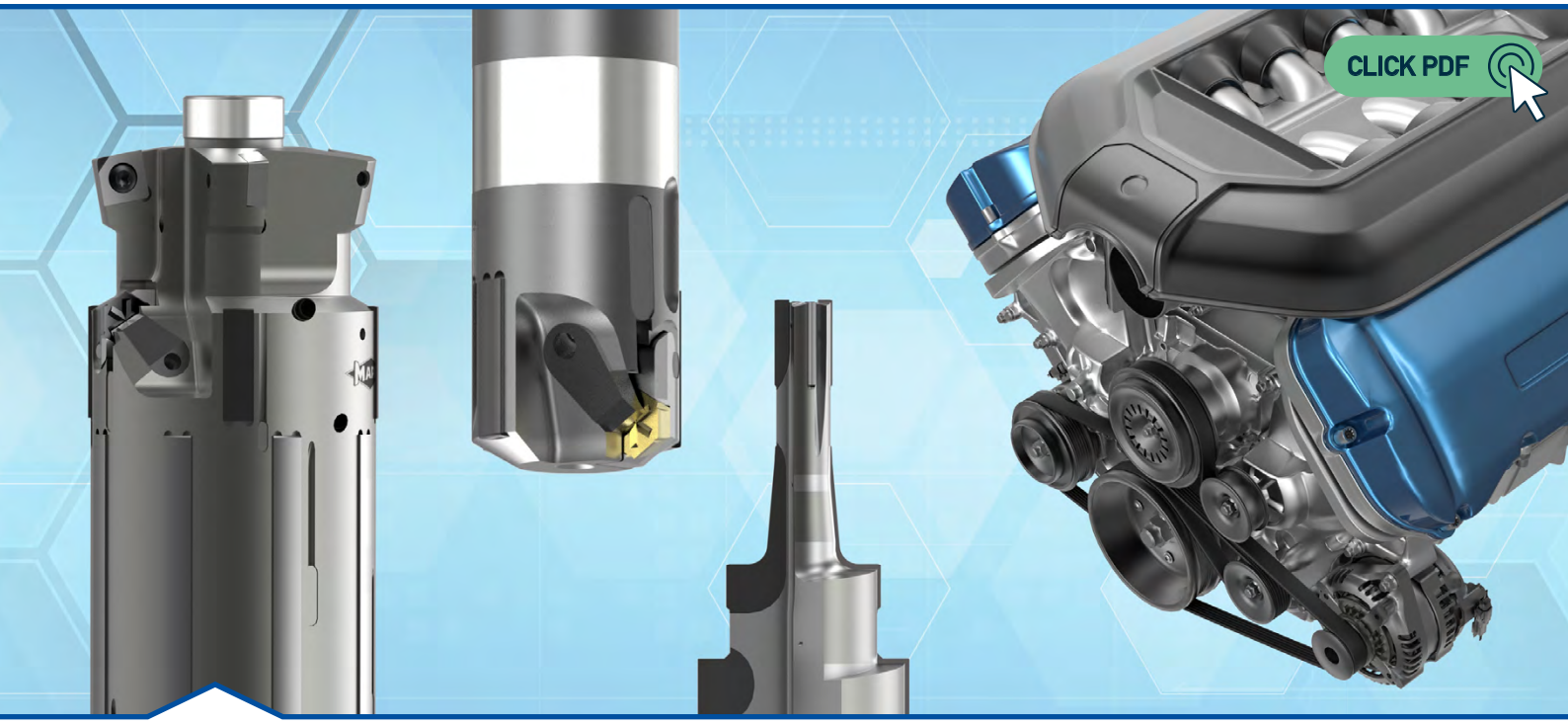


Your technology partner for cost-effective machining

COMBUSTION ENGINE

Markets and sectors

MAPAL has developed an in-depth understanding of processes and applications in machining manufacturing through many years of close cooperation with customers. The areas of application for MAPAL machining solutions extend across various sectors.

MAPAL has been developing innovations to meet the challenges of the automotive industry and large-scale production for a long time. These innovations are successfully used by reputable manufacturers and their suppliers in combustion engines as well as in the suspension, brakes and powertrain, and in electric mobility.

MAPAL is an accredited partner to the aerospace industry and sets trends and standards in manufacturing and machining technology with reliable solutions.

When it comes to demanding machining for hydraulic and pneumatic parts in different dimensions, customers have relied on MAPAL's expertise for many years. On top of this, an extensive range of products for die and mould making rounds off the offering.

Germany
Headquarters of the group of companies

Close to the customer – globally

The close dialogue with customers and thus the early recognition of technological requirements and approaches for innovations are essential pillars of the MAPAL company policy. As a result, MAPAL is directly represented with production and sales branches in 25 countries. This ensures close proximity, personal contacts and long-term partnerships.

In addition to the main production facilities in Germany, local production facilities in strategically important markets worldwide guarantee short delivery times. They are responsible for the manufacture of selected products as well as for reconditioning, repairs and repeat orders for the local market.

In addition to its own branch offices, MAPAL products are available through sales agencies in a further 19 countries.

No. 1
technology leader for the machining of cubic parts

Branch offices with production, sales and service in
25 countries.

Yearly investment in research and development amounting to
6% of turnover.

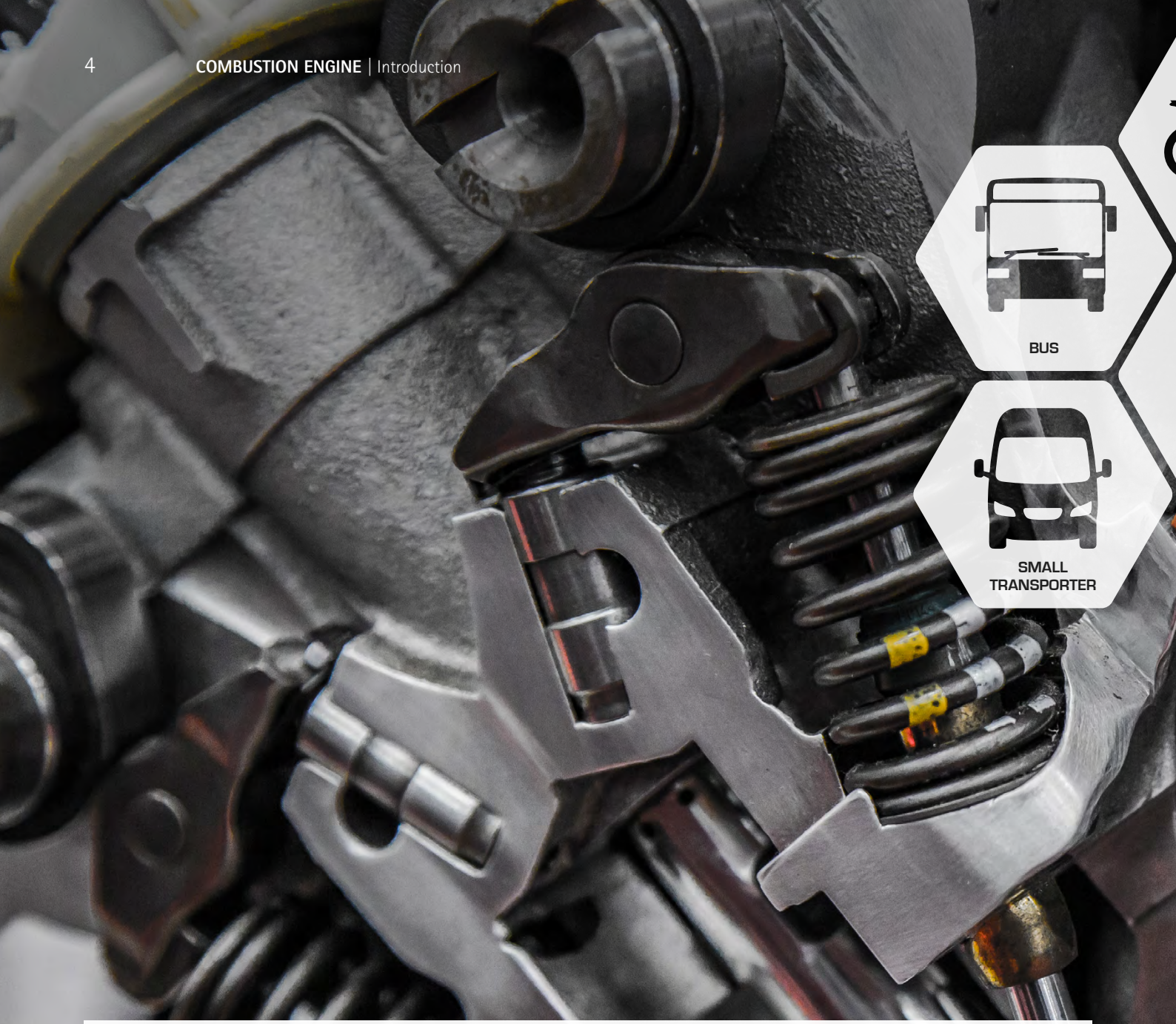
Over
450
technical consultants in the field.

More than
300
apprentices worldwide.

Our biggest asset:
4,850
employees worldwide.

MAPAL sectors

1 Automotive
2 Fluid power
3 Aerospace
4 Energy production
5 Electric mobility
6 Medical technology
7 Die & mould
8 Shipbuilding
9 Rail transport



Solutions for the combustion engine

Precision for complex requirements

Despite the growing focus on alternative drive technologies, the combustion engine remains a key aspect of modern mobility – particularly in hybrid vehicle concepts and markets with limited infrastructure for electric mobility. Its components are highly complex and exposed to significant thermal and mechanical load, and set the most stringent requirements of manufacturing.

Machining components like cylinder heads, crankshafts or connecting rods requires precision down to the last micrometre – and a deep understanding of materials, machining strategies and process reliability. Fluctuations in casting quality, composite materials and tight tolerances make machining demanding – and a crucial factor in the engine's efficiency, performance and emissions behaviour.

MAPAL approaches the challenges of engine machining with tailor-made tool solutions, maximum cost-effectiveness and process reliability. As an experienced manufacturer of precision tools and machining solutions, MAPAL has in-depth expertise in the machining of complex engine components.

Through intensive market research, close partnerships with universities, institutes and leading industry partners, and direct dialogue with customers, MAPAL identifies technological trends at an early stage and implements them in innovative machining processes. The result: solutions that are precisely tuned to the relevant requirements – and help the machining of combustion engines continually evolve.

CONTENTS

Learn more about solutions for
COMBUSTION ENGINES

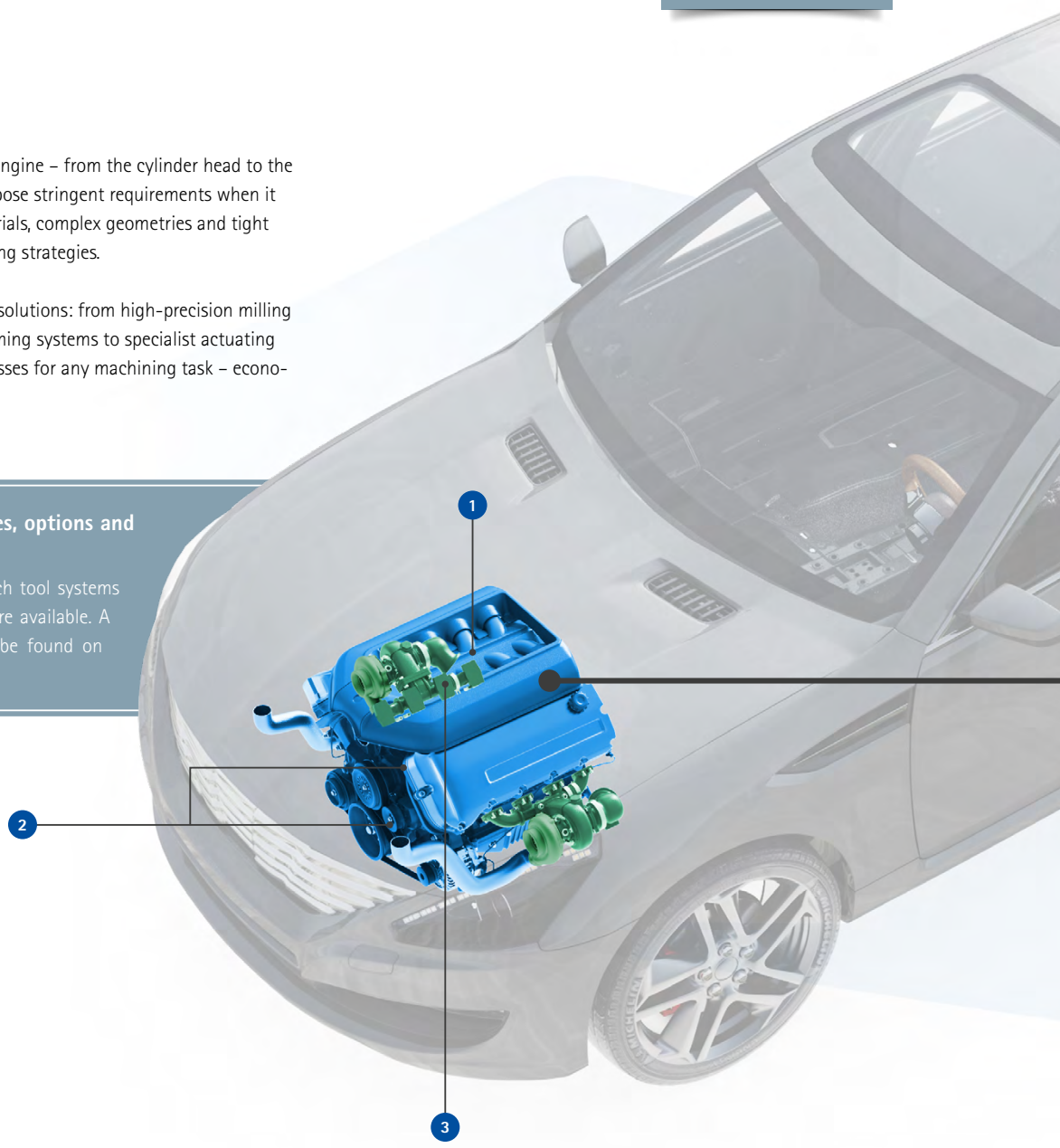
Combustion engine expertise

The components of a combustion engine – from the cylinder head to the crankcase and the turbocharger – pose stringent requirements when it comes to machining. Various materials, complex geometries and tight tolerances require tailored machining strategies.

MAPAL offers a wide range of tool solutions: from high-precision milling and drilling tools and modular reaming systems to specialist actuating solutions. The result is stable processes for any machining task – economical and reliable.

Pictograms make technologies, options and functions clear at a glance.

For each solution, they show which tool systems are used and which alternatives are available. A full overview of all symbols can be found on **page 47.**



SOLUTIONS FOR THE COMBUSTION ENGINE

1

Cylinder head

N

- Precise reaming and fine boring solutions for tolerances down to the µm range in the valve train.
- Process-stable machining for complex functional bores despite casting fluctuations.

>> More from page 8

2

Cylinder crankcase

N

- Boring/fine boring solutions for coaxial cylinder and bearing bores.
- Safe machining with minimal stock removal, varying casting and mixed materials.

>> More from page 18

Face and sealing surfaces

N

- Face machining with high surface quality, flatness and freedom from burrs – even dry.
- Optional defined surface profiles for functional surfaces that must be absolutely leak-proof.

