Welcome to the Tooling University. This course is designed to be used in conjunction with the online version of this class. The online version can be found at http://www.toolingu.com. We offer high quality web-based e-learning that focuses on today's industrial manufacturing training needs. We deliver superior training content over the Internet using text, photos, video, audio, and illustrations. Our courses contain "roll-up-your-sleeves" content that offers real-world solutions on subjects such as Metal Cutting, Workholding, Materials, and CNC with much more to follow. Today's businesses face the challenge of maintaining a trained workforce. Companies must locate apprenticeship programs, cover travel and lodging expenses, and disrupt operations to cover training needs. Our web-based training offers low-cost, all-access courses and services to maximize your training initiatives.

Grinding Processes 120
Class Outline

Objectives
The Importance of Grinding
Grinding Machine Characteristics
Surface Grinding
Center-Type Cylindrical Grinding
Chucking-Type Cylindrical Grinding
Centerless Grinding
Internal Centerless Grinding
Creep Feed Grinding
Snagging and Offhand Grinding
Tool Grinding
Cutoff Operations
Summary
Lesson: 1/13

Objectives
- Describe the benefits of grinding.
- Name some characteristics of grinding machines.
- Describe surface grinding.
- Describe center-type cylindrical grinding.
- Describe chucking-type cylindrical grinding.
- Describe centerless grinding.
- Describe internal centerless grinding.
- Describe creep feed grinding.
- Identify common methods of imprecise grinding.
- Describe tool grinding.
- Describe cutoff grinding.

Figure 1. A center-type grinding operation. (Courtesy of Royal Master Grinders, Inc.)
Lesson: 2/13

The Importance of Grinding

Grinding is the most common abrasive machining process. Using a rotating, bonded abrasive wheel attached to a machine, grinding removes material from the surface of parts. Grinding is used to make parts fit better, perform better, or just look better, depending on the specifications of the particular job.

However, grinding is not just a process used on flat exterior surfaces. Grinding is performed on a variety of different surfaces for both finishing and shaping parts, as shown in Figure 1. It may be used simply to remove excess material off a part or to make intricate shapes. Because of the variety of parts and materials that require finishing and abrasive shaping, there are a number of different types of machines and processes that perform grinding.

This class will teach you the most common grinding processes and describe the machines that perform them. You will learn how and why grinding takes place, and in some cases, why grinding may be preferred over other machining operations.

Figure 1. The parts on the left have finished surfaces from grinding.
Lesson: 3/13

Grinding Machine Characteristics
The main difference between grinding and many other machining operations is that grinding can produce parts with very tight tolerances. This means that if a finished part, say an engine component, has to have a certain measurement, grinding is one way to bring it closer to that measurement.

Because grinding produces precision parts, the machines that perform the grinding must be precise as well. Grinding machines are constructed accurately, with tight measurements of their own. They tend to be made of heavy materials and have rigid frames to prevent movement and vibration. They have high-quality moving parts that are protected to keep dust and swarf away and make sure that stray grains will not rub against components and ruin them. Figure 1 shows a modern grinding machine.

Because of these characteristics, grinding machines can be rather expensive, and they require careful operation and maintenance to keep them accurate. This means that operators should be trained to both use them and care for them.

Figure 1. Grinding machines are built to resist movement and vibration. (Courtesy of Royal Master Grinders, Inc.)
Surface Grinding

Surface grinding is one of the most common types of grinding operations, and it is performed on a surface grinding machine. Although surface grinding is normally used to grind flat surfaces, shapes or grooves may be produced on otherwise flat pieces by using a formed grinding wheel.

Surface grinding machines have two main components: a table that holds the pieces that must be ground and a spindle that holds and rotates the grinding wheel. The table may have a manual workholding device or a magnetic workholding device for metal parts, while the spindle may have a vertical or horizontal orientation. The table may reciprocate, which means to repeatedly move back and forth, or it may rotate, which means to spin. The different combinations of spindle and table result in four types of surface grinding operations, as shown in Figures 1 and 2:

- Horizontal spindle and rotary table.
- Horizontal spindle and reciprocating table.
- Vertical spindle and rotary table.
- Vertical spindle and reciprocating table.

