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Wheel Blast Cleaning Systems

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Wheel blast cleaning systems can provide cost effective and high quality surface preparation of steel with close adherence to process controls and rigorous maintenance to assure consistency and economy of production.

These blasting systems can be permanent fixtures or part of an automated system in a blast hall for the preparation of steel plates and sections before painting. Centrifugal blast cleaning systems also can be found in portable machines used in the field for the preparation of steel and concrete substrates for maintenance painting.

This article begins by looking at blast cleaning abrasives and their effect on cleaning, surface profile, and appearance. It also looks at the importance of selecting and maintaining an appropriate operating mix. Finally, it describes the operation of the sub systems of a centrifugal blast system with the most effect on the process and the control of product quality, including the blast wheel, the abrasive recycling system, and the dust collector.

ABRASIVES

The desired degree of cleanliness, degree of roughness (surface profile), and characteristics of surface texture are affected by the choice of abrasive, together with the establishment of appropriate operating procedures for the blast machine. Steel shot or grit are used almost exclusively for cleaning structural steel. Size, shape, hardness and a properly balanced and controlled operating mix of abrasive particles are the main factors in determining whether the desired finish will be attained.

Type, shape, and hardness (effect on cleaning)

Tight and slightly rusted mill scale (ISO Rust Grades A and B) are most effectively removed with operating mixes of steel shot or steel grit of 40 50 Rockwell (Rc). Grit particles will tend to ball up and become less angular in shape.

Nevertheless, operating mixes of grit with this hardness will contain a greater percentage of angular particles and be slightly more effective than shot in removing light rust deposits, flaking mill scale and weld slag, or torch burned scale from fabricated components.

For Rust Grades C and D, steel grit of 50 60 RC hardness is more effective than steel shot or grit of lower hardness. An operating mix of the harder grit effectively penetrates surface pits to remove contaminant particles. The mix contains a greater percentage of abrasive particles retaining a predominantly angular shape than grit particles of lower hardness.

A mixture of steel shot (40 50 Rc) and steel grit (50 60 Rc) may be used in a carefully controlled machine operation to effectively clean all rust grades, particularly Rust Grades C and D. Generally, the proportions selected for the mix will range from ratios of 1:1 shot to grit to 3:2 shot to grit. Such mixes are difficult to maintain because the harder grit will break down faster than the shot. Therefore, the newly added abrasive must contain a higher percentage of grit than the percentage of grit to be maintained in the operating mix. The grit and shot should be of comparable size and should be pre mixed when added to the system.

Routinely screening and checking particle shape during operation of the equipment may dictate an adjustment of the proportions of shot and grit for addition of new abrasive.

Maintaining a desired operating mix demands careful attention to

- control of abrasive losses from the system,
- efficient operation of the separator, and
- close control of additions of new abrasive to the system.

Effect on surface profile

- Steel shot (40 50 Rc) produces relatively smooth bottomed craters or pits and generally an undulating surface of well defined craters.
- Steel grit (40 50 Rc) produces a slight angularity of profile shape.
- Steel grit (50 60 Rc) produces greater sharpness of peaks and valleys and generally a slightly higher profile than softer grit of the same size.
- A combination mix of steel shot and grit (40 50 Rc) produces a surface typical of the harder grit but with a slightly reduced profile height because of the effect of the steel shot.
- Surface profile height depends on the size, type, hardness, and velocity of the abrasive, as well as the hardness of the workpiece being processed.

Effect on surface appearance

Different abrasives produce different “colours” on blast cleaned surfaces. The colour varies because changes in the angularity of the surface profile produced by the various abrasives change the reflectivity of the surface. However, these differences in appearance are difficult to describe.

Operating mix

It is important to determine the type, nominal size, and hardness of the abrasive required to produce the desired surface finish and to maintain an operating mix of abrasive that will provide economical, efficient, and high quality operations. These process control functions cannot be emphasized too strongly.

Abrasive selection

Pre production trials may need to be conducted to establish operating conditions and to select an abrasive mix.

- Abrasive already in a machine must have been recycled for a sufficient length of time to have generated an operating mix as evidenced by screen analyses.
- If a substantial change in abrasive type, size, or hardness is necessary, the user should consult the machine supplier, abrasive supplier, or both.

- A specifically formulated (screened and sized) operating mix may be obtained from abrasive suppliers for starting up a new machine.
- Once a desired surface finish is achieved, abrasive screen analyses can be made and recorded for reference during later production operations.

