TECHNICAL SPOTLIGHT

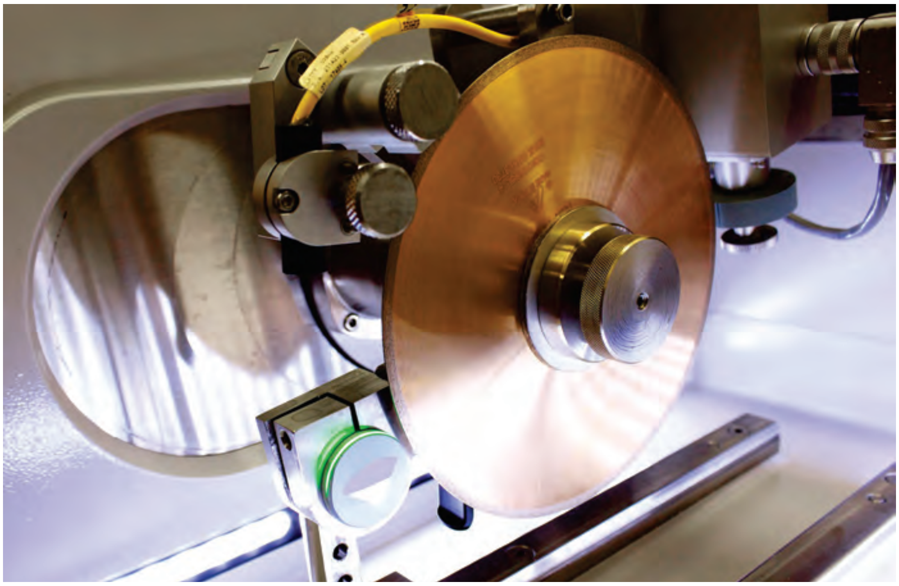
HOW TO MAKE SAMPLE CUTTING MORE EFFICIENT

New designs of precision cutters are optimizing sample preparation for greater efficiency, consistency, and precision.

Precision sample preparation of metals and composites is the key to reliable, high volume product testing and diagnostics in a wide variety of industries. In aerospace manufacturing, for example, metals are being combined with advanced plastics and composites to address stringent performance demands. In addition to the need to cut flawless samples to meet exacting dimensional specifications, changes are taking place in the overall quality control/quality assurance environment. Some of these include satisfying the continuous demands of high volume testing and the ever increasing precision of components and parts. In a high volume production environment, hundreds of samples from production batches must be run through the lab on a daily basis.

For metallographic studies, the process often requires parts to be sectioned, a destructive technique by necessity. Sectioning, the first step in the metallographic preparation procedure, creates a damaged layer at the cut surface. The extent of this damage is a function of the sectioning technique, machine design, material being cut, nature of the wheel or blade selected (including the abrasive type, size and distribution, bonding agent, and thickness), and the cutting parameters utilized, including the feed rate, blade rpm, coolant flow, and other variables.

Sectioning inherently causes some level of damage to the specimen. As demands for higher sample quantities increase—along with stricter quality benchmarks—companies are seeking ways to minimize damage caused by sectioning. Precision sectioning reduces kerf loss, is exact enough to be used when specimens must be sectioned at precise locations, and is delicate enough for use with fragile or friable specimens. Surface finish is also better than that produced by other cutting methods. Time savings is another factor to consider: After precision sectioning, there is no need for coarse abrasives to remove the kind of damage produced by other sectioning techniques. The goal with precision cutting is to minimize damage to the sample and maximize the flawless surface area available for analysis. Other benefits of high volume sample testing include:



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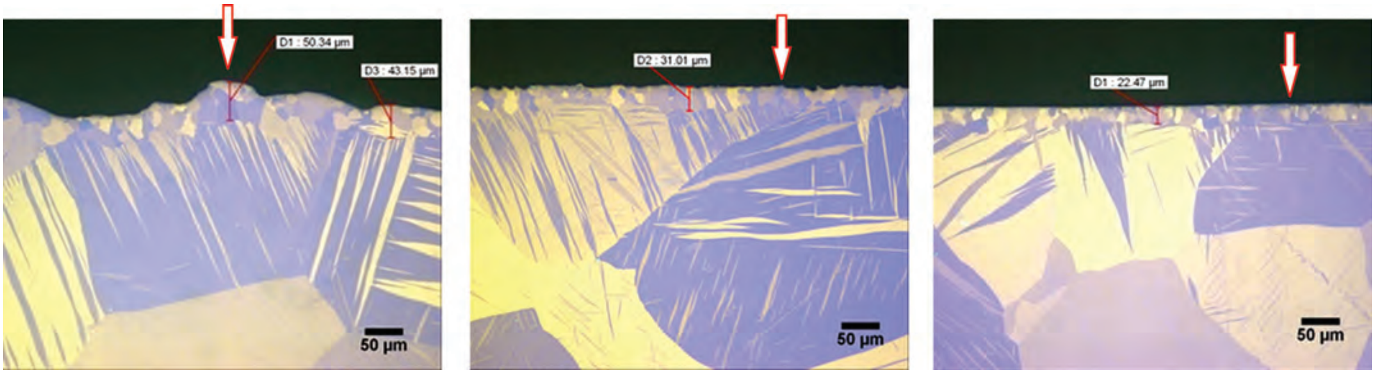
Fastener integrity is crucial to aircraft safety and performance. Integrity is verified by stringent sample analysis.

