Trade of Metal Fabrication	
Module 1:	Basic Fabrication
Unit 4:	Bench Work
	Phase 2

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Document Release History

Date	Version	Comments
09/08/06	First draft	
13/12/13	SOLAS transfer	

Module 1 – Basic Fabrication

Unit 4 – Bench Work

Duration – 15 Hours

Learning Outcome:

By the end of this unit each apprentice will be able to:

- Mark out, cut, drill and file metal and fabricate specified exercises
- Drill – tap – countersink
- Cut threads on round bar

Key Learning Points:

Rk	- Types and functions of different drilling machines - Speeds and feeds - drilling machines - Types of drill bits and their uses - Coolants
Sk	Operation of drilling machines.
Sk	Drill sharpening technique.
H	Safe work holding secure clamping.
Rk	Types of materials.
Sk Rk	Reamers, stocks - dies - taps/tapping & threading.
P	Planning procedures - work sequence.
H	Eye care, safety clothing. *(See "Bibliography" for reference to safety videos).*
M	Fractions and decimal calculations.

Training Resources:

Std. fabrication workshop equipment, Apprentice tool kit, safety clothing and equipment Notes, handouts and texts.

Key Learning Points Code:

M = Maths D= Drawing RK = Related Knowledge Sc = Science

P = Personal Skills Sk = Skill H = Hazards

Forms of Structural Material in Common Use

Beams and Columns

In 1962-63 the Iron and Steel Industry authorised a rationalisation of hot rolled steel sections to achieve greater economy in steel construction. The aims were as follows:

1. To concentrate on universal beams and columns, which are more efficient than the old conventional beams and reduce running costs by permitting the use of plain rather than compound members.
2. To provide lighter and more efficient joists in smaller sizes.
3. To roll channels and angles with square toes in order to facilitate welding.
4. To publicise information on circular hollow sections (designated C.H.S.) and rectangular hollow sections (designated R.H.S.), including square hollow sections.

Note: BS 4 Part 2 designates both imperial and metric equivalents. In Figure 1, the x and y axis denote the centre of gravity of sections. (The key to symbols is given for sections but not repeated where obvious.)

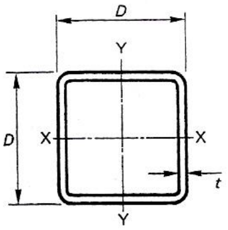


Fig. 2.1 Square hollow section
D= depth of section
t= thickness

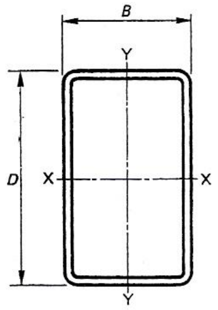


Fig. 2.2 Rectangular hollow section
D= depth of section
B= breadth of section

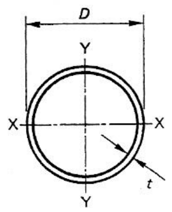


Fig. 2.3 Circular hollow section
D= outside diameter
t= thickness

Figure 1 - Beams and Columns

Rolled Steel Angles (R.S.A.)

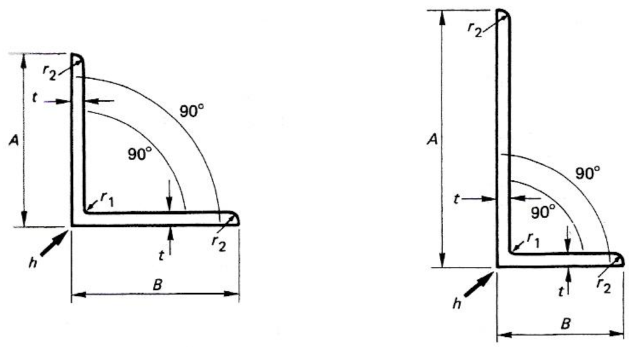


Figure 2 - Rolled Steel Angle

AxB = size

r_1 = root radius

r_2 = tow radius (note square toes)

h = heel of angle

Rolled Steel Channels (R.S.C.)

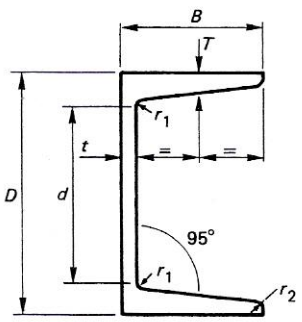


Figure 3 - Rolled Steel Channel

5º taper on flange

D = Depth

d = parallel length between fillets

B = flange breadth

T = mean flange thickness

t = web thickness

Rolled Steel Joists (R.S.J.)

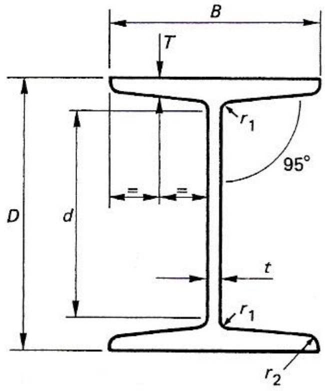


Figure 4 - Rolled Steel Joist

5º taper; max 203mm x 101mm (8in. x 4in.)

Universal Columns (U.C.)

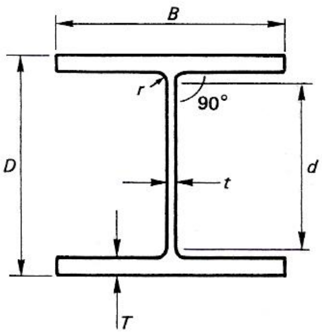


Figure 5 - Universal Column

Parallel flanges

Rolled Steel Tees (R.S.T.)

(Note: Tees may be cut from universal beams and columns)

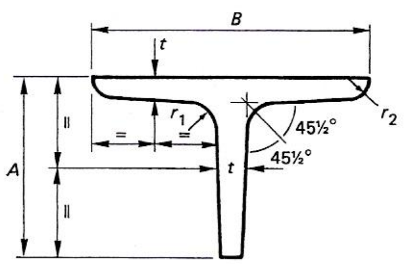


Figure 6 - Standard Tee

1º taper on stalk.

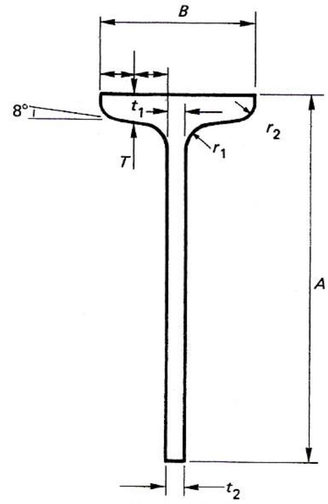


Figure 7 - Long Stalk Tee

8º taper on flange.

Universal Beams (U.B.)

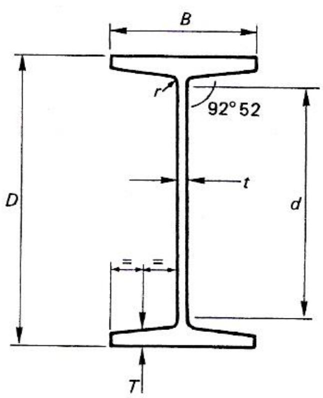


Figure 7 - Universal Beam

2º52' taper on flange or with a parallel flange.

Plates

Flat

Hot rolled flat plate is rolled in various sizes, both imperial and metric. The plates may be cut to specific lengths and widths to order when the edge is reasonably square, or the plates may still have the mill-rolled rounded edge.

Tread Plate and Floor Plate

The old Admiralty diamond chequer plate has now been replaced by the super grip floor plate (Durbar) shown in Figure 8 for steels, but it should be noted that heavy chequer diamond, five bar and tread plate are all rolled in aluminium plate. The basic difference between the two is that steel floor plate is load bearing but not the aluminium tread plate.

(p-g-p = positive grid pattern tread plate.)

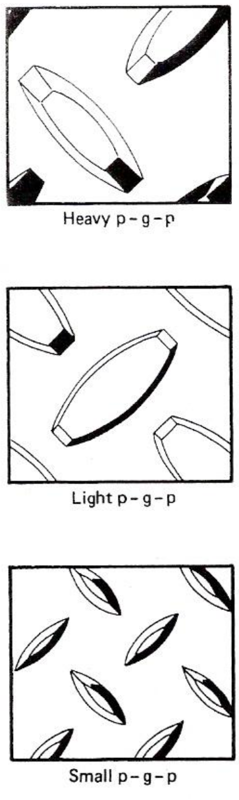


Figure 8 - Super-Grip Floor Plate (Steel)

Pedestal Drill

Safe Work Practices

Objective

To drill metal in a safe manner.

Personal Protective Equipment

Overalls, safety boots, safety glasses.

Procedure

1. Inspect equipment to ensure there are no obvious defects.
2. Check that the vice is clamped properly.
3. Check that the chuck guard is in working order and is in position.
4. Ensure correct sized drill bit is used and correctly tightened in chuck - remove key.
5. Insert material to be drilled in vice and securely tighten.
6. Adjust table up or down to correct height and lock in position.
7. Select drill speed (using levers).
8. Turn on isolator and press START button.
9. Turn on START switch and turning the lever, drill the material.
10. When finished drilling, withdraw and power down.

Safety Issues

1. Ensure that all personal protection is worn at all times.
2. Ensure that no loose clothing, particularly loose cuffs, ties etc. are worn.
3. Ensure that vice is clamped properly to drill frame and that material is clamped properly to vice.
4. Ensure chuck is tightened properly and key is removed from chuck.
5. Ensure chuck guard is in place.
6. Ensure eye protection is worn at all times.

