LKC Hand Tools - Metal

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Contents

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 slideway 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.

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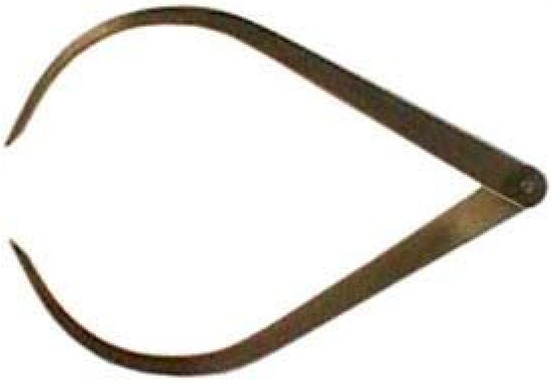
3. Measuring Tools in Workshop

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: -

Outside Calipers

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

Figure 1. Outside Calipers

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.

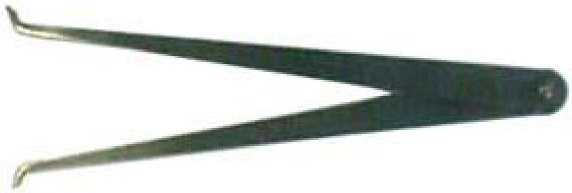


Figure 2. Inside Calipers

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.

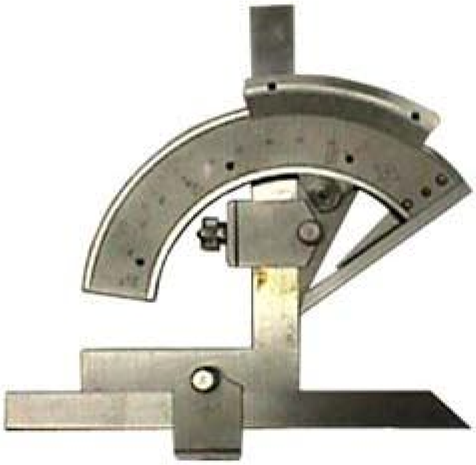


Figure 10. Vernier Protractor

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.

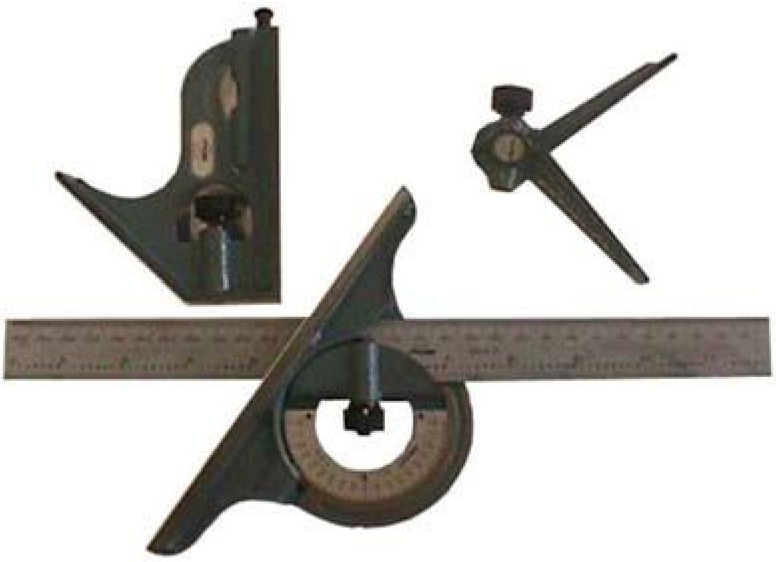


Figure 11. Combination Set

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

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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.

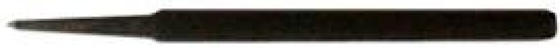

Figure 13. Scriber

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.

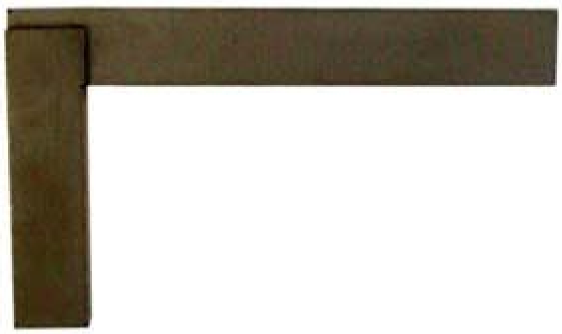

Figure 14. Engineer's Square

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.

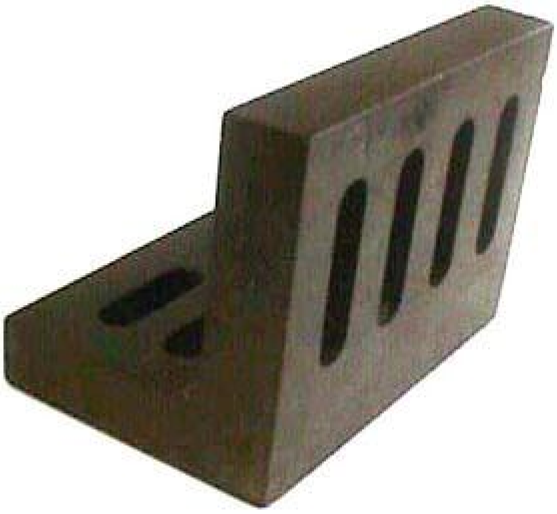

Figure 18. Angle Plate

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.

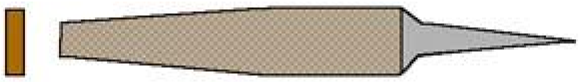

Figure 22b. Flat File

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.

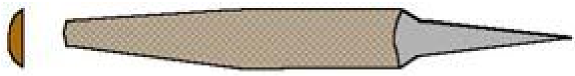

Figure 22c. Half-round File

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.

6. Drill and Drilling

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.

Figure 27. Drilling Machine

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 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.

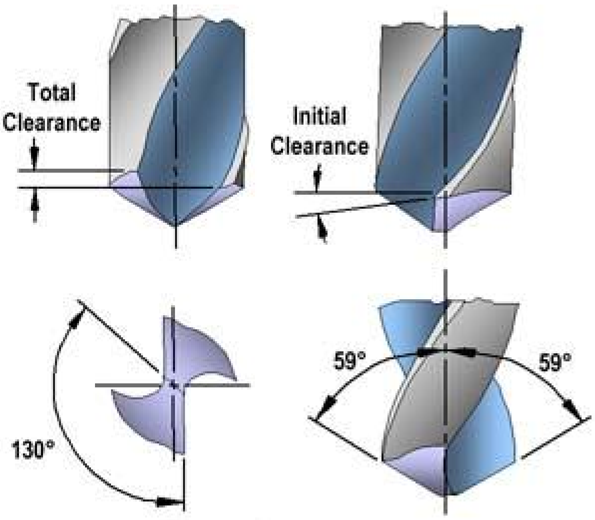

Figure 29. Drill Features

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.


Figure 30. Counterbore Drill

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.

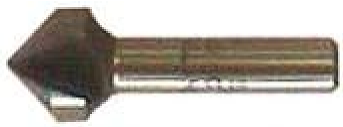
Figure 31. Countersink Drill

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

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.

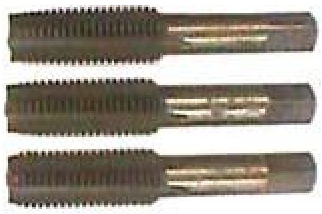

Figure 36. Taps

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.
g. 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.