

DRIVETRAIN PRODUCTS

MADE BY
POWDER
METALLURGY



Advanced precision and quality



CONTENT

3	BENEFITS OF POWDER METALLURGY
4-5	PM IS AN AVENUE OF INNOVATION
6	ENGINEERING CAPABILITIES
7	MATERIAL CAPABILITIES
	GKN DRIVETRAIN PRODUCTS
8	ALL PM G-ROTOR PUMPS
9	BEARING ADJUSTERS
10	CAM RINGS
11	CLUTCH HUBS
12	CLUTCH & PRESSURE PLATES
13	DIFFERENTIAL CAPS
14	DIFFERENTIAL GEARS (FORGED)
15	HELICAL GEARS
16	TORQUE CONVERTER ONE WAY CLUTCH ASSEMBLY
17	INNER AND OUTER RACES (FORGED)
18	ONE WAY CLUTCHES
19	PARKING GEARS (FORGED)
20	PLANETARY CARRIERS
21	SHIFT FINGERS
22	SYNCHRONIZER HUBS
23	SYNCHRONIZER SLEEVE AND HUB INSERT
24	SYNCHRONIZER RINGS FOR TRUCKS (FORGED)
25	SYNCHRONIZER CONES AND RINGS
26	HYBRID DRIVE COMPONENTS
27	TRANSFER CASE COMPONENTS
28	TURBINE HUBS
29	VARIABLE VANE PUMP COMPONENTS
30-31	NOTES

GKN Sinter Metals is the world's largest producer of precision powder metal products. We are focused on superior delivery, quality and total solutions and offer extensive technical expertise in design, testing and process technology.

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) IS IN LIGHT VEHICLES AND DRIVETRAIN PRODUCTS. THIS BROCHURE PROVIDES INSIGHT INTO THE BROAD SPECTRUM OF INNOVATIVE PRODUCT SOLUTIONS WE ARE DEVELOPING AND MANUFACTURING.

THINK > BENEFITS OF POWDER METALLURGY

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



- > Net shape forming
- > Design solutions for less process steps



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



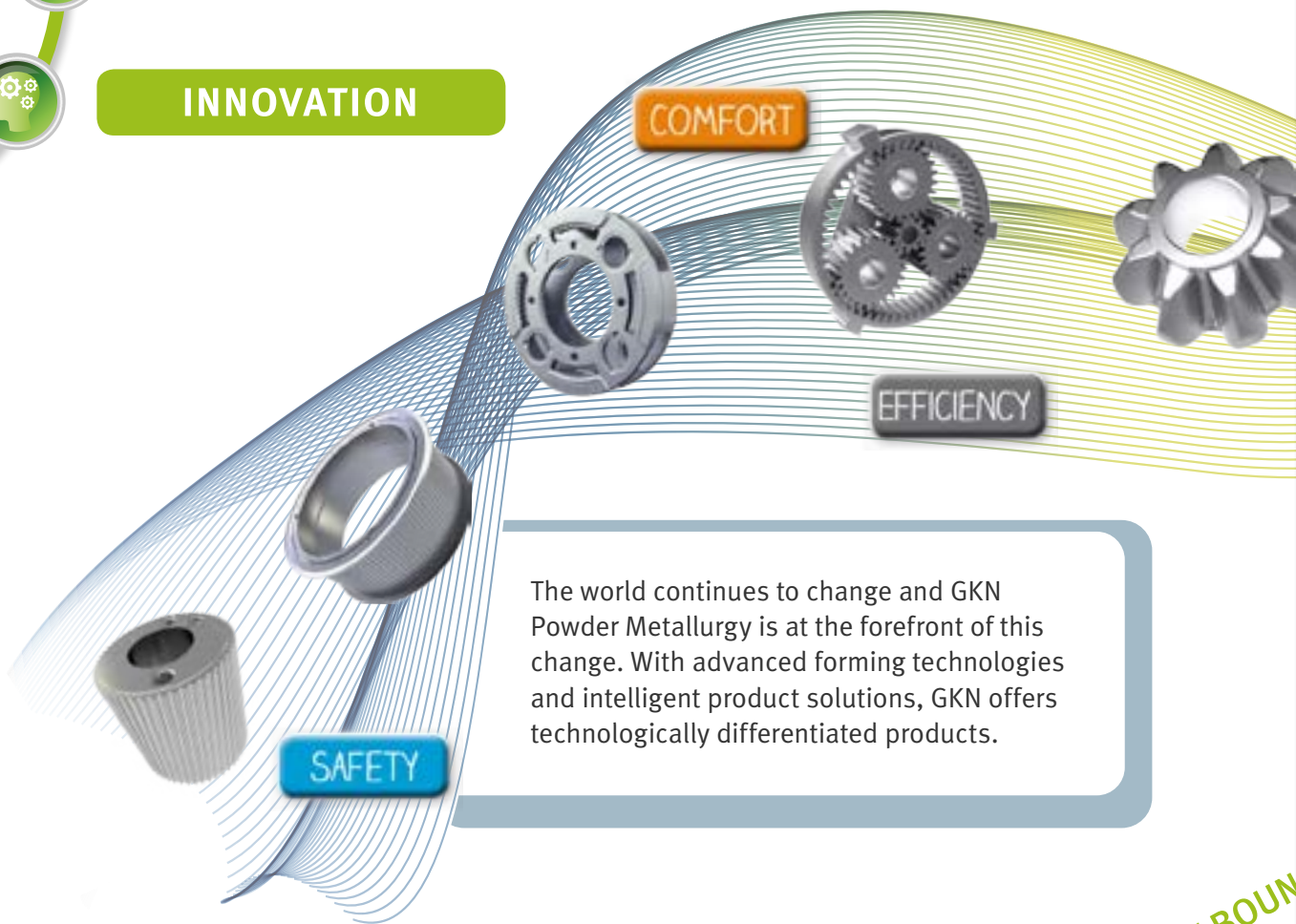
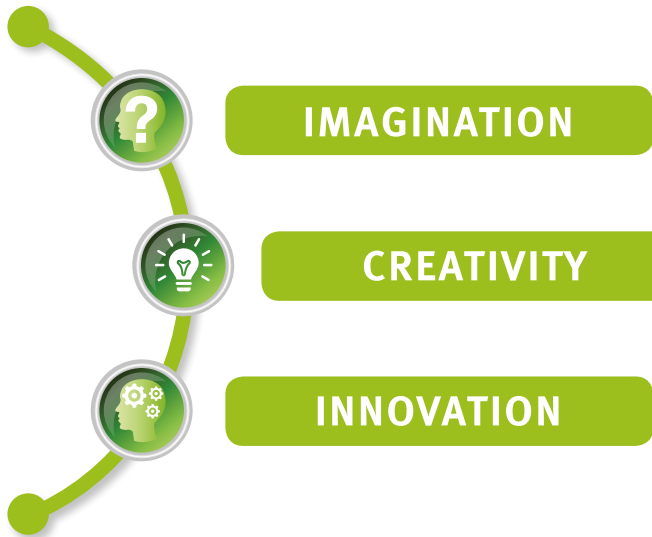
- > Lightweight materials
- > Weight reduction features by PM design



