

Speaking Up For Creep-Feed Grinding

Creep-Feed grinding is no longer an alien concept to most people in the metalworking field, yet this advocate of the process believes that it is too often overlooked for applications where both overall productivity and quality would benefit substantially.

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Let's start with the definition of creep-feed grinding.

Creep-feed grinding is actually a milling process, using the grinding wheel for the milling cutter. Traditionally in milling operations, you take during very slow "creep" feeds. In conventional surface grinding, the table reciprocates back and forth many times, like a pendulum, taking very, very small depths of cut per pass. In creep-feed, the table doesn't reciprocate. It slowly feeds across the workpiece to remove a very large amount of stock. Properly applied, this technique promises increased productivity and improved part quality.

Why is creep-feed grinding described as being "tailor made" for precision machining applications?

To answer this question, let's use a good example of a precision machining application: Turbine blades.

Creep-feed is a viable process that allows us to produce precision components in a highly productive manner without damage to the workpiece. These parts are made from superalloys that are very sensitive to heat and prone to thermal damage during grinding. Traditionally, we had to grind these parts very slowly and very carefully, which is very time consuming.

The parts are also very expensive---worth \$500 to \$1,500 apiece. Using a creep-feed process, we can produce finished parts with high dimensional accuracy and good part quality, in a much larger volume. An example would be a creep feed installation that does turbine blades. It grinds every part, every surface on the blade, without anyone touching it. It can produce a part every three to four minutes. That's an extreme improvement in productivity over the old ways.

How much of an improvement?

This cell cuts machining time by at least 15 to 20 minutes per part---or more. Using traditional methods, you would need several operations to finish several different surfaces; so the average production cycle time would probably be four to five times longer, not counting many more setups.

What are some advantages of creep-feed?

With difficult-to-grind alloys, burrs have historically been a problem and have required a separate operation for their removal. Therefore, the workpiece has to be handled again.

Creep-feed grinding creates very small chips which leave little or no burr; so the deburring operation can often be eliminated.

Creep-feed grinding allows you to consolidate operations---every time a step is added to a process, the exposure to possible errors increases---and to cut down on workpiece handling. These factors have the potential for a huge payback in terms of profitability and delivery.

In terms of quality, is the product comparable with those produced using traditional grinding methods?

It's arguably a better product. Because of the nature of the chip that is produced in creep-feed grinding, the process actually puts the workpiece in a residual compressive stress state, which improves surface integrity. The residual compressive stresses allow the part to run longer or be used longer without fatigue failure.

In general, creep-feed grinding also offers better control over part geometry.

What scale of investment is required to install a creep-feed operation? You can't add creep-feed wheels to your existing machines.

Creep-feed takes a major commitment to the process---a huge capital investment. A properly equipped creep-feed grinder may cost ten times more than a standard surface-grinding machine, but the technology allows you to utilize a cell approach that consolidates many operations into one machine. While creep-feed grinding may require a major capital investment up front, the point to remember is that it produces very expensive parts in a highly productive fashion. The payback is also very fast.

Creep-feed grinding calls for a change in outlook. The value of staying competitive in the long run has to become a priority. If managers are very short sighted, they can find a thousand reasons not to make this capital investment, but will soon be lagging behind the competition and struggling to survive.

Creep-feed is a sensitive operation. Everything has to be done right, starting with a willingness to make an adequate investment. It's not wise or cost effective to try to retrofit existing equipment to run creep-feed operations.

What are the pitfalls to be aware of?

Creep-feed grinding is an unforgiving operation. That's why it's not a good idea to retrofit---in the long haul, you're always going to be fighting it. In creep-feed, we're dealing with very powerful machines, machines rated at a much higher horsepower than conventional machines, because the process by nature removes a great deal of material quickly. A typical conventional grinder may be rated at 3 to 20 hp, but a grinder designed for creep-feed may be rated 25-200 hp.

You have to pay attention to coolant application, fixturing, dressing parameters, and grinding wheel specifications. These must all be right for the creep-feed process to work properly. If any one element is not properly taken care of, the system fails.

Naturally, big machines featuring high horsepower, high accuracy, aggressive coolant application system, and so on---require much more maintenance than standard, simple machines. Of course they are also much more expensive.

How would you characterize the growth of creep-feed grinding in the United States?

It's still relatively new, but because it is a new technology, its growth has been extremely fast---faster than a two-to-one ratio over the last five years. It's going to grow at two-to-one over the next five years as acceptance starts to level off, but that's still a remarkable growth rate. Five years ago there were maybe two or three major installations. Today, there are probably 25 to 30 major installations---either cells or high-volume creep-feed production shops---although there are hundreds of smaller installations in the field. About 75 percent of all these are in the aerospace market.

But, there's still some reluctance to accept creep-feed grinding.

I attribute this reluctance to the natural tendency to resist change. Successful creep-feed grinding calls for a radical change, and takes a major commitment.

