Lesson 1: Working With Cold Metal

Working with cold metal in agricultural mechanics has many applications, including fabrication, repair, and assembly of machines, equipment, tractors, tools, and buildings. This lesson covers some of the common tools and processes.

Common Layout and Marking Tools

The marking tools for cold metal either mark or scratch the surface of the metal. Using these tools to make an accurate layout is essential to a successful project. Some common tools for marking cold metal are as follows.

A scratch awl is used with a straight edge to scratch straight lines in metal. It consists of a pointed metal shaft attached to a wood or plastic handle. An awl must be kept sharp to ensure fine, accurate markings.

Dividers are used for scribing arcs and circles on metal. They also are used to transfer dimensions from one scale or object to another item. They consist of two steel legs with sharp points to mark on dark metal.

Soapstone, a soft, gray rock, is cut into thin pieces and used like a pencil to mark metal. The stone marks the surface of metal rather than scratches it. Soapstone marks are harder to rub off than chalk or pencil marks.

A permanent marker that has a hard tip and fine point can also be used to mark an accurate line on metal. A marker is safer to use than an awl and its mark is harder to rub off than a pencil or chalk mark.

A layout dye is commonly applied to metal before marking to make the layout lines sharper and more visible. Before applying the dye, grease and oil should be removed from the surface of the metal to make sure the dye adheres properly to the surface.

A center punch is a pencil-shaped tool that is used to make a small dent in metal for marking the center of a hole and starting a twist drill bit. It is made out of steel with the end ground to a 90-degree angle. To mark a hole, the point of the punch is positioned on the metal and the other end is tapped lightly with a hammer.

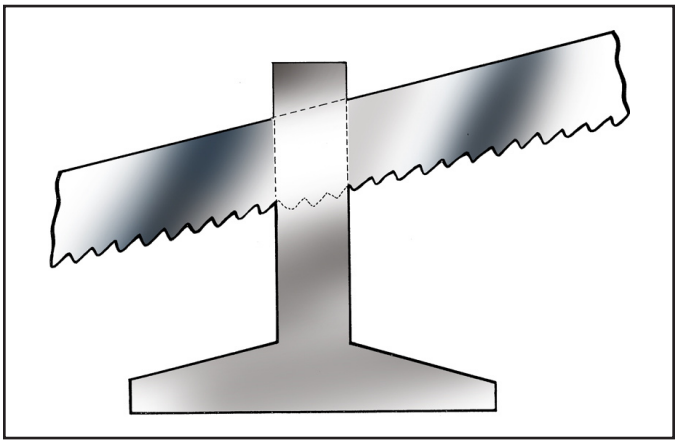
Common Cutting Tools

The following common metalworking tools cut cold metal and remove unwanted material in different ways.

Hacksaw

A hacksaw is one of the most useful cutting tools for metal. Main parts include a handle, frame, and blade. An important factor for selecting the correct blade for the material is the blade's pitch (the number of teeth per inch). Blades are available with 14, 18, 24, and 32 teeth per inch. For example, a blade with 18 teeth per inch is an 18-pitch blade. The correct pitch depends on the shape, hardness, and thickness of the metal. One rule of thumb is the thicker the metal, the lower the pitch should be. The size of the metal to be cut should be compared with the pitch to ensure that three teeth are on the metal at all times. See Figure 1.1. This helps eliminate clogging the teeth, which can happen if too many teeth are on the metal. It also prevents breaking the teeth, which can happen when fewer than three teeth are on the metal. Hacksaw blades are also available in different sets (positioning of teeth). The set of the blade allows the teeth to make a slightly wider cut or kerf than the blade so that the blade will not bind.