Machines are often designed to perform a particular type of surface grinding. For example, the machine in Figure 3 is a surface grinder with a horizontal spindle and reciprocating table.

---

**Figure 1.** Surface grinding operations with horizontal spindles.

**Figure 2.** Surface grinding operations with vertical spindles.

**Figure 3.** A horizontal spindle surface grinder with a reciprocating table. (Courtesy of United Grinding.)
Lesson: 5/13

Center-Type Cylindrical Grinding
As the name suggests, **cylindrical grinding** is generally used to create **concentricity** on the exterior surface of cylindrical parts. One of the most common types of cylindrical grinding is **center-type cylindrical grinding**, which is illustrated in Figure 1. During center-type grinding, the workpiece is held between **centers**, which are hardened, pointed cylindrical bars. The points of the centers are inserted into matching holes at each end of the workpiece to hold it in place. Figure 2 shows a part mounted on the machine.

To grind the surface, both the grinding wheel and the workpiece rotate in the same direction. This causes motion in opposite directions at the point of contact. The grinding wheel and workpiece are then forced into one another, and the wheel travels along the length of the part. The result is a concentric cylindrical surface.

Center-type grinding may be used to grind the entire length of the part. In some cases, operators will feed the wheel into the part in specific locations to change its shape.

![Figure 1. A center-type cylindrical grinding operation.](image1)

![Figure 2. A center-type cylindrical grinder. (Courtesy of Royal Master Grinders, Inc.)](image2)
Lesson: 6/13

Chucking-Type Cylindrical Grinding
Another common type of cylindrical grinding is **chucking-type cylindrical grinding**. Instead of holding the workpiece at both ends, a chucking-type grinder holds the cylindrical part on one end while a small-diameter grinding wheel grinds its interior surface to make it concentric. Figure 1 illustrates this process.

For chucking-type grinding, the machine typically clamps the workpiece with a **chuck**. As you can see in Figure 2, a chuck has three or four jaws that tighten down on the part’s exterior. Because the part is held on one end, the grinding wheel can enter a hole and grind its interior. In fact, almost all chucking-type grinding operations are used to grind interior surfaces. The grinding wheel must be small enough to fit into the hole.

In some cases, the part may be held with a **collet**. However, collets are most often used to hold smaller parts and are generally not used to grind interior diameters. No matter what type of holder is used, chucking-type grinders are generally used only for high-production grinding of relatively short parts.

![Figure 1. A chucking-type cylindrical grinding operation with the part held in a chuck.](image)

![Figure 2. The moveable jaws of a chuck clamp the workpiece.](image)
Lesson: 7/13

Centerless Grinding

Centerless grinding is another common type of cylindrical grinding. Instead of mounting the cylindrical part between centers or in a chuck, centerless grinding uses two wheels and a work rest blade. These components hold the workpiece horizontal, rotate it, and grind its surface, as shown in Figure 1.

Each component plays a role in the grinding process. The work rest blade supports the part slightly above the center of the wheels during grinding. It is made of wear-resistant materials and is angled at the top. The regulating wheel rotates the cylindrical part and slowly pulls it forward. Regulating wheels are commonly made of plastic or a rubber bond. To provide the part’s through feed, the regulating wheel is slightly angled. The actual grinding is performed by the grinding wheel. Both the regulating wheel and grinding wheel must be periodically dressed to maintain precise concentricity.

Figure 2 shows a typical machine built for centerless grinding. Centerless grinders are not capable of other work, and the parts they grind always must be round. However, setup is fast because the part is not mounted, and the process can be automated. Centerless grinding also generates very tight tolerances with little difficulty.

Copyright © 2015 Tooling U, LLC. All Rights Reserved.
Lesson: 8/13

Internal Centerless Grinding

Internal centerless grinding is used to grind the interior surfaces of tubular parts. Its setup is similar to regular centerless grinding because the workpiece is not held between centers. However, instead of a work rest blade, internal centerless grinding uses two support rolls to hold the piece against a regulating wheel. The grinding wheel pushes against the interior of the piece.

As Figure 1 shows, the support rolls are on the opposite side of the workpiece from the regulating wheel, with one not quite under the workpiece and the other not quite parallel to the regulating wheel. The grinding wheel, attached to a spindle long enough to accommodate the tube, is fed inside.

