the use of all traditional hydraulic-pump flow/ pressure control architectures.

Control, operation performance and diagnostic monitoring are all accomplished through the inverter's discrete I/O or CANopen interface.

The EHP system enables electrohydrostatic actuation (EHA) which, in applications in mining equipment, allows the implement (for example, shovel or scoop) to be decoupled from the IC engine. By reducing the power draw on the engine in this way, the engine size can be optimised, leading to reduced emissions and notable fuel savings.

The system is also well suited for the development of hybrid and allelectric equipment solutions. Its power-on-demand capability, variable-speed control and high-

BELOW: Parker's EHP system enables decoupling of the implement from the IC engine

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ELECTRIC DRIVES

efficiency components, plus the ability to regenerate energy into the battery pack/ultracapacitors, all contribute to extending the vehicle's operating time between recharging its batteries.

The EHP PMAC motor/generator is available in a wide range of voltage configurations (24-800V DC) and four diameters (142, 210, 310 and 470mm). With patent-pending cooling technology for optimum performance, the EHP motor has a power density up to 3.9kW/kg.

EHP motors can also couple to virtually any Parker hydraulic pump, creating considerable flexibility when designing a hydraulic system.

If the cap fits...

Heavy equipment expends a great deal of energy digging, dragging and dumping in mining operations, but a lot of the muscle is simply going up in smoke – or heat, in this case – that could be harnessed to reduce fuel consumption, increase productivity and improve efficiency.

New car designs using regenerative braking to capture kinetic energy to power start-stop systems that kill the engine when a vehicle stops before restarting it when it begins moving

ABOVE: Maxwell's ultracapacitors deliver rapid, reliable bursts of power for hundreds of thousands of duty cycles again are becoming increasingly common. These new energy storage systems capture and utilise kinetic energy that would otherwise be lost as heat in friction-based braking systems – and have been shown to considerably increase fuel efficiency. But how does that apply to heavy equipment moving tons of earth?

Take a new hydraulic mining shovel that has just hit the market. By using innovative hydro-electric regenerative technology with an innovative energy storage system, this hydraulic shovel cuts fuel use per ton by an estimated 25%.

At the heart of this system, large ultracapacitors store the energy that is created by the shovel during the swing deceleration and boom-down movements, and then use it to help power the hydraulic system when the machine requires peak power, such as during the digging portion of the cycle.

Based in San Diego, California, USA, Maxwell Technologies is a global leader in the development and manufacture of ultracapacitors. The company is keen to highlight that unlike batteries, which produce and store energy by virtue of a chemical reaction, ultracapacitors store energy in an electric field. This enables them to quickly charge and discharge, perform normally in temperatures from -40° to +65°C, cycle more than one million times and resist shock, vibration and overcharging.

Ultracaps are also maintenancefree, immune to water and dust, and built on green technology that requires no special recycling – making the technology an ideal solution for applications in harsh mining environments. **iVT**

MAKE MINE A SMALL ONE

A key part of GE Mining's Invertex system for underground vehicles is the advanced Durathon battery energy storage system. Having acquired Fairchild Mining Equipment in August 2012, the company wasted no time in integrating the high-performance 270kW battery and 240V AC drive system into a Fairchild utility scoop to demonstrate to Minexpo visitors how leveraging the technology can improve efficiency, safety and maximise the use of space to improve manoeuvrability.

The scoop can now enjoy reduced wheel slip and improved speed on grade due to the compact variable frequency combo-drive that controls the traction and pump motors. The traction motor's frameless construction reduces overall weight, and employs a waterproof design to withstand wet conditions and an easy-access connection cavity.

The Durathon battery energystorage system is based on non-toxic sodium-nickel chemistry, and is 50% smaller and 25% lighter than lead-acid of battery systems, enabling more energy to be stored in a smaller space. Modified to house the smaller battery unit, the utility scoop now features a specially integrated battery tray. The smaller battery package also makes the unit lighter, reducing tyre wear.

Able to operate effectively in extreme temperatures, and with no memory effect, Durathon batteries are claimed to double the life of current battery technology – approximately 10 years lifespan versus four to five years for lead-acid.

And, according to a spokesman on the GE Mining booth, further benefits of the sodium-nickel chemistry include approximately 25% longer shift life –

partly as a result of regenerative braking – and because no cool-down period is required, only one additional battery pack is required. He was unable to comment on how the battery pack's footprint would compare with a lithiumion equivalent, but pointed out that the latter would be unsuitable for underground applications due to the possible explosion risks. The cells are recyclable, making the battery a truly sustainable technology.

"Several features of the Invertex electric drive system will be very attractive to mines," says Dann Gwyn, underground product manager, GE Mining. "The compact energy density makes for longer charge cycles with a smaller footprint and the system requires far less maintenance than the traditional lead-acid system. The result is more uptime and better utilisation of assets."

The Durathon battery was originally developed for underground power systems, making the Fairchild scoop its first mobile application. The machine will shortly go into field tests in a coal mine in Virginia, USA.

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WOULD LIKE TO MEET: **ISO 3450**

IN THE FIRST OF A NEW SERIES LOOKING AT PRODUCTS TO ENABLE COMPLIANCE WITH TRICKY STANDARDS, WE TACKLE ISO 3450, WHICH DEFINES THE BRAKING REQUIREMENTS FOR WHEELED OR HIGH-SPEED RUBBER-TRACKED VEHICLES

> Most countries and major mining companies require all mobile machinery involved in their operations to meet the performance requirements of an international brake system standard.

For earthmoving machinery with wheels or high-speed rubber tracks, ISO 3450 is the standard that defines the requirements and performance of the brake system. While this standard encompasses a variety of requirements, one in particular is quite challenging – the dynamic stopping performance requirement.

This specifies that machines, when at their maximum gross weight and travelling at close to maximum speed, must be able to perform multiple stops within a specified distance. This requirement is especially difficult for large mining dump trucks because the gross machine weights are very large, the speeds are high, and the test is performed on a downhill grade. The truck must stop five times within a specified distance with a 10-20 minute interval between stops without the assistance of an electric or mechanical retarder – this, of course, places a tremendous force and energy (heat) load on the braking system.

The most obvious product for enabling compliance with ISO 3450 is the brakes. Typically, two types of mechanical braking systems are considered for bringing dump trucks to a halt – dry disc brakes and oil-cooled disc brakes (wet disc brakes). The former are similar to the brakes used on a typical automobile, with brake calipers arranged around the disc within the rim, with the heat generated by braking being dissipated by the air moving across the surfaces of the discs.

On the other hand, wet disc brakes have multiple friction discs that are stacked within a housing that fits inside the rim and dissipate braking heat by circulating cooling fluid through the sealed housing. Wet brakes offer several performance advantages that are instrumental in the certification of ISO 3450.

By using stacked discs, wet brakes more effectively make use of the available space within the rim and can provide more braking force than

STANDARDS

LEFT AND BELOW: Wet disc brake designs, such as those from Pioneer Solutions, ease compliance with ISO 3450

dry brakes. And, by using circulating oil to cool the brake, heat fade is not an issue (as it is with dry brakes) and consistent brake force is generated, even after multiple stops.

These wet brake advantages, as well as other performance, productivity and safety benefits, contribute to an increasing number of dump truck OEMs adopting both front- and rearaxle wet brakes.

Wet brake solutions

Pioneer Solutions' Manufactured Products Division supplies dump truck OEMs with wet brake solutions that exceed the requirements of ISO 3450, and provide a higher degree of performance, productivity and safety to be able to endure abusive mining applications while maintaining reliable, cost-effective performance.

The company has put its over 30 years of experience in brakes and braking systems into the design and manufacture of front and rear wet brakes for mechanical and electric drive dump trucks with payloads of between 25 and 400 tons.

Pioneer Solutions' brakes have been specially engineered to provide the most reliable performance while maintaining a flexible design that can adapt to a variety of OEM axle configurations and hydraulic systems.

Brake actuation is performed by multiple modular pistons, rather than a single annular piston, and provides higher sealing reliability, accommodates a variety of hydraulic apply pressures, and includes an automatic wear-adjustment feature.

High-quality, glaze-resistant and industry-proven friction material is used in the brake friction pack to yield a longer service life. The friction pack is expandable and can be customised to handle different energy and stopping requirements with minor changes to the brake.

The cost-effective brake design, which maximises parts commonality between the front and rear brakes, simplifies maintenance training and spare parts inventory. Pioneer brakes have been successfully prototyped, tested and certified to ISO 3450, and are now operating in mine sites.

Pioneer's Manufactured Products Division is well organised to deliver

STANDARDS

customer satisfaction throughout the life of the product. In addition to designing and manufacturing the wet brake products, Pioneer Solutions provides technical support to OEMs to assist in the design of the hydraulic brake systems and axle-brake mechanical interfaces, assembly training, factory and ISO 3450 testing, and aftersales support.

Beat the big drum

"Could we get your S-cam drum brake in a bigger size?" was the gist of a question recently put to Knott by one off-highway vehicle OEM. The manufacturer needed a new pneumatic brake for applications where the use of the more common wedge brakes is neither possible nor desirable, for instance for packaging reasons. Therefore, in keeping with its philosophy of 'serving the interests of the customer', the technical experts in Eggstätt, Germany, got straight down to work.

What emerged was the biggest S-cam drum brake ever developed and produced at Knott: 500x200mm!

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Despite its large dimensions, this brake can be classed as a piece of highly compact technical wizardry. Its future uses will include dump trucks and large-scale field sprayers; however its intended sphere of application was for use in transport machines, where absolute power and reliability are vital. These include vehicle applications ranging from mining, through road trains, to container handlers used in ports: in other words, wherever enormous loads not only have to be moved, but, most importantly, braked extremely safely.

With its amazing braking torque, this is all in a day's work for the S-cam drum brake. "Even we were surprised," admits Knott's chief engineer Franz Schweiger. "The brake was initially designed to deliver a braking torque of 30,000Nm, but on the test rig it proved easily capable of reaching 38,000Nm under extreme test conditions – at least for short-term application."

Incidentally, this is the highest braking torque so far

TWO BIRDS WITH ONE STONE

Vimoter's newly developed inching device deftly accomplishes the important function of disengaging the transmission during the braking phase in order to accurately operate the vehicle and provide 'millimetric' control of it.

It provides the most accurate manoeuvring precision for smallto medium-sized off-highway and materials handling machinery.

The initial pedal stroke provides the inching function but, once passed, the braking phase starts. Therefore the driver is able to modulate the stopping phase according to his requirements by adjusting the foot force on the pedal.

