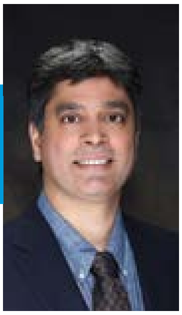

AN INSIDER'S PERSPECTIVE

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The Logic Behind Selecting Hard Media

INTRODUCTION

The great Leonardo da Vinci, in current times, would have been considered an individual with unsure prospects due to his variable interests. He was an active painter, draughtsman, engineer, scientist, theorist, sculptor, and architect (and you thought your life was difficult because you had to re-plot a saturation curve due to media contamination). Nevertheless, one of his quotes reads, "Nature is the source of all true knowledge. She has her own logic, her own laws, she has no effect without cause nor invention without necessity." Incapable of such profound thoughts, I am going to plagiarize his revelation into a relevant article for our discussions here!

Recently, I was trying to analyze the actions of a customer that attempted to optimize their cleaning process. This customer had determined that changing shot size from S-230 to S-330 would give them better quality cleaning, reduced re-blast and other related benefits—all positively impacting productivity. This exercise did result in some process improvements but there was a price to pay with the use of a larger size media. Tight geometries on their structural steel fabrication remained uncleaned. I attributed this to the fact that due to its relatively larger size, S-330 had less particles per pound of shot than S-230. Further, the reduced percentage of small particles in their work mix might have contributed to lack of "scouring" action that was previously carried out by smaller particles of abrasive. Cause and effect were clear and obvious.

Yet another example I present is with a customer that peens parts for the oil and gas industry. Since they were peening an experimental part to prove-out the benefits of shot peening, they were at liberty to select media size without being constrained by a drawing or specification that limited the peening media size they could use. They were pleased with the intensity and coverage provided by S-460 until their design team demanded a marginal but higher intensity than before. Upon deliberation, and the desire to keep the rate of coverage unchanged, they stayed with the same shot size but switched to a higher hardness to achieve their increased intensity target retaining their original cycle time for 100% coverage. Cause and effect resulted in a positive outcome this time! I often remind myself to bring this up with product and process designers for consideration before switching shot sizes.

When this topic comes up for discussion at peening workshops, I explain that switching to a higher hardness grade will result in a 0.0015" to 0.002" increase in intensity. Further, I have also informed my class, purely from anecdotal reports, that this increment in intensity is exponentially higher with larger shot sizes such as S-460 and above. It was time to test out these hypotheses, and I managed to do so recently at Ervin's test lab in Tecumseh, Michigan.

THE TEST PROCESS

Common applications are served by S-110, S-170 and S-230 sizes of cast steel shot. To address non-Aerospace and high intensity applications such as in Railway and Oil & Gas, I also included S-550 in my testing. As you know, AMS grade media is manufactured in two hardness ranges (ASR: 45 to 52 HRC and ASH: 55 to 62 HRC). However, SAE grade media, or media designated for land-based vehicles, is manufactured in four different grades of hardness: 40 to 51 HRC (categorized as standard hardness, 'S' by Ervin Industries), 47 to 56 HRC (M hardness), 54 to 61 HRC (L hardness) and min 60 HRC (H hardness). For the purposes of my tests, I used S, M and H hardness ranges of media in all sizes listed above.

Along with SAE grade media, I also tested with ASR170 and ASH170 to compare outcomes. In addition to the difference in hardness grades, AMS grade media (or MILSPEC as some continue to refer to it as) is screened to a tighter tolerance and conditioned to remove mis-shaped particles—generally held to a tighter manufacturing tolerance. Since my test would involve multiple media changes (11 to be exact), I elected to use a small pressure blast cabinet with vacuum recovery system and manual blast capability. A centrifugal wheelblast machine would have resulted in insufficient clean-out of the previous media size and potential cross-contamination. My previous experience with peening experiments in a test lab with wheelblast machines and multiple media sizes regularly resulted in cross-contamination between media sizes with the inevitable double-knee saturation curve (the first knee from the smaller media size, followed by the second representing the larger media). Therefore, a wheelblast machine was not an option for my test. The media that I used for my tests was unused and based on experience I know that screening practices at Ervin will guarantee particle size distribution conforming to SAE J-444 and AMS 2431/1 or /2 as applicable. Media breakdown was not a significant criterion given the few cycles that my testing consisted of.

