Unfortunately, we don't know who wrote this article and therefore cannot give credit for this practical and enlightening series. However, we can thank Ken Dykstra of Precision Automation Inc. for submitting it to us for publication.

Impact cleaning, commonly called grit blasting or sandblasting, is a process of bombarding a work surface with small particles traveling at high speeds. The particles are called the abrasive or the shot. Angular, blocky or sharp particles are abrasive since they "chip or cut." Special smooth particles are shot and pound or dent rather than cut.

The velocity or speed of the particles can be imparted to the particles in two manners:

1. Mechanical - a throwing action with a centrifugal wheel; or
2. Hydraulically - where the particles are entrained in a liquid or gas (air) which is pumped or forced through a nozzle at high pressure to accelerate the particles.

Factors which influence the type and amount of work done on the work surface are numerous. The most important of these factors are:

1. Type of Particle
   a. heavy - high specific gravity (S.G.)
   b. light - low S.G.
   c. large
   d. small
   e. sharp or blocky
   f. round (spherical and smooth)
   g. range of particle sizes in the abrasive "mix"
   h. hard
   i. soft

2. Velocity of particle
   a. Low velocity - low impact energy
   b. High velocity - high impact energy

3. Angle of impact
   Usually varies from 20 deg. to 90 deg.
   a. 90 deg. (or normal to surface) imparts highest percentage of particle energy to surface
   b. Lower angles of impact impart lower energy and below 20 deg. particle bounce and perform very little work

4. Workpiece material characteristics - varies greatly
   a. Hard and brittle
   b. Hard and tough
   c. Soft or malleable
   d. Hard coating on softer substrate
   e. Soft coating on hard substrate
   f. Elastic or rubbery surfaces

5. Number of particles impacting each unit area of the work surface in a unit of time.
   This can influence the amount of work performed and can also influence the surface finish or texture achieved.

6. Other minor factors are:
   a. Initial condition of surface such as roughness
   b. Temperature of work surface

How each particle works
   Each particle has a certain "mass" or weight. Causing this particle to move at a high speed gives it energy.

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The energy of each particle is proportional to the product of the mass times the velocity squared. The equation is 
\[ E = \frac{1}{2} MV^2 \]
where \( E \) is the kinetic energy, \( M \) is the mass and \( V \) the velocity.

It can be seen that a large particle at low speed can have the same energy as a small particle at high speed. When a particle impacts the work surface only a small portion of the surface of the particle contacts the surface. The particle deforms and bounces and then either shatters or returns to its original shape.

The portion of the work surface contacted by the particle also deforms. If the forces involved are large enough the work surface stays permanently deformed. If very high stresses are involved a portion of the work surface may be split or cracked or fractured off the surface. In the case of a resilient paint coat on a hard surface the particle may either deform or penetrate the coating until it deforms the substrate surface. The rapid deformation of the substrate breaks the bond between coating and the surface and allows the coating to spall or split away from the substrate.

It can be seen that a large round particle would contact a larger surface area than would a small round particle or a large (or small) sharp particle. Thus, the available energy would be expended over a larger area and hence the stresses induced would be smaller. It is for this reason that sometimes a smaller particle traveling at high speed is more effective than a larger particle at lower speed - even if the energy levels are the same.

Massive quantities of particles are involved in all impact cleaning operations. For example - very seldom are the particles larger than 1/32 of an inch average diameter. For a 1/32” particle of steel, one cubic foot contains nearly 60 million particles. One pound contains over 200,000 particles.

Each particle weighs about 4-1/2 one millionth of a pound. If a jagged piece of such a small particle traveling at an average velocity of 250 feet per second, contacts an equally small portion of the surface of a steel workpiece the force exerted by the particle is over ten million pounds per square inch.

When you consider that the best cast iron has a compressive strength of 100,000 pound per square inch and the best alloy steel perhaps 200,000 psi, you can see that this particle has 100 times the necessary energy to change or etch or indent the tiny surface with which it comes in contact, no matter what the surface may be.

For a nozzle with a throat size of 1/2 inch accelerates 100 lbs. of steel shot or grit per minute up to this speed. This represents over 20 million particles per minute. It may typically clean 10 square feet of surface per minute. So 2 million particles hit each square foot. This represents 13-1/2 particles contacting each 1/32” x 1/32” area.

And a particle 1/32” diameter is much larger than the usual particle used in most blasting operations. A much more common particle is an 80 mesh or 0.007” diameter particle. This is 1/125 of the weight of the 1/32” particle. So the same nozzle would deliver 2,500 million particles per minute and can clean the same area in the same time. So 250 million particles would hit each square foot; and

84.5 particles would attack each area measuring 0.007” x 0.007”. Even with this small particle the energy level is sufficiently high to develop forces many times the compressive strength of the workpiece.

**Particle Behavior**

A few things to remember regarding the behavior of small particles thrown or blown against a workpiece:

1. Particles cannot effectively each do the required amount of work on the work surface if the “cloud” of particles arriving at the surface is too dense. This is particularly critical in cases where very fine particles are used. Too close a spacing of particles leads to too much particle interference. The work surface can be covered by a layer of moving particles which interfere with the trajectory of new on-coming particles.

