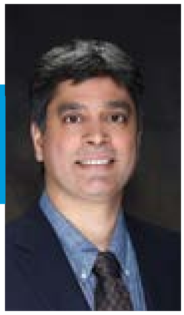

AN INSIDER'S PERSPECTIVE
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Future of Wheelblast Peening

Background

The image of a shot peening machine seldom includes centrifugal blast wheels. Instead, it is more common to see blast nozzles articulating in an automated arrangement with sophisticated work handling systems. In an effort to provide a balanced training experience, I start my first class at the shot peening workshops enquiring about the volume of wheelblast machine users in the audience. Along with the small fraction of hands that are raised, I am often greeted with quizzical stares offering validation that I had just introduced them to a new concept!

Though wheelblast machines have been used for shot peening long before nozzles became prominent, their lower population can be attributed to the dominance of Aerospace peening applications. In Aerospace, barring a fraction of wheelblast peening machines for structural components and landing gear, the majority of applications use compressed air type media propulsion. Therefore, it is not surprising that much has been documented and reported on airblast peening techniques and less with blast wheels.

I started my career working with wheelblast machines and later got introduced to airblast. This has provided me the opportunity to understand the subtle nuances of both types of propulsion systems while appreciating the role different process variables play in both, particularly in shot peening. A detailed discussion can be found in a two-series article[1], and I will try to incorporate some new perspectives on such machines through interviews with wheelblast equipment manufacturers and end-users.

Bob Schoen, Director of Technical Services at Blast Cleaning Technologies (BCT) in West Allis, Wisconsin (USA), is a good friend and past work colleague and he was kind enough to contribute to this discussion. An average month has me visiting upwards of twenty customers in multiple industries. Through these visits, in addition to Bob Schoen, I have interviewed several end-users to add to the content of this article. Due to corporate confidentiality reasons, I am unable to list their identities here.

[1] The Role of Wheelblast in Shot Peening – Part I and II, *The Shot Peener*, Spring and Summer 2017.

My goal is to address the following:

(a) key considerations when designing a wheelblast machine suitable for shot peening,
(b) mechanical and controls enhancements between cleaning and peening,
(c) challenges when peening with blast wheels and possibilities to overcome them, and finally
(d) where the R&D dollars are being allocated in wheelblast peening equipment.

Stepping outside of airblast

With the exception of a handful of Aerospace applications identified earlier, wheelblast machines are prevalent in other industries that peen their components. These include Automotive, Mining and Railway to list the major ones. Machine types are tables, tumblasts, spinner hangers and some with pass-through work-handling arrangements. Though AMS conformance may not necessarily be their target, users in these industries understand the need to monitor and control media velocity, size and flow rate. Since blast wheels are less discriminating in impacting specific areas, users regularly employ innovative masking techniques, including shadow masks that are not generally seen in airblast machines. The ultimate goal of countering tensile stresses in their components by imparting compressive stresses remains the same as in airblast applications.

As a design engineer during the early part of my career, the challenge of proper blast wheel placement often made me nervous. The flexibility of an articulating nozzle regularly mocked the rigidity of a blast wheel with its permanent seat on the cabinet walls. I learnt early on that wheel placement could spell trouble if not done properly. Bob Schoen (BCT) explained the importance that his company places on blast patterns. "At BCT, we spend a great deal of our preliminary engineering time focusing on wheel patterns and locations. Our 3-D simulation software not only scans the part geometry but also extrapolates changes in its position during rotation and re-positioning (indexing) during different stages of the peening cycle. Unlike cleaning, in peening applications we do not rely on rebound/ricochet for coverage. Our faith is in the first impact which we know is critical in peening to ensure uniform transfer of energy. Our engineers are also mindful that the rebound stream does not conflict with the outbound media from the blast wheel, thereby preventing loss of incident velocity. Instead of creating potential confusion with multiple wheel styles, we have focused our energies on perfecting the design and material of blast wheel parts so that wear is predictable. This helps standardize media velocity and assists with the ability of the media stream to impact the desired part surface."

Bob went on to explain the importance of proper fixture design which goes hand in hand with wheel placement. "Fixture design must allow unimpeded drainage to prevent semi-closed areas from flooding with shot. Majority of our cleaning and all of our peening machines are fitted with variable frequency drives to alter the speed (velocity) of the blast wheels and MagnaValves for flow control. We follow a strict regiment of controlling the wheel current in peening machines within a closed feedback loop. Ensuring an uninterrupted flow of media to all wheel locations is critical, and shallow feed angles must be avoided at all costs, and with that the unreasonable expectation that shot will flow like water through a pipe!"

Mechanical advances in wheelblast

"Our portfolio includes a large percentage of machines destined for less-forgiving production environments such as foundries and primary steel," explained Bob Schoen. "For such applications, we designed an innovative airwash separator with an intuitive lip that opens only when shot volume for full length of media curtain is established. We use a similar system for our peening machines as well." Bob describes the lung of any blast machine—the **Airwash Separator**. Though we generally do not associate generation of dust with peening operations, it remains important to eliminate broken media particles (fines) and any dust from the media stream. A discontinuous shot curtain at the airwash will result in inadequate separation of dust from media.