Fitting and Assembling 1: Screwing, Tapping and Riveting

Taps

Taps are used for cutting internal threads, such as the thread on a nut. This is called tapping. There are three kinds: taper tap, second or intermediate tap and plug or bottoming tap.

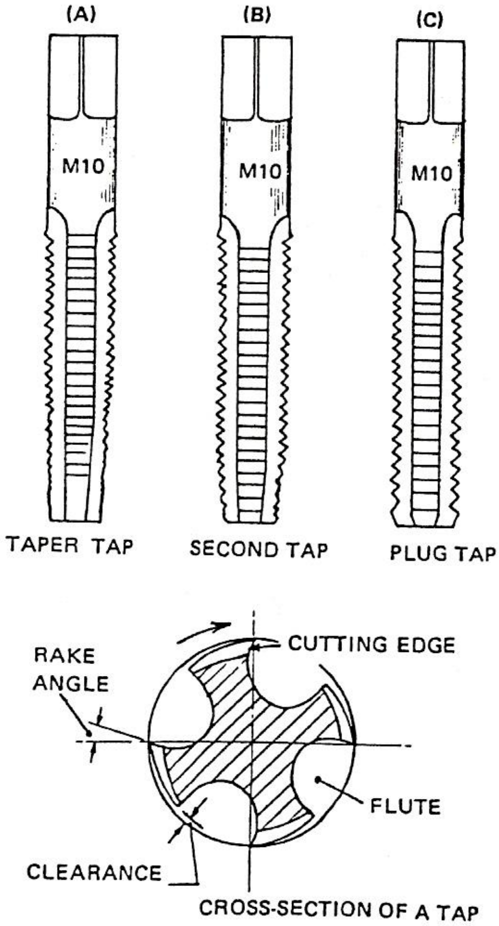


Figure 9 – Taps

Taper tap: This is tapered over the first 8 to 10 threads, allowing it to enter the hole and gradually cut to the full thread depth.

Second tap: This is tapered over the first four threads or so, and is used after the taper tap when tapping a deep hole or a blind hole.

Plug tap: This has only a short taper, one or two threads. It is used for finishing the thread at the bottom of a deep or a blind hole.

Taps are made from high-speed steel. They are hard and brittle and must be used with care to avoid breaking them, especially the smaller ones. The flutes along the body provide the cutting edges, also spaces for the chips being cut, and passageways for the cutting fluid to reach the cutting edges. The ends are square for gripping in a tap wrench. Taps should always be cleaned after use.

Tap Wrench

A tap wrench is used to rotate taps. There are two types shown in Figure 10.

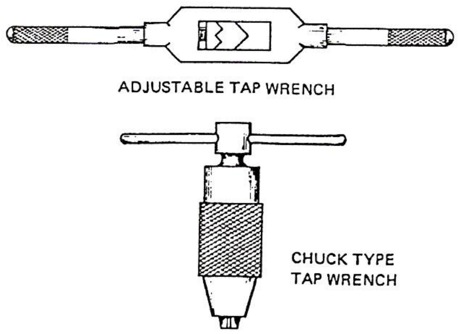


Figure 10 - Tap Wrenches

Tapping

When mating parts are being threaded, the tapping should be done first. The reason for this is that the size of the tap is fixed, but the die for cutting an external thread can be adjusted slightly, so that the thread on the bar can be progressively deepened until it just fits the tapped hole.

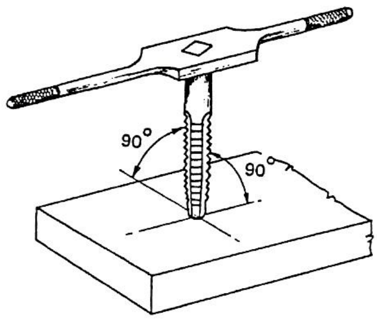


Figure 11 – Tapping

Before tapping, a 'tapping size' hole is drilled. This is smaller than the size of the tap. The drill size can be got from a table. If a table is not available, it may be got by trying the taper tap in the drill gauge until the hole is found into which it fits to a depth of three threads. Another method is to select the drill which just passes through a nut with the same size and type of thread.

To tap the hole, grip the taper tap in the tap wrench and enter it in the hole. Apply a slight downward pressure, keeping the tap in line with the hole, and turn it clockwise until it starts to cut. When it has just gripped, check if it is square with the face of the work. Correct, if necessary, and apply a cutting fluid, unless tapping cast iron or brass. Rotate the tap clockwise again for about half a turn, and then reverse it about a quarter of a turn to break off the chips. Continue in this manner, gradually screwing the tap into the hole.

If the hole is all the way through and the material is thin, the thread can be finished with the taper tap. If the material is thick, the second tap must be used after the taper tap, and sometimes the plug tap, depending on the depth of the hole. The second and plug taps must be also reversed about every half turn, to break off chips.

Tapping a Blind Hole

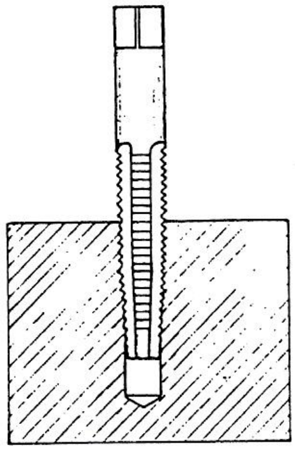


Figure 12 - Tapping a Blind Hole

A blind hole cannot be threaded at its bottom with a taper tap. Therefore, the second and plug taps must also be used. The taper tap is used first, and then the second tap and finally the plug tap to finish the thread to the bottom. During the tapping, the tap must be withdrawn from time to time to remove swarf from the hole and from the tap flutes. Care must be taken to avoid breaking the tap by forcing it against the bottom of the hole. If the blind hole is shallow, it may not be possible to start the thread with the taper tap. It should therefore be drilled deeper than the required length of thread, if possible. If not; it may be started with the second tap, but special care must be taken.

Examples of common tapping faults and their possible causes are given in the table below:

Fault	Causes
Broken tap	Tapping hole too small. Not reversing tap to break off chips. Tap not in alignment with hole. Not starting with taper tap. Attaching wrench while tap is in hole.
Shallow thread	Tapping hole too big.
Stripped thread	Not reversing tap. Tap flutes clogged. Lack of cutting fluid.
Rough thread	Lack of cutting fluid. Tap flutes clogged.
Bolt not square with work face	Hole not drilled square with work face.

Table 1 - Common Tapping Faults

Stocks and Dies

Stocks and dies are used for cutting external threads on round bars and on pipes. This is called screwing. The dies are made from high carbon steel or from high-speed steel. They are held in stocks to rotate them.

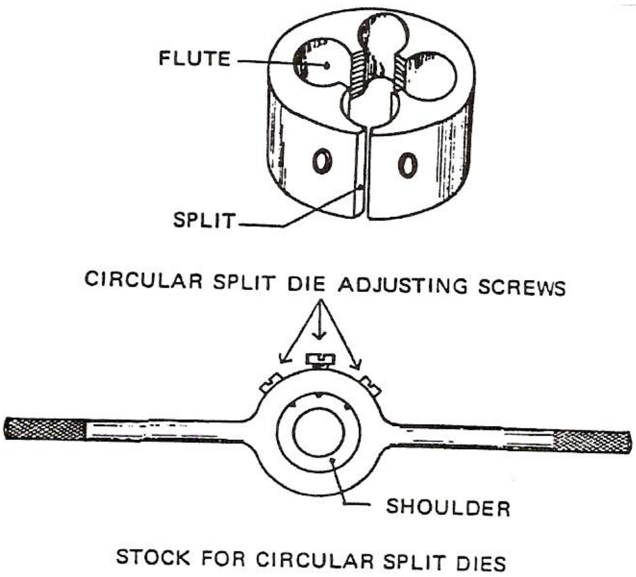


Figure 13 - Stocks and Dies

There are different forms of stocks and dies avai1able. Circular split dies are the ones mostly used in school workshops. The split permits a small amount of opening and closing of the die. The point of the central adjusting screw in the stock fits into the split in the die. To open the die, the screws at either side are slackened off and the centre one tightened. After adjusting, the side screws are retightened to lock the die in the stock. To close the die, the centre screw is slackened off and the side screws tightened. The first two or three threads on one side of the die are chamfered to make starting easier.

Before fitting the die, the stock recess must be thoroughly cleaned out to allow the die to seat properly. When fitted, the die chamfer must be on the underside and the stock retaining shoulder on top.

Screwing

The end of the bar should be chamfered to help start the die. If using a circular split die, it should be opened fully to take a light first cut.

Place the die on the end of the bar with its chamfered side down. Rotate the die, keeping it square with the bar, and apply downward pressure until it begins to cut. Check for squareness and correct if necessary. Continue rotating, reversing after about each full revolution, to break off the chips. Apply cutting fluid as for tapping.

When the required length is reached, remove the die by turning it in the opposite direction. Clean the thread and try a nut on it, or try it in a tapped hole. If too tight, close the die slightly and take another cut, as before. The deepening of the thread must continue until the nut can be just screwed on by hand without any slackness.

