Module 2

1. Milling Machines
2. Drilling Machines
3. Shaping, Planing & Slotting Machines
4. Grinding Machines

Milling Machines

Milling machine tool:

Milling is a metal cutting operation in which the cutting tool is a slow revolving cutter having cutting teeth formed on its periphery. The milling cutter is a multipoint cutting tool. The work piece is mounted on a movable worktable, which will be fed against the revolving milling cutter to perform the cutting operation.

Working Principle:

Figure shown above is the principle of cutting action of a milling cutter. The milling cutter is mounted on a rotating shaft known as arbor. The work piece which is mounted on the table can be fed either in the direction opposite to that of the rotating cutter as shown in above fig (a) or in the same direction to that of the cutter as shown in above fig (b).

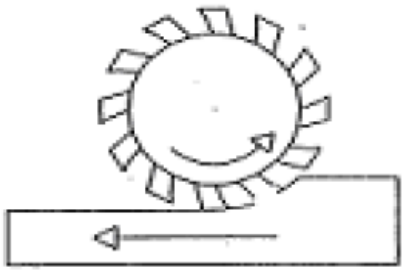
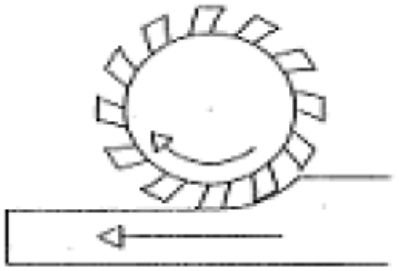


Fig (a): Up Milling



(b): Down Milling

Up Milling & Down Milling

Difference between up milling and down milling	
Up Milling	**Down Milling**
1. Cutter rotates against the direction of table feed.	1. Cutter rotates along the direction of table feed.
2. Chip load on teeth (or uncut chip thickness) increases gradually from zero to maximum during the contact period for each tooth.	2. Chip load on teeth (or uncut chip thickness) decreases gradually from maximum to zero during the contact period for each tooth.
3. Cutting force in up milling is directed upward, and thus it tends to lift off the workpiece from worktable.	3. Cutting force is directed downward, and thus it tends to press the workpiece rather than lifting off.
4. Burr is formed only on unfinished surface ahead of the tool feed; however, majority of such burr is removed in the subsequent passes.	4. Burr is formed at finished surface in opposite side of the tool feed. Thus these burrs are not removed automatically. This leads to degraded cutting quality.
5. Here tooth experience gradual loading as contact starts with zero chip load.	5. Here tooth experience impact loading due to sudden mating with maximum chip load.
6. No backlash eliminator is required.	6. Backlash eliminator is required, if machine is older one.
	www.difference.minaprem.com

Types of Milling Machines

- Column & knee milling machines
  - Plain column & knee Type milling machine
    - Horizontal spindle
    - Vertical spindle
  - Universal Plain column & knee Type milling machine
- Bed type milling machine
- Planer type milling machine
- Special purpose milling machine
  - Tracer-controlled milling machine
  - Thread milling machine
  - CNC milling machine

Horizontal Milling Machine

The main part of machine is base, Column, Knee, Saddle, Table, Overarm, Arbor Support and Elevating Screw.

1. Base: It gives support and rigidity to the machine and also acts as a reservoir for the cutting fluids.

2. Column: The column is the main supporting frame mounted vertically on the base. The column is box shaped, heavily ribbed inside and houses all the driving mechanisms for the spindle and table feed.

3. Knee: The knee is a rigid casting mounted on the front face of the column. The knee moves vertically along the guide ways and this movement enables to adjust the distance between the cutter and the job mounted on the table. The adjustment is obtained manually or automatically by operating the elevating screw provided below the knee.

4. Saddle: The saddle rests on the knee and constitutes the intermediate part between the knee and the table. The saddle moves transversely, i.e., crosswise (in or out) on guide ways provided on the knee.

5. Table: The table rests on guide ways in the saddle and provides support to the work. The table is made of cast iron, its top surface is accurately machined and carriers T-slots which accommodate the clamping bolt for fixing the work. The worktable and hence the job fitted on it is given motions in three directions:

a). Vertical (up and down) movement provided by raising or lowering the knee.

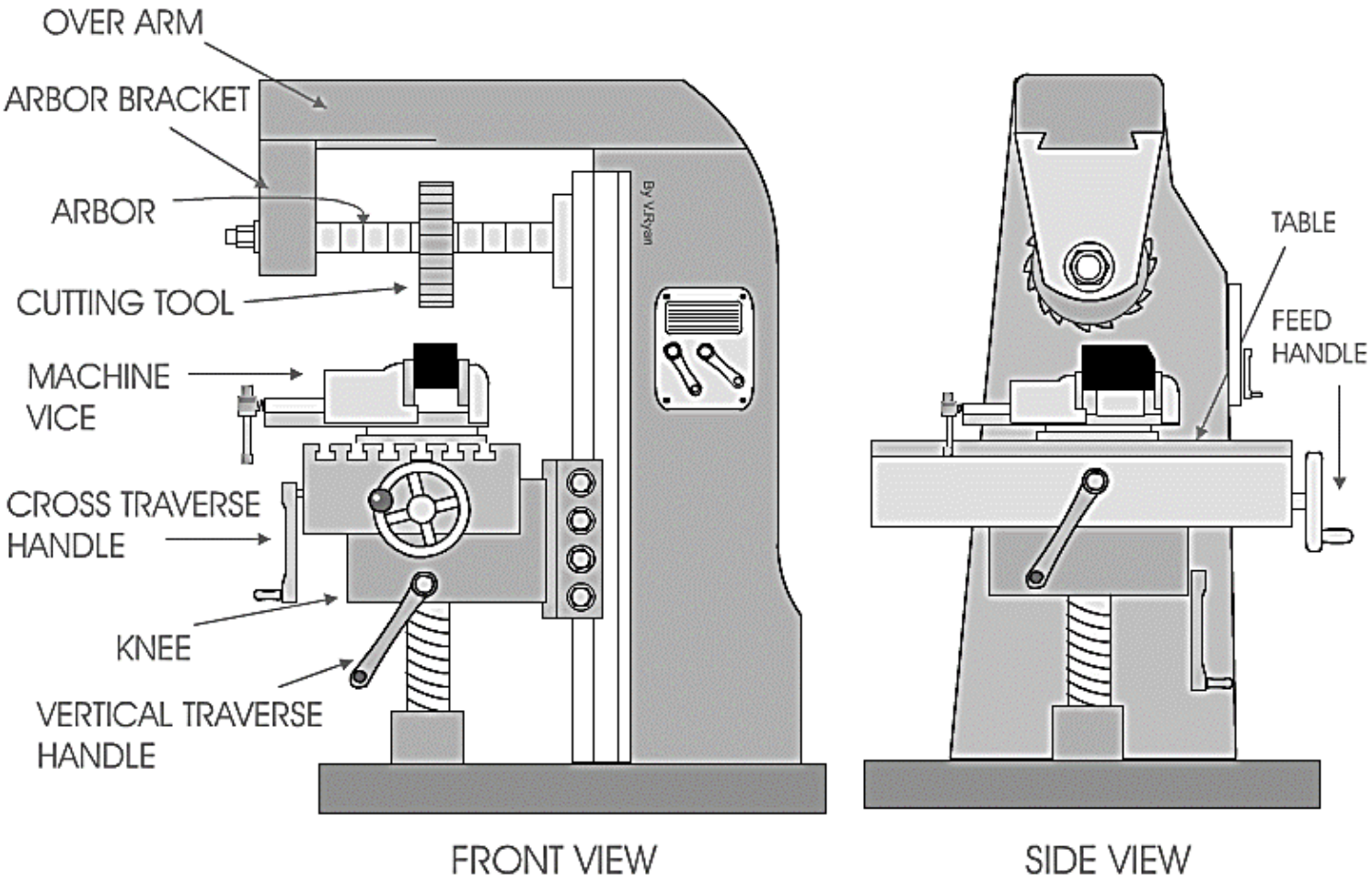
b). Cross (in or out) or transverse motion provided by moving the saddle in relation to knee.

c). Longitudinal (back and forth) motion provided by hand wheel fitted on the side of feed screw. In addition to the above motions, the table of a universal milling machine can be swivelled 45° to either side of the centre line and thus fed at an angle to the spindle.

