BLAST FINISHING

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Blast finishing, with all its variations, is powerful enough to remove heavy mill scale and rust or gentle enough to take paint off delicate aircraft skins. Blasting is used for finishing, cleaning, coating removal, surface preparation, and surface treatment. Here are some common applications of this versatile process:

Finishing: Add matte or satin finish, frost, decorate, remove glare, blend tooling marks and imperfections, hone and burnish, and mark identifications.

Cleaning and removal: Rust/oxidation, coatings, paint, sealants/adhesives, carbon deposits, excess brazing, casting medium, flash, and burrs.

Surface preparation: Etch for bonding and adhesion of subsequent coatings, expose flaws for inspection, and remove hard cast surfaces for subsequent machining.

Surface treatment: Shot peen for increased fatigue resistance, strengthen, increase wear properties, improve lubrication, reduce design weights, reduce susceptibility to corrosion, seal porous surfaces, and correct distortion.

Several blasting methods and a variety of equipment options are available to do the job. Blast cabinets are self-contained units where the user is isolated from the process for safety. Cabinet enclosures are used for manual systems where an operator accesses the part through rubber gloves. Larger blast rooms require the operator to suit up to blast very large parts. Automated machinery uses an enclosure to protect passersby. Dust removal and grir reclamation are usually integral to all blast systems.

Media selection plays an important role in effective blasting. Many kinds of manufactured and natural abrasives, ranging from 12-gauge mesh to powders, can be used. Depending upon the amount of pressure exerted through the blast nozzle and the surface being processed, each type of media can achieve different results.

The finishes produced by blasting are almost limitless. Change a few variables and the results can change dramatically. It is important, therefore, to "lock-in" the variables after the right combination has been found for consistent, high-quality results.

BLAST METHODS

There are many ways to deliver the working medium to the surface being treated, including compressed air, mechanical, and water slurry. The most popular is compressed air.

Air Blast

Air blast is categorized into two methods of media delivery: suction blast and pressure blast.

Suction blast systems are selected for light to medium amounts of production and moderate budgets. Suction is not as efficient as pressure, so the range of applications is more limited, but it often yields comparable results. Suction systems have the ability to blast continuously without stopping for media refills. They are also simpler to use and have fewer wear parts, making them inexpensive and easy to maintain.

Suction systems work on the principle that air passing over an orifice will create a vacuum at that point. This action takes place in the hand-held suction gun, with a media hose connected from the vacuum area to a media storage hopper. Compressed air is piped into the back of the gun and causes the lifted media to be blown out of a nozzle on the front of the gun. Energy is expended indirectly to lift the media and then mix it with the compressed air, making suction less efficient than a pressure system.

Pressure blasting feeds media into the compressed air stream at a pressurized storage vessel. The media then accelerates in the air stream as it is routed by a blast hose to the nozzle. Resulting media velocity is often several times that of a suction system, resulting in a common fourfold increase in production.

Direct pressure uses force, rather than suction, so it offers much more control at very high and very low operating pressure. Low pressure is used for delicate or fragile substrates, such as removing carbon from aluminum pistons or flash from integrated circuits. High pressure may be necessary for removing a tight mill scale. Direct pressure systems are especially useful for finishing hard-to-reach recessed areas and odd shapes, and in the case of very demanding applications (such as removing tight mill scale), they may be the only choice.

Options for Air Blast Systems

A variety of options is available for suction and pressure blasting systems. Options can tailor the system to your needs for increased productivity, material handling, longevity, and ease of use. Many of these will come as standard equipment with the cabinet, and most can be added after the fact without difficulty.

Media reclaimers remove useless dust and debris from otherwise reusable media and are generally included in production blasting systems. The reclaimer aids economy by reducing media waste, keeping blasting speed constant, and improving finish consistency by reentering media particles in the proper size range only.

Spent media, dust, and debris are conveyed pneumatically from the bottom of the blast cabinet to the reclaimer inlet. Heavier particles are thrown against the reclaimer wall, where there is less air movement due to laminar flow, and are pulled down to the storage hopper by gravity. Debris is screened off there. Lighter particles and dust enter a counter vortex in the center of the reclaimer and are sucked off to a dust collector.

Dust collectors filter dust-laden air from the blast cabinet or reclaimer, if so equipped. A dust collector will allow plant air to be recycled back into the plant, saving heat or air conditioning costs. Many states now mandate and regulate dust collector use.

There are two general types of dust collectors used for dry blasting: bag and cartridge. Traditional bag collectors trap dust on a cloth filter, usually cotton. Cleaning these bags is accomplished with a rapping mechanism that can be automated. Cartridge collectors are generally more efficient and are typically self-cleaning but are more expensive.

Extended wear packages protect vulnerable surfaces inside the system from wear. A typical package includes rubber curtains for the cabinet walls, heavy duty conveying hose, reclaimer wear plates, and carbide nozzles.