Majority of peening applications, particularly in Aerospace, tend to be with airblast machines. Therefore, I created a baseline by developing saturation curves at 40 PSI. In order to draw parallels with the velocity generated in a wheelblast machine, I developed another set of saturation curves under similar conditions except at 70 PSI. Field data gathered over the past has indicated that velocity in the range of 250 to 270 FPS is generated at 70 PSI. This is the range where most wheelblast peening applications operate.

Pros of this test

1. Manual operation allowed an 80–85 degree impact angle on the Almen strip
2. Small blast cabinet provided a highly controlled environment with minimal cross-contamination
3. Small cabinet limited the variability of stand-off distance
4. Rapid media changeover due to the size of the cabinet and reclaim system

Cons of this test

1. Holding the nozzle in a steady fashion in relation to the Almen strip was challenging at high pressures, particularly with large media sizes.
2. Though 70 PSI testing was to simulate a blast wheel, several other factors such as wheel condition and settings (control cage, impeller, and blades) will also influence the outcome. This was difficult to simulate in my test.

Other constant parameters in my testing included a stand-off distance between 4" to 6", media flow rate of 6 lb per minute using a ¼" nozzle for smaller sizes and a 3/8" for S-550. My goal as stated earlier was to study the effect of media hardness on intensity values so that I could guide my blast clean and shot peen users on their media choice. In spite of some of the constraints (cons) listed above, I am hopeful that this exercise will achieve the desired outcome.

Figure 1. Manual blast test set-up

THE OUTCOME

Let us start with some fundamental information on the peening media that was chosen for the tests. Table 1 lists nominal diameters of different shot sizes along with their volumes. Volumetric increase is quite significant from one size to the other in our choice of sizes; notwithstanding the fact that a few SAE sizes have not been listed and tested between S-230 and S-550. This data might partly explain the results depicted in Chart 1 on page 16.

1. The spike in intensity values is consistent between standard and M hardness shot, i.e., from 40-51 to 47-56 HRC, between 30-40%.
2. The percentage increase in calculated intensity is higher going from M to H hardness (47-56 to min. 60 HRC), with increase in shot size. As to be expected, increase in intensity from standard to high hardness is significant. Is that justification enough to use a harder shot simply to take advantage of the high-particle count? It is important to remember that hard particles are also more brittle and susceptible to fracture faster than their softer counterparts. In shot peening applications, one of the goals in media maintenance is to keep sharp edges generated from broken particles out of the media stream.
3. Increase in particle volume and mass (mass = density x volume) could be an obvious reason contributing to this spike.

	Nominal diameter	Volume	Increase	Range	Particles/lb
	Inches	Cubic Inches			
S-110	0.011	0.0000007			2,100,000
S-170	0.017	0.0000026	269%	S-110 to S-170	745,000
S-230	0.023	0.0000064	148%	S-170 to S-230	324,000
S-550	0.055	0.0000871	1267%	S-230 to S-550	240,000

Table 1: Volume of different shot sizes

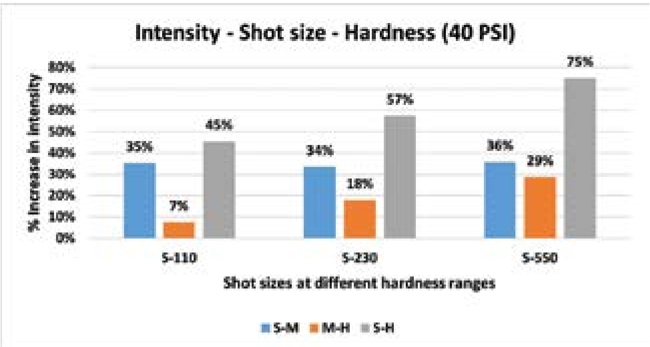

Chart 1: Characterization of three common media sizes at different hardness ranges

