

ENGINE PRODUCTS

**MADE BY
POWDER
METALLURGY**



Solutions with great performance & high quality

CONTENT

3	BENEFITS OF POWDER METALLURGY
4-5	PM IS AN AVENUE OF INNOVATION
6	ENGINEERING CAPABILITIES
7	MATERIAL CAPABILITIES
	GKN ENGINE PRODUCTS
8	ALL PM G-ROTOR PUMPS
9	BALANCER WEIGHTS
10	CAM CAPS IN ALUMINIUM
11	CAMSHAFT COMPONENTS
12	FORGED PM CONNECTING RODS
13	INJECTOR CLAMPS
14	MAIN BEARING CAPS
15	ROLLER FINGER FOLLOWER
16	START-STOP COMPONENTS
17	TIMING GEARS
18	TRI-OVAL PULLEYS AND SPROCKETS
19	TURBO/SUPERCHARGER MIM COMPONENTS
20	VALVE COMPONENTS
21	VARIABLE VANE PUMP COMPONENTS
22	VARIABLE VALVE TIMING COMPONENTS
23	NOTES

GKN Sinter Metals is the world's largest producer of precision powder metal products. With a focus on superior delivery, quality and total solutions, we offer extensive technical expertise in design, testing and various process technologies.

Our global footprint spans more than 13 countries across five continents. With more than 30 global locations and more than 6,000 employees we are always in close proximity to our customers.

ONE OF THE KEY APPLICATION AREAS OF POWDER METALLURGY (PM) IN LIGHT VEHICLES ARE ENGINE PRODUCTS. THIS BROCHURE PROVIDES INSIGHT INTO THE BROAD SPECTRUM OF INNOVATIVE PRODUCT SOLUTIONS WE ARE DEVELOPING AND MANUFACTURING HERE.

THINK > BENEFITS OF POWDER METALLURGY

- > Improved wear capability
- > Improved thermal conductivity
- > Tighter tolerances



- > Net shape forming capabilities
- > Ability to create design solutions that save secondary processes



- > > 95% material utilization
- > Recycled raw materials
- > Lower energy consumption with reduced processes



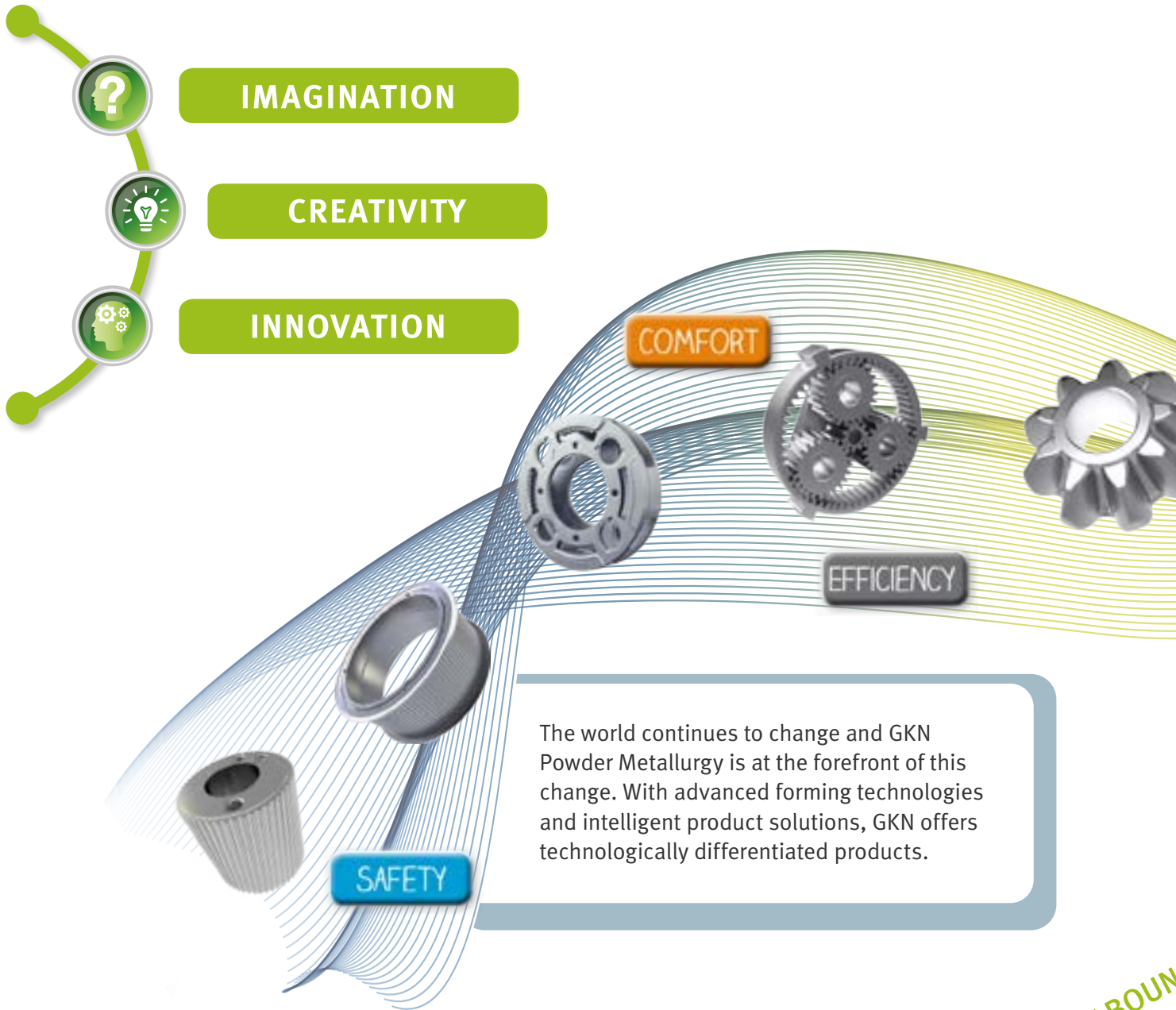
- > Use of lightweight materials
- > Weight reduction capability through design (for PM)



