Marking Out, Measurement, Fitting & Assembly

1. Introduction

This training module is designed to give you a good appreciation on the various types of band tools commonly used for measurement, marking out, and metal removal. Emphasis is not placed on you to become a skilful fitter within such a short period of training, but rather to let you understand the uses of common hand tools and appreciate the importance of fitting work in the trade. Nevertheless, on completion of the training and through the hands-on practice given, you will acquire some of the basic skills and techniques involved with these hand processes.

To get the maximum benefit from the training, it is essential that you use every opportunity to consolidate what you observe and to interact between yourself and the staff member in charge of your training. This is self-motivated and the drive must come from you.

---

2. Why Use Hand Tools?

"Man without Tools is nothing; with tools he is all." - This sentence is defined by Thomas Carlyle has well elaborated the importance of tooling to a man.

The term '**Tooling**' as applied to the engineering discipline refers to any equipment or instruments that give helps in the production of a product or any related activities. Simply speaking, it ranges from the most fundamental type of hand tools such as a File to the very complex machine tools such as a CNC Machining Centre.

Thus, one may ask the question - Why we still have to use band tools in this modern age of technologies?

Yes, it is reasonable to say that the efficiency of any hand processes is low and the outcome quality depends highly upon the skill of individuals. Perhaps it is fair to consider the following points before a definite answer is given to the above question: -

1. Accuracy

Although the CNC machine can give a higher degree of dimensional accuracy when compared with the inconsistent outcome of hand fitting, the extreme high degree of flatness required for a surface table or a machine slide way is usually obtained by hand scraping only.

2. Flexibility

Hand processes are very flexible and can be carried out at any place where necessary while machining processes are not. In addition, machining usually require a rigid setting up, while fitting is simple.

3. Quantity

For large batch size, advanced production machines are commonly employed in order to maintain the accuracy as well as the efficiency. But for "jobbing type" works, such as the manufacture of a prototype or the repairing of a single component, it would be uneconomic to use these advanced machine tools. Instead, "jobbing type" works are usually produced by conventional machining and followed by hand fitting where necessary.

4. Final Assembly

In the assembly of precise component parts, no matter how accurate they are being produced, a skilled fitter is often required to give the necessary "finishing touch" on them to ensure that everything goes together correctly.

---

3. Measuring Tools in Workshop

3a. Calipers

Calipers are the very simple tools used together with a steel rule for the measurement or comparison of linear dimensions. An experienced worker can achieve +/- 0.05mm in the measurement. Calipers are classified into two types: -

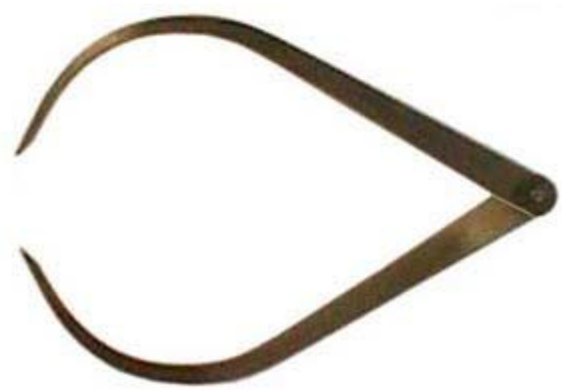


Figure 1. Outside Calipers

Outside Calipers

Outside calipers (figure 1) are used for measuring external dimensions such as the length, diameter, or even the thickness of a solid.

Inside Calipers

Inside calipers (figure 2) are used for measuring internal dimensions such as the diameter of a hole, or the width of a slot etc.

Figure 2. Inside Calipers

3b. Vernier Calipers

Vernier Calipers (figure 3) are more precise tools capable for measuring external dimensions, internal dimensions, and depths. Besides the two pairs of measuring jaws and the depth gauge, its main features also include a main scale and a vernier scale.

Figure 3. Vernier Calipers

The resolution of a vernier scale is determined by the difference on the distance of one division on the main scale and one division on the vernier as shown in figure 4. For example: A vernier scale of length 49mm is divided into 50 equal divisions. That means **ONE** division on the vernier represents 49/50=0.98 mm while ONE division on the main scale represents 1mm. Then, the resolution of the vernier is 1mm - 0.98mm = 0.02mm.

Figure 4. Vernier Reading

3c. Vernier Height Gauge

A vernier height gauge (figure 5) is used for measuring height of an object or for marking lines onto an object of given distance from a datum base.

Figure 5. Vernier Height Gauge

3d. Micrometer

A micrometer is a more precise measuring instrument than the vernier calipers. The accuracy is come from the fine thread on the screw spindle. The ratchet prevents excess force from being applied. Generally, the screw spindle has a pitch of 0.5mm. The thimble is divided into 50 equal divisions.

Common types of micrometers used in the workshops are: -

Outside Micrometer

An outside micrometer (figure 6) is used for measuring external dimensions. The work to be measured is placed between the anvil and the tip of the spindle.

Figure 6. Outside Micrometer

Inside Micrometer

This is similar in structure to an outside micrometer and is used for measuring internal dimensions as shown in figure 7.

Figure 7. Inside Micrometer

Depth Micrometer

A depth micrometer (figure 8) is used for measuring the depth of a hole, slot and keyway etc. A complete set of depth micrometer is equipped with spindles of different lengths, which can be interchanged to suit different measuring ranges.

Figure 8. Depth Micrometer

3e. Protractor

Engineer's Protractor

Engineer's protractor (figure 9) is a general purpose tool used for the measuring / checking of angles e.g. the angle of drill head, angle of cutting tool, and even for the marking out of angles on a component part.

Figure 9. Engineer's Protractor

Vernier Protractor

This is a precision measuring tool that the accuracy of measurement can reach ¡Ó5 minutes of an angle through the vernier scale as shown in figure 10.

Figure 10. Vernier Protractor

3f. Combination Set

Combination set (figure 11) is a set of equipment combining the functions of protractor, engineer square, steel rule, Centre finder, level rule, and scriber.

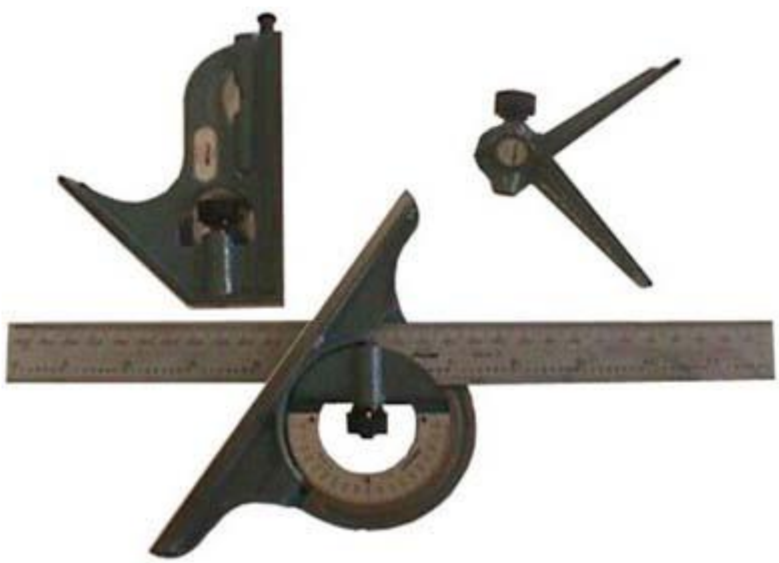


Figure 11. Combination Set

3g. Dial Indicator

The principle of dial indicator (dial gauge) is that the linear mechanical movement of the stylus is magnified and transferred to the rotation of pointer as shown in figure 12. The accuracy of dial indicator can be up to 0.001mm. It is usually used for calibration of machine.

Figure 12. Dial Indicator

4. Marking Out Tools in Workshop

Marking out is the preliminary work of providing guidance lines and centres before cutting and machining. The lines are in 3-D and full-scale. The workpiece can then be cut or machined to the required shapes and sizes. The common tools used for marking out are as follow:

4a. Scriber

A scriber (figure 13) is used for scratching lines onto the workpiece. It is made of hardened tool steel.

Figure 13. Scriber

4b. Engineer's Square

Engineer's square (figure 14) is made of hardened tool steel. It is used for checking the straightness and the squareness of a workpiece. It can also be used for marking perpendicular lines onto a workpiece.

Figure 14. Engineer's Square

4c. Spring Dividers

Spring dividers (figure 15) are made of hardened tool steel. The legs are used for scribing arcs or circles onto a workpiece.

Figure 15. Spring Dividers

4d. Punch

There are two types of punch namely the Centre Punch and the Dot Punch. A dot punch has a point angle of 60¢X and it is used for making of small dots on the reference line. The centre punch has a point angle of 90¢X as shown in figure 16 and it is used for making a large indent on a workpiece for drilling. Both punches are made of hardened tool steel.

Figure 16. Punch

4e. Surface Plate

Surface plate (figure 17) is made of malleable cast iron. It has been machined and scraped to a high degree of flatness. The flat surface is being used as a datum surface for marking out and for measuring purposes. If it can stand on the floor, it is called surface table.

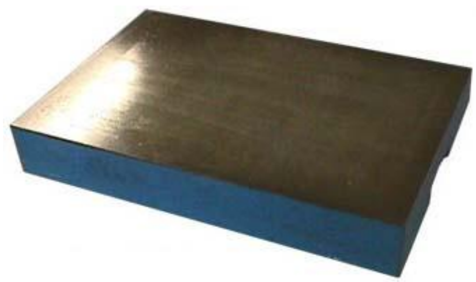


Figure 17. Surface Plate

4f. Angle Plate

An angle plate (figure 18) are used for supporting or setting up work vertically, and are provided with holes and slots through which securing bolts can be located. It is made of cast iron and ground to a high degree of accuracy.

Figure 18. Angle Plate

4g. Vee Block

Vee blocks (figure 19) usually in a couple are made of cast iron or steel in case-hardening. They are generally used for holding circular workpiece for marking out or machining.

Figure 19. Vee Block

---

5. Hand Tools for Workshop

5a. Bench Vice

A bench vice (figure 20) is the device for holding the workpiece where most hand processes to be carried out. The body of the vice is made of cast iron while the two clamping jaws are made of hardened tool steel. Some bench vice has a swivel base, which can set the workpiece at an angle to the table. The vice height should be correct ergonomically. Vice clamps, made of copper are fitted over the vice jaws when holding finished work to avoid damage to the finish surfaces.

Care of Vices

a. Do not direct impact the vice body by the hammer.
b. Light hammering can be done on and only on the anvil of the vice.
c. To avoid over clamping, the handle of the vice should be tightened by hand only

Figure 20. Bench Vice

5b. Files

Files are the most important hand tools used for the removal of materials. They are made of hardened high carbon steel with a soft 'tang'. to which a handle can be fixed. Files are categorised as follows:-

Figure 21. File

Length - measured from the shoulder to the tip.
Shape - the cross-sectional profile.
Grade - the spacing and pitch of the teeth.

Cut - the patterns of cutting edge.

Save Edge

There are no cutting edges on one side of the hand file. The purposes for the save edge is to avoid the worker damage the work, when he is filing a shoulder position. Shape of Files

1. **Hand File -** The common file used for roughing and finishing. It is a rectangular in section and parallel in width. It has double cut teeth on two faces, single cut teeth on one edge, and one save edge.


Figure 22a. Hand File

2. **Flat File -** It is similar to a hand file rectangular in section, tapered slightly in width and thickness towards the tip. It has Double Cut teeth on two faces and Single Cut teeth on two sides.


Figure 22b. Flat File

3. **Half-round File** - The section is a chord of a circle with its taper towards the tip. It is used for forming radii, grooves, etc. and the flat side is used for finishing flat surfaces.


Figure 22c. Half-round File

4. **Round File** - This is of round section tapering toward the end. It is used for enlarging holes, producing internal round corners. Usually double cut in the larger sizes, and single cut for the smaller sizes.


Figure 22d. Round File

5. **Square File** - This is square in section, with tapered towards the tip, and usually double cut on all four faces. It is used for filing rectangular slots or grooves.


Figure 22e. Square File

6. **Three Square File -** It is also known as triangular file. This is a triangular in section, with tapered towards the tip with double cut on both faces. It is used for filing corners or angles less than 90°


Figure 22f. Three Square File

7. **Needle Files** -

Needle files are a set of small files with their shapes made in a way similar to the large ones. They are generally used for small and delicate works such as the repair of small instruments.

Grade

This refers to the pitch (spacing) of the teeth that spread throughout the whole length of the file. Files with a rougher grade of cut give a faster metal removal rate but a poorer surface finish or the vice versa. It should be noted that, for the same grade of cut, a longer file would have a coarser pitch than a shorter one.

The grades are as follows:

Bastard cut - medium teeth for general purposes, especially suitable for mild steel.

Second cut - finer teeth for cutting hard metals.

Smooth cut - fine teeth for finishing.

Three grades of cut are in common use

Cut Pattern

Single Cut - There is only one set of cutting teeth to one edge. It gives a less efficient cutting but a better finish. It is suitable for the soft metal.

Double Cut - A double cut file has one set of teeth cut at 70 degrees to one edge, and another set of grooves cut at 45 degrees to the other edge. It is thus more efficient in cutting. It is easy to clog the teeth when it is work on the soft metal.

Rasp - Very coarse teeth, like the nail, it is commonly used for the cutting off soft materials such as rubber, PVC, or wood etc.

Safety and Care of Files

Files teeth are brittle and therefore file should be placed properly and should not be stacked on other tools.. New files should never be used on hard materials. E.g. castings or welding. Some brittle metal, e.g. brass is not readily filed with the worn teeth. A new file should be used for these purposes and the file must be kept in another stock. Remove the pinning regularly by a file card/wire brush. Cutting is carried on the forward stroke. It is very danger to use files without handles.

5c. File Card

When filing the soft metals, the small pieces of metal will tend to clog the teeth. If the file is not cleaned, this small piece of metal will scratch on the surface of the work. We call it pinning. This case is frequently appeared when applying a new smooth file on the soft metals. The pinning can be removed with a File Card as shown in figure 23, which is a wire brush mounted on a block of wood. Sweep the file card along the grooves on the file until the pinning is removed.

Figure 23. File Card

-

5d. Hacksaw

A hacksaw is generally used for cutting a metal into pieces.

It consists of a frame and a saw blade as shown below. It is a "U" shaped steel frame with a pistol handgrip and a saw blade as shown in figure 24. The frame may be of fixed type to take only one length of blade, or adjustable to take different blade lengths. It has a wing nut to adjust the tension of the blade.

Figure 24. HackSaw

Saw Blade

Saw blades are made of high carbon steel, alloy steel or High Speed Steel. They are supplied according to material, hardening, length and pitch.

1. Hardening - Usually the saw blade is supplied with all hard or flexible grade. The all hard is very brittle, and it is suitable for the skillful user only. The flexible grade is tough, so it can twist an angle. It is suitable for cutting a curve or for the beginner to use.

2. Material - Usually the saw blade is supplied with High Carbon Steel (HCS) and High Speed Steel (HSS). The HCS will annealed from the heat generated by fraction of cutting. The HCS, saw blade will lost its hardness when cutting the hard metal. The HSS can keep its hardness unless improper use.

3. Pitch - It is grading according to the number of teeth per 25mm.
Coarse blade (18T) is most suitable for soft material and thick workpiece.
Medium blade (24T) is suitable for steel pipe.
Fine blade (32T) is suitable for the thin metal sheet and thin copper pipe.

For safety, it is advice that to keep at least 3 teeth of the blade, stand on the workpiece.

Figure 25. Pitches of Saw Blade

4. Length - The length of the blade is determined by the distance between the outside edges of the holes, which fit over the pegs.

5. Set - The teeth have a "set" to either side alternately, which causes the blade to cut a slit wider than the thickness of the blade, to prevent jamming.

Safety and Care of Hacksaw

1. The cutting action is carried on the forward action only. So the blade must be mounted with its teeth pointing forward.
2. Suitable tension should be applied on the blade to avoid breakage or loosen.
3. Change the blade if some teeth are broken.
4. Avoid rapid and erratic strokes of cut.

5. Avoid too much pressure.
6. Workpiece must be hold firmly.

5e. Hammer

The type most commonly used is the ball pein hammer, which has a flat striking face and a ball-shaped end (call the pein). Hammer heads are made from medium carbon steel. The two ends must be hardened and tempered, the centre of the head with the eye being left soft. It is specified according to its weight.

Figure 26. Hammer

Safety and Care of Hammer

1. The hammer head is firmly fixed to the shaft by a wedge.
2. The striking face of the hammer head does not wear.

5. Drill

6. Drill and Drilling

Drill Chuck With Key

Figure 27. Drilling Machine

Drill Chuck without Key

Figure 28. Twist Drills

Drilling is the process of cutting holes in metals by using a drilling machine as shown in figure 27. Drills are the tools used to cut away fine shavings of material as the drill advances in a rotational motion through the material.

6a. Twist Drill

The twist drill (figure 28) is made from High Speed Steel, tempered to give maximum hardness throughout the parallel cutting portion. Flutes are incorporated to carry away the chips of metal and the outside surface is relieved to produce a cutting edge along the leading side of each flute.

6b. Drill Features

The point of the drill is ground to an angle of 59¢X to the centre line to give two equal cutting edges, and each side is ground back to give " relief " of about 12¢X to each cutting edge as shown in figure 29.

It is very important that drill points are central and that the lip angles are equal and that the cutting edges are unchipped and the clearance angle correct. To obtain this state and ensure correct angles it is important that drills are ground in a grinding machine.

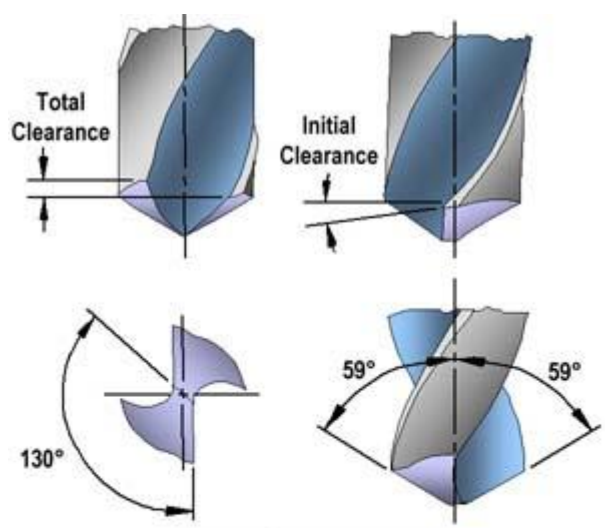


Figure 29. Drill Features

6c. Drill Operating Parameters

It is essential to select the correct cutting speed and the feed. Followings are the most common used cutting speed and feed rate.

Cutting Speed	
Material	**Cutting Speed**
Mild steel	6 - 9 m/min
Stainless Steel	4 ¡V 9 m/min
Aluminium	30 ¡V 36 m/min
Feed Rate	
5.5 mm diameter twist drill	0.08 ¡V 0.15 mm/rev
30 mm diameter twist drill	0.04 ¡V 0.55 mm/rev

6d. Special Type of Drill

Counterbore Drill (figure 30) ¡V To form a flat, or cylindrical recess to accommodate the head of the bolt. It is also used to provide a level base on the rough surfaces for nuts and washers.

Countersink Drill (figure 31) ¡V To form a conical shaped recess to enable a countersunk screw or bolt to fit flush with the surface of the work.

Figure 30. Counterbore Drill

Figure 31. Countersink Drill

6e. Safety and Care on Drilling

i. Twist drill must be clamped in the drill chuck tightly
ii. The workpiece to be drilled must be firmly secured by vice, or clamps.
iii. Drill guard (figure 32) must be closed before switch on the machine.
iv. Use the correct drilling speed and apply suitable drilling force It is advisable to release the drill occasionally, lift the drill, and clear the hole of cutting.
v. Apply cutting fluid in the cutting except for drilling Cast iron.
vi. Take care, when the drill is nearly penetrated through the workpiece.
vii. The "screw in" action can lift up the workpiece.

Figure 32. Drill Gaurd

---

7. Reamer and Threading Tools

7a. Reamer

Functions of reamer are

1. to control the diameter of a hole
2. to improve the internal surface finish
3. to improve the roundness of the hole

Reamer is made of hardened High Carbon Steel or High Speed Steel. It is classified into hand reamer and machine reamer.

1. Hand Reamer

Hand reamer (figure 33) has two types of flutes: - straight and spiral flutes. The spiral flutes hand reamer has a left hand spiral flutes. The purpose of the design is to prevent the reamer "screw in" the hole.

Figure 35. Hand Reamer

2. Machine Reamer

Machine reamer (figure 34) has a straight shank or taper shank (Morse taper). The taper shank can fit directly into the spindle of a machine while the straight shank is hold by the collet.

