TECHNICALLY speaking

BY DAVID A. DAVIDSON, SOCIETY OF MANUFACTURING ENGINEERS,
2008 CHAIR: DEBURRING/SURFACE CONDITIONING TECHNICAL GROUP,
SPOKANE, WASH.

Vibratory Finishing: Versatile, Effective, and Reliable

As industrial manufacturing standards evolve, tried-and-true mass finishing processes must keep in lockstep with end-user demands.

Figure 1: This large tub-style vibratory finishing system has been fitted with dividers, so larger parts can be processed without impingement or damage from part-on-part contact.
Photo courtesy of Giant Finishing, Inc.

Mass media finishing processes have gained widespread acceptance in many industries, primarily as a technology for reducing the costs of producing edge and surface finishes. This is particularly true when manual deburring and finishing procedures can be minimized or eliminated.

There are a number of different mass finishing processes in common use throughout industry. Among these are barrel, centrifugal, vibratory, and spindle finishing. Vibratory systems have become the predominant method due to advantages inherent to the method in terms of ease of use, automation, and material handling. When first developed in the 1950s, these systems were typically modest in size, and were used for deburring and finish processing of smaller components. Being able to process larger batch lots of modestly sized parts was important to competitiveness.

The face of American manufacturing has changed considerably since those days. Smaller, more simply designed parts in large numbers are now almost always sourced offshore. Much of American manufacturing and machining is now concentrated on making larger, higher value, and more complex parts. As part size has grown, so has the size and processing capability of vibratory systems. Many larger and complex parts commonly finished in vibratory equipment today would not have been considered as viable candidates for this type of automated mechanical finishing in the past. For example, 100 ft^3, and even 200 ft^3 capacity vibratory systems capable of handling very large and heavy components are utilized in a number of different industries for large-part surface finishing.

Vibratory finishing is an important component of a group of industrial processes referred to as mass finishing or mass media finishing. Mass finishing is a term used to describe a group of abrasive industrial processes by which large lots of parts or components made from metal or other materials can be economically processed in bulk to achieve one or several of a variety of surface effects. These include: deburring, descaling, surface smoothing, edge-break, radius formation, removal of surface contaminants from heat treat and other processes, preplate and prepaint, or coating surface preparation. These might also entail blending in surface irregularities from machining or fabricating operations, producing reflective surfaces with nonabrasive burnishing media, refining surfaces, and developing superfinish or microfinish equivalent surface profiles. All mass finishing processes utilize a loose or free abrasive material referred to as media

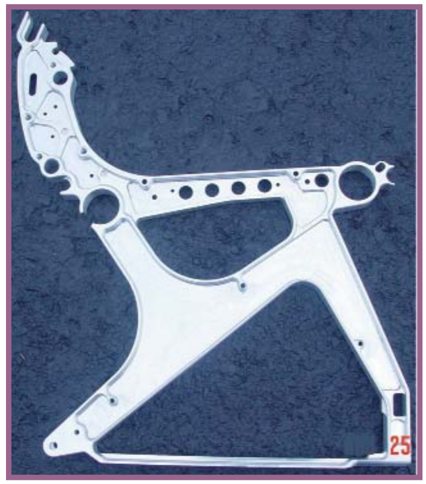

Figure 2: Parts such as this aircraft seat can be edge finished in vibratory equipment with dividers that segregate or isolate the parts from each other.

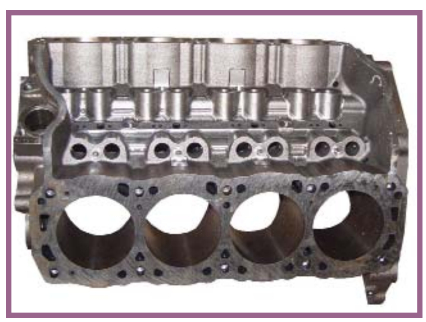

Figure 3: The capacity of tub-style vibratory equipment makes it possible to develop uniform edge contour and surface finish on larger components in an overall sense. This was not possible with methods dependent on single point of contact, which permitted substantial variation in edge and surface effects.
Photo courtesy of Giant Finishing, Inc.

within a container or chamber of some sort. Energy is imparted to the abrasive media mass by a variety of means to impart motion to it and to cause it to rub or wear away at part surfaces.

Nearly all manufactured parts or components require some measure of surface refinement prior to final assembly, or the final finish or coating required to make the parts acceptable to the consumer or end-user. Most manufacturing companies that employ mass finishing techniques do so because of the potential economic advantages, especially when compared with manual deburring and surface finishing techniques.

