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FRAUNHOFER INSTITUTE FOR PHYSICAL MEASUREMENT TECHNIQUES IPM

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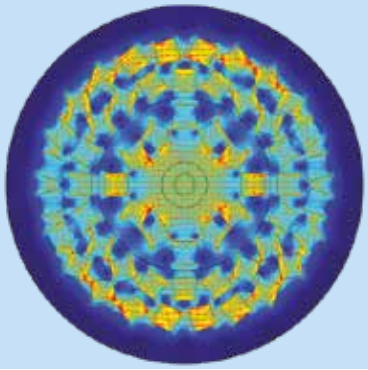

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1 *Magnet systems for movable samples.*
2 *Simulated magnetic field distribution for a three-fold Halbach array.*

PERMANENT MAGNET SYSTEMS

DESIGN, SIMULATION, AND CONSTRUCTION

Magnetic fields can be generated by electromagnet or permanent magnet systems. The latter have several advantages over electromagnets: They work without electricity and do not require costly cooling. Permanent magnets based on new materials have been on the market for several years and are being incorporated into applications in increasing numbers. For instance, permanent magnets have already become established in permanent-magnet synchronous motors in electric cars. And they are used in laboratory measuring equipment in order to identify the properties of materials in a magnetic field. A possible field of application is NMR spectroscopy, which requires strong magnetic fields especially for the analysis of large molecules. Expensive and sensitive superconducting magnets are normally used in this context. Permanent magnets made of modern materials have the potential to be used for generating magnetic fields of up to 2 T, allowing light, portable analysis devices.

Customized design of magnetic systems

Magnetic fields of a defined strength and orientation can be generated by individual arrangements of permanent magnets. One of the significant challenges in the design and construction of magnetic systems is generating the strongest possible field with the least possible material, since material is generally the biggest cost factor for a magnetic system. Fraunhofer IPM designs magnetic systems that are attuned to customer-specific applications.

Scientists at the Institute are specialized in designing and constructing permanent magnet systems for refrigerant -free cooling using magnetocaloric materials. These systems could offer an alternative to classic compressor-based cooling in the future. During magnetocaloric cooling, permanent magnets stimulate the magnetocaloric material.

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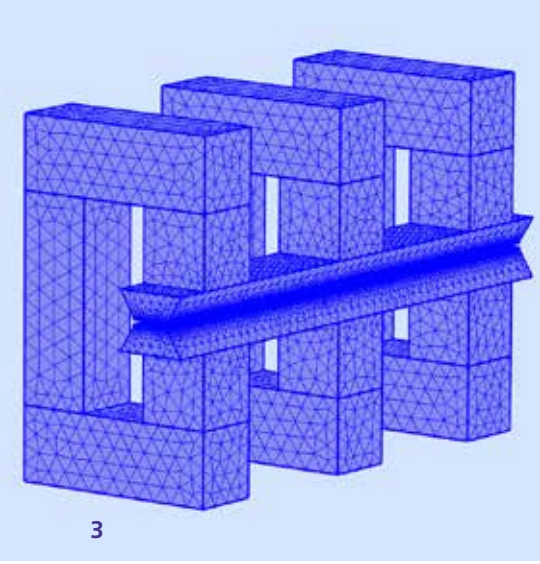

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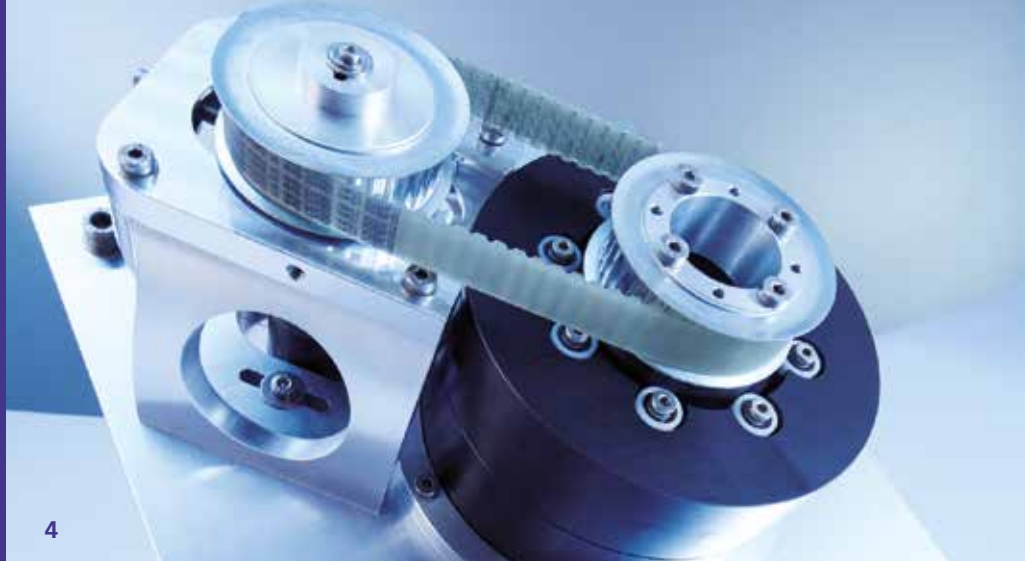

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3 *Geometry of an FEM model yoke system.*

4 *Implemented magnet system with an integrated Halbach array for a tunable field strength.*

Calculation of complex magnetic fields

During the construction of such systems, simulations of the finite element method (FEM) are conducted in order to predict the magnitude, orientation, and location of the magnetic field. Losses due to stray fields can also be calculated and thus minimized by guiding the field through soft magnetic materials. The optimum magnetic system design is developed on the basis of the simulation results. This involves not only the individual magnets, but, as required, the use of an iron yoke or pole shoes. Various material classes and special requirements on the installation space can be observed.

Our offer

- Design of permanent magnet systems using finite element simulation (such as Halbach arrays)
- Construction od magnet systems including guiding of the field through soft magnetic materials and control of switchable magnet components
- Arrangement and construction of magnet systems

Halbach arrays for tunable magnetic fields

Generating a magnetic field of a particular magnitude is not the only purpose of permanent magnets. The arrangement of permanent magnets in Halbach arrays allows the tuning of a magnetic field, that is, the variation between zero and a finite magnetic field. Fraunhofer IPM constructs arrangements of individual magnets in double or triple Halbach arrays with complex supporting systems and especially stable non-magnetic materials. For instance, a Halbach system that allows variation of field strength between 0.1 and 0.5 T was designed and built at the Institute. To allow a field to be tuned, a certain number of individual magnets must be able to change their positions. In the Fraunhofer IPM Halbach system, the control of the movable individual magnets has already been integrated.

Applications for systems consisting of permanent magnets

- Magnetic cooling on the basis of magnetocaloric materials: refrigerant-free cooling
- Laboratory systems for characterizing materials in a magnetic field
- Systems for generating a magnetization in functional materials during manufacture, such as for hot press or metal injection molding
- Halbach arrays for tunable magnetic fields