



Your technology partner for economic machining

FLUID POWER



Markets and sectors

After many years of close cooperation with customers, MAPAL has acquired a profound understanding of almost all processes and applications in machining production. The fields of application in which machining solutions from MAPAL are used are found in a wide variety of industries.

For the raw materials often used in Fluid power such as cast iron, steel, stainless steel and non-ferrous metal, MAPAL provides economical process solutions due to great expertise in bore machining as well as milling applications. When it comes to demanding machining for hydraulic and pneumatic parts in different dimensions, customers have relied on MAPAL's expertise for many years.





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.

Subsidiaries with production, sales and service in

25 countries.

Annual investment in research and development of

6% of turnover.

Over

450

technical consultants on the road.

More than

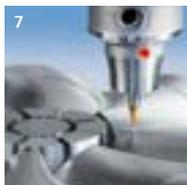
300

trainees worldwide.

Our most important asset: More than

5,000

employees worldwide.



- 1 Fluid power
- 2 Automotive
- 3 Aerospace
- 4 Power generation
- 5 Electric mobility
- 6 Medical technology
- 7 Die & Mould sector
- 8 Shipbuilding
- 9 Rail transport

Solutions for fluid power

Everything depends on the main bore. Manufacturing valve housings is the supreme discipline in the world of fluid power. For years, MAPAL's expertise has been in demand for the spool bore. The gap dimension with the spool depends on the accuracy of this bore, so that the hydraulic oil can only flow in the required direction without leaking. This is very narrowly defined in modern hydraulic valves. The roundness, cylindrical form, straightness and surface finish of this bore are therefore crucial.



AEROSPACE



CONSTRUCTION MACHINES





CONTENTS

Introduction

Fluid power competence	6
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Solutions for fluid power

Machining solutions for hydraulic valve housing	8
Application solution 1 - 4 for hydraulic	10-16
Additional machining solutions on hydraulic valve housing	18
Machining solutions for pneumatic valve housings	20
Application solution 5 for pneumatic	22
Additional solutions in fluid power	24

MAPAL Services

MAPAL as technology partner	26
Toolmanagement 4.0	28



Fluid power competence

Fluid

Hydraulic

By using liquids under pressure, forces and movement are generated, controlled and efficiently transferred.

PROPERTIES

- Durability
- Precise control
- Strong forces

APPLICATIONS

Mobile hydraulic



- Construction machinery
- Loading platforms, tippers, grippers
- Agricultural machinery

Stationary hydraulic



- Presses
- Lifting and material handling systems
- Manufacturing and assembly machines

SOLUTIONS FOR HYDRAULIC VALVE HOUSINGS

Application solution 1

Small and medium series with fixed tools.

>> More from page 10

Application solution 2

Large series with solid and adjustable tools.

>> More from page 12

Application solution 3

Small lot sizes. Reduced tool changes due to combination tools.

>> More from page 14

Application solution 4

Flexible honing on the machining centre.

>> More from page 16

power

Pneumatic system

By using air or gas under pressure, forces and movement are generated, controlled and efficiently transferred.

PROPERTIES

- Simple installation
- Quick movement
- Cleanliness

APPLICATIONS



- Machine engineering
- Logistics
- Space technology
- Medical technology
- Procedural industry

SOLUTIONS FOR PNEUMATIC VALVE HOUSING

Application solution 5

Large series with combination tools for highest requirements and productivity.

>> More from page 22

SOLUTIONS FOR TOOL MANAGEMENT

Tool management solution

Tool management for large series with billing based on costs per part (CPP) and highest productivity increase.

>> More from page 28

Machining solutions for hydraulic valve housing

Control valves

Control valves are mechanically or electronically actuated valves with several switch positions. Depending on the specified position of the spool along the control edges, a volume flow is set for operating the connected working equipment. The individual pressure compensator adjusts a constant load pressure drop via the supply control edge of the spool, so that a load

pressure-independent volume flow control is achieved across the whole adjusting range, also in parallel operation (load compensation). The system must be leakage-free, to prevent accidental dropping of the load, even with parallel operation.



Illustration: Generic component

MACHINING REQUIREMENTS

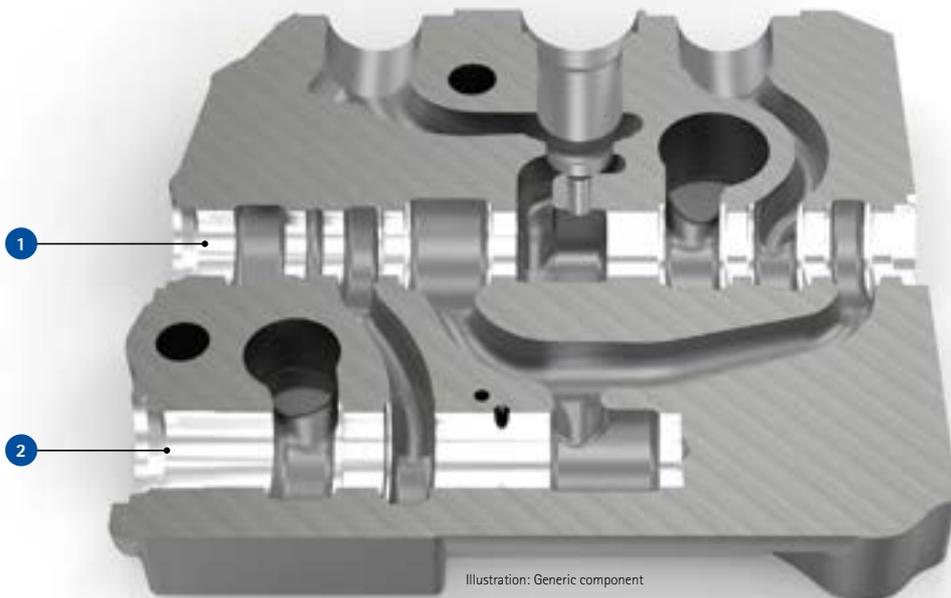
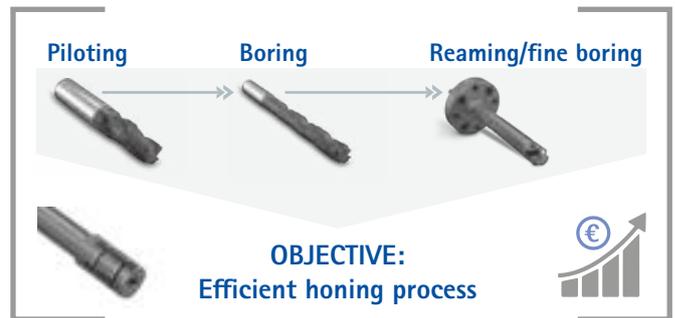
- Fluctuating cast allowance situation
- Heavily interrupted cuts
- Avoid ring formation during boring and ensure safe chip removal from the housing
- Avoid macroscopic flaws on the control edges in the boring process
- Very high demands on form and position tolerance
- Constant stock removal before honing
- Take part variance and limited tool storage places in the machining concept into account

Basic procedure – analysis of the machining process

As technology partner, MAPAL supports customers with regard to complete process design. The experts pay particular attention to the cost drivers here, which can often be found in the function-relevant bores.

Based on the respective honing procedure, the part requirements and lot sizes, MAPAL designs the perfect machining strategy in dialogue with the customers.

One objective unites all activities: designing the most economic process, starting with piloting, boring and semi-finish machining up to the efficient honing process.



1 SPOOL BORE

The relative movement of the spool along the control edges controls the flow direction of the fluid.

2 COMPENSATOR BORE

Despite different loads on agricultural and construction machinery, the volume flow for the lifting and lowering speed on an excavator shovel, for example, must remain constant. If a low load is present, the spring-preloaded pressure compensator releases a smaller cross-section, to keep the volume flow constant. With high loads, a larger cross-section is released. The working speed of the hydraulic cylinder connected to the excavator shovel thus always remains the same.

