HEMBRUG DANOBAT

Got a Challenge?

FINISH HARD TURNING

What you did not know yet

The manufacturing industry continuously demands more flexibility, greater accuracy and a higher productivity. A finish hard turning process for hardened workpieces offers many advantages and can help meeting these demands. The suitability of this process is however application dependent and therefore does not offer the same advantages to every manufacturer.

In this whitepaper we examine what finish hard turning really is and what is involved. How it relates to other machining techniques and for whom it may be suitable. We also look at the tooling, combining finish hard turning with other finishing techniques and automation.

Contents

About Hembrug

This whitepaper is brought to you by Hembrug. Hembrug is a leading manufacturer and provider of high precision finish hard turning machines and hybrid machines with turn/ grind capabilities. With a rich heritage of cutting edge technologies spanning over more than 7 decades, Hembrug has become a trusted name in industries that demand the highest level of precision and flexibility.

Finish hard turning and the advantages

Finish hard turning refers to the process of turning hardened steel workpieces within a hardness range of 55 to 70 HRC. From a process management perspective, it is little different from working with a conventional CNC lathe. The aim of this process is however to create ready to use, high precision workpieces without the need for any additional finishing process. Finish hard turning involves complete machining in one set-up.

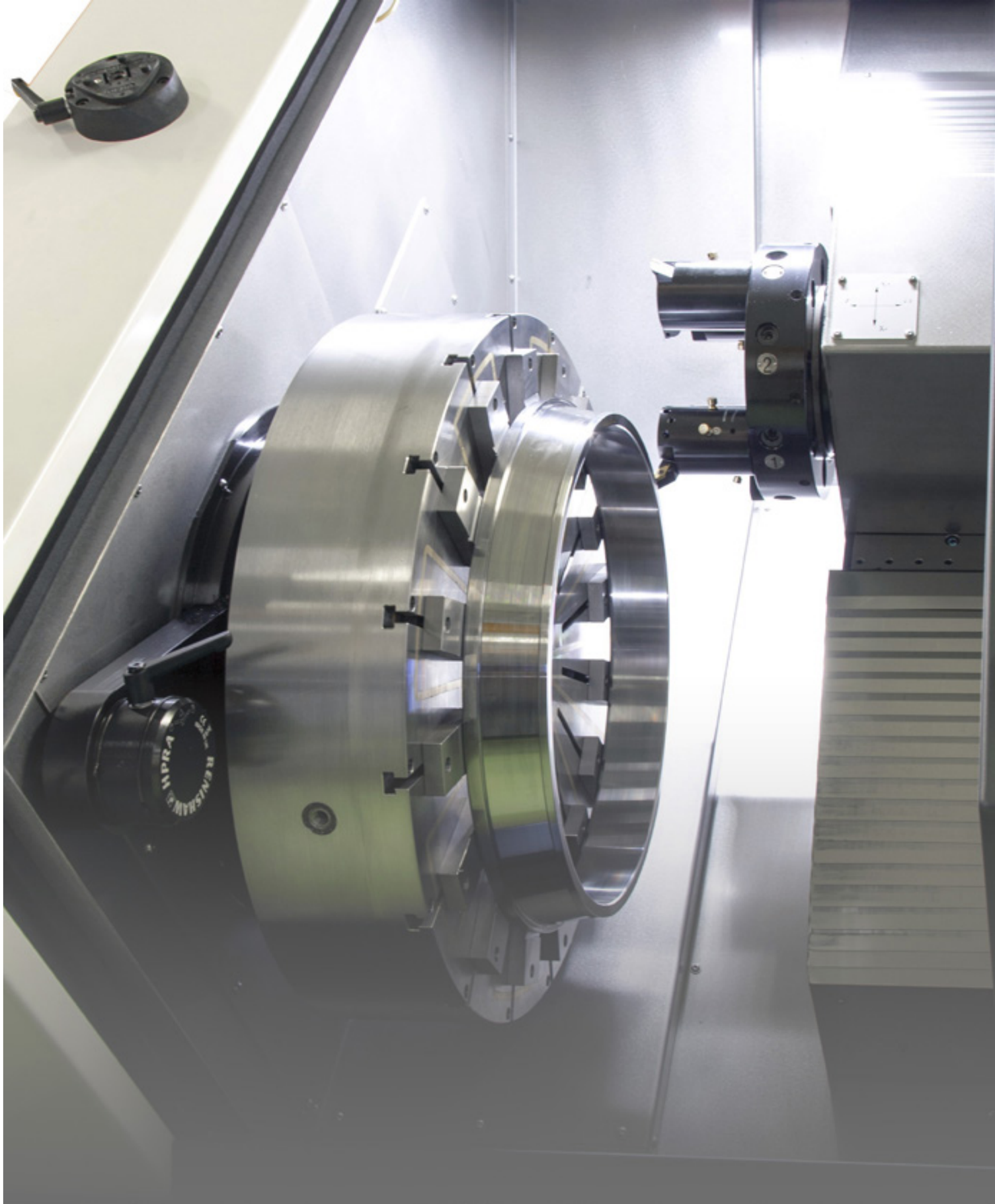
The strong points

- Feasible tolerances in the sub-micron tolerance range
- Complete machining of complex geometric shapes combined with ID and OD machining in one set-up
- Reduced capital investment; fewer machines needed because of complete machining on one machine
- Higher material removal rate helps to reduce cycle times
- Simple process set up and changeover in under 30 minutes
- Environmentally friendly due to the absence of e.g. grinding slugs

Achievable tolerances

A true finish hard turning machine should be able to achieve sub-micron workpiece quality and match a high precision, cylindrical grinding machine. The following accuracy tolerances may be demanded of a true finish hard turning machine:

- Form and dimensional : < 2 micron
- Surface finish (Ra) : 0.1 – 0.4 micron



Finish hard turning vs precision turning

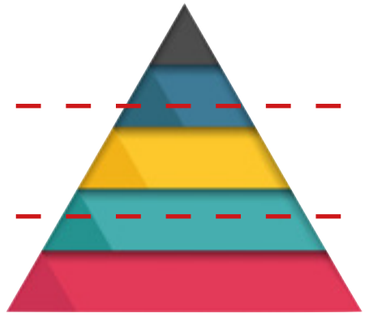
The majority of all hard turning operations worldwide are actually performed with conventional CNC precision turning machines. These machines can produce workpieces with reasonable accuracy. However, if submicron accuracy and the highest process stability is required, then a machine specially developed finish hard turning is a must.

