Digital displacement cuts **energy use**

RSSB-funded research into hydraulic energy storage has demonstrated a potentially cost-effective way of reducing diesel fuel consumption and cutting exhaust emissions by up to 30%.

The converted DVT has been tested on the Bo'ness & Kinneil Railway in Scotland.

A new design of hydraulic transmission intended to improve the acceleration of diesel multiple-units and reduce fuel consumption has been successfully demonstrated in Scotland under an 18-month programme led by technology firm Artemis Intelligent Power.

The £1·7m project was part-funded by the UK Rail Safety & Standards Board through its 'Powertrain' competition. It has brought together partners including Artemis, Chiltern Railways, JCB, Centa Transmissions and Hydac to retrofit a hydrostatic transmission to a Mk III driving van trailer loaned by Chiltern Railways. This 33 tonne vehicle had similar mass and overall dimensions to a standard DMU car.

According to Artemis project manager Gordon Voller, 'most existing diesel railcars use engines which do not meet the latest emissions regulations and transmissions that are inefficient, especially at low speeds. Rail vehicles are very long-lived assets and the emissions regulation rules allow the continued use of diesel engines with a very poor environmental footprint. Our technology tackles this head on.'

Whilst electrification is helping to decarbonise the UK's rail sector, the high capital cost means that much of the rural rail network is expected to rely on diesel traction for some time. Despite the current wiring programme in central Scotland, less than 25% of the country's 2 776 route-km has yet been electrified, for example. Hence the interest in improving the efficiency of diesel.

Artemis believes its technology offers a cost-effective route to reduce diesel exhaust emissions significantly without recourse to public subsidy.

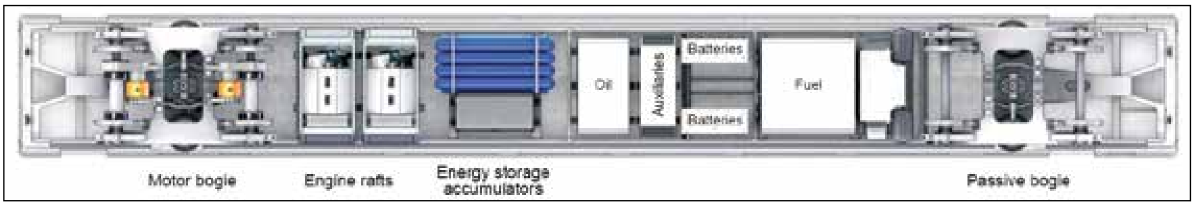
Paving the way for the project, Artemis and ScotRail began by instrumenting a DMU vehicle in order to collect performance data across a range of route profiles and conditions. Voller says 'we discovered that on a standard commuter route, between 65% and 73% of a train's energy was being lost through braking and transmission inefficiencies. More than half of the energy was dissipated as heat and wear in the brakes and nearly one fifth in the transmission.'

Mechatronic controls

Known as Digital Displacement, the Artemis hydrostatic transmission is based around an innovative radial-piston pump/motor, in which ultra-fast mechatronic valves controlled by an embedded computer are used to enable and disable cylinders in real time. The digital controls mean that an Artemis motor can be extremely efficient, as the individual cylinders are only called into action when required.

The demonstrator vehicle is fitted with two hydraulic pumps powered by off-the-shelf industrial diesel engines mounted in underfloor engine rafts. These in turn drive two hydraulic motors on one bogie which are connected to the axles by a final drive. Instead of a mechanical drive shaft and gearboxes, flexible hydraulic lines connect the main pumps to the motors.

Fig 1. All of the traction equipment is mounted under the floor of the former driving trailer vehicle.



Artemis says this hydrostatic drive helps to reduce energy losses between the engine and wheels. Meanwhile, the infinitely-variable 'gear ratio' allows the engine to operate at maximum fuel efficiency at all times.

However, Voller points out that 'energy recovery and re-use was one of the key objectives for the Powertrain project'. The test vehicle has been fitted with a bank of high-pressure accumulators coupled to the hydraulic circuit, which can be used to capture regenerated braking energy. The diesel engines can be throttled back or turned off as the train approaches a station, and the primary deceleration is achieved by reversing the drive motors to act as hydraulic pumps. This feeds energy back into the drive line which can be captured and stored for reuse and for acceleration from stations.

Using the stored energy as an additional power source allows for faster acceleration, and Artemis estimates that the system offers the potential to improve the performance of diesel vehicles to match the acceleration of electric multiple-units. This offers the prospect of shorter journey times. Voller also points out that 'the recovery of braking energy brings additional benefits, such as the capacity to switch off diesel units in stations and reduce urban emissions.'

The energy storage capability and infinitely-controllable transmission also mean that the system can operate with smaller diesel engines than would normally be required for such duties. The modified DVT is powered by two standard JCB ecoMAX engines rated at 129 kW, compared to around 300 kW for a typical DMU application.

Development and testing

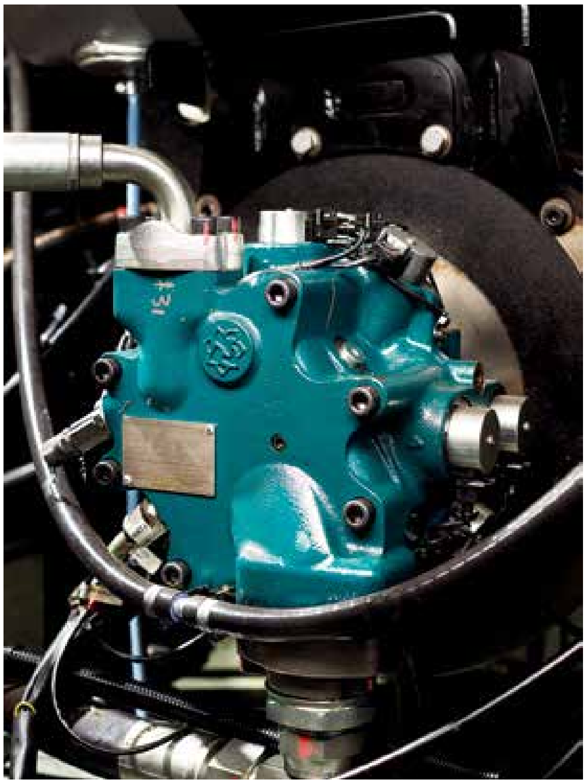
The development and testing work was undertaken on the Bo'ness & Kinneil Railway in central Scotland, which includes a steeply graded section on which to put the vehicle through its paces. Voller says the extensive test programme 'enabled us to prove the reliability of our technology in a working demonstrator. The initial results were in line with our modelling.' These suggest that fuel savings of more than 30% are obtainable.

Following the successful completion of the test programme, an industry demonstration day was held in October last year at which the project partners were able to showcase the demonstrator's capabilities.

Testing of the Digital Displacement transmission on other transport modes with heavy-duty drive cycles, such as buses and delivery vehicles, demonstrated fuel savings of between 20% and 30%. In addition, Artemis has worked with ScotRail to trial Digital Displacement pumps in the auxiliary drive of a Class 170 Turbostar DMU in revenue service, which also demonstrated significant fuel economies.

Following the successful completion of the RSSB powertrain project, Artemis is keen to explore options to commercialise its transmission technology for rail applications. ■

For more information about the project, please contact Gordon Voller at g.voller@artemisip.com.



Top right: The Artemis radial pump/motor uses mechatronic control of individual cylinders.

Right: An extra screen in the cab (right) allows the driver to monitor the traction system.

Below: The hydraulic motors power both axles on one bogie.