ADVANTAGES WITH THE MAPAL SOLUTION

- Reliable achievement of the required accuracies of spool and compensator bore
- Increased competitiveness
- Ideal interplay of spool and bore on the part
- No leakage loss on the end product, safe operation and functionality of the end product (e.g. excavator shovel)
- Consistent load pressure ensures highest safety through highly accurate machining operations
- Consistently high machining quality
- Start-up support for new parts

Solutions for hydraulic valve housings

Initial situation at the customer

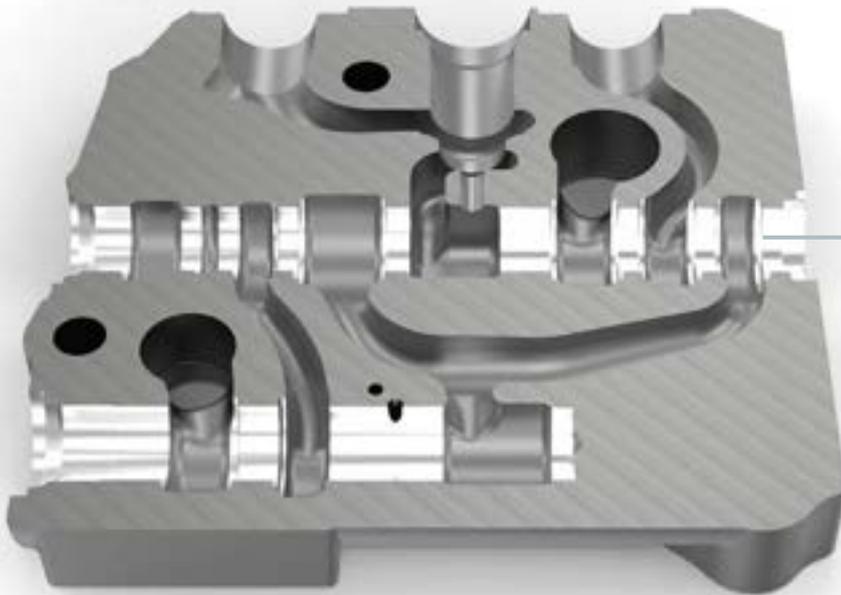
Valve housing EN-GJS-400-15 – spool bore

- Individual orders, smaller and medium quantities
- No option for tool setting
- Short cycle times required
- High machine hourly rates
- Stable oscillating honing available
- Tool concept adapted to several part versions

Quantity



Accuracy



ADVANTAGES

- Minimal investment
- Low cycle time
- High availability of the machining centre
- Low production costs
- No tool setting required
- Option for regrinding worldwide

Spool bore

1. Piloting

- Solid carbide-boring tool with six margin lands for perfect roundness and straightness
- Optimum chip flow and extended regrinding options through multicut technology and suitable coolant supply

2. Boring

- Solid carbide boring tool with three cutting edges and six margin lands and special lead geometry
- Straight bore, ideal chip flow und guide across the entire bore length



3. Control edge machining

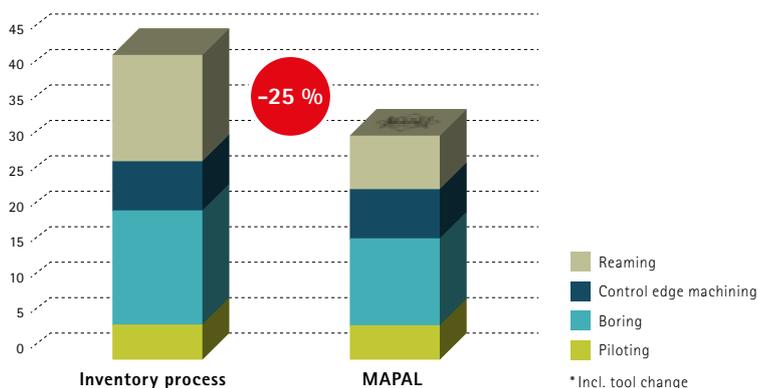
- Significant cycle time savings with special solid carbide circular milling cutter
- Defined control edges without macroscopic flaws

4. Reaming

- Multi-bladed reamer for high cutting data
- Perfect chip control due to left-hand twist and optimum coolant supply



MACHINING TIME PER SPOOL BORE [SEC.] *



SPECIAL FEATURES OF THIS SOLUTION

- No ring formation in the cavities due to special bore geometry → no costs for removal of rings
- Optimum results in the pre-machining due to a coordinated piloting and boring process → Support of boring tools in the pilot bore = optimum straightness, position
- High productivity with perfect pre-machining quality → High cutting values – machining time is reduced

Solutions for hydraulic valve housings

Initial situation at the customer

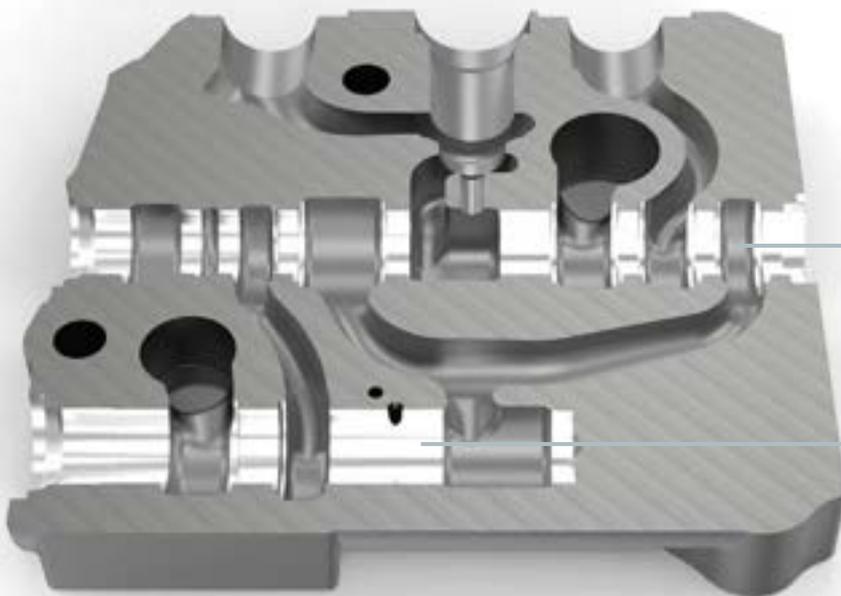
Valve housing EN-GJS-400-15 – spool bore and compensator bore

- Large-scale series
- Tool setting desired
- High machine hourly rates
- High costs for subsequent single pass honing

Quantity



Accuracy



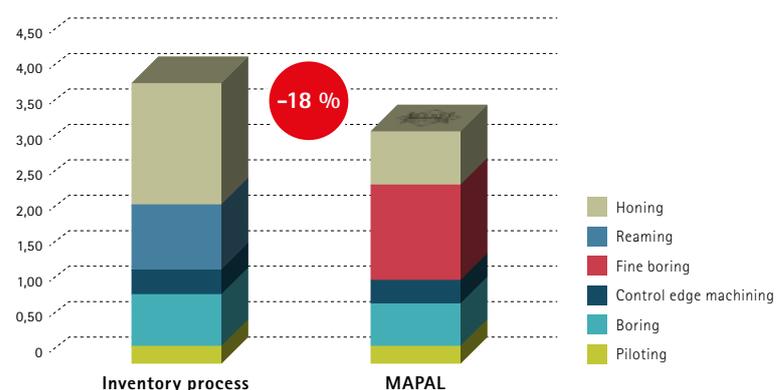
ADVANTAGES

- Expensive honing process shortened in spool bore
- Low tool costs per bore
- Shorter non-productive times due to clever engineering in cooperation with the customer
- Significant cost savings, as honing process no longer required in the compensator bore

The required tolerances are reliably complied with without additional honing using the MAPAL solution:

Generated roundness:	RONp under 1 µm
Generated straightness:	STRsa under 1 µm
Average roughness depth:	Rz 3.8 µm
Material content (contact ratio):	Pmr over 97%

PRODUCTION COSTS PER SPOOL BORE [€]



