Lapping is a final abrasive finishing operation that produces extreme dimensional accuracy, corrects minor imperfections of shape, refines surface finish and produces close fit between mating surfaces. Most lapping is done with a tooling plate or wheel (the lap) and fine-grained loose abrasive particles suspended in a viscous or liquid vehicle such as soluble oil, mineral oil or grease.

Honing is a low-velocity abrading process. Material removal is accomplished at lower cutting speeds than in grinding. Therefore, heat and pressure are minimized, resulting in excellent size and geometry control. The most common application of honing is on internal cylindrical surfaces. The cutting action is obtained using abrasive sticks mounted on a metal mandrel. Since the work is fixed in such a way as to allow floating, without clamping or chucking, there is no distortion.

**Lapping process**

The principal use of the lapping process is to obtain surfaces that are truly flat and smooth. Lapping is also used to finish round work, such as precision plug gages, to tolerances of 0.0005 in. to 0.00002 in.

Work that is to be lapped should be previously finished close to the final size. While rough lapping can remove considerable metal, it is customary to leave only 0.0005 in. to 0.005 in. of stock to be removed.

Lapping, though it is an abrasive process, differs from grinding or honing because it uses a "loose" abrasive instead of bonded abrasives like grinding wheels.

These abrasives are often purchased “ready mixed” in a “vehicle” often made with an oil-soap or grease base. These vehicles hold the abrasive in suspension before and during use. The paste abrasives are generally used in hand-lapping operations. For machine lapping, light oil is mixed with dry abrasive so that it can be pumped onto the lapping surface during the lapping operation.

**Lapping machines.**

These machines are fairly simple pieces of equipment consisting of a rotating table, called a lapping plate, and three or four conditioning rings. Standard machines have lapping plates from 12 in. to 48 in. in diameter. Large machines up to 144 in. are made. One- to 20-hp motors run these tables.

The lapping plate is most frequently made of high-quality soft cast iron, though some are made of copper or other soft metals. This plate must be kept perfectly flat. The work is held in the conditioning rings. These rings rotate. This rotation performs two jobs. First, it ”conditions” the plate — meaning that it distributes the wear so that the lapping plate stays flat for a longer time. Second, it holds the workpiece in place. The speed at which the plate turns is determined by the job being done. In doing very critical parts, 10 to 15 rpm is used. When polishing is involved, up to 150 rpm is used.
Lapping and Honing Operations

Abrasive grit must be uniformly graded to be effective in lapping.

A pressure of about 3 pounds per square inch (psi) must be applied to the workpieces. Sometimes their own weight is sufficient. If not, a round, heavy pressure plate is placed in the conditioning ring. The larger machines use pneumatic or hydraulic lifts to place and remove the pressure plates.

The work piece must be at least as hard as the lapping plate, or the abrasive will be charged into the work. It will take from 1 to 20 minutes to complete the machining cycle. Time depends on the amount of stock removed, the abrasive used and the quality required.

**Grit and plate selection.**

Flatness, surface finish and a polished surface are not necessarily achieved at the same time or in equal quality. For example, silicon carbide compound will cut fast and give good surface finish, but will always leave a "frosty" or matte, surface.

The grits used for lapping may occasionally be as coarse as 100 to 280 mesh. More often, the "flour" sizes of 320 to 800 mesh are used. The grits, mixed in slurry, are flowed onto the plate to replace worn-out grits as the machining process continues.

The case for using diamond super abrasives rather than conventional abrasives such as aluminum oxide or silicon carbide can be summed up in three words. Diamonds are faster, cleaner and more cost-effective.

With diamond slurries, the lapping and polishing phases of a finishing operation can often be combined into one step. Also, less time is required for cleaning parts and processing waste. Throughput, along with overall productivity, is increased.

Lapping plates are manufactured from various materials and are available in standard sizes from 6 to 48 inches in diameter. Plates are supplied with square, spiral, and concentric and radial grooves.

**Advantages and limitations**

Any material, hard or soft, can be lapped, as well as any shape, as long as the surface is flat.

**Advantages.** There is no warping since the parts are not clamped and very little heat is generated. No burrs are created. In fact, the process removes light burrs. Any size, diameter, and thickness from a few thousandths thick up to any height the machine will handle can be lapped.

**Limitations.** Lapping is still something of an art. There are so many variables that starting a new job requires experience and skill. Even though there are general recommendations and assistance from manufacturers, and past experience is useful, trial and error may still be needed to get the optimal results.
Honing processes

As stated, honing is a low-velocity abrading process. Material removal is accomplished at lower cutting speeds than in grinding. Therefore, heat and pressures are minimized, resulting in excellent size and geometry control. The most common application of honing is on internal cylindrical surfaces.

