Drilling processes - Drilling Machines, Types, Use and Care

Objectives: At the end of this lesson you shall be able to
- **name the various types of drilling machines**
- **name the parts of the bench and pillar type drilling machines**
- **compare the features of the bench and pillar type drilling machines.**

The principle types of drilling machines are

– the sensitive bench drilling machine

– the pillar drilling machine

– the column drilling machine

– the radial arm drilling machine (radial drilling machine).

(You are not likely to use the column and radial type of drilling machines now. Therefore, only the sensitive and pillar type machines are explained here)

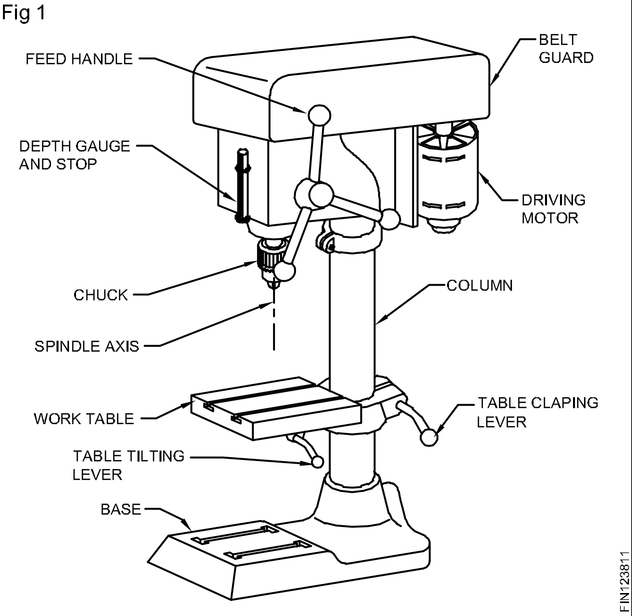
The sensitive bench drilling machine (Fig 1)

The simplest type of the sensitive drilling machine is shown in the figure with its various parts marked. This is used for light duty work.

This machine is capable of drilling holes up to 12.5 mm diameter. The drills are fitted in the chuck or directly in the tapered hole of the machine spindle.

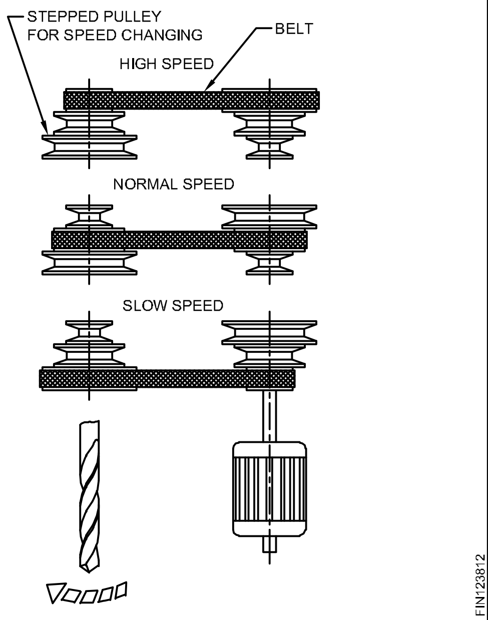
For normal drilling, the work-surface is kept horizontal. If the holes are to be drilled at an angle, the table can be tilted. (Tilting arrangemented is shown in Fig.1)

Fig 1



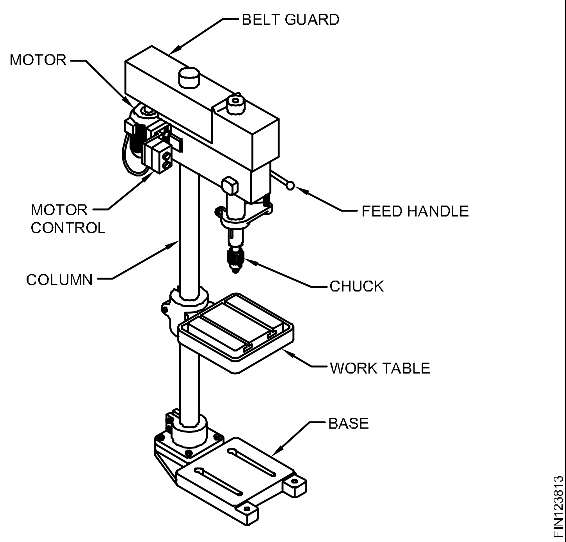
Different spindle speeds are achieved by changing the belt position in the stepped pulleys. (Fig 2)

Fig 2



The pillar drilling machine (Fig 3)**:** This is an enlarged version of the sensitive bench drilling machine. These drilling machines are mounted on the floor and driven by more powerful electric motors.

Fig 3



They are also used for light duty work. Pillar drilling machines are available in different sizes. The larger machines are provided with a rack and pinion mechanism to raise the table for setting the work.

Drill - Holding devices

Objectives : At the end of this lesson you shall be able to

- **name the types of drill-holding devices**
- **state the features of drill chucks**
- **state the functions of drill sleeves**
- **state the function of drift.**

For drilling holes on materials, the drills are to be held accurately and rigidly on the on the machines.

The common drill-holding devices are drill chucks and sleeves and sockets.

Drill Chuck

Straight shank drills are held in drill chucks. For fixing and removing drills, the chucks are provided either with a pinion and key or a knureld ring.

