

Training Objectives

After watching the video and reviewing this printed material, the viewer will gain knowledge and understanding of lathe principles and be able to identify the basic tools and techniques used in turning.

- "turning" is defined and explained
- critical lathe dimensions are detailed
- stock holding methods are demonstrated
- both external and internal turning processes are explained
- numerically controlled lathes are examined
- toolholding methods and turning parameters are detailed

The Lathe

Turning is one of the most common of metal cutting operations. In turning, a workpiece is rotated about its axis as single-point cutting tools are fed into it, shearing away unwanted material and creating the desired part. Turning can occur on both external and internal surfaces to produce an axially-symmetrical contoured part.

Parts ranging from pocket watch components to large diameter marine propeller shafts can be turned on a lathe. The capacity of a lathe is expressed in two dimensions. The maximum part diameter, or "swing," and the maximum part length, or "distance between centers."

The general-purpose engine lathe is the most basic turning machine tool. As with all lathes, the two basic requirements for turning are a means of holding the work while it rotates and a means of holding cutting tools and moving them to the work.

The work may be held on one or by both its ends. Holding the work by one end involves gripping the work in one of several types of chucks or collets. Chucks are mounted on the spindle nose of the lathe, while collets usually seat in the spindle. The spindle is mounted in the lathe's "headstock," which contains the motor and gear train that makes rotation possible. Directly across from the headstock on the lathe is the "tailstock." The tailstock can hold the work by either a live or dead center. Work that is held at both ends is said to be "between centers." Additionally, longer workpieces may have a "steady rest" mounted between the headstock and tailstock to support the work. Typically workpieces are cylindrical, but square and odd shaped stock can also be turned using special chucks or fixtures.

Lathe cutting tools brought to the work may move in one or more directions. Tool movement on the engine lathe is accomplished using a combination of the lathe's "carriage", "cross slide", and "compound rest".

The carriage travels along the machine's bedways, parallel to the workpiece axis. This axis is known as the "Z" axis.

Motion perpendicular to the work is called the "X" axis. On an engine lathe this motion is provided by the cross slide mounted on the carriage.

Atop the cross slide is the "compound rest," which can be rotated to any angle and secured. The compound rest also holds the "tool post," where tools are mounted. Tools may also be mounted in the tailstock for end-working operations.

External turning can be broken down into a number of basic operations. "Straight turning" reduces the work to a specified diameter equally along the work's axis. "Taper turning" produces a taper along the axis of the workpiece. Tapers are produced by either offsetting the tailstock from centerline or by using a "taper attachment." Some short, steep tapers can be obtained by using the compound rest alone. "Contour turning" or "profilng" uses a single-point cutting tool to reproduce a surface contour from a template. This operation has been almost entirely replaced by numerically controlled or "NC" programming. "Forming" uses a cutting tool ground with the form or geometry of the desired shape. This forming tool is advanced perpendicular to the axis of the work to reproduce its shape on the workpiece.

Other external lathe operations include "chamfering" to remove sharp edges, "grooving" to produce recesses and shoulders, "facing" to finish the ends of a workpiece, "parting" to cut off finished pieces from the stock, and "thread chasing" with tools to produce the desired thread form.

The most common method of internal turning on the lathe is to present the rotating end of a workpiece to the point of a non-rotating drill bit mounted in the tailstock. Roughly drilled holes are finished to exact size by using a reamer which also mounts in the tailstock. Large diameter holes are made by boring. A boring bar with a cutting tool attached is moved along the work's axis as in surface cutting, but inside a previously drilled hole. Internal threads are obtained by using tapping tools mounted in the tailstock.

Turning can produce long chips that may interfere with the work in progress. The right cutting tools and proper lubrication are used to control chip formation.

Many types of lathes are used for production turning. A cousin of the low volume engine lathe is the electronic engine lathe. This lathe is able to operate semi-automatically and fully automatically through electronic controls. The major production lathe today is the numerically controlled or "NC" lathe. These lathes can perform both linear and rotary cuts simultaneously with great precision to produce large numbers of identical parts. Any motion which can be expressed mathematically can be programmed into the lathe's computer control.

