THINK Innovations in Powder Metal

The world's largest manufacturer of sintered component solutions

ENGINEERING THAT MOVES THE WORLD
GKN SINTER METALS IS THE WORLD’S LARGEST PRODUCER OF PRECISION POWDER METAL PRODUCTS.

Our global production and sales network employs more than 6,500 associates in more than 30 facilities on five continents. With a history dating back to the 1930s, today we have production sites in Germany, Italy, South Africa, India, China, Brazil, Canada, USA and Turkey.

With a focus on superior delivery, quality and total solutions, GKN offers extensive technical expertise in design, testing and various process technologies. Our dedicated Research and Development centers and global manufacturing facilities are committed to connecting our customers to the latest advancements in powder metal (PM) technology.

GKN Sinter Metals offers a full range of more than 10,000 complex shape and high-strength products for the automotive, commercial vehicle, home appliance, lawn and garden, office equipment, power tool, recreational vehicle and process industry markets.

VISION AND STRATEGY

GKN’s vision is to deliver sector-leading, sustainable value creating global growth and to continuously enhance our position as the world’s number one sinter metals company.

GKN’s strategy is to design, manufacture and supply market leading and technologically differentiated sinter metal components, products and services to our customers globally, driven by a dynamic customer focused team of people. We always aim to fulfill or even excel expectations of our customers globally, delivering opportunities for our shareholders and employees.

SINTERING | VERB

To make a powdered material into a solid or porous mass by compacting and heating for the purpose of increasing its strength by bonding together its particles.
OUR CAPABILITIES

RESEARCH AND DEVELOPMENT IS AT THE FOREFRONT OF THE GKN SUCCESS STORY.

GKN Sinter Metals operates a world-class, dedicated research and development center in Europe and a regional facility in America. Both are focused on leading technology development through innovation in support of the company’s vision and goals.

This ongoing, balanced R&D keeps GKN Sinter Metals at the forefront of powder metal technology for materials, processes and equipment to:

- Improve product performance
- Reduce energy consumption and material cost
- Develop green technology
- Enhance material properties and performance
- Increase net shape capabilities

These activities are essential and enable GKN to provide creative solutions to our global customer base.

CONVENTIONAL PM
Improvements in materials and processes has resulted in a new class of high performance, consistent, competitive and creative products.

ALUMINIUM PM
Providing engineers with a new tool for weight reduction and improved product performance, GKN is taking PM Aluminium to a new level by leveraging unique materials capabilities not possible with competing technologies.

SOFT MAGNETIC PM
Enables engineers to develop smaller products with improved performance for electric motors and electromechanical systems.

SURFACE DENSIFIED PM
This technology enables GKN to deliver gears that combine the net shape advantages of PM technology with the performance of wrought steel.

POROUS METAL FILTERS
These filters and components are based on GKN’s controlled porosity materials for demanding applications where traditional filters are unable to deliver.

METAL INJECTION MOLDING (MIM)
MIM is 3D shape capability of plastic injection molding combined with the performance of alloy steels, stainless steels and high temperature alloys.

STAINLESS STEEL PM
Excellent choice for optimum corrosion resistance in high demand applications.

FORGED PM
This process step creates a nearly full dense part with high dynamic loads by utilizing a closed die which creates high axial precision.

ADDITIVE MANUFACTURING
In a competitive environment, speed is a crucial enabler and getting your solution to market first is a clear advantage. GKN’s additive manufacturing capabilities are allowing us and our partners to develop products more rapidly without need for product specific molding tools.
ENGINEERING CAPABILITIES

3D DESIGN FREEDOM
GKN’s 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.

This outstanding design freedom enables innovative and more efficient designs.

OUR INNOVATION CENTRES
As an essential building block of our company, the three innovation centers of GKN are supporting the development processes of our customers. The R&D centers are equipped with full size production facilities and advanced materials laboratories.

The analysis and simulation service of our R&D centers covers the entire life-cycle from the review of the technical feasibility of new ideas and technologies, up to the product development and production phase.