Fault	Causes
Broken die teeth	Oversize bar. Jerking the die. Not starting with chamfered side of die. Die not square with bar. Not reversing die.
Stripped thread	Cut too heavy. Deepening the cut after it has been started. Lack of cutting fluid. Not reversing die. Clogged flutes.
'Drunken' thread (Bar going from side to side as it is screwed into tapped hole).	Not starting die square with bar.
Difficulty in starting die square.	Uneven chamfer on bar. Broken teeth on starting side of die.
Rough threads	Lack of cutting fluid. Cut too heavy. Clogged flutes.
Bar end twisted off.	Over-size bar. Cut too heavy

Table 2 - Faults Which May Occur When Screwing

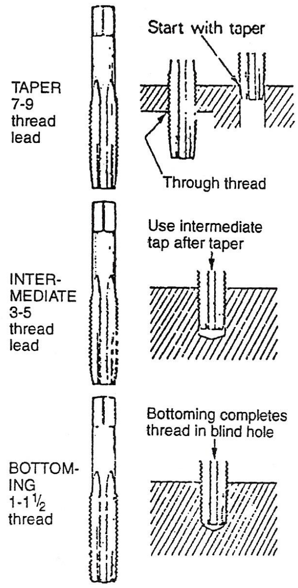
Bench Fitting

Type of Taps

Taps are normally used in sets of three, to allow progressive cutting of the threads.

Regular hand taps are used for most general work. Each set consists of a taper, intermediate and plug or buttoning taps. Each tap in a set has identical length and thread measurements and only the tapered lead is different.

- The taper tap should always be used to start the thread. Through holes can be completely threaded with the taper tap.
- Use the intermediate tap in deep through holes and in blind holes.
- Use the plug or bottoming tap to complete the thread to the correct depth in a blind hole.



Tapping a Through Hole

The method of tapping a through hole is shown in the following sequence:

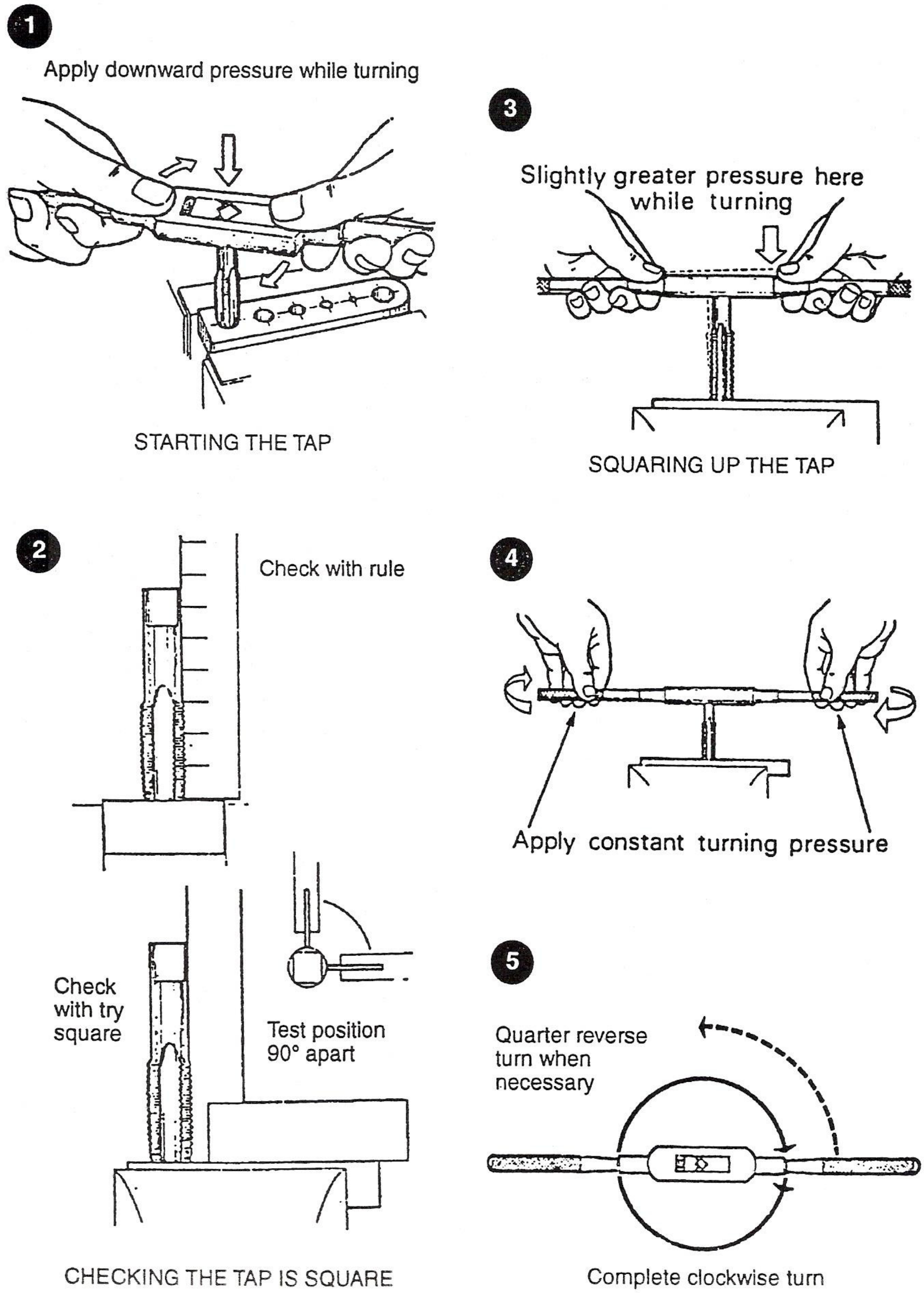


Figure 14 - Tapping a Through Hole

Hand Threading

The stock is the tool used to hold and turn a threading die when producing external threads by hand.

Stocks are made from mild steel or malleable cast iron and usually have:

- A central recess for holding one of a range of different sized dies.
- Means of slightly adjusting the size of the die to alter the depth of the thread cut.
- Provision for guilding the die.
- Knurled handles to turn the die.

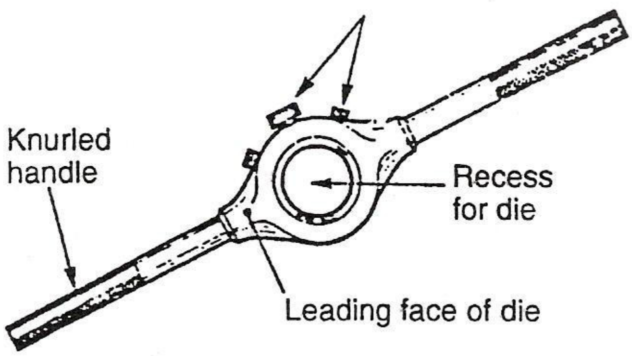


Figure 15 – Stock

Dies are made from alloy tool steel that is hardened and tempered and have:

- Accurately cut internal threads.
- Three or more flutes to form cutting edges on the internal threads and cavities for removal of the chips.
- Chamfers ground on the first few threads of leading end of the die to allow easy starting.
- Some form of split or division to permit a very small adjustment to the depth of thread they cut. Screws in the or in the stock or both are used for this adjustment.

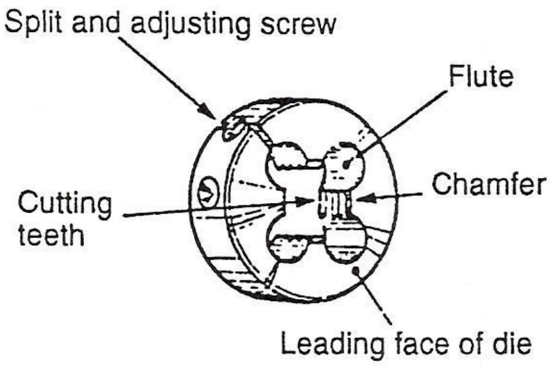


Figure 16 - Large Button Die

Diagrammatic Sequence of Cutting a Thread

After grinding the chamfer on the edge of the material the sequence for cutting the thread is shown in the following diagrams.

