Electromagnetic Applications

Powder Metallurgy meets Electro Magnetics
GKN ELECTROMAGNETICS

3D DESIGN FREEDOM
GKN’s competence and experience offers excellent opportunities to create highly complex, 3-dimensional products in powder metallurgy. Even undercuts can be realised with the sophisticated compaction technology developed by GKN. Due to this outstanding design freedom, innovative and more efficient product designs are feasible, in particular with soft magnetic materials.

GKN ELECTROMAGNETICS
Innovative and performance-oriented soft magnetic products usually require specific magnetic properties combined with an optimum of material utilization. Many solutions fail due to excessively costly operations caused by alternative manufacturing processes.

Powder metallurgy allows to produce optimized customer specific finished products for all industrial sectors at affordable costs.

- SOFT MAGNETIC COMPOSITES (SMC)
Our technology for innovative, high performance electric motor components and high frequency applications.

- SINTERED SOFT MAGNETICS
Our material and technology for complex structural parts in electromagnetic applications like linear and rotational actuation.

- ENGINEERING
GKN’s competence in engineering and design for best possible customer satisfaction.

- MATERIAL OVERVIEW
Engineered powders optimized to reach mechanical and magnetic properties.
DESIGN FOR PM

- Exploit GKN's know-how as your partner in product development
- Technology-oriented design for cost efficient production
- Reduced development periods
- Added value due to integrated functionality

MATERIALS & ENGINE TEST BENCHES

- In-house materials test center for tensile testing, service life tests, elevated temperature testing, tribological testing
- In-house variable engine test bench for performance tests, long-run performance, thermal performance

SIMULATION

- Electromagnetic 3D simulation and system design
- Thermal simulation
- Structural mechanic simulation

METROLOGY

- B-H field meter
- Coercimat
- Resistance test

B-H HYSTERESIS CURVE

This curve describes a typical complete magnetizing cycle of a ring shaped test sample. The magnetic field strength $H$ is generated by a primary coil, the resulting induction or magnetic flux density $B$ is registered by a secondary coil.

Essential parameters are the following:

- $B_r$ in [T]: Remanence, indicates how much "residual magnetism" remains in the core after the coil has been switched off.
- $H_c$ in [A/m]: Coercive force, represents the magnetic field that has to be built up by the coil to de-magnetize the core ($B = 0$ T).
- $\mu_r$: Maximum permeability, an indication of how "quickly" the induction follows the magnetic field $H$.
- $B_s$: Saturation induction, indicates how far the induction increases before the material is saturated and cannot be further magnetized.
The main constituent of soft magnetic composites is pure iron powder. The most notable feature of these soft magnetic particles is their electrically isolating coating which remains active even after pressing and curing.

Due to the coated iron powder particles the electrical resistivity of the material is high and the formation of eddy currents in alternating field applications is prevented.

This leads to a substantial reduction of eddy-current losses in electromagnetic applications as compared to traditional technologies.

Another specific property of SMC is the extremely low remanence of this material. The powder based structure and GKN’s press technology enable the creation of 3-dimensional designs with these exceptional advantages.

**MANUFACTURING PROCESS FOR SMC COMPONENTS**

The processing route for SMC components is characterized by an extremely lean sequence of manufacturing steps.

The powdered raw material is compacted into the desired shape on powder presses that have been specially developed for these products. This step allows to adjust the density, even within a component, depending on the requirements of the application.

Advanced materials and innovative production equipment enable GKN to realize densities up to 7.5 g/cm³. In the subsequent curing process that is carried out at relatively low temperatures below 600°C the SMC components attain their strength and are ready for assembling.

Optional:
overmould with coil

Optional:
coating
SMC enables entirely new approaches in electric motor design, as demonstrated by GKN’s spectacular transversal flux motor ELEKTRA.

CLAW POLE DESIGN for transversal flux engines can only be realized with SMC. GKN can support your developments in all stages from simulation and design up to testing of motors.

AXIAL FLUX MOTORS made with SMC offer more design flexibility and allow to simplify assembling procedures. GKN is your partner to design highly integrated systems based on powder metal products.

CORES for inductors and transformers made from SMC offer clear benefits due to weight reduction and higher power density of the components.
SINTERED SOFT MAGNETIC MATERIALS

Sintered soft magnetic materials are superior to other materials in certain aspects. Due to their complex near-net shape and high strength design they promise excellent magnetic properties and one hundred percent raw material utilization.

MANUFACTURING PROCESS FOR SOFT MAGNETIC SINTERED COMPONENTS

A variety of materials that can be adapted to the requirements and desired properties is available for the production of soft magnetic components.

Advanced compaction presses with multiple platen technology are used to produce highly complex parts with a homogeneous density distribution.

The “green” part produced by pressing attains its high strength and the desired magnetic properties in the subsequent high temperature sintering process in a controlled hydrogen atmosphere.

Finally, sintered structural parts can be finished without problems using secondary operations such as sizing, steam treatment, machining, or coating.

In addition to the density, which is variable as a free parameter affecting the saturation induction, for example, alloying additions such as phosphorus and silicon are available to adjust further magnetic properties depending on the application.

By alloying with up to 19% chromium it is also possible to produce ferritic structural parts that exhibit outstanding corrosion resistance.

