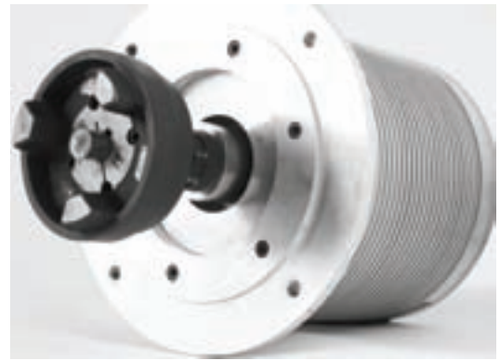
New drive system takes gears out **of the equation**

Dr Richard Clark of Magnomatics explains how his company's patented Pseudo Direct Drive is a completely new take on the direct drive motor that enables dramatic reductions in motor frame size and/or cooling requirements for a given load



The Pseudo Direct Drive (PDD) offers a significant advance over conventional motor technology, achieving a step-change in continuous torque density of up to eight times that of equivalently cooled permanent magnet machines. This dramatic increase in torque density allows the motor to directly drive many industrial and process control loads where conventionally a motor and gearbox combination would be employed.

High-torque, low-speed loads are traditionally driven by a high-speed motor, usually an induction motor operating at around 1500 or 3000rpm, in combination with a mechanical gearbox with final output speeds of 100-600rpm. While the efficiency of the motor and gearbox combination is typically in the order of 90% at full load, at lower loads the efficiency can drastically reduce.

In many applications, significant performance benefits can result from replacement of the motor and gearbox with a direct drive motor. Primarily, efficiency is improved due to the removal of gearbox losses and gear wear is eliminated, but also the removal of the need for lubrication reduces servicing requirements and the potential for contaminating oil leaks on a production line. Further benefits include prevention of failure mechanisms such as jamming and reduced levels of noise and vibration.

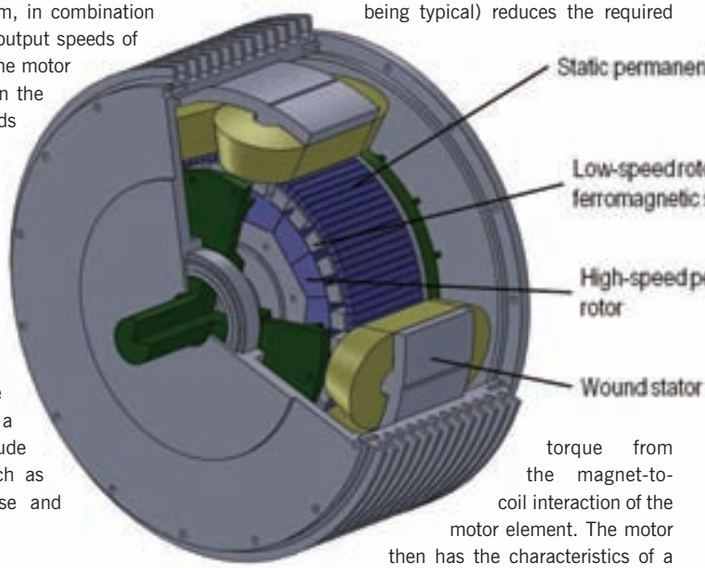
Traditional limitations

To achieve high torques at low speeds in direct drive systems, brushless permanent magnet motors are typically used due to their superior torque density and torque-speed characteristics. However, due to limits on magnetic, electrical and thermal stresses, even when employing high energy rare-earth permanent magnets, the continuous torque output per-unit-volume/mass is limited. The resulting direct-drive motor is then often prohibitively large.

Magnomatics' PDD motor overcomes the torque density limitations of conventional direct drive PM motors by exploiting a mechanically and magnetically integrated passive magnetic gear which acts as a speed-reducing, torque-increasing transmission without requiring lubrication. The resulting motor offers superior torque density allowing for drastic reductions in motor frame size for a given load while maintaining the practical advantages of a naturally cooled system.

An inner high-speed permanent magnet rotor and outer stator carrying windings act as a conventional permanent magnet brushless DC or AC motor. The rotation of the high-speed inner rotor is magnetically geared to give a high-torque, low-speed output on a second rotor.

The integral magnetic gear element exploits the very high torque capability of magnet-to-magnet interaction or coupling and is capable of bearing the high load torques. The magnetic gearing (with gear ratios of 5:1 to 15:1 being typical) reduces the required torque from the magnet-to-coil interaction of the motor element. The motor then has the characteristics of a high-speed, low-torque PM machine at the electrical terminals. The windings operate with a low current density, reducing copper losses and hence allowing very efficient operation. All of this gives the PDD a number of important benefits:



- High torque density (delivering a more compact machine for a given torque)
- High efficiency across a wide operating range
- Removes the need for a gearbox
- Very low vibration and acoustic noise
- No, or minimal, cooling required
- High power factor operation
- Uses standard off-the-shelf power electronics and/or drive technology

A totally enclosed naturally ventilated PDD machine with a rated continuous torque capability of 95Nm has been realised, with a stator stack diameter of 180mm and length 45mm. The machine has a rated output speed of 400rpm and has an efficiency of 95% at rated load, requiring no forced cooling.

The active torque density is 83Nm/m^3 and is eight-times greater than a conventional naturally ventilated permanent magnet motor of a similar size. It also offers significant weight saving with an active mass of only 8kg giving a continuous torque to weight ratio of 12 Nm/kg. A typical figure for a standard direct drive PM machine with a similar diameter and cooling would be nearer 2 Nm/kg.

The PDD allows the significant advantages of removing a gearbox – such as high reliability and reduced servicing – without incurring the mass and volume penalty of a conventional direct drive motor. It is highly scalable and is an attractive technology option where an end user is already considering moving to a variable speed drive in order to better match the drive to varying load requirements to reduce energy consumption. Typical applications include: fluid control valves; mixers and stirrers; grinders, crushers and mills; low speed drilling; material cutting and forming; extruders and injection moulding machines.

Magnetic gearing technology

Magnomatics is also developing technologies based around magnetic gearing, including passive magnetic gears with gear ratios of up to 1000:1 as well as a magnetic continuously variable transmission (CVT). The magnetic gear technology can provide a non-contact, lubricant-free, geared transmission through a membrane removing the need for dynamic seals and preventing contamination, which is particularly attractive for food, chemical and pharmaceutical industries. The magnetic gear and PDD technologies are scalable and Magnomatics is currently developing solutions with torque ratings from a few Newton-metres up to MegaNewton-metres.

More Information:

Enter R265 on the enquiry card or visit 'latest issue stories' at www.industrialtechnology.co.uk for further details from Magnomatics and more news on direct drive motors