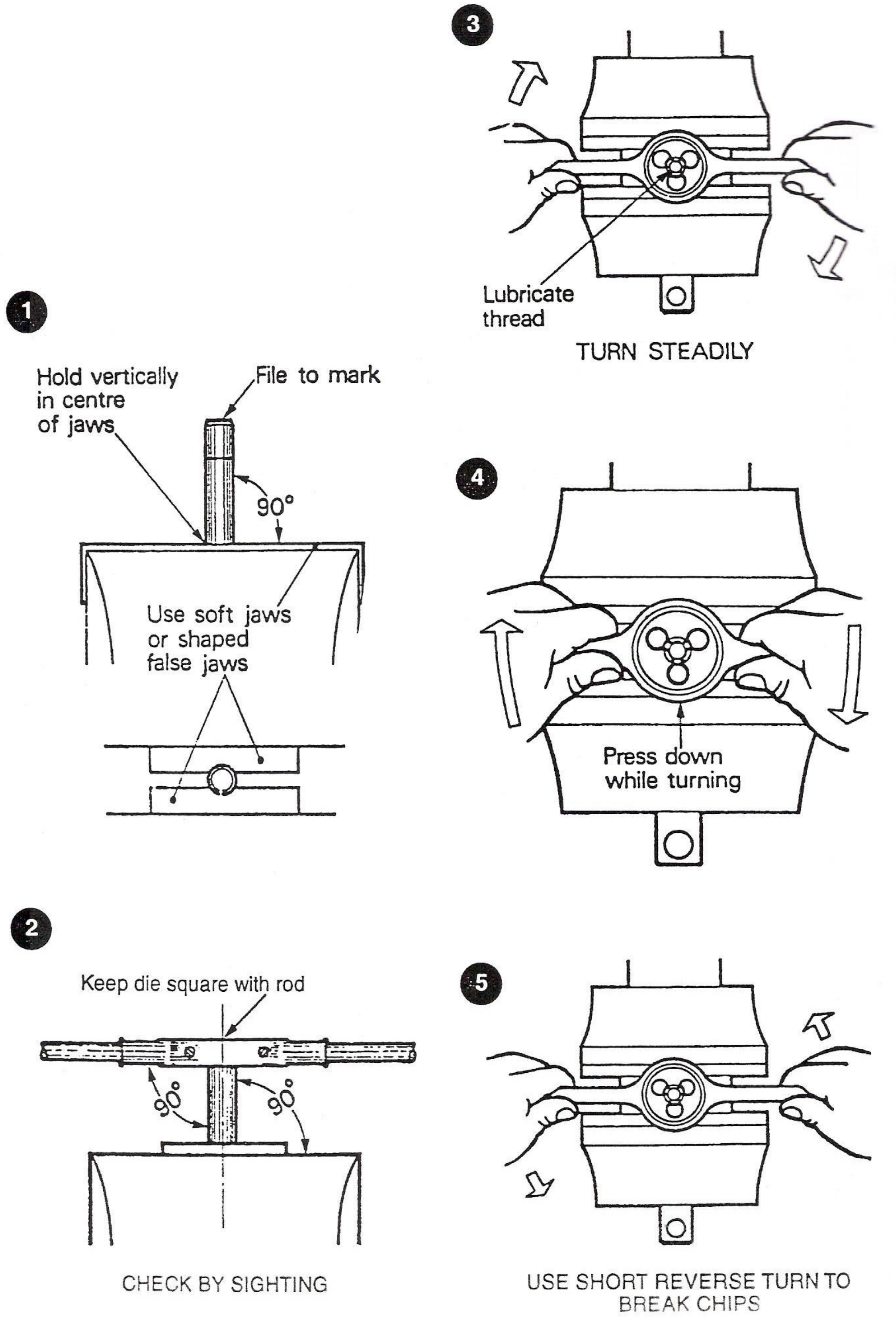


Figure 17 - Sequence of Cutting a Thread

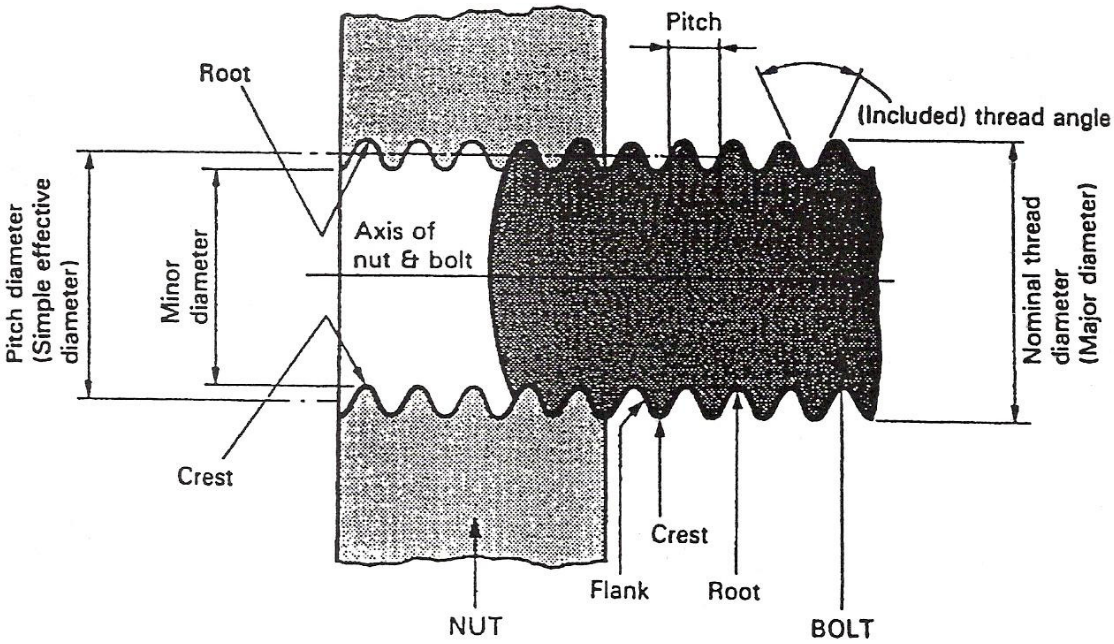


Figure 18 - Screw Thread Terminology

Tapping Drill Sizes for ISO Metric Threads

Nom. Dia. Tap m/m	Pitch m/m	Tapping Drill	Nom. Dia. Tap m/m	Pitch m/m	Tapping Drill
2.0	0.40	1.65 or 1.60 m/m	14.0	1.50	12.50 or 12.60 m/m
2.2	0.45	1.80 or 1.75 m/m	14.2	1.25	12.80 or 12.90 m/m
2.5	0.45	2.10 or 2.05 m/m	16.0	2.00	14.00 m/m
3.0	0.50	2.55 or 2.50 m/m	16.0	1.50	14.50 or 14.60 m/m
3.5	0.60	2.95 or 2.90 m/m	18.0	2.50	15.50 or 39/64"
4.0	0.70	3.30 m/m	18.0	1.50	16.50 m/m
5.0	0.80	4.20 m/m	20.0	2.50	17.50 or 11/16"
5.0	0.50	4.50 m/m	20.0	1.50	18.50 m/m
6.0	1.00	5.10 or 5.00 m/m	22.0	2.50	19.50 or 19.75 m/m
6.0	0.75	5.20 or 5.30 m/m	24.0	3.00	21.00 or 21.25 m/m
7.0	1.00	6.10 or 6.00 m/m	27.0	3.00	24.00 or 24.25 m/m
8.0	1.25	6.90 or 6.80 m/m	30.0	3.50	26.50 or 1.3/64"
8.0	1.00	7.00 or 7.10 m/m	33.0	3.50	29.50 or 1.5/32"
9.0	1.25	7.90 or 7.80 m/m	36.0	4.00	32.00 or 1.1/4"
10.0	1.50	8.60 or 8.50 m/m	39.0	4.00	35.00 or 1.3/8"
10.0	1.25	8.80 or 8.90 m/m	42.0	4.50	1.31/64" or 37.50 m/m
10.0	1.00	9.00 or 9.10 m/m	45.0	4.50	1.39/64" or 40.50 m/m
11.0	1.50	9.60 or 9.50 m/m	48.0	5.00	1.45/64" or 43.00 m/m
12.0	1.75	10.40 or 10.20 m/m	52.0	5.00	1.55/64" or 47.00 m/m
12.0	1.50	10.50 or 10.60 m/m	56.0	5.50	2" or 50.50 m/m
14.0	2.00	12.20 or 12.00 m/m	60.0	5.50	2.5/32"

Table 3 - Tapping Drill Sizes for ISO Metric Threads

The formulae below are used for calculating the depth of threads.

P = pitch

ISO = 0.6495 x P

BSW = 0.640 x P

BA = 0.600 x P

Sharpening a Twist Drill

A twist drill can be successfully sharpened on a bench grinder by using the following method.

(For this exercise a 10 to 15 mm diameter twist drill would be suitable).

- Check that the surface of the wheels is running true and they are dressed clean.
- Make sure the tool rests are adjusted correctly and tightened.
- Put on a pair of well-fitting safety goggles.

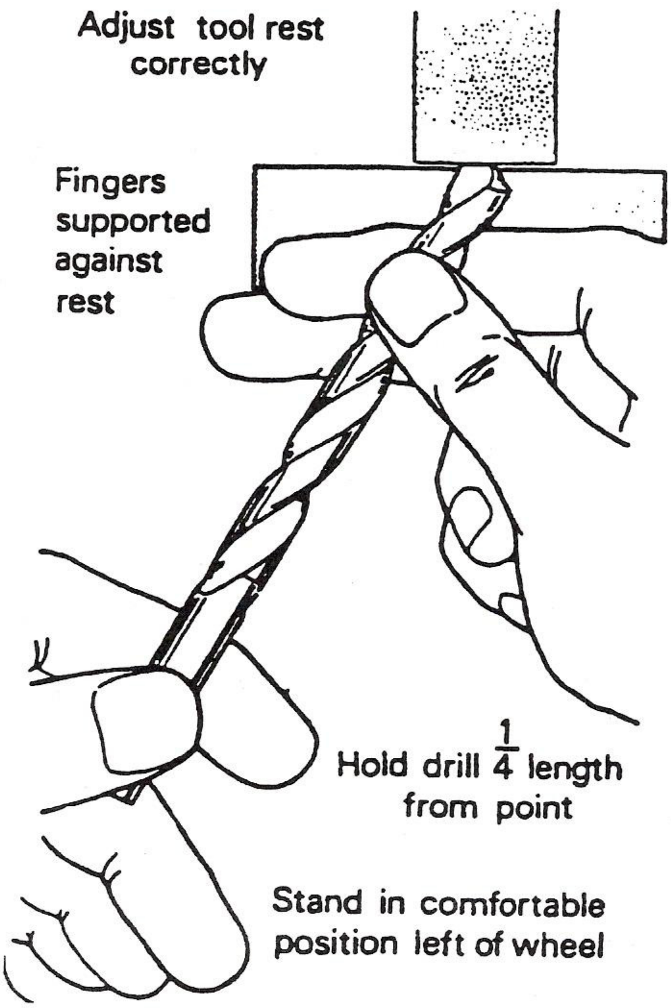


Figure 19 - Sharpening a Twist Drill

Establishing the Cutting Angle

- Hold the drill at about one quarter of its length from the point, between the thumb and first finger of the right hand.
- Support the hand on the tool rest with the other fingers.
- Hold the shank of the drill between the thumb and fingers of the left hand.
- Keep both elbows against the side.
- Position yourself by moving the feet so that the drill makes an angle of 59° to 60° to the wheel face.
- Hold the drill level. Twist it until one cutting edge is horizontal and parallel to the wheel face.

