Introduction

Several processes which are used on workpieces as the final finishing operations fall into this category. These processes mainly utilize fine abrasive grains. Finishing operations can contribute significantly to production time and product cost. Thus, they should be specified with due consideration to their costs and benefits.

Grinding is not actually a finishing operation. Grinding is a chip removal process that uses an individual abrasive grain as the cutting tool.

Metal finishing operations have grown very large in number now a day. Various industries and production of various products required various kinds of finishing operations. Thus different types of finishing operations have been grown. It has become itself a huge subject. All the finishing operations and their study is not possible in such small context. While searching on the internet it was found that various company offers expertise over finishing, each and every of them requiring money. Good texts are also available but can not get without money. However some good free resource was also available.

In the following pages important metal finishing operations are discussed giving definitions, operations, metal removing, and examples for each of the finishing process. Thus comparison is shown without using tabular approach. Because if the matter was presented in a table, that would not fit properly in the screen and on printer. In some cases good text was not available, those may have some lag.

Some web resources are provided which was found useful. Some of them contain good material but requires money, which can be useful in commercial applications.

Grinding

Grinding is the process of removing metal by the application of abrasives which are bonded to form a rotating wheel. When the moving abrasive particles contact the work piece, they act as tiny cutting tools, each particle cutting a tiny chip from the work piece. It is a common error to believe that grinding abrasive wheels remove material by a rubbing action; actually, the process is as much a cutting action as drilling, milling, and lathe turning.

The grinding machine supports and rotates the grinding abrasive wheel and often supports and positions the work piece in proper relation to the wheel. The grinding machine is used for roughing and finishing flat, cylindrical, and conical surfaces; finishing internal cylinders or bores; forming and sharpening cutting tools; snagging or removing rough projections from castings and stampings; and cleaning, polishing, and buffing surfaces. Once strictly a finishing machine, modem production grinding machines is used for complete roughing and finishing of certain classes of work.

Grinding machines have some special safety precautions that must be observed.