The drill chucks are held on the machine spindle by means of an arbor fitted on the drill chuck. (Fig 1)

Taper Sleeves and Sockets (Fig 1)

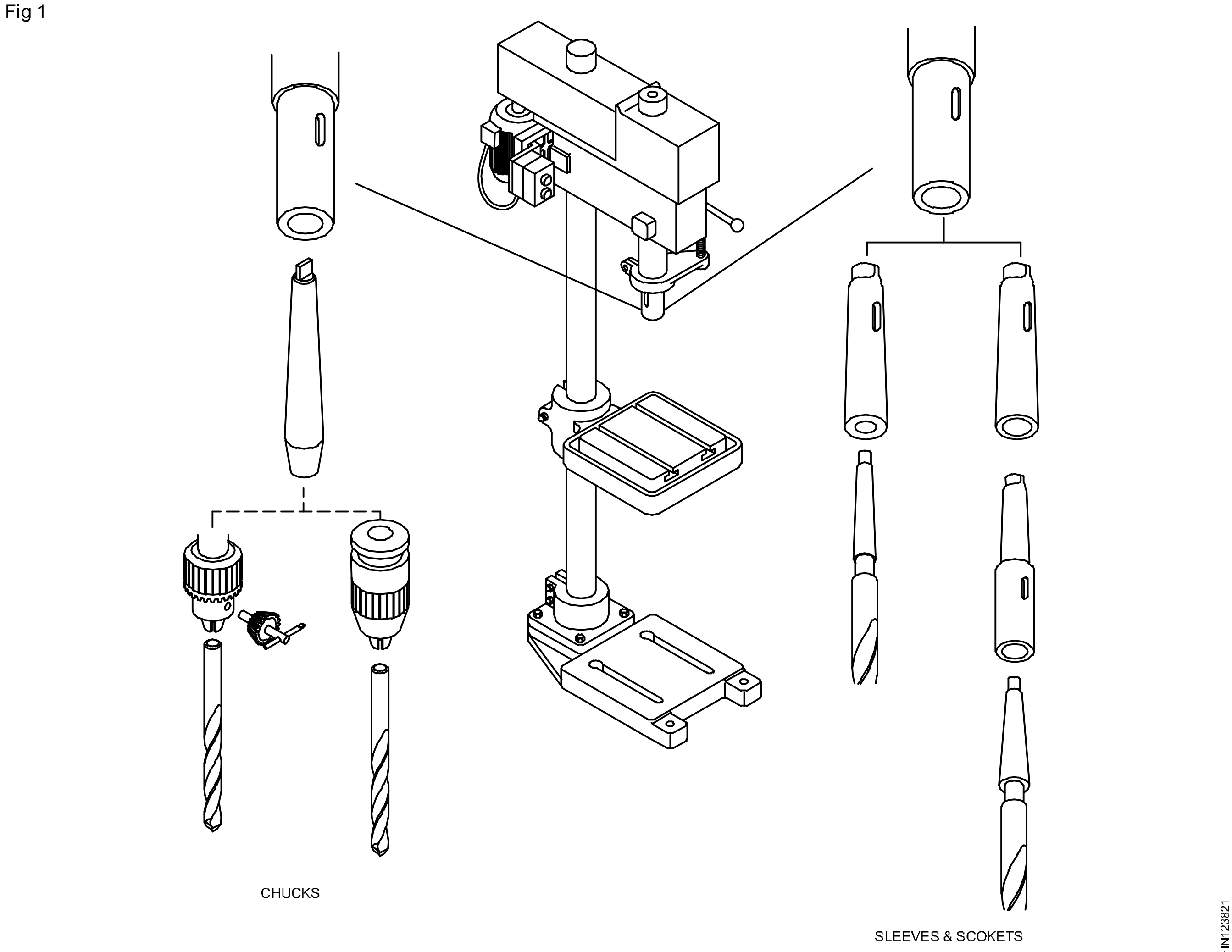
Taper shank drills have a morse taper.

Sleeves and sockets are made with the same taper so that the taper shank of the drill, when engaged, will give a good wedding action. Due to this reason morse tapers are called self-holding tapers.

Drills are provided with five different sizes of morse tapers, and are numbered from MT1 to MT5.

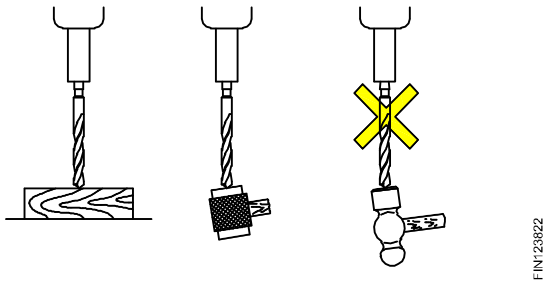
In order to make up the difference in sizes between the shanks of the drills and the type of machine spindies, sleeves of different sizes are used. When the drill taper shank is bigger than machine spindle, taper sockets are used. (Fig 1)

Fig 1



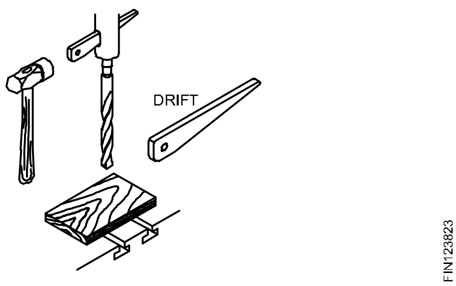
While fixing the drill in a socket or sleeve, the tang portion should align in the slot. (Fig 2) This will facilitate the removal of drill or sleeve from the machine spindle.