ENGINEERING
• GKN’s competence in engineering and design for best possible customer satisfaction
• ~ 550 highly qualified engineers and designers

SIMULATION
• Structural mechanic simulation and system design
• Thermal simulation
• Electromagnetic simulation

DESIGN FOR PM
• Benefit from reduced total-cost-of-ownership (TCO) through GKN's development experience and support
• Technology-oriented design for cost efficient production
• Reduced development periods
• Added value due to integrated functionality

ADVANCED ENGINEERING POWDER METALLURGY SITES
RADEVORMWALD  AUBURN HILLS  CINNAMINSON
MATERIAL OVERVIEW

- Engineered powders optimized to reach mechanical and magnetic properties
- Extensive knowledge on characteristics of our materials

METROLOGY

- B-H field meter
- Coercimeter
- Resistance test

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

NOTCH SENSITIVITY

GKN has introduced a worldwide accepted correction factor to figure out the lower notch sensitivity of PM-steels. With that approach, the effective stress concentration of a notch in different materials can be predicted more realistically. The part design and the material can be adopted. Sintered steels are less notch sensitive.

FATIGUE ENDOURANCE LIMIT

The estimation of the fatigue endurance limits is an important step for GKN for the prediction of the part’s endurance.

The fatigue endurance limits and the scatter bands of sintered steels are comparable to those from conventional design materials. They can be influenced by the density, material alloys and by a potential following heat treatment.

TENSILE STRENGTH

Sintered metal is light and strong. The weight advantage of sintered metal is based on its lower density at a comparable tensile strength. The density can be adjusted customer-specifically by the compaction pressure.
The world continues to change and GKN Powder Metallurgy is at the forefront of this change. With advanced forming technologies and intelligent product solutions, GKN offers technologically differentiated products.
Living the avenue of innovation, GKN is steadily expanding the boundaries of powder metallurgy in order to open up new areas of automotive and industrial applications for powder metal. We are focusing our research and development with activities in providing further unique product solutions for today and to enable life changing technologies for the future.
## MARKETS AND PRODUCTS

