AN INSIDER'S PERSPECTIVE

Kumar Balan | Blast Cleaning and Shot Peening Specialist

So, Are You Shot Peening?

INTRODUCTION

Confucius, the great Chinese educator and philosopher, said, "To know what you know and what you do not know, that is true knowledge." I start with this thought not to insinuate anything about peening practices but to establish the fact that there is still so much for all of us to learn. Confucius strived to make education broadly available which is our goal as well through this platform! During the early part of my sales career, I had an excellent boss whose line of motivation was, "go out and even lose a project, at least I know you're doing something." I am going to draw on some examples from the past to demonstrate that "something" which continues to be categorized as shot peening by different users. At that time, it appeared that such users were cleaning and not peening. However, upon more recent contemplation, I am beginning to wonder if their activities did have merit and perhaps my dismissive attitude was premature. Condoning a supposed peening process as incorrect or terming it blast cleaning is an obvious outcome when looked at under the lens of specifications that we are required to conform to. Justifiably, to most of us, work life outside of these peening specifications is non-existent and our actions are heavily influenced by the need for conformance to such documents!

In these discussions, I propose to infuse renewed energy into those entities, projects, and applications that perhaps do not (required to) monitor velocity, media shape, size, credit them as appropriate and maybe offer a few suggestions to help them develop their processes.

THE CLEANING/PEENING MACHINE

A satisfying day's work must involve a good story. A combination of all such stories generates an interesting resume. An interesting resume sometimes leads to a good job. A string of good jobs could result in a fulfilling career! This story for me certainly counts as one within that string.

A few years ago, during a routine machine/process inspection at a spring peening facility, I was exposed to what was described to me as a "cleaning/peening" machine. Let us term this Machine A. Machine A was routinely fed "peening" media that was deemed unsuitable for a more critical peening process Machine B that used larger media (S-550). Machine B, through use, broke down the S-550 into smaller sized particles which were deemed suitable/adequate for what Machine A did. In other words, Machine A always received a working mix of media.

When questioned, I was told that Machine A was a cleaning/peening machine depending on the needs of that day. There were parts with heat-treat scale that were processed in the machine for descaling. There are other batches of clean parts that were processed through for shot peening. Therefore, the moniker. Typically, we thrive with and insist on a working mix of multiple size particles for efficient cleaning but never for peening.

Our claim is that only a single, constant media size, within tolerance, is capable of transferring repeatable and identical impact energy on all surfaces and geometry of the component being peened. We do not qualify anything short of that as proper peening. As I finished explaining this to the engineer, he revealed to me that: (a) it has always been done this way, and (b) x-ray diffraction has shown that the components regularly register the required residual compression at three depths (their process requirement).

My attempt at starting a discussion about saturation curves and the possibility of a double-knee due to the presence of small- and large-sized particles was also nullified. The value created by the creation of compressive residual stress more than satisfied the requirements of this manufacturer's end-user. So, a process that would leave you AMS 2432 types in shock continues to provide perfectly acceptable results to this OEM. My conclusions upon further review of this process are:

- Non-mission critical components governed by OEM specifications have not been updated to reflect the need for process control.
- Possibly a higher than required value of intensity compensates for potential misgivings from using non-conforming media particles in a relaxed process.
- The true relationship between intensity, process control and residual stress is still not well-researched. This understanding is of great importance to all of us, particularly when drafting or reviewing peening specifications. Are there aspects of shot peening that are forgiving without significantly altering the result?
- Is the marginal amount of peening and residual stress created when simply blasting a part during cleaning sufficient for most non-critical peening applications?

RAILWAY – A MODEL NON-AEROSPACE SPEC DOCUMENT

My first exposure to shot peening was with railway wheels in a centrifugal wheelblast machine at one of the Indian Railway plants. Being the densest railway network in the world, India has multiple railway wheel plants that clean and shot peen railway wheels, in distinct machines. But first, about the application. Railway wheels are typically forged or cast with the former used in passenger cars and latter in freight cars. These wheels are peened on both sides (front and back) simultaneously in the area extending from one-half of the way into the hub fillet and one half of the way up the rim fillet. In other words, in the areas of maximum tensile stress concentration.

Shot peening is managed by AAR M-107/M-208 (Association of American Railroads). I will start with the current version of this document (implemented 09/29/2020), section 7.0 Shot Peening. My focus for this discussion is to illustrate the clarity and simplicity with which a non-aerospace specification document can be written (take note, non-aerospace industries that are working on developing a specification document).

1. 7.1 – the scope clearly describes the purpose of peening as "improved resistance to plate fatigue and stress corrosion cracking by the introduction of beneficial compressive residual stresses." It lists all variables such as mass, hardness, velocity, angle of impingement and stand-off distance. It talks about coverage, both on the strip (yes, you read that right) and part surface.
2. 2. 7.2.1 and 7.2.2 – Shot and size control. The document offers tolerance to shot size selection and leaves the choice open to S-660 or larger. Shot addition practices indicate the minimum percentage requirement of a designated shot size.
3. 3. 7.2.3 – Intensity determination is explained as being through plotting a saturation curve and lists the minimum intensity at 10C. The description for processing time (cycle time) is a bit fluid in this document for understandable reasons (due to wide tolerances including, S-660 or larger shot size, minimum 10C intensity, etc.). Therefore, it places a constraint that "the processing time must be no less than the time required to reach saturation as determined by the saturation curve." Since wheels are manufactured in different diameters, this document states that the processing time for large wheels can also be used for the smaller diameter wheels. There is no room for ambiguity. If you are thinking that cycle time is a function of coverage/exposure, you are correct. The specification recognizes that as well and elaborates that in future sections.
4. 7.2.4 – Coverage. It explains that coverage has to be assessed on a "complete previously unpeened wheel" and lists the requirement in SAE J2277 for inspection. Interestingly, it also describes coverage measurement on the Almen C strip. Though this is not an indication of processing time, it addresses the need to have uniform denting on the strip to determine arc height. Note: An earlier version of this specification had listed that the minimum peening time had to only ensure that full coverage was attained on the Almen C strip. The document has since been revised to a more elaborate and accurate description of coverage than before.