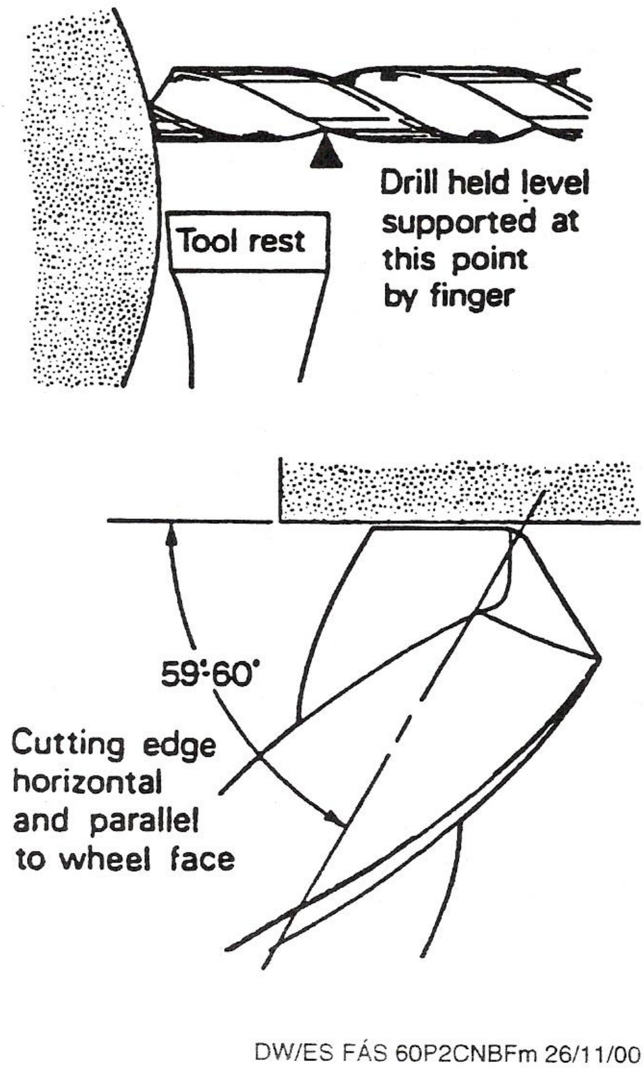


Figure 20 - Establishing the Cutting Angle

Drilling

The Drilling Machine

A pillar drilling machine is shown in Figure 21. This type is bolted directly to the floor. The table is at right angles to the chuck spindle. It can be raised, lowered or rotated on the column and is held in the required position by means of a clamp. The height at which the table is set depends on the height of the workpiece and the length of the drill bit being used. The table must be supported whenever the clamp is loosened, to prevent it from falling suddenly.

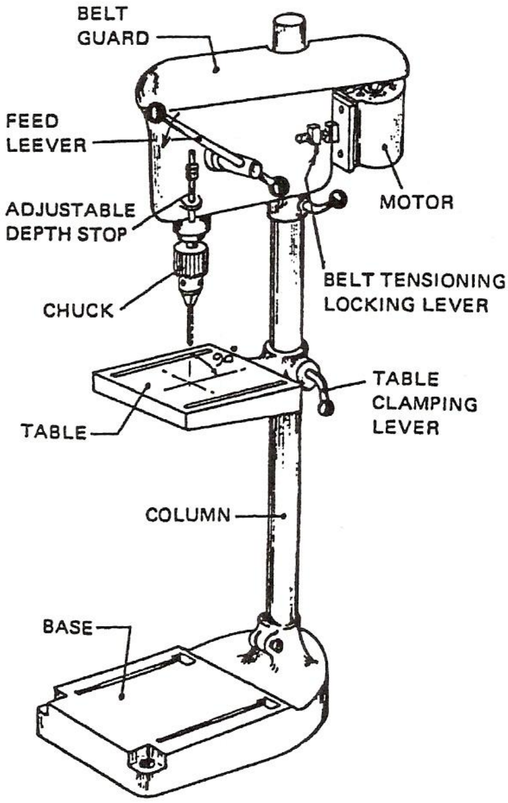


Figure 21 - Pillar Drilling Machine

The upper surface of the base is machined, so that it can be used to support work which would be too high for the table. When the base is being used, the table must be swung to the side. The table and base have slots to accommodate bolts for a machine vice or work-holding clamps.

The chuck is lowered or raised by means of a 'rack and pinion' mechanism. The feed lever is attached to the spindle of the pinion and the chuck is lowered by turning the lever by hand. When the pressure is released, the pinion is turned in the opposite direction by means of a coil spring, thus returning the chuck to its original position.

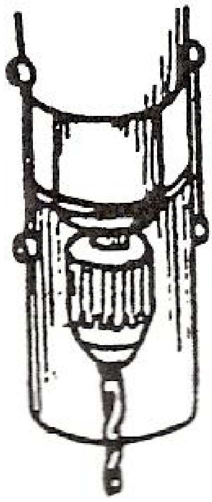


Figure 22 – Chuck/Guard Assembly

A chuck guard is fitted to the drilling machine to protect the operator and the machine should never be used without it.

The bench drilling machine is another type. It is similar to the pillar type, but has a shorter column and is mounted on a bench.

Using the Drilling Machine

1. Make sure hair or clothing does not get caught up in the twist drill or chuck. Never use the drilling machine without the chuck guard.
2. When changing the vee belt, take care not to switch on the machine until the belt guard is replaced.
3. Never clean away swarf from under the twist drill by hand, as you could receive a bad cut from the point of the drill or from the swarf. If the machine is running, there is also a great risk that your sleeve may get wrapped around the drill.
4. Ensure that the work is firmly gripped.
5. Check that the drill speed is correct.
6. Position the centre punch mark under the drill point before starting the machine. After the hole has been started, recheck its position. Use a cutting fluid as required.
7. Reduce the pressure on the twist drill when it is breaking through, in case it binds in the hole.
8. Take care not to drill into the vice or machine table.

Holding the Work for Drilling

Figure 23 shows a machine vice which is suitable for holding work to be drilled. It has a slotted base for bolting to the drilling machine table. Care must be taken to avoid marking it with the twist drill. One way of protecting the vice, is to place a piece of wood under the workpiece, Figure 24. The top and bottom faces of the wood must be parallel to ensure that the hole being drilled will be perpendicular to the face of the workpiece.

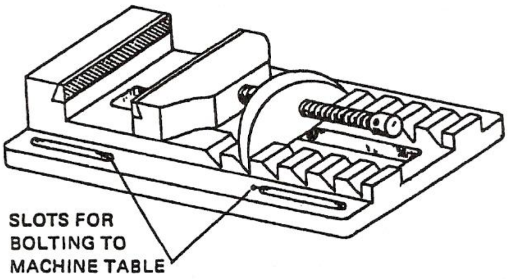


Figure 23 - Machine Vice

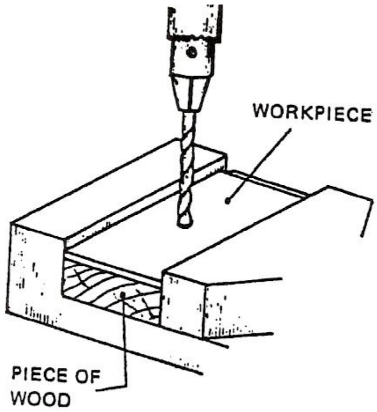


Figure 24 - Top and Bottom Faces of the wood

Various types of clamps are also used for holding work for drilling. Two methods of clamping work are shown in Figure 25.

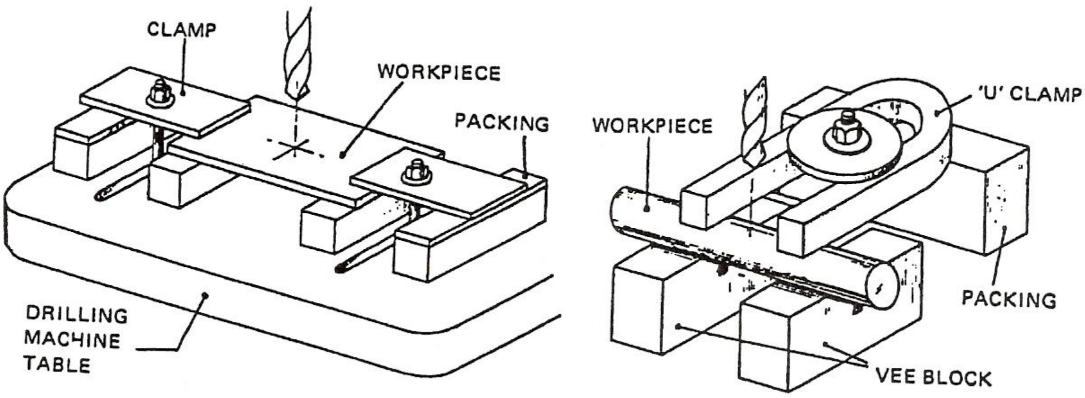


Figure 25 - Methods of Clamping Work

Electric Hand Drill

This drills holes much faster and requires less effort than the hand or breast drills. It is useful for drilling work which cannot be taken to, or set up on, a drilling machine, also for drilling a component part of an assembly without having to dismantle it. Large electric hand drills can take drills up to 13mm in diameter.

