Technical article

May, 2015

Parting & Grooving: How to achieve greater performance, quality and tool life in the 21st century

Production engineers faced with overcoming the challenges of parting and grooving need reliable tools able to deliver class-leading performance in terms of productivity, quality and tool life. To ensure this market demand is met, Sandvik Coromant has invested many decades and considerable resources into continuous research, development and testing of parting and grooving technologies. Conducted in close unison with customers, each technology is developed to bring direct benefits to the end user. The following text aims to share some of the knowledge gained throughout the years and serves as a guide for the latest cutting edge technology and best practices for parting and grooving.

It started 40 years ago

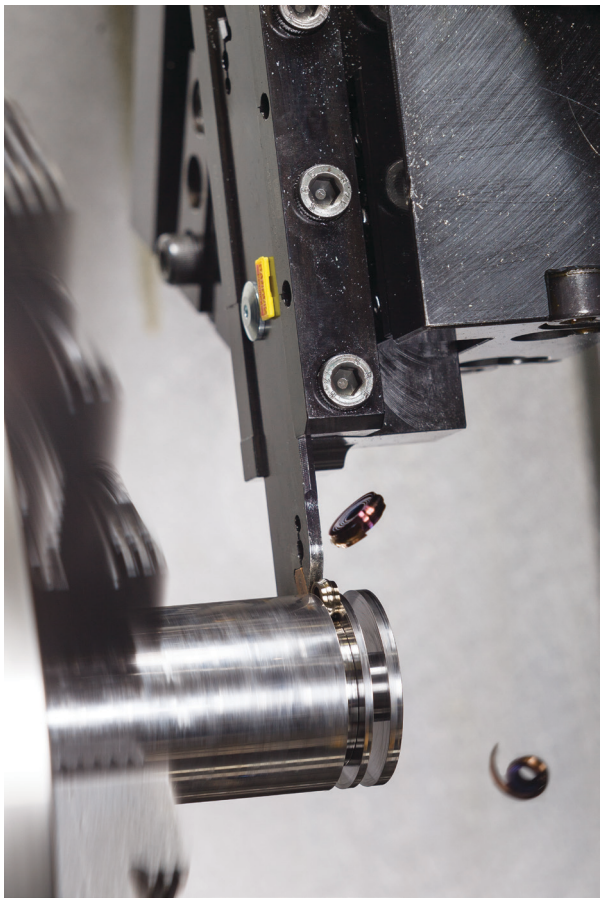
Sandvik Coromant has a long-established and proven track record in highly successful parting and grooving technologies that dates back over four decades. It was 1973 when the company launched its T-Max® parting tool, the first ever indexable insert concept for this type of operation. The following decade saw the Q-Cut® programme of indexable insert parting and grooving tools take hold in industry, which was followed in the 1990s by the unveiling of the Sandvik Coromant CoroCut® concept, which remains central in the company's portfolio to this day. The 2000s witnessed the introduction of CoroCut MB and CoroCut XS for small components, while 2014 saw the release of CoroCut QD, the new Sandvik Coromant flagship product for parting off and machining deeper grooves with long overhangs.

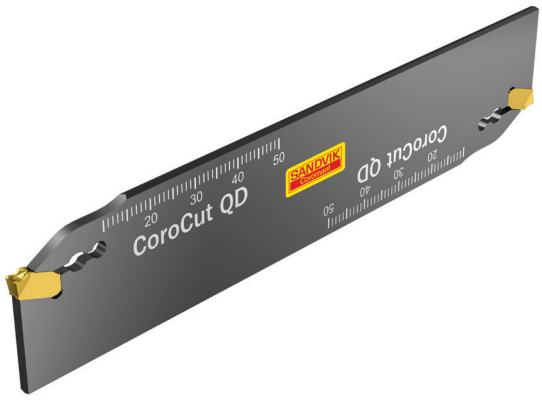
Solving machining challenges with CoroCut QD

Solving the long overhang machining challenge

One of the main factors in all parting and grooving operations is to minimize tool overhang wherever possible. However, when parting-off large diameter bars, long overhang is unavoidable, if there is a need to reach past a sub-spindle, for example. This means the tool has to compensate for the inherent instability of the operation, offering the capability for safe, reliable machining that is also highly competitive. CoroCut QD, a parting-off tool system of inserts, holders and unique plug and play coolant adaptors has been developed from this market demand, allowing users to apply tools confidently without the tendency to under-perform the operation in the name of "just-in-case" security.

