Switch to hard-part turning

High-productivity, high-quality finish turning of case-hardened steel surfaces
More than just a tool supplier

With more than 25,000 products on our shelves, Sandvik Coromant is the world’s leading manufacturer of cutting tools for the metalworking industry. But that’s only one side of the coin! Thousands of specialists are also available to ensure that each product gets the technical support it deserves. Around the world and around the clock, they are hard at work advising tool users how to get the best from their turning, milling, drilling and boring operations.

A true productivity partner

Our tools and specialists have one common mission – to improve your productivity and profitability. We take this task seriously. Outstanding tools, extensive application know-how, and professional service are all geared up to give maximum customer value in terms of performance, quality, security, flexibility and total economy.

Full control from powder to recycling

Close control every step of the way is essential if we are to live up to our commitments. This we have. With the most advanced production system plus the latest technology solutions, we control the entire product manufacturing process from raw material to finished tool. Moreover, we also make sure that the environment benefits as well. For example, our used carbide collection service promotes the efficient recycling of this material in an ecologically responsible manner.

Sandvik Coromant is certified according to ISO 9001.
Hard-part turning comes of age

Hardening steel component surfaces has long been used to increase wear resistance. It has also necessitated finishing by grinding – a reliable process but not without its disadvantages.

Now, however, hard-part turning (HPT) is winning ground. In machining shops throughout manufacturing industry, the technology is replacing grinding – cutting costs and raising productivity accordingly.

The advent of super-hard cutting tool materials such as cubic boron nitride (CBN) and aluminium oxide ceramics, plus new optimized machines, makes HPT a viable manufacturing process for mass production. Today, HPT is well accepted and well able to meet industry productivity goals of higher quality and shorter cycle times.

New CBN inserts for productive, high-quality finishing of case-hardened surfaces.

In the automotive industry, HPT is especially competitive. Increased demands for improved productivity and cost-efficiency have driven the turning of gearbox and drive-train components in the hardened state. Manufacturers now design these components for HPT rather than grinding. Other industries are following suit, and experiencing the same productivity gains.

Successful HPT goes beyond mere cutting tools and components. It encompasses the complete machine environment. Start, for example, by ensuring that your soft-part machining creates the best possible conditions for finishing the hardened material.

These guidelines demonstrate that Sandvik Coromant has this broad perspective. Plus a complete HPT solution.

A complete HPT solution, plus in-depth application know-how and back-up.

Hard-part turning. Make the switch. Then make the part.
Turning vs. grinding – the hard facts

Turning hardened steel rather than grinding it offers many advantages.

As a single-point contact method, HPT can easily accomplish complex contours without need for the costly form wheels that multi-point contact grinding requires. Similarly, HPT permits machining of multiple operations with just one set-up. The result is excellent positional accuracy, reduced part handling and less risk of part damage. The environment also benefits from HPT as the technique eliminates grind waste and does not require coolant.

All in all, HPT reduces machine tool costs and gives better production control, quicker throughput and higher quality. Add these plus points together and the cost-savings brought about by switching to HPT are considerable.

<table>
<thead>
<tr>
<th>Surface generation</th>
<th>Turning</th>
<th>Grinding</th>
</tr>
</thead>
<tbody>
<tr>
<td>Method</td>
<td>Single point contact</td>
<td>Multi point contact</td>
</tr>
<tr>
<td>Profile</td>
<td>Periodic One</td>
<td>Irregular Many</td>
</tr>
<tr>
<td>Residual stress</td>
<td>Compressive (mainly)</td>
<td>Compressive (mainly)</td>
</tr>
<tr>
<td>Surface profile</td>
<td><img src="image1.png" alt="Turning Surface Profile" /></td>
<td><img src="image2.png" alt="Grinding Surface Profile" /></td>
</tr>
</tbody>
</table>

HPT produces a better hardened steel surface than grinding.

Cost estimates for hard part turning compared to grinding

Investment in machine | Tools and consumables | Floor space | Manpower and fixed costs

Grinding

Hard part turning

HPT generates significant savings in manpower and fixed costs compared with grinding.

“Depending on part geometry, a reduction of machining time and cost of well over 70% can be achieved while maintaining accuracy and surface finish.”

Fraunhofer Institute, USA
Start with a soft approach

As with all technical processes, preparation is everything.

Prior to HPT, perform soft machining with a Sandvik Coromant wiper insert to create the best possible conditions for HPT. Correct soft machining equalizes surface topography and stabilizes hardening effects. It will also permit completely dry HPT and minimize inheriting surface imperfections. Due to the relatively small depths of cut in HPT, close dimensional tolerances in soft machining are one of the keys to HPT process consistency.