>> More from page 26

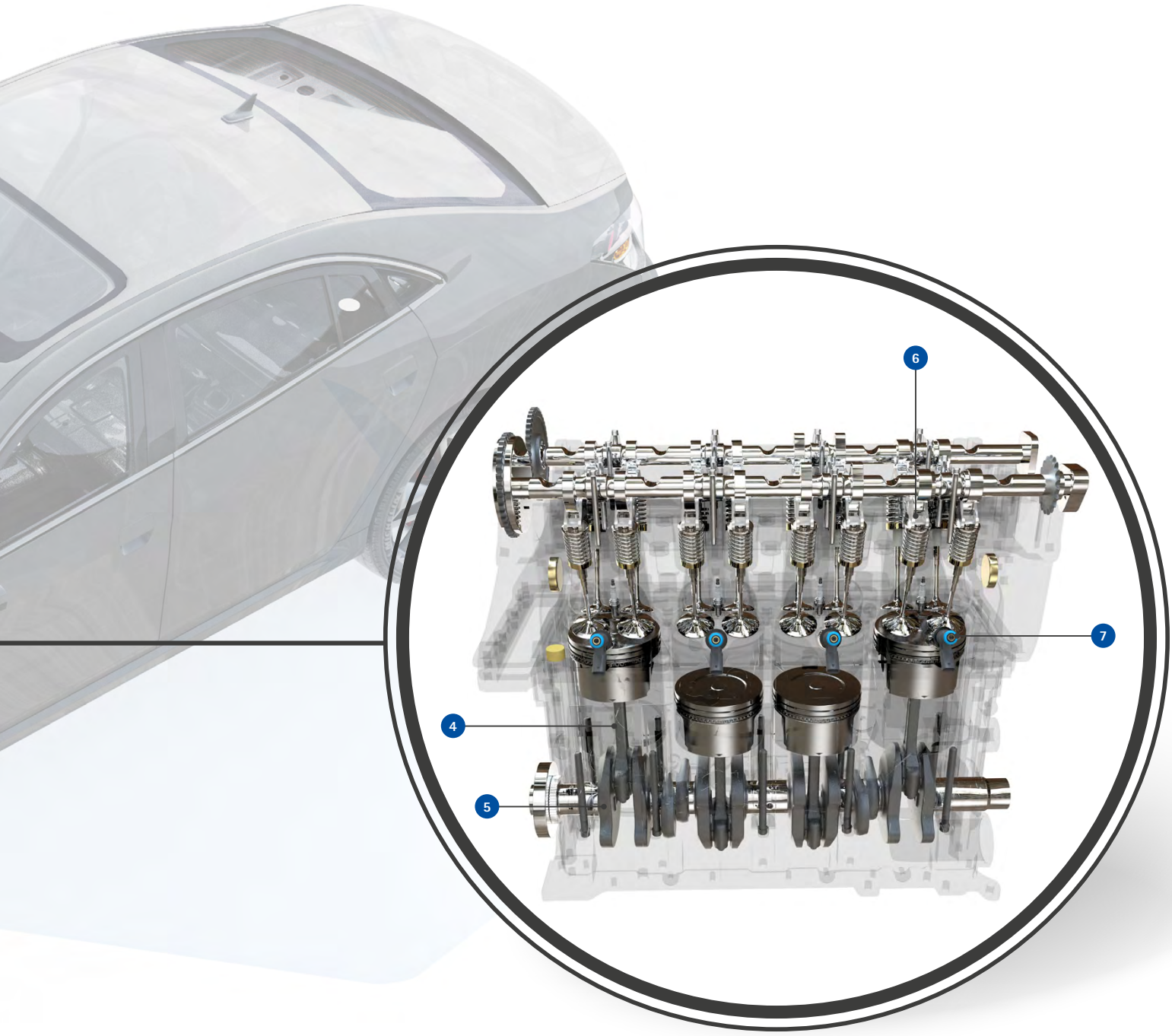
3

Turbo-charger

M K N S

- Machining with contour accuracy of complex inner geometries in abrasive, heat-resistant workpiece materials.
- Solutions offering process reliability for thin-walled areas and interrupted cuts.

>> More from page 28



4

Connecting rod

P

- Combined machining concepts for circularities down to the µm range in the big and small end.
- Solutions for varying component geometries, spot drilling situations and defined contours.

>> More from page 34

5

Crankshaft

P

- Process-reliable deep drilling of large machining depths with stable chip transport.
- Dimensionally accurate complete machining of functional surfaces with changing cutting conditions.

>> More from page 40

6

Rocker arm/ cam follower

P

- Precise fine machining of smaller bearing points with tight tolerances and circularities down to the µm.
- Setups ensuring stable processes for fluctuating casting quality and short cycle times.

>> More from page 42

7

Rail

P

- Deep drilling and reaming strategies for hard forging scale and large drilling depths.
- Dimensionally accurate inner machining for high-pressure channels that must be absolutely leak-proof and have tight tolerances.

>> More from page 44

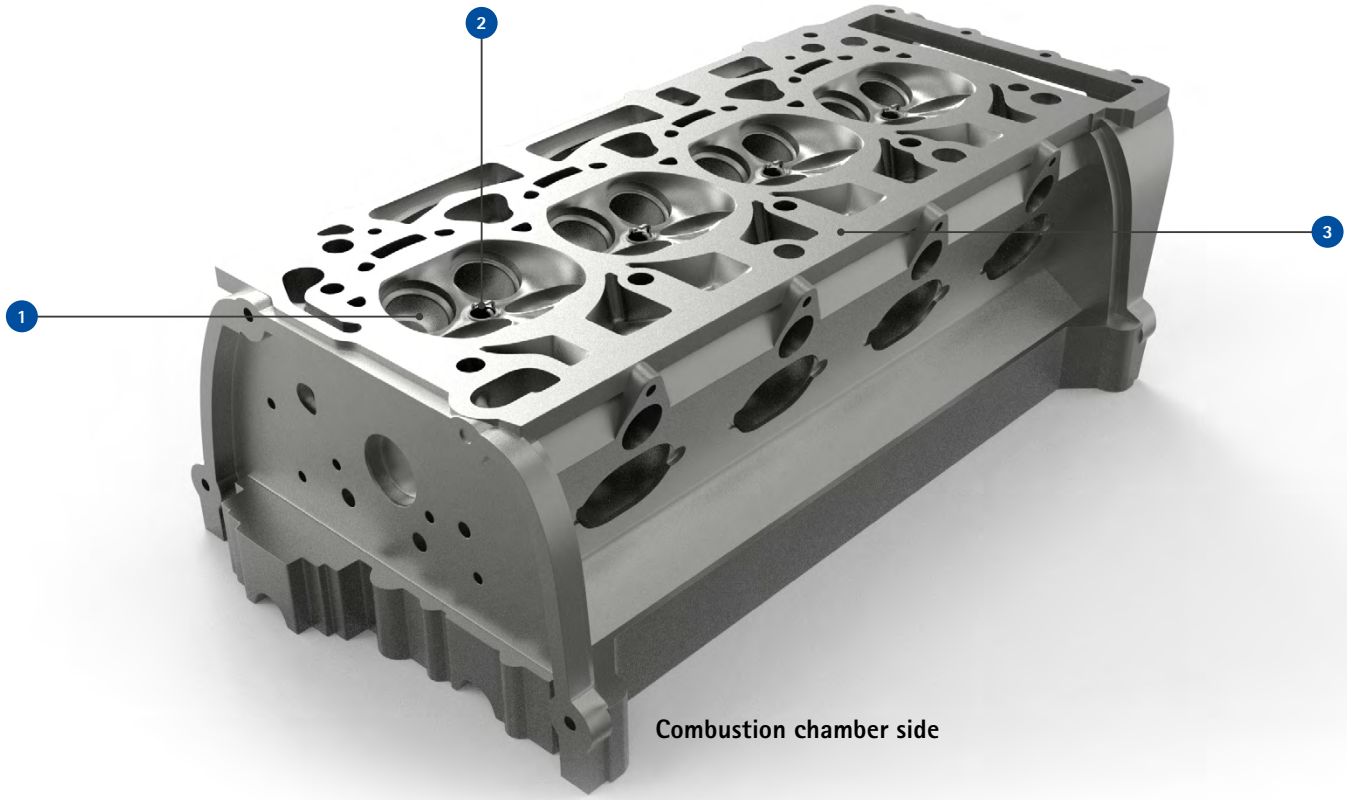
Cylinder head

When it comes to cars, the cylinder head is cast from aluminium alloys. The configuration and features for machining vary according to the engine fuel. The cylinder head is fitted on the cylinder crankcase and is responsible for the fuel and fresh air supply.

Due to its stringent requirements for quality and tolerance, it is the most demanding component for machining in engine manufacture. Through precise valve control and minimal friction losses in the camshaft bearings, fuel consumption and emissions are already reduced before the combustion process.

Required dimensional tolerances based on the example of the valve train

0,010 mm | <0,050 mm | 0,015 mm | 0,008 mm | 0,010 mm



1

Valve train

The valve train blind bore requires precision boring with high cylindricity and tight diameter tolerances. Material fluctuations through the casting process present a challenge.

>> More from page 10

2

Injector bore

The injector bore comprises large step changes and poses a challenge with regard to chip removal. Various casting situations make machining difficult.

>> More from page 12

3

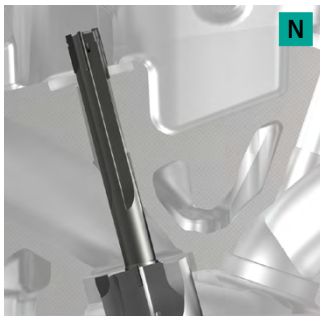
Face and sealing surfaces

Flatness, straightness and burr-free machining are important for face milling. Machining is often undertaken dry.

>> More from page 26

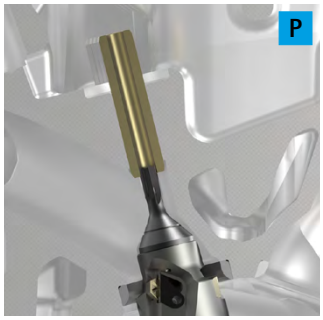
Valve train in focus – basic procedure

1. Pre-machining – blind bore
High feeds and large chip quantities require sturdy, PCD-tipped boring tools with efficient chip removal. Machining forms the foundation for all subsequent process steps in the valve train.

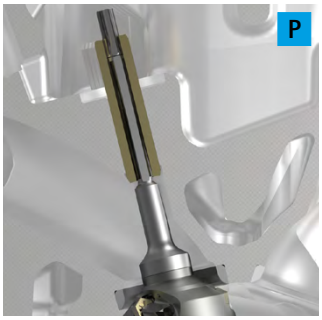


2. Finishing – blind bore
Multi-blade, PCD-tipped boring tools ensure dimensional accuracy and surface quality. In this machining step, precision is crucial so that the valve seat rings and valve guides can be pressed in later.

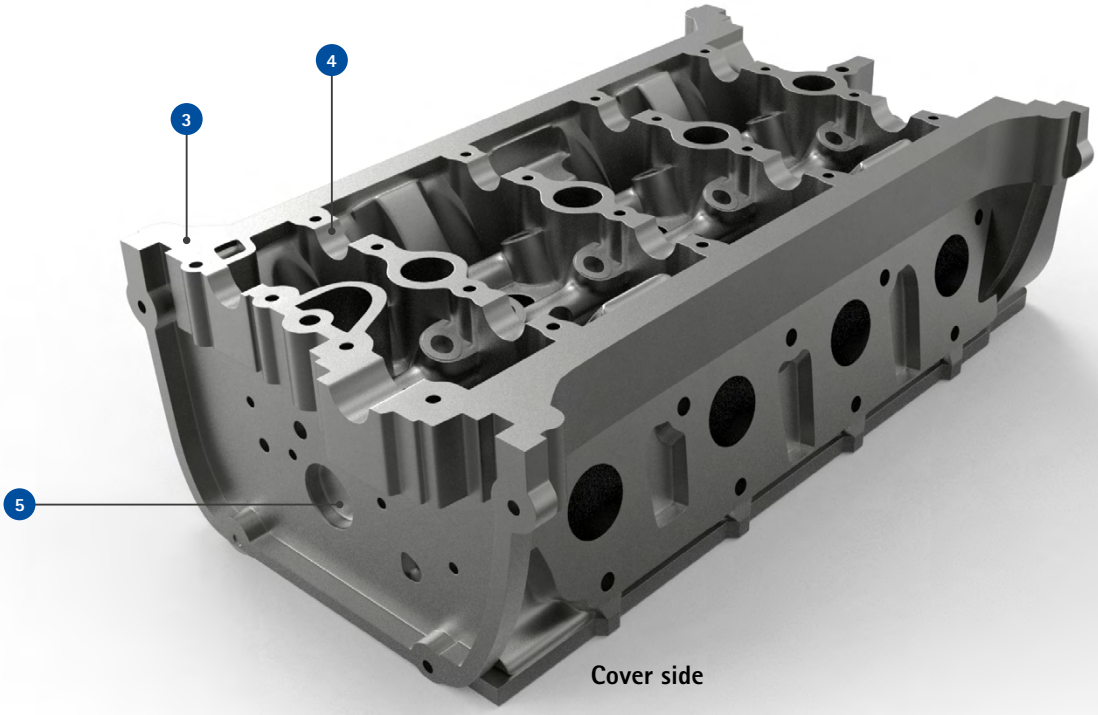
PRESSING IN THE VALVE SEAT RING AND VALVE GUIDE



3. Pre-machining – valve seat and valve guide
Once the valve seat ring and valve guide are pressed in, machining of the hard workpiece materials takes place. Extremely tight tolerances and wear-resistant cutting materials are required.



4. Finishing – valve seat and valve guide
Fine boring or reaming tools are used for precise sealing surfaces. These ensure high process reliability and long tool lives.



Cover side

4

Camshaft bearing bore

The camshaft bearing bore requires high cylindricity and circularity. Long tools and repeated cutting of the bearing journals due to the interrupted cuts are characteristic here.

>> More from page 14

5

Core plug bore

The surface of the core plug bore must be free from scratches and scores. The bore must be free from chips after machining.

>> More from page 16

Cylinder head – valve train

PROCESS CONDITIONS

- High-precision requirements for form and position tolerance
- Cylindricity 10 µm
- Diameter tolerance 15 µm
- Coaxiality from valve seat to valve guide
- Circularities < 8 µm
- Angle tolerances on the valve seat ring in the µm range
- Materials with high resistance to wear on valve seat ring
- Maximum process reliability and accuracy of repetition

N BLIND BORE

1. Pre-machining

2. Finishing

OPTION
Shorter machining times due to higher number of teeth

OPTION
Increased process reliability due to tool alignment with tool adapter

PCD boring tool

Short and stable tool design for maximum positional accuracy.

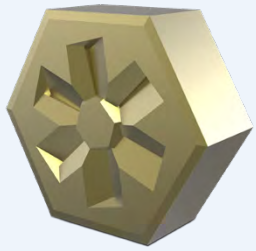
PCD boring tool

Multi-blade tool concept for short processing times.