BELOW RIGHT: Mobeus

automotive-level safety

BELOW: Knott's biggest

drum brake: despite its

enormous braking torque

of 30,000Nm, the 500x200

S-Cam brake is a compact

to off-highway

solution

braking components bring

The full system is comprised of a brake pedal assembly with master or power cylinder, inching valve, reservoir, connections and whatever else is required to meet any specific system requirement. The chart below shows how the valve allows the brake circuit to be onened once the

achieved with a Knott S-cam drum brake. This record is only surpassed by another class of drum brakes: Knott's wedge duplex brakes, which easily reach 40,000Nm. What this goes to show is that, at a time when demands and legislation are growing increasingly stringent, size really does matter.

Automotive-style performance

Mico Inc has drawn on a background of over 60 years of rugged hydraulic brake design and manufacturing for heavy equipment, and 10 years of electrohydraulic braking expertise, to design Mobeus, a new generation of intelligent electrohydraulic braking systems.

Heavy mobile equipment efficiency, reliability and safety have made incredible progress over the past decade. Much of that evolution has been driven by the integration of electronics into overall machine design, including in hydraulic components and systems.

Mico's Mobeus family of braking components uses the integration of electronics to create improved performance and efficiency for braking on- and off-highway machinery. The range includes a wide range of sensors, actuators, valves, controllers and software, all of them designed to work seamlessly together inside the vehicle network.

The safety and reliability that antilock braking (ABS), traction control, and electronic stability control (ESC) have brought to the automotive industry in the past are now available to off-highway OEMs.

Mobeus products are designed to provide a more controlled braking experience for drivers operating mobile machinery. ABS decreases the probability of wheel lock-up during braking and can also increase the stability and steerability of the vehicle during a braking event. Traction control provides intelligent control of wheel spin to assist a vehicle in slippery or difficult terrain, while stability control employs sensors to measure yaw rate and the centrifugal forces a vehicle encounters while turning, and assists in corrective action to stabilise the vehicle.

The system provides operators with greater predictability by offering similar features to their personal automobiles, making these larger vehicles respond in a familiar fashion.

Another benefit is the potential cost saving, which can be realised with decreased tyre wear due to the intelligent braking provided by ABS. In addition, ESC can reduce vehicle instability, potentially reducing the likelihood of vehicular rollover. **IVT**

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The BOXER armored personnel carrier vehicle combines the utmost maneuverability with the highest possible load carrying capacity. A V8 power plant, delivering 530 kW, accelerates the BOXER, which weighs up to 33 tonnes, to a top speed in excess of 60 mph, a performance kept in check by KNOTT brakes. The fail-safe parking brake, which can be released from inside the cabin by means of a hand pump in an emergency, was also developed by KNOTT.

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ENGINE COOLING

BY INCREASING HEAT REJECTION REQUIREMENTS, THE LATEST RAFT OF ENGINE EMISSIONS LEGISLATION HAS HAD AN ADVERSE EFFECT ON FUEL ECONOMY. BUT IN RESPONSE, MORE EFFICIENT COOLING SOLUTIONS ARE BEING DEVELOPED TO HELP THINGS RETURN TO NORMAL

Demands on off-highway cooling systems have increased dramatically in recent years – and not just due to the side-effects of meeting the latest emissions regulations. The trend towards air-conditioning means there is now another fluid to cool, in addition to the hydraulic oil and increased intake air – especially given the proliferation of turbochargers and air-to-air aftercoolers. And, of course, there is the ever-increasing creep towards higher horsepower output.

These problems are exacerbated in off-highway machinery, which typically has a high-load duty cycle, where the engine is working hard

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but at a low ground speed, meaning there is minimal ram air to assist with the rejection of thermal energy.

Add to that the need to design the cooling package for peak conditions – i.e. when running at full power on the hottest day of the year – and fuel that could be more usefully employed elsewhere will be diverted as a result.

There are three main factors that affect a cooling system's power draw: Peak Ambient Design temperature or actual ambient temperatures (for variable airflow systems), cooling load (i.e. heat rejection needs) and radiator/fan size. The appropriate Peak Ambient Design temperature must therefore be selected: just as unacceptable as a design temperature that is too low is an excessively high peak ambient temperature that can result in considerable performance penalties. The cooling package must then be tested for both adequacy and overdesign.

Bear in mind that if you can only achieve the required level of cooling by moving twice the amount of air through a radiator, the only way to do so is to move it twice as fast – but this requires eight times more energy. High-efficiency radiators that minimise the required airflow are therefore a good first step.

DURABLE AND EFFICIENT

Modern heat exchangers, such as radiators and charge-air-coolers (CACs), have to be thermally efficient, durable at elevated temperatures, and resistant to different kinds of corrosion.

All these performance requirements can be fulfilled by using CuproBraze technology from FinnRadiator. Developed for the manufacture of durable, heavy-duty mobile and industrial heat exchangers in the 1990s, the technology has been in commercial operation since 2000.

Innovative brass and copper alloys offer high durability, high thermal performance and corrosion resistance, as well as excellent retention of strength at elevated operating temperatures. These materials contain, besides their main elements, copper and zinc with certain additions of chromium and iron. The copper and brass alloys receive outstanding technical properties through optimised annealing processes, resulting in strong, thin materials that facilitate low pressure drop and down-gauging to save space. The brazing process is carried out in a protective atmosphere that provides high-strength joints and excellent surface cleanliness of the finished product.

Due to the improved technical properties of the materials, thinner materials can be used for the radiators. This leads to a lower pressure drop and, as a result, smaller fans consuming less energy can be used. Ultimately this results – depending on the radiator size – in reduced fuel consumption.

Working hard on TIER 4 emissions?

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Another company relying on

CuproBraze technology is the Dolphin Group, which claims that many industrial vehicle OEMs feel that aluminium heatexchanger designs have reached their performance limit and cannot fulfil future demands.

As current engine development continues to make use of variable geometry turbochargers, which give increased boost pressure at low engine speeds and maximised power output, the performance envelope of the intercooler needs to be improved. This can be easily achieved by using CuproBraze charge-air coolers.

A CuproBraze CAC can operate in temperatures as high as 300°C

without metallurgical problems such as creep and fatigue affecting performance and causing failures. This enables the engine's output and thermal performance to be maximised without compromising the size of the heat exchanger.

CuproBraze technology enables the production of thinner fin and tube material than aluminium can offer. This again results in higher overall heat-transfer efficiency and up to 24% lower air-pressure drop. This advantage can be capitalised on in the form of reduced fan power, or, optionally, by designing for more thermal performance or smaller core size, or an optimal combination of the two. www.dolphinheattransfer.com

ENGINE-FRIENDLY EGR COOLERS

Senior Flexonics is also developing its products to help reduce fuel consumption. Its EGR coolers, for example, are designed to not only deliver high levels of performance and reliability, but with minimal taxation on the engine to deliver that performance.

The company's design team has relied heavily on CFD and FE analysis to minimise pressure drops on the exhaust and coolant circuit, which will reduce engine pumping losses and improve fuel economy. It has been able to achieve as much as a 35% reduction in gas pressure drop through analytical optimisation, combined with other advanced manufacturing techniques on its corrugated tubes.

Another key area for engine losses is water pump sizing. EGR coolers rely on relatively large quantities of engine coolant, both to properly cool the exhaust gas, as well as to

prevent excessive thermal stresses. By optimising structure, and building thermal compensation directly into the cooler, considerable reductions in the quantities and flow of coolant can be achieved, enabling smaller water pumps to be used on the engine.

Building on the already high levels of performance and reliability in its products, this kind of ongoing advancement in fuel consumption behaviour have placed Senior's EGR coolers firmly on the map. www.seniorflexonics.com

LEFT: Advanced CFD analysis allows for reduction in gas flow losses

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Multi-Wing has designed a new high performing fan blade to handle the high heat rejection requirements and ambient temperatures that result from Tier4/Stage III B emissions standards. As cooling demands increase cooling packages become larger leaving less space for the fan in the engine compartment. The 2Z2 is what we call a nearly zero blade deflection profile. Its narrow axial depth makes it a perfect fit for tight Tier 4 engine compartments while still producing the required high pressure rates.

The new 2Z2 sickle fan has an available diameter range of 450 to 805 millimeters and is molded in glass-reinforced polyamide.

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For further information: www.cuprobraze.com

Space

HOW EFFICIENT IS YOUR FAN?

Minimising cooling loads is the next step. An 80-90% efficient fan means that 10-20% of the energy gets transferred into heat in the hydraulic oil – which then must be cooled by the fan itself. This can account for 5-7% of the overall cooling load during peak conditions. As a result, peak fan horsepower requirements increase by 16-22% just to provide the extra cooling required by the fan system – added to the initial 10-20% inefficiency, this means that a total of 26-42% more peak fan hp is being used than is necessary. In comparison, belt-driven systems are typically 93-98% efficient and add no cooling load.

Flexxaire points out that by increasing the diameter of a fan/radiator, the same amount of air can be moved at a lower velocity. A 10% larger fan/radiator, for example, will use 32%

less hp to move the same air. Bigger is better, so use the largest combination possible.

Variable airflow systems are another ideal strategy, enabling machines to have high peak ambient temperature capability without the associated horsepower penalties. The two most popular methods of achieving variable airflow are variable speed and variable pitch.

In the White Paper available on www. ivtinternational.com, Flexxaire provides test data from the use of one of its fans running at 1,850rpm and various pitches in a cooling package with a peak ambient design temperature of 43°C.

Its Figure 2 shows three sets of curves: airflow as a function of static pressure for various fan blade pitches; horsepower as a function of static pressure for the same fan blade pitches; and a system curve. A fan curve describes the relationship between airflow through a radiator and static pressure: as the static pressure increases, the airflow decreases. Fan power curves show the link between airflow and power draw for various fan blade pitches. A system curve describes the amount of air that will flow through a radiator: as more is pushed through, more pressure is needed.

Overlaying a system curve with a fan curve allows for the determination of operating points. Such operating points are indications of the airflow and pressure that a specific fan and radiator arrangement will provide.

By combining Figures 1 & 2 with a curve showing the relationship between percentage of maximum airflow as a function of ambient temperature for an air-to-air heat exchanger, a graph that displays fan power requirements as a function of ambient temperature can be created. This shows how the power draw requirements reduce quickly as ambient temperature drops – at just 17°C below the peak design temperature, power draw has dropped by more than 50%. In relatively warm weather (27°C) over 50% of the parasitic fan power load could therefore be saved. *www.flexxaire.com*

AWARD NOMINATION IS MORE THAN JUST HOT AIR

An invention from a Volvo CE engineer designed to help the company achieve Tier 4 Final compliance has been shortlisted in the embedded and critical systems category of the Institution of Engineering and Technology Innovation Awards. The preheated, self-regulated air intake system was developed by design engineer Joakim Haegerstam to ensure Volvo's articulated haulers will meet the strict engine emission regulations, while maintaining, or even improving, performance in cold climates.

