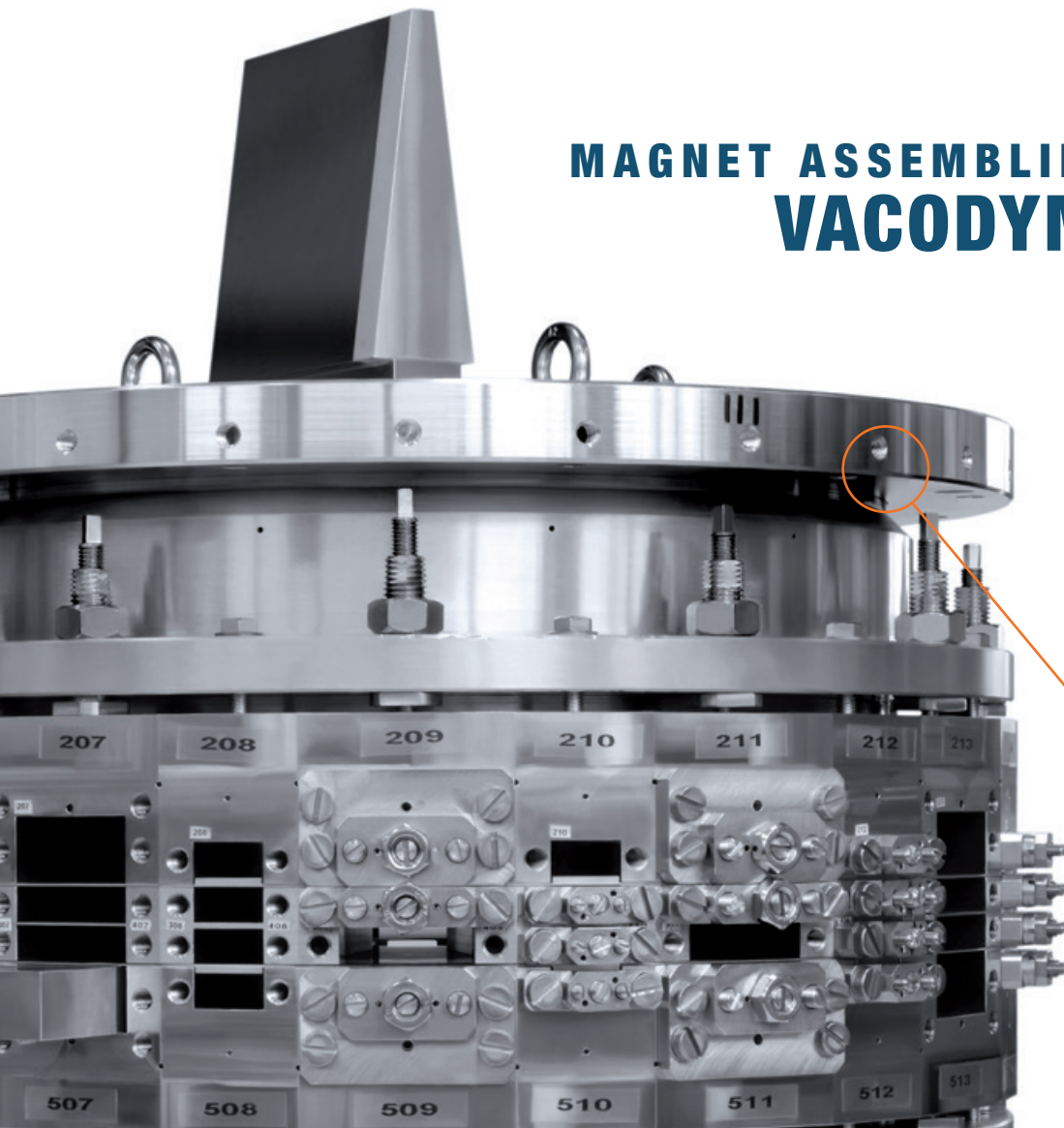


MAGNET ASSEMBLIES VACODYM VACOMAX



ADVANCED MATERIALS – THE KEY TO PROGRESS

VAC[®]
VACUUMSCHMELZE



DELIVERING EXCELLENCE FOR OVER 90 YEARS

VACUUMSCHMELZE is one of the leading global manufacturers of advanced magnetic materials and related products. Our company is represented globally in over 50 countries with over 4,000 employees. The headquarters and operational centre of VACUUMSCHMELZE is in Hanau, Germany, and the company also has facilities in Finland, Slovakia, China and Malaysia.