Machining a hole to within less than 0.001 in. in diameter and maintaining true roundness and straightness with finishes less than 20(µ) in. is one of the more difficult jobs in manufacturing.

Finish boring or internal grinding may do the job, but spindle deflection, variation in hardness of the material, and difficulties in precise workholding make the work slow and the results uncertain. Honing, because it uses rectangular grinding stones instead of circular grinding wheels, can correct these irregularities.

Honing can consistently produce finishes as fine as 4(µ) in., and even finer finishes are possible. It can remove as little as 0.0001 in. of stock or as much as 0.125 in. of stock. However, usually only 0.002 in. to 0.020 in. stock is left on the diameter for honing.

Honing machines

For most work, honing machines are quite simple. The most-used honing machines are made for machining internal diameters from 0.060 in. to 6 in. However, large honing machines are made for diameters up to 48 in. Larger machines are sometimes made for special jobs.

The length of the hole that can be honed may be anything from 1/2 in. to 6 in. or 8 in. on smaller machines and up to 24 in. on larger machines. Special honing machines will handle hole lengths up to 144 in.

Horizontal spindle machines. Horizontal-spindle honing machines, for hand-held work with bores up to 6 in., are among the most widely used. The machine rotates the hone at from 100 to 250 fpm.

The machine operator moves the work back and forth (strokes it) over the rotating hone. The operator must “float” the work — that is, not press it against the hone or the hole will be slightly oval. Sometimes the workpiece must be rotated. Horizontal-spindle honing machines are also made with ”power stroking.” In these, the work is held in a self-aligning fixture and the speed and length of the stroke are regulated by controls on the machine. As a hone is being used, it is expanded by hydraulic or mechanical means until the desired hole diameter is achieved. Various mechanical and electrical devices can be attached to the honing machine to control the rate of expansion, and stop it when final size is reached.

On the simplest hand-held machines, the operator may check the bore size with an air gage, continue honing, and recheck and so on until the size is correct.
Lapping and Honing Operations

**Vertical spindle machines.** Vertical-spindle honing machines are used especially for larger, heavier work. These all have power stroking at speeds from 20 to 120 fpm. The length of the stroke is also machine controlled by stops set up by the operator.

Vertical honing machines are also made with multiple spindles so that several holes may be machined at once, as in automobile cylinders.

_Hone body:_ The hone body is made in several styles using a single stone for small holes, and two to eight stones as sizes get larger. The stones come in a wide variety of sizes and shapes. Frequently, there are hardened metal guides between the stones to help start the hone cutting in a straight line.

_Cutting fluid:_ A fluid must be used with honing. This has several purposes: to clean the small chips from the stones and the workpiece, to cool the work and the hone and to lubricate the cutting action.

A fine mesh filtering system must be used, since recirculated metal can spoil the finish.

**Abrasive tool selection**
The abrasive honing stone must be selected for the proper abrasive type, bond hardness and grit size to deliver the fastest stock removal and desired surface finish. This selection is simple if done in the following three steps:

**Step one:** Select the abrasive type with respect to the material composition of the bore. There are four different types of abrasives: aluminum oxide, silicon carbide, diamond and CBN. (All four of these were discussed in the previous chapter.) Each type has its own individual characteristics that make it best for honing certain materials. Some simplified guidelines for their use are:

Diamond and CBN are considered super abrasives because they are much harder than conventional abrasives. They cut easily and dull slowly, therefore allowing them to hone certain materials much faster and more efficiently than conventional abrasives. However, as shown above, super abrasives are not suited to honing all materials. For instance, diamond does not hone steel very well, and CBN may not be as economical as using aluminum oxide to hone soft steel.

**Step two:** Use the stone hardness suggested in the manufacturer's catalog. If the stone does not cut, select the next softer stone; if the stone wears too fast, select the next harder stone. Stone hardness does not refer to the hardness of the abrasive grain, but to the strength of the bonding material holding the abrasive grains together, as discussed in the previous chapter.