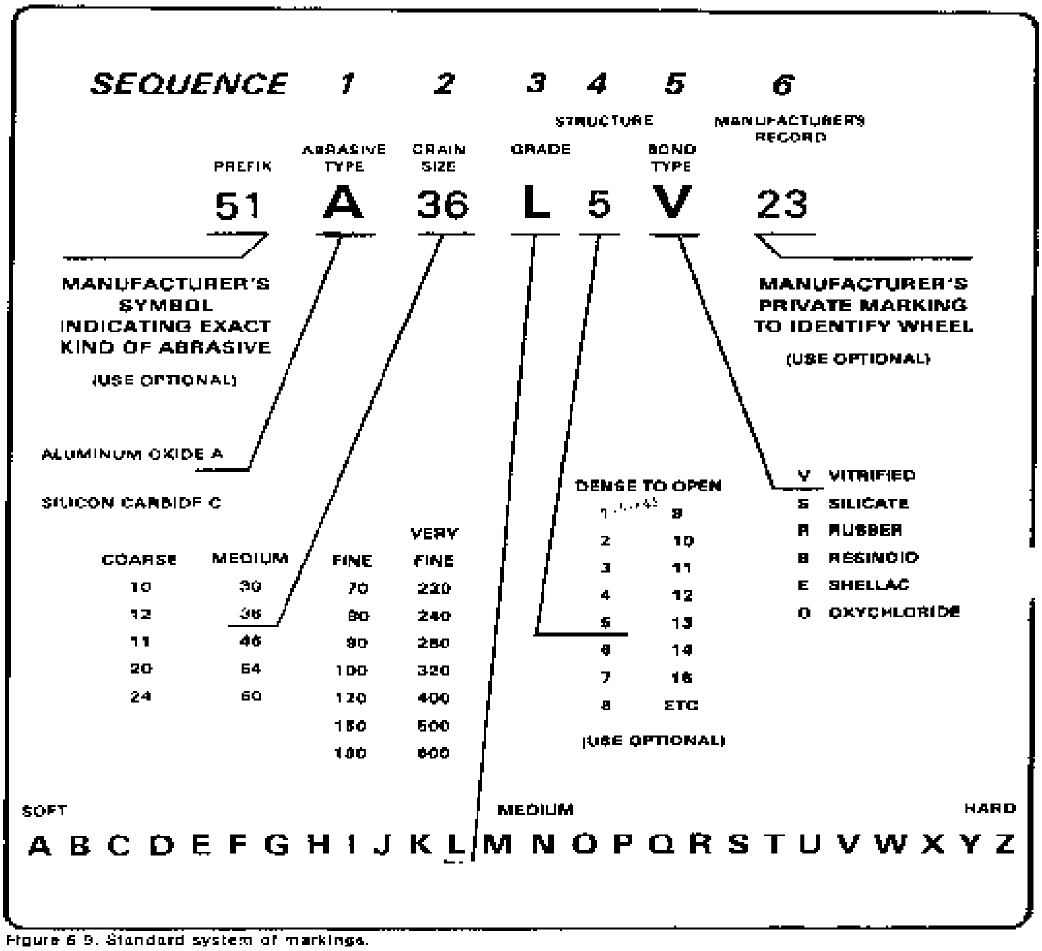


Figure 6 9. Standard system of markings.

Standard system of markings

Operations: Grinding is done on surfaces of almost all conceivable shapes and materials of all kinds. Grinding may be classified as non precision or precision, according to purpose and procedure. Non-precision grinding, common forms of which are snagging and off-hand grinding, is done primarily to remove stock that can not be taken off as conveniently by other methods from castings, forgings, billets, and other rough pieces. The work is pressed hard against the wheel, or vice versa. The accuracy and surface finish obtained are of secondary importance. Precision grinding is concerned with producing good surface finishes and accurate dimensions. The wheel or work or both are guided in precise paths.

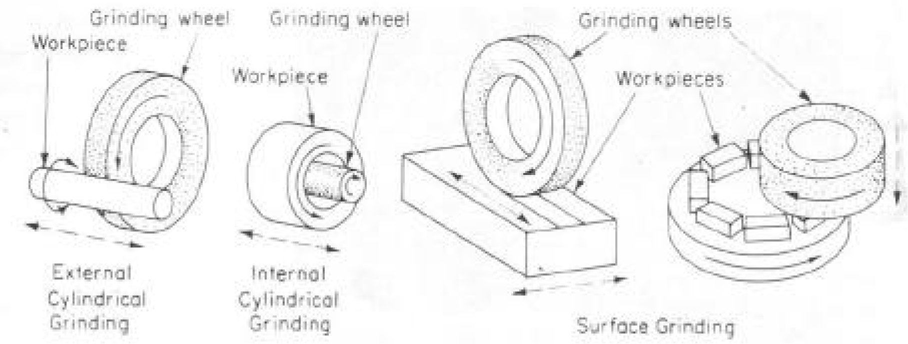


Figure 27-7 Basic precision grinding operations.

Basic precision grinding operations

Grinding is able to produce accurate and fine surfaces because it works through small abrasive cutting edges, each of which takes a tiny bite. On the ither hand, appreciable quantities if material can be removed by grinding because a large number of cutting edges are applied at high frequency. For instance, about 39,000,000 cutting points act in a minute when a 46-grit wheel, 450 mm (18 in.) in diameter and 50 mm (2 in.) wide, is revolved with a surface speed of 1500 m/min (5000 fpm).

Surface Grinding: Surface Grinding involves grinding flat surfaces and is one of the most common grinding operations.

Cylindrical Grinding: In Cylindrical Grinding, also called center-type grinding, the external cylindrical surfaces and shoulders of the work piece are ground. Typical applications include crankshaft bearings, spindles, pins, bearing rings, and rolls for rolling mills.

Internal Grinding: In internal grinding, a small wheel is used to grind the inside diameter of the part, such as to bushings and bearing races.

