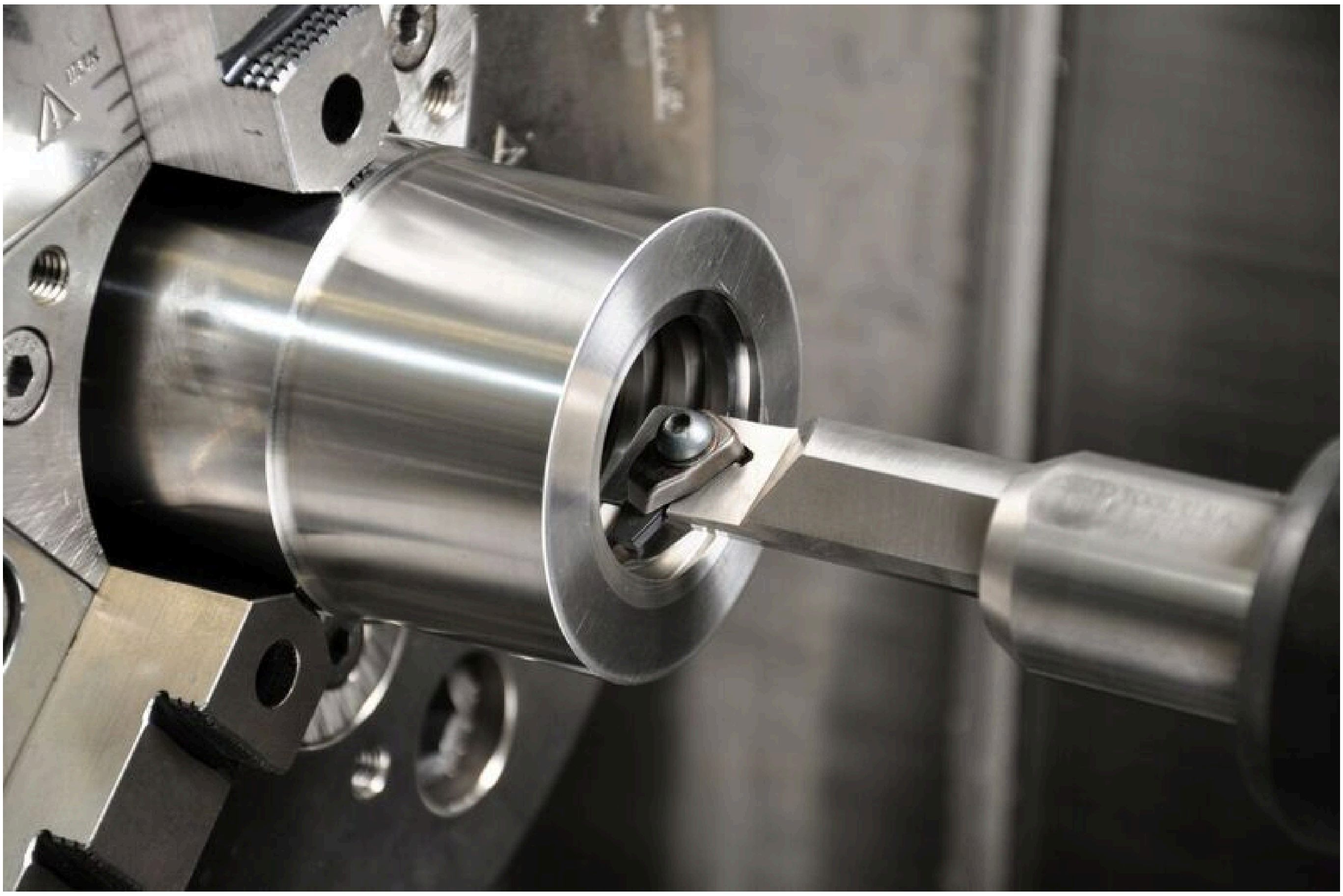

Metalworking

Hardened Parts Prove The Common Thread For Today's Shops

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For a rapidly increasing number of manufacturers, particularly those within the medical, aerospace and oil and gas industries, hardened components provide extreme wear resistance and strength along with superior surface finish quality. However, the typical production of such parts can be time consuming and costly – components are conventionally machined close to size in the soft or "green" state, sent out for heat treating, then returned for finish processing.

With each of these process interruptions comes the increased risk of both human and operational errors – logistical issues, parts loaded incorrectly or warping from heat treating – that can result in a scrapped part. For this reason, many of today’s shops will, if possible, machine parts completely from raw hardened material.

When parts are machined and/or threaded in the hardened state, accuracy is spot on, and the potential for error is dramatically reduced. Shops gain more control over their part processing as well as the confidence that comes from producing parts completely in house. Plus, after hard machining, the result is a finished part ready to ship in most instances.

For one shop, the ability to not only hard mill turn and drill, but in particular hard thread, proved quite a challenge and one that several tooling suppliers believed was impossible to overcome.

The part material was chilled iron with a hardness of 70 Rc. It measured 5" in diameter with a 2.500" ID bore that required a 4" long internal 2 ACME thread – a large actuating-type thread form with thread depth around 0.265". And, as if that wasn't enough of a challenge, the part needed several ¼-20, 0.600" deep threaded blind holes.

The launch of a new product line hinged on the shop's ability to quickly and cost-effectively produce this particular component. Unfortunately, no matter what tooling it tried – carbide, CBN and others – the shop was unable to thread the part.

The shop did consider threading the part soft, then having it hardened and chasing the threads. That was found to be an unworkable solution due to the other required operations and because of time in terms of longer machining cycles and short tool lives cost and, most importantly, quality issues involved with those other methods *(see sidebar)*.

This is when the shop contacted tooling specialists Don Halas and Aaron Eller from Seco Tools for help. Both Halas and Eller immediately ruled out carbide because such a tool would wear out before completing the entire thread form. Instead, they suggested Seco's existing standard universal Secomax CBN200 insert grade.

The grade is well suited for heavy interrupted cutting in steels and cast irons. For the shop's threading operation, Seco had to enhance the insert's geometry and edge prep to contend with the highly abrasive, super hard chilled iron.

The newly enhanced Secomax CBN200 CBN-tipped trapezoidal insert delivered the toughness, wear resistance and long tool life the shop needed. In fact, the enhanced inserts performed the process three times faster and reduced cycle time by 33%.

Under normal/soft part conditions, a carbide tool would generate the particular ACME thread in about 18 passes. With the part in the hardened state, the operation required about 40 passes at shallower depths of cut. That number of passes, according to Halas and Eller, was quite acceptable considering the alternative. "This operation was a first for the customer and us," commented Halas. "We had to design and produce all the components - insert, holder, cutting parameters, etc. - that were completely specific to this shop and the job."

In addition to the minor program alterations, there are several tooling requirements for such a hard part and its large size thread form. The most important is high rigidity and strength in not only the cutting tool itself, but also the toolholder and machine tool performing the operation.

For the ID threading application, Seco produced two versions of a toolholder made from a heavy, super dense material with added tungsten. The two versions were a C-lock hole clamping style for confined machining operations and a pin-lock-and-clamp style for general- and heavy-duty applications.

As it did for the ID threading, toolholding also had a profound effect on the part's blind-hole threading operations. Initially, Seco drilled the holes with a CBN-tipped drill and used a standard carbide thread mill to cut the threads. With this setup, Seco was able to produce two, sometimes three, complete threaded holes.

"We decided to put the thread mill in a heat-shrink toolholder. Doing so increased output to about eight holes, but the drill still only lasted for maybe three holes," explained Halas. "This was when we incorporated circular interpolation to hard mill the holes instead, which gave us three times the tool life over that of the drill."

The circular interpolated milled hole size was about 0.200" diameter, which is quite a small hole, Halas pointed out. The tool used was a standard solid-carbide Jabro end mill in a shrink-fit toolholder.

Once the shop realized all that was achieved with the hardened part, it had Seco evaluate the majority of its other machining operations. The shop wanted Seco to identify other parts and operations that could be optimized through changes and/or tweaks in tooling.

"There was really nothing new, tooling technology-wise, involved with this project," said Eller. "CBN has been around for a long time, as has carbide. But what was key to the project's success was that we evaluated the whole part process. We went from the beginning all the way to the end and developed the tooling that would optimize all aspects and allow the shop to achieve its machining goals. The development of the enhanced CBN threading insert and how it was applied is a perfect example of Seco's complete process approach."

At peak periods of demand, the shop now pumps out thousands of the hardened parts per year. It also produces various diameter sizes of the part as well.

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Hard Ways to Thread

When it comes to hard threading, shops do have some options. However, most of them involve multiple operations and tools, each of which heightens the risk of human error, and may hinder part consistency and increase cycle times.

Below are three such tooling setup options, along with their limitations:

A tungsten-carbide tip insert brazed on to a steel stick-type tool.

▪ Every tool change requires datums to be set again, which extends downtime.

▪ Material has to be annealed prior to machining, then re-hardened afterwards, increasing the risk of thread distortion.

▪ Tool life is short, and cutting speed is typically limited to about 40 m/min.

▪ Long cycle times, often measured in days, occur because of multiple operations.

A brazed tungsten carbide or polycrystalline boron nitride (PCBN) grooving tool for roughing and an insert made from either of those materials to finish profile.

▪ This time-consuming, two-tool operation requires annealing of the workpiece if using the tungsten-carbide tool.

▪ Brazed tool joint needs coolant and limits cutting speed because of heat.

▪ Low cutting speeds extend cycle times – a 33mm-pitch ACME thread can take up to five hours.

▪ Rapid flank wear and built-up edge (BUE) occur due to low cutting speeds.

PCBN-tipped insert brazed to a steel shank.

▪ Every tool change requires datums to be set again, which extends downtime.

▪ Brazed tool joint needs coolant and limits cutting speed because of heat.

▪ Low cutting speeds extend cycle times – a 33mm - pitch ACME can take as long as three hours.

▪ Rapid flank wear and BUE occur due to low cutting speeds.