Customer requirements were prioritized during the development phase. Aside from process security factors such as rigidity, strength and excellent chip control, the focus was on extended tool life, ease of use, high surface finish, and optimized productivity to ensure low machining cost per cut. Also, there was a clear requirement to develop an easy-to-select yet comprehensive programme covering as many applications, machines and materials as possible.





The narrow blade challenge

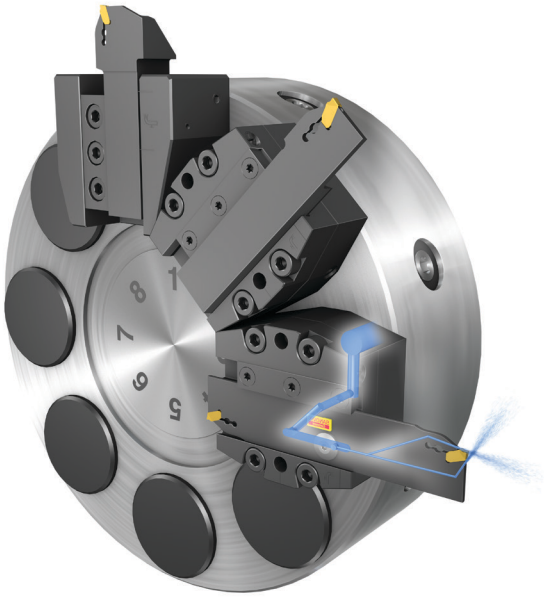
Parting-off and deep grooving are operations that make most operators nervous. Ultra-thin inserts and holders, matched with high rpm and tough materials, often have operators stepping back from the machine, but this needn't be the case. Relatively narrow blades are necessary in parting-off to help avoid material wastage, but how narrow can they be without risking security and limiting performance? With CoroCut QD, a new balance between blade width and performance capability has been struck, partly thanks to blade material development, where improved cutting action from inserts and better location and support are important contributing factors.

The new tool steel alloy for the blades has considerably higher fatigue strength (+12 percent), bending resistance and better insert seat properties. The quality of the insert location design plays a major role here and the QD-railed interface provides new levels of precision and reliability. The interface between the blade and the insert makes possible dependable blade widths of down to 2 mm for parting-off operations.

Increased speed and tool life

For parting-off with blades on bar-fed turning centres, sliding head lathes and multi-spindle automatics, CoroCut QD is the first choice for bar stock of 38-160 mm diameter. For external grooving, depths of 15-80 mm are possible in widths of 2-8 mm. All tools are available with internal over- and under-coolant, thus offering a high precision coolant (HPC) system. Over-coolant takes care of chip control while under-coolant prolongs tool life, and no other comparable system offers this technology as standard.

Importantly, HPC also allows operators to increase the surface speed, typically by 30-50%. As a result there is less insert-workpiece contact time at the same feed, subsequently delivering more parts per edge. The biggest benefit of HPC, however, is consistently extended tool life. In 200 tests against the competition, the average tool life increase achieved using CoroCut QD was 80 percent. In fact, customers often achieve two or three, or even four times greater tool life in comparison with their previous system, especially on exotic materials such as titanium and nickel-based heat resistant super alloys.