Centerless Grinding: Centerless grinding is a high-production process for continuously grinding cylindrical surfaces in which the workpiece is supported not by centers or chucks, but by a blade.

Precision Finishing

Lapping

Lapping, like polishing, is an abrading process in which small amounts of material are removed. Unlike polishing, however, lapping is intended to produce very smooth, accurate surfaces, and is never used instead of polishing or buffing when clearance is the only consideration.

Vertical Lapping Machine

Depending on the hardness of the workpiece, lapping pressure range from 7 kPa to 140 kPa (1 to 20 psi). Dimensional tolerances on the order of ±0.0004 mm (0.000015 in.) can be obtained with the use of fine abrasives up to grit size 900. Surface finish can be as smooth as 0.025 to 0.1 µm (1 to 4 µin.).

Operation: Fine loose abrasive mixed with a vehicle, bonded abrasive wheels, or coated abrasives are used for lapping. Only the finest abrasives are used for lapping. These may be either natural or artificial. Abrasives for lapping range from No. 220 to No. 600 or No. 800 which are very fine flours. Lapping compounds are generally mixed with water or oil so that they can be readily applied to the lap.

Lapping is accomplished by charging metal forms called laps with flour-fine abrasives and then rubbing the work piece with the lap. The lap may be of any shape and may be designed to fit into most power machine tools. The only requirements of the lap are that it be of softer material than the material being lapped, and that it be sufficiently porous to accept the imbedded abrasive grain. Common materials for laps are soft cast iron, copper, brass, and lead. Some laps are flat and others are cylindrical to fit on steel arbors for internal lapping of bores. Cutting oil is recommended for most lapping operations.

A centerless lapping machine is like a center less grinder but hasextra wide wheels. Lapping wheel speed may be 150 to 600 m/min (500 to 2000 fpm), and work speed 45 to 150 m/min (150 to 500 fpm). Stock removal is usually 5 µm (0.0002 in.) or less, and fine surfaces 50 nm (2 µin.) R_a (or better) and close tolerances [1.5 µm (ca. 0.00005 in.) for size and half as much for straightness] are produced.

Honing

Honing is an abrading operation mostly for finishing round hoes but also to lesser extent external flat and curved surfaces by means of bonded abrasive stones. Because the abrasive is not free to embed in the surface, soft metallic and nonmetallic as well as hard materials can be honed. Typical applications are the finishing of automobile engine cylinders, bearings, gun barrels, ring gages, piston pins, shafts, and flange faces.

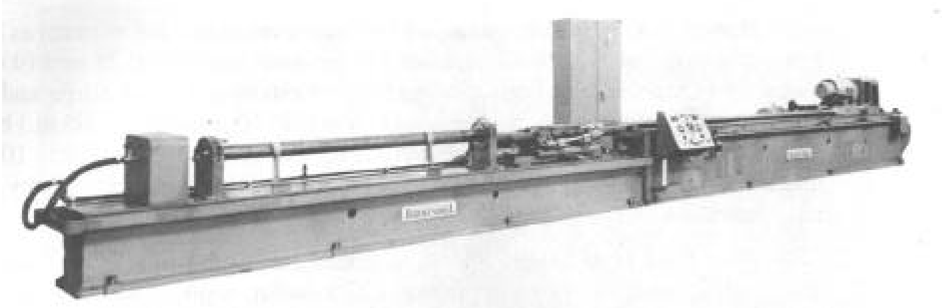
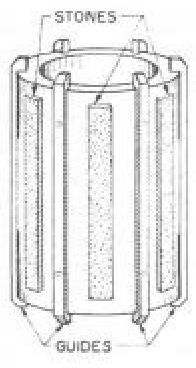


Figure 29-3 Single-stroke horizontal honing machine with a 3.7-m (12-ft) spindle travel for finishing 105-mm gun barrels. (Courtesy Barnes Drill Co.)