Basic NC lathes include the two axis, single turret models and two turret, four axis models. Milling operations can also be added to a lathe's capabilities by using rotating tools or "live tools" on workpieces. Additionally, some NC lathes incorporate a secondary or sub-spindle to expand the lathe's production capacity.

Other lathe types include the automatic screw machine for high production and unattended operation. They can have either single or multiple spindles for holding one or more workpieces.

The swiss-type automatic is used on long, thin parts. The stock is fed longitudinally through the head stock and turned immediately by using radially mounted tools next to the head stock bushing.

Very large work with swing dimensions beyond the capacity of a horizontal machine are turned on vertical lathes that can accept work two to six feet in diameter.

Raw stock is brought to the lathe in several ways. Long lengths can be fed through the head stock, short lengths or "slugs" can be manually or automatically chucked. Gantry systems are used to handle large, heavy pieces of stock.

Production lathes bring tools and arrangements of tools to the work by the use of turrets on larger machines and slide mounted "gang tooling" on smaller, more compact lathes.

Regardless of the type of lathe, three key parameters determine productivity and part quality. These parameters are:

- the cutting speed
- the feed rate
- the depth of cut

The cutting speed is the speed of the work as it rotates past the cutting tool. The feed rate is the rate at which the tool advances into the work. The depth of cut is the amount of material removed as the work revolves on its axis. Other factors include the machinability of the stock, the type and the geometry of the cutting tool, the angle of the tool to the work, and the overall condition and power of the lathe itself.

Review Questions

1. The capacity of a lathe is expressed as:
 - a. horsepower and chuck diameter
 - b. swing and distance between centers
 - c. bed length and spindle speed
 - d. tool post size and travel
2. The carriage of the lathe travels along which axis:
 - a. the "B" axis
 - b. the "Z" axis
 - c. the "Y" axis
 - d. the "X" axis
3. The basic turning lathe is:
 - a. the turret lathe
 - b. the automatic lathe
 - c. the engine lathe
 - d. the swiss type lathe
4. "Forming" on a lathe is accomplished by:
 - a. specially shaped cutting tools
 - b. compound rest travel
 - c. rotating fixtures
 - d. by cutting grooves and chamfers
5. Large diameter holes are produced on a lathe by:
 - a. step drilling
 - b. facing
 - c. reaming
 - d. boring
6. Vertical lathes are used for work requiring a:
 - a. larger swing
 - b. more powerful engine
 - c. greater distance between centers
 - d. multiple jaw chuck
7. The swiss-type automatic lathe is used primarily for:
 - a. heavy turnings
 - b. slug turnings
 - c. long thin turnings
 - d. threading
8. Feed rate refers to:
 - a. spindle speed
 - b. chuck rotation
 - c. tool advancement into the work
 - d. depth of cut

Turning and Lathe Basics

Answer Key

1. b
2. b
3. c
4. a
5. d
6. a
7. c
8. c

Turning Glossary

apron	That portion of a lathe carriage that contains the clutches, gears, and levers for moving the carriage. It also protects the mechanism.
bed	One of the principal parts of a machine tool, having accurately machined ways or bearing surfaces for supporting and aligning other parts of the machine.
bench lathe	A small lathe mounted on a bench or table.
bore	To enlarge and finish the surface of a cylindrical hole by the action of a rotating boring bar (cutting tool) or by the action of a stationary tool pressed (fed) against the surface as the part is rotated.
boring	A precision machining process for generating internal cylindrical forms by removing metal with single-point or multiple-edge tools.
boring bar	A combination tool holder and shank. Also known as a cutter bar.
boring tool	A cutting tool in which the tool bit, the boring bar and, in some cases, the tool holder are incorporated in one solid piece.
carriage	A principal part of a lathe that carries the cutting tool and consists of the saddle, compound rest, and apron.
center	A point or axis around which anything revolves or rotates. In the lathe, one of the parts upon which the work to be turned is placed. The center in the headstock is referred to as the "live" center and the one mounted in the tailstock as the "dead" center.
center, dead	A center that does not rotate; commonly found on the tailstock of a lathe. Also, an expression for the exact center of an object.
center, half male	A dead center that has a portion of the 60 degree cone cut away.
center, live	A center that revolves with the work. Generally, this is the headstock center; however, the ball bearing type tailstock center is also called a live center.
centers	Conical pins of a machine upon which the work is centered, supported, and rotated during cutting or grinding.