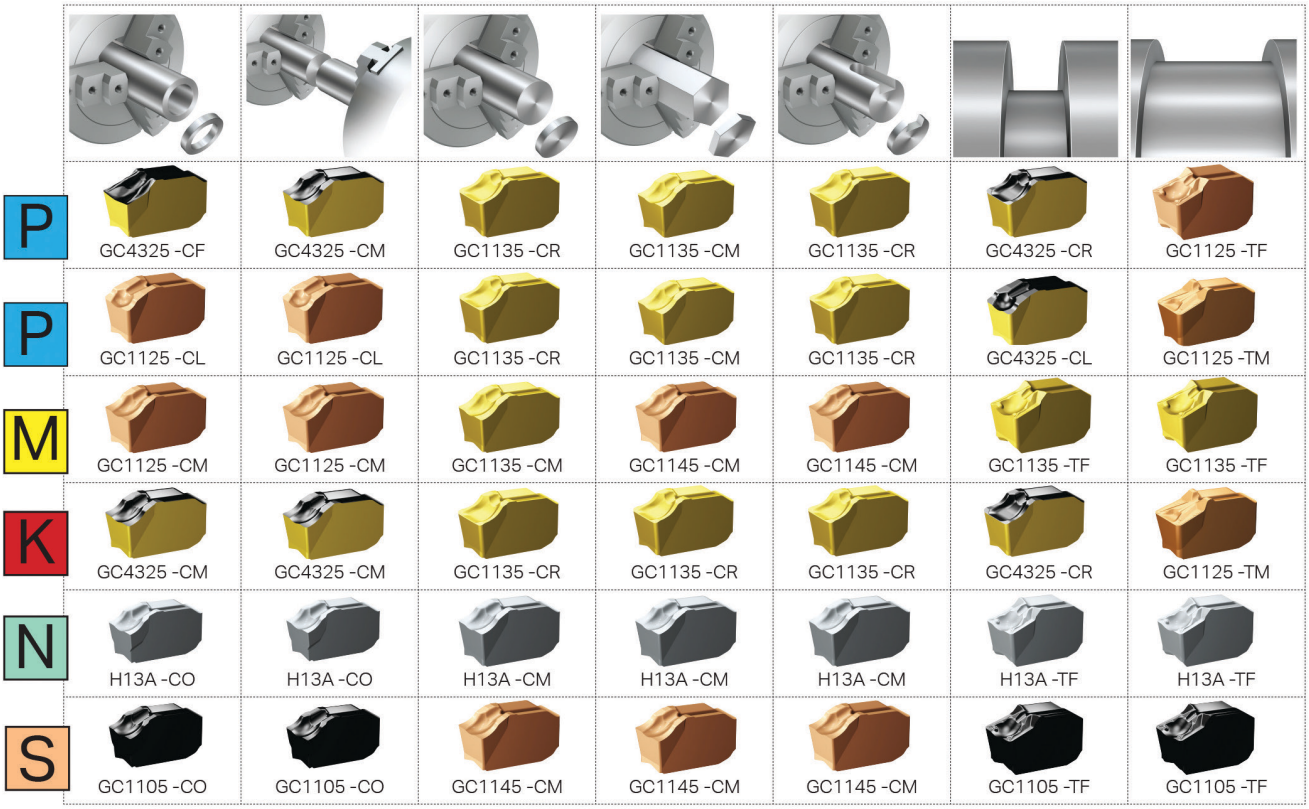


The insert edge matters

In parting-off there are three stages of the plunge: the main long cut through most of the bar; the approach towards the end of the cut; and the short stage just before reaching the centreline. With regard to inserts, the strength of the cutting edge, resistance to built-up-edge (BUE) and the durability of the coating are all critical factors. However, this also has to be combined with achieving insert grade capability for high cutting speeds and feeds during the main plunging cut.

Dedicated inserts for parting-off and deep grooving have been developed with new geometries for all materials, including chip breaking where needed and wiper cutting edges for enhanced surface finish. Inserts have also been designed to make optimum use of the precision coolant jets that are applied as part of the CoroCut QD concept. This helps ensure that lower cutting forces are generated along with high levels of chip control for efficient evacuation. The inserts have a specially developed channel as part of the geometry to ensure that coolant and lubricant reaches the right place at the cutting edge and on to the chip forming part. Improved insert grades have been established for the programme where coating adhesion and edge-line security have been prioritized to better cope with all the stages of the parting-off plunge.

Importantly, the geometry is designed to 'fold' the chip over, making it narrower than the groove being created so that it evacuates without becoming trapped. Almost all machine operators can recount horror stories of trapped swarf when parting and grooving, an issue that can cause both tool and workpiece damage. The latest inserts, which offer high edge-line security, are available in various grades to suit all workpiece materials. There are three PVD variants (GC1105, GC1125, and GC1145), two CVD grades (GC1135 and GC4325 with Inveio™ technology) and one uncoated grade (H13A). In terms of geometries, there are five for parting-off (-CF, -CM, -CR, -CO and -CL), two for grooving (-TF and -TM) and two Wiper inserts (-CF and -TF).