Figure 35. Machine Reamer

3. Expanding Reamer/Adjustable Reamer

The cutting diameter can be slightly varied by adjusting an inner taper against the loss cutting blades as shown in figure 35. This type is used primarily for repetitive work to maintain a consistent size throughout.

Figure 35. Adjustable Reamer

4. Safety, Precautions & Operation in Reaming

a. Care the sharp cutting edge especially in handling.
b. The amount of material to be removed by a reamer should be as small as possible, approximately 2-4% of diameter.
c. Reamer must only be turned in one direction, both cutting and removing the tools, otherwise the tool may jam.
d. Lubricant oil should be used except when cutting cast iron and brass.
e. Reaming can enlarge the size of hole, but cannot correct the position error in drilling.

7b. Tap

Taps (figure 36) are used to cut the internal screw threads. Taps are made of hardened High Carbon Steel or High Speed Steel. The ends of the shank are square to fit a wrench (figure 37). Usually taps are provided in set of three -- taper, second and plug tap.

1. Taper Tap
The tap is tapered off for a length of 8 to 10 threads and is the first tap to be used in a hole to start the thread form.

2. Second Tap
The tap is tapered off for a length of 4 to 5 threads to facilitate picking up the threads cut by the taper tap.

Figure 36. Taps

3. Plug Tap
This is fully threaded throughout its length and is called a 'bottoming' tap. This tap used to cut the bottom of a blind hole.

Figure 37. Tap Wrench

Precautions & operation in tapping

a. The size of the hole is important and the correct drill size should be determined from the handbook, standard table in the workshop or the recommendation on the shank of the tap.
b. Use taper tap first ensuring that it is kept square with top surface of work
c. Always use the correct size of wrench for the tap in use.
d. Lubricant oil should be used except when cutting cast iron and brass.
e. Use both hands to hold the wrench to maintain even torque.
f. About every half turn reverse action slightly to break the swarf and clear the threads.

When the tap reaches the bottom of the blind hole, care must be taken not to force as tap may break in the hole.

7c. Die

Dies are used for cutting external threads on round bar or tubes. Dies are made of Hardened High Carbon Steel or High Speed Steel.

1. Split Die or Button Die
Split die is held in place in the stock as shown in figure 38. The split permits a small amount of adjustment in the size of the die by adjusting the screws in the stock. Since split dies cut their thread complete in one cut, the die thread are tapered and back off for one third of their length.

Figure 38. Split Die & Stock

2. Die nuts
Die nuts (figure 39) are not capable of any adjustment. They are not usually employed for cutting threads from the bar, but for rectifying damage to existing threads. They are externally formed to hexagonal shape for use with a spanner.

Figure 39. Die Nut

Precautions and Operation of Die

a. The diameter of the blank rod must not larger than the outside diameter of thread to be cut.
b. Ensure that the die is set perpendicular to the rod.
c. Lubricant oil should be used except when cutting cast iron and brass.
d. About every half-turn reverse frequently to break the swarf otherwise the thread will tear.

Sheet Metal Work and Its Tools

Introduction:

The sheet metal process is one of the important processes in workshop activity. It deals with the working of metal sheets. The various operations performed in a sheet metal shop are cutting, shearing, bending etc. In this chapter, we shall discuss the sheet metal tools and the various processes briefly.

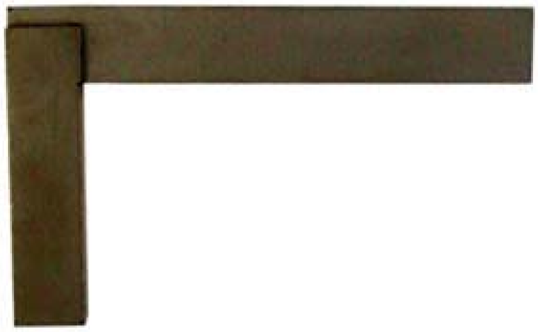
Metals Used in Sheet Metal Works:

1. Galvanized iron sheet (G. I. Sheet)
2. Black iron sheet
3. Tin plate
4. Copper plate
5. Brass plate

Sheet Metal Tools:

The tools used in sheet metal work are as follows:

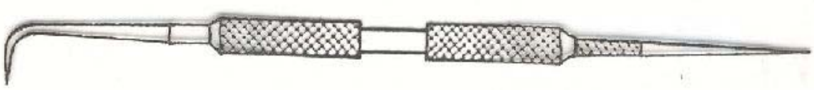
1) Try Square



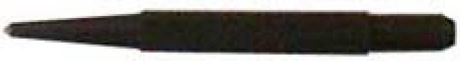
2) Steel Rule

Steel Rule

3) Marking Steel Scriber

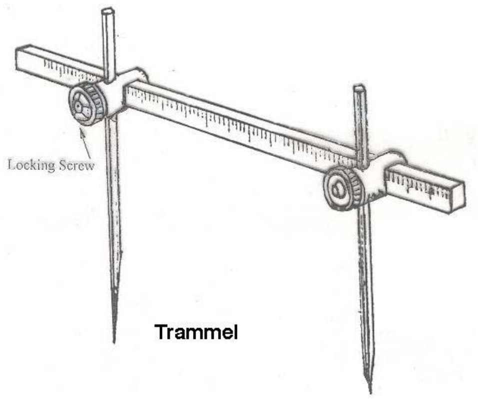


4) Centre Punch



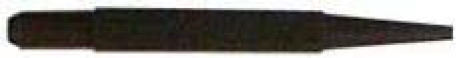
5) Divider

6) Trammel

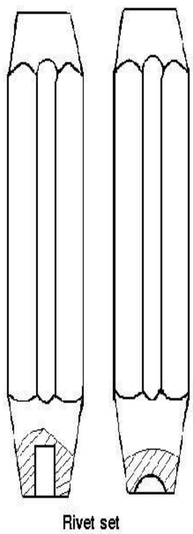


7) Prick Punch

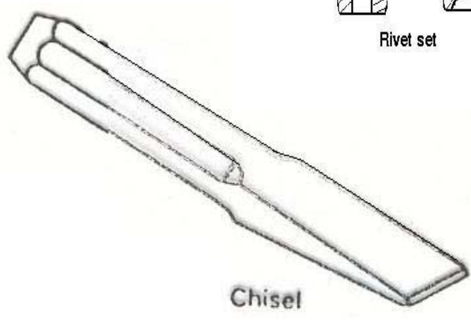
8) Drift/Solid Punch



9) Rivet Punch/Set

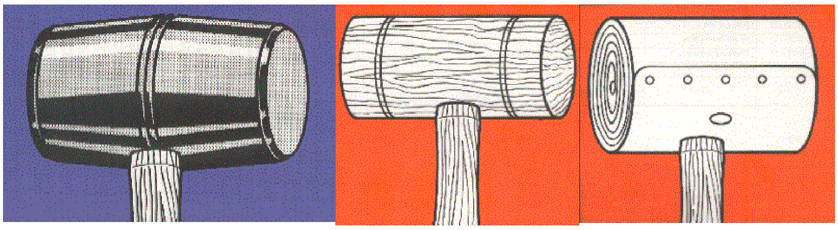


10) Chisel

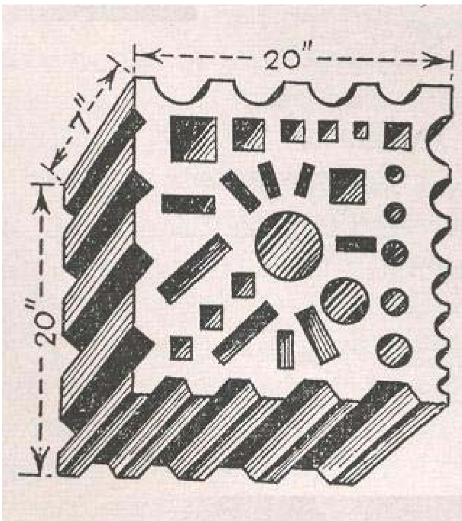


11) Steel Hammer

12) Mallet Hammer



13) Swage Block

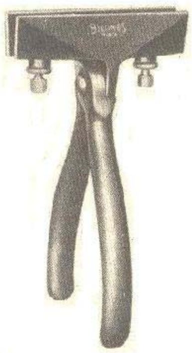


Swage Block.

14)

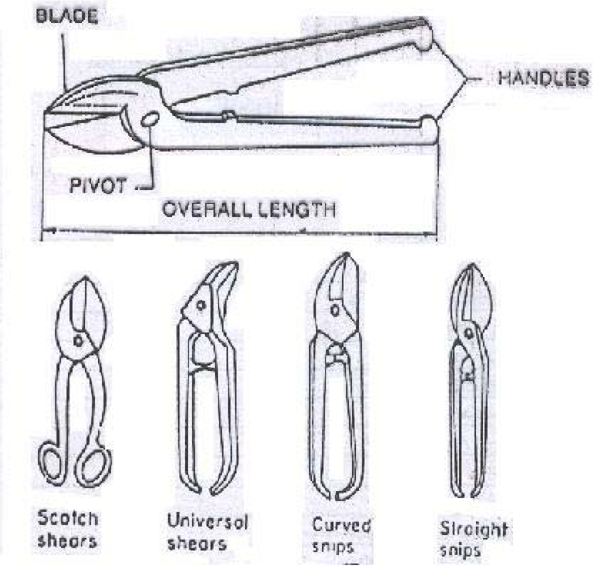
Stake

15) Hand Seamer

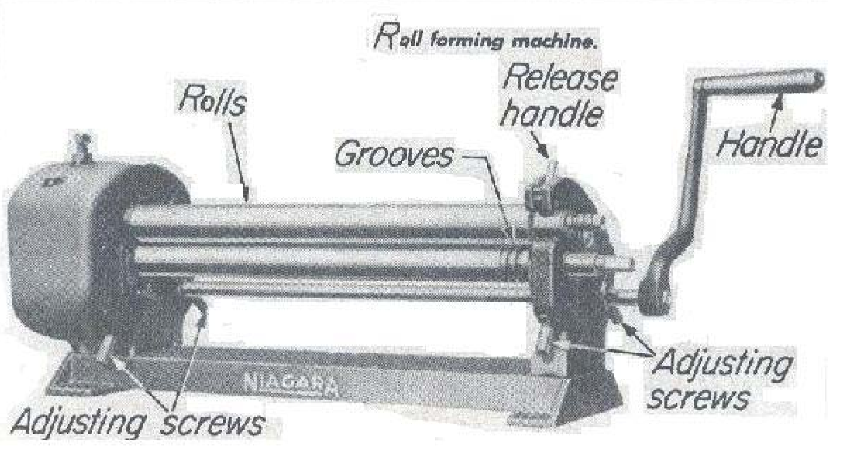


Hand Seamer

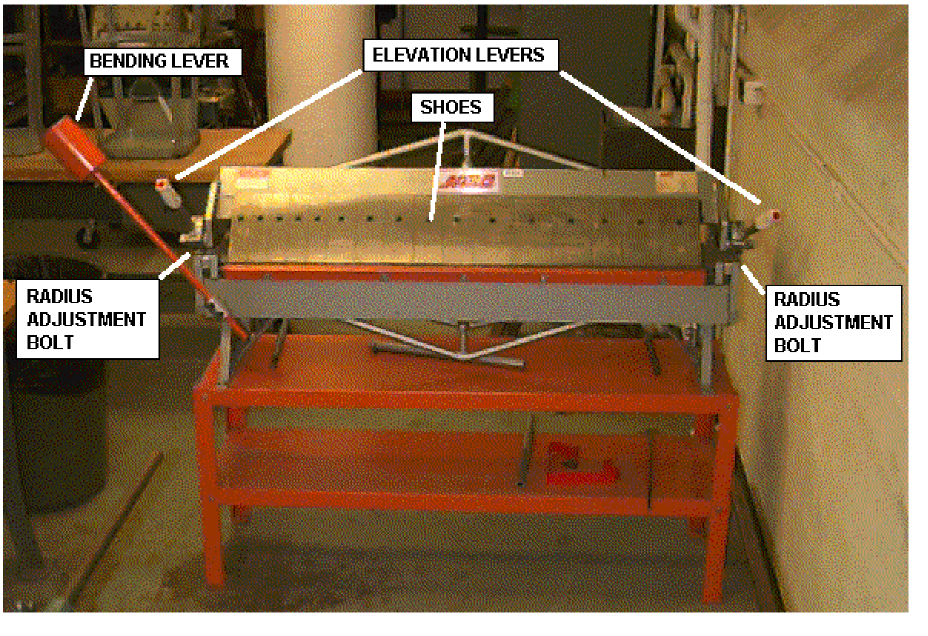
16) Snips/hand Shear



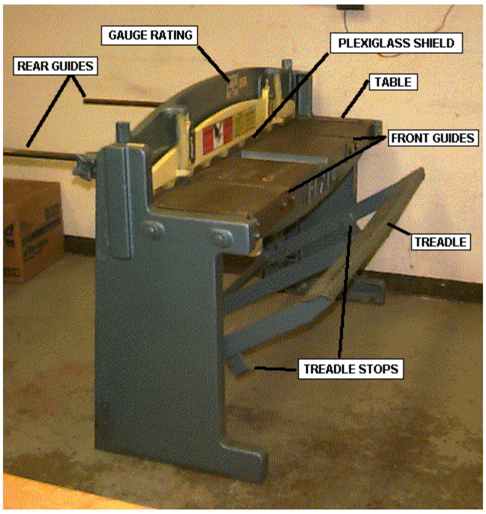
17) Rolling Machine



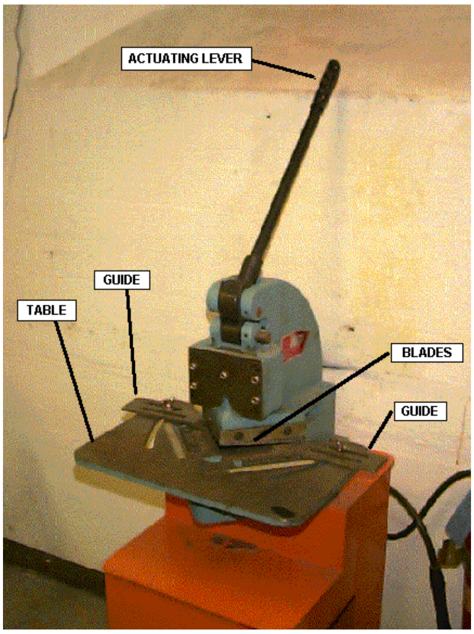
18) Folding Machine/
Folding Bar



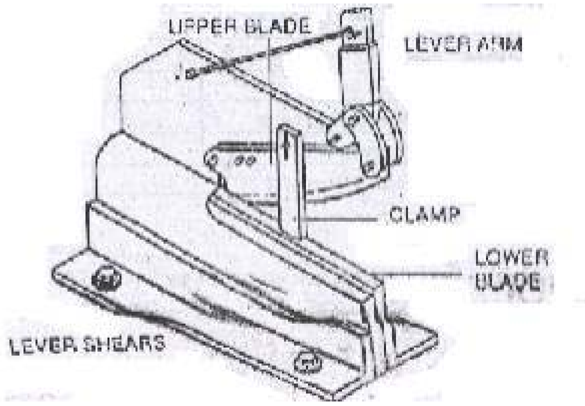
19) Foot shear



20) Notching Machine



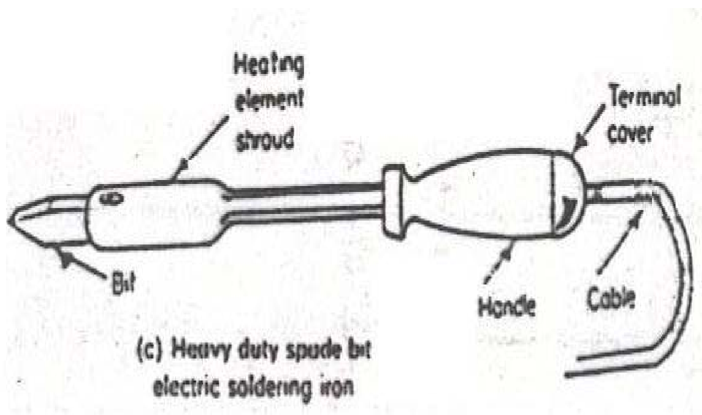
21) Lever Shear



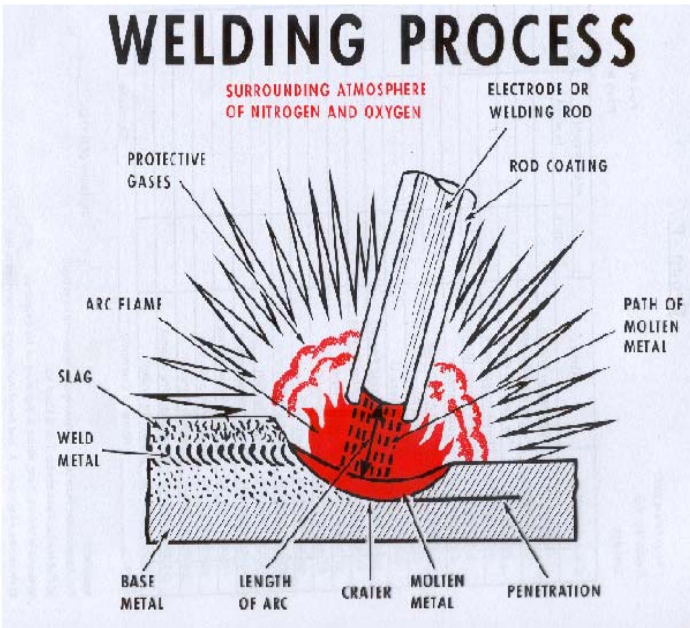
22) Band Saw

23) Small Band Saw

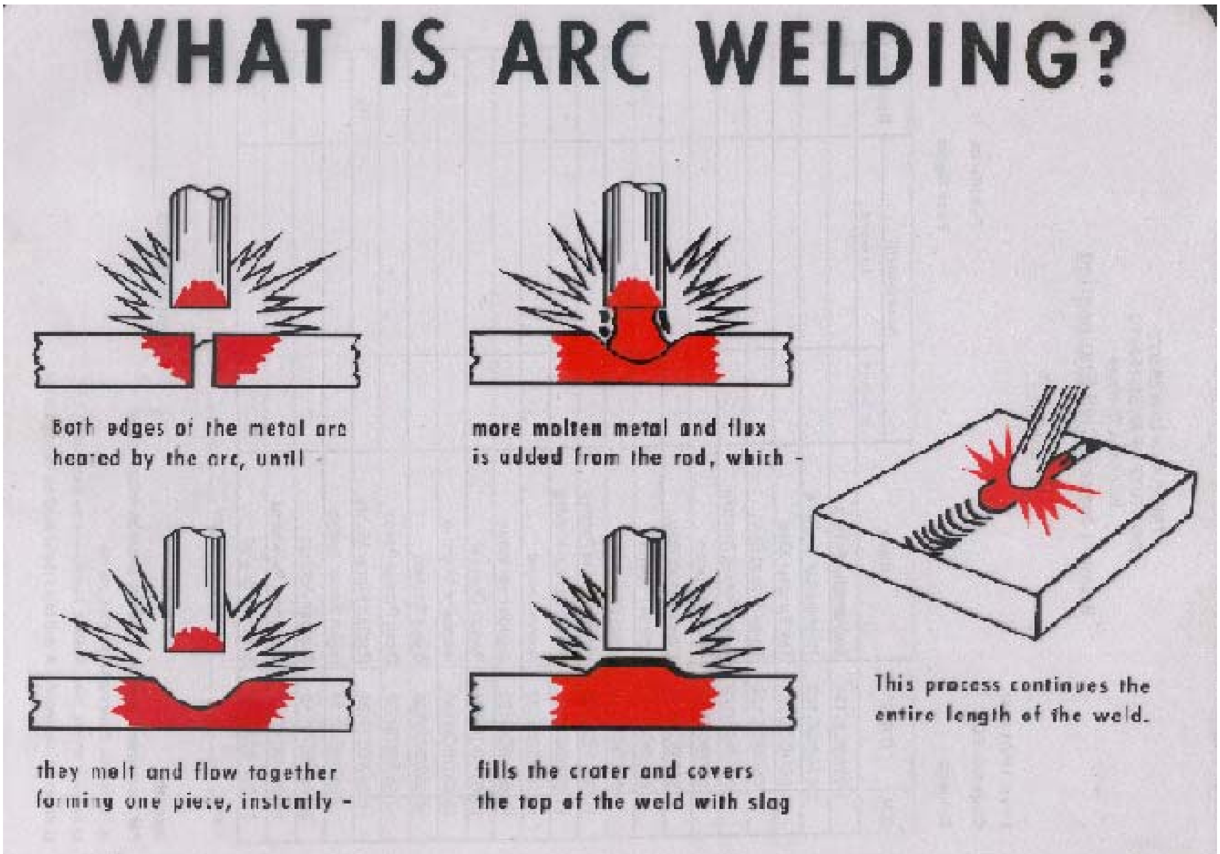
Soldering:



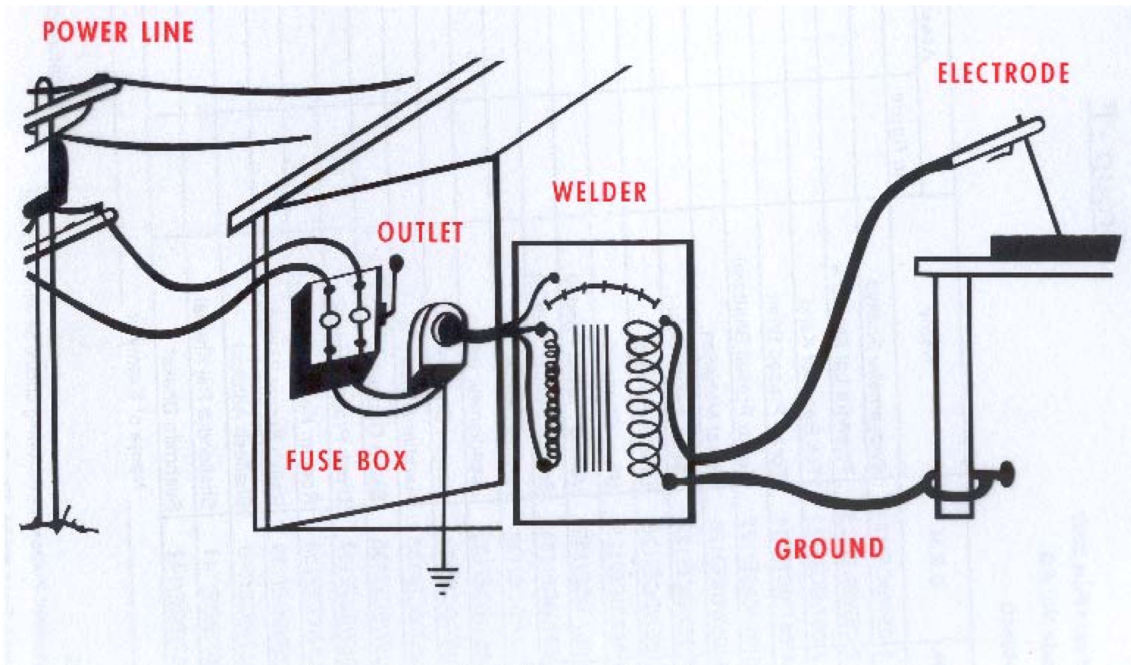
Arc Welding



WELDING PROCESS
SURROUNDING ATMOSPHERE OF NITROGEN AND OXYGEN
ELECTRODE OR WELDING ROD
PROTECTIVE GASES
ROD COATING
ARC FLAME
PATH OF MOLTEN METAL
SLAG
WELD METAL
BASE METAL
LENGTH OF ARC
CRATER
MOLTEN METAL
PENETRATION



WHAT IS ARC WELDING?
Both edges of the metal are heated by the arc, until -
more molten metal and flux is added from the rod, which -
they melt and flow together forming one piece, instantly -
fills the crater and covers the top of the weld with slag
This process continues the entire length of the weld.



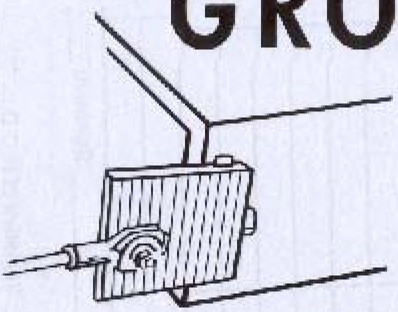
POWER LINE
ELECTRODE
WELDER
OUTLET
FUSE BOX
GROUND

ELECTRODE CHART

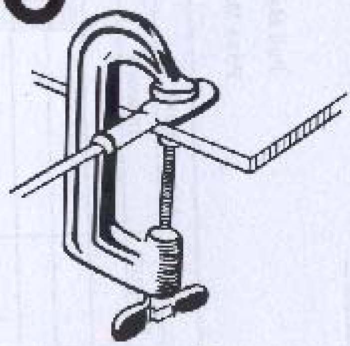
AVERAGE ARC LENGTH, CURRENT RANGE AND WORK THICKNESS FOR DIFFERENT SIZES OF ELECTRODES

Thickness of Work in inches	Diameter of Electrode in Inches	Maximum Arc Length in Inches	Current Range Amperes
1/16	3/32	1/16	25- 65
1/8	1/8	1/8	60-110
3/16	5/32	5/32	110-170
1/4	3/16	3/16	150-225
3/8	1/4	1/4	150-350
1/2	1/4	1/4	190-350
3/4	5/16	5/16	200-450
1	5/16	5/16	200-450

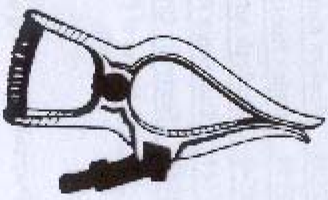
GROUNDING



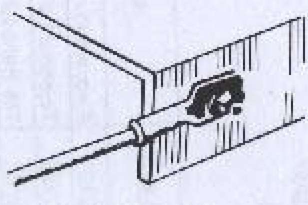
tack welded



clamped

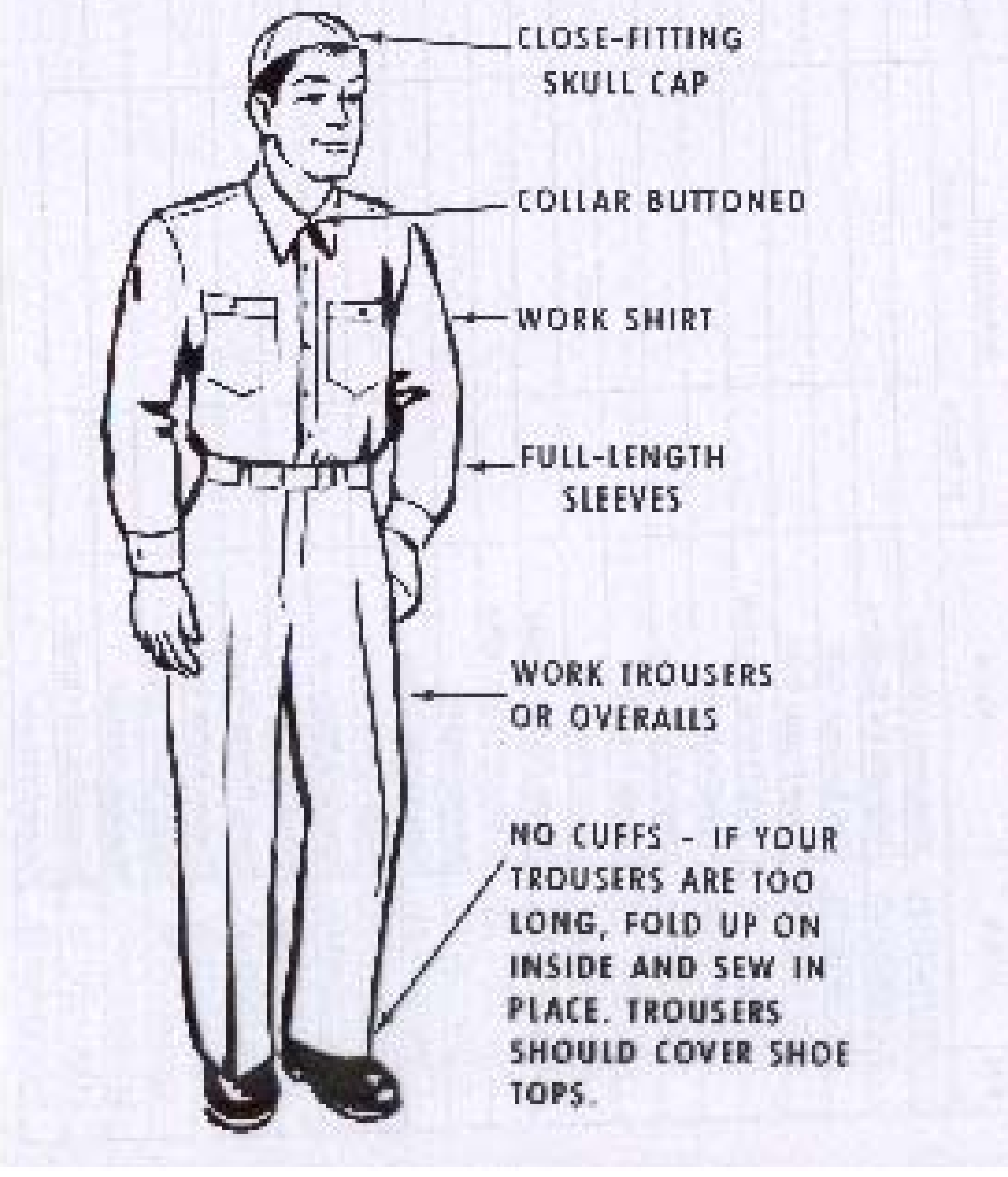


ground clamp

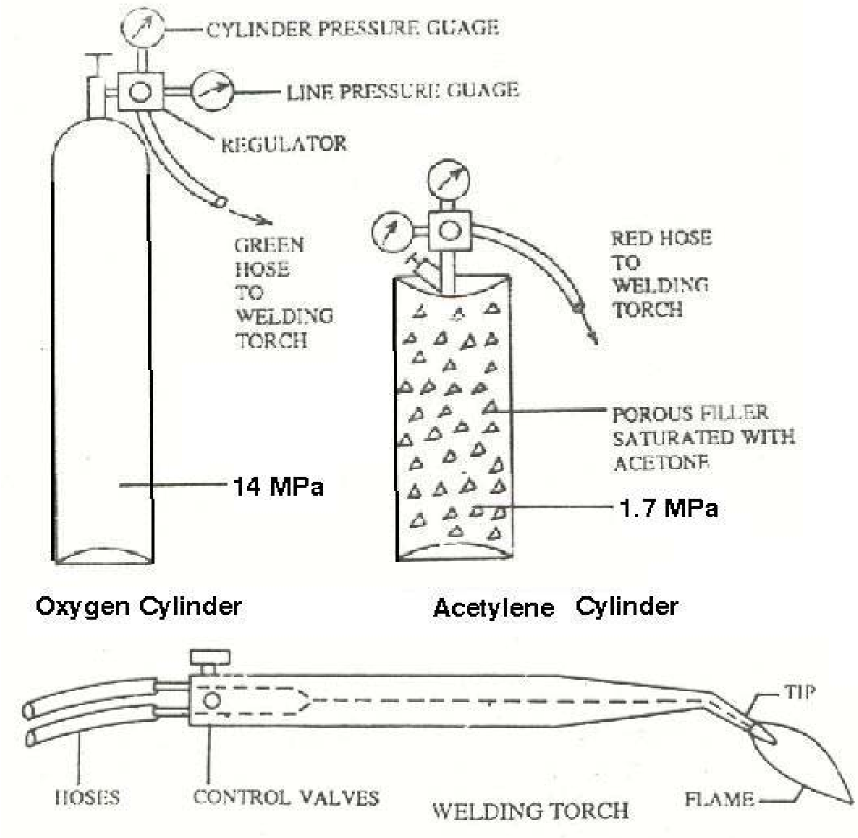


bolted

WELDERS DRESS

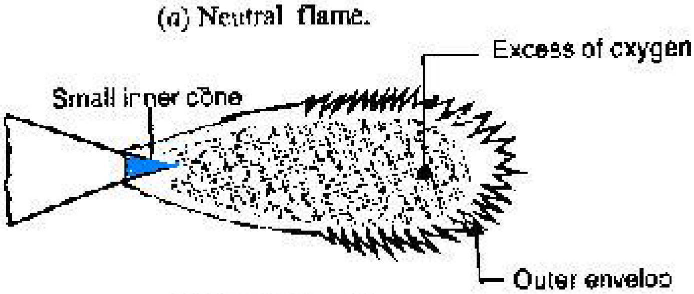


Gas Welding :

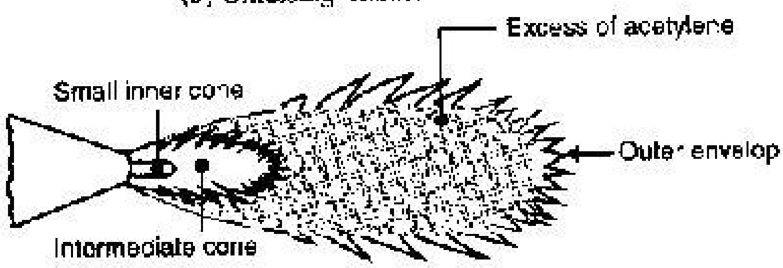


Gas Welding Equipment

(*a*) Neutral flame.



(*b*) Oxidising flame.



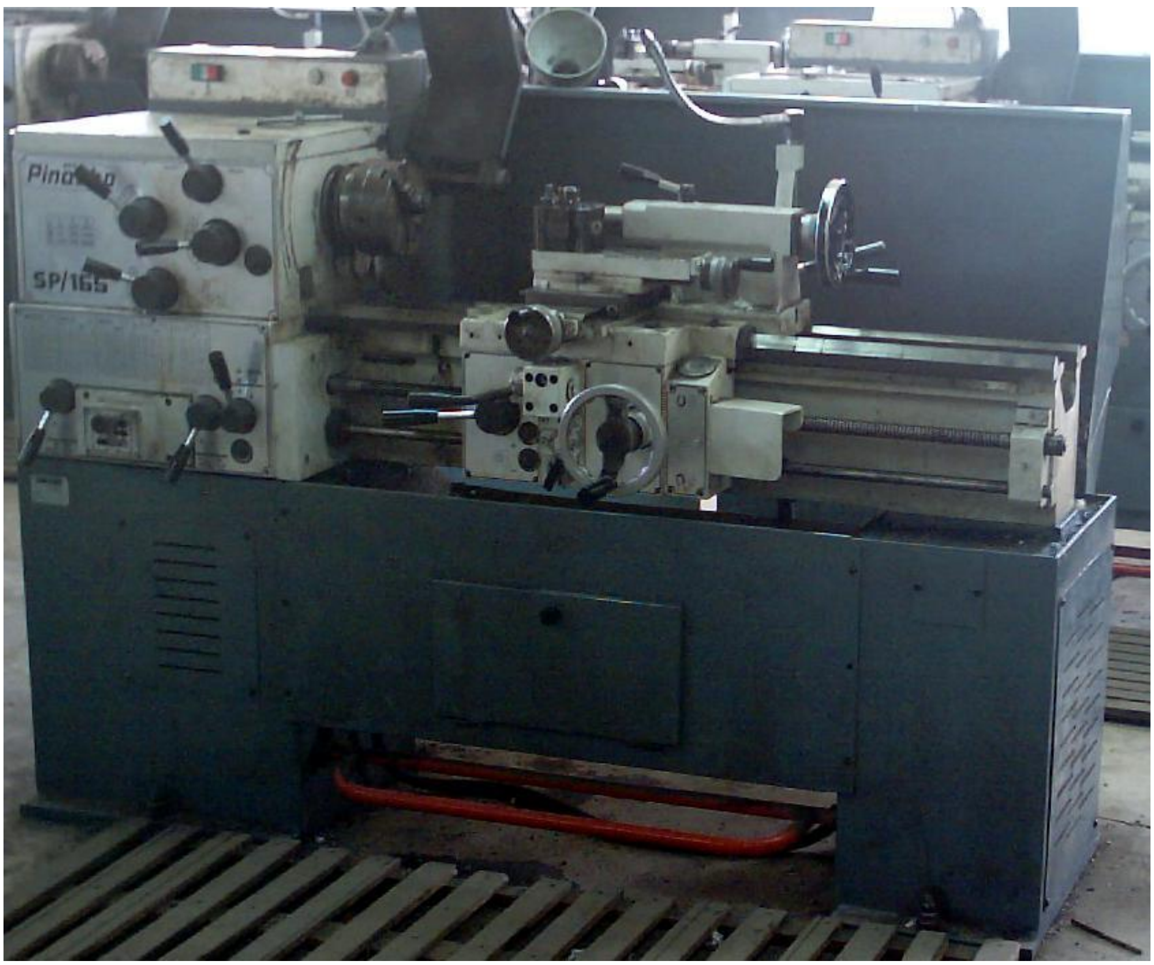
(*c*) Reducing or carbonising flame.

1. Introduction

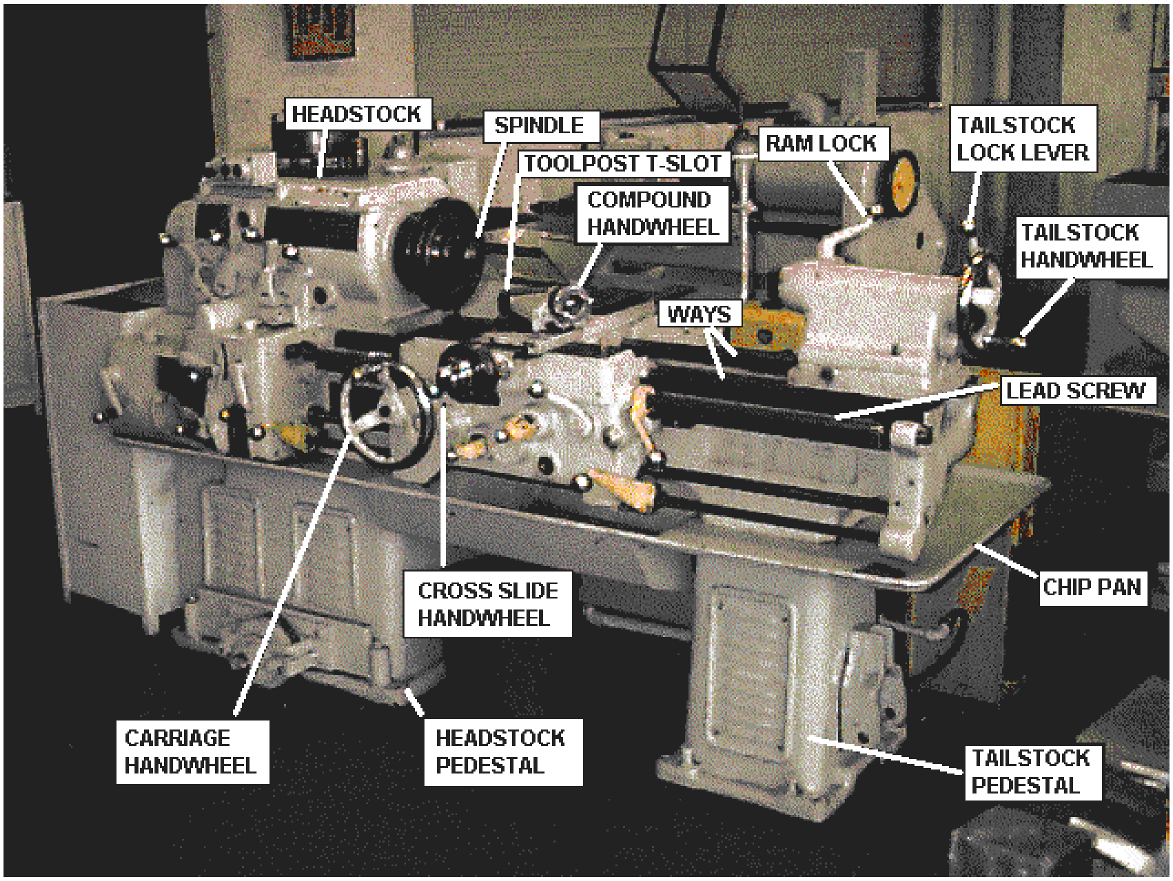
This training module is designed to give you 'hands-on' experience through which you can gain a good appreciation of this well-known type of machine tool. In particular your attention will be directed towards its operational uses and parameters, the general layout of controls, accessories, associated tooling, and the maintenance factors related to lathes.

In order that you can make the most use of the limited time available on lathes it is essential that you use every chance to consolidate what you observe. This type of work is largely self-motivated and the drive and desire to find out must come from you.

It takes a considerable time to become a skilled lathe operator and to possess all the skill of hand that goes with it. Therefore it is not expected that you will be manually skilled on completion of the module but you will have gained intellectually and without doubt, by practical involvement, some skill of hand will be achieved.



Lathe machine in Pulchowk Campus



---

2. Centre Lathe

The term Centre Lathe is derived from the fact that in its operation the lathe holds a piece of material between two rigid supports called centers, or by some other device such as a chuck or faceplate which revolves about the centre line of the lathe.