Spool bore

1. Boring

- Optimum results in the pre-machining due to a coordinated piloting and boring process
- Optimum chip flow and extended regrinding options through multicut technology and perfect coolant supply
- No ring formation in the cavities due to special bore geometry => no costs for removal of rings

2. Control edge machining

- Solid carbide profile tool
- Highest accuracy and surface finish of control edges
- Defined control edges without macroscopic flaws

3. Fine boring

- Fine boring tool with EasyAdjust system and guide pads
- Reliable precision machining with easy handling
- Best cylindrical forms due to optimum guidance



Compensator bore

1. Boring

- Solid carbide boring tool with six margin lands and special lead geometry
- Straight bore, ideal chip flow und guide across the entire bore length
- Reduced non-productive times due to two machining operations in one tool

2. Contour machining

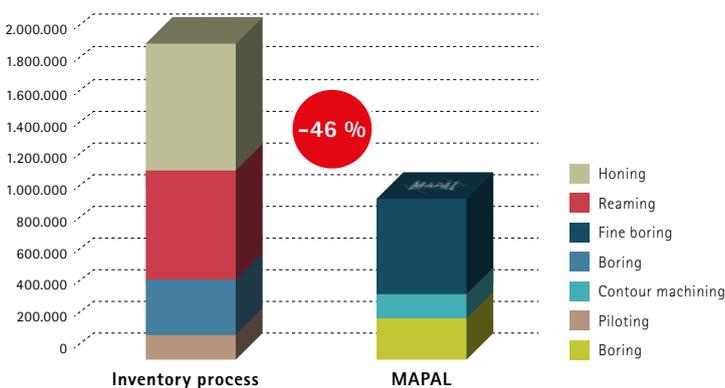
- Double edge boring tool with form cutting edges
- Reliable machining of the contour
- Easy handling with low cutting material costs

3. Fine boring

- Fine boring tool with EasyAdjust system and guide pads
- Reliable precision machining with easy handling without subsequent honing
- Best cylindrical forms due to optimum guidance



ANNUAL PRODUCTION COSTS OF THE COMPENSATOR BORE [€]



SPECIAL FEATURES OF THIS SOLUTION

- Ideally matched separate tools guarantee optimum preconditions for a reduced honing process
- The honing process can be eliminated with certain part requirements

Solutions for hydraulic valve housings

Initial situation at the customer

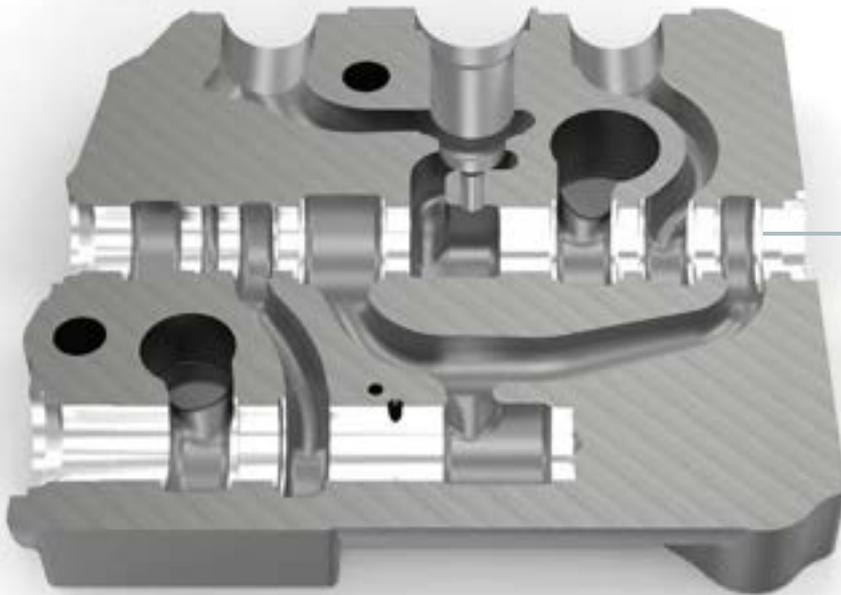
Valve housing EN-GJL-300 – spool bore

- Small lot sizes
- Option for tool setting available
- Too many/frequent tool changes
- High machine hourly rates
- High effort due to single pass honing process

Quantity



Accuracy



ADVANTAGES

- Optimally matched process due to solution with multi-stepped boring tool with indexable inserts, control edge machining and fine boring
- Best accuracy and process reliability
- Reduced effort when honing, resulting in cost savings

Spool bore

1. Piloting and boring

- Multi-stepped boring tool with radial and tangential indexable inserts
- Pre-machining spool bore and completion of contours in one processing step

2. Control edge machining

- Solid carbide profile tool
- Highest accuracy and surface finish of control edges
- Defined control edges without macroscopic flaws

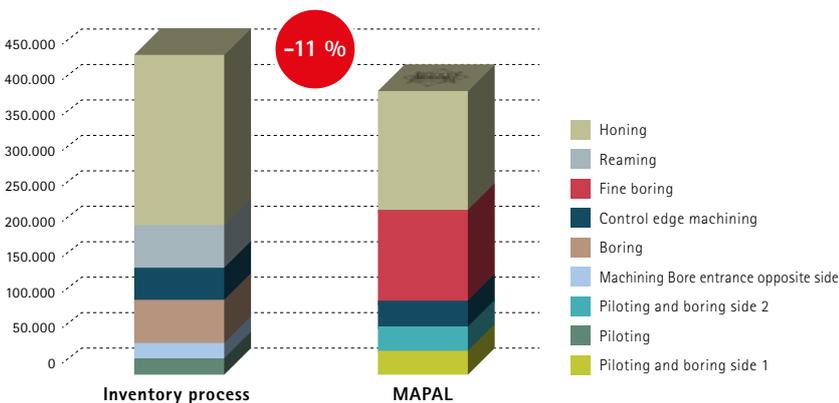


3. Fine boring

- Fine boring tool with indexable inserts and guide pads
- Ideal for bar machining of highly accurate and long bores



ANNUAL PRODUCTION COSTS SPOOL BORE [€]



SPECIAL FEATURES OF THIS SOLUTION

- Tool change reduced due to multi-stepped boring tool with indexable inserts
- The contour can be completed in one processing step
- The fine boring tool creates highest bore quality and compensates the axial offset of the bores with pre-machining from two sides

Solutions for hydraulic valve housings

Initial situation at the customer

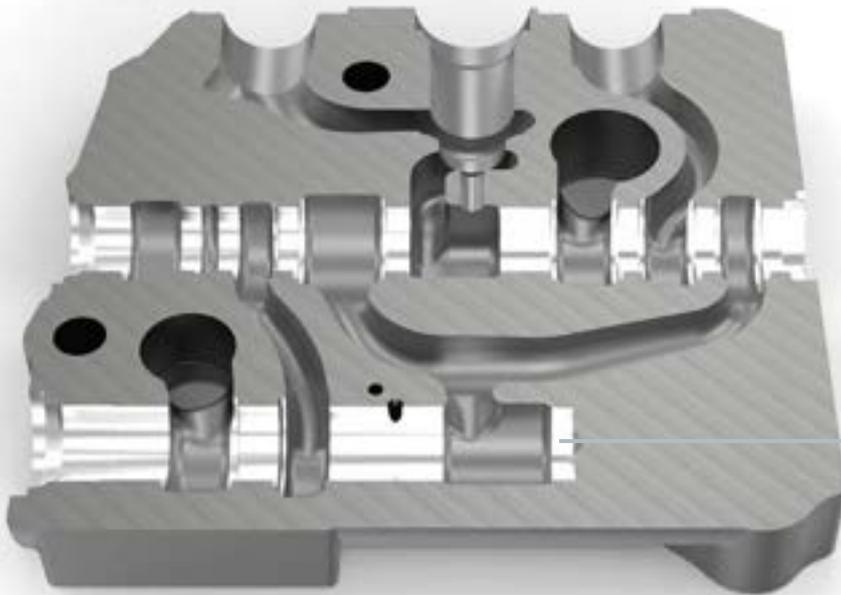
Valve housing EN-GJS-400-15 – Compensator bore / honing