- > Elimination of secondary machining
- > Reduced part complexity utilizing fewer components



PM IS AN AVENUE OF INNOVATION

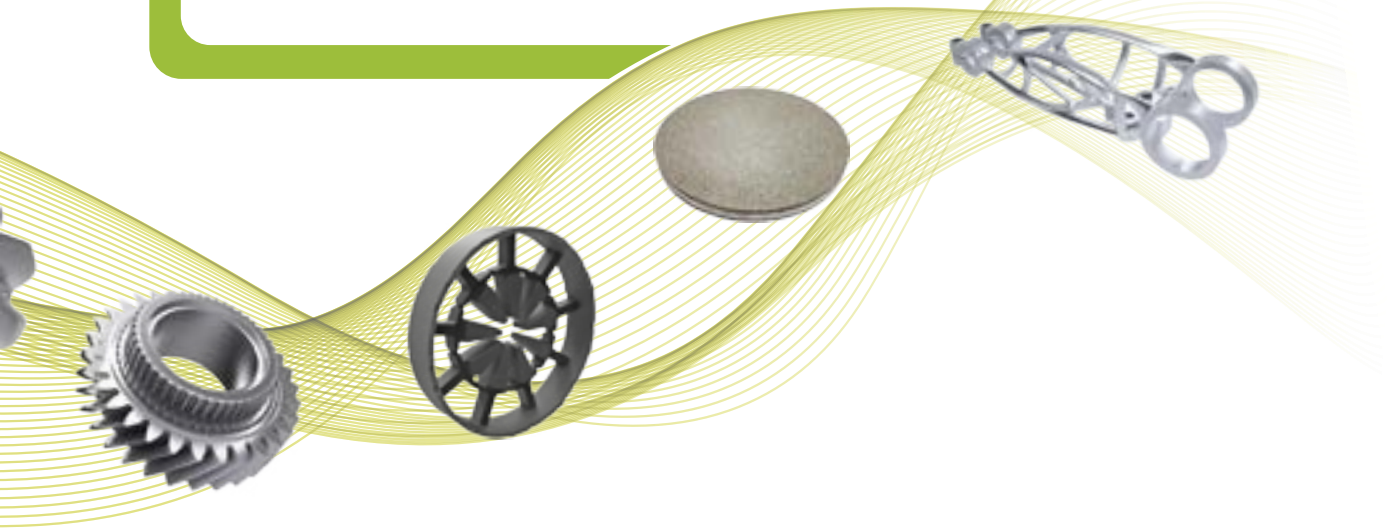


The world continues to change and GKN Powder Metallurgy is at the forefront of this change. With advanced forming technologies and intelligent product solutions, GKN offers technologically differentiated products.