Single stroke horizontal honing machine

Operations: Honing stones are made fro the common abrasive and bonding materials, often impregnated with sulfur, resin, or wax to improve cutting action and lengthen tool life. Grain sizes range from 80 grit for roughing to 320 for finishing hard materials to 500 for soft materials. The stones are expanded, when working, by a cone or wedge inside the holder. A flexible honing tool consists of a brush with abrasive nodules on the ends of the bristles. The tool or workpiece, or both, are rotated and reciprocated in relation to each other to hone a hole. The two movements are run purposely out of phase to cover all the surfaces without a regular pattern or scratches.



Honing Tool

Hone forming simultaneously plates metal onto a base material and abrades the new surface to a desired dimension and finish. While a honing tool is revolved and reciprocated, electrolyte is circulated through the hole, and a current is passed between the tool and the workpiece. The operation is fast: for example, in one operation 50 μm (0.002 in.) of copper is deposited inside a steel cylinder, and the surface is cleaned and finished to size, all in less then a minute.

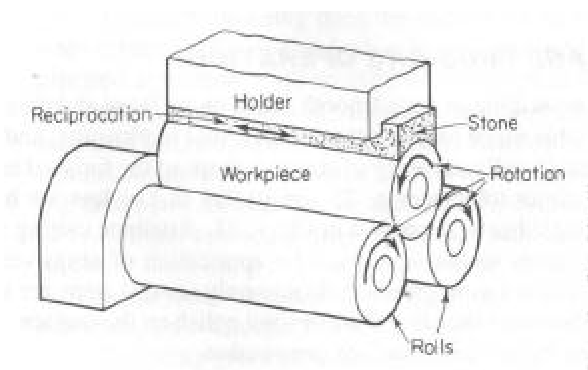
An example of performance is the removal of 0.1 mm (0.004 in.) of stock in each of eight cylinders in 30 seconds to a tolerances of less then 12.5 μm (0.0005 in.).

Superfinishing

Superfinishing, also called microstoning and microfinishing, is done by scrubbing with a stone or stones pressed against a surface to produce a fine-quality metal finish. It is not basically a dimension-creating operation, although it can correct out-of-roundness as much as 75% and size to less than 30 µm (ca. 0.001 in.). Stock removal is limited to about 10 µm (0.0004 in.) and is often less. Substantial geometrical and dimensional accuracy must be created first, usually by grinding. Superfinishing is intended to correct minute surface defects like chatter marks and is also effective in removing amorphous, fuzzy, broken, and burned material, and leaves a true surface of parent base metal. Practically perfect surfaces with no apparent scratch pattern may be produced at one extreme, and at the other, surfaces with readings of 750 nm (30 µin.) R_a and more and a deliberate crosshatched scratch pattern for lubricating qualities.

Operations: A superfinishing operation is done by rapidly reciprocating a fine grit stone bond and pressing it against a revolving round workpiece. The stone quickly wears to conform to the contour and to cover a large area of the workpiece. The motions are arranged so that a grit never follows the same path more than once around the workpiece. Spherical and flar surfaces may be superfinished by the edge of a cup wheel which is rotated during multi-direction traversing over the work surface.

The workpiece and tool is superfinishing are flooded with cutting fluid to carry away heat and particles of metal and abrasive. Although little force is imposed on the stone, the contact pressure is high at first because the stone touches only a few high spots, and the cutting action is rapid. The stone is able to bridge and equalize a number of surface defects at one time and corrects to the average of the rough profile. When the surface becomes smooth, the pressure decreases, and the stone rides on a film of fluid and ceases to cut. A short surface may be refined to better than 0.1 µm (4 µin.) in less than a minute.

