Lathes

One of the most important machine tools in the metalworking industry is the lathe. A lathe operates on the principle of a rotating workpiece and a fixed cutting tool. The cutting tool is feed into the workpiece, which rotates about its own Z-axis, causing the workpiece to be formed to the desired shape.

The lathes in the Student Shop are commonly referred to as “engine lathes”. This is the most popular type of lathe in industry because of its versatility and ease of operation. Some of the more frequently performed operations on the engine lathe are: turning cylindrical surfaces, facing flat surfaces, drilling and boring holes, and cutting internal or external threads. Although relatively simple, these few operations provide a wide range of manufacturing ability.

Lathes are classified according to the maximum diameter, (know as the “swing”), and the maximum length of the workpiece that can be handled by the lathe. Another important characteristic of any lathe is the maximum horsepower that can be supplied to rotate the workpiece. A new way lathes are being classified today is by their controls, manual, computer-numerically-controlled, (commonly called CNC), and the latest referred to as hybrid lathes. Hybrid lathes are a cross between the standard manually operated lathe and the computer operated lathe, CNC.

Lathe Construction;

There are four main groups of components that comprise the basis for all engine lathes. These consist of the: bed, headstock, tailstock, and the carriage. Please refer to figure for clarity.

The bed is the foundation of the engine lathe. The bed is a heavy, rugged casting made to support the working parts of the lathe. The size and mass of the bed gives the rigidity necessary for accurate engineering tolerances required in manufacturing today. On top of the bed are machined ways that guide and align the carriage and tailstock, as they are move from one end of the lathe to the other. The headstock is clamped atop the bed at the left-hand end of the lathe. The headstock contains the motor that drives the spindle through a series of gears. The workpiece is mounted to the spindle through means of a chuck, faceplate, or collet. Since the headstock contains the motor and drive gears, the speed or RPM at which the spindle rotates is also controlled here. The headstock also contains the power feed adjustments, which are the controls for the rate at which the carriage moves when the power feed lever in engaged.

The carriage assembly moves lengthwise, (longitudinally), along the ways between the headstock and the tailstock. The carriage is composed of the cross slide, compound rest, saddle, and apron. The saddle is an H shaped casting mounted on top of the ways, and supports the cross slide and compound rest. The apron is fastened to the saddle, and houses the automatic feed mechanisms. The cross slide is mounted on top of the saddle, and can be moved either manually or automatically across the longitudinal axis (Z-axis) of the spindle. This provides the lathe’s X-axis, which is the diameter the workpiece is machined to. The compound rest holds the tool post, which supports the cutting tool. Mounted on top of the cross slide, the compound rest can be swiveled to any angle in the horizontal plane. This is useful when cutting angles and short tapers on the workpiece.
Proficiency in lathe operations involves more than simply “turning” metal. Quality work can be produced on the lathe if the job is planned in advance. There are two main categories of procedures to be followed when machining parts on a lathe: the preliminary operations, and the machining operations.

**Preliminary Operations**

*Cleaning* - The first, (and last), procedure in any machining operation. Without clean equipment and tools, the accuracy of the finished product diminishes quickly. The accuracy, durability, and longevity of the equipment and tools depend on being kept clean. In today’s high tolerances in engineering, cleanliness is critical.

*Holding the workpiece* - There are several types of holding devices used on the engine lathe. The most common is the three-jaw chuck (see figure). This chuck permits all three jaws to work simultaneously, automatically centering round or hexagonal shaped pieces. Each jaw only fits with the particular groove in the exact chuck it was made for, so the jaws are not interchangeable between chucks. The advantages of this type of chuck are that it is very versatile, quick set-up, large range of sizes, and uniform holding pressure on the workpiece. The disadvantage is that is the least accurate of the holding devices in the Student Shop. The three-jaw chuck only has an accuracy of between $\pm 0.005''$ to $\pm 0.010''$, depending upon its condition.

The second type of chuck is the four-jaw chuck, (see figure). This is also called the independent chuck because each of its jaws operates independent of the other three. This permits odd shaped work to be held and centered about a feature. The advantages are that it is versatile, provides a secure hold o the workpiece, large range of sizes, and has extremely accurate centering method. The four-jaw chuck is accurate to $\pm 0.0005''$. The main disadvantage is the long process necessary to center the workpiece, requiring a high level of in the use of a dial indicator.