- Request for reduction of ancillary costs
- Existing machining centre re-tooled to TOOLTRONIC
- Honing for prototype manufacture, as well as small and medium-scale production runs
- Requirement for saving the honing process on separate machine

Quantity



Accuracy



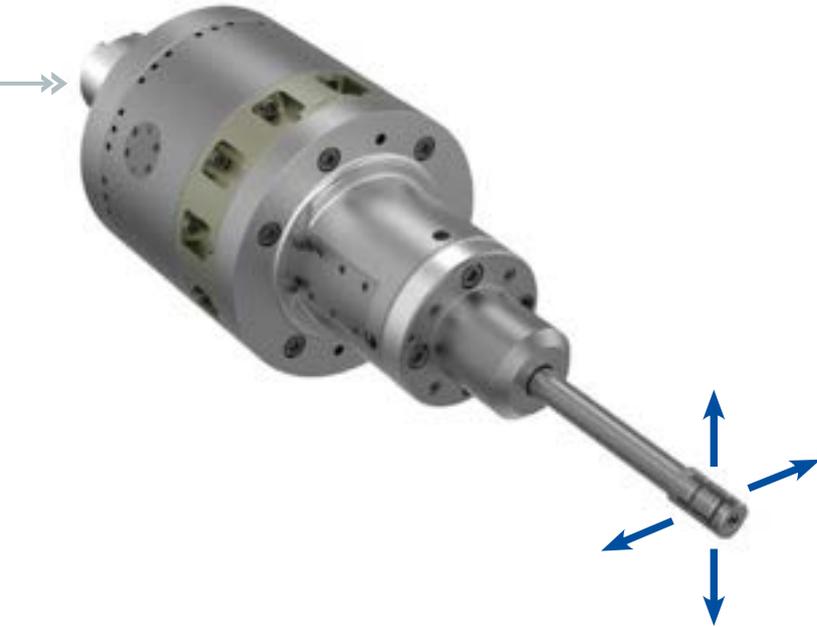
ADVANTAGES

- Tolerances to be achieved: Accuracy of diameter IT 6 and roundness <math>< 5 \mu\text{m}</math>
- Turning with a stationary, firmly clamped part
- Burr-free, rounded transitions possible
- Reduced/low number of custom tools
- Low-maintenance system with eccentric actuating tool (EAT system)
- Almost all machining centres can be re-tooled to MAPAL TOOLTRONIC technology
- Reclamping error due to re-tooling to honing machine no longer applies
- Complete process of compensator bore can be mapped by MAPAL (highest economic efficiency & process reliability)

Compensator bore

1. Fine machining with honing

- Significant shortening of production and cycle times
- Greater contour accuracy

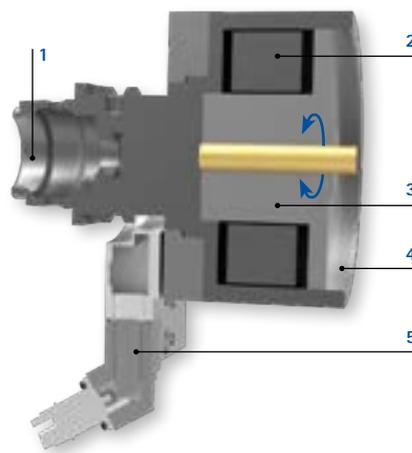


Honing with TOOLTRONIC

Machining with MAPAL TOOLTRONIC achieves high surface quality and dimensional accuracy with tightest manufacturing tolerances as well as high flexibility in manufacturing. The wear of the honing bars is reliably compensated by a highly sensitive and precise actuating movement (EAT system).

ADVANTAGES OF THIS HONING

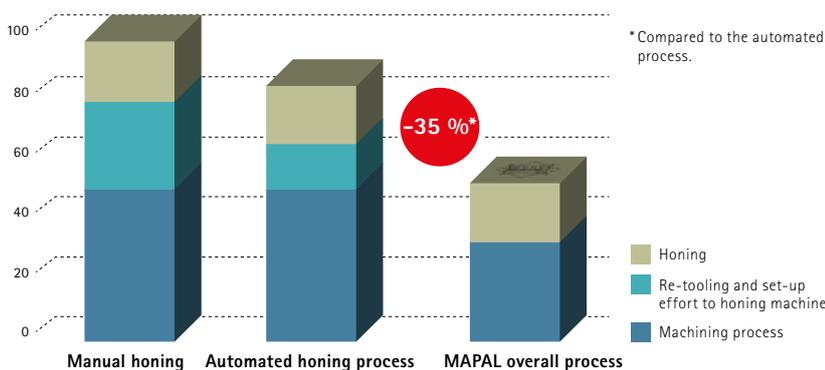
- Very tight manufacturing tolerances as well as flexibility in manufacture
- High surface quality and dimensional accuracy
- Major saving and quality potential for prototypes, small-scale and medium-scale series production
- Time-consuming re-tooling is not necessary



TOOLTRONIC design for machining centres:

- 1 Machine connection
- 2 Electronics
- 3 Motor unit with defined connection point
- 4 Modular connection
- 5 Stator (stationary unit)

PROCESS TIMES [%]