- Less rework on sample cuts, saving both sample material and lab time
- More samples cut in a single day, enabling lab staff to focus on other tasks

SAMPLE CUTTING VARIABLES

Three main factors impact the sample cutting process: blade speed, blade composition, and control of heat and cutting load. Here we consider each of these variables:

Blade speed. Power hack saws, band saws, and shop abrasive saws (generally run without a coolant) are



(a) (b) (c)

Sectioning damage on an hcp zinc sample. a) Band saw recrystallization depth is 50 microns; note that the jagged edge and heavy mechanical twinning will prolong grinding time; b) abrasive wheel recrystallization depth is 30 microns; sample exhibits some mechanical twinning; and c) precision blade recrystallization depth is 20 microns; sample shows minimal twinning.

aggressive sectioning devices that generate considerable damage at the cut interface. Likewise, metal shears also produce substantial damage. This damage must be removed to reveal the true microstructure.

When used properly, laboratory sectioning devices produce less damage than machine shop devices. In general, two main types of laboratory cutting devices are used by metallographers. The first is the abrasive cutter, which uses consumable wheels. Wheel diameters range from about 9 to 14 in. (229 to 356 mm); laboratory style cutters with larger diameter wheels (up to 18 in./457 mm diameter) exist, but they are generally used outside the laboratory due to their large physical size.

The second device is the low-speed saw, which has evolved over the last 30 years into the precision saw. Early versions of these low-speed saws had a maximum speed of 300 rpm and used gravity feeding. Current state-of-the-art saws feature a maximum speed of 5000 rpm and use linear feeding along with other options such as automated blade dressing and automated serial cutting. These saws use both consumable and nonconsumable blades.

Blade composition. Metal-bonded diamond blades are available with high or low diamond concentrations in a variety of particle sizes. High-concentration diamond blades are recommended for cutting metals and polymers (ductile materials), which are cut by a ploughing mechanism. Diamonds plough through the sample and hardened strips of material become brittle and break off.

Besides the high or low diamond concentration, blades are made using a variety of mean diamond particle sizes, using an arbitrary scale from 5 (finest) to 30 (coarsest). A blade with a rating of 10 will have larger abrasive particles than one with a rating of 5, yet they are not necessarily twice as large. A general rule for cutting is the smaller the abrasive, the lower the resulting deformation.

Control of heat and cutting load. Heat, which is generated by friction from the cutting process, damages the sample surface. Controlling the amount of heat is an effective way to minimize damage. Super thin diamond cutting blades combined with proper lubrication can reduce heat, as well as applying just the right amount of cutting head load during the cutting process. By keeping the load low and cutting capability high, along with proper blade selection, the sample can be prepared for analysis under the microscope with virtually no damage to the surface.

An experienced lab technician can determine if the cutting load is being properly applied, but consistency is difficult to maintain over the course of a long day of testing. Newly developed software can monitor motor current and translate that data into cutting head load. The software allows the load to get to a certain point and then, in order to prevent the load from increasing, instructs the saw to back off on the cutting rate. Because the software is reading the motor current, factors such as material composition and sample thickness do not need to be taken into consideration by the operator.

Other cutting system advancements developed to enhance precision and efficiency include:

- Simplified controls that reduce training time, ensure process repeatability, and facilitate enhanced control over cutting wheel position
- Offline fixturing systems that enable a part to be prepped for mounting while the saw is cutting another part, resulting in reduced downtime
- An innovative dressing system that cleans debris from the cutting wheel to allow a fresh layer of diamond coating, saving time and maintaining optimum quality. Currently, many machines allow the operator to dress the diamond blade before or after a cut, but this can degrade both cutting speed and quality during a single cut. Automatic dressing, such as the system developed for the IsoMet high-speed precision saw, periodically occurs during the cut and significantly improves speed, quality, and consistency. **~AM&P**

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