Selecting an insert

Always start with the recommended first choice grade. By way of a guide, harder substrates and higher coating thickness give increased wear and temperature resistance, while thinner coatings have better adhesion (it is important to avoid flaking when parting-off to the centre). For increased tool life, make sure to apply all the “hints and tips”, then select a harder grade and/or a grade with thicker coating. Always commence with the recommended cutting speed and feed rate for the material. As a rule of thumb, cutting speed can be increased by the following values when internal coolant is used: 10 bar, vc +10%; 30 bar, vc +30%; and 70 bar, vc +50%.

In terms of geometry, a ‘harder’ and more aggressive chip breaker gives shorter chips but also shorter tool life, while positive and light cutting geometries generally improve tool life. Geometries are also available with either curved or straight cutting edges which offer different chip forming capabilities depending on whether deep or shallow grooves are required. Wiper geometries should be selected where very high surface finish is required.

Ease of use

When it comes to changing a worn insert, there is no need to use a torque wrench. Instead of the traditional screw clamp, which is subject to under- or over-tightening, an innovative clamping solution is deployed on CoroCut QD. This makes use of a simple, quick release key that fool-proofs the entire process of achieving the correct clamping force every time. Furthermore, a unique top and bottom railed insert seat makes for stable and precise insert location.

An optimized, FEM-simulated tip seat angle is provided that inclines the insert 20° to better absorb cutting forces. The result is that when beginning the cut, the main cutting force is directed downwards, introducing inherent stability and security into the process.

Adapting to success

Tooling systems that are user-friendly are becoming more sought after in machining because of the difference they make to machine stoppages, as a security factor for correct tool changes and in setting-up.

With this in mind, Sandvik Coromant has developed plug and play adaptors for easy and rapid coolant connection. The assortment covers most common machine tool interfaces for connecting shanks and parting blades in turning centres, and QS™ stops for sliding head machines.

Stable internal grooving

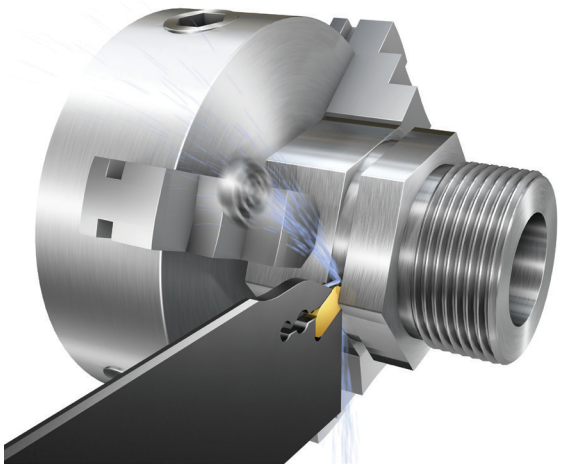
The latest advance to the CoroCut QD concept makes it possible to deliver reliable machining for internal deep grooves with the addition to the programme of CoroTurn® SL blades. This added process flexibility is supported by the modularity of the CoroTurn SL interface, which enables tool assemblies to be optimized for specific applications.

Internal grooving requires stability and tooling solutions that keep vibration to a minimum. With this in mind, the stable clamping mechanism on CoroCut QD tools is now supported by the potential to use Silent Tools™ damped boring bars for vibration-free machining with long overhangs. For tube-shaped components, typically found in the oil and gas industry, this is welcome news that enables deep internal grooving with high process security.

For internal grooving using the CoroTurn SL blades, the Serration Lock (SL) interface is extremely robust and allows users to create a range of tool combinations from a small inventory of adaptors and cutting heads. The maximum cutting depth with CoroTurn SL heads is 40 mm.

Application successes

There are no end of customer success stories for CoroCut QD. For example, when parting-off a stainless steel tube at higher cutting data and with 25 percent decreased cutting widths, CoroCut QD increased tool life by 106 percent, while at the same time reducing cycle time in comparison with the customer's previously deployed parting system. Another example, this time parting-off a 45 mm diameter stainless steel bar as part of a shower mixer machining process, saw tool life boosted by 283 percent. This meant that the machine could be run for a longer time, thus facilitating unmanned production.



