Flexible Finishing With Dry Blast Deburring

author

BRIAN MCHUGH
Product Manager, Automatic Systems
Guyson Corporation
Saratoga Springs, New York

abstract

This paper examines the finishing process of dry blasting and its application for automatic deburring. It examines several common methods of finishing and compares them to the dry blast process. Types of blast media are discussed and their varying effect on a burr. This paper explains how the dry blast process works, available machine concepts and how several finishing needs can be combined with dry blasting to further streamline production processes.

conference

THE INDUSTRIAL PRODUCTION CONFERENCE
October 11-14, 1988
Toronto, Ontario-Canada

index terms

Deburring
Sand Blasting
Finishing
Shot Peening
Abrasives
Theoretically, a precision machined or cast component can be taken directly from the manufacturing area, and a perfect part - free of burrs and cosmetically superior - can be supplied to the customer. However, the realities of dull cutting tools, poor maintenance, varying materials and production demands make secondary operations a necessary part of most production processes.

High volume manufacturing is a highly competitive, cost-conscious business. Due to the high costs of machinery, cutting tools, maintenance and labor, maximum running time on equipment is desired before tooling is repaired or replaced. However, these cost reduction or control efforts often result in reduced quality of the finished component requiring secondary operations, such as deburring, to provide the customer with an acceptable product.
This paper explores some of the common methods of mass finishing as they relate to deburring, and examines particularly dry blasting as a flexible method of automatic deburring. Commonly used deburring methods include vibratory, thermal and hand deburring, dry blast finishing or a combination of these methods. The best solution depends on your definition of the problem: part size, material, part configuration and location of the burr, as well as the desired finish and other downstream process requirements.

WHAT IS A BURR

Perhaps the most critical element in selection of a deburring process and judging the results of a chosen method lies in your definition of a burr, and hence, what has to be removed. Unfortunately, there is not a single definition of a burr that meets the requirements of all industries or products. One product may only require that no material come loose if it is turned upside down, another may be examined under 40 or more magnification to inspect for burrs. One company may be only concerned with any loose chips or burrs that might fall off the part interfering with fit or operation and another may need microscopic examination and precision in their product. One application might consider a raised or rough edge as a part of the parent metal and not of concern, while another might judge such an imperfection as a burr that must be removed. It is easy to overspecify the deburring requirements on a part. Given enough magnification one can argue that it is impossible to ever completely eliminate burring. Overspecifying the deburring requirements for a given product will limit your finishing method alternatives, as well as add unnecessary cost to finishing and inspection processes. A realistic definition of a given part's needs must be reached before searching for automated methods of deburring.

Burrs might be thought of in two general categories. One type is the rather obvious burr that is protruding or hanging as a result of a machining operation. This type of burr, depending on its relative size, and the type of material involved, often can be put through some type of process to break it off from the parent material. A second type of burr can be thought of as moved metal, and is securely attached to the parent component. This type of burr has to undergo removal by some type of process that will erode it away, as it cannot be broken loose without affecting the parent material.
Sample Definitions

1. Aluminum Automotive Component:
   The manufacturer in this instance defined a burr to be any material that could be dislodged by 80 psi compressed air or interfered with the proper fit of the component. If it could not be dislodged by high pressure compressed air, it was considered parent material and a concern of the machining process, rather than the finishing process. This is a specific definition that fits the requirements of the product. The major concern was for any loose aluminum that could dislodge in the part and clog the final assembled parts. The part is not under extreme pressures during use and a liberal burr definition could be adopted. A process that would break off a burr rather than wear it away would meet their requirements.

2. Aluminum Gyroscope for Missile Guidance System
   This component required inspection for burring under 50 magnification. The part is rotated at high speeds and must be balanced for proper operation. A rigid definition and inspection process were adopted for this component. A small raised edge is a concern for deburring, as well as minute imperfections on machined edges. An abrasive process to erode away burring was required.

