**JOHAN SJÖBERG**, IVT INTERNATIONAL



# energy hit

A HYBRID DRIVETRAIN AND SUPERCAPACITOR-BASED ENERGY STORAGE GIVE A NEW REACH STACKER RADICALLY IMPROVED PERFORMANCE AND GREATLY REDUCED FUEL CONSUMPTION, MAKING IT A HIT WITH DRIVERS AND MANAGEMENT ALIKE

The new hybrid reach stacker from Konecranes Lift Trucks was developed for busy ports requiring many rapid accelerations and lift actions, combined with good fuel efficiency and low emissions

If you are reaching for something new, then what better way to do it than with a reach stacker? A little over two years ago, Konecranes Lift Trucks set out to establish a new standard in energy efficiency for this type of machine and started designing a prototype, which is currently on trial in the port of Helsingborg, Sweden. The trials have turned out better than expected – to the point where the drivers in the port actually prefer the new machine to the ones they have been using for years.

The reason for the popularity of the new (hybrid-drive) reach stacker is that energy efficiency – in this application – is not just some lofty concept that will only benefit the environment or somebody further down the line. Here, the efficient use of energy helps the drivers by making more energy available where it's needed – i.e. at the wheels and in the lift. For instance, the boom can be moved at full power even while the reach stacker is moving at top speed – normally power would have to be distributed between the lift and the drivetrain. This enables the driver to move the boom without any limitation and get the spreader into position for the next operation while the vehicle is in motion.

And with more torque available at the wheels, acceleration has also improved – when going head to head with a conventional reach stacker of the same design, the hybrid version reaches top speed two to three truck lengths ahead.

"Our drivers prefer this one, even though it is a prototype," says Mats Fernebrand, maintenance manager at Port of Helsingborg. "We have trialled the new reach stacker here for 500 hours since last December to help Konecranes find out how it handles in real operation. Prototypes usually have a few minor problems but this one just works really well."



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ABOVE & RIGHT: **The blue box for energy storage on the side of the vehicle indicates that this is not an ordinary Konecranes reach stacker**

## Perfect proving ground

Helsingborg is only an hour's drive from Konecranes' production facility in Markaryd, Sweden, and therefore makes for an ideal testing site. Over 350,000 TEUs pass through the port – situated at the narrowest point of the sound between Sweden and Denmark – each year. While cargo and passenger transport are a very important part of its business, it prides itself on being a container specialist. This is confirmed by the many Konecranes reach stackers that ply the dock area, seamlessly linking sea and rail transport.

"On a site such as this, quick acceleration is very important for productivity, as you keep stopping and starting all the time," explains Göran Bakos, field test manager at Konecranes Lift Trucks. "The longest journeys will only be a few hundred metres. The improved acceleration therefore means more containers can be shifted per cycle."

"In addition, driving this vehicle is more intuitive, as it enables operators to drive as they would like to. While making a lift, drivers will already be thinking about the next operation, so it is very tempting for them to start planning their return journey by engaging reverse gear while still moving forwards. Over the years, countless gearboxes have been damaged this way – but with this vehicle, we actually encourage this style of driving. The braking energy is fed back to the electric motors, which go into generating mode and help reduce power consumption."

## Conserve your energy

Reach stackers and lift-trucks have been part of the Konecranes product range since 2004, when the company acquired SMV Lifttrucks of Markaryd, Sweden. Its reach stackers provide a high stacking capacity and can reach over the first row of containers to the row behind as well as the next one, enabling blocks to be kept up to six rows deep with access from both sides.

With a 45-tonne lifting capacity, the 72-tonne SMV 4531 TB5 HLT features a hybrid diesel-electric driveline, an electrified hydraulic lifting system and supercapacitor-based energy storage – all of which considerably improve energy use, resulting in better performance as well as reduced fuel consumption and emissions. Depending on driving style, it uses 20-30% less fuel than a conventional machine of this type.

This is particularly beneficial at sites with a demanding usage pattern, where many quick accelerations and rapid lifts are required. The improved energy efficiency has been achieved by electrifying all flows of energy across the driveline, hydraulic lifting system and energy storage system.

"Propulsion and lifting are both powered by dedicated electric motors that can all operate in regenerative mode," says Anders Nilsson, technical director of Konecranes Lift Trucks. "The energy generated from braking and load lowering is recovered so it can be stored for later use. This means reduced diesel consumption and less environmental impact. Meanwhile, productivity is increased in terms of quicker response and higher acceleration."

## Generating interest

The prime mover is a 12-litre Scania diesel engine. Used in a conventional driveline, it would drive an automatic gearbox, but in this case it drives a permanent magnet generator supplied by BAE Systems, which is connected directly to the crankshaft. This means that gearbox losses and maintenance requirements are eliminated.