The lathe shown above is a typical example. This machine is usually used in a jobbing (one off) situation or for small batch work where it would be too expensive to specially 'tool up' for just a few items.

The lathe on which you will work is a machine used to cut metal. The spindle carrying the work is rotated whilst a cutting tool, which is supported in a tool post, is made to travel in a certain direction depending on the form of surface required. If the tool moves parallel to the axis of the rotation of the work a cylindrical surface is produced as in Fig 2 (a) , whilst if it moves at right angles to this axis it produces a flat surface as in Fig 2 (b).

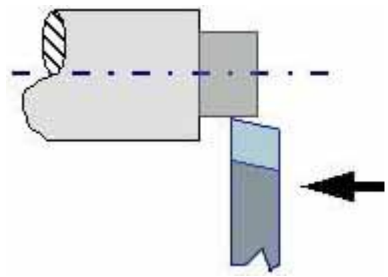


Figure 2a. Producing a Cylindrical Surface

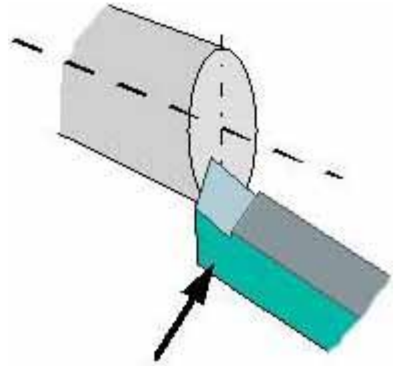


Figure 2b. Producing a Flat Surface

The lathe can also be used for the purposes shown in Fig 2c, 2d, 2e and 2f.

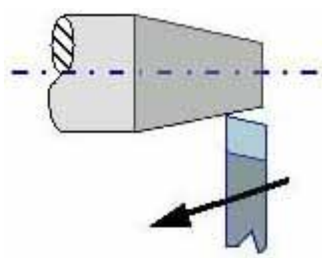


Figure 2c. Taper Turning

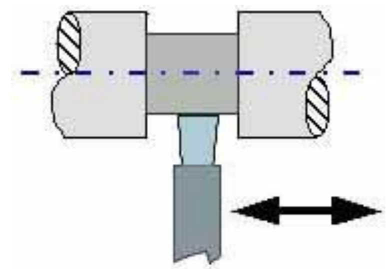


Figure 2d. Parting Off / Under Cutting

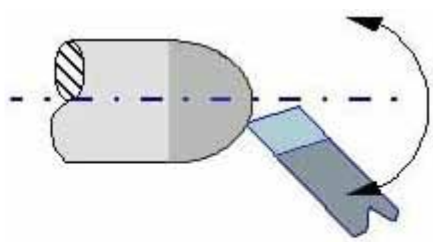


Figure 2e. Radius Turning Attachment

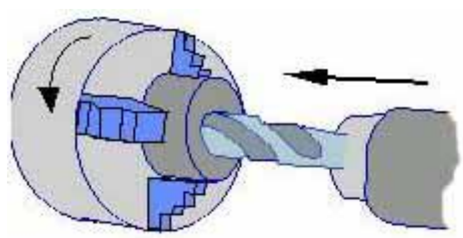


Figure 2f. Drilling on a Lathe

3. Cutting Tools

The tool used in a lathe is known as a single point cutting tool. It has one cutting edge or point whereas a drill has two cutting edges and a file has numerous points or teeth.

The lathe tool shears the metal rather than cuts as will be seen later and it can only do so if there is relative motion between the tool and the workpiece. For example, the work is rotating and the tool is moved into its path such that it forms an obstruction and shearing takes place. Of course the amount of movement is of paramount importance - too much at once could for instance result in breakage of the tool.

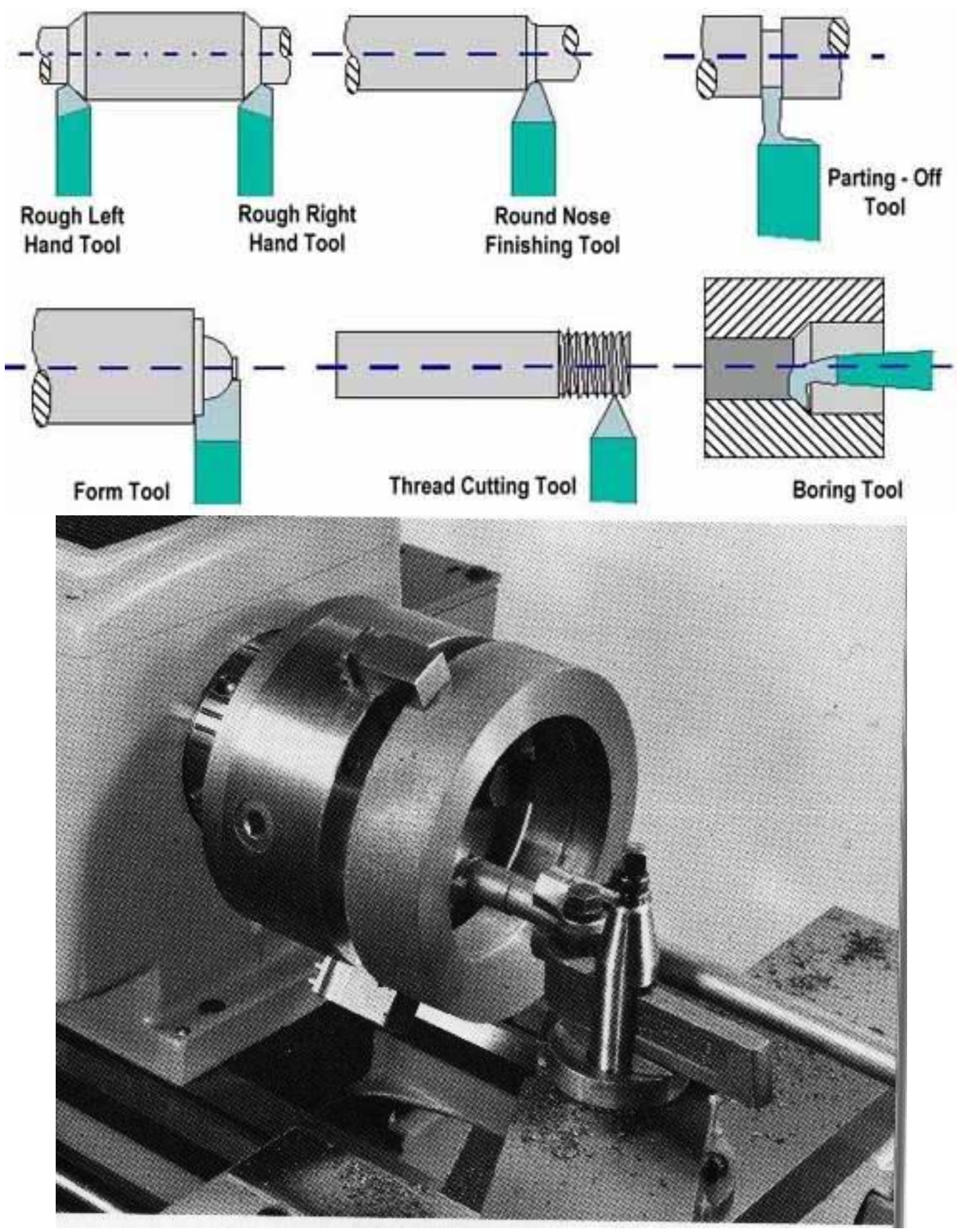


Figure 3. Types of Cutting Tool

The type and design of the tools selected will depend on the job in hand, the machining operation selected and the material to be cut. The correct tool especially the various face angles are essential if the operation is to be done in a cost-effective (i.e. productive) way. The tools used in a lathe are various, some of which are shown in figure 3.

The range of cutting tool types is extensive and a few examples only are shown in this handout. Nonetheless you should take every opportunity to look deeper into the types of tools available.

4. Basic Metal Cutting Theory

The usual conception of cutting suggests clearing the substance apart with a thin knife or wedge. When metal is cut the action is rather different and although the tool will always be wedge shaped in the cutting area and the cutting edge should always be sharp the wedge angle will be far too great for it to be considered knife shaped. Consequently a shearing action takes place when the work moves against the tool.

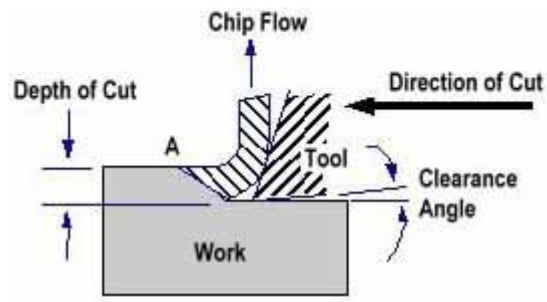


Figure 4. Basic Metal Cutting Theory

Figure 4 shows a tool being moved against a fixed work piece. When the cut is in progress the chip presses heavily on the top face of the tool and continuous shearing takes place across the shear plane AB. Although the Figure shows a tool working in the horizontal plane with the work piece stationary, the same action takes place with the work piece revolving and the tool stationary.

5. Tool Angles

There are three important angles in the construction of a cutting tool rake angle, clearance angle and plan approach angle.

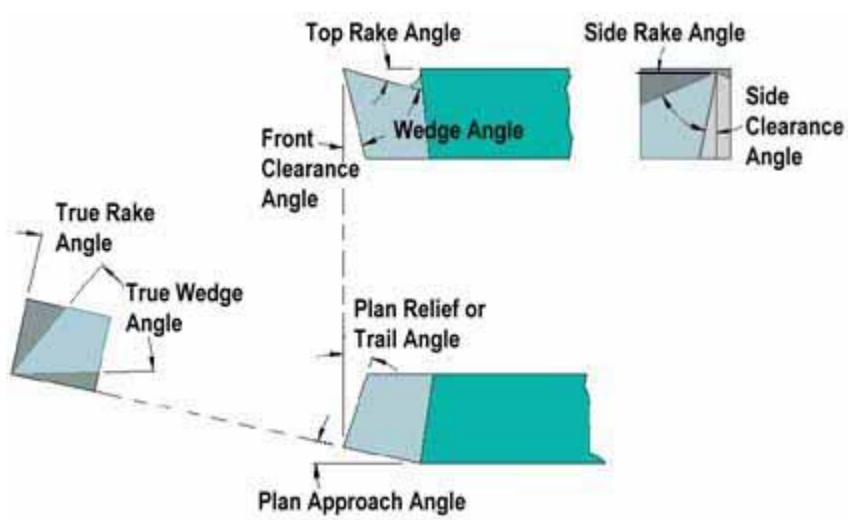


Figure 5. Main Features of a Single Point Cutting Tool

Rake Angle

Rake angle is the angle between the top face of the tool and the normal to the work surface at the cutting edge. In general, the larger the rake angle, the smaller the cutting force on the tool, since for a given depth of cut the shear plane AB, shown in Figure 4 decreases as rake angle increases. A large rake angle will improve cutting action, but would lead to early tool failure, since the tool wedge angle is relatively weak. A compromise must therefore be made between adequate strength and good cutting action.

Metal Being Cut	Cast Iron	Hard Steel / Brass	Medium Carbon Steel	Mild Steel	Aluminium
Top Rake Angle	0°	8°	14°	20°	40°

Table 1. Typical value for top rake angle

Clearance Angle

Clearance angle is the angle between the flank or front face of the tool and a tangent to the work surface originating at the cutting edge. All cutting tools must have clearance to allow cutting to take place. Clearance should be kept to a minimum, as excessive clearance angle will not improve cutting efficiency and will merely weaken the tool. Typical value for front clearance angle is 6° in external turning.

Plan Profile of Tool

The plan shape of the tool is often dictated by the shape of the work, but it also has an effect on the tool life and the cutting process. Figure 6 shows two tools, one where a square edge is desired and the other where the steps in the work end with a chamfer or angle. The diagram shows that, for the same depth of cut, the angled tool has a much greater length of cutting edge in contact with the work and thus the load per unit length of the edge is reduced. The angle at which the edge approaches the work should in theory be as large as possible, but if too large, chatter may occur. This angle, known as the Plan Approach Angle, should therefore be as large as possible without causing chatter.

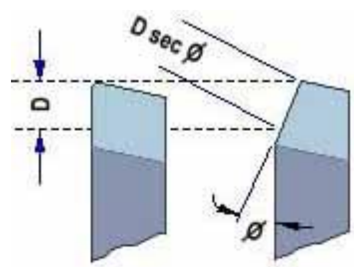


Figure 6. Plan Approach Angle

The trailing edge of the tool is ground backwards to give clearance and prevent rubbing and a good general guide is to grind the trailing edge at 90° to the cutting edge. Thus the Trail Angle or Relief Angle will depend upon the approach angle.

A small nose radius on the tool improves the cutting and reduces tool wear. If a sharp point is used it gives poor finish and wears rapidly.

---

6. Characteristics of Tool Material

For efficient cutting a tool must have the following properties:

Hot Hardness

This means the ability to retain its hardness at high temperatures. All cutting operations generate heat, which will affect the tool¡¦s hardness and eventually its ability to cut.

Strength and Resistance to Shock

At the start of a cut the first bite of the tool into the work results in considerable shock loading on the tool. It must obviously be strong enough to withstand it.

Low Coefficient of Friction

The tool rubbing against the workpiece and the chip rubbing on the top face of the tool produce heat which must be kept to a minimum.

---

7. Tool Materials in Common Use

High Carbon Steel

Contains 1 - 1.4% carbon with some addition of chromium and tungsten to improve wear resistance. The steel begins to lose its hardness at about 250° C, and is not favoured for modern machining operations where high speeds and heavy cuts are usually employed.

High Speed Steel (H.S.S.)

Steel, which has a hot hardness value of about 600° C, possesses good strength and shock resistant properties. It is commonly used for single point lathe cutting tools and multi point cutting tools such as drills, reamers and milling cutters.

Cemented Carbides

An extremely hard material made from tungsten powder. Carbide tools are usually used in the form of brazed or clamped tips. High cutting speeds may be used and materials difficult to cut with HSS may be readily machined using carbide tipped tool.

---

8. Tool life

As a general rule the relationship between the tool life and cutting speed is

$$VTn = C$$

where;
V = cutting speed in m/min
T = tool life in min
C = a constant

For high-speed steel tools the value of C ranges from 0.14 to 0.1 and for carbide tools the value would be 0.2.

---

9. Chip Formation & Chip Breaker

The type of chip produced depends on the material being machined and the cutting conditions at the time. These conditions include the type of tool used tool, rate of cutting condition of the machine and the use or absence of a cutting fluid.

Continuous Chip

This leaves the tool as a long ribbon and is common when cutting most ductile materials such as mild steel, copper and Aluminium. It is associated with good tool angles, correct speeds and feeds, and the use of cutting fluid.

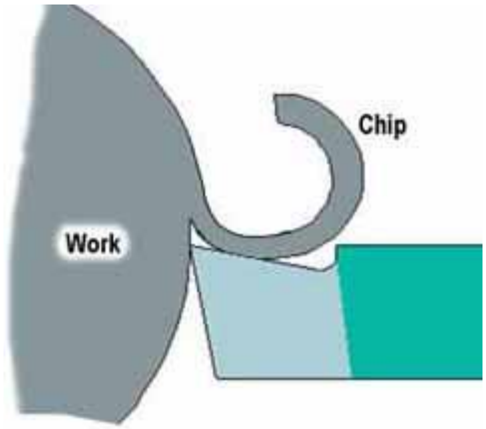


Figure 7. Continuous Chip

Discontinuous Chip

The chip leaves the tool as small segments of metal resulted from cutting brittle metals such as cast iron and cast brass with tools having small rake angles. There is nothing wrong with this type of chip in these circumstances.

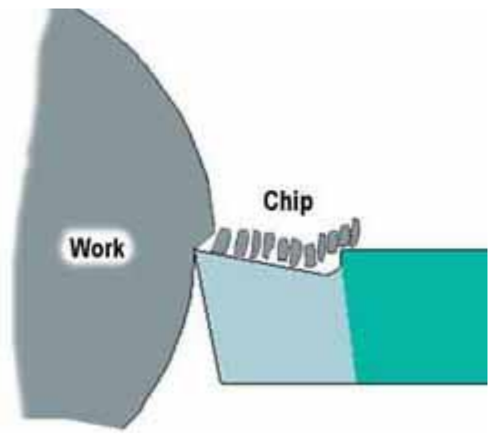


Figure 8. Discontinuous Chip

Continuous Chip with Builtup Edge

This is a chip to be avoided and is caused by small particles from the workpiece becoming welded to the tool face under high pressure and heat. The phenomenon results in a poor finish and damage to the tool. It can be minimised or prevented by using light cuts at higher speeds with an appropriate cutting lubricant.

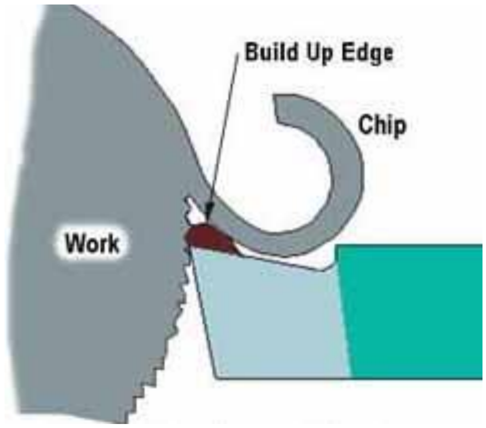


Figure 9. Continuous Chip with Buildup Edge

Chip Breaker

A chip breaker is used to break the continuous chip into sections so that the chips cannot tangle around the cutting tool. The simplest form of chip breaker is made by grinding a groove on the tool face a few millimeters behind the cutting edge.

---

10. Cutting Speed & Feed

As you proceed to the process of metal cutting, the relative `speed' of work piece rotation and `feed' rates of the cutting tool coupled to the material to be cut must be given your serious attention. This relationship is of paramount importance if items are to be manufactured in a cost-effective way in the minimum time, in accordance with the laid down specifications for quality of surface finish and accuracy. You, as a potential supervisory / management level engineer, must take particular note of these important parameters and ensure that you gain a fundamental understanding of factors involved.

Cutting Speed

All materials have an optimum Cutting Speed and it is defined as the speed at which a point on the surface of the work passes the cutting edge or point of the tool and is normally given in meters/min. To calculate the spindle Speed required,

$$N = \frac{CS \times 1000}{\pi d}$$

Where:
N = Spindle Speed (RPM)
CS = Cutting Speed of Metal (m/min)
d = Diameter of Workpiece

Table 2 shows the cutting speed recommended for some common metals. It may be possible to exceed these speeds for light finishing cuts. For heavy cuts they should be reduced.

Metal	meters /min
Cast Iron	20-28
Mild Steel	18-25
High Speed Steel	12-18
Brass	45-90
Bronze	15-21
Aluminium	up to 300

Table 2. Cutting Speed

Feed

The term `feed' is used to describe the distance the tool moves per revolution of the workpiece and depends largely on the surface finish required. For roughing out a soft material a feed of up to 0.25 mm per revolution may be used. With tougher materials this should be reduced to a maximum of 0.10 mm/rev. Finishing requires a finer feed then what is recommended.

---

11. Cutting Fluid & Lubricant

The aims in metal cutting are to retain accuracy, to get a good surface finish on the workpiece and at the same time to have a longer tool life.

However during the metal cutting process heat is generated due to:

- the deformation of the material ahead of the tool
- friction at the tool point

Heat generated due to friction can readily be reduced by using a lubricant. Heat caused by deformation cannot be reduced and yet it can be carried away by a fluid. Thus the use of a cutting fluid will serve to reduce the tool wear, give better surface finish and a tighter dimensional control.

The proper selection, mixing and application of cutting fluids is however often misunderstood and frequently neglected in machining practice. In order that the cutting fluid performs its functions properly it is necessary to ensure that the cutting fluid be applied directly to the cutting zone so that it can form a film at the sliding surfaces of the tool.

Cutting fluids in common use

Water

It has a high specific heat but is poor in lubrication and also encourages rusting. It is used as a cooling agent during tool grinding.

Soluble Oils

Oil will not dissolve in water but can be made to form an intimate mixture or emulsion by adding emulsifying agents. The oil is then suspended in the water in the form of tiny droplets. These fluids have average lubricating abilities and good cooling properties. Soluble oils are suitable for light cutting operations on general purpose machines where high rates of metal removal are often not of prime importance. There are many forms of soluble oil in the market and the suppliers instruction should be followed regarding the proportions of the `mix'.

Mineral Oils

They are used for heavier cutting operations because of their good lubricating properties and are commonly found in production machines where high rates of metal removal are employed. Mineral oils are very suitable for steels but should not be used on copper or its alloys since it has a corrosive effect.

