



MANUFACTURING GLOSSARY

Aging – A change in the properties of certain metals and alloys that occurs at ambient or moderately elevated temperatures after a hot-working operation or a heat-treatment (quench aging in ferrous alloys, natural or artificial aging in ferrous and nonferrous alloys) or after a cold-working operation (strain aging). The change in properties is often, but not always, due to a phase change (precipitation), but never involves a change in chemical composition of the metal or alloy.

Abrasive – Garnet, emery, carborundum, aluminum oxide, silicon carbide, diamond, cubic boron nitride, or other material in various grit sizes used for grinding, lapping, polishing, honing, pressure blasting, and other operations. Each abrasive particle acts like a tiny, single-point tool that cuts a small chip; with hundreds of thousands of points doing so, high metal-removal rates are possible while providing a good finish.

Abrasive Band – Diamond- or other abrasive-coated endless band fitted to a special band machine for machining hard-to-cut materials.

Abrasive Belt – Abrasive-coated belt used for production finishing, deburring, and similar functions. *See coated abrasive.*

Abrasive Cutoff Disc – Blade-like disc with abrasive particles that parts stock in a slicing motion.

Abrasive Cutoff Machine, Saw – Machine that uses blade-like discs impregnated with abrasive particles to cut/part stock. *See saw, sawing machine.*

Abrasive Flow Machining – Finishing operation for holes, inaccessible areas, or restricted passages. Done by clamping the part in a fixture, then extruding semisolid abrasive media through the passage. Often, multiple parts are loaded into a single fixture and finished simultaneously.

Abrasive Machining – Various grinding, honing, lapping, and polishing operations that utilize abrasive particles to impart new shapes, improve finishes, and part stock by removing metal or other material. *See grinding.*

Abrasive-Wire Band Sawing – A variation of band sawing that uses a small-diameter wire with diamond, cubic boron nitride (CBN), or aluminum-oxide abrasives bonded to the surface as the cutting blade. Abrasive-wire band sawing is an alternative to electrical-discharge machining for product dies, stripper plates, electrodes, and cams from difficult-to-machine conductive and nonconductive materials. *See band sawing.*

Additive – Sulfur, chlorine, and other materials added to cutting fluids to improve lubricity, stabilize oil emulsions, and prevent chip welding under high heat and pressure. *See cutting fluid.*

Admixture – Mixture of concentrate and water prepared to restore depleted cutting fluid to its original state.

Angle Plate – Solid adjustable or nonadjustable plate that holds work at a precise angle to the spindle during milling and grinding. Also used for other cutting operations and for inspection.

Arbor – Shaft used for rotary support in machining applications. In grinding, the spindle for mounting the wheel; in milling and other cutting operations, the shaft for mounting the cutter.

Assembly – Joining together two or more parts to complete a structure.

Automatic Bar Machine – Production machine for turning bar stock. Similar to an automatic chucking machine except that stock size is limited to through-the-spindle capacity and work is held by push, draw, or stationary collets rather than by chucks. *See automatic chucking machine; turning machine.*

Automatic Chucking Machine – Machine with multiple chucks and toolholding spindles that permits either processing of several parts simultaneously or multiple machining steps in one pass through the machine. *See automatic bar machine.*

Automatic Screw Machine – Turning machine designed to produce parts automatically from coil or bar stock. The two basic types are cam (mechanical) and programmable (computer-controlled). Usually single-spindle, but “Swiss types” often have multiple spindles. *See lathe; turret lathe.*



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Automatic Toolchanger – automatic mechanism typically included in a machining center that, on the appropriate command, will remove one cutting tool from the spindle nose and replace it with another. The changer restores the used tool to the magazine, and selects and withdraws the next desired tool from the storage magazine. The toolchanger is controlled by a set of prerecorded/ predetermined instructions associated with the part(s) to be produced.

Automation – Approach under which all or part of a machining or manufacturing process is accomplished by setting in motion a sequence that completes the process without further human intervention. May be mechanical (controlled by stops, cams, etc.), electrical (relays, contact switches, etc.), or electronic (computer- or microprocessor-controlled). “Fully automated” implies computer integrated manufacturing.

AWJ, Abrasive Waterjet – System that uses high-pressure waterjets in combination with a slurry of fine abrasive grains to machine materials. *See waterjet cutting.*

Axial Rake – On angular tool flutes, the angle between the tooth face and the axial plane through the tool point.

Backing – Flexible portion of a band saw blade; also the support material behind the cutting edges of tools, and the base material for coated abrasives.

Backlash – A reaction in dynamic motion systems where potential energy that was created while the object was in motion is released when the object stops. The release of this potential energy or inertia causes the device to quickly snap backwards relative to the last direction of motion. Backlash can cause a system’s final resting position to be different from intended and from where the control system intended to stop the device.

Backoff – Rapid withdrawal of the tool from the workpiece.

Back Rest – Support that mounts on a cylindrical grinder to prevent deflection when grinding long, small-diameter stock.

Bactericide – Material added to cutting fluids to inhibit bacterial growth. *See fungicide.*

Band, Band Saw Blade – Endless band, normally with serrated teeth, that serves as the cutting tool for cutoff or contour band machines.

Band Polishing – A variation of band sawing that uses an abrasive band to smooth or polish parts previously sawed or filed.

Band Saw – Powered machine that utilizes an endless band, normally with serrated teeth, for cutoff or contour sawing. *See saw, sawing machine.*

Band Sawing – Power band sawing, often called band machining, uses a long endless band with many small teeth traveling over two or more wheels (one is a driven wheel, and the others are idlers) in one direction. The band, with only a portion exposed, produces a continuous and uniform cutting action with evenly distributed low, individual tooth loads. Band sawing machines are available in a wide variety of types to suit many different applications.

Barrel Finishing – A mass finishing process. It involves low-pressure abrasion resulting from tumbling workpieces in a barrel (usually of hexagonal or octagonal cross section) together with an abrasive slurry. *See finishing.*

Blocks – Workholding devices used on milling machines. Styles include step, finger-holding, telescoping, and quick-clamp.

Boring – Enlarging a hole that already has been drilled or cored. Generally, it is an operation of truing the previously drilled hole with a single point, lathe-type tool. Boring is essentially internal turning, in that usually a single-point cutting tool forms the internal shape. Some tools are available with two cutting edges to balance cutting forces.

Bonded Abrasive – Abrasive grains mixed with a bonding agent. The mixture is pressed to shape and then fired in a kiln or cured. Forms include wheels, segments, cup wheels, etc. Bond types include oxychloride, vitrified, silicate, metal, resin, plastic, rubber, and shellac. Another type of bond is electroplating, wherein the abrasive grains are attached to a backing by a thick layer of electroplated material.



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Boring Bar – Essentially a cantilever beam that holds one or more cutting tools in position during a boring operation. Can be held stationary and moved axially while the workpiece revolves around it, or revolved and moved axially while the workpiece is held stationary, or a combination of these actions. Boring bars are installed on milling, drilling, and boring machines, as well as lathes and machining centers.

Boring Cutter, Boring Tool – Cutting tool mounted in a boring bar (the holder) that enlarges a cored or drilled hole. May be a single-point or multiple-cutting-edge tool. Can be adjustable.

Boring Machine – Similar to a turning machine except that the cutting tool (single-point or multiple cutting- edge), rather than the workpiece, rotates to perform internal cuts. However, boring can be accomplished by holding the tool stationary and turning the workpiece. Takes a variety of vertical, slanted, and horizontal forms, and has one or more spindles. Typically a large, powerful machine, it can readily hold tolerances to ten-thousandths of an inch. *See jig bore; lathe; turning machine.*

Boundary Additives – Sulfur, chlorine, and other materials added to cutting fluids to fill in surface irregularities at the tool/workpiece interface, creating a lubricating film. *See lubricity.*

Broach – Tapered tool, with a series of teeth of increasing length, that is pushed or pulled into a workpiece, successively removing small amounts of metal to enlarge a hole, slot, or other opening to final size.

Broaching – An operation in which a cutter progressively enlarges a slot or hole, or shapes a workpiece exterior. Low teeth start the cut, intermediate teeth remove the majority of the material, and the high teeth finish the task. Broaching can be a one-step operation, as opposed to milling and slotting, which require repeated passes. Typically, however, broaching also involves multiple passes.

