Controlling the Centrifugal Blast-Cleaning Process

by Einar A. Borch
Ervin Industries, Inc.

Molten metal is channeled into streams and dropped onto jets of water under pressure, atomizing the molten metal into random sizes of shot.

The reception offices of many, if not most, manufacturing firms prominently display wall plaques declaring that corporate goals (variously stated) are now centered on quality, productivity, and cost-competitiveness. The plaques also affirm the dedication and commitment of management to implementation of these goals.

Centrifugal blast cleaning is that necessary and vital operation in the fabricating and painting shops about which management historically has talked and complained the most, but about which the very least has been done. Failure to convert into action management's concerns about the blast-cleaning phase of the operation has resulted in totally shocking and dismay ing blast-cleaning performance throughout the metalworking industry. Results from blast cleaning have been found to be diametrically opposed to corporate goals.

Principal findings of a recently completed two-year survey and in-depth study by Ervin Industries of the blast-cleaning operations of more than 115 major users of the process throughout the U.S. and Canada reveal the following:

- In fully nine out of ten instances, the quality of finish after blast cleaning was found to be substandard, with inconsistent cleaning and profile results from day to day. Too often, contamination was not completely removed; too often, an excessively rough surface profile was produced.
- In nine out of ten cases, calculations by the survey team revealed that the total cost of blast cleaning was, on the average, at least 33 percent to 50 percent higher than it should be.
- In nine out of ten cases, productivity of the blast-cleaning function was 33 percent or more below what it should be.
- Incredibly, again in nine out of ten instances, cost control records for blast cleaning were either totally inadequate or nonexistent.

Results such as these, which in no way measure up to management's goals, would appear to be a most damning indictment of the blast-cleaning process. Actually, however, the blast-cleaning process itself is no more to blame than is the golf club or golf ball when we slice the ball into the lake, because at the moment of truth, when club met ball, we failed to keep our eye on the ball.

And so it is in blast cleaning: failure to "keep our eye on the ball" is precisely what produced the dismay ing blast-cleaning performance outlined above!

In blast cleaning, the "moment of truth" occurs when the abrasive particle impinges on the work-piece. When we focus our attention upon conditions existing at this moment of truth, and then work our way back through the system, we can quickly identify the critical prob-
lem areas and the causes of poor finish quality, low productivity, and prohibitively high costs of operation.

Interestingly, even though a list of 50 or more potential variables in the blast-cleaning process could be made, just three basic variables have been found to account for as much as 90 percent of all problems experienced relative to finish quality, productivity, and cost. And each of the three basic variables relates directly to that "moment of truth" when the steel shot or grit strikes the work-piece surface.

Using the "moment of truth" analogy as it would apply to the sport of bird-hunting enables us to crystallize the three basic causes of problems. Consider the problems one could expect if he took his shotgun to go bird-hunting and discovered:

- the shotgun shells were loaded with the wrong size pellets (We shall refer to this factor as "size");
- the shotgun wasn't correctly sighted: the shot-blast pattern didn't go where it was aimed (We shall refer to this factor as "aim"); and
- the shotgun shells not only contained the wrong size pellets, but also were only partially filled, having only one-half to two-thirds the number of pellets they should contain. (We shall refer to this factor as "load").

Obviously, any one of these factors would give the bird better odds than it needs. With any combination of two of these factors, or all three, the hunter has totally wasted his time. Putting these same three factors into terms of blast cleaning, the result is obvious: disaster, just what the survey results revealed, in an alarming nine out of ten instances! As much as 90 percent of all blast-cleaning problems relating to finish quality, productivity, and cost were found to be related to the factors of size, aim, and load at the "moment of truth" when the abrasive was fired at the work-piece.

Dealing with these three basic variables is the thrust of this article. Our approach will tend to be non-technical, overall; we purposely wish to avoid using technical jargon that would tend to unduly glamorize what is essentially a simple process. The beauty of the blast-cleaning process is its elemental simplicity: All we do is fire some steel BB's at the work-piece, then air-wash the mix of abrasive and dislodged contaminants, sending the contaminants and spent abrasive fines to the dust collector, and recycling the usable BB's so that again they can be fired at the work-piece, with this process repeated until the desired finish results are achieved. It is an incredibly simple process that can produce simply incredible results, such as can be achieved with a multiple-wheel system designed to clean and profile a 60 ft steel box-car in less than 15 minutes!