6. Overarm: The Overarm is mounted at the top of the column and is guided in perfect alignment by the machined surfaces. The Overarm is the support for the arbor.

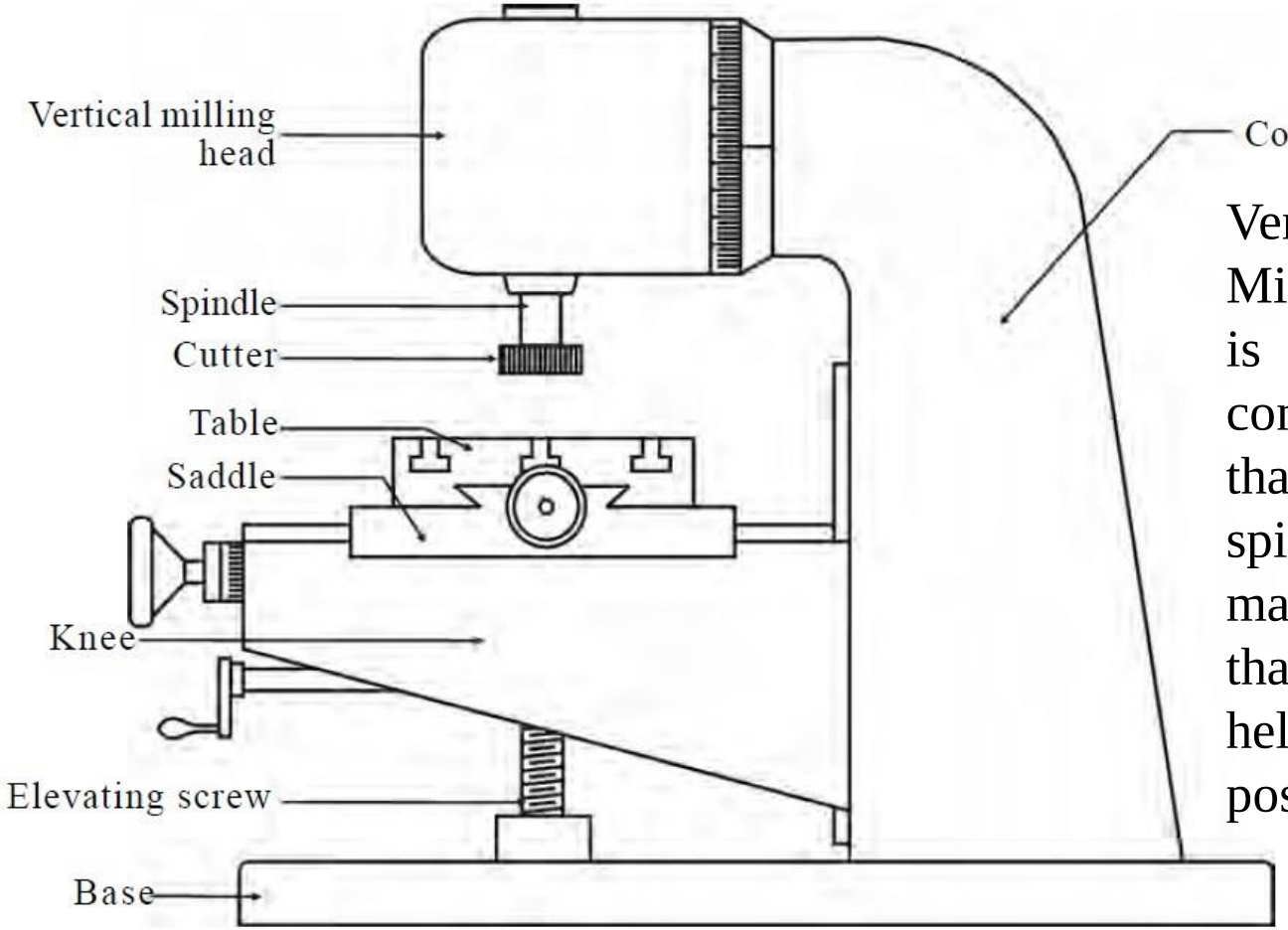
7. Arbor support: The arbor support is fitted to the Overarm and can be clamped at any location on the Overarm. Its function is to align and support various arbors. The arbor is a machined shaft that holds and drives the cutters.

8. Elevating screw: The upward and downward movement to the knee and the table is given by the elevating screw that is operated by hand or an automatic feed.



Horizontal Spindle Column & Knee Milling Machine

Vertical Milling Machine



Vertical Spindle Milling machine is similar in construction as that of horizontal spindle milling machine. Except that the spindle is held in vertical position.

Machining Processes on Milling Machine

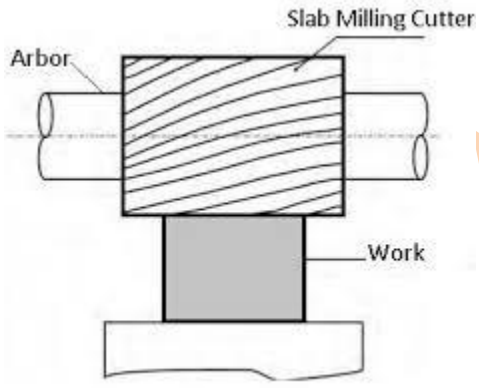
- Plain or Slab milling
- Face milling
- End milling
- Slot milling
- Angular milling
- Form milling
- Straddle milling
- Gang milling
- Gear cutting or Gear Milling
- Thread milling

Machining Processes on Milling Machine

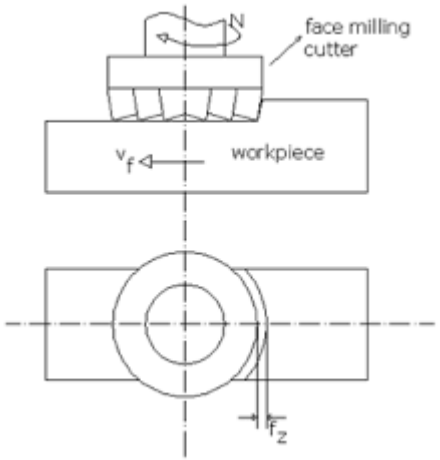
Plain/Slab Milling: Plain milling, also called surface milling, peripheral milling or slab milling is a machining process for production of a plain horizontal surface with a cutter whose axis is parallel to the surface of the workpiece being machined. Process ins being carried out on a horizontal milling machine with a cutter having straight or helical teeth formed on the periphery of a cylindrical surface.

Face Milling: It is a process of producing a flat surface, which is perpendicular to the axis of rotating cutter. Process is carried out on a vertical machine, having milling cutter diameter larger than that of the workpiece.