Mass finishing processes often reduce or eliminate many procedures that are labor intensive and require extensive part handling. This is especially important in meeting increasingly stringent quality control standards, as most mass finishing processes generate surface effects with part-to-part and lot-to-lot uniformity that cannot be replicated with processes in which parts are individually handled. It has become a manufacturing engineering axiom that part reject and rework rates will plummet if a mass finishing approach can be implemented to meet surface and edge finish requirements.

Although each of the mass finishing process types carries a unique set of process strengths and weaknesses, all of them are sufficiently versatile to be able to process a wide variety of part types successfully. A plethora of abrasive media types, sizes, and shapes makes it possible, in many cases, to achieve very different results within the same equipment, ranging from heavy grinding and radiusing to final finishing. Components from almost every conceivable type of material have been surface conditioned using mass finishing techniques, including ferrous and non-ferrous metals, plastics, composition materials, ceramics, and even wood. Vibratory finishing is still the most predominant method in the United States, and it falls into two broad categories in terms of the equipment being used: round bowl and tub designs.

Figure 4: This photo shows two round-bowl vibratory systems being used in series. (An automated part feeder meters in parts.) After processing in an initial operation, parts can be separated and then transferred to either a secondary finishing operation or dried.
Photo courtesy of Giant Finishing, Inc.

ROUND-BOWL VIBRATORY SYSTEMS

Round-bowl equipment normally has a processing chamber that resembles the bottom half of a doughnut. Although up to 20% slower than tub-style machines, and having occasionally more unwieldy media changeover routines, the advantages in automation and material handling for these machines have often given them an edge in any processing cost-per-part analysis. The vibratory motion generator on these machines is customarily a vertical shaft mounted in the center-post area of the bowl. Adjustments related to the eccentric weights on this shaft will affect the rolling motion of the media, as well as the forward spiral motion of the media in the bowl chamber. This spiral motion is one of the machine's more salient advantages, as it promotes an even distribution and segregation of parts in the mass, thus lessening the chance of part-on-part contact.

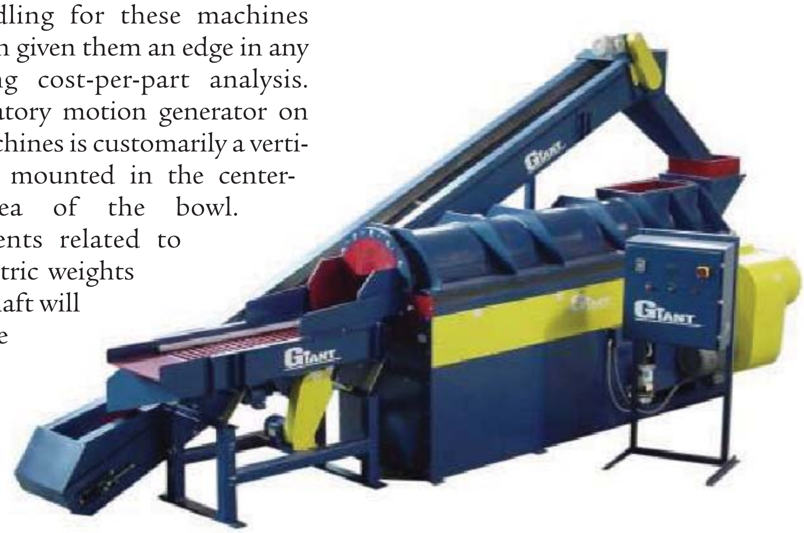

Figure 5: This type of "inline continuous" or "flow-through" unit is used to accommodate very high volumes of parts. After deburring, parts and media are then separated at the end of the tube, and media is conveyed back to the head of the machine. Here, it is reintroduced to the media mass inside the processing chamber tube.
Photo courtesy of Giant Finishing, Inc.

Like tub machines, equipment size varies from small bench models—whose capacity are measured in quarts or gallons—to very large equipment in excess of 100 ft^3 capacities. Successful processing requires appropriate media and compound selection, correct amplitude and frequency adjustments of the motion generator, and precisely determined water flow rate and compound metering rates. Unlike barrel systems, whose water levels are determined once at the beginning of the cycle, vibratory systems have a constant input and throughput of water into the system (both flow-through and recirculation systems are employed, although flow-through is generally much preferred).

