Powder Press Shaping of Magnetic Materials – Key Technology for E-Mobility, Sustainable Power Generation and Grid Infrastructure

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DORST TECHNOLOGIES/DE develops and supplies complete systems for shaping rare earth magnets, hard and soft ferrites as well as complex SMC components made of powder materials with and without magnetization.

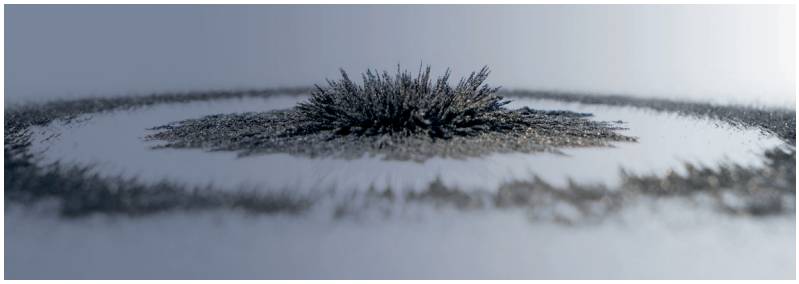

Fig. 1 Fascination magnetism – a masterpiece of nature

Magnetism has always had a fascinating, almost mystical effect on mankind since its discovery. An invisible force, tangible, sometimes elusive, and yet also enormously powerful. Even in ancient times, explorers and navigators used natural magnetic iron to steer a course to new destinations. And today it is magnetism in electric drives, in medical devices, in sensors and measuring systems that enables mankind to rethink mobility, to use regenerative energy sources efficiently and to develop groundbreaking new technologies.

PM parts for the needs of their time

The anisotropic shaping of magnetic powder materials has a long tradition at DORST. For more than 40 years, the international markets have been served with customized solutions for the shaping of ferrites, rare earth magnets and soft magnetic metal alloys.

Over the years, technical progress has repeatedly ensured that mass-produced items have disappeared from the market, while new products and component families have been developed. For example, there is hardly any need for ferritic deflection yokes for CRT screens anymore.

In contrast, the demand for antennas, shielding, chokes and interference suppression filters is increasing all the more today due to the rise in wireless data transmission, mobile communications and the digitalization of all areas of life. The expansion of the charging infrastructure, decentralized power generation, power distribution and storage would be inconceivable without high-quality pressed ferrite and magnetic components.

The ambitions for CO_2-emission-free mobility are driving the rapid development of increasingly powerful yet lightweight and compact electric drives based on rare earth magnets

Fig. 2 Powder-pressed parts, deflection yokes and coil cores made of ferrite

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or so-called Soft Magnetic Composite (SMC) components.

Hard and soft ferrites

Ferrites (MnZn ferrites, NiZn ferrites) belong to the so-called classic ceramic magnets on a favorable material cost basis. A basic distinction is made between hard and soft ferrites. Hard ferrites can be magnetized more strongly than soft ferrites and can also retain their magnetic properties as so-called permanent magnets. Typical applications for soft magnetic ferrites are coil cores, chokes, interference suppression filters, microwave systems and transformers. Hard magnetic ferrites are used as permanent magnets in loudspeakers, electric motors and sensors.
Pressable ferrite granulate can be produced ideally and cost-effectively by water-based spray drying using nozzle atomization.
Simple mechanical axial presses are still used for shaping, but in the meantime modern, CNC-controlled hydraulic or servo-motorized powder presses are increasingly being installed. With the current press generations from DORST TECHNOLOGIES of the EP, EP-M and TPA /4 HP series, a wide range of high-performance, highly accurate and at the same time energy-efficient powder presses with all known features such as single and multi-plate capability is available to the markets.

Soft Magnetic Composites – SMC

Soft magnetic composites, on the other hand, are a relatively recent development from the 1990s. Iron powder is coated with an electrically non-conductive coating and processed into complex PM components by axial powder pressing.
The possibility of generating a 3D magnetic flux with SMC materials is very interesting for electrical drive development. This makes it possible to build very compact and weight-optimized parts for highly efficient axial flux machines with high power density. In terms of production technology, all the advantages of powder metallurgical molding of modern CNC axial powder presses can be used:

- Near net-shape press forming of complex component geometries
- Optimal use of materials
- High production output in fully automated process
- Reduced scrap rates due to excellent process control

