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Shot Peening's Contribution to Blast Cleaning Equipment

WHILE THIS ARTICLE'S HEADLINE suggests that blast cleaning is somehow dependent on shot peening, the truth is shot peening might not exist if it weren't for blast cleaning. For those who are familiar with the history of shot peening, and with apologies to village blacksmith whose original utilization of peening is often ignored, beneficial residual compressive stresses were discovered in automotive engine valve springs that had been shot blasted to remove paint. John Almen, an engineer at General Motors in the 1930s, made this discovery and developed the tools that became crucial to today's commercial shot peening process.

The automotive industry began peening components, such as high-volume springs and transmissions, and the process quickly gained recognition. The Almen gage, Almen strips and SAE specifications gave shot peening credibility as a repeatable and measurable process and soon aerospace came on board. Aerospace added shot peening to their list of techniques for the manufacturing and refurbishing of landing gear, engine components and aircraft structures.

Blast cleaning doesn't have such a well-documented history or dramatic evolution, but its purpose was not an accidental discovery. The vast number of parts and surfaces that have been cleaned in the last hundred years attest to its popularity. In addition, the life of a downstream coating is only as efficient as the pretreatment process and blast cleaning is the most popular pretreatment process. Blast cleaning takes the largest share of investment funds in the surface finishing market.

So how does our industry view these closely related processes? The following are common perceptions from users of blast cleaning and shot peening equipment:

Blast Cleaning	Shot Peening
Commoditized	Critical
Low-Tech	Controlled and Regulated
Volume-Based	Specification-Based
Dirty and Noisy	Training is Essential
A Necessary Evil	Beneficial

Clearly, blast cleaning deserves more respect because blast cleaning equipment has evolved over the last 20-25 years to incorporate:

- PLC for programmable features
- Affordable and sophisticated automation (Example: robotics)
- Better dust collection techniques
- Adoption by demanding industries (Example: medical)

These improvements were adapted from shot peening equipment. Let's look at the features of shot peening that have migrated to blast cleaning and how these features are changing the blast cleaning machine industry.

Measurement, Quantification and Repeatability

Shot peening results are objective and blast cleaning results are subjective. The goal in peening is a numerical value of intensity (i.e., the transfer of impact energy), leading to a residual compressive stress value and expected improvement in the fatigue life of the component. The quantification of results leads to validating the process independent of the machine operator, equipment, location and any other non-process related variable. For example, the peening intensity of 0.011 A (or 11A), determined by using Almen strips and plotting a saturation curve, can only mean the transference of a finite amount of impact energy.

In contrast, a component is determined to be "clean" by visual inspection only. What if we recognize that measuring the part's cleanliness via Almen strips could be a more valuable tool than visual inspection? The benefits would be:

a) the establishment of a quality standard for cleaning

b) proactive identification of the deterioration of the process that addresses the classic conundrum: "Nothing has changed with the machine but the parts aren't getting as clean"

c) a simple check of the machine's health and wear of machine components

d) opportunities to introduce cleaning to industry sectors with established processes

Blast cleaning facilities with niche applications have implemented Almen strip practices to quantify and validate their cleaning operations. It's reasonable to expect that demanding industries, like medical, will adopt this practice, too.

Efficiency and Cost Controls

Blast cleaning machines run much larger production volumes than shot peening machines. Therefore, the opportunities for cost savings are greater in blast cleaning operations. Let's consider one such opportunity: **cleaning velocity**. In a centrifugal wheelblast machine, the media velocity is directly proportional to the wheel speed and diameter. Some wheels are capable of generating velocity in excess of 360 feet per second (110 meters per second). Similarly, airblast machines can generate velocity as high as 600 feet per second (183 meters per second) with the appropriate nozzle type and air pressure. Since there's a misplaced belief that high velocity will lead to faster cleaning, machines continue to blast at unnecessarily high impact energies, leading to greater media breakdown rates and increased operation costs.

In shot peening, we have a clear understanding of abrasive velocity and the need for its control. Higher or lower than optimum velocity will lead to incorrect peening results and potentially disastrous product failure. The closed feedback loop for air pressure, commonly seen in peening equipment, is now being employed to moderate air pressure in cleaning applications with the subsequent reduction in media and machine maintenance costs.

Choosing the correct **media hardness** can also reduce costs. Abrasive is typically manufactured in three hardness grades: Soft, medium and hard with brittleness increasing with the hardness level. In shot peening, there is a 0.001 to 0.002 increase in intensity from one hardness grade to the next. Because media hardness affects intensity, it is often part of a specification and the appropriate hardness levels have received a great deal of attention in shot peening applications. Using shot peening's knowledge base on media hardness, we can select the correct hardness for our cleaning applications and get a handle on operating costs. For example, your cleaning application may work to optimum levels with a softer grade of abrasive. But due to incorrect advice, your machine may be using a harder grade, leading to increased breakdown rates.

In general, increased **media flow rates** result in faster work cycles. This is also true for shot peening, with a slight twist. Increased abrasive flow could flood intricate areas of the part resulting in 'abrasive-on-abrasive' instead of 'abrasive-on-part' impact. This could also happen in cleaning applications, particularly when targeting small, confined areas (we are working with the assumption that the correct media size is being used). In shot peening, we have learned to monitor and control media flow rates. Some cleaning machines now employ automated flow control techniques, too. Commercially available flow control valves, such as the MagnaValve®, are designed with closed feedback loops to ensure constant media flow rate. Some foundries are adopting this valve because it doesn't have any moving parts and therefore requires little maintenance.

Controls

All shot peening processes are driven by specifications. In addition to the process specification, a part-centric specification is utilized to achieve desired the fatigue strength. Specifications have been defined to the point that they categorically state the requirement for Computer Monitored Peening (AMS 2432). The advantages of AMS 2432 are traceability, repeatability and accuracy. In addition to computer controls, peening applications have embraced robotics and advanced automation. Blast cleaning operations for the automotive industry are no longer content with relying solely on visual inspection—they are purchasing blast cleaning machines that have adopted the controls and technology of shot peening machines. Computer controls now allow critical process data from cleaning machines to be recorded and analyzed in a database to improve cleaning results and control operating costs. (An interesting note: The successful transfer of technology from shot peening to blast cleaning equipment is mostly due to OEMs that manufacture both.)

In Conclusion

As we have reviewed in this article, blast cleaning equipment design has greatly benefited from the shot peening process and equipment. However, there is the potential for even greater technology transfer. For example, shot peening operations, particularly in aerospace and medical, operate under very clean and relatively quiet conditions—two work conditions alien to many cleaning environments. To achieve these benefits, shot peening machines are built with sound-deadening materials and improved cabinet and work seals. Blast cleaning machines can certainly evolve in this area and quieter, cleaner blast cleaning operations would radically improve the perception of this vital industry. And as government and safety regulations increase, a cleaner and quieter factory floor might become mandatory.

More shot peening equipment will connect to the Industrial Internet in the next few years and real-time machine data will be captured and used to increase productivity and reduce downtime. Think of the implications for blast cleaning machines that tend to need more maintenance due to the wear and tear to their components from the abrasive and whose profitability is directly linked to productivity.

We hope this discussion has expanded your appreciation for blast cleaning and the close relationship between the improvements between shot peening and blast cleaning equipment. Shot peening equipment will continue to improve and the progression will continue to the benefit of us all.