Broaching Machine – Machine designed specifically to run broaching tools; typically designated by operating characteristics (pull, push, rotary, continuous, blind spline), type of power used (hydraulic, mechanical), and tonnage ratings. Broaching is also performed on arbor presses (manual and powered).

Brushing – Use of rapidly spinning wires or fibers to effectively and economically remove burrs, scratches, and similar mechanical imperfections from precision and highly stressed components. The greatest application has been made in the manufacture of gears and bearing races where the removal of sharp edges and stress risers by power methods has increased the speed of the operation.

BUE, Built-Up Edge – Material from workpiece that adheres to cutting tool during cutting.

Buffing – Smoothing and brightening a surface by pressing an abrasive compound, embedded in a soft wheel or belt, against the workpiece.

Burr – Stringy portions of material formed on workpiece edges during machining. Often sharp; can be removed with hand files, abrasive wheels or belts, wire wheels, abrasive-fiber brushes, or waterjet equipment.

Bushing – A cylindrical sleeve, typically made from high-grade tool steel, inserted into a jig fixture to guide cutting tools. There are three main types: renewable, used in liners that in turn are installed in the jig; press-fit, installed directly in the jig for short production runs; and liner (or master), installed permanently in a jig to receive renewable bushing.

CAD, Computer-Aided Design – Product-design functions performed with the help of computers and special software.

CAM, Computer-Aided Manufacturing – Use of computers to control machining and manufacturing.

Canned Cycle, Fixed Cycle – Subroutine or full set of programmed numerical-control or computernumerical- control steps initiated by a single command. Operations are done in a set order; the beginning condition is returned to when the cycle is completed.

Cam-Cutting Attachment – Device for cutting face, peripheral, or cylindrical cams from flat camformer stock.

Carriage Stop – Mechanical device placed on the lathe head or ways to prevent over-travel that might damage the machine or workpiece.

Cavity Cutting – Machining entirely within the body of a workpiece.



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Cell Manufacturing – Grouping processes, equipment, and people together to manufacture a specific family of parts. Highly automated and able to change over quickly to produce a different part within the family of parts. *See family of parts; group technology.*

Center Drill – Drill used to make mounting holes for work to be held between centers. Also used to pre-drill holes for subsequent drilling operations.

Center Drilling – Drilling tapered holes for mounting work between centers. Center-drilled holes also serve as preliminary “starter” holes for drilling larger holes in the same location. *See drilling.*

Center Rest – Support provided at the center of the working area of a cylindrical grinder to prevent part deflection during grinding.

Centering – Process of locating the center of a workpiece to be mounted on centers. Also, the process of mounting the workpiece concentric to the machine spindle.

Centerless Grinding – Grinding operation in which the workpiece rests on a knife-edge support, rotates through contact with a regulating or feed wheel, and is ground by a grinding wheel. This method allows grinding long, thin parts without steady rests; also experiences lessened taper problems. Opposite of cylindrical grinding. *See grinding; cylindrical grinding.*

Centers – Cone-shaped pins that support a workpiece by one or two ends during machining. The centers fit into holes drilled in the workpiece ends. Centers that turn with the work are called “live” centers; those that do not are called “dead” centers.

Chamfering – Machining a bevel on a workpiece or tool to improve the tool’s entrance into the cut.

Chamfering Tool – Cutter or wheel that creates a beveled edge on a tool or workpiece.

Chatter – Irregularity in cutting action caused by tool or workpiece vibration, resulting in noise, poor finish, and possible damage to tool and work. May be the result of improper tool geometry, the wrong feed and speed, a loose setup, or worn machinery.

Chuck – Workholding device that affixes to a mill, lathe, or drill-press spindle. It holds a tool or workpiece by one end, allowing it to be rotated. May also be fitted to the machine table to hold a workpiece. Two or more adjustable jaws actually hold the tool or part. May be actuated manually, pneumatically, hydraulically, or electrically. *See collet; magnetic chuck.*

Chip – Small piece of material removed from a workpiece by a cutting tool.

Chipbreaker – Groove or other tool feature that breaks chips into small fragments as they come off the workpiece. Designed to prevent chips from becoming so long that they are difficult to control, catch in turning parts, and cause safety problems.

Circular Saw – Cutoff machine utilizing a circular blade with serrated teeth. *See saw, sawing machine.*

Circular Saw Blade – Cutting tool for a cold or circular saw. Round with serrated cutting teeth.

Clearance – Space provided behind a tool’s land or relief to prevent rubbing and subsequent premature deterioration of the tool. *See relief.*

CNC, Computer Numerical Control – Microprocessor-based controller dedicated to a machine tool that permits the creation or modification of parts. Programmed numerical control activates the machine’s servos and spindle drives, and controls the various machining operations. It can easily hold tolerances to ten-thousandths of an inch. *See DNC, direct numerical control; NC, numerical control.*

Coated Abrasive – Flexible-backed abrasive. Grit is attached to paper, fiber, cloth, or film. Types include sheets, belts, flap wheels, and discs.

Collet – Flexible-sided device that secures a tool or workpiece. Similar in function to a chuck, but can accommodate only a narrow size range. Typically provides greater gripping force and precision than a chuck.

Concentrate – Agents and additives that, when added to water, create a cutting fluid.

Contouring Attachment – Handwheel-operated mechanism for holding and guiding the work while sawing contours on a contour band saw.



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Coolant – Fluid that reduces temperature buildup at the tool/workpiece interface during machining. Normally takes the form of a liquid such as soluble-oil or chemical mixtures (semisynthetic, synthetic), can be pressurized air or other gas. Because of water's ability to absorb great quantities of heat, it is widely used as a coolant and vehicle for various cutting compounds, with the water-to-compound ratio varying with the machining task. *See cutting fluid; semisynthetic cutting fluid; soluble-oil cutting fluid; synthetic cutting fluid.*

Cooling – The process of reducing the heat content of a tool, part, assembly, or material. Cooling may be required for a variety of reasons: to improve tool life, increase cutting speeds, and ensure workpiece tolerances by controlling expansion. Electrical and computer equipment requires cooling to maintain a safe operating temperature. When heat-treating metal parts, part of the process is cooling, either by air, water, or oil.

Counterbalancing – Use of weights or mechanisms to balance a workpiece, grinding wheel, rotating tool, or other device. Minimizes machining vibration and maximizes cutting force.

Counterbore – Tool, guided by a pilot, that expands a hole to a certain depth.

Counterboring – The process of enlarging one end of a drilled hole, which is concentric with the original hole, is flat on the bottom. Counterboring is used primarily to set bolt heads and nuts below the workpiece surface.

Countersink – Tool that cuts a sloped depression at the top of a hole to permit a screw head or other object to rest flush with the surface of the workpiece.

Countersinking – Cutting a beveled edge at the entrance of a hole so a screw head sits flush with the workpiece surface. *See counterboring; spotfacing.*

Cratering – Depressions formed on the face of a cutting tool, caused by heat, pressure, and the motion of chips moving across the tool's surface.

Creep-Feed Grinding – Grinding operation in which the grinding wheel is slowly fed into the work at sufficient depth of cut to accomplish in one pass what otherwise would require repeated passes.

Curtain Application – Arrangement of multiple nozzles that apply fluid to a broad cutting area, as is found on a horizontal post-type band machine or a large hacksaw.

Cutter Compensation – A feature that allows the operator to compensate for tool diameter, length, deflection, and radius during a programmed machining cycle.

Cutter Path, Tool Path – Path followed by the tool in machining the part.

Cutting Fluid – Liquid used to improve workpiece machinability, enhance tool life, flush out chips and machining debris, and cool the workpiece and tool. Three basic types are: straight oils; soluble oils, which emulsify in water; and synthetic fluids, which are water-based chemical solutions having no oil. *See coolant; soluble-oil cutting fluid; synthetic cutting fluid.*

Cutting-Velocity Vector – Vector or direction the tool's cutting edge takes as a result of the interplay of forces applied and generated during the chipmaking process.

Cutoff – Step that prepares a slug, blank, or other workpiece for machining or other processing by separating it from the original stock. Performed on lathes, chucking machines, automatic screw machines, and other turning machines. Also performed on milling machines, machine centers with slitting saws, and sawing machines – cold (circular) saws, hacksaws, band saws, or abrasive cutoff saws. *See micro-slicing; sawing; turning.*

Cutoff Blade – Blade mounted on a shank or arbor and held in a milling-machine spindle for simple cutoff tasks.