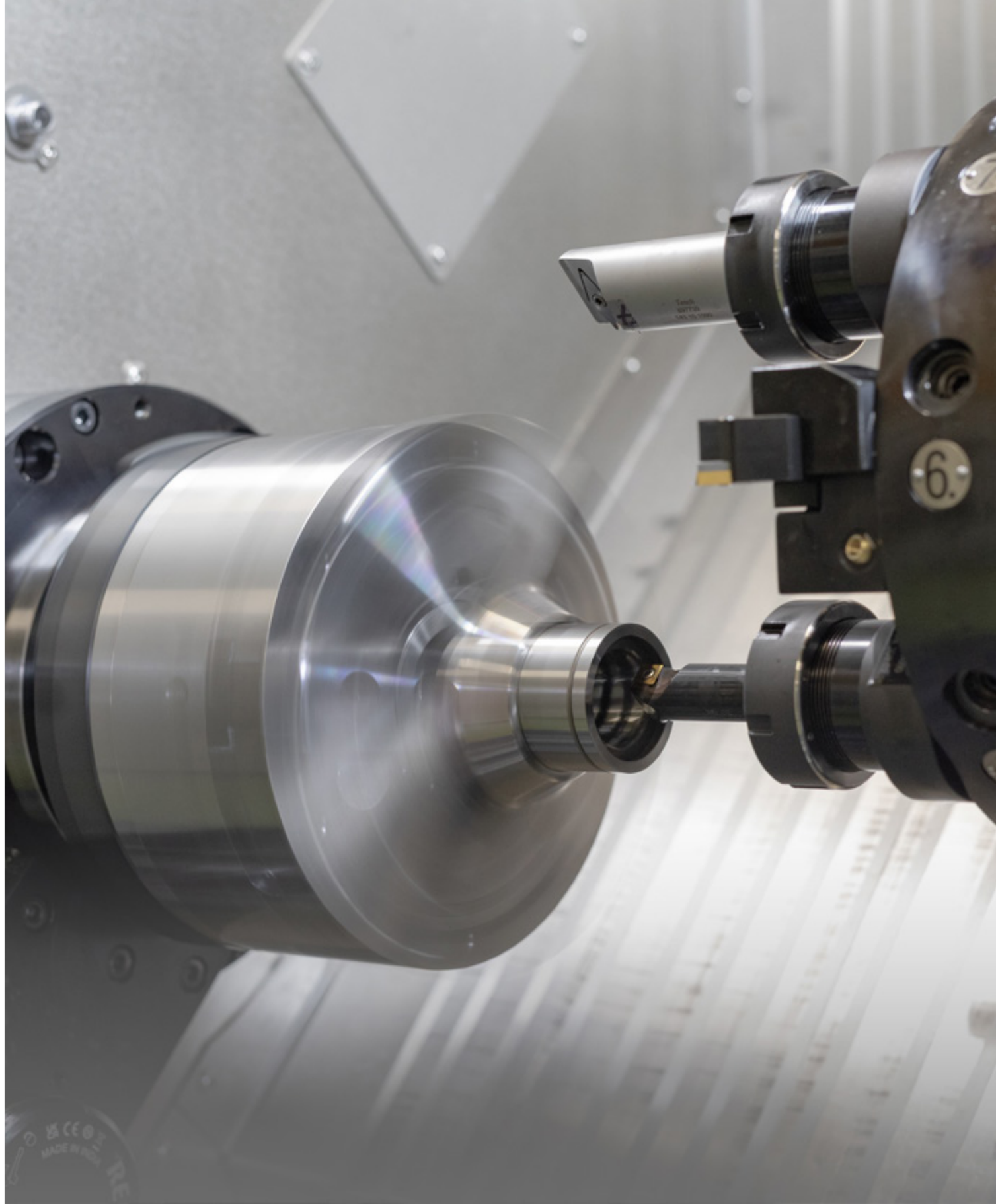
Turning operations can be classified into three classes, based on accuracy and applicability.

Finish hard turning with workpiece tolerances of < 2 micron micron

Conventional CNC turning with workpiece tolerances between 3-12 micron

Pre-processing to get hardened workpieces into a certain shape





Finish hard turning vs grinding

Cylindrical grinding high precision workpieces was the norm in the industry before the introduction of finish hard turning in the 1990's. Finish hard turning has since then however replaced less efficient processes and earned its place in the high precision manufacturing industry. Which process is most suitable depends however on the workpiece type, the material and batch sizes among others.

Hard turning offers advantages for:

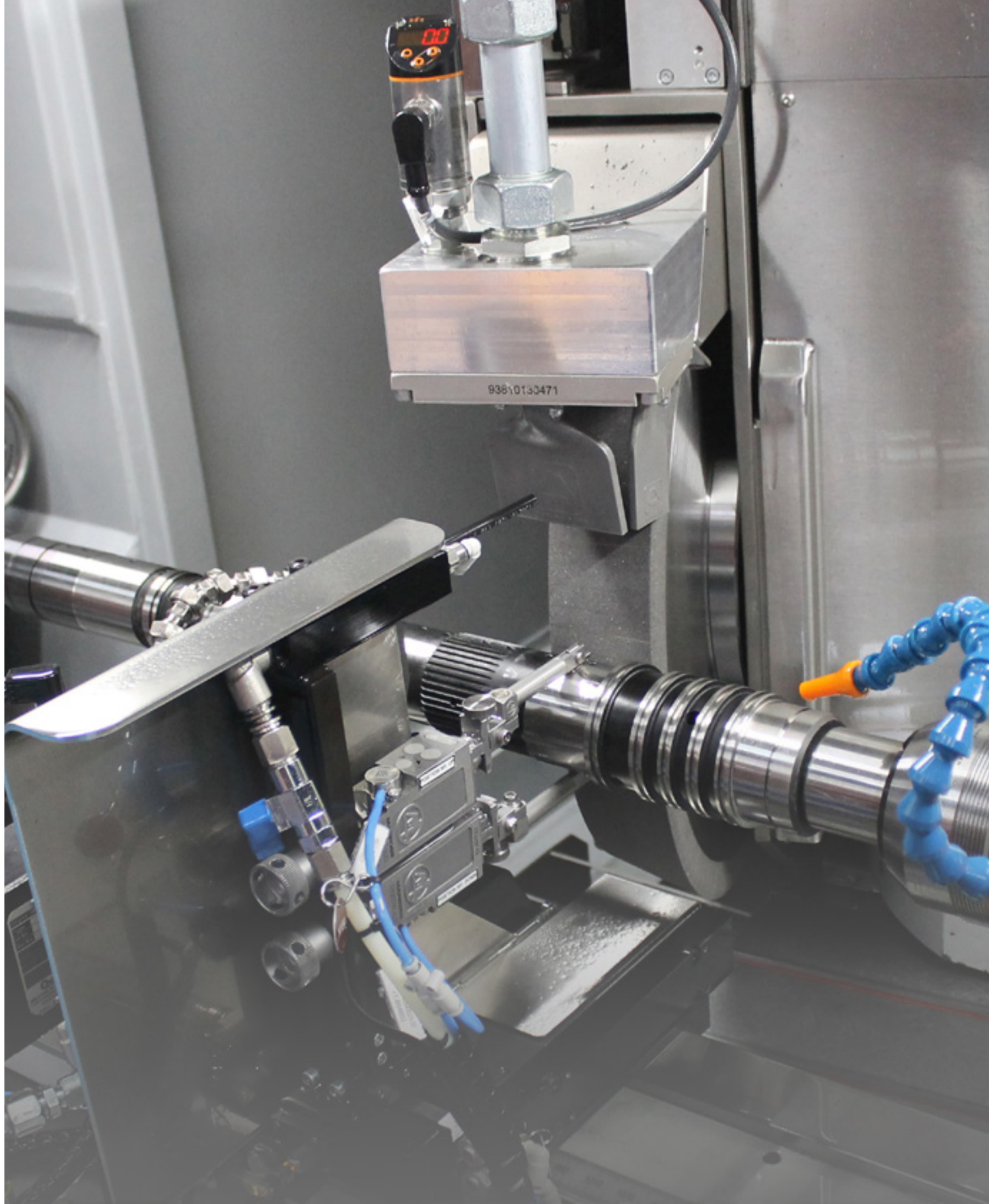
- Workpieces having complex geometries.
- Multi-surface workpieces
- Small and often changing product series. (High-mix/low-volume)

Grinding offers advantages for:

- Thin-walled workpieces and/or workpieces with a large length/diameter ratio.
- Large and infrequently changing product series and accuracy requirements of < 0.1 micron.
- Strongly interrupted surfaces in combination with large series.
- A wider range of materials such as ceramics

The inherent advantage of hard turning is that it is a simpler and more flexible process. From a setup and process management perspective, it's little different from working with a conventional lathe. The main advantage of grinding is that it is a very stable process. Grinding wheel behavior remains constant during its entire life and in process measuring greatly contributes to achieve high precision tolerances.

The above explanation serves as a general guide from a "helicopter point of view". There are of course workpieces that can be machined by both methods. A test always gives more clarity as to which technique is best suited for a particular type of workpiece at a given batch size.



Why is a special finish hard turning machine a must?

Hard turning is in principle possible on any CNC precision turning machine. However, in order to exploit the full precision potential of finish hard turning, a machine specially developed for finishing hard turning is necessary.