The company's success story started in 1923 with the melting of alloys under vacuum in a small factory in Hanau. With over 90 years of experience, and in combination with our exceptional process-related know-how, we are able to offer you high-quality materials with special magnetic and physical properties.

We have always manufactured our alloys in Hanau in accordance with industry required quality standards (certified according to ISO/TS 16949:2002). Cost-effective production equipment, the latest testing techniques and the responsible protection of resources are as natural for our company as is active environmental protection (certified according to DIN EN 14001) and continuous improvement training of our staff.

OUR PRODUCT RANGE – THE KEY TO YOUR PROGRESS

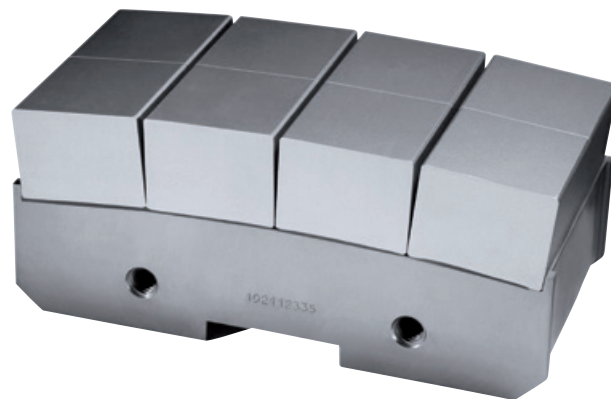
From large volume production in the automotive industry to small series production in the aerospace industry, or even one-off high-tech components for top level scientific research, our products and assemblies have a proven track record for their high quality and reliability, in practically every sector and branch of industry.

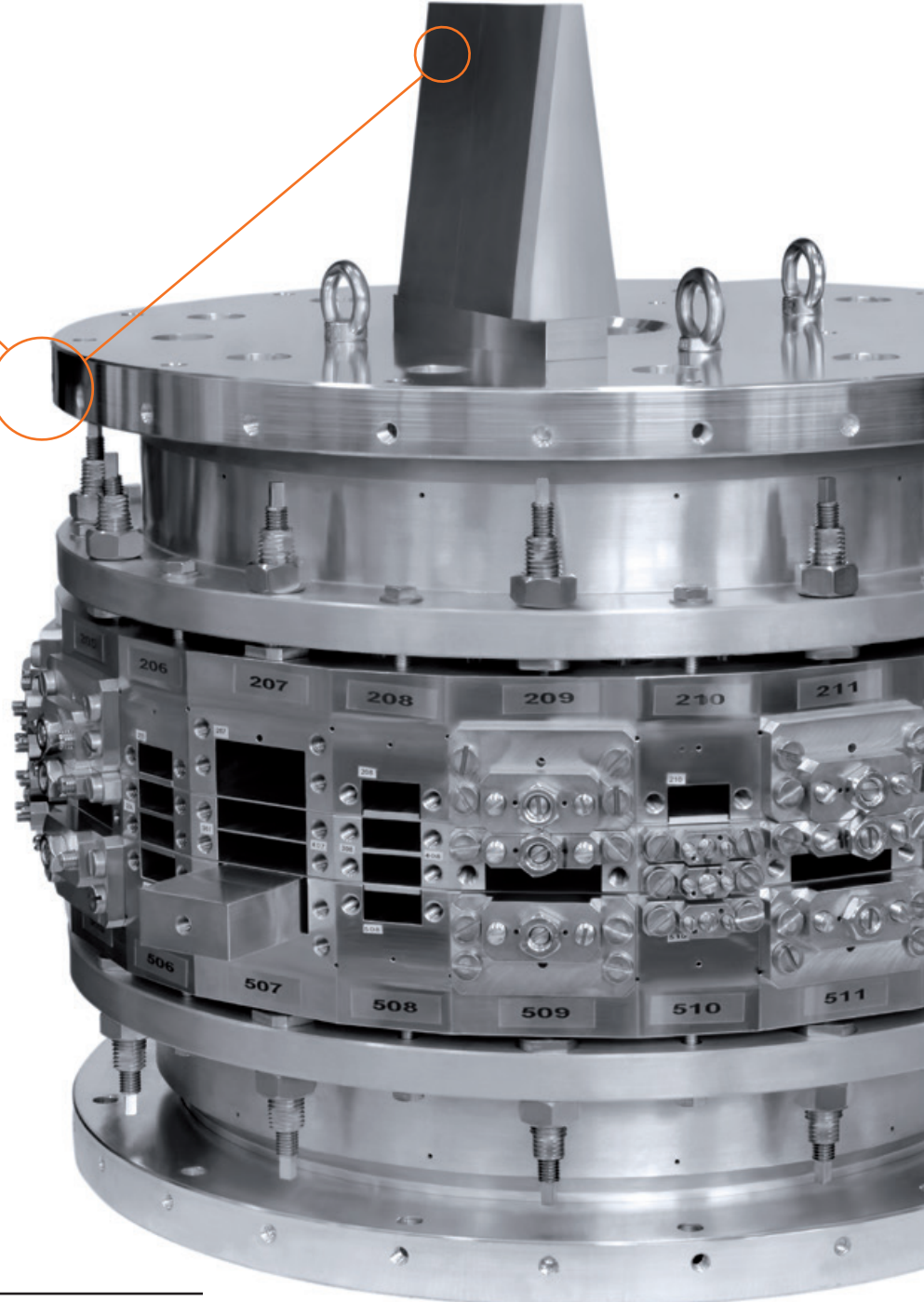
The VACUUMSCHMELZE product range spans:

- Rare-earth permanent magnets
- Magnetically soft semi-finished products and parts
- Toroidal cores
- Inductive components
- Magnetic shielding
- Diverse materials with special physical properties
- Complete components and assemblies to customers' specifications

We assist our customers with the development process, implement their requirements and produce custom-built magnet assemblies. Therefore our services extend from consulting at the initial planning stage to the design engineering and the actual production of the magnets, parts or assemblies.

Magnet pole assembly for a large generator





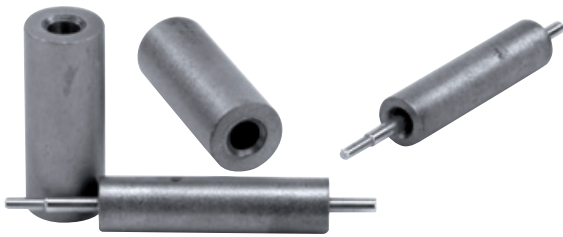
Magnet structure
for a magnetic resonance
imaging application

MAGNET ASSEMBLIES IN EVERY SIZE AND LEVEL OF COMPLEXITY

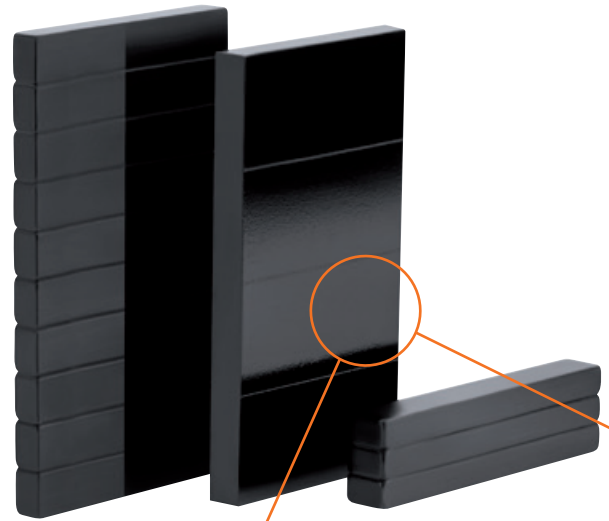
For you, we are not only a supplier of magnets but also your competent partner for the development and manufacture of advanced components and magnet assemblies, in every size and required level of complexity. We apply our decades of experience using our own permanent magnets and soft magnetic materials to manufacture a large number of these magnet assemblies at our two production plants in Hanau and Horná Streda (Slovakia).

We ensure optimum material properties throughout the whole manufacturing process. Small series and precision components with extremely tight tolerances are made in Hanau. For large volume production, we use our flexible and partially automated production lines in Slovakia.

Whether it is for the manufacture of one-off prototypes and small series or fully automated large volume production running to millions – we can perform all the processing steps in-house: From the melting of the alloy under vacuum and the coating and magnetization processes, through to assembly and final inspection.



