Electric vehicles shift gear

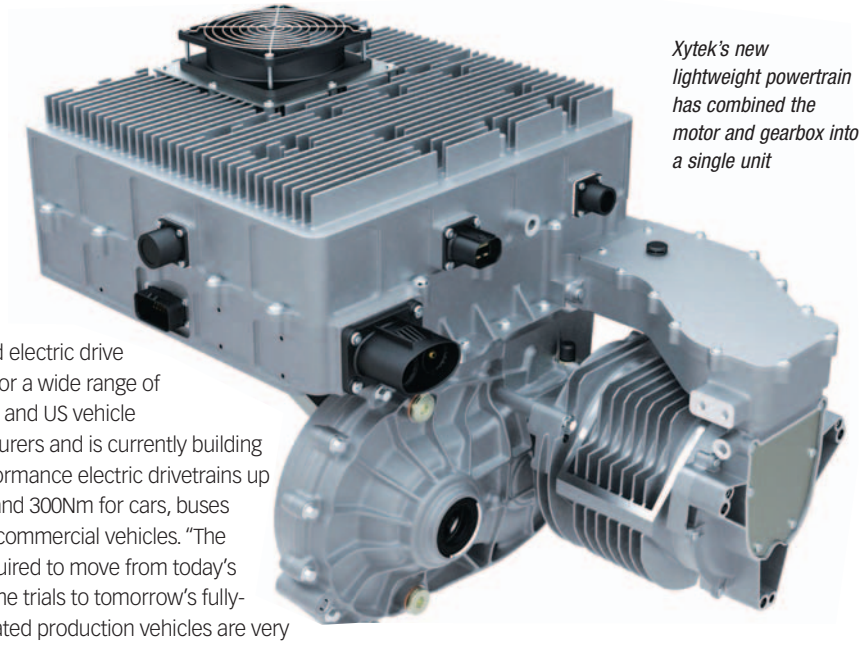
Changes to the transmission systems of electric vehicles could have a significant impact on the commercial viability of electric vehicles, as *Eureka* discovers.

For all the research and development currently devoted to them at the moment, it seems fair to say that electric vehicles still have a long way to go before they become a widely-accepted, mainstream technology.

Range anxiety caused by short battery life, high vehicle costs and a lack of charging infrastructure are the major factors holding the technology back. Thus, in the short term, the most likely niche market for electric vehicles is as second cars, but research nonetheless continues apace.

Battery life and cost are the main obstacles at the moment. As Neil Cheeseman, engineering programme manager for automotive engineering specialist Zytek, puts it: "A typical fuel light on an internal combustion engine (ICE) vehicle comes on with 70 miles to go. A typical electric vehicle starts with 70 miles to go. That's not a good starting point for people who are used to ICE vehicles." While he makes it clear that battery costs and sizes have to improve, he also acknowledges that changes to the powertrain of electric vehicles are necessary to bring down vehicle weight to reduce power consumption and thereby close the gap.

Zytek has designed and integrated electric drive systems for a wide range of European and US vehicle manufacturers and is currently building high performance electric drivetrains up to 70kW and 300Nm for cars, buses and light commercial vehicles. "The steps required to move from today's low-volume trials to tomorrow's fully-homologated production vehicles are very substantial and must not be under estimated," says Zytek Automotive managing director Neil Heslington. "Everything has to be re-evaluated, from development processes to dealer training.



Xytek's new lightweight powertrain has combined the motor and gearbox into a single unit

This new powertrain, combined with our substantial experience of EV and hybrid vehicle production programmes, will take time and cost out of this activity while helping to deliver the quality, refinement and driving experience that discerning customers demand."

The turnkey package Zytek has developed is extremely compact and in air-cooled configuration is up to 45% lighter than today's production EV powertrains. Even the water cooled version, suitable for demanding drive cycles, is up to 30% lighter. Available in sizes from 25kW, the highly integrated modular system can be configured for a wide range of vehicle sizes, applications and architectures. The high maximum machine speed of 14,000 rpm has enabled generated torque and hence machine size to be reduced considerably, bringing further reductions in cost and weight.

One of Zytek's key innovations in driving down the size and weight of the powertrain has been by building the motor and gearbox as a single unit. The benefits of this are clear, as Neil Cheeseman points out: "A typical transverse IC engine gearbox width is about 950mm, is driven by four cylinders

in a row and then a gear cluster on the end of that. The total width of ours is approximately 300mm. So you're looking at a powertrain that is less than a third of the size. This has only been possible because we've put those two items together. So at less than a third of the size, you've got major weight benefits as well."

