End of the line

Are wheel end-mounted motors the future of electric commercial vehicles, asks Steve Banner

Deciding how big the battery pack should be and where it should be installed is not the only challenge electric vehicle designers face. Determining whether one or more electric motors should be fitted and where they should be located represents a further conundrum.

The same question has to be addressed by businesses developing commercial vehicles powered by fuel cells.

Based on the MIRA Technology Park, Innervated Vehicle Engineering (IVe) is busy working on a concept 3.5-tonne fuel cell van called IndiGo. Says chief executive officer, Ram Gokal: "We're looking at building a version that will use electric hub motors and trialling it for six months to see what benefits they bring."

Hub motors fitted to each of the back wheels have a number of potential advantages, he believes. For example, the ability to run them at different speeds enables rear- as well as front-wheel steering, creating a tight turning circle – a useful attribute if you happen to be on last-mile delivery work in narrow urban streets. "They can also be used to help resist side winds so that the van is always tracking straight and true," he contends.

If the driver is heading down the motorway for several miles, then it might be possible to switch one of the motors off, thereby saving power, especially if the vehicle is lightly laden.

Much depends on the type of hub motor that is installed. IVe had planned to employ axial-flux motors, but the supplier it had in mind was taken over by a major vehicle manufacturer that clearly wanted to employ the technology in its own products.

With an axial-flux motor, the gap between the stator and the rotor and the direction of the magnetic flux between them is aligned in parallel with the axis of rotation. "You get a better torque curve, especially at low speeds," Gokal says.

Across the pond, embattled US start-up Lordstown Motors Corporation is predicting that its Endurance double-cab pick-up will become the first electric light commercial with a hub motor in each wheel to go into volume production, hopefully later this year. Abandoning the use of drive shafts and universal joints as well as the engine and gearbox equals reduced weight, says the Ohio manufacturer, and hub motors offer a low centre of gravity as well as increased stability. Its hub motors come from Elaphe of Slovenia, pictured above.

INSTALLED BASE

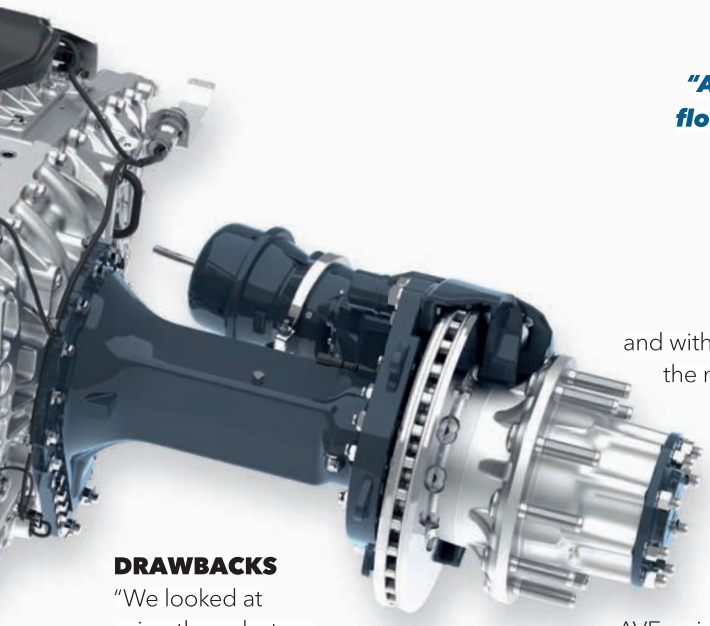
Hub motors are already in service in city buses, thanks to ZF's development of the AxTrax AVE electric portal axle (pictured, lower right) as an alternative to its CeTrax electric central drive.

Its pair of liquid-cooled asynchronous motors have a combined output of 250kW, and the axle has a capacity of up to 13 tonnes. Fitting hub motors to a bus means a lower floor height can be created, which makes access easier for passengers. It also means the floor can be kept flat, which makes it simpler to lay out the seats.

Indeed, the flexibility such motors offer allows designers plenty of scope to position items such as battery packs without having to worry that drivetrain components will get in the way. They can also be used to conjure up front-, rear, or four-wheel-drive configurations.

AxTrax AVE customers include Switch Mobility – formerly known as Optare – which has installed it in its Metrodecker EV double-decker.

Hub motors have their drawbacks, though, says Duncan Forrester, chief communications officer at Volta Trucks.



"A crucial point [about the Allison eGen series] is that the energy flow is not forced through a change of direction at any point. You lose efficiency every time you change direction"

Alexander Schey

DRAWBACKS

"We looked at using them, but we concluded that you're increasing your chances of something going wrong if you fit multiple motors," he observes. "They add a significant amount of complication to a vehicle that has to be durable above all else."

Their location also means that they risk becoming covered in road dirt, with all the implications that has for reliability and maintenance costs. "Difficulties in sealing them properly mean it has been a struggle to get them to last for more than 150,000 miles," reckons one automotive engineer.