<table>
<thead>
<tr>
<th>Market</th>
<th>Products</th>
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| Aerospace        | - Camshaft Components  
|                  | - Connecting Rods  
|                  | - Main Bearing Caps/Inserts  
|                  | - Timing System Components  
|                  | - Variable Valve Timing  
|                  | - Camshaft Caps  
|                  | - Turbocharger Components  
|                  | - Starter and Stop/Start System Components  |
| Automotive       | - Engine Components:  
|                  |  - Camshaft Components  
|                  |  - Connecting Rods  
|                  |  - Main Bearing Caps/Inserts  
|                  |  - Timing System Components  
|                  |  - Variable Valve Timing  
|                  |  - Camshaft Caps  
|                  |  - Turbocharger Components  
|                  |  - Starter and Stop/Start System Components  |
| Bicycles         | - Engine Components:  
|                  |  - Camshaft Components  
|                  |  - Connecting Rods  
|                  |  - Main Bearing Caps/Inserts  
|                  |  - Timing System Components  
|                  |  - Variable Valve Timing  
|                  |  - Camshaft Caps  
|                  |  - Turbocharger Components  
|                  |  - Starter and Stop/Start System Components  |
| Compressors      | - Fluid Technology Components:  
|                  |  - Compressor Components  
|                  |  - Gear Pump Components  
|                  |  - Planetary Rotor Pump  
|                  |  - Oil- and Water Pump Components  
|                  |  - Crescent Pump Components  
|                  |  - External Gear Pump Components  
|                  |  - G-Rotor Pump Components  
|                  |  - Pendulum Pump Components  
|                  |  - Piston Pump Components  
|                  |  - Vacuum Pump Components  
|                  |  - Constant Vane Pump Components  
|                  |  - Variable Vane Pump Components  |
| Food Industry    | - Fluid Technology Components:  
|                  |  - Compressor Components  
|                  |  - Gear Pump Components  
|                  |  - Planetary Rotor Pump  
|                  |  - Oil- and Water Pump Components  
|                  |  - Crescent Pump Components  
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|                  |  - Pendulum Pump Components  
|                  |  - Piston Pump Components  
|                  |  - Vacuum Pump Components  
|                  |  - Constant Vane Pump Components  
|                  |  - Variable Vane Pump Components  |
| Furniture        | - Fluid Technology Components:  
|                  |  - Compressor Components  
|                  |  - Gear Pump Components  
|                  |  - Planetary Rotor Pump  
|                  |  - Oil- and Water Pump Components  
|                  |  - Crescent Pump Components  
|                  |  - External Gear Pump Components  
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|                  |  - Piston Pump Components  
|                  |  - Vacuum Pump Components  
|                  |  - Constant Vane Pump Components  
|                  |  - Variable Vane Pump Components  |
| Lawn & Garden    | - Fluid Technology Components:  
|                  |  - Compressor Components  
|                  |  - Gear Pump Components  
|                  |  - Planetary Rotor Pump  
|                  |  - Oil- and Water Pump Components  
|                  |  - Crescent Pump Components  
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|                  |  - Vacuum Pump Components  
|                  |  - Constant Vane Pump Components  
|                  |  - Variable Vane Pump Components  |
| Market Appliances| - Fluid Technology Components:  
|                  |  - Compressor Components  
|                  |  - Gear Pump Components  
|                  |  - Planetary Rotor Pump  
|                  |  - Oil- and Water Pump Components  
|                  |  - Crescent Pump Components  
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|                  |  - Piston Pump Components  
|                  |  - Vacuum Pump Components  
|                  |  - Constant Vane Pump Components  
|                  |  - Variable Vane Pump Components  |
| Medical          | - Fluid Technology Components:  
|                  |  - Compressor Components  
|                  |  - Gear Pump Components  
|                  |  - Planetary Rotor Pump  
|                  |  - Oil- and Water Pump Components  
|                  |  - Crescent Pump Components  
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|                  |  - Piston Pump Components  
|                  |  - Vacuum Pump Components  
|                  |  - Constant Vane Pump Components  
|                  |  - Variable Vane Pump Components  |
| Motorcycles      | - Fluid Technology Components:  
|                  |  - Compressor Components  
|                  |  - Gear Pump Components  
|                  |  - Planetary Rotor Pump  
|                  |  - Oil- and Water Pump Components  
|                  |  - Crescent Pump Components  
|                  |  - External Gear Pump Components  
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|                  |  - Piston Pump Components  
|                  |  - Vacuum Pump Components  
|                  |  - Constant Vane Pump Components  
|                  |  - Variable Vane Pump Components  |
| Off-Highway      | - Fluid Technology Components:  
|                  |  - Compressor Components  
|                  |  - Gear Pump Components  
|                  |  - Planetary Rotor Pump  
|                  |  - Oil- and Water Pump Components  
|                  |  - Crescent Pump Components  
|                  |  - External Gear Pump Components  
|                  |  - G-Rotor Pump Components  
|                  |  - Pendulum Pump Components  
|                  |  - Piston Pump Components  
|                  |  - Vacuum Pump Components  
|                  |  - Constant Vane Pump Components  
|                  |  - Variable Vane Pump Components  |
| Power Tools      | - Fluid Technology Components:  
|                  |  - Compressor Components  
|                  |  - Gear Pump Components  
|                  |  - Planetary Rotor Pump  
|                  |  - Oil- and Water Pump Components  
|                  |  - Crescent Pump Components  
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|                  |  - Vacuum Pump Components  
|                  |  - Constant Vane Pump Components  
|                  |  - Variable Vane Pump Components  |
| Sub Segments     | - Fluid Technology Components:  
|                  |  - Compressor Components  
|                  |  - Gear Pump Components  
|                  |  - Planetary Rotor Pump  
|                  |  - Oil- and Water Pump Components  
|                  |  - Crescent Pump Components  
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|                  |  - Piston Pump Components  
|                  |  - Vacuum Pump Components  
|                  |  - Constant Vane Pump Components  
|                  |  - Variable Vane Pump Components  |
| Sewing Machines  | - Fluid Technology Components:  
|                  |  - Compressor Components  
|                  |  - Gear Pump Components  
|                  |  - Planetary Rotor Pump  
|                  |  - Oil- and Water Pump Components  
|                  |  - Crescent Pump Components  
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|                  |  - Piston Pump Components  
|                  |  - Vacuum Pump Components  
|                  |  - Constant Vane Pump Components  
|                  |  - Variable Vane Pump Components  |
| Trucks & Buses   | - Fluid Technology Components:  
|                  |  - Compressor Components  
|                  |  - Gear Pump Components  
|                  |  - Planetary Rotor Pump  
|                  |  - Oil- and Water Pump Components  
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### ENGINE
- Camshaft Components
- Connecting Rods
- Main Bearing Caps/Inserts
- Timing System Components
- Variable Valve Timing
- Camshaft Caps
- Turbocharger Components
- Starter and Stop/Start System Components