3. Titanium Threaded Fluid Connectors for Aircraft:
   This product required burr inspection under 10 power magnification for burrs in the threads and for removal of any raised metal as the cutting tool exited the component. The critical nature of the application and the associated selling price allowed rigid inspection and required an unusually precise burr definition. An abrasive process to wear away burring was required.

Common Alternatives for Automated Deburring

Vibratory

Vibratory equipment is commonly used for deburring. Vibratory systems incorporate a mixture of abrasive media and a cleaning solution. The vibratory media, commonly referred to as vibratory stone, is placed in a holding container, such as a tub or drum, with the cleaning solution. The container is vibrated, causing the mixture to agitate. The solution is constantly circulated through
the container providing lubrication for the media, and thus, facilitating a smooth tumbling action. The components to be deburred are placed in the unit where they circulate through the agitated media. The vibration, agitation and tumbling action cause the components and media to rub together. The abrasive characteristics of the media slowly wear the burr from the part.

Since the smallest media normally available is about 1/8" by 11/32", physical limitations prevent burr removal from narrow recesses and component intricacies. Vibratory finishing often is not appropriate for complex components, since intricate areas of parts are very often the most in need of deburring. The nature of the finishing action also produces a slight radius on any sharp edge, which often is unacceptable. Vibratory finishing can be quite effective on exterior burrs or interior burring on larger components where an edge break on the component is not an undesirable side effect. Because vibratory finishing is a relatively slow process, a large vibratory tank may be required to process large numbers of parts in order to meet production schedules.

After deburring, it is necessary to separate the media from the components and to dry the parts. Additional cleaning may be required to remove residue produced after evaporation of the cleaning solution. It may also be expensive to dispose of the cleaning fluids when they must be changed.

Vibratory deburring is a process that is used to wear away a burr condition. The process cannot be selective in its attack on a burr. It will wear all areas on a component fairly equally until the burr in required areas is removed. Vibratory deburring can be an effective process on an appropriate type of component where the burr type is one that should be worn away rather than broken off, and where an altered surface finish is desired.

**Thermal Deburring**

Thermal deburring is one of the most common methods used to remove burrs on high volume production of small components. This method has been found to be effective under controlled burr conditions to remove loose or hanging burrs, especially with components of complex configuration. The thermal process literally burns off the burr material. A combustible gas and oxygen are introduced into a pressurized chamber, where the mixture is ignited, producing an intense burst of heat for a fraction of a
second, removing the burrs from the part. This process
does have some drawbacks. The larger the burr, the hotter
the burn required. In cases where burr size varies
greatly, there may a danger of the burn destroying the part
itself. The combustion also produces a scale that may
reduce the cosmetic appeal of the part and reduces the
material's natural lubricity as well. The melted burrs
sometimes produce a beaded edge on a part or the splatter
from burrs removed may end up in undesirable areas of the
component. In addition, if a burr is large enough to be
bent over, touching the parent part, the parent can act as
a heat sink and the burr will not be removed. Thermal
processing is effective in removing only loose and hanging
burrs and cannot be used where abrasive properties are
required to wear away a burr from parent material. Further
cosmetic finishing is usually required to remove the heat
scale or discoloration from the component. Finally, the
energy, and particularly the equipment costs, can be quite
high.

Hand Deburring

Hand deburring still is widely used on complex parts,
in low volume applications, or when consistency in tooling
or materials creates an unusual burr condition. The labor
intensity of hand deburring, although being highly
versatile, makes this type of processing the most
expensive, while providing the least consistent results.
The use of Dremel tools, flap wheels, grinders, etc. fall
into this category.

Blast Deburring

Blast finishing has proven to be effective in high
production situations, resulting in relatively low
component finishing costs. Many of the basic drawbacks of
other finishing methods are not inherent to blast
deburring. This process can be used where abrasive burr
removal is required or where the burr is to be broken off
and the rest of the component not to be affected. The type
of blast media used and the method of propelling the media
determine the effect on the component and the burr, and are
selected according to the application requirements.