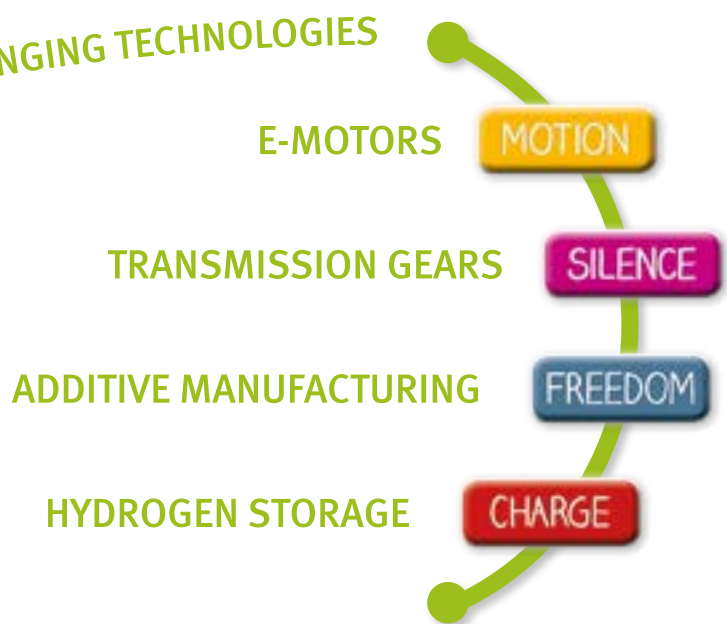


TECHNOLOGICALLY DIFFERENTIATED PRODUCTS + EXPANDING THE BOUNDARIES

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 activities in providing further unique product solutions for today and to enable life changing technologies for the future.



BOUNDARIES OF POWDER METALLURGY > LIFE CHANGING TECHNOLOGIES



ENGINEERING CAPABILITIES

3D DESIGN FREEDOM

GKN's capabilities 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.

This exceptional design freedom enables innovative and more efficient designs.



OUR INNOVATION CENTRES

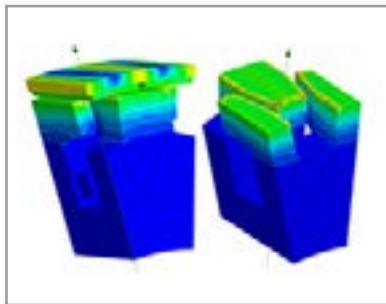
As an essential building block of our company, the three innovation centers of GKN are supporting the development processes of our customers. The R&D centers are equipped with full size production facilities and advanced materials laboratories.

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 global engineering team has the resources and expertise to optimise product design generating value for our customers
- ~ 550 highly qualified engineers and designers



SIMULATION

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



DESIGN FOR PM

- Utilise GKN's know-how as a partner in product development
- 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 CAPABILITIES

MATERIAL OVERVIEW

- Engineered powders optimized to reach mechanical and magnetic properties
- Know How on Characteristics of our material



METROLOGY

- B-H field meter
- Coercimeter
- Resistance test



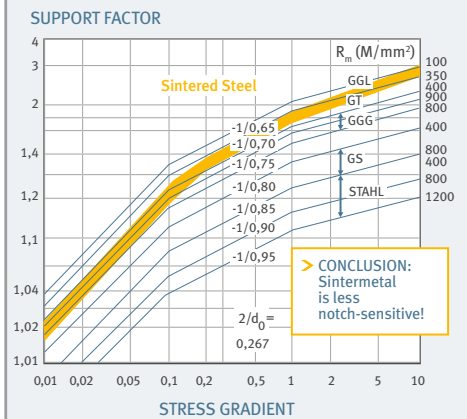
MATERIALS & ENGINE TEST BENCHES

- In-house materials test center for tensile testing, service life tests, elevated temperature testing and tribological testing
- In-house variable engine test for performance tests, long-run performance and 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. Sintered steels are less notch sensitive.