- > No secondary machining
- > Low complexity by using less components



PM IS AN AVENUE OF INNOVATION

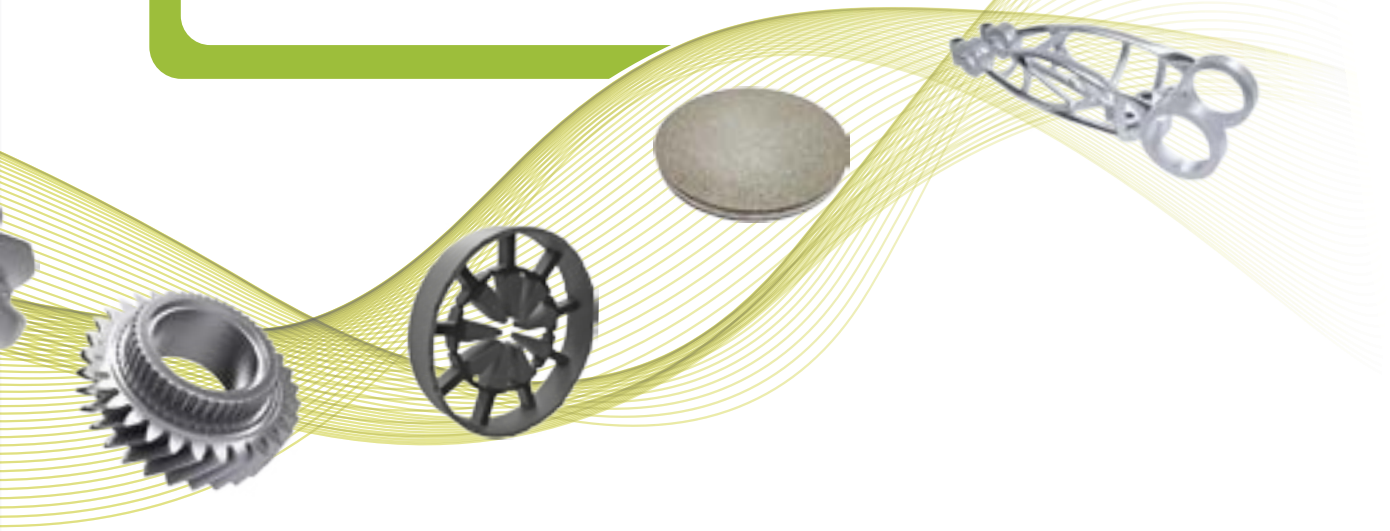


The world continues to change and GKN Powder Metallurgy is at the forefront of this change. With advanced forming technologies and intelligent product solutions, GKN offers technologically differentiated products.

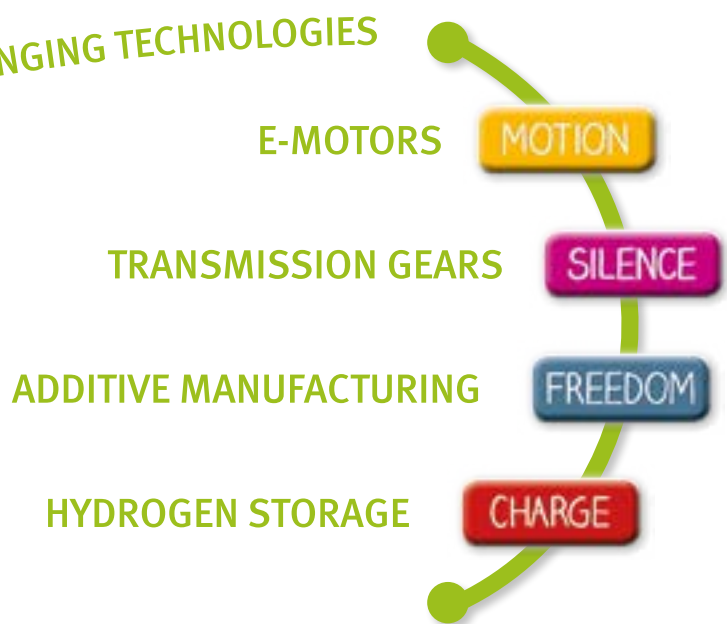


TECHNOLOGICALLY DIFFERENTIATED PRODUCTS + EXPANDING THE BOUNDARIES

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

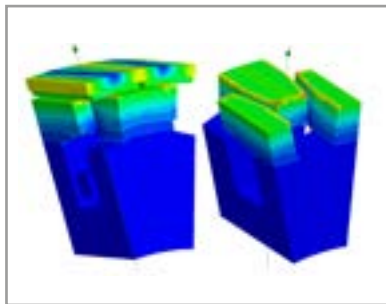
As an essential building block of our company, the three innovation centers of GKN are supporting the development processes of our customers. The R&D centers are equipped with full size production facilities and advanced materials laboratories.

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



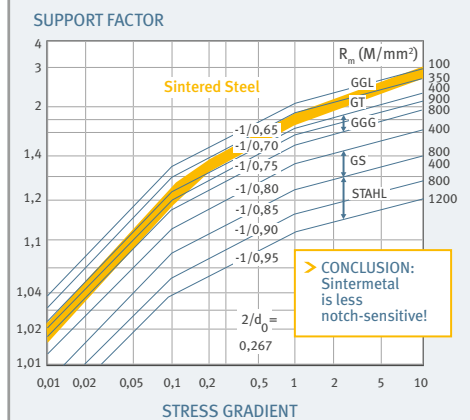
MATERIALS & ENGINE TEST BENCHES

- 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.