Fig 2



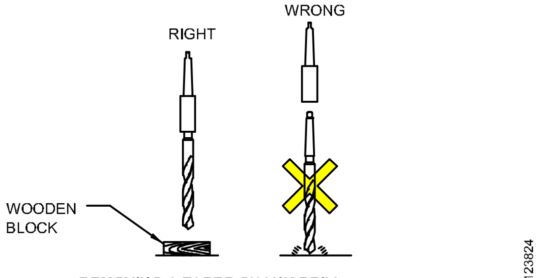
Use a drift to remove drills and sockets from the machine spindle. (Fig 3)

Fig 3



While removing the drill from the sockets/ sleeves, don't allow it to fall on the table or jobs. (Fig 4)

Fig 4



REMOVING A TAPER SHANK DRILL

Work-holding devices

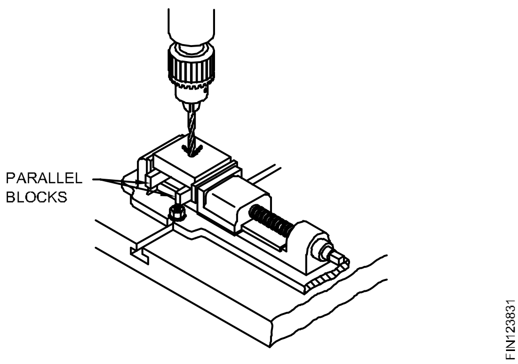
Objectives : At the end of this lesson you shall be able to
- **state the purpose of work-holding devices**
- **name the devices used for holding work**
- **state the precautions to be observed while using work-holding devices.**

Workpieces to be drilled should be properly held or clamped to prevent from roating along with the drill. Improperly secured work is not only a danger to the operator but can also cause inaccurate work, and breakage to the drill. Various are used to ensure proper holding.

The machine vice

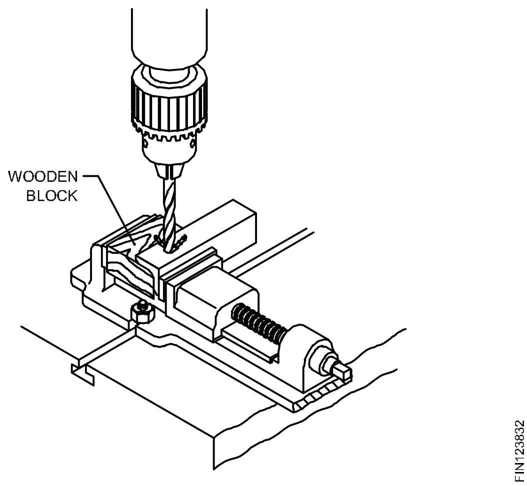
Most of the drilling work can be held in a machine vice. Ensure that the drill does not drill through the vice after it has passed through the work. For this purpose, the work can be lifted up and secured on paralle blocks providing a gap between the work and the bottom of the vice. (Fig 1)

Fig 1



Workpieces which are not accurate may be supported by wooden pieces. (Fig 2)

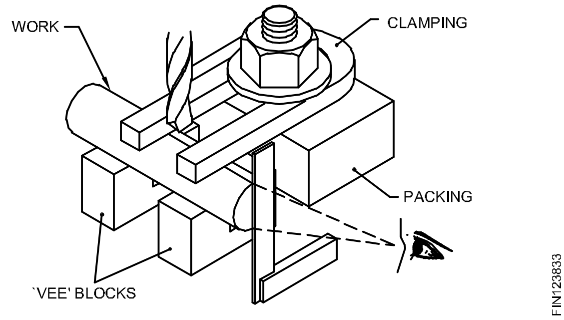
Fig 2



Clamps and bolts

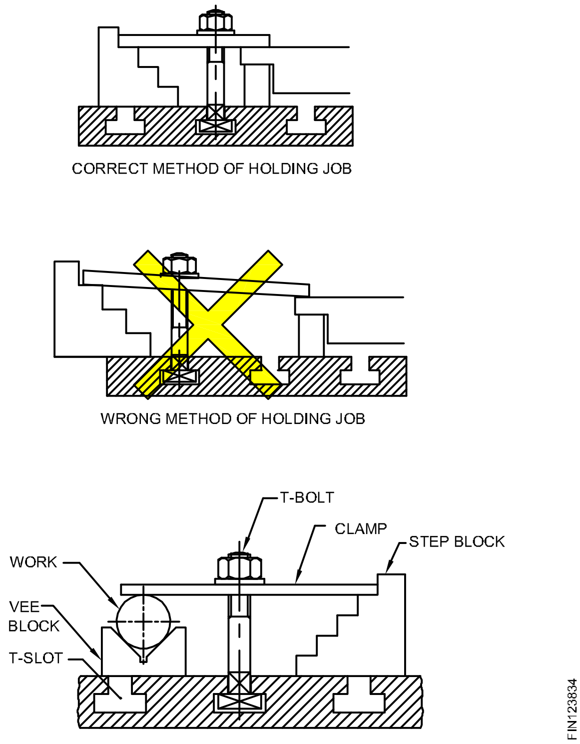
Driling machine tables are provided with T-slots for fitting bolt heads. Using clamps and bolts, the workpieces can be held very rigidly. (Fig 3) While using this method, the

Fig 3



packing should be, as far as possible, of the same height as the work, and the bolt nearer to the work. (Fig 4)

Fig 4



There are many types of clamps and it is necessary to determine the clamping method according to the work. (Fig 5& 6)