The preheated, self-regulated airintake system introduces a completely new way to regulate the air intake temperature. To work correctly, Volvo CE's exhaust aftertreatment system requires high exhaust temperatures – this innovation enables that without increasing fuel consumption.

"The basic principle is that waste heat from the engine heats the intake air and that causes the machine to experience higher ambient temperature than is really the case," Haegerstam explains. "When the engine requires warmer air, the charge-air fan speed is reduced so that no ambient air enters the engine compartment and only preheated air enters the air intake. With this system, the machine believes the outside temperature is up to 30°C higher than it actually is - for every 1°C the air intake temperature is raised, 1.5°C is gained in the exhaust gas temperature. This technology reduces fuel consumption compared with the current, conventional heat modes,

which raise the exhaust temperature but are also known for high fuel consumption."

As well as providing hot air and enabling articulated haulers to work in a fuel-efficient way in cold conditions, the preheated self-regulated air intake system also allows the articulated hauler to obtain ambient air – depending on which it requires. When the engine needs cooler air, the charge-air fan speeds up so that ambient air enters the engine compartment and the air intake. This means that the vehicle can work with increased efficiency in both extremely cold and hot environments.

Another benefit of the system is that now that the air intake is located inside the engine compartment – in a much cleaner and less dusty area – the filter service interval is expected to increase. Tests to determine the extent of this improvement are currently ongoing.

ENGINE COOLING

THE NEED FOR HIGH-PRESSURE FANS

When Multi-Wing launched its PressureMax design initiative, the axial fan manufacturer wanted to create a vital tool to assist engine manufacturers in meeting Tier 4 emissions standards. Achieving compliance has resulted in some complex aftertreatment systems that have increased heat-rejection by 40% in some configurations. As space in engine compartments dwindled to accommodate these systems, the need for a narrowprofile versatile impeller that can generate higher static pressures in the cooling package was evident.

Using CFD, 3D modelling, flow diagnostics and rapid prototyping, the design team studied variables such as turbulence intensity and the effect of contraction ratios in the working section of the blade to hone the impeller's performance for the target design criteria.

Tier 4 engine compartments essentially require high-pressure fans, and the PressureMax delivers up to 20% more pressure than standard airfoils. The new profile

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is also a high-efficiency fan, which helps reduce emissions. In fact, the PressureMax reduces parasitic power loss, providing 5-7% more efficiency than highefficiency airfoil blades. That translates to a real return on investment through increased fuel savings over available fans.

Multi-Wing's R&D engineers used several special techniques to study blade behaviour during operation, inspiring designers to create a blade that delivers virtually zero deflection. This high-efficiency design reduces airflow turbulence across the blade, giving the impeller a low noise signature.

Ultimately, the new profile has combined revolutionary engineering and a glass-reinforced polyamide construction to deliver a high-pressure, high-efficiency fan with virtually zero deflection: crucial for the broad range of demands and limited space in Tier 4 installations. www.multi-wing.com

A STATE OF INDEPENDENCE WITH HYDRAULIC FAN DRIVES

Traditional direct-drive enginemounted fan systems consume excess power because the fan speed is dependent on engine rpm – as this changes, the fan is often driven faster than what is required to cool the engine. This inefficiency becomes even worse at high fan speeds as the power required to increase fan speed increases exponentially by the power of 3. Direct-drive systems also have difficulty achieving high cooling levels at the intermediate speeds that form a large part of industrial vehicles' duty cycles.

These systems also require a larger tip clearance to allow for independent movement between the engine and radiator assembly. This reduces the efficiency of the cooling air flow across the radiator by as much as 10-15% compared

with a hydraulic fan-drive system where the radiator, fan motor and fan are attached to each other.

A hydraulic fan-drive system enables variable fan speed that is independent of the engine rpm, providing only the cooling that is required throughout the whole operating range, including such requirements as the maximum engine-rated torque point where high cooling may be required at lower-than-maximum rpm. It also allows for ramping of the fan speed command to avoid shock and to idle the fan during engine start-up to preserve power. This full fan control can vield considerable fuel savings.

Parker has three fan drive motor and pump technologies that can be supplied for fan drive functions. Each of these technologies – gear, vane and piston – offers distinct advantages in terms of initial purchase cost, lifetime cost, efficiency and noise.

The most efficient hydraulic fan-drive solution consists of a variable piston pump driving the vane motor. This produces the exact flow needed to control all the functions, including the desired fan speed, with no inefficient bypass flow diverted to tank. A fan-reversing valve cleans the radiator and ensures optimal radiator efficiency. A fan-speed sensor can also be installed in the vane motor to, for example, ensure fan speed is at its lowest before it reverses.

Total efficiencies of Parker's P1 piston pump range from 85-91% depending on pump size and operating conditions to ensure maximum power stays with the vehicle. *www.parker.com*

ENGINE COOLING

AVID – OUR FRIENDS ELECTRIC

Providing for the highly accurate control of the fan system with a degree of packaging flexibility can be achieved via electrification of the cooling fans and the use of hydraulic drives. However, for a fully featured system that has been correctly designed for the application, an electric fan solution can offer the greatest degree of flexibility and, when combined with an efficient vehicle charging system, the best overall efficiency.

Avid Technology and its partner EMP Advanced Products are seeing their eFan Micro Hybrid systems become widely adopted across the heavy-duty vehicle industry, with over 6,000 units fitted in the USA, delivering fuel savings of 5-15%. The system uses ultra-highperformance electric cooling fans, an electronic controller and a new heat exchanger design to create a highly efficient thermal management system.

The fans can be easily reversed to clear trapped debris out of the heat exchangers, so the cooling pack can be kept cleaner more easily, which not only leads to a reduction in overheating, but also increases the life of the heat exchanger. The risk of damaging the

> FLEXXAIRE Robust Intelligence | Engine Cooling Systems

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heat exchangers during cleaning is also greatly reduced.

Another factor in increased machine uptime is that it uses a bank of several fans, which provide a certain degree of redundancy should any one part of the system develop a fault. The system also has a greater degree of control, so it is better designed to cope with sudden surges of heat in the cooling module.

The technology has been embraced by the bus industry and Avid is now developing systems for off-highway applications in heavy-duty mining and construction machinery. The system offers great potential to improve fuel consumption, and also increase machine reliability.

For example, one customer, who previously suffered overheating-related breakdowns at least every week in a bus application, has not had a single incident for over nine months (including the summer months) since adopting the eFan Micro Hybrid system.

Another customer reported that maintenance cost savings resulted in a payback of under 12 months, because the extensive heat exchanger cleaning and replacement regimes that were

needed to keep its vehicles operational have now been reduced to a weekly press of the system's fan reversal button. The same customer also noticed a significant fuel saving.

Avid has recently designed and installed a Micro Hybrid system to suit the engine characteristics and packaging constraints on a rigid dump truck (see above) operating in an opencast mine. The system included a high-efficiency 12kW alternator, which provides the electrical power for the system at full load, with the total load on the engine being around 14kW – comparing very favourably to over 110kW used by the standard fan. This should result in a corresponding reduction in fuel burn. Avid is keen to develop systems for other off-highway machinery and is looking for partners with suitable applications. *www.avidtp.com/microhybrid*

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A clean radiator saves fuel while increasing performance.

Flexxaire's TACfan technology provides optimized engine cooling allowing your machine to work harder, save money... and keep your radiator clean.

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Make mine a large one

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THE LAUNCH OF A 95-LITRE 4,200BHP ENGINE LOOKS LIKE IT COULD WELL GIVE RISE TO A GENERATION OF EVEN LARGER HAUL TRUCKS. UNTIL THEN, THE QSK95'S SUPERB POWER OUTPUT AND RELIABILITY WILL KEEP 400-TON MODELS TICKING OVER NICELY

At MinExpo 2012, Cummins proudly displayed its new QSK95 engine. The QSK95 will provide a 4,200bhp (3,132bkW) capability for ultra-class mine haul trucks, representing the highest-ever power output introduced by the company for severe dutycycle operations.

The 95-litre displacement QSK95 was purpose-designed to provide enhanced strength for 360-ton and 400-ton payloadclass trucks, with the capability to increase truck speeds for climbing steep-gradient haul roads and boost hauling productivity with reduced operating cycle times. The huge 4,200bhp output also provides the possibility for the next generation of ultraclass haul trucks to move beyond 400 tons of payload capacity.

The QSK95 will be available as a global mining engine platform that is capable of operating at mine sites anywhere in the world, and meeting all emissions standards – including Tier 4 Final in North America, with the use of Cummins Selective Catalytic Reduction (SCR) aftertreatment.

The 16-cylinder QSK95 provides the mining power output previously available only from 20-cylinder engines. High power density is achieved with a hardened cylinder featuring the strongest single-piece forged-steel piston available in the industry. Deep structural strength is provided by an all-new ductile iron-skirted block. This increased strength contributes considerably to higher engine uptime availability, extended life-to-overhaul and more cost-effective rebuilds.

"The QSK95 is designed to meet the highest expectations in the mining industry regarding uptime availability, reliability and durability that will exceed all other previous engines intended for ultra-class haul trucks," says David Geraghty, executive director, Cummins Mining Business.

"This combination of deep inherent strength and proven systems means that the QSK95 will be equipped to provide outstanding performance on the mine site



from day one. It will fully complement the success of our QSK60 and QSK78 engines in ultra-class haul trucks. These engines offer the widest and most flexible power choice in the industry," he adds.

Tough enough

The stronger engine design of the QSK95 means more reliability in service and less to rebuild at overhaul, which greatly reduces total lifecycle costs. Capable of consuming more than 1.7 million gallons of fuel before needing a rebuild, it provides an extremely long life-to-overhaul, with the advantage of requiring no mid-life intervention.

High fuel efficiency is achieved with the use of Cummins' next-generation Modular Common-Rail System (MCRS), even when operating at maximum power output. With up to 2,200 bar high-pressure fuel injection, MCRS reduces noise, offers smooth idle stability and eliminates visible smoke across the entire operating range.

Cummins' new NanoNet fuel filtration gives superior fuel cleanliness and enhances durability of the MCRS – a huge advantage for engines required to operate anywhere in the world where fuel quality varies. A quad-turbocharging system brings the simplicity of the single-stage air-handling system already proven on the QSK60 engine. The four compact turbochargers, one arranged for each bank of four cylinders, provide outstanding step-load acceptance and transient response. This enables the QSK95 to deliver more rapid power across the entire rpm range, thereby improving haul truck speed at full payload capacity.