MAPAL solutions expertise

HNHX – 12 CUTTING EDGES FOR MAXIMUM ECONOMIC EFFICIENCY

- With fixed blade seat or adjustable depending on component tolerance specification
- Up to 24 cutting-edge inserts possible at maximum cutting-edge utilisation
- Various PcBN cutting materials for all common valve seat materials



P VALVE SEAT / VALVE GUIDE

3. Pre-machining

4. Finishing

OPTION
Maximum tolerance requirements are achieved by the adjustable fine boring tool

OPTION
Plug-and-play with fixed blade seat

Pilot tool

Short, stable tool ensures maximum positional accuracy for the subsequent finishing tool.

H7 | PcBN | SC | 1

Finishing tool

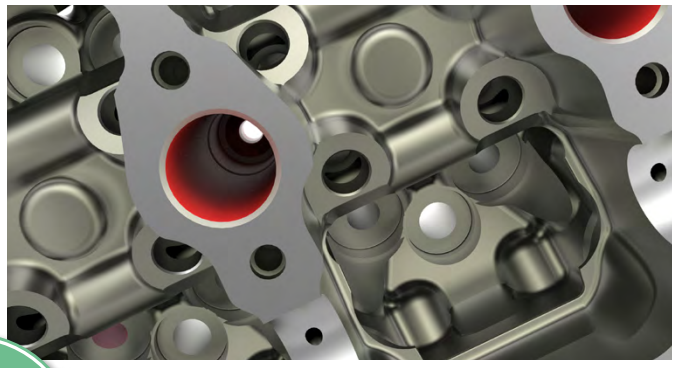
High-precision fine machining with adjustable fine boring tool with EA system and quick-change valve guide reamer.

H7 | EA | PcBN | SC | 1

Cylinder head – injector bore

PROCESS CONDITIONS

- Very large step changes > 10 mm
- Critical chip removal due to component contour
- Fluctuating casting situations
- Surface requirements of up to Rz 4
- Diameter tolerances in H7 range
- Wide range of contour designs with multiple tight-tolerance radii and chamfers (± 0.1 mm)



3-step process for maximum process reliability

N INJECTOR BORE

1. Pre-machining
2. Semi-finishing
3. Finishing

PCD multi-stage solid drill

Multi-blade solid drill and boring tool with brazed PCD inserts and special chip flutes for optimal chip removal.

Solid carbide step drill

Special cutting-edge geometry and spirali-sation for the best chip breaking and chip removal.

PCD step reamer

Multi-blade step reamer with brazed PCD inserts, special cutting-edge geometry and expanded chip flutes for optimal chip removal.

MAPAL solutions expertise

INSERT DRILL FOR RESOURCE-SAVING PRODUCTION

The insert drill makes it easy to replace the worn drilling from solid stage – irrespective of the boring stage. Due to suitability for repeat regrinding, optimal use is made of tool life. The targeted replacement of the wear-prone machining stage saves material and contributes to sustainability.

Two-step process for maximum productivity

1. Pre-machining

2. Finishing

PCD boring tool with solid carbide drill

Maximum usable tool life of PCD inserts due to drilling from solid stage that can be changed separately.

PCD | SC | 2

PCD step reamer

Multi-blade step reamer with brazed PCD inserts and expanded, polished chip flutes for optimal chip removal.

H7 | PCD | 4

Cylinder head – camshaft bearing bore

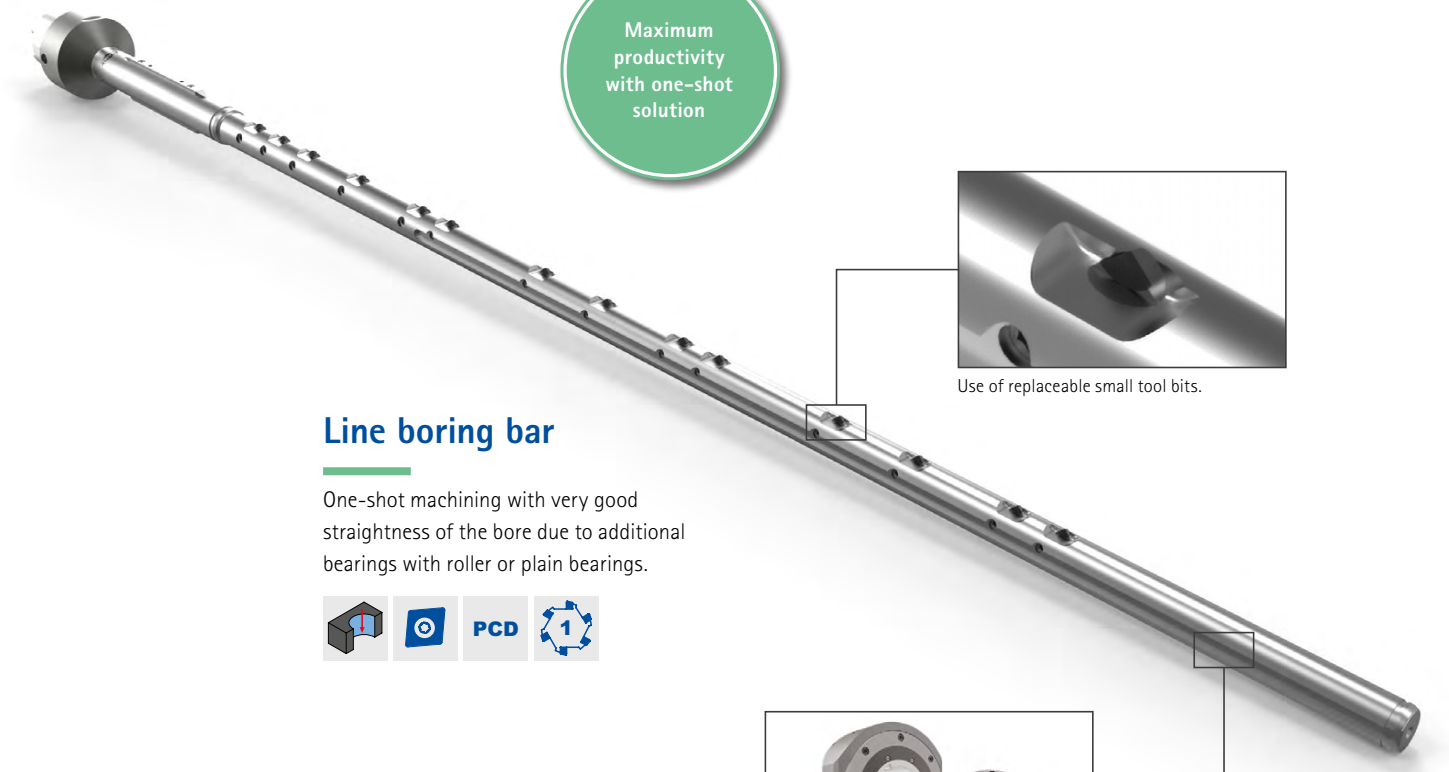
PROCESS CONDITIONS

- Cylindricity (15 µm over 100 mm)
- Circularity < 5 µm
- Diameter tolerances of 15 – 20 µm
- Surface qualities of < Rz 5 µm
- Repeated cutting due to the interrupted cut
- Tools with very high length-diameter ratio

N CAMSHAFT BEARING BORE

1. Pre- and finishing machining

Maximum productivity with one-shot solution

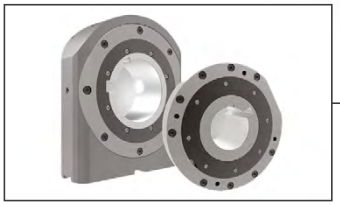


Use of replaceable small tool bits.

Line boring bar

One-shot machining with very good straightness of the bore due to additional bearings with roller or plain bearings.

PCD 1



Very good straightness of the bore despite long length due to multiple bearings and perfectly aligned line boring bar.

Ultimate process reliability with 2-step process

N CAMSHAFT BEARING BORE

1. Pre-machining

OPTION
Highest feeds with multi-blade tool design

2. Finishing

OPTION
Reduced process times and **plug-and-play** with multi-blade HPR interchangeable head

Fine boring tool

Guided fine boring tool with easy-to-adjust HX indexable inserts.

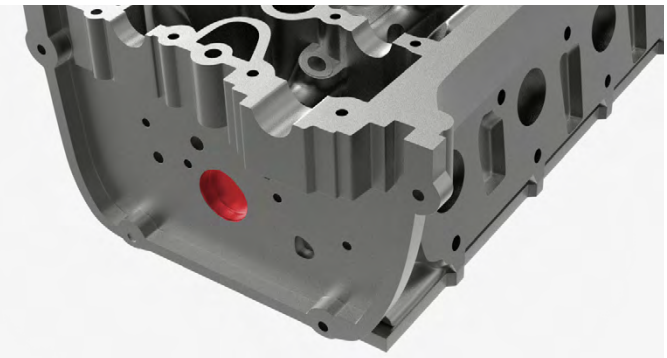
Fine boring tool

Guided fine boring tool with indexable inserts – with simple blade configuration and additional pre-cutting stage for maximum quality requirements.

Cylinder head – core plug bore

PROCESS CONDITIONS

- Surface quality Ra < 16 µm
- Circularity 0.05 mm
- Diameter tolerance H7
- Positional accuracy

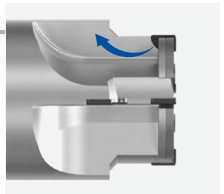


N CORE PLUG BORE

1. Semi-finishing

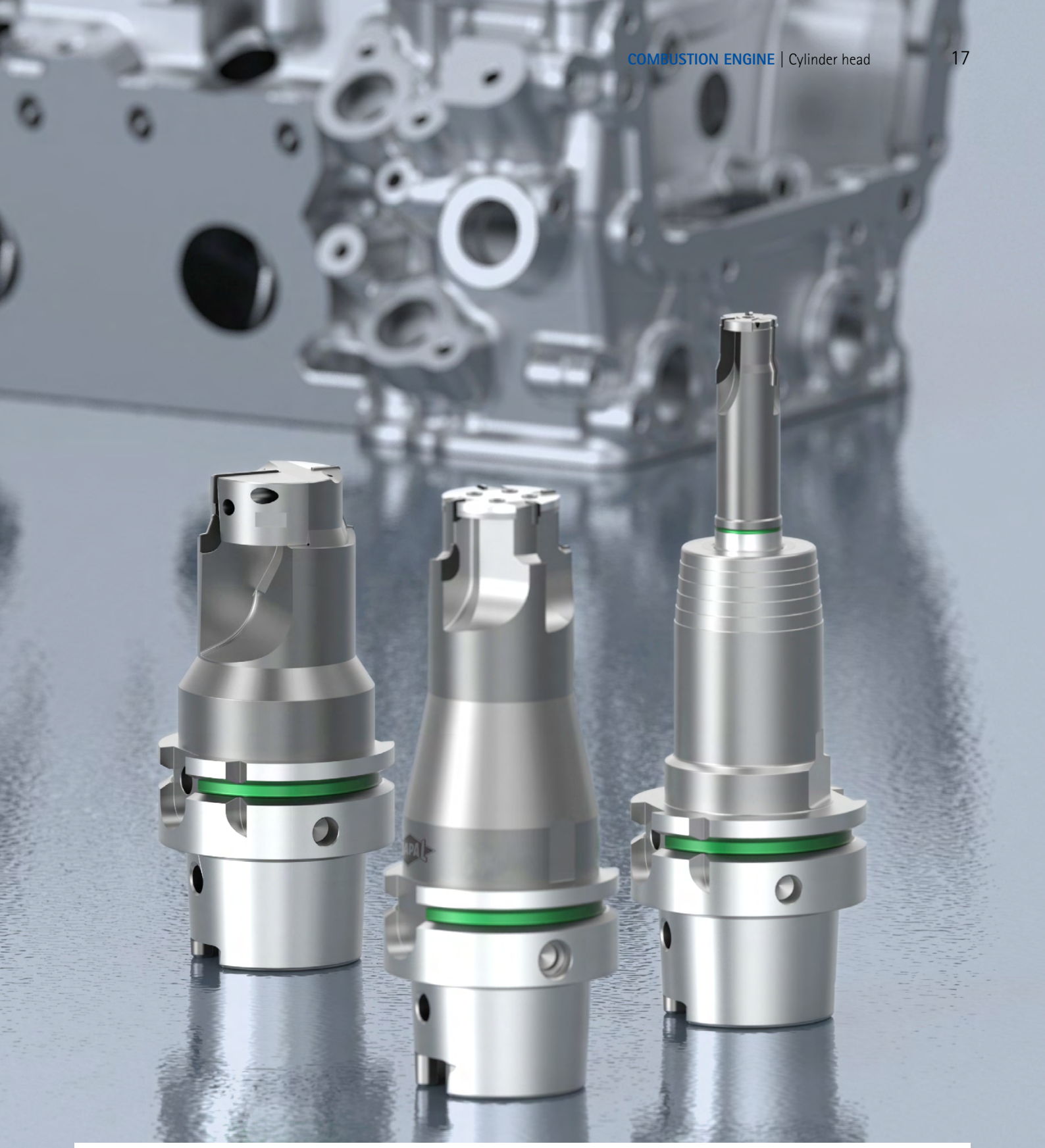
PCD step boring tool

Short, compact tool design for maximum tool stability.



OPTION

Safe and controlled chip removal due to chip deflector with built-in backflushing



MAPAL solutions expertise

PROCESS-RELIABLE CHIP REMOVAL DUE TO INNOVATIVE BACKFLUSHING

- Controlled chip removal keeps chips out of the component and makes it easier to clean
- High process reliability due to clean machining and reduced tool wear
- Very good component quality due to clean surface and fewer rejects as a result

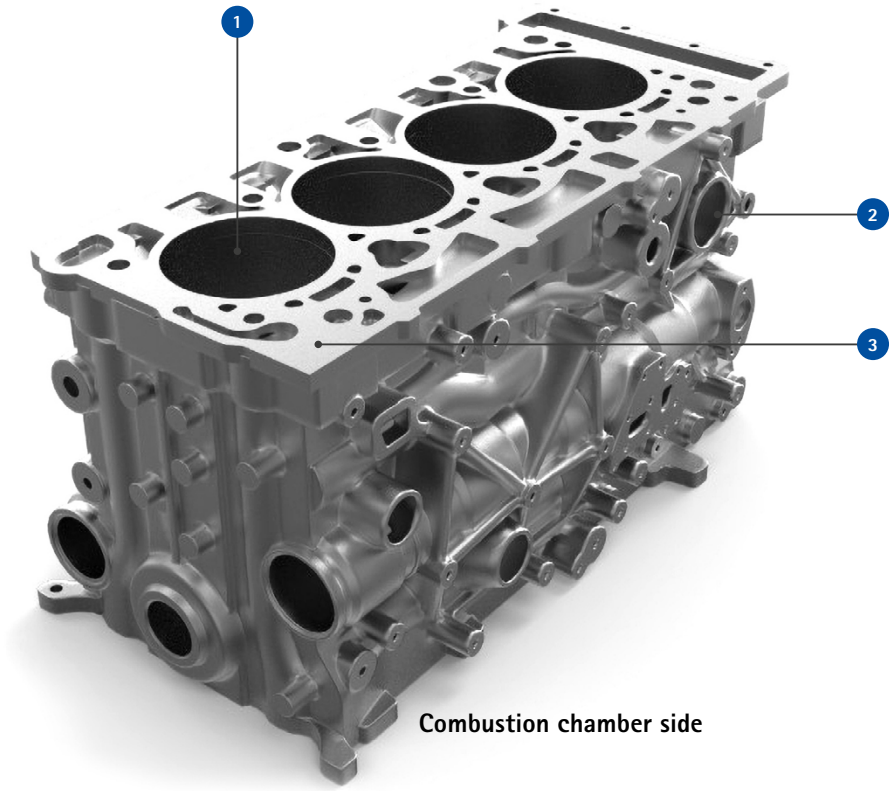
Cylinder crankcase

The cylinder crankcase, also known as the engine block, is the central element of the combustion engine. Depending on the vehicle model and engine size, different models and sizes are available, from the 2-cylinder series engine to the 12-cylinder engine in V-configuration. In the automotive sector, aluminium alloys are mainly used due to the weight advantage. For the cylinder bore, this requires the use of cast sleeves or wear-resistant coatings to ensure a high mileage. In machining, this often involves mixed machining with aluminium and cast iron and the use of extremely abrasive coatings.