Figure 1.1 – Three Teeth on the Metal When Cutting With a Hacksaw Blade



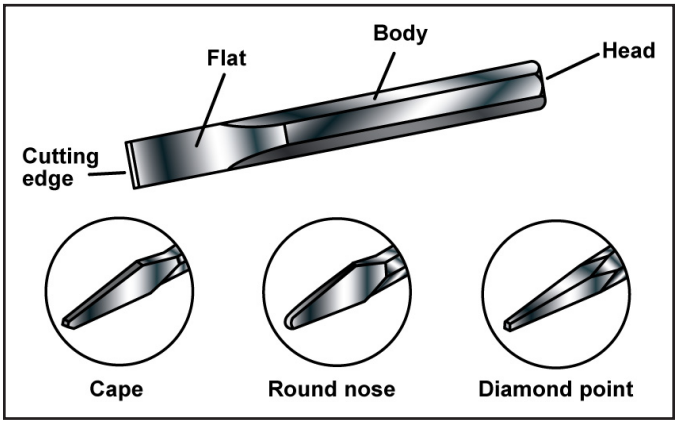
The blade of a hacksaw is designed to cut on the forward stroke and must be installed so that the teeth face the front of the saw, away from the handle. When cutting with a hacksaw, strokes should be long and even, exerting light

pressure on the forward stroke and no pressure on the backward stroke. A new blade will have a wider set than a used one, even if both blades are the same type and pitch. Consequently, if a blade breaks while a cut is being made, a new blade should not be used to complete the cut. The cut should be started in a different place because a new blade will be damaged when forced into the kerf made by a used blade.

Cold Chisel

A cold chisel is used for chipping (removing or cutting pieces of metal) and shearing (cutting metal apart). Parts of a chisel include a cutting edge, body, and head. Common types of chisels, named according to their cutting edge, include flat, cape, round nose, and diamond. See Figure 1.2.

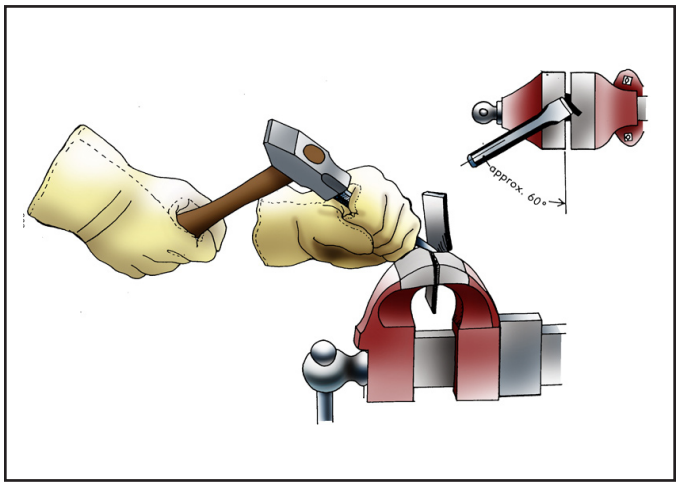
Figure 1.2 – Common Types of Chisels



The flat chisel is the most common and is used for cutting and shearing. Cape, round-nose, and diamond chisels are used for cutting grooves of different shapes.

To cut metal with a chisel, the cutting edge is positioned on the work and the head is hit firmly with a hammer. When shearing metal that is held in a vise, the chisel should be held at a 60-degree angle to the work. See Figure 1.3. The chisel should be positioned after each blow so that the center of the blade makes the cut. A method for cutting thick or round metal is to make a groove with a chisel along the line that is to be cut. The piece is then bent back and forth until it breaks.

Figure 1.3 – Position of the Chisel When Cutting Metal



A chisel's cutting edge and head must be kept ground to the proper angle and shape for safe use. For example, a mushroomed head should be reconditioned because when the head is struck, metal chips can break off and cause injury.

Snips and Shears

Snips and shears are scissorlike tools for cutting metal, such as wire and sheet metal. Regular snips have handles like scissors, which require all the force to be provided by the operator. They are designed for various purposes, such as cutting straight or curved lines or making left-hand or right-hand cuts. Combination snips cut both straight and curved lines. Compound or aviation snips have heavier handles, which increase the leverage and allow cutting of heavier metal.

