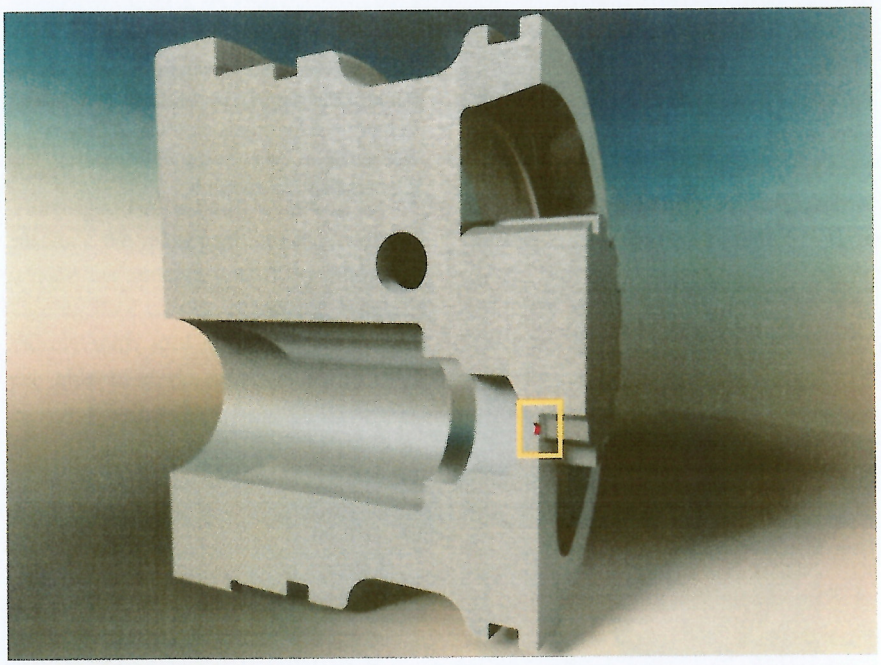
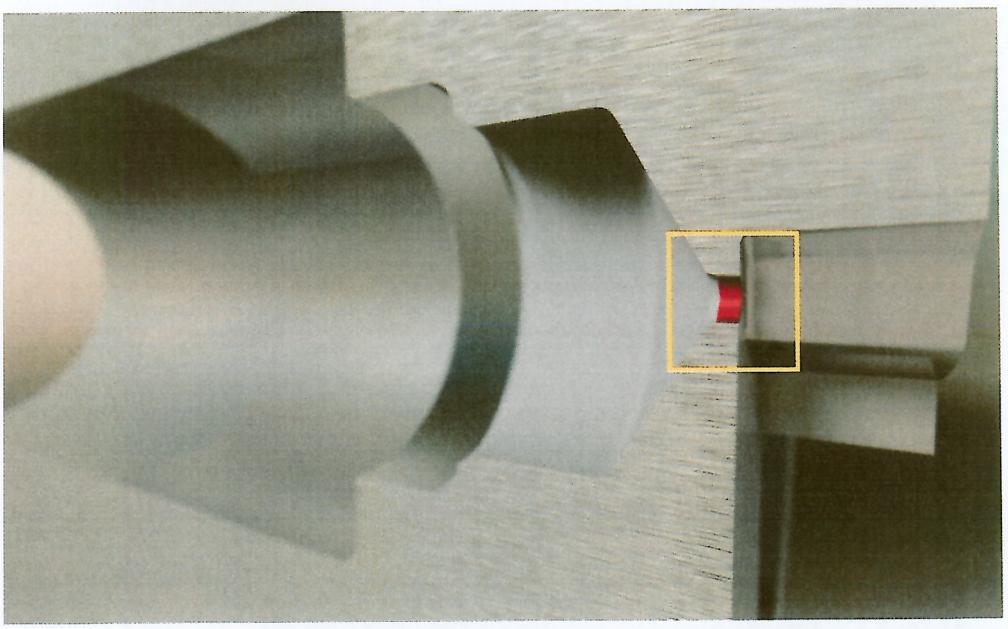
Bore precision machining

High precision size and shape

Microcut Bore Sizing is a method for finishing highly precise and economical bores. The number of applications continues to grow and ranges from automotive engineering, medical and aeronautical engineering through to the watchmaking industry.





1 The Precision machining of a hot runner system shut-off nozzle in an injection moulding mould insert (marked yellow) is a typical application for Microcut Bore Sizing (Photo: Microcut)

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→ There are a number of reasons why you might need to precision machine a bore. The most compelling is that in its raw state, a bore does not satisfy functional requirements, particularly with regard to shape, surface or dimensional accuracy. Typical shape defects include out-of-roundness, bell mouths, undulations, tapering or 'banana shape'. This is where the Microcut Bore Sizings (MBS) technology comes into play. Switching from a conventional finish processing method such as honing or grinding to this precision machining process normally results in a leap forward in terms of quality. What is more, direct or indirect costs can be reduced.