Diamond and CBN abrasive grains dull so slowly that standard ceramic or resin bonds may not be strong enough when honing rough out-of-round bores in hard materials, or when CBN is used to hone soft steel. Metal bonds are best suited for these applications because the grains are held in a sintered metal matrix that is much stronger than standard bonds. As with choosing abrasive type, stone bond hardness must be matched to the application to maximize life and stock removal rates.
**Lapping and Honing Operations**

**Step three:** Select the largest abrasive grit size that will still produce the desired surface finish. Surface finish is a function of the height of microscopic peaks and valleys on the bore surface and honing can produce almost any degree of roughness or smoothness through the use of different abrasive grit sizes.

Honing oil can improve stock removal rates by helping the cutting action of the abrasive grains. It prevents pickup (spot welding of tool to bore) and loading (chips coating the stone). Honing oil does this, not by acting as a coolant, but through chemical activity.

**Cylinder block honing**
Bores sometime require a preliminary rough honing operation to remove stock, followed by finish honing to get the desired surface finish. A characteristic feature of a honed surface finish is crosshatch, which makes an excellent oil retention and bearing surface. The crosshatch pattern is generated in the bore surface as the workpiece is stroked back and forth over the rotating honing tool.

**Plateau honing:** Some years ago a special surface finish generated interest in the engine rebuilding market. With this finish, the valleys are deep and the peaks have been removed to form plateaus, giving the name plateau honing or plateau finishing. A test by a ring manufacturer showed that an engine with a true plateau finish consumed one-tenth the oil and had 80 percent less cylinder-bore wear than the engines with conventional finishes.

**Laser honing:** With this process, considerably better results are achieved compared to traditional honing. Precisely defined surface structures can be obtained with laser technology. Laser honing is a combination of honing and laser processing. This process generates laser-produced reservoirs into a specifically defined area in order to achieve an ideal plateau surface finish. Such a hydrodynamic system can be produced exactly where it is required.

Application of the laser-honing process requires three steps. In the first step — rough honing — the macro-form of the bore is produced. In the second step, precisely defined lubricant reservoirs are produced with the laser. In step three — finish honing — an extremely fine surface finish is obtained, resulting in increased engine life by reduction of wear in the cylinder surface and on the piston rings.

**Production honing**
Honing will not only remove stock rapidly, but it can also bring the bore to finish diameter within tight tolerances. This is especially true if the honing machine is equipped with automatic size control. With every stroke, the workpiece is pushed against a sensing tip that has been adjusted to the finish diameter of the bore. When the bore is to size, the sensing tip enters the bore and the machine stops honing. Size repetition from bore to bore is 0.0001 in. to 0.0002 in. The operator simply loads and unloads the fixture and presses a button; everything else is automatic.

**Single-stroke honing:** A still faster and more accurate method of honing a bore to final size is single-stroke honing. The single-stroke tool is an expandable diamond-plated sleeve on a tapered arbor. The sleeve is expanded only during setup. No adjustments are necessary during honing.
Lapping and Honing Operations

Unlike conventional honing, where the workpiece is stroked back and forth over the tool, in single-stroke honing the rotating tool is pushed through the bore one time, bringing the bore to size. The return stroke does nothing to the bore except get the workpiece off the tool. Single-stroke honing is so accurate and consistent that honed bores do not require gaging.

Although single-stroke honing has many advantages, it is limited in the types and volumes of material that can be removed. The size and overall volume of chip produced in one pass must be no more than the space between the diamond grits, or the tool will seize in the bore.

Workpieces are best suited for single-stroke honing when they are made of materials that produce small chips, such as cast iron, and when they have interruptions that allow chips to be washed from the tool as the bore is being honed. Conventional honing should be used whenever the material to be honed produces long stringy chips or when the amount of stock to be removed is large.

Advantages and limitations
Honning has developed into a productive manufacturing process, with particular advantages and disadvantages:

Advantages: The workpiece need not be rotated by power, there are no chucks, faceplates, or rotating tables needed, so there are no chucking or locating errors. The hone is driven from a central shaft, so bending of the shaft cannot cause tapered holes as it does when boring. The result is a truly round hole, with no taper or high or low spots, provided that the previous operations left enough stock so that the hone can clean up all the irregularities.

Honing uses a large contact area at slow speed compared with grinding or fine boring, which use a small contact area at high speed. Because of the combined rotating and reciprocating motion used, a crosshatched pattern is created which is excellent for holding lubrication. Diameters with 0.001 to 0.0001 inch and closer accuracies can be honed by using diamond stones similar to diamond wheels.

Limitations: Honing is though of as a slow process. However, new machines and stones have shortened hone times considerably. Horizontal honing may create oval holes unless the work is rotated or supported. If the workpiece is thin, even hand pressure may cause a slightly oval hole.