For best results when cutting with snips, the metal must be lifted up and out of the way as the cut is being made. See Figure 1.4. It also helps to open the blades wide to improve leverage. The metal should be inserted as far back as possible in the blades and the blades should not be closed completely on a cut. Closing them completely can cause a ragged edge on the cut.

Figure 1.4 – Lifting Metal Out of the Way When Using Snips to Cut Metal

Power Shears

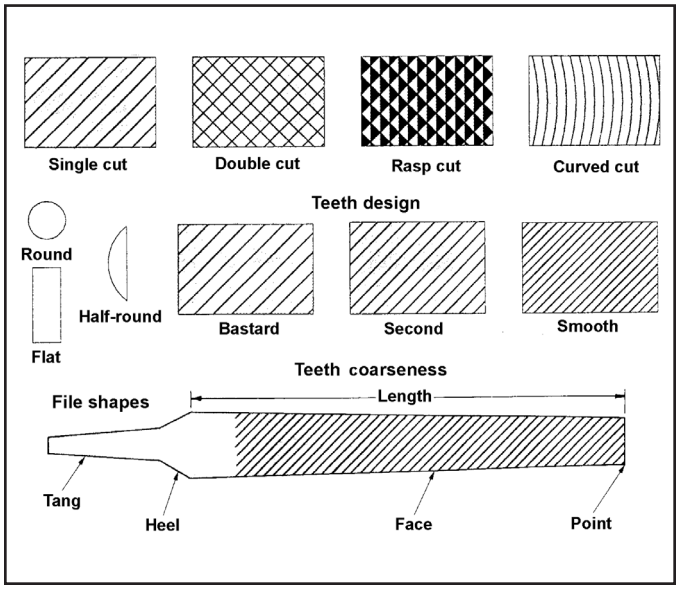
Power shears do the same job as snips and shears but make cuts faster and cleaner. They are especially useful for cutting metal such as structural steel, which would be difficult or slow to cut by hand or with a power saw. Power shears can be operated by hand, treadle, or hydraulics.

To cut with power shears, the handle of the shears is raised and the cut mark on the metal is lined up with the stationary blade. The metal is held level and the handle is lowered to make the cut. It is important to properly shut down the power shears and follow all other safety and use procedures recommended by the manufacturer and instructor. Power shears can cause injury if the handle is operated accidentally.

Files

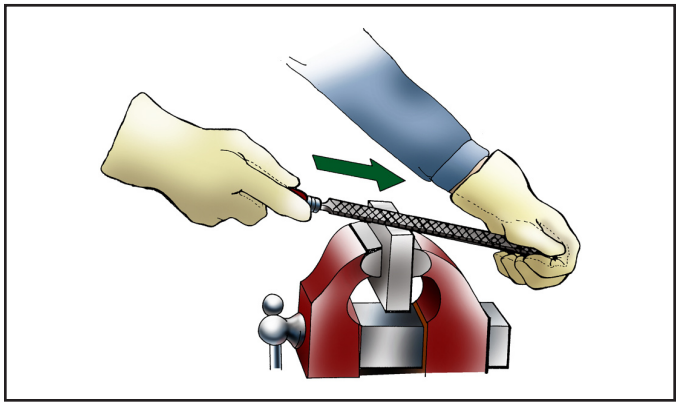
Files are used to change the shape of the work, remove material, and finish the surface. They are available in different cuts, shapes, and coarseness. The cuts of metalworking files include single (parallel rows of teeth all going the same direction), double (teeth that cross one another), rasp (individual teeth that are raised and sharp), and curve (teeth in a curved pattern). The shapes of the file itself are flat, round, half-round, and three cornered. Different coarseness of cuts are bastard, second, and smooth. See Figure 1.5.