Cylindrical Grinding – Grinding operation in which the workpiece is rotated around a fixed axis while the grinding wheel is fed into the outside surface in controlled relation to the axis of rotation. The workpiece is usually cylindrical, but it may be tapered or curvilinear in profile. *See grinding.*



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Cylindrical-Grinding Attachment – Device that mounts to the table of a surface grinder or lathe, permitting both straight and tapered grinding of round stock.

DNC, Direct Numerical Control – Actions of multiple machine tools controlled by a single computer. *See CNC, computer numerical control; NC, numerical control.*

Deionization – Removal of ions from a water-based solution. *See semisynthetic cutting fluid; soluble-oil cutting fluid; synthetic cutting fluid.*

Diamond Band Sawing – Machine operation in which a band with diamond points is used to machine carbides, ceramics, and other extremely hard materials.

Disc-Cutting Attachment – Adjustable device for a contour band saw that positions stock to allow the sawing of arcs and circular shapes on a contour band saw.

Disc Grinding – Operation in which the workpiece is placed against the side of a wheel rather than the wheel's periphery. *See grinding.*

Dish – Form of relief given to the face of an endmill to prevent undesirable contact with the work. Similar to clearance.

Dividing Head – Attaches to a milling-machine table and precisely indexes the workpiece. Allows equally spaced cuts to be made when machining gear and sprocket teeth, spline keys, serrations, etc.

Dovetail Cutter – Cutter for milling dovetail slots. *See milling cutter.*

Dressing – Removal of undesirable materials from “loaded” grinding wheels using a diamond or other tool, single- or multi-point. The process also exposes unused, sharp abrasive points. *See loading; truing.*

Drill, Drill Bit, Drilling Tool – End-cutting tool for drilling. Tool has shank, body, and angled face with cutting edges that drill the hole. Drills range in size from “micro-drills” a few thousandths of an inch in diameter up to spade drills, which may cut holes several inches in diameter. Drills may have tapered shanks with a driving tang, and fit directly into a spindle or adapter, or they may have straight shanks and be chuck-mounted. The rake angle varies with the material drilled. Styles include twist drills, straight-flute drills, half-round and flat drills, oil-hole drills, and specials.

Drill Jig – Accessory that holds a workpiece securely while guiding a drill or other tool into the workpiece; ensures accurate, repeatable location.

Drilling – Operation in which a rotating tool is used to create a round hole in a workpiece. Drilling is normally the first step in machining operations such as boring, reaming, tapping, counterboring, countersinking, and spotfacing.

Drilling Machine, Drill Press – Machine designed to rotate end-cutting tools. Can also be used for reaming, tapping, countersinking, counterboring, spotfacing, and boring.

Drive Plate – Attaches to a lathe spindle; has a slot or slots that engage a driving dog to turn the work. Usually used in conjunction with centers. *See centers; driving dog.*

Driving Dog – Device having a ring or clamp on one end that slips over the workpiece to be turned; a screw secures the workpiece in place. The dog's opposite end (tail) fits into a drive plate attached to the machine spindle. *See centers, drive plate.*

Emulsion – Suspension of one liquid in another, such as oil in water.

Endmill – Milling cutter held by its shank that cuts on its periphery and, if so configured, on its free end. Takes a variety of shapes (single- and double-end, roughing, ballnose, and cup-end) and sizes (stub, medium, long, and extra-long). Also comes with differing numbers of flutes. *See milling cutter.*



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ECM, Electrochemical Machining – Operation in which electrical current flows between a workpiece and conductive tool through an electrolyte. Initiates a chemical reaction that dissolves metal from the workpiece at a controlled rate. Unlike traditional cutting methods, workpiece hardness is not a factor, making ECM suitable for machining tough materials. Takes such forms as electrochemical grinding, electrochemical honing, and electrochemical turning.

EDG, Electrical-Discharge Grinding – A process similar to conventional EDM except a grindingwheel type of electrode is used.

EDM–Formed Electrode – A process using a shaped electrode made from carbon or copper. The electrode is separated by a nonconductive liquid and maintained at a close distance (about 0.001”). A high DC voltage is pulsed to the electrode and jumps to the conductive workpiece. The resulting sparks erode the workpiece and generate a cavity in the reverse shape of the electrode, or a through hole in the case of a plain electrode. Permits machining shapes to tight accuracies without the internal stresses conventional machining often generates. Also known as “die-sinker” or “sinker” electrical-discharge machining.

EDM–Standard Electrode with CNC – Similar to the standard electrical-discharge-machining process, but uses a CNC to generate shapes with standard electrodes. The conventional electrical-discharge machining process must have an electrode that conforms to the required shape.

EDM–Wire – A process similar to conventional electrical-discharge machining except a small-diameter copper or brass wire is usually used in conjunction with a CNC and will only work when a part is to be cut completely through. A common analogy is to describe wire electrical-discharge machining as an ultraprecise, electrical, contour-sawing operation.

EP (Extreme Pressure) Additives – Cutting-fluid additives (chlorine, sulfur, or phosphorous compounds) that chemically react with the workpiece material to minimize chipwelding; good for high-speed machining.

Economies of Scale – Achieving low per-unit costs by producing in volume, permitting “fixed costs” to be distributed over a large number of products. Implies inflexible production methods involving interchangeable parts or products. *See economies of scope; interchangeable parts.*

Economies of Scope – Achieving low per-unit costs by computerizing production; allows goods to be manufactured economically in small lot sizes.

Electrochemical Deburring – A variation on electrochemical machining designed to remove burrs and impart small radii to corners. The process normally uses a specially shaped electrode to carefully control the process to a specific area. The process will work on material regardless of hardness.

Electrochemical-Discharge Grinding – A combination of electrochemical grinding and electrical-discharge machining. Material is removed by both processes. The workpiece and the grinding wheel never come into contact as in any other electrical-discharge machining process.

Electrochemical Grinding – A variation on electrochemical machining that uses a conductive, rotating abrasive wheel. The chemical solution is forced between the wheel and the workpiece. The shape of the wheel determines the final shape.

Emulsion – Suspension of one liquid in another, such as oil in water.

Endmill – Milling cutter held by its shank that cuts on its periphery and, if so configured, on its free end. Takes a variety of shapes (single- and double-end, roughing, ballnose, and cup-end) and sizes (stub, medium, long, and extra-long). Also comes with differing numbers of flutes. *See milling cutter.*

Endmilling – Operation in which the cutter is mounted on the machine’s spindle rather than on an arbor. Commonly associated with facing operations on a milling machine. *See milling.*

FMS, Flexible Manufacturing System – Automated manufacturing system designed to machine a variety of similar parts. System is designed to minimize production changeover time. Computers link machine tools with the workhandling system and peripherals. Also associated with the machine tools grouped in “cells” for efficient production. *See cell manufacturing.*

Face – A flat surface, usually at right angles and adjacent to the ground hole.



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Facemill – Milling cutter for cutting flat surfaces. *See milling cutter.*

Facemilling – A form of milling that produces a flat surface generally at right angles to the rotating axis of a cutter having teeth or inserts both on its periphery and on its end face. *See milling.*

Facing – Preliminary “cleanup” operation that provides a true reference surface before beginning another operation.

Face plate – Flat, round workholder with slots used to hold regular- or irregular-shaped stock. If stock is markedly asymmetrical, counterbalances may be needed to prevent vibration. *See drive plate.*

Family of Parts – Parts grouped by shape and size for efficient manufacturing.

Feather Burr – A very fine or thin burr.

Feather Edge – The same as a feather burr except that feather edge can also refer to a very thin machined ridge located at the ends of a lead-in or lead-out thread. It is sometimes called a wire edge or whisker-type burr.

Filing – Operation in which a tool with numerous small teeth is used manually to round off sharp corners and shoulders and remove burrs and nicks. Although often a manual operation, filing on a power filer or contour band machine with a special filing attachment can be an intermediate step in machining low-volume or one-of-a-kind parts.

Filing Attachment – Mounts on a contour band saw for power-filing operations.

File Bands – Segmented files mounted on an endless band for use on a powered band-type filing machine or on a contour band machine with filing attachment.

Fillet – Rounded corner or arc that blends together two intersecting curves or lines. In three dimensions, a fillet surface is a transition surface that blends together two surfaces.