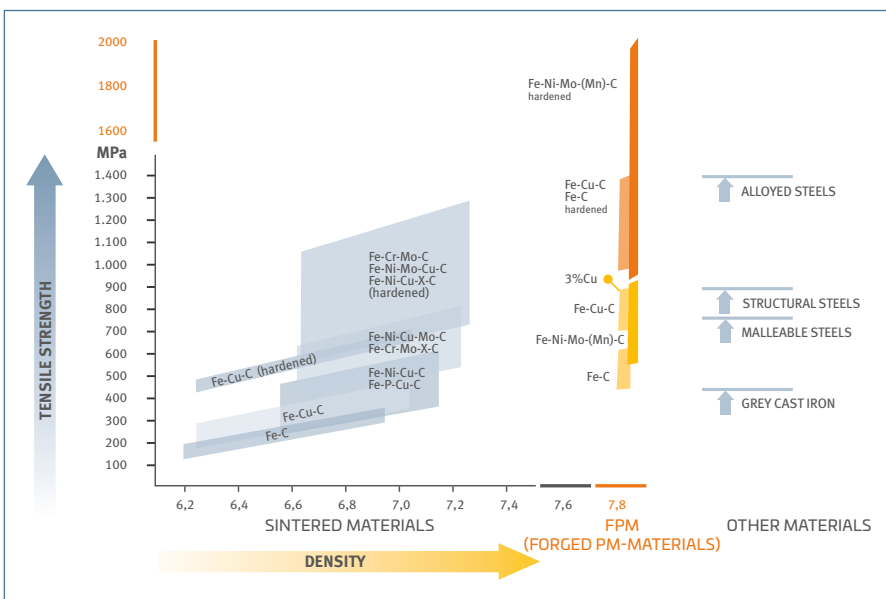
FATIGUE ENDURANCE LIMIT

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

The fatigue endurance limits and the scatter bands of sintered steels are comparable to those from conventional design materials. They can be influenced by density, alloying or 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 by customer specific compaction pressure.



ALL PM G-ROTOR PUMPS



The common pump design considers a mix of different materials. Due to different expansion factors of each material, this ends up with some performance drop in case of temperature variations during the real driving cycle of a vehicle.

The integration of an all-PM-pump, which uses PM steel only, prevents performance loss. The expansion is uniform for all pump components and aids in better performance, saving of energy and reduction of CO₂ emissions.

KEY BENEFITS

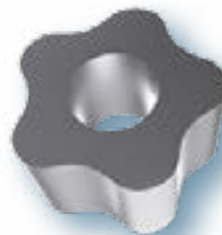
- Tailor made design according customer needs
- Long service life
- Reduced wall thickness
- Lubrication and actuation pumps
- High efficiency due to optimized clearances ends up in CO₂ reduction
- Excellent hydraulic volumetric efficiency
- PM net shape advantage reduces material waste and machining costs



G-ROTOR/ STATOR PAIR



G-STATOR



G-ROTOR



PUMP FACE COVER



BALANCER WEIGHTS



HIGHLY PRECISE BORE,
PROFILE AND
MASS CONTROL

KEY BENEFITS

- Unparalleled design freedom for optimized balancing and light weight
- Highly precise bore, profile and mass control
- Nearest to net shape design with reduced machining operations
- Supplied machined or only sized, depending on customer specific requirements

Customer expectations for smooth running and quiet engines have increased the need for balance shafts which are added to engines to minimize vibration. Composite or modular balance shafts, made by assembling counterweights, drive gears and other components onto a tube, offer a lightweight and competitive solution.

Reduced weight variation assures balance shaft performance to offset engine vibration. Optimized geometries and tolerances assure accurate fit and simple assembly to the shaft and drive system.

CAM CAPS IN ALUMINIUM



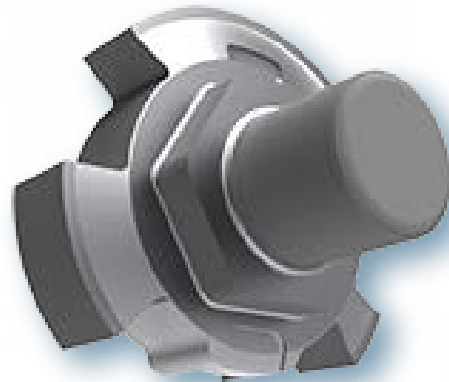
KEY BENEFITS

- Engineered light weight product – ready to install in engine
- Near net shape design – only single line boring operation needed
- Designed for precise and low force installation, removal and reinstallation
- Integrated dowel option – eliminates costly machining and dowels
- Lower friction during cold startup – due to oil retention in controlled micro porosity
- Unique material solutions: standard, heat treated, or metal matrix composite materials for increased strength and wear resistance at elevated temperatures

Camshaft caps (cam caps) are structural light weight aluminum engine components used to mount the camshaft to the cylinder head. They are used in internal combustion engines where increasing demands and complexity make them ideally suited to the PM process.

GKN's PM aluminum cam caps offer unsurpassed dimensional control, strength, wear resistance and oil retention characteristics. The combination of design freedom, net shape capability and the established performance of the PM process delivers a highly competitive solution, managing logistics and ensuring simple installation.