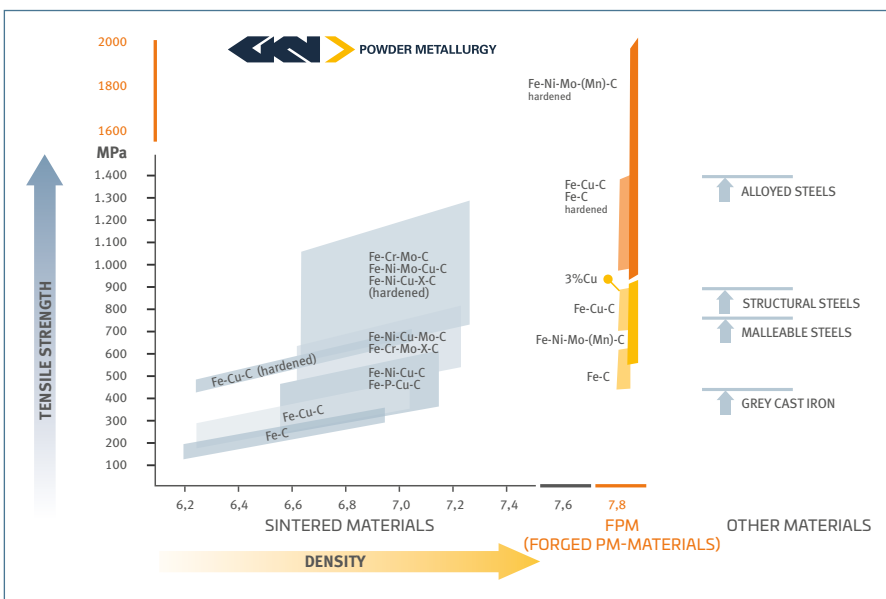
FATIGUE ENDURANCE LIMIT

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.



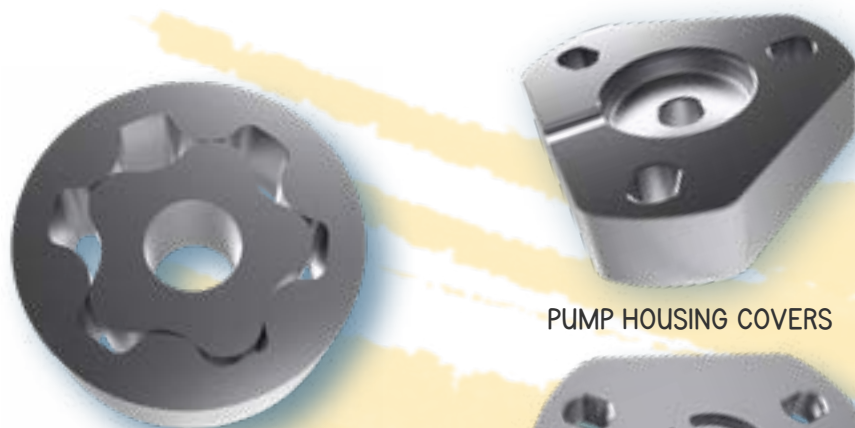
ALL PM G-ROTOR PUMPS

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

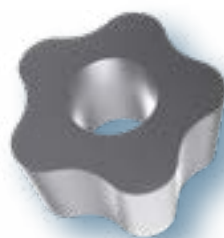


GEROTOR SETS

PUMP HOUSING COVERS



OUTER ROTOR



INNER ROTOR



ROTOR HOUSING



BEARING ADJUSTERS



LIGHT WEIGHT,
SPACE SAVING,
OPTIMIZED DESIGNS



Within the front or rear axle system of an automobile lies a differential which transmits the appropriate amount of power to the right or left drive wheels during cornering. The differential is free to rotate on a bearing system. During construction of the axle, the specified tension on these bearings is established by rotating the differential bearing adjuster nut.

The adjuster nut is locked into place to maintain the specified tension. PM technology has proven to be a competitive and successful solution for these products by delivering optimized, space saving and light weight products.

KEY BENEFITS

- 100% PM solution
- Space saving, optimized designs
- Outstanding performance through highest precision
- Efficiency advantages due to constant clearance behavior over temperature
- Cost advantages through minimized machining

CAM RINGS



GKN Driveline's "disconnect all-wheel drive system" includes a power transfer unit (PTU), linked to the transmission's final drive differential. The PTU contains a fast-disconnect device and a brake that can bring the all-wheel drive system to rest upstream of the hypoid gears. An electro-mechanically actuated clutch, located in the rear axle, both biases drive torque and disengages the all-wheel drive system downstream of the hypoid gears to reduce CO₂.

GKN Sinter Metals is manufacturing the „Driven Cam Ring“ (with teeth) and the „Fixed Cam Ring“ (without teeth) for this system.

KEY BENEFITS

- Sinter hardening and tempering to avoid external heat treatment
- Improved accuracy
- Near netshape
- Reduced machining
- Lower friction through design lubrication slots and PM material
- Reduced CO₂





HIGH DENSITY,
INTRICATE DESIGNS AND
NETSHAPE TECHNOLOGY

For producing clutch hubs with high performance and innovative and creative shape, the PM technology is the best solution. They are heat treated directly in the sintering process and without additional machining operation.

A cooperation between GKN and the customer in the co-design phase opens creative ways to optimize assembly and function and minimise cost.

KEY BENEFITS

- Design optimization and weight reduction
- Sinter hardening process
- High density
- High material performance
- Net shape



KEY BENEFITS

- OD/ID Spline/geometry – “Green drilled” – lubrication features
- Large size “net shape” 250 mm step designs
- Flexible manufacturing cells in production at many GKN Plants
- Specifically developed GKN PM material 901 with highest resistance to bending and thermal fatigue
- GKN PM 901 material enables process reduction (no secondary grinding needed)
- Single press high density $> 7.2 \text{ g/cm}^3$

A clutch plate is designed to handle different levels of force and apply different ranges of friction depending on its design and material.

Clutch plates transmit torque in the transmission.

An automatic transmission contains several clutches. These clutches engage and disengage various sets of planetary gears. Each clutch is put into motion using pressurized hydraulic fluid. When the pressure drops, springs cause the clutch to release. Evenly spaced ridges, called splines, line the inside and outside of the clutch to lock into the gears and the clutch housing.

DIFFERENTIAL CAPS



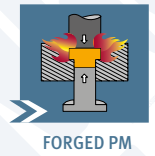
Within the front or rear axle system of an automobile lies a differential which transmits the appropriate amount of power to the right or left drive wheels during cornering. The differential is free to rotate on a bearing system. Differential bearing caps are used as clamps to retain the bearings and attach the differential to the axle housing.

PM technology has proven to be a competitive and successful solution for these products by delivering light weight and reliable designs.