Film Strength – Relative ability of a fluid to form a film between workpiece and tool, under the influence of temperature and pressure, to prevent metal-to-metal contact. *See boundary additives; lubricity.*

Finish Cut – Final cut made on a workpiece to generate final dimensions or specified finish. Often made using reduced feeds and higher speeds. Generally, the better the surface finish required, the longer the finish cut takes. Also, the final cut taken on an electrical-discharge-machined part.

Finish Feed – Feeding in small increments for finishing the part.

Finishing Tool – Tool, belt, wheel, or other cutting implement that completes the final, precision machining step/cut on a workpiece. Often takes the form of a grinding, honing, lapping, or polishing tool. *See roughing cutter, roughing tool.*

Finishing – Any of many different processes employed for surface, edge, and corner preparation, as well as conditioning, cleaning, and coating. In machining, usually constitutes a final operation. In recent years, there has been dynamic growth in the development and improvement of these processes, as well as the equipment, tooling, media, and compounds used.

Fixture – Device, usually made in-house, that holds a specific workpiece. *See jig; modular fixturing.*

Flank Wear – Reduction in clearance on the tool’s flank caused by contact with the work. Ultimately causes tool failure.

Flat, Screw Flat – Flat surface machined into the shank of a cutting tool for enhanced holding of the tool.

Flood Application – Fluid applied in volume by means of a recirculating system comprised of a reservoir, filters, chip-removal components, pump, hoses, and positionable application nozzles, along with movable splash shields, valves for adjusting flow, and other controls. Normally permits the highest metal-removal rates possible with fluids. It requires careful setup and adjustment, as the stream and attendant splashing may obscure the cut point from the operator’s view.

Flushing Hose – Hand-operated hose and nozzle added to machine’s cutting-fluid-application system to permit manual flushing of table and workpiece areas.



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Flutes – Grooves and spaces in the body of a tool that permit chip removal from, and cutting-fluid application to, the point of cut.

Fluting – Cutting straight or spiral grooves in drills, endmills, reamers, and taps to improve cutting action and chip removal.

Follower Rest – A work rest or supporting device attached to the carriage that “follows” the cutting tool, keeping support near the point of cut. *See back rest; steady rest.*

Form Cutter – Cutter shaped to cut stepped, angular, or irregular forms in the workpiece. The cutting-edge contour corresponds to the workpiece shape required. The cutter can often be reground repeatedly without changing the cutting-edge shape. Two general classes: straight and circular.

Form-Rolling Machine – Used to roll splines, gears, worms, and threads. A cold-forming machine for production processing of previously machined parts. *See broaching machine.*

Friction Sawing – Sawing with a special band machine capable of achieving band velocities of 15,000 sfm or more. Metal removal is accomplished in two steps: Frictional heat softens the metal, then the teeth scoop out the molten material. Carbon-steel bands are used for flexibility and to maximize band life. Excellent for cutting extremely hard alloys, but cannot be used on most aluminum alloys or other materials that load the teeth of conventional blades. *See sawing.*

Fungicide – Material added to chemical or soluble-oil cutting fluids to inhibit the growth of fungi and bacteria. *See bactericide.*

Gang Cutting, Milling, Slitting – Machining with several cutters mounted on a single arbor, generally for simultaneous cutting.

Gear Cutter – Cutters (mills, broaches, hobs, etc.) designed for machining gears.

Gear Shaper – Machine that, in contrast to mills and hobbing machines, reciprocates the tool to cut the gear.

Grinding – Machining operation in which material is removed from the workpiece by a powered abrasive wheel, stone, belt, paste, sheet, compound, slurry, etc. Takes various forms: precision surface grinding (creates flat and/or squared surfaces); cylindrical grinding (for external cylindrical and tapered shapes, fillets, undercuts, etc.); centerless grinding; chamfering; thread and form grinding; tool-and-cutter grinding; offhand grinding; lapping and polishing (grinding with extremely fine grits to create ultrasmooth surfaces); honing; and disc grinding.

Grinding Machine – Powers a grinding wheel or other abrasive tool for the purpose of removing metal and finishing workpieces to close tolerances. Provides smooth, square, parallel, and accurate workpiece surfaces. When ultrasmooth surfaces and finishes on the order of microns are required, lapping and honing machines (precision grinders that run abrasives with extremely fine, uniform grits) are used. In its “finishing” role, the grinder is perhaps the most widely used machine tool. Various styles are available: bench and pedestal grinders for sharpening lathe bits and drills; surface grinders for producing square, parallel, smooth, and accurate workpieces; cylindrical and centerless grinders; center-hole grinders; form grinders; facemill and endmill grinders; gear-cutting grinders; jig grinders; abrasive belt (backstand, swing-frame, belt roll) grinders; tool-and-cutter grinders for sharpening and resharpening cutting tools; carbide grinders; hand-held die grinders; and abrasive cutoff saws.

Grinding Ratio – Ratio of work material removed to grinding-wheel material lost.

Grinding Wheel – Wheel formed from abrasive material mixed in a suitable matrix. Takes a variety of shapes, but falls into two basic categories: those that cut on their periphery, as in reciprocating grinding, and those that cut on their side or face, as in tool-and-cutter grinding.

Grit Size – Specified size of the abrasive particles in grinding wheels and other abrasive tools. Determines metal-removal capability and quality of finish.

Grooving – Machining grooves and shallow channels. Example: grooving ball-bearing raceways. Typically performed by tools that are capable of light cuts at high feed rates; gives high-quality finish.

Group Technology – Classifying large numbers of different parts by characteristics (shape, configuration, holes, threads, size, etc.) before creating families of parts, with special consideration given to size. Also involves clustering machines into cells for efficient flow of parts between machines and operations. May involve automated workhandling.



MANUFACTURING GLOSSARY

Gundrill – Self-guided drill for producing deep, long holes with good accuracy and fine surface finish; has coolant passages that deliver coolant to the tool/workpiece interface at high pressure.

Gundrilling – Drilling process using a self-guiding tool to produce deep, precise holes. High-pressure coolant is fed to the cutting area, usually through the gundrill's shank.

Hacksaw Blade – Serrated blade for a manual or power hacksaw that cuts on the forward or return stroke.

Headchanging Machine – Like machining centers, this is a relatively new class of multifunction, numerical-control machine tool. It differs from machining centers in that single- or multi-spindle heads, rather than tools, are transferred to a single workstation in proper sequence to perform the required series of operations. The single workstation is equipped with a spindle drive and slide feed unit; the workpiece remains in a fixed or indexable position. Additional workstations can be added on some machines if required.

Heeling, Heel Drag – Rubbing that occurs on the cutter's heel, the area just behind the tooth's cutting edge.

Helical Cutter – Endmill or other cutter with spiral or helical flutes. May be right- or left-hand.

Helix Angle – Angle that the tool's leading edge makes with the plane of its centerline.

High-Speed Milling Attachment – Device, typically combined with a universal milling attachment, that has gearing to turn small endmills at high speeds. *See universal milling attachment.*

Hob – A rotating tool with teeth arranged along a helical path, used for cutting (hobbing) worm, spur, and helical gears; splines; etc.

Hobbing – A gear-tooth-generating process consisting of rotating and advancing a fluted steel worm cutter past a revolving blank. In the actual process of cutting, the gear and hob rotate together. The speed ratio of the two depends on the number of teeth to be generated on the gear, and on whether the hob is single or multi-threaded. The hob cutting speed is controlled by change gears that vary the speed of the hobbing machine's main drive shaft.

Hobbing Machine – Machine in which a hob and a blank rotate in precise relation to each other to create worm, spur, and helical gears and splines. *See gear shaper.*

Holemaking – Using a consumable tool such as a drill, reamer, punch, liquid medium, or electrode to produce holes in the workpiece. Often a preliminary step to subsequent machining and finishing operations.

Hold-Down – T-slot bolt, strap clamp, or other device for securing the workpiece to the machine tool.

Honing – 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 (aluminum oxide and silicon carbide) mounted on a metal mandrel. Since the work is fixtured in such a way as to allow floating and no clamping or chucking, there is no distortion. Also used to give cutting tools ultrafine edges.

Honing Tool – Abrasive segments affixed to the periphery of a tool head and used to bring internal bores to an accurate, fine finish. Most often used for precision sizing and finishing of bores, but can be used to hone other shapes and to impart thin, ultrasharp cutting edges. For certain applications, may be hand-held.

Hook – Concave shape on the face of a cutting edge or blade tooth that tends to pull the cutter or blade into the work.