For a process industry component, CoroCut QD was able to machine more than double the number of customer parts compared with a competitor system. The operation involved parting-off a 70 mm diameter steel bar of 195 HB hardness using an emulsion coolant. The application of QD allowed the cutting speed to be increased from 100 m/min (from 90 m/min) and feed to be increased from 0.07 to 0.1 mm/rev. What's more, tool life could be shown of 100 pieces in comparison with just 45 produced by the competitor system, representing a 122 percent increase.
The results were equally impressive when parting-off a 46 mm diameter stainless steel bar (320 HB) for an automotive valve. The use of CoroCut QD and an internal emulsion allowed cutting speed to be boosted to 105 m/min (from 85 m/min) and feed to be increased from 0.15 to 0.17 mm/rev. In addition, CoroCut QD demonstrated a tool life of 220 pieces versus just 120 completed by the competitor system, a gain of 83 percent.

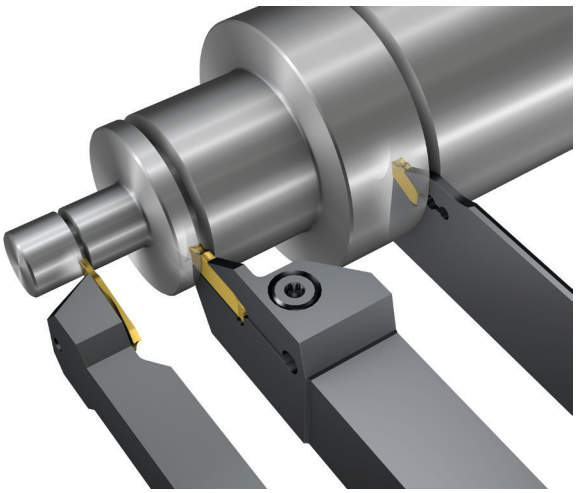
At another customer which had been experiencing issues for some time in terms of unpredictable tool life and lack of productivity, CoroCut QD delivered remarkable results. A key aspect of the problem was that the tools in use had external coolant only. This led to chip control issues and a need for pecking during the part-off, which slowed the process down. By switching to CoroCut QD, the customer could machine four times the amount of 54 mm diameter stainless steel pump adaptors compared with the previous parting tool, while also increasing the cutting speed. By applying high precision internal coolant, chip control was improved considerably, thus eliminating the need for a pecking cycle. All together it saved the customer 34 hours in production time per year and led to an impressive 43 percent productivity increase.

Hints and tips for best practice in parting off, grooving and face grooving

Successful parting

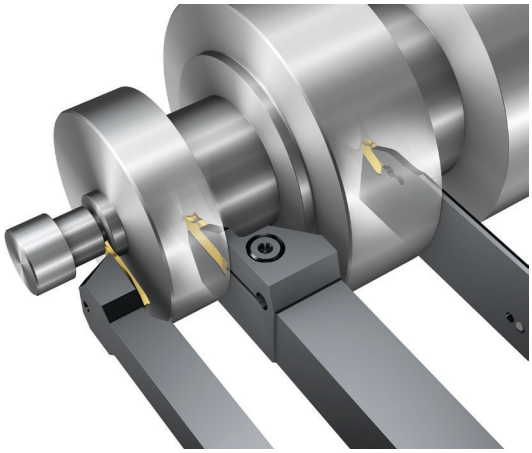
Firstly, always keep overhangs as short as possible (maximum 8-10 x insert width) to increase stability. Secondly, save material by selecting a narrow insert width. Other tips include checking the centre height to make sure it is within ±0.1 mm as this will ensure best performance cutting – below centre will increase the pip size and above centre will accelerate flank wear. However, at long overhangs it is worth setting the cutting edge 0.1 mm above centre to compensate for downwards bending.

