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INTENSITY AND COVERAGE

In This Issue

by Jack Champaigne

Two critical factors in the shot peening process are intensity and coverage. These may be compared to time and temperature in the heat treating process. In both cases these parameters must be correctly specified.

The survey conducted in the previous issue of The Shot Peener provided interesting study. a tabulation of the data appears in Table 1. One of the more surprising results was the large number of multiple responses where both intensity and coverage were used to determine peening exposure time.

A description of terms should help the discussion. Intensity is the energy level of the shot stream as indicated by Almen strip deflection. The curvature of the Almen strip is plotted as a function of exposure time. The strip is at saturation when its curvature no longer increases upon additional exposure. In essence, the strip has absorbed all of the energy it is capable of holding by plastic deformation.

The term coverage describes the denting of the surface caused by shot impacts. Complete coverage occurs when the entire surface is deformed by adjacent impact craters. (A purist would add that only the largest shot, striking at the highest velocity at the greatest angle contribute to effective peening and therefore coverage is not achieved by smaller impacts.)

AN ANALOGY

Suppose you have been asked to help prepare dinner and you are to determine the temperature of the oven prior to roasting a large holiday turkey. The oven has been heating for quite some time. Suppose you hold a thermometer inside the oven for ten seconds and indicate a temperature of 100 degrees F.

Certainly a discussion would follow. It must be hotter than that! Place the thermometer inside for 30 seconds. This time the reading rises to 140 degrees, but skepticism continues. A plan is devised whereby a longer period will be used and a chart and graph constructed. Intervals of 1, 2, 3 and 6 minutes are chosen and results are shown in Table 2.

By examination, agreement is reached that the oven temperature is (approximately) 390 Degrees.

Additional study of the graph reveals that the thermometer reached its final value, or saturation, within about 3 minutes. Since we are cooking a large turkey, and guests are coming, we decide we want to ensure complete baking so we set the oven timer for 6 minutes. This gives us 200% intensity.

You probably are not willing to accept this technique. Although for the preparation of biscuits, this might actually provide usable (edible) results, it certainly won't accommodate our turkey.

Shot peening should be considered in the same way. Unless your target material happens to be SAE 1070 steel of hardness Rockwell C 44-50, your peening time for complete surface coverage will not be related to Almen strip saturation time. (1)

Soft materials, like Aluminum, allow creation of larger impact craters and coverage is achieved rather quickly. Harder materials, like Titanium, require a longer exposure time to achieve complete surface coverage.

The question then arises, "How do you select the correct exposure time for a particular workpiece?" The answer is, "It's empirical." The fatigue life testing of various samples is the only accurate way to know if you have achieved the expected peening benefits.

COVERAGE

Effective peening is performed when the largest shots, traveling at the highest velocity and striking at the greatest angle impact the surface and cause a plastic deformation that results in a residual compressive stress at a desired depth and magnitude. Smaller shots, lower speed shots or shots striking at a lower angle do not instill effective stress at the desired depth.

The above implies that the entire surface is uniformly treated, meaning impacts will be overlapping to cause an even distribution of stress. This can be evaluated with the aid of a 5x or 10x magnifying glass. Visual examination will determine the time required to achieve 100% surface denting.

However, not all peening needs to be done at 100%

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Intensity vs. Coverage
SURVEY RESULTS

For peening exposure time, we peen to:

INTENSITY	44%
COVERAGE	17%
TRACER REMOVAL	3%
INTENSITY & COVERAGE	31%
INTENSITY & TRACER REMOVAL	1%
INTENSITY, COVERAGE & TRACER REMOVAL	4%

We require exposure at least:

100%	40%
101%-150%	20%
151%-200%	28%
Over 200%	12%

Table 1

Intensity And Coverage *continued from page 1...*

coverage. Significant resistance to fatigue failure can occur at 50%-75% coverage. Although additional benefits may or may not occur at 100% coverage. The lower exposure time may produce acceptable results and provide a higher productivity rate. Each case must be evaluated separately. (2)

WHAT ABOUT TRACER REMOVAL AS A COVERAGE TOOL?

Chemical tracers, such as Dye Scan, Nat Scan, Dykem Blue or Magic Marker have been used for both targeting and coverage control. There isn't much dispute about their effectiveness as a targeting tool - you can see the area struck by the stream of shot particles. However, much caution should be used for any implications regarding coverage.

Broken shot, grit or contaminants may have a more abrasive, and therefore higher erosive effect on the tracer. Since "effective peening" implies impacts by full size shot, a false conclusion may be reached. Also, ricochet shot, especially broken or grit, can scrape away tracer rather than remove by direct impact. Only visual examination will show whether a full size impact crater covers the surface.

Another characteristic of tracer removal is its surface binding tenacity. Different chemicals, or differing dilutions, may result in additional exposure time required for removal. Tests should be performed to correlate tracer removal and surface denting.

In Conclusion...

Much of the peening done today is at an exposure time that relates to Almen strip saturation. It's true that strip placement at critical areas may demonstrate the requirement for longer exposure time due to angle impacts. And, it's also true that fatigue life cycle testing shows improved product performance (by coincidence?). But, the Almen strip is an indicator of process consistency, not product performance. Visual examination is the most rigorous method of determining coverage.

My own thoughts: Use Almen strip to define shot stream intensity. Use tracer removal to confirm targeting. Use visual examination to confirm coverage.

(1) *It was apparently coincidental that the depth of compression in the Almen strip was equal to the Almen strip curvature.*

(2) *Each shot impact creates a compressive stress in a volume of subsurface material. This volume is typically three times the diameter of the impact crater. It is therefore conceivable that a complete or thorough layer of residual stress may be generated even though the surface denting appears incompletely covered. Again, only fatigue life testing will show success of the peening process. The original intention of the Almen strip was to demonstrate process consistency, not product performance. The Almen strip, just like our thermometer example, doesn't know about the product peening requirements. his very effective as a SPC tool, but a poor predictor of product performance.*

10 Sec – 100°
30 Sec – 140°
1 Min – 230°
2 Min – 330°
3 Min – 360°
6 Min – 390°

Table 2