Whitepaper

Exploiting the benefits of coolant in parting and grooving

Conventionally speaking, parting-off and grooving are not the favourite machining tasks of machine shop operatives. The combination of thin inserts and holders and often tough materials make for a nerve-wracking experience. Will the insert chip? Will swarf jam in the groove? Will the workpiece become damaged and have to be scrapped? All of these potential scenarios serve to raise tension. In parting and grooving operations, the insert is surrounded by material, which means it becomes exposed to a lot of heat. So, what's the answer? Well, in many cases the correct application of coolant can be both a problem-solver and process optimiser – and yet it's often overlooked. This technical paper sets out to explain why machine shops should give greater consideration to the significant advantages that effective coolant delivery can bring in parting and grooving operations.

High precision coolant

High precision coolant can prove very effective in maintaining high process reliability, productivity and quality in parting and grooving operations. Indeed, the deeper the cuts and grooves, the greater the need for high precision coolant as the cutting zone is difficult to access using conventional coolant set-ups.

The challenges of applying coolant as a performance enhancer in parting and grooving can today be overcome using a number of technology developments. For instance, new tooling enhancements for this area include internal coolant delivered with precision that helps impact the exact cutting zone (the point of contact between insert and workpiece), penetrating into spaces and grooves where it can make a real difference to machining.

Chip control

Satisfactory chip control is clearly vital to avoid unplanned machine stops or tool breakage. This is especially true in parting operations with deeper cuts, which can give rise to long, stringy chips that wrap around the tool and get stuck in the chip conveyor. If chips are not formed properly and not reduced in width, they can become stuck in the groove being cut, leading to excessively high tool load, an unreliable process, and poor surface finish. Improved chip control and chip evacuation in combination with better lubrication of the groove side walls will improve surface finish and lower the risk of scratches or marks being caused by chips – coolant helps flush chips from the groove.

Coolant as a lubricant is essential in parting operations. When the long, slender parting tool is fed deep into a workpiece, it is important to establish measures that enable sufficient coolant to reach the cutting zone (as an effective jet), where it is most needed. Even when traditional coolant set-ups are used, most of the coolant will inevitably be blocked by the chip being formed. Ergo, a coolant jet is critical to success.

Avoiding BUE

An additional advantage of high precision coolant is the prevention of built-up edge (BUE), thanks largely to its lubrication properties. However, the underlying cause of BUE is too low or too high machining temperatures in smearing materials like duplex stainless steels. As a result, when the cutting speed slows down towards the centre of the bar, the coolant should be switched off to avoid the temperature dropping to the point where BUE starts to form.

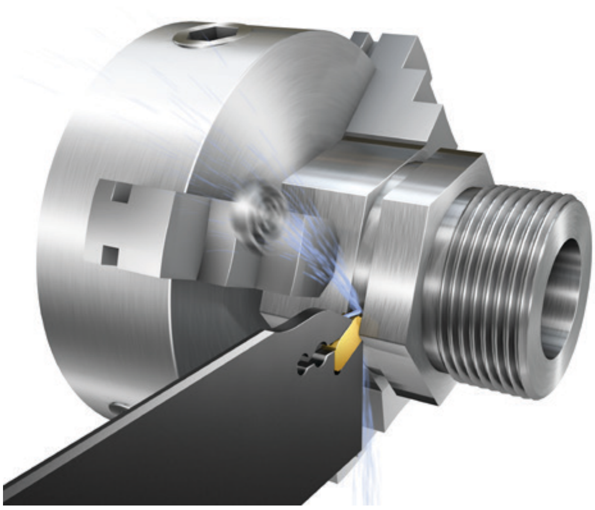
In terms of feed rate, this should be reduced up to 75 percent around 2 mm (0.079 inch) prior to part fall-off as this will lower the cutting forces and increase tool life considerably. In addition, to avoid breakages never feed beyond the centre point; stop 0.5 (0.02 inch) mm before (the part will fall 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.

Over- or under supply of coolant, or a combination?

Depending on machining conditions, a choice can be made between using through-tool coolant applied over or under the cutting edge. In many cases, a combination is ideal. Over-coolant reduces the friction between the chip and insert, and thereby thwarts BUE formation and improves chip control, which is the secret to long tool life and fewer machine stoppages. However, BUE is also dependent on temperature – very good coolant will reduce temperature to a zone where BUE is created – therefore always increase cutting speed by 30-50% when using over- and under-coolant supply.

Coolant applied from below reduces temperature from friction and the amount of flank wear, as well as contributing to chip evacuation. Under-coolant will lubricate and reduce friction on the relief side of the insert and thereby reduce abrasive flank wear. This impact is largest in abrasive materials like cast iron, but also delivers a significant tool life increase in steel, stainless steel and heat resistant super alloys. Coolant from below is particularly advantageous at extended in-cut times (deep grooves), where temperature is often a limiting factor.