Inaccuracies and increased tool wear with a precision turning machine

The force required to take the material away from the workpiece, the relative cutting forces, are much higher when machining hardened steel compared to soft steel. A higher force results in a significantly higher back pressure force on the guideways. Precision turning machines are not equipped to handle these higher reaction forces (too high for the guideways). It leads to form inaccuracies, lower surface quality and increased tool wear.

What conditions must a high precision, finish hard turning machine meet?

1) High static and dynamic rigidity

A real finish hard turning machine will have a high static and dynamic rigidity to absorb the high process forces released when machining hardened steel. This rigidity is absolutely necessary to suppress as much as possible vibrations at the cutting tool. The high dynamic rigidity (= damping) is also decisive for a high surface finish and a good tool life.

2) High thermal stability

Thermal stability is required to minimize deformation due to temperature change. Temperature change can be caused by changing ambient temperatures or heat generating sources such as motors, electrical components or a hydraulic circuit. Good thermal stability lays the foundation for aspects such as dimensional stability in the production of large(r) series.

3) Geometrical precision

Finally the machine must logically be highly accurate. The accuracy relates to the concentricity of the main spindle (< 0.1 micron), the repeatability (± 0.2 micron) and positioning accuracy (< 1 micron) of the guides, the resolution of the measuring system and the CNC control. The straightness of the slide movements also contributes to the accuracy of the workpiece shape.

It may not be visible on the outside, but a true finish hard turning machine combines all of the above traits. Therefore, no concessions can be made to the machine when sub-micron workpiece accuracies are required.

The tooling

The suitable tooling is actually only cubic boron nitride, abbreviated CBN. CBN is the second hardest cutting material after diamond and hard enough to machine hardened steel between 55 and 70 HRC with a sufficiently long tool life. In addition, it is also heat resistant to about 1200 degrees. The cutting temperature in hard turning operations varies between 700 and 1100

What does an insert cost and how long does it last?

The cost per insert varies between 15 and 30 EURO per cutting edge. However, there are many different types of inserts available and which one is most suitable is determined by the workpiece to be made.

How long an insert will last depends on several factors. Some suppliers indicate a tool life between 30 and 40 minutes under normal circumstances. Hembrug, on the other hand calculates with a standard cutting length of 6-8 km at every machining proposal. And if the process is very well set up, even > 10 km.

Parameters and factors affecting tool life

A less stable machine will have higher vibrations at the tool tip leading to a higher tool wear and higher costs. Interrupte surfaces also affect tool life negatively. Some parameters you need to reckon with when choosing an insert:

- The geometry of the insert is dependend on the type of operation, for instance finishing
- A large nose radius has to chosen for strength and recessing
- The insert size depends will depend on the depth of cut
- A small nose radius is the choice if there is a tendency to vibration

A good hard turning partner will advise and support you in selecting the right tools with good tool life. After a project is completed, you usually continue to work with a dedicated tool supplier.degrees.

Combining hard turning with fine grinding techniques

Sometimes a surface structure and accuracy is required that cannot be achieved with finish hard turning. By cleverly combining turning and fine grinding in one machine, great gains can be made in flexibilty and productivity.

Integrating a finish grinding option into a hard turning machine makes sense:
- when a lead free surface structure is required. This is the case for sealing surfaces on drive shafts for hydraulic pumps, for example.
- when having to machine workpieces with large interrupted surfaces
- when grinding on certain surfaces is mandated, such as in the aircraft industry.
- or when long or thin walled workpieces are also part of the production batches.