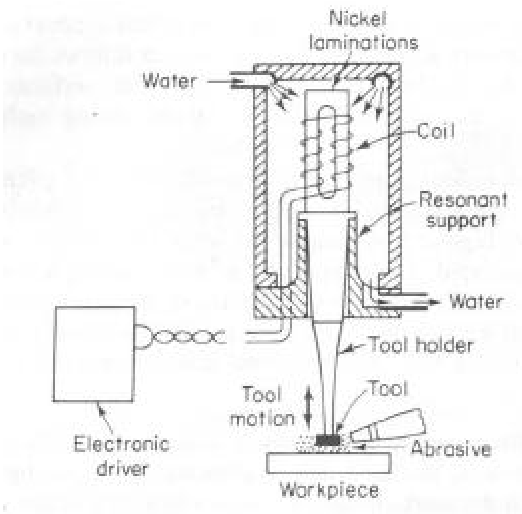


Scheme of centerless microstoning

Ultrasonic Impact Grinding

Ultrasonic impact grinding is a means of cutting shapes of all kinds in hard materials of all kinds by rapid and forceful agitation of fine abrasive particles in a slurry between tool and work piece. The tool is an image of the form to be cut, which may be a hole of almost any shape, a cavity, or figure in relief or intaglio. A sharp, pointed tool may be applied for engraving or die sinking. Vibrations of 15 to 30 kHz are generated by an electric driver, consisting of an oscillator and high output amplifier which supply high-frequency current to a coil around a laminated nickel core. This core has the property of expanding and shrinking under the influence of the alternating current.

The ratio of stock removed to tool wear is about 10:1, and tool life is tolerable. Because it is slow, ultrasonic grinding in practical only for substances harder then 64 R_c and shapes not amenable to regular grinding. In cemented carbide, stock removal is less than ½ cm^3/min (0.03 $in.^3$/min). Ultrasonic grinding can do much the same work as EDM and ECM (even though slower) and has the advantage that it works on nonmetallic substances while the others cannot. Typical jobs include dies for cemented carbide, slicing semiconductor materials, and engraving delicate patterns in glass. The action does not heat nor disturb the material below the work piece surfaces. Practical finishes obtainable are around 0.25 µm (10µin.) R_a, and tolerances 50 µm (0.002 in.) or less.



