Value-added **Services** and **Solutions**

"Over the past 35 years, we have accumulated a large database and much know-how for magnetic coupling applications"

Developing a high-performance permanent magnet coupling device is a highly demanding task today, driven not only by a rapid development and commercialization of various magnetic materials, but also by an ever-growing business competition and non-saturating market/customer needs. Bakker Magnetics is, in such demanding circumstances, able to and capable of creating more values for our customers by providing services and innovative solutions. Just to name a few:

Magnetic material selection, specification and validation

A booming application of magnetic materials is in full swing. However, an appropriate and cost-effective selection of magnetic materials is becoming a specialist area, due to the fact that there is a large range of both permanent and soft magnetic materials of varying types and grades. Even within each type of magnetic material, the magnetic, electrical, mechanical and thermal properties and capabilities change to a great degree. In case of modern NdFeB permanent magnets, there are more than 100 types and grades available for a device design engineer, including both sintered and bonded types.

Selection and specification of the best magnetic material for a specific application is a joint effort of the cost consideration and the material performance over the device service time in a specific environment. In this circumstance, the continuous working temperature and the maximum transient temperature is a common issue that has a tremendous impact on the magnetic material. Furthermore, an appropriate range of testing and measurement methods and equipment must be chosen for the magnets specified to be validated for a targeted application. Over the past 35 years, we have accumulated a large database and much know-how for magnetic coupling applications.

Magnetic circuit synthesis, analysis and optimization

A desired magnetic circuit structure, for a given magnetic material, delivers a specific magnetic field profile across a defined air gap, in order to meet or exceed a torque curve requested or defined by the customer. We have a wide range of expertise and design tools, both analytically and numerically, to overcome any coupling challenge.

Magnetization, stabilization and demagnetization service

Permanent magnets, and in particular high energy rare earth magnets, are difficult or even dangerous to handle. It is preferred, in some cases, that the magnets are assembled in a non-magnetized state which will be magnetized after a final assembly. In this context, an appropriate magnetizer, which could be DC-electromagnetic field, pulsed field, or even permanent magnetic field-based, must be compared and selected. Quality of permanent magnet magnetization, including level of saturation, magnetization/orientation direction and its deviation, plays a key role in permanent magnet coupling performance.

Rapid prototyping and testing

Once the design and optimization of a specific PMC is finalized, it is common to make a prototype in order to ascertain and evaluate the design results. We are able to perform a fast prototyping made by our skilled technicians with a number of modern machine tools.

Assembly know-how

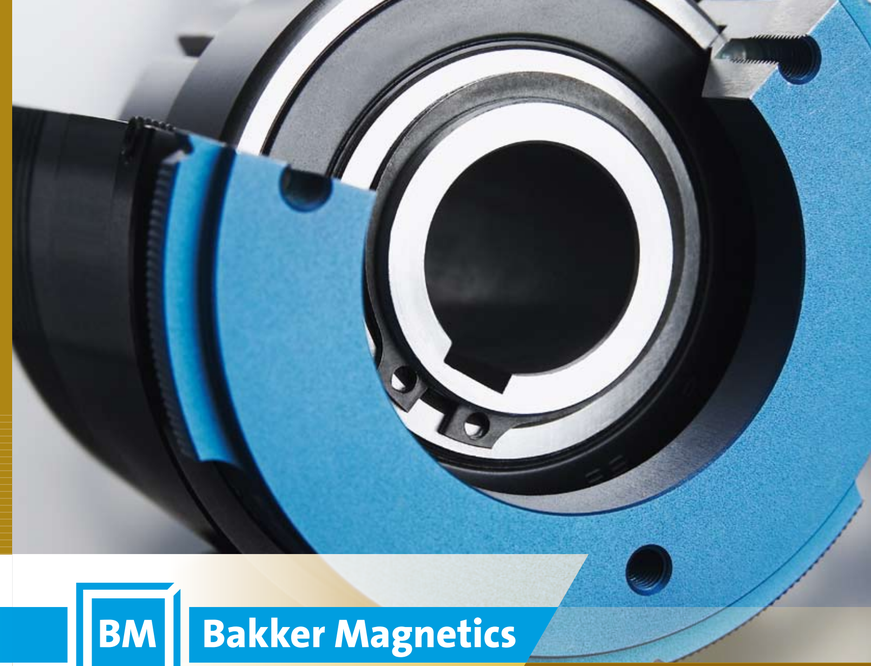
Great care must be taken when assembling or mounting magnetized high energy rare earth permanent magnets due to a dangerous repulsion and attraction among the magnets themselves, and between the magnets and the soft magnetic steels as a flux return path.

We have considerable experience in permanent magnet gluing, screwing, anchoring and retaining by various high strength sleeves or tapes. In addition, a large number of in-house assembly tools and methods for various magnetic components and devices have been developed.

Centre of **magnetic** knowledge...

Summary

Bakker Magnetics is in an excellent position to meet or exceed all your demands in all types of power transmission applications by exploring the applied magnetism, with abundant knowledge and expertise. Above all, we strive to achieve the best ratio of machine performance and system cost.