Air dryers and moisture separators condition the compressed air by removing moisture that can cake media. Aerated regulators and vibrating screens keep fine and lightweight media flowing smoothly through the system. Magnetic separators remove ferrous particles that may harm the workpiece.

Manual turntables facilitate handling of heavy, bulky, or delicate parts. Stationary low-profile designs make it easier to access the full height of the workpiece as it rotates. Turntables can also be situated on carts to move a heavier part into and out of the cabinet.

Automation packages may consist of powered rotary turntables, multiple blast guns, oscillating movement for the blast guns, and timer controls. They cover more area faster, enable the operator to perform other tasks, and often increase part-to-part consistency.

Ergonomic designs are relatively new to the market. They conform the machine to the operator, rather than the other way around. Blast cabinet operators can therefore perform at peak efficiency longer and turn out higher quality finishes because distractions have been eliminated. Common ergonomic modifications include a "sit-down" cabinet, padded arm rests, a positionable foot rest, and sound-suppressing devices.

Custom modifications build the machine around a particular part or process. For example, an extra tall part may require a higher cabinet ceiling and two operator positions to allow access to the full height of the part. The same part may be conveyed around the plant on an overhead monorail, so an overhead cable slot may be cut into the roof of the cabinet.

Automatic Blast Systems

Automatic blast systems can increase production and part-to-part consistency when the expense can be justified. They are dedicated to a single workpiece or family of parts. The basic elements of an automated system include material handling (conveyor, rotary, indexing satellites), fixturing, blast (suction or pressure, multiple-oscillating guns), dust collection, media conveying and conditioning, and controls.

Wheel Blast

Mechanically propelled blasting machines differ from air-blast systems in that they apply the media to the workpiece by centrifugal force from a power-driven, high-velocity bladed wheel. They also lend themselves to automatic and semiautomatic production techniques.

Cabinet mechanical blast finishing is the most common, but tumbling equipment is also used. The wheel is enclosed in a protective housing, so there is no danger of stray abrasives. Considerable wear can be expected; therefore, the parts are designed for ease of replacement. Heavy rubber mats are also used to pad worktables and prevent damage from abrasive shot.

Wheel blast equipment covers a wider blast swath and can impact harder than air-blast equipment. Media used are usually limited to steel shot and steel grit because they are durable, less erosive to the equipment, and have maximum "throw weight."

Wet Blast

Wet blasting is a precision finishing operation. It normally consists of an air-blasted slurry of fine abrasive suspended in chemically treated water. Wet blasting can be controlled to avoid metal removal and hold dimensional tolerance to within 0.0001 in. It is also used to hone multitooth hobs and finish fragile items such as hypodermic needles.

Wet-blasting equipment usually incorporates a cabinet. It is frequently modified with auxiliary strippers, take-off conveyors, and wash-rinse-dry stations.

Although wet blasting is usually reserved for small, delicate workpieces, it can be used to remove light surface residues, blend scratches, and correct other surface defects on large pieces. In addition, wet blasting is used to reveal scores, heatchecks, porosity, or metal fractures to determine whether any particular operation has damaged the part.

Abrasive Jet Machining

Abrasive jet machining (AJM) is a specialized form of blast finishing. In this system, a highly controllable precision tool is used to cut, abrade, frost, polish, or peen very hard materials. Examples of such hard materials include ceramics, glass, and germanium.

With AJM, operators are able to cut a 0.0005-in.-thick sheet of tungsten without cracking or splitting the sheet. It can also allow blast finishers to mechanically roughen the surface of a 3-mm-thick germanium Hall-effect device to ensure maximum electrical conductivity. Abrasive jet machining makes frosting glass, microdeburring, and cutting thin precise grooves in bearings possible.

The abrasive particles used in AJM may be as small as 10μm in size; the nozzle opening could be only 0.0002 in2. In the process, the media is fed from a reservoir into a high-speed gas stream, which then propels the particles with explosive force. This force sends the media against the surface to be treated at high velocity. The action is shockless, and any heat generated is dissipated by the enveloping gas stream.

MEDIA

The media used in blasting varies greatly in material, size, and shape. This is key to the versatility of blasting. Dry blasting employs abrasive and nonabrasive particles of 12- to 300-gauge mesh; wet blasting particles vary from 60- to 5,000-gauge mesh. Particles smaller than 300-gauge mesh can be used in dry blasting, but special handling systems are required.

When considering different media, keep these factors in mind:

Suitability for the purpose—density, shape, hardness
Working speed
Reusability, breakdown percentage
Dust levels generated by broken media
Probability of surface removal for close tolerance parts
Possibility and consequences of substrate contamination
Equipment modifications
Disposal

Glass bead is the most common medium and is often used as an all-purpose media for general cleaning and finishing, including contaminant, coating, or burr removal; honing, blending, and peening. Weld and solder flaws can be detected with glass beading. Glass beads are noncontaminating, leave dimensions unchanged, and are available in the widest variety of sizes. Further information on glass beads is found in the section "Impact Blasting with Glass Beads" elsewhere in this Guidebook.

