

# Powder Metallurgy Case Studies

A booklet containing a selection of Powder  
Metallurgy Component Case Studies



# Global Powder Metallurgy Database

## Global Powder Metallurgy Database



This online database provides comprehensive information on a wide range of PM Materials

Over 5000 users now registered

Free Access / Registration

Worldwide Availability

Supplier Contact Details



[www.pmdatabase.com](http://www.pmdatabase.com)

## Introduction

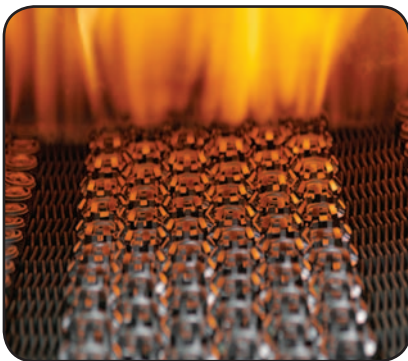
Powder Metallurgy (PM) is a continually and rapidly evolving technology embracing most metallic and alloy materials and a wide variety of shapes. Powder Metallurgy is a highly developed method of manufacturing reliable ferrous and non-ferrous parts. The European Market alone has a turnover of over Six Billion Euros per year, with annual worldwide metal powder production exceeding one million tonnes.

PM Components are created by mixing elemental or alloy powders and compacting the mixture in a die, with the resultant shapes heated or “sintered” in a controlled atmosphere furnace to bond the particles metallurgically. The high precision forming capability of PM generates components with near net shape, intricate features and good dimensional precision pieces. Pieces are often finished without the need of machining.

Whether it is by controlling porosity to develop the unique capability of self-lubrication or by optimising the chemistry to provide improved longevity in wear parts, PM has a solution.

The benefits of using PM Components include:

- Structural pieces with complex shapes
- Special properties such as hardness and wear resistance
- Great precision and good surface finish
- Large series of pieces with narrow tolerances
- Controlled porosity
- Reduced component weight



The case studies shown in this publication are examples of the wide range of PM products, materials and applications that are in current production. Each and every day a new PM part helps a company to open up new market opportunities.



Copyright © European Powder Metallurgy Association 2011, 1st Edition 2011

## Gearset for Bush Cutter

**Application Sector:** Consumer Goods

The gearset is made up of two components, the gear and pinion. The pinion gear was particularly challenging as the tooth density is crucial to fulfil the customer requirements. The customer undertakes Gearhead Assembly tests for strength and endurance, making the two gears the most critical components. In this instance Powder Metallurgy parts have helped to increase the durability of the assembled product.



**Product Density:** 7.2 g/cm<sup>3</sup>

**Tensile Strength:** 850 (N/mm<sup>2</sup>)

**Product Hardness:** 68HRA, 750 HVO, I

**Finishing:** Pressing, Sinter Hardening, Oil Impregnation

## Ablation System Electrode

### Application Sector: Medical

An Electrode and Insulator together form the electrode tip of an ablation system powered by radiofrequency (RF) energy. When the energy, through the electrode, encounters the higher impedance of the human tissue, heat is generated. The heat destroys and coagulates the cells. Electrode 90-S which has flower-shaped tip with intricate three-dimensional features on average measuring 0.7mm, is especially designed for MIM (Metal Injection Moulding). The tungsten-iron-nickel composition for this component reflects the greater freedom MIM offers in terms of material selections.



**Product Density:** 18.4 g/cm<sup>3</sup>

**Tensile Strength:** 800 MPa

**Product Hardness:** 25 HRC

**Finishing:** Sizing

## Sintered Camshaft Gear

**Application Sector:** Automotive

This sintered camshaft gear works at a performance level that was previously restricted to wrought steel. It actually replaced an existing steel gear. The application of surface densification of the flank, as well as the tooth root, on a prealloyed sintered steel led to a performance level similar to case hardened steel (e.g. 16 Mn Cr5).

Since their first introduction in 2004 - several other applications of sintered gears have been introduced into mass production or are under development for use in internal combustion engines.



**Product Density:** (g/cm<sup>3</sup>) 7.0 up to 7.8

**Product Tensile Strength:** 590 (core)

**Product Hardness:** 750 HV5 toothflank, 200 HV5 core

**Finishing:** Heat treatment

## TE-C3X Drill Bit

**Application Sector:** Construction

The TE-C3X is the world's first truly mass produced, bulk, functionally graded hardmetal part. It uses separation of functions within a single component - drilling and joining - by spatial variation of properties in a single, axially pressed and liquid phase sintered hardmetal component.

