Chip Control: a Readers' Digest Version

Recommendations on chip management from the experts

Since its founding in 2012, Shop Metalworking has interviewed hundreds of machining specialists. Many suggested that chip control is one of the key attributes of a stable, predictable, and efficient machining process. Achieving it, however, remains elusive for some shops, which is why we've collated the following list of tips and techniques from the experts on breaking, blasting, and carrying away productivity-busting swarf. It's by no means complete, but should provide the basics by which anyone struggling with bird's nests and chip recutting can improve their machining processes.

Drilling right

Randy McEachern is a frequent contributor to the magazine. A product and applications specialist for holemaking and tooling systems at Sandvik Coromant Canada Inc., he notes that effective chip management in drilling operations depends on a number of factors, but starts by looking at the chips. With most indexable drills, there's only one insert working at the nominal diameter, McEachern explains. This should produce a cone-shaped chip, with chips like "Cs or 6s" coming from the peripheral insert(s).

Solid carbide or exchangeable tip drills, on the other hand, provide a more balanced cutting action that produces similar chips from both flutes. In either case, it's imperative that machinists "drill one or two holes, stop the process, review the chips, check the hole size and finish, then make any required changes to the drilling process." His article "Managing Your Chips" provide a host of timeless advice on ways to achieve these desirable chip shapes, extend drill life, and improve hole quality.

Mighty milling

Milling is a big topic in any shop. Unfortunately, at least for job shops and others that machine a wide variety of materials, effective chip management might require investment in material-specific cutting tools. "Selecting the right geometry is dependent, in part, on the material you're cutting," says Tim Aydt, product manager for indexable milling tools, Seco Tools Inc. "When you consider different materials, each require different geometry forms for different types of operations you're performing in a machine."

Alyssa Walther, an applications engineer for milling products at OSG USA Inc., suggests that cutting tool manufacturers advanced flute geometries are ground into many cutting tools because of their ability to curl and cut chips more effectively for better chip evacuation. "The design of a flute dictates how well the chip curls," says Walther, "Chip curl is important because you don't want chips to stick to the tool. The correct flute form helps you to achieve a smoother curl, generate less heat, and throw the chips out faster."

Cut thin to win

In that same article, Chipping Away at a Problem, Seco's Aydt speaks to the importance of cutting tool lead angles in milling and turning operations. "If you're taking a 3 mm depth of cut with a tool with a 90° lead angle, 3 mm of that edge is in the cut," notes Aydt. "But if you take a 45° lead angle at the same depth of cut, more of the insert is engaged in the cut at this angle than the 90° one. So you have thinned out the chip with the 45° lead angle so the average chip thickness starts to go down, which means you can increase the feed rate."

"This is the basic principle behind high feed milling," adds Tungaloy Canada's general manager, John Mitchell. "Due to the lead angle, a typical high feed milling cutter will produce an average chip thickness of less than 20 per cent of the programmed chip per tooth, calling for extremely high feed rates." What does any of this have to do with chip control? Plenty. These and other machining experts will tell you that, without sufficient feedrate, there's no chance of breaking chips into manageable pieces.

Lumps and bumps

Of course, there's little chance without the correct chip-breaker, either. That's according to Kurt Ludeking, director of marketing for Walter USA, who explains in Stop the Stringers that effective chip control often comes down to proper placement of bumps and waves on the surface of the turning insert. "These serve to fold the metal, cold working it into a shape that causes it to break away," he says. "A specific amount of edge rounding is also needed, to reinforce the cutting edge according to the cutting conditions. A roughing insert, for example, requires a stronger edge than does one used for finishing, and therefore requires additional honing."

Gary Kirchoff agrees, but suggests that selecting the wrong chipbreaker is often just as bad as no chipbreaker at all. "It's very important to choose a chipbreaker that is designed to effectively curl and break the chip," says Kirchoff, a product specialist at cutting tool manufacturer Dormer Pramet. "If the depth of cut (DOC) and feedrate are proportioned correctly to the width of the T-Land and chipbreaker groove, the material enters the groove and is curled properly. The chip is broken and the chipbreaker does its job. But if the T-Land is too wide, or a DOC and feedrate too small in relation to it are used, then the material does not reach the chipbreaker groove, and it cannot do its job."