Because the grinding wheel must be fed in and out of the workpiece, production speeds are not as high as with other processes. However, internal centerless grinding is capable of achieving very close concentricity between the interior and exterior of parts.

Figure 1. An internal centerless grinding operation.
Creep Feed Grinding

Creep feed grinding can be performed either as a surface or cylindrical grinding operation. However, the grinding action is quite different from normal grinding. In creep feed grinding, the depth of cut, which controls how much of the surface is removed, is greatly increased. At the same time, the feed, which controls the lateral direction of the cut, is greatly decreased. This means that the wheel moves forward slowly while cutting deeply. This is the reverse of most typical operations, in which the wheel would move forward quickly while making a shallow cut. Figure 1 compares conventional surface grinding with creep feed grinding.

The purpose of creep feed grinding is to remove a great deal of material while leaving an improved surface finish. It eliminates the need for other, rougher metal removal operations, such as milling, which often would be followed by a grinding step to produce the proper finish. Instead, the whole operation is performed in one step with the creep feed grinder. Creep feed grinding generally takes place on a type of powerful horizontal spindle surface grinder designed to take the extreme forces required by creep feed grinding.
Lesson: 10/13

Snagging and Offhand Grinding

Snagging and offhand grinding are two grinding methods that produce similar results. They are both used to remove excess material without regard to surface finish.

Snagging is normally performed on workpieces that require large amounts of material removal, such as built-up areas on parts that are joined by welding. Because it is not a precise process, snagging may be performed using many different types of grinding machines. The workpiece is simply placed on the worktable and manually fed past the rotating wheel until the desired amount of material is removed. For larger pieces that will not fit on a worktable, an operator might use a hand-held, portable grinder instead.

In offhand grinding, the major difference is that the workpiece is usually held in the operator’s hand and placed against the rotating wheel. Another difference is that sometimes the operator will choose to use a coated abrasive belt, as shown in Figure 1. The belt’s flexibility makes it more forgiving and less likely to gouge the piece. Also, less material is generally removed in offhand grinding.

Figure 1. A coated abrasive belt may be used for offhand grinding.
Lesson: 11/13

Tool Grinding
Most shops rely on numerous cutting tools to make parts. As metal cutting takes place, these tools gradually wear. Tool wear eventually leads to poor finishes on parts and damaged tools. To maintain cutting tools, shops frequently rely on tool grinding to sharpen tools and increase their useful life. Figure 1 shows a sophisticated tool grinder.

Effective tool sharpening must be performed regularly and accurately. Tools may be sharpened by offhand grinding or by using specialized machines called universal tool and cutter grinders. Simple, single-point tools may be sharpened by hand. However, improper grinding may cause tiny cracks or areas of softness that will cause early tool failure. Tool grinding machines generally produce tools with more predictable tolerances.

Tool grinding machines are similar to center-type cylindrical grinders, but their main components can be moved and swiveled into almost any direction and locked into position. This allows the tool grinder to produce and maintain the precise angles and shapes that cutting tools require. Because of the precision involved, many shops use tool grinders with computer numerical controls to achieve the tolerances they need.

Figure 1. This tool grinding machine holds multiple wheels and can grind at various angles. (Courtesy of United Grinding.)
Lesson: 12/13

Cutoff Operations

A cutoff operation is exactly what it sounds like. An abrasive wheel is applied to a metal part to separate one portion from another. Although sawing and other methods are used in cutoff operations, abrasive wheels can sometimes perform the job quicker for less overall cost. Abrasive wheels are definitely preferable for cutting materials of extreme hardness, such as tool steels.

As you can see in Figure 1, cutoff operations use straight wheels, which are thin, flat, bonded abrasive wheels. Cutoff operations may be performed with a hand-held tool fitted with a small wheel. The machines that perform larger cutoff operations often have a manually operated or hydraulic arm that is raised and lowered on the workpiece.

For best results and proper wheel wear, cutting off should be performed quickly and with the hardest grade possible. Cutoff operations might be used to clean up or square off the ends of an irregular part or to make uniform slices of stock.