Fig 5

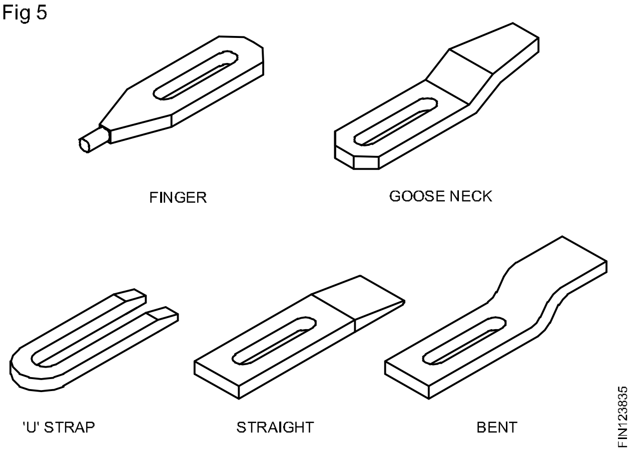
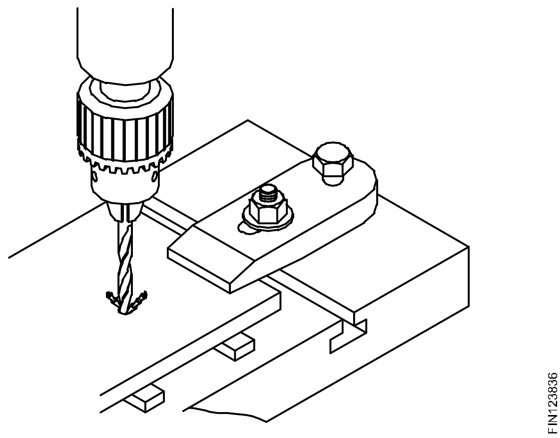


Fig 6



Cutting speed and RPM

Objectives : At the end of this lesson you shall be able to
- **define cutting speed.**
- **state the factors for determining the cutting speed**
- **differentiate between cutting speed and RPM**
- **determine RPM/spindle speed**
- **select RPM for drill sizes from tables.**

For a drill to give a satisfactory performance, it must operate at the correct cutting speed and feed.

Cutting speed is the speed at which the cutting edge passes over the material while cutting, and is expressed in metres per minute.

Cutting speed is also sometimes stated as surface speed or peripheral speed.

The selection of the recommended cutting speed for drilling depends on the materials to be drilled, and the tool material.

Tool manufacturers usually provide a table of cutting speeds required for different materials.

The recommended cutting speeds for different materials are given in the table. Based on the cutting speed recommended, the RPM, at which a drill has to be driven, is determined.

Materials being drilled for HSS	Cutting speed (m/min)
Aluminium	70 - 100
Brass	35 - 50
Bronze(phosphor)	20 - 35
Cast iron (grey)	25 - 40
Copper	35 - 45
Steel (medium carbon/mild steel)	20 - 30
Steel (alloy,high tensile)	5 - 8
Thermosetting plastic (low speed due to abrasive properties)	20 - 30

Calculating RPM

$$v = \frac{n x d x \pi}{1000} m/min$$

$$n = \frac{v x 1000}{d x \pi} RPM$$

n - RPM

v - cutting speed in m/min.

d - diameter of the drill in mm

π = 3.14

Examples: Calculate the RPM for a high speed steel drill ∅ 24 to cut mild steel.

The cutting speed for MS is taken as 30 m/min. from the table.

$$n = \frac{1000x30}{3.14x24} = 398 RPM$$

It is always preferable to set the spindle speed to the nearest available lower range. The selected spindle speed is300 RPM.

The RPM will differ according to the diameter of the drills. The cutting speed being the same, larger diameter drills will have lesser RPM and smaller diameter drills will have higher RPM.

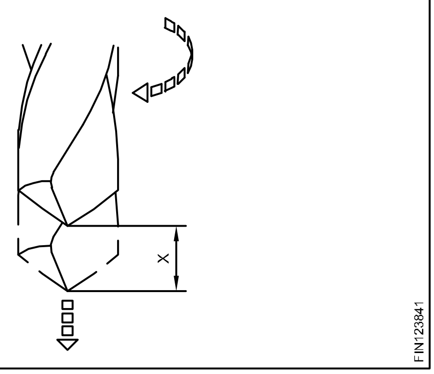
The recommended cutting speeds are achieved only by actual experiments.

Feed in drilling

Objectives : At the end of this lesson you shall be able to
- **state what is meant by feed**
- **state the factors that contribute to an efficient feed rate.**

Feed is the distance (X) a drill advances into the work in one complete rotation. (Fig 1)

Fig 1



Feed is expressed in hundredths of a millimeter.

Example - 0.040mm

The rate of feed is dependent upon a number of factors.

Finish required

Type of drill (drill material)

Material to be drilled

Factors like rigidity of the machine, holding of the workpiece and the drill, will also have to be considered while determining the feed rate. If these are not to the required standard, the feed rate will have to be decreased.

It is not possible to suggest a particular feed rate taking all the factors into account.

The table for the feed rate given here is based on the average feed values suggested by the different manufacturers of drills. (Table 1)

TABLE 1

Drill diameter (mm) HSS	Rate of feed (mm/rev)
1.0 - 2.5	0.040 - 0.060
2.6 - 4.5	0.050 - 0.100
4.6 - 6.0	0.075 - 0.150
6.1 - 9.0	0.100 - 0.200
9.1 -12.0	0.150 - 0.250
12.1 - 15.0	0.200 - 0.300
15.1 - 18.0	0.230 - 0.330
18.1 - 21.0	0.260 - 0.360
21.1 - 25.0	0.280 - 0.380

Too coarse a feed may result in damage to the cutting edges or breakage of the drill.