Of course, the process needs some help in order for it to perform up to its capability. Included in this article is a suggested seven-step program, which, when implemented, virtually assures that the three critical factors of size, aim, and load can be controlled, and, in turn, world-class quality of finish, optimum productivity, and reduced operating costs would be attained. The seven-step program doesn't cost, it pays.

First, we must deal with our "moment of truth." When one considers steel pellets the size of the letter "o" and the periods appearing on this printed page, we must marvel that such insignificant looking particles can do the required job of removing tough, tenacious oxide scale, rust, and aged coatings, while at the same time providing an etched profile or anchor pattern on the work-pieces.

The following quotation, well over 100 years old, relates to sandblasting, but holds equally true for today's blast cleaning with steel shot or grit: "Sandblasting has best been described as an impact cleaning operation that is neither cutting, grinding, nor abrading. It is essentially a pounding, battering, or bombardment of the work surface by successive impact of the flying abrasive" (from General Benjamin Tighlman, inventor and holder of early sandblasting patents).

Thus, the key factor in our analysis of blast cleaning's moment of truth is impact. To understand how the impact factor of these small particles of steel abrasive relates to the devastating cleaning power developed, consider
a pellet of S-280 (steel shot 1/32 in. in diameter) thrown at a velocity approaching 250 ft/sec (a golf pro's 300-yard drive leaves the tee at only 135 ft/sec, by comparison). The area of impact penetration by the S-280 pellet is about four-millionths of a sq in. The resulting equivalent crushing pressure is 10,200,000 pounds per sq in., and high quality steel can absorb only 120,000 pounds per sq in.

Because the impact energy of the steel abrasive is expended on such a small point of contact, tremendous cleaning/profiling power results at the "moment of truth." It is now most obvious that control of the blast-cleaning operation must center on the relative impact values of the mix of different sizes in the abrasive working mix. This is the factor of "size," one of the three critical variables.

The impact value of an abrasive particle relates to the formula for kinetic energy: \( KE = \frac{1}{2}MV^2 \) where \( M \) stands for Mass (the abrasive particle's size) and \( V \) stands for Velocity (resulting from blast-wheel diameter and RPM). With any given blast-cleaning installation, the factor of velocity can be considered constant. Thus, the relative size (Mass) of the abrasive particles is the significant variable, as Table 1 reveals.

### Table 1
**Effect of Abrasive Size on Impact Energy**

<table>
<thead>
<tr>
<th>SAE Shot Designation</th>
<th>Actual Size</th>
<th>Approximate Relative Impact Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>S-70</td>
<td>–</td>
<td>1</td>
</tr>
<tr>
<td>S-110</td>
<td>–</td>
<td>5</td>
</tr>
<tr>
<td>S-170</td>
<td>–</td>
<td>10</td>
</tr>
<tr>
<td>S-230</td>
<td>–</td>
<td>20</td>
</tr>
<tr>
<td>S-280</td>
<td>–</td>
<td>40</td>
</tr>
<tr>
<td>S-330</td>
<td>–</td>
<td>60</td>
</tr>
<tr>
<td>S-390</td>
<td>–</td>
<td>110</td>
</tr>
</tbody>
</table>

Data is based on mid-size pellet of SAE size.
The weight of a particle of S-70 is considered as the base of 1. All other values are relative to that base, varying as the cube of the diameter.

An abrasive work-mix in a blast-cleaning system where S-390 is the new shot size in use, for example, contains a range of impact values of over 100:1, from the largest to the smallest particles. It's like having a mix of 20-lb sledge hammers, 2-lb ball peen hammers, and tack hammers. Regardless of what original, new size of shot or grit is used, a work-mix will be generated that has a range of impact values from the largest to the smallest particles; the extent of the range is dependent on the new size used and the size of the fines extracted from the system by the airwash. It is control of this mix (size) that determines the effectiveness and efficiency of the blast-cleaning operation and the consistency of profile.