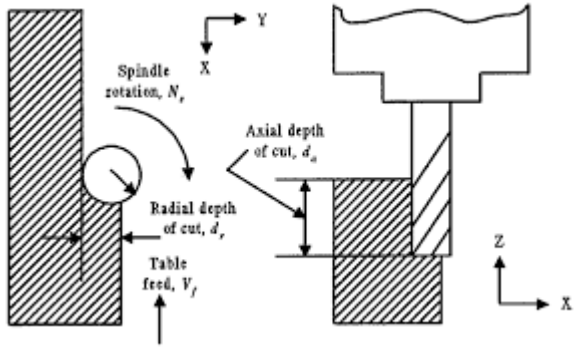
End Milling: Process for producing flat surfaces, slots, grooves or finishing the edges of workpiece by means of tool called end milling cutter, this tool has teeth on the end as well as the periphery for machining both its end as well as its sides.



Plain Milling Operation



Face Milling



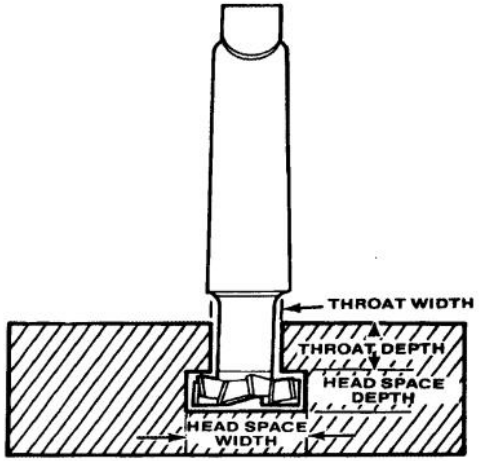
End Milling

Machining Processes on Milling Machine

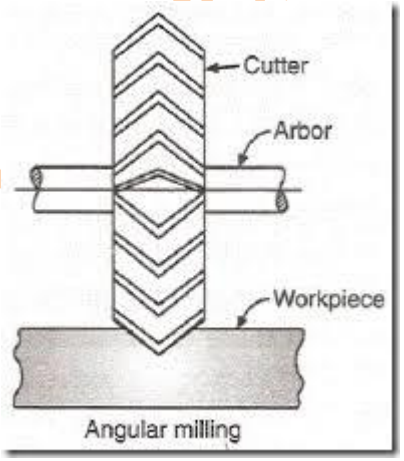
Slot Milling: Is a machining process for producing slots like T-slots, Plain slots, Dovetail slots, etc., it can be performed by using either end milling cutter, T-slot cutter, Dovetail cutter or side milling cutter. The type of cutter selected depends on the shape to be cut.

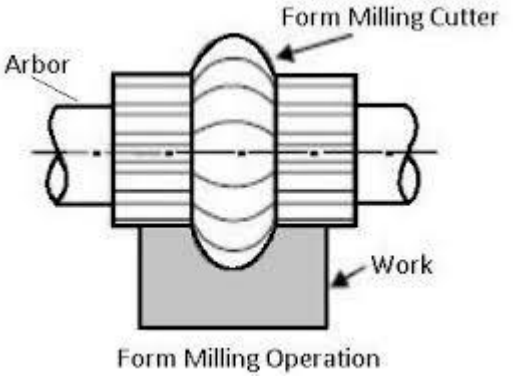
Angular Milling: This is a machining Process for producing all types of angular cuts like V-notches and grooves, serrations and other angular surfaces.

Form Milling: This is a machining process carried out for producing a variety of shapes such as concave, convex, spline etc., using cutters edges is shaped to produce a special configuration on the surface of the workpiece.



Slot Milling



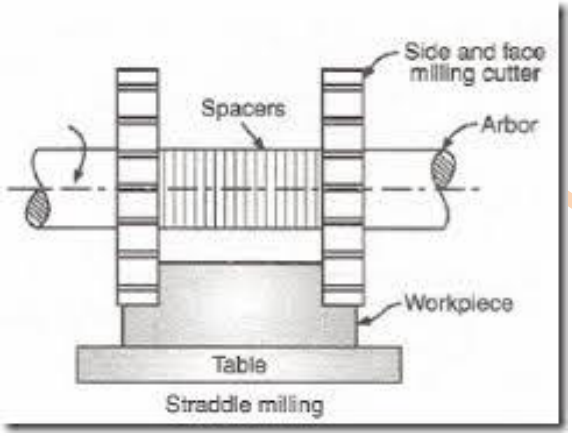


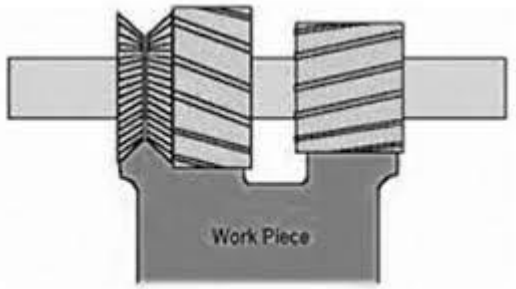
Machining Processes on Milling Machine

Straddle Milling: Is a machining process in which a pair of side milling cutters is used for machining two parallel vertical surfaces. The side milling cutter can have cutting edges on one or both sides as well on its periphery.

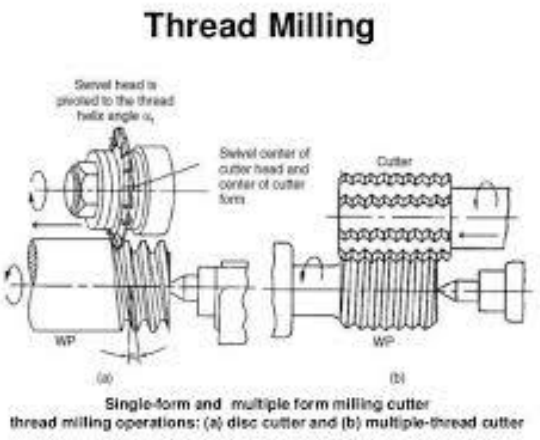
Gang Milling: It is a machining process in which two or more milling cutters are mounted on the same arbor, so that different profiles required on the workpiece can be machined simultaneously in a single pass as shown.

Thread Milling: Is the operation carried out on milling machines to cut threads & worms by means of suitable cutters. Two cutters are generally used, 1st type is called single cutter: consists of single row of teeth mounted on periphery, 2nd type consists of teeth in a number or rows, spaced from one another at a distance equal to the pitch as shown.





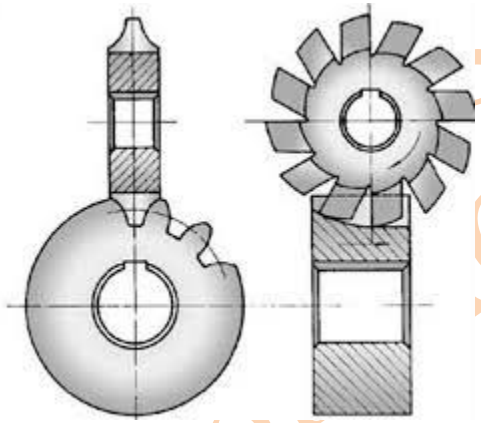
Gang Milling



Single-form and multiple form milling cutter thread milling operations: (a) disc cutter and (b) multiple-thread cutter

Indexing

Gear Cutting/Gear Milling: It is a machining process carried out for cutting teeth of different shapes by using form milling cutters or involute cutters.



Gear Milling/Gear Cutting

Indexing: Milling operations some times require the rotation of workpiece, correct to fraction of minutes, for each groove, slot, gear teeth, etc., to be cut evenly on the work surface. The accuracy of spacing b/w each cut becomes very important, and this is accomplished by means of specialized attachment called indexing head.

Indexing: This can be defined as " the process of evenly dividing the circumference of a circular workpiece into equally spaced divisions, in order to perform certain machining operations such as gear teeth cutting, splines, grooves in reamers & taps etc.,

Indexing Mechanism

The indexing mechanism is as shown in the figures, consists of 40 tooth worm wheel fastened to the index head spindle, a single start threaded worm, a crank for turning the worm shaft and an index plate.