Figure 1.5 – Types of Files



Metal should be put in a vise with the area to be filed just above the jaws of the vise. This will hold the metal firmly and reduce vibrations during filing. A file should always be used with a handle on the tang (smooth, pointed end) to prevent serious injury. The correct way to hold a file is to grasp the point with the thumb and index finger and hold the handle in the other hand. See Figure 1.6. Files are designed to cut only on the forward stroke. Filing strokes should be long and even, with light pressure on the forward stroke and no pressure on the backward stroke.

Figure 1.6 – Correct Way to Hold a File When Filing Metal



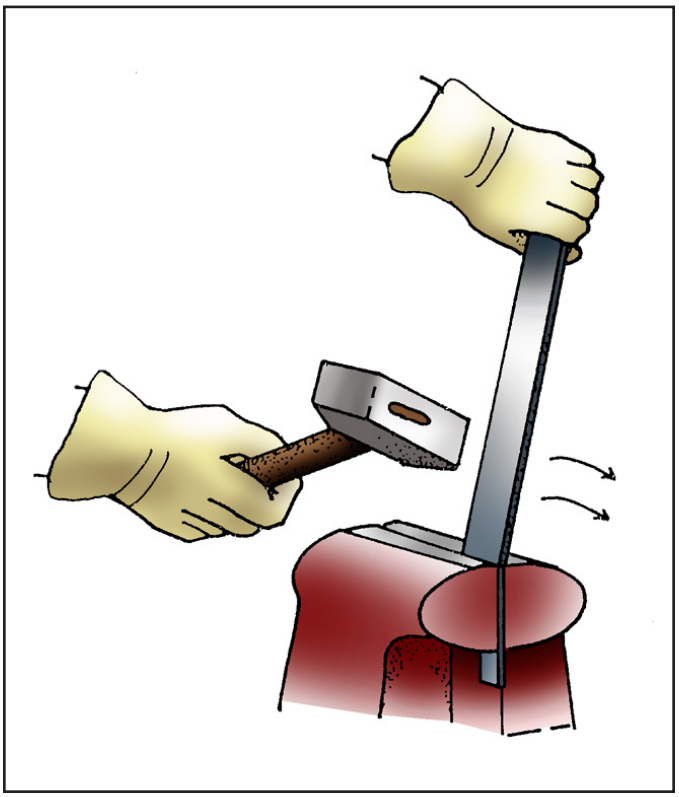
To maintain files, they should be kept dry to prevent rust. A file card or brush is used to clean the teeth to keep them free of material. In addition, to prevent dulling their teeth, they should not be dropped or stored with other files or hardened steel tools.

Techniques for Bending Cold Metal

Some metals can be bent cold if they are not too thick. For example, mild steel can be bent cold in sizes up to the following dimensions: 1/2 in. square, 1/2 in. round, and 3/16 in. x 1 in. flat. Common techniques for bending cold metal are described below.

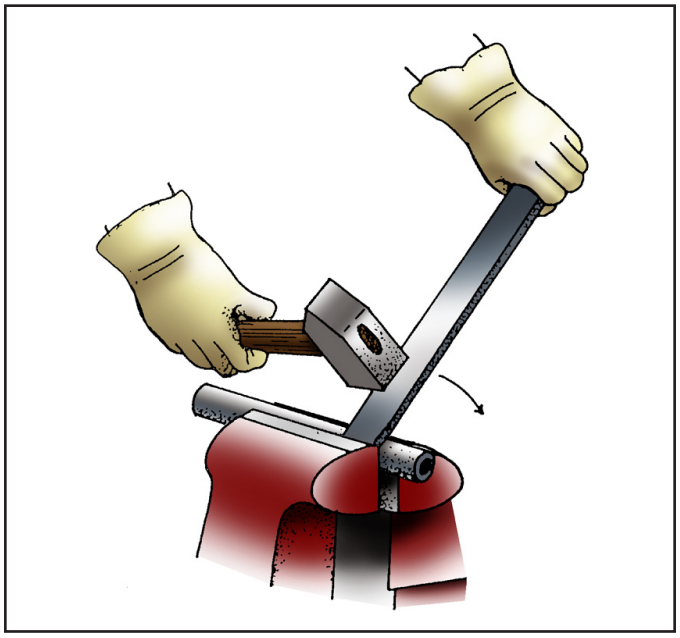
- Cold metal can be bent at an angle with the use of a vise and ball-peen or blacksmith's hammer. The metal should be secured in the vise with the mark for the bend at the top of the jaws and the longest part of the metal extending above the vise. The metal is pushed with one hand while hammering the metal just above the vise with the other hand. It is important to bend the metal sharply at the jaws of the vise and not above them. See Figure 1.7.

