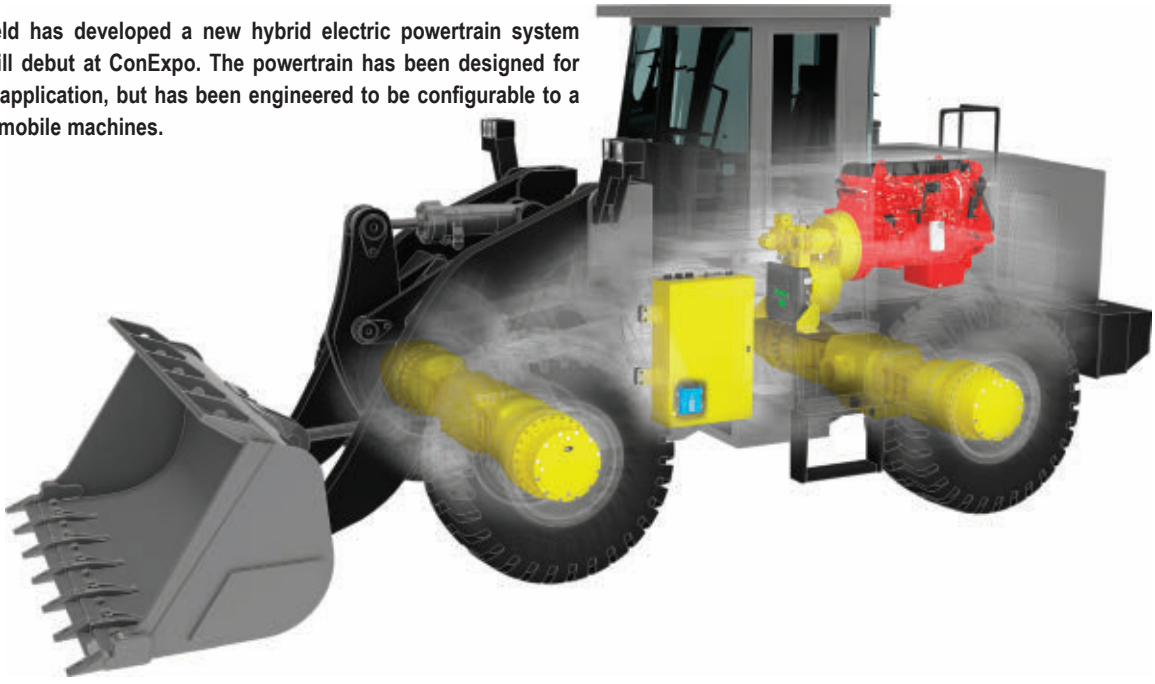
See It @ CONEXPO-CON/AGG 2014

Oerlikon Fairfield has developed a new hybrid electric powertrain system concept that will debut at ConExpo. The powertrain has been designed for a wheel loader application, but has been engineered to be configurable to a broad range of mobile machines.



PROPOSING A POWERTRAIN OF THE FUTURE

Oerlikon Fairfield unveiling complete hybrid electric powertrain system for off-highway applications at ConExpo-Con/Agg

BY MIKE BREZONICK

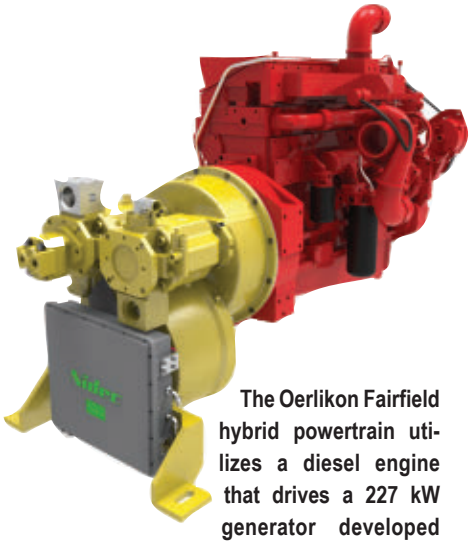
Like literally all of the hundreds of construction industry suppliers participating in ConExpo-Con/Agg 2014, Oerlikon Fairfield will be displaying some of its newest and most innovative products, such as the latest generations of its TorqueHub planetary driveline, its RHD260 roadheader gearbox (see September 2013 *Diesel Progress*), its TorqueLock spring apply/hydraulic release brakes and its custom gear systems.

Yet the highlight of the company's exhibit is nothing less than a look at one potential future for mobile powertrain technology.

At its stand in Las Vegas, Oerlikon Fairfield will unveil a prototype of a new diesel-electric series hybrid system for mobile equipment applications. While initially configured for a 30-ton wheel loader, the patent-pending system has been engineered to be highly modular and adaptable to a broad scope of construction, mining or agricultural applications, the company said.