Figure 1. Cutoff machines use flat, straight wheels.
**Lesson: 13/13**

**Summary**
Almost all grinding operations involve the use of a bonded abrasive wheel to remove material from the workpiece surface. Many grinding operations involve surface grinding, which generally grinds the flat surface of a workpiece. Surface grinding is further divided into categories depending on the orientation of the spindle and movement of the table.

Operators also frequently grind cylindrical parts. Center-type cylindrical grinding holds the workpiece between centers, which are hardened, pointed cylindrical bars. Chucking-type cylindrical grinding holds the part in either a chuck or collet. Centerless grinding supports the part with a work rest blade and positions the part between the grinding wheel and a regulating wheel.

Other grinding operations include creep feed grinding, snagging and offhand grinding, and tool grinding. Creep feed grinding removes a great deal of material while leaving an improved surface finish and requires very powerful, rigid machines. On the other hand, snagging and offhand grinding rapidly remove material without regard to surface finish. Tool grinding involves any precise grinding used to sharpen tools within the shop. Operators also can use thin wheels to perform cutoff operations. All of these various grinding operations play a key role in manufacturing.

---

**Figure 1.** Surface grinding operations with horizontal spindles.

**Figure 2.** A center-type cylindrical grinding operation.

**Figure 3.** A centerless grinding operation.
Class Vocabulary

**Center**
A hardened, pointed, cylindrical component used to hold the end of a workpiece by inserting its tip into a matching hole in the part. Centers are generally used in pairs.

**Centerless Grinding**
A type of grinding in which cylindrical parts are not held between centers but are supported on a work rest blade and rotated.

**Center-Type Cylindrical Grinding**
A type of cylindrical grinding in which each end of the workpiece is mounted on a pointed bar, or center. It is similar to a lathe.

**Chuck**
A device that holds a workpiece in place as it rotates. The chuck commonly has three or four jaws that can be adjusted to fit various sizes.

**Chucking-Type Cylindrical Grinding**
A form of cylindrical grinding that uses a workholding device to hold and steady the work at one end.

**Coated Abrasive Belt**
A grinding tool in the form of a loop of fabric or other material that has been layered with adhesives and abrasive grains.

**Collet**
A slitted device that holds a workpiece in place as it rotates. A collet has a hole through which the workpiece passes, and it is designed to hold specific dimensions.

**Computer Numerical Control**
A type of programmable automation, directed by mathematical data, which uses microcomputers to carry out various machining operations. Usually referred to as CNC, the computer controls the steps in an operation.

**Concentricity**
The degree to which a given dimension resembles a perfectly round circle or cylinder.

**Creep Feed Grinding**
A grinding method in which the depth of cut is increased while the feed rate is decreased compared with normal grinding practices. It is used for large amounts of material removal.

**Cutoff**
To separate a workpiece into two or more parts.

**Cutting Tool**
A device with one or more edges used to create chips and remove metal. Cutting tools are either single point or multi-point tools.

**Cylindrical Grinding**
A grinding process used to make cylindrical parts concentric. It is generally used on long, cylindrical bars and is similar to a lathe.

**Depth Of Cut**
In grinding, it is how far into the workpiece a grinding wheel plunges.

**Feed**
The rate at which the grinding wheel and the workpiece move in relation to one another.

**Formed Grinding Wheel**
An abrasive wheel with a distinct profile that is used to grind shapes or contours into a workpiece.

**Grade**
In grinding, it is the way in which the hardness of the bond in an abrasive wheel is classified.

**Grinding**
The use of an abrasive to wear away at the surface of a workpiece and change its shape.

**Grinding Machine**
A mechanical device that rotates an abrasive wheel. Grinding machines are available in a variety of arrangements.

**Internal Centerless Grinding**
A form of centerless grinding in which the grinding wheel contacts and grinds the internal surface of the work. It uses two support rolls and a drive wheel.

**Milling**
A machining operation that uses a multi-point horizontal or vertical cutter to remove metal from the surface of a workpiece.

**Offhand Grinding**
A form of rough grinding used to remove excess material without regard to surface finish. The
Today's businesses face the challenge of maintaining a trained workforce. Companies must locate apprenticeship programs, cover travel and lodging.