Effective Use of Steel Shot and Grit for Blast Cleaning

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Essential for an effective and cost efficient blast cleaning operation is a solid, basic understanding of the characteristics of cast steel blast cleaning abrasives, their selection and use, as well as knowledge of the blast cleaning equipment, its maintenance, and key process control features.

Metalworking industries are the principal users of cast steel shot and grit: Steel mills, ferrous and nonferrous foundries, forge shops, and metal fabricators. Blast cleaning with steel abrasives is a vital and critical operation at various stages of primary metal production. The basic functions performed by blast cleaning fall into these categories:

(1) Remove surface contamination, providing a completely clean surface that aids in inspection for process defects.

(2) Surface preparation: provide a surface profile (etch, matte finish, or anchor pattern) preparatory to further processing such as painting, coating, bonding, etc.

The Blast Cleaning Process

Blast cleaning with cast steel shot and grit can best be described as an impact cleaning operation, in which the workpiece surface is subjected to successive bombardment by a high velocity blast stream containing millions of hardened, effective-size cast steel abrasive particles. The effect of this powerful blast stream impacting upon the work is two-fold:

(1) Contaminant is broken, pulverized, and removed, exposing the clean, virgin metal surface.

(2) Simultaneously, the impact-force of the individual steel particles will impart to the clean workpiece surface a finish profile, the appearance and texture of which is determined by the user's choice of steel abrasive size, hardness and shape (shot or grit).

Mechanics of Blast Cleaning

Properly operated, not only will the blast cleaning process be effective in satisfying the users' quality needs and goals, but will also assure optimum productivity and the lowest possible operating costs.

Surveys conducted by Ervin Industries' Blast Cleaning Task Force have revealed that seven out of ten users of the process often fail to observe proper operating practices. Result: Substandard finish quality, productivity 33% to 50% lower than it should be, and operating costs 50% and more higher than they should be. There are three key operating variables that account for 90% of the reasons why users' fail to achieve both effective cleaning and acceptable operating costs.

The purpose of this article is to make users aware of the three variables and describe the simple, easy-to-use control measures needed to protect against the devastating problems they cause.

Given that it is the impact-force of the individual steel particles that performs the dual function of contaminant removal and profiling, it is necessary to understand how the impact-force is first generated, then harnessed and controlled, to assure effective and cost-efficient results. Certainly, it can be seen that the process must impose a mighty big challenge for these mighty small steel abrasive particles:

S-660 size - 1/16 inch

S-70 size - approx 1/100 inch

Impact energy of the steel abrasive is governed by its mass and velocity in accordance with the equation for kinetic energy: KE = 1/2 MV squared.

The key to understanding the effect on the "mass" factor via size choice, is that the mass of a sphere varies as the <u>cube of its diameter.</u>

Doubling shot size increases the mass, or impact-power per pellet <u>eight times</u>! Conversely, doubling shot size reduces the pellets per pound to <u>one-eighth</u>.

Velocity is derived from either airless blast equipment where steel shot or grit is hurled by centrifugal force from a bladed wheel (Fig. 1), or by air-blast equipment in which the abrasive is contained and metered into a compressed airstream via conveying hoses and nozzles to impact on the workpiece. Velocity in centrifugal blast units is governed by wheel diameter and RPM. Standard 19-1/2" diameter wheels, at 2250 RPM, develop an abrasive velocity of approximately 245 FPS.

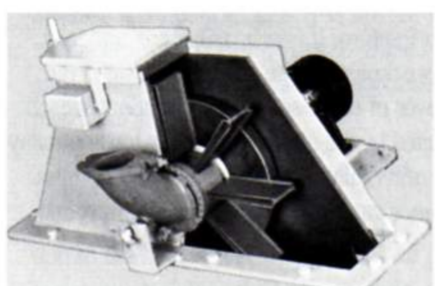

Fig. 1. A bladed wheel hurls the abrasive in centrifugal blast units.

Field experience, over the years, has found the velocity of 245 fps to be effective for the vast majority of blast cleaning applications. Where standard wheels are in use, the velocity factor can be considered a constant. <u>Thus, the impact-force delivered to the workpiece will change only if the mass factor (the abrasive size) is altered.</u>

The relationship of abrasive size to both impact-power and coverage is shown in Fig. 2 (next page).

Fig. 2. Relationship: Shot Size to Impact & Coverage

Shot Size (Mid-Range)	Approx. Impact Value	Approx. Pellets Per Lb.	Equiv. Size Grit
70	1	8,200,000	G-80
110	4	2,100,00	G-50
170	9	745,000	G-40
230	20	324,000	
280	33	192,000	G-25
330	55	114,000	
390	90	68,000	G-18
460	150	40,000	G-16
550	260	24,000	G-14
660	440	14,000	G-12

Shot Impact Value varies as the cube of the diameter
(2:1 Size = 8:1 Impact Value and 1:8 pellets/lb)

Screen Sizes in accordance with SAE J-444

Impact-Force: How Much?