This newly developed powder metallurgical technology will be applied to other components that require locally adapted properties, such as cutting and wear parts. Finally, and most importantly for the customer, the performance (speed and lifetime) of the TE-C3X bit has been improved measurably, while at the same time, the robustness has been improved substantially.



**Relative Density:** >99.99%

**Product Hardness:** 1250 to 1450 (HV10)

**Final Weight:** 1 gramme to 30 grammes

**Finishing:** Galvanic coating of cobalt

## Spring Hinge

**Application Sector:** Consumer Goods

The concept by Tag Heuer was to produce spectacles without edges and corners that look like they have been formed from a mould. The edgeless hinge movement was designed as two disk-shaped forms that slid over each other. MIM technology was the only possibility here as the complexity of the component made production via conventional metal-removing processing too expensive. Tolerances meant that the form required could not be produced via waste-wax casting but only via MIM.



**Product Density:** (g/cm<sup>3</sup>) 7.9

**Product Tensile:** 510

**Product Hardness:** 120 HV1

**Process Steps:** Tapping, Sand Blasting, Polishing, Plating

## Shock Absorber Piston

**Application Sector:** Automotive

The piston is integrated in a shock absorber system that maintains the vehicle at the same height under any loading condition, without any external energy input. For this purpose a piston had to be designed that allows an optimal adjustment to be made to different vehicles and settings. This is only possible via slanted flow through openings, which also allow the largest possible quantities to pass through.

This type of combination is not possible to produce in any other economical manufacturing process.

The slanted flow channels are achieved by combining two piston halves (the connection design is protected by a patent). Using PM means that substantially larger channels, which are optimal for the application, can be produced in contrast to drilling. Thus a PM part with very filigree geometries and very thin wall thicknesses is required. Particularly high demands are made of the tolerances and these are safely fulfilled in mass production.



**Product Density:** (g/cm<sup>3</sup>) 3.92

**Product Hardness:** 80 HRB

**Finishing:** Press fitting and sizing, turning the groove, steam treatment

## Rotary Hinge (Shaft & Plate)

**Application Sector:** Consumer Goods

The characteristics of MIM in high strength, complex geometry and high volume production, enables it to be the preferred manufacturing technique for such metal hinges in consumer electronics. In particular, the use of rotary hinge allows the manufacturers to differentiate its products through strength, reliability and style. In essence the rotary MIM hinge portrayed a very strong product differentiation, and an ingenuity that will inspire others.

A normal clamshell phone provides more space for a bigger display than a Candy-bar phone, but clamshell phones with the rotary hinge help to create more viewing angles. The 2-degree-of-freedom movement made possible by the rotary hinge, gives the consumers a swivel screen that fulfills the function of the phone and the camera.



**Product Density:** 7.6g/cm<sup>3</sup>

**Product Tensile:** 950 as sintered

**Product Hardness:** 25 HRC

**Final Weight:** Sintered part: Shaft (1.652g), Plate(1.639g)

**Finishing:** Shot peening, passivation, sizing

## Neck Link

### Application Sector: Medical

Heine has been producing its Diagnostic Center EN 100 since 1998. It contains among other instruments an otoscope, an ophthalmoscope and an extension unit. All instruments use the same holder.

One of the critical components of this holder is the patented automated locking device that allows for one handed opening and closing of the locking mechanism, and is still considered an ideal solution for the precise fit of the instruments.



**Product Density:** 7.6g/cm<sup>3</sup>

**Product Hardness:** core 120 HV1

**Sintered Weight of Component:** 15.91g

**Finishing:** Mechanical secondary operations for the outer diameter 20.8+/-0.03 and the inner diameter 8H7

## Rain Sensor Ring

**Application Sector:** Automotive

Rain sensors are becoming increasingly common in modern vehicles as a safety feature.

The complex geometry found in this item is usually impossible to manufacture via die compaction. However, the use of undercut technology with different tool levels allows the close approximation to the geometry of cast parts, with higher strength, better dimensional precision and competitive cost.