The purpose of this discussion is to introduce our readers in industries outside of aerospace to the possibility of a specification that is not as onerous as an AMS document and yet addressing important requirements. I would like to point out that the AAR document is not an OEM specification, but one that is developed by an industry association. This might provide inspiration to industries such as Mining and Power (Oil & Gas) to work on a similar document.

SPECIFICATIONS FOR NON-PEENERS

Though there is room for improvement, I believe that credit should be given to those users that have adopted the tenets of the process even without a binding document. This includes, but not limited to: (a) grit blasting applications commonly seen in medical and aerospace, (b) etching applications in automotive, (c) applications that "dent" the surface to create smooth reservoirs to store lubricant, and the list goes on.

I was approached by a foundry user of blast cleaning equipment recently to find ways to use their cleaning machine for the occasional peening project. He explained that the occasion could be frequent over a six-month period and then none for the next few months, eliminating justification for a new, dedicated machine. Being an organization that relied on standards and structure, they were interested in a document that would allow them to peen in their existing set-up. With some minor equipment modifications such as the inclusion of an inverter with the blast wheel motor, an offline media classifier and media flow controls, the equipment was able to perform shot peening functions.

However, this was not all. The transformation of the machine from cleaning to peening could not happen by the mere flip of a switch. A section of their specification document listed all the necessary steps to be followed to initiate a successful transformation. This involved a thorough clean-out to eliminate contaminants such as scale and tramp metal dislodged during cleaning (by operating the reclaim system without parts in the machine for at least four hours), continuous classification of shot through the classifier to maintain uniform shot size, calibration of critical components such as blast wheel motors (speed/velocity), flow control valves (through media drop tests), and proper saturation curves instead of a single verification strip.

The process was rigorous, but in the end a document evolved that allowed them to convert it into a multi-purpose machine. I am not implying that this could be done every-

where. However, in situations where users are "testing out" the process for its efficacy, a different style of specification curated to their application needs can be designed. This could be a stop-gap arrangement and a reference document to use until a dedicated peening machine can be incorporated into their production process.

I would like to again refer to section 7.3.1 in the AAR document discussed earlier, Wheel Surface Condition. This clause goes to the extent of specifying that "the peened appearance of rim and hub shall not be cause for rejection." Some of us polish peened parts to remove the "dented" appearance. This clause explains that this may not be necessary when peening wheels, especially given the high intensity that these wheels are peened to. Practically any aspect of your process that is specific to your application or part can be inserted into a specification to make it relevant to you. The AAR document, along with several other clauses specific to their industry, teaches us that.

WHY BOTHER NOW?

Knowing what you don't know is true knowledge. I'd like to extend that to read, "adapting what you know to what is useful to you is true wisdom." Though I am not suggesting that you bind yourself with a rigid specification, you might want to consider documenting what you do and establish a set of rules for your peening process. This document will help with the following:

1. Standardization of your process through multiple manufacturing locations
2. Traceability when non-conformities creep in
3. Assurance and consistency of quality—following a well-documented process will lead to predictable results
4. Accurate estimation of costs and selling price of the final product
5. First-mover advantage if you initiate a document before being forced into one by others

"Are you still using MIL-S-13165" (*The Shot Peener,* Summer 2022) provides some references as you consider working on a document. That is because, before we started adopting AMS 2430 and 2432, we focused on MIL-S-13165 alone. This document is comprehensive, particularly for non-aerospace users of this process. Though cancelled, this document continues to be used outside of aerospace. Perhaps this could be your reference document and if you feel that your process can withstand more rigor, you can move up to the AMS adaptations referred above.

CONCLUSION

As I get this draft ready for review, a small group consisting of industry participants from different parts of the supply chain are getting ready to meet at SAE in Troy, Michigan. At this meeting, we will discuss modifications to several SAE and AMS documents. Ideas will be exchanged on how best to re-write a certain clause on testing techniques, clarify a screening tolerance, add a paragraph that reflects advancement in equipment, characterize shot shape in a more scientific method than pictorial representations, and so on. Such interactions help us keep pace with the technology growth being experienced by our customers, who are also part of this group.

Different committees work together towards a common goal—advancement of our industry. Your goal might have a different benefits analysis. Maybe the components you manufacture are not mission-critical and not left without recourse at 40,000 feet above sea level, yet you recognize the benefit of adopting this process. This discussion is for you. Starting to peen is important, peening correctly is growth. It is not that complicated. Transfer a constant magnitude of impact energy on to a component and manage all those variables that will assure this constant!