Vegetable Oils

They are good lubricants but are of little used since they are liable to decompose and smell badly.

---

12. Screw Cutting

During this module you are required to explore the use of the lathe to cut, amongst other things, a metric screw thread on a bar. It is a slightly more difficult task than plain turning because it involves accurate setting up of the tool and exact setting of feed in relation to the work rotation. Once this is done however, and this you will be shown, the process of screw cutting becomes relatively simple. Fig 10 shows the arrangement in simplified form.

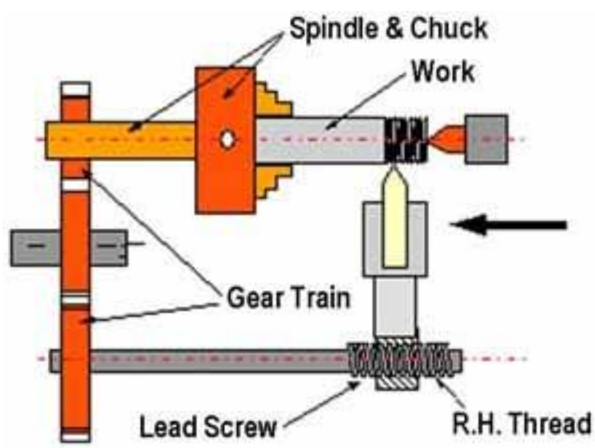


Figure 10. Screw Cutting Set-up

There are many different forms of screw thread, Fig 11 shows the 'sections' of three most common types.

More types and specifications of screw threads can be found in any Workshop Technology Hand Books and you must get used to finding such information and knowing how to apply it.

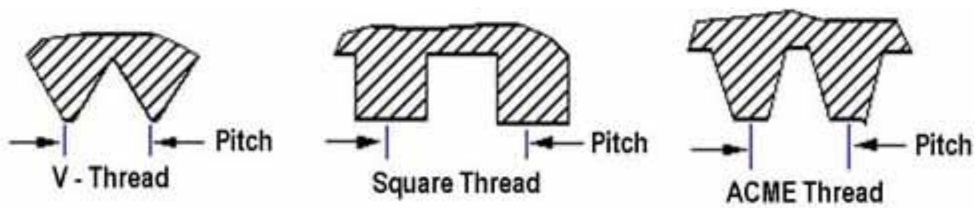


Figure 11. Types of Screw Thread

---

13. Safety

It is imperative that you fully understand that machine tools are potentially dangerous and that you must at all times:

Follow the laid down Section and IC Safety Rules.

> Know what to do in an emergency. NEVER switch your machine tool on for the first time until given permission by your Staff Member to do so. At varying stages in your programme if the Staff Member is satisfied with your operational knowledge you will be given permission to proceed on specific steps unsupervised. This is a measure of the Staff Member confidence in you and you should be pleased that you are so trusted and live up to that trust by taking all reasonable safety precautions.

Well-qualified and enthusiastic IC staffs are ready and willing to help you and it is up to you to make most use of their willingness to transfer their technical knowledge and their experience to you.

---

14. Conclusion

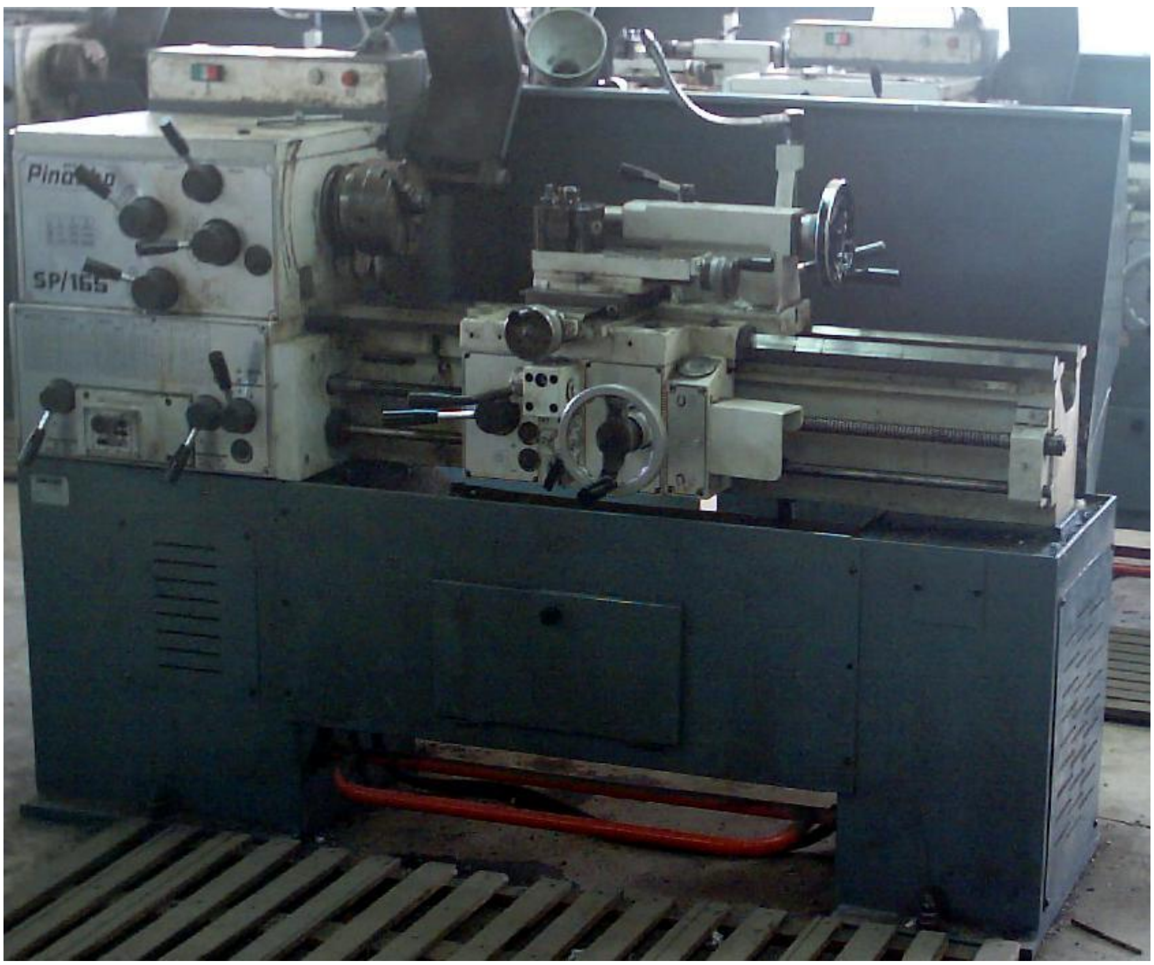
Lathes are normally robust in construction and they will, with good care, last for many years. It is not unusual for instance to see good lathes still in uses that are 50 years old. To ensure good, accurate, trouble free use it is necessary that the correct maintenance routines are regularly carried out and that important surfaces such as slide-ways are kept well protected so as to reduce wear and thus maintain good accuracy. This aspect of 'good husbandry' should be of interest to you and you will be expected to demonstrate an understanding of this. In this respect the types of maintenance routine carried out, the design and accessibility of the maintenance system, and the lubricants used, are all factors that require your attention.

1. Introduction

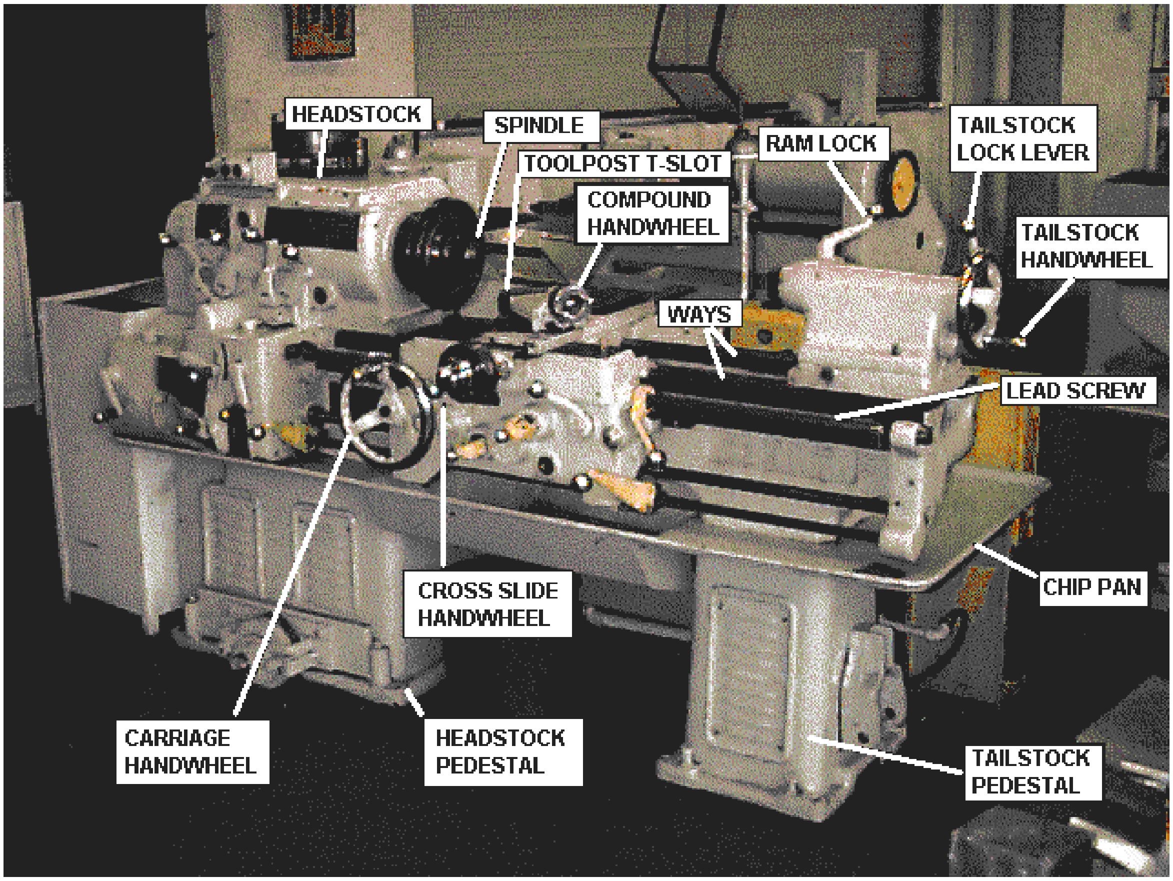
This training module is designed to give you 'hands-on' experience through which you can gain a good appreciation of this well-known type of machine tool. In particular your attention will be directed towards its operational uses and parameters, the general layout of controls, accessories, associated tooling, and the maintenance factors related to lathes.

In order that you can make the most use of the limited time available on lathes it is essential that you use every chance to consolidate what you observe. This type of work is largely self-motivated and the drive and desire to find out must come from you.

It takes a considerable time to become a skilled lathe operator and to possess all the skill of hand that goes with it. Therefore it is not expected that you will be manually skilled on completion of the module but you will have gained intellectually and without doubt, by practical involvement, some skill of hand will be achieved.



Lathe machine in Pulchowk Campus



---

2. Centre Lathe

The term Centre Lathe is derived from the fact that in its operation the lathe holds a piece of material between two rigid supports called centers, or by some other device such as a chuck or faceplate which revolves about the centre line of the lathe.

The lathe shown above is a typical example. This machine is usually used in a jobbing (one off) situation or for small batch work where it would be too expensive to specially 'tool up' for just a few items.

The lathe on which you will work is a machine used to cut metal. The spindle carrying the work is rotated whilst a cutting tool, which is supported in a tool post, is made to travel in a certain direction depending on the form of surface required. If the tool moves parallel to the axis of the rotation of the work a cylindrical surface is produced as in Fig 2 (a) , whilst if it moves at right angles to this axis it produces a flat surface as in Fig 2 (b).

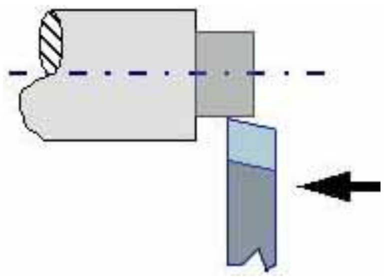


Figure 2a. Producing a Cylindrical Surface

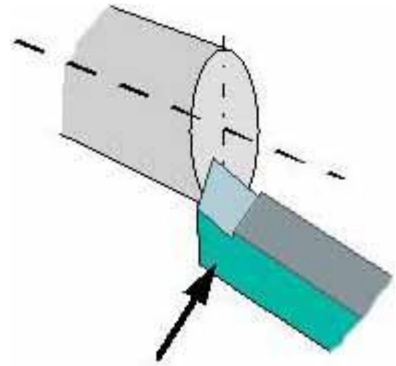


Figure 2b. Producing a Flat Surface

The lathe can also be used for the purposes shown in Fig 2c, 2d, 2e and 2f.

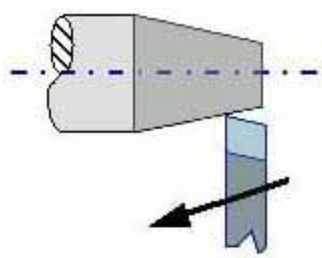


Figure 2c. Taper Turning

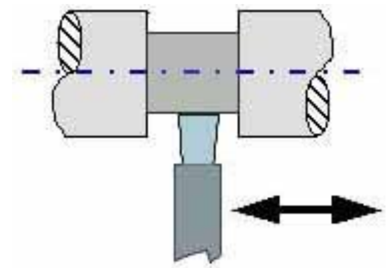


Figure 2d. Parting Off / Under Cutting

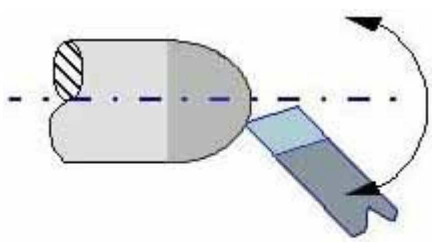


Figure 2e. Radius Turning Attachment

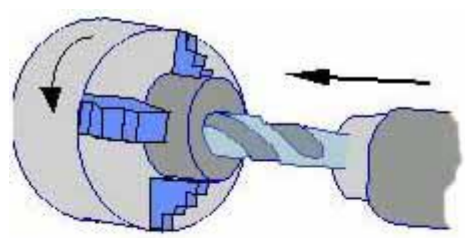


Figure 2f. Drilling on a Lathe

---

3. Cutting Tools

The tool used in a lathe is known as a single point cutting tool. It has one cutting edge or point whereas a drill has two cutting edges and a file has numerous points or teeth.

The lathe tool shears the metal rather than cuts as will be seen later and it can only do so if there is relative motion between the tool and the workpiece. For example, the work is rotating and the tool is moved into its path such that it forms an obstruction and shearing takes place. Of course the amount of movement is of paramount importance - too much at once could for instance result in breakage of the tool.

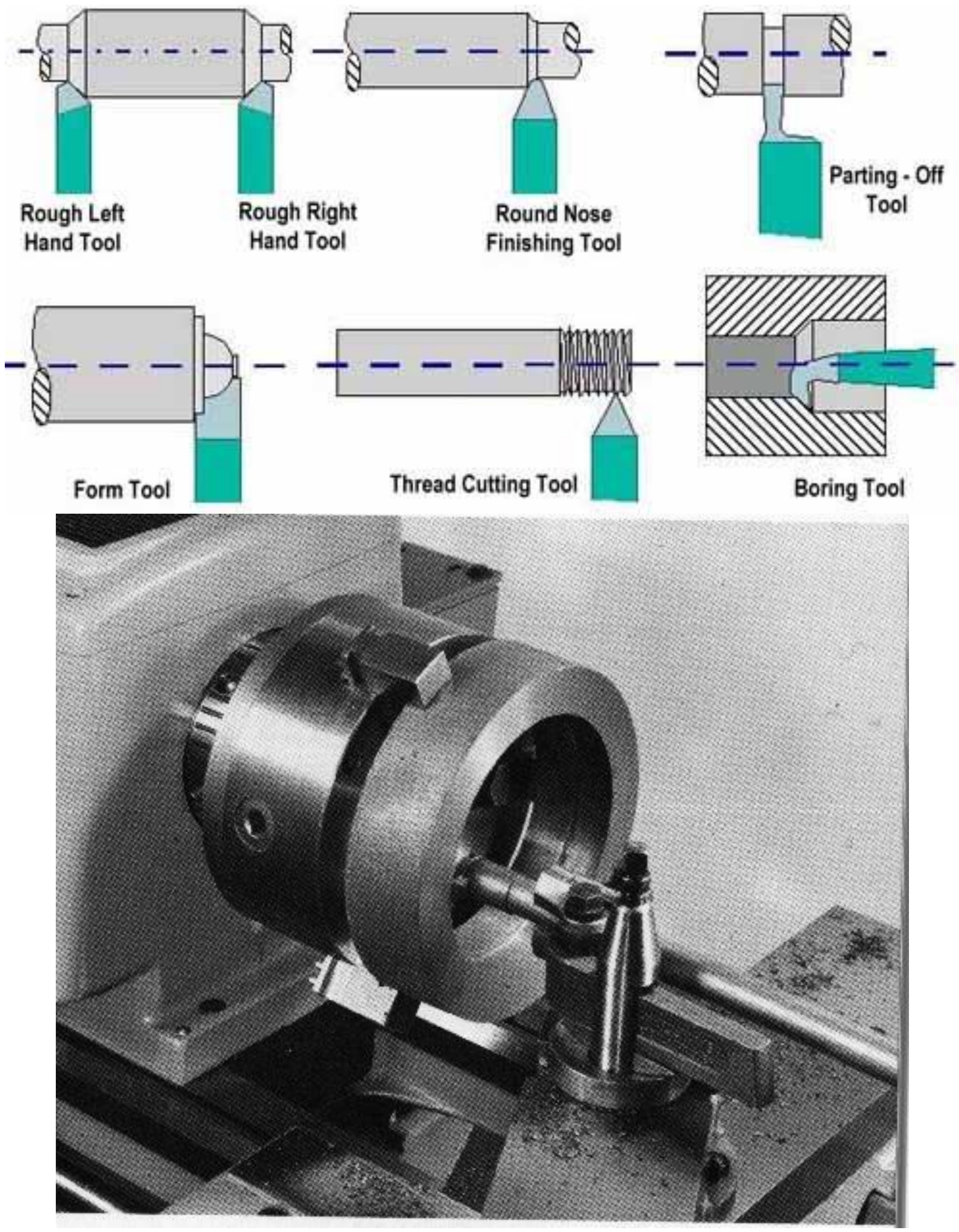


Figure 3. Types of Cutting Tool

The type and design of the tools selected will depend on the job in hand, the machining operation selected and the material to be cut. The correct tool especially the various face angles are essential if the operation is to be done in a cost-effective (i.e. productive) way. The tools used in a lathe are various, some of which are shown in figure 3.

The range of cutting tool types is extensive and a few examples only are shown in this handout. Nonetheless you should take every opportunity to look deeper into the types of tools available.

---

4. Basic Metal Cutting Theory

The usual conception of cutting suggests clearing the substance apart with a thin knife or wedge. When metal is cut the action is rather different and although the tool will always be wedge shaped in the cutting area and the cutting edge should always be sharp the wedge angle will be far too great for it to be considered knife shaped. Consequently a shearing action takes place when the work moves against the tool.

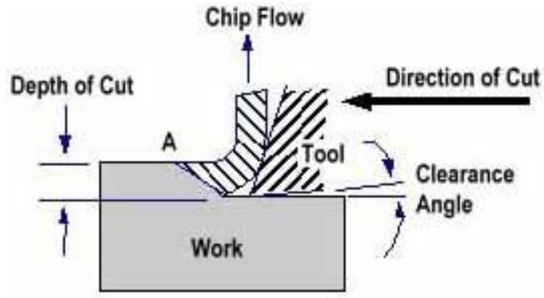


Figure 4. Basic Metal Cutting Theory

Figure 4 shows a tool being moved against a fixed work piece. When the cut is in progress the chip presses heavily on the top face of the tool and continuous shearing takes place across the shear plane AB. Although the Figure shows a tool working in the horizontal plane with the workpiece stationary, the same action takes place with the work piece revolving and the tool stationary.

---

5. Tool Angles

There are three important angles in the construction of a cutting tool rake angle, clearance angle and plan approach angle.