In short, reduced temperature in the cutting zone using both over- and under-coolant allows the use of softer but tougher insert grades without the risk that they might collapse from the combination of high temperature and high force on cutting edge and corner radii – so-called plastic deformation. This provides the basis for more predictable tool life and a more secure machining process.



In parting-off it is hard to break the chip into small segments by coolant pressure alone – the sideways formed chip is too strong for that. However, upper-coolant will improve chip formation and the effect is larger in long chipping materials that form a segmented chip. The impact in steel is lower, but it will still improve chip formation. Under coolant will also improve chip evacuation, but not chip breaking.

It’s true to say that high precision coolant has a varying impact depending on workpiece material. Its effect is greatest when machining materials with low thermal conductivity, such as some stainless steels, titanium and heat resistant super alloys. High precision coolant also has a large impact on surface smearing materials such as low carbon steels, aluminium and duplex stainless steels, where chip control is also an issue.

Deep grooves

To achieve the best performance in deep parting and grooving operations, a system of strong tools and inserts with rigid clamping and plug and play coolant supply is a prerequisite. Systems such as CoroCut® QD not only deliver all these process demands, but enhance chip control further by combining over- and under-edge coolant supply (also available on the CoroCut® 1-2 system for medium-to-small sized bar diameters). This restricts temperature build-up at the cutting edge so that less tool wear occurs and a more stable performance is upheld. Chip evacuation is also enhanced.

Importantly, systems such as CoroCut QD also allow operators to increase surface speed, typically by 30-50 percent. This means that there is less insert-workpiece contact time at the same feed, subsequently delivering more parts per edge. As a rule of thumb, cutting speed can be increased by the following values when internal coolant is used: 10 bar (145 PSI), v_c +10 percent; 30 bar (435 PSI), v_c +30 percent; and 70 bar (1015 PSI), v_c +50 percent.

However, it's important not to get carried away, as in some cases tool life starts to reduce at pressures in excess of 100 bar (1450 PSI), which counteracts the benefits of delivering highly precise coolant on systems such as CoroCut QD, which in 91 tests against 16 competitors showed an average tool life increase of 85 percent. In fact, customers often achieve two or three, or even four times greater tool life in comparison with their previous system, especially when performing parting and grooving on exotic materials such as titanium and nickel-based heat resistant super alloys.

Coolant delivery criteria

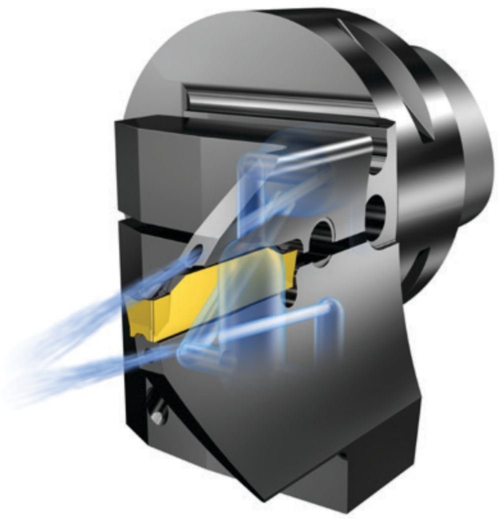
Importantly, inserts need to feature a specially-developed channel as part of their geometry to further ensure that coolant and lubricant reaches the right place in the cutting zone. What's more, delivering the coolant at sufficiently high volume and pressure through the machine, holder and tool interfaces has to be established with a minimum of effort – tool changing and connecting the coolant supply must not be time consuming. As a result, the use of dedicated adaptors is essential to make the system user-friendly and avoid any need for coolant tubes or hoses.

Modern, through-tool coolant supply with facilitated connections for easy plug-and-play has done away with bespoke plumbing, thus allowing rapid tool changing. In fact, using modern nozzle technology, some improvements can even be had with coolant pressures as low as at 10 bar when applied correctly.