Enough, but not too much

As hinted at earlier, stocking all these different geometries, grades, and now chip-breakers can be problematic for shops that machine aluminum one day, carbon steel the next, and superalloy the day after that. Walter's Ludeking says not to worry. "Most cutting tool suppliers can suggest four or five geometries that will handle 90 per cent of applications pretty well. For the rest, a few feed and speed tweaks should do the job."

Steve Geisel, senior product manager at Iscar Tools Canada, says he can appreciate concerns over too many part numbers in the tool crib. Aerospace, mould and die, and especially automotive shops typically cut the same kinds of materials on a constant basis, however, making it perfectly justifiable to stock the exact inserts needed for a specific job. "For shops that do high mix, low volume work, it's just as important to select the right insert, but sometimes you need to go with a more general purpose tool," he says. "This can create tradeoffs in performance, something that has to be weighed against the number of different inserts you keep in stock."

Geisel reiterates what Ludeking and other say, that "a little feed and speed tweaking can go a long way towards effective chip control, even when the chipbreaker is less than ideal." Shops that cut titanium, however, should take care. "TiC, TiN, and other coated inserts actually contain titanium, which is why I always recommend uncoated inserts. I've gone to many shops struggling with titanium and given them an uncoated tool with the exact same chipbreaker and nose radius as what they were using, and ended up with three times the tool life."

Precision coolant

Iscar, Walther, Sandvik, and indeed most cutting tool manufacturers now offer toolholders with built-in precision coolant channels. These are quite effective at chip-breaking, especially when high pressure cutting fluid is applied. "Consider superalloys, where you not only need a very strong, sharp cutting edge, but also a geometry that can cold work the metal enough to make it break away," Ludeking says. "Without it, you'll end up with a giant bird nest of chips. This is one area where toolholders with integrated coolant really shine, as they remove heat very effectively from the cutting zone."

"Apart from better chip control, we've seen a substantial improvement in tool life and productivity—up to 150 per cent in some cases." That's according to Abhay Chaubal, product manager for North America at Seco Tools LLC, who recommends cutting fluid pressures of at least 300 psi to be effective, with 1,000 psi more than sufficient for most applications. "However, even with the low-pressure pump that comes standard on most machine tools, precision coolant delivery provides a host of benefits. These include less built-up edge (BUE), as well as reduced flank wear, chipping, and deformation."

Fast and furious

That's from the article Clearing Chips, which also featured Ron Parker, national product manager for high pressure coolant systems at LNS North America. He says the traditional low pressure approach to cutting fluid delivery is "unacceptable," providing little to no lubrication in the cutting area, extreme and inconsistent temperatures, and inefficient chip removal. "Flood coolant typically turns to super-heated steam before it can reach the tip of the cutting tool. The result is poor tool life and even damage to the workpiece."

At pressures of 1,000 psi (70 bar) or higher, though, cutting fluids can reach the work zone and are forced into the area between the cutter and workpiece. Not only does this increase lubrication where it's needed most, but the lower temperatures eliminate the "steam effect" while also shortening the chip's shear zone, which helps to break them up. Chip evacuation becomes easier, tool life improves and grows more predictable, and feeds and speeds can generally be raised, leading to higher productivity.

Finally, there's this comment from Bill Fiorenza, die and mould product manager for Ingersoll Cutting Tools, who is a big advocate of education for cutting tools. "When customers are looking for chip management or require extended reach applications, I usually suggest a particular insert in our milling line to begin with and the reason I do this is because you have to learn how a cutter performs since all cutter geometries perform differently in milling applications," he says.

Fiorenza's words are no different than any of his colleagues, all of whom promote continuous education for machinists, programmers, and others who make chips for a living. So does Shop Metalworking Technology, which encourages readers to review the articles presented here for additional recommendations on chip management. The information is every bit as valid today as it was when we printed it and the suppliers no less knowledgeable. Lean on them; your chip control (and productivity) depend on it.

Information provided by GWS Tool Group