Impact deburring is a more descriptive term for this
process. The finishing action, in this instance deburring,
is accomplished by propelling a particle at the work
surface or the area of the part to be deburred. As the
particle (or media) strikes the component at high
velocities, it breaks away the burr from the component. A
non-abrasive blast media, such as a plastic, is used where
the requirement is to break off a burr without affecting
surrounding parent material. An abrasive media is used when the requirement is to wear away, as well as break off the burr.

**Media Selection**

Blast media is available in sizes small enough to reach even some of the most recessed and intricate areas of a component. Media can be effectively used and recovered in production type equipment down to 50 microns in size and as large as 2mm. The application and desired surface finish will determine the size, composition, and velocity of the blast material selected. In general, an angular particle, such as aluminum oxide, or angular abrasive plastic is used in applications that require wearing away material to deburr a component. A rounded or softer material is used to remove a burr by breaking it away from the parent material. Blast medias range from plastic or organic media to angular or spherical metallic or glass and ceramic particles. Still other medias are available, such as steel shot, which in addition to having some deburring abilities is used to stress-relieve the component surface by shot peening, adding to component reliability.

The size, mass, shape and breakdown characteristics of a blast media determine its effectiveness for a given application. There are dozens of different types of material that can be used for blasting and within each type of media there are a dozen or more possible particle sizes to select from. Many diverse composite and special alloys have been added to the list of abrasive media in recent years. These have been developed to address specific deburring needs and different finish requirements. The list of potential materials is extensive and an industry specialist or consultant should be contacted to determine the best media for a given application. The type of media used, as well as its size will each have a different effect on the component being blasted. If the media fractures on impact to an angular shape during use, this must also be considered when selecting a media type and judging its probable effectiveness. Some medias do not fracture and retain their shape after many impacts.

The following series of electron microscope photographs, at 80x magnification, dramatize the difference between some common types of blast media. Particles of media that are round and stay round after cycling through a blast process, such as metallic media are non-abrasive, as are cubical particles of plastic. Materials such as aluminum oxide, ground plastic or used glass bead appear as sharp angular particles that are best suited to remove a burr when an abrasive process is required.
Photo #1 - Cubical Plastic (80x)

Photo #2 - Abrasive Plastic (80x)
Photo #3 - Aluminum Oxide (80x)

Photo #4 - Glassbead - Unused (80x)
Photo #5 - Glass bead - Used (80x)

Photo #6 - Metal shot - Used (80x)
The use of these different medias on a common burr shows the varying effects each can have. This series of photographs was taken of an edge burr on 6061 aluminum and is shown under 80x magnification. The burr before removal is a hanging burr that runs diagonally across the photograph. The abrasive media which are angular, remove the burr by erosion. The parent part surface is also affected relative to the size, hardness, shape and mass of the particle used. The aluminum oxide produces a fine matted surface because it was the smallest size in this sample group.

The cubical plastic deburrs by breaking off the burr and does not affect the parent material. The round, metal media tends to break off the larger of the hanging burrs and peens down the remaining edge. The glassbead, because of the fractured particles that are abrasive, looks much like a more eroded version of the aluminum oxide sample. The ground plastic removes most of the hanging burr and has a minimal effect on the part surface.
Photo #8 - After Blasting with Cubical Plastic (80x)
Non-Abrasive Blast Media

Photo #9 - After Blasting with Aluminum Oxide (80x)
Abrasive Media
Photo #10 - Used Glassbead Media (80x)

Photo #11 - After Metal Shot (80x) Non-Abrasive Media
The next photos are of an internal burr on a steel component created by a drilling operation. The part is shown under 10x magnification. This part was deburred using as non-abrasive plastic where the objective was to remove the hanging burr without affecting the component dimensionally or cosmetically.
Photo #13 - Before Blasting - Hardened Steel Burr Formed on I.D. of Component from Drill Operation (10x)

Photo #14 - After Blasting (10X)
Cubical Non-Abrasive Media
The following photos are of an aluminum component where the objective is to remove the hanging burr and any remaining "bump" on the edge left over from the machining process. The parts are shown under 14x magnification. One part was processed with an abrasive plastic and one part with a glassbead media. Note that the abrasive plastic has abraded away the edge burr, where the round glassbead has knocked off the hanging burr and has removed less of or peened over the remaining "bump."