Steel shot is another commonly used media. It is a solid, round particle that causes a peening action and produces a dimpled surface. Steel shot has a relatively high mass, which gives this media greater impact and a hammering action.

Steel grit is an angular product that acts like thousands of tiny chisels. Steel grit cleans quickly and efficiently and produces an excellent surface to which almost any new coating can adhere.

Aluminum oxide is widely used as a cutting media. This substance can produce an anchor pattern in preparation for a new coating. It can also remove heavy foreign

Table I. Pressure Blast Air Requirements (scfm)

Pressure (psi)	20	30	40	50	60	80	100	120
$^1/_8$-in. nozzle	6	8	10	13	14	17	20	25
$^3/_{16}$-in. nozzle	15	18	22	26	30	38	45	55
$^1/_4$-in. nozzle	27	32	41	49	55	68	81	97
$^5/_{16}$-in. nozzle	42	50	64	76	88	113	137	152
$^3/_8$-in. nozzle	55	73	91	109	126	161	196	220

Table II. Suction Blast Air Requirements (scfm)

Pressure (psi)	30	40	50	60	70	80	90	100
$^1/_4$-in. nozzle, -in. air jet	6	7	8	10	11	12	13	15
$^1/_4$-in. nozzle, -in. air jet	10	12	15	17	19	21	23	26
$^5/_{16}$-in. nozzle, -in. air jet	15	19	23	27	31	37	38	42
$^7/_{16}$-in. nozzle, -in. air jet	31	38	45	52	59	66	73	80

matter, deburr, frost or decorate glass, and letter on stone. Aluminum oxide is economical because it can be used over and over again. It is classified in various sizes for a wide selection of finishes.

Silicon carbide is similar to aluminum oxide, but is especially useful for cleaning very hard surfaces, such as tungsten carbide. Silicon carbide is a sharp media that is extremely fast cutting.

Garnet is manufactured from the natural mineral. It, too, is hard and fast cutting. It is used to remove heavy material such as rust and weld scale and leaves a uniform anchor pattern.

Plastic media are relatively soft and gentle. They are most often used for paint removal from delicate substrates such as aircraft, fiberglass and automobiles. Plastic media are also used to deflash molded parts and for cleaning precision molds, dies, electronic connectors, and circuit boards. They can deburr soft materials such as aluminum.

Agricultural media, such as walnut or pecan shells and corn cob, are soft enough to remove foreign matter without etching, scratching, or marring the cleaned areas. They find use cleaning molds, electric motors, and windings.

Two newer media are *wheat starch* and *sodium bicarbonate* (baking soda). Wheat starch can replace plastic for paint removal. Sodium bicarbonate is a water-soluble medium that is convenient for cleaning contaminated surfaces as well as for stripping paint. Sodium bicarbonate requires a flow agent to work reliably, and the large volume of dust generated must be suppressed. Both are soft, low-aggression media that are unlikely to damage parts.

Sand has lost favor to longer life, less dusty, and more versatile media. Silica sand dust has also been found to cause health problems such as silicosis. Alternative media should be explored for anyone still using sand abrasive.

BLAST PRESSURE

The correct blasting pressure (psi) and impact angle must be determined to achieve the best possible blasting results. Correct pressure selection will also make any blasting operation more cost efficient. See the air charts in Tables I and II.

Direct pressure uses compressed air more efficiently, so anyone currently blasting with a suction gun at 100 psi may get the same results faster using 60 psi with direct pressure. As shown in the tables, less air volume (scfm) is used for the given unit of work produced, making direct pressure more economical in the long run.

Additionally, the use of excessive pressure only accelerates the breakdown of the media with minimal decrease in blasting time. For example, blasting at 100 psi may reduce the time cycle by 5% as compared to blasting at 60 psi, but the abrasive may break down at a 50% higher pace.

Pressure selection must also take the type of media into account. For instance, if intricately designed jewelry is to be blasted, a fine abrasive with a soft texture would be used at a pressure of 10 to 15 psi. On the other hand, the removal of scale from steel castings could require a coarse, hard abrasive and an air pressure of 80 to 100 psi.

The next variable to be considered is the blast angle vis-a-vis the workpiece. If using aluminum oxide at a 45|Ao angle, maximum scuff, cut, and roughness result. This may be fine if blasting is performed for adhesion or bonding operations; however, if the finest surface finish and the widest possible blast pattern are required, the aluminum oxide should be blasted at a 30o angle. This will produce a smoother scuff pattern.

The distance from the nozzle to the part being blasted should remain constant throughout the process, but this distance may vary from project to project. When synthetic abrasives are used, the recommended distance is 6 to 12 in. More distance is required for heavy ferrous metal media. Softer, natural media should be blasted from a distance of 3 to 6 in., depending on the action needed. Lightweight particles are expelled with more momentum from a direct pressure nozzle and retain their energy component over a much greater distance. For blasting at distances over 12 in., a direct pressure system is by far the most effective.