KEY BENEFITS

- Strength to weight ratio better than cast iron
- Engineered product - delivered "ready to install"
- Nearest to net shape solution – only minimal bore machining required
- More precise positioning/ repositioning with integrated dowel option
- Excellent machinability
- In-house performance and validation testing

FORGED DIFFERENTIAL GEARS



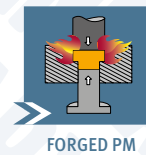
GKN is providing enhanced differential gear options to the market by introducing the forged PM technology. This enables for improved power density, increased design safety factor or space & weight savings at higher torque demand, especially for eDrive gearboxes and for edrive AWD power transfer units.

At the heart of the differential is a set of four bevel gears: two side gears that connect to the left and right axles and two pinions which transmit torque between the side gears.

KEY BENEFITS

- Highest torque capacity gears
- Enables smaller differentials – weight saving
- Superior material performance – higher strength to weight ratio
- Higher load carrying capability
- Designs optimized for highest efficiency
- Net shape forged PM gear profile, spline and retaining groove

HELICAL GEARS



REDUCED NVH,
HIGH DENSITY & TORQUE
PERFORMANCE

FEASIBLE
IN FORGED PM, TOO

While the weight and cost benefits of standard powder metal based processing techniques are attractive for helical transmission gears, the torque to be transmitted is limited due to the porous structure.

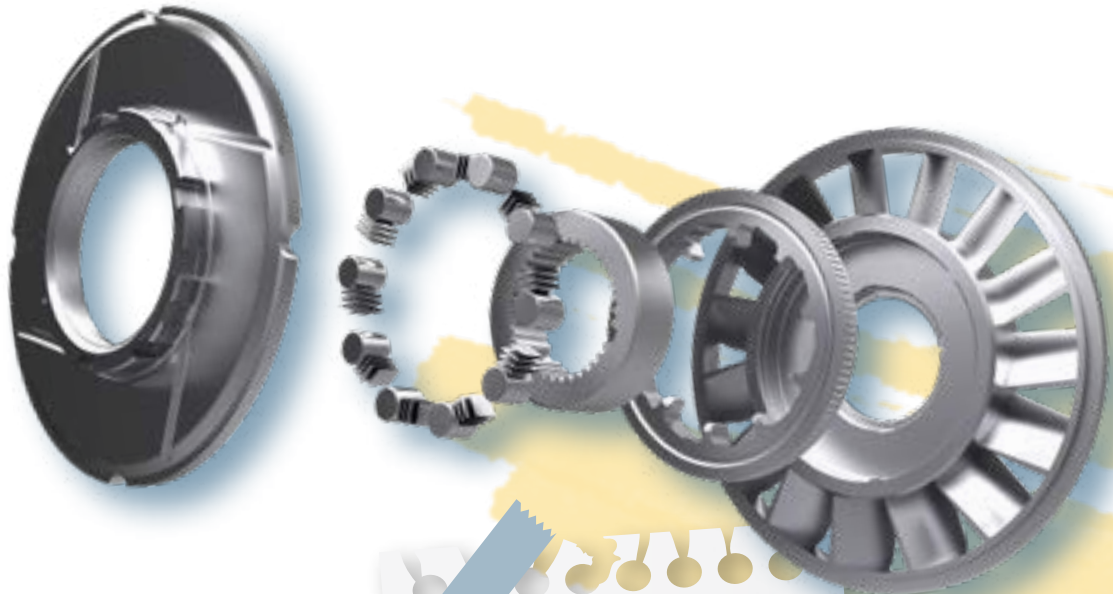
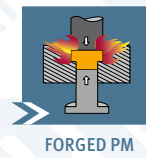
GKN has developed a process for surface densification which allows accurate strengthening of defined areas of the gear.

The process creates gear teeth with properties comparable to a traditionally forged part while crucially improving the NVH characteristics of the component.

KEY BENEFITS

- Reduced NVH due to enhanced damping behaviour
- Extreme forming (34° helix angle)
- Reduced machining/near net shape
- Capex avoidance for customer
- Multipart substitution
- > 10% weight reduction at performance level from full steel

TORQUE CONVERTER ONE WAY CLUTCH ASSEMBLY



Automatic transmissions rely on a torque multiplying system that delivers increased torque for initial acceleration. Within the transmission's torque converter is a one way clutch which locks up to deliver the initial increased torque and subsequently turns freely when cruising speeds are reached.

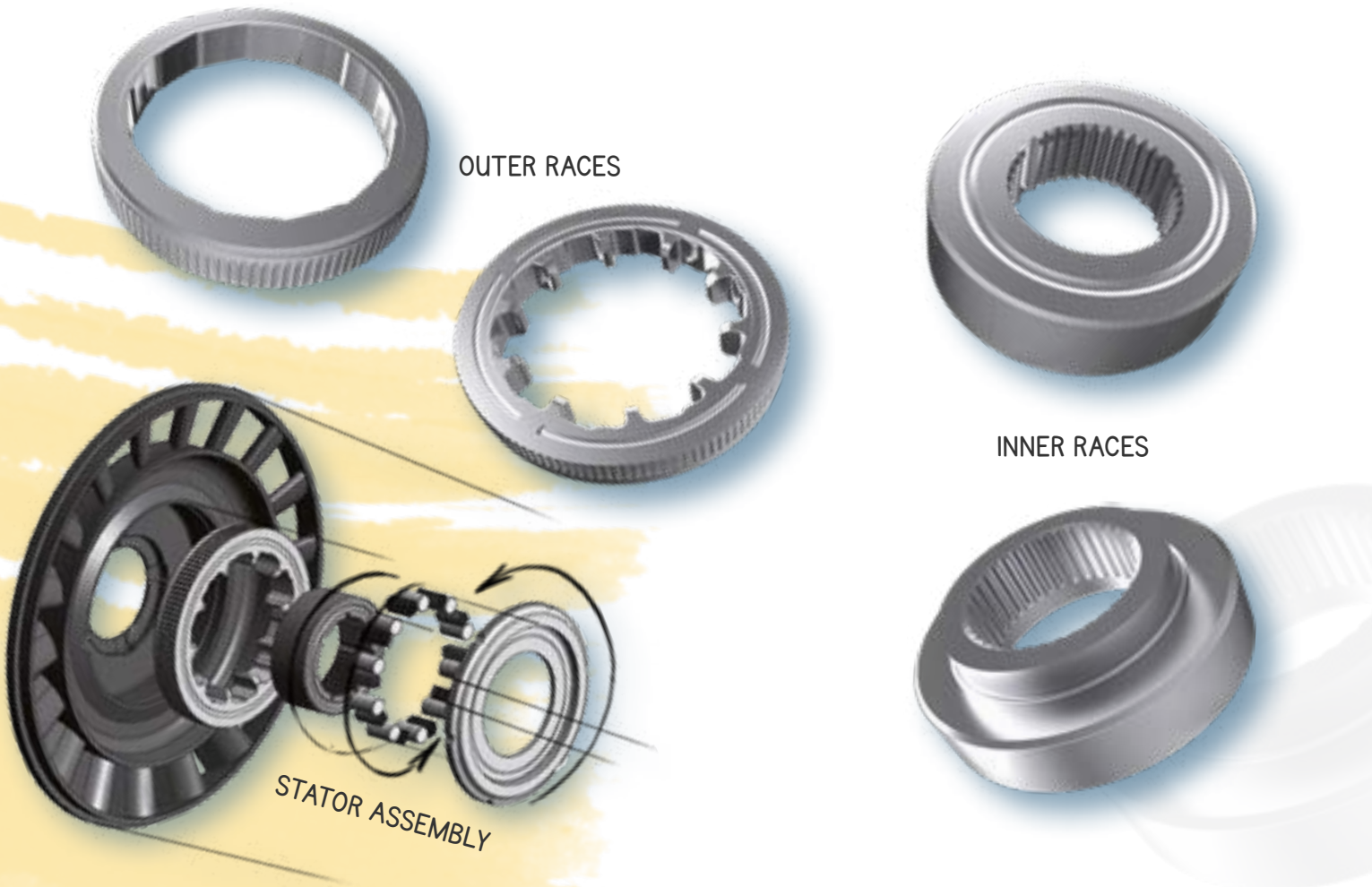
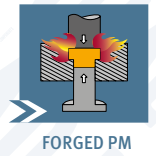
GKN pioneered the nearest to net shape forged PM torque converter one way clutch and now supplies these products fully assembled for many applications.