Hydrodynamic Machining – General term for various forms of waterjet and abrasive waterjet machining. In all cases, a fine, highly pressurized jet of water cuts and removes the material. *See AWJ, abrasive waterjet; waterjet cutting.*

ID, Inner Diameter – Dimensions that define the inside of a part. *See OD, outer diameter.*

Inclination Angle – Angle that the cutter edge makes with a plane that is perpendicular to the direction of tool travel. Determines the direction the chip curls.



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Indexable Insert – Replaceable tool that clamps into a toolholder, drill, mill, or other cutter body designed to accommodate inserts. Most inserts are made of cemented carbide; often they are coated with titanium nitride or other such hard material. Other insert materials are high-speed steels, ceramics, cermets, polycrystalline cubic boron nitride, and polycrystalline diamond. The insert is used until dull, then indexed, or turned, to expose a fresh cutting edge. When the entire insert is dull, it is usually discarded; some inserts can be resharpened. Indicator drop measurement – Method of determining if the primary and secondary reliefs on an endmill or other cutter have been properly ground. *See clearance; relief.*

Interchangeable Parts – Parts and components produced to specified tolerances, permitting them to be substituted for one another. Essential to mass production, permitting the high-volume output that results in “economies of scale.” Less critical to operating costs in computer-integrated manufacturing operations, but facilitates maintenance and repair.

Interpolation – Process of generating a sufficient number of positioning commands for the servomotors driving the machine tool so the path of the tool will closely approximate the ideal path.

Interrupted Cut – Cutting tool repeatedly enters and exits the work; subjects tool to shock loading, making tool toughness, impact strength, and flexibility vital. Closely associated with milling operations. *See shock loading.*

Jig – Tooling usually considered to be a stationary apparatus. A jig assists in the assembly or manufacture of a part or device. It holds the workpiece while guiding the cutting tool with a bushing. A jig is used in subassembly or final assembly might provide assembly aids such as alignments and adjustments. *See fixture.*

Jig Bore – Precision boring machine that resembles a milling machine. Originally designed to make precision jigs, fixtures, dies, and other tooling, this machine is now used for production machining of precision parts, extremely accurate hole location, and similar tasks. Employs a precision spindle that drives the cutting tool and an accurate, stable workholding table. Basic types include fixed-bridge, open-side or “C-frame”, and adjustable-rail machines. Often used under climate-controlled conditions. *See boring machine; mill, milling machine.*

Jig Boring – High-precision machining (a sophisticated form of milling) that originally pertained to jig and fixture manufacturing. Basic jig-boring processes include centering, drilling, reaming, through and step boring, counterboring, and contouring. The continually increasing demands for accuracy within many branches of metalworking have extended the application possibilities for jig-boring machines.

JIT, Just In Time – Philosophy based on identifying, then removing, impediments to productivity. Applies to machining processes, inventory control, rejects, changeover time, and other elements affecting production.

Kerf – Width of cut left after a blade or tool makes a pass.

Keyseating – Milling or grinding an internal keyway. *See slotting.*

Knockout – A mechanism for releasing workpieces from a die; it is also called ejector, kickout, liftout, or shedder.

Knurling – Rolling depressions into the surface of a handle or similar part to provide a better gripping surface. In automotive machining, this process is used to enhance clearances and help pistons and valve guides retain oil.

Knurling Tool – Normally a lathe tool for impressing a design on a rod or handle to improve gripping. May be either a cutting or forming operation.

Lapping – Finishing operation in which a loose, fine-grain abrasive in a liquid medium abrades material. Extremely accurate process that corrects minor shape imperfections, refines surface finishes, and produces a close fit between mating surfaces.

Lapping Compound, Powder – Light, abrasive material used for finishing a surface.

Laser-Beam Machining – Cavity Type – A process that removes material by focusing a concentrated laser beam onto the workpiece. The material is melted and vaporized. In the cavity process, the beam is carefully controlled to prevent burning through the workpiece.



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Laser Machining – Intensified, pulsed beams of light generated by lasers—typically carbon dioxide or neodymium-doped yttrium aluminum garnet (Nd:YAG)—that drill, weld, engrave, mark, slit, caseharden, etc. Usually under computer numerical control, often at both high cutting rates (100 linear in./sec/) and high power (5 kW or more). Lasers also are used in conjunction with in-process quality-control monitoring systems allowing measuring accuracies of 0.00001”.

Lathe – Turning machine capable of sawing, milling, grinding, gear-cutting, drilling, reaming, boring, threading, facing, chamfering, grooving, knurling, spinning, parting, necking, taper-cutting, and cam- and eccentric-cutting, as well as step- and straight-turning. Comes in a variety of forms, ranging from manual to semiautomatic to fully automatic, with major types being engine lathes, turning and contouring lathes, turret lathes, and numerical-control lathes. The engine lathe consists of a headstock and spindle, tailstock, bed, carriage (complete with apron), and cross slides. Features include gear- (speed) and feed-selector levers, toolpost, compound rest, leadscrew and reversing leadscrew, threading dial, and rapid-traverse lever. Special lathe types include through-the-spindle, camshaft and crankshaft, brake drum and rotor, spinning, and gun-barrel machines. Toolroom and bench lathes are used for precision work; the former for tool-and-die work and similar tasks, the latter for small workpieces (instruments, watches), normally without a power feed. Models are typically designated according to their “swing,” or the largest-diameter workpiece that can be rotated; bed length, or the distance between centers; and horsepower generated. Modern lathes often are equipped with digital readouts and computer numerical controls.

Lathe Bit, Lathe Tool – Cutting tool for lathes and other turning machines. Normally a single-point cutting tool, square in cross section and ground to a shape suitable for the material and task. Intended for simple metal removal, threading, slotting, or other internal or external cutting jobs. Clearance to prevent rubbing is provided by grinding back rake, side rake, end relief, and side relief, as well as side- and end-cutting edges.

Lathe Turning – Machining operation in which a workpiece is rotated, while a cutting tool removes material, either externally or internally.

Layout – Use of scribes, ink, and prick punches to create a part outline that machinists use to visually check part shape during machining of prototypes or during tool-and-die work.

Lip angle – Included angle between a cutter’s tooth and relieved land.

Loading – In grinding, the wheel’s tendency to accumulate workpiece material between its abrasive points. In milling, drilling, and other operations, excessive packing of chips in cutter flutes or at cutter edge.

Lubricant – Substance that reduces friction between moving machine parts. Can be liquid (hydrocarbon oil), solid (grease), or gaseous (air). Important characteristics are to prevent metal-to-metal contact between moving surfaces, be a cooling medium, and protect surfaces from rust and corrosion.

Lubricity – Measure of the relative efficiency with which a cutting fluid or lubricant reduces friction between surfaces.

MRP, MRP-II, Materials Requirements Planning, Manufacturing Resources Planning – Management method, normally computer-aided, for cost-effective control of manufacturing support functions, such as inventory, production equipment, and personnel. MRP was the initial, somewhat limited method; MRP-II implies a more sophisticated system.

Machining – Process of giving a workpiece a new configuration by cutting or shaping it. Typically performed on a machine tool or machining center. Includes cutting and shaping all kinds of materials, not just metals. Generally associated with precision and high-quality fit.

Machining Center – A computer-controlled machine tool capable of drilling, reaming, tapping, milling, and boring. Normally comes with an automatic toolchanger. *See automatic toolchanger.*

Magnetic Chuck – Workholding device used on surface grinders and milling machines for holding ferrous parts with large, flat sides. Holding power may be provided by permanent magnets or by an electromagnetic system. *See chuck.*

Mandrel – Workholder for turning that fits inside hollow workpieces. Types available include expanding, pin, and threaded.



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Mass Production – Large-scale manufacturing with high-volume production and output; implies precomputer-era methods, with departmentalized operation and reliance on “economies of scale” to achieve low per-unit costs.

Materials Handling – Methods, equipment, and systems for conveying materials to various machines and processing areas and for transferring finished parts to assembly, packaging, and shipping areas.

Metalcutting – Any machining process used to part metal or a material or give a workpiece a new configuration. Conventionally applies to machining operations in which a cutting tool mechanically removes material in the form of chips; applies to any process in which metal or material is removed to create new shapes.

Metalforming – Manufacturing processes in which products are given new shapes either by casting or by some form of mechanical deformation, such as forging, stamping, bending, spinning, etc. Some processes, such as stamping, may use dies or tools with cutting edges to cut as well as form parts.

