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It may be penny-wise to refurbish PCD cutting tools, but it also may be productivity-foolish.

BY DENNIS MYERS

# Best Cost Scenario

Cutting tool users are a frugal group. They frequently refurbish cutting edges rather than buy new tools. This practice is especially prevalent when it comes to polycrystalline diamond cutting tools.

While these tools are especially effective in machining highly abrasive materials, they have a higher unit price compared to conventional carbide and coated-carbide tools. Practical shop supervisors often say, “These edges are hardly worn. Let’s reuse the PCD as much as we can.”

This logic has been applied for years, but new evidence suggests it may not be the best practice.

## Put to the Test

From a physical standpoint, it’s important to remember that PCD can be structurally damaged during a rebrazing process. (*Editor’s note: PCD is damaged during the initial braze, but all the surfaces are ground afterward, thus removing most of the damage. Regardless of the initial damage, that establishes the baseline of performance. Moreover, retippers usually don’t regrind all surfaces.*)

While conclusive evidence has been lacking on how rebrazing impacts tool productivity, the rush to reduce costs seems to have dulled sensitivity to the issue. The cost of PCD from suppliers has dropped dramatically over the years. A standard PCD disc that used to cost thousands of dollars can now be purchased for hundreds, changing the cost formula on which decisions are based.

Dave Kropfl, engineering manager for sp$^3$ Inc., Mountain View, Calif., decided to see if he could answer the question regarding PCD damaged as a result of rebrazing. The intent of Kropfl’s work was to quantify the decrease in productivity from the rebrazing process.

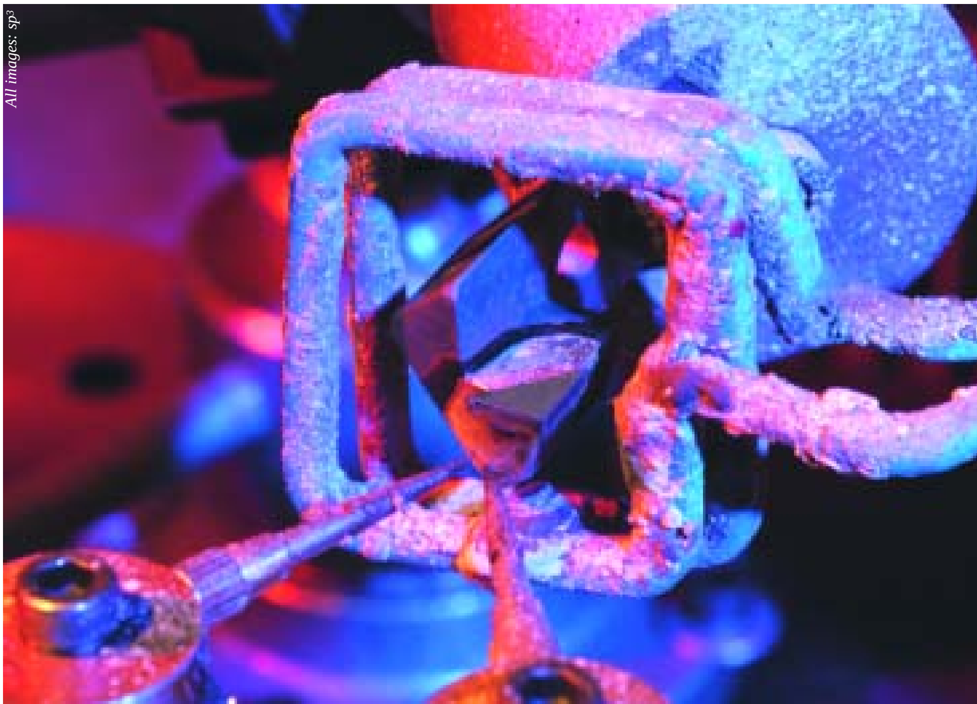
The testing procedure was simple but precise. Identical PCD inserts were tested. What varied was the number of times their tips were debrazed and rebrazed. The various test samples were subjected to the brazing process one, two, three, five or nine times. These tools were then ground to their final dimensions.

There was no attempt made to ensure the tools’ heat-affected zones were removed during grinding. (To do so would require use of analytical equipment not readily available to tool refurbishers.)

Standard refurbishing practice calls for an insert with less than 0.020" of wear to be debrazed, have its tip relocated and then have the insert reground to size.

All tools were checked dimensionally against ANSI specifications. These measurements were made on a horizontal optical comparator. The digital readout was accurate to 0.000050".