The QSK95 is configured to provide faster and easier servicing procedures, with simple access to all cooling, oil and fuel system maintenance points on the engine. Service intervals are a minimum of 500 hours, with the option of much-extended oil change intervals available using the Eliminator oil purification system mounted on the engine.

The goal of a leak-free engine is achieved by premium 'press-in-place' seals on all critical joints, such as flywheel housing, gear housing and oilpan-to-cylinder block. A special perimeter seal to the cylinder head guarantees that airborne debris cannot penetrate this critical sealing interface.

Advanced electronics enable the QSK95 to be custom-calibrated for specific duty cycles, with the flexibility for performance to



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be optimised for fuel consumption, transient response and emissions reduction to suit different haul truck applications.

Reduced emissions with SCR

The QSK95 utilises an SCR aftertreatment system to meet Tier 4 Final low-emissions

standards, with a highly flexible installation package intended to replace the exhaust muffler. And, depending on the particular application, the Cummins SCR system is even capable of achieving incremental fuel savings of 5-7%. These fuel reductions will cut the cost of operation by more than the

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cost of Diesel Exhaust Fluid (DEF) required for the functioning of the SCR system.

A considerable advantage of using Cummins' proven SCR aftertreatment is that the QSK95 avoids the need for using an Exhaust Gas Recirculation (EGR) system on the engine to reduce NOx (oxides of nitrogen) emissions. The SCR system also provides a simpler solution than the inherent complexity of applying EGR to high-output engines, and means that no compromise is made to serviceability.

As a further benefit, using SCR means that no additional heat rejection is generated by the engine, avoiding both an installation cost and space impact. Cummins' SCR system provides the rugged reliability to withstand the most extreme vibration and shock loads associated with haul truck operation. **iVT**

Kevan Browne is Cummins' global off-highway communications director

www.cumminsengines.con

CONTACT



FAR LEFT: The Cummins QSK95 engine, with up to 4,200bhp, is designed for the highest output mining applications

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The sound of the underground

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YOU'RE MORE LIKELY THAN EVER TO HEAR VOLVO PENTA ENGINES IN OPERATION, NOW THAT THEY'VE ACHIEVED CERTIFICATION FOR USE IN DEMANDING MINING APPLICATIONS. MEETING TIER 4i WITH A LIMITED NUMBER OF TECHNICAL CHANGES WILL BE A BOON TO OEMS, TOO

With environmental care being one of its parent group's long-held core values, an environmental focus comes naturally to Volvo Penta. The company has been well ahead when it comes to meeting new, tougher emission regulations, which is once again emphasised with its new Tier 4 Final engine range for 2014.

Over the years, Volvo Penta has served a large number of industries with engines and power systems. Now the aim is to increase focus on the electric power-generation, materials handling, construction and raw-material exploration markets.

In 2011, the company was one of the first diesel engine manufacturers to receive Stage IIIB and Tier 4i certification for its entire line-up. These engines have been successfully proven for use for many years in the demanding underground mining segment. Now the same engines are also certified by the Mine Safety and Health Administration (MSHA) and CANMET. Volvo Penta has received MSHA as well as CANMET-MMSL certification for its 13-litre Tier 4i diesel engines. This was the first engine to receive the certification and there is more to come.

At 350-550bhp, the TAD1360/61/62/63/64/65VE series of diesel engines offers ventilation rates that are among the lowest in the industry for the given power category. The ventilation rate is around 30cfm/hp - considerably lower than traditional diesel engines used in mines today.

In 2011, Volvo Penta and Sandvik Mining and Construction AB signed a co-operation agreement with the specific goal of enhancing the long-term competitiveness of the OEM's products. The company has since integrated Volvo Penta engines in several models from its product lines for crushers, drilling rigs, loaders and haulers.

"Volvo Penta has been very receptive to our requirements during the development of these machines, and we are pleased with the engineering support they provide us," says Chris Jobburn, senior product support engineer at Sandvik Construction.

Installing aftertreatment systems has turned out to be a major issue for many equipment builders in the USA and EU. For Sandvik engineers, however, the incorporation of SCR technology has not been a big challenge. "This was just another regular engine installation," states Seppo Karhu, Sandvik Mining's RIGHT: Volvo Penta D11 VE BELOW: Sandvik underground mining

LHD powered by a

Volvo Penta D13

manager for engine installations, after the first-ever loader with SCR for mining and tunnelling applications had been developed.

"With SCR technology, ventilation rates become so low that it is no longer toxic emissions, but carbon dioxide or fuel consumption that sets the limits. And the Volvo engines do have low fuel consumption," concludes Olli Koivisto, global product line manager for load and haul at Sandvik Mining.

A whole new engine range

The new Volvo Penta engine range for off-highway applications consists of five basic engines. Due to the SCR system, it has been possible to meet the new emission standards with only a limited number of technical alterations. This is why the component commonality of the engines is particularly valuable to OEMs who include several engine sizes in their product applications.

All engines in the range will be ready for delivery in 2014 – and are ready for the OEMs' drawing boards right now. The D5 is a completely new Volvo Penta

design, being a 5-litre, four-cylinder, 105-160bkW engine with a maximum torque of 900Nm. The D8 is also an entirely new Volvo Penta design – this is an 8-litre, six-cylinder, 160-235bkW engine boasting a maximum torque of 1,300Nm.

As a new version of a proven Volvo Penta design, the 11-litre, six-cylinder, 235-265bkW D11 engine has a maximum torque of 1,950Nm. The D13 is a powerful 13-litre, six-cylinder, 285-405bkW engine with a maximum torque of 2,650Nm, while the D16 is the most powerful engine in the range. This 16-litre, six-cylinder, 405-565bkW engine has a maximum torque of 3,200Nm. All engine data is preliminary.

Volvo Penta supplies OEMs all over the world with high-performance engines and power systems – but that is just one part of the deal. For the OEM and, not least, the end user, its service and support network is just as important as product performance, because when it comes to product qualities, uptime is king.

The fact that these engines can all be developed, manufactured and serviced by one company is critical for the overall performance of every application. Volvo Penta's continuously expanding service network – currently close to 700 dedicated industrial service dealers – is therefore a vital part of these products. With service agreements, scheduled maintenance and preventive repairs, the company can help customers to optimise machine uptime even further. No product benefit can ever compensate for downtime! **iVT**

Åke Edman is director of public relations at Volvo Penta, where he has worked since 1970. His main focus is PR related to industrial engines and power systems



Spare the horses

JSW DIDN'T SET OUT TO CUT ITS FUEL BILL IN HALF WHEN IT DECIDED TO REPOWER ONE OF ITS MINERAL SAMPLE DRILL RIGS – BUT INSTALLING A NEW, 120BHP-SMALLER, V8 ENGINE HAS REDUCED CONSUMPTION BY AROUND 400 LITRES PER DAY, WHILE BOOSTING RELIABILITY

JSW Australia, a reverse circulation and waterwell drilling company services the mining, petroleum/gas and government sectors in specialist drilling applications, predominantly in the outback of Western Australia (WA). The company demands the lightest, most efficient, environmentally friendly and powerful engines with high uptime and reliability for its drilling business, which works seven days a week collecting dirt samples for mining company analysis.

The nature of the drilling requires high-power engines that run at relatively low rpm for 10-12 hours each day. JSW also needed a physically small motor to fit its rig, which would be working in the field 350km northeast of Kalgoorlie.

Scania Australia's Jeremy Tennant worked with JSW to ensure that an engine with the correct specifications could be obtained, installed and commissioned. "We discussed with the company at length the requirement for driving air compressors and the hydraulic system loadings, as well as ensuring the air-cleaner flow rate and cooling package was suitable," Tennant says. "JSW's previous engine was rated at 820bhp, but when we ran the figures we determined that our 700bhp engine would do the job, so we air-freighted a 16-litre V8 into Australia as the rig was already in the workshop awaiting a new motor.

"This project has helped us explain to some prospects that they may not need as much power as they think they do," he says. "Choosing the right engine according to the requirements of the application is a smarter way of doing business. Our initial calculations suggested the engine would run at 80-90% load, but in the field it runs at only 70%, which means greater reliability. Average running speed is between 1,550 and 1,700rpm, and JSW has told us it delivers the power very smoothly, which obviously has durability and reliability benefits for the rest of the drilling rig gear.

"We used a ComAp engine control system to control and monitor the Scania engine. The controller is a ComAp Mobile, which we are using for the first time with a Scania engine in Australia. We selected it because its extra functionality enables monitoring of the air circuit and hydraulics, plus we can remotely control and view the engine. In addition to handling the drilling operating requirements very successfully, the Scania engine is used to power the hydraulics that



LEFT: The Scania V8 delivers its power very smoothly and frugally, improving durability and reliability as well as reducing fuel consumption and emissions

PRODUCTS & SERVICES

ALEXANDER CORNE

BELOW LEFT: The Scania-powered JSW drill rig is now almost twice as efficient. It is working in the Pilbara in northwestern Australia



manoeuvre the rig from place to place. The operator uses a Bluetooth-linked remote-control panel to direct the rig's movements."

Creating a buzz

According to Tennant, news of the Scania engine's impressive performance has spread throughout the drilling community. Several operators are monitoring the progress of the engine at JSW. Within six months of commissioning it has been moved to a new site in the Pilbara, in northwestern WA.

"We have been in discussions with a number of potential customers and we have supplied 3D drawings that help rig builders decide if the engine will fit their design, or work out how to make it fit," he says. "A good sign is that these customers are asking more about specifications. They are focused on technical information, power, airflow and heat rejection – not just the price."

For JSW Australia, a major benefit has been a substantial reduction in fuel costs resulting from the impressive efficiency of the V8 700bhp engine. "We have seen fuel use fall from around 900 litres a day to about 500 litres, which is not only a huge cash saving but also means less emissions are being pumped into the atmosphere, and that less downtime is required for refuelling," explains Steve Payne, JSW Australia's operations director.

"We service our engines on a strict routine," he adds. "We run in dirt and heat in the Pilbara, so we change the oil and filters every 250 hours. The oil and fuel filters are so well placed around the engine that it makes service time quick and easy. The oil company asks us why we throw away so much oil, but I always say 'new oil must be better than old oil', and it is cheaper to replace the oil and filters than to do a rebuild – not to mention the downtime saving.

"A technical feature I like is that Scania uses an oil spinner on its engines; the centrifuge spins out heavy particles. It's a great way to trap muck in the oil."