- Workpiece is secured to the index head spindle
- Goal of indexing is to control the rotation of index head spindle & hence the workpiece can be divided into number of equal division [any equal number]
- Worm shaft carries the crank at its outer end, which in turn supports a spring loaded plunger, Index plate is also mounted on the same shaft,
- The index pin works inside the plunger & can be adjusted to lock into desired hole
- By pulling the index pin outwards & rotating the plunger, the crank and hence the worm can be rotated, this causes the worm shaft to rotate causing the worm to drive the wheel and consequently the spindle head and workpiece to rotate

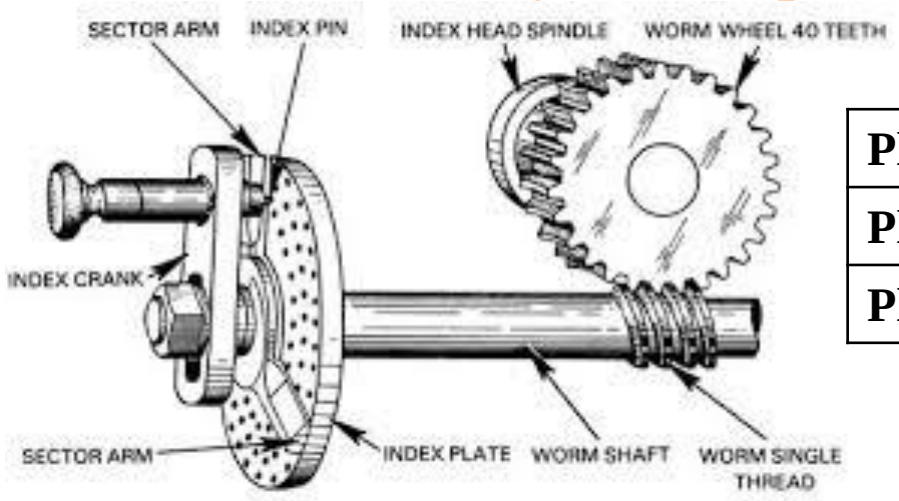


Plate 1	**15, 16, 17, 18, 19, 20 holes**
Plate 2	**21, 23, 27, 29, 31, 33 holes**
Plate 3	**37, 39, 41, 43, 47, 49 holes**

Simple Indexing

Simple Indexing: in this method of indexing, the workpiece is rotated by turning the crank. When the crank is rotated , the worm shaft rotates causing the worn to drive the worm wheel & consequently the spindle to turn. As the spindle rotates, the workpiece that is secured to the spindle by means of a suitable holding device also rotates. The angle though which the workpiece rotates for each revolution of the crank depends on the velocity ration b/w the worm & worm wheel.

Simple Indexing

To calculate velocity ratio

- The worm has a single start thread & the worm wheel 40 teeth, one revolution of crank causes the worm wheel to rotate through one pitch distance., i.e., equal to $1/40^{th}$ of a revolution, two turns of the crank will make worm wheel/workpiece to rotate through 2/40 or $1/20^{th}$ of a revolution and so on
- In other words, 40 revolution of crank will make the worm wheel/workpiece to complete one full turn or 360° revolution thereby making the ratio 40:1
- Therefore, one turn of the index crank =360/40=9°
- Thus it is clear, larger revolution of the crank results in small rotation of the workpiece, therefore the circumference can be divided into any equal divisions
- For 2 division on work piece, the crank has to rotate = 40/2 = 20 turns for each divisions
- For 4 divisions on work piece, the crank has to rotate = 40/4 = 10 turns for each division
- Therefore for N divisions on the work piece, the crank has to be rotated 40/N for each division

Simple Indexing

To index 23divisions on workpiece

If the workpiece has to be divided into 23 divisions, the crank movement is calculated as follows:

Index crank movement = 40/N = 40/23 =1 $\frac{17}{23}$, for each division.

This means that, for each division on the workpiece, the crank should be given 1 full turn, plus a fraction $\frac{17}{23}$ of a turn. This is here, where the circular holes provided in the index plate comes to use.

In the fraction term, the numerator denotes the number of holes to be moved in the index plate, while the denominator denotes the number of holes on the circle to be used.

Comparing the denominator with the counts available on the index plate the denominator 23 matches with the count available in plate 2. hence plate 2 can be used for indexing.

Plate 1	**15, 16, 17, 18, 19, 20 holes**
Plate 2	**21, 23, 27, 29, 31, 33 holes**
Plate 3	**37, 39, 41, 43, 47, 49 holes**

Compound Indexing

Compound Indexing: This method of indexing is employed when the number of divisions required on the workpiece cannot be obtained with simple indexing method. This method involves two separate indexing movements that give the name compound indexing method.

1. The 1st movement is obtained by turning the index crank, a definite amount in one direction in one direction in the same way as in simple indexing, i.e., the crank pin is rotated through a required number of spaces in one of the hole circle of the index plate and then the crank pin is engaged with the plate, as shown in figure (a)
2. The 2nd index movement is obtained by turning the index plate along with the crank as shown in figure (b)

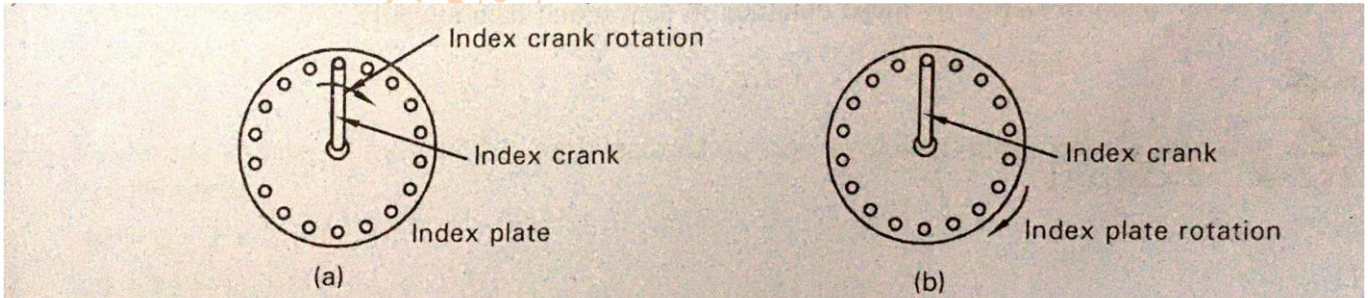


Figure 2.19 Movement of index crank in compound indexing

Numerical on Compound Indexing:

Show the calculations for setting dividing head to mill 69 divisions on a spur wheel blank by compound indexing?

Sol: Index crank movement = 40/N = 40/69 for each division

As there is no 69 hole circle in any of Brown & Sharp plates (Indexing Plates) simple indexing cannot be used, as result compound indexing is used.

Step 1: resolve into factors the number of divisions required on the workpiece. 69=23*3, 23-hole circle is available in plate 2 of Brown & Sharp type.

Step 2: choose randomly another hole circle on the Brown & Sharp plate, let 33-hole circle be selected. Thus N_1 = 23 & N_2 = 33. Therefore, 23 & 33 are the two hole-circles chosen for indexing

Step 3: subtract the hole number of circle from the other 33-23 = 10

Step 4: factors of the difference obtained in step 3, factors of 10 = 2*5

Step 5: factors of the division required and factors of difference obtained in step 3.

69=23*3; 10=2*5

Step 6: factors the no. of turns of the crank required for one revolution of spindle (40), and also, factor the hole-circles chosen: 40=2*2*2*5; 23=23*1; 33=3*11

Step 7: divide the factors obtained in step 5 by those obtained in step 6

Numerical on Compound Indexing continued…:

After simplification, the value of the numerator is unity. It means that the two holes circles 23 hole & 33 hole circle chosen can be used for indexing.