2. Particles decelerate, or lose their speed rapidly after leaving the accelerating device, be it wheel or air nozzle. The lighter and the smaller the particle the more rapid the rate of deceleration. Thus nozzle distance is a factor in selecting the best abrasive. Remember, a small particle traveling at a high speed can indent a surface to the same extent as a larger particle traveling at a lower speed.

3. A wheel or mechanical throwing device throws all size particles of, for instance, steel shot at the same speed. Wheel speed is varied to alter particle speed. A compressed air operated nozzle at a given pressure throws the large particles at a lower speed than the small particles. Two things can be varied to alter the speed of particles coming out of an air nozzle:
   a. The air pressure can be varied - this alters the air speed
   b. The weight of particles fed into the nozzle can be varied. A “rich” feed means low particle speed, and a “lean” feed means a higher particle speed.

4. The weight of a particle of a given size varies with the Specific Gravity (density) of the material the particle is made from. High specific gravity particles (steel grits and steel shot) can be accelerated (thrown) by mechanical devices (wheels) and by compressed air nozzles. Low specific gravity particles (sand, aluminum oxide, glass beads) cannot be as effectively thrown by mechanical devices but are thrown effectively by compressed air.

5. In a mechanical device the horsepower is purely dependent on the weight of abrasive thrown per minute and the speed the abrasive is thrown at - which is a matter of wheel speed and wheel diameter.

6. In a compressed air nozzle the horsepower of compressed air used is more dependent on other factors:
   a. A compressed air nozzle throwing no abrasive will use more horsepower than one which has abrasive feeding through it.
   i. The volume of air passed by the nozzle decreases as abrasive is introduced into the air stream.

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b. The richer the feed, the less the air consumption
c. The leaner the feed, the more the air consumption
d. With feed rates that most effectively use the particular abrasive being blasted the highest specific gravity particles use less air.

The low S.G. particles use more air. The pounds per minute thrown is more when using high S.G. particles and the number of particles is less. With low S.G. particles less weight is thrown per minute but more particles.

Example:
1. A 1/2” pressure nozzle at 80 psi will throw 100 lbs. weight per minute of 80 mesh steel grit and use 200 cubic feet per minute of compressed air.
2. The same nozzle at the same pressure will throw 35 lbs per minute of 80 mesh sand and will use 280 cubic feet of air per minute.
3. Both nozzles will clean the same steel at approximately the same rate. The sand is actually slightly faster.
4. If the particles in the above case are the same size and similar shape the number of particles in the sand example is 10% or so more than the number of steel grit particles thrown per minute.

Remembering the incredibly high number of particles thrown per minute and the density of the particles in the air stream, it is easy to realize that if more than the desirable amount of particles are introduced into the air stream then the slower each particle travels and the more the particles interfere - and in fact the cleaning rate drops with richer flows.

In the next issue will be a continuation of this three part technical bulletin discussing “What Makes A Good Abrasive?".

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Patents Granted

In the Blast Cleaning Field
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Cleaning Method Utilizing Sodium Bicarbonate Particles
A.C. Rubey III, San Antonio, TX
A.M. Taylor, San Antonio, TX
A method for effecting the continuous reliable supply of sodium bicarbonate particles to a blasting nozzle employing pressured air or water as the means for conveying such particles into impact engagement with a surface to be cleaned.

Method and System for the Abrasive Cleaning of Surfaces
R.A. West, Bay Village, OH
A system for abrasively cleaning surfaces such as by sandblasting and including a vacuum arrangement for recovering the material abratively removed from the surface as well as the abrasive material is provided with a control circuit operable to actuate an alarm and/or deactivate the abrasive cleaning operation by sensing a drop in the vacuum pressure at the blast head which is indicative of an inappropriate positioning of the blast head and thus discharge of the abratively removed material and abrasive material to the surrounding environment.

Containing Structure for Abrasive Blast Head Rigging and Tank Side Cleaning Apparatus
M.D. Smith, Concord NC
G.E. Wells, Charlotte, NC
A portable containment structure for abrasive blasting equipment is designed for particular application in the cleaning of large storage tanks and for bridges. The unit includes a portable blasting room which fully encloses the blasting apparatus and operating personnel, in a secure environment having ventilating and vacuum means for the safe removal and containment of particulate materials and contaminate. The unit is supported by cables and includes rigging which provides for both horizontal and vertical movement along the surface being treated.

Blasting Apparatus for Coating Removal
US Patent 5,092,084 March 3, 1992
H.D. Schlick, assignor to Schlick-Roto-Jet Maschinenbau GmbH, Matelen, Germany
An apparatus for abrassively removing coatings from plastic surfaces comprising utilizing a centrifugal impeller wheel, which can be moved relative to a surface at a substantially constant distance therefrom, to direct a blast of abrasive particles at the surface consisting of sharp-edged, steel elastic plastic granules.