Miniature rotors for ultra-small drives using VACODYM magnets



Segmented magnets with VACCOAT® 20021 adhesive coating

CUSTOMIZED INTELLIGENT SOLUTIONS

We manufacture our magnet assemblies strictly to customers' specifications. The solutions we develop together with our customers meet the highest possible requirements in terms of precision and reliability.

® = Registered trademark of VACUUMSCHMELZE GmbH & Co. KG

DEDICATED TO MATERIALS

Our work with the magnetic properties and applications of such special metallic materials dates back more than 90 years. For the development and production of our magnet assemblies, we use our own high-quality rare-earth permanent magnet materials VACOMAX® and VACODYM®.

Our production of VACOMAX permanent magnets based on samarium and cobalt and manufactured using powder metallurgical methods, started in 1973. Since 1986, we have produced VACODYM on an industrial scale. VACODYM magnets are based on neodymium-iron-boron alloys and exhibit the highest energy densities currently available.

For support parts, we also have a wide range of soft magnetic materials, e.g. VACOFLEX® and VACOFER®. Our magnets have precisely defined magnetic properties and provide the ideal basis for a wide range of customer-specific functional requirements.

Knowing the special properties of our materials enables us to adjust them throughout the whole manufacturing process. The result is optimized production, from the raw material through to the final assembly, with the desired material properties guaranteed at all times.

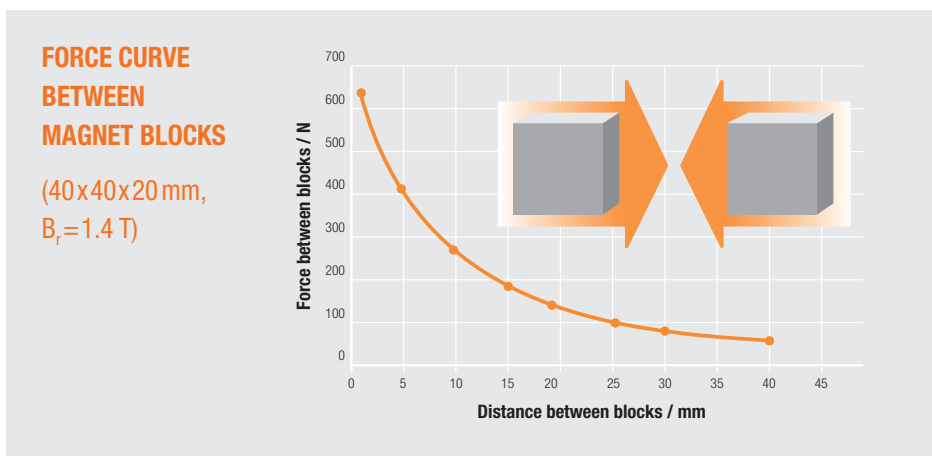
ADVICE FROM EXPERTS

We apply the basic principles, data and our expert know-how to the design process for your magnet assembly. Our in-depth knowledge of the physical and mechanical properties of our magnetic materials is applied right from the start of the planning phase. We are therefore able to provide you with optimum support on the definition of functional parameters and the selection of suitable materials, and also identifying possible alternatives for an efficient and cost-effective production process.

This includes:

- Analytical methods to describe the magnetic circuits
- Simplified calculation methods for dimensioning pure permanent magnet circuits
- Numeric approximation methods for complex simulations
- Finite element processes in two and three dimensions

To provide you with this service we simply require your initial design sketches and specification profile describing the required function of the magnet assembly, the acceptable dimensions, the thermal and environmental conditions, and the electrical limiting conditions. Or you can simply contact us directly, and we will provide you with expert assistance for the analysis of the problem. Based on the specification profile, we can develop a basic concept with an approximate price for the realization of the assembly.