New abrasive

Contract specifications may state the abrasive to be used in a structural steel cleaning application. Size, type, hardness, and applicable manufacturing specification should be clearly indicated on all pertinent documents.

New abrasive should not be procured on the basis of price alone. Cast steel abrasives, for instance, may have a defective microstructure even though they have the proper hardness. Such abrasive will fail prematurely, resulting in excessive fines in the operating mix and high costs of abrasive consumption. Excessive abrasive fines may overload the recycling and ventilation systems, cause erratic abrasive flow, reduce cleaning effectiveness, and necessitate reduction of cleaning speeds.

The process of evaluating abrasive is time consuming. Approximate comparisons of quality can be conducted by the average user with procedures, information, and assistance provided by abrasive manufacturers. The most important point is that the lowest priced new abrasive can sometimes become the most expensive to use.

Maintaining the operating mix

Abrasive impact life cycles can be measured in kilograms used per blasting hour. New abrasive should be added continuously during blasting in amounts equal to the rate of withdrawal or loss from the system.

In the absence of automatic additions, new abrasive should be added once each shift, or after each eight hours of wheel blasting. It is recommended that individual additions not exceed 10-15% of abrasive storage hopper capacity.

Delay in adding new abrasive tends to decrease the percentage of coarser sizes in the operating mix. The result will likely be poorer quality cleaning and reduction in the depth of the anchor pattern.

However, adding a large quantity of new abrasive at one time increases the percentage of coarser sizes, resulting in a coarsening of surface profile, and for a given through put speed, insufficient coverage and poorer cleaning. The result in either case is reduction in operating efficiency, product quality, or both.

Maintaining a uniform and stabilized operating mix requires the abrasive particles removed from the blast machine to be of uniform size. To realize the greatest economic benefits from using metallic abrasives, the particle size removed should be the largest size that is ineffective in the cleaning operation. Control of the size to be removed requires careful attention to adjustment of the separator system and of the air flow through the separator.

Care must be taken to prevent (or minimize) losses of abrasive by carryout on the workpieces, by loss through work entry and exit seals on the cabinet, or by leakage elsewhere on the machine.

Generally, the operating mix should contain close to 50% of sizes equivalent to or larger than the newly purchased (nominal screen) size. Also, the operating mix should typically contain particles of sizes ranging from one screen size larger to four or more screen sizes smaller than the nominal screen size of the new abrasive.

Production rate and cost considerations

The smallest size of abrasive that will produce the desired cleaning results is generally the most productive and most economical to use. Consumption of abrasive due to the size of the abrasive particles removed through the separator must be monitored to prevent withdrawal of usable size abrasive particles. Increasing the hardness of steel grit or shot in a given operation will increase the breakdown rate of the abrasive. Similarly, faster rates of wear will occur on the machine parts (wheel components, cabinet liners, and conveyor components). A combination of hardnesses of steel shot and grit will result in "somewhere in between" costs of abrasive consumption and wear on machine parts.

PROCESS CONTROLS

Efficient and trouble free performance depends on the care and attention given to the system by operating and maintenance personnel. Equipment manufacturers provide comprehensive instruction manuals, and the user should be thoroughly familiar with them.
Generally, as long as the work handling system properly delivers workpieces to the blast of the wheels, only normal maintenance of the equipment is required. In the cabinet, the entry and exit seals and interior liners must be maintained. Sufficient ventilation must be provided to assure positive flow of air from the outside to the cabinet interior and positive withdrawal of dust to the dust collector.

Sub systems that differ most in design details and have the most influence on the process and the control of product quality are:

- the blast wheels,
- the abrasive recycling systems, specifically the separator,
- the dust collector.

Following are descriptions of each of these sub systems, including information about common causes and cures for loss of operational efficiency or for deterioration of quality in the finished workpiece.

Blast wheel (general description)

Abrasive is fed to the center of the blast wheel, which is driven at high speed either by belts or by direct connection to the drive motor shaft. In one wheel design configuration , the abrasive is fed into a cast steel impeller that rotates with the wheel. The impeller imparts initial velocity to the abrasive as it carries the abrasive to an opening in a stationary control cage, through which the abrasive is discharged onto the wheel blades.

In another configuration , abrasive is fed into an adjustable nozzle and is propelled into the wheel center and outward to the blades through the nozzle by high volume, low pressure air from a low horsepower blower. The direction of the blast from the wheel is controlled, in the first case, by the peripheral location of the control cage opening and, in the second case, by the location of the nozzle outlet.