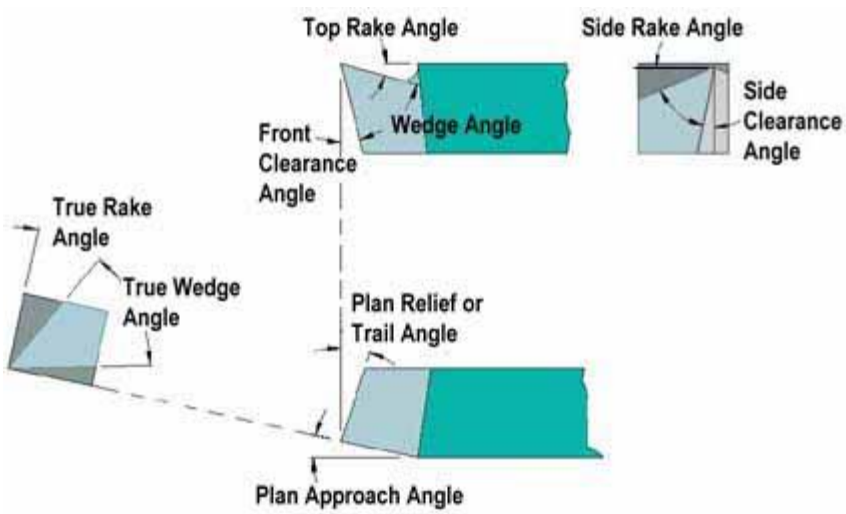


Figure 5. Main Features of a Single Point Cutting Tool

Rake Angle

Rake angle is the angle between the top face of the tool and the normal to the work surface at the cutting edge. In general, the larger the rake angle, the smaller the cutting force on the tool, since for a given depth of cut the shear plane AB, shown in Figure 4 decreases as rake angle increases. A large rake angle will improve cutting action, but would lead to early tool failure, since the tool wedge angle is relatively weak. A compromise must therefore be made between adequate strength and good cutting action.

Metal Being Cut	Cast Iron	Hard Steel / Brass	Medium Carbon Steel	Mild Steel	Aluminium
Top Rake Angle	0°	8°	14°	20°	40°

Table 1. Typical value for top rake angle

Clearance Angle

Clearance angle is the angle between the flank or front face of the tool and a tangent to the work surface originating at the cutting edge. All cutting tools must have clearance to allow cutting to take place. Clearance should be kept to a minimum, as excessive clearance angle will not improve cutting efficiency and will merely weaken the tool. Typical value for front clearance angle is 6° in external turning.

Plan Profile of Tool

The plan shape of the tool is often dictated by the shape of the work, but it also has an effect on the tool life and the cutting process. Figure 6 shows two tools, one where a square edge is desired and the other where the steps in the work end with a chamfer or angle. The diagram shows that, for the same depth of cut, the angled tool has a much greater length of cutting edge in contact with the work and thus the load per unit length of the edge is reduced. The angle at which the edge approaches the work should in theory be as large as possible, but if too large, chatter may occur. This angle, known as the Plan Approach Angle, should therefore be as large as possible without causing chatter.

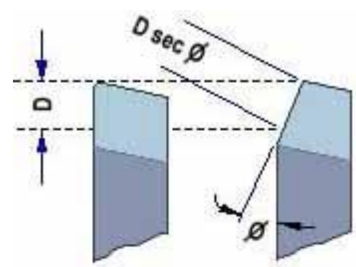


Figure 6. Plan Approach Angle

The trailing edge of the tool is ground backwards to give clearance and prevent rubbing and a good general guide is to grind the trailing edge at 90° to the cutting edge. Thus the Trail Angle or Relief Angle will depend upon the approach angle.

A small nose radius on the tool improves the cutting and reduces tool wear. If a sharp point is used it gives poor finish and wears rapidly.

---

6. Characteristics of Tool Material

For efficient cutting a tool must have the following properties:

Hot Hardness

This means the ability to retain its hardness at high temperatures. All cutting operations generate heat, which will affect the tool¡¦s hardness and eventually its ability to cut.

Strength and Resistance to Shock

At the start of a cut the first bite of the tool into the work results in considerable shock loading on the tool. It must obviously be strong enough to withstand it.

Low Coefficient of Friction

The tool rubbing against the workpiece and the chip rubbing on the top face of the tool produce heat which must be kept to a minimum.

---

7. Tool Materials in Common Use

High Carbon Steel

Contains 1 - 1.4% carbon with some addition of chromium and tungsten to improve wear resistance. The steel begins to lose its hardness at about 250° C, and is not favoured for modern machining operations where high speeds and heavy cuts are usually employed.

High Speed Steel (H.S.S.)

Steel, which has a hot hardness value of about 600° C, possesses good strength and shock resistant properties. It is commonly used for single point lathe cutting tools and multi point cutting tools such as drills, reamers and milling cutters.

Cemented Carbides

An extremely hard material made from tungsten powder. Carbide tools are usually used in the form of brazed or clamped tips. High cutting speeds may be used and materials difficult to cut with HSS may be readily machined using carbide tipped tool.

---

8. Tool life

As a general rule the relationship between the tool life and cutting speed is

$$VTn = C$$

where;
V = cutting speed in m/min
T = tool life in min
C = a constant

For high-speed steel tools the value of C ranges from 0.14 to 0.1 and for carbide tools the value would be 0.2.

---

9. Chip Formation & Chip Breaker

The type of chip produced depends on the material being machined and the cutting conditions at the time. These conditions include the type of tool used tool, rate of cutting condition of the machine and the use or absence of a cutting fluid.

Continuous Chip

This leaves the tool as a long ribbon and is common when cutting most ductile materials such as mild steel, copper and Aluminium. It is associated with good tool angles, correct speeds and feeds, and the use of cutting fluid.

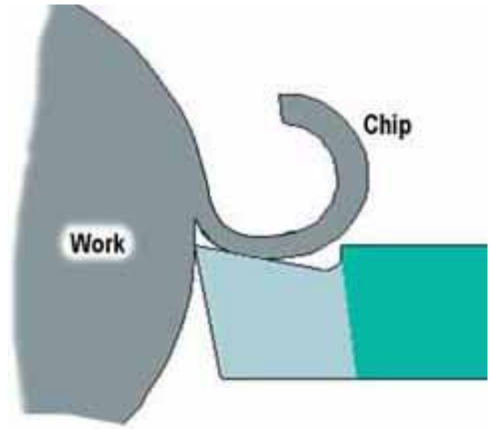


Figure 7. Continuous Chip

Discontinuous Chip

The chip leaves the tool as small segments of metal resulted from cutting brittle metals such as cast iron and cast brass with tools having small rake angles. There is nothing wrong with this type of chip in these circumstances.

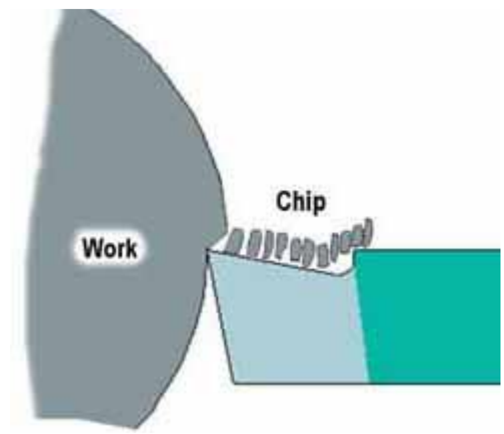


Figure 8. Discontinuous Chip

Continuous Chip with Builtup Edge

This is a chip to be avoided and is caused by small particles from the workpiece becoming welded to the tool face under high pressure and heat. The phenomenon results in a poor finish and damage to the tool. It can be minimised or prevented by using light cuts at higher speeds with an appropriate cutting lubricant.

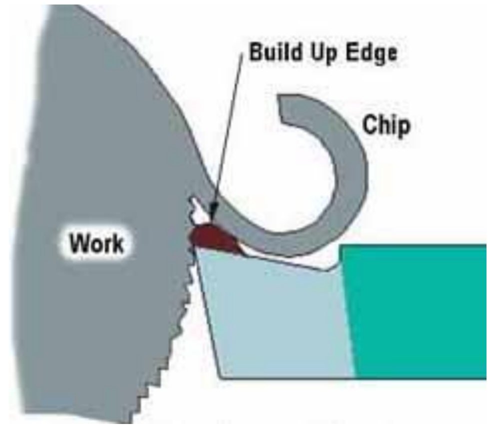


Figure 9. Continuous Chip with Buildup Edge

Chip Breaker

A chip breaker is used to break the continuous chip into sections so that the chips cannot tangle around the cutting tool. The simplest form of chip breaker is made by grinding a groove on the tool face a few millimeters behind the cutting edge.

---

10. Cutting Speed & Feed

As you proceed to the process of metal cutting, the relative `speed' of work piece rotation and `feed' rates of the cutting tool coupled to the material to be cut must be given your serious attention. This relationship is of paramount importance if items are to be manufactured in a cost-effective way in the minimum time, in accordance with the laid down specifications for quality of surface finish and accuracy. You, as a potential supervisory / management level engineer, must take particular note of these important parameters and ensure that you gain a fundamental understanding of factors involved.

Cutting Speed

All materials have an optimum Cutting Speed and it is defined as the speed at which a point on the surface of the work passes the cutting edge or point of the tool and is normally given in meters/min. To calculate the spindle Speed required,

$$N = \frac{CS \times 1000}{\pi d}$$

Where:
N = Spindle Speed (RPM)
CS = Cutting Speed of Metal (m/min)
d = Diameter of Workpiece

Table 2 shows the cutting speed recommended for some common metals. It may be possible to exceed these speeds for light finishing cuts. For heavy cuts they should be reduced.

Metal	meters /min
Cast Iron	20-28
Mild Steel	18-25
High Speed Steel	12-18
Brass	45-90
Bronze	15-21
Aluminium	up to 300

Table 2. Cutting Speed

Feed

The term `feed' is used to describe the distance the tool moves per revolution of the workpiece and depends largely on the surface finish required. For roughing out a soft material a feed of up to 0.25 mm per revolution may be used. With tougher materials this should be reduced to a maximum of 0.10 mm/rev. Finishing requires a finer feed then what is recommended.

---

11. Cutting Fluid & Lubricant

The aims in metal cutting are to retain accuracy, to get a good surface finish on the workpiece and at the same time to have a longer tool life.

However during the metal cutting process heat is generated due to:

- the deformation of the material ahead of the tool
- friction at the tool point

Heat generated due to friction can readily be reduced by using a lubricant. Heat caused by deformation cannot be reduced and yet it can be carried away by a fluid. Thus the use of a cutting fluid will serve to reduce the tool wear, give better surface finish and a tighter dimensional control.

The proper selection, mixing and application of cutting fluids is however often misunderstood and frequently neglected in machining practice. In order that the cutting fluid performs its functions properly it is necessary to ensure that the cutting fluid be applied directly to the cutting zone so that it can form a film at the sliding surfaces of the tool.

Cutting fluids in common use

Water

It has a high specific heat but is poor in lubrication and also encourages rusting. It is used as a cooling agent during tool grinding.

Soluble Oils

Oil will not dissolve in water but can be made to form an intimate mixture or emulsion by adding emulsifying agents. The oil is then suspended in the water in the form of tiny droplets. These fluids have average lubricating abilities and good cooling properties. Soluble oils are suitable for light cutting operations on general purpose machines where high rates of metal removal are often not of prime importance. There are many forms of soluble oil in the market and the suppliers instruction should be followed regarding the proportions of the `mix'.

Mineral Oils

They are used for heavier cutting operations because of their good lubricating properties and are commonly found in production machines where high rates of metal removal are employed. Mineral oils are very suitable for steels but should not be used on copper or its alloys since it has a corrosive effect.

Vegetable Oils

They are good lubricants but are of little used since they are liable to decompose and smell badly.

---

12. Screw Cutting

During this module you are required to explore the use of the lathe to cut, amongst other things, a metric screw thread on a bar. It is a slightly more difficult task than plain turning because it involves accurate setting up of the tool and exact setting of feed in relation to the work rotation. Once this is done however, and this you will be shown, the process of screw cutting becomes relatively simple. Fig 10 shows the arrangement in simplified form.

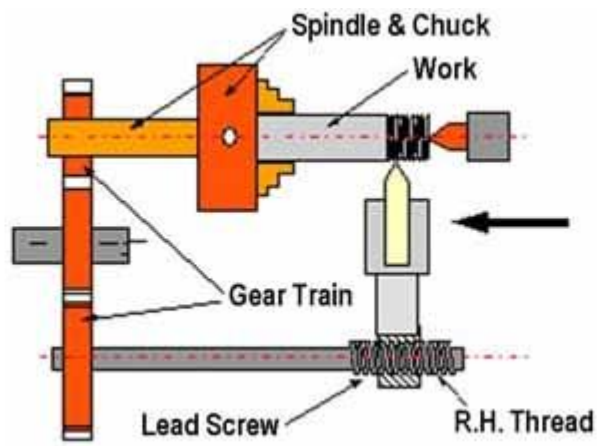


Figure 10. Screw Cutting Set-up

There are many different forms of screw thread, Fig 11 shows the 'sections' of three most common types.

More types and specifications of screw threads can be found in any Workshop Technology Hand Books and you must get used to finding such information and knowing how to apply it.

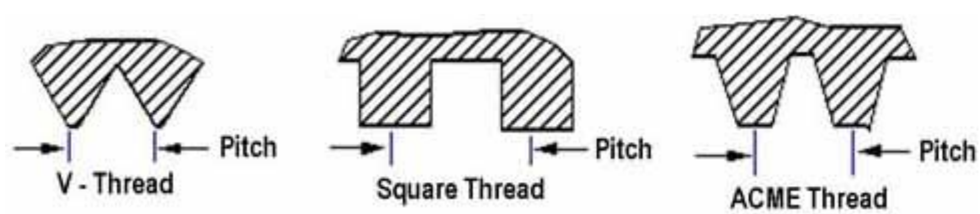


Figure 11. Types of Screw Thread

---

13. Safety

It is imperative that you fully understand that machine tools are potentially dangerous and that you must at all times:

Follow the laid down Section and IC Safety Rules.

Know what to do in an emergency. NEVER switch your machine tool on for the first time until given permission by your Staff Member to do so. At varying stages in your programme if the Staff Member is satisfied with your operational knowledge you will be given permission to proceed on specific steps unsupervised. This is a measure of the Staff Member confidence in you and you should be pleased that you are so trusted and live up to that trust by taking all reasonable safety precautions.

Well-qualified and enthusiastic IC staffs are ready and willing to help you and it is up to you to make most use of their willingness to transfer their technical knowledge and their experience to you.

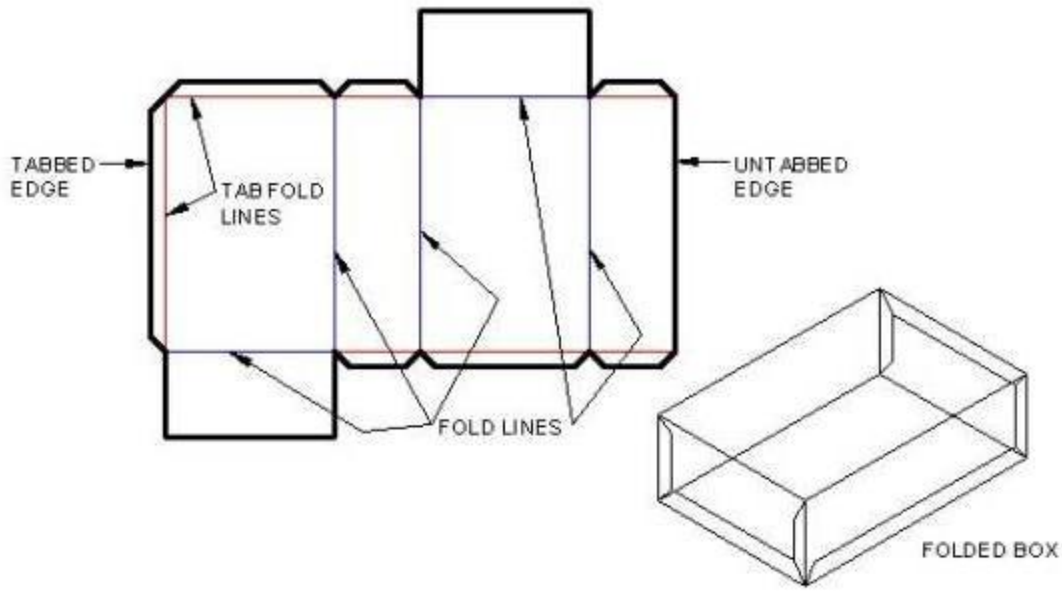
---

14. Conclusion

Lathes are normally robust in construction and they will, with good care, last for many years. It is not unusual for instance to see good lathes still in uses that are 50 years old. To ensure good, accurate, trouble free use it is necessary that the correct maintenance routines are regularly carried out and that important surfaces such as slide-ways are kept well protected so as to reduce wear and thus maintain good accuracy. This aspect of 'good husbandry' should be of interest to you and you will be expected to demonstrate an understanding of this. In this respect the types of maintenance routine carried out, the design and accessibility of the maintenance system, and the lubricants used, are all factors that require your attention.

Sheetmetal Drawings

Many objects, such as cardboard and metal boxes, cake pans, mail boxes, HVAC ducts, roof gutters, are made from flat sheet material that, when folded, formed, or rolled, will take the shape of an object. Since a definite shape and size are desired, a regular orthographic drawing of the object is made first: then a development drawing is made to show the complete surface or surfaces laid out in a flat plane. Sheetmetal or surface development drawings are sometimes referred to as pattern drawings.



Beads:

Raised or depressed areas in sheet-metal parts usually provided for purpose of rigidity.

Bend Allowance:

Length of material required for a bend from bend line to bend line.

Bend Angle:

Full line through which metal is bent: not to be confused with angle between flange and adjacent leg.

Bend Line:

Tangent line where bend changes to a flat surface. Each bend has two bend lines.

Blank:

A flat sheet metal piece, approximately correct size, on which a pattern has been laid out and is ready for machining and forming.

Center Line of bend:

A radial line, passing through bend radius, which bisects included angle between bed lines.

Developed Length;

Length of flat pattern layout. This length is always shorter than the sum of mold line dimensions on part.

Flat Pattern:

Pattern used to lay out sheet metal part blank.

Leg:

The flat or straight section of a part after bending or forming.

Mold Line:

A line of intersection formed by projection of two flat surfaces.

Setback:

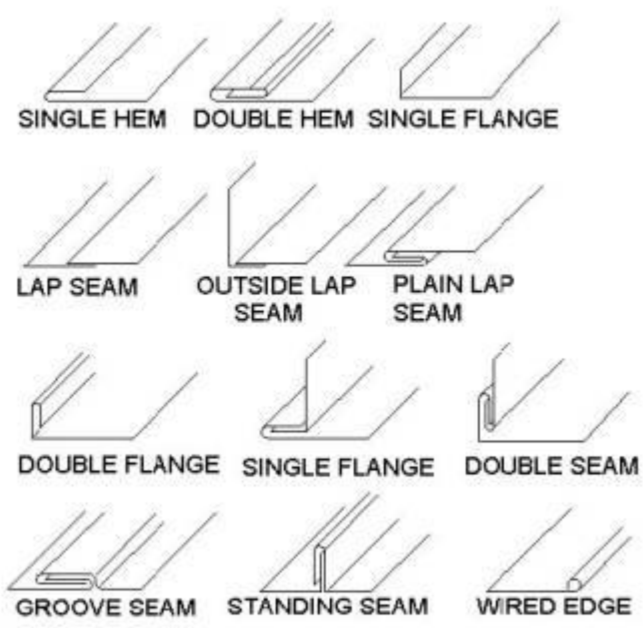
Amount of deduction in length resulting from a bend to be developed in a flat pattern.

Straight-Line Development:

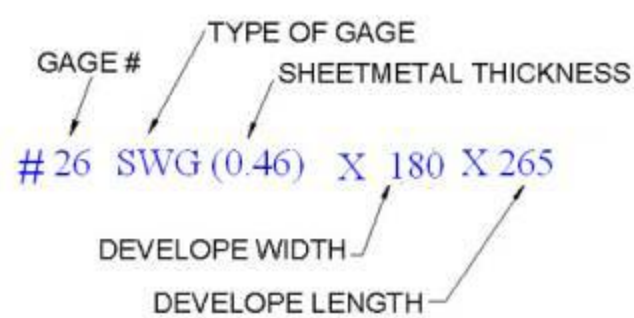
The term given to the development of an object that has surfaces on flat plane of projection (Flat Pattern).