Thus $N_1 = 23$ & $N_2 = 33$. if the numerator is not unity then it means that the two hole selected cannot be chosen for indexing.

Step 8: multiply the factors that remains un-cancelled in step 7 to obtain the spaces to be moved for indexing i.e., $n_1=44=n_2$.

Step 9: apply rule for compound indexing:

Rule for compound indexing as $40/N=n_1/N_1-n_2/N_2$

$40/69=44/23-44/23= 1\frac{21}{23}-1\frac{11}{33}$

Thus for indexing 69 divisons, the index crank should be moved by 21 holes in 23 hole circle in forward direction and further the index plate along with crank is moved by 11 holes in a 33 hole circle in backward or reverse direction.

Differential Indexing

Differential indexing is similar to the compound indexing, wherein, the required division of the periphery of the job is obtained by the combination of two movements:

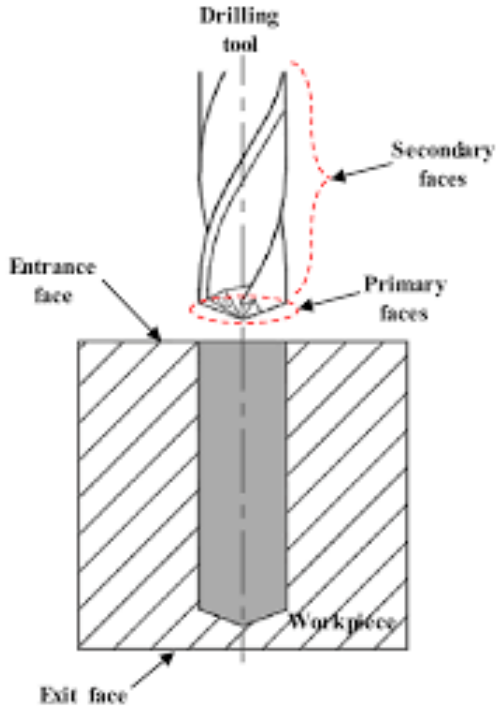
1. The movement of the index crank through the required number of spaces in one hole circle of the index plate as in the case of simple indexing and.,
2. The simultaneous movement of the index plate along with the crank, either in the same direction or reverse direction, thus adding (gain) further movement to, or subtracting (lost) from that obtained in the first movement

The only difference b/w compound & differential indexing is that the movement of the index plate is accomplished by moving the plate by means of a train of gear connecting the index head spindle to the worm shaft

Drilling

Drilling: "It is a machining process/operation of producing a cylindrical hole in a solid workpiece by means of a revolving tool called drill bit".

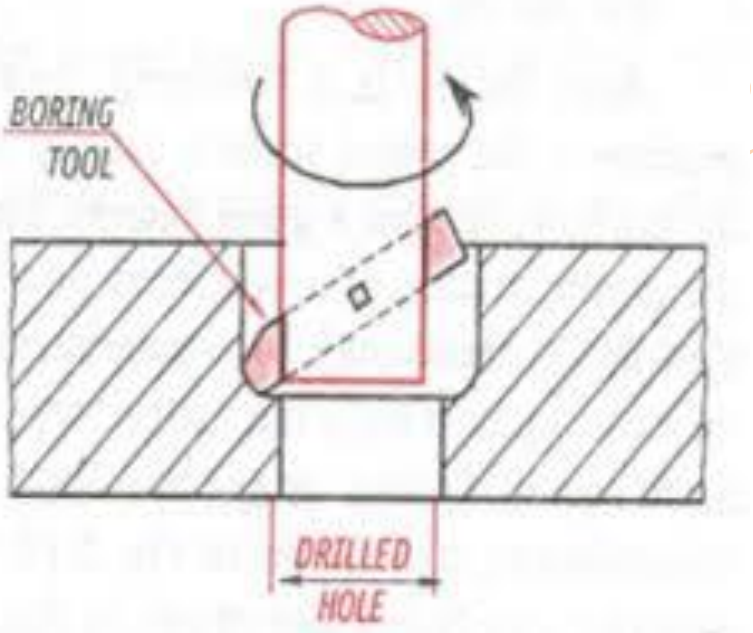
Process: The drill bit is held rigidly in the chuck of the m/c & rotated by the spindle at high speeds. By hand wheel or by automatic means the bit is forced to move against the clamped workpiece. Hole is generated by the bit &b the excess material is extruded through the helical grooves provided in the drill bit. The toll apart from performing the cutting action also extrudes the cut material from the workpiece.

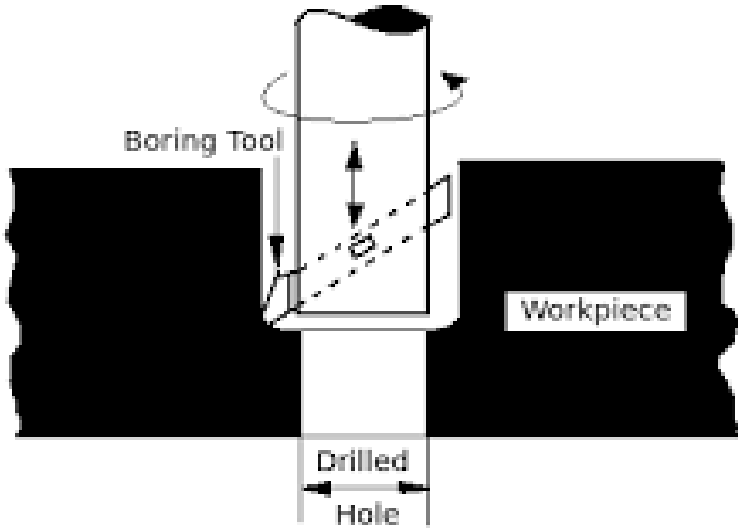


Boring

Boring: "It is the process of enlarging a previously drilled hole by means of an adjustable cutting tool having only one cutting edge".

Process: This operation usually performed when the drill bit the size is not available. In such cases a hole is initially drilled to the nearest dimension & then a single point cutting is fastened & adjusted to a boring bar to enlarge the size of the existing hole to the required dimension. Boring tool is rotated at a speed slower than that of reaming. Apart from enlarging a previously drilled hole boring operation also corrects the hole location & out of roundness if any as the tool can be adjusted to remove more metal from one side of the hole than the other.

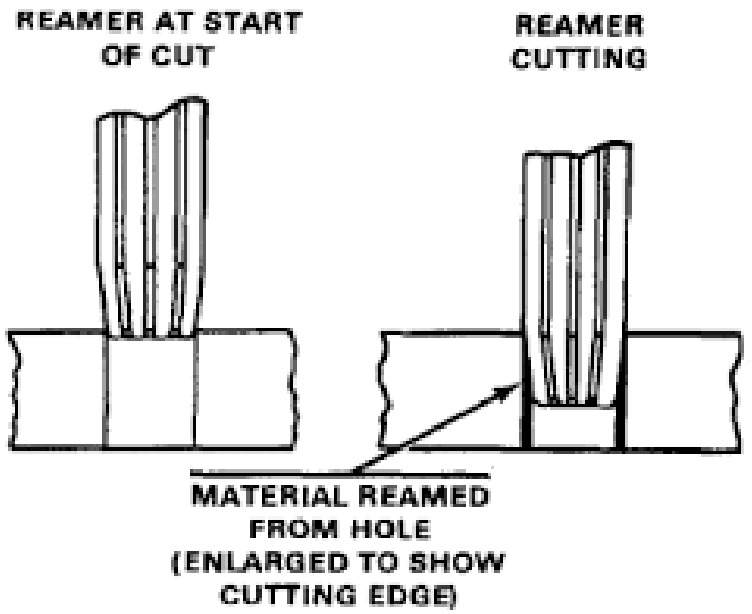




Reaming

Reaming: "It is a machining process carried out for finishing a previously drilled hole so as to bring it to more exact size & to improve the surface a previously drilled hole ".