Points to remember when planning your soft machining conditions include:

- Avoid burrs
- Keep close dimensional tolerances
- Chamfer and make radii in the soft state
- Do not enter or leave cut abruptly
- Enter or leave by programming radius movements

Correctly executed soft machining will allow more reliable HPT.
Stability − the key to success

Stability in many different forms
is a key success factor in HPT.

Not only machine stability, but also
rigidity and thermal stability are vital
components in producing an accurate,
high-quality finished part.

High machine rigidity and stability
will minimize the impact of variable
cutting force on the surface profile pro-
duced. This results in a better process
capability.

Guiding accuracy and positioning
accuracy of the carriage are also
important criteria to consider when
choosing machines for HPT. Not
surprisingly, the better the stability
of your overall machine concept, the
closer the tolerances you will be able
to keep.

Machine thermostability also re-
duires some thought. Heat generated
at any place in the machine affects
the tolerance of the work-piece, so
it must be controlled accurately.
Removing heat by cooling the spindle
or transporting it away in heat-contain-
ing chips will pay dividends in better
tolerances. In this respect, vertical
lathes (pick-up machines) with no
resting place for chips to accumulate
are good examples of ‘thermostable
machining systems’.

Take into account all these stability
parameters − machine, tooling and
temperature − and choose the correct
Sandvik Coromant wiper technology, and
you can achieve surface qualities fully
on par with grinding.
Clamp work-pieces for maximum rigidity

Work-piece clamping and alignment are next to consider when setting up a machine for HPT.

As the ability to accurately rotate the work-piece is vital for achieving close dimensional tolerances, work-piece clamping has an important role to play in machine set-up. Thin-walled components especially place very stringent requirements on clamping. Make sure that you employ wide clamping jaws – they offer many benefits compared to ordinary three-point jaws.

As a guideline, a length-to-diameter ratio of up to 2:1 is normally acceptable for work-pieces supported on one end only. With additional tailstock support, this ratio can be extended. Aligning headstock and tailstock properly also promotes maximum rigidity and good conical point contact, both of which contribute to a first-class finished product.

Note that a thermally symmetric headstock and tailstock design will add extra dimensional stability.

Properly aligned headstock and tailstock promote rigidity. Some work-pieces tolerate clamping via the headstock only, but if they are long and slender, tailstock clamping is also required.

Ordinary three-point jaws can distort the roundness of your work-piece due to local excessive clamping forces.

Wide jaws distribute clamping forces over a larger area for better HPT and narrower dimensional tolerances.

Properly aligned headstock and tailstock promote rigidity. Some work-pieces tolerate clamping via the headstock only, but if they are long and slender, tailstock clamping is also required.
Added strength for tool holder and insert clamping

Tool and insert clamping are next in line when getting ready to turn case-hardened steel surfaces.

Tool holder deflection increases by the cube of the added overhang, so simple mathematics tell you to keep the overhang as short as possible or, if feasible, use a rigid tool with a large cross-section.

To further improve stability, especially for small diameter tools, consider using carbide shanks.

It pays to keep overhang as short as possible.

With a clamping force of several tons, the tapered polygon and flange location face of the Coromant Capto® tooling system result in a strongly clamped joint that is extremely resistant to bending and twisting.

In addition to strong tool holder clamping, HPT also requires a rigid means of clamping inserts. CoroTurn® RC and CoroTurn® 107 provide this rigidity by clamping the insert in two directions, combining downward forces with insert positioning accuracy.

Impressive clamping strength from the Coromant Capto tooling system.
Chips and coolant – get rid of both!

Evacuating chips and eliminating coolant are key parts of the machining strategy related to the cutting tool.

Efficient chip evacuation avoids scratching the turned surface and prevents chips getting stuck inside the bore prior to the second cut. Chips interfering with part handling must also be eliminated.

Chip flow is influenced by several factors. Gravity is one, so the mounting direction of the tool requires consideration. Others include cutting data, insert radius and coolant or forced air. Changing feed rate changes the direction of chip flow. Likewise, changing cutting speed affects chip temperature and hardness, thereby redirecting its flow. Thin chips do not generally break. However, increasing feed will increase chip thickness and thus promote chip breaking.

A larger radius or wiper radius allows increased feed rate while still maintaining surface finish. Changing tool path can also give a completely different chip flow path.

Continuous cut HPT without cooling is the ideal situation, and is entirely feasible. Both CBN and ceramic inserts tolerate high cutting temperatures, which eliminates the cost and bother of handling coolants, and allows easy and cost-effective chip removal.

Some applications may nevertheless require coolant, e.g. to control the thermal stability of the work-piece. In such cases, ensure a continuous flow of coolant throughout the entire turning operation.
Insert selection – time for a geometry lesson

The options you have are many, but the advice we give is unbeatable. Make your choice with confidence!

Different geometries (wiper, chamfer and hone) plus a range of grades mean that there are many factors to consider when choosing the correct insert for your HPT machining strategy. The final choice will depend on your specific application, but this brief guide illustrates some general aspects to keep in mind.