Too slow a rate of feed will not bring improvement in surface finish but may cause excessive wear of the tool point, and lead to chattering of the drill.

For optimum results in the feed rate while drilling, it is necessary to ensure the drill cutting edges are sharp. Use the correct type of cutting fluid.

Radial drilling machines

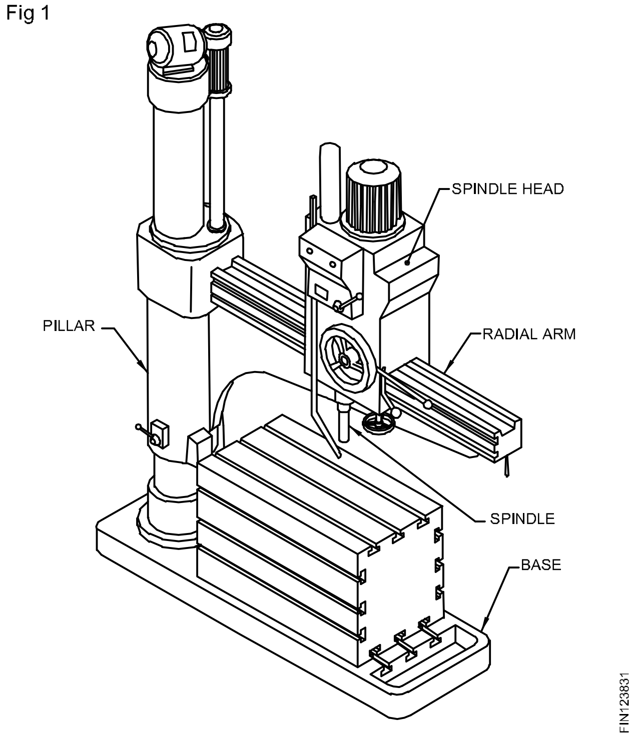
Objectives : At the end of this lesson you shall be able to
- **state the uses of a radial drilling machine**
- **state the features of radial drilling machine.**

Radial drilling machines are used to drill

- large diameter holes
- multiple holes in one setting of the work
- heavy and large workpieces.

Features (Fig 1)

Fig 1



The radial drilling machine has a radial arm on which the spindle head is mounted

The spindle head can be moved along the radial arm and can be locked in any position

The arm is supported by a pillar (column). It can be rotated about with the pillar as centre. Therefore, the drill spindle can cover the entire working surface of the table. The arm can be lifted or lowered.

The motor mounted on the spindle head rotates the spindle.

The variable-speed gear box provides a large range of R.P.M.

The spindle can be roated in both clockwise and anticlockwise directions.

Angular holes can be drilled on machines having tilting tables.

A coolant tank is mounted on the base.

Precautions

Ensure that the spindle-head and the arms are locked properly to avoid vibration.

The workpiece and the drill should be rigidly held.

Bring back the spindle head nearer to the pillar after use.

Switch off power when not in use.

Use the drill drift for removing the drills, chucks or sockets.

Use a minimum number of sockets and sleeves to make for the spindle bore size.

Clean and oil the machine after use.

Stop the machine to remove the swarf.

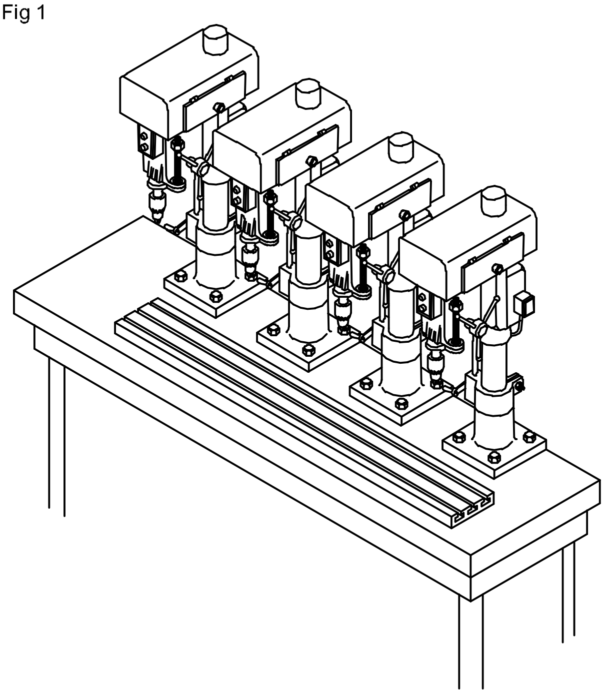
Use a brush to clean the chips and swarf.

Gang drilling machine and multiple spindle head drilling machine

Objectives: At the end of this lesson you shall be able to
- **state the uses of a gang drilling machine**
- **state the construction of a gang drilling machine**
- **state the uses and construction of a multiple spindle head drilling machine.**

Gang drilling machine (Fig 1)

Fig 1



GANG OF FOUR DRILLING MACHINES

EACH MACHINE IS FITTED WITH A DIFFERENT CUTTING TOOL. AS THE WORK MOVES FROM POSITION TO POSITION A DIFFERENT OPERATION IS PERFORMED

FIN123861

It consists of a large base supporting a long table. The top of the table is designed in such a way that several units may be mounted on it. Each spindle is driven by its individual directly connected motor.

