(10) A Wide Variety of Grinding

Grinding is a large and diverse area of manufacturing and toolmaking. It can produce very fine finishes and very accurate dimensions; yet in mass production contexts it can also rough out large volumes of metal quite rapidly.

It is usually better suited to the machining of very hard materials than is "regular" machining (that is, cutting larger chips with cutting tools such as tool bits or milling cutters), and until recent decades it was the only practical way to machine such materials

as hardened steels. Compared to "regular" machining, it is usually better suited to taking very shallow cuts, such as reducing a shaft's diameter by half a thousandth of an inch or 12.7 um.

Grinding is a subset of cutting, as grinding is a true metal-cutting process. Each grain of abrasive functions as a microscopic single-point cutting edge (although of high negative rake angle), and shears a tiny chip that is analogous to what would conventionally be called a "cut" chip (turning, milling, drilling, tapping, etc.). However, among people who work in the machining fields, the term cutting is often understood to refer to the macroscopic cutting operations, and grinding is often mentally categorized as a "separate" process. This is why the terms are usually used in contradistinction in shop-floor practice, even though, strictly speaking, grinding is a subset of cutting.
Similar abrasive cutting processes are lapping and sanding.

Selecting which of the following grinding operations to be used is determined by the size, shape, features and the desired production rate.

Surface grinding

Surface grinding uses a rotating abrasive wheel to remove material, creating a flat surface. The tolerances that are normally achieved with grinding are $\pm 2 \times 10^{-4}$ inches for a grinding a flat material, and $\pm 3 \times 10^{-4}$ inches for a parallel surface (in metric units: 5 μm for flat material and 8 μm for parallel surface).

The surface grinder is composed of an abrasive wheel, a workholding device known as a chuck, either electromagnetic or vacuum, and a reciprocating table.

Typical workpiece materials include cast iron and steel. These two materials do not tend to clog the grinding wheel while being processed. Other materials are aluminum, stainless steel, brass and some plastics.

Cylindrical grinding

Cylindrical grinding (also called center-type grinding) is used to grind the cylindrical surfaces and shoulders of the workpiece. The workpiece is mounted on centers and rotated by a devise known as a drive dog or center driver. The abrasive wheel and the workpiece are rotated by separate motors and at different speeds. The table can be adjusted to produce tapers. The wheel head can be swiveled.

The five types of cylindrical grinding are: outside diameter (OD) grinding, inside diameter (ID) grinding, plunge grinding, creep feed grinding, and centerless grinding.

A cylindrical grinder has a grinding (abrasive) wheel, two centers that hold the workpiece, and a chuck, grinding dog, or other mechanism to drive the work. Most cylindrical grinding machines include a swivel to allow for the forming of tapered pieces.

The wheel and workpiece move parallel to one another in both the radial and longitudinal directions. The abrasive wheel can have many shapes. Standard disk shaped wheels can be used to create a tapered or straight workpiece geometry while formed wheels are used to create a shaped workpiece. The process using a formed wheel creates less vibration than using a regular disk shaped wheel.

Tolerances for cylindrical grinding are held within five ten-thousandths of an inch (+/- 0.0005) (metric: +/- 13 um) for diameter and one ten-thousandth of an inch(+/- 0.0001) (metric: 2.5 um) for roundness. Precision work can reach tolerances as high as fifty millionths of an inch (+/- 0.00005) (metric: 1.3 um) for diameter and ten millionths (+/- 0.00001) (metric: 0.25 um) for roundness. Surface finishes can range from 2 to 125 microinches (metric: 50 nm to 3 um), with typical finishes ranging from 8-32 microinches. (metric: 0.2 um to 0.8 um)

Creep-feed grinding

Creep-feed grinding (CFG) was invented in Germany in the late 1950s by Edmund and Gerhard Lang. Unlike normal grinding, which is used primarily to finish surfaces, CFG is used for high rates of material removal, competing with milling and turning as a manufacturing process choice. Depths of cut of up to 6 mm (0.25 inches) are used along with low workpiece speed. Surfaces with a softer-grade resin bond are used to keep workpiece temperature low and an improved surface finish up to 1.6 micrometres Rmax With CFG it takes 117 sec to remove 1 in.3 of material, whereas precision grinding would take more than 200 sec to do the same. CFG has the disadvantage of a wheel that is constantly degrading, and requires high spindle power, 51 hp (38 kW), and is limited in the length of part it can machine.[3]