Plus, creep-feed grinding has been held back by a wait-and-see attitude. This attitude may offer security for the moment, but it can cost a shop its technical edge over time. There has been some reluctance on the part of some engineers who said creep-feed would never work. Now, it has definitely cost them in terms of market share, and some of them will have to revisit creep-feed when they see what their competitors are doing.

Should job shops take a look at creep-feed for their operations?

Although these machines are generally high-production units designed, built and set up to run thousands of parts, some job shops are using creep-feed grinding for 500- or 250-piece runs. In these situations, they have found creep-feed grinding to be very cost-effective for them, if not in terms of productivity, then in terms of improved part quality, yield and fewer rejections.

Or, in some cases, the nature of the operation may be so aggressive or so severe that the job can only be done profitably with creep-feed grinding. The creep-feed process could make sense for grinding just one part, if it allows that part to be produced in an hour instead of a week.

What advice can you share with shops and plants considering an investment in creep-feed grinding?

The most important thing that any prospective user must understand is how important every element of the process is and how different those elements may be from what they're used to. They're looking at buying an extremely rigid machine with high horsepower---much higher horsepower than in traditional grinding machines. They're looking at machines with very positive drives, usually ballscrews. And they must realize that rigidity is so important, tight down to designing the fixtures that are very rigid. This is important because the machine is only as rigid as its weakest link---in a lot of cases, that's the fixture.

Remember we're grinding with much higher forces to make that deep cut, and the actual horsepower needed to drive that wheel is extremely high. In total, the normal and tangential forces on the part in the fixture are very high and change depending on the application. They can be anywhere from 50 to 500 lbs per inch of wheel contact thickness. The wheel contact areas can produce up to 2,000 lbs of total force. So it's very important to make sure that fixtures are extremely rigid---at least as rigid as the rest of the machine. If they are not, the user will not be taking advantage of this machine and the benefits that make this process worthwhile.

Another example of how important every element in the process is, is the kind of grinding wheel selected for each application. The key here is a quality wheel with adequate, uniform porosity. One way you can test this is by blowing smoke through the wheel in order to see if the porosity is proper---if it is like a filter, then you know that its porosity is what you need.

What do you look for in a creep-feed grinding wheel?

Consistent, uniform porosity is the chief requirement for a creep-feed grinding wheel. More than half of any creep-feed wheel is air. Creep-feed wheels are induced-pore products, manufactured to create many interconnected air holes throughout the wheel. The air holes conduct coolant into the cut and facilitate the flow of swarf out. Remember this wheel is taking deep cuts, so the wheel is essentially buried in the part. There is no place for the coolant or the swarf to go but to be carried into the wheel before it exits the cut. Therefore, I consider high-quality, induced-pore grinding wheel products an essential.

The quality factor is important because the pore distribution, uniform density and balance of the wheel are all extremely critical. All of these attributes are related. If the pores aren't

distributed properly, for example, it affects density and balance.

To give you an idea of how important these wheel quality considerations are, I'd like to point out that balance and grade limits are cut in half for Norton Company's creep-feed products compared to standard wheels. There's simply a lot of demand on the wheel in the creep-feed process.

We also recognize that offering the technical expertise of experienced engineers is important since any shop or plant applying creep-feed will likely have questions and concerns that are vital to the success of their particular application.

What is next in creep-feed technology?

Superabrasives and ceramic abrasives are emerging. They're out there now, but there's a limited use for them. Here applications will grow slowly as the technology we use to make these products improves---and as the alloys get more and more difficult to grind.

While alloys are always being changed to make them lighter or improve their performance under higher heat, they're also becoming much harder to grind and machine. Naturally, the tools to grind these products have to keep improving, and we may find 20 years from now that a good portion of creep-feed grinding involves superabrasives or ceramic abrasives.

Superabrasives---such as cubic boron nitride (CBN)---excel where it's critical to hold very tight tolerances on intricate forms made of difficult-to-grind or hardened alloy materials. An example would be the grinding of small corner radii. Ceramic abrasives are a new class of products that promise to yield higher productivity, longer wheel life, and improved part quality compared to conventional aluminum oxide creep-feed wheels. The Norton SG seed-gel ceramic aluminum oxide products are in this class, for example.

Any final advice to those currently involved in---or thinking of getting involved in---creep-feed grinding?

There's no mystery to creep-feed grinding. It's not black magic. The science of creep-feed grinding is accessible and practical. Do your homework Attend technical seminars. Go out of your way to obtain information about this process. There are many technical articles and papers that have been published on creep-feed grinding. There is also a fair number of competent and reputable technical experts who offer consulting services, including ours at Norton Company.

Try first to have an understanding of what the process is, then you can look at applying it to some of your current processes---bottle neck operations, quality problems and labor intense operations.

But get smart first. The more you pay attention to the details of creep-feed grinding, the grater the edge you'll have over your competitor.