A third important holding device is the spring collet. This is a popular style due to its ease of use and good accuracy. The spring collet will usually repeat within $\pm 0.001''$. Disadvantages to the spring collet are limitations to the size of each collet, ($\pm 0.005''$), restrictive to only round workpieces, and a maximum diameter of 1-1/16''.

![3-Jaw Chuck](image1.png)  ![4-Jaw Chuck](image2.png)  ![Spring Collet](image3.png)
**Tooling**- Tools must be clamped securely to the tool post regardless of what type of tool is being used. It is also recommended to have the cutting tool extended the least amount possible to reduce torque and vibrations induced in the tool when cutting. The tools must be adjusted so that their cutting edge is at the height of the exact center of the workpiece. This Defined as a line running between the center of the headstock and tailstock spindles. Each lathe has a turning, facing and parting tool as part of its tooling accessories.

**Machine Controls**- Many factors must be considered when determining the correct speed, (RPM), and feed rates. Some of these are:
1. Type of material being machined.
2. Desired finish to the workpiece.
3. Condition of the lathe.
4. Rigidity of the workpiece. Smaller diameters are less rigid.
5. Shape and size of the workpiece.
6. Size and type of tooling being used.

**Machining Operations;**

Once the set-up is complete, a quick check should be made of the machine settings. Next, the work should be checked that it is in the holding device correctly. This is done with the machine OFF, manually rotate the chuck, seeing if there are any interference points or possible inference points. Once this is complete, the machining operations can being. There are usually two phase to machining, roughing and finishing.

The roughing operation is the process of removing the unwanted material to within about 1/32”, (about 0.030”), of the finished dimension. Roughing speeds are approximately 80% of the finishing speeds. Roughing feed rates are from 0.005” to 0.010”/revolution. Sizes and lengths should be check after the roughing operation before going on to the finish operation.

Finish operations are used to bring the workpiece to the required size, length, shape, and surface finish. Depending upon the surface finish desired, feed rates are generally between 0.001” to 0.005”/revolution.

The main difference between roughing and finishing cuts is the depth of cut. Depth of cut refers to the distance the cutter has been fed, or advanced, into the workpiece surface. The depth of cut, like feed rates, varies greatly with the machining conditions. Material, hardness, speed, and total material needed to be removed all play a part in figuring the depth of cut amount. Roughing depth of cuts are greater, or deeper than finishing depth of cuts, which are finer or shallower.

All cuts, whether roughing or finishing, should be made from right to left. Traveling towards the chuck as oppose to away from it offers the greatest rigidity and therefore the greatest safety.
Safety:

The lathe can be a safe machine, but only if the student is aware of the hazards involved. In the machine shop you must always keep your mind on your work in order to avoid accidents. Distractions should be taken care of before machining is begun. Develop safe working habits in the use of safety glasses, set-ups, and tools. The following rules must be observed when working on the lathes in the Student Shop:

1. No attempt should be made to operate the lathe until you understand the proper procedures for its use and have been checked out on it.
2. Dress appropriately. Remove all watches and jewelry. Safety glasses or goggles are a must.
3. Plan out your work thoroughly before starting.
4. Know were the location of the OFF switch is.
5. Be sure the work and holding device are firmly attached.
6. Turn the chuck by hand, with the lathe turned OFF, to be sure there is no danger of striking any part of the lathe.
7. Always remove the chuck key from the chuck immediately after use, and before operating the lathe. Make it a habit to never let go of the chuck key until it is out of the chuck and back in its holder.
8. Keep the machine clear of tools. Tools must not be placed on the ways of the lathe.
9. Stop the lathe before making any measurements, adjustments, or cleaning.
10. Support all work solidly. Do not permit small diameter work to project too far from the chuck, (over 3X’s the work’s diameter), without support.
11. If the work must be repositioned or removed from the lathe. Move the cutting tool clear of the work to prevent any accidental injuries.
12. You should always be aware of the direction of travel and speed of the carriage before you engage the automatic feed.
13. Chips are sharp. Do not attempt to remove them with your hand when they become “stringy” and build up on the tool post or workpiece. Stop the machine and remove them with plies.
14. Stop the lathe immediately if any odd noise or vibration develops while you are operating it. If you can not locate the source of the trouble, get help from the instructor. Under no circumstance should the lathe be operated until the problem has been corrected.
15. Remove sharp edges and burrs from the work before removing it from the lathe.
16. Use care when cleaning the lathe. Chips sometimes get caught in recesses. Remove them with a brush or short stick. Never use a floor brush to clean the machine. Use only a brush, compressed air, or a rag.