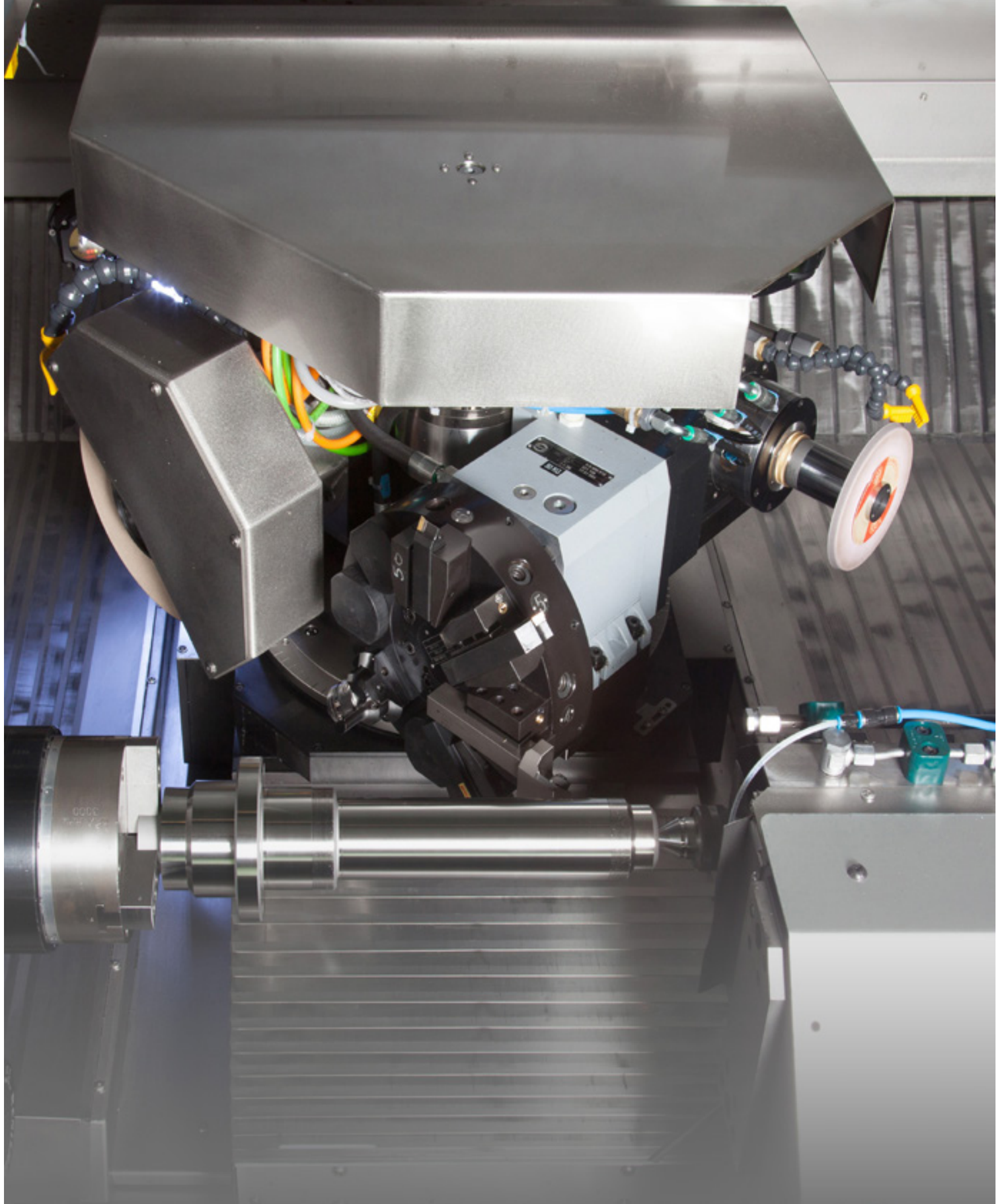
The advantages:

- **Improved Efficiency:** The hybrid machine eliminates the need for multiple setups, transfers between separate machines and increases overall productivity.
- **Enhanced Precision:** The combination of cutting and grinding actions allows creating an excellent surface finish and precise control over dimensional accuracy.
- **Reduced costs:** Consolidating two processes into one machine reduces capital investment, and floor space requirements.
- **Versatility:** a hybrid machine allows you to handle a wide range of applications and workpiece materials.

The dominating technique

It is important however to consider which technique dominates when opting for a hybrid process. Having a grinding capability in a finish hard turning machine means hard turning is always the main machining technique. The finish grinding operation is then done with the aim of achieving a certain surface structure and/or surface finish.