JSW Australia's first Scania-powered drill rig is unlikely to be its last, with two more rigs requiring repowering in the near future. **iVT**

Alexander Corne is the PR manager for Scania Australia, and an experienced engineering journalist and editor



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Well cool

PRODUCTS & SERVICES

ANDREA NICOLI

A FAN SPECIALIST WENT BACK TO THE DRAWING BOARD TO DEVELOP A MULTI-FAN ARRAY SOLUTION FOR VERMEER. USED AS A MORE EFFICIENT ALTERNATIVE TO STANDARD HYDRAULIC COOLING SYSTEMS, IT HAS ALSO HELPED REDUCE OVERALL MACHINE SIZE

As a result of its collaboration with Vermeer and US cooler manufacturer Rocore, Spal Automotive, a specialist in the design and manufacture of electrical fans and blowers since 1959, has introduced an ingenious type of cooling solution: the multi-fan array.

Vermeer, a leading manufacturer of woodwaste processing and recycling machinery, recently launched its HG4000 horizontal grinder onto the market. To ensure that this new grinder passed Tier 4 regulations and European emissions standards, the OEM decided to modify the existing cooling system layout. The original installation in the previous version of this grinder was a single hydraulic fan, which cooled the entire radiator package. On the HG4000, however, Vermeer was able to use a more compact design as a result of the Spal multi-fan array solution, thereby reducing the size of the overall machine layout. The arrangement covers the whole of the radiator surfaces with 14 brushless fans, which are able to cool the 332bkW FPT diesel engine.

This multi-fan array system has been designed by Vermeer and Rocore to dedicate 12 fans to cooling the radiator and charge-air cooler, and the other two fans for cooling the hydraulic oil cooler. Another important feature is the ability of the Spal brushless motor to spin the fans at different speeds, as different radiators have different cooling needs.



The HG4000 uses 14 Spal brushless fans



ABOVE: New Vermeer electrically cooled HG4000 horizontal grinder

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Efficiency improvement

Brushless fans provide more efficiency in the cooling system, by reducing the amount of cooling power needed. Through their ability to be driven at different speeds, according to the information received by the ECU of the vehicle through a PWM signal, the fans will provide the exact amount of airflow as required. This saving in kilowatts brings about an overall fuel saving, which contributes to reducing the operating costs of the vehicle.

The main benefits of this new cooling layout are:

• Efficiency, which is increased due to the fans working only when required, with the exact amount of air required;

• Power saving, which has been achieved through the increased efficiency, which contributes to fuel saving;

• Noise reduction, due to stepless speed regulation and the low-noise blade design;

• A clean cooling package: when required by the application and duty cycle, the fans will spin in reverse mode in order to clean debris from the radiator, which is essential when working in dirty environments;

• Cost saving: this kind of system represents a cost reduction for the OEM who decides to get rid of an entire hydraulic cooling system.

The main benefit the brushless motor can offer to the cooling system is an increase in overall efficiency. Spal's brushless fans are designed to meet the most stringent engineering standards for performance and durability. Featuring embedded electronics, a heavyduty design and a completely sealed brushless motor, which has been certified accordingly to IP68 and IP6K9K, this fan has been designed, tested and manufactured by the company at its headquarters in Correggio, Reggio Emilia, Italy.

The increased efficiency of this design, combined with optimised control, low noise, stable current consumption and multiple protective features, has been designed to provide new options in off-highway cooling systems. **IVT**

Andrea Nicoli is account manager for the off-highway market at Spal Automotive Srl



Heated exchange

THE ARGUMENTS FOR SUSTAINABLE DEVELOPMENT ARE CLEAR, BUT CALL FOR MORE COMPLEX HEAT EXCHANGER TECHNOLOGY THAN EVER BEFORE. SO WHAT WORKS BEST – ALUMINIUM OR COPPER-BRASS SYSTEMS?

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Sustainability is at the top of everyone's radar at the moment, which means that environmental aspects are highlighted in legislation to contribute sustainable solutions for the future. For instance, the US Environmental Protection Agency and EU Stage standards are forcing both engine and off-highway manufacturers to rethink their engine concepts to achieve the required reductions in NMHC, PM and NOx emissions. These emissions standards are feasible using catalysed diesel particulate traps, EGRs, NOx absorbers and various other diesel technologies. The emissions levels required from 2014 onwards on offhighway and industrial applications means that when running an engine in a smog-polluted inner-city area, its exhaust emissions contain less NOx and PM than the air it takes in. In other words, the engine helps to purify the air.

The need for heat treatment

There's an industry-wide consensus that clean diesel engines will require more complex heat exchangers than in the past. More heat at higher temperatures will need to be removed to gain control over the combustion processes. One widely used technology, exhaust gas recirculation (EGR), uses exhaust gas as an oxygen-depleted gas to be partially recirculated back to the intake manifold and into the combustion chamber. In this manner, NOx emissions can be reduced because too much oxygen results in high combustion temperatures that produce oxides of nitrogen. The exhaust gas needs to be cooled by an



Regardless of the harsh environmental conditions affecting most off-highway vehicles, brazed copperbrass radiators offer reliability and minimised downtime in operations



CuproBraze produces strong and reliable copper-brass radiators with several performance and cost advantages over aluminium radiators

EGR cooler and then compressed by the turbocharger. Meanwhile, the usual intake air is compressed by the turbocharger and cooled in the charge-air cooler (CAC).

At some stage, the exhaust gas and atmospheric air must be mixed. The aluminium tubes in currentgeneration charge-air coolers are unreliable above 180°C, and maximum specification temperatures for aluminium CACs typically are even lower. Serious problems occur at temperatures above 200°C, at which the strength of aluminium drops 40-60% compared with its strength at 150°C. As a conservative estimate, for example, aluminium tubes with a tensile strength of 150MPa at 150°C may experience a 40% drop in strength to 90MPa at 200°C. As a result, aluminium CACs fail prematurely in the field when subjected to high temperatures. Tube cracking and tube-to-header joint failure are common failure modes of aluminium CACs in the field.

Temperature cycling and fatigue contribute to failure in both cases. On the radiator side, stainlesssteel EGR systems are, in most cases, integrated into the cooling circle and cooled down by the radiator, which increases the heat load of the radiator by up to 25-30%. To cope with this change, one option is to increase the size of the radiator, which is a solution with many negatives. Now Dolphin Group, a heat exchanger manufacturer based in the United Arab Emirates, is entering both the OE and aftermarket with a technology that fits the new requirements perfectly.

CuproBraze technology is a sophisticated and visionary way of manufacturing heat exchangers, resulting in unrivalled functional properties. The introduction of this technology has greatly changed the design parameters for CACs and radiators.

Considering the former, a brazed copper-brass CAC can withstand very high inlet temperatures, retaining much of its strength and avoiding metal fatigue. The tensile strength for tube brass used in CuproBraze heat exchangers is more than 300MPa at 200°C and still well above 250MPa even at 300°C. A useful interpretation of strength-versus-temperature data for brass-versus-aluminium is to calculate strength ratios at different temperatures. For example, brass tube is 1.75 times stronger than aluminium tube at room temperature, but four or five times stronger at 250°C.

High-temperature performance is not the only reason to choose CuproBraze. Another advantage is the lower airside pressure drop, as it is estimated that a copper-brass heat exchanger will have a 20-30% lower air pressure drop than aluminium. Other heat exchanger applications in clean diesel engines may well benefit from a same-sized copper-brass heat exchanger with higher heat rejection than an aluminium heat exchanger, or a smaller copper-brass heat exchanger with the same performance.

Whatever types of clean diesel engines are developed in the next few years to meet the stringent reductions in emissions, CuproBraze technology is likely to play a vital role as the material system of choice for advanced cooling systems and exhaust aftertreatment equipment. **IVT**

Juho Partanen is global sales and marketing manager at Dolphin Group



The secret life of batteries

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A BREAKTHROUGH IN BATTERY MONITORING TECHNOLOGY IS DELIVERING MAJOR BENEFITS ACROSS THE ELECTRIC VEHICLE INDUSTRY, FROM BATTERY MANUFACTURERS AND VEHICLE OEMS TO THE END USERS

Battery management is a complex issue for fleet managers and other end users. For reasons of productivity, safety and cost control, it is essential to know how long the battery life will be, what the state of charge is, how healthy the battery is, and other key aspects of battery functionality. Damage, premature depletion and improper battery maintenance can lead to vehicle downtime or costly battery replacement.

Concerning the science of battery life, Eugene Finger wrote *The Battery Book*. Finger was a Curtis Instruments engineer whose comprehensive analysis of battery functionality became the standard industry reference. His book is still available, and can now be downloaded from the Curtis website.

Battery monitoring

Historically, Curtis Instruments – a global leader in integrated systems technology for electric offhighway vehicles – has also been a leader in battery monitoring. Founded in 1960, Curtis patented Battery Discharge Indicators (and coined the term BDI) in the 1970s. However, while these early battery fuel gauges were the state-of-the-art in battery charge measurement, they only indicated discharge.

Early-generation BDIs were mostly used on forklift trucks that typically ran in three shifts. These gauges rode on the vehicle, measuring only the voltage of the battery. The management method was to use the battery almost to the point of depletion, then drive the vehicle to a battery-changing station, where a crane would lift out the drained battery and replace it with a fully charged one. An expensive, awkward and time-consuming system, to say the least.

Finger dreamed of a better solution. He foresaw more accurate measurements and readings by understanding not just the voltage, but also the current of the battery, and what specifically happened during the charge cycle. He realised that if you could measure both current and voltage, and if the device travelled with the battery, then you would achieve the most accurate assessment of the state-of-charge (SOC).

Now Curtis has achieved that goal, and made it affordable for the marketplace. The Acuity battery monitoring system is a revolutionary step in modern vehicle battery monitoring. It is a highly intelligent battery monitor that delivers considerable benefits



Battery information is displayed in real time on the Curtis enGage VII or any other CAN-based display

right across the industry, to battery manufacturers, vehicle OEMs and end users alike.

During the Acuity development process, Curtis engineers sought to fulfil three key value points:

• Provide the highest accuracy SOC information possible, clearly quantifying the amount of energy remaining at any given time;

• Serve as a warranty witness (validating that the battery has or has not been operated within its conditions of warranty);

• Function as a productivity tool, indicating the condition of the battery in addition to SOC.

The new Curtis Acuity mounts directly onto the battery for exact readings of both voltage and current, delivering the most accurate SOC possible. As the industry's most reliable battery monitoring tool, Acuity is a viable warranty witness and productivity tool, providing detailed information on

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battery life, state of charge, maintenance and abuse incidents. Many decades of battery expertise have enabled its development.

