AN INSIDER'S PERSPECTIVE

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Tribal Knowledge in the Blast Industry

Part Two

LOOKING AHEAD FROM PART 1

I hope you enjoyed Part 1 of our discussions in the Fall 2020 edition of *The Shot Peener*. The feedback from the global shot peening community was quite encouraging. It is either the pandemic that has afforded folks more time to read magazines or a genuine stoking of their nostalgia that the article partly intended to do! Regardless, it was enough impetus to prompt re-visiting this topic! In Part 1, we discussed the importance of velocity and tried characterizing the magic number of 240 feet per second that we were familiar within the industry. My four retired colleagues that contributed to the article's content had a variety of other information to share from the "tribe", but velocity being such a profound topic, I got lost in the depth of that discussion, necessitating a sequel to Part 1.

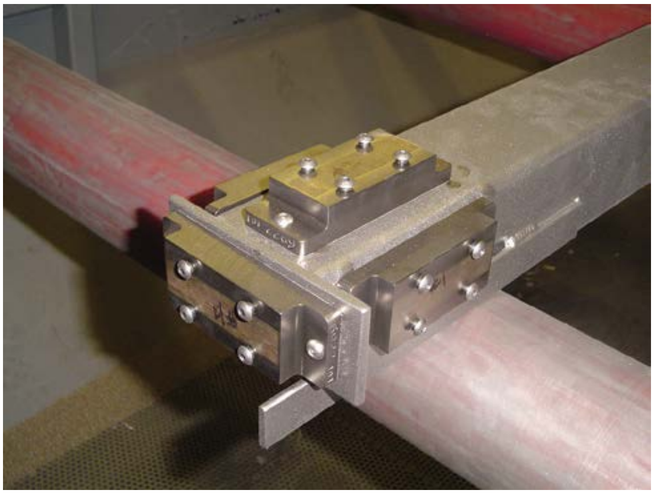
Most recently, I had the opportunity to work on an application to peen the ID of cylindrical aerospace components. This brought me face-to-face with another important aspect that could not find a place in our earlier discussion. That is, discharge velocity is also dependent on the nature of device responsible for generating it. For example, at 50 PSI, a venturi-style nozzle blasting in an open environment can generate the maximum velocity it is capable of (just like a blast wheel discharging its abrasive inside a contained enclosure, i.e., blast cabinet). In both cases, the discharge is unrestricted. However, when blasting inside a cylindrical tube, most applications require the media stream to be deflected on to the ID walls. This deflection, which is the function of a deflector tip at the discharge of the nozzle, results in loss of energy at that point. Velocity losses as high as 25% to 30% are common in such instances and the user needs to accommodate for this loss by increasing the air pressure (or by reducing media flow) to maintain the comparable impact energy as a conventional nozzle.

FIXTURES

My colleague Ron Barrier at Wheelabrator was prolific with what we termed "Barrierisms." He was known to come up with terms that would challenge English majors, and one such term was "obviosity." When interviewing for this article, Ron related this story about fixturing a large bathtub for a customer demo that went in vertical and came back horizontal. Ron remarked, "the obviosity of the occurrence never struck me. Parts seldom stay in the loaded orientation once inside the machine. When impacted by multiple wheels, angles, and in some cases varying wheel velocities, re-positioning of the part was only obvious (validating his coining of the term!). The part came out shaded and demanded the need for drastic re-fixturing."

Fixturing is often the most ignored step in cleaning operations but thankfully taken seriously in shot peening. When cleaning, assuming the intent is to clean without any surface reservations such as masking or overspray concerns on the part, the operator only needs to ensure that the part stays long enough in the machine to get thoroughly cleaned. The work handling arrangement often dictates the type of fixture to be used. Batch style processes do not require individual part fixtures, whereas parts (or a single part) on a rotary table almost always need fixturing. In other cases, parts are suspended and spun from a hanger hook, or passed through on a monorail or placed on a work car without elaborate fixturing. Though it sounds easy, fixturing details are usually finalized only before an actual production run as a last minute rush. The reason being that parts perform differently under blast conditions and no matter the time and effort one has invested in designing a fixture in advance, change is inevitable. Though Ron does not discourage preparation work in advance of the actual testing, he recommends making allowances for the shift during the actual production run.