Process: The operation is carried out using a multi-tool revolving tool called reamer, which consists of a set of parallel straight or helical edges along the length of the cylindrical body. The speed of the spindle is reduced to nearly half of that of drilling. The material is removed in small amounts and hence the surface of the drilled hole is finished with high accuracy.



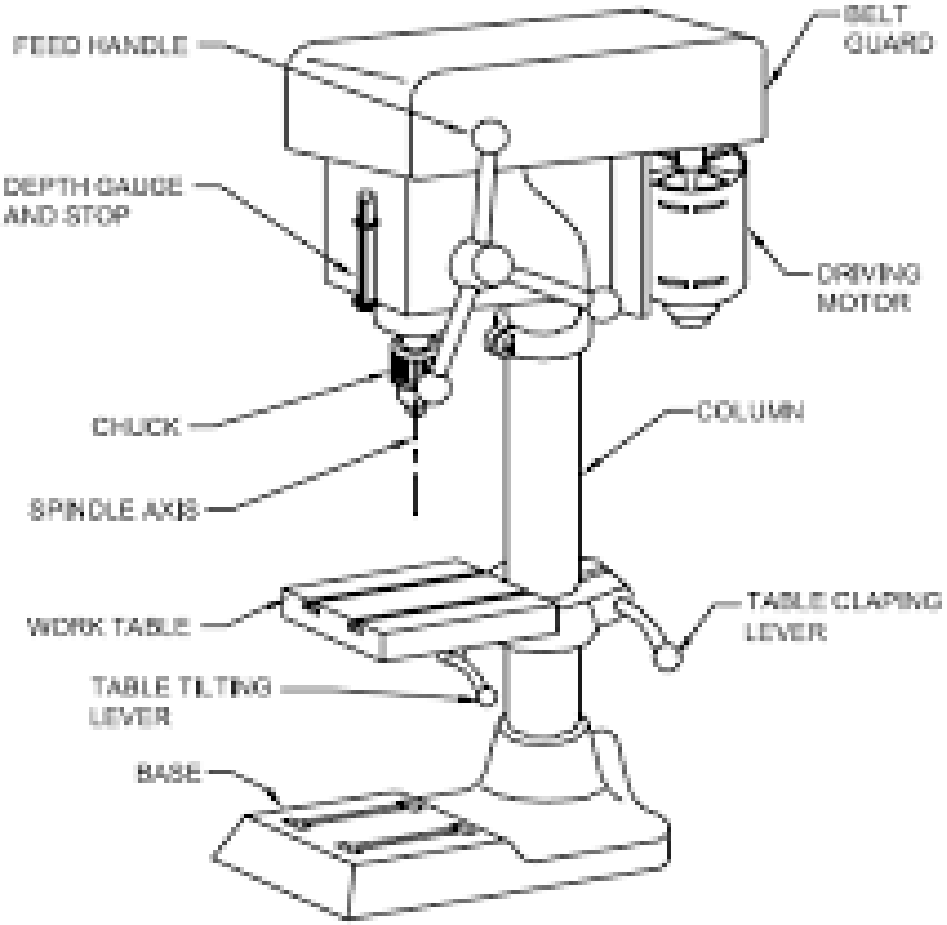
Difference b/w Drilling Boring, Reaming

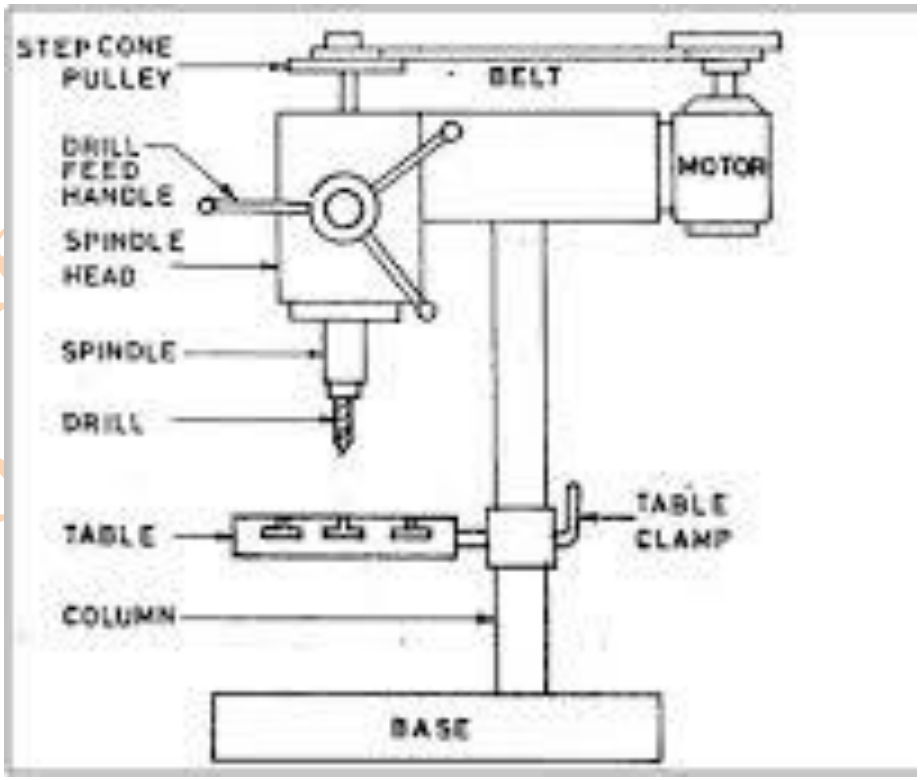
Drilling	Boring	Reaming
Used to generate a hole in a solid workpiece. It is considered as a primary operation.	Used to enlarge an existing hole.it is considered as a secondary operation.	Used to improve the surface finish & tolerance of existing hole. It is considered as secondary operation
Cutting tool is called twist drill bit.	Cutting tool is called boring bar.	Cutting tool is called reamer.
Twist drill is a single point cutting tool	Boring is a single point cutting tool.	Reamer is multi-point cutting tool.
Drilling can increase the length of the hole, but cannot change the diameter unless the twist drill is changed.	Boring can increase the diameter of the existing hole by adjusting the cutting tool, but cannot increase the length of the hole.	Neither diameter nor the length can be changed by reaming.
Metal removal rate (MMR) is higher.	MRR is in b/w drilling & reaming.	Due to reduction is speed, MRR is low. However MRR does not have any role in reaming, as its aim is to improve the hole finish & tolerance.

Classification of Drilling Machines

- Portable drilling machine
- Bench or sensitive drilling machine
- Radial drilling machine
  - Plain radial drilling machine
  - Universal radial drilling machine
  - Semi-universal radial drilling machine
- Upright drilling machine
  - Round column/Pillar drilling machine
  - Box column upright drilling machine
- Multi spindle drilling machine
- Gang drilling machine
- Automatic drilling machine
- Deep hole drilling machine
- CNC drilling machine

Bench Drilling Machine





Bench Drilling Machine

Base: It is made from CI & supports the vertical column. The base is provided with hole to secure firmly to the table or bench with the help of bolts & nuts.