The size distribution of the work-mix undergoes constant change due to the abrasive breakdown caused by the abuse to the abrasive as it delivers its devastating impact on the work-piece surface. The abrasive, after it work-hardens and fatigues, tends to break into half-pieces, then the halves subsequently break into quarter-pieces, then into eighths, etc., until the particles are small enough for the airwash to pull them out of the system. Controlling the work-mix size distribution and maintaining a stabilized work-mix (size) are vital factors in maintaining a consistent production rate and a quality finish. The larger pellets impart the greatest impact energy per pellet, cracking or fragmenting heavy surface contaminants, and imparting indentations of maximum peak-to-valley values.

Medium and smaller pellets provide greater coverage for scouring and complete removal of contaminant in cracks, crevices, and pits. Due to the lesser impact energy of the smaller particles, the peak-to-valley value is lower, but because of the greater number of impacts on a given area, a greater peak-count results.

Control over the size distribution in the work-mix requires that replenishment of new abrasive be made frequently (each operating shift), in an amount equal to the rate of withdrawal or loss from the system. The abrasive feed hopper should never be permitted to fall below the two-thirds level. Equally important is control over the airwash separator system to
ensure that only those abrasive particles too small to be effective are removed. This requires careful adjustment of the separator system and the air flow through the separator.

The following case history dramatically and effectively demonstrates the need for proper control of the size factor. It explains why an improperly balanced work-mix can create havoc at that “moment of truth” when the abrasive pellets impact on the work surface.

Figure 1 depicts a 60-ft steel boxcar emerging from the blast-cleaning room, where it has been subjected each and every minute to bombardment by literally billions upon billions of steel pellets traveling at 250 ft/sec, thrown by a “horseshoe” of high power blast wheels, to remove all contaminants and to provide an anchor-pattern profile (with peak-to-valley height and peak count per inch stipulated) for optimum adherence of its subsequent coating. In this instance, the abrasive was a mixture of SAE S-280 steel shot and G-25 steel grit.

Case History Problems

Productivity was so poor that it was taking more than twice the normal time to remove all contaminant. The finish profile was too rough and the peak count too low. Three times the normal amount of paint was required, and abrasive consumption was double the normal usage. Combined, these factors resulted in tremendously high operating costs.

Working back from the “moment of truth,” samples of both the work-mix and the separator discard were taken from the system and screen-analyzed for size distribution. Figure 2 shows the screening results: a total of 79 percent of the work-mix was equivalent to the S-280/G-25 SAE original size; there was only one percent equivalent to S-170; and none were as small as S-110 or S-70. Thus, the work-mix delivered maximum impact (mostly all “sledge hammers” and virtually no “tack hammers”), with the result that it created deep craters requiring three times the paint, and the poor coverage due to absence of smaller particles required twice the cleaning time.

The cause of the excessively coarse work-mix was improper airwash separation. The separator not only pulled out all the mid-size and small-size work-mix particles, but even extracted some original size material. With this strong signal that something was drastically wrong in the separator system, maintenance tracked down the problem and took corrective measures.

Figure 3 shows the proper balance of abrasive size after the correction to the operation of the separator. The profile now met specifications, and the time to blast clean returned to normal, as did both abrasive and paint usage. The operating conditions, and results, returned to normal simply because the size variable at the “moment of truth” had been corrected.

Shown in Figure 4 is a trouble-shooting checklist for correcting the system once screen analysis of the work-mix and discard material reveals problems. (See your maintenance manual.)

The above case history related strictly to problems with the size variable. However, in
most instances encountered in the industry-wide survey referred to earlier, in addition to the size variable, problems were also experienced with the variables of "aim" and "load."

As described earlier, the "V" in the formula for kinetic energy, \( \frac{mv^2}{2} \), refers to velocity. It is the blast wheel that imparts velocity to the abrasive particles so they can perform their task of removing contaminants and producing the desired profile. As stated, for all practical purposes, the velocity can be considered a constant in any given blast-cleaning installation. But the blast wheel, the heart of the blast-cleaning system, also is the key to controlling the variables described as "aim" and "load." Figure 5 shows the components of a typical blast wheel, and pinpoints those areas where excess wear will adversely affect the aim factor.

