Troubleshooting a Shot Peening Process Gone Astray

by Jack Champaigne, Electronics Inc.

One of the my most satisfying roles at Electronics Inc. is as a troubleshooter. On any given day, I will get a phone call from a colleague with a problem: "Jack, why isn't this process working? What are we doing wrong?" The following is a good example of the challenges I'm presented on a regular basis.

I was invited to give a short seminar on peening to a company in the automotive industry. A staff engineer was tasked with a project to investigate and remedy fatigue life problems with a particular component. Failures were occurring after about 200-300K cycles while a competitor's product easily met the 1M cycle life test. The engineer shared with me what he had discovered so far in his investigation and then I visited the facility.

During my visit, I was able to evaluate the process and also the equipment. Parts placed onto a conveyor passed under four abrasive-throwing wheels. The first two wheels were running at 2450 RPM and the second two were running at 1450 RPM. The staff engineer wasn't sure why it was done this way but that's the way it had been done for a long time. It wasn't clear when the fatigue failures were first noticed and what process change may have been responsible for the failures so a thorough investigation was in order.

The process required peening to an intensity range of .012-.020"A with minimum of 100% coverage. I needed to determine why the wheel speeds were different and why the fatigue life was so low. Usually my first candidate for peening problems is the condition of the media and that's where I started.

I generally focus on three areas of importance during my investigations: media quality, intensity and coverage.

I obtained a small sample of media from the air-wash separator system and noticed a wide range of media sizes and shapes. The air-wash separator was not adjusted properly which allowed a large amount of undersized media to stay in the process. I also learned that the original shot-adder system had been disabled and media replenishment rate of one ton of shot was allowed.

Air-wash separators were designed to remove sand from the media in abrasive blast cleaning systems in foundries. Sand from the castings would get mixed in with the media and this was very detrimental to the blast wheels. A small percentage of sand (4-8%) can reduce wheel blade life to less than 40 hours. The air-wash separator works on the principle of drawing air through a curtain of falling media. The low density sand is easily extracted from the high density abrasive media. It is very difficult to maintain the air-wash system so that it can efficiently separate undersized media from full size media. The systems often either remove large amounts of good media or fail to remove the undersized.

I mentioned the importance of media maintenance to the staff engineer and learned that he had earlier purged the machine of media and installed ten tons of new media. Unfortunately, the fatigue test results did not show any improvement and, in fact, may have shown lesser capability. I found this to be very curious because I always emphasize the dominant importance of media quality. I still had more to learn about this project.

I next turned my attention to peening intensity. A scrap part with Almen holder affixed was passed through the machine and the resulting arc height of the Almen strip was recorded. A new strip was attached to the holder and the fixture was passed though the machine twice and the arc height was recorded. This process was repeated again with the fixture going through the machine four times. We were able to construct a saturation curve and I was surprised to see an "intensity" of .053". The SAE limit on intensity range for the "A" strip is .024".

The SAE limit on intensity range for the "A" Almen strip is .024". Higher Intensity ranges should use the thicker "C" strip. The "C" strip equivalent of .024"A is approximately .008" C.

I suppose you're wondering how the intensity could be .053" when it was supposed to be .012-.020". It seems that the intensity checks consisted of passing the fixture through the machine only once and recording the arc height. Obviously this practice does not reveal intensity since the strip would not be exposed long enough to achieve saturation.

Although I didn't understand everything I had learned at this time, I proceeded to ascertain that coverage met the 100% minimum and it did. However, inspection of the peened surface revealed abnormally high surface roughness. Later inspection with high magnification showed extensive peened surface extrusion folds. Surface extrusion folds are tears and laps in the surface caused by high peening intensity. This condition is often accelerated whenever large amounts of broken media are used or if excessive high intensity or long exposure time is allowed. This creates stress risers at the surface with tensile stresses and will very often lead to early fatigue failures.

So, here I was—a component failing after 200K cycles and the competitor's component lasting over 1M cycles. What could be wrong with this picture? First, they were peening at too high of an intensity. They were damaging the part by severely overworking the surface. The new load of media? This actually

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aggravated the symptoms because the full size shot caused an even higher peening intensity. So, why did running the second set of wheels at a lower speed seem to help? Because they were, without knowing it, practicing duplex peening.

Duplex peening is a common practice in both the spring and gear industries where components are peened twice. The first treatment is with a very high intensity to get a very deep compression. That's the good news. The bad news is that this is detrimental to the surface making it very rough and subject to tension and crack propagation. The second peening treatment is at much lower intensity, essentially healing the surface. The first set of wheels provided the high intensity treatment; the second set of wheels provided the low intensity treatment. (For additional information on duplex peening visit our library at www.shotpeener.com)

The following were my recommendations for this company:

1. Install a shot adder system. A shot adder system will replenish the media at the same rate of consumption and tends to keep the media mix constant.
2. Install screen separators. The use of screens to eliminate the undersized media offers a great improvement over the air-wash separator. Experience has shown that only 10% of the reclaimed media needs to be diverted to the screens to insure proper media size control.
3. Perform periodic media size inspections. (Ro Tap sieve tests)
4. Establish intensity levels (separately) for each set of wheels so duplex peening can be controlled. Run saturation curves for the first set of wheels without the second set running. Run saturation curves for the second set of wheels without the first set running.
5. Everyone involved with the shot peening process in the organization should read *The Shot Peener.*
6. Send operators to the EI shot peening workshop.

Jack Champaigne leads a demonstration at a Shot Peening Workshop.

TROUBLESHOOTING
Supporting Documentation: AMS-S-13165

4.2.1 Sampling. At least one intensity determination shall be made to represent each machine for each two hours of continuous operation or fraction there of where glass beads are used, for each four hours of continuous operation or fraction thereof where ceramic beads are used, and for each eight hours of continuous operation or fraction thereof where cast steel, cast iron, or cut steel wire (or stainless cut wire) shot is used. In all cases, at least one determination shall be made at the beginning and one at the end of each period of operation or part change.

4.3 Shot size and uniformity

4.3.1 Sampling. Sampling for shot size and uniformity shall be at the frequencies specified in 4.2.1 for intensity. Where cut wire shot is used, it shall be inspected for absence of sharp edges and roundness (see 3.1.3).

4.3.2 Test procedure. Tests for shot size and uniformity for compliance with the requirements of 3.1 shall be made using sieves conforming to Federal Specification RR-S-366.

4.3.3 Visual examination (sample size). Samples of shot for visual examination shall consist of the number of shot in one layer which completely fills an area of 1, 1 /2, 1 /4, or 1 / 8 inch square as applicable (see table I). If feasible a minimum of 100 beads or pieces of shot shall constitute a single sample (see 6.16). Acceptable and unacceptable shapes are shown in figure 7.

3.3.9 Shot maintenance. The shot or beads shall be maintained in the machine so that not more than 20% of the particles, by weight, shall pass through the sieve number specified in table VII for the shot size used. Metallic shot shall be checked at least every eight hours of operation to assure that not more than the shot by actual count is deformed or broken; glass beads shall be checked at least every two hours of operation to assure that not more than 10% of the beads by actual count are deformed or broken (see 3.1.3 and table I). When wet glass peening is used, the entire slurry charge shall be changed at least every two hours for compliance with this requirement. Ceramic beads shall be checked at least every four hours to assure that not more than 5% of the beads by actual count are deformed or broken. In all cases, at least one determination shall be made at the beginning and one at the end of each period of operation or part change.