Suitable for through holes, even in very hard materials

The MBS can be regarded as the next step in arbor honing (single-stroke honing). This development increases performance and significantly expands the range of applications. The method is an economical solution for function optimisation of small and interrupted through holes, particularly in hard and difficult-to-machine materials. The technology enables the shape, surface and diameter of a bore to be reliably finished to very tight tolerance ranges.

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The one-piece MBS tools are coated with a single layer of diamond or CBN (undefined cutting edge) and have a conical and cylindrical section. The tools are dressed to the nominal size. During the machining process, the tool is driven by the machine through the bore to be machined in a force-controller manner with rotational and translational movements (multiple-stroke).

The MBS method opens up new applications or typically replaces conventional methods such as honing with expandable tool, single-stroke honing method (arbor honing, supersizing, single-stroke), internal cylindrical grinding, manual arbor lapping or wire honing.

Although the Microcut Bore Sizing process has its roots in microtechnology, due to the stated advantages it is increasingly also used for larger bores, i.e. it is developing against the general trend from small to larger diameter values.

It is a simple principle with high process reliability. Taking all direct and indirect expenses into account, MBS generally offers a superior cost-benefit ratio. The process is stable and force-controlled with minimal shape, surface or dimensional variance – even in harsh environments. The entire system is easy to adjust, as the shape (cylinder) and the dimensional accuracy of the diameter do not need to be set and maintained by means of measurement and control.

The corresponding machines are easy to operate

The result of this special technological process is fundamentally better shape accuracy (jig quality) than that achieved with conventional methods, in particular with bores with recesses or extremely short or long bores. Not only are the corresponding machines energy efficient, they are also easy to operate with minimal tuning required, which also makes them suitable for use by non-specialists. Furthermore, even very small diameters can be machined.

The shape accuracy (cylindrical shape) is set automatically in relation to the process, without measurement control, in a similar way to arbor honing. The final diameter of the shaped element is determined by the one-piece tool.

The one-piece tool determines the final diameter

The tools with precisely dressed dimensions are one-piece which means they offer maximum rigidity, and they define the final diameter almost regardless of the ambient conditions (heat for example). In proportion to their diameter, the MBS tools are very long; their coated length is typically 350 mm. This means that a relatively large allowance can be removed (conical tool section) and the wear per part is minimal (cylindrical tool section). No spontaneous changes such as grain break-out arise on the tool, which has a single-layer coating.

It can also be used manually, on a lathe, for example in tool manufacture. »

2 **The three pillars of an MBS system are machines, tools and services** (Photo: Microcut)

In this case, the machine operator takes on the force-controlled guidance.

The tool feed is carried out in a force-controlled manner. This prevents elastic expansion of a thin-walled component, for example. The tool is not overloaded or underused; there is no unproductive 'air grinding' here. Raw bore diameters that are too small or too large are detected and intercepted, thereby preventing tool breaks.

One important component is the workpiece holder. After all, the workpiece must not be deformed during fixing. The workpiece position is normally determined by the tool axis.

A feature: minimum variation in the processing results

The Microcut Bore Sizing process is basically suitable for small batch sizes, like those often found in the mould making industry, but can also be used for large-volume production. Once a tool has been defined and is available, this diameter can be very quickly and also reliably reproduced.

Due to the simple, stable technological process, which works well without measurement control, even simple automation solutions, which can be controlled directly with the machine tool control system, are worthwhile. The manufacturer offers corresponding scalable solutions.

A key feature of the Microcut Bore Sizing is the minimum variation in the processing results, which means that no parts lie outside the tolerance due to variations. When carrying out standard honing or internal grinding, the shape must be permanently controlled through the stroke position and length and the dimension via the feed of the tool via a measurement and control circuit.

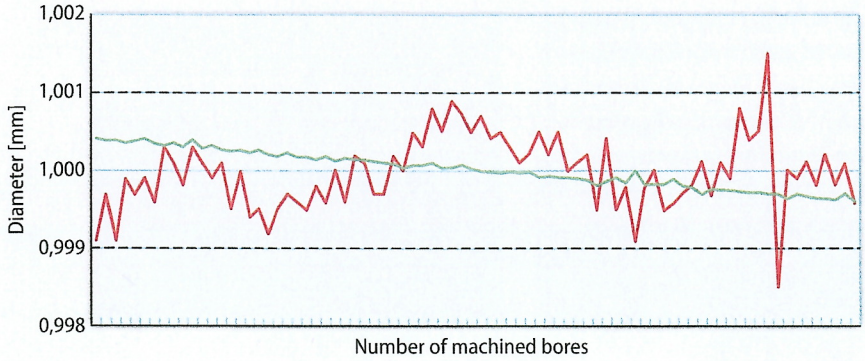
It should also be noted that the uncertainty involved in an in-process measurement, above all the shape, is considerable. Furthermore, the tools must also be dressed or spontaneously renew themselves as required, which also has a negative effect on the variation.

The Microcut Bore Sizing process is steady and not erratic within a diameter tolerance of +/- 0.001 mm for example. In Figure 3, the green curve for Microcut Bore Sizing shows continual minimum tool wear, and thus a bore becoming smaller.