Looking at the other side of the coin, what are the characteristics of the contaminant to be removed? How much impact-force is required?

Before the advent of metallic abrasives, blast cleaning was done using sand as the media, i.e, sandblasting. Even with lightweight sand, the impact was sufficient to remove the contaminant and produce an etch finish. Size for size, at the same velocity, steel abrasive has 2-1/2 times more impact-force than sand, and when steel shot or grit is larger than sand, its impact-force would be many, many times greater, thereby cleaning faster and better.

Consider, for example, oxide scale. Typically, it is hard and brittle. If a small piece is pried or chipped off, then struck lightly with a hammer, it will go to powder. It doesn't require a sledgehammer blow (which would also do a great job of destroying the workpiece).

The challenge for removing most oxide scale is not its toughness and high resistance to fracture. It is primarily the manner in which it is attached to the workpiece at the interface between the virgin metal and the first layer of oxide scale. Each fraction of each square inch must be impacted by the abrasive. Only by hurling many millions per minute of the mini-ballpeen hammers (shot) or mini-chisels (grit) at the workpiece can the job be done effectively and cost-efficiently.

An Effective Work-Mix

An effective, cost-efficient work-mix contains a properly balanced distribution of large, medium, and small particles. The larger pellets, with maximum impact-force, must be large enough to perform the major task of loosening thick, tightly adhering contaminants, and still provide an acceptable finish profile. The small particles provide the coverage necessary for fast removal of the lighter contaminants, and to scour and clean rust, etc., in minute pits and crevices that large shot or grit cannot reach.

Selection of the new, original size shot or grit to be used, automatically determines how large the largest particles in the work-mix will be. What determines how small the smallest particles should be? First, all contaminants (oxide scale, sand, spent abrasive, etc.) **must be kept out of the work-mix.** (As little as 2% sand in the work-mix can double wear on blast wheel components.) The separator and dust collector system, its condition and its operation, determine what is removed - and what remains in the system!

How small can the abrasive particles be and still aid in cleaning? Perhaps this is best answered by pointing out that shot as small as S70 is effective in removing tenacious oxide scale from hot-rolled stainless steel strip.

Development of a Work-Mix

Given reasonably good assistance via proper operating practices, Mother Nature will develop a well-balanced work-mix. While sand as a blast cleaning media could not withstand the punishment of even one impact against the workpiece, steel shot and grit will withstand many hundreds of punishing impacts before finally succumbing.

The first effect of the impact punishment is to work-harden the surface of the steel particle, which leads to the flaking/spalling action shown in Fig. 3. This "onion-peel" effect can cause a pellet to lose enough diameter to become one or two sizes smaller than when new.

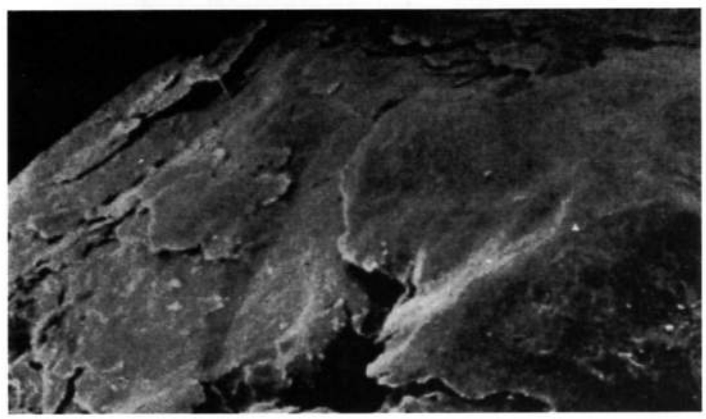

Fig. 3. Flaking/Spalling of Steel Shot

During the flaking/spalling phase, severe internal damage is inflicted on the pellets, evidenced by voids and ruptures, which ultimately work their way to the surface and cause fracture-failure. Fractured particles, amazingly, upon further repeated impacts, are cold-worked, or forged, into spheres of smaller diameter, which ultimately re-fracture into even smaller particles.

It is this combination of events that produces the work-mix. This mixture of new, nearly new, onion-peeled, and fractured particles make up the needed balance of proper impact and coverage. The size distribution of the work-mix will undergo constant change, as spent fines are exhausted from the system and new abrasive additions are made (frequently enough to avoid having the work-mix swing from too fine to too coarse).

Noting the tremendous differences in impact by shot size in Fig. 2, it is obvious that controlling the size distribution in the blast stream work-mix must be a high-priority challenge for the user's cleaning room team.

Out-of-Balance Work-Mixes

A work-mix with a preponderance of fines has insufficient impact-force to be effective (too few large pellets to break up thick contaminant). Conversely, a work-mix with a preponderance of large pellets has a low pellet count resulting in a wide, open pattern that requires much more blast time to do the job.