Always reduce the feed rate by up to 75 percent around 2 mm prior to part fall-off as this will lower the cutting forces and increase tool life drastically. Furthermore, coolant should be turned off when the machine reaches the rpm limit to avoid BUE, especially in stainless steel workpieces – the rpm limit is normally when the speed drops below 100 m/min. In addition, to avoid breakages never feed beyond the centre point, stop 0.5 mm before (the part will fall off anyway due to its weight and length). If a sub-spindle is used, stop before the centre and pull the component away with the sub-chuck.



In terms of using coolant applied at pressure, this will have a varying impact depending on workpiece material. The effect from high pressure coolant is greatest when machining materials with low thermal conductivity, such as some stainless steels, titanium and heat resistant super alloys. High pressure coolant also has a larger impact on smearing materials such as low carbon steels, aluminium and duplex stainless steels, where chip control is also an issue. The latest nozzle technology can help direct the jet precisely to the right place, assisted by dedicated insert geometry, to deliver improved cutting data, tool life and chip control. In short, keeping a parallel, laminar jet aimed at the chip/tool interface is the secret to successful high pressure coolant application.

For burr-free parting the trick is to use right or left-hand style ground inserts with front angle. Several front angles are available: 5° in CF, CM and CR geometries; and 10° and 15° in CS geometry. It is worth noting that although a large front angle reduces burr it may not produce a straight cut and can result in poor surface finish and short tool life, not to mention a scrapped component. As a consequence, the advice is to always use as small a front angle as possible. For reducing internal burrs, use the CoroTurn XS insert, which is dedicated to pre-parting and chamfering



Successful grooving

Where possible, single cut grooving is always the most economical and productive way of producing grooves. However, when wide grooves or turning between shoulders is required, the most common methods of production are multiple grooving, plunge turning or ramping. All three methods are roughing operations and must be followed by a separate finishing operation. Use the following rule of thumb: if the width of the groove is smaller than the depth, then use the multiple grooving method. Here, flanges left for final cuts will be thinner than the insert width and can be machined at 30-50 percent greater feed. The first choice geometry is -GM.

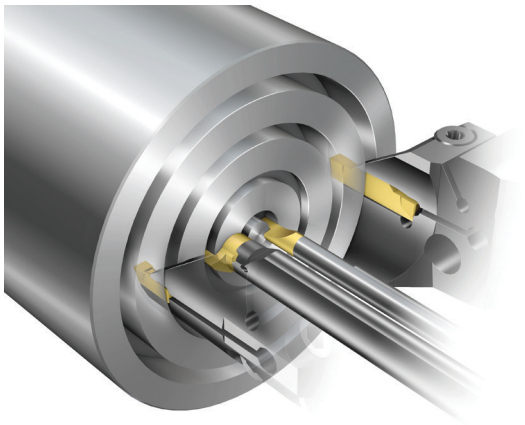
If the width of the groove is larger than the depth, opt for plunge turning, where first choice geometries are -TF and -RM. However, do need feed against shoulders.

For slender parts, the ramping method is best deployed as this offers optimum chip control thanks to minimized radial cutting forces and notch wear. First choice geometries are -RO and -RM.

To avoid deflection when performing the finishing cut, use a cutting depth larger than the corner radius of the insert. Here, a turning geometry such as TF can be deployed or, alternatively, a profiling geometry such as -RM with large grooves. The recommended axial and radial cutting depth is 0.5 to 1.0 mm.

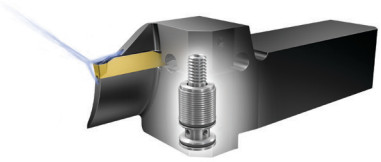
Successful face grooving

Always start on the largest diameter and work inwards. Furthermore, use the tool for the largest diameter which fits the groove. This is because a tool for a larger diameter is less curved and hence more stiff and reliable, while chip forming is easier and more stable on larger diameters. Another tip is to use side turning rather that overlapping cuts when machining wide grooves as this offers improved chip control.



Although -TF geometry is the first choice for face grooving, the ground -GF geometry is recommended if there is a tight tolerance on groove width. In terms of grade, GC4325 with Inveio™ technology is the first choice for steel and cast iron applications, while GC1125 and GC2135 are the options for stainless steels in stable and unstable conditions respectively. Similarly, GC1105 (stable conditions) and GC1145 (unstable conditions) are the best grades when face grooving heat resistant super alloys.

