Minimizing destructive material testing

Features - Cover Story

Precision cutter technology optimizes sample cutting for higher efficiency and consistency in medical device manufacturing.

May 1, 2018
Dr. Evans Mogire

Figure 1 Hip Replacement

Precision sample preparation of metals and composites is key for reliable high-volume product testing and diagnostics in medical manufacturing. Along with the need for flawlessly cut samples for dimensional specifications, changing conditions in the quality control/quality assurance (QA/QC) environment include meeting the need for ever-increasing precision.

In high-volume medical parts production, hundreds of samples from production batches need to be run through the lab daily. For metallographic studies, the process often requires parts to be sectioned, an often-unavoidable destructive technique. Sectioning, the first step in the metallographic preparation procedure, produces a damaged layer at the cut surface.

The extent of this damage is a function of the sectioning technique and machine chosen, the material being cut, the nature of the wheel or blade selected (abrasive type, size and distribution, bonding agent, thickness), and cutting parameters (feed rate, rpm of blade, coolant flow).

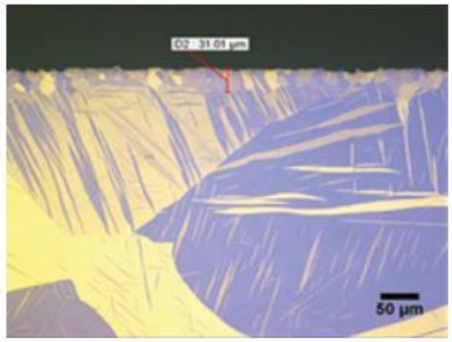
Sectioning necessarily causes some specimen damage. Increasing demand for higher quantity and quality of samples is forcing medical manufacturers to seek ways to minimize the damage caused by sectioning. Precision sectioning minimizes the kerf loss, is exact enough to be used when specimens must be sectioned at very precise locations, and is delicate enough for use with fragile or friable specimens.

The surface finish is also better than that produced by other cutting methods, and the steps following precision sectioning do not include time spent using excessively coarse abrasives to remove damage produced with other sectioning techniques.

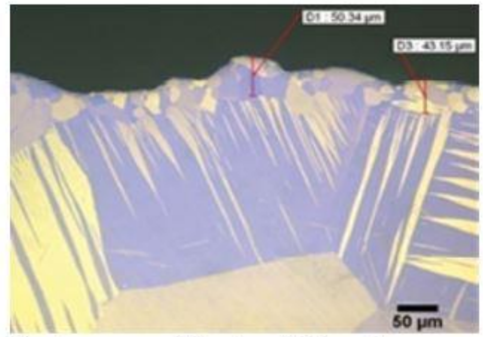
The goal with precision cutting is to minimize damage to the sample and to maximize the amount of flawless surface available for analysis. Other benefits include:

- Less redo on sample cuts, saving sample material, lab time
- More samples cut in a single day, enabling lab staff to focus on other activities

Three factors can maximize the sample cutting process – speed, blade composition, and load.



Abrasive wheel recrystallization at 30µm shows some mechanical twinning.



Band saw recrystallization at 50µm shows jagged edges and heavy mechanical twinning that could prolong grinding time.

Precision blade recrystallization at 20µm shows minimal twinning.

New systems

Other cutting system advancements have been developed to enhance precision and efficiency for medical parts testing:

- Simplified controls reduce training time, increase process repeatability, enhance control over the position of the cutting wheel
- Off-line fixturing systems enable a part to be prepped for mounting while the saw is cutting another part to reduce system downtime
- Dressing systems can clean debris from the cutting wheel, allowing a fresh layer of diamond coating, saving time, maintaining optimum quality; many machines allow the operator to dress the diamond blade before or after a cut, but this can degrade cut speed and quality during a single cut

1. Blade speed

Power hack saws, band saws, and shop abrasive saws (generally run without a coolant) are very aggressive sectioning devices that generate considerable damage at the cut interface, as do metal shears. This damage must be removed to expose the true material microstructure.

Laboratory sectioning devices, when properly used, produce less damage than machine shop devices. Two types of laboratory cutting devices used by metallographers are:

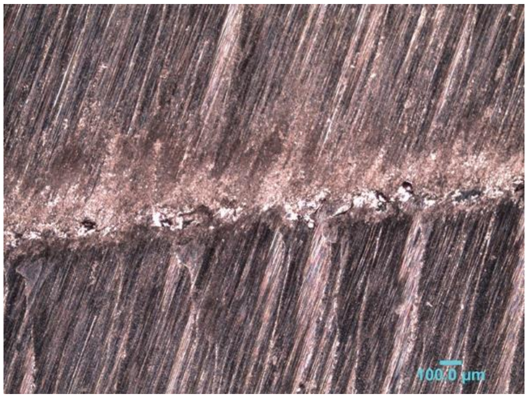


Figure 2 At the interface with the coating, material has been heavily damaged and fallen out requiring extended grinding and polishing to recover.