Out-of-balance work-mixes requiring extended blast time, or reduced line speed, and/or re-blast, have serious adverse effects on product finish, productivity, and operating costs.

Troubleshooting Check-List

Work-Mix Too Coarse: Causes

(a) Large and infrequent additions of new material.

(b) Excessive air through separator, pulling out medium and small abrasive particles.

(c) Excessive carry-out with work, requiring heavy replenishment.

Work-Mix Too Fine: Causes

(a) Poor distribution over shed plate.

(b) Insufficient air through separator.

(c) Excessive time lapse between additions.

(d) Large, sporadic additions of recycled abrasive from floor spillage or system leakage.

Controlling the Work-mix

(1) Add new abrasive every operating shift. Maintain feed hopper at or above 3/4 level at all times.

(2) Do not allow abrasive spillage or leakage to accumulate; return to system daily.

(3) Check work-mix size distribution weekly. Recommended: Use the Ervin Spot-Check Gauge (Fig. 4), which requires less than five minutes to use, providing instant feedback indicating whether or not the work-mix is in proper balance.

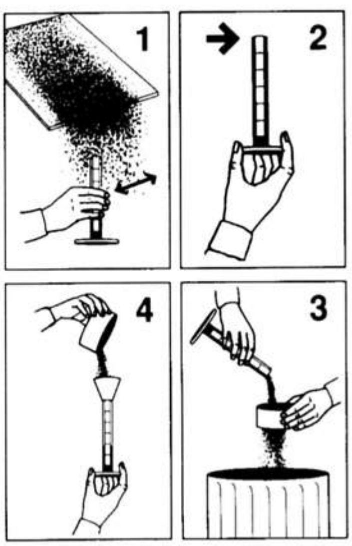

Fig. 4. Ervin Spot-Check Gauge

The Blast Stream...Is It On Target?

Misdirection of the blast stream, with some abrasive missing the work, and impacting instead on equipment wear parts, results in these problems:

1. Incomplete contaminant removal
2. Excessive parts wear
3. Excess machine downtime
4. Excess abrasive usage
5. Lower productivity due to extended blast time or re-blast

When asked—"When did you last check your blast pattern, and how frequently is it done?"— most users did not know, never having seen it done. Other thought it unnecessary, because "the setting of the wheel clock dial is where it's always been." Ervin Task Force surveys have found as many as 7 out of 10 with off-target blast streams—fig. 5. As little as a 10% shift in blast pattern away from proper aim can translate into 25% loss in cleaning efficiency.

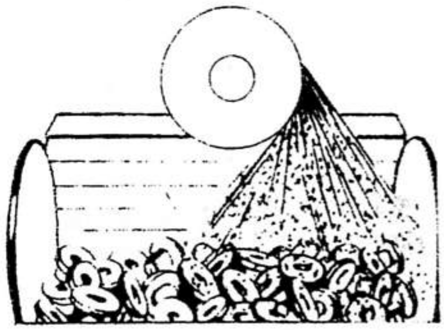

Fig. 5. Poorly aimed blast stream

What must be recognized is that the inevitable factor of wear and tear on blast wheel components will eventually cause a shift in the location and concentration of the blast pattern. Exceptional wear tolerance has been built into blast equipment, but when wear goes beyond that tolerance, components can no longer perform properly, and the blast pattern strays from target.

Consider a 40 HP wheel: Every minute, 1,000 pounds of abrasive passes through the impeller, out the control cage opening, and is then hurled off the blades. **Impeller:** When wear on the leading edge of the impeller segments exceeds 1/8'', the abrasive will hit the back of the blade rather than being delivered to the throwing face. The hot-spot and overall blast pattern becomes badly diffused. Bad aim! **Control Cage:** When wear of the beveled edge exceeds 1/2'' (in some cases only 1/4'', the blast pattern is lengthened, often to the point some abrasive misses the work. **Blades:** When blades become deeply grooved, channeling of the abrasive occurs, and because it is not flowing across the full width of the blade, the pattern is distorted. **Tramp Metal:** When wedged between the impeller and control cage, tramp metal can cause the cage and the blast pattern to shift.

Checking the Blast Pattern

Consider where the workpiece surface to be cleaned is in relation to the blast wheel. The object is to place and secure a sheet metal target-plate at the location of the workpiece, then, after blasting for 10, 20, or 30 seconds, check to see the area and location of the blast pattern. The hot-spot (hot to the touch, and usually about 3'' x 10'') should be located approximately 8'' in advance of the centerline of the wheel. This is the area of concentrated, maximum intensity.

While inspection of degree of wear of the components should be routine (every eight (8) hours of operation), determining the exact degree of wear vs. the critical wear tolerance is difficult at best. Too often judgment is erroneous. A weekly blast pattern check is a foolproof procedure that tells you, now, whether the blast pattern is on target.