GKN supplies both assemblies and the races.

KEY BENEFITS

- Complete component design and validation capability
- Utilizes a lower cost stator
- Supplied as assembled into a traditional stator, or as a drop in unitized design
- Consistently proven race designs reduce tool cost and time to production
- Unique designs for light weight and optimized fluid flow
- Fully dense forged PM inner and outer races deliver reliable and unmatched strength and predictable performance

FORGED INNER AND OUTER RACES



Inner and outer races are used for transmission torque converter stators and one-way clutch (OWC) assemblies.

KEY BENEFITS

- Full service supplier – components and assemblies
- Design services – TS16949 certified
- 30+ years detailed application and process history – providing a diverse range of products meeting customer requirements
- Adaptable standardized designs
- Peak torque testing capability exceeding 2250 Nm
- Sinta-Carb™ process – superior OWC performance and durability
- Reduced tooling and gauging costs – fast prototyping
- CAD and FEA support – full testing services

ONE WAY CLUTCHES



One way clutches are a key component of automatic transmissions. PM's design freedom combined with dimensional precision and high performance materials facilitated the development of new one way clutch systems that are more easily integrated into compact and efficient transmission designs.

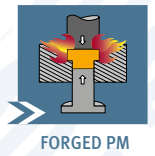
GKN is the market leader for PM One way clutch's with an established track record of delivering optimized and competitive solutions for many customers and applications.

KEY BENEFITS

- Lightweight optimized designs
- Net shape capability and consistent dimensional precision reliably delivers complex geometry with minimal machining
- Consistent, low distortion sinter hardening process eliminates variation inherent to competing hardening processes
- Option to integrate OWC into other components – such as planetary carriers



FORGED PARKING GEARS



PARKING GEARS

WEIGHT- AND
INERTIA OPTIMIZED DESIGN

KEY BENEFITS

- Superior performance and high strength
- Net-shape and light weight gear design
- Consistent high material quality
- Reduction of additional machining processes (e.g. Broaching)
- Standard heat treatment conditions
- Reduced machining
- Cost effective

Parking gears are utilized in automatic transmissions. They interact with a parking pawl to lock the transmission. It's main function is to hold the vehicle in a static position when parked. The gears are high density high strength steel to provide exceptional impact properties. The gears are typically heat treated to provide a balance of strength and toughness. The parts are produced as forgings or double press double sintered. Forged Powder Metal (FPM) parking gears are forged net-shape and show superior performance in terms of bending and wear resistance after case hardening.

Additional design features, e.g. holes in the gear body for mass reduction, can be forged easily due to the design freedom coming from the conventional PM pre-form process. Also internal involute splines can be forged directly. In addition, cleaner raw materials avoid inhomogeneity's and failure risk.

PLANETARY CARRIERS



ALSO AVAILABLE
IN PM ALUMINIUM
- LIGHT WEIGHT
AND HIGH STRENGTH



PM ALUMINIUM
DESIGN



PM STEEL
DESIGN

Planetary carriers are a key component of automatic transmissions.

As CO₂ legislations increased the demand for more fuel efficient vehicles and transmissions with more forward speeds, planetary carriers became more complex and also began to serve multiple functions.

PM technology has delivered an essential solution by facilitating the integration of carrier housings with one way clutches, hydraulic pressure systems and clutch backing plates – resulting in unprecedented savings in weight, space, and cost vs. competing technologies.

KEY BENEFITS

- Design freedom of PM (DPM) facilitates unique designs and integrated functions
- Minimal machining required due to near net shape capability
- Lightweight, high strength designs
- Pinion gear contact surfaces are net shape and include geometry to optimize lubrication
- Sinterbrazing reliably joins multiple levels and different materials

SHIFT FINGERS



INTEGRATED
FUNCTIONS FOR
SHIFTING COMFORT
BY DESIGN FOR PM

Manual, automated manual and double clutch transmissions rely on a series of components to engage and move the synchronizer system during shifts between gears.