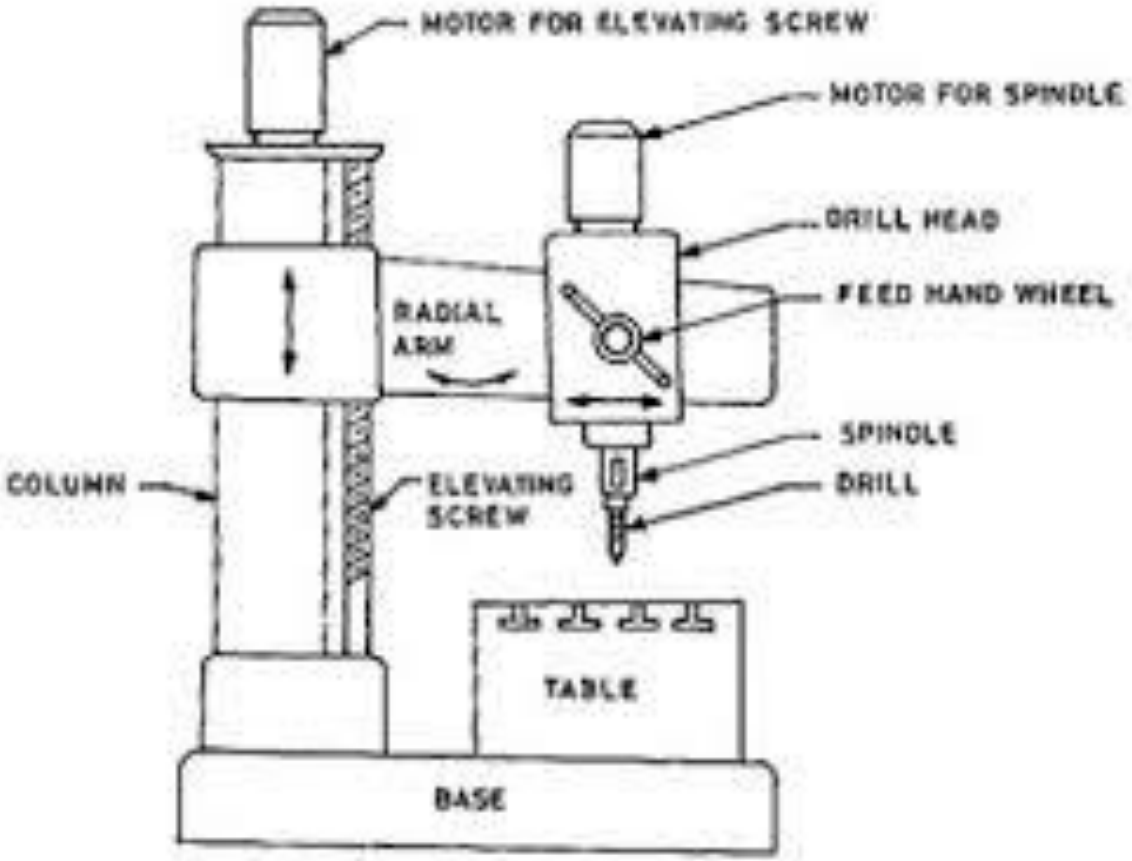
Vertical Column: It is hollow steel pipe mounted rigidly on the base. It supports the drill head & worktable.

Work-Table: It supports the workpiece to be drilled. The table can be raised or lowered and can be clamped to the vertical column at any desired position. This helps to accommodate different sizes of the work pieces on the table. The table can also be swirled around the vertical column to any desired position, if be needed.

Drill-Head: A fixed drill head located at the top of the vertical column carries an electric motor trough which the spindle can be made to rotate as well as slide up & down. The top end of the spindle is connected to a stepped cone pulley which obtains power from the motor shaft though a v-belt arrangement. The lower end of the spindle carries a socket/drill chuck to hold the drill bit during operation. The vertical movement of the spindle & hence the bit is controlled by the feed lever.

Note: This machine are used for drilling small holes at high speeds is small sized work pieces. The dia of the hole drilled ranges from 1.5mm to 15mm.

Radial Drilling Machine



Radial Drilling Machine

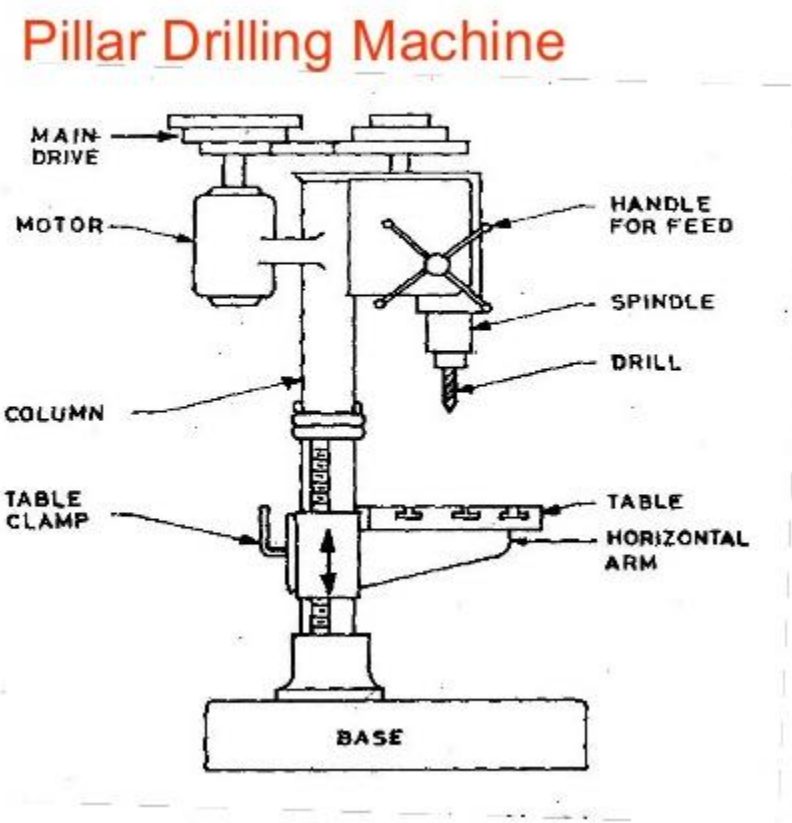
Base: It is made from CI & supports the vertical column. The base is provided with T-slots, which helps the workpiece to be clamped rigidly to the base of the machine.

Vertical Column: It is a long cylindrical shaped part fastened rigidly to the base. The column carries a radial arm that can be raised or lowered by means of an electric motor and can be clamped to any desired position also the arm can be swirled to one complete rotation.

Drill-Head: The drill head is mounted on the radial arm & carries a driving motor & a mechanism for revolving and feeding the drill bit in to the workpiece. The drill head can be moved horizontally on the guide ways provided in the radial arm and can be clamped to any desired position.

Note: This machine are used for drilling medium or large holes up to 50mm.