The higher combustion pressures in modern engines increase mechanical and thermal loads, resulting in more stringent quality requirements for the features to be machined.

Required dimensional tolerances based on the example of the cylinder bore

0,014 mm	0,020 mm	0,175 mm	0,009 mm	0,060 mm



Combustion chamber side

1

Cylinder bore

Machining the cylinder bore requires maximum precision despite fluctuating casting stock removal, mixed machining, difficult access and tight tolerances.

>> More from page 20

2

Water pump bore

The bore for the water pump requires high dimensional accuracy and tightness. Machining usually takes place in several steps to produce an exact fit and sealing surface.

>> More from page 23

3

Face and sealing surfaces

In face milling, the sealing surface between the cylinder head and block is machined. Flatness, straightness and a burr-free surface – often in dry machining conditions – are crucial.

>> More from page 26

Cylinder bore in focus – basic procedure

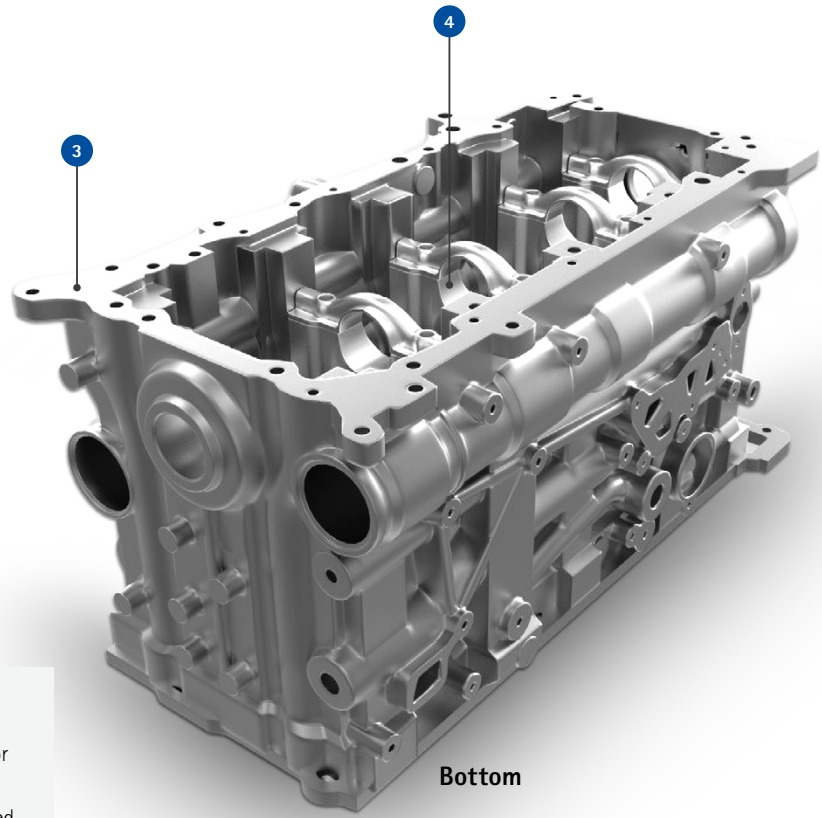
1. Pre-machining – cylinder bore
Pre-machining includes boring cylinder bores with sturdily designed indexable insert tools. They handle high and fluctuating stock removal. Depending on the workpiece material, PCD-tipped or coated HM indexable inserts are used to ensure long tool lives and high precision.

COATING OR USING LINERS

2. Finishing – cylinder bore
Fine boring tools bring the bore to the exact dimension for subsequent coating or liner use. The tools are designed for high stability and feeds. They also produce the required dimensional accuracy and surface quality.

3. Finishing – cylinder bore surface
After coating or liner fitting, the final machining of the bore surface takes place. Precise fine boring tools ensure dimensional and shape accuracy, have cutting compensation, and enable contact-free retraction from the bore.

4. Honing relief
Honing relief is mostly produced with special milling or actuating tools. The complex transition geometries and mixed machining that sometimes occur require coordinated tool and cutting material selection.



Bottom

4

Crankshaft bearing bore

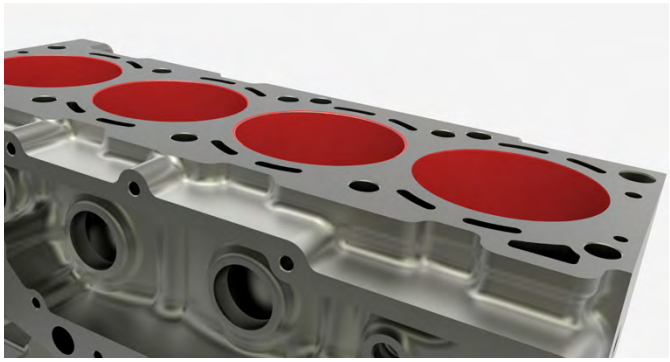
This bore poses stringent requirements for coaxiality and cylindricity across multiple bearing points. Long tools and finely tuned machining strategies ensure the necessary precision.

>> More from page 24

Cylinder crankcase – cylinder bore

PROCESS CONDITIONS

- Fluctuating casting and stock removal situations
- Wear-resistant coatings (TWAS coating) are sometimes included in the components
- Partly mixed machining through the use of different materials → aluminium crankcase and grey cast iron cylinder liner
- Machining with poor accessibility due to component size
- Diameter tolerance before honing of up to 40 µm



N BLIND BORE

1. Pre-machining

2. Finishing

Boring tool

Stable and cost-effective tool design with indexable inserts and easy-to-adjust cartridges, including for fluctuating component stock removal.

PCD 3

Fine boring tool with EA system

Compact multi-blade tool design for maximum feed rates and easy adjustment.

EA PCD 5

Alternative manufacturing process with thermal spray coatings.

K CYLINDER BORE SURFACE WITH SLEEVE

3. Finishing

The right solution for every machine concept

Machining centre

Custom machine

FUNCTION

Blade readjustment down to the exact µm – manual or automated in the machining centre.

FUNCTION

High process reliability due to scoring-free machining with cutting-edge lifting

OPTION

Cutting-edge lifting through increasing coolant pressure. Five-blade design

5

Honing relief on next page

Compensation tool

Cutting compensation through face-side serration can be implemented automatically and directly in the machine. Cutting-edge lifting through positional offset and special tool design enable contact-free retraction.

H7 PcBN 3

Actuating tool

Depending on the machine type, the inserts are retracted and actuated in a defined manner using a drawbar, adjusting spindle or rotary drive. This enables contact-free retraction and precision blade readjustment.

U-AXIS PcBN 3

K N CYLINDER BORE SURFACE

4. Honing relief

The right solution for every machine concept

Machining centre

Custom machine

Circular milling cutter

Multi-blade tool design with maximum flexibility in the selection of indexable inserts.

PCD 3

Actuating tool

Defined blade actuation through drawbar/push rod. Flexible contour possible.

U-AXIS SC 1

MAPAL solutions expertise

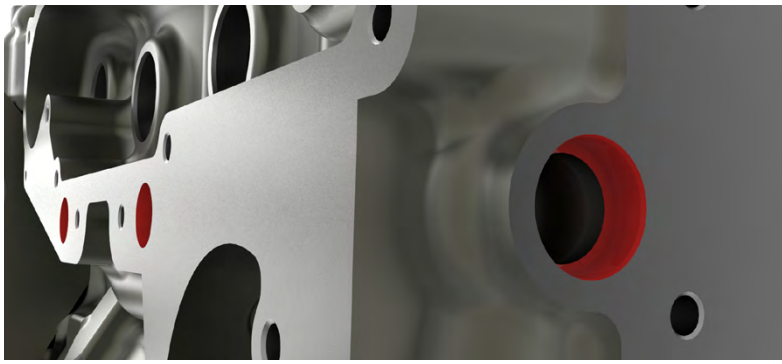
FLEXIBLE TOOL CONCEPT FOR COMPONENT VARIANTS

- One tool – tailored with insert variants for each design
- Solutions offering process reliability for mixed machining (cast iron/aluminium or aluminium/steel)
- Special blades for radial transitions and geometries with poor accessibility
- Maximum precision at diameter tolerances of ±0.2 mm
- Cost-effective machining for series production

Cylinder crankcase – water pump bore

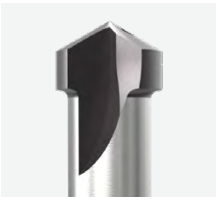
PROCESS CONDITIONS

- Multi-stage bore with defined radius transitions
- Diameter tolerances in H8 range
- Circularities of 10 – 20 µm



N WATER PUMP BORE

1. Semi-finishing



FUNCTION
Interchangeable solid carbide drill

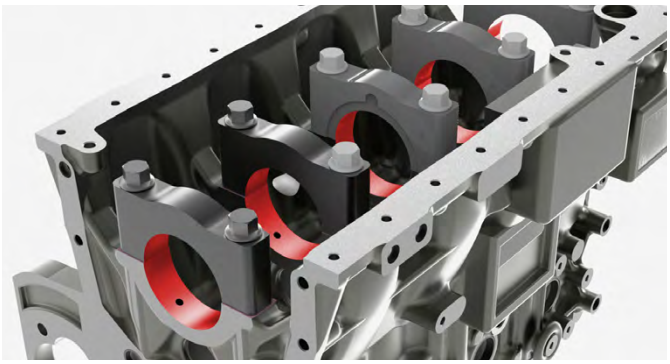
PCD step boring tool

Optimised PCD insert geometry for controlled chip breaking and with interchangeable solid carbide drill for efficient use of cutting edges on boring stages.

Cylinder crankcase – crankshaft bearing bore

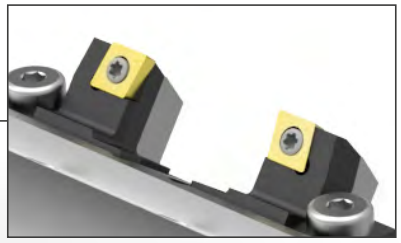
PROCESS CONDITIONS

- High coaxiality of the individual bearing journals to each other
- Repeated cutting due to the interrupted cut
- Mixed machining for fine machining through bearing shells
- Diameter tolerances of 0.2 mm
- Surface specifications of Rz 3.2 µm
- Circularity < 3 µm



K N CRANKSHAFT BEARING BORE

1. Pre- and finishing machining



Combination of journal- and thrust-bearing machining with integrated spools.
Exact, simplified setting of the inserts using finely adjustable cartridges.

Maximum productivity with one-shot solution

Precision line boring bar

Optimum coaxiality on the component due to additional bearings opposite the machine spindle, including for long component lengths.

2. Finishing

OPTION

Maximum surface qualities due to precise adjustable indexable inserts for the finishing stage

MP

Ultimate process reliability with 2-step process

1. Pre-machining

Fine boring tool

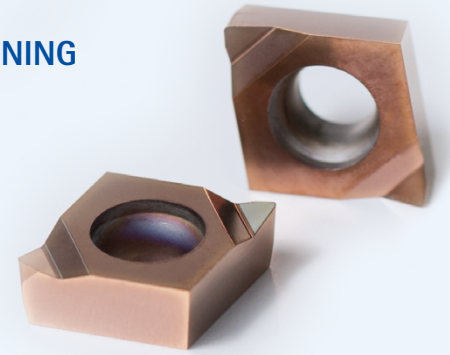
Pre-machining stage and additional micro-machining at the finishing stage for the highest quality requirements and process reliability.

H7 EA PCD 4 MODUL

MAPAL solutions expertise

CUTTING MATERIAL SERIES FOR MIXED MACHINING

Workpiece material combinations such as aluminium/cast iron or aluminium/sintered steel require special cutting materials. The MAPAL range includes indexable inserts for these machining situations with adapted substrates, geometries and TiAlN coating for long tool lives and cost effectiveness.



Face and sealing surfaces

Machining flat sealing surfaces in the combustion engine requires the utmost in dimensional accuracy, flatness and surface quality – often in dry conditions.

MAPAL supplies high-performance face milling tools with maximum number of teeth, sturdy tool design and optimal chip removal. Whether roughing or finishing: The solutions are designed for cost-effectiveness, process reliability and component quality.

N FACE MILLING

NeoMill-T-Rough

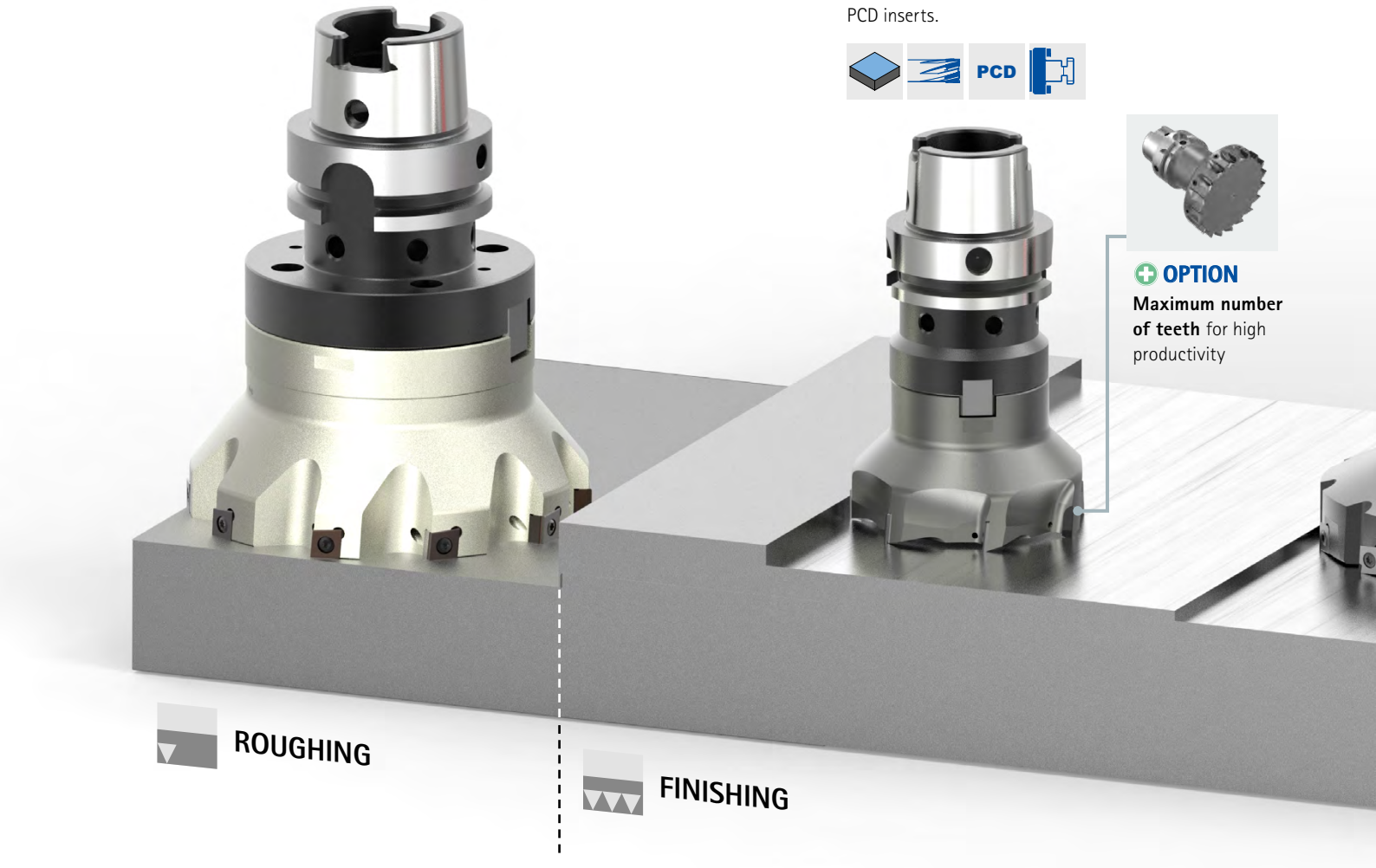
Tangential roughing tool for stable machining at high volumes.