Acuity resolves the ongoing debate between vehicle manufacturers, battery manufacturers and end users as to when battery performance is not as guaranteed. It provides proof positive of compliance or non-compliance within warranty guidelines.

The technology also enables end users to manage their fleets with far more efficiency. They can get the most work out of each charge and each battery; can know in advance what will need replacing, and when; identify abuse patterns that can be rectified; and, in general, achieve more control over fleet performance.

In order to technically solve the problem of a more complex, comprehensive battery reading, a new algorithm was needed. The old maths calculated SOC by integrating the battery voltage over time. As work



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The Curtis Acuity device connects directly to the vehicle battery, where it collects and transmits accurate battery state-of-charge and battery-condition information.

was done by the vehicle, the battery voltage decreased and the time that the voltage was below a reference voltage was accumulated, with the resulting SOC being displayed on the gauge.

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The new algorithm to calculate a more accurate SOC takes into account multiple charge and discharge scenarios. Acuity calculates SOC by integrating current, voltage and temperature (using an integrated temperature sensor) at multiple discharge rates. It is far more precise than previous algorithms and is what Curtis engineers like to call 'the secret in the sauce'.

Each Acuity device mounts onto the battery, has a unique serial number, and is intended to spend its life on the battery. It provides a full and constantly updated history: how long the battery has been in service, how often it has been charged, and to what level discharged. Any discrepancies in usage are noted. There are about two dozen data points – see the box overleaf for a sample listing.

Longevity and ease of use

Acuity connects to the vehicle's CANbus system, integrating seamlessly into the Curtis drive system. It also communicates effortlessly with all standard Curtis products and tools, including all enGage displays, all CAN-based motor controllers (including AC), and is accessible with Curtis handheld programmers via Curtis's Vehicle Control Language (VCL).

Installation could hardly be more simple, without any hardware or brackets involved. You basically just put the battery cable through the Acuity current sensor, connect the CAN wires, and tie it into place for pluq-and-play performance.

All solid state, Acuity has no moving parts, and is designed to last at least 10 years – the average life cycle of a forklift truck. It is equally at home on golf cars, aerial lifts, sweeper/scrubbers, scissor lifts, etc.

Although the device attaches to the battery and is meant to stay connected for the life of that battery, Acuity is not averse to remarriage. It can be remounted on a new battery if it outlasts its first companion.

The standard Curtis Acuity system enables users to access battery data from the vehicle's CANbus

either via the on-vehicle display or via the handheld programmer or equivalent device using VCL. Once the device is in place, you get information, not just data. Tools to program, read, interpret and apply the information include an on-vehicle display, PC software tools and a handheld programmer connected to the controller. ۲

Rich information

Curtis has created a standalone software program – an optional Acu-Set software kit that greatly enhances this process. The kit consists of software and a dongle which allows the Acuity data to be read by a PC. This proprietary software reads the data and translates it into clearly accessible and actionable information.



The Curtis Acuity Battery Monitoring System is easy to install. Shown is the Curtis Acuity on the battery of a Class 3 powered pallet truck



The Acu-Set software translates the Acuity battery data into easy-to-read performance data. It also calculates Percent Rated Capacity (PRC) – the actual energy the battery can deliver as compared with its rated capacity

The Acu-Set tool also allows easy programming of the Acuity, the ability to read instantaneous battery data and store battery data into the PC. Matching Acuity parameters to a specific battery brand and model is easier than ever: most models can be selected from a comprehensive pull-down menu, or a custom battery profile can be manually entered.

Reading battery information for productivity, maintenance and warranty witness is extremely simple with this software tool. The user can see instantaneous or historical data of the measured values in comprehensive displays, including in chart format. Fleet managers can easily access the full range of battery data points via wired or wireless means. The Acu-Set software also stores the data collected by the Acuity battery monitoring system.

With battery costs running in the range of US\$5,000-7,000, the economical Acuity can very quickly pay for itself by identifying faulty batteries and preventing abuse that shortens battery life. It therefore presents an extremely affordable battery monitoring solution with excellent ROI by saving abuse and forcing warranty terms.

Looking ahead

Curtis Acuity presents the possibility of a new business model: a rental approach to EV usage. Dealers can approach their customers and say: "Only pay for the energy you are using" – similar to paying for mileage on a rental car or truck.

Also to be seen in the near future, a working model of a wireless communications version is now in the Curtis engineering lab. This variation will enable Acuity to communicate via Zigbee, WiFi or Bluetooth. Any time the device is in range of a WiFi hotspot, the operator or manager can access and 'talk to' the vehicle from anywhere in the world. Readings can be made from the fleet manager's office, warehouse or company HQ, supplying vital data for superior battery management and optimal fleet performance. **iNT**

Mike Miller is director of product management, Curtis Instruments, Inc.

Keeping track

Based on Acuity readings, operators can avoid the leading causes of battery damage:

- True accuracy in measuring depletion avoids usage below 80% depth of discharge, the recommended recharge level;
- Because batteries are strongly affected by temperature extremes, Curtis Acuity includes a temperature sensor integrated into the harness.
 Acuity provides data – translated by Curtis

software into readable information – on the following points:

- Battery voltage;
- Battery current;
- Battery temperature;
- Ampere hours in;
- Ampere hours out; State-of-charge (SOC);
- State-of-health;
- Battery serial number;
- Highest voltage measured;
- Lowest voltage measured;
- Highest temperature measured;
- Lowest temperature measured;
- Current measured at highest voltage;
- Current measured at lowest voltage;
- Highest SOC measured;
- Lowest SOC measured;
- Date;
- Time;
- ... and more!



CONTACT www.curtisinstruments.com www.evbatterymonitoring.com

PRODUCTS & SERVICES SVANTE DRESEN

The common touch

IT SEEMS EVERYONE HAS INCREASED EXPECTATIONS ABOUT WHAT A MULTIPIN CONNECTOR SHOULD DELIVER. THANKFULLY, THE DRCP SERIES' USE OF COMMON CONTACTS IMPROVES PERFORMANCE AND RELIABILITY, NOT TO MENTION EASE OF SERVICING

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The demands on multipin connectors used in off-highway equipment are constantly increasing. Not only are higher pin counts and increased current capacity in demand, but the expectations of protection against increasingly adverse environmental conditions are higher than ever before.

Nevertheless, cost-effectiveness and easy handling remain primary goals, in particular in environments where moisture, salt spray, dust, dirt and rough terrain can contaminate or damage electrical connections. Deutsch (now TE Connectivity) engineers answered these needs and expectations with the new Deutsch Rectangular Common Platform (DRCP) series of connectors. DRCP series connectors are constructed of heavy-duty thermoplastic, boast high pin densities with 86- and 126-cavity arrangements, and are designed for use with multiple wire gauges. The 86-cavity arrangement is offered with bulkhead and PCB mounting options, and accepts 80 size 20 contacts and six size 12 contacts. The PCB-mounted 126-cavity connector accepts 120 size 20 contacts and six size 12 contacts. Keying enables multiple usage of the DRCP connector in one unit.

Common contact system

As with most of the company's connectors, the DRCP series also uses the common TE Connectivity contacts. The word 'common' is used because the contacts may be used interchangeably in many of the company's connectors and across most of its industrial connector series.

The common contact system improves performance, reliability and maintainability by reducing necessary changes in the assembly of the wire harness. The use of this system can eliminate many of the failures reported in harnesses that use hundreds of different terminals. Most harness housings may be used and are equipped to handle these contacts, of which there are two styles – stamped and formed, and solid. While the former offer a cost-effective solution at a



known quality level, solid contacts could be the preferred choice from wire size or field service perspectives. Dedicated hand tools for solid contacts can be used for servicing machinery, even in remote locations.

The DRCP Series 80 and 120 size 20 contacts are able to carry 7.5A continuously at a maximum ambient temperature of 125°C. The high operational tolerances may, however, also permit reliable function under other, highly specialised conditions outside published limits (e.g. fuel injectors).

TE Connectivity engineering is happy to consult in these situations and can evaluate or ensure the specialised use knowing the current profile that is required. A minimised voltage drop for low signals can be effectively addressed with optional gold plating on contacts. Both versions offer an additional six size 12 contacts for applications requiring more current; these allow a continuous 25A at maximum ambient temperature. These power contacts are optional and need not be included for affordability.

DRCP models include integrated terminal position assurance (TPA), ensuring proper contact alignment and ease of assembly. The TPAs are designed so that the contacts are protected even if the connectors are unmated. This feature is termed 'scoop proof', indicating that the contacts, either male or female, are prevented from being touched by the front part of the mating connector. In respect of ISO 20653, this feature will be called IP2X. The interface seal is also protected so that handling at harness houses, initial vehicle assembly or service does not cause any damage of the seal and consequential leakage of the connector.

The PCB receptacle carries a seal around the pin contacts to protect the control unit or similar device even when the mating connector is not in place. Tests have shown a protection level of IP67 (ISO 20653) for the unmated PCB connector. If the DRCP is mated, environmental sealing is assured to IP6k9k. The integrated wire router, together with multiple universal tie-wrap attachment positions on the plug and in-line receptacle assemblies, allow various harness routeings. Optional backshells support this approach.

Field serviceable

The DRCP series addresses the off-highway, trucking and marine industries, which rely on the simple handling of connectors – in particular where vehicles will need remote service far from suitable garages. Deutsch engineers paid particular attention to this requirement – the DRCP requires no special tooling to be serviced. A small, standard screwdriver is enough to remove the TPA and release single contacts from the connector.

Easy handling, the common contact system and advanced features preventing connection failures make the DRCP the connector of choice. **iVT**

Svante Dresen is key account manager, Industrial & Commercial Transportation, TE Connectivity

ABOVE: 86/126-pin heavyduty connectors are scoop proof, easy serviceable and environmentally sealed up to 25A

germany-pic@te.com

CONTACT

Long time, no CE?

IF YOUR EFFORTS TO ACHIEVE ISO 13849-1 (OR OTHER INTERNATIONAL FUNCTIONAL SAFETY STANDARDS) ARE ENCOUNTERING DIFFICULTIES, MAYBE IT'S TIME TO LOOK AT INCORPORATING A NEW LINE OF COMPLIANT SAFETY CONTROLLERS

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Ever since late 2009, all off-highway mobile equipment exported to, or manufactured in, the European Union (EU) must comply with European Machinery Directive 2006/42/EC if it is to establish an EC Declaration of Conformity and earn a CE vehicle marking. International safety standards, such as the recently harmonised International Organization for Standardization (ISO) 13849-1, have now been updated accordingly.