Ultrasonic Transducer

Non-Precision Finishing

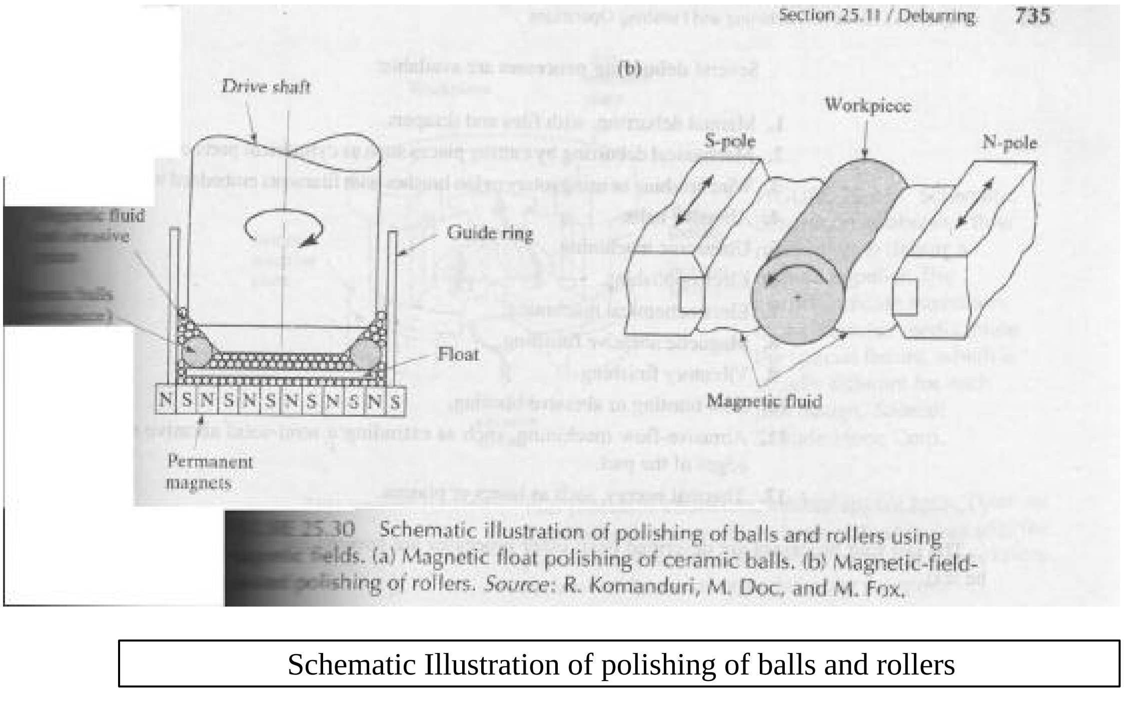
Polishing

Polishing is an abrading process in which small amounts of metal are removed to produce a smooth or glossy surface by application of cushion wheels impregnated or coated with abrasives. Polishing may be used for reduction or smoothing of the surface to a common level for high finish where accuracy is not important, or it may be employed for removing relatively large amounts of material from parts of irregular contour. Rough polishing is performed on a dry wheel using abrasives of No. 60 grain (60 grains per linear inch) or coarser. Dry finish polishing is a similar process where No 70. grain to No. 120 grain abrasives are used. Oiling is the term applied to polishing with abrasive finer than No. 120 grain. In this process, the abrasive is usually greased with tallow or a similar substance.

Polishing Abrasives: The abrasive grains used for polishing must vary in characteristics for the different operations to which they are applied. Abrasive grains for polishing are supplied in bulk form and are not mixed with any vehicle. The abrasives, usually aluminum oxide or silicon carbide, range from coarse to fine (1 to 20 grains per inch).

Other Polishing Types:

(a) Chemical mechanical polishing
(b) Elctropolishing
(c) Polishing process using magnetic fields



Schematic Illustration of polishing of balls and rollers

Buffing

Buffing is a smoothing operation which is accomplished more by plastic flow of the metal than by abrading. The abrasives are generally finer than those used in polishing and instead of being firmly cemented to the wheel are merely held by a "grease cake" or similar substance. Buffing is used to produce a high luster or color without any particular regard to accuracy of dimension or plane. Cut down buffing produces a rapid smoothing action with fast-cutting abrasives and relatively hard buffing wheels. It is accomplished with high speeds and heavy pressures to allow a combined plastic flow and abrading action to occur. Color buffing is the imparting of a high luster finish on the workpiece by use of soft abrasives and soft buffing wheels.

Buffing Abrasives: Buffing abrasives are comparatively fine and are often made up in the form of paste, sticks, or cakes; the abrasive being bonded together by means of grease or a similar vehicle. The abrasive sizes for buffing are 280, 320, 400, 500, and 600. Some manufacturers use letters and numbers to designate grain size such as F, 2F, 3F, 4F, and XF (from fine to very fine). Pumice, rottenstone, and rouge are often used as buffing abrasives.

Polishing and Buffing Speeds: The proper speed for polishing and buffing is governed by the type of wheel, workpiece material, and finish desired. For polishing and buffing in general where the wheels are in perfect balance and correctly mounted, a speed of approximately 1,750 RPM is used for 6-inch to 8-inch wheels; up to 6-inch wheels use 3,500 RPM. If run at a lower rate of speed, the work tends to tear the polishing material from the wheel too readily, and the work is not as good in quality.

Power Brushing

High-speed revolving brushes are applied to improve surface appearance and remove sharp edges, burrs, fins and particles. This tends to blend surface defects and irregularities and rounds edges without excessive removal of material. Surfaces may be refined to around 0.1 μm (4 μin.) R_a when desired. Brushing action helps avoid scratches that act as stress raisers.

Common power brushes are wire bristles, hard cord, and Tempico or tough fiber wheels. They are naturally flexible, able to conform to quite irregular surfaces, and can get into otherwise hard to reach places. Abrasive compounds are often put on brushes. Brushing is done by hand but is readily adaptable to semiautomatic machines.