Fixturing in shot peening applications is better defined. This is due to the nature of the operation and expected results. The shot peener relies on use of an MVT (Machine Verification Tool) or PVT (Part Verification Tool). The former (example in picture on page 22) considers the possibility that parts of varied geometry will be processed in the machine and that the machine should be able to produce repeatable results no matter the part geometry.



A PVT, on the other hand, is part specific and mimics the actual part. Fixturing this in the machine offers insights into what the actual part-holding fixture might look like. The PVT accounts for areas needing intensity verification, and considers aspects of overspray and masking.

Ron adds some common tips to be followed during fixture design: (a) avoid multiple moving parts and design single-piecepart fixtures, (b) ensure that fixture wear will not dislodge or re-position parts without adequate warning (routine wear) and finally, to re-iterate, (c) plan for the impact of multiple blast wheels or nozzles on your part positioning.

There are instances where part masking also doubles up as fixtures. An example of this fortunate situation is when separately peening the root and airfoil section of engine blades. Different intensity ranges in the two critical areas of the blade require masking of one when peening the other. In this case, masks perform a dual function when fixturing the part on a rotary table.

As a side note, blast wheel positioning has other ramifications in addition to shifting the part during blasting. This can be better quantified in peening machines where we indirectly measure the transmitted energy through deflection of the Almen strip. "All upblast wheels generate lower arc heights and most of them are victimized by 'rain down' from the downblast wheels," explains Ron Barrier. We have often heard that the optimum blast angle is when the media stream impacts the part at about 70 to 80 degrees. This eliminates the likelihood of energy loss due to opposing stream interference when blasting at 90 degrees. This situation is sorted out quite easily in an automated airblast machine by simply altering the angle of impact, but not so in a wheelblast machine where wheels are mounted in fixed positions. Ron's solution to this situation is to plan for higher wheel speeds (using inverters) in upblast wheels, and stagger the upblast from downblast wheels if that is a possibility. Such situations, though not common, are often noticed in pass-through wheelblast machines that shot peen complex aircraft structures requiring blast wheels to be located at compound angles and sometimes in upblast orientation.

TUMBLAST MACHINE CHARACTERISTICS

Switching gears from fixtures, masking, and wheel positioning, let us discuss some characteristics common to machines of interest. During the maiden days of shot peening (and to date) in the automotive industry, tumblast-style machines were largely employed to peen valve springs in small batches. Such tumblasts range from 3 CFT up to 14 CFT in volumetric capacity. Tumblasts are also seen in foundries, where "the rule of thumb is to load them up to 180 lb per CFT of volumetric capacity," explained Bill Raby, a knowledgeable, retired colleague that invested a significant time in foundry applications. "The capacity calculation is a general rule of thumb, part geometry will dictate the actual loading capacity in a tumblast. When parts present the threat of nesting into each other, or 'bond' with one another due to surface tension, you will need to introduce dummy pieces along with the actual part load to break this bond and allow the flat parts to achieve proper exposure during cleaning. An example would be to mix cylindrical parts instead of processing all flat parts," added Bill Raby. Loading a tumblast, though seemingly straightforward, can get complicated fast depending on the part type. I recall an instance where the customer was cleaning heavy duty anchor chains in a tumblast. Due to the rigidity of the links, the chain started "climbing up" inside the tumblast mill to a point where it started physically interfering with the blast wheel and damaging the unit!

Tumblasts are one of the oldest machine types used in blast cleaning and shot peening applications. As such, everyone has a tumblast story or tip to offer. The highlight of my tumblast experience was seeing a 100 CFT capacity tumblast in a Brazilian foundry—the largest I have seen in my 30+ years in the industry! Later, I learnt that Wheelabrator used to demonstrate the volume (size) of this machine by positioning a VW Beetle inside the mill. Jay Benito (retired from Wheelabrator and Pangborn) had his own set of tips to share on this machine type. "Tumblast machines suffer when they're loaded at less than 2/3rd their capacity. At lower volumes, the parts tend to travel towards the left of the mill,

exposing the right to the brunt of the blast wheel. Depending on the direction of wheel rotation, this could shift to the opposite side, but nonetheless result in improper cleaning and undue wear of machine components (slats and end liners). Tumblasts are most efficient when they are loaded to their full capacity," explains Jay. On the topic of part nesting and drop in exposure, Jay recommends welding or bolting a "tumbling bar" (as shown in above image) at defined intervals along the width of the belt.