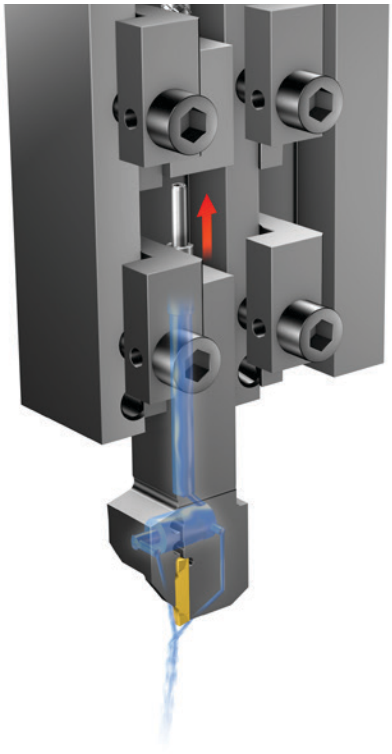
Coolant type

Although coolant is used in parting and grooving to minimise friction at the cutting edge, as well as heat at the tool and workpiece, it also keeps the machine clean and lubricated, prevents rust and transports chips. All of these facts need to be considered when selecting the type of coolant to be deployed. Different coolant media, emulsion and oil will give different results. For instance, oil has a higher lubricating effect but its cooling properties are lower than emulsion.

The correct selection and application of coolant is vital because its purchase costs, along with handling and disposal, are substantial. It has been calculated that, in many cases, coolant cost represents around 15 percent of the machine cost per component. Coolants thus command a higher portion of machining costs than tools, which



on average account for 3 percent. With this in mind, the application of coolants should be viewed critically, and if they are to be used, to ensure they are put to best use – not just applied passively or routinely. This stream of thought has led to a turning of the tide, and production engineers now view coolants as serious productivity enhancers in parting and grooving.



Sliding head operations

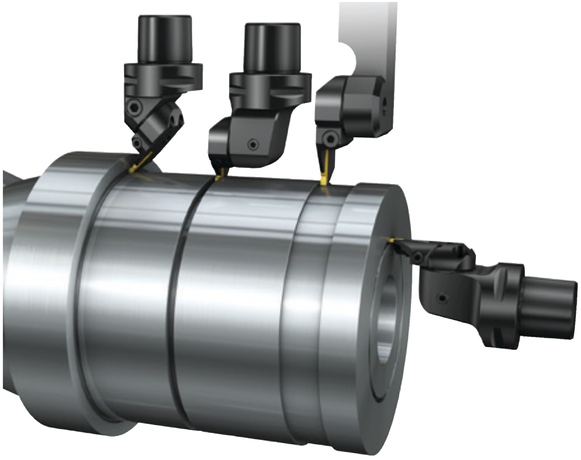
QS-shanks can be connected easily to coolant in different ways, either mounted in an adaptor, such as VDI, or Coromant Capto®, while the QS adaptors and tools can be used with coolant pressures up to 150 bar (2176 PSI). Connections are available for common machine interfaces such as shank turrets, VDI star and face turrets, Coromant Capto and HSK-T.

For precision parting and grooving on sliding head lathes, a tangentially mounted system such as CoroCut® XS is preferable. The system, which is available with high precision coolant, can also be used for turning, back-turning and threading applications where very sharp cutting edges perform best at low feeds. The benefits of the system include high precision, easy indexing and a wide variety of insert widths – ideal for internal grooving at very small diameters. The first choice system is however CoroCut® 1-2, which assortment of grades and geometries cover all applications and material groups. Its rigid rail interface between tool holder and insert provides high accuracy and efficient machining.

Machine requirements

The adoption of HPC might present some issues to consider, but in modern machinery, 70 bar (1015 PSI), coolant pressure is usually standard, or an option, and provides the basis for making much better use of coolants as a serious performance improver. However, although there are clear benefits to be had from coolant delivered at pressures ranging from 10 bar (145 PSI) up to 70 bar (1015 PSI), these advantages are reduced at pressures from 70 bar to 100 bar (1015 PSI to 1450 PSI). With this in mind, there is little point specifying a machine with coolant pressure delivery capabilities beyond 70 bar (1015 PSI). As a point of note, coolant nozzle holes in tooling are inherently small, which means the use of a machine coolant filter with a 5–25 µm mesh is recommended.

Other machine considerations should include stability, power and torque, as well as the number of tool stations available and any limitations in rpm.



reduces temperature in the cutting zone and improves chip evacuation. When external coolant is applied conventionally in parting and grooving, the amount of coolant that actually gets into the groove is very small and the effect is minimal, especially when machining deep grooves. However, with qualified, high precision, high pressure coolant application, accurately directed jets properly access the cutting edge, even in deep grooves.

Advantages with modern through-tool coolant typically include scope for higher cutting data or the use of tougher insert grades, as well as enhanced chip control and consistent surface finish. Further benefits include longer tool life and short, easy tool changing and set-up.

Online support tools

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 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. Here, a parting and grooving landing page (**www.sandvik.coromant.com/en-gb/tools/parting-and-grooving)** makes life simple for online visitors by gathering tool recommendations, applications knowledge and other useful information in one place. Clicking on the required tool provides access to product details, success stories and assortment information.

Conclusion

The use of high pressure and high precision coolant has a large impact on performance and process security in parting and grooving. If applied correctly, it

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