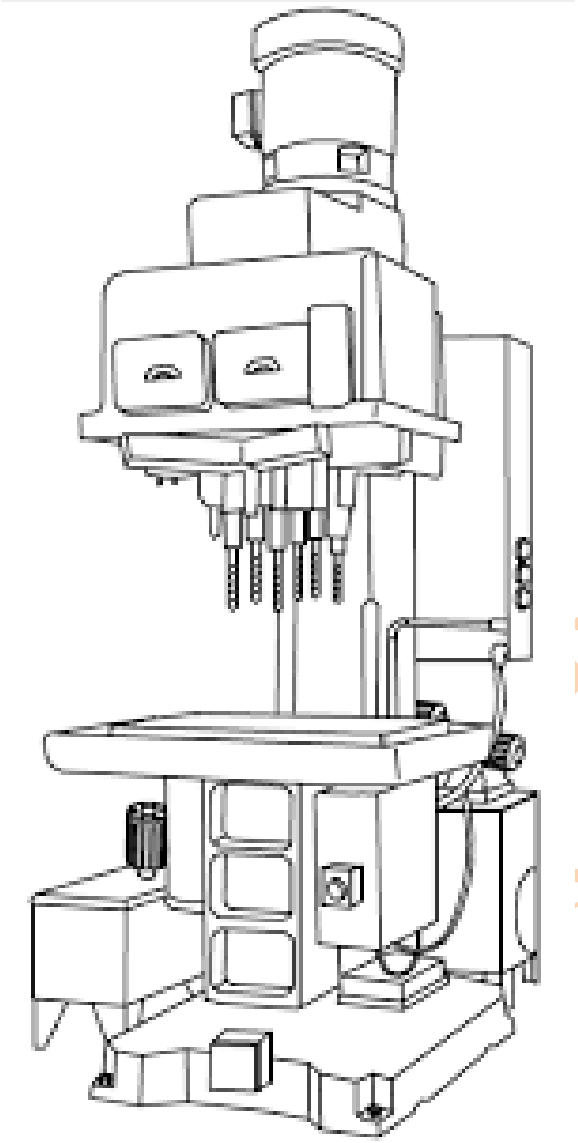
Round column Upright Drilling Machine/ Pillar Drilling Machine



Round column Upright Drilling Machine/ Pillar Drilling Machine

- The m/c consists of a round vertical column, referred to as pillar, mounted on a strong & rigid base which rests on the floor
- The vertical column carries a power head at the top & a table arm, which supports the work table
- The table arm can be raised or lowered on the vertical column with the help of a rack & pinion. This arrangement facilitates for accommodating workpieces of different height
- The table arm can be swiveled/rotated in an arc upto 180° around the vertical column & can be clamped at any desired position
- Large work pieces that cannot be mounted on the worktable may be supported directly on the base
- Apart from two movements of the table arm, there is another adjustment given to the worktable which is supported on the table arm. The round worktable may be rotated about its own axis by 360°, this permits drilling holes on pitch circle

Multiple Spindle Drilling Machine

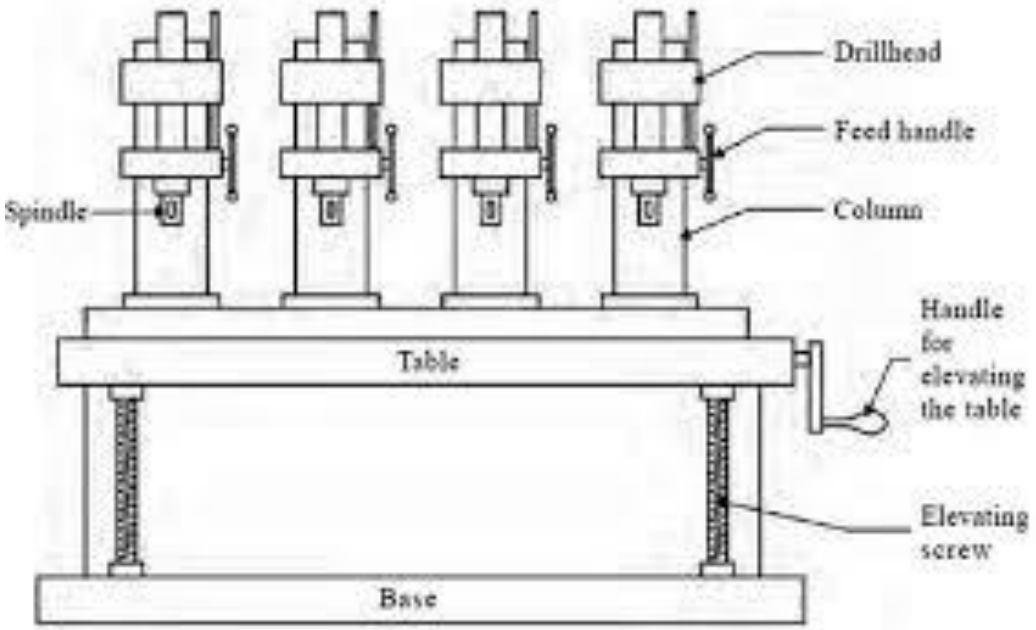


THE DRILLING HEADS CAN BE POSITIONED TO MEET VARIOUS SPECIFICATIONS

Multiple Spindle Drilling Machine

- Multiple spindle drilling m/c, as the name suggests, have several spindles driven by a single power head, & all the spindle holding the drill bits are fed into the workpiece simultaneously
- The spindles are so constructed that their centre distance can be adjusted in any position within the drill head depending on the job requirement
- For this purpose, the drill spindles are connected to the main drive by means of universal joints
- The spindles in a multiple spindle drilling machine may carry bits of similar or different sizes depending on the diameter of the holes to be drilled
- Either the spindles move downwards or the worktable is designed to move upwards
- Most m/c's are designed with worktable moving upwards along the guide ways of the column
- The spindle heads can also carry different tools for performing different operations on the workpiece
- The m/c is designed to hold as many as 50 spindles operated by a common drive & are mostly used in mass production

Gang Drilling Machine



Gang Drilling Machine

- It is used when several related operations such as drilling, reaming, counter boring etc., are to be performed in succession on a single workpiece
- The m/c consists of independent columns, head and spindles mounted rigidly on a common base
- Spindles maybe driven by power or manually by hand and can be independently or collectively set for the desired speed and depth
- The ,m/c carries a single worktable on which the workpiece can be slid into position for the operation at each spindle, the table may be of stationary or adjustable type
- Gang drilling m/c's are designed with drill spindles permanently spaced, or in some machines the position of columns maybe adjusted, so that the space b/w the spindles may be varied
- Gang drilling is used in mass production applications, wherein a single operator or more than one operator may be employed to perform various operations

Boring Machine

Boring Machine: It is a m/c used to enlarge a previously drilled hole to the correct size, epically in large & heavy parts like pumps, turbine, railroad wheels, etc., by means of a single point cutting tool. The operation performed is referred as boring. Besides enlarging holes, a boring m/c can also be used to perform operations like drilling, facing, milling etc.

Classification of Boring Machine

- Horizontal boring machine
  - Table type
  - Planer type
  - Floor type
  - Multiple type
- Vertical boring machine
  - Single column
  - Double column
- Jig boring machine (Precision boring machine)
- Diamond (Fine) boring machine
- CNC boring machine

Table Type Boring Machine

Vertical main column: It is rigidly mounted on the bed of the machine & supports the head stock unit. The column carries a vertical guide way along which the heads tock travels up & down. The column is usually made hollow in order to accommodate the counter weights which balance the head stock & make it easier to moves

Headstock: It carries the horizontal assembly, electric motor and a no. of different units & mechanisms in it, to support, drive, & feed the boring tool. The head stock can be moved vertically on the column by means of elevating screws & can be clamped at any desired position.

Horizontal spindle: It is suitably housed in the head stock, it is hollow, it end carries a tapered hole in order to receive a shanks of cutting tools. This spindle rotates b/w two precision rollers bearings & can be fed axially either forward or backward according to the requirements.

Worktable & Saddle: The m/c consists of a saddle & a rotating worktable. Bottom face of the saddle fits in the horizontal guide ways provided on the bed, thereby allowing it to be moved longitudinally along the bed, while the upper face of the saddle is provided with guide ways to accommodate the worktable which can be moved at the right angles to the longitudinal motion. The movement of the saddle & the worktable can be done either manually or by power as desired.

Table Type Boring Machine

Bed: It is a heavy CI structure supporting all the parts of the m/c. the bed houses in it various mechanisms for vertical movement of the head stock & longitudinal traverse of the worktable, apart from various toolings over it.

End Support Column: It is designed to support one end of the long & heavy boring tool during operation. The column is provided with vertical guideways along which the bar travels up & down.