CAMSHAFT COMPONENTS



TARGET WHEEL

The global automotive market for camshafts has been steadily transitioning from solid cast iron camshafts to lighter weight modular assembled camshafts to optimize performance and reduce finishing costs.

PM components offer a competitive and high performance solution.

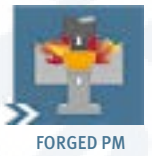


CAM LOBES

KEY BENEFITS

- Elimination of induction hardening by one-step-sinter-hardening
- Reduced finish grinding – improved dimensional precision or cam lobes
- Unique design solutions for dual profile cam designs
- Target wheels with complex net shape geometry & excellent magnetic material response

FORGED PM CONNECTING RODS



Connecting rods are key engine components that are the link between the piston and the crankshaft. This allows the reciprocating motion resulting from combustion to be converted into the rotary motion of the crankshaft. The energy is transmitted through the connecting rod, making this a highly stressed component.

Forged PM technology has a long and proven track record of meeting performance and competitive requirements for many customers and applications.

KEY BENEFITS

- Low reciprocating mass, high stiffness, optimized designs, efficient material utilization
- Class-leading strength and performance consistency due to fully homogenous alloy microstructure
- Highly consistent mass control – lowest number of weight classes
- Near net shape capability and fracture split notches enable for fewer finishing operations
- Machinability and strength matched to customer requirements
- In house performance validation and machinability testing



GKN'S PRECISION FORGED PM CONNECTING RODS ARE FEATURING FRACTURE SPLIT NOTCH.



INJECTOR CLAMPS



Fuel injected engines require a clamp to retain the injector in place. PM technology has proven to be an effective and competitive solution for this application.

PM injector clamps are fully engineered products which leverage advanced designs, high strength materials and net shape capability.

KEY BENEFITS

- Engineered product – ready to install
- Unparalleled design freedom and high strength materials to minimize size and weight
- Optimized clamping contact patterns
- Net shape designs
- Heat treated if required
- High accuracy
- No plastic deformation



Main Bearing caps are used in engines to secure the crankshaft to the engine block. GKN pioneered the PM main bearing cap (MBC) and introduced the near to net shape “ready to install” engineered MBC to the market.

By focusing on improved materials and advanced designs, GKN has helped many customers optimize their engines and realize the most competitive, highest performance and lightest weight solution.

KEY BENEFITS

- Strength to Weight ratio better than ductile cast iron
- Delivered “ready to install”- minimal crank bore machining required
- Geometry optimized for ease of installation, removal and reinstallation
- In-house validation and machinability testing
- Net shape, low material waste
- Global capability: manufactured in three regions
- Reduced process steps compared to common technology, therefore higher quality aspect
- Flexible design possibilities

ROLLER FINGER FOLLOWER



The 'roller finger follower' is an excellent example of how Metal Injection Moulding (MIM) design can integrate a variety of functions in a single component.

This part is used in the valve train of passenger cars as part of a cam follower system that is capable of shutting off a cylinder while the engine is running. Due to the high strength of the heat treated steel a lightweight design can be achieved.

KEY BENEFITS

- High strength and wear resistant materials
- Complex part design with integrated functions
- High dimensional accuracy
- Optimized for minimum friction and valve clearance compensation

Start-stop technology in cars is increasingly prevalent as vehicle manufacturers seek to reduce CO₂ emissions.

Ring gears are one of the main components of the gear set in the starter motor and are typically made from plastic. Within the start-stop technology gears need to be stronger and more durable to withstand more frequent stress.