### TRANSMISSION
- Torque Converter
- One Way Clutch
- Planetary Carriers
- Transmission One Way Clutch
- Clutch Hubs/Plates
- Parking Gears
- Main Drive Gears
- Shifting/Synchronizer Components

### BODY & CHASSIS
- Mirror & Sensor Fixtures
- Door Components
- Passenger/Pedestrian Safety Components
- Seating Components
- Steering System Components
- Braking System Components
- Exhaust Components
- Gear Drives
- Shock Absorber Components

### DRIVELINE
- Differential Gears and -bearing Caps
- Rear Axle Bearing Adjusters
- Transfer Case Components
- Cam Rings

### FLUID TECHNOLOGY
- Compressor Components
- Gear Pump Components
- Planetary Rotor Pump
- Oil- and Water Pump Components
- Crescent Pump Components
- External Gear Pump Components
- G-Rotor Pump Components
- Pendulum Pump Components
- Piston Pump Components
- Vacuum Pump Components
- Constant Vane Pump Components
- Variable Vane Pump Components

### MECHATRONICS
- Sensor Components
- Solenoid Components
- Heat Sinks
- Electromagnetic Clutch and Brake Components
- Axial Flux Motor and Generator Components
- Linear Motor Components
- Transversal Flux Motor/Generator Components

### FILTERS APPLICATIONS
- Beverage Industry – Filters and Spargers
- Catalyst Recovery Filter
- Catalyst Recovery Filter in H2O2 Production
- Chemical Industry
- Flame Arrestors
- Fluidization Elements
- Hotgas > 300°C: Polysilicone
- Oil Burner Filter
- Pneumatic Silencer
- Sensor Protection
- Spargers
GKN SINTER METALS OFFERS THE BROADEST MATERIAL SELECTION IN THE INDUSTRY TO MEET A WIDE RANGE OF NEEDS.

Manufacturing components from metal powder can reduce weight as well as minimize manufacturing costs through a process that allows broader design capabilities.

When selecting the best PM material for a particular application, consideration is given to requirements such as strength, ductility and wear-resistance. With our advanced alloys and processing techniques, GKN PM components often exceed industry performance standards.

**Powder Metallurgy: A Recognized Green Technology**

GKN Sinter Metals’ technologies are environmentally friendly and save natural resources through recycling. All manufacturing processes are energy-efficient, yield low emissions and conserve raw materials.

<table>
<thead>
<tr>
<th>Classification</th>
<th>Description</th>
<th>Conventional</th>
<th>Forged</th>
<th>MIM *</th>
<th>Filters</th>
<th>Bearings</th>
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<tbody>
<tr>
<td>Iron &amp; Steel</td>
<td>Iron</td>
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<td>Plain Carbon Steel</td>
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<td>(Cu, Ni, Mo, Mn, Cr) **</td>
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<td>Specialized Alloy Steel **</td>
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<td>Stainless Steel</td>
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<td>(P, Si, and Ni) **</td>
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<td>Diluted Bronze</td>
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<tr>
<td>Aluminum Alloys ***</td>
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<td>Thermal Series (TC-2000)</td>
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<td>Mechanical Strength Series (MMC-1)</td>
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</table>

* Metal Injection Molding
** Several PM alloying methods are utilized: elemental blends, diffusion bonded, fully alloyed, or combinations of these.
*** Various alloys are available including 2014 (Al-Cu-Mg-Si), 6061 (Al-Mg-Si-Cu) and 7075 (Al-Zn-Cu-Mg) plus Metal Matrix Composite (MMC) variants.
THE PM PROCESS

GKN’S POWDER METAL MANUFACTURING PROCESS IS BEST-IN-CLASS FOR INNOVATION AND NET SHAPE CAPABILITIES.