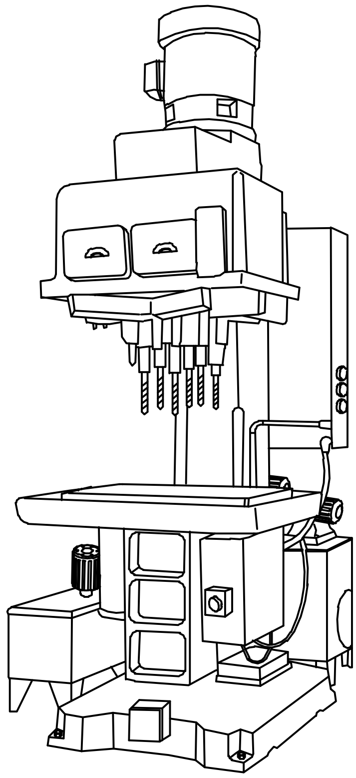
The table has a groove around the outside for the return of the cutting lubricant, and may have ‘T’-slots on its surface for ease in clamping the work to the table.

This type of machine is generally preferred when the work is to be moved from spindle to spindle for successive operations.

Multiple spindle head drilling machine (Fig 2)

The multiple spindle head drilling machine may have any number of spindles - from 4 to 48 or more, all driven from the one-spindle drive gear in one head.

Fig 2



THE DRILLING HEADS CAN BE POSITIONED TO MEET VARIOUS SPECIFICATIONS

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The multiple spindle head drilling machine is specially designed for mass production operations such as drilling, reaming or tapping many holes at one time in a specific unit of work such as an automobile engine block.

There may be two or more drill heads on one machine, each with many spindles. This is necessary when holes are drilled from more than one direction - for example, on the top side, and the end of a piece of work. Production units of this type are seldom used in a tool room that usually does highly skilled work.

Hand taps and wrenches

Objectives: At the end of this lesson you shall be able to
- **state the uses of threading hand taps**
- **state the features of hand taps**
- **distinguish between different taps in a set**
- **name the different types of tap wrenches**
- **state the uses of diffrerent types of wrenches.**

Use of hand taps

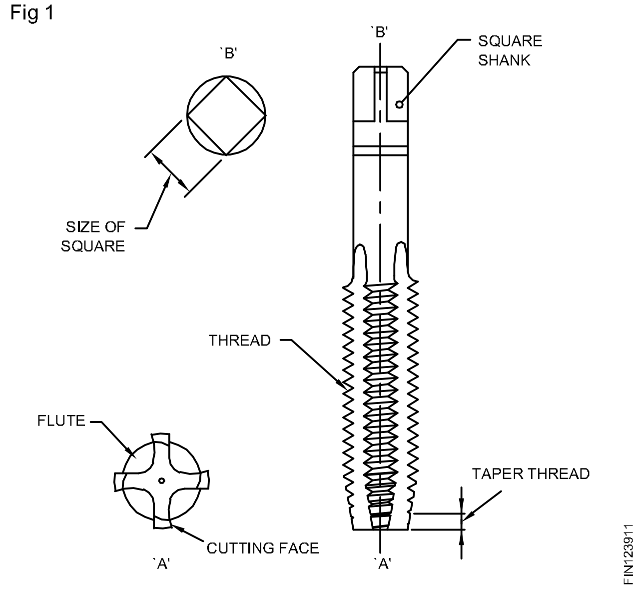
Hand taps are used for internal threading of components.

Features (Fig 1)

They are made from high carbon steel or high speed steel, hardened and ground.

Threads are cut on the surface, and are accurately finished.

Fig 1



To form the cutting edges, the flutes are cut across the thread.

For holding and turning the taps while cutting threads, the ends of the shanks are squared.

The ends of the taps are chamfered (taper lead) for assisting, aligning and starting of the thread.

The size of the taps and the type of the thread are usually marked on the shank.

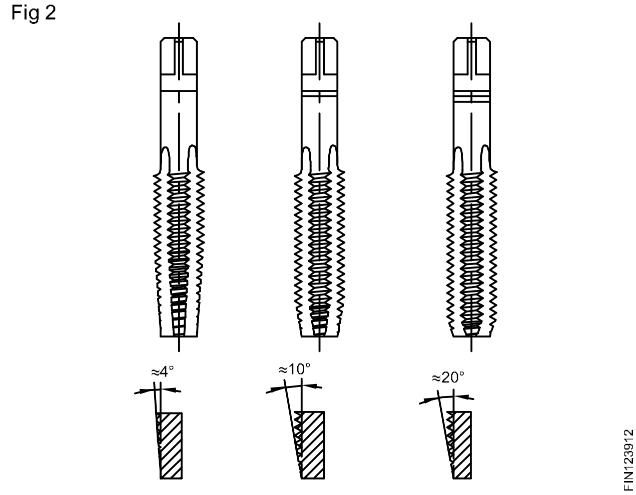
In certain cases, the pitch of the thread will also be marked.

Markings are also made to indicate the type of tap i.e. first, second or plug.

Types of Taps in a set

Hand taps for a particular thread are available as a set consisting of three pieces. (Fig 2)

Fig 2



These are

first tap or taper tap

second tap or intermediate tap

plug or bottoming tap.

These taps are identical in all features except in the taper lead.

The taper tap is to start the thread. It is possible to form full threads by the taper tap in through holes which are not deep.

The bottoming tap (plug) is used to finish the threads of a blind hole to the correct depth.

For identifying the type of taps quickly - the taps are either numbered as 1, 2 and 3 or rings are marked on the shank.