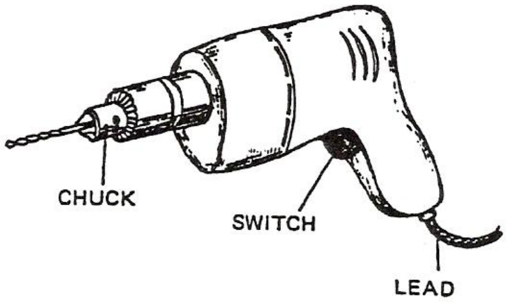


Figure 26 - Electric Hand Drill

Twist Drills

Twist drills are made from high speed steel or from high carbon steel. Drills up to about 13mm usually have parallel shanks. Larger ones have taper shanks, Figure 30. The parallel shank drills are held in a drill chuck. The taper shank ones are held in the taper bore of a drilling machine spindle.

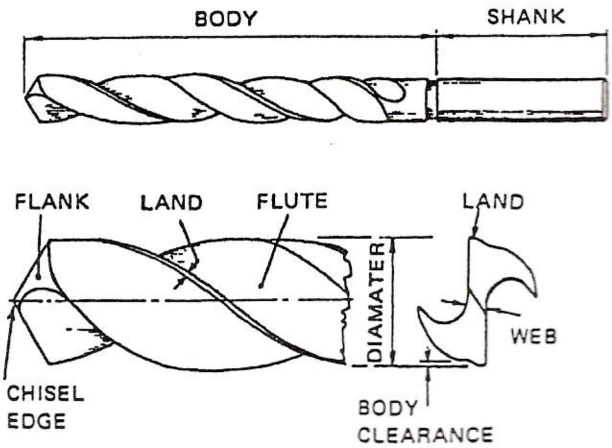


Figure 27 - Drill Parts

The drill flutes provide the cutting lips and also a passageway for the swarf to escape and for cutting fluid to reach the cutting edges.

Body clearance is provided by having the body diameter slightly less than the width across the lands. The purpose of body clearance is to reduce friction.

Standard drills have a point angle of 118°, Figure 28, on each side of the centre line. This is the most suitable angle for general work. The lip clearance angle is usually about 12°.

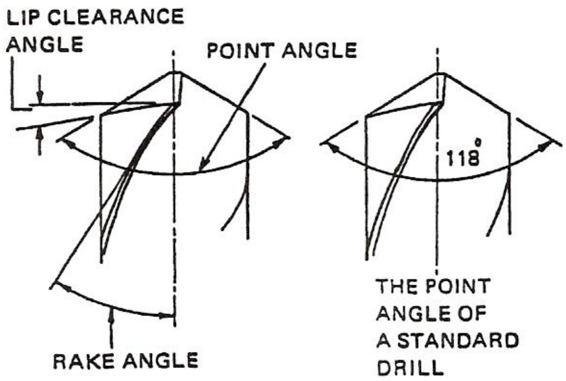


Figure 28 - The Angles on the Point of a Drill

There are special drills available with 'slow' or 'quick' helixes, Figure 29. The effect of the slow helix is to reduce the rake angle. Slow helix drills are used for drilling brass and bronze. The quick helix gives a greater rake angle and quick helix drills are used for drilling soft materials, such as copper and aluminium.

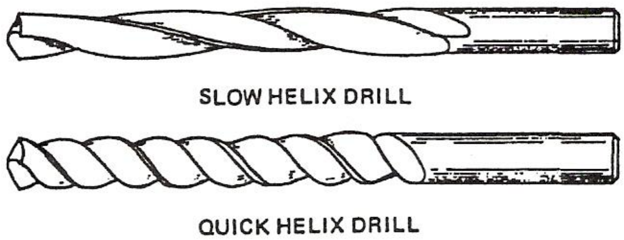


Figure 29 - Drills with Special Helix Angles

Drill size markings often become obliterated as a result of the drill slipping in the chuck. When this happens, the drill size must be checked with a drill gauge.

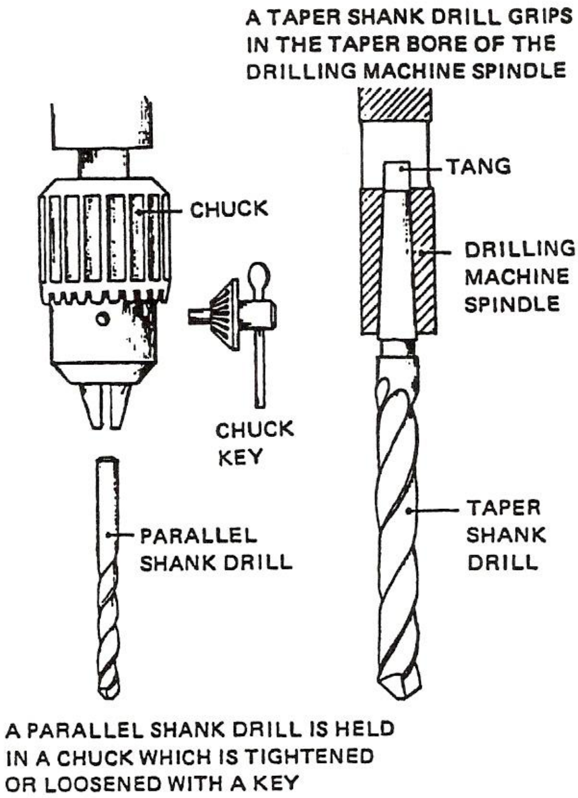


Figure 30 - Gripping Drills

Drill Grinding/Sharpening

Twist drills must be re-ground if the lips become blunt or chipped, or if the land becomes worn away towards the point. To cut efficiently and accurately, the clearance angle and the point angle must be correct. Both lips must beat the same angle to the drill axis and of equal length.

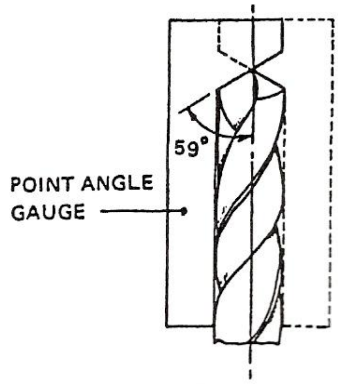


Figure 31 - Both Lips Must be at the Same Angle to the Drill Axis

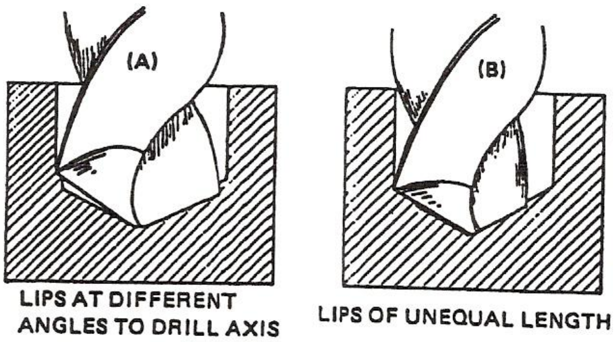


Figure 32 – Oversize Holes as a Result of Faulty Grinding

Drill Drift

A drift is used for removing tools, such as drills, reamers and arbors, from the drilling machine spindle, Figure 33 (A), or from taper sleeves. A small block of wood should be placed on the machine table underneath the tool, Figure 33 (B), to prevent damage to the tool and table during the removal.

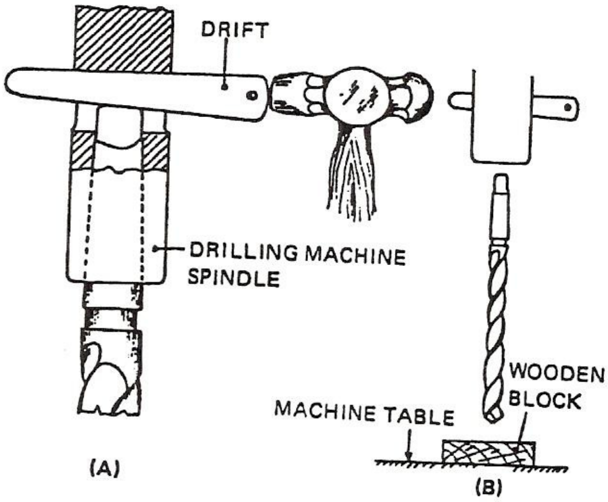


Figure 33 - Using a Drift

Morse Taper Sleeves

Morse taper sleeves are used when the taper shank of a tool is too small for the machine socket in which it is to be used. The shank of the tool is inserted into the sleeve, which is then inserted into the tapered socket of the machine, Figure 34 (B). Sometimes, more than one sleeve is required. They are commonly used for holding such tools as 68 taper shank drills and reamers in drilling machine spindles, and in lathe tailstocks.

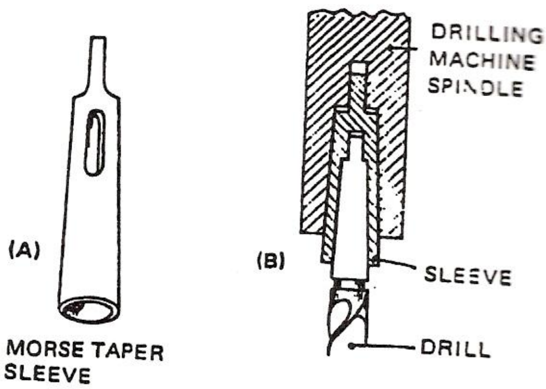


Figure 34 - Morse Taper Sleeves

Spindle Speed of Drilling Machines

The spindle speed (revolutions per minute) of a drilling machine depends on:

1. The size of the drill: The larger the drill the slower the spindle speed.
2. The type of material being drilled: Usually, the softer the material, the higher the speed.
3. The type of drill: High-speed steel drills can be run at far higher speeds than high carbon steel ones, as they retain their hardness up to a far higher temperature.
4. The use of a coolant: Using a coolant when appropriate, allows the drill to be operated at a higher speed.

