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Effective Use of Fluorescent Tracers for Peening Coverage

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1 Abstract

Fluorescent tracers for determining shot peening coverage have been in use for several decades. Their most appropriate applications are nozzle targeting and detection of coverage in difficult to peen areas. To determine actual percent coverage more sophisticated techniques are required. Frequently, tracers are not used properly or effectively. The most common misuse is to assume that full coverage always requires complete tracer removal. In fact, supplier instructions warn against this assumption and recommend the use of a standard on which tracer removal is compared with magnified visual determination of coverage. Tracer misuse often results in over-coverage by continuing peening well past full coverage until all tracer is removed. Under-coverage is also possible where excessive small or abrasive media prematurely removes the tracer. Neither is good for fatigue protection. This paper describes the removal behavior of fluorescent tracers under a range of peening media and process conditions and part material hardness. Analysis of the data suggests methods that make 100 % coverage more easily determinable by tracers. The purpose of the study was to increase the effectiveness of using fluorescent tracers and also their credibility. The author believes that if they are used with knowledge and common sense, improved production efficiency will result and over-peening will be minimized.

2 Results, Conclusions and Recommended Practice

Tests in a peening machine, described in detail later, show that tracer removal exactly corresponds with peening coverage under conditions that are moderately aggressive – for instance, S110 shot at 6A intensity with an impingement angle of 45 degrees. Larger shot at a higher intensity also fits this favorable situation. This correlation was valid for all the target materials tested – from soft aluminum to hard tool steel. Lower intensities, larger shot, hard materials or more direct impingement reduce the aggressiveness and thereby the effectiveness of tracer removal. Rough machined surfaces can also interfere with tracer removal.

Less than complete tracer removal at 100 % coverage does not render the process less useful. It does however, make essential the use of a standard (part material piece) which has been peened by the part peening process to 100 % coverage. Observation of tracer removal from the standard shows what tracer removal should look like on production parts. The tracer manufacturers recommend the use of such standards.

In addition to reinforcing the need for standards, the author recommends the use of more effective magnifiers, such as low cost 20× binocular microscopes. Especially useful can be the use of both ultraviolet and white light under the microscope to determine peened and unpeened areas in situations where dimples are shallow and difficult to see.

3 Description of Fluorescent Tracers

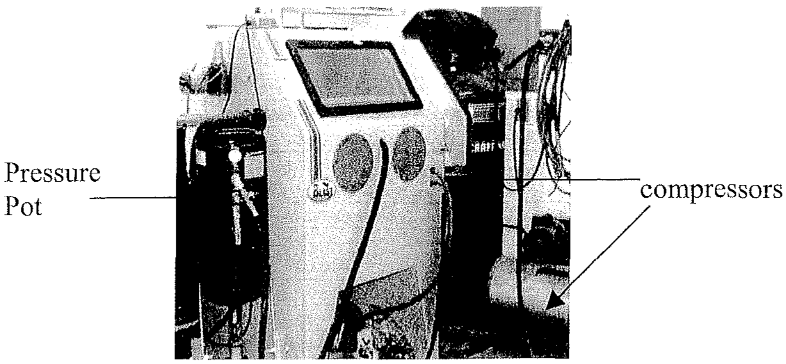
Fluorescent peening tracers are proprietary mixtures of fluorescent dyes and organic compounds in quick drying solvents. Alcohol and Methyl Ethyl Ketone (MEK) are typically used solvents, with MEK usually preferred because its tracers puddle less on reapplication to spots missed on the first application. Unfortunately, MEK is considered a health risk in some societies. Actual risk is very small because of the minute quantities used.

The tracer utilized in this investigation was Fluoro-Finder III produced by American Gas and Chemical. Spot comparisons with other available tracers during the tests confirmed that these other tracers behave similarly in removal behavior.

4 Experimental Equipment

The equipment used was simple in construction because it is based on a modified hand blasting cabinet using a single fixed position nozzle. Nozzles were constructed of small diameter steel pipe so that nozzle length could be changed easily. Surprisingly, they worked better than on-hand commercial blasting nozzles in reaching desired intensities with available 6.5 plus 2 hp air compressors. The addition of the following made the setup quite reliable and intensity/coverage reproducible:

- Pressure pot
- Shot flow control
- Cast and cutwire steel shot to AMS 2431 specifications
- Fixed speed turntable
- Stopwatch timing
- Intensities by computer generated saturation curves
- Startup off the samples until shot flow uniformity achieved
- Screens to separate previous shot after shot size change