Photo #15 - (Before) Aluminum Component with Burr (14x)
Photo #16 - (After) Glass bead Media (14x)

Photo #17 - (After) Mesh Abrasive Plastic (14x)
The Dry Blast Process

The two most common types of dry blast machines are airblast systems (that use compressed air to propel the blast media against the component) and the airless turbine wheel-type systems which use centrifugal force to propel the media. An airblast system normally uses a blast gun which is connected to two hoses, one for incoming compressed air, the other for the blast media. The incoming air to the gun creates suction which pulls the blast media from the feed hopper and forces it out of the blast nozzle. An automated system normally would have several blast guns with individual pressure regulators, so the media spray can be selective; that is, directed at normal hard-to-reach spots or heavier burrs. (See Fig. A)

The equipment operates by virtue of a vacuum which is created by compressed air passing through a small jet in the suction gun (A) into an induction chamber (B) before passing through a larger nozzle (D).

The abrasive (C) is pulled to the blast gun through a feed hose by the suction created in the induction chamber (B) behind the large nozzle by the jet of the high velocity compressed air from the small nozzle (A). Expanded air and abrasive are passed through the larger nozzle (D) and directed at the component to be cleaned.

Figure A: Suction Type Blast Gun

A variation of the air blast process is a direct pressure system. Blast media is propelled under direct air pressure from a pressurized media storage vessel. This results in high velocity of the blast media out of a single hose. A direct pressure system normally is used in extremely heavy-duty applications. The airless turbine wheel system uses a high-speed rotating paddle wheel which propels the blast media randomly against the components. Because the blast stream is random, this type of system is well suited when an overall finish is required. It is excellent for light burr removal, cosmetic finishing and surface preparation. (See Fig. B)
The abrasive is fed by gravity into the centre of the wheel and then fed through a regulator and distributor which controls the amount fed to the blades. It is accelerated along the flat blades of the rotating wheel where it is discharged at high velocity, both radially and tangentially, to the wheel rotation.

Figure B: Airless Wheelblast System

All types of blast systems incorporate a blast media reclaimer and a dust collector. The media reclaimer automatically separates the reusable media, recycles it, and removes the fractured particles and debris to the dust collector. A media reclaimer is required to insure consistent deburring results by allowing only reusable media to be propelled against the component. A reclaimer also helps control media consumption costs in that during operation only "topping off" of media is required, rather than batch replacement. Complete automation is available on airblast or airless blasting systems. Operator costs can be nearly eliminated by using conveyors or robotic loading and unloading. Selection of the method of blast finishing and the degree of automation are made on the basis of the most efficient type of blast system and the finishing requirements of a given application. (See Fig. C)
Basic Blast Systems

Three basic processing concepts are available in blast systems, including batch tumbling, rotary tables and in-line conveyors. The following is an example of each, as applied to compressed air units.

Small, intricate components, such as components for locks, lend themselves well to tumble blast batch finishing. The gentle tumbling action turns the parts in all directions, exposing all surfaces and angles to the blast stream. In Photo #18, parts are held in the top parts bin, where they automatically batch load into the tumble basket. The parts are automatically deburred by the media propelled out of the blasting nozzles for a pre-programmed time. After blast deburring, the components are airwashed to remove residual media and dust. After the airwash cycle, the parts exit the machine through a chute at the bottom of the tumble basket. By simply adding a conveyor feed and removal system, this machine will be totally operator-independent.