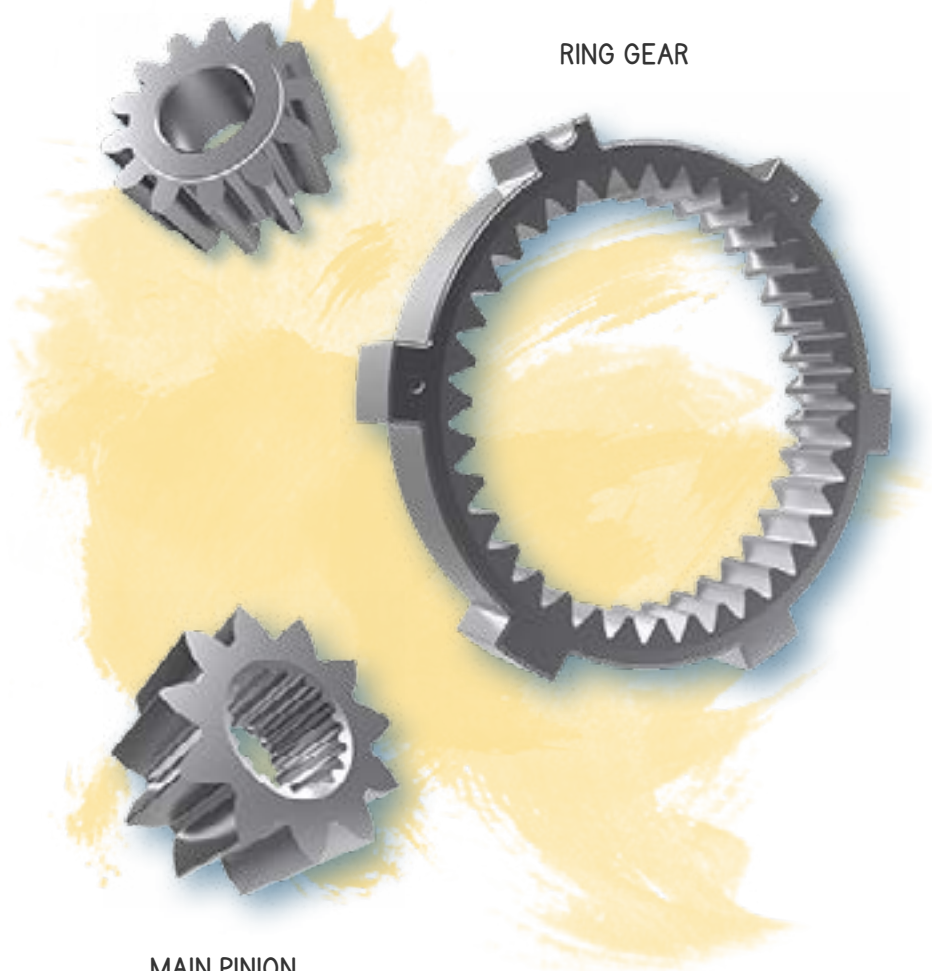
Creating the ring gears from powder metal provides a lightweight, high-performing solution, which is more resistant to wear and can achieve tighter tolerances.



PLANETARY GEAR SET

PLANETARY GEAR

RING GEAR



MAIN PINION

KEY BENEFITS

- Low friction surfaces
- Best net shape tolerances
- High density & torque performance
- Custom-tailored tooth spline geometry

TIMING GEARS



GKN Sinter Metals produces high-performing gears for engine applications.

With the specific "design for PM" approach the manufacturing process is significantly reduced, limiting the need for machining, energy and waste.

KEY BENEFITS

- Reduced noise, vibration harshness (NVH)
- Net shape or near to net shape designs save machining at customers.
- Tailor-made PM design with multipart substitution and downsizing
- Enables light weight solutions
- Easy to assemble zero backlash solution due to reduction in the number of parts

TRI-OVAL PULLEYS AND SPROCKETS



UNIQUE GEOMETRY ENABLED BY PM REDUCES NVH



PULLEY

SPROCKET

Pulleys and sprockets are typically used in engines to drive crankshaft and camshaft timing systems. Complex geometry makes these products an ideal application for PM technology.

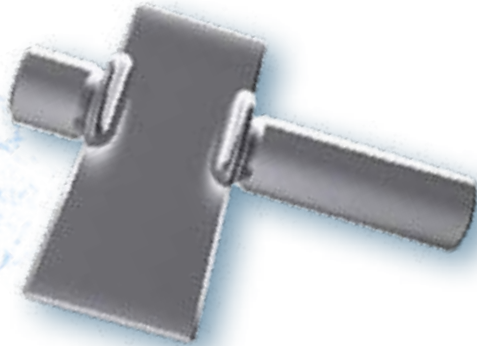
Net or near net shape teeth, weight reduction features and integrated drive features gives PM an advantage over other metal working processes.

With decades of design, engineering and manufacturing experience combined with advanced process and material solutions, GKN has helped many customers optimize their product designs according to the specific application requirements.