Hybrid electric systems in and of themselves are not new, having been used for some time in applications such as mining — the largest capacity haul trucks have been diesel-electric hybrids for decades — rail engines and marine propulsion systems. On the on-highway side, hybrids are found in a growing number of regional over-the-road trucking applications and have fulfilled a significant niche in utility trucks.

Over the last several years, hybrids



The Oerlikon Fairfield hybrid powertrain utilizes a diesel engine that drives a 227 kW generator developed in partnership with Nidec. The generator is driven via a 3.3:1 step-up gear set that is coupled to the diesel engine with a torsional isolator.

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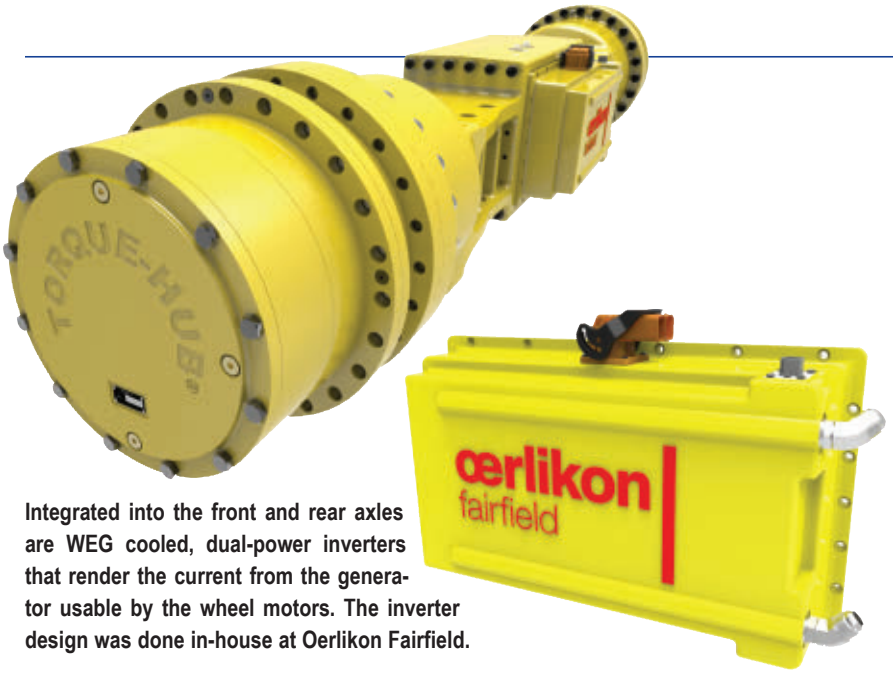

Integrated into the front and rear axles are WEG cooled, dual-power inverters that render the current from the generator usable by the wheel motors. The inverter design was done in-house at Oerlikon Fairfield.

have begun to make inroads into mainstream nonroad machinery markets, as several equipment manufacturers in the U.S. and elsewhere have launched hybrid loaders and excavators. So the timing might indeed be favorable for Oerlikon Fairfield.

"There are some real potential advantages to hybrid technology," said Dan Phebus, head of the Business Unit – Americas at Oerlikon Fairfield. "It can give operators more comfort and better control and it can provide longer periods between overhauls. For the OEM, it may provide a simpler configuration, where they don't have to be tied to a mechanical driveline in the center of the machine.

"Initially, we are targeting large-end wheel loaders because the return on investment would be much sooner for a production machine that operates 3000 to 5000 hours a year, rather than a contractor or rental machine that may only operate less than a thousand hours a year."

The Oerlikon Fairfield hybrid system incorporates a number of primary components, several of which were either engineered by Oerlikon Fairfield or were developed by suppliers with significant design input from the company. Driven off the engine — in the system on display at ConExpo, a Cummins 12 L diesel — is an electric 227 kW generator developed in partnership with Nidec. The generator, which can act as a starter motor — thus eliminating the need for a starter — is driven via a 3.3:1 step-up gear set that is coupled to the diesel engine with a torsional isolator.

"The generator is a switched reluctance design," said Vern Caron, electrical vehicle engineer at Oerlikon Fairfield. "We looked at different options, from induction ac to permanent magnet and really focused on this particular technology due to its broad constant power region that provides very good performance over a very wide speed range. It's consistent with what is used today, for example, in very large electric wheel loaders or electric dozers or other off-highway equipment.

"The construction of the motor is very scalable, which allows us to vary the torque as required for the application. This lends itself to flexibility so we can take it from application to application without significant reinvestment in fixed tooling to produce a new motor."

The generator also supports accessory drives to power hydraulic pumps used to drive the loader's auxiliary hydraulic systems. "On the generator drive, there can be no pump pads, one pump pad, or two or three pads — whatever the OEM vehicle might require," Phebus said.

The generator incorporates gearing that enables it and the hydraulic pumps to operate at their required speed, while keeping the engine within a narrow operating range, Caron added.

