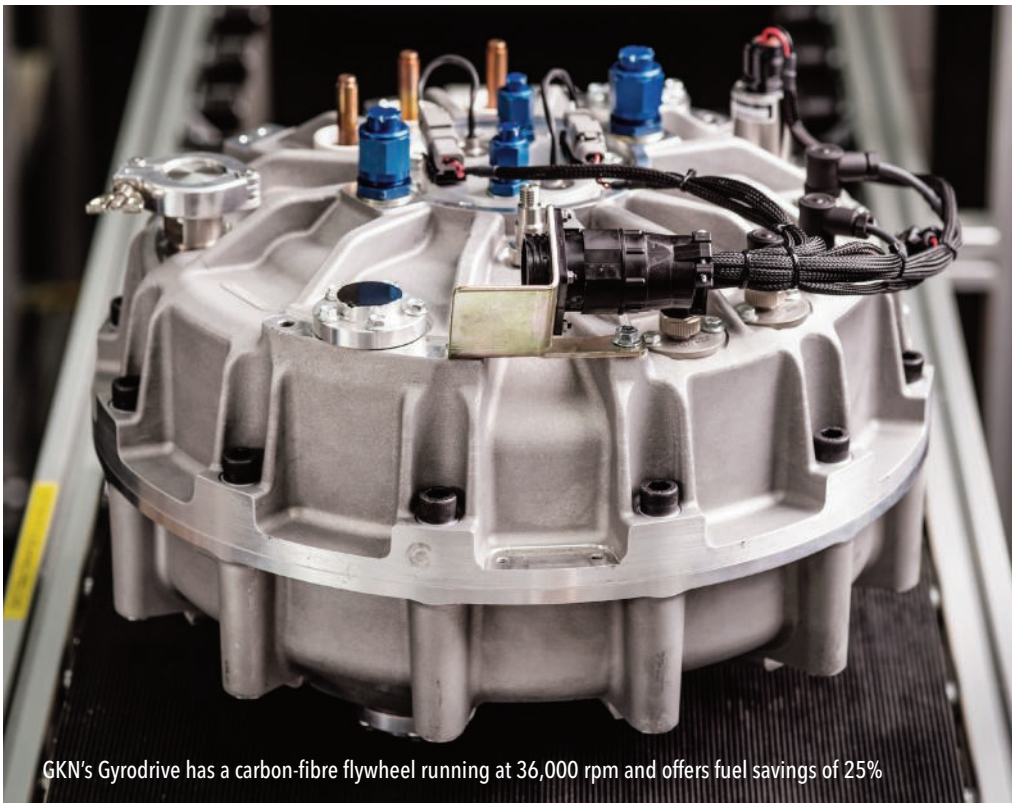
SMARTER ENGINES

Hybrid powertrains are now common in cars, and the technology is creeping into vans, light trucks and PSVs. Toby Clark examines the ranges of systems, and their implications



GKN's Gyrodrive has a carbon-fibre flywheel running at 36,000 rpm and offers fuel savings of 25%

There is a wide spectrum of hybrid systems, using different types of energy storage, traction motor and controls. All have an internal combustion engine as the primary power source, electric batteries or other systems to store and release energy and a supplementary drive. Most are 'parallel hybrids', which use the ICE and other sources together, with a control system to balance them. But whatever the structure, the effect should be improved fuel efficiency and often better performance and driveability.

For Luca Zai, chief engineer at Ricardo's hybrid and electronic systems product group, take-up is about whether they can hit a payback target. "If calibrated for a specific mission, then yes. This is particularly true in the case of city buses or refuse trucks where they have high stop density and a predictable route."

HYBRID VARIETY

The simplest systems are 'microhybrids' – such as used in the Citroen Berlingo e-HDi van – which combine a stop-start function with regenerative braking. A reversible starter-alternator harvests kinetic energy as the vehicle slows. This is stored briefly in a capacitor and used to start the vehicle again. Citroen claims this reduces fuel consumption by 15%.

The other extreme of hybrid is demonstrated by US firm Oshkosh, with its ProPulse military truck, an off-road-capable 8x8 'series hybrid', with no connection between the ICE and the final drive. Electric motors on each axle are powered by a diesel generator via a bank of ultra-capacitors.

In the middle are 'mild hybrids', which again use a combined starter-alternator but have more substantial energy storage and traction systems that can contribute to acceleration. The energy storage can take the form of batteries, capacitors or a kinetic energy recovery system (KERS). The latter flywheel-based systems have been used in buses: GKN's Gyrodrive, for example, with a carbon-fibre flywheel running at 36,000 rpm, has resulted in fuel savings of 25%, and the firm claims the payback period for bus operators is three to four years. It adds that the system is smaller than battery or super-capacitor units.