The bore boundary layer is also compressed

The tool wear and thus the number of parts within the diameter tolerance depend on the material to be machined, the length of the bore, the allowance and the tool geometry. This can vary from less than 100 to several thousand parts with a tolerance window of 1 µm. Thanks to the system, the process is not temperature-sensitive, this means that even production startup or larger tempera-

3 **Precision comparison of MBS and conventional machining, green is MBS while red represents methods such as honing or internal cylindrical grinding with measurement control** (Photo: Microcut)



ture fluctuations have practically no negative effect on the dimensional stability of the bore diameter.

Due to the cold micro machining, damaged edge structures are removed and the bore boundary layer is also compressed (inherent compressive stresses). The surface structure of the workpiece can be defined and reproduced as often as it is required; a roughness value R_a of 0.05 µm (N2) is typically achieved with tools with bonded grain. In the case of hard materials such as carbide, loose grain and special tools can be used to create a mirror-like surface.

Application examples confirm the effectiveness

The application examples which confirm the effectiveness of the method include a hydraulic control valve. In the case of such control valves or sliding sleeves with cross holes, very high requirements are placed on the cylindrical shape (roundness and straightness) of the bore and also on the surface, from customers in diverse industry branches such as the aviation industry or automotive engineering (Figures 4 and 5).

As the MBS tools are one-piece and are coated along a length of 350 mm, the tool lies against the circumference of the bore and along the whole length. This enables optimum correction of the bore in terms of straightness. In addition, this advantage is also beneficial for the roundness, as the surface pressure between the tool and bore wall is distributed very homogeneously. In the case of a tool such as a short honing tool or a mounted point, which is shorter than the bore length, the forces vary much more strongly due to the cross bore, which is as a result reflected in the shape of the finished bore.

The fact that, with MBS, all movements and force measurements are effected by the tool plays a role in a second practical example. In this way, even small, very short offset bores can be machined in relatively large mould inserts. The position of the bore in the workpiece is not changed by this.

Burr formation on the injection part is kept to a minimum

A second example of the results achievable with the MBS process relates to a key application in the manufacture of injection moulding tools: shut-off nozzles. Here, it is important that the needle seals precisely, which requires an optimum shape and surface as well as absolutely precise bore dimensions. In this way, burr formation on the injection part is kept to a minimum.

The hot runner systems can be used longer on the machine

Due to the fact that the bore is after this special treatment much more precise geometrically, the diameter of the needle can be more precisely defined, which results in minimum mating play. This prevents burr formation on the injection part right from the get go, as there is no material between the bore wall and the needle. The advantage of a highly cylindrical bore with optimised surface can be seen, above all, in needle guides during the production phase: the hot runner systems can be used longer on the machine, because the wear on the needle and bore is much smaller than before. This increases availability and reduces maintenance work on the tool.

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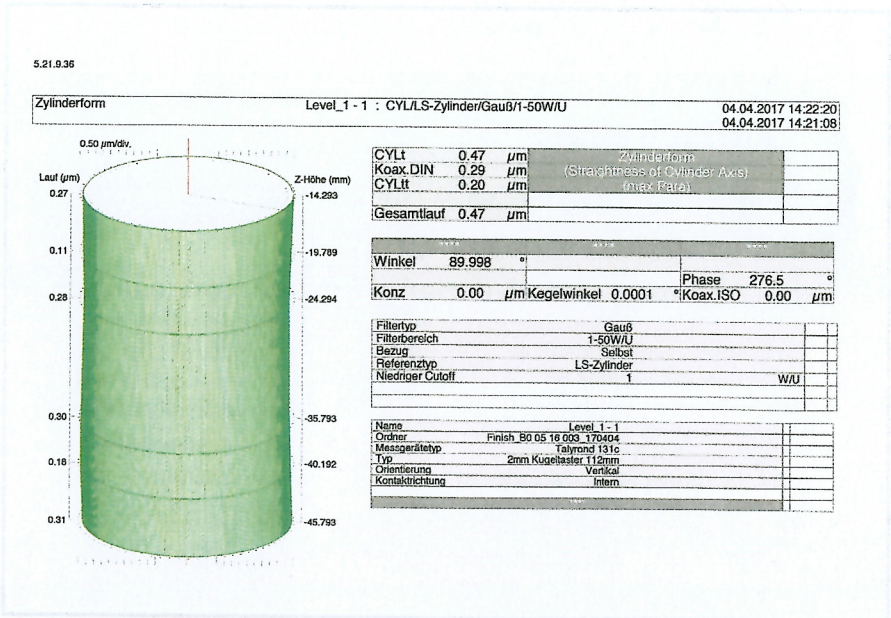
4 **The MBS easily provides the high level of accuracy required when processing this sliding sleeve with cross bores for hydraulic applications** (Photo: Microcut)



5 **The measurement record of the sliding sleeve from Figure 1 confirms the following values: cylindrical shape CYLt = 0.47 µm, straightness of the cylinder axis coax. DIN = 0.29 µm and roundness in a plane RONt = 0.06 µm** (Photo: Microcut)