"Functional safety must be addressed by all offhighway vehicle OEMs, however, not just those active in the EU," says Joseph P. Maher, manager, sales EC (Electronic Components), Americas for Sauer-Danfoss. "The directive applies globally because supporting engineering standards are developed by ISO, which has established 'state-of-the-art' standards for OEM functional safety design architecture – regardless of the region of the world in which the vehicle is designed, produced or sold."

Facilitating compliance

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The brand-new series of Sauer-Danfoss PLUS+1 SC controllers offers outstanding functional safety capabilities to OEM designers of off-highway vehicles worldwide. Designated SC024-010, SC024-020 and SC050-020, these devices simplify and streamline the application process, facilitating easier compliance with stringent functional safety standards. The three safety controller variants help vehicle manufacturers

meet European Machinery Directive 2006/42/EC and are designed to achieve SIL 2 (Safety Integrity Level 2 according to IEC 61508) and PL-d (Performance Level d per ISO 13849-1) standards, while third-party certification is pending.

"Our three new PLUS+1 SC controllers provide superior functionality and system design flexibility," Maher explains. "These solutions enable OEM customers to safety-certify their control systems, meet functional safety mandates, bring vehicles to market and certification faster, and reduce development and maintenance costs."

The new safety controllers update three highervolume Sauer-Danfoss controllers to add improved functional safety capabilities. Each programmable device is a single controller module that includes two independent microprocessors with redundant control of each output. Integral safety layer software provides automatic fault-detection monitoring, and enables programming of application-specific responses to fault conditions. The design architecture facilitates use of the primary microprocessor for non-safetycritical applications, isolating the control of safety functions in the secondary or safety microprocessor. The GUIDE-programmable devices are pin-for-pin compatible with equivalent Sauer-Danfoss MC controllers, requiring no wiring changes to transition from the standard controller to a safety controller.

The safety controller series features enhanced performance derived from the logical incorporation

FAR LEFT: The new series of Sauer-Danfoss PLUS+1 SC controllers offers outstanding functional safety capabilities to OEM designers of mobile off-highway machinery

LEFT: Sauer-Danfoss can help OEMs to safetycertify their control systems, meet functional safety mandates, bring vehicles to market and certification faster, and reduce development and maintenance costs

RIGHT: All off-highway mobile equipment exported to or manufactured in the European Union (EU) must meet European Machinery Directive 2006/42/EC, which took effect in late 2009



GLOBAL IMPACT

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European Machinery Directive 2006/42/EC mandates a Hazard Analysis and Risk Assessment, which must be performed and documented by the vehicle OEM according to ISO 13849 or another functional safety standard as required by national law. ISO 13849 refers to International Electrotechnical Commission (IEC)-61508 in regard to electronically programmable systems and encourages the use of Safety Integrity Level (SIL)-certified components and software. The result of the IEC-61508 analysis is calculation of SIL level, which has a clear relation to a Performance Level (PL). SIL levels 1-4 are calculated based on the likelihood and consequences of hazards for each safety-critical function.

OEMs are responsible for obtaining SIL certification. While SIL-compliant components and software cannot guarantee a SIL- or PL-compliant system, they can greatly reduce an OEM's vehicle certification effort.

of state-of-the-art electronic technology. Upgrades include an increased memory capacity, higher environmental performance and enhanced input/ output flexibility. The primary controller offers 512K of flash memory, while the secondary controller provides 128K of flash memory. The operating temperature range of the device has been increased to 85°C. Some multifunction inputs can now read 4-20mA current, while digital inputs are now digital/ analogue to facilitate smart digital inputs. The frequency range of PWM outputs has been expanded to 33-4,000Hz or 20,000Hz and supports separate PWM frequencies per channel.

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"When a fault is detected, the new safety controller can shut down individual outputs," Maher states. "Competitive solutions only have the capability to shut down banks of outputs, so this offers a significant advantage to our OEM customers."

Additional enhancements include:

• Configurable sensor power featuring a selectable range from 3-12V;

• A lower-power mode enabling application software to command internal power supplies to shut down when the controller is idle; The capability of running on as little as 7V, providing the ability to remain on through engine crank;
A 150 V/m EMI/RFI rating.

In support of the new PLUS+1 SC controllers,

Sauer-Danfoss offers a team of subject matter experts with expertise in the development of OEM customer strategies to achieve functional safety compliance. The company is able to contribute by providing technical input, integrating products to develop subsystems and solutions, and offering detailed information about the functions and reliability characteristics of such product assemblies.

"Functional safety compliance can be complex and confusing, but Sauer-Danfoss specialists have the know-how to assist our OEM customers," comments Ruediger Huettmann, product compliance manager at the company.

"Sauer-Danfoss is the ideal partner for OEMs seeking effective and efficient solutions to meet functional safety needs and get to market faster." **iVT**

Warren Joiner works in the market communications department at Sauer-Danfoss



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BULLETIN BOARD

FULL METAL JACKET

As part of its Geomet zinc flake anticorrosion technology, NOF Metal Coatings Europe is proposing two topcoats for fasteners based on a waterbased and low VOC content chemical: Plus VLh and Geokote.

For many years, one of the major standards of the German automotive industry has been the Plus VL applied onto a Geomet 321 grade A coating, combining excellent anticorrosion performance with control of tightening, all for a very competitive price.

The Plus VLh topcoat improves performances linked to friction for difficult tightening cases, particularly for multitightening in aluminium and onto catophoretic paint.

It is also effective in cases of loosening at high temperatures, while avoiding stick-slip problems when tightening.

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The Plus VLh topcoat can be applied in just one coat onto the Geomet 321 grade A coating.

Currently used in the mass production of external parts (locks for doors and engine bonnets, for example) Geokote topcoat has been developed to provide resistance to chemicals



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such as hydrochloric, sulphuric and phosphoric acids, as well as repetitive abrasion. The excellent results obtained now enable it to be used on new applications such as fasteners.

Geokote combines a thin layer of optimal corrosion resistance with superb assembly properties. It enables, for instance, the avoidance of the stick-slip effect occurring when tightening.

Geokote is available in black, clear and in other shades, which enables, for instance, the quick identification of parts. It can be applied both by dip-spin or by spray on the existing lines of the company's global applicators network.

ENQUIRY No. 501 NOF Metal Coatings Europe www.nofmetalcoatings.com

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Webasto's automated engine-off heating technology is an ideal way to maintain the comfort and efficiency of off-highway machines throughout the day – and still cut costs effectively.

To keep the engine at normal working temperature – and keep the cabin interior warm – it will typically be running while the vehicle is stationary or waiting. Engine idling often accounts for up to 50% of total engine time!

Various studies concerning cost allocation have shown that idling can raise the total cost of ownership by up to 17%.

Although the machine isn't in productive use, fuel is consumed unnecessarily, and the overall number of working hours goes up. Not only does this have an immediate effect on costs, but it also has a huge impact on the vehicle's maintenance cycle and warranties: for example, a wheeled loader with 527hp can waste \in 13,000 of fuel per year in unnecessary idling.

In a nutshell: to save money, avoid idling! With Webasto's engine-off heating technology, it actually becomes superfluous: the coolant heating system keeps the engine and cabin interior at the right temperature, even when the engine is switched off.

The benefits at a glance:

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- No more idling;
- Fully automatic activation of coolant heating system;
- No more cold starts;
- Always the right temperature
- in the cabin interior;
- A reduction in fuel costs.

ENQUIRY No. 502

Webasto Thermo & Comfort SE www.construction.webasto.com info@webasto.com +49 89 857940

MAKING LIGHT OF DIFFICULT CONDITIONS

The new Nordic N46 LED Scorpius worklight provides operators with superior illumination in an evenly distributed light pattern. Boasting a theoretical output of 5,800 lm and an operational output of 3,600 lm, it offers a very strong light. With a power consumption of 50W it gives a high lumen/watt efficiency.

The worklamp is offered in four light patterns; high beam, low beam, wide flood and flood. With a size of 108x110x115mm and a weight of 1.5kg, it gives impressive light in a relatively small package.

Other features of the lamp include an optically even distribution of light pattern, minimum maintenance and a long lifetime due to its heavyduty construction. Multivoltage, waterproof and with a replaceable lens and extensive EMC, it is protected against load dumps, over-voltage, reverse voltage and overheating.

The light's IP rating covers IP68 and IP6K9K, and it withstands salt mist according to ISO 9227 for over 240 hours. The Nordic N46 LED Scorpius fulfils the EMC standards of ISO 13766, ISO 14982 and ISO 7637-2.

Nordic Lights is a company based in Finland developing and manufacturing LED, HID (xenon) and halogen worklights for the heavy-duty onand off-highway industry's typically severe working environments. Using the company's products ensures that darkness, vibration, shock, dust and humidity will not affect visibility when the results of your work and safety depend on effective lighting.



BULLETIN BOARD

TRACTORS NEXT UP FOR THE ELECTRIC TREATMENT?

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The importance of electrification is increasing for many types of machinery. One such example is ElecTra, ZF's new electric drive concept for tractors. This is not simply about hybridisation, but also the efficient electric operation of agricultural machinery for tasks such as sowing, fertilising and the control of pests. These operations require finely nuanced control of the high-tech machinery hooked up to the tractors.

"Drive units for agricultural machinery need to be efficient and easy to use," says Karl Grad, ZE's head of development for agricultural machinery transmissions. "The electric systems can help to overcome the deficiencies of the mechanical and hydraulic drives widely used today."

Dirk Bald, ZF's head of product line for forklift systems and electric drives, sees further potential for introducing electric drives into conveyor systems with a small operating radius, such as rail-mounted container loaders at ports and freight marshalling yards. They can be supplied



with energy from the grid and are then powered entirely by electricity.

Electrification is also gaining in importance for urban construction sites as local authorities are increasingly demanding reductions in exhaust emissions and noise levels. Conventional excavators still move their excavator blades, shovels and grippers into the desired position by hydrodynamic rotation. "Systems like this can be replaced by electrotechnical solutions," says Bald. In Asia, the first wheeled and tracked excavators are already being fitted with drives of this type. The ZF Group has access to a massive knowledge base on electric drives, opening up new possibilities for mobile machinery. Bald also has his sights on smart electrification as a profitable area of activity – for example, cooling in motors that is carried out by electronic fans rather than mechanical fans during operating activities.

As an example, instead of letting a 370bkW engine continue to run while waiting for a truck or combine harvester, tractor cabs can now be cooled with battery-powered ventilation and air conditioning to make life easier for the driver. This would considerably cut emissions, while at the same time reducing operating costs. Seriestested modules from forklift drive technology are available to perform these functions.