Figure 1.7 – Making a Right-Angle Bend



- Metal can be rounded using a piece of pipe or round stock that is the correct diameter for the desired bend. The metal is positioned tightly between the jaw of a vise and the pipe. Like the above method for angling, the metal is pushed with one hand and hammered with the other. After rounding one part of the metal, the jaws of the vise are opened and the metal is adjusted around the pipe. The jaws are tightened and the metal is hammered. These steps are repeated until the desired rounding is obtained. See Figure 1.8.

Figure 1.8 – Using a Pipe to Round Metal



- To increase leverage, the above techniques can be done with a pipe slipped over the metal. The pipe is hammered with the metal inside of it.
- Cold metal can be twisted using a vise and an adjustable wrench. The metal is marked in two places: 1) where the twist is to begin and 2) above the first mark, a distance of one and a half times the width of the metal. The metal is then positioned and tightened in the vise, with the twist mark just above the jaws. The adjustable wrench is positioned so that the bottom of the wrench is even with the second mark and its jaws extend the width of the metal. The metal is held with one hand while the wrench is turned with the other hand until the desired amount of twist is obtained.

- Sheet metal is another metal that can be bent using hand tools. The position for the bend is marked on the metal and the mark is positioned flat on the edge of a bench top. If the edge of the bench is not sharp enough, an angle iron can be clamped to the edge. The metal is hammered over the edge of the bench until the angle is obtained.
- For bending small pieces of sheet metal, pieces of angle iron can be used in a vise to extend the work surface. With this method, two pieces of angle iron are placed in the jaws of a vise. The metal is positioned between the two irons, the vise is tightened, and the metal is bent over the angle iron using a hammer.
- Machines, such as the cornice brake and the box and pan brake, are also used to bend cold metal. They can be used on different types and shapes of metal and can make various types of bends, depending on the design of the machine. These machines exert a great amount of force and it is important to follow all guidelines from the manufacturer and instructor for safe and correct use.

Methods for Fastening Cold Metal

Metalworking projects can be fastened by various means. Some projects may require a combination of several methods. Choosing the right method for the job is important. Common types of fasteners for cold metal are discussed below.

Screws and Bolts

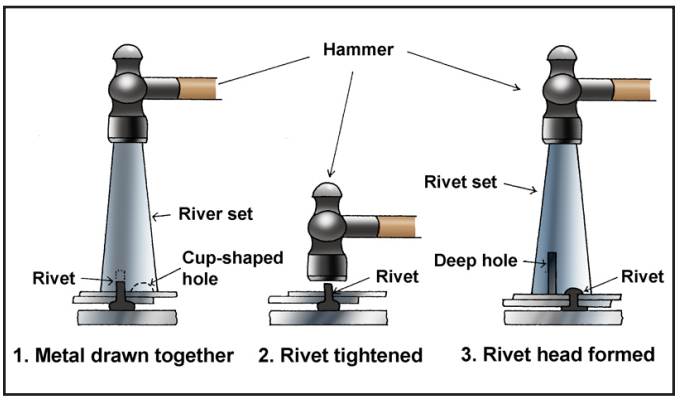
Screws and bolts have the advantage of allowing easy assembly and disassembly of parts. Many types of screws and bolts are available. Two of the most commonly used screws for fastening metal are sheet metal screws and cap screws. As its name indicates, a sheet metal screw is designed for fastening thin stock, such as sheet metal. Sheet metal screws have wide threads that run the length of the shank and allow the metal to sit between the threads. A cap screw is designed for fastening thick metal that has been threaded to match the screw. Three ways to fasten with screws and bolts are the following:

- Fastening metal with a bolt and nut consists of drilling or punching a hole through pieces of metal the same diameter as the bolt, inserting the bolt through the holes, threading a lock washer and nut on the bolt, and tightening the bolt.
- Fastening with only a bolt is a similar procedure, except that the hole that the bolt threads into needs to be slightly smaller to leave enough material to cut internal threads. Internal threads are cut with a tap, which is discussed in more detail later in this lesson.
- Fastening with a sheet metal screw consists of drilling or punching a hole in the first piece of metal to accommodate the shank of the screw, drilling or punching a smaller pilot hole in the second piece of metal, assembling the pieces, and inserting the screw and tightening it. The screw should not be overtightened because overtightening will strip the threads in the pilot hole. The screw will not hold if the threads are stripped.

Rivets

A rivet is a nonthreaded metal pin with a head on one end. Rivets are available in different designs and are typically made of copper, steel, or aluminum. A general rule for determining the correct length of rivet to use is as follows: it should be as long as the thickness of both pieces of metal together plus the diameter of the rivet. For example, a 1/8-in. diameter rivet should extend 1/8 in. above the two pieces of metal. To join metal together, a rivet is placed with the headless end up in the holes of two or more pieces of metal. The end of the rivet is then hammered with a ball-peen hammer to form a rounded head. See Figure 1.9. A special tool called a rivet set can be used to draw the pieces of metal together and form a smooth rounded head. The head of the rivet should not be flattened because this weakens the rivet.

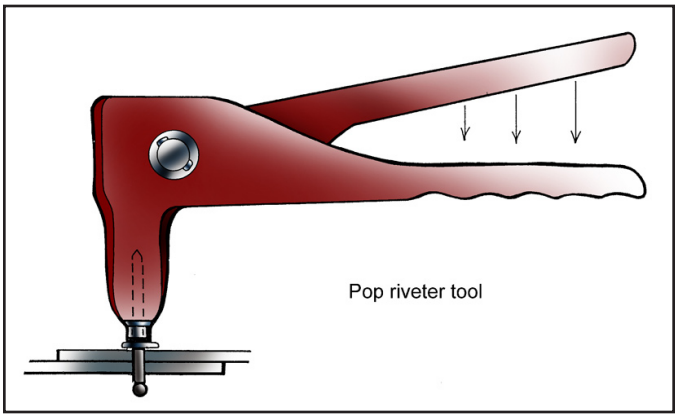
Figure 1.9 – Steps for Fastening With a Rivet



Pop Rivets

Pop rivets consist of a metal sleeve with a flange on one end and a stem that fits in the sleeve. They are installed on one side of the piece or pieces of metal with a special tool called a pop riveter. See Figure 1.10. Pop rivets are useful for situations in which it would be difficult to support the rivet and use a hammer at the same time or when only one side of the metal is accessible. The pop rivet gets its name from the popping sound that is made when the stem breaks off during installation. When choosing pop rivets, be sure to select ones that are compatible with the metal being fastened. For example, aluminum rivets should not be used to fasten steel.

Figure 1.10 – Fastening With Pop Rivets



Tap and Die Set

Threads can be cut in metal by hand with the use of a tap and die set. A tap is a cutting tool that is turned with a tap wrench to cut internal threads in a hole. A die is a cutting tool that is turned with a die stock to cut external threads on round metal, such as a rod or bolt.