Blast pattern

The blast pattern can be inspected by a procedure commonly referred to as " checking the hot spot." A metal target plate (10 12 gauge) is placed in line with the blast. The metal target will become hot when subjected to a blast of 30 seconds or longer. After the blast, the hot spot can readily be felt in the area where the abrasive has impacted the target most heavily. The target plate also will visibly show the area over which the blast has effectively impacted the surface. Rotation of the control cage or nozzle will adjust the blast pattern to the desired location.

Principal causes of changes in the blast pattern are wear on the impeller and control cage, the nozzle (or

blower malfunction), and the blades. These parts must be inspected regularly and replaced as soon as excessive wear or malfunction are detected.
Wear on the impeller vanes and control cage spreads out (lengthens) the blast pattern and moves the hot spot. Abrasive leaving the worn vanes of the impeller will hit the back edges of the blades and land high on the face of the following blades rather than on the inner ends or proper spot on the blade faces. Wear on the control cage opening alters the location of the hot spot because it allows a greater opening through which the abrasive is thrown, Badly worn or pitted blades offer resistance to abrasive flow along the blade face. As a result, the hot spot shifts, and the total pattern may be lengthened as abrasive velocity is decreased. An increase in the percentage of fines in the abrasive operating mix also will change the location of the blast pattern. Finer abrasive particles tend to hang onto the wheel blade faces for a longer time. It should be noted that a 10% misalignment of the pattern could reduce cleaning efficiency by 25% or more.

Abrasive flow

Cleaning efficiency can be maintained only with continuous full flow of abrasive through the blast wheels. An ammeter is provided on the machine control panel for each blast wheel so the operator can detect any erratic flow of abrasive.

For example, for a typical wheel of 50 cm in diameter and 6.4 cm in width using a 15 horsepower motor on a 440-volt circuit, approximately 8 amperes will be required to rotate the wheel without abrasive flow. Under a full load of abrasive flow at 170 kg/min, approximately 20 amperes will be required. Abrasive is thus propelled at the rate of –14 kg/min per ampere difference between a "no-load" and a "full load" current. A reduction to about 17 amperes would correspond to an abrasive flow reduction of 42 kg/min, with a resulting loss in cleaning efficiency of about 25 percent.
When the wheel is operating at less than full amperage, the cause should be determined. There may be a need to add abrasive to the system, or the wheel may be flooded with excessive abrasive flow. A very simple test can determine the cause. Block the flow of abrasive to the wheel. If the amp reading increases before falling off to a no load reading, the cause is an excessive flow of abrasive. If the amp reading simply declines, there is insufficient flow of abrasive. The difficulty may be a malfunctioning flow control valve, worn wheel parts, obstructions in the abrasive recirculating system, or a loss of power due to worn or loose drive belts at the wheel shaft.

Abrasive recycling system (general description)

Abrasive handling and recycling systems for centrifugal wheel blast machines include the following elements:

- an abrasive elevator;
- a method of transferring abrasive from the elevator to the separator;
- an air wash separator to remove abrasive particles that have been reduced to unusable size, fine particles, and dust that have been generated in the removal of mill scale, rust, paint, and other materials;
- a hopper for storage of clean, reusable abrasive; a hopper to direct refuse removed from the abrasive to floor level;
- a device to control and meter flow of abrasive to the wheel; and
- a means of moving abrasive and contaminant particles from the base of the cabinet to the elevator, such as by gravity, by helicoid screw, or shaker conveyor.

Transfer of the abrasive from the elevator to the separator may be accomplished by gravity or by a rotary screw conveyor.
In some installations, a rotary or tray type screen may be provided to remove foreign objects that have passed through other screening devices. Such objects may include pieces of welding rod, steel stampings, cigarette butts, and wrappers, etc.

Separator Functions

Most separators use the air wash principle because of the ultra fine adjustment possible with this method. The separator works much like a vacuum cleaner to remove dust, fines, and undersized abrasive from a curtain of falling abrasive. Uniform air flow through a uniformly distributed curtain of abrasive is essential. A separator has the following basic functions.

- It removes contaminant fines (rust, scale, paint particles, dust, and sand granules, etc.) so only good, clean abrasive is fed to the wheels.'
- It controls abrasive consumption rates determined by the size of the abrasive pellets removed from the recirculating abrasive.
- It also controls the sizing of the abrasive operating mix, This is an extremely important function and a major influence on surface quality and system operating efficiency.