The tools were optically examined with a metallographer’s microscope to evaluate the surface condition of the PCD prior to grinding. Cutting edge, rake surface and braze joint on each tool



All images: sp$^3$

A custom diamond tip brazing station.

were examined at 40× magnification for signs of thermal and/or mechanical damage. There were no apparent differences noted at this magnification.

Finally, the inserts were evaluated by flycut-milling Duralcan, a metal-matrix composite made from high-silicon aluminum. The tests were conducted at a speed of 2,500 sfm, a chip load of 0.008 ipt and a depth of cut of 0.025"; aqueous flood coolant was applied. Both conventional and climb milling were performed, and tests were conducted by alternating the sample tools in the cut at random intervals and then measuring the wear scar along the cutting edge. Each tool was run until a minimum of 0.005" of flank wear could be measured.

The results showed that there was a noted difference in performance associated with the number of times a tool was subjected to the thermal cycle induced during brazing (Table 1). The decrease in performance ranged from 20 percent for a tool brazed two times to 38 percent for a tool brazed nine times.

| Sample No. | No. of Brazing Cycles | Minutes to 0.005" of Flank Wear | % Decrease from Single Cycle |
|---|---|---|---|
| 101 | 1 | 9.75 | — |
| 102 | 2 | 7.8 | 20 |
| 103 | 3 | 7 | 28 |
| 105 | 5 | 6.6 | 33 |
| 109 | 9 | 6 | 38 |

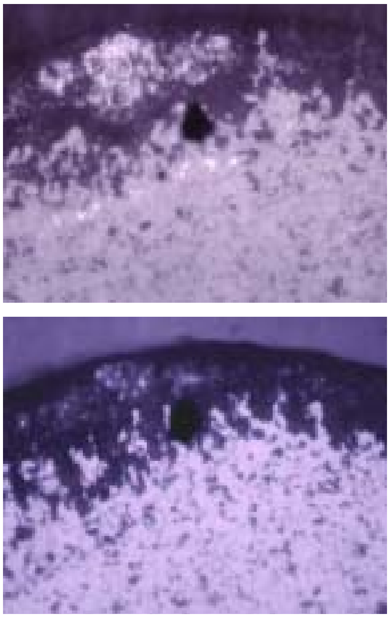
**Table 1: The amount of time refurbished PCD inserts were in a cut before 0.005" flank wear was realized.**

It appears that any significant damage due to the thermal cycling occurred during the second or third brazing operations (Figure 1). Wear curves generated for a standard single-braze-cycle insert were compared to those produced by inserts brazed two and three times. There was a decrease in performance of 20 percent from the "virgin" standard—brazed only once—and the insert brazed two times. After the third rebraze, the degradation slowed but still worsened.

The percentage of change in performance as a function of the number of times a tool was brazed was also plotted (Figure 2). The $R^2$ value of 0.9643 confirms at a high confidence level that there is a direct correlation between the number of times a tool is thermally cycled and its decrease in performance. The second and third rebrazings inflict the greatest damage.

## Remember What Mom Said

Rebrazing does degrade the overall performance of PCD inserts. The repeated cycling of the diamond to the elevated temperatures associated with atmospheric brazing leads to a "softening" of the surface region. The softening results from the migration of cobalt into the



**Metallograph images of PCD-tipped inserts that have suffered 0.005" of flank wear in their heat-affected zones. The difference is that the top insert, which only experienced a single "virgin" braze, lasted 9.75 minutes in-cut before degrading to this level. The bottom insert, which was originally brazed, then debrazed, then rebrazed, lasted 7.8 minutes in-cut before experiencing the same flank wear.**