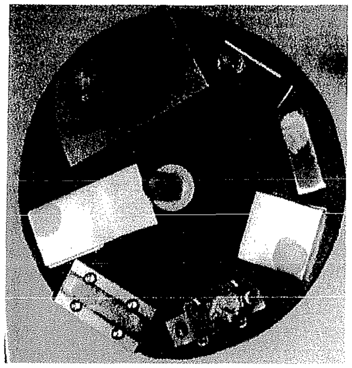


5 Sample materials

Test samples included a range of materials and hardnesses:

- Aluminum - HRB 48
- Titanium 6-4 - HRB 80
- Titanium 6-4 - HRC 36
- Titanium 6-2-4-6 - HRC 46
- Nickel-base Rene' 88 - HRC 43
- Steel 1070 - HRC 47
- Tool steel - HRC 63

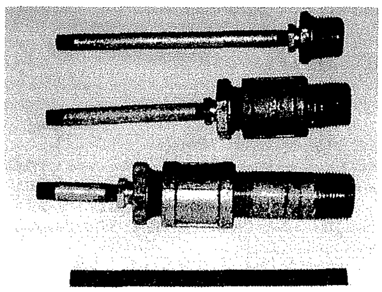
Sample preparation for each test run comprised removing the peening dimples of the previous run by (1) orbital machine sanding with 240 grit paper, (2) longitudinal hand sanding with 240 grit paper, (3) transverse hand sanding with 400 grit paper and (4) longitudinal hand sanding with 600 grit paper. After solvent cleaning, the tracer was applied with a cotton swab and allowed to dry. The samples were mounted on a 10 inch diameter turntable.



Shot utilized included cast steel S110, S230 and S330 and conditioned cutwire CW14. The cast shot was supplied by Ervin Industries and the cutwire shot by Premier Shot Company.

Shot flow control was by MagnaValve from Electronics Inc.. Screens were from W. S. Tyler.

Addition of the pressure pot and nozzle fabrication was by the author. The nozzles are shown below. The extra pipe fittings for the shorter nozzles were used to maintain nozzle to sample di-



stance. Nozzle wear was minimal during the tests, though they were made from commercial galvanized pipe – 1/8 NPT – internal diameter ¼ inch.

6 Test Results

The tests were conducted in the following sequence:

Table 1: Sequence of Tests

Shot	Intensity	Angle [°]	Nozzle [inch]	Distance [inch]	Mass flow [lb/min]	Air pressure [psi]
S230	15A	90	6	6	18	60
S230	11A	90	2	6	18	60
S230	14A	90	6	6	2	60
S230	6A	90	2	6	10	30
S230	5A	90	2	6	10	20
S230	3A	90	2	6	10	10
S230	12A	90	2	6	2.5	70
S230	7A	90	2	6	2.5	20
S230	7A	90	2	8	2.5	20
S230	6A	90	2	8	10	20
S230	12A	90	2	8	2.5	70
S110	9A	90	6	8	2.5	70
S110	8A	90	4	8	2.5	70
S110	9N	90	2	8	10	20
S110	9N	45	2	7	10	30
S110	6A	45	2	7	2.5	70
S330	13A	45	4	7	10	70
S330	7A	90	2	8	10	20
CW14	8A	90	6	8	2.5	70

7 Summarizing the test observations:

The most aggressive conditions of 45 degree impingement angle with S110 shot at 6A and S330 at 13A showed complete tracer removal from every dimple and complete removal at 100% coverage. (1) Reducing the aggressiveness by changing to 90 degrees (lower shot velocity to reach same intensity), (2) reducing intensity and (3) increasing shot size at same intensity (shallower dimple – same dimple diameter) incrementally reduced the correlation of tracer removal with coverage. The soft aluminum and annealed titanium maintained the correlation further down the progression to decreased aggressiveness. As levels decreased, determining coverage on the harder materials became increasingly more difficult, especially on the HRC 63 tool steel. CW14 behaved exactly the same as S110 which is the same diameter.

As coverage determination became more difficult with lower aggressiveness levels, a helpful technique emerged. Looking at the peened surfaces through a 20× binocular microscope and alternating between white and ultraviolet light made it much easier to determine dimples from areas not impacted. The white light picture below may illustrate. The UV light did not generate enough light for picture taking.

Another coverage observation was made that may contradict folklore and some existing specifications. It was found that the Almen strips at the saturation point were usually not 100 % covered. This makes sense to the author, because even though the term "saturation" is used, the strip is not really "saturated". It is still increasing in curvature as time is increased. To make that happen, it makes sense that the coverage is yet to be completed.

In determining intensities for this study, a computer generated saturation curve program was utilized. This made intensity determination more accurate because the program picks an exact point from which arc height rises 10 % on doubling the time. It also gave the author confidence that the peening system was working consistently because the curve was very smooth without any outlying points. An example is shown below.