CoroCut family – tools for every parting and grooving operation



CoroCut 1–2

As the name indicates, CoroCut 1-2 features one or two cutting edges and is designed for smaller bar diameters of 6-38 mm. The system, which is also suitable for face grooving, is based on a patented rail and V-shaped design tip seat which together with a long insert gives high stability. In a recent development, CoroCut 1-2 has been updated to feature spring clamp technology. This not only provides increased stability but eliminates the operator judgement required when using a torque wrench on conventional screw clamps.

Strong tool material (fatigue resistant alloy), high rigidity and effective chip control offer the potential to increase feed rates when using CoroCut 1-2. In fact, longitudinal turning tests confirm that the new spring clamp allows for a feed rate increase of up to 27 percent with maintained deflection. This is because deflection is 2.7 times less with a spring clamp in comparison with a screw clamp. Like QD, CoroCut 1-2 offers over- and under-coolant on all tools. The CoroCut 1-2 system includes more than 700 standard inserts and is suitable for all material types.

CoroCut XS

CoroCut XS is a tangentially mounted system for the precision machining of slender components in sliding head machines. The system is used for external parting, grooving, turning, back-turning and threading applications where very sharp cutting edges perform best at low feeds. The benefits of the system include high precision and easy indexing with a wide variety of insert widths.

CoroTurn XS

Designed for internal machining at diameters as small as 4.2 mm, CoroTurn XS is a precision system where exact insert position is required. Also suitable for face grooving operations, CoroTurn XS is available with high pressure coolant. The large variety of adaptors fit most types of sliding head machines.

CoroCut family – tools for every parting and grooving operation

CoroCut 3

CoroCut 3 (three cutting edges) is designed as an economic solution for shallow parting and circlip grooving, and offers good cost efficiencies in mass production. In some instances it is possible to save kilometres of material by reducing the insert width with CoroCut 3. Grooving widths of 0.5 to 3.18 mm are available to produce depths up to 6.4 mm. In terms of parting, the system is suitable for diameters of less than 12 mm, while extremely small parting widths are available down to 1 mm.

CoroCut MB

CoroCut MB is a high precision system for internal grooving and pre-parting. The edge line of the cutting edge is sharp with a thin-layered coating, which in combination with the stability of the tools makes it ideal for vibration-free internal machining, even when working at long overhangs.

Digital support tools

Using the online tool builder (www.tool-builder.com) offers a quick and easy way to select modular tooling systems with plug and play coolant, helping the user to find the right combination of cutting tool and adaptor for parting and grooving with the minimum of effort. Through a user-friendly interface, the viewer can select the relevant application, machine interface and other variables, and be given the most suitable tool and adaptor for the application. Users will see a 3D rendering of the set-up and get a direct link to the items for order on the Sandvik Coromant website. The application works on smart phones, tablets, MAC and PC, and greatly simplifies the selection process.

The Sandvik Coromant website also offers extensive information. Simply click on the products tab to see a list of parting and grooving systems under the 'turning tools' heading. Website visitors can click on the required tool for access to product details, success stories and assortment information.

A detailed parting and grooving catalogue is available from Sandvik Coromant's Digital Library called Publications to find and order tools offline and online or by downloading the 'Publications' App via **www.sandvik.coromant.com/publications.**

The Sandvik Coromant FirstChoice tool offers recommendations on tools specific for your application needs and advise how to get started. The tool is available under **www.sandvik.coromant.com/firstchoice.**

Conclusion

With an enviable track record in providing parting and grooving solutions to real customer problems, Sandvik Coromant has proven itself as the market's competent leader in this technology area. Matched with a comprehensive support network, parting and grooving tools from Sandvik Coromant put the customer in control. Put simply, superior productivity, quality and tool life ensure competitive gain, a vital factor in today's extremely competitive global marketplace.

Sandvik Coromant

Sandvik Coromant is a global leading supplier of cutting tools, tooling solutions and know-how to the metalworking industry. With extensive investments in research and development we create unique innovations and set new productivity standards together with our customers. These include the world's major automotive, aerospace and energy industries. Sandvik Coromant has 8000 employees and is represented in 130 countries. We are part of the business area Sandvik Machining Solutions within the global industrial group Sandvik.

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