Tapping is done by turning the tap clockwise in the hole with a tap wrench and backing it off to break chips of metal that form. These steps are performed until the tap is through the metal or the bottom of the hole is reached. Oil should be added during the process to keep the hole and the tap threads lubricated. A tap must be handled carefully because it is brittle and breaks easily. The tap must be started square and kept straight during the threading process, so that the threads will be straight.

To select the right size tap to thread a hole for a bolt, the type of threads (thread system) and the diameter of the bolt must be determined. The different types of thread systems commonly encountered in the United States are as follows:

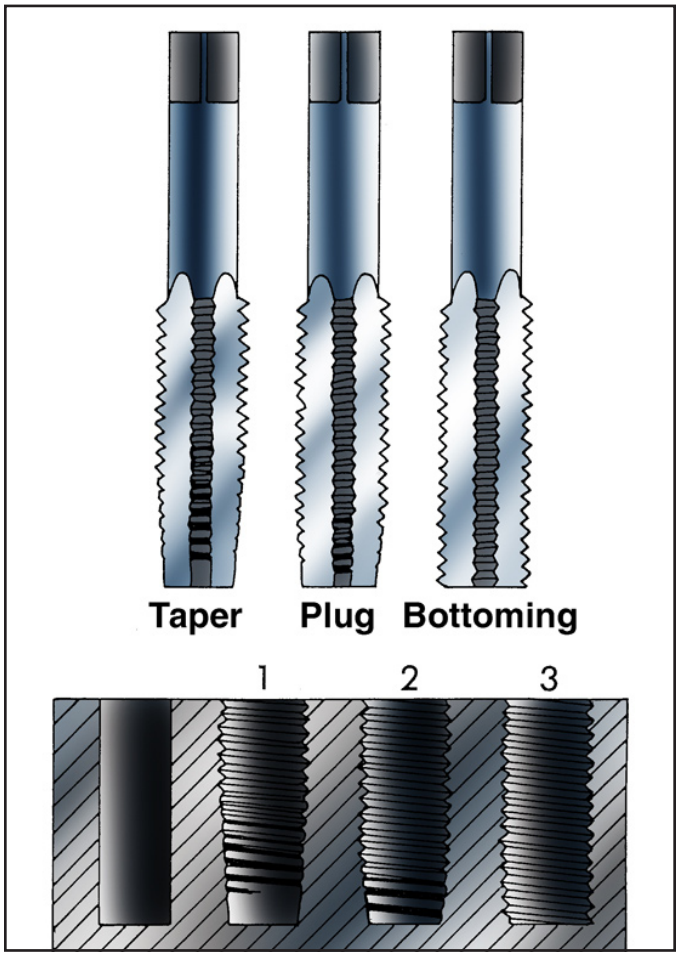
- National Coarse (NC): This type of thread is frequently chosen for general-purpose work. Coarse threads allow for quicker assembly and are not as prone to cross-threading as fine threads.
- National Fine (NF): This thread is frequently used for precision assemblies and for assemblies that must withstand high stress and high loads. Fine threads are less likely to loosen under such conditions.
- International Standards Organization (ISO) coarse: These are coarse metric threads.
- International Standards Organization (ISO) fine: These are fine metric threads.
- National Pipe Threads (NPT): These threads are tapered to create a tight fit that can hold gas, liquid, or steam under pressure without leaking.

Taps are usually available in a set of three types for a specified diameter. See Figure 1.11. The three types are as follows:

- Taper tap: This tap is tapered at the end for the first six or more threads. It is useful for starting a thread in a hole or for threading a hole that goes all the way through the metal.
- Plug tap: This tap is tapered at the end for only approximately the first three threads. A plug tap is used after the taper tap to thread part of the distance required.
- Bottoming tap: This tap is tapered approximately one to one and a half threads. It is used to finish a blind hole (hole that does not go all the way through the metal). The correct sequence for threading a blind hole is to first use the taper tap to start the hole, use the plug tap for a distance, and then the bottoming tap to finish the hole.

