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Understanding parting-off operations.

Parting Know-How

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PART 1 OF 2

'P*arting is such sweet sorrow.*"

It's doubtful that Shakespeare ever thought that one of his most famous lines would apply to modern metalworking. But, in the case of parting-off operations, it certainly does.

These operations are often "sweet" because they involve long runs of parts made from bar stock. They can be performed on everything from standard automatic-style machines to the most modern CNC machines equipped with sophisticated bar-feed attachments. These longer production runs usually are profitable, steady work.

The "sorrow" arises when a parting-off operation is performed incorrectly. The misapplication of carbide parting tools can cause significant downtime and lead to costly tool replacements, scrapped parts and even machine tool damage.

Achieving optimal results requires a thorough understanding of the mechanics of parting off. A number of variables must be taken into consideration. Some of the most significant are the:

- workpiece material and shape;
- machine tool;
- cutting tool edge in relation to the centerline of the part;
- type of insert and chipformer;
- grade of carbide and coating; and
- other cutting conditions that influence tool life and the workpiece.

Part 1 of "Parting Know-How" looks at the first three variables. The remaining three will be examined next month in Part 2.

Material and Shape

There are endless combinations of material types, shapes and sizes that we could consider. To simplify matters, though, let's examine the three most common shapes: solid stock, hollow stock (or tubing) and irregular shapes that require an interrupted cut, such as square or hex stock, or hollow stock with an uneven wall thickness.

Material types can be broken down into several different categories. The major manufacturers of replaceable carbide parting tools all offer a wide range of geometries and carbide grades to handle specific materials. Again, to simplify matters, we will break the types of materials down into three categories.

The first are those that require a sharper, positive-rake inclination at the cutting edge. Among them are high-temperature alloys, titanium, aluminum, most plastics and other nonferrous materials, as well as austenitic stainless steels. A sharper cutting edge helps prevent workhardening of these materials.

A sharper edge also allows most low-silicon aluminums to shear cleanly without built-up edge. This allows higher cutting speeds and feeds. The same holds true for most nonmetallics, such as plastics, nylons and other soft, free-machining materials.

The second category consists of those materials that can be cut well with a neutral- or negative-rake angle at the cutting edge. This would include standard carbon and alloy steels and cast irons. The neutral- and negative-style tools provide greater frontal cutting edge strength. This stronger edge allows faster feed rates and also protects the edge from damage during interrupted cuts.

Most materials that produce long, continuous chips will benefit from this type of insert geometry. It is the most commonly used style in the industry.

The third category includes those materials that call for a very aggressive chipformer. (Chipformer styles will be discussed later in the article.) These materials produce long, stringy chips at normal speeds and feeds. Examples are 52100 and other high-grade steels used by the bearing industry.

Often, the machine tool dictates the use of a very aggressive chipformer. Soft, low-carbon and alloy steels machined at a low, fixed feed rate will often produce long, undesirable chips. They usually require the operator to regularly stop the machine to clear chips. This slows productivity and can endanger the operator, because these types of chips are very sharp.

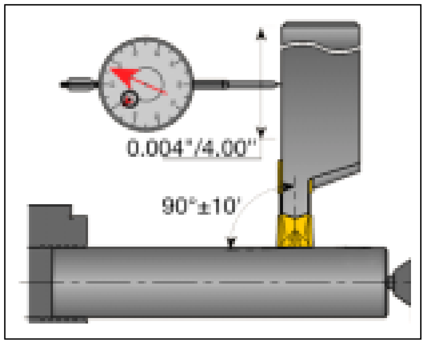

Figure 1: To ensure that the tool is square and perpendicular to the workpiece, use a dial indicator to measure the deviation of the tool over a 4.00" length of travel. Variance should not exceed 0.004".

Some types of high-temperature alloys that are machined at very low cutting speeds also cause the same problems.

When choosing a part-off insert, select the geometry you would use for other turning, or even milling, operations on the same material. If you normally work a certain material with a high-positive-rake turning or milling insert, for example, select the same geometry when parting off.