Tumbling

The operation called tumbling, rolling, or barrel finishing consists of loading workpiece in a barrel about 60% full of abrasive, grains, sawdust, wood chips, natural or artificial stones, cinders, sand, metal slugs, or other scouring agents, depending on the work and action desired. Water is usually added, often mixed with an acid, a detergent, a rust preventative, or a lubricant. The barrel is closed or tilted and rotated. With the right load and speed, the workpieces slide over each other, producing a scouring, trimming, and burnishing action as the barrel turns.

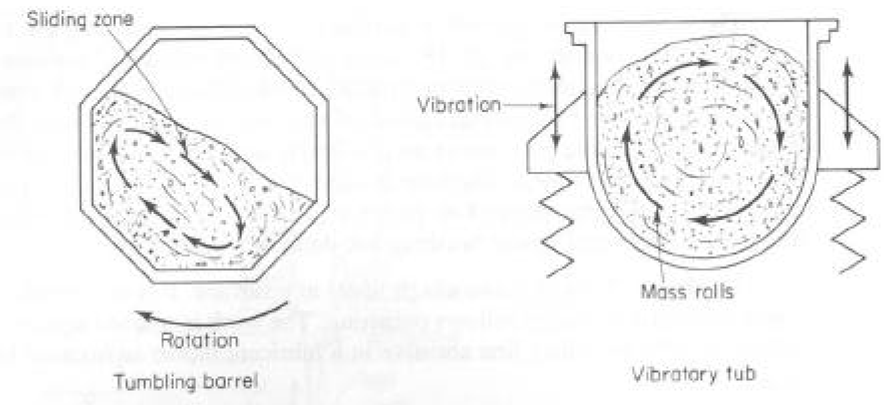


Figure 29-6 Principles of tumbling and vibratory finishing.

Principles of tumbling and vibratory finishing

Vibratory Finishing

Vibratory finishing does the same work as barrel finishing, but it is done in an open rubber or plastic-lined tub or trough nearly filled with workpieces and media and vibrated at around 1000 to 2000 Hz with about 3 to 10 mm (? to ? in.) amplitude. Various ways of inducing vibrations are employed; a common way is by means of eccentric weights on a revolving shaft. The action makes the entire load rotate slowly in a helical path, but the whole mass is agitated, and scouring, trimming, and burnishing take place throughout the mixture. Therefore, vibratory finishing is much faster (2 to 20 times and sometimes more) than tumbling where the action is confined to the pieces in the sliding zone at any one time. Much vibratory finishing is done in batches, but the process is readily adaptable to continuous and automatic flow-through operation because of the steady movement of the mass.

Shot- and Sand- Blasting

Shot- and sand-blasting are done by throwing particles at high velocity against the work. The particles may be metallic shot or grit; artificial or natural abrasive, including sand; agricultural products such as nut shells; glass beads, and ceramics, depending upon what is to be done and the condition of the workpiece. A primary reason for blasting is to clean surface. This may mean removing scale, rust, or burnt sand from castings by means of shot or sand, stripping paint by sand-blasting from objects to be redecorated, cleaning grease or oil from finished parts by means of nut shells, or any number of similar operations. A clean, uniform, and in many cases final surface finish is obtained by blasting. In addition, shot-blasting peens surfaces and leads to the advantages of appreciably increasing fatigue strength and stress corrosion resistance, reducing porosity in nonferrous castings, improving surface wearability as on gear teeth, and improving the oil retentively of some surfaces.

Internet Resources

Collections of metal finishing links
http://www.pprc.org/pprc/sbap/metalfin.html

Bookstore only on metal finishing
http://www.aesf.org/bookstore

A free web book "FUNDAMENTALS OF MACHINE TOOLS"
http://www.adtdl.army.mil/cgi-bin/atdl.dll/tc/9-524/toc.htm
http://www.adtdl.army.mil/cgi-bin/atdl.dll/query/download/TC+9-524

Finishing related video - messages
http://www.finishing.com/0400-0599/488.html

National Metal Finishing Resource Center
http://www.nmfrc.org/

Grinding and Lapping Compound
http://www.mfginfo.com/mfg/lapvalve/lapartical.htm