GKN’s manufacturing process offers one of the most cost effective ways to produce high volume parts with the highest demand on accuracy, reproducibility, cleanliness and quality.

The PM production technique excels when compared with the cost of other metal shaping processes. Four important criteria characterize the process:

- 100% material utilization (no scrap loss)
- Wide variety of design possibilities with limited impact on production costs
- The utilization of all material properties in order to enhance the component functionality
- Environmentally-friendly

AWARDS

Awards from our customers, business partners and other organisations we work with are highly valued and we take great pride in these achievements. They reflect best our constant drive towards customer satisfaction and business excellence.
GROUP OVERVIEW

GKN IS A GLOBAL ENGINEERING GROUP.

Every day we drive the wheels of hundreds of millions of cars, we help thousands of aircraft to fly, we deliver the power to move earth and harvest crops, and we make essential components for industries that touch lives across the globe.

Approximately 56,100 people work in GKN companies and joint ventures around the world. Together, we use our footprint in over 30 countries, harnessing our technology and our considerable manufacturing resources to supply the highest quality systems, structures, components and services.

OUR OPERATIONS.

We have three operating divisions: GKN Powder Metallurgy, GKN Driveline and GKN Aerospace.

Every division is a market leader, each outperforming its markets, giving unrivalled expertise and experience in delivering cutting-edge technology and engineering to our global customers.

GKN POWDER METALLURGY

GKN Powder Metallurgy is a partnership of GKN Sinter Metals and Hoeganaes, one of the world’s largest metal powder manufacturers.

Hoeganaes produces the metal powder used by GKN Sinter Metals to manufacture precision components for automotive, industrial and consumer applications.

GKN AEROSPACE

GKN Aerospace is a leading global tier 1 supplier of airframe and engine structures, components, assemblies and transparents to a wide range of aircraft and engine prime contractors and other tier 1 suppliers.

It operates in three main areas: aerostructures, engine components and subsystems, and special products.

GKN DRIVELINE

As a global business serving the world’s leading vehicle manufacturers, GKN Driveline develops, builds and supplies an extensive range of automotive driveline products and systems for use in the most sophisticated premium vehicles that demand complex driving dynamics to the smallest ultra low-cost cars.
GLOBAL SALES OFFICES

AMERICAS
USA
1670 Opdyke Court, Auburn Hills, MI 48326-2431, USA
infona@gknpm.com

MEXICO
Av. Dr. Jesús Valdes Sánchez 1
Parque Industrial Amistad Chuy Maria
38187 Apaseo el Grande, Guanajuato
infomexico@gknpm.com

BRAZIL
Av. Emancipação, 4.500
CEP 13186-542
Hortolândia – SP, Brazil
infobrazil@gknpm.com

ASIA
CHINA
Suite 1105-1110, POS Plaza
1600 Century Avenue
Pudong, Shanghai 200122, China
infochina@gknpm.com

INDIA
14/6 Mumbai - Pune Road
Pimpri, Pune 411018
Maharashtra, India
infoindia@gknpm.com

JAPAN
Senri Life Science Center Bldg, 12F
1-4-2 ShinSenri Higashi-machi
Togonaka-city, Osaka, 550-0082
Japan
infojapan@gknpm.com

EUROPE
UNITED KINGDOM
Unit 7 Chestnut Court, Jill Lane
Sambourne, Redditch
Worcestershire, B96 6EW, UK
infouk@gknpm.com

GERMANY
Krebsstuge 10
42 477 Radevormwald, Germany
infogermany@gknpm.com

ITALY
Fabrikstrasse 5
39 031 Bruneck (BZ), Italy
infoitaly@gknpm.com

SWEDEN
Gothenburg, Sweden
infosweden@gknpm.com

FRANCE
6 Lotissement les Cruzettes
38210 Tullins, France
infofrance@gknpm.com

TURKEY
Istanbul Ataturk Havalimani serbest bolgesi
L Blok No:2
34149 Yesilkoy-Istanbul/Turkey
infoturkey@gknpm.com

Over 30 locations in 13 countries on 4 continents

For specific details and contact information please write to us at contact@gknpm.com or visit our website www.gknpm.com