The major diameter of a tap, number of threads per inch, and type of thread are stamped in a code on the tap. For example, a stamp of 3/8 - 16NC indicates a 3/8-in. tap with 16 threads per inch of the National Coarse system.

Figure 1.11 – Three Types of Taps



A tap drill is used to drill a hole for the tap. It is important to choose a tap drill that is the correct size for the bolt. The tap drill hole must be slightly smaller than the tap to leave enough material in the stock for the tap to cut the thread. To determine the correct tap drill size, consult tables or use the following formula.

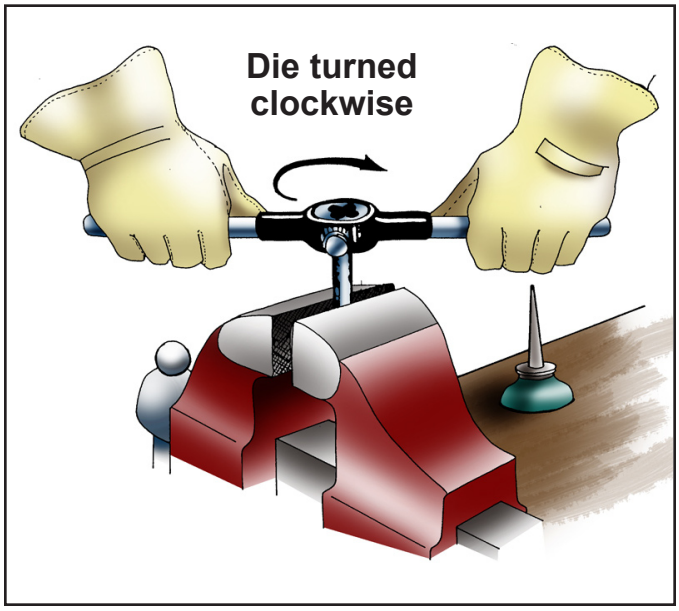
TDS = D - 1/N
(Note: TDS means tap drill size, D means the major diameter of tap, and N means number of threads per inch.)

For example, to find the tap drill size for a 3/8 - 16NC tap, the following formula can be used.

TDS = 3/8 - 1/16
TDS = 6/16 - 1/16
(Converted 3/8 to the common denominator of 16)
TDS = 5/16
A 5/16-in. hole must be drilled for this tap.

There are solid dies (not adjustable) and adjustable dies available in the same thread systems as taps. Adjustable dies can be adjusted to different thread sizes. Before threading a rod with a die, the end of the rod is chamfered to a 45-degree angle with a file. This step makes it easier to start the die. The tapered side of the die is placed on the rod end. Similar to the tapping process, threading with a die basically consists of turning the die clockwise with a die stock and backing it off to break chips of metal that form. These steps are performed until the rod is threaded the desired length. See Figure 1.12. Oil should be added during the process to keep the die and chamfered end of the rod lubricated. The die must be started squarely on the work and kept straight during the threading process.

Figure 1.12 – Using a Die to Thread a Rod



Removing Burrs From Cold Metal

Drilling and cutting procedures cause burrs around holes and on cut edges. Burrs are the sharp, turned-up edges on metal. Burrs should be removed to allow for safe handling, provide for the correct fit of parts, avoid damage to tools and equipment, and improve the appearance of the work. Removal of burrs on the cut edges of metal is usually done with a file or grinder. Burrs on the edges of holes can be removed by drilling a small chamfer around the hole using a drill bit that is two times the size of the hole.

Summary

Working with cold metal involves numerous procedures, such as marking the layout of cutting lines and drill holes, cutting and filing to remove or shape metal, bending and fastening, and removing burrs from cut edges and holes. Workers should be familiar with metalworking tools and procedures before attempting to work with cold metal.

Credits

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