Metalworking – Any manufacturing process in which metal is processed or machined such that the workpiece is given a new shape. Broadly defined, the term includes processes such as design and layout, heat-treating, material handling, inspection, etc.

Metal-Removal Factor – The volume of metal removed per unit of power in a given period of time (reciprocal of the specific power-consumption factor). Also known as the “K-factor,” it is primarily dependent on the properties of the metal being cut, is only slightly dependent on feed, and has virtually no dependence on depth of cut.

Micro-Slicing – Cutting very small or thin parts from a larger base part. Uses a special machine with a thin, tensioned blade that takes a minimum kerf. Process for cutting expensive materials such as silicon, germanium, and other computer-chip materials.

Mill, Milling Machine – Runs endmills and arbor-mounted milling cutters. Features include a head with a spindle that drives the cutters; a column, knee, and table that provide motion in the three Cartesian axes; and a base that supports the components and houses the cutting-fluid pump and reservoir. The work is mounted on the table and fed into the rotating cutter or endmill to accomplish the milling steps; vertical milling machines also feed endmills into the work by means of a spindle-mounted quill. Models range from small manual machines to big bed-type and duplex mills. All take one of three basic forms: vertical, horizontal, or convertible horizontal/vertical. Vertical machines may be knee-type (the table is mounted on a knee that can be elevated) or bed-type (the table is securely supported and only moves horizontally). In general, horizontal machines are bigger and more powerful, while vertical machines are lighter but more versatile and easier to set up and operate. Modern mills often are equipped with digital readouts and computer numerical controls.

Milling – Machining operation in which metal or other material is removed by applying power to a rotating cutter. Takes two general forms: vertical and horizontal. In vertical milling, the cutting tool is mounted vertically on the spindle. In horizontal milling, the cutting tool is mounted horizontally, either directly on the spindle or on an arbor. Horizontal milling is further broken down into conventional milling, where the cutter rotates opposite the direction of feed, or “up” into the workpiece. Milling operations include plane or surface milling, endmilling, facemilling, angle milling, form milling, and profiling.

Milling Arbor – Shaft or toolholder that inserts in the machine spindle and holds a peripheral milling or facemilling cutter.

Milling Cutter – Loosely, any milling tool. Horizontal cutters take the form of plain milling cutters, plain spiral-tooth cutters, helical cutters, side-milling cutters, staggered-tooth side-milling cutters, facemilling cutters, angular cutters, double-angle cutters, convex and concave form-milling cutters, straddle-sprocket cutters, spur-gear cutters, corner-rounding cutters, and slitting saws. Vertical mills use shank-mounted cutting tools, including endmills, T-slot cutters, Woodruff keyseat cutters, and dovetail; these may also be used on horizontal mills.

Miscibility – Ability of a liquid to mix with another liquid. *See emulsion.*

Mist Application – Atomized fluid generally applied when a clear view of the cut point is needed, as in contour band sawing or manual milling. The airborne mist can be directed precisely to the point of cut, sometimes reaching areas flood-applied coolant will not penetrate. The water evaporates on contact, providing further cooling, and leaves oils and additives on the work. *See flood application.*



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Mixture Ratio – Ratio of water to concentrate in certain cutting fluids. *See semisynthetic cutting fluid; soluble-oil cutting fluid; synthetic cutting fluid.*

Modular Design, Construction – Manufacturing of a product in subassemblies that permit fast and simple replacement of defective assemblies and tailoring of the product for different purposes.

Modular Fixturing – System in which fixtures are constructed from standardized, reusable components. Fixtures are assembled and disassembled quickly. Basic styles are subplate, dowel-pin, and T-slot.

Modular Tooling – Tooling system comprised of standardized tools and toolholders. Devices that allow rapid mounting and replacement of tools. Commonly used with carousel toolchangers and other computerized machining operations.

Multifunction Machines – Machines and machining/turning centers capable of performing a variety of tasks, including milling, drilling, boring, turning, and cutoff, usually in just one setup.

NC, Numerical Control – Any controlled equipment that allows an operator to program its movement by entering a series of coded numbers, symbols, etc. *See CNC, computer numerical control; DNC, direct numerical control.*

Nontraditional Machining – Variety of chemical, electrical, mechanical, and thermal processes for machining workpieces. Originally applied to new or emerging processes, it designates any process developed since 1945.

OD, Outer Diameter – Dimensions that define the exterior of a part. *See ID, inner diameter.*

Offhand Grinding – Hand-feeding a workpiece into a bench grinder. Usually utilized in the shop to resharpen tools. Attachments or other mechanical devices are required for increased efficiency and accuracy. *See grinding.*

Orthogonal Chip Formation – Concentrated shear action at the point of cut that results in the formation of a continuous chip. *See shear plane.*

Overshoot – Deviation from nominal path caused by momentum carried over from the previous step, as when a tool is rapidly traversed a considerable distance to begin a cut. Usually applies to numerical-control/computer-numerical-control machining. *See undershoot.*

Parallel – Strip or block of precision-ground stock used to elevate a workpiece, while keeping it parallel to the worktable, to prevent cutter/table contact.

Parting – When used in lathe or screw-machine operations, this process separates a completed part from chuck-held or collet-fed stock by means of a very narrow, flat-end cutting tool (parting tool). **Peripheral milling** – A form of milling that produces a finished surface generally in a plane parallel to the rotating axis of a cutter having teeth or inserts on the periphery of the cutter body. *See milling.*

Photochemical Machining – A variation on chemical machining that uses a chemically resistant mask that is sensitive to light. Light activates the mask only in the areas to be protected. The remaining mask is washed away. The process is typically used to produce parts such as circuit boards and other delicate items.

Pitch – On a saw blade, the number of teeth per inch. In threading, the number of threads per inch.

Planer, Planing Machine – Machines flat surfaces. Planers take a variety of forms: double-housing, open-side, convertible and adjustable open-side, double-cut, and milling. Large multi-head (milling, boring, drilling, etc.) planers and planer-type milling machines handle most planing work.

Planing – Machining operation that creates flat surfaces. The workpiece is reciprocated in a linear motion against one or more single-point tools. Also used to create contours or irregular configurations.

Planing Bit – Cutting tool similar in appearance to a turning tool, but with a longer shank.

Point Angle – The included angle at the point of a twist drill or similar tool; for general-purpose tools, the point angle is typically 118°.



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Point-to-Point System – Numerical-control system normally used for drilling and other operations where center-point location is readily determined. Tool is rapidly moved to a position, then drills, taps, reams, bores, counterbores, countersinks, or performs some other task.

Polar Additives – Animal, vegetable, or synthetic oils that, when added to a mineral oil, improve its ability to penetrate the tool/workpiece interface.

Polishing – Abrasive process that improves surface finish and blends contours. Abrasive particles attached to a flexible backing abrade the workpiece.

Polishing Attachment – Abrasive grinding device that mounts on a contour band saw and used fine-grit belts to grind and polish.

Power Brushing – Any process that uses a power-driven, rotating industrial brush to deburr, clean, or finish a metal part. Depending on the application, the brush fibers, collectively known as brush fill material, may be metal wires; fiberglass-coated, abrasive-filled plastics; synthetics such as nylon and polypropylene; natural animal hairs such as horsehair; or vegetable fibers such as tampico and bahia.

Power Hacksaw – Machine fitted with serrated blade held taut in a reciprocating frame that cuts in one direction, either on the forward or return stroke. *See saw, sawing machine.*

Power Hacksawing – A sawing process that uses the back-and-forth motion of a short, straight toothed blade to cut the workpiece. Hacksawing machines are generally electrically driven, and may not provide for application of cutting fluid to the saw blade or workpiece.

Productivity – Measure of the efficiency with which human and material resources are used to produce goods and services. Output per man-hour has traditionally been the most stable measure, but since direct labor is sharply reduced by computer-aided design, computer-aided manufacturing, and computer-integrated manufacturing, alternative methods of measuring may be more accurate. Software and other support/service functions must be factored into the equation.

Profiling – Machining vertical edges of workpieces having irregular contours; normally performed with an endmill in a vertical spindle on a milling machine or with a profiler, following a pattern.

Quick-Change Toolholder – Cutter holder that permits rapid tool changes. Generally associated with automatic or semiautomatic machining operations. *See toolholder.*

RIM, Reaction Injection Molding – a molding process that allows the rapid molding of liquid materials. The injection-molding process consists of heating and homogenizing plastic granules in a cylinder until they are sufficiently fluid to allow for pressure injection into a relatively cold mold, where they solidify and take the shape of the mold cavity. For thermoplastics, no chemical changes occur within the plastic, and consequently the process is repeatable. The major advantages of the injection molding process are the speed of production; minimal requirements for postmolding operations; and simultaneous, multipart molding.