SC

FaceMill-Diamond

Strong, regrindable tool with brazed PCD inserts.

PCD

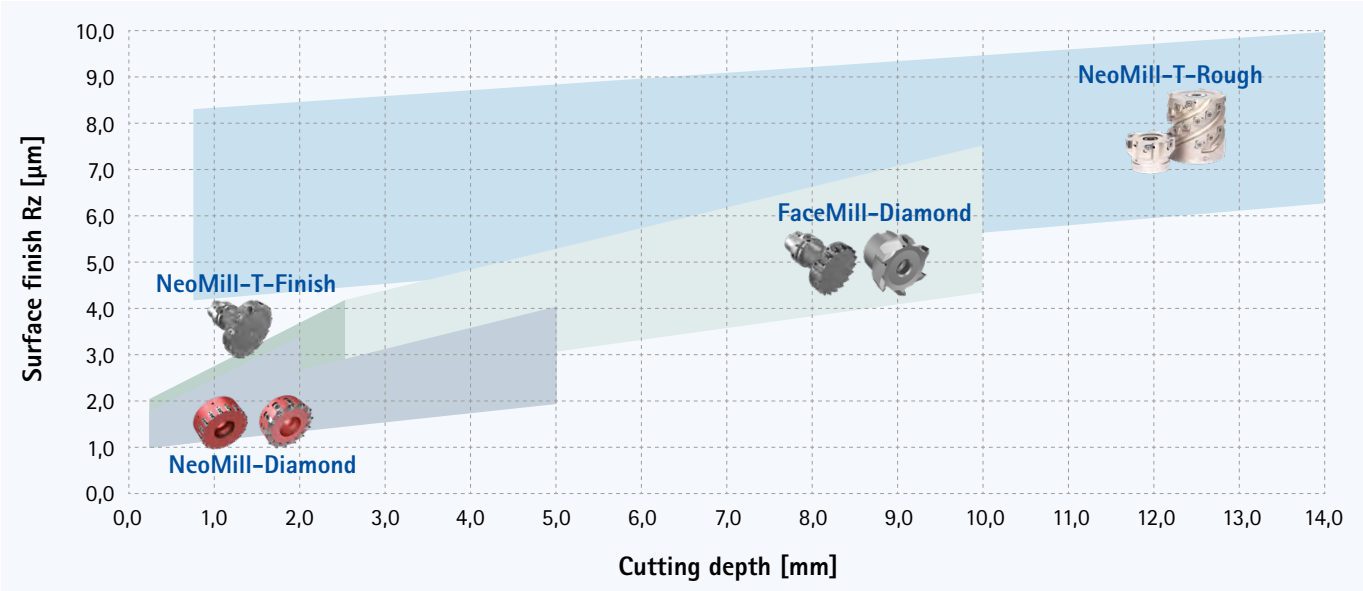


OPTION
Maximum number of teeth for high productivity

ROUGHING

FINISHING

Overview of face milling systems



NeoMill-T-Finish

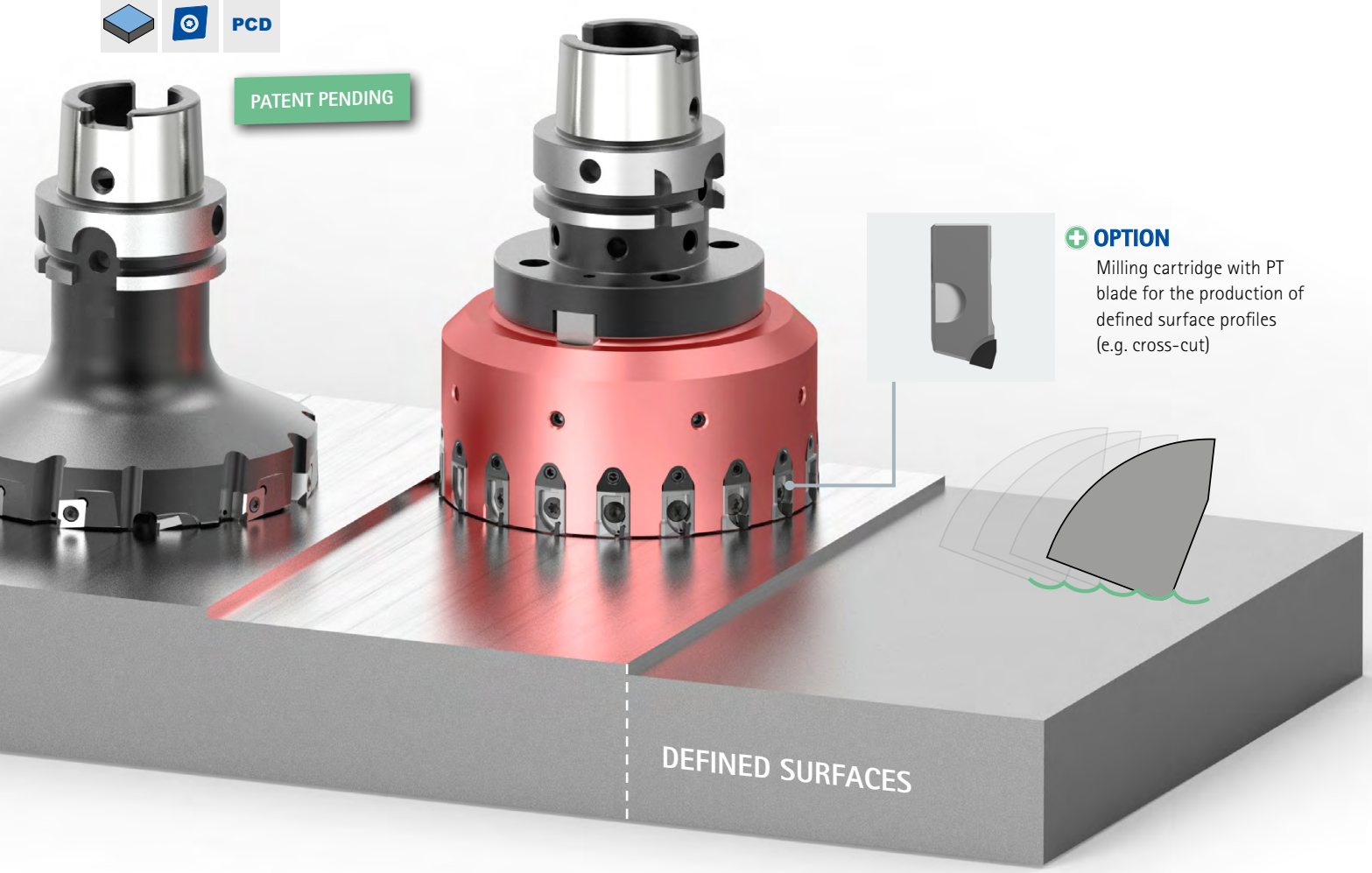
Plug-and-play solution with indexable inserts through high-precision insert seat.

PCD

NeoMill-Diamond

Milling tool body with interchangeable PCD cartridges and precise blade adjustment.

PCD



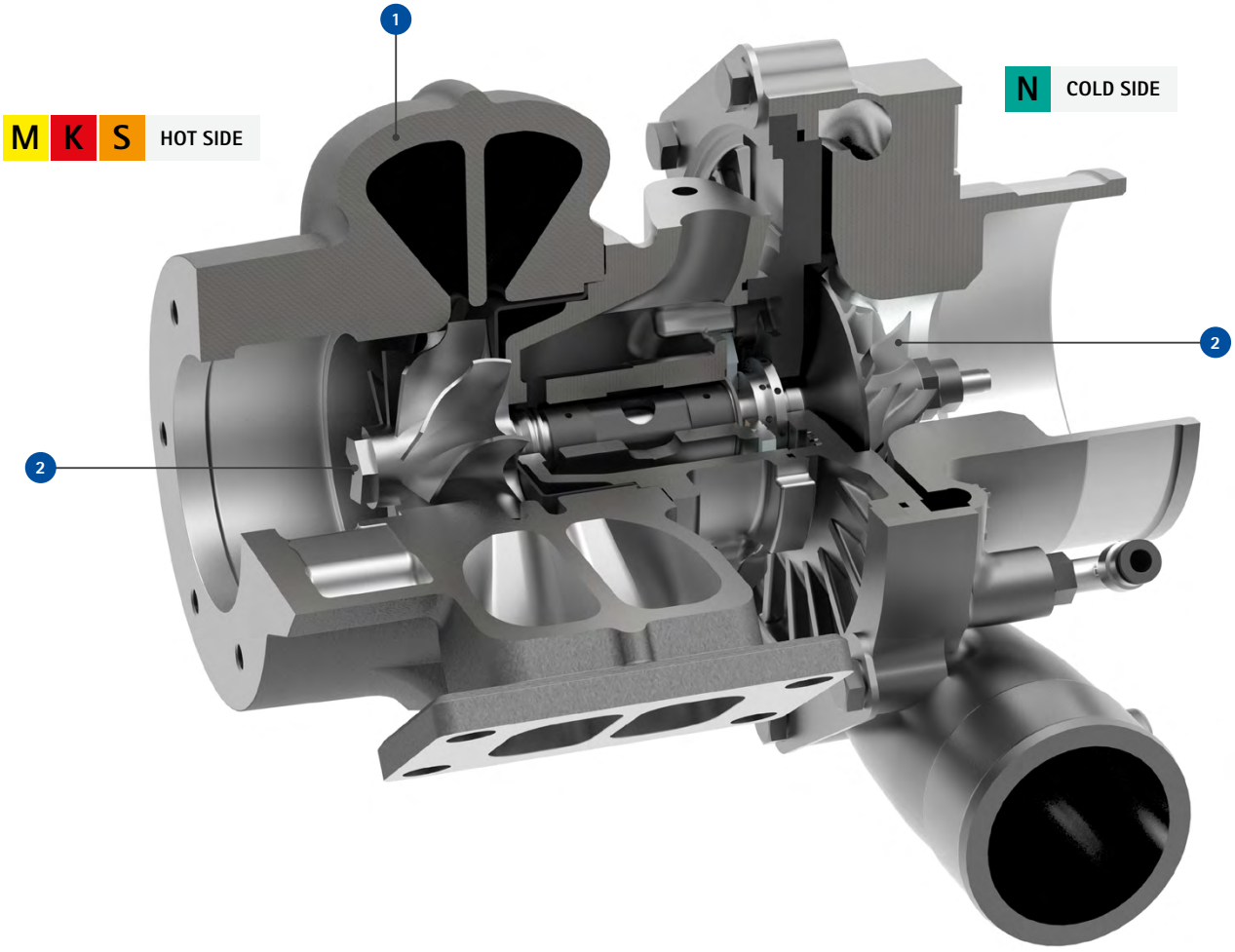
OPTION

Milling cartridge with PT blade for the production of defined surface profiles (e.g. cross-cut)

Turbocharger

Exhaust gas turbochargers are used to boost the performance and efficiency of modern combustion engines. The compressed air supply increases efficiency while reducing emissions – a key aspect of current climate strategies.

The most stringent requirements for coaxiality and circularity apply at speeds of up to 300,000 rpm. Particularly on the exhaust side (hot side), high-alloyed, abrasive workpiece materials pose extreme requirements for machining tool wear resistance. At high quantities, even small improvements in tool life for each tool lead to significant cost advantages in series production.



1

Turbocharger housing

K

Complex contours and high thermal load require precise machining and burr-free surfaces.

>> More from page 30

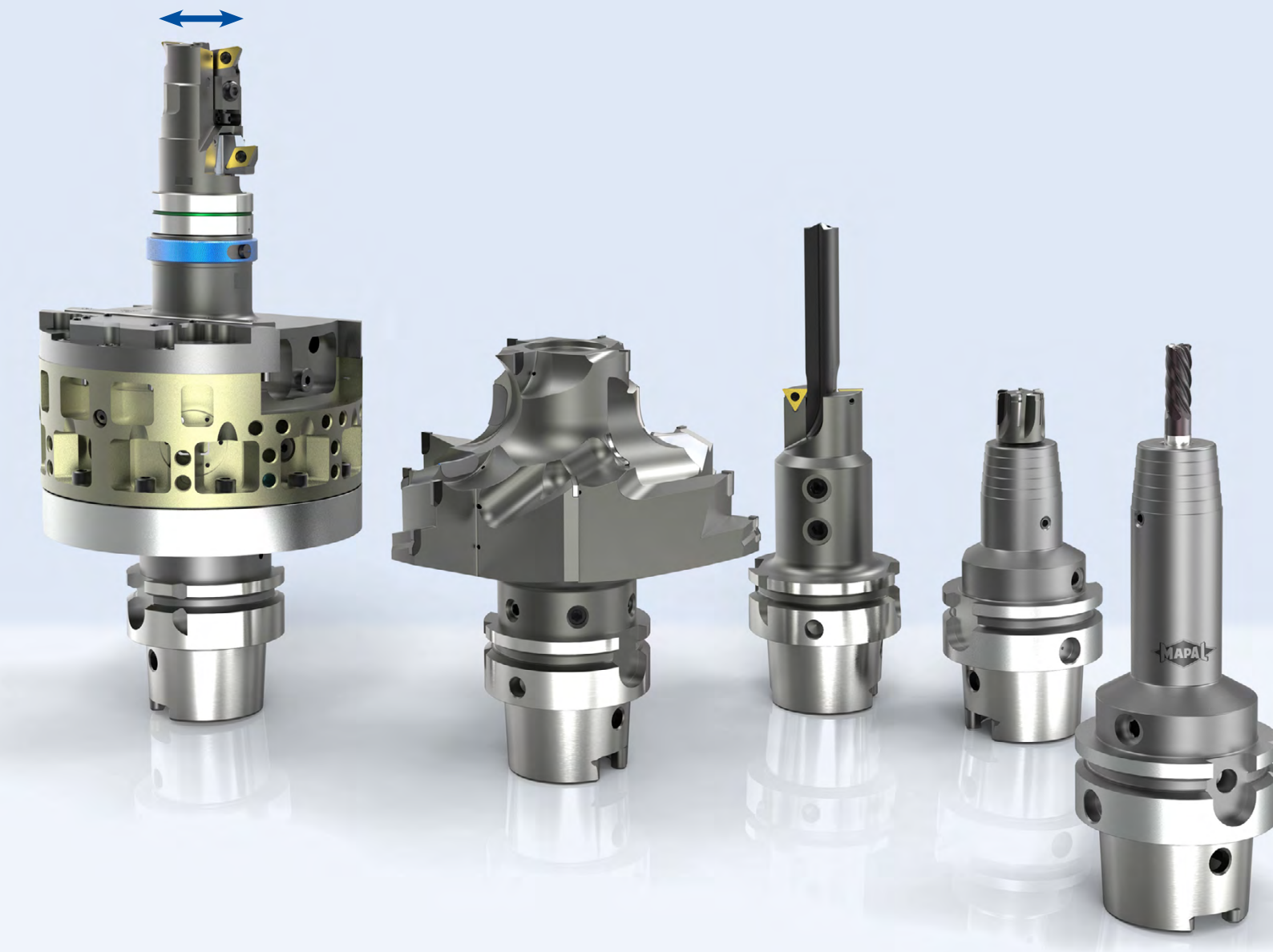
2

Impeller/vane wheel

M N S

Free-form surfaces and tight tolerances at high speed – demanding machining for geometries under dynamic load.