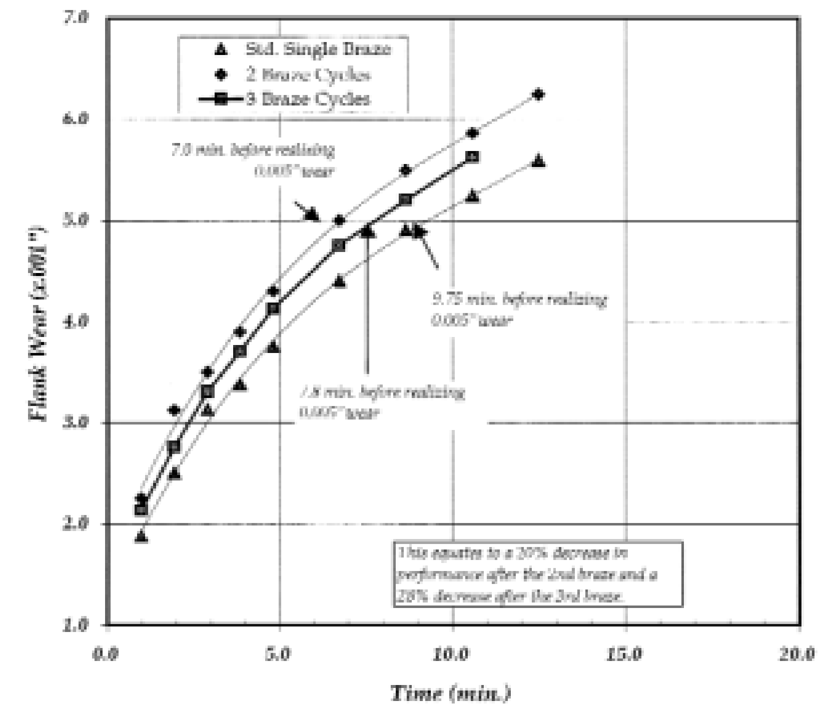



**Figure 1: Performance comparison of PCD tools subjected to single and multiple braze cycles that were applied to a fly-cut milling operation run at 2,500 sfm, 0.008 ipt and 0.025" DOC with flood coolant.**

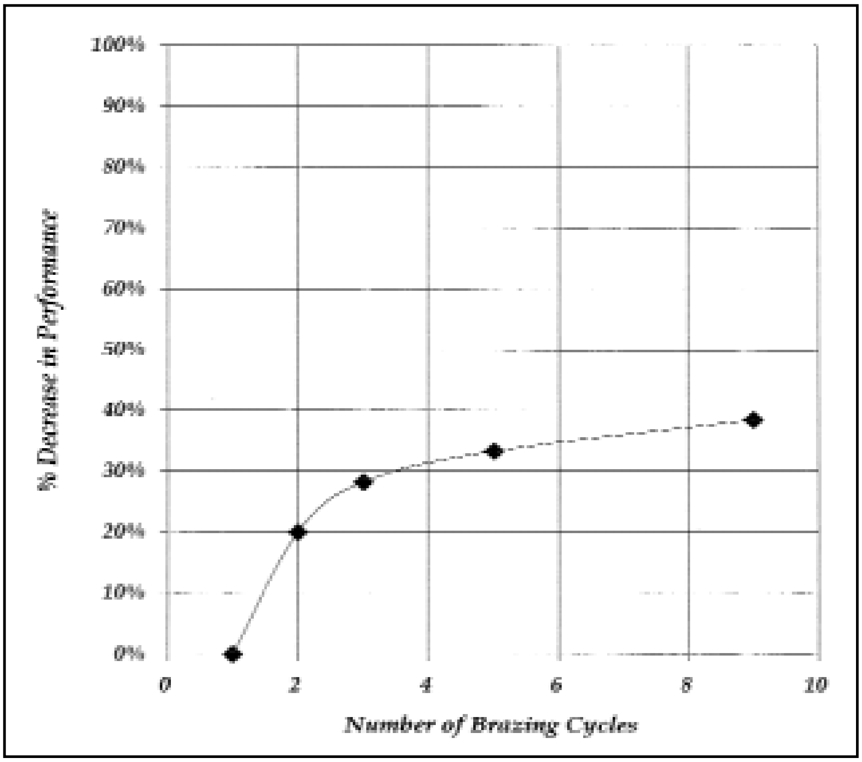



**Figure 2: Change in PCD tool performance as a function of the number of times a tip is rebrazed.**

PCD surface and the transformation of the surface diamond to graphite. Cobalt is much softer than diamond, and graphite, with its platelet-type structure, collapses under the heat and loads generated during metalcutting.

Findings like these make it clear that rebrazing a PCD tool represents false economies. The savings gained by refurbishing a cutting tool vs. a new purchase are insignificant compared to reduced productivity per tool. Working with a mixture of rebrazed PCD tools on a shop floor invites inconsistent cycle times, extra tool changes and surface-finish variations that add up to higher costs. Saving some money on an insert cannot make up the losses.

But wait. Some will say that is not a problem. That it can be countered by just knowing the performance level at which the tool rebrazed the most times operates and changing all tools before this known failure point. True, this could be done, but then you are leaving more money on the table from under-utilization of tools than is returned in per-insert price reductions.

Many a mother has told her child that, “If you want it to taste like butter, you have to put butter in the recipe.” In other words, to get the best taste you can’t cut corners. The same is true for a metalworking shop that seeks to be “world class.” More new PCD in your machining recipe might help that cause.

## About the Author

*Dennis Myers is the founder of DE Myers Group, a manufacturing consulting company based in Laguna Beach, Calif. He has held engineering, manufacturing, marketing and sales positions at General Electric Co., Excellon Industries, Mitsubishi Materials USA and other companies.*