To address the problem of wheel sharpness, continuous-dress creep-feed grinding (CDCF) was developed in the 1970s. It dresses the wheel constantly during machining, keeping it in a state of specified sharpness. It takes only 17 sec. to remove 1 in3 of material, a huge gain in productivity. 38 hp (28 kW) spindle power is required, and runs at low to conventional spindle speeds. The limit on part length was erased.

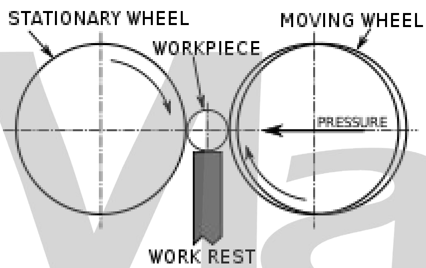
High-efficiency deep grinding (HEDG) uses plated superabrasive wheels, which never need dressing and last longer than other wheels. This reduces capital equipment investment costs. HEDG can be used on long part lengths, and removes material at a rate of 1 in3 in 83 sec. It requires high spindle power and high spindle speeds.

Peel grinding, patented under the name of Quickpoint in 1985 by Erwin Junker Maschinenfabrik, GmbH in Nordrach, Germany, uses a tool with a with superabrasive nose and can machine cylindrical parts.

VIPER (Very Impressive Performance Extreme Removal), 1999, is a process patented by Rolls-Royce and is used in aerospace manufacturing to produce turbine blades. It uses a continuously dressed aluminum oxide grinding wheel running at high speed. CNC-controlled nozzles apply refrigerated grinding fluid during the cut. VIPER is performed on equipment similar to a CNC machining center, and uses special wheels.

Ultra-high speed grinding (UHSG) can run at speeds higher than 40,000 fpm (200 m/s), taking 41 sec to remove 1 in.3 of material, but is still in the R&D stage. It also requires high spindle power and high spindle speeds.

Others



Centerless grinding is when the workpiece is supported by a blade instead of by centers or chucks. Two wheels are used. The larger one is used to grind the surface of the workpiece and the smaller wheel is used to regulate the axial movement of the workpiece. Types of centerless grinding include through-feed grinding, in-feed/plunge grinding, and internal centerless grinding.

Form grinding is a specialized type of cylindrical grinding where the grinding wheel has the exact shape of the final product. The grinding wheel does not traverse the workpiece.

Internal grinding is used to grind the internal diameter of the workpiece. Tapered holes can be ground with the use of internal grinders that can swivel on the horizontal.

Pre-grinding When a new tool has been built and has been heat-treated, it is pre-ground before welding or hardfacing commences. This usually involves grinding the OD slightly higher than the finish grind OD to ensure the correct finish size.

Electrochemical grinding is a type of grinding in which a positively charged workpiece in a conductive fluid is eroded by a negatively charged grinding wheel. The pieces from the workpiece are dissolved into the conductive fluid.

Electrolytic in-process dressing (ELID) grinding is one of the most accurate grinding methods. In this ultra precision grinding technology the grinding wheel is dressed electrochemically and in-process to maintain the accuracy of the grinding. An ELID cell consists of a metal bonded grinding wheel, a cathode electrode, a pulsed DC power supply and electrolyte. The wheel is connected to the positive terminal of the DC power supply through a carbon brush whereas the electrode is connected to the negative pole of the power supply. Usually alkaline liquids are used as both electrolytes and coolant for grinding. A nozzle is used to inject the electrolyte into the gap between wheel and electrode. The gap is usually maintained to be approximately 0.1mm to 0.3 mm. During the grinding operation one side of the wheel takes part in the grinding operation whereas the other side of the wheel is being dressed by electrochemical reaction. The dissolution of the metallic bond material is caused by the dressing which in turns results continuous protrusion of new sharp grits.