Abrasive cutters – Generally use consumable wheels with diameters from about 9" to 14" (229mm to 356mm); laboratory style cutters with larger diameter wheels (up to 18"/457mm diameter) are generally used outside the laboratory due to their large size.

Low-speed saws – Evolving throughout the last 30 years into the precision saw; early versions had a maximum speed of 300rpm and gravity feed. Current models have a 500rpm max. speed and linear feed, along with options such as automated blade dressing and automated serial cutting. Saws use both non-consumable and consumable blades.

2. Blade composition

Metal-bonded diamond blades are available with either high or low diamond concentrations and with various particle sizes. High-concentration diamond blades are best for metals and polymers – ductile materials – cut by a ploughing mechanism. The diamonds plough through the sample and hardened strips of material become brittle and break off. Low-concentration diamond blades are recommended for cutting hard ceramics – brittle materials – cut by a brittle fracture mechanism.

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 10 rating will have larger abrasive particles than one with a 5 rating, yet they are not necessarily twice as large. A general rule for cutting is the smaller the abrasive, the lower the resulting deformation.

A rigid, uncoated component, such as a titanium hip prosthesis, can be sectioned directly using a larger abrasive cutter, taking precaution on how the samples are clamped to avoid damage.

Sectioning should be performed using an appropriate diamond blade for titanium alloys or using a recommended ferrous abrasive blade. After sectioning, coated samples can be mounted and ceramic- coated samples can be re-mounted, using castable and hot compression mounting.

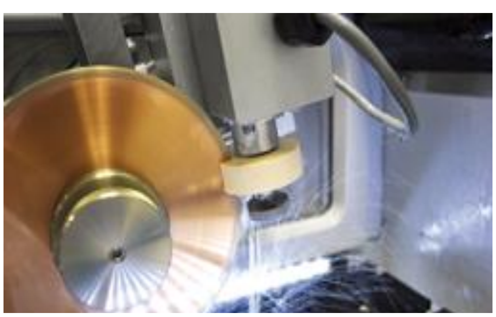


Figure 3 Automatic dressing, periodically during the cut, improves, speed, quality and consistency.

3. Load

Heat generated by the friction from the cutting process itself damages the sample surface. Controlling the amount of heat generated can effectively minimize damage.

Very thin diamond cutting blades combined with good lubrication can reduce heat, but so can applying just the right amount of cutting head load when cutting. By keeping the load low and the cutting capability high, along with proper blade selection, the sample can be moved to analysis under a macro/microscope, depending on the structure and/or depth of analysis being investigated, with virtually no surface damage.

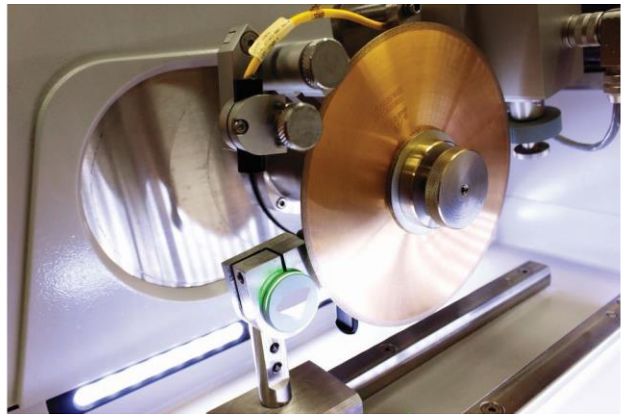


Figure 4 The goal with precision cutting is to minimize damage to the sample and to maximize the amount of flawless surface available for analysis.

An experienced lab technician can determine if the cutting load is being properly applied, but consistency is difficult to maintain throughout a long day of testing. Newly developed software can monitor motor current and translate that reading into cutting head load.

The software lets the load reach a certain point and then prevents it from increasing by having the saw back off the rate of cut. Because the software is reading motor current, the operator does not have to consider factors such as material composition or sample thickness.

Conclusion

In-house QA/QC labs for medical manufacturing are facing many challenges around the ability to provide accurate testing, working in a high-volume sample-testing environment with various materials. In addition to advancements in cutting saw technology, local metallurgical equipment reps can determine which system is suitable.

Buehler, a division of Illinois Tool Works Inc.
www.buehler.com

About the author: Dr. Evans Mogire, EMEA Laboratory and Technology Manager for Illinois Tool Works division Buehler, can be reached at evans.mogire@buehler.com .