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ASSEMBLY ALL FROM ONE SOURCE

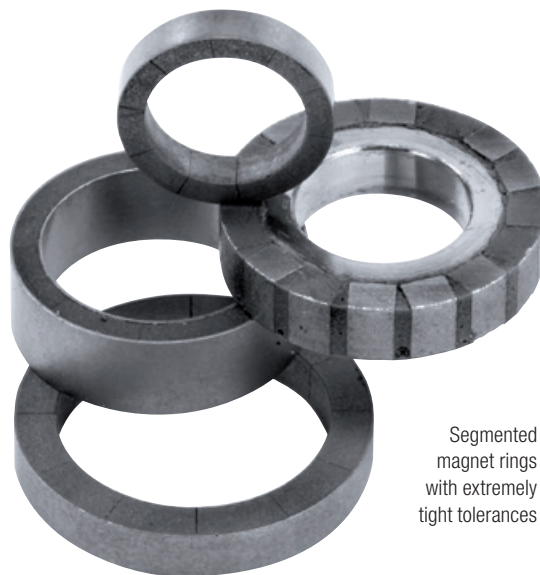
The positioning of magnets with extreme precision, especially small ones, and the very high forces associated with large-volume magnetized parts, make the assembly of magnet systems a challenging task. For this process, we can apply our extensive experience in the design and construction of assembly tools and our expert knowledge in the selection of a suitable bonding process.

SPECIALISTS IN ADHESIVE TECHNOLOGY

Most of the magnet assemblies we manufacture are constructed using adhesives. This enables the components to be positioned to extremely tight form and position tolerances during bonding. It also provides an effective means of achieving fast and permanent fixation.

The quality of the adhesive bond depends mainly on the quality of the surfaces to be bonded, the right choice of adhesive and a reproducible joining process which is suitable for the task. We take the special conditions involved in each case into consideration and select the appropriate adhesive.

We have a wide range of tested and approved adhesives at our disposal, as well as production facilities specially designed for these processes, enabling us to use the optimum method for each individual requirement.



Segmented magnet rings with extremely tight tolerances

CORRECT PREPARATION OF THE SURFACES TO BE JOINED

Bonding is a very challenging process. Since non-destructive testing of the bond is not possible, the bonding process must be reproducible in terms of quality and reliability. The surfaces to be joined not only have to be absolutely clean and free of grease, but also, in most cases, have to be activated as well using appropriate processes. This is the only guaranteed method of ensuring fully effective adhesion.

Our permanent magnets are passivated following final cleaning. The resulting surface coating is an ideal primer for many adhesives. We also use mechanical, chemical or physical methods for pre-treating the surfaces to improve their adhesiveness. As a result, we are able to achieve the optimised preconditions for an ideal permanent adhesion.

THE APPROPRIATE ADHESIVE FOR EVERY BONDING PROCESS

The selection of an appropriate adhesive for the manufacture of magnet assemblies is critical and the following special points must be taken into consideration:

- Static and dynamic stress of the bond (strength specifications)
- Thermal load (duration/temperature cycles on the bond)
- Properties of the bonded elements
- Corrosive stress of the bond (climatic and chemical resistance of the adhesive)
- Condition of the surfaces (coating, roughness)
- Width of the bonding gap

For the selection of the adhesive we can call on a wide range of adhesives which have been qualified and tested in our company for the most diverse surfaces. The bonding of materials, especially ones which are already magnetized, is a challenging and complex task. To do this successfully, magnetization must take place at the last possible moment and suitable jigs and adhesives have to be used for bonding the magnetic components.

For the bonding process itself, numerous parameters such as pot life, reaction time in the bonding gap or the time required for sufficient hardening of the bond have to be taken into consideration.

On the basis of all these requirements and conditions we determine the optimum bonding process for the product concerned, in order to achieve the top quality products expected by our customers, and in compliance with industrial safety requirements.

QUALITY ASSURANCE

Quality assurance has a high priority in the production process, because it is not possible to perform non-destructive tests on single parts, prototypes and small series production runs. Therefore special care is taken to ensure that all requirements applicable to the bonding process are fulfilled. This is complemented by our strict quality management system, which is applied in practice on a daily basis. As a consequence, we ensure that our adhesive bonds are safe and our production processes are stable and reproducible.

Furthermore, for serial production we use mainly automated processes, resulting in process stability and consistently high quality. Where required by the customer, we also perform in-process destructive tests on samples and can therefore provide verification of the consistently high quality of our magnet assemblies over the entire lifecycle of the product.



Rotor for a fan motor

HIGH-PERFORMANCE MAGNET SYSTEMS FROM EXPERTS

We perform all stages of assembly for everything from prototypes to large volume production runs. Our experienced and highly qualified staff, together with our approved process steps, provides the guarantee for consistently high reproducibility and quality.