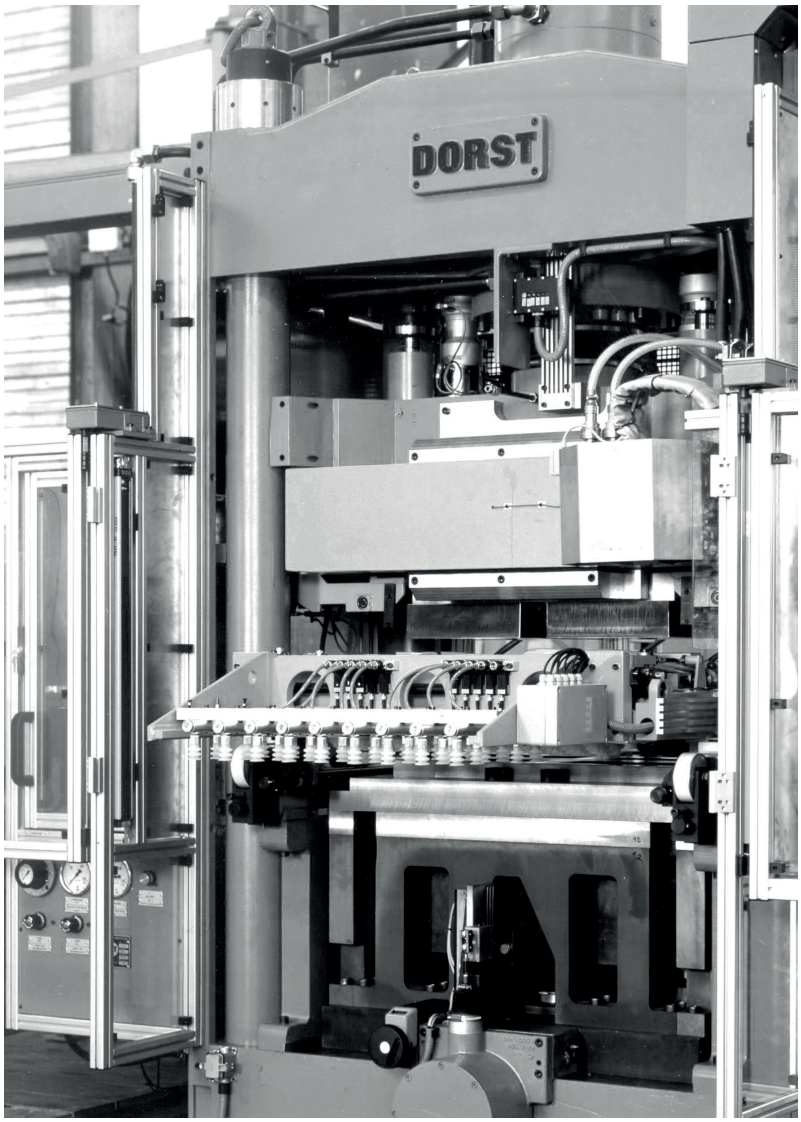

Fig. 3 Anisotropic shaping in a wet pressing process with magnetic field 2008

Fig. 4 E-Mobility as a driver for pressed parts made from magnetic materials (Source: Samuel B. – stock.adobe.com)

Fig. 5 Examples of PM soft magnetic composite pressed parts

- Minimized rework
- High cost efficiency.

DORST TECHNOLOGIES offers a wide range of single and multi-platen axial powder presses from 160 kN to 20 000 kN for both simple and complex geometries of SMC compacts. Up to a nominal press force of 2000 kN, 100 % purely electrically driven servo-motor CNC presses dominate, while from 2500 kN to 3000 kN hybrid machines are also available. In addition, customers from the PM industry worldwide trust the proven, hydraulically driven CNC axial powder presses from DORST TECHNOLOGIES with their well-known top-quality die sets and robot automation integrated as standard.

Rare earth magnets

The strongest magnets with the highest useful energy density are rare earth magnets based on metal alloys such as neodymium-iron-boron and samarium-cobalt. The latter are particularly well suited for applications at higher temperatures up to 300 °C. In addition, a whole range of other elements of the periodic system are used for magnets produced by powder metallurgy. Typical examples from the rare earth family are lanthanum, cerium, praseodymium, europium, gadolinium, terbium, dysprosium, holmium, erbium, thulium, ytterbium, lutetium, scandium, and yttrium. For simple applications and mass production, magnets made of Al–Ni–Co alloys are widely used.

Fig. 7 Sintered NdFeB magnets for highest power density

Fig. 6 Hybrid multi-platen CNC Axial Powder Press TPA300 HPE

Besides isostatic pressing, axial powder pressing is the most widely used process for shaping such high-performance magnets. Due to their very high energy density in a very small space, rare earth magnets are the first choice for all types of electric motors, generators, stator drives, clutches, and similar functional assemblies. This makes rare earth magnets indispensable for the growth market of e-mobility and all types of electrically based automotive solutions. Other important applications are found in medical technology, wind turbines, civil and military aviation, defense technology and aerospace.

Powder pressing under magnetic field

The preparation of pressed powders for rare earth magnets is demanding and requires precise process control during mixing and milling of the raw materials. A reproducible, fine particle distribution ensures the desired alignment of the particles along the field lines during pressing under magnetic field. The anisotropy of the pressed part thus produced is decisive for the subsequent magnetic properties and quality. In certain cases, an externally applied magnetic field can also be used to improve the powder flow and thus the filling of the pressing die. Inhomogeneities in the powder filling can be elegantly eliminated by utilizing the magnetic field. Powder pressing under a magnetic field is possible in both single and multiple cavity molds.