**Composition:** FeCu

**Weight:** 36g

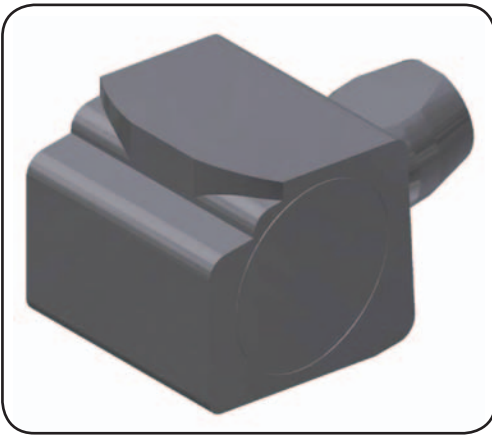
**Annual Production Quality:** 200,000

## Locking Device for Spectacles

**Application Sector:** Consumer Goods

For this revolutionary and extremely small locking device for spring hinges in spectacles the minimized size is combined with a complex shape. For a safe locking function the geometry of the part had to be designed with special features.

The component was designed from the beginning to be made using MIM, as its weight of only 0.028g and high precision, meant only MIM could guarantee the necessary specification. This is also due to the huge quantity per year needed using a 32 cavity mould.



**Product Density:** (g/cm<sup>3</sup>) 7.9

**Product Tensile Strength:** 510 MPa

**Product Hardness:** 120 HV10

**Weight** 0.028g / 0.046g depending on version

**Finishing:** Only tumbling operation is needed

## Planetary Assembly

### Application Sector: Automotive

This part is assembled in the transmissions of the Volkswagen Touareg and the Porsche Cayenne, where it supports the planetary gears used in the transfer case of 4WD vehicles. In any of the 6 holes, a shaft is fitted, where planetary gears are turning.

The part only works when the short speeds are connected. In any other case, the part is turning free without any work. So the part is acting as a speed reduction of the transmission shaft. Therefore, given the shape of the part and the dimensional accuracy, PM technology offers the customer many economical savings. Also the design is very compact, so space is saved. PM offers the possibility to join parts during sintering. In this case, a sinterbrazing technique is used to join the front and the rear during sintering, so a joining step is saved.



**Product Density:** Front: 6,85 g/cm<sup>3</sup>, Rear 6,8 g/cm<sup>3</sup>, Bushing 6,7 g/cm<sup>3</sup>

**Product Hardness:** Front 230 HV10, Rear 250 HV10

**Tensile Strength:** Front 620 MPa, Rear 600 MPa, Bushing RCS 150 MPa

**Product Yield:** Front 350 MPa, Rear 400 MPa

**Final Weight:** 557+500+58=1.115 g.

## Planetary-Carrier with Sun Gear

**Application Sector:** Consumer Goods

The customer was looking for a method to produce cost efficiently some 12 million high torque Planet-Carriers with Sun Gear for its volume requirement of planetary gear boxes, with an outer diameter of only 6.2mm. These Planetary-Gear Boxes are intended to be used in an opening and closing mechanism for cellular phones.

The most cost effective manufacturing route for the high production volumes proved to be MicroMIM because instead of assembling 5 parts, MicroMIM can produce the Planet-Carrier with Sun Gear in one part. Cost savings compared to traditional production techniques, which are in the range of 40%, sealed the capture of this new application.



**Product Density:** 7.8g/cm<sup>3</sup>

**Product Hardness:** 450-550 HV1

**Surface Roughness:** Better than Ra 0.4

## Transfer Case Sliding Sleeve

**Application Sector:** Automotive

This part is used in a transfer case on 4WD SUVs. It combines two main functions: the upper part is a sliding sleeve similar to what could be found in a standard manual transmission and the lower part a ring gear as in an automatic transmission planetary assembly.

Traditionally this part was made out of two wrought steel forged parts (sliding sleeve and ring gear), with the sleeve press fitted on the ring gear then welded onto it. Thanks to PM's unique capabilities the entire part can be produced in one operation. This enables a major cost saving of some 20% compared to conventional production methods.



**Product Density:** 7.5 g/cm<sup>3</sup>

**Tensile Strength:** 1200 MPa

**Product Hardness:** 750 Hv0.1

**Finishing:** Sizing, Rolling, Machining, Heat treatment

## Diamond Bead for Stone Cutting

**Application Sector:** Mining / Construction

The fabrication of the beads for diamond wires for stone cutting is commonly performed by means of hot pressing, both uniaxially and isostatically, but more and more often by means of the press-and-sinter route. In the former processes the densification of the powders is aided by a pressure applied by a graphite ram or by an inert gas; on the contrary, in the press-and-sinter process densification occurs at low pressure (or vacuum) only because of the effect of temperature. In all cases a preforming of the green bead by means of uniaxial cold pressing is required. A totally new patented system based on Metal Injection Moulding (MIM) technology has been developed and offers considerable advantages in speed and cost saving.