Rack-Milling Attachment – Attachment for cutting gear teeth, usually in a straight line, but when used in conjunction with universal spiral-index centers on a universal mill, it allows the machining of worms.

Radial Drill – Large drill with an arm that pivots about a column to provide positioning flexibility and great reach and stability. *See drilling machine, drill press.*

Radial Rake – Also known as the tool back rake, the angle between the tooth face and the radial plane through the tool point.

Rake – Angle formed between a tooth face and a line perpendicular to the cutter centerline.

Rancidity – Bacterial and fungal growths in water-miscible fluids that cause unpleasant odors, stained workpieces, and diminished fluid life.

Reamer – Rotating cutting tool used to enlarge a drilled hole to size. Normally removes only a small amount of stock. The workpiece supports the multiple-edge cutting tool. Also for contouring an existing hole.



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Reaming – A machining process that uses a multi-edge, fluted cutting tool to smooth, enlarge, or accurately size an existing hole. Reaming is performed using the same types of machines as drilling. Reaming is simpler to perform than boring, but it is not as precise. *See drilling.*

Relief – Space provided behind the cutting edges to prevent rubbing. Sometimes called primary relief. Secondary relief provides additional space behind primary relief. Relief on end teeth is axial relief; relief on side teeth is peripheral relief.

Rotary Attachment – Bolts to a milling machine to permit machining such shapes as circular T-slots and cams.

Roughing Cutter, Tool – Tool for high-volume metal removal; normally followed by finishing passes. *See finishing tool.*

Saw, Sawing Machine – Machine designed to use a serrated-tooth blade to cut metal or other material. Comes in a wide variety of styles, but takes one of four basic forms: hacksaw (a simple, rugged machine that uses a reciprocating motion to part metal or other material); cold or circular saw (powers a circular blade that cuts structural materials); band saw (runs an endless band; the two basic types are cutoff and contour band machines, which cut intricate contours and shapes); and abrasive cutoff saw (similar in appearance to the cold saw, but uses an abrasive disc that rotates at high speeds rather than a blade with serrated teeth).

Sawing – Machining operation in which a powered machine, usually equipped with a blade having milled or ground teeth, is used to part material (cutoff) or give it a new shape (contour band sawing, band machining). Four basic types of sawing operations are: 1. hacksawing: power or manual operation in which the blade moves back and forth through the work, cutting on one of the strokes; 2. cold or circular sawing: a rotating, circular, toothed blade parts the material much as a workshop table saw or radial-arm saw cuts wood; 3. band sawing: a flexible, toothed blade rides on wheels under tension and is guided through the work; and 4. abrasive sawing: abrasive points attached to a fiber or metal backing part stock; could be considered a grinding operation.

Scalloping, Scallops – Wavy surface condition caused by deflection, unbalanced tool, loose workpiece or tooling, worn machine, etc.

Semisynthetic Cutting Fluid – Water-based chemical solution that contains some oil. *See synthetic cutting fluid.*

Shank – Main body of a tool; the portion of a drill or similar end-held tool that fits into a collet, chuck, or similar mounting device.

Shaper, Slotting Machine – Vertical or horizontal machine that accommodates single-point, reciprocating cutting tools to shape or slot a workpiece. Normally used for special (unusual/intricate shapes), low-volume runs typically performed by broaching or milling machines. *See broaching machine; mill, milling machine.*

Shaper Tool – Single-point tool that traverses the workpiece in a reciprocating fashion to machine a desired shape.

Shaping – Using a shaper primarily to produce flat surfaces in horizontal, vertical, or angular planes. It can also include the matching of curved surfaces, helixes, serrations, and special work involving odd and irregular shapes. Often used for prototype or short-run manufacturing to eliminate the need for expensive special tooling or processes.

Shear Plane – Plane along which the chip parts from the workpiece. In orthogonal cutting, most of the energy is used to create the shear plane.

Shock Loading – Tool is subjected to sudden, heavy loads and/or impacts, as in interrupted cutting. *See interrupted cut.*

Shop Air – Pressurized air system that cools the workpiece and tool when machining dry. Also refers to central pneumatic system.

Slotting – Machining, normally milling, that creates slots, grooves, and similar recesses in workpieces, including T-slots and dovetails.

Slotting Attachment – Converts a milling machine's rotary spindle motion into a reciprocating motion for machining keyways and slots.



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Soluble-Oil Cutting Fluid – Fluid in which oil is suspended in water. Since water is a superior heatremoval agent, this fluid is primarily used when lubrication is desirable, but cooling is the key consideration. The ration of oils and other additives to water varies with the application. For milling, the ratio of water to oil/additives runs 20:1 to 25:1. For sawing and other work, where a more confined tool/chip/workpiece condition is normal, a 10:1 ration is used to improve lubricity. Additives include emulsifying agents that help keep the oil in suspension and substances that promote wetting, enhance lubricity, prevent chipwelding, and inhibit rusting. Also known as emulsified oil. *See cutting fluid.*

Spade Drill – A flat end-cutting tool, used to produce holes ranging from about 1” to 6” in diameter. Space drills consist of an interchangeable cutting blade and a toolholder that has a slot into which the blade fits. In horizontal applications, a spade drill can achieve extreme depth-to-diameter ratios, but in vertical applications the tools are limited by poor chip evacuation.

Spade Drilling – Drilling operation in which a machine powers a cutting tool consisting of a holder and flat, interchangeable end-cutting blades. Spade drilling takes over where twist drilling leaves off; requires more power and a larger machine, but offers lower cost and greater rigidity. Largediameter spade drills are used when trepanning is impractical or impossible. Spade drills are not, however, precision tools. *See drilling; trepanning.*

Specific Cutting Energy – Measure of the total energy required to make the cut, including the energy needed to part the stock and overcome frictional forces generated during cutting.

Spindle Adapters – Bushings of toolholders that permit affixing a variety of taper- and straightshank tools to a machine spindle.

Spindle Finishing – A mass finishing process in which workpieces are individually mounted on spindles, the lowered into a rotating tub containing the finishing media. In most applications, the spindles rotate at 10 to 3000 rpm, but in some cases the spindles oscillate up and down instead of rotating. The process is sometimes automated for robotic loading and unloading. *See finishing.*

Spiral Milling – Milling while simultaneously rotating and feeding the workpiece to create a spiral form. Often used to mill flutes on endmill and twist-drill blanks.

Spotfacer – Tool, guided by a pilot, used to machine a recess around a hole.

Spotfacing – Similar to counterboring except that, in spotfacing, material around the original hole is cut. Application example: the recessed area that a washer fits into. *See counterboring; countersinking.*

Straight-Cut System – Numerical-control system wherein tools move at either 45° or 90° angles to the coordinate axes. Used in turning shoulders or milling rectangular shapes; normally is combined with point-to-point system for greater efficiency and flexibility.

Straight Oil – Cutting fluid that contains no water. Produced from mineral, vegetable, marine, or petroleum oils, or combinations of these oils.

Steady Rest – Supports long, thin, or flexible work being turned on a lathe. Mounts on the bed’s ways and, unlike a follower rest, remains at the point where mounted. *See follower rest.*

StereoLithography–Metal – A process similar to plastic StereoLithography, but uses powder metal to build up the part.

StereoLithography–Plastic – A process that uses a combination of lasers and photosensitive, liquid plastics to generate models. The desired workpiece is electronically “sliced” into thin sections. The laser beam scans over a bath of uncured polymer and only turns on where material should exist, duplicating the sliced section. The polymer partially hardens in these areas. By lowering the workpiece into the polymer bath and scanning successive layers, the part is developed. When the part is completely built up, it is removed from the bath and finish-cured with intense ultraviolet light. Can be used to generate complex models.

Superabrasive Tools – Abrasive tools made from diamond or cubic boron nitride (CBN), the hardest materials known.

Surface Grinding – The machining of a flat, angled, or contoured surface by passing a workpiece beneath a grinding wheel in a plane parallel to the grinding wheel spindle. *See grinding.*

T-slot Cutter – Milling cutter for machining T-slots. Desired T-slot shape is reverse of cutter shape.