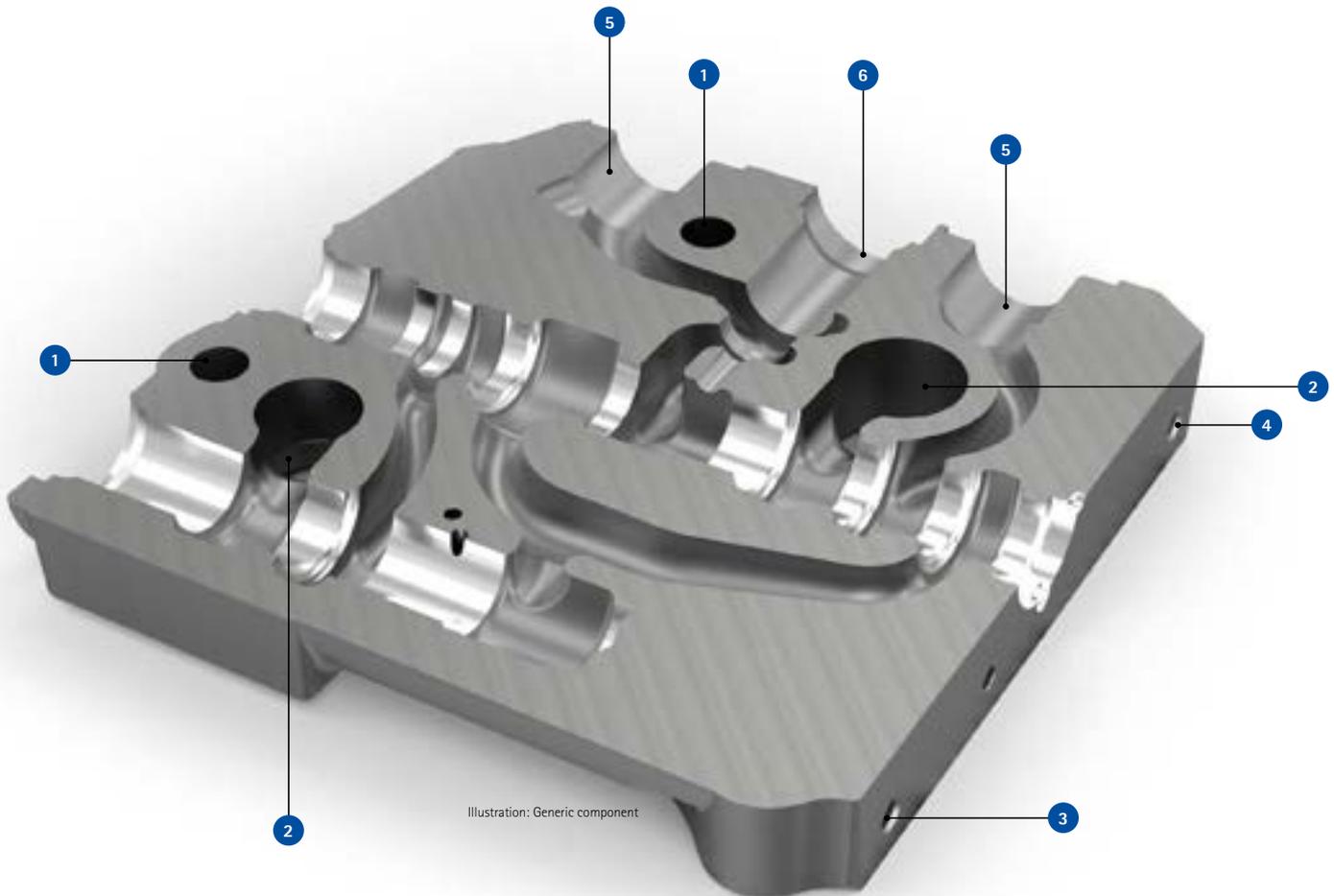


SPECIAL FEATURES OF THIS SOLUTION

- A full NC axis incorporated in the machine control system
- Shortening of production and lead times
- Improved surface quality
- Greater contour accuracy

Solutions for hydraulic valve housings

Additional bore machining



1. Tie rod hole

Bore for tie rod, which keep the individual valve blocks together.

2. O-ring bore (O-ring hole)

Countersink for O-rings for sealing the plane surfaces between individual modules.

3. Oil bore (oil hole)

Oil channel for distributing the oil in the part.

4. Thread bore (thread hole)

Bores for fastening attachments.

5. Port hole

Bore for connecting the individual consumers to the valve block.

6. Check valve hole

Check valves for blocking a volume flow.

	Pre-machining	Finishing	Alternative finishing
1			
2			
3			
4			
5			
6			

The tool design is adapted depending on the part dimensions, workpiece clamping and quantities.

Innovative tool technology

For additional machining requirements on the valve housing

Milling cutters with indexable inserts

The radial NeoMill milling series from MAPAL with its face, shoulder, slot, shell end face and high-feed milling cutters stands for maximum productivity and economic efficiency, especially in series production. The development was based on many years of experience with custom tools, which the industry uses to produce large quantities very efficiently with consistent quality. The face and shoulder milling cutter NeoMill-16-Face und NeoMill-4/8-Corner are suitable for machining operations of face surfaces on the valve housing.



Scan the QR code to learn more about the NeoMill milling series!



NEOMILL-16-FACE

- 16-edge indexable insert / 45°
- First choice for cast iron and heat-resistant cast steel
- \varnothing area 63-200 mm / a_p max. 4 mm
- Low cutting forces despite a negative shape
- Maximum economic efficiency for face milling



NEOMILL-8-CORNER

- Eight-edge indexable insert / 90°
- First choice for cast iron
- \varnothing area 50-200 mm / a_p max. 8 mm
- Maximum economic efficiency for shoulder milling



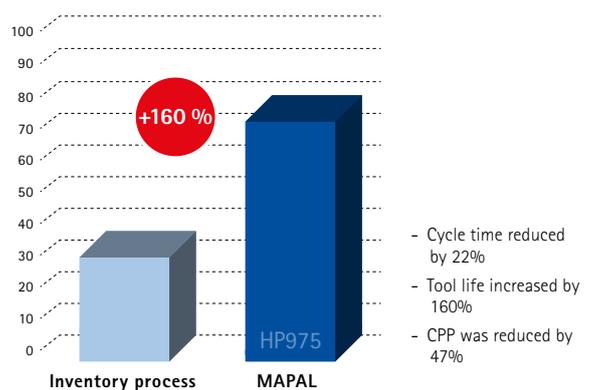
NEOMILL-4-CORNER

- Four-edge indexable insert / 90°
- Highly suitable for steel, stainless steel, cast iron and heat-resistant cast steel
- \varnothing area 25-100 mm / a_p max. 10 mm
- Multipass milling of high shoulder dimensions
- Very low cutting forces despite a negative shape

NEOMILL APPLICATION EXAMPLE VALVE HOUSING

	■	■
Workpiece material	EN-GJS-500-7	
Tool	Face milling cutter	Standard face milling cutter NeoMill-16-Face
Tool \varnothing [mm]	200	
Number of teeth z	12	14
vc [m/min]	300	180
fz [mm]	0.12	0.2
vf [mm/min]	660	804
a_p (mm)	4	

MACHINED PARTS [QUANTITY]



Clamping technology

MAPAL's clamping technology range guarantees performance and process reliability as well as radial run-out and changeover accuracy for every application. Manufactured using the most modern technologies, our specialists are continuously developing our chucks further. In response to customers' requirements and situations, a large variety of systems have been made available in the standard range: from hydraulic expansion and shrink chucks to mechanical clamping systems for HB shanks and adapters.



Scan the QR code to learn more about the UNIQ chuck series!

UNIQ Mill Chuck & UNIQ DReaM Chuck 4.5°

Both hydraulic chuck series – UNIQ Mill Chuck and UNIQ DReaM Chuck – clearly combine the performance promise of quality and function in their new design. This is achieved through an optimal interplay of geometric and functional properties.



UNIQ MILL CHUCK

- Highly thermal stability from 80 °C even with very long milling cycles (over 240 minutes)
- For high-performance milling operations up to max. 33,000 revolutions per minute
- Highest process reliability



UNIQ DReaM CHUCK 4.5°

- Hydraulic chuck with the original dimensions of a shrink chuck (DIN contour with 4.5°)
- Application-oriented system design
- Maximum process reliability and tool life
- Faster and highly precise tool change



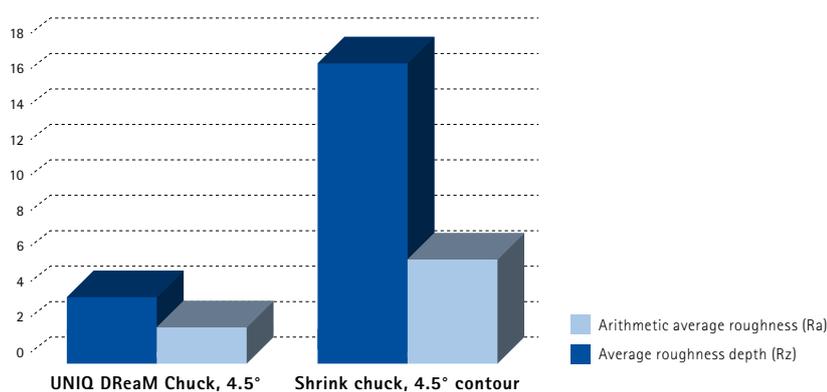
Mill Chuck, HB

The new Mill Chuck HB side lock chuck impresses with strong clamping, simple handling and a high radial run-out accuracy. Coolant channels parallel to the axis in the clamping range ensure an optimum coolant supply.