"We gear up the generator so it runs about three and a half times the crankshaft speed," Caron said. "We also gear up the hydraulic pumps so they can run near their best operating point. Basically, we really want to run this engine at a fixed speed, the best BSFC (brake specific fuel consumption) operating point."

The generator provides the energy to power four geared-traction motor drives at each wheel end. The motors are rated 65 kW peak output (45 kW continuous) and generate a peak output torque of approximately 704 lb.ft.

"We have a fairly high gear ratio which allows for high motor speeds and good performance over a wide ground speed range," Phebus said. "In comparison with a single-drive motor, this design allows us to do

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One of the more unique aspects of the Oerlikon Fairfield hybrid system is that it uses ultracapacitors to store energy developed by the generator and/or recovered through regeneration, rather than a bank of batteries.

The hybrid vehicle control unit and control logic for the Oerlikon Fairfield hybrid system is supplied by U.K.-based Vocis, which is controlled by Oerlikon Graziano, a sister company to Oerlikon Fairfield.

torque vectoring and traction control, reducing tire wear and giving us more flexibility from platform to platform."

Integrated into the front and rear axles are WEG cooled, dual-power inverters that render the current from the generator usable by the wheel motors. "It was not convenient to take an off-the-shelf inverter and adapt it for the drive wheels," Phebus said. "We talked to several inverter companies and we ended up using software from the electrical machine provider but the inverter design itself was something that we did in-house.

"We were able to package dual inverters strategically between the wheels in the space normally occupied by a differential. This close proximity to the traction motors allows most of the cabling to be kept securely within the axle housing and allows the existing machine's attachment points to be used with the electric driveline. It makes for a nice tidy package, using the space available where the mechanical drive system used to be so there are no loose wires or high-voltage connections exposed on the vehicle."

One of the more unique aspects of the Oerlikon Fairfield hybrid system concerns how it stores energy developed by the generator and/or recovered through regeneration. Rather than relying on lithium-ion batteries — which most on-highway hybrid systems use — this system instead incorporates a bank of ultracapacitors.

"Keeping batteries happy can be difficult," Caron said. "They don't like to work over a wide temperature range, they don't like to do a lot of cycles and it can be quite tricky to know the state of charge of the battery pack, especially if it's lithium ion.

"We looked at ultracapacitors because they can handle a lot of cycles. They also accept energy quickly and deliver it back into the system quickly. With excess energy in the ultracapacitor bank, you can put out more power than the engine is putting out and use that to raise the bucket at the same time you're accelerating the vehicle. This improves productivity and reduces fuel consumption."

Depending on the duty cycle, the fuel economy improvement could be between 20 and 30%, Caron said. And with a storage capacity of approximately 1400 kJ, ultracapacitors also negate the need for an alternator as they can deliver energy for engine starting and can be used to charge the vehicle's standard battery system.

"The ultracapacitor bank also offers the potential to add engine stop/start," Caron said. "If the machine was spending substantial time idling, it would shut down and the high-torque generator would seamlessly restart the engine."

The ultracapacitors are packaged with a dc/dc converter, high-voltage junction box and the final major segment of the system, the hybrid vehicle control unit. The hardware and control logic is supplied by U.K.-based Vocis, which is controlled by Oerlikon Graziano, a sister company to Oerlikon Fairfield.

"Vocis provides the control unit and software that communicates with the electronic control unit on the engine and interprets the operator's commands to make the machine perform as expected when he moves the joystick or steps on the brake pedal," Phebus said. "It also allows for additional features such as idle reduction, which allows us to stop the engine and conserve fuel if the machine is idling for too long. The hybrid control unit can provide precise inching, because the ground speed of the vehicle is independent of the engine speed."

After the system technology debuts at ConExpo, Phebus said the company plans show it again later in the year at bauma China 2014 on a demonstrator machine.

"We fully anticipate our initial production applications to be outside the scope of our wheel loader demonstration vehicle," Phebus said. "If the first production application were an agricultural machine rather than a construction machine, we wouldn't be surprised at all.

"One of the big advantages in an electric driven agricultural platform is the high number of auxiliary drives. On current agricultural platforms, the auxiliary drives may be mechanical or hydraulic, and not all of those systems are reliable or fuel-efficient. If they utilized electrical drives throughout the machine, having an electric driveline may be secondary to the real advantage of the system overall. For example, an electrified harvesting machine could provide significant savings related to the driveline and more on everything else on the machine."

Depending on test results done on the demonstrator machine and other market factors, production of the system could begin in late 2016, Phebus said.

"Some OEMs have developed similar drivelines in-house, but not necessarily with all of the technologies we are developing," Phebus said. "OEMs can rely on Oerlikon Fairfield to provide a complete driveline system, allowing them to expand on current technology and speed their time to market." dp

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