VERSATILE ASSEMBLY TECHNIQUES

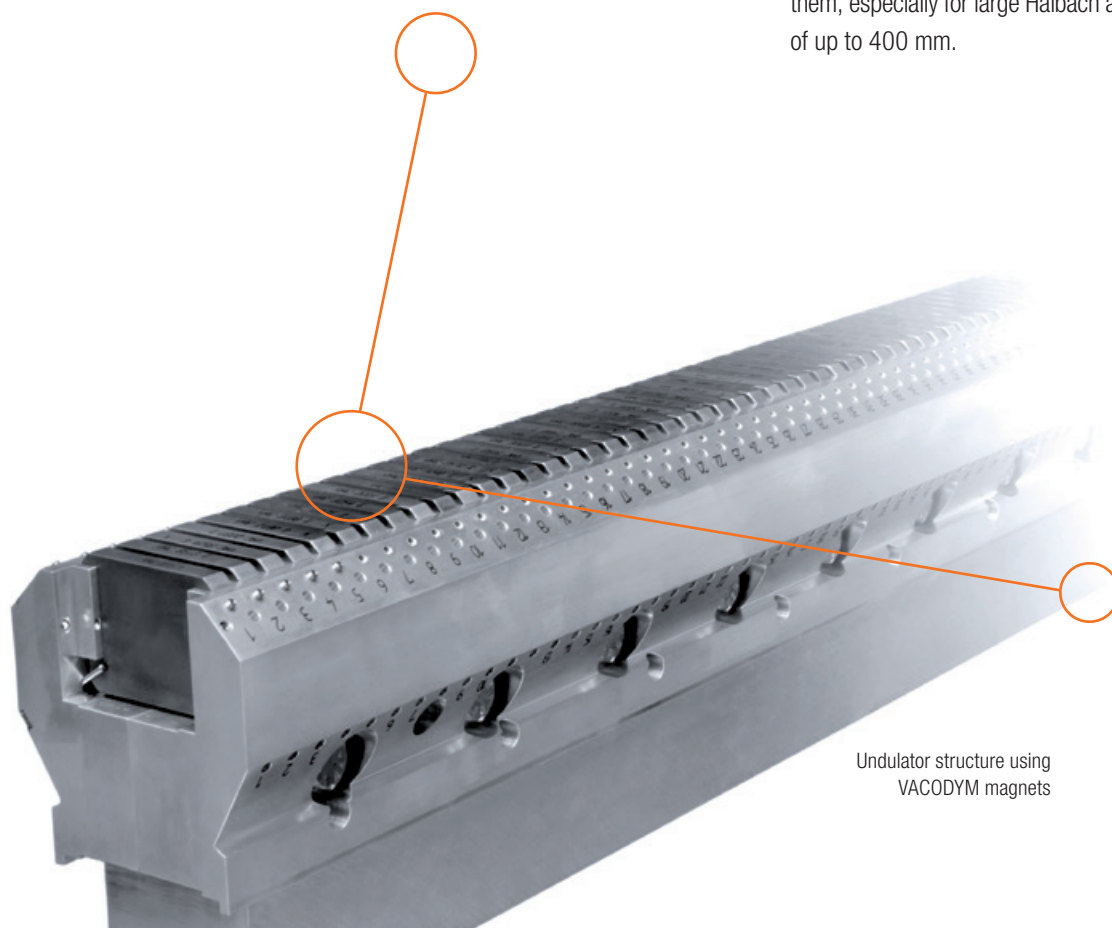
In addition to optimised bonding, correct and controlled assembly is also critical. This applies especially where very tight tolerances or large magnetized parts are involved. Since the magnetic forces increase rapidly at decreasing distances (see the force curve, p. 5), the magnetization of stronger RE permanent magnets is performed as late as possible in the assembly process.

From our experience and extensive know-how, we are able to offer our customers both manual and automated assembly of high-precision magnet assemblies – and our range of components covers everything from masses of just a few grams to several tons.

MANUAL ASSEMBLY

We manufacture small series, prototypes and test devices at our factory in Hanau, Germany. We have a team of highly specialized and experienced experts at our disposal, who look forward to every new challenge, especially complex ones.