In the shot peening world, I have often recommended that users, instead of simply tossing in an Almen block with a strip inside the tumblast to check arc height, use a flat bar or angle with Almen test blocks in at least two locations and then check results. Not much is written about blast wheels in the shot peening world, especially in the aerospace industry. I would like to take advantage of this lacuna and transfer the sage advice offered by my retired colleagues. "Blast wheels with eight and twelve blades are the most common ones that prevailed in the market," says Ron Barrier. Having worked for a large company, Wheelabrator, Ron's exposure has always been to such wheel designs. Though wheels have been designed with lesser (four and six blades), eight-bladed wheels were found to offer the best compromise between cleaning speeds and an efficient blast pattern. Jay Benito adds, "Eight bladed wheels offered a distinct hot spot that was diminished in the twelve-wheel design. The selling feature of the 12-bladed wheel was that the abrasive was spread over 12 blades, effectively reducing the wear on each blade. There wasn't much conclusive evidence whether this factor actually played a role in cleaning efficiency, resulting in this wheel not gaining wide popularity."

Let us compare this with the airblast world where a similar analogy can be made between straight-bore and venturi-style nozzles. The latter is preferred for most applications today due to its uniform blast pattern. In terms of blast pattern, an ideal pattern is about 1.25" to 1.5" diameter with a pressure blast nozzle and significantly smaller with a suction-style gun. For this reason, a good designer follows a "convergence" pattern where two or more nozzles, when used in an automated airblast machine, are located so that they converge to form a pattern consisting of ovals overlapping each other.

SHIFTING OF PATTERNS IN BLAST WHEELS

It is common knowledge that wheel and nozzle wear will cause a shift in the blast pattern. This shift, unless corrected (compensated), will lead to cabinet areas, instead of parts, receiving the wasted impact of media and a drop in coverage on the part being peened. So, how does one go about checking the pattern?

Ron Barrier explained this technique used in his demo lab: Right after the blast wheel has been fitted with new wear parts (control cage, impeller and blade set), perform a blast test with a 14 ga sheet of metal. In a multi-wheel machine, perform this test for each blast wheel separately. When blasting this thin metal sheet, make sure that blasting is carried out for a short duration of about 15 seconds. Mark the hot spot on this template. You now have a template to compare against after the wheel has worked for a few hours and experienced wear. Repeat this test periodically through the wheel's useful life. Compare the pattern with the original template. Shifting of blast pattern does not mean that the wear parts must be replaced. It could be a simple case of re-setting the control cage to bring back the pattern to as close as possible to the original. If shifting the cage still does not bring back the pattern to its original location, it may be time to change the main wheel wear parts, such as blades, impeller, and the control cage.

Though tempting, always change the entire blade set and not just the ones that are worn. Blades are dynamically balanced as a set and changing just one or two blades will result in imbalance in the wheel, especially when turning at considerably high speeds. Similarly, changing the shot size will also result in a pattern shift. Switching from one shot size to another will result in a linear shift in pattern. Run your template after the size change so that the control cage can be re-set accordingly. Along similar lines, the abrasive leaves the blast wheel around 140˚ to 160˚from the opening of the control cage. This will also need to be monitored when adjusting your blast pattern.

TO BE CONTINUED...

A few other topics were unearthed when I discussed this article with my colleagues. Such subjects included shot storage, airwash separator settings, use of rotary screen, etc. This makes it worth continuing our discussion to Part 3 of this subject. I expressed optimism that such information, though absent in textbooks, is still available with these profound human repositories! My goal is to bring them out to you, the regular users of this process, with the hope that they will add value to your peening and cleaning operations. I look forward to writing for you again in a few weeks. ●