Machine Tool

The key to efficient parting-off operations is being able to adequately control the cutting speed and feed rate. The correct combination will yield superior tool life, chip control and dimensional stability. The machine tool used—its design and features—largely dictates how well you are able to control the cutting parameters.

Machines can be broken down into two main categories: CNC and non-CNC. One of the most common styles for large-volume production runs is the automatic. Normally, this machine has cam-actuated tool slides and runs at a fixed rpm. This can pose significant problems when using carbide insert part-off tooling.

A cutting tool that runs correctly at the slowest speed dictates the maximum rpm at which a machine can run. And since several tools are cutting at different positions simultaneously, there is very little control over the process. So, for example, if a HSS drill or form tool is being used in one of the slide positions, its optimal cutting speed would govern the speed of all the other tools employed. This speed often is too slow for most carbide grades.

The newer styles of automatics offer the operator more control over the feed rate. There are also CNC-style automatics that give almost complete control over the entire cutting cycle.

The machine used impacts the grade of carbide selected, as well as the type of chipformer and cutting edge chosen. For traditional automatics, choose a tough grade of carbide. It is needed to withstand the lower-than-normal cutting speeds carbide tools will experience on an automatic.

Submicron-carbide grades have greatly improved the performance of part-off tools used on automatics. They have the same strength as HSS yet exhibit the wear characteristics common to all carbide grades.

Another common style of machine tool for part-off operations is the full-CNC lathe. It is often equipped with a bar-feed attachment or similar device intended for large production runs.

There are many advantages to this type of machine tool. The most important is that it provides full control of the speed and feed rates throughout the cutting cycle. This allows the application of a carbide insert, which can be run at a much higher speed and work more efficiently. (It is important that the cutting speed and feed stay within the manufacturers recommended parameters.)

Full-CNC lathes are easy to program and change over between parts. For these reasons, they are often the preferred style of machine for shorter part runs. The ability to better regulate the cutting speed and feed also helps control chips and makes for more consistent tool life.

Proper Setup

When parting off with a carbide insert, it is crucial that the tool be properly set up. If there is an improper alignment between the cutting edge and the workpiece, the tool can crash and/or the part can be damaged. Sometimes, even the machine tool suffers damage.

The two most common problems are that the part-off tool is not perpendicular and square to the workpiece, or the cutting edge is set too high or too low in relation to the centerline of the part. If one or both of these conditions exist, there will be problems with tool life, chip control and maintaining a straight, flat parting off. These conditions can lead to the finished part having a concave or convex surface. And if the problem is too extreme, the tool will fail—usually without warning.

To ensure that the tool is square and perpendicular to the workpiece, you should follow a simple setup procedure. First, thoroughly clean the clamping area and assemble the part-off tool in the turret. Then, using a dial indicator, measure the deviation of the tool over a 4.00" length of travel (Figure 1). It should have a variance of no more than 0.004".

A common way to determine if the tool is not square and perpendicular is to examine the chips produced. If a chip comes off the workpiece in a long spiral that flows off to one side, it may mean that the tool is not set up correctly. Another symptom is premature wear on one corner of the part-off insert. This indicates that one side is experiencing more pressure than the other.

If a change in the performance of the tool or the quality of the parts produced occurs at any time during the operation, follow the aforementioned setup steps. Sometimes, the most minor tool crash can cause a deviation. (We all know that minor incidents are not always reported!)

It is a good idea to check the condition of the part-off tool early and often after completing a setup. Doing so will help you identify and prevent serious malfunctions.

The other main consideration during the setup stages of a part-off operation is the relationship of the cutting edge to the centerline of the workpiece. If the insert is not positioned correctly, a host of problems can arise. The most common are premature and sudden failure of the tool, poor chip formation, poor side-wall finish and chatter.

These problems can be further complicated by the fact that it is sometimes difficult to ascertain the true position of the cutting edge. This tends to occur more often on older manual and automatic-style machine tools.