>> More from page 32



MAPAL solutions expertise

TOOLTRONIC® – A FULL-FLEDGED ADDITIONAL TOOL AXLE

MAPAL actuating tools offer the ultimate in precision and flexibility in the machining of complex contours, face surfaces and recesses – like on the turbocharger housing. With the mechatronic tool system TOOLTRONIC from this family, machining on cubic workpieces can be carried out efficiently and with high precision in one clamping system on machining centres.

Turbocharger housing

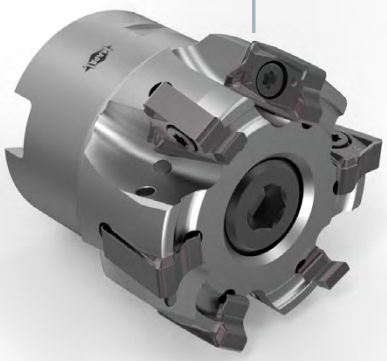
The turbocharger housing on the exhaust side is exposed to extreme thermal and mechanical loads. It directs the hot exhaust gases – with temperatures of up to 1,050 °C – onto the turbine wheel to drive its rotation.

The housing geometry has a significant impact on charger response and efficiency. Workpiece materials resistant to high temperatures, such as Ni or Fe-based cast alloys, are used. Manufacturing requires precise casting processes and complex finishing to ensure dimensional accuracy and surface quality – particularly in the area of contours relevant to fluid mechanics.

PROCESS CONDITIONS

- Highly heat-resistant and ultra-abrasive materials
- Complex geometries and contours with chamfers, radii and transitions
- Tight form, position and surface tolerances
- Interrupted cuts

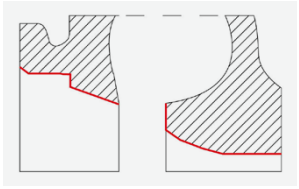
K HOT SIDE



Shoulder milling of surfaces

NeoMill-4-Corner

Short, sturdy tool design for maximum stability and specially developed indexable inserts for workpiece materials that are difficult to machine.

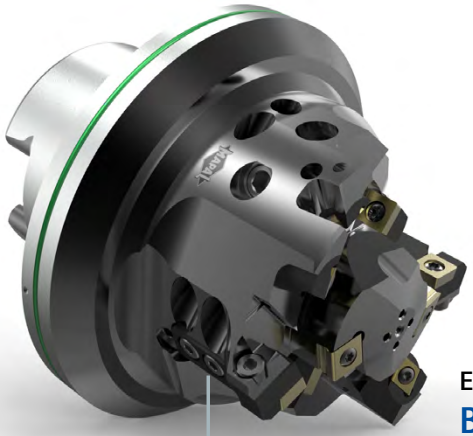


Contour of a turbocharger

Internal contour machining

TOOLTRONIC® tool

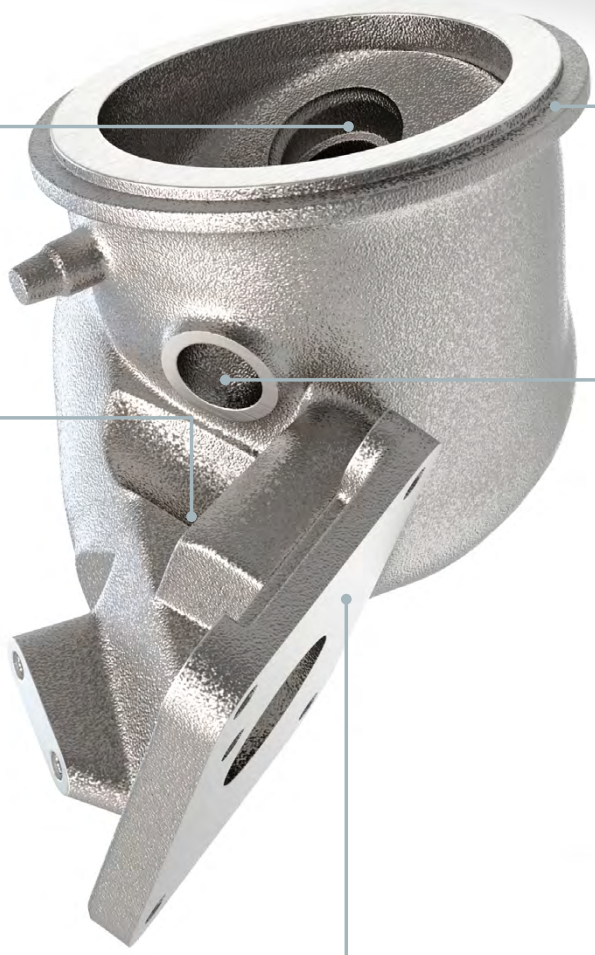
Flexible machining with an additional machining axis (U axis) with maximum flexibility for contour changes or wear corrections.



Exhaust manifold connection machining

Boring tool

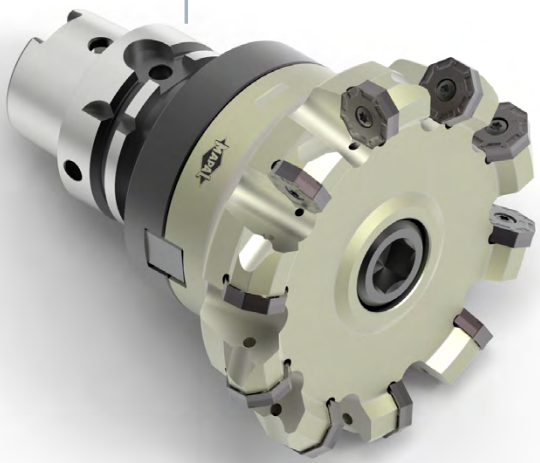
Tool design with adjustable indexable inserts for short processing times.



Control pin bore

High-performance reamer

Tool design with specially arranged inserts for optimal chip removal, including at the highest feeds.



Turbocharger housing connecting surface

NeoMill-16-Face

Maximum number of teeth and indexable inserts with 16 cutting edges for maximum tool lives and low costs per component.

Turbocharger – impeller / vane wheel

The impeller is the key component on the compressor side of a turbocharger. It accelerates the drawn-in air radially outwards, thereby increasing its pressure and temperature.

Modern impellers are mostly made from high-strength aluminium or titanium and are produced through 5-axis milling or precision casting. The aerodynamically optimised vane geometry is crucial to efficiency and boost pressure behaviour. The most stringent requirements for balancing quality, strength and dimensional accuracy must be met due to high speeds of up to 300,000 rpm.

PROCESS CONDITIONS

- Workpiece materials that are difficult to machine on the hot side
- Material fluctuations and alloy differences
- Complex machining in hard-to-reach places
- High-precision requirements for radial run-out
- Surface requirements of Ra < 0.4 µm

M S HOT SIDE

1 Shaft bore

2 Balancing surface

MEGA-Speed-Drill-Titan

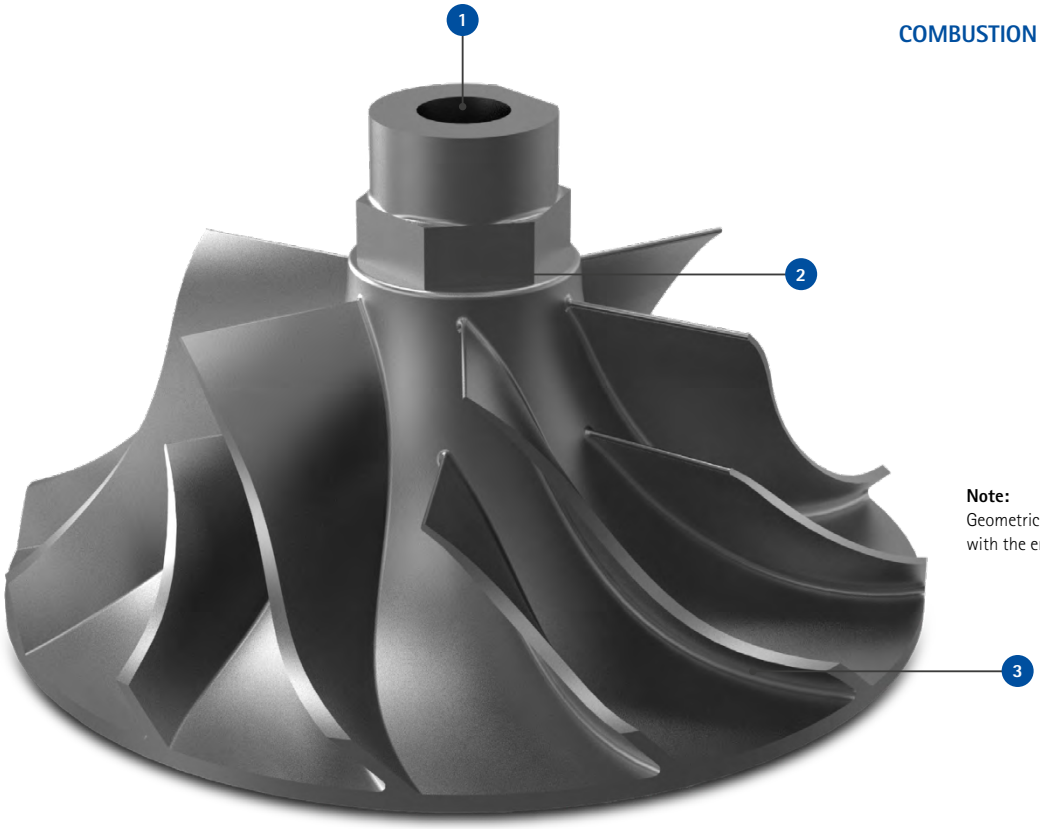
Special cutting geometry and coating that reduces the formation of built-up edges and optimises chip removal.

SC 2

Profile milling cutter

Multi-blade, coated solid carbide milling cutter, developed for workpiece materials that are difficult to machine.

SC 6



Note:
Geometric design in collaboration with the end customer.

N COLD SIDE

1 Shaft bore

Tritan-Drill-Alu

Three-blade solid carbide drill for the highest feeds.

SC 3

2 Balancing surface

PCD shoulder milling cutter

Multi-blade PCD-tipped milling cutter for the longest tool lives.

PCD 6

3 Vane machining

Coated form cutters

Form cutters adapted to the component contour for roughing, semi-finishing and finishing.

SC 2 3

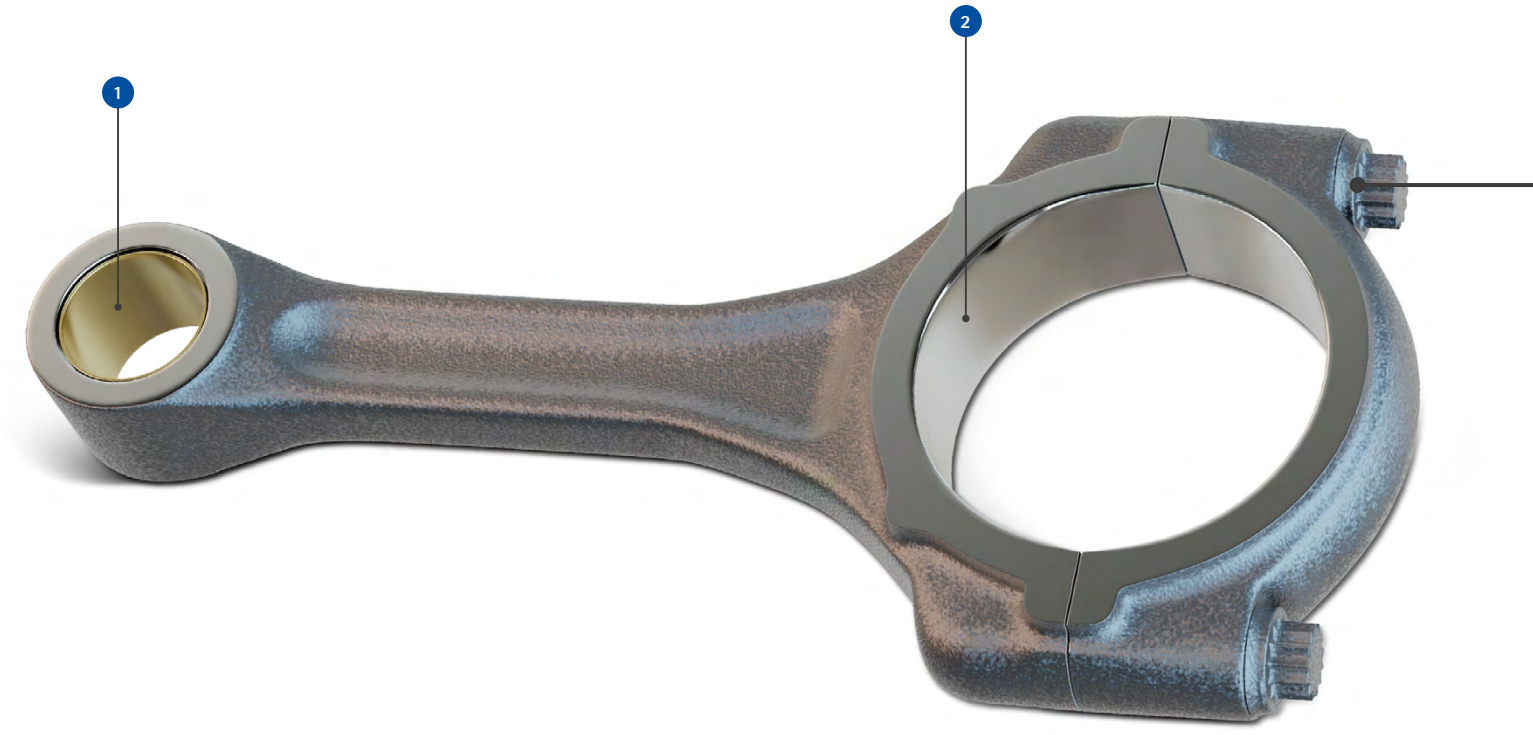
Connecting rod

Connecting rods are subject to high dynamic loads in engine operation. High-strength steel materials like 70MnVS4 or C70 are used to meet these requirements. Their role: To convert the linear motion of the piston into a rotating motion of the crankshaft. To minimise the moving mass, connecting rods are consistently optimised for weight. The result is a wide range of variants – from parallel and trapezoidal to step shapes. This variety poses stringent requirements for manufacturing, particularly in machining the small end of the connecting rod.