The taper tap has one ring, the intermediate tap has two rings and the bottoming tap has three rings. (Fig 2)

Tap Wrenches

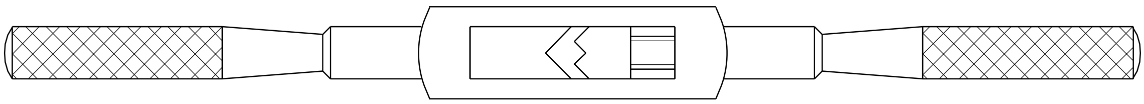
Tap wrenches are used to align and drive the hand taps correctly into the hole to be threaded.

Tap wrenches are of different types.

Double ended adjustable wrench, T-handle tap wrench, solid type tap wrench.

Double-ended Adjustable Tap Wrench or Bar Type Tap Wrench (Fig 3)

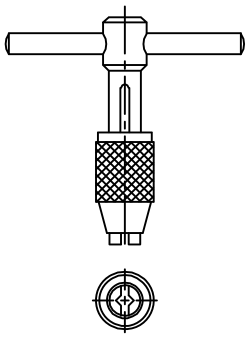
Fig 3



This is the most commonly used type of tap wrench. It is available in various sizes. These tap wrenches are more suitable for large diameter taps, and can be used in open places where there is no obstruction to turn the tap. It is important to select the correct size of wrench.

T-Handle tap wrench (Fig 4)

Fig 4



These are small adjustable chucks with two jaws and a handle to turn the wrench.

This tap wrench is useful to work in restricted places, and is turned with one hand only.

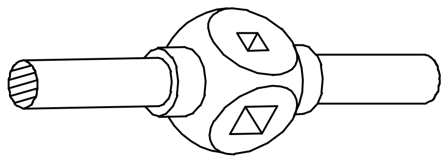
This wrench is not available for holding large diameter taps.

Solid type tap wrench (Fig 5)

These wrenches are not adjustable.

They can take only certain sizes of taps. This eliminates the use of wrong length of the tap wrenches, and thus prevents damage to the taps.

Fig 5



Tap drill size

Objectives: At the end of this lesson you shall be able to
- **state what is tap drill size**
- **choose the tap drill sizes of different threads from tables**
- **calculate the tap drill sizes for ISO metrice and ISO inch.**

What is a tap drill size?

Before a tap is used for cutting internal threads, a hole is to be drilled. The diameter of the hole should be such that it should have sufficient material in the hole for the tap to cut the thread.

Tap drill sizes for different threads

ISO Metric Thread

Tapping drill size

for M10 x 1.5 thread

Minor diameter = Major diameter – 2 x depth

depth of thread = 0.6134 x pitch of a screw

2 depth of thread = 0.6134 x 2 x pitch

=1.226 x 1.5 mm = 1.839 mm

Minor dia (D1)=10 mm – 1.839 mm

=8.161mm or 8.2 mm

This tap drill will produce 100% thread because this is equal to the minor diameter of the thread. For most fastening purposes a 100% formed thread is not required.

A standard nut with 60% thread is strong enough to be tightened until the bolt breaks without stripping the thread.

Further it also requires a greater force for turning the tap if a higher percentage formation of thread is required.

Considering this aspect, a more practical approach for determining the tap drill sizes is

Tap drill size = Major diameter – pitch

= 10 mm - 1.5 mm

= 8.5 mm.

Compare this with the table of tap drill sizes for ISO metric threads.

ISO Inch (Unified) threads Formula

Tap Drill size =

$$\text{Major diameter} - \frac{1}{\text{Number of threads per inch}}$$

For calculating the tap drill size for 5/8" UNC thread

Tap drill size = 5/8" – 1/11"

= 0.625" – 0.091"

= 0.534"

The next drill size is 17/32" (0.531 inches)

Compare this with the table of drill sizes for unified inch threads.

What will be the tapping size for the following threads?

(a) M 20

(b) UNC 3/8

Refer to chart for determining the pitches of the thread.

COMMERCIAL DRILL SIZES ISO INCH (UNIFIED) THREAD

NC National Coarse				NF National Fine		
Tap size	**Tharads per inch**	**Tap dirll size per inch**		**Tap size**	**Therads**	**Tap drill size**
5	40	38		5	44	37
6	32	36		6	40	33
8	32	29		8	36	29
10	24	25		10	32	21
12	24	16		12	28	14
1/4 "	20	7		1/4 "	28	3
5/16 "	18	F		5/16 "	24	1
3/8 "	16	5/16 "		3/8 "	24	0
7/16 "	14	U		7/16 "	20	25/64 "
1/2 "	13	27/64 "		1/2 "	20	29/64 "
9/16 "	12	31/64 "		9/16 "	18	33/64 "
5/8 "	11	17/32 "		5/8 "	18	37/64 "
3/4 "	10	21/32 "		3/4 "	16	11/16 "
7/8 "	9	49/64 "		7/8 "	14	13/16 "
1"	8	7/8 "		1 "	14	15/16 "
1 1/8 "	7	63/64 "		1 1/8 "	12	1 3/6 "
1 1/4 "	7	17/64 "		1 1/4 "	12	1 11/6 "
1 3/8 " "	6	17/32 "		1 3/8 "	12	1 19/64
1 3/4 "	5	1 9/16 "				
2 "	4 1/2	1 25/32 "				
NPT National pipe thread						
1/8 "	27	11/32 "		1 "	11 1/2	1 5/32 "
1/4 '	18	7/16 "		1 1/4 "	11 1/4	1 1/2 "
3/8 "	18	19/32 "		1 1/2 "	11 1/2	1 23/32 "
1/2 "	14	23/32 "		2 "	11 1/2	2 23/16 "
3/4 "	14	15/16 "		2 1/2 "	8	2 5/8 "