Excess wear of the impeller (beyond 1/8 in. wear of the leading edges) and control cage (approaching 1/2 in. wear on the beveled leading edge) will cause the blast pattern to become disturbed, and will spread and lengthen the "hot spot," where the greatest concentration of impact intensity should be. Excess wear alters the aim, resulting in loss of cleaning effectiveness.

Badly worn (pitted, grooved) blades create drag to the abrasive as it comes off the blade face. This, in turn, also causes the hot spot to shift, lengthening the overall blast pattern and decreasing abrasive impact intensity. Aim is disturbed and cleaning effectiveness is adversely affected.

As little as ten percent shift from the proper blast pattern alignment can cause a 25 percent loss in cleaning effectiveness; i.e., 25 percent reduction in the system's ability to remove contaminant and produce the required profile. In addition, shifting the blast pattern will obviously accelerate wear on cabinet interiors. With so much at stake (quality of finish, productivity, and operating costs), it becomes mandatory that inspection of wear to the wheel components be made every eight hours of operation.

Even though blast pattern direction may be set by a pre-determined clock-dial setting, it is possible for pieces of tramp metal that passed the 1/4 in. scalp screen to wedge between the impeller and control cage, causing a shift in the direction of the blast stream. Blast pattern checks should be made regularly, preferably, weekly. Some firms maintain records of parts wear versus wheel hours operated, and have determined that a policy of automatically replacing these components after a given number of hours of operation is a discipline that prevents occurrence of the problems.

The factor of load, the amount of abrasive thrown by the blast wheel, is monitored by use of an ammeter that registers the amperage load on the motor driving the blast wheel. The motor nameplate will indicate full load amperage, the reading at which full abrasive flow through the wheel occurs.

The survey referred to earlier revealed that fully nine out of ten blast-cleaning operations were running at ammeter readings signifi-
significantly below full load to reduce abrasive flow by as much as one-quarter to one-third; the adverse effect on cleaning speed and ability to remove contaminant is most obvious.

The most common cause for running at low ammeter readings is simply that the abrasive level in the feed hopper is too low. Making abrasive additions every operating shift, in an amount that never permits the abrasive to go below the two-thirds level in the feed hopper, provides insurance against reduced abrasive flow. At the same time, this practice helps maintain the correct size distribution of the work-mix. Thus, both factors, size and load, are kept under control by making proper additions.

There are other factors that can cause low ammeter readings. The importance of monitoring and recording ammeter readings every shift cannot be overstated.

THE SEVEN-STEP PROGRAM

Implementing the following program will virtually assure proper control over the critical factors of size, aim, and load. In listing the seven steps, their relation to aiding in control of the respective factors of size, aim, and load is shown.

Step 1
Keep all paper, cardboard, plastic, wood, and other trash out of the blast-cleaning system (affects size and load factors).

Step 2
Replenish abrasive each operating shift; never let the abrasive feed-hopper go below two-thirds full (affects size and load factors).

Step 3
Install dribble valves (flapper valves) on all air-wash separator and expansion-trap discharge pipes (affects size factor).

Step 4
Conduct daily inspections: Inspect blast-wheel components for excess wear; check scalp screen for holes or plugging; check and record ammeter readings; check dust collector manometer readings.

Conduct weekly inspections: Inspect for major system leaks; check ventilation pipes for plugging; check blast pattern hot spot.

Step 5
Maintain a supply of key replacement parts, so timely replacement can be made when indicated by Step 4 (affects size, aim, and load factors).

Step 6
At least once a week, screen-analyze and record the pellet size distribution of the abrasive work-mix, and the abrasive discard from separator and expansion-trap discharge pipes. Forms should be available from the abrasive supplier (affects size and load factors).

Step 7
Maintain daily record of abrasive additions and parts replaced versus wheel hours of operation. Chart the pounds of abrasive used per wheel hour. Forms should be provided by the abrasive supplier (affects size, aim, and load factors).

Because as much as 90 percent of all problems experienced in blast cleaning relate directly to size of work-mix, aim of the blast stream, and load, implementing the seven-step program is essential. It is a discipline that doesn’t cost; it pays! World-class quality of finish and optimum productivity will be achieved, and at greatly reduced operating costs!

BIBLIOGRAPHY