Water levels are critical to process success. Too much water will impede the vibratory motion of the mass,

Figure 6: A number of companies utilize special chemistry to develop micro-surfaces to improve part performance in heavy load situations. These include conveyor chains, precision washers, forge dies, cast iron piston sleeves, camshafts, crankshafts, engine valves, and hydraulic pumps.

while too little will permit a soils/sludge buildup on the media, thereby reducing its cutting efficiency. Flow-through functions can be automated with appropriate controls and metering devices. For parts requiring relatively short cycle times, round-bowl machines can be configured to perform in a continuous mode—the parts being metered in, then making one pass around the bowl and exiting via the internal separation deck. Some designs include a spiral bottom to enhance loading from the machine onto the separation deck, lessening the likelihood of part-on-part contact at the entrance to the separation deck.

Ease of use and economy are the hallmarks of vibratory finishing methods—factors that have contributed to making this perhaps the most accepted deburring and surface conditioning method for finishing parts in bulk. The equipment performs well in either batch or continuous applications. Standard applications usually can be run most economically in round-bowl-type equipment. Larger parts may require more specialized tub-type equipment. Large volumes of parts can be processed in relatively short cycles, and can make use of continuous tub or bowl equipment, or even multipath equipment. The latter can offer parts transfer from one operation to a secondary-type operation within the confines of the same machine but different chambers. Vibratory action itself often will preclude the ability to develop superfinishes or microfinishes unless specialized chemically accelerated methods are adopted.

Vibratory equipment ranges in size from 1 ft^3 capacity up to 200 ft^3. Tub vibrators are considered to have more aggressive media action than round-bowl machines, and they are capable of processing very large, bulky parts (as large as 6 ft × 6 ft) or potentially awkward part shapes (parts 40 ft long and longer). The vibratory motion generators consist of rotating shafts with sets of eccentric weights attached either at the bottom of the U-shaped tub or one of the sidewalls. This equipment is usually loaded from the top of the chamber and usually unloaded through a discharge door located on a side panel. Parts and media can be screened on an external separation deck. This arrangement allows for relatively quick load/unload or media changeover cycles when compared with other equipment.

Tub-shaped or tubular-shaped vibrators are commonly utilized for continuous, high-volume applications where the time cycle required to process the parts is relatively short. Media return conveyors and feed hoppers are used to meter the correct ratio of media and parts to the loading area of the machine, while media and parts are separated on a continuous basis by a screen deck located at the unload or discharge area of the machine. Tub-type machinery is also used extensively for batch applications and can be easily subcompartmentalized for parts that require total segregation from each other.

Many manufacturers have discovered that as mass finishing processes have been adopted, put into service, and the parts involved have developed a working track record, an unanticipated development has taken place. Their parts are better—and not just in the sense that they no longer have burrs, sharp edges, or that they have smoother surfaces. Depending on the application, they last longer in service, are less prone to metal fatigue failure, exhibit better tribological properties (translation: less friction and better wear resistance) and, from a quality assurance perspective, are much more predictably consistent and uniform.

The question that comes up is, "Why do commonly used mass media finishing techniques produce this effect?" There are several reasons. First, these methods produce isotropic surfaces with negative or neutral surface profile skews. Additionally, they consistently develop beneficial compressive stress equilibriums. These alterations in surface characteristics often improve part performance, service life, and functionality in ways not clearly understood when the processes were adopted. In many applications, the uniformity and equilibrium of the edge and surface effects obtained have produced quality and performance advantages for critical parts that can far outweigh the substantial cost-reduction benefits that were the driving force behind the initial process implementation.

FURTHER READING

Thompson SR. Selection of Vibratory Equipment. ***SME Technical Paper MR81-381.*** Dearborn, MI: Society of Manufacturing Engineers, 1981.

Thompson SR. Comparison of Rectangular Tub and Inline Continuous Vibratory Equipment. ***SME Technical Paper MR83-679***. Dearborn, MI: Society of Manufacturing Engineers, 1983.

Kittredge JB. Selection of Mass Finishing Equipment. ***SME Technical Paper MR87-153.*** Dearborn, MI: Society of Manufacturing Engineers, 1987.

Gillespie L. *Mass Finishing Handbook*. New York, NY: Industrial Press, 2007: 237–47.

BIO

David A. Davidson is the 2008 Chair, Deburring/Surface Conditioning Technical Group, Society of Manufacturing Engineers,

Spokane, Wash. He has written extensively on the subject of mass finishing, particularly vibratory finishing. He may be reached at ddavidson@deburringsolutions.com.