Most carbide inserts from the major suppliers are designed to cut directly on centerline to slightly ahead (above) of centerline. This positioning is needed to take advantage of the molded chipformers in the carbide insert and to ensure that the insert remains secure in the toolholder.

When the insert is on or slightly ahead of centerline, the tangential forces are directed against a larger segment of the carbide. This maximizes the tool's strength and keeps the insert securely positioned in the pocket of the toolholder. The rotation of the part pushes the insert down and into the toolholder.

Additionally, today's carbide part-off insert is designed for maximum strength and rigidity when a specific angle is maintained between the workpiece and the cutting edge. If the insert sits too far ahead of centerline, the clearance angle is diminished. The result will be rubbing on the front flank area, which creates a great deal of heat in the cutting zone. This, in turn, causes premature wearing of the insert and workhardening of the material being cut. The most common indicator of this condition is excessive flank wear on the front of the insert after a short period of time in the cut.

Inserts that cut behind (below) centerline can prove even more problematic than those that cut ahead. As the insert drops down in relation to the centerline, the clearance angle begins to increase. This leaves a small cross section of the insert tip to shoulder all of the cutting pressure, which shortens tool life and increases the likelihood of sudden tool failure.

Another problem with carbide inserts that are run behind center is erratic deflection. With the majority of tool pressure directed toward the tip, it will tend to vibrate and bounce, similar to the way a diving board bounces up and down after the diver has jumped. This erratic motion will create tool life problems, usually in the form of chipping of the frontal edge.

The vibration associated with this cutting action will create chatter marks at the bottom of the groove and poor surface finish on the side walls of the part.

One of the most serious consequences of using a part-off tool behind centerline is insert "pull out." As the insert approaches the center of a solid bar stock, the rotation of the part actually pulls the insert out of the pocket (Figure 2). The stub burr, or nib, left in the center of the part that is still held by the chuck climbs over the cutting edge and, as it continues to rotate, pulls the insert from the holder pocket.

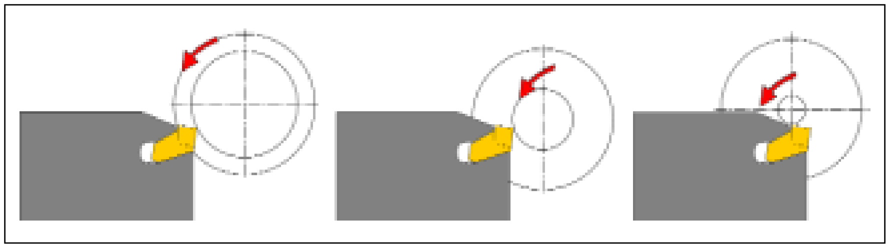

Figure 2: As the insert approaches center when parting solid bar stock, the rotation of the part can actually pull the insert out of the pocket. The stub burr left in the center of the part that is still held by the chuck climbs over the cutting edge and, as it continues to rotate, pulls the insert from the wedge pocket.

If this condition is not identified instantly, the toolholder—minus its insert—will be destroyed during the next part cycle. Most likely, too, the part being produced will be ruined and the machine tool could be damaged. It also means that valuable machine time will be wasted while a new setup is prepared. And even if the insert is not pulled out of the pocket, the rotating stub burr traveling across the top of the cutting edge of the insert can cause damage.

For these same reasons, it is important to halt the in-feed of the part-off tool past the center of the workpiece. At a point past center, the effective cutting rotation reverses and the force generated can pull the insert from its holder. This rotation will also begin to rub up from under the cutting edge, causing premature tool wear.

To counter the pull-out problem, many manufacturers of carbide part-off inserts utilize the Self Grip concept of clamping, pioneered by Iscar in the early 1970s. This method involves no external screws or levers to hold the insert in place. It relies on the rotation of the part and tool pressure to keep the insert seated inside a wedge-style pocket. This permits an almost unlimited depth of cut without interference from a clamp (Figure 3).