The right partner will look at your requirements and will advice which configuration is most suitable for you. You should expect the right partner to be able to offer a turning/grinding machine or solution.



Finish hard turning and automation

Automating your manufacturing process increases your productivity, reduces total cycle time and reduces your dependency on a full time operator for your process. These advantages directly lead to a reduction on the cost per part too. Nowadays, automation is part of our production environments thanks to the ease of use and adaptability. However, choosing the most suitable automated system for your turning process depends on factors such as workpiece shape, clamping system and batch sizes.

What type of automation?

You can automate your process by means of a robotic, gantry or hybrid system. A robotized system offers great flexibility, is compact and has a small footprint. Apart from this an endless number of auxiliary stations can be included. A robotized system can be suitable for medium to smaller batches too.

External gantries on the other hand allows you to transport large and heavier parts. They can also be extended to automate several machines in line when successive operations are carried out on the same parts on different machines.

A hybrid gantry/robotized system can be competitive when the loading-unloading needs to be separated into two. One system for loading-unloading the workpiece at the machine and one outside the machine for feeding any auxiliary station. This guarantees short cycle times in an extensive and adaptable solution.

Feeding and auxiliary systems

Another point to consider is workpiece feeding and quality control. This mainly depends on the autonomy required and workpiece characteristics. Auxiliary process such as NOK (rejected workpieces) and SPC (Statistical Process Control), pre- or post-process measurements among others greatly improve process reliability in addition to the increase productivity.

In summary, setting up a fully automated process requires a bit of homework but offers many benefits. The right partner however will help you with an efficient and productive system that contributes to your productivity goals and improves competitivity.

Frequently asked questions

Do I need to use coolant?

Finish hard turning offers the possibility of dry machining and is applicable for small workpieces where there are short chisel contact times. Cooling with coolant, however, plays an important role in process reliability, on the one hand to carry the heat generated during cutting, and on the other hand to wash away the chips during machining. It also increases tool life. Whether or not to use cooling is therefore application-dependent, and the right partner can provide good advice.

Can I machine workpieces interrupted surfaces?

A well-finished hard turning machine can machine workpieces with interrupted surfaces without sacrificing workpiece quality. The damping characteristics of the machine are important here, as are the process parameters and which type of CBN insert is used. For example, when machining interrupted surfaces, inserts with a high(er) CBN content should always be chosen.

Doesn’t hard turning have the disadvantage of white layer?

No, it does not. You can prevent this by using the correct machining parameters such as feed rate. In this regard however it is vital to keep tool wear under control. A worn tool creates more friction, which generates more heat and consequently increases the likelihood of forming white layer.

Which max. length/diameter ratios are possible?

Finish hard turning, unlike cylindrical grinding, has geometric limitations. When machining an inner diameter, the max. length to diameter ratio is determined by the stiffness of the bore bar. This can however easily be determined with a calculation. For finish hard turning, ID diameter/length is generally maintained at 1:5.

For outer diameters a length to diameter ratio of 2:1 is used. However, this can be increased to 4:1 with a tail stock and steady rest. With a double steady rest this ratio can be increased even further, but a test will then have to show how much exactly.

Got a challenge?

Hembrug is part of the Danobat family of companies together with Overbeck. Combined, the three companies manufacture everything from individual machines to fully automated production systems. It can offer you a suitable, objective machining solution for a wide variety of applications without bias toward a specific machining technique.

DANOBAT

www.danobat.com

THE NETHERLANDS
Hembrug
H. Figeeweg 1a+b
2031 BJ Haarlem
T + 31 23 5124900
sales@hembrug.com

SPAIN
Danobat
Arriaga kalea, 21
E-20870 Elgoibar
Gipuzkoa
T + 34 943 748 044
danobat@danobat.com

GERMANY
Overbeck
Konrad-Adenauer-Str. 27
35745 Herborn
T + 49 (0) 2772 801 0
danobatoverbeck@danobat.com