Problems and corrections

Excessive air flow in the separator can remove too large a size of abrasive particle; too little air flow can permit the retention of fines. Air flow can be corrected by adjusting a slide gate in the duct between the separator and dust collector.

Another common problem is an uneven curtain of abrasive flow through the air stream. This condition can occur for several reasons. One is foreign objects lodging against spreader bars or baffle plates after passing through wear enlarged or torn holes in the scalping screen above the separator lip. Another reason is warped or missing spreader bars or baffles. These conditions will disrupt the uniformity of the abrasive curtain, causing large abrasive particles to be sucked out when the abrasive flow is sparse and leaving contaminants in the abrasive when the flow is heavy.

Monitoring operations

A regular schedule should be established for monitoring and checking the operation of the separator. It is recommended that the user establish an inspection schedule with the assistance of the machine manufacturer, abrasive supplier, or both.

An inspection should include routine visual examination of the following functions by experienced personnel.

- The discharge from the separator into the refuse hopper should be examined for the presence of usable sizes of abrasive particles.
- A similar examination should be made of the abrasive as it falls at a point below the air wash curtain and into the abrasive hopper to detect the presence of dust or fines or the absence of usable sizes of abrasive particles.
- The abrasive curtain should be examined to assure uniform flow across the width of the separator.

These are simple checks. They are non-quantitative but can serve well to reveal early indications of separator malfunction. It is strongly suggested these checks be made on a daily basis.

Screen analysis

This is a quantitative analysis that provides an exact measure of the abrasives according to particle size. The data, when plotted graphically, provides a visual picture of the abrasive mix. Screen analysis procedures are too lengthy to be included in detail in this article. Recommended procedures specifically applicable to blast cleaning operations can be provided and demonstrated by the machine manufacturer or abrasive supplier. However two significant screen analyses should be conducted.

- The cleaned abrasive being fed to the wheel should be analyzed. Preferably, the abrasive sample should be taken at a point just prior to entry into the blast wheel. When access to the abrasive flow at this point is impeded, the abrasive sample may be taken at the abrasive curtain in the separator, at a point below the air wash area, where the abrasive falls into the hopper. Care must be exercised to assure that the entire curtain width of the abrasive flow is sampled.

- The abrasive discharged from the separator into the refuse hopper should be analyzed to determine whether or not abrasive of usable size is being withdrawn from the system. Abrasive samples should be taken directly from the discharge tube rather than from the bulk material in the discharge container.

Usable abrasive may sometimes be drawn into the dust collector. It can be detected by examination of the collector "dust." When good abrasive is found, screen analysis of the collector discharge, together with the analyses of the separator discharge, can be used to establish abrasive losses. This emphasises the importance of efficient separator adjustment. Dust collector screen analyses are more difficult to perform. Procedures can be demonstrated by the machine supplier or the abrasive supplier.

Dust collector

An adequate and properly operating dust collector system is necessary to assure positive ventilation of the blast machine, to eliminate dusting around the machine, and to minimize the presence of dust on the blast cleaned surfaces. Most structural cleaning machines are also equipped with brushes or air blow-off systems or both to remove dust and abrasive from the workpiece as it exits the cabinet.
Dust collectors for blast machines vary in design, but all of them use some type of bag or cartridge for dust to be deposited and collected on one side. Dust laden air entering the collector first baffle plate. The sudden change in velocity and direction causes heavier particles to drop into the hopper, leaving only the finest floating dust particles to reach the bags. The bags are shaken when limp to remove dust build up.

A pre determined and balanced flow of air through the machine must be maintained since a change in air flow from the machine cabinet will also affect the air flow through the separator. Failure to maintain this flow will cause a reduction in cleaning efficiency, dusting conditions around the machine, and the presence of fine abrasive particles and contaminants in the operating mix. A periodic check on air volumes will reduce the possibility of gradual degradation of operation.

OPERATION AND MAINTENANCE PROGRAM

Centrifugal blast cleaning machines can clean steel surfaces efficiently, economically, and to a consistently high degree of quality.
Operators should be thoroughly familiar with the machines and the operation of their major sub systems. They must be able to detect any problems that might occur, as evidenced by the quality of the cleaning the machines produce and their cleaning rate.

Managers should establish and enforce a program of record keeping, routine inspections, and preventive maintenance. This can be a simple or an involved program.
Finally, the equipment manufacturer can provide expertise and assistance in organizing a workable program, including the establishment of an adequate spare parts and abrasive inventory, recommendations for desired controls and appropriate production and cost records; and training for management