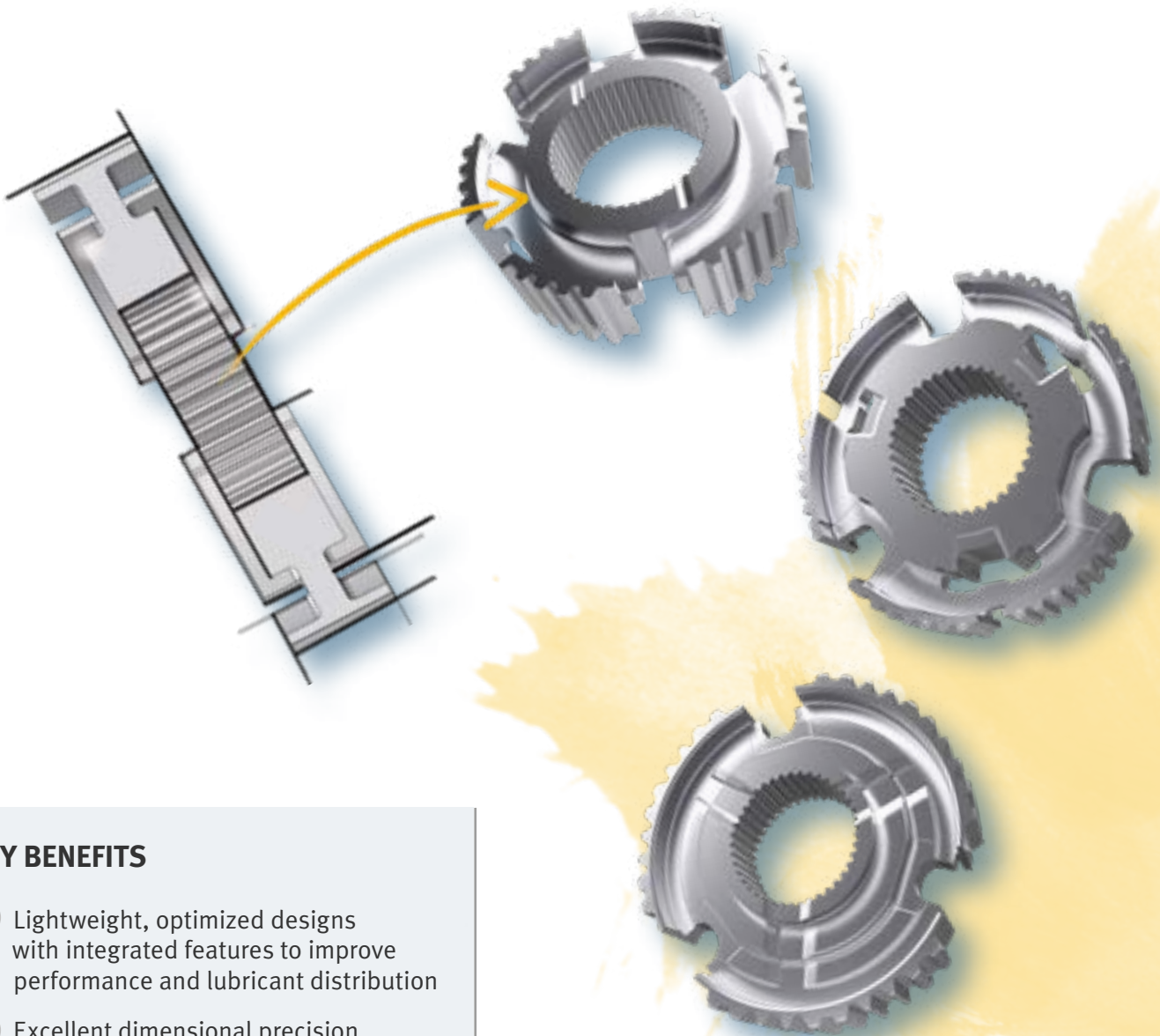
As transmissions become more advanced and more compact, the complexity of the shifting system is increasing. PM is an ideal choice and gives engineers the freedom to optimize the shift components for smooth and reliable operation.

PM components are key for an improved gear shift feeling.

KEY BENEFITS

- High strength, hardness and ductility
- Net shape capability for complex shapes
- Excellent surface finish and smooth edges
- Proven manufacturing capability to meet automotive requirements
- Integrated functions for shifting comfort made by design for PM
- Two piece design (two fitted PM parts) depending on customer design

SYNCHRONIZER HUBS



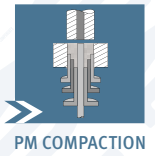
KEY BENEFITS

- Lightweight, optimized designs with integrated features to improve performance and lubricant distribution
- Excellent dimensional precision for improved shift feel
- Minimal machining is required due to near net shape capability
- Materials matched to performance requirements
- In-house fatigue performance testing
- Global capability: multi-site manufacturing equipment (state-of-the-art)
- High density $>7,3\text{g/cm}^3$ approaching steel performance

Synchronizer hubs are the core product for the shifting mechanism in all double clutch and manual transmissions. PM has proven to be the premier solution for this component and has facilitated improvements in performance while also reducing weight.

GKN has a proven track record of developing optimized and competitive solutions for many different customers and applications on a global basis.

SYNCHRONIZER SLEEVE AND HUBS INSERT

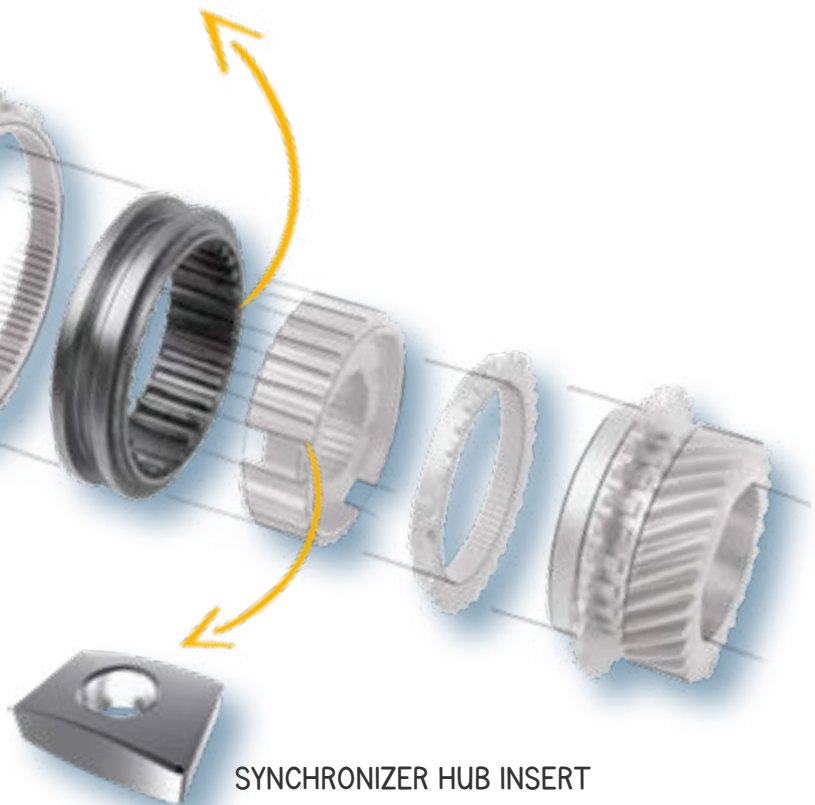


The shifting sleeve pushes the synchronizer ring over this inserts towards the clutch body and synchronizes in this way the transmission gear speed through friction. After that the gear can be engaged.