**Product Density:** > 8

**Product Hardness:** > 240 HV

**Weight:** 2.15g

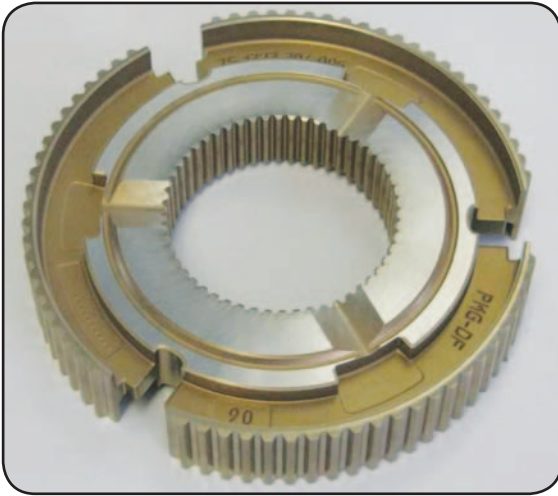
**Finishing:** The bead is sintered onto a steel cylindrical support, and then brazed to the support with a eutectic Cu/Ag alloy

## Synchroniser Hub

**Application Sector:** Automotive

This part is unusually large compared to typical synchronizer hubs. This part is manufactured for high torque applications using a press and sinter process without secondary hardening (sinter hardening material) and very little machining.

Conventional synchronizer hubs have their splines broached; this expensive process step is not needed with Powder Metal technology, thus enabling a cost saving to be passed on to the customer.



**Density (g/cm<sup>3</sup>):** max 6.95

**Tensile Strength:** 820MPa

**Hardness:** min 330 HV5

**Final Weight:** 720g

**Finishing:** Annealing, Machining, Brushing

## Aluminium VCT Sprocket and Rotor

**Application Sector:** Automotive

Using aluminium metal powder combines the benefits from standard sintered iron components (like near net shape capability) with the advantages of lightweight materials: compared to a standard sintered iron cam-phaser design, weight is reduced from 900 grams to 450 grams. Additionally, fuel saving is due to the reduced weight, rotating inertia is reduced as well, improving dynamic response behaviour of the cam-phaser, thus giving another benefit to engine performance and efficiency.

The rotor and sprocket are used in an automotive cam-phaser application and are the first known such components being manufactured from aluminium powder metal in large scale production.



**Product Density:** (g/cm<sup>3</sup>) 2.65

**Product Tensile:** 300

**Product Hardness:** 700 + 200

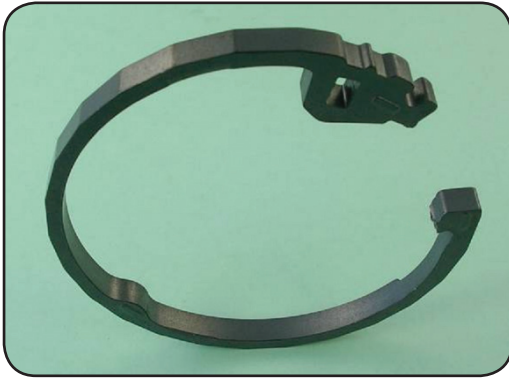
**Finishing:** Sizing, Tempering, Machining

## Brake Band Component

### Application Sector: Automotive

These components are used in manual seat-height adjustment devices in automobiles. With a total of five other uniaxial compacted powder-metal components, a set of two brake bands are fitted into each adjustment unit. It is precisely the narrow tolerances of this component with a thinnest wall thickness of less than 2mm, and an outside diameter of 53mm, which pose a big challenge for the process technology.

Furthermore, high tolerance demands are placed on the evenness of the component, amounting to 0.2mm with the total height of the part being 4mm. The manufacture of several million such components in compliance with the tolerance demands a carefully controlled and fully linked production process.