Feed

Feed is the amount per revolution which the drill penetrates into the material being drilled. If too much pressure is applied to the feed lever, there is a danger that the drill will overheat, bind in the hole, or break. If the pressure is too little, the drill may just rub without cutting, which may cause it to lose its edge. The feed should be reduced when the drill point is breaking through.

Drilling Sheet Metal

Care must be taken not to apply too much pressure to the feed lever when drilling through sheet metal. There is a danger of the drill catching in the work and carrying it around. It is also difficult to get the hole circular. These difficulties can be overcome by clamping the sheet metal between two thicker pieces of material, marking the position of the hole on the upper one, and then drilling through the three of them. Making the drill point angle more obtuse also helps when drilling sheet metal.

Locating a Hole Centre

Locate the position of the hole centre by means of intersecting lines, Figure 35. Lightly centre-punch the intersection. If the punch mark happens to be slightly off, it should be drawn over with the centre-punch before deepening it with a heavier blow. The work must be so positioned on the drilling machine that the drill point fits into the punch mark without any deflection of the drill. If a drill starts off-centre, it can be corrected by cutting a small groove at one side of the hole with a diamond point or round nose chisel.

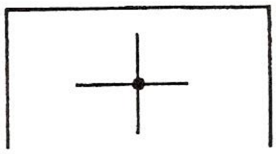


Figure 35 - Locating a Hole Centre

Pilot Hole

A pilot hole, Figure 36, must be drilled before using a large drill. This keeps the large drill central, and it also means that the chisel edge of the drill does not have to do any cutting.

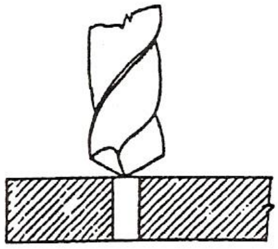


Figure 36 - Pilot Hole

Tapping Size Hole

This is a hole that is drilled prior to cutting an internal thread. It must be smaller than the tap to allow for the depth of the thread.

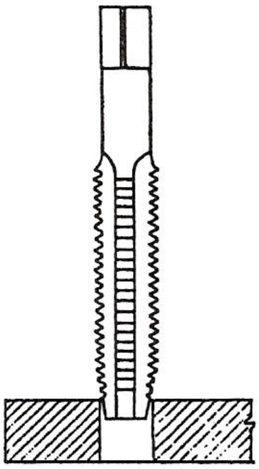


Figure 37 - Tapping Size hole

Clearance Hole

A clearance hole is slightly larger than the bolt, stud or screw that passes through it. When two parts are to be bolted together, Figure 38 (A), both must have clearance holes. When a part is secured to another by means of screws, Figure 38 (B), the outer one must have clearance holes. The clearance enables bolts to be inserted quickly. Without clearance, all bolts cannot be inserted if anyone of the holes is slightly out.

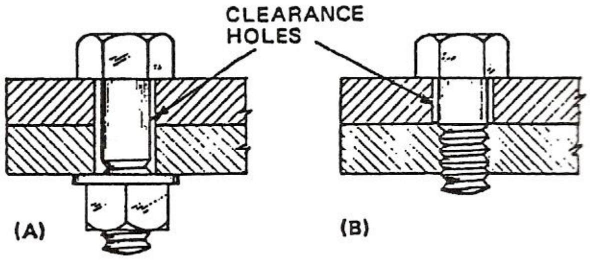


Figure 38 - Clearance Holes

Blind Hole

This is a hole that does not go all the way through a part. When it is not practical to have a bolt going through a part, a blind hole can be drilled in it, then tapped and a stud or screw used. This is done on engine blocks, for instance.

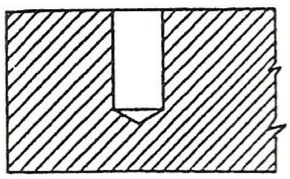


Figure 39 - A Blind Hole

Countersinking

Countersinking is the enlarging of the mouths of holes to accommodate the heads of countersunk head screws and rivets. Countersinking cutters have point angles of either 60° or 90°, Figure 40. A twist drill can also be used, but the point must be ground to the required angle.

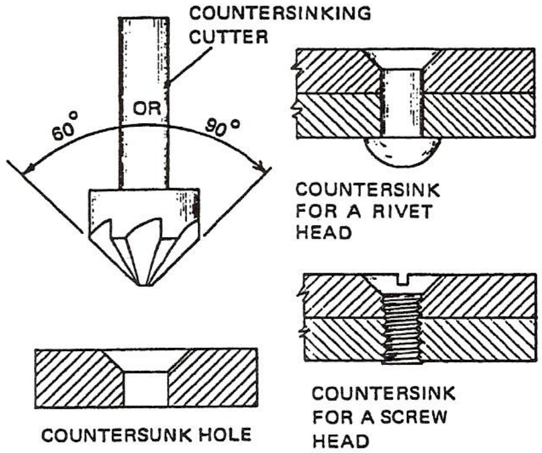


Figure 40 – Countersinking

Counterboring

This is the increasing of hole diameters to certain depths, usually to accommodate the heads of screws, such as allen screws and cheese head screws. It allows the heads to be flush with or to be below the surface of the part. A counterboring cutter, Figure 41, is used for this work.

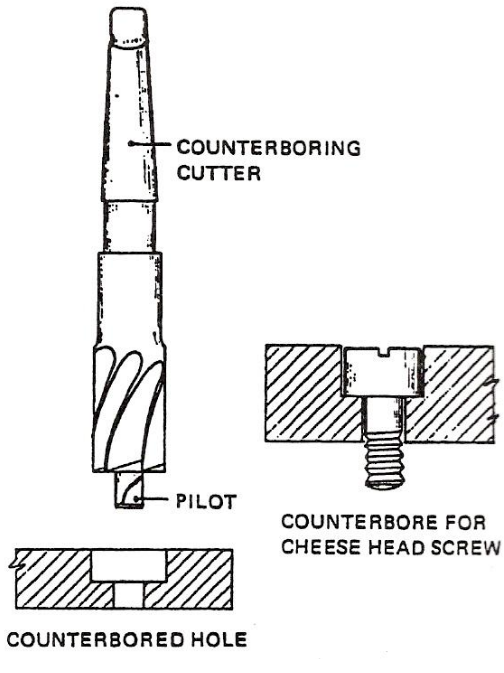


Figure 41 - Counterboring

Reamers

Reamers are used for finishing holes smoothly and accurately. A slightly undersize hole is first drilled and the reamer is then used to finish it to size. Reamers are usually made from high-speed steel. There are various types available. A hand reamer, Figure 42 (A), has a square end for a tap wrench and can have either straight or helical flutes. Figure 42 (B) shows a machine reamer. It has a taper shank and is held in the drilling machine spindle or in the tailstock of the lathe. A taper pin reamer is shown in Figure 42 (C). It is used to enlarge and taper a hole to suit a taper pin, Figure 43. A reamer must always be turned clockwise, whether being entered or withdrawn from a hole, and a cutting fluid should be used as appropriate.

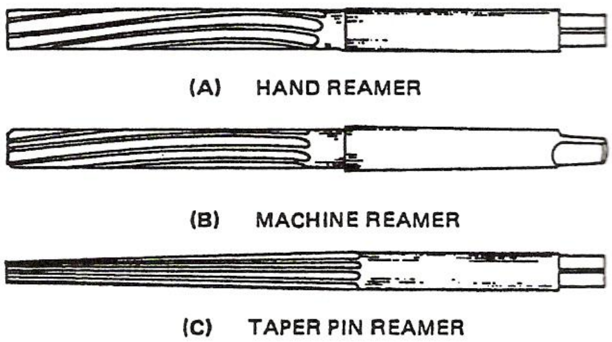


Figure 42 – Reamers

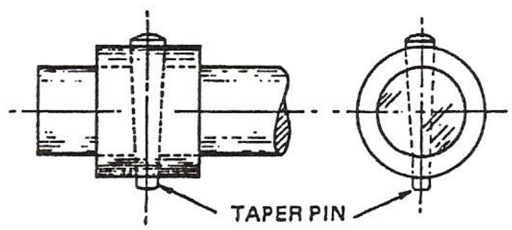


Figure 43 - A Collar Fixed to a Shaft by Means of a Taper Pin

Cutting Fluids

Cutting fluids, sometimes called 'coolants' or 'cutting lubricants', are used to aid machining operations, for instance drilling and turning. The following are advantages that can be gained by use of a cutting fluid:

- The cutting tool lasts longer;
- The machining can be carried out at a higher speed;
- A better surface finish is produced;
  The chips are carried away.

A cutting fluid works in two ways:

- As a coolant, carrying away the heat generated, keeping the tool and workpiece cool;
- As a lubricant, reducing friction and thereby the amount of heat generated.

Fraction to Decimal Conversion

To convert a fraction into a decimal we divide the denominator into the numerator.

EXAMPLE 1:

Convert $^{27}/_{32}$ to decimals,

$^{27}/_{32} = 27 \div 32 = 30.84375$

EXAMPLE 2:

Convert $2\,^{9}/_{16}$ to decimals, when we have a mixed number to convert into decimals. We need only deal with the fractional part.

$\therefore\ ^{9}/_{16} = 9 \div 16 = 0.5625,\quad Ans\ 2.5625$

Sometimes a fraction will not divide out exactly, as in ⅓, to decimals,

⅓ = 1÷3 = 0.333.