BM Bakker Magnetics

Permanent Magnet Couplings

for magnetic energy transmission

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Centre of **magnetic** knowledge...

Permanent **Magnet** Couplings

Introduction and Classification

Bakker Magnetics, located in Eindhoven, the Netherlands, is a leading European magnetic powerhouse. In addition to delivering diverse conventional and standardized magnetic products and solutions, we are specialized in developing custom-made magnetic components.

One such speciality is the design, engineering and manufacturing of Permanent Magnet Couplings (PMC) for transmitting torque (rotational motion) and/or force (translational motion). The main benefits of applying PMC technology are:

- **Reliability.** In a diversified world of motion and drives, the separation of a driven part from a driving part is often required, for example for harmful or corrosive fluid pumping, motion transmission across a vacuum barrier. Conventional seals used in this context are prone to fluid leakage or performance failure. PMC enables a contact-free motion transmission, thus enhancing the driving safety and reliability.
- **Durability.** If the PMC is designed in such a way that the permanent magnets employed remain stable under severe operating conditions like overloading and at high temperature, the working service time should be unlimited.
- **Cost-effectiveness.** As described, the PMC is a contact-free driving technology and therefore there is no friction between the driving and driven part (except for a small amount of bearing friction). As a result, the mechanical wear and tear of the major components is eliminated, significantly reducing the maintenance and downtime cost.

The PMC can be categorized into four groups as follows:

- Synchronous coupling
- Hysteresis coupling
- Eddy current coupling
- Variable-reluctance coupling

Each type of the machine has its own unique performance characteristics and can be designed in many ways with a wide spectrum of active materials, including permanent magnetic materials, hysteresis materials, soft magnetic materials, and electrical conductors (for eddy current devices). These PMCs are summarized in Table 1. However, the most common type is the Synchronous Permanent Magnet Coupling (SPMC).

Coupling type	Common topology		Motion mode		Key features
	Radial-flux	Axial-flux	Rotary	Linear	
Synchronous	◆	◆	◆	◆	High torque/force; syn. speed
Eddy current	◆	◆	◆	◆	Torque/force vary with speed
Hysteresis	◆	◆	◆	◆	Constant torque/force over speed
Variable reluctance	◆	◆	◆	◆	Low torque/force; small airgap required; high Temp. application

Table 1 Major types of PMC with their key features

Synchronous permanent **magnet** coupling

The underlying physics

A schematic construction of a SPMC, with a radial flux topology, is shown in Figure 1. As illustrated, PMC is capable of transmitting magnetic torque or force without direct contact, depending upon the motion desired. Typically, a driving part or a driver is connected to a motor, serving normally as an external member, and a driven part, which is an internal member segregated by a separation cup from a driver, is connected to a pumping body.

The separation cup, functioning as a barrier wall, completely separates the sensitive or aggressive media from the external driver and its environment. Such a barrier wall must be designed in such a way that it is able to withstand the pressure difference, eddy current losses and sometimes the corrosion. The power transmission efficiency can be maximized by minimizing the power losses due to eddy currents induced and/or a rising temperature, as governed by the following equation: $P_{out} = P_{in} - P_{loss}$

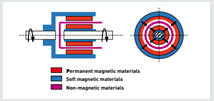

Fig. 1 Schematic representation of a radial flux type SPMC

Radial-flux type

The terminology is based on the main magnetic flux path in which the flux lines flow radially as seen in Fig. 2 and Fig. 3. This type of SPMC is called concentric type or co-axial type. Fig. 2 presents a case where the two rotary members are precisely aligned, with no transmitted torque produced. A maximum torque transmitted is achieved when the maximum co-energy variation over the rotary angle is reached, as shown in Fig. 3.

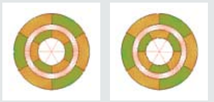

Fig. 2 Radial-flux type PMC when aligned
Fig. 3 Torque produced due to Push-Pull

The typical static torque curve as a function of the slip angle, which is computed by means of the-state-of-art electromagnetic FEA-based software package, is shown in Fig. 4.

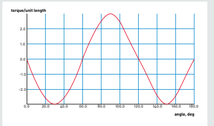

Fig. 4 Static torque curve computed as a function of rotation angle

Axial-flux type

This type of PMC is called a disc type or face type. Which is a compact machine with a flat structure. The Axial Flux type PMC (AF PMC) has a main magnetic flux path where the magnetic flux lines flow axially, making the analysis and design of the device a 3-dimensional problem. Fig. 5 shows a 4-pole disc type PMC for a sealless mixing application. 3D FEA software is employed to finally optimize the design and performance on the basis of the results approximated analytically or by means of 2D FEA. A magnetic flux density mapping obtained by 3D FEA is shown in Fig. 6.

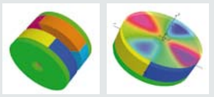

Fig. 5 4-pole disc-type PMC configuration
Fig. 6 Magnetic field mapping across air gap (with one part hidden)