The vehicle is driven on the front wheels by an oil-cooled 250bkW asynchronous electric motor running on 735V DC; the motor is integrated into a TorqE axle assembly from BAE Systems (see Military hardware goes civilian box, above). The axle is fitted with a differential, enabling output to be distributed between the two sides. The wheels feature Kessler planetary gears and wet disc brakes.

The generator is also used to drive the electric motors for the Parker hydraulic pumps that power the lift. Being reversible, these switch into generating mode when the load is lowered. All of the lift operations are managed by a Parker control system, while the driveline from BAE has its own control system.

"When the driver pushes on the accelerator, a request is sent to the control system for more wheel speed and torque," explains Nilsson. "The operation of the lift system works in a similar manner – the driver requests and the system delivers. Meanwhile, the diesel engine works at relatively constant revs, supplying power to


## Military hardware goes civilian

The front axle used in Konecranes' latest reach stacker is a design that was originally developed for military use. The SEP modular armoured vehicle was a hybrid diesel-electric-powered armoured fighting vehicle developed by BAE Systems for the Swedish Army.

It was also intended for use with the UK's Future Rapid Effect System (FRES). When the UK MOD sidelined the project in 2007, the Swedish Defence Materiel Administration decided that it would be too costly to continue without a partner and also pulled out. BAE Systems continued to develop the system with its own resources, and when the contract for new armoured personnel carriers for the Swedish Army was put out to tender, the contract was eventually won by the Finnish company, Patria.

Having been left with a highly sophisticated hybrid drive system but no buyer, BAE Systems then decided to develop a version for civilian use, which later became the TorqE front axle.

TOP: **The electric motor is integrated into the front axle of the TorqE drive system delivered by BAE**

ABOVE: **The reach stacker's hybrid driveline is derived from the SEP armoured vehicle**

RIGHT: **At Konecranes' manufacturing facility in Markaryd, Sweden, each machine is built from beginning to end by the same two people to ensure continuity in craftsmanship and quality**

BELOW: **The control system's response to the driver's requests for speed and torque is independent of the speed of the engine**

BELOW RIGHT: **The vehicle features Kessler hubs with wet disc brakes**

the energy store via the generator, and has nothing to do with the speed of the vehicle."

## Look – no batteries

The difference between energy input and output is picked up by the energy storage system. Somewhat unusually for a hybrid vehicle, this one has no batteries – instead, supercapacitors from Maxwell Technologies are used for energy storage. These offer a capacitance a million times greater than a conventional electrolytic device and can deliver very powerful bursts of energy, primarily due to a much higher surface area.

"Batteries are good for storing energy but less good at releasing it," says Nilsson, explaining the choice of storage medium.

The capacitors can store 1kWh and are able to deliver 300kW in less than four seconds – a rapid rate of discharge that would be a problem for a battery. To offer a service life of one million lifting cycles, which is desirable from a maintenance point of view, a battery would need to be discharged by only 10%. A deeper discharge rapidly reduces battery life – with 50% discharge, only 100,000 lift cycles can be offered.

Nilsson says: "The energy storage system also ensures that power is available instantaneously – there is no need to wait for the diesel engine to rev up. This enables operators to work the lift and the telescopic boom simultaneously, without reducing the speed of either. It also gives the reach stacker far better acceleration than other vehicles of this type."

## Separate and lift

BAE Systems in Örnsköldsvik, Sweden, delivered the driveline for the reach stacker. As well as improving energy performance and acceleration, the driveline also helps generate power for the hydraulic lift.

"The hybrid driveline is another factor behind the improved lifting response," adds Nilsson. "The diesel can normally deliver 225bkW that has to be divided between the lift and the driving wheels; if the wheels are moving, lifting will be slower. Here, the energy storage system can deliver 300kW momentarily, while the wheels are still moving with the power from the engine through the generator, delivering the same lift performance as when the vehicle is stationary."

Excess energy is recovered when the stacker reduces speed or the load is lowered. When the driver brakes, the motor in the front axle goes into generating mode and delivers power back to the energy storage system. The same goes for the hydraulics; when the load is lowered, the returning fluid causes the hydraulic pumps to start spinning in reverse while the electric pump motors switch into generating mode, delivering energy back to the energy storage system.

While this is a first for a lift-truck application it is by no means unique – similar drivetrain designs are used in mining vehicles and modern town buses. Hydraulic systems with energy recovery are also used by some waste-collection vehicles.

The alternating current generated onboard is converted into DC by a series of inverters, as direct current is required by the energy storage system and is also compatible with the standard electrical system used by Konecranes. The onboard electrical system has more in common with cranes than with lift-trucks, being based on a standard industrial 700V DC system. However, compared with a crane, the reach stacker has notably less space on board for the equipment, which caused some challenges for the designers.

Field tests of the new hybrid Konecranes reach stacker continue, with the first deliveries expected during 2014. "We will initially aim the new reach stacker at markets in Europe," Nilsson concludes. "Many ports in this part of the world are in built-up areas with restrictions on emissions. With its low emissions, the hybrid reach stacker will have yet another advantage here." **ALT**