We also have more insert data available, plus extensive practical experience. For further information, contact a Sandvik Coromant applications expert directly.

Simple guidelines when considering standard radius vs. wiper radius are:

- Twice the feed rate gives the same surface finish; the same feed rate gives twice as good a surface finish.

![Standard radius vs. wiper radius. A standard radius produces a certain surface finish at a certain feed rate. A wiper radius can produce this same finish profile at twice the feed rate, or twice as good a finish profile at the same feed rate.](image)

CBN inserts from Sandvik Coromant have wiper options optimized for specific applications. WH (wiper HPT) generates low cutting forces for best surface integrity; WG (wiper general) permits higher feed capacity.

![CBN inserts from Sandvik Coromant have wiper options optimized for specific applications. WH (wiper HPT) generates low cutting forces for best surface integrity; WG (wiper general) permits higher feed capacity.](image)

![Virtually all HPT inserts have a chamfer, which is essential for controlling their performance. In addition, a honed edge is less sensitive to chipping and generally performs more consistently.](image)

<table>
<thead>
<tr>
<th>Surface roughness, $R_z$</th>
<th>0</th>
<th>5</th>
<th>10</th>
<th>15</th>
<th>20</th>
</tr>
</thead>
<tbody>
<tr>
<td>Feed, $f_n$, mm/r</td>
<td>0.12</td>
<td>0.24</td>
<td>0.36</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

![Sandvik Coromant inserts have application-optimized wipers.](image)

![Chamfer angle influences wear resistance and toughness.](image)
CBN inserts are your first choice for turning high quality steel surfaces in the hardness range 58-65 HRC. CB7015 grade has extra performance and reliability for light interrupted cutting.

New CB7015 is perfect for light interrupted finishing of very hard steel surfaces.

Tool wear – when the insert reaches the end of its life

There’s no escaping the fact that in one respect, tools for HPT are just like all others. They wear out.

Crater and flank wear develop during the working life of all HPT tools. Knowing how wear arises and the effect it has will nevertheless help maximise the productivity benefits of finish turning case-hardened steel surfaces.

Crater wear is normally the dominating wear mode. It gradually affects the insert strength and at the end of tool life also the surface finish.

In contrast, flank wear gradually affects the dimensional tolerance of machined parts over a period of time. The tolerance of more than one component is thus at risk if this category of wear is not understood and monitored closely.

Crater and flank wear are each affected differently by different cutting data. The cutting data range also differs for different insert grades.

Crater and flank wear develop during the working life of all HPT tools and affect their finishing performance in different ways. Flank wear, for example, can impact dimensional tolerances on a number of finished components.

Cutting speeds affect crater and flank wear differently. Speed range also differs for different grades of insert.
Surface generation – is there a clear-cut strategy?

One-cut and two-cut machining strategies have advantages and disadvantages. We clarify both alternatives.

Opting for a one-cut or a two-cut machining strategy is a matter of weighing the demands for surface accuracy against overall productivity. Both have their place in today’s HPT environment.

A one-cut ‘metal removal’ strategy is feasible for stable set-ups with a one times diameter (1xD) overhang in internal cutting. For good machining, we recommend chamfered, lightly-honed inserts (S-type) and moderate speed and feed.

Advantages of this approach are quickest possible machining time plus the use of only one tool. Disadvantages include difficulties in meeting stringent dimensional tolerances, shorter tool life (than two-cut), tolerance deviations due to relatively rapid wear, and the fact that post-hardening shape deviations will impact that of the finished component.

A two-cut strategy allows unattended machining of high-quality finished surfaces. We recommend the one-cut roughing inserts with a 1.2 mm radius plus finishing inserts with a chamfer only (T-type).

Advantages include tooling optimized for roughing and finishing, greater security, closer tolerances and potentially longer runs to tool change. On the other hand, two inserts are needed and total machining time is longer.

To meet very demanding surface quality criteria, we strongly recommend WH wiper geometry, which is specially developed for HPT.
Tool change criteria – cutting-edge know-how helps

Some users run inserts until they break. This is their preferred criterion. Others prefer bad surface finish or out-of-dimension-tolerance. We favour the following alternatives.

Predetermined surface finish is a frequent and practical tool change criterion. Surface finish is automatically measured in a separate station and a value given to a specified finish quality. When this set value is reached, it’s time to change the tool. If parts are loaded manually, the machinist can also sample and monitor surface finish. Using the same set value, he can quickly determine when tool change is needed.

When properly applied, predetermined surface finish will ensure that a predictable and satisfying number of parts are machined prior to change. In transfer lines or highly automated manufacturing, predetermined number of components is the most preferred and common criterion.