Media analysis for size and shape is required for new and in-process shot. New media is evaluated before being introduced into the machine and requires no more than a sample splitter to obtain a representative sample. Sample collection for in-process media is a bit more involved, especially in a wheelblast machine. "To facilitate retrieval of a true sample, we have designed a remote abrasive sampling port that can be attached to the feed spout of the blast wheel. This is as close as practical to obtain a media sample that is just about to be introduced to the blast wheel," stated Bob. I regularly remind our customers to refrain from collecting media samples from an area of static accumulation such as from inside the blast cabinet.

Wheelblast patterns comprise of a heading, tailing and hot spot where about 70% of the energy of the media stream is concentrated. Wheel parts such as the control cage, impeller and blades are subject to constant wear, and this results in gradual shifting of the blast pattern. Most manufacturers will recommend blast testing a template and study the pattern to assess wear halfway through the expected life cycle. This will be followed by re-adjustment of the control cage clock dial to return the hot spot to its original position. One of the risks associated with this practice is the possibility that the control cage might not be installed correctly after reset.

Bob Schoen explained to me that BCT has eliminated this and recommend replacement of the control cage altogether after designated usage. "To facilitate this, we manufacture our wear parts from material with greater wear resistance than currently offered within the blast industry," added Bob.

In one of my earlier articles, I introduced our readers to a technology that was introduced by the German Technology Center of Wheelabrator where they had installed sensors at the extremities of the control cage opening to detect wear outside of preset tolerance and automatically adjust the control cage to its original setting. In addition to such techniques, the industry has undertaken several other initiatives to:

(a) improve material technology of blast wheel parts to increase wear life (leading to predictability of wheel patterns and velocity),

(b) quick-change arrangements to remove wheel parts or the entire blast wheel during times of maintenance, and

(c) mobilize blast wheels by fitting them on to oscillating panels that coordinate with part movement in the blast cabinet. All of them aim to ensure accuracy, repeatability and consistency of results that are pivotal to a successful peening operation. Given the volume of shot that a blast wheel propels, such practices are not easily accomplished in wheelblast machines.@

Process-related advancements

Aerospace end-users are familiar with PVTs (Part Verification Tool) and MVTs (Machine Verification Tool). This concept is now being developed in wheelblast machines as well as for non-Aerospace applications. Though the optimum means of peening a part is to spin it about its own axis, the spinner hanger does not always offer good predictability in terms of impact from rebound media on part areas that are on the far side of a pattern. The classic example is an X-mas tree type hanger fixture that is fixtured with individual, small automotive components on its branches. When tested at regular intervals, an MVT comprised of a fixture with Almen blocks on different branches of this fixture can be used to validate that all parts will receive proper coverage at the required intensity and impart the expected residual compressive stress.

One of the earliest machines used for shot peening is the popular Tumblast. A batch of parts is tumbled in an endless mill in this machine type, with active part-part contact. When testing Almen strips in this machine, common practice is to toss in a couple of Almen blocks to read arc heights. Manufacturers, such as BCT, advocate validating arc heights with the blocks in static condition and testing without running the mill. Though it is important to conduct testing in conditions that would prevail when peening actual parts, movement of parts in a tumblast is random and a better measurement of impact energy can be obtained with the Almen strips in static position.

It will be inspiring to see the following process-related advancements:

- Realtime measurement of media velocity. I acknowledge the challenge that this could present given the widespread nature of the blast pattern generated by a wheel. However, I am confident that alternate parameters to wheel speed and diameter could be utilized to characterize this critical variable.
- Coverage predictability based on media flow rate and part positioning. With blast wheels flowing about 10x the amount of peening media as nozzles, a better estimate of coverage could positively impact processing time and operating cost.
- Advanced techniques in in-line size and shape control since current technology limits the monitoring to a fraction of the total flow rate.

Where are we headed with wheelblast?

The answer to this question is subject to the industry to which it is posed. Let me explain the response I received from users in Automotive. A census of machines in this industry revealed the average age of equipment to be around 25 years. Users reported that most of these machines are overdue for replacement and will benefit from technology developments such as direct drive wheels, VFDs, MagnaValves, etc., when replaced. Some of those relay-logic controls will benefit from PLCs and HMIs that are more intuitive to the operator. As the awareness of proper peening techniques increases, these control systems have started to incorporate saturation curve solver software as part of the HMI, leading to reporting and storage of critical data.

Aerospace end-users report a different dynamic. Though their machines are also aged, I noticed that their ability to maintain these machines to higher repeatability levels is quite impressive. We are aware of the challenges the pandemic posed on almost all industries including Aerospace where its highly skilled workforce started receding. To mitigate the impact of such events in the future, there is a push towards automating certain activities that are currently manual. This includes machine tending, fixturing, part loading/unloading and transfers. There are discussions around AGVs to transport components from one operation to the other and robotization initiatives that were until now commonly seen in automotive.

End-user needs are ideally provided by the equipment manufacturers, and to some extent that is true in our industry as well. That said, I would like to report on a fascinating experience with a foundry customer that might evoke some ideas in others too. This customer realized that their specific reporting needs can only be addressed by those close to their process. This led to in-house development of software for real-time monitoring and reporting of its shot addition, waste analysis, and quality of shot input to its machines.

Though my intention is not to diminish the efforts and advances of our equipment manufacturers, it seems to me that the most efficient process design is not obtained by picking from a database of screens but achieved through a healthy collaboration with the end-user. The progress with wheelblast machines may not appear to keep pace with robotic nozzle peening machines, but there still exist many opportunities for optimization in those high-volume applications peening Automotive parts that might set the precedent for advancements in wheelblast.