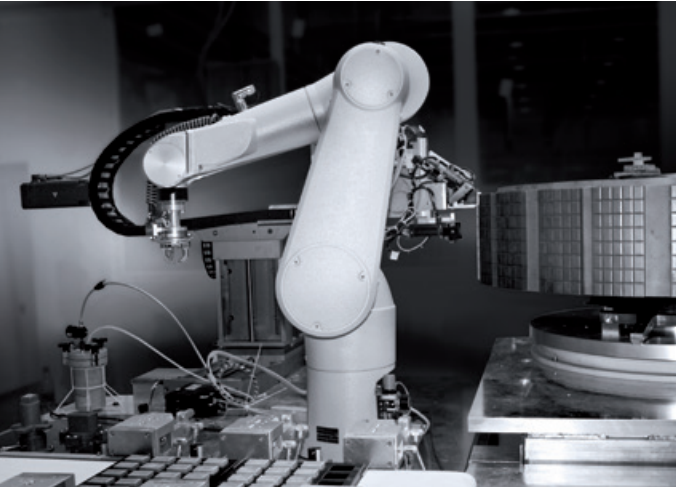
Whether it is for research and development, aviation or motorsports – a wide diversity of what are often highly sophisticated one-off components and small series are produced in Hanau. One example is provided by Halbach arrays, which are comprised of segments of permanent magnets with the directions of magnetization angled against each other. These assemblies are produced with the utmost precision and, for example, are used as electromagnetic “lenses” with very high magnetic fields. Since magnetization of such structures after bonding is no longer possible, we use specially designed assembly equipment to manufacture them, especially for large Halbach assemblies with diameters of up to 400 mm.



Undulator structure using
VACODYM magnets

AUTOMATED ASSEMBLY

We manufacture large batches at our facility in Horná Streda in Slovakia. For the production of large volumes, we have a selection of a number of high-performance lines, automatic assembly units and highly flexible assembly robots.



Automated assembly of large magnet assemblies

For example, we assemble components comprised of magnets and return paths for the automotive industry. We manufacture these magnet assemblies in batches of millions and supply them ready-to-use so that they can be integrated directly into the customers' automation lines. We can also manufacture larger systems cost-effectively at our factory in Horná Streda. Magnetization after assembly is not normally possible for such systems. We therefore use robotic assembly units suitable for the high strength requirements involved for positioning heavy magnetized components.

EXPERTS IN MAGNETIZATION

For our VACODYM magnets we use special magnetization fixtures with which we can generate fields of more than 2500 kA/m during the magnetization process, or even in excess of 3500 kA/m in the case of VACOMAX magnets. What is important in this magnetization process is the actual point at which this occurs in the production process. Application at the latest possible stage allows the parts to be assembled largely without the influence of the magnetic forces. However, conversely, achieving full magnetization in the case of assembled magnet assemblies often requires considerable effort, because of the special arrangement and the shielding effect of the support parts.

Therefore we plan and manufacture your magnet assemblies to ensure that magnetization is always applied at the optimum moment for each system. For an optimum production process we can call on our extensive experience, suitable magnetizing units and a wide range of assembly tools.

YOUR SYSTEM – OUR FACILITIES

We have a wide spectrum of measuring equipment for taking very precise mechanical and magnetic measurements of our assemblies. If required by the customer, we can encase the assemblies in stainless steel, glass-fibre or carbon-fibre reinforced containment systems, including the required layouts. The result is that we deliver a magnet assembly perfectly tailored to customer requirements and application.

We naturally also provide appropriate packaging (including shock or thermal sensors if necessary) together with the according shipping conditions. On request, we will also be pleased to undertake the work of installation and adjustment on site.

EXAMPLES FROM PRACTICE

We are your reliable partner when it comes to the development and production of a wide range of magnet assemblies. The examples and applications described below demonstrate just how diverse the possibilities are in terms of design engineering and realization.