KEY BENEFITS

- Pointing operation by sizing instead machining
- More chances to have a creative design in order to implement more function
- With a sleeve co-design in the first step of a new project GKN can generate solution where hub insert is not necessary
- Shifter stop operation can be done by tooling instead machining or rolling with special design
- Ring roundness < 0.05 mm
- Opportunity to optimize geometry if there is the chance to develop more components in PM in the assembly

SYNCHRONIZER SLEEVE

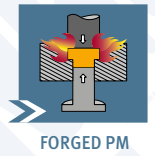


KEY BENEFITS

- Netshape geometry
- High precision
- High performance materials
- High wear resistance

Synchronizer hub inserts are used in manual and double clutch transmissions. Usually three of them are mounted in a synchronizer hub.

FORGED SYNCHRONIZER RINGS (FOR TRUCKS)



Synchronizer rings for heavy duty truck applications are forged to meet the requirements and provide superior performance in the application. Forged PM synchronizer rings are produced near-net-shape with a minimum of machining stock and free of burrs.

Additional operations like hardening, coating and grinding can be used without FPM related modifications. Due to the clean forging grade powders and the variable graphite content FPM synchronizer rings can be case hardened or induction hardened.

KEY BENEFITS

- Tailored heat treatment and surface technology for high precision and excellent surface quality
- Design optimization and weight reduction
- High density compaction and high performance materials
- Advanced press and CNC tool technology
- Advanced powder metal manufacturing techniques



SYNCHRONIZER CONES AND RINGS



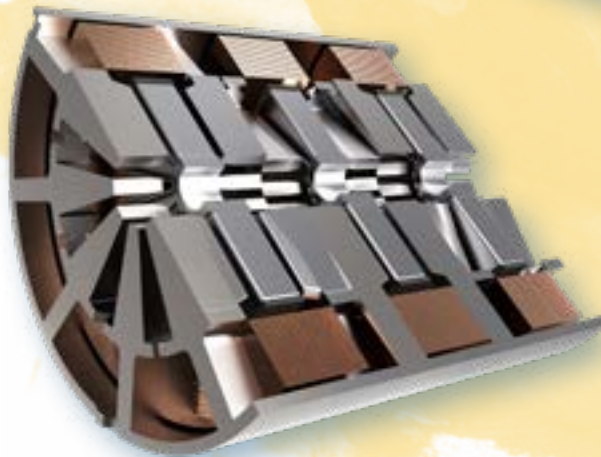
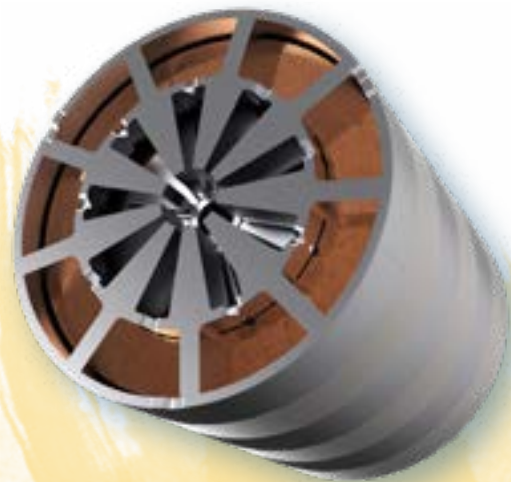
Synchronizer rings and cones can be produced using Powder Metallurgy (PM) technology to meet the required performance. The Powder Metal process is efficient, flexible with respect to shape and economical.

Recent improvements in PM Technology, such as new material, the sinter hardening process and new CNC compaction offer new opportunities in synchronizer assemblies.

This component was produced near-net-shape, free of burrs, requiring minimal machining operations. Additional operations such as hardening, coating and grinding can be applied as required.

KEY BENEFITS

- Design optimization and weight reduction
- Sinter hardening process
- High density compaction
- Advanced press and CNC tool technology
- Advanced powder metal manufacturing techniques and extensive experience for the development and series production of net shape manufactured transmission components



The trend towards higher efficiencies and reduced CO₂ emissions in the automotive industry accelerates the growth of electrification in the drivetrain. This forces the engineers to develop and integrate new kinds of high efficiency electric systems into their drivetrain structures.

Powder metallurgy and in particular Soft Magnetic Composites (SMC) with their unique electro-magnetic properties can help establish innovative motor-designs.

Fulfilling the highest demands in the fields of torque & efficiency such E-motors can be easily integrated into different applications due to their overall compactness and the PM ability to shape very complex parts.

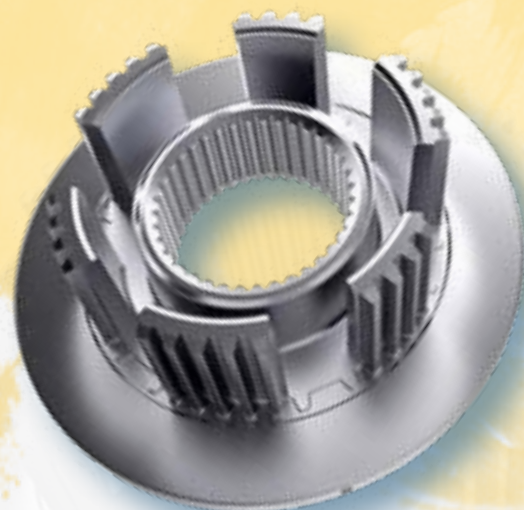
KEY BENEFITS

- 3D-Design freedom for E-motors
- Suitable for complex designs
- Precise dimensions
- Up to 2 times better efficiency, high torque, low speed (e.g. Start-stop traffic)
- Highest torque densities achievable
- Simplified production processes

TRANSFER CASE COMPONENTS



TRANSFER CASE SPROCKET



TRANSFER CASE CLUTCH HUB

KEY BENEFITS

- Net shape manufacturing with reduced machining
- High performance materials through novel alloys
- Opportunity to employ dual material compaction for strength and cost benefit
- Integrated functions such as backing plates and dog clutch features
- Net shape high precision splines
- High demand loading
- Impact resistance

Transfer case components include a combination of gears, clutch hubs and clutches which transfer and distribute torque within AWD systems. Components incorporate complex geometries and utilize high performance materials for strength and durability.