Optional: stream treatment, annealing

Optional: sizing, machining, coating

Metal powder

Metal powder
LINEAR ACTUATION
Soft magnetic components made by powder metallurgy technology have proven successfully by the millions in switching, lifting and proportional magnetic circuits thanks to their excellent performance.

ROTATIONAL ACTUATION
Due to the design freedom of sintering technology, components of complex shapes can be realized. They are custom-tailored to fit the magnetic and mechanical requirements of innovative, efficient applications.

MAGNETIC COILS
Sintered structural parts are ideal cores for compact, reliable magnetic coils due to their good magnetic properties and a high potential for integrated functions.

SENSOR SYSTEMS
High precision sintered parts are the core elements of many electromagnetic sensor systems and, due to their excellent reproducibility, guarantee continuously exact measurement data.
### Sintered soft magnetic materials

<table>
<thead>
<tr>
<th>Designation</th>
<th>Density [g/cm³]</th>
<th>Coercive force Hc [A/m]</th>
<th>Bmax @ 1200 A/m [T]</th>
<th>Permeability</th>
<th>Hardness</th>
<th>Hardness</th>
<th>UTS [MPa]</th>
<th>YS₀₂ [MPa]</th>
<th>A El [%]</th>
<th>E [GPa]</th>
<th>Composition</th>
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<tbody>
<tr>
<td>PM4EM 1000D</td>
<td>7.0</td>
<td>170</td>
<td>1.05</td>
<td>2,300</td>
<td>50 HRF</td>
<td>50 HB</td>
<td>195</td>
<td>115</td>
<td>12</td>
<td>140</td>
<td>Fe</td>
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<td>150</td>
<td>1.25</td>
<td>3,200</td>
<td>55 HRB</td>
<td>95 HB</td>
<td>380</td>
<td>270</td>
<td>12</td>
<td>155</td>
<td>Fe0.45P</td>
</tr>
<tr>
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<td>1.35</td>
<td>3,600</td>
<td>65 HRB</td>
<td>115 HB</td>
<td>415</td>
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<td>15</td>
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<td>15</td>
<td>155</td>
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<td>275</td>
<td>170</td>
<td>15</td>
<td>110</td>
<td>Fe50Ni</td>
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<tr>
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<td>390</td>
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<td>85 HRB</td>
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<td>16</td>
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</table>

1) Fe [wt.-%] balance, Tested with standard rings under ideal processing; Values may vary for structural parts.

### Soft magnetic composites (SMC)

<table>
<thead>
<tr>
<th>Designation</th>
<th>B @ 10 kA/m [T]</th>
<th>µmax</th>
<th>Hc [A/m]</th>
<th>P @ 50Hz [W/kg]</th>
<th>P @ 400Hz [W/kg]</th>
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<td>234</td>
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<td>58</td>
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</table>

3) C [wt.-%] < 0.1; Co [wt.-%] < 0.1, Tested with standard rings under ideal processing; Values may vary for structural parts.
### Chemical composition

<table>
<thead>
<tr>
<th>Designation</th>
<th>Typical properties</th>
<th>Application</th>
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<td>PM4EM 50NiE</td>
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<tr>
<td>PM4EM SS430D</td>
<td>7.0</td>
<td>Sint-PM4EM SS430D</td>
</tr>
</tbody>
</table>

**UTS**: ultimate tensile strength, **YS**: yield strength, **A/El**: elongation to fracture, **E**: Young's modulus
# CHECK LIST FOR ENQUIRIES ON SOFT MAGNETIC COMPONENTS

## 1. CUSTOMER INFORMATION
- **Company name**: ________________________________
- **Company address**: ________________________________
- **Business areas**: ________________________________
- **Contact person**: ________________________________

## 2. COMPONENT DETAILS
- **Component designation**: ________________________________
- **Drawing/enquiry number**: ________________________________
- **Target application**: ________________________________
- **Annual quantities**: ________________________________
- **Expected SOP & lifespan**: ________________________________
- **Material (if specified)**: ________________________________

## 3. APPLICATION DETAILS
- **Frequency**: DC [ ] AC [ ] AC at frequency ______ Hz
- **Max. Induction**: ______ T [ ] (label) [ ] high priority
- **Applied field**: ______ A/m [ ] high priority
- **Max. coercivity**: ______ A/m [ ] high priority
- **Permeability**: ______ [ ] high priority
- **Max. losses**: ______ W/kg at ______ Hz & ______ T [ ] high priority
- **Min. strength/ test method**: ______ N/mm² in ____________ [ ] high priority

## 4. ADDITIONAL REQUIREMENTS
- **Rust protection**: [ ] oil impregnation  [ ] steam treatment  [ ] zinc plating  [ ] others
- **Secondary operations**: [ ] welding/brazing  [ ] machining  [ ] bonding  [ ] overmoulding  [ ] others ____________

## 5. DEVELOPMENT SUPPORT BY GKN
- **Blanks**: [ ] Yes  dimensions: ______ quantity: ______ date: ______
- **Sample parts (tool compacted)**: [ ] Yes  quantity: ______ date: ______
- **Others**: [ ] Yes  how: ______ quantity: ______ date: ______

## 6. COMMENTS
- __________________________________________________________
- __________________________________________________________
- __________________________________________________________
- __________________________________________________________
Do you have any more questions? Or do you need more information about our innovative products, technologies or materials?

Then please contact us directly:

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