SEGMENTED MAGNETS

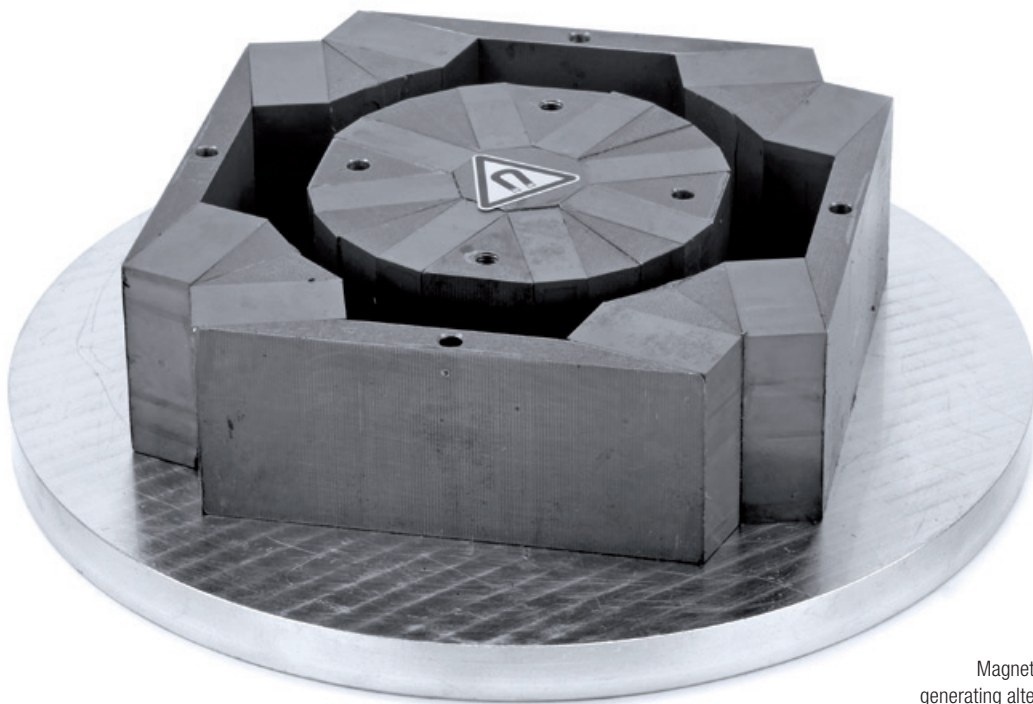
To reduce eddy current losses, magnets are need to be segmented. This is achieved by first joining the individual segments with adhesive as precisely as possible prior to the final assembly process. In a process that we have developed specifically for the purpose, we apply a thin film of adhesive to the segments. This enables us to achieve an ultra-thin and uniform bond layer which provides reliable electrical insulation.



Segmented magnet for the suppression of eddy current losses

MAGNETIZATION FIXTURES

To generate magnetic fields of different polarity, we use special magnetization fixtures made of permanent magnets. This method is considerably more energy efficient than the use of electrical power for electromagnets.



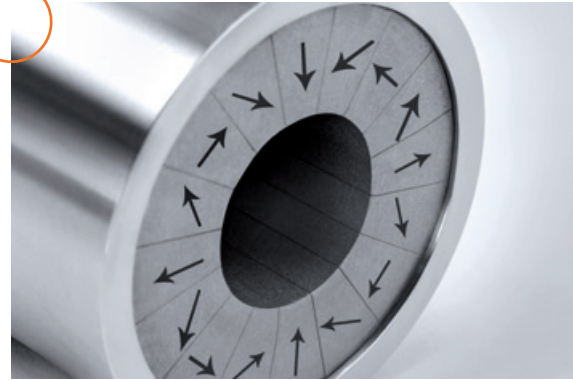
Magnetization fixture for generating alternating polarities

MAGNET ASSEMBLIES FOR MINIATURE DRIVES

Miniature drives require extremely small rotors with high precision tolerances and we have the right solutions for these special requirements. We have efficient in-house production processes with which we can manufacture particularly small and high precision magnets – for example for use in high-performance ultra-small motors.

USE OF PERMANENT MAGNETS FOR SAVING ENERGY

The protection of global resources is now a key topic for research and development. For example, research institutions currently use quadrupole magnets in accelerators.



Halbach system for beam guidance in scientific applications

Unlike resistive solutions, which use electricity for generating magnetic fields, these types of magnets do not need a permanent supply of energy. Numerous scientific institutions count on the expertise, reliability and quality of VAC in this specialized sector.

SUCCESSFUL PARTNERSHIPS – WHEN ARE WE STARTING OURS?

Magnet assemblies are always individual solutions. As leading experts in the manufacture of magnet assemblies on the basis of RE permanent magnets, we can assist you from the outset of the development stage to the manufacture of the components. Our range of products and services extends from particularly challenging one-off products and prototypes to cost-effective serial production running to millions.

We will be pleased to assist you and look forward to receiving your enquiry.



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PD-004 MAGNET ASSEMBLIES EDITION 2014



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