Magnetic coil design by FEM

The heart of every rare earth magnetic powder press is the magnetizing coil. The coils,

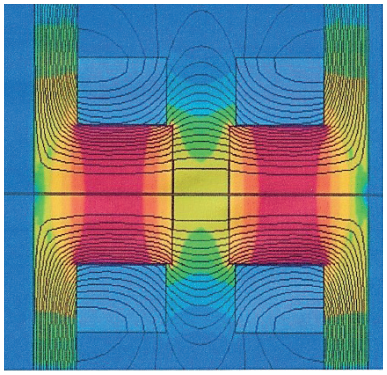

Fig. 8 FEM calculation of the magnetic flux in the coil

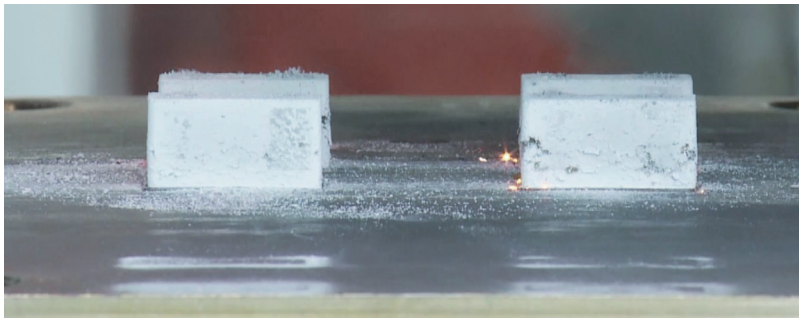

Fig. 9 Special solution magnet production by hot plastic pressing

including the yoke, are specifically designed for each application and according to the customer's requirements. In detail, the magnetizing system always consists of coil, yoke, cooling system and rectifier.

The part geometry and the subsequent application determine the orientation of the magnetic field to be applied and thus the arrangement of the coils in the working area of the press. With a transversal magnetic field across the press direction, closed-loop controlled magnetic powder presses from DORST TECHNOLOGIES allow the magnetic coils to be arranged both stationary and moving with the die. The entire sequence can be programmed in the press visualization in an operator-friendly manner. Of course, coil arrangements for radial and axial magnetization are also possible.

Coil dimensioning and magnetic flux can be optimized very well with the help of the finite element method. FEM allows to keep power losses low and to develop important potentials for energy saving for the operation of magnetic particle presses.

Inertization

Rare earth magnetic powders and pressed parts react strongly with oxygen. On the one hand, oxidation is detrimental to the magnetic properties, and on the other hand, it represents a great danger regarding spontaneous ignition during processing. For this reason, it is strongly recommended that all steps, from powder feeding, through press forming, to part manipulation, are carried out under an inert gas atmosphere. Nitrogen or argon are common here.

Rare earth magnetic powder presses are supplied by DORST TECHNOLOGIES with customized, gas-tight protective equipment, appropriate monitoring devices and safety strategies.

Integrated automation

Modern magnetic powder presses must be regarded as fully integrated and digitized production systems. This means that, in addition to powder feeding, press forming under magnetic field and protective gas enclosure, the press part automation is also an integral part of the system. As with conventional solutions, DORST TECHNOLOGIES prefers the use of standard robots with application-specific gripper systems.

Customized solutions from a single source

Inquiries for magnetic powder presses are served from the standard delivery program of DORST TECHNOLOGIES for hydraulic and servo motorized CNC presses, which guarantees high reliability from many years of field experience, the use of well-known system technology and good spare parts availability. The process-related special features and the required larger installation space for the magnetizing coil are covered by special press architectures, if required.

Whereas in earlier years magnetic powder presses were often only basic machines that were upgraded by the customers themselves, today the focus is on dedicated customer-specific solutions consisting of a high-performance press with an application-specific magnetizing coil, inertization and suitable press part automation from one single supplier.

Special solutions for rare earth magnets, e.g., processes similar to the forging and upsetting process with hot pressing, have already been implemented.

Summary and outlook

The current and future market opportunities for sintered magnets, SMC components and ferrite components are considered to be very positive worldwide. The requirements of e-mobility alone, including charging infrastructure, but also of regenerative power generation and robust power distribution are immense.

The market leader is China with a market share of approx. 86 % for sintered NdFeB magnets. But in Europe and USA, too, there are currently increasing efforts to bring the produc-tion of magnets back to the national level. The pressure arises from the need to diversify supply chains for system-relevant future technologies.

DORST TECHNOLOGIES offers the most comprehensive and modern machine program of magnetic powder presses and magnetic powder forming technologies on the market. Water-based spray dryers for ferritic materials round off the service package starting from powder preparation.