HB MILL CHUCK SIDE LOCK CHUCK

- Easy to handle thanks to use of a differential screw
- Maximum economic efficiency and precision
- Axial tool positioning can be defined using spring system
- Optimum positioning of profile tools for control edge machining

SURFACE FINISH [µm]



MACHINING DATA

Workpiece material	K720 1.2872 90MnCrV8
Machining	Finish machining
n [rpm]	~ 7,500
vc [m/min]	140
fz [mm]	0.13
vf [mm/min]	1,950

Solutions for pneumatic valve housing

Initial situation at the customer

Valve housing AlMgSi-T6

- Very high quantities
- High cycle time requirements
- High hourly rates
- High demand for process reliability
- High demands on quality of surface, shape and position tolerances
- Burr-free / scoring-free machining

Quantity



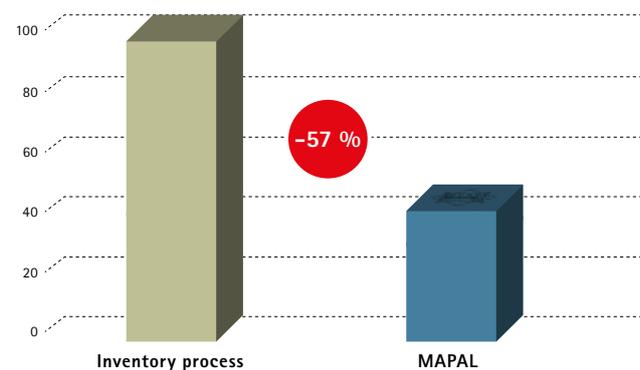
Accuracy



ADVANTAGES

- Precisely coordinated processes between pre-machining and finishing
- Reduced non-productive times
- Cycle time saving with increased quality
- High process reliability in series production
- The long-standing experience with regard to the development and production of PCD or solid carbide tools enables optimum process design, whatever the requirements

MACHINING TIME PER PART [%]



Tool highlights for pneumatic valve housings

Stepped bores

- Solid carbide-multi-stepped tool with special multicut technology and chip guiding stage for ideal chip control and frequent re-grinding capability



Solution in one processing step for cone contours

- PCD step drill for the process-reliable machining of cone contours as solution in one processing step



Contour machining

- Multi-stepped PCD combination tool
- Highest productivity as well as concentricity for highly complex contour machining

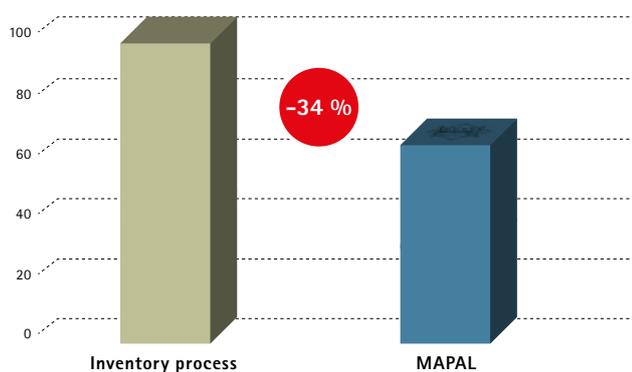


Control edge machining

- PCD circular milling cutter for highest surface finish and perfectly coordinated control edges



PRODUCTION COSTS PER PART [%]

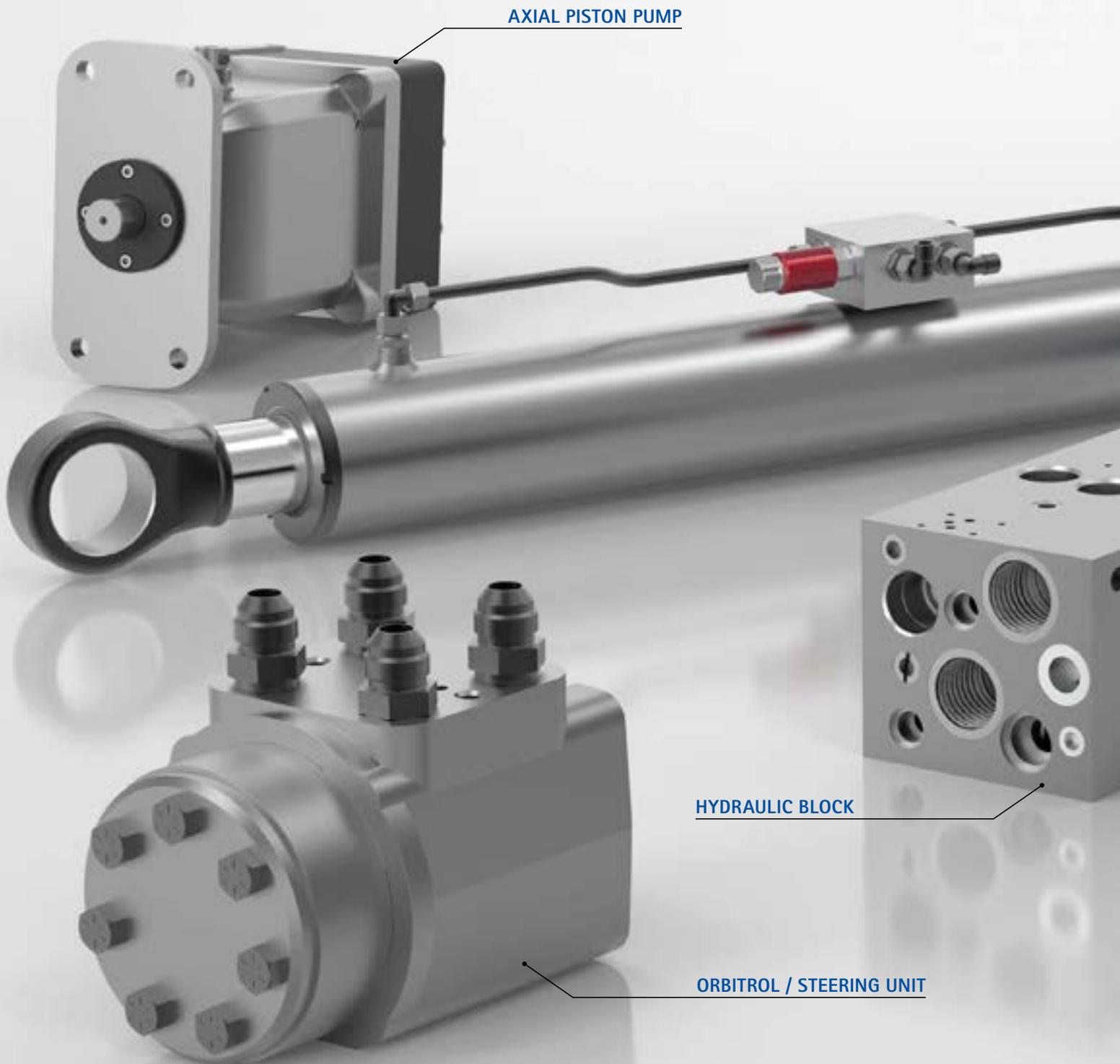


SPECIAL FEATURES OF THIS SOLUTION

- Ideal chip breaking due to special cutting geometries
- Perfect surfaces and contact ratios due to high-quality PCD finish tools ($R_z = 1 \mu\text{m}$)
- Combination tool for optimum process design and cycle time reduction

Additional solutions in fluid power

MAPAL technology is used for the machining of many additional parts in fluid power





MAPAL provides support for complete machining of additional fluid power parts in almost all part dimensions with efficient solutions for function-relevant machining requirements.