Different geometries result in varying spot drilling situations that must be resolved with precision and cost-effectiveness. Cost-effectiveness is a priority in series production. The high quantities require stable processes, short cycle times and maximum tool lives.

Required dimensional tolerances based on the example of the small end

4 – 6 µm	±3 µm	60 – 200 µm	5 – 10 µm	max. Ra 0,8 µm



1

Small end

Wide variety, bell-mouthed shape and tolerances down to the µm: Machining the small end requires maximum precision and flexible tool solutions.

>> More from page 36

2

Big end

High cutting forces and tight shape tolerances necessitate sturdy tools and precise machining strategies.

>> More from page 38

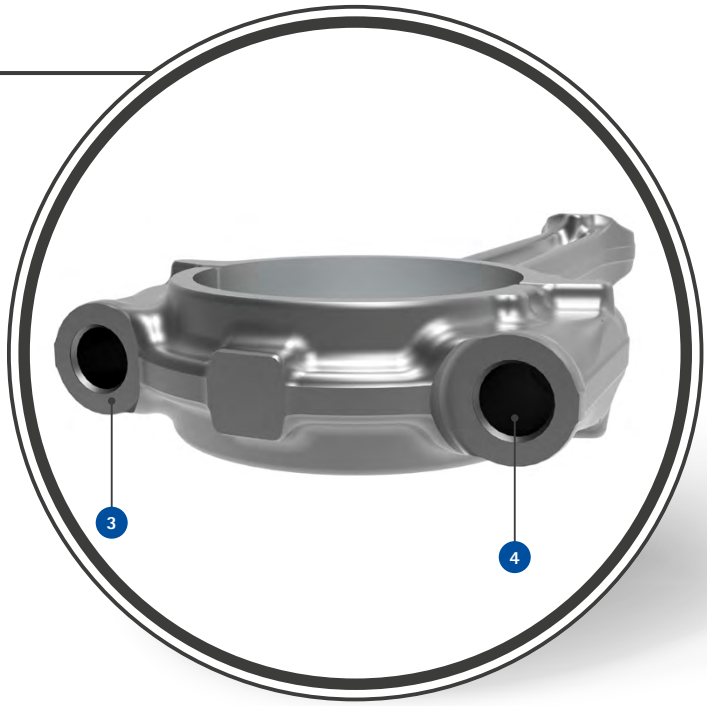
Small end in focus – basic procedure

1. Pre-machining
Various connecting rod forms require flexible tool solutions. A special solid drill combines drilling, boring and chamfering on both sides. The challenge: stable processes despite varying geometries.

PRESSING IN THE SLEEVE

2. Semi-finishing
Radially adjustable ISO inserts compensate for shape deviations and prepare the bore for the sleeve. Dimensional accuracy and even material distribution are crucial for subsequent fitting.

3. Finishing
Fine boring tools with PCD guide pads create the best surface qualities and circularities under 10 µm.



3

Bolt locating surface

Precise surface machining for secure bolt seating surfaces – high dimensional accuracy and defined geometry for varying connecting rod shapes.

>> More from page 39

4

Bolt hole bore

Multi-stage bore with tight tolerances – sturdy tools and optimised cutting geometries for maximum process reliability and tool life.

>> More from page 39

Connecting rod – small end

PROCESS CONDITIONS

- Spot drilling and boring due to different connecting rod shapes
- Surface requirements of maximum Ra 0.8 µm
- Diameter tolerances of 6 µm
- Circularities of 5 – 10 µm
- Partly specified bore shapes such as the bell-mouthed shape

P SMALL END

1. Pre-machining

WP solid drill

Short, sturdy tool design enables drilling from solid, boring and chamfering on both sides with just one tool.

The right solution for every requirement

2. Semi-finishing and finishing machining

Maximum tool life

Fine boring tool

Pre-machining stage for maximum tool life and for the stringent quality requirements of the fine boring stage.

Maximum productivity

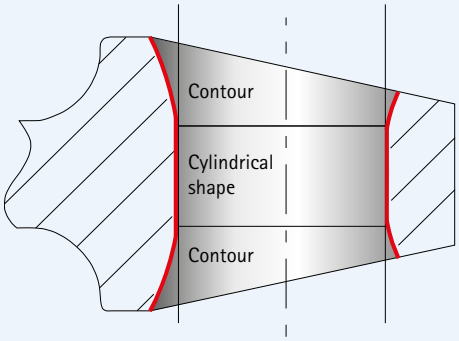
HPR replaceable head reamer

Multi-blade, regrindable replaceable head for short processing times and long tool lives.

MAPAL solutions expertise

BELL-MOUTHED SHAPE

The bell-mouthed shape is used to minimise the edge loading and ensure optimal force transmission between gudgeon pin and connecting rod. This shape helps exploit the material properties to the fullest and compensates for the distortion of the bolt at the end of the connecting rod.



N SMALL END WITH SLEEVE

More on actuating

3. Finishing

The right solution for every contour

Cylindrical shape

Bell-mouthed shape

Fine boring tool

Pre-machining stage and adjustable WP fine machining stage for the most stringent quality requirements and maximum tool life.

Actuating tool

Additional U axis for semi-finishing and finishing machining for big and small end. Maximum contour flexibility and simple wear contour.

Connecting rod – big end

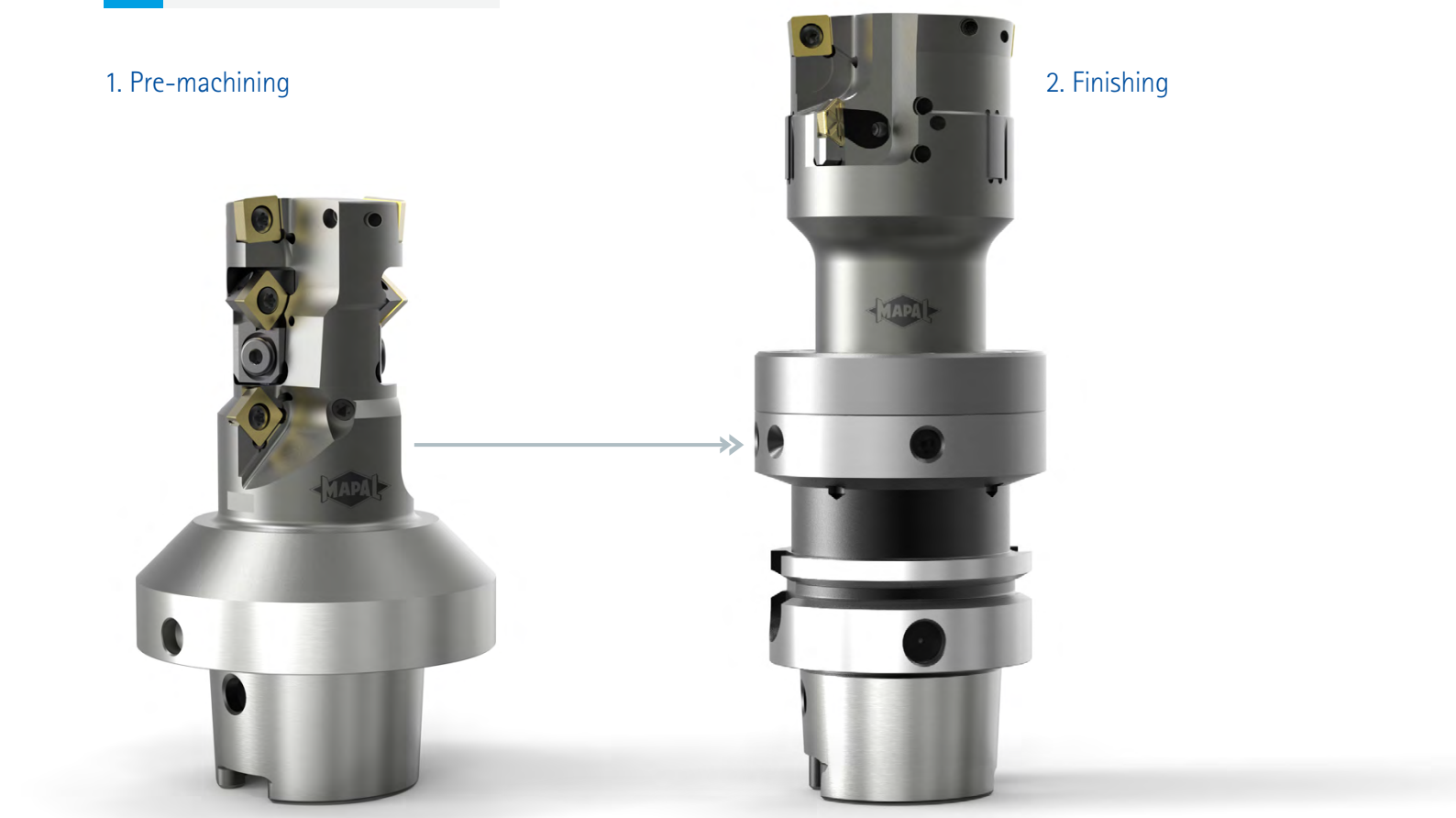
PROCESS CONDITIONS

- Wear-resistant carbide on the crack notch
- Different stock removal situations
- Highest quality requirements for bore geometry
- Circularities of 5 – 8 µm
- Diameter tolerances of 10 µm
- Defined surface values of ~ Rz 6 µm to Rz 11 µm

P BIG END

1. Pre-machining

2. Finishing



Roughing tool

Stable, multi-blade tool design for the combination of multiple process steps (roughing, boring, chamfering).

SC 3

Fine boring tool

Boring and fine boring for defined stock removal, maximum tool life and the most stringent quality requirements.

H7 SC 1 MODUL

Connecting rod – bolt locating surface / bolt hole bore

PROCESS CONDITIONS

- Positional accuracy of +/- 0.10 mm
- Surface finish requirement Ra 3.2 µm
- Concentricity 0.20 mm
- Diameter tolerances 0.05 mm to 0.10 mm
- Bore design with multiple step changes
- Materials difficult to machine with additional hard-forged outer skin

P BOLT LOCATING SURFACE

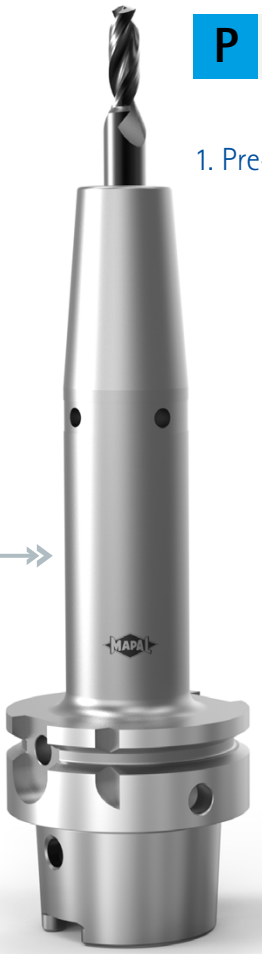
1. Grooving/milling

Solid carbide milling tool

Face geometry that cuts across the centre for milling and grooving contact surfaces.

P BOLT HOLE BORE

1. Pre- and finishing machining



Solid carbide step drill

Multi-stage one-shot design with optimum chip breaking at boring stages.

Crankshaft

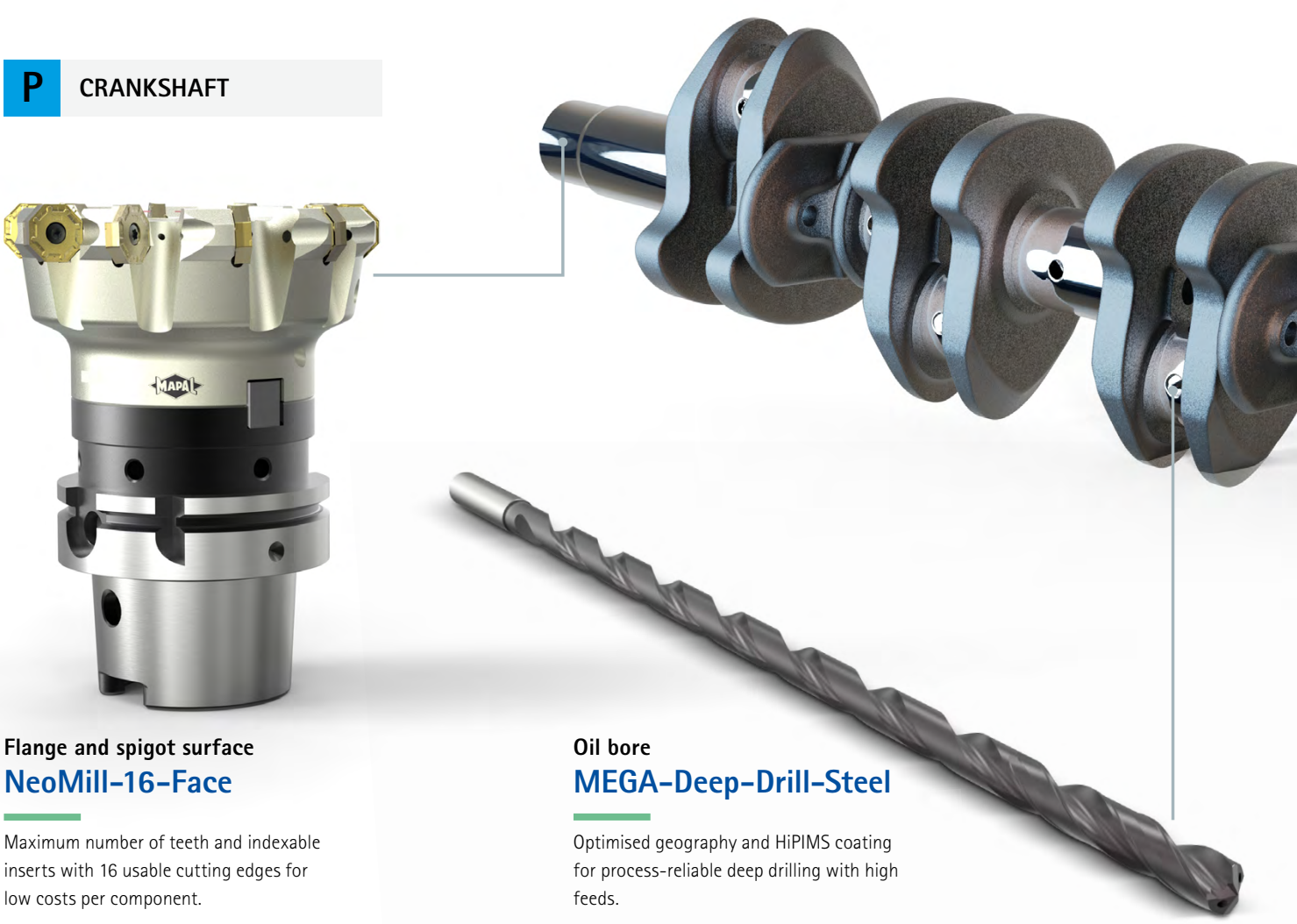
The basic crankshaft design is determined by the number of cylinders and engine layout. To reduce emissions, the mostly forged steel shafts must be increasingly optimised for weight. This requires additional machining steps for already complex components. At the same time, rising combustion pressures lead to higher bending and torsional loads – and therefore stricter quality requirements for dimensional accuracy, strength and surface quality.