ENQUIRY No. 504

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ATTRACTIVE PROPOSITION

Employing a new magnetic measuring principle, Sauer-Danfoss's precision EMD speed sensor for orbital motors delivers improved motor controllability and system flexibility. The sensor is claimed to have the highest speed resolution in the industry while indicating direction.

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CANbus communication and compliance with the Sauer-Danfoss PLUS+1 electronic control platform are among the strong new features.

The company has developed a patented contact-free sensing mechanism that follows the movement of a magnet inside a steel plug. Even a small rotational movement is detected due to a direct connection to the cardan shaft via a flexible axle. A microcontroller inside the sensor measures the speed and direction of the magnet as it rotates – a task that until now has required two sensors.

OEMs count on top precision when optimising productivity and efficiency to meet today's stringent emissions legislation. Salt spreaders, forestry machinery, skid-steers, pavers and harvesters can now reach an unsurpassed level of mobile control.



ENQUIRY No. 505
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WATER GREAT SOLUTION

Amphibious excavators are used on many construction projects on lakes, rivers and coastal areas. But working in water has its challenges. Movements of the excavator and weight transferal resulting from the additional weight of a full bucket cause various stresses and have a negative effect on stability.

ContiTech Vibration Control has now developed a conical bearing suitable for these demands. What is particularly special about the new bearing is its dimensions – so with a load transferal capacity of 50-150kN approximately, the bearing can handle large loads and fulfil the special requirements of wet working applications.

For use as an excavator slew bearing, two separate bearing elements are braced against each other over a rod. Inside, the conical bearing has a large rubber pad, which provides good lateral stability due to its specially designed contour. As a result of its high spring stiffness of 2,200N/mm, the conical bearing effectively reduces the swaying of the vehicle. Installation of the bearing means that it is tear-proof and



thereby optimal for use in construction machines. It can also be used as an unbraced individual element.

"The new bearing was specially developed for the elastic bearing of an excavator on a floating pontoon, but it will certainly soon find uses in other application areas," ContiTech product developer Henri Scherrens declares.

ENQUIRY No. 506

ContiTech Vibration Control www.dunlop-oil-marine.co.uk dunlop.sales@dunoil.com +44 1472 359281

BULLETIN BOARD

GET EVERYTHING UNDER CONTROL

Nimco Easyprog is an easy to use, intuitive software for programming the different Nimco CANbus modules. The interface is based on logic programming using Boolean operators to define the program instructions. A relay schematic is available as support for the programmer to get an easy-to-read overview of the program. No programming experience is needed to start building programs in EasyProg.

The EasyProg programming software is the perfect tool for OEMs to build and maintain their control systems. It combines functionality and intelligence for sensors and actuators on mobile machines and utility vehicles. EasyProg is a very user-friendly, flexible control system that connects to a broad range of intelligent I/O modules.

Application areas cover most kinds of offhighway machinery, and because EasyProg has a modular structure, the system can be fitted to almost all assignments. This excellent flexibility makes it an ideal automation platform that is suitable for large and small production series.

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Its I/O modules are specially designed for the typically demanding off-highway environment. The modules are hermetically sealed inside a stable aluminium enclosure, which makes them a solid unit – and therefore not affected by vibrations and rough weather conditions. The temperature range stretches from -30° to $+80^{\circ}$ C, while the EMC corresponds to the tough standards of the vehicle industry.

EasyProg is a distributed real-time system that consists of a modular combination of different I/O modules. Together, they form a complete system that does not require a central control unit. Instead, each module has its own built-in



intelligence and reads the necessary signals from sensors and other units over a CANbus interface.

The EasyProg modules can be combined and programmed independently to obtain the desired function. The system is very flexible and can be expanded with additional modules if any more functions are needed.

ENQUIRY No. 507 Nimco AB

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THE MK OF QUALITY

PMP Industries has announced the introduction of two new members in the Fluid Power Division product range. This division is dedicated to the design and manufacturing of high-pressure axial piston pumps and motors for a wide range of mobile and industrial purposes.

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PMP has recently introduced the MK series, plug-in axial piston motors, both in the fixed- (MKF) and in the variable-displacement (MKV) version. MKF and MKV motors are designed for highpressure (up to 450 bar) heavyduty applications and feature the most compact design with several valve options available.

In the MKV version, the displacement is fully customisable and several controls are available for displacement change. The present range includes 55-180cc versions.

The Fluid Power Division product range includes also PMH M hydraulic motors, PMH MT swing motors, PMH MI integrated motors, and PMH P hydraulic pumps, which, combined with the mechanical products of the company's Power Transmission Division, enable PMP Industry to act as a unique partner for providing complete solutions for a wide range of applications.



PMH high-pressure axial motors and pumps are the result of PMP's 20-years of experience with hydraulic transmissions. Knowledge gained from field experience, intense testing and design activities, and continuous improvements are key elements in a range of products that delivers efficiency and durability throughout its operating life.

Moreover, these hydraulic transmissions are manufactured entirely by PMP: this level of vertical integration allows for full control of the manufacturing processes and competitive production lead times.

DENQUIRY No. 508

PMP Industries www.pmp-industries.com sales.eu@pmp-industries.com +39 0432 863 611

SWEET 16D

Dana offers a comprehensive line of Spicer drivetrain products designed to provide the vehicle performance, efficiency, reliability and reduced operating costs that are required in mining.

Over the past two-and-a-half years, the company's output of transmissions, driveshafts and axles rose by nearly 50% at its four mining facilities across the world to meet the growing needs of OEMs.

The company has also greatly enhanced its global aftermarket service, and now operates 17 distribution centres to provide logistical support, a full supply of genuine aftermarket products, and maintenance kits that will reduce downtime encountered at remote mining locations.

The Spicer Model 16D axle is one of five models of mediumand large-sized Spicer mining axles now in production at its facility in Wuxi, China, to better support the world's largest market for mining machinery.

The Model 16D axle provides rugged strength and dependable performance under the most severe operating conditions. Commonly used on 4.4- to 6.5-tonne LHDs and 25- to 33tonne mining trucks hauling up to 16,068kg, the Model 16D offers excellent torque capacity, with a maximum output of 111,600Nm. Engineered with an enhanced braking system and no-spin differentials for terrainspecific traction and controlled operating, it transmits more power and offers greater reliability in severe environments.

The Model 16D is available in various dimensions and features a modular design that simplifies installation and reduces the need for maintenance. A double gear reduction design reduces vehicle wear, increases ground clearance, and improves turning capabilities with a 4.94 wheel-end ratio.

ENQUIRY No. 509 Dana Off-Highway Products www.dana.com/offhighway info@dana.com +1 704 878 5886



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THE INSIDER



REDUCING EMISSIONS THROUGH THE USE OF UREA, WHILE LEAVING ENGINE DESIGNS UNTOUCHED, IS JUST MISSING THE POINT

I have too much time to think on long flights. After pondering whether it would ever be possible to develop a more uncomfortable seat than those in the economy cabin of the Airbus A380 on which I was travelling, I began to muse on the fact that we, like the Romans, have finally found a use for urea. They used it to wash their togas, now we are using it to clean our diesel engine exhaust emissions. Granted, theirs was 'on draught' while ours is manufactured and - presumably because any other colour might be deemed inappropriate - coloured blue, but it's basically the same stuff.

TOXIC EMISSIONS **FROM ANY** SOURCE SHOULD BE **AVOIDED -**WHICH IS WHY **I QUESTION** THE DUMPING **OF UREA BY THE BUCKET-**LOAD INTO THE AIR THAT WE BREATHE

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One of my colleagues was recently bemoaning the arrival of Tier 4i and the problems that the accommodation of the aftertreatment plant poses to those who are tasked with vehicle packaging. These systems are huge! The layout we were perusing looked like the air-conditioning system of a small shopping centre, even though the engine was relatively modest.

From our discussion, it seemed that the tweaks to achieve Tier 4i have more to do with the aftertreatment than the actual engine, which has remained pretty much the same since Tier 2. I'm no engine expert, but I'm not overly happy with the situation. I mean, is this it? Are we to meekly accept that the way to operate diesel engines in future is to wrap them in a system that dumps tonnes of urea into the exhaust stream, is expensive to install and run, and is, almost by definition, technically fragile?

Sorry guys, this might seem like an idle criticism, and I'm sure you've done the best you can, but... really? Already, the developing nations are reeling at the introduction of the common-rail concept and struggle daily with the associated problems of fuel quality and availability of maintenance on such engines, so why on earth would they ever think of embracing aftertreatment?

If Tier 4 was rolled out worldwide tomorrow, how long do we seriously believe that such a system would stay in use in the middle of the African jungle? Probably little more time



than it takes for the ope.... service guy to open his tool box!

Those operating in first-world locations, who are obliged by their government to adopt these systems, might grumble, 'What about the cost?' To which millions of environmentally inclined individuals will 'tut-tut' and mumble overused sentiments such as, 'But what about the cost to the planet?' I cannot disagree! Toxic emissions from any source should be avoided - which is why I question the need to dump urea by the bucketload into the air we breathe.

Getting back to costs, though, this is a serious issue. The cost hike on the finished vehicle or machine alone is now considerable and, while it is claimed that SCR reduces fuel consumption, there has still been a noticeable increase over Tier 0 units.

So, with fuel prices being squeezed ever upwards, the threat that we will be 'adding blue' to our running costs makes me even more convinced that this is the wrong solution. If we take it that, for at least the foreseeable future, we will need to burn diesel to produce the power for our machinery, the AdBlue method must be purely an interim solution. Whatever needs to be done to reduce emissions levels must be integral to the base engine design if it is to work. If that cannot be done, then we need either to revise our emissions targets or look for an alternative propulsion method.

Unfortunately, the targets for emissions are not set by practical people; they are dreamed up by committees who believe in a 'perfect world'. These targets have been set too high and introduced too quickly, which has given some of the largest nations abundant opportunity to opt out of the game, citing the complexity or the cost of introduction as ample justification to remain non-compliant.

So, while western nations are burdened with these higher costs, those 'less developed' pollute and waste while creaming the markets by lowering their costs. Emissions levels above Tier 2 should have been approached on a global footing, with Tier 2 set as the base level everyone must conform to, then slowly raising the bar for all, in such a way that we all 'hold hands' and walk forward in an orderly fashion. The improvement would have been gradual but universal and no one would have been left behind or had their economy stymied by striving to emit breathable fumes while others just fog up as usual and save millions.

I just hope that, somewhere, someone in our industry has taken the same view and is preparing to tell the world that they can still operate their diesel engines cleanly without having them piped through to the nearest latrine. If they aren't, they should be - and the sooner the better! iVT Comments: theinsider@ukipme.com