HYDRAULIC CYLINDER



GEAR PUMP



PNEUMATIC CYLINDER



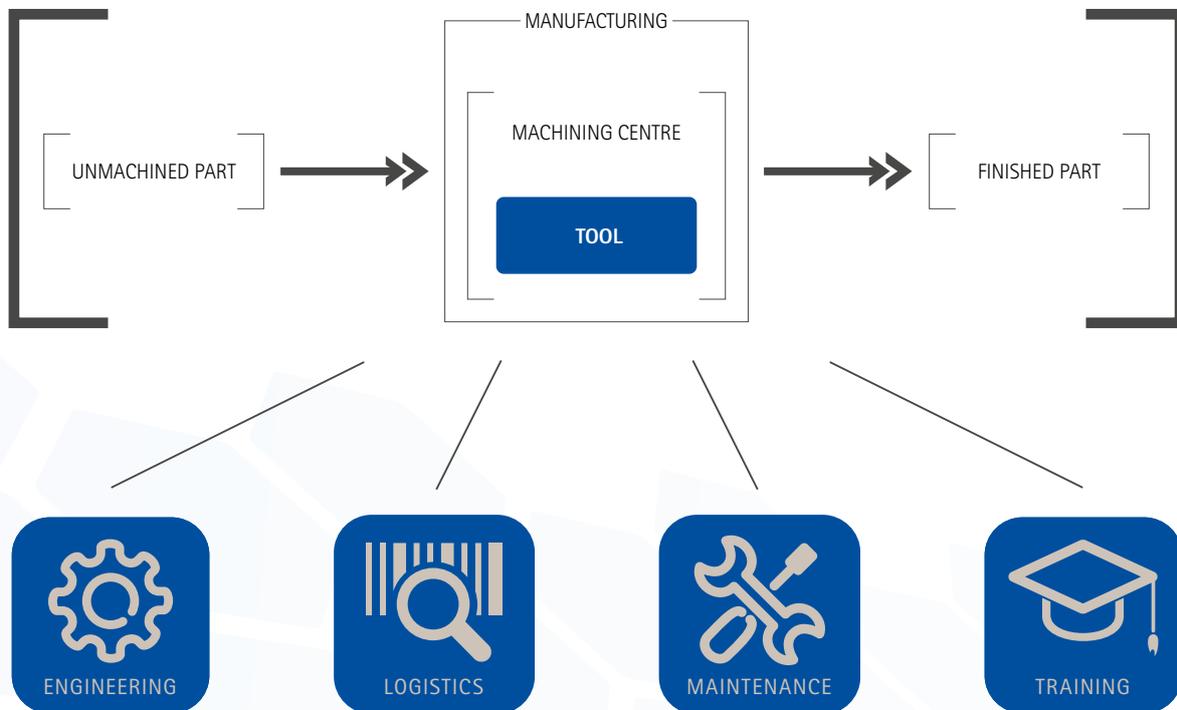
HYDRAULIC MOTOR

Individual, customised 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 re-tooled 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 lead over their competitors.

All of the services offered by MAPAL focus on optimal processes and comprehensive support on the way to Industry 4.0. The goal is to always significantly assist the customer in achieving smooth, productive and economical manufacturing.

ADVANTAGES

- Solutions for complete parts including tools, fixtures, NC programs and commissioning
- Complete process design and implementation from a single source
- Fast and flexible on-site support worldwide
- Efficient and cost-optimised tool technology
- Optimum coordination of tool, part, fixture and machine
- Highest product quality, process reliability and economic efficiency right from the start
- Fast throughput from planning to implementation with maximum planning security

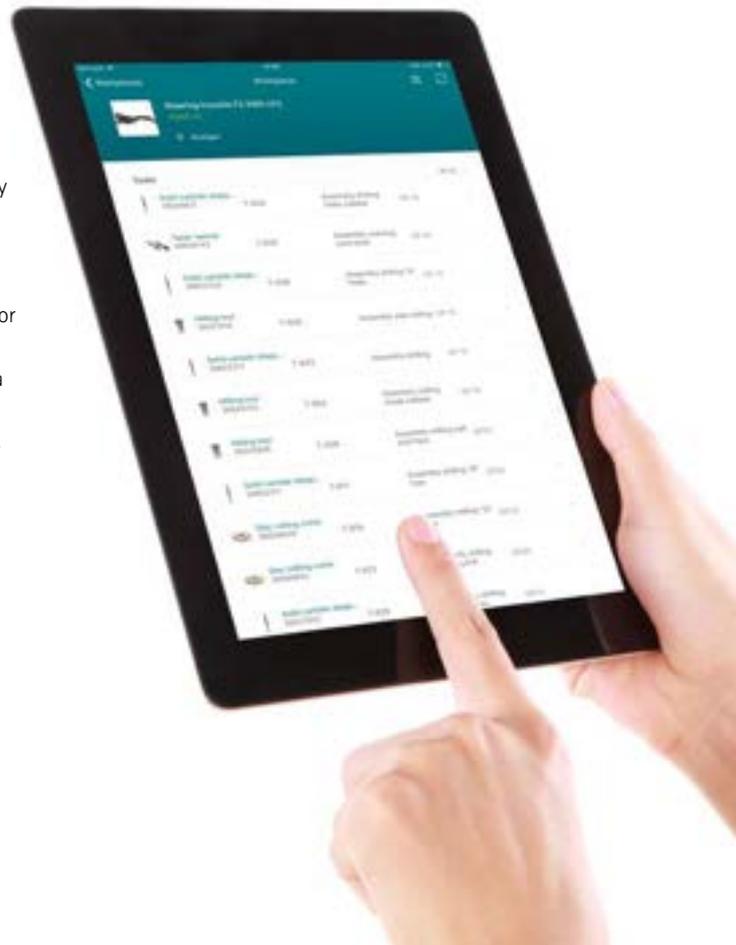
Investment in tool control

MAPAL's offering of logistics services ranges from the analysis of the tool inventory with suggestions for optimisation and the provision of tools to complete tool management by personnel on site.

Irrespective of the scope: Customers benefit from high tool competence, more free capacities in production and focus on the core business. As a long-term technology partner, MAPAL continuously optimises all processes related to the tool and in this way increases your productivity sustainably.

Depending on the size of production and the way it is organised, the parts produced and the tool consumption, an individual, cost-optimised logistics concept is created. For maximum customer benefit and the biggest savings potential, MAPAL usually focuses on digital tool management 4.0. This means data and information can be provided in a much more transparent and consistent manner for all parties involved – manufacturing, purchasing, planning, tool managers and suppliers. In this way, the overall process is more efficiently structured.

This gives rise to a cross-functional and group-wide technology database for companies. Redundant structures are a thing of the past.



INITIAL SITUATION

CLEAR ORGANISATION OF YOUR TOOL INVENTORY

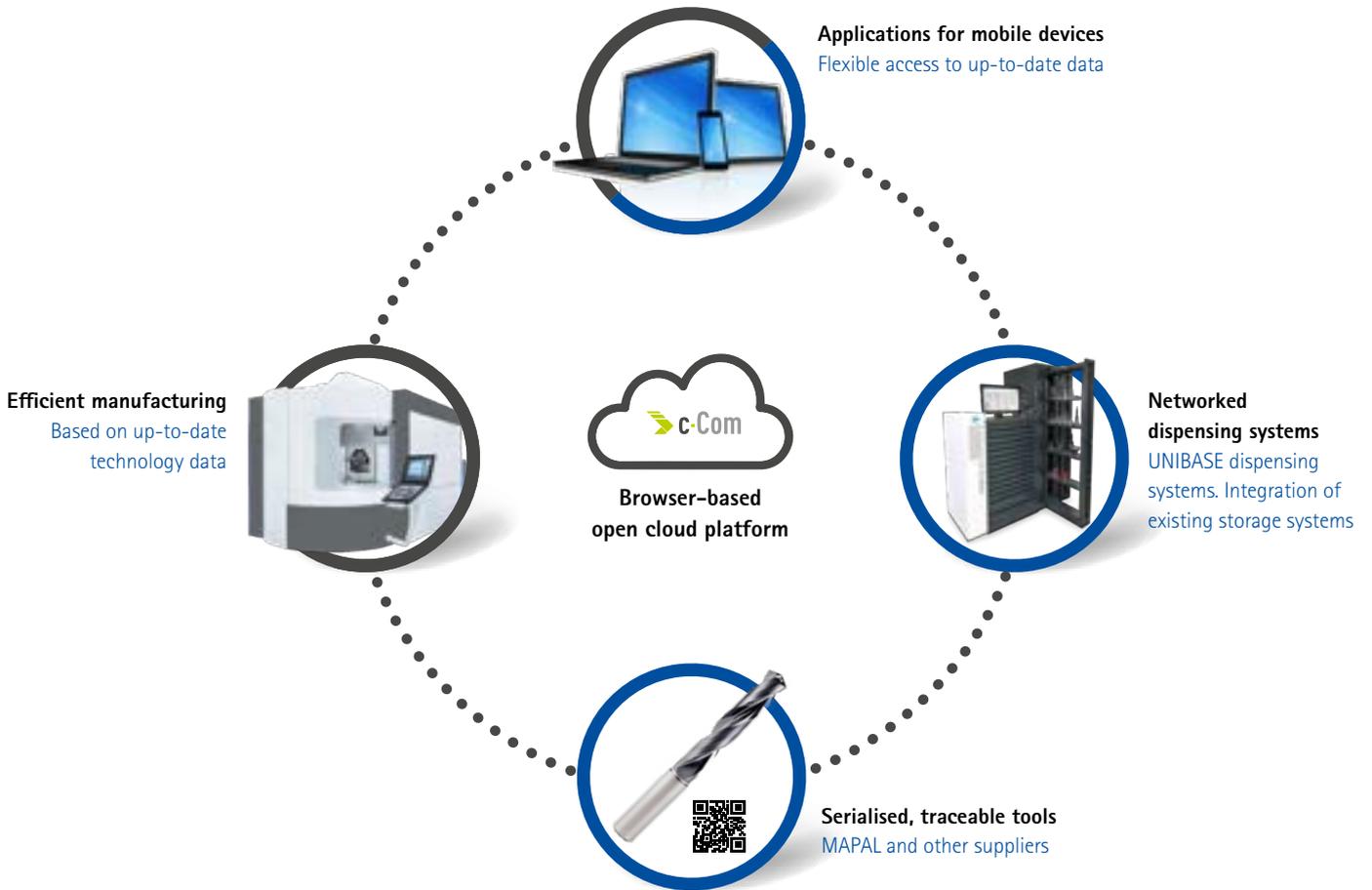
MAPAL ensures clear organisation and optimisation of the tool inventory based on transparent data. This way, unnecessary machine downtimes and unnecessary capital commitment are avoided.

