ZF makes magnet-free electric motor uniquely compact and competitive

- Inductive current transmission unit inside the rotor enables ultra-compact e-motor design
- Performance data on par with permanent-magnet synchronous machines, currently the most common form of drive for electric vehicles
- Advantages: no magnets or rare earth materials, increased security of supply, and better sustainability and efficiency

Friedrichshafen, Germany. ZF has developed an electric motor which does not require magnets. In contrast to the magnet-free concepts of so-called separately excited synchronous motors (SESM) already available today, ZF’s I²SM (In-Rotor Inductive-Excited Synchronous Motor) transmits the energy for the magnetic field via an inductive exciter inside the rotor shaft. This makes the motor uniquely compact with maximum power and torque density.

This advanced variant of a separately excited synchronous motor is thus an alternative to permanent-magnet synchronous machines (PSM). The latter are currently the motors most frequently used in electric vehicles, but they are based on magnets which require rare earth materials for their production. With the I²SM, ZF is setting a new standard for making e-motors both extremely sustainable in production and highly powerful and efficient in operation.

“With this magnet-free e-motor without rare earth materials, we have another innovation with which we are consistently improving our electric drive portfolio to create even more sustainable, efficient and resource-saving mobility,” said Dr. Holger Klein, CEO of ZF. “This is our guiding principle for all new products. And we currently see no competitor that masters this technology as well as ZF.” Compared to common SESM systems, the inductive exciter can reduce losses for the energy transmission into the rotor by 15 percent. In addition, the CO₂ footprint in...
production, which arises with PSM e-motors in particular due to magnets including rare earth materials, can be reduced by up to 50 percent.

“This uniquely compact electric motor without magnets is impressive evidence of our strategy to make e-drives more resource-efficient and sustainable, primarily through efficiency improvements,” said Stephan von Schuckmann, Member of the Board of Management of the ZF Group.

In addition to the benefits of eliminating rare earth materials in a compact and powerful package, the I2SM eliminates the drag losses created in traditional PSM e-motors. This enables better efficiency at certain operating points such as long highway trips at high speed.

**Advanced rotor design makes e-motor very compact**

To ensure that the magnetic field in the rotor is built up by current instead of magnets, the conventional SESM concepts currently still require sliding or brush elements in most cases, which force compromises: A dry installation space, i.e. not accessible for oil cooling and with additional seals, is necessary. As a result, conventional SESMs take up around 90 mm more space axially. As a result, manufacturers generally cannot flexibly vary between PSM and SESM variants in their model planning without additional effort.

In order to offer the advantages of separately excited synchronous machines competitively, ZF has succeeded in compensating for the design-related disadvantages of common separately excited synchronous machines. In particular, the torque density has been significantly increased compared to the state of the art thanks to an innovative rotor design. The space-neutral integration of the exciter into the rotor means that there are no axial space disadvantages. In addition, an increase in power density in the rotor leads to an improvement in performance.

**Inductive excitation as a key technology**

The technological prerequisite for the ZF innovation is that energy is transferred inductively, i.e. without mechanical contact, into the rotor,
generating a magnetic field by means of coils. Thus, the I²SM does not require any brush elements or slip rings. Furthermore, there is no longer any need to keep this area dry by means of seals. As with permanently magnetized synchronous motor, the rotor is efficiently cooled by circulating oil. Compared to common separately excited synchronous motor, the ZF innovation requires up to 90 millimeters less axial installation space. In terms of power and torque density, however, the ZF innovation operates at the level of a PSM.

ZF plans to develop the I²SM technology to production maturity and offer it as an option within its own e-drive platform. Customers from the passenger car and commercial vehicle segments can then choose between a variant with 400-volt architecture or with 800-volt architecture for their respective applications. The latter relies on silicon carbide chips in the power electronics.

Caption:
World’s most compact and torque dense e-motor without magnets and rare earths: With the I²SM concept, ZF develops a sustainable and powerful alternative to common e-drives.
Picture: ZF

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About ZF

ZF is a global technology company supplying systems for passenger cars, commercial vehicles and industrial technology, enabling the next generation of mobility. ZF allows vehicles to see, think and act. In the four technology domains of Vehicle Motion Control, Integrated Safety, Automated Driving, and Electric Mobility, ZF offers comprehensive product and software solutions for established vehicle manufacturers and newly emerging transport and mobility service providers. ZF electrifies a wide range of vehicle types. With its products, the company contributes to reducing emissions, protecting the climate and enhancing safe mobility.

With some 165,000 employees worldwide, ZF reported sales of €43.8 billion in fiscal 2022. The company operates 168 production locations in 32 countries.

For further press information and photos, please visit: www.zf.com