Bend Relief Cutouts:

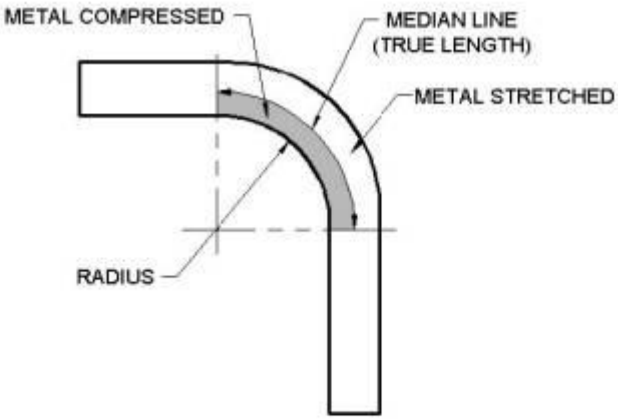
When bends intersect, a relief (notch) must be cut out to prevent the part from buckling or wrinkling.



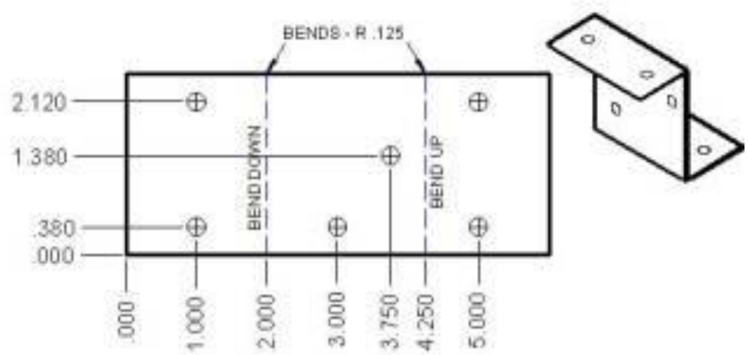
Here you are given some of the most common sheet-metal hems and joints used in the industry. They are used to bend single sheets of sheetmetal or join to pieces of sheet-metal together to form a bond

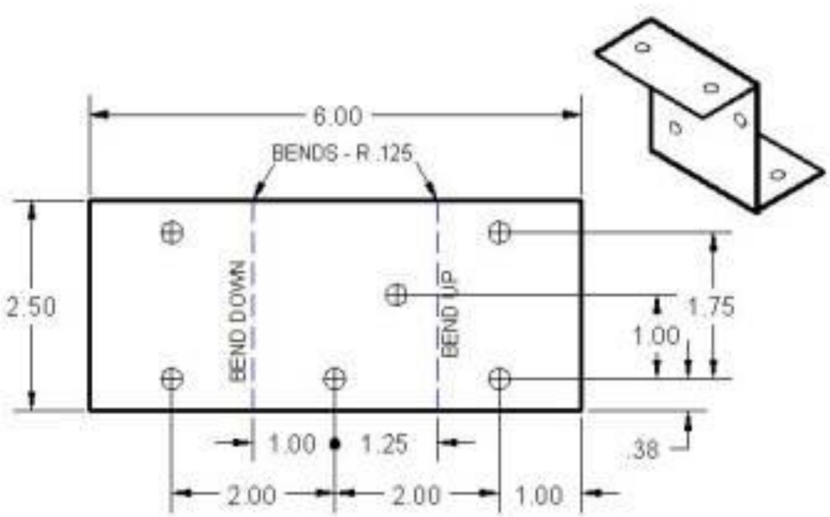


Here is you are given a typical sheet-metal call out you might see on a drawing. Each part of the call out is broken down into its individual meaning.



When sheet metal is bent, the medium line along the interior of the metal remains true length throughout the bending process. The metal on the outside of this line is stretched and the metal on the inside of the bend is compressed. For most metals, the median line is approximately 44 percent of the distance from the interior face. The location of the median line forms the basis for the bend allowance calculations. The harder the metal, the greater the bend length. In actual practice some experimentation may need to be done with the different metals and the different shipments of the same metal alloy to arrive at the correct allowance.





Sheetmetal is usually dimensioned using the unidirectional method of dimensioning. Dimensions are read from top to bottom and from left to right. Under the unidirectional method of dimensioning two types of dimensioning styles may be used, they are the **linear;** and **datum;** styles. The linear dimension style, dimensions are displayed horizontal and vertically on the object. In the datum dimensioning style all dimensions are taken from a 0 reference point and may be used by a CNC machine to drill and cut holes into the Sheet metal.

Top | Home

Marking Out, Measurement, Fitting & Assembly

1. Introduction

This training module is designed to give you a good appreciation on the various types of band tools commonly used for measurement, marking out, and metal removal. Emphasis is not placed on you to become a skilful fitter within such a short period of training, but rather to let you understand the uses of common hand tools and appreciate the importance of fitting work in the trade. Nevertheless, on completion of the training and through the hands-on practice given, you will acquire some of the basic skills and techniques involved with these hand processes.

To get the maximum benefit from the training, it is essential that you use every opportunity to consolidate what you observe and to interact between yourself and the staff member in charge of your training. This is self-motivated and the drive must come from you.

---

2. Why Use Hand Tools?

"Man without Tools is nothing; with tools he is all." - This sentence is defined by Thomas Carlyle has well elaborated the importance of tooling to a man.

The term '**Tooling**' as applied to the engineering discipline refers to any equipment or instruments that give helps in the production of a product or any related activities. Simply speaking, it ranges from the most fundamental type of hand tools such as a File to the very complex machine tools such as a CNC Machining Centre.

Thus, one may ask the question - Why we still have to use band tools in this modern age of technologies?

Yes, it is reasonable to say that the efficiency of any hand processes is low and the outcome quality depends highly upon the skill of individuals. Perhaps it is fair to consider the following points before a definite answer is given to the above question: -

1. Accuracy

Although the CNC machine can give a higher degree of dimensional accuracy when compared with the inconsistent outcome of hand fitting, the extreme high degree of flatness required for a surface table or a machine slide way is usually obtained by hand scraping only.

2. Flexibility

Hand processes are very flexible and can be carried out at any place where necessary while machining processes are not. In addition, machining usually require a rigid setting up, while fitting is simple.

3. Quantity

For large batch size, advanced production machines are commonly employed in order to maintain the accuracy as well as the efficiency. But for "jobbing type" works, such as the manufacture of a prototype or the repairing of a single component, it would be uneconomic to use these advanced machine tools. Instead, "jobbing type" works are usually produced by conventional machining and followed by hand fitting where necessary.

4. Final Assembly

In the assembly of precise component parts, no matter how accurate they are being produced, a skilled fitter is often required to give the necessary "finishing touch" on them to ensure that everything goes together correctly.

---

3. Measuring Tools in Workshop

3a. Calipers

Calipers are the very simple tools used together with a steel rule for the measurement or comparison of linear dimensions. An experienced worker can achieve +/- 0.05mm in the measurement. Calipers are classified into two types: -

Figure 1. Outside Calipers

Outside Calipers

Outside calipers (figure 1) are used for measuring external dimensions such as the length, diameter, or even the thickness of a solid.

Inside Calipers

Inside calipers (figure 2) are used for measuring internal dimensions such as the diameter of a hole, or the width of a slot etc.

Figure 2. Inside Calipers

3b. Vernier Calipers

Vernier Calipers (figure 3) are more precise tools capable for measuring external dimensions, internal dimensions, and depths. Besides the two pairs of measuring jaws and the depth gauge, its main features also include a main scale and a vernier scale.

Figure 3. Vernier Calipers

The resolution of a vernier scale is determined by the difference on the distance of one division on the main scale and one division on the vernier as shown in figure 4. For example: A vernier scale of length 49mm is divided into 50 equal divisions. That means **ONE** division on the vernier represents 49/50=0.98 mm while ONE division on the main scale represents 1mm. Then, the resolution of the vernier is 1mm - 0.98mm = 0.02mm.

Figure 4. Vernier Reading

3c. Vernier Height Gauge

A vernier height gauge (figure 5) is used for measuring height of an object or for marking lines onto an object of given distance from a datum base.

Figure 5. Vernier Height Gauge

3d. Micrometer

A micrometer is a more precise measuring instrument than the vernier calipers. The accuracy is come from the fine thread on the screw spindle. The ratchet prevents excess force from being applied. Generally, the screw spindle has a pitch of 0.5mm. The thimble is divided into 50 equal divisions.

Common types of micrometers used in the workshops are: -

Outside Micrometer

An outside micrometer (figure 6) is used for measuring external dimensions. The work to be measured is placed between the anvil and the tip of the spindle.

Figure 6. Outside Micrometer

Inside Micrometer

This is similar in structure to an outside micrometer and is used for measuring internal dimensions as shown in figure 7.

Figure 7. Inside Micrometer

Depth Micrometer

A depth micrometer (figure 8) is used for measuring the depth of a hole, slot and keyway etc. A complete set of depth micrometer is equipped with spindles of different lengths, which can be interchanged to suit different measuring ranges.

Figure 8. Depth Micrometer

3e. Protractor

Engineer's Protractor

Engineer's protractor (figure 9) is a general purpose tool used for the measuring / checking of angles e.g. the angle of drill head, angle of cutting tool, and even for the marking out of angles on a component part.

Figure 9. Engineer's Protractor

Vernier Protractor

This is a precision measuring tool that the accuracy of measurement can reach ¡Ó5 minutes of an angle through the vernier scale as shown in figure 10.

Figure 10. Vernier Protractor

3f. Combination Set

Combination set (figure 11) is a set of equipment combining the functions of protractor, engineer square, steel rule, Centre finder, level rule, and scriber.

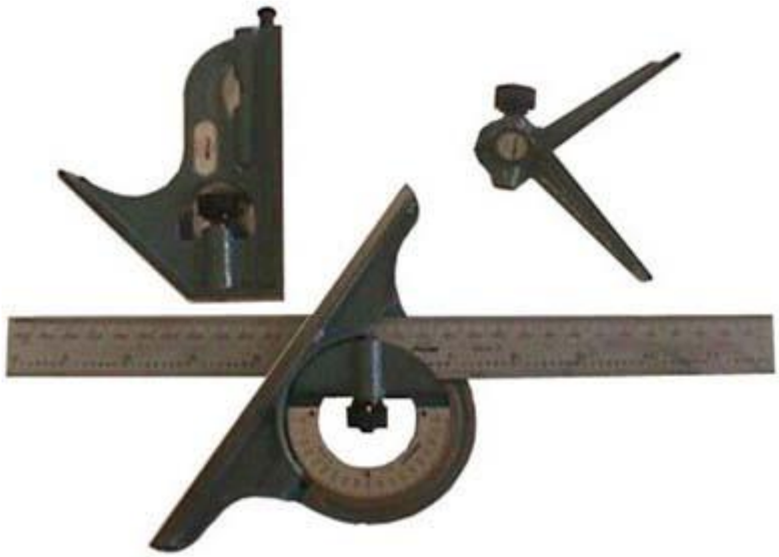


Figure 11. Combination Set

3g. Dial Indicator

The principle of dial indicator (dial gauge) is that the linear mechanical movement of the stylus is magnified and transferred to the rotation of pointer as shown in figure 12. The accuracy of dial indicator can be up to 0.001mm. It is usually used for calibration of machine.

Figure 12. Dial Indicator

4. Marking Out Tools in Workshop

Marking out is the preliminary work of providing guidance lines and centres before cutting and machining. The lines are in 3-D and full-scale. The workpiece can then be cut or machined to the required shapes and sizes. The common tools used for marking out are as follow:

4a. Scriber

A scriber (figure 13) is used for scratching lines onto the workpiece. It is made of hardened tool steel.

Figure 13. Scriber

4b. Engineer's Square

Engineer's square (figure 14) is made of hardened tool steel. It is used for checking the straightness and the squareness of a workpiece. It can also be used for marking perpendicular lines onto a workpiece.

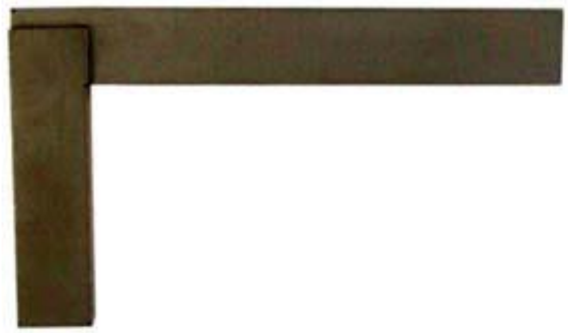


Figure 14. Engineer's Square

4c. Spring Dividers

Spring dividers (figure 15) are made of hardened tool steel. The legs are used for scribing arcs or circles onto a workpiece.

Figure 15. Spring Dividers

4d. Punch

There are two types of punch namely the Centre Punch and the Dot Punch. A dot punch has a point angle of 60¢X and it is used for making of small dots on the reference line. The centre punch has a point angle of 90¢X as shown in figure 16 and it is used for making a large indent on a workpiece for drilling. Both punches are made of hardened tool steel.

Figure 16. Punch

4e. Surface Plate

Surface plate (figure 17) is made of malleable cast iron. It has been machined and scraped to a high degree of flatness. The flat surface is being used as a datum surface for marking out and for measuring purposes. If it can stand on the floor, it is called surface table.

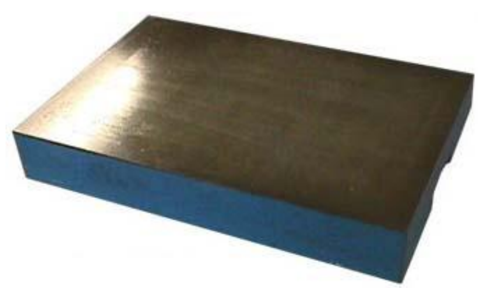


Figure 17. Surface Plate

4f. Angle Plate

An angle plate (figure 18) are used for supporting or setting up work vertically, and are provided with holes and slots through which securing bolts can be located. It is made of cast iron and ground to a high degree of accuracy.

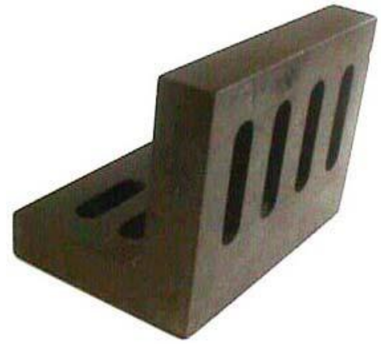


Figure 18. Angle Plate

4g. Vee Block

Vee blocks (figure 19) usually in a couple are made of cast iron or steel in case-hardening. They are generally used for holding circular workpiece for marking out or machining.

Figure 19. Vee Block

5. Hand Tools for Workshop

5a. Bench Vice

A bench vice (figure 20) is the device for holding the workpiece where most hand processes to be carried out. The body of the vice is made of cast iron while the two clamping jaws are made of hardened tool steel. Some bench vice has a swivel base, which can set the workpiece at an angle to the table. The vice height should be correct ergonomically. Vice clamps, made of copper are fitted over the vice jaws when holding finished work to avoid damage to the finish surfaces.

Care of Vices

a. Do not direct impact the vice body by the hammer.
b. Light hammering can be done on and only on the anvil of the vice.
c. To avoid over clamping, the handle of the vice should be tightened by hand only

Figure 20. Bench Vice

5b. Files

Files are the most important hand tools used for the removal of materials. They are made of hardened high carbon steel with a soft 'tang'. to which a handle can be fixed. Files are categorised as follows:-

Figure 21. File

Length - measured from the shoulder to the tip.
Shape - the cross-sectional profile.
Grade - the spacing and pitch of the teeth.
Cut - the patterns of cutting edge.

Save Edge

There are no cutting edges on one side of the hand file. The purposes for the save edge is to avoid the worker damage the work, when he is filing a shoulder position. Shape of Files

1. **Hand File** - The common file used for roughing and finishing. It is a rectangular in section and parallel in width. It has double cut teeth on two faces, single cut teeth on one edge, and one save edge.

Figure 22a. Hand File

2. **Flat File** - It is similar to a hand file rectangular in section, tapered slightly in width and thickness towards the tip. It has Double Cut teeth on two faces and Single Cut teeth on two sides.

Figure 22b. Flat File

3. **Half-round File** - The section is a chord of a circle with its taper towards the tip. It is used for forming radii, grooves, etc. and the flat side is used for finishing flat surfaces.

Figure 22c. Half-round File

4. **Round File** - This is of round section tapering toward the end. It is used for enlarging holes, producing internal round corners. Usually double cut in the larger sizes, and single cut for the smaller sizes.

Figure 22d. Round File

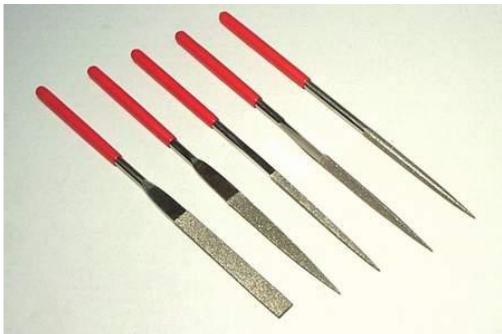
5. **Square File** - This is square in section, with tapered towards the tip, and usually double cut on all four faces. It is used for filing rectangular slots or grooves.

Figure 22e. Square File

6. **Three Square File** - It is also known as triangular file. This is a triangular in section, with tapered towards the tip with double cut on both faces. It is used for filing corners or angles less than 90°

Figure 22f. Three Square File

7. **Needle Files** -



Needle files are a set of small files with their shapes made in a way similar to the large ones. They are generally used for small and delicate works such as the repair of small instruments.

Grade

This refers to the pitch (spacing) of the teeth that spread throughout the whole length of the file. Files with a rougher grade of cut give a faster metal removal rate but a poorer surface finish or the vice versa. It should be noted that, for the same grade of cut, a longer file would have a coarser pitch than a shorter one.

The grades are as follows:

Bastard cut - medium teeth for general purposes, especially suitable for mild steel.

Second cut - finer teeth for cutting hard metals.

Smooth cut - fine teeth for finishing.

Three grades of cut are in common use

Cut Pattern

Single Cut - There is only one set of cutting teeth to one edge. It gives a less efficient cutting but a better finish. It is suitable for the soft metal.

Double Cut - A double cut file has one set of teeth cut at 70 degrees to one edge, and another set of grooves cut at 45 degrees to the other edge. It is thus more efficient in cutting. It is easy to clog the teeth when it is work on the soft metal.

Rasp - Very coarse teeth, like the nail, it is commonly used for the cutting off soft materials such as rubber, PVC, or wood etc.

Safety and Care of Files

Files teeth are brittle and therefore file should be placed properly and should not be stacked on other tools.. New files should never be used on hard materials. E.g. castings or welding. Some brittle metal, e.g. brass is not readily filed with the worn teeth. A new file should be used for these purposes and the file must be kept in another stock. Remove the pinning regularly by a file card/wire brush. Cutting is carried on the forward stroke. It is very danger to use files without handles.

5c. File Card

When filing the soft metals, the small pieces of metal will tend to clog the teeth. If the file is not cleaned, this small piece of metal will scratch on the surface of the work. We call it pinning. This case is frequently appeared when applying a new smooth file on the soft metals. The pinning can be removed with a File Card as shown in figure 23, which is a wire brush mounted on a block of wood. Sweep the file card along the grooves on the file until the pinning is removed.

Figure 23. File Card

5d. Hacksaw

A hacksaw is generally used for cutting a metal into pieces.

It consists of a frame and a saw blade as shown below. It is a "U" shaped steel frame with a pistol handgrip and a saw blade as shown in figure 24. The frame may be of fixed type to take only one length of blade, or adjustable to take different blade lengths. It has a wing nut to adjust the tension of the blade.

Figure 24. HackSaw

Saw Blade

Saw blades are made of high carbon steel, alloy steel or High Speed Steel. They are supplied according to material, hardening, length and pitch.

1. Hardening - Usually the saw blade is supplied with all hard or flexible grade. The all hard is very brittle, and it is suitable for the skillful user only. The flexible grade is tough, so it can twist an angle. It is suitable for cutting a curve or for the beginner to use.

2. Material - Usually the saw blade is supplied with High Carbon Steel (HCS) and High Speed Steel (HSS). The HCS will annealed from the heat generated by fraction of cutting. The HCS, saw blade will lost its hardness when cutting the hard metal. The HSS can keep its hardness unless improper use.

3. Pitch - It is grading according to the number of teeth per 25mm.
Coarse blade (18T) is most suitable for soft material and thick workpiece.
Medium blade (24T) is suitable for steel pipe.
Fine blade (32T) is suitable for the thin metal sheet and thin copper pipe.

For safety, it is advice that to keep at least 3 teeth of the blade, stand on the workpiece.

Figure 25. Pitches of Saw Blade

4. Length - The length of the blade is determined by the distance between the outside edges of the holes, which fit over the pegs.

5. Set - The teeth have a "set" to either side alternately, which causes the blade to cut a slit wider than the thickness of the blade, to prevent jamming.