UK firms are at the forefront of kinetic battery technology: Torotrak has the Flybrid, while Ricardo's TorqStor is proposed for use in off-highway trucks. The TorqStor's flywheel is mounted in a chamber having a permanent vacuum (rivals use vacuum pumps), with the drive transferred via a magnetic coupling. Zai points out, however, that

flywheel technology is not suitable for pick up and delivery, "because the energy decay is too much".

Further 'mild hybrid' advantages are possible if the vehicle uses 48V electrical architecture. Taylor Hansen, vice president of CPT, says: "Compared with 200–600V full hybrid and battery-electric vehicles, the low-voltage approach avoids the need for high-cost safety features and large battery packs."

And Zai adds that, for vehicles up to 5 tonnes gvw, benefits include "engine downsizing; filling the 'torque hole' during initial acceleration with the motor/generator and supercharger; and electrification of ancillaries, such as the oil and water pumps". This is 'intelligent electrification' or 'smart hybridisation'.

Meanwhile, electrically-driven superchargers, such as CPT's COBRA, can benefit heavier vehicles, too. Air is delivered rapidly to the ICE, improving combustion in transient conditions and at low speeds. It also increases fuel economy, reduces the need for exhaust after-treatment and allows downsizing.

That said, battery technology is key to the future of general purpose 'full hybrids'. Lithium-ion (Li-ion) or Lithium-Polymer (LiPo) batteries currently yield an energy density up to 240Wh/kg – and some claim up to 800Wh/kg. "Li-ion chemistry will be the mainstream for years to come," comments Zai. Certainly, it is the most weight efficient,

CPT's COBRA can benefit heavier vehicles, too

but other chemistries based on lithium and sodium are waiting in the wings.

Indeed, lithium-sulphur (LiS) batteries could be next in line, with an energy density of 500Wh/kg, and a life of more than 1,500 charging cycles. Lithium-air batteries theoretically offer energy densities as high as 12,000Wh/kg – similar to petrol – but are perhaps 20 years from commercial application.

Older designs of hybrid vehicles tend to use nickel metal hydride (NiMH) traction batteries, which do not have the energy density of Li-ion but are stable and reliable: reportedly, just 0.003% of Toyota Prius batteries have failed. But recently, BASF demonstrated NiMH batteries with a capacity of 140Wh/kg, and is aiming for half the cost of Li-ion.

Meantime, the lead-acid battery still has a future: in hybrids and EVs, it is generally used for SLI (starting, lighting and ignition), and is being developed further with lead-carbon chemistry. But for 48V mild hybrid an 'Ultrabattery' has been tested. This has a super-capacitor in the negative plate itself, improving service life by keeping the battery in the optimum state of charge during the frequent charge/discharge cycles of regenerative braking and starting.

What about electric motors? Well design is moving quickly here, too. While traction motors use powerful permanent magnets incorporating rare-earth metals, switched reluctance (SR) motors avoid them. Instead, a steel rotor is attracted to electromagnet stators, switched by the motor controller. These units offer good power density, and both Ricardo and CPT have demonstrated SR motor-generators for 48V mild-hybrid applications. GKN's EVO motor is a similarly compact 'axial flux' permanent magnet design, used in the firm's two-speed eAxle and as a starter-generator.

Whatever the architecture, a hybrid must be properly specified. "At the end of the day, it's down to the specific calibration," advises Zai. But he says reliability is not a concern: "Systems have been certified by OEMs or Tier 1 suppliers… The reliability of components, such as power electronics, is high. But control software and energy management are key." TE

Potter Logistics' Canter eco-Hybrids

Potter Logistics has been using a pair of Mitsubishi Canter eco-Hybrid trucks for 18 months. These 7.5-tonne gvw curtainsiders operate on collections and deliveries for the Palletline network.

"There have been no issues at all," says fleet manager Colin Bamford. "When we first bought them, we heard a few scare stories, but they've been fine."

The trucks do around 10 stops a day – not a high stop density – but Bamford is pleased with their economy. "Fuel consumption was predicted at about 17–18 mpg, and it's doing it."

The Canter has a 150bhp Euro 6 diesel with a six-speed automated transmission, a 40kW electric motor-generator and a 270V, 2kWh Li-ion battery pack. There is no load space penalty and, even with a tail-lift, payload is 3.2 tonnes.

The trucks are no more difficult to service than conventional vehicles, states Bamford. Staff had some training at Northside Mercedes, but the fluids and lubricants are all standard spec. There have been no issues with low temperatures either.