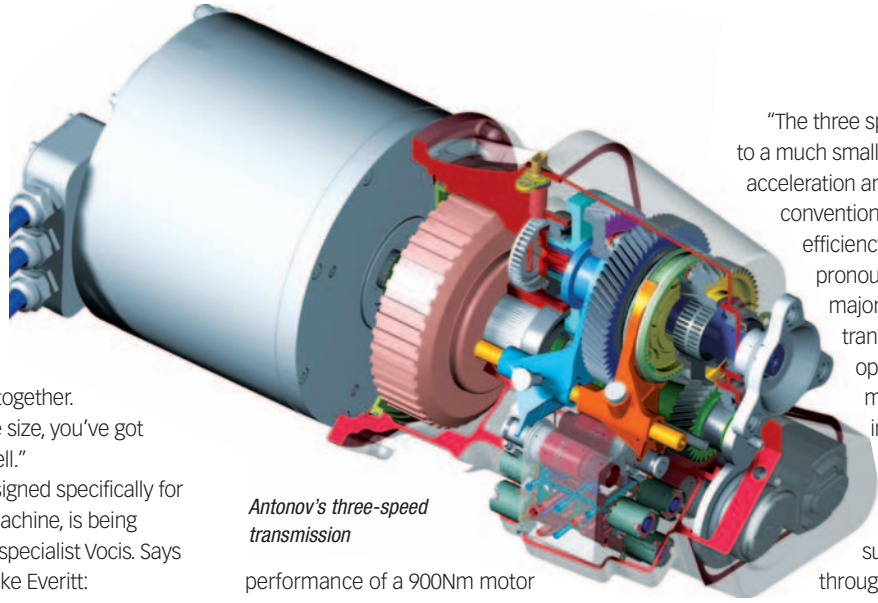
A new transmission, designed specifically for use with the new electric machine, is being developed by transmission specialist Vocis. Says Vocis' managing director Mike Everitt: "Transmission weight is only 10kg, which we have achieved without any compromise in performance."

Because Zytek has increased the speed of the machine to 14,000rpm for the same wheel torque (a figure imposed by off-the-shelf component availability rather than a machine limit), it has been possible to de-rate the torque rating of the machine. Says Cheeseman: "If you want 1000Nm of wheel torque with a 10:1 gear ratio, you'll need 100Nm of motor torque. If you want 1000Nm at a 14:1 gear ratio, you'll need less torque – around 65Nm. Torque in an electric motor is produced by magnets and copper and steel – all of which are expensive components. By increasing the speed, you drive down the number of expensive components in your powertrain."

For use on smaller vehicles, Zytek has opted for a single-ratio gearbox. Says Cheeseman: "There are some arguments for a two and three speed gearbox. But I think if you're designing these two items from scratch, the case for a single ratio gearbox is pretty strong. When you go up in vehicle size, then maybe there's an argument for a two-speed gearbox, but certainly with something this small, with an aggressive pressure on cost, a single speed gearbox is the way to go."

Now that electric drives are once again becoming popular in motor vehicles, there is considerable argument as to whether to have wheel motors or single motors with transmission systems, whether motors should be equipped with gearboxes, and whether people should be going for permanent magnet or induction motors.

There is some debate, however, about whether a transmission is necessary at all. One company that continues to believe in gearboxes is Antonov. "A three speed transmission coupled to a 400Nm electric motor can easily match the performance of a 900Nm motor with no transmission", according to Simon Roberts, the company's chief commercial officer. "The latter is like putting a V8 engine in a dragster; it delivers so much power and torque that you can throw away the gearbox, but it's not very fuel efficient. That's why the automotive industry trend is to downsize the engine and match it to an efficient transmission and driveline. And it's the same principle for traction motors, though in practice not yet generally applied. Smaller and lighter electrical machines use less aluminium, copper and steel. They also require smaller batteries and reduce the need for highly rated power electronics. So the same virtues of downsizing apply to electrical machines."



Antonov's three-speed transmission

In consequence, the company has been awarded a project by the UK's Technology Strategy Board to design and develop a three speed power shift transmission suitable for hybrid vehicles, which will initially feature in Jaguar's Limo-Green electric vehicle research project.

"The three speed transmission can be coupled to a much smaller electric motor, yet deliver acceleration and top speed comparable to a conventional power train," says Roberts. "The efficiency of an electric motor is far more pronounced than the torque curve, so the major benefit of a multispeed transmission is to keep the motor operating as close as possible to its most efficient speed, which will increase vehicle range."

However, there is no gearbox in the Mini E car, as the torque provided by the electric motor is sufficient without multiplication through a transmission, but there is a conventional reverse-neutral-drive shifter on the floor. The car is powered by a single 150kW four pole AC induction motor with inverter controlled magnetic flux, designed by Californian company AC Propulsion. It can accelerate from 0 to 100km/h in 8.5s acceleration. Pressing the accelerator speeds the car, while lifting the pedal applies regenerative braking. The range is said to be about 100 to 120 miles. The only problem with the concept is that the car weighs 1465kg, which includes 300kg of lithium ion batteries, which occupy the space where the rear seats would normally go.

While the economics of the car are excellent in terms of the cost of the power consumed, the cost of the 300kg of lithium ion batteries required to store the 28 kWh would be substantial in the present design.

www.zytekgroup.co.uk
www.antonovplc.com
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