Safety and Care of Hacksaw

1. The cutting action is carried on the forward action only. So the blade must be mounted with its teeth pointing forward.
2. Suitable tension should be applied on the blade to avoid breakage or loosen.
3. Change the blade if some teeth are broken.
4. Avoid rapid and erratic strokes of cut.
5. Avoid too much pressure.
6. Workpiece must be hold firmly.

5e. Hammer

The type most commonly used is the ball pein hammer, which has a flat striking face and a ball-shaped end (call the pein). Hammer heads are made from medium carbon steel. The two ends must be hardened and tempered, the centre of the head with the eye being left soft. It is specified according to its weight.

Figure 26. Hammer

Safety and Care of Hammer

1. The hammer head is firmly fixed to the shaft by a wedge.
2. The striking face of the hammer head does not wear.

5. Drill

6. Drill and Drilling

Drill Chuck With Key

Drill Chuck without Key

Drilling is the process of cutting holes in metals by using a drilling machine as shown in figure 27. Drills are the tools used to cut away fine shavings of material as the drill advances in a rotational motion through the material.

6a. Twist Drill

The twist drill (figure 28) is made from High Speed Steel, tempered to give maximum hardness throughout the parallel cutting portion. Flutes are incorporated to carry away the chips of metal and the outside surface is relieved to produce a cutting edge along the leading side of each flute.

Figure 27. Drilling Machine

Figure 28. Twist Drills

6b. Drill Features

The point of the drill is ground to an angle of 59¢X to the centre line to give two equal cutting edges, and each side is ground back to give " relief " of about 12¢X to each cutting edge as shown in figure 29.

It is very important that drill points are central and that the lip angles are equal and that the cutting edges are unchipped and the clearance angle correct. To obtain this state and ensure correct angles it is important that drills are ground in a grinding machine.

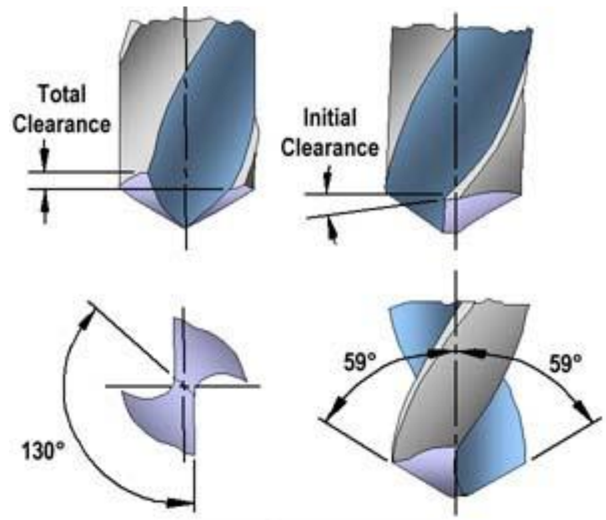


Figure 29. Drill Features

6c. Drill Operating Parameters

It is essential to select the correct cutting speed and the feed. Followings are the most common used cutting speed and feed rate.

Cutting Speed	
Material	**Cutting Speed**
Mild steel	6 - 9 m/min
Stainless Steel	4 ¡V 9 m/min
Aluminium	30 ¡V 36 m/min

Feed Rate	
5.5 mm diameter twist drill	0.08 ¡V 0.15 mm/rev
30 mm diameter twist drill	0.04 ¡V 0.55 mm/rev

6d. Special Type of Drill

Counterbore Drill (figure 30) ¡V To form a flat, or cylindrical recess to accommodate the head of the bolt. It is also used to provide a level base on the rough surfaces for nuts and washers.

Countersink Drill (figure 31) ¡V To form a conical shaped recess to enable a countersunk screw or bolt to fit flush with the surface of the work.

Figure 30. Counterbore Drill

Figure 31. Countersink Drill

6e. Safety and Care on Drilling

Figure 32. Drill Gaurd

i. Twist drill must be clamped in the drill chuck tightly
ii. The workpiece to be drilled must be firmly secured by vice, or clamps.
iii. Drill guard (figure 32) must be closed before switch on the machine.
iv. Use the correct drilling speed and apply suitable drilling force It is advisable to release the drill occasionally, lift the drill, and clear the hole of cutting.
v. Apply cutting fluid in the cutting except for drilling Cast iron.
vi. Take care, when the drill is nearly penetrated through the workpiece.
vii. The "screw in" action can lift up the workpiece.

7. Reamer and Threading Tools

7a. Reamer

Functions of reamer are

1. to control the diameter of a hole
2. to improve the internal surface finish
3. to improve the roundness of the hole

Reamer is made of hardened High Carbon Steel or High Speed Steel. It is classified into hand reamer and machine reamer.

1. Hand Reamer

Figure 35. Hand Reamer

Hand reamer (figure 33) has two types of flutes: - straight and spiral flutes. The spiral flutes hand reamer has a left hand spiral flutes. The purpose of the design is to prevent the reamer "screw in" the hole.

2. Machine Reamer

Figure 35. Machine Reamer

Machine reamer (figure 34) has a straight shank or taper shank (Morse taper). The taper shank can fit directly into the spindle of a machine while the straight shank is hold by the collet.

3. Expanding Reamer/Adjustable Reamer

Figure 35. Adjustable Reamer

The cutting diameter can be slightly varied by adjusting an inner taper against the loss cutting blades as shown in figure 35. This type is used primarily for repetitive work to maintain a consistent size throughout.

4. Safety, Precautions & Operation in Reaming

a. Care the sharp cutting edge especially in handling.
b. The amount of material to be removed by a reamer should be as small as possible, approximately 2-4% of diameter.
c. Reamer must only be turned in one direction, both cutting and removing the tools, otherwise the tool may jam.
d. Lubricant oil should be used except when cutting cast iron and brass.
e. Reaming can enlarge the size of hole, but cannot correct the position error in drilling.

7b. Tap

Taps (figure 36) are used to cut the internal screw threads. Taps are made of hardened High Carbon Steel or High Speed Steel. The ends of the shank are square to fit a wrench (figure 37). Usually taps are provided in set of three -- taper, second and plug tap.

1. Taper Tap
The tap is tapered off for a length of 8 to 10 threads and is the first tap to be used in a hole to start the thread form.

2. Second Tap
The tap is tapered off for a length of 4 to 5 threads to facilitate picking up the threads cut by the taper tap.

Figure 36. Taps

3. Plug Tap
This is fully threaded throughout its length and is called a 'bottoming' tap. This tap used to cut the bottom of a blind hole.

Figure 37. Tap Wrench

Precautions & operation in tapping

a. The size of the hole is important and the correct drill size should be determined from the handbook, standard table in the workshop or the recommendation on the shank of the tap.
b. Use taper tap first ensuring that it is kept square with top surface of work
c. Always use the correct size of wrench for the tap in use.
d. Lubricant oil should be used except when cutting cast iron and brass.
e. Use both hands to hold the wrench to maintain even torque.
f. About every half turn reverse action slightly to break the swarf and clear the threads.

When the tap reaches the bottom of the blind hole, care must be taken not to force as tap may break in the hole.

7c. Die

Dies are used for cutting external threads on round bar or tubes. Dies are made of Hardened High Carbon Steel or High Speed Steel.

1. Split Die or Button Die
Split die is held in place in the stock as shown in figure 38. The split permits a small amount of adjustment in the size of the die by adjusting the screws in the stock. Since split dies cut their thread complete in one cut, the die thread are tapered and back off for one third of their length.

Figure 38. Split Die & Stock

2. Die nuts
Die nuts (figure 39) are not capable of any adjustment. They are not usually employed for cutting threads from the bar, but for rectifying damage to existing threads. They are externally formed to hexagonal shape for use with a spanner.

Figure 39. Die Nut

Precautions and Operation of Die

a. The diameter of the blank rod must not larger than the outside diameter of thread to be cut.
b. Ensure that the die is set perpendicular to the rod.
c. Lubricant oil should be used except when cutting cast iron and brass.
d. About every half-turn reverse frequently to break the swarf otherwise the thread will tear.

Introduction

Workshop technology is the technology that gives the idea about materials and tools used and manufacturing process for proper job. It gives the ideas about handling machines, names of parts of machines and their function.

Also, in the field of engineering it gives lot of techniques and knowledge of forming the articles like dust pan, hammer etc. with the help of bench work. The production of article by using basic hand operation and simple hand tools is known as bench work. It gives the knowledge of using the proper tools for proper job.

Objectives:

1. To name and describe the use of different types of measuring instrument in workshop.
2. To know the functions and parts of each and every tools during job.
3. To describe the necessity of safety precaution that is to be considered during job.
4. To describe the working principle and uses of machines tools like drilling, grinding, shaping, lathe, etc.
5. To get the knowledge of proper tools for appropriate job.
6. To know the process of filling, types of file, hammer, types of hammer, saw, types of saw etc.

Tools and materials required:

Materials required are:

S.N.	Product	Materials required	Dimension (mm)
1	Dust pan	GI Sheet	250*200
2	hammer	a) Metal bar	25*25*100
		b) Metal rod	L=250, radius=9

Tools required are:

1. Bench vice
2. Steel scale
3. Scissors
4. Hacksaw
5. Hammers
    a) Ball peen hammer
    b) Cross peen hammer
    c) Plastic hammer
    d) Mallet hammer
6. Centre punch
7. Scriber
8. Rivets
9. Number punch
10. Files
11. Caliper

Procedure for constructing the dust pan:

1. Tin sheet having rectangular shape of dimension 250mm*200mm was taken and cleaned and metal sheet was made smooth by mallet hammer.

2. The layouts were drawn according to require dimensions as given in figures with the help of scriber.

3. Unwanted parts of plate were cut off by scissors and 6mm of shared sides were folded and bent as per the dimension.

4. For handle part, a tin sheet having dimension of 250mm*30mm was taken .margin were done according to the dimensions and unwanted edge were removed. The margined part was then folded as per the dimension.

5. Central punch was made on the points where the drilling was to be done, to join the side of pan and its handle.

6. Handle and side pan were fixed by reverting with the help of ball peen hammer.

7. Filling was done at the shape end of dust pan to remove its sharpness

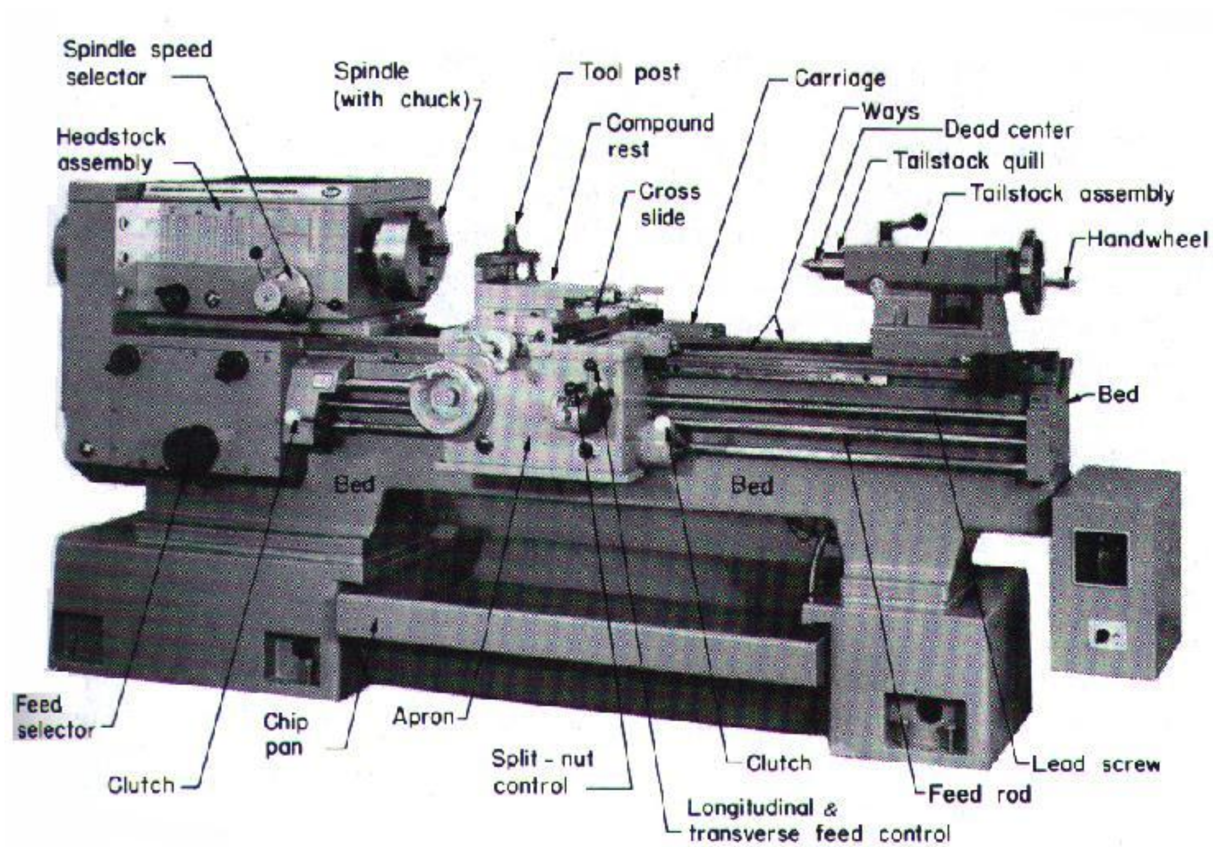
8. Finally the dust pan was made smooth with the help of rubber hammer.

Lathe machine:

A lathe is machine in which work piece is rotated against the cutting tools. The cutting tool is moved lengthwise (parallel or at an angle), crosswise (perpendicular or at angle) to the axis of the bed and the shape of work generated depends upon the operation. The operation are accomplished by holding the work securely and rigidly on the machine and then turning it against cutting tool which removes metal from the work in the form of clips. Turning, boring, thread cutting, etc. are performed in lathe.

Main components of lathe:

1) Headstock
2) Carriage
3) Tailstock
4) Bed



Headstock

The main spindle mounted on bearing transmits the rotary motion to work piece. The spindle that is securely mounted, is sturdy and of best steel. In most cases the spindles are hollow. So that the bar stock can be guided through. The bearing surfaces of the spindles are hardened and ground plain bearings made of bronze are often used for spindles. Rollers bearings have less friction and are also commonly used. The spindle must run freely on the bearings. Too much play in bearings causes chatter marks on the turned face of the work piece which may also become oval.

The head of the main spindle is provided with threads for fixing all kind of chucking equipment. Lathe centers can be inserted in the tapered hole of the main spindle. The spindle is driven by the main drive of the lathe.

Carriage

The carriage mainly supports and carries the turning tool and also contains the feed mechanism and its adjustment. This carriage consists of the saddle, the cross slide, the compound slide with tool holder and apron. The slide should move in the guide ways freely without any play. The saddle and the cross slide are either operated by feed shaft or screw.

Tailstock

It serves as a support for turning long work pieces. For drilling and reaming operations, the tailstock can be used as the tailstock sleeve that has been provided with a mores taper to accommodate the respective tools. The tailstock can be shifted on the lathe bed and can be clamped in position through the base with a locking lever. The tailstock spindle with hand wheel is used for shifting the tailstock sleeve. With the set screw the sleeve can be clamped in position.

Lathe bed

It carries all lathe parts. It is supported by the pedestals. The carriage and the tailstock move on the guide ways which are usually “V” and flat shaped. Bigger diameters can be turned on the lathe with gap bed. It consists of following parts: saddle, cross slide, compound slide, tool post and apron.

Lab work on lathe:

We have known the operation and mechanism of lathe machine. We used it for making hinge in lab. The lathe machine can be used for various purposes such as straight turning, chamfering, shoulder turning, facing, thread cutting filing, knurling, taper turning, polishing, grooving, spinning, forming, drilling, reaming, boring, taping, grinding and milling.

Different types of hammers:

1) **Ball Peen Hammer**: Those hammer which contain ball on it one part of the head and the flat surface on one side. Mainly used in the work with rivet.
2) **Claw Hammer:** those hammer which contain a claw on one side. Used for taking out the nails and rivets which are fixed on certain surface.

3) **Cross Peen Hammer**: Hammer with the pin, used for the works when the acting surface area is small.

4) **Wood Hammer**: Hammer made up of wood, commonly used for the sheet working.
5) **Club Hammer**: Hammer used for the heavy work, like in works related with heavy metal, hard surface area.

FILES: The files are the surface or the metal layer which I used to make any surface smooth, free of rust. There are different types of files, some of them are Flat file, Round file, semi round file, triangular file, square file etc. the efficiency of different files are known by its pitch i.e. distance between the two teeth.

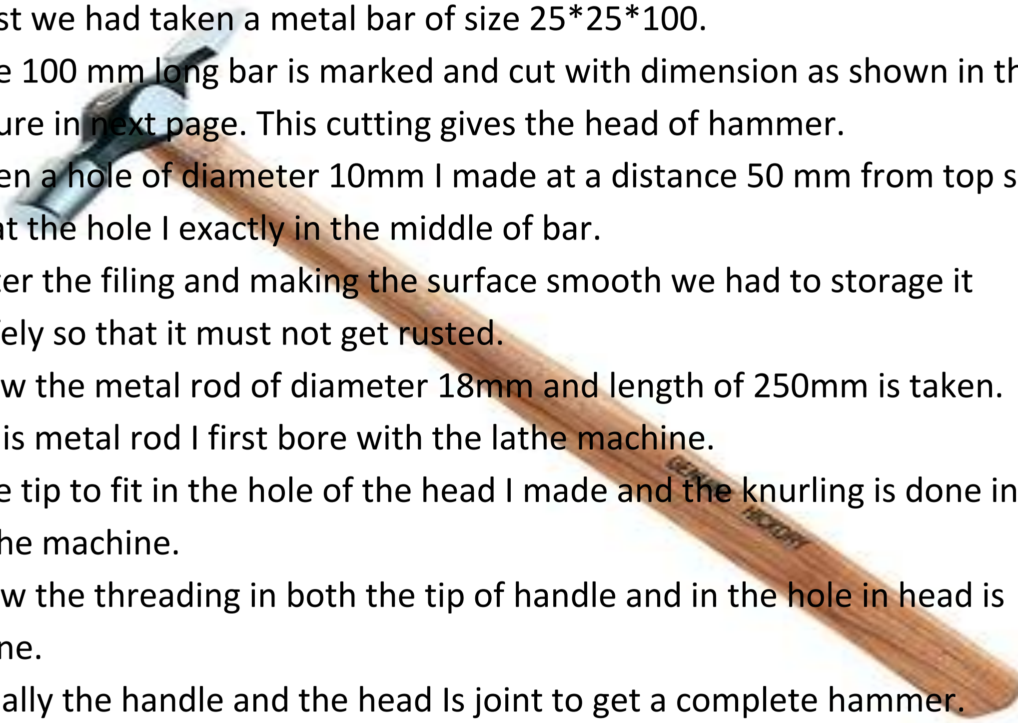
HACK-SAW: The hack-saw Is the device used for cutting propose, physically it consist of hack saw frame , blade, handle etc., the blade are set on the frame and the operation I carried out, the cutting Is done in forward stroke, and the back stroke help to clean path for next stroke.

RIVETS :Rivets are made up of oft metal which Is used to joint two or more then plates or pieces of metals with each other fat and permanently, joint made with rivets are called rivets joint. Mainly used in boiler, bridge etc.

Safety Measures:

1) The working area should be kept neat and clean.
2) If any accident happens, it should be reported to supervisor immediately.
3) Files, scrapers etc. should not be used without handle.
4) It should be checked whether the machines and tools are in proper condition or not before doing job.
5) Hair should be kept short or one should wear cap.
6) We should not play in the workshop.
7) Rings, watches, ties as well as college dress shouldn't be worn during job.
8) Machine, equipment, tools should be kept clean and in good condition.
9) The machine should be switched off immediately if anything goes wrong.
10) We should wear safety glasses, shoes and apron during workshop.

Procedure for making hammer:



1) First we had taken a metal bar of size 25*25*100.
2) The 100 mm long bar is marked and cut with dimension as shown in the figure in next page. This cutting gives the head of hammer.
3) Then a hole of diameter 10mm I made at a distance 50 mm from top so that the hole I exactly in the middle of bar.
4) After the filing and making the surface smooth we had to storage it safely so that it must not get rusted.
5) Now the metal rod of diameter 18mm and length of 250mm is taken.
6) This metal rod I first bore with the lathe machine.
7) The tip to fit in the hole of the head I made and the knurling is done in lathe machine.
8) Now the threading in both the tip of handle and in the hole in head is done.
9) Finally the handle and the head Is joint to get a complete hammer.

Conclusion:

Hence we are able to make dustpan and hammer by using different hand tools which are used in our daily life. After finishing this lab, we have learned many more about the use of tools, machine and equipment's and their functions. We became familiarize about drilling, shaping, surfacing, filing, threading, knurling etc.