TABLE FOR TAP DRILL SIZES- ISO METRIC THREADS

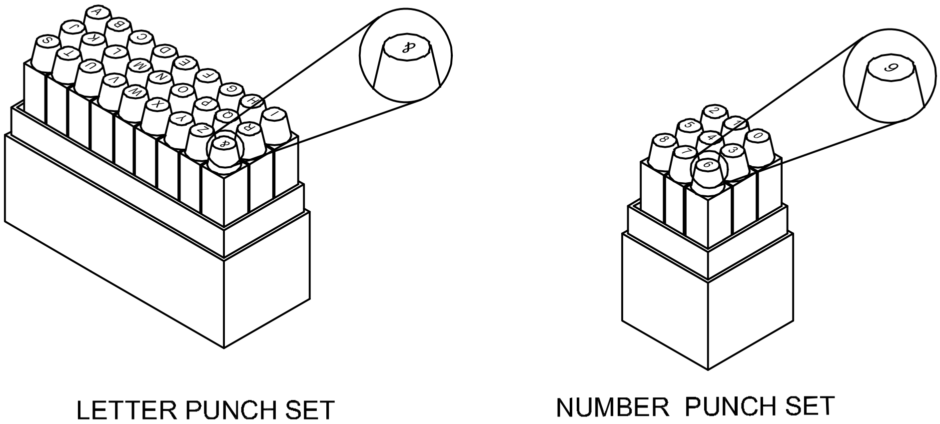
PITCH / NOMINAL DIA.	0.25	0.3	0.35	0.4	0.45	0.5	0.6	0.7	0.75	0.8	1	1.25	1.5	1.75		2.5	3	3.5	4	4.5	5	5.55
1	0.75																					
1.1	0.85																					
1.2	0.95																					
1.4		1.10																				
1.6			1.25																			
1.8			1.45																			
2				1.60																		
2.2					1.75																	
2.5			2.15		2.05																	
3			2.65			2.50																
3.5							2.90															
4						3.50		3.30														
4.5						4.00			3.70													
5						4.50				4.20												
5.5						5.00																
6									5.20		5.00											
7									6.20		6.00											
8									7.20		7.00	6.80										
9									8.20		8.00	7.80										
10									9.20		9.00	8.80	8.50									
11									10.20		10.00		9.50									
12											11.00	10.80	10.50	10.20								
14											13.00	12.80	12.50		12.00							
15											14.00		13.50									
16											15.00		14.50		14.00							
17											16.00		15.50									
18											17.00		16.50		16.00	15.50						
20											19.00		18.50		18.00	17.50						
22											21.00		20.50		20.00	19.50						
24											23.00		22.50		22.00		21.00					
25											24.00		23.50		23.00							
26													24.50									
27											26.00		25.50		25.00		24.00					
28											27.00		26.50		26.00							
30											29.00		28.50		28.00		27.00	26.50				
32													30.50		30.00							
33													31.50		31.00		30.00	29.50				
35													33.50									
36													34.50		34.00		33.00		32.00			
38													36.50									
39													37.50		37.00		36.00		35.00			
40													38.50		38.00		37.00					
42													40.50		40.00		39.00		38.00	37.50		
45													43.50		43.00		42.00		41.00	40.50		
48													46.50		46.00		45.00		44.00		43.00	
50													48.50		48.00		47.00					
52													50.50		50.00		49.00		48.00		47.00	
56																						50.50

Letter punch and number punch

Objective: At the end of this lesson you shall be able to
- **state the uses of letter Punch and Number Punch**

Metal stamps are used to mark or identify work pieces. They are available for stamping letters (Letter Punch) and Numbers (Number punch). They can not be used on hardened metal surfaces (Fig.1)

Fig 1



The letter punch set consists of A, B, C, D, E, F, G, H, N, I, J, K, L, M, N, O, P,Q, R, S, T, U, V, W, X, Y, Z, and '&' (Symbol) of 27 Letter punches in a set. The Number punch set consists of 0,1,2,3,4,5,6,7,8, the number punch 6 will the used for punching number both 6 and 9 .

The letters and numbers are formed in the reverse order. So that while punching letters and numbers will be in correct position. A base line should be scribed on the metal surface, before stamping the letter or number using these punches. Also to locate the position of middle letter (Fig.2) or number (Fig.3) or space (Fig.4) a centre line should be scribed on the base line (Fig.2) Letters or numbers before stamping should be placed on either side of the line from center line, so that middle letter is stamped over the centreline large size letter number punchs are used for better impression by applying more than one stroke. While Punching on cast iron or hot rolled steel, the hard outer layer of the metal should the removed by grinding or filing or machining for better impression are visibility.

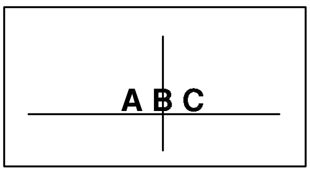


Fig 2

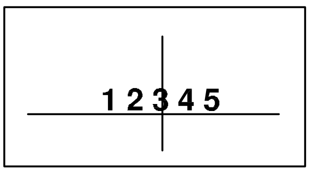


Fig 3

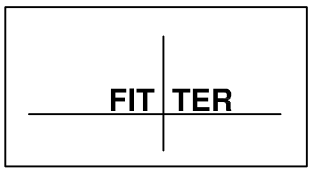


Fig 4

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