KEY BENEFITS

- Net shape designs optimize light weighting
- Design freedom facilitates unique net shape features such as lightening holes and drive features like keys, keyways and slots
- Induction hardened or low distortion sinter hardened options
- Unique joining technology facilitates the addition of stamped flanges or sensor rings

TURBO/SUPERCHARGER MIM COMPONENTS



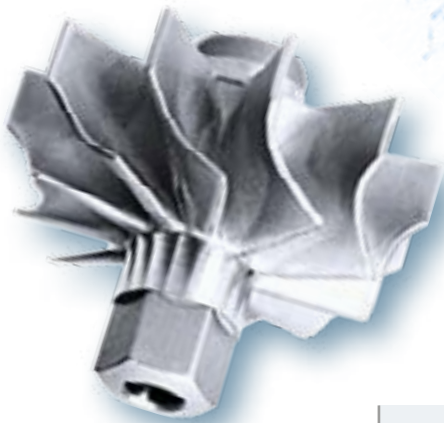
VANE



VANE LEVER



ADJUSTMENT RINGS



IMPELLER

KEY BENEFITS

- Near net shape capabilities - only minor machining required
- Unique high temperature corrosion and wear resistant materials
- Proven manufacturing capability

Variable geometry turbochargers (VGT's) are designed to allow the aspect ratio of the system to adjust to the optimum pitch depending on engine speeds.

A key component in this system is a ring of aerodynamically-shaped, movable vanes in the housing at the turbine inlet.

Complex geometry combined with a high temperature corrosive environment are ideally matched to the shape and materials capabilities of the Metal Injection Molding (MIM) process.

KEY BENEFITS

- Unique materials combine excellent valve lubrication and machinability
- Improved wear and scuffing resistance
- Improved lubrication by filling micro-porosity with oil by vacuum impregnation
- Near net shape – only minimal finish machining required

Valve Guides: PM has proven to be the excellent solution for valve guides through the combination of unique wear resistant and self-lubricating materials, which provides an optimal combination of wear & scuffing resistance, lubrication and machinability. Inherent porosity helps in oil retention giving additional lubricity and reduced wear.



KEY BENEFITS

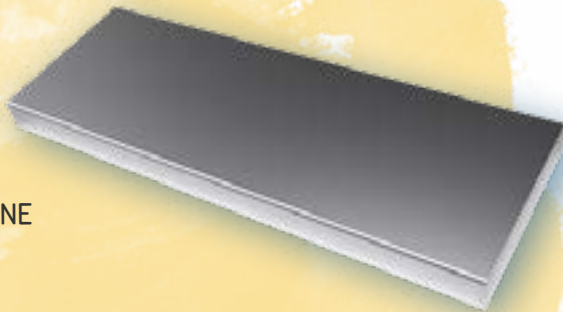
- Unique materials combine excellent machinability, thermal conductivity and wear resistance
- Dual material compaction technology allows high alloy material in valve seating area and lean alloy material at bottom, providing both higher performance and cost optimization
- Fully dense matrix by copper infiltration enhances thermal properties and machinability
- High material utilization through near net shape capability which requires minimal finish machining

Valve Seat Inserts: PM provides the possibility of combining various alloy systems which allows application specific solutions ranging from 80cc engine to as high as 17.0L engine. Wear resistance at high temperatures, excellent thermal properties and very good machinability are the major advantages of PM valve seat inserts.

VARIABLE VANE PUMP COMPONENTS



HOUSING



VANE



ROTOR

Variable vane pumps can be adjusted so that the output is adapted to application demands. This allows for improved efficiency and lower energy consumption.

Due to the complex geometry and requirements for high precision and performance, PM technology has proven to be an ideal manufacturing solution for many challenging applications.

GKN supplies rotors, vanes and housing components and works on all PM pump solutions.

KEY BENEFITS

- Improved surface tribology
- Net shape vane geometry
- Reduced energy consumption
- All PM version for highest efficiency
- Material & hardness custom-tailored to match performance requirements

VARIABLE VALVE TIMING COMPONENTS



In order to achieve requirements to reduce both automotive fuel consumption and CO₂ emissions, while also increasing performance, systems that optimize camshaft or valve timing are of increasing importance.

PM has proven to be an ideal solution for variable cam timing (VCT) and variable valve timing (VVT) components by facilitating freedom of design and delivering highly precise, complex products.