TURBINE HUBS



KEY BENEFITS

- Net shape forming capabilities enable weight saving features with minimal machining
- Optimized oil flow geometry - with no sharp edges or loose burr risks
- Proven, high strength materials
- Cost effective solutions using multi-level technology
- Superior material utilization
- Selective heat treatment to avoid distortion
- Extensive engineering experience with turbine hub applications

Automatic transmissions rely on a torque converter to engage and disengage engine power without the need for a driver-operated clutch. The main part of a torque converter is a fluid turbine which selectively transfers engine power into the transmission. A turbine hub is the coupling that connects the engine to the torque converter.

PM technology has proven to be a highly competitive and high performance solution for many customers and applications. This is accomplished through flexible turbine hub designs, improved material systems and cost-effective manufacturing processes.

VARIABLE VANE PUMP COMPONENTS



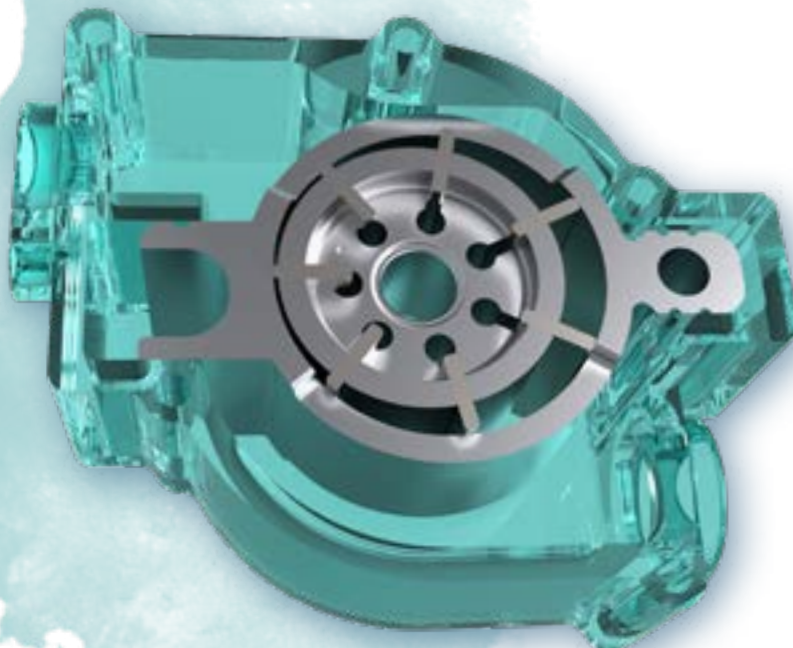
SETTING RING



VANE



ROTOR



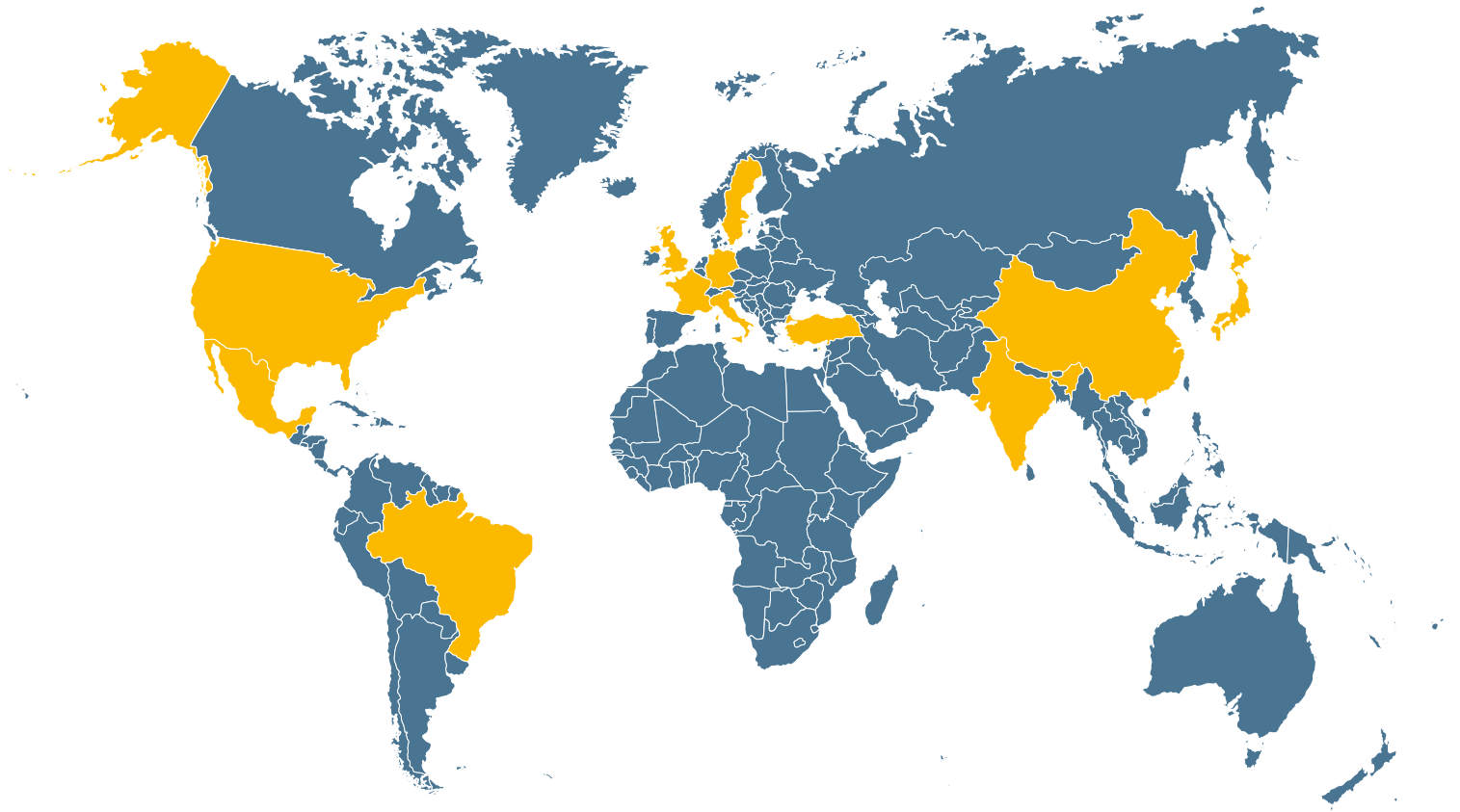
Variable vane pumps can be adjusted so that the output is adapted to application demands. This allows for improved efficiency and lower energy consumption.

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 features as well all PM pump solutions.

KEY BENEFITS

- Improved surface tribology
- Net shape vane geometry
- All PM solution for highest efficiency



GKN Locations

Over 30 locations
in 12 countries
on 4 continents

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