To these concerns can be added another issue that can sometimes arise: coping with a rise in un-sprung mass, the mass of all the components on a chassis that are not supported by the suspension. Hub motors fall into this category because they typically sit below a vehicle's springs, making it harder to minimise noise, vibration and harshness.

They create further challenges when it comes to packaging braking systems, although at 165mm long and with a diameter of 300mm, the motors fitted to AxTrax AVE are compact. It should also be noted that hub motors can in effect act as retarders, delivering regenerative braking as the driver slows.

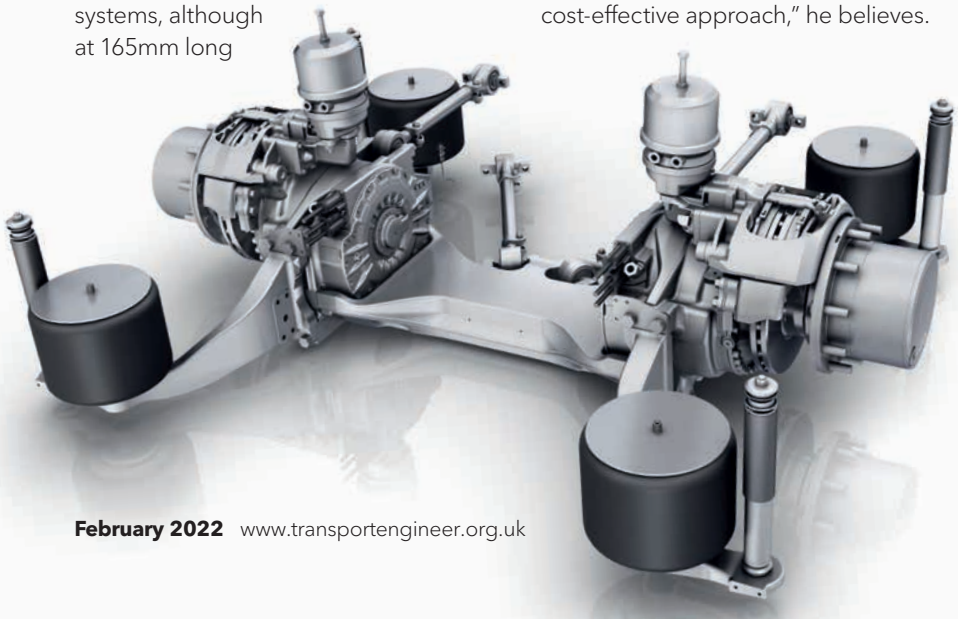
Furthermore, AxTrax AVE weighs 1,220kg, including the motors; around 500kg less than some more-conventionally engineered axles with a centrally positioned electric motor.

In response, hub motor critics point to two other drawbacks: the risk that they might be stolen, and the cost and weight of a spare wheel with a motor mounted inside it.

SMALL TORQUE

A key difficulty with hub motors is that they have to be massive in order to generate the amount of power and torque required to propel a fully laden heavy truck, says Chris Baillie, e-Axle engineering director at Allison Transmission. If you are designing a tri-axle rigid chassis, for instance, then you will require a motor for each wheel; and that spells extra cost and complexity.

Instead, Allison has developed the eGen Power series of electric axles (pictured above is the 100D model) which feature an integrated two-speed transmission optimised to enable a high torque launch, says Baillie. "It's a more cost-effective approach," he believes.



Customers include Cumnock, East Ayrshire fire appliance manufacturer Emergency One. It wants its products to be able to accelerate rapidly in an emergency as well as offer a reduced carbon footprint.

The line-up being rolled out by Allison includes the dual-motor 130D, which is rated at up to 13 tonnes and could be used in chassis grossing at 44 tonnes. Sitting in the axle's upper left and right corners, its twin motors deliver a total of 487kW and a combined peak power of 652kW. A gear on the front of each motor connects to a central gear that is on the same axis as the axle. The central gear transfers power through the optimal of two gear paths, and is then mated to a differential from which drive shafts go out to the wheels on either side, as with a conventional truck axle.

The axles also remove a potential point of failure by eliminating the traditional hypoid gear, he contends. They use up to 9% less energy than a hypoid, right-angled drive set-up, and offer more than 90% efficiency across a wide speed range.

Says Alexander Schey, Allison's managing director, electrification: "A crucial point is that the energy flow is not forced through a change of direction at any point. You lose efficiency every time you change direction.

"That lost energy could be better used in improving the vehicle's range. Eliminating the hypoid gear also removes a potential source of failure because of the high regenerative braking loads that would go through a relatively small gear," Schey adds.

No weight penalty is imposed by eGen Power. The most powerful variant tips the scales at less than a tonne fully dressed, says Baillie.

Torque is not in short supply; the 130D can produce over 47,000Nm. "It would be hard for hub motors to try to get to this figure," he comments, no matter how hard they tried. TE