CONTINUOUSLY OPTIMISE THE INVENTORY

Upon request, a MAPAL specialist is also available on-site who provides long-term support for customers and implements continuous measures for the optimisation of tool costs.

OUTSOURCING OF TOOL MANAGEMENT

In this case, MAPAL staff take over the complete procurement and management of the tools, including all tasks in the tool-setting area.



With Tool Management 4.0, customers benefit from a comprehensive know-how as a complete supplier for machining. Along with leading tool solutions and services related to the machining process, MAPAL offers highly accurate setting fixtures, as well as intelligent dispensing systems developed in-house. The browser-based open cloud platform c-Com networks tool, warehouse and production and ensures you can access your data in real time from anywhere. This provides full control of all costs incurred at all times.

Technology data are entered and managed centrally. In this way, it is ensured that all employees at all sites have access to the same up-to-date data at all times. This way, all those involved benefit from the accumulated knowledge and know-how. As a consequence, manufacturing is more efficient and the costs can be reduced.

ADVANTAGES

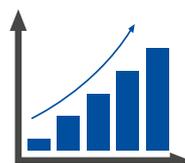
MORE networking



MORE transparency



MORE efficiency



MORE cost control



Solutions for tool management

Initial situation at the customer

Valve housing EN-GJS-400-15 – complete machining

- High inventories
- Processes in the tool-setting area not optimal, and incomplete data quality
- Cost transparency is not sufficient
- High fluctuation due to general lack of skilled workers
- Problems with tool breakage
- High tool costs

Quantity

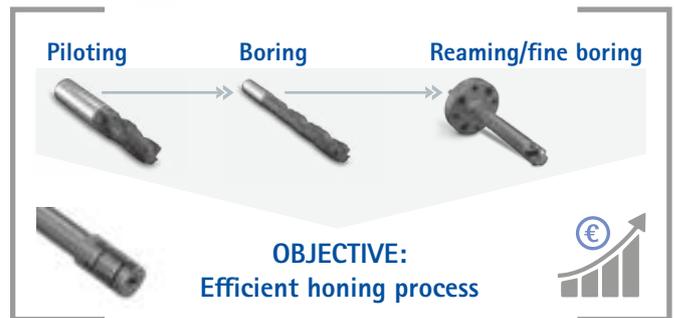


Accuracy



Tool management for the complete business process

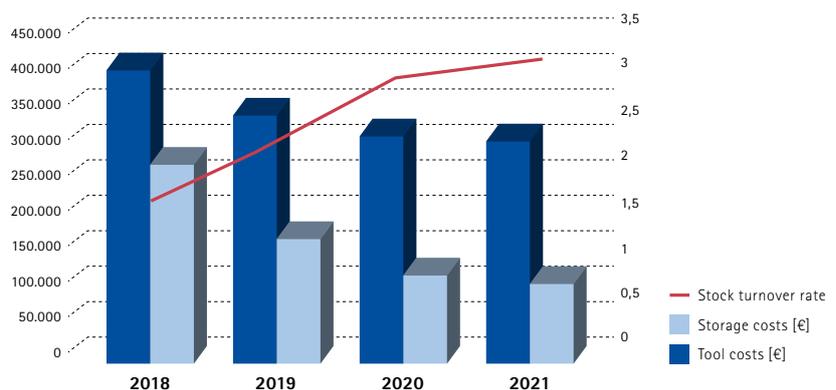
In one example, a customer transferred the responsibility for the complete tool management to MAPAL. The customer's goal was to reduce as far as possible the tool costs, as well as the value of the inventory and the costs per part, and in this way to significantly increase the efficiency of his production. To further increase productivity, the cycle time was also to be reduced. Here, MAPAL's combined tool and process experience paid off particularly well.



ADVANTAGES

- Using up of excess inventory
- Cost transparency
- Latest tool technologies
- Reduced tool variety and standardisation
- Tools are provided on the machine by MAPAL personnel
- Constant tool use
- Predictable and consistent tool costs due to billing based on costs per part (CPP).

KPI DEVELOPMENT [€]





UNIBASE software

- Web interface for external access via an app
- Optional connection to the cloud-based open platform c-Com
- Comprehensive assessment possibilities
- Few clicks to the dispensing of an item
- Permanent, automatic stock monitoring
- Possibility of connection to existing ERP systems



UNIBASE-M

- Ideal storage system for tools, parts and accessories
- Limited dispensing for the targeted withdrawal of individual parts
- Variable drawer arrangement



UNIBASE-V

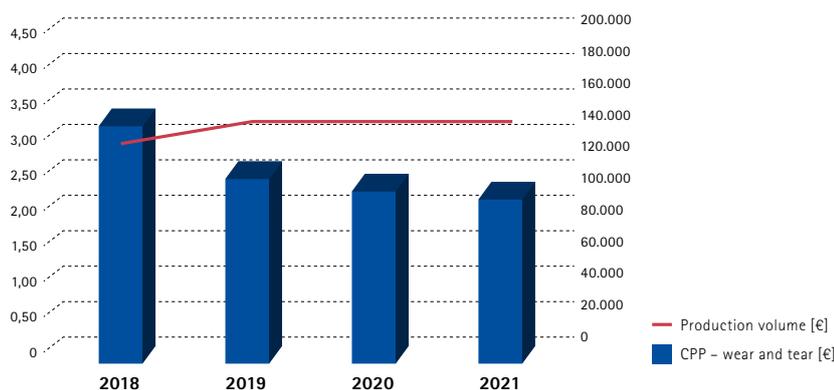
- Safe storage of completely assembled tools
- Storing long tools vertically
- No risk for the inserts
- Upright cabinets with roller-guided drawers
- Can be integrated into existing systems
- Proven in use for tool management projects



UNIBASE-C

- Single dispensing system
- Storage of small and individual parts
- Single dispensing increases theft protection
- Ready for use as a single solution or in existing systems

CPP DEVELOPMENT [€]



BILLING OPTIONS

After withdrawal

With this billing model, you receive one invoice with all the tools used at the end of the month. Your procurement effort and your financial bookkeeping are significantly simplified as a result.

Cost per part

You remain particularly flexible and are guaranteed annual savings. With this model the tool costs per part produced are calculated. This option ensures optimal cost distribution with fluctuating volumes.



Discover tool and service solutions now that give you a lead:

BORE MACHINING

REAMING | FINE BORING

DRILLING FROM SOLID | BORING | COUNTERSINKING

MILLING

CLAMPING

TURNING

ACTUATING

SETTING | MEASURING | DISPENSING

SERVICES

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