PROCESS CONDITIONS

Example of central relief bore:

- Multiple spot drilling
- Bore depths up to 800 mm
- Coordinated process parameters for simultaneous drilling and deburring
- Coaxiality
- Varying machining conditions due to casting fluctuations

P CRANKSHAFT



Flange and spigot surface

NeoMill-16-Face

Maximum number of teeth and indexable inserts with 16 usable cutting edges for low costs per component.

Oil bore

MEGA-Deep-Drill-Steel

Optimised geography and HiPIMS coating for process-reliable deep drilling with high feeds.

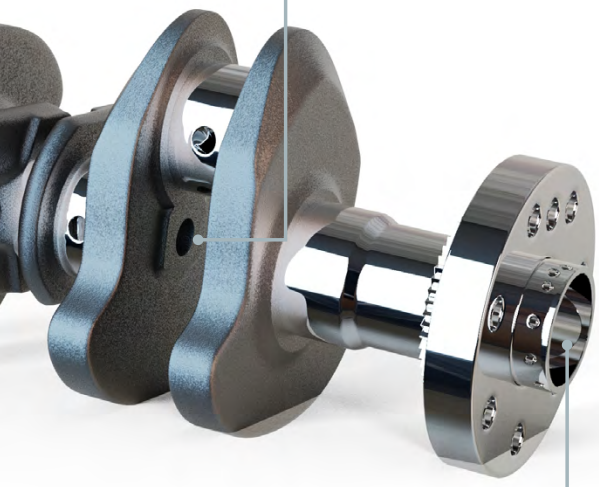
More on drilling
from solid and milling

Central relief bore

TTD bore deburring tool

Replaceable head system with TTS connection and replaceable chamfer insert for forward and/or backward chamfering.

FUNCTION
MAPAL replaceable head system and chamfer insert from the company HEULE for bore entry and exit.



P FACE BEARING BORE

1. Pre-machining

WP drill

Short, stable tool with multiple process steps integrated in one tool (roughing, boring, chamfering).

2. Finishing

High-performance reamer

Multi-blade plug-and-play reamer for finishing diameter and chamfer.

Rocker arm / roller cam follower

Precise control of inlet and outlet valves is crucial for the performance and efficiency of modern combustion engines. In automotive technology, four valves per cylinder are usually used – two for the intake of fresh air or air-fuel mixture, two for the exhaust gas outlet. Depending on the engine concept, rocker arms or (roller) cam followers are used for valve operation. The aim is to minimise friction and wear and tear for moving components. The valve clearance can be adjusted precisely using built-in setting discs to ensure a stable combustion process and prevent engine damage.

PROCESS CONDITIONS

Bearing bore example:

- Diameter tolerances in H7 range
- Surface requirement in Rz 3 µm range
- Circularity in range of few µm
- Fluctuating casting quality

P PRECISION FIT BORE

1. Finishing

The right solution for every requirement

Maximum precision

Highest productivity

Indexable insert fine boring tool

Guided fine boring tool with adjustable inserts for the most stringent quality requirements.

HPR replaceable head reamer

Multi-blade regrindable reamer with HFS connection for a simplified tool change.

P BEARING BORE

1. Finishing

Highest productivity

HPR replaceable head reamer

Multi-blade regrindable replaceable-head reamer with HFS connection for rapid tool change in the machine.

The right solution for every requirement

Maximum precision

Indexable insert fine boring tool

Guide pad and adjustable indexable inserts for the most stringent quality requirements.

Rail

Like in diesel engines with common rail systems, fuel is increasingly injected straight into the combustion chamber in modern petrol engines, too. The mixture formation takes place only in the combustion chamber, boosting performance and efficiency and reducing emissions. The increasing injection pressures of up to 2,500 bar set stringent requirements on components and workpiece materials. Materials that are difficult to machine are used, such as cast steel or stainless steel – connected with complex machining processes.

PROCESS CONDITIONS

Central rail bore example:

- Extremely hard outer forging scale
- Extreme drilling depths of up to 25xD
- Diameter tolerances of 0.20 mm
- Long chipping workpiece materials

P RAIL

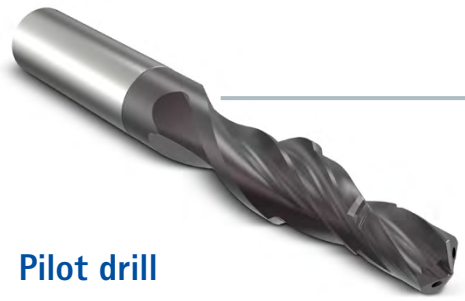
P CENTRAL RAIL BORE

High-pressure connection

Solid drills

Solid carbide drills for the smallest bore diameters.

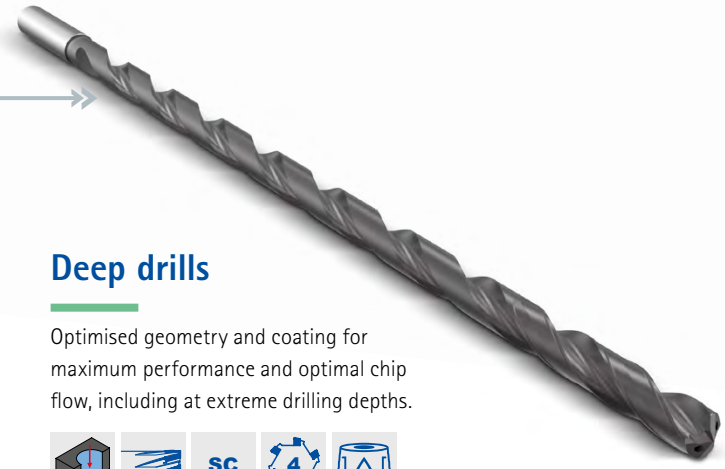
1. Pre-machining



Pilot drill

Special geometry for the outer forging scale that is difficult to machine, perfectly adapted to the subsequent deep-hole drill.

2. Drilling from solid



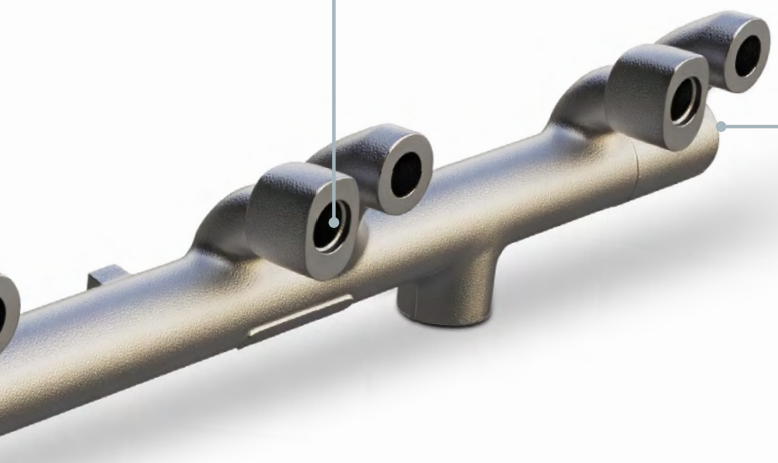
Deep drills

Optimised geometry and coating for maximum performance and optimal chip flow, including at extreme drilling depths.

Injector bore

Coated solid carbide step reamer

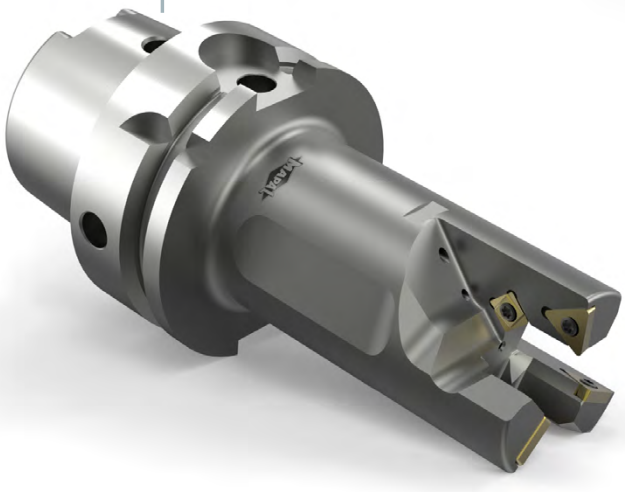
Special tool design for optimal cut distribution and chip control at the step changes.



End machining

Face cutter head

Multi-blade combination tool for face milling and pre-grooving of the face-side chamfers.



Connection machining

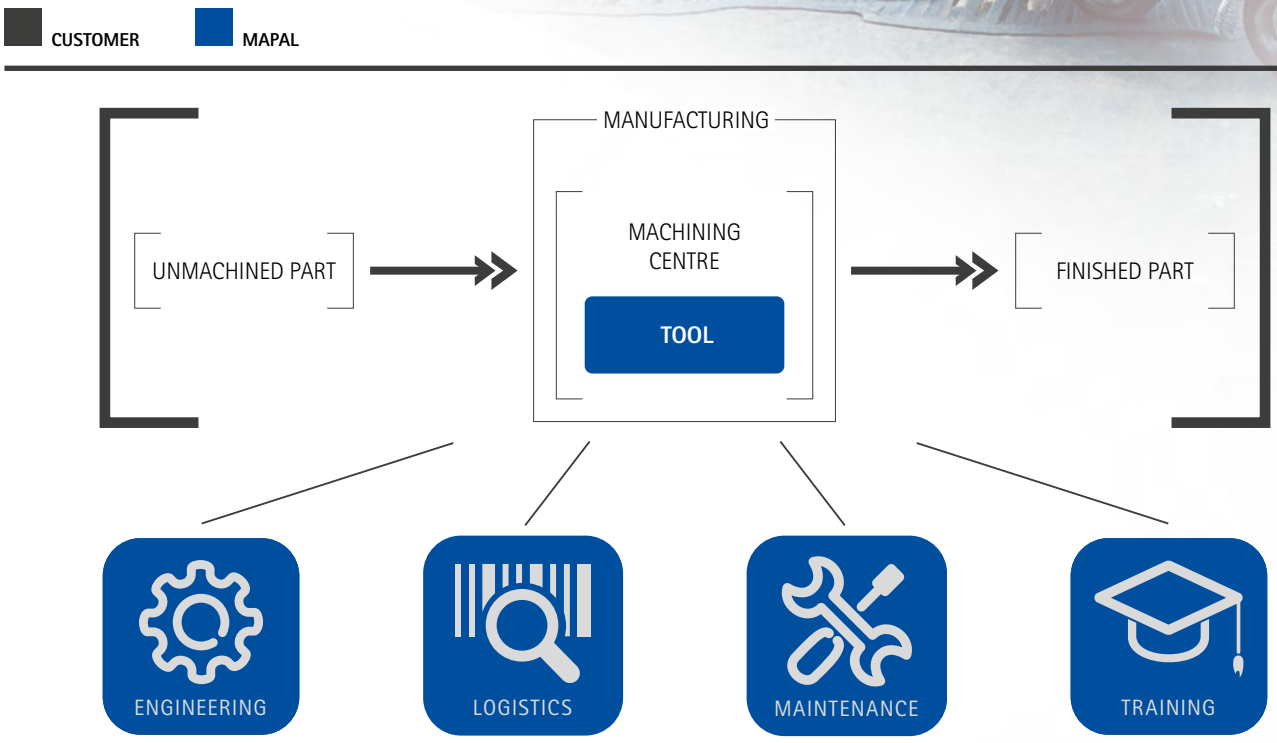
Face counterbore

Monolithic tool design with indexable inserts for machining diameter and chamfer.

Individual, needs-based service

MAPAL's roots lie in the manufacture of custom tools. The focus is therefore always on holistic advice and support for machining tasks and processes.

MAPAL provides support in all phases and areas of production with an extensive range of services. Regardless of whether a new production facility is to be set up, processes need to be optimised, new technologies need to be introduced, machines need to be converted to new parts, the tool inventory needs to be optimised or the know-how of employees needs to be expanded.



With the engineering service module, MAPAL guarantees fast, precise and safe manufacturing. Further savings potential can be tapped in the area of logistics and maintenance. And in the area of training, MAPAL ensures that the specialist know-how it has gathered is transparently and completely available to the customer – this gives customers a decisive advantage over their competitors.

All of the services offered by MAPAL focus on optimal processes and comprehensive support. The goal is to always significantly assist the customer in achieving smooth, productive and economical manufacturing.

Pictograms

Manufacturing processes


Milling


Drilling

Reaming and fine boring

Actuating

Cooling

Minimum quantity lubrication
Reduces lubricant consumption and ensures clean, sustainable processes – ideal for modern manufacturing concepts.

Cutting technology


Fixed blades
Maximum process reliability due to the highest stability and radial run-out accuracy – ideal for series production with high cutting data and long tool life.


Replaceable inserts
Rapid insert replacement without readjustment saves time on maintenance and reduces costs – especially cost-effective for high quantities and changing materials.


Adjustable – cartridge
Easy, manual fine adjustment of indexable inserts for precise fine boring and boring – universal and cost-efficient.


Adjustable – milling cartridge
Adjustable PCD milling cartridges enable a precise Z-adjustment for perfect face surfaces – optionally also for the production of defined surface profiles.

Adjustable – MAPAL principle
High-precision adjustment of diameter and back taper for maximum dimensional accuracy – perfect for demanding bores with tight tolerances and high accuracy of repetition.

Adjustable – EA system
Easy and precise adjustment of diameter – the back taper is already integrated into the cassette. Minimises operating errors and reduces training outlay.

Cutting material

PCD
Offers maximum resistance to wear and the best surfaces for non-ferrous metals – ideal for large series.

PcBN
Ideal for machining wear-resistant and abrasive materials – perfect for drilling processes with tight tolerances and high dimensional accuracy.

Solid carbide
Universal application – optimal for medium-sized series with a balanced ratio of cost and performance.

Cermet
Ideal for high dimensional accuracy and surface quality – perfect for finish machining steel.

Number of main cutting edges

One
main cutting edge

Two
main cutting edges

Three
main cutting edges

Four
main cutting edges

Five
main cutting edges

Six
main cutting edges

Eight
main cutting edges

Ten
main cutting edges

Connection


HFS system for replaceable head reamers
Reliable radial run-out and changeover accuracy of <3 µm and simple handling on tool change.


TTS system for replaceable drill head
Serration with form fit for optimal torque transmission – ideal for dynamic machining with flexible tool geometry.

Module adapter
Alignment accuracy in the µm range to compensate for spindle and tool errors – ideal for large projection lengths and complex components.


Hydraulic clamping technology
Consistent radial run-out and changeover accuracy of <3 µm with built-in vibration damping – ideal for precise and sustainable processes.


Shrinking technology
Very high initial radial run-out accuracy – ideal for applications with high speed and low changing frequency.


Mechanical tool technology
High clamping force, preventing tool pull-out – optimal for stable milling at the limit range.


Arbor
Robust connection for large milling tools – proven in difficult machining situations and with high load.

Discover tool and service solutions now that will put you ahead:

BORE MACHINING

REAMING | FINE BORING

DRILLING FROM SOLID | BORING | COUNTERSINKING

MILLING

CLAMPING

TURNING

ACTUATING

SETTING | MEASURING | DISPENSING

SERVICES

FOLLOW US

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