Another factor to consider when establishing and maintaining correct centerline position is the type of toolholder and insert used.

One of the most common part-off tools in use today is the block-and-blade system. It incorporates a clamping block mounted into the machine turret and a replaceable blade, often double-ended, that holds the carbide insert. A self-gripping type of pocket is employed for the blade.

The insert and blade should have some means of fixing the location of the cutting edge so that it will not vary from insert to insert, when applied under heavy loads, or due to wear in the pocket.

Figure 4 depicts two styles of insert/blade combinations. The T-style incorporates a simple wedge clamp. It has prisms on the top and bottom of the insert that match the ones on the blade. The insert is wedged into the pocket and held by the tension created by the holder. Under certain conditions, the insert can be driven further back into the pocket, changing the position of the cutting edge. It will begin to drop behind center. Heavy feed rates, interrupted cuts or a worn-out pocket can cause this to happen.

The F-style insert and blade have a fixed pocket location. A stop molded into the insert makes contact with the top of the support blade. Once it is seated, it will maintain its position.

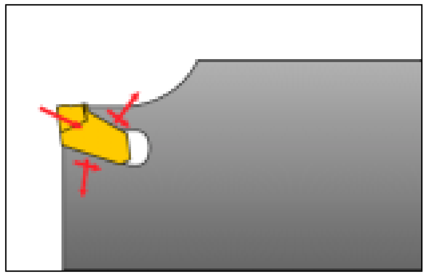

Figure 3: This clamping technique, pioneered by Iscar, involves no external screws or levers to hold the insert in place. It relies on the rotation of the part and tool pressure to keep the insert seated inside of a wedge-style pocket.

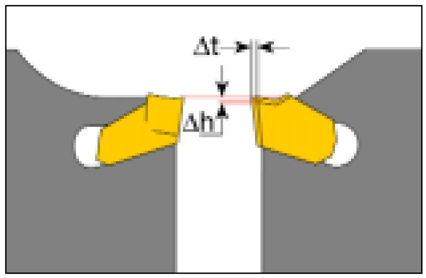

Figure 4: The T-style (right) insert/blade combination incorporates a simple wedge clamp. The insert is wedged into the pocket and held by the tension created by the holder. The F-style insert and blade have a fixed pocket location. A stop molded into the insert makes contact with top of the support blade. Δt=change in travel, Δh=change in height.

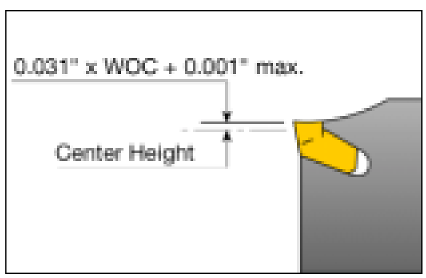

Figure 5: The formula shown can be used to determine the proper center height for insert widths of 0.118" and above.

Any insert/blade combination should allow chips to freely evacuate the cutting zone. If chips build up and break off in the groove prior to separation of the part, there is a strong possibility that the insert will double-cut them and fail without warning. And if chips rub excessively on the tool blade, excess heat will be generated. This will cause fatigue and hasten failure.

All manufacturers of carbide parting tools offer recommendations about the proper center height for their particular product. These recommendations should be strictly followed.

The geometry of the insert and design of the toolholder have a direct influence on the proper center-height setting. In general, though, for insert widths of 0.118" and above, the following formula works well: 0.031" × width of cut + 0.001" maximum (Figure 5).

The important thing to remember when parting off is that the cutting edge should be either right on or slightly ahead of centerline. Operators and setup personnel who use HSS part-off blades or similar tools often assume, or have been taught, that these tools will work better when positioned behind center.

This isn't the case with modern carbide inserts. Running below centerline with them will lead to a poor parting-off operation.

This concludes the first portion of "Parting Know-How." The second installment will appear in the March issue.

About the Author

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