70 PSI			
	S-M	M-H	S-H
S-110	31%	3%	35%
S-230	39%	10%	53%

Table 2: Increase in intensity between different hardness ranges at 70 PSI

	40 PSI	70 PSI
ASR-ASH170	31%	34%

Table 3: AMS grade media performance

4. Chart 1 depicts results when peened at 40 PSI. The results were comparable when peened at 70 PSI to mimic wheelblast velocities. Similar results were noticed with AMS (formerly MILSPEC) grade media.
5. Though the tests were carried out with only cast steel shot, a similar outcome can be logically expected with regular and high hardness conditioned cut wire.

CHALLENGES AND ANOMALIES

- One of the challenges of peening anything manually, including an Almen strip, is that it achieves coverage quite rapidly. Therefore, at low air pressures and small media sizes, the possibility of achieving saturation before the first data point is quite high. My first data point was at 15 seconds—peening for shorter duration than was impractical.
- Among a total of 19 saturation curves, I finished with three, type 2 saturation curves. Though a type 2 curve doesn't necessarily imply an error in the process, it is important to be able to identify a potential incorrect data point falsifying type 2 curve conditions. In such cases, it is best to repeat the data point or the entire exercise if necessary.
- I noticed an anomaly during the AMS media portion of the test. Whereas all tests were conducted with a media flow rate of 6 lb/min, an incorrect valve adjustment resulted in a 12 lb per minute flow rate with ASR170 at 40 PSI. When the error was detected (the nozzle appeared to be choking), the valve was closed a few rounds to reduce the flow to 6 lb/min and testing continued. The recorded arc heights and resulting intensity surprisingly showed very little variation from the high flow rate condition, leading to anomalous conclusions. *I would have expected the intensity to increase with reduced media flow.*

HOW IS THIS DATA USEFUL?

1. The tests validate the possibility of using higher hardness peening media to achieve higher intensity values. The quantitative data validates that this increase can be made in stages with the first stage (S-M) leading to a significant jump in intensity. It is useful to point out here that hardening transforms the metal, in our case, media particle to a stronger structure and a different metallurgical state. The downside to this transformation is that it becomes brittle and easier to break.
2. A direct result of using hardened material is that the increase in intensity will not be at the cost of reduced coverage. On the contrary, coverage will be impacted (slower) had you opted for a larger size shot to achieve the same goal.
3. It is useful to know that the trend is the same at different air pressures (especially in the range of velocity generated by a centrifugal blast wheel).
4. Applications that have the flexibility to peen with SAE grade media can test four different hardness grades (instead of two with AMS grade) to determine the optimum balance between intensity, coverage, shot size and hardness (taking media breakdown into consideration).
5. All the above apply to cleaning applications as well where tenacious scale or rust might require the use of harder media without affecting cycle time or re-clean potential.

FUTURE STEPS

I have often commented on the slow pace of development in our industry, but there are still a lot of nuances that when explored could make peening (and cleaning) much more effective. Some future possibilities include:

- Filling the blanks and creating a matrix with other media sizes that were not tested.
- Non-metallic peening media such as glass bead and ceramic. Possibly conduct similar tests with aluminum oxide, commonly used in grit blasting Aerospace parts prior to thermal spray. Our goal is to study the change in impact energy with hardness, and this energy is vital in cleaning as well as grit blasting in terms of creating uniform surface topography.
- Media degradation (metallic and non-metallic) and its effect on intensity.
- Creating a similar set of data with suction guns (with non-metallic peening media and small size shot).

I look forward to reporting on the above as we continue on our path!

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