**Product Density:** (g/cm<sup>3</sup>) 6.85

**Product Tensile:** 250

**Product Hardness:** 80 HV10

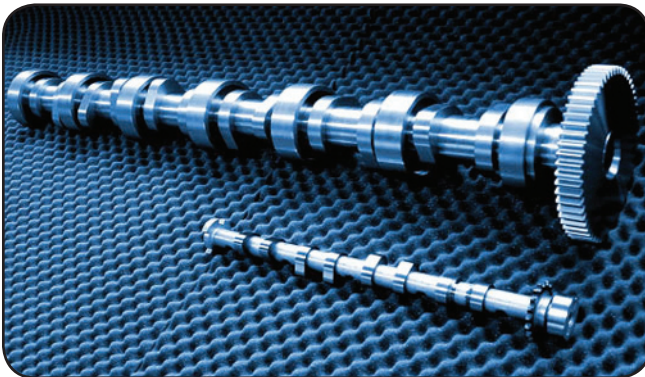
**Finishing:** Deburring, Steam Treatment, Cracking

## Journal Bearing

**Application Sector:** Automotive

During the assembly of the full camshaft, the Automotive Tier 1 customer, uses this part (“Journal Bearing”) press fitted on to the shaft to intercalate them between the lobes of each cylinder. That means that in a six-cylinder engine they use six Journal Bearings and in each end of the camshaft they fit the “Thrust-rings”, one at the Front and the other at the Rear.

All these parts were typically made in the past from plain steel and heat-treated to achieve the needed hardness. The outside surface works as a shaft in the bearing to support the camshaft in eight points, assisting in weight reduction.



**Product Density:** g/cm<sup>3</sup> 7.0

**Product Tensile:** 420 MPa

**Product Hardness:** 70 HRB

**Finishing:** Compacting, Sintering, Sizing, Induction Hardening, Tempering

## Contributing Companies

With thanks to the following companies who have received the EPMA Awards of Excellence in recent years.

AMES SA  
AMT Advanced Materials Technologies Pte Ltd  
Federal Mogul Sintertech SAS  
GKN Sinter Metals GmbH  
Hilti AG  
MG Mini Gears  
MIBA Sinter Austria GmbH  
Mimitalia srl  
OBE Ohnmacht & Baumgärtner GmbH  
Parmaco Metal Injection Molding AG  
PMG Füssen GmbH  
Schunk Sintermetalltechnik GmbH  
SHW Automotive GmbH

The EPMA website [www.epma.com](http://www.epma.com) is a world leading source of PM information. The EPMA Members online directory is an easy-to-use searchable database that provides detailed company profiles, product listings and contact details.

If you would like to see more case studies then we have over 120 on the EPMA website at [www.epma.com/case\\_studies](http://www.epma.com/case_studies)

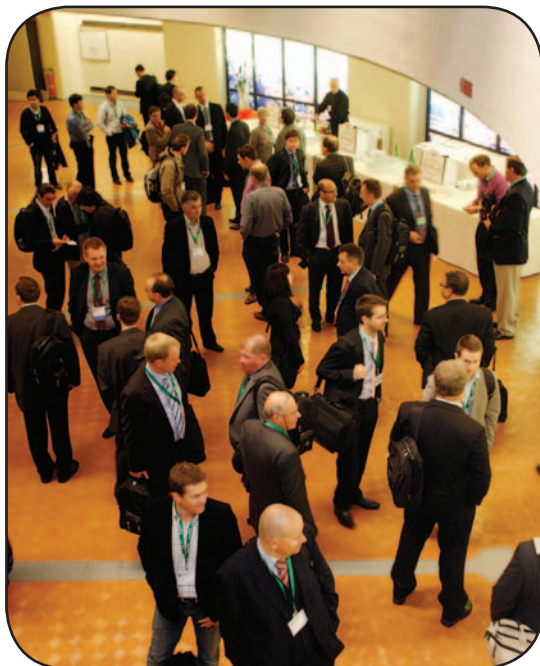


european powder  
metallurgy association



# Euro PM Congress & Exhibition

The Euro PM Congress & Exhibition is not only the place to network with the full range of PM suppliers from component manufacturers through to material specialists. The varied programme of special interest seminars and workshops ensures you maximise your potential at this annual event.



[www.epma.com](http://www.epma.com)

EURO PM  
congress & exhibition

Thinking about using Powder Metallurgy?

Then find out more with

# Design for PM

A new e-learning resource for designers and engineers



**Gain the  
benefits of  
PM for your  
components**

[www.designforpm.net](http://www.designforpm.net)