KEY BENEFITS

- Best net shape accuracy
- Compact light weight designs
- Reduced machining with multi part design
- Low friction with custom surface geometry
- Proven dimensional precision reduces internal oil losses
- Unique machining process simplifies deburring
- Induction hardened or low distortion sinter-hardened sprockets

COMBINED VVT SPROCKET-STATOR



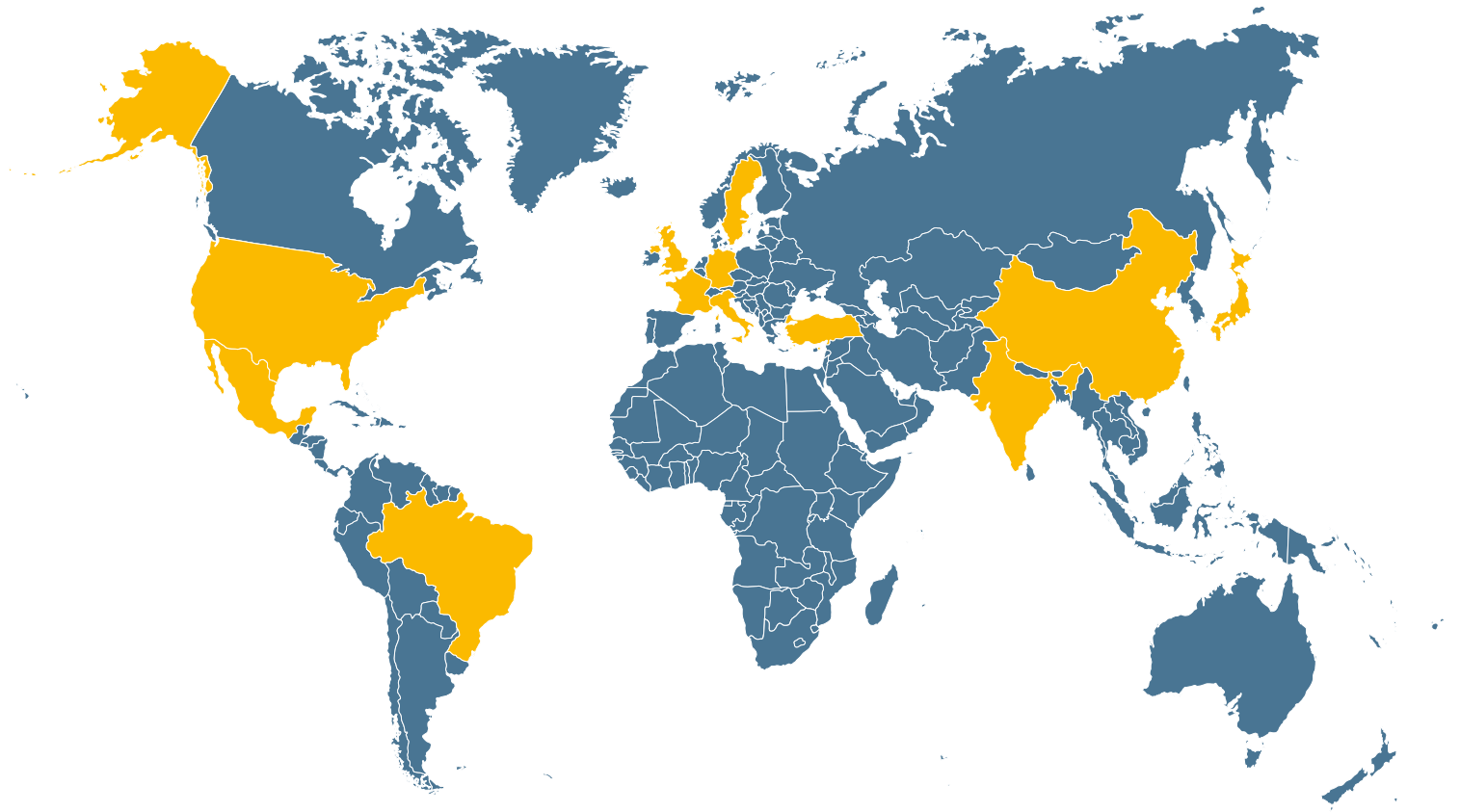
ROTOR VVT



STATOR VVT



ROTOR VVT



GKN Locations

Over 30 locations
in 12 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

GLOBAL SALES OFFICES

AMERICAS

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

MEXICO
Av. Dr. Jesús Valdés Sánchez, No. 104
Parque Industrial Amistad Chuy María
38194 Apaseo El Grande, Gto.
infomexico@gknpm.com

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

ASIA

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

INDIA
146 Mumbai - Pune Road
Pimpri, Pune 411018
Maharashtra, India
infoindia@gknpm.com

JAPAN
Senri Life Science Center Bldg. 12F
1-4-2 ShinSenri Higashi-machi
Toyonaka-city, Osaka, 560-0082
Japan
infojapan@gknpm.com

EUROPE

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

GERMANY
Krebsöge 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