As stoppages in both situations mean greater loss of production than with manual loading, set the predetermined number of components to 10–20% less than the average tool life of an optimized process. The exact figure needs to be determined on a case-to-case basis.

Predetermined surface finish or predetermined number of components have much to recommend when planning tool change for maximum convenience and productivity.

To fully optimize tool change, a closer analysis of application, machining strategy, user manufacturing policy and performance demands is recommended. Our unique know-how is at your disposal.
“We switched to hard-part turning”

“Cut cycle time per part by at least 50% and at most 80%”

HPT is now replacing grinding as the main method for machining transmission shafts with hardnesses of 58 to 62 HRc at the Carr Hill Plant of Case Tractors in Doncaster, UK. Sandvik Coromant CBN inserts are used for finishing cuts as well as interrupted cutting.

Manufacturing engineers report that HPT has boosted output by cutting cycle time per part by at least 50% and at most 80% of that taken to grind components. In addition, one CNC lathe now does the job of two grinding machines.

<table>
<thead>
<tr>
<th>Turning vs. grinding</th>
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<tbody>
<tr>
<td>Component: Pinion shaft, 59-62 HRc</td>
</tr>
<tr>
<td>Previous manufacturing method</td>
</tr>
<tr>
<td>• rough-, finish- and groove grinding done on separate machines</td>
</tr>
<tr>
<td>New manufacturing method</td>
</tr>
<tr>
<td>• 4 axis CNC lathe</td>
</tr>
<tr>
<td>Semi-finishing</td>
</tr>
<tr>
<td>Ceramic insert</td>
</tr>
<tr>
<td>Cutting speed $v_c = 200$ m/min</td>
</tr>
<tr>
<td>Feed $f_n = 0.18$ mm/r</td>
</tr>
<tr>
<td>Depth of cut $a_p = 0.08$ mm</td>
</tr>
<tr>
<td>Finishing</td>
</tr>
<tr>
<td>CBN, Multi corner insert</td>
</tr>
<tr>
<td>Cutting speed $v_c = 160$ m/min</td>
</tr>
<tr>
<td>Feed $f_n = 0.08$ mm/r</td>
</tr>
<tr>
<td>Depth of cut $a_p = 0.05$ mm</td>
</tr>
</tbody>
</table>

| Result: |
| • 1 CNC lathe replaced 3 grinding machines. |
| • Cycle time reduced by up to 80%. |

“Major productivity improvement compared with grinding”

ATA Gears in Tampere, Finland, design and manufacture transmission equipment and turbines. Their helical gear wheels enjoy international recognition. HPT is a growing part of ATA’s production.

A typical gearwheel at ATA is made from hardened 17CrNiMo4 steel with 58 to 62 HRc using Sandvik Coromant multi-corner inserts with wiper. Compared with grinding, the productivity improvement for a 400 mm diameter gear wheel with this HPT solution is very significant indeed.

<table>
<thead>
<tr>
<th>Wiper vs. conventional geometry</th>
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<tbody>
<tr>
<td>Component: Gear, 58 HRc</td>
</tr>
<tr>
<td>Previous cutting data</td>
</tr>
<tr>
<td>• CBN</td>
</tr>
<tr>
<td>Cutting speed $v_c = 230$ m/min</td>
</tr>
<tr>
<td>Feed $f_n = 0.08$ mm/r</td>
</tr>
<tr>
<td>Depth of cut $a_p = 0.3$ mm</td>
</tr>
<tr>
<td>New cutting data</td>
</tr>
<tr>
<td>• CBN, Multi corner insert with WH wiper</td>
</tr>
<tr>
<td>Cutting speed $v_c = 230$ m/min</td>
</tr>
<tr>
<td>Feed $f_n = 0.25$ mm/r</td>
</tr>
<tr>
<td>Depth of cut $a_p = 0.3$ mm</td>
</tr>
</tbody>
</table>

| Result: |
| • Cycle time reduced by 50%. |
| • Cost per part reduced by 42%. |
Now it’s your turn. We’re with you all the way.

The productivity benefits of hard-part turning are clear for all to see. Moreover, there’s never been a better time to make the switch from grinding.

In the automotive industry especially, HPT is highly competitive. And in the US alone, manufacturing industry as a whole is seeking to save billions of dollars in machining operations.

Sandvik Coromant is well equipped to help. From your overall machining strategy to the finer points of insert geometry selection, we combine in-depth technical know-how with vast applications experience.

We see the big picture. We supply the complete solution.

Hard-part turning.

Make the switch.
Then make the part.
Buy a cutting tool
and get an expert as well

Sandvik Coromant can analyze your machining operations and offer you expert advice – from tool choice to method choice. Our ultimate aim is to reduce your final cost-per-component, thereby making you more competitive in mass production.

Working together, we set up priorities and objectives, test solutions, analyze the end-results, and agree on future action.