chuck	A device attached to the work spindle that holds the workpiece, usually gripping it with jaws or fingers.
chuck jaws	The actual gripping members in a chuck. Also referred to as fingers.
chuck, independent jaw	A chuck, each of whose jaws (usually four) is adjusted with a screw action independently of the other jaws.
chuck, universal	A chuck whose jaws are so arranged that they are all moved together at the same rate by a special wrench. Also known as a self-centering chuck or concentric chuck.
collet	A precision work holding chuck which centers finished round stock automatically when tightened. Specialized collets are also available in shapes for other than round stock.
compound rest	The part of a lathe set on the carriage that carries the tool post and holder. It is designed to swing in any direction and to provide feed for turning short angles or tapers.
contouring control system	An NC system that generates a contour by controlling a machine or cutting tool in a path resulting from the coordinated, simultaneous motion of two or more axes.
counterboring	A machining process related to drilling that uses an end-cutting tool to concentrically enlarge a hole to a limited depth.
cross slide	The slide that gives the wheelslide its cross-axis or crossfeed motion.
cutoff	In machining, the separation of a part from a larger piece of stock by means of a parting tool (lathe turning) or a thin abrasive cutoff wheel. Also known as in machining.
cutoff burr	A projection of material left when the workpiece falls from the stock before the separating cut has been completed.
cutting speed	The tangential velocity on the surface of the workpiece in a lathe or a rotating cutter, commonly expressed in feet per minute (FPM) and converted to revolutions per minute (RPM) for proper setting on the machine.
dead center	A center that does not rotate; commonly found on the tailstock of a lathe. Also, an expression for the exact center of an object.

face	To machine a flat surface, as in the end of a shaft in the lathe. The operation is known as facing.
faceplate	A large circular plate with slots and holes for mounting the workpiece to be machined. It is attached to the headstock of a lathe.
facing	The process of making a flat or smooth surface (usually the end) on a piece of stock or material.
feed rate	The rate of movement between a machine element and a workpiece in the direction of cutting. Expressed as a unit of distance relative to time or a machine function such as spindle rotation or table stroke.
follower rest	A support for long, slender work turned in the lathe. It is mounted on the carriage, travels close to and with the cutting tool, and keeps the work from springing away.
following error	The distance lag at any specific time between the actual position and the command position in a closed-loop servo system for NC contouring machines.
footstock	Part of an indexing attachment which has a center and serves the same purpose as the tail stock of a lathe.
gantry	An adjustable hoisting machine that slides along a fixed platform or track, either raised or at ground level, along the x, y, z axes.
headstock	The fixed or stationary end of a lathe or similar machine tool.
lead screw	The long, precision screw located in front of the lathe bed geared to the spindle, and used for cutting threads; also, the table screw on the universal milling machine when geared to the indexing head for helical milling.
machinability	The degree of difficulty with which a metal may be machined; may be found in appropriate handbooks.
parting	The operation of cutting off a piece from a part held in the chuck of a lathe.
setup	The preparation of a machine tool to complete a specific operation. It includes mounting the workpiece and necessary tools and fixtures, and selecting the proper speeds, feeds, depth of cut and coolants.

spindle	A rotating device widely used in machine tools, such as lathes, milling machines, drill presses, and so forth, to hold the cutting tools or the work, and to give them their rotation.
spindle speed	The RPM at which a machine is set. See cutting speed.
steady rest	A support that is clamped to the bed of a lathe, used when machining a long workpiece. Sometimes called a center rest.
swing	The dimension of a lathe determined by the maximum diameter of the work that can be rotated over the ways of the bed.
tailstock	That part of a machine tool, such as a lathe or cylindrical grinder, which supports the end of a workpiece with a center. It may be positioned at any point along the way of the bed, and may be offset from center to machine tapers.
taper	A uniform increase or decrease in the size or diameter of a workpiece.
tumbler gears	A pair of small lever-mounted gears on a lathe used to engage or to change the direction of the lead screw.
ways	The flat or V-shaped bearing surfaces on a machining tool that guide and align the parts which they support.