This is an example of recurring decimal and in order to prevent endless repetition the results written as 0.3.

Further examples of recurring decimals are; $^{2}/_{3},\ ^{1}/_{6},\ ^{5}/_{11}\ and\ ^{3}/_{7}$.

Conversion of Decimals to Fractions

We know that decimals are fractions with denominator 10, 100, 1000 etc. Using this we can always convert a decimal to a fraction.

EXAMPLE 1.

Convert 0.32 into a fraction.

$0.32 = ^{32}/_{100} = ^{8}/_{25}$

EXAMPLE 2.

Convert 0.125 into a fraction.

$0.125 = ^{125}/_{1000} = ^{1}/_{8}$

EXAMPLE 3:

Convert 0.8 into a fraction.

$0.8 = ^{8}/_{10} = ^{4}/_{5}$

EXAMPLE 4:

Convert 0.2 into a fraction.

$0.2 = ^{2}/_{10} = ^{1}/_{5}$

Changing Vulgar Fractions to Decimals

This is achieved by dividing the denominator into the numerator thus:

(1) $\frac{7}{8}$ = 0·875 because 8) $\underline{7·000}$
0·875

(2) $\frac{3}{5}$ = 0·6 because 5) $\underline{3.0}$
0·6

(3) 13 $\frac{3}{4}$ = 13·75 because 4) $\underline{3.00}$
0.75

Important: When dealing with mixed numbers as in (3) above do not include the whole number part in your division.

Extended Decimal Fractions

Many vulgar fractions make lengthy decimals when converted; in fact some are unending! In such cases it is usual to evaluate only to the degree of accuracy required by the work concerned.

You may be asked to give an answer correct to 'so many' places of decimals.

METHOD:

1. Carry out the division to one more place of decimals than is required.
2. If the last figure is 5 or over, add one to the preceding figure.
3. If the last figure is less than 5, discard it completely.

EXAMPLE 1:

Express $\frac{2}{7}$ as a decimal correct to three places of decimals.

Dividing 2 by 7, we have 7)$\underline{2·00}$
0·2857

Since the fourth figure is over 5, the third figure becomes 6 and the answer is 0·286 correct to three places of decimals.

EXAMPLE 2:

Express 50 $\frac{1}{9}$ as a decimal correct to two places of decimal is.

Dividing 1 by 9, we have 9)$\underline{1.000}$
0.111

Since the third figure is under 5 the answer correct to two places of decimals is $50.1\dot{1}$.

The use of the dot over the last 1 indicates that it is a recurring decimal. If the division had been continued tile result would have been 50·111111111 ... etc.

Significant Figures

Values are sometimes required to 'so many' significant figures. The procedure is then as before, but the numbers of figures in the answer are counted including the whole number part.

EXAMPLE 1

Express 1·0346 correct to four significant figures.

There are 5 figures altogether in the number. As the last figure is over 5 the preceding figure must be increased to 5 and the answer is 1·035 correct to four significant figures.

EXAMPLE 2

Express 123·73 correct to four significant figures.

Since the last figure is less than 5 it is discarded and the answer is 123·7 correct to four significant figures.

Degree of Accuracy

This is largely a matter of common sense. You would not express the area of a plot of land as 450·001m² as this is only 10cm² over the 450m², a negligible amount. Again you would not work out the capacity of a large reservoir tank to the nearest millilitre (ml) since this is an extremely small unit. On the other hand you would not give a man's wages as €12·60 instead of €12·59 as the difference is 1c and this sort of approximation could lead to considerable losses on a large wages bill.

Calculations Involving Decimals

Addition and Subtraction

This should not present any difficulty provided the decimal points are kept directly underneath one another. Failure to do this will always give you trouble and probably lead to errors.

EXAMPLE 1:

$$\begin{array}{r} 563{\cdot}624 \\ -\underline{247{\cdot}324} \\ 316{\cdot}3 \text{ Ans} \end{array}$$

EXAMPLE 2:

$$\begin{array}{r} 2{\cdot}45 \\ +3.271 \\ +\underline{16.008} \\ 21{\cdot}729 \text{ Ans} \end{array}$$

EXAMPLE 3:

What is the inside diameter of a cylinder which has an outside diameter of 1·240m and is made of concrete 75mm thick?

Inside dia. = 1.240 – (2x0.075) (changing the 75mm to m)

= 1.240 – 0.150

= 1.090m Ans

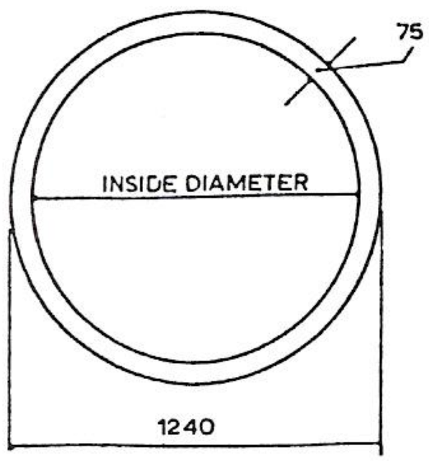


Figure 44 - Calculate the Inside Diameter of a Cylinder

Multiplying Decimals

The problem of placing the decimal point correctly is easily solved if you remember that the number of decimal places in the answer will always be the sum of the number of decimal places in the two numbers which you have multiplied.

Important: The noughts, if any, must also be counted when applying this rule.

EXAMPLE

16.342 x 7.32

$$\begin{array}{r} 16.342 \\ \underline{7{\cdot}32} \\ 32684 \\ 49026 \\ \underline{114394} \\ 11962344 \end{array}$$

Now fix the position of the decimal point in the answer as follows:

1. Count the total number of decimal places in the question - in this case five, made up of three in 16.432 and two in 7.32.
2. Transfer this number of decimal places to the answer by counting from right to left. In this case a total of 5 decimal places gives an answer of 119.62344 Ans.

FURTHER EXAMPLES

1. Multiply 106.72 by 23.4 and give the answer to six significant figures.

$$\begin{array}{rl} 106.72 & \\ \underline{\ \ 23.4} & \\ 42\,688 & \\ 320\,16\ \ & \\ \underline{2134\,4\ \ \ \ } & \\ 2497\,248 & = 2497{\cdot}248 \\ & = 2497{\cdot}25 \text{ Ans} \end{array}$$

2. Find by using decimals the value of $1\frac{3}{5}$ *of* $21\frac{3}{8}$ (First express mixed numbers as decimals.)

$21\frac{3}{8} = 21.375$ $\quad 1\frac{3}{5} = 1.6$

$$\begin{array}{rl} 21.375 & \\ \underline{\ \ 1.6} & \\ 12\,8250 & \\ \underline{21\,375\ } & \\ 34\,2000 & = 34.2000 \\ & = 34{\cdot}2 \textit{ Ans} \end{array}$$

Note how the noughts must be included when finding the position of the decimal point.

Division of Decimals

In this it is necessary to make the divisor (the number you are dividing by) into a whole number by moving the point the required number of places to the right. Move the point the same number of places to the right in the dividend (the number you are dividing into), and then proceed with the division.

Thus (1) Divide 16.32 by 0.2

This may be written $\frac{16.32}{0.2}$ and becomes $\frac{163.2}{2}$

Now both numerator and denominator are ten times as large so that the value of the fraction remains the same.

The answer is obviously 81.6.

(2) Find the value of $\frac{16.75}{0.25}$

This becomes $\frac{1675}{25}\cdots$

$$\begin{array}{r} 67 \\ 25\overline{)1675} \\ \underline{150} \\ 175 \\ \underline{175} \\ \cdots \end{array}$$

$= 67$ *Ans*

(3) 9.375 ÷ 4.76 to three sig. figs.

$$= \frac{9.375}{4.76} = \frac{937.5}{476} = \begin{array}{r} 1.969 \\ 476\overline{)937.500} \\ \underline{476} \\ 461.5 \\ \underline{428.4} \\ 33.10 \\ \underline{28.56} \\ 4.540 \\ \underline{4.284} \\ .256 \end{array}$$

$= 1.97$ to three sig. figs. *Ans*

APPLICATION:

Study the following examples carefully before attempting the final exercise in this chapter.

EXAMPLE 1:

Find the value of: $\frac{(2.25+14.6)\times(3.4-1.15)}{0.05}$

Remembering to work the brackets first,

2.25	3.4
+14.6	-1.15
16.85	2.25

Fraction = $\frac{16.85\times 2.25}{0.05}$

Now the multiplication:

```
16.85
 2·25
  8425
 3 370
33 70
37 9125
```

Fraction $= \frac{37.9125}{0.05}$

$= \frac{3791.25}{5}$

Dividing denominator into numerator,

Fraction = 758.25 *Ans*

Self Assessment

Questions on Background Notes – Module 1.Unit 4

1. What is a Dial Gauge used for?

2. What are Trammel Heads used for?

3. What are the two main standards of length in measurement?

Answers to Questions 1-3. Module 1.Unit 4

1.

Used for checking Concentricity and Eccentricity:

Example:
A rotating shaft that has been pressed into a sleeve, its accuracy can be measured using a Dial Gauge.

2.

Used to mark large Radi and Arcs.

3.

a. The International Metre (Metric) / Millimetres.

b. The Imperial Standard Yard (Imperial) / Yards / Inches.

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Welder on Site…Be Aware (Vocam) *Powered hand tool safety (Vocam)* *Industrial Ergonomics (Vocam)*	*Circle organisation Ltd.* *Moira Has., Trinity Street,, Dublin 2, Ireland.* *Website: www.vocam.com*

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