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TOP, Technical Office Protocol – Standardized computer communications for the office; combines with manufacturing automation protocol to permit office/plant computer integration of multi-vendor systems and software. *See MAP, manufacturing automation protocol.*

Tailstock Drill and Tapholder – Accessory that mounts in a turning machine's tailstock for centerdrilling chucked work and tapping. *See chuck.*

Tang – Extended flat portion of tapered drill shank, endmill, or other tool that allows maximum power transmission and proper positioning of the tool. Reverse shape of the machine-spindle slot it fits into.

Tap – Cylindrical tool that cuts internal threads and has flutes to remove chips and carry tapping fluid to the point of cut. Normally used on a drill press or tapping machine, but also may be operated manually.

Tap Reamer – Reamer designed to produce a reamed hole with a specified taper. Principles of standard reamers apply. *See reamer.*

Taper-Turning Attachment – Guide to which a cross slide is attached that permits the turning of tapers without disturbing the alignment of the tailstock. Also permits taper boring.

Tapping – Machining operation in which a tap, with teeth on its periphery, cuts internal threads in a pre-drilled hole having a smaller diameter than the tap diameter. Threads are formed by a combined rotary and axial-relative motion between tap and workpiece.

Tapping Attachment – Fits in a drill-press spindle and automatically reverses the tap when the thread is completed, ensuring proper retraction of the tool.

Tapping Machine – Production machine used for high-volume tapping. Offers repeatability, high production rates, and reduced tap breakage. Comes in a variety of configurations, including indexing units with multiple tapping spindles. Precise stroke-depth settings and automatic features generally make tapping machines very cost-effective.

Threading – A process of both external and internal (tapping) cutting, turning, and rolling of threads into particular material. Standardized specifications are available to determine the desired results of the threading process. Numerous thread-series designations are written for specific applications. Threading often is performed on a lathe. Specifications such as thread height are critical in determining the strength of the threads. The material used is taken into consideration in determining the expected results of any particular application for that threaded piece. In external threading, a calculated depth is required as well as a particular angle to the cut. To perform internal threading, the exact diameter to bore the hole is critical before threading. The threads are distinguished from one another by the amount of tolerance and/or allowance that is specified. *See turning.*

Thread Chaser – Die-type external threading tool. Makes final threading pass.

Thread Grinder – Typically a form grinder as well as a thread grinder, this machine differs from other grinders in that precision gears and leadscrews ensure a precise traverse to impart the correct lead to a thread.

Threading Machine – Typically takes the form of multi-spindle, universal threading machines that use dieheads and thread chasers to cut threads, often automatically or semiautomatically. Threading also is performed on lathes and automatic screw machines.

Toolchanger – Carriage or drum attached to a machining center that holds tools until needed; when a tool is needed, the toolchanger inserts the tool into the machine spindle.

Toolholder – Secures a cutting tool during a machining operation. Basic types include block, cartridge, chuck, collet, fixed, modular, quick-change, and rotating.

Toolroom Lathe – High-precision lathe built to hold tighter tolerances than regular, generalpurpose lathes can hold tighter tolerances than regular, general-purpose lathes can hold. *See lathe; turning machine.*

Tooth Rest – Finger of metal that contacts a cutter edge during resharpener on a tool-and-cutter grinder, ensuring accurate location of edges so they are properly ground.



MANUFACTURING GLOSSARY

Tracer Attachment – Used to duplicate a workpiece. A stylus connected to a servo traces a template or sample workpiece. The attachment directs the movements of a machine tool that cuts a duplicate workpiece. For machining complex parts.

Trepanning – Drilling deep holes that are too large to be drilled by high-pressure coolant drills or gundrills. Trepanning normally requires a big, powerful machine. Shallow trepanning operations can be performed on modified engine or turret lathes, or on boring machines. *See boring; drilling; spade drilling.*

Truing – Using a diamond or other dressing tool to ensure that a grinding wheel is round and concentric and will not vibrate at required speeds. Weights also are used to balance the wheel. Also performed to impart a contour to the wheel's face. *See dressing.*

Turning – A workpiece is held in a chuck, mounted on a face plate, or secured between centers and rotated while a cutting tool, normally a single-point tool, is fed into it along its periphery or across its end or face. Takes the form of straight turning (cutting along the periphery of the workpiece); taper turning (creating a taper); step turning (turning different-size diameters on the same work); chamfering (beveling an edge or shoulder); facing (cutting on an end); turning threads (usually external but can be internal); roughing (volume metal removal); and finishing (final light cuts). Performed on lathes, turning centers, chucking machines, automatic screw machines, and similar units.

Turning machine – Any machine that rotates a workpiece while feeding a cutting tool into it. *See lathe.*

Turret Lathe – Differs from engine lathe in that the normal compound rest is replaced by pivoting, multi-tool turrets mounted on the cross slide and tailstock. *See lathe.*

Turret Ram Mill – Variation of the vertical milling machine; has a movable ram mounted on a swivel base atop the column, providing positioning flexibility. *See mill, milling machine.*

Twist Drill – The most common type of drill, having one or more cutting edges, and having helical grooves adjacent thereto for the passage of chips and for admitting coolant to the cutting edges. Twist drills are used either for originating holes or for enlarging existing holes. Standard twist drills come in fractional sizes from 1/16" to 1 1/2", wire-gage sizes from 1 to 80, letter sizes from A to Z, and metric sizes.

Ultrasonic machining – Material-removal operation in which an abrasive slurry flows between a tool, vibrating at a high frequency, and a workpiece.

Undercut – In numerical-control applications, a cut shorter than the programmed cut resulting after a command change in direction. Also a condition in generated gear teeth when any part of the fillet curve lies inside of a line drawn tangent to the working profile at its point of juncture with the fillet. Undercut may be deliberately introduced to facilitate finishing operations, as in preshaving.

Undershoot – Tendency of a numerical-control/computer-numerical-control machine to round off the corners of a programmed path because of servo lag or backlash, or because mechanical systems cannot react quickly to programmed instructions, especially when the machine is cold.

Universal Milling Machine – A horizontal mill equipped with a table that swivels, with respect to the saddle, allowing angular surfaces to be cut without changing the workpiece's position.

Universal Head – Facilitates setups on a tool-and-cutter grinder by allowing the grinding head to rotate away from the work area, leaving table alignment undisturbed. Also called a swivel attachment.

Universal Milling Attachment – Mounts on a horizontal mill, permitting the spindle to be set at almost any angle.

Universal Spiral-Milling Attachment – On a universal mill, permits milling helices with a helix angle greater than 45°. Mills gears, screw threads, worms, twist drills, spiral-milling cutters, and other helical shapes. Mounted to a plain milling machine equipped with a dividing head, it permits the mill to handle work that otherwise would require a universal mill.

V-block – Workholding device with V-shaped slot for holding pipe and other round stock during machining or inspection.



MANUFACTURING GLOSSARY

Vacuum Bag Molding – A process for molding reinforced plastics in which a sheet of flexible, transparent material is placed over the lay-up on the mold and sealed. A vacuum is created between the sheet and the lay-up. The entrapped air is next mechanically worked out of the lay-up and removed by the vacuum; finally, the part is cured.

Viscosity – Measure of a fluid's tendency to flow; varies with temperature.

Vertical Milling Attachment – Permits a horizontal mill to perform vertical and angled milling.

Vise – Workholding device that mounts on various machining tables. Designs vary from plain to flanged to swiveling. Multi-angle vises, such as the toolmaker's universal vise, accurately hold work to allow machining at virtually any angle.

Waterjet Cutting – A fine, high-pressure (up to 50,000 psi or greater), high-velocity jet of water directed by a small nozzle to cut material. The pressure of the waterjet is usually thousands of psi and the velocity of the stream can exceed twice the speed of sound. The small nozzle opening ranges from between 0.004" to 0.016" (0.10mm to 0.41mm), producing a very narrow kerf. *See AWJ, abrasive waterjet.*

Web – On a rotating tool, the portion of the tool body that joins the lands. Web is thicker at the shank end, relative to the point end, providing maximum torsional strength.

Wheel-balancing stand – Used to ensure that a grinding wheel is balanced before mounting it on the machine.

Wheel Flange – Metal plate inside the grinding-wheel hole that allows the wheel to be mounted on a spindle.

Woodruff Cutter – Milling cutter used for cutting keyways.

Work-Squaring Bar – Mounts to the table of a contour band machine and automatically squares the work to the blade.