Photo #19 is an example of a rotary table deburring system, used when parts cannot be tumbled or require selective treatment. This machine can operate in three distinctive modes: continuous rotary, rotary index or rotary index with satellite work spindles. Operating in continuous rotation, the components to be deburred are
placed on the table, rotated into the machine under the blast nozzles, pass through an airwash and exit the machine ready for unloading.

The rotary index mode operates in much the same way, except the components to be finished are placed in designated areas of the table. Each part will then be indexed into place, where it is deburred for a pre-programmed time before the next index. To conserve compressed air, the nozzles operate only when a component is in position, not between indexes.

The third mode operates much the same as the rotary index, except that the components are fixtured onto rotary spindles. The spindle is rotated when in the blast workstation, which allows a single blast nozzle to cover the entire circumference of the part, or inside intricate details. Up to 16 nozzles may be included, allowing various combinations of blast guns to be used, depending on the part size and configuration, and minimizing set-up time between different parts. Pick and place robotics can be used to complete the automation process.

For large components in high production situations, a conveyor system is a natural choice. Systems can be designed to finish both the top and bottom of a part simultaneously. A conveyor system can be integrated directly into present plant material handling systems. The components are simply placed onto the conveyor, passed into the machine, under the blast nozzles, through an airwash and out the opposite side, completed.

Further Automation

It is also possible to combine several finishing processes within a single blast system. For example, performing both deburring by breaking off burrs with a non-abrasive and eroding burrs with an abrasive media can be accomplished within a single finishing system. Combining of several finishing processes within a single machine can even include washing and drying of the components and automatic masking of critical surface areas from an abrasive blast (photo #20). This type of flexibility can greatly improve a machine’s ROI payback by combining a deburring operation with other finishing requirements, all with one operator or load/unload device. This eliminates two or more separate machines with associated material handling, machine and labor costs.
Process Limitations

Blast deburring is generally limited in its effectiveness by the size and type of burr to be removed, as well as its location on the component. An interior burr, for example, needs to be accessible to the blast spray from outside the component if the passage is not large enough to allow a nozzle to enter the component. If an abrasive removal process is required on a component that has critical surface profile or size requirements that cannot be otherwise compensated for, the surrounding areas to the burr will be affected if the component is not mechanically masked either before blasting or automatically by the equipment. Blast deburring is normally a very fast process when the burr is of a reasonable size. On larger burrs on hard materials where the burr cannot be broken off, this process is generally not aggressive enough to remove the burr in time periods comparable with grinding or sanding methods. If the material in need of deburring is extremely ductal, a blast process may only move a burr from one direction to another, and not be able to break it off or erode it away, as in some thermoplastic materials.

CONCLUSION

Blast deburring offers a versatile, often inexpensive alternative approach to deburring and other secondary operations. Operation and maintenance costs are low compared with many alternatives, and a single machine can process an array of parts without excessive set-up time between runs. This type of equipment is ideal to interface directly with automated machining equipment, performing the required deburring automatically as the parts are processed. The range of applications is diverse, depending on desired finish and production requirements, and even difficult burrs often can be removed in extremely short time cycles without otherwise affecting the component or producing the undesirable side effects often associated with other finishing methods.

Blast deburring is a highly flexible process. It can be used in applications that require only breaking off a hanging burr without affecting the part surface, or by merely using a different media in applications that require an abrasive removal process. It is a fast process that can be easily integrated or even combined with present manufacturing processes or used to cosmetically change a component with no regard to burrs or flash.
Photo #18 – Automatic Load/Unload Tumbleblast System
Photo #19 - Rotary Index Table Blast System with Component Spindles
Photo #20 – Blast System Incorporating Wash System, Rinse System, Steam Heated Dryer, Blast Deburring and Blast Finishing with Automatic Masking. Production Rate of 400 Parts per Hour