How-to

Heavy Duty Machining - but Safe

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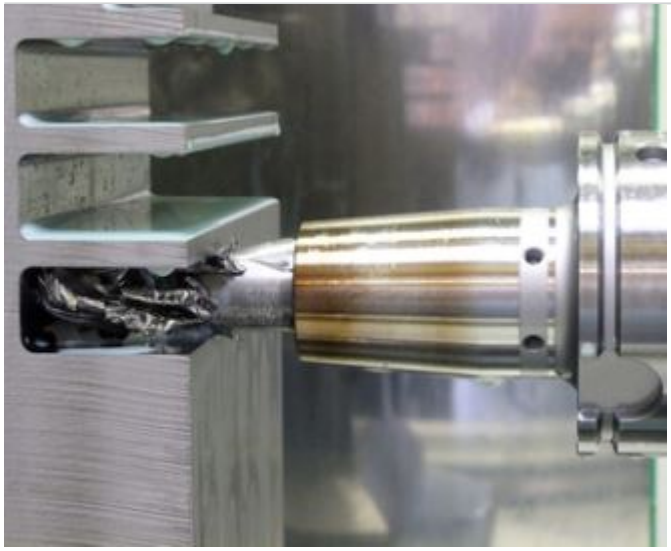
What You Need to Know

Roughing is a highly promising process.
Tool holding - an important factor for productivity.
Gaining new insights from difficult cases.
Prevent tool pull-out.



Roughing operation with titanium: without Safe-Lock™ the tool pulled out of the standard shrink fit chuck and broke at ap = 2 x D. With HAIMER Power or Heavy Duty Chucks and Safe-Lock™ it was possible to reliably mill full slots at ap = 2 x D.

The importance of the tool holder is still understated, especially when it comes to roughing and heavy duty machining. Metal removal rates in these types of processes are absolutely crucial for the productivity of the machining operation. By using special shrink fit chucks with drive pins and spiral grooves in the tool shank it is now possible to perform high-feed full slotting of up to 2 x D (50 mm) or more in difficult to machine materials. Application studies conducted by the machine tool manufacturer Heller have proven the effect of the HAIMER Safe-Lock™ system.

Especially within the aerospace, energy and mechanical engineering sector, production managers have to bridge the gap between economic efficiency and high process reliability when working with materials that are difficult to machine. Fortunately there is peace of mind in knowing that the machine technology innovations continue to develop to meet the ongoing demands of manufacturing. Heller machine tools is known as a source of inspiration for these kinds of innovations. The company, located in Nuertingen, Germany, is known for its high quality 4 and 5-axis CNC machining centres, CNC mill/turning centres, CNC machines for crankshaft and camshaft machining as well as flexible manufacturing systems. Customers value their availability of products and their competency in managing special processing demands. Both qualities stem from Heller's in-house manufacturing, which relies on closer collaboration with customers, suppliers and research institutes to remain on the forefront of innovation.

Roughing is a highly promising process

Werner Kirsten, who is working in the Technology Development Department at Heller and is responsible for the area of "difficult to machine materials“, explains: "our service includes optimizing the machining processes together with our customers and

suppliers. To support such services with practical trials, our Technology Center is equipped with a variety of machines". In most cases the aim is to increase the productivity without compromising the process reliability. Technologist Kirsten adds, "We often achieve this aim with an optimized roughing operation which ultimately results in a reduced finishing process. By maintaining the same technology values, but shortening the finishing depth of cut by 50%, the overall machining time is reduced to half. However, this requires process reliable and controllable systems during roughing."

In this regard, all machining components in the process chain have to be considered in order to improve productivity. The machine tool is the most evident component of the machining process, however the tool, the tool holding system, the coolant supply and other elements are also essential for a successful operation. "In the end the weakest link of the process chain limits the success," Werner Kirsten emphasizes. In his opinion most machine shops don't pay attention to the tool holder even though it is especially significant for high performance cutting. "Many of the trials which we carried out during the last few years have proven this point", Werner Kirsten explains. We realized that the tool holder has an incredible influence on the machining process. In the case of reinforced shrink fit chucks, for example, the vibration node is closer to the bearing point (due to the larger mass). The result is a smoother machining process with less vibration and a better surface finish quality while using the same tool, machine, process parameters and fixturing technology."

Tool holding - an important factor for productivity

By selecting the right tool holder you can even achieve good productivity and surface quality results using basic standard cutting tools. Werner Kirsten refers to comparative tests with basic four-edge cutting tools without an inner coolant supply. As an alternative to a standard shrink fit chuck he selected a HAIMER Power Shrink Chuck with Cool Flash which ensures that the coolant is transported directly to the cutting edges. "Compared to using a normal shrink fit chuck and external coolant, we were able to achieve significantly better results."

When a group of representatives from the aerospace industry, the Technical University of Dortmund and Technical University of Hamburg-Harburg visited Heller, an especially extensive milling application study was conducted in Titanium Ti-6Al-4V.

Gaining new insights from difficult cases

The available machining center was a four axis Heller H 5000 with a gear unit and HSK-A100 spindle, which yields torques up to 2.290 Nm. In order to demonstrate the machining potential, different 25mm diamteter end mills were used to mill full slots into a titanium plate. To simulate holder conditions used in the aerospace industry, the tools were clamped into reinforced shrink fit chucks. At an axial cutting depth of 0.5 to 1.0 x D the machining process was found to be very reliable. Since the spindle was not running at full capacity, the trial participants agreed to increase full slotting depth to 2 x D. Werner Kirsten explains: "Under these conditions the tool pulled out of the shrink fit chuck during the machining operation, creating a slot closer to 2.5xD as it progressed through the part. Towards the end of the slot the tool finally broke as a result of increased cutting forces."

The milling specialists all agreed that the clamping force of the chuck was the limiting factor in this process. As soon as the axial pressure and process related vibrations are too high the tool moves out of the chuck and further into the workpiece. At the same time the cutting pressure increases such that in the end the tool breaks and the workpiece is irreversibly damaged.

Reasons and possible countermeasures were discussed intensively. In the end, Werner Kirsten developed the idea that the tools are forced to navigate towards the spindle when the holding forces are exceeded. This is how he ultimately noticed the patented HAIMER Safe-Lock™ system which in addition to frictional clamping forces, has the same helix pattern as the tool. Theoretically, he realized that even if the tool got loose while using Safe Lock™, it would be pulled into the holder through the helical drive keys and not into the part. A movement that can be easily prevented through the use of length presetting screws.

Prevent tool pull-out

Werner Kirsten got in contact with HAIMER, the European market leader for tool holding technology, in order to test the Safe-Lock™system: "we wanted to know if our ideas could be put into practice using the HAIMER system in an even less forgiving environment." The Heller technology developer repeated the described trial, with a few major changes. HAIMER Safe-Lock™ grooves were subsequently added on similar solid carbide tools, but the application would be run again with a reduced spindle taper interface (HSK 63 instead of HSK 100), with a less rigid 5-axis gear driven spindle and a less stable diagonally fixtured workpiece.

The result: Despite these additional limiting factors, the tool was able to process a full slot of 2 x D = 50mm with complete process reliability. Werner Kirsten says: "this way we were able to indirectly prove that Safe-Lock™ works and that the shrinking technology has even more potential with HSK-A100, especially on 5-axis machining centers with gear spindles." Afterwards this sample machining on Ti-6Al-4V was carried out various times, including during the Airshow in Farnborough, whereby it was proven that the previous limit of 1 x D = 25 mm full slotting in titanium could be doubled with the use of Safe-Lock™.

Kirsten summarizes the results as follows: "For roughing operations this is a reliable process. Therefore I consider the HAIMER Safe-Lock™ system a practical, easy to handle and process reliable addition to the shrinking technology which we already utilize, especially in connection with standardized tools of other manufactures."

Key Takeaways

The importance of the tool holder in manufacturing is still understated despite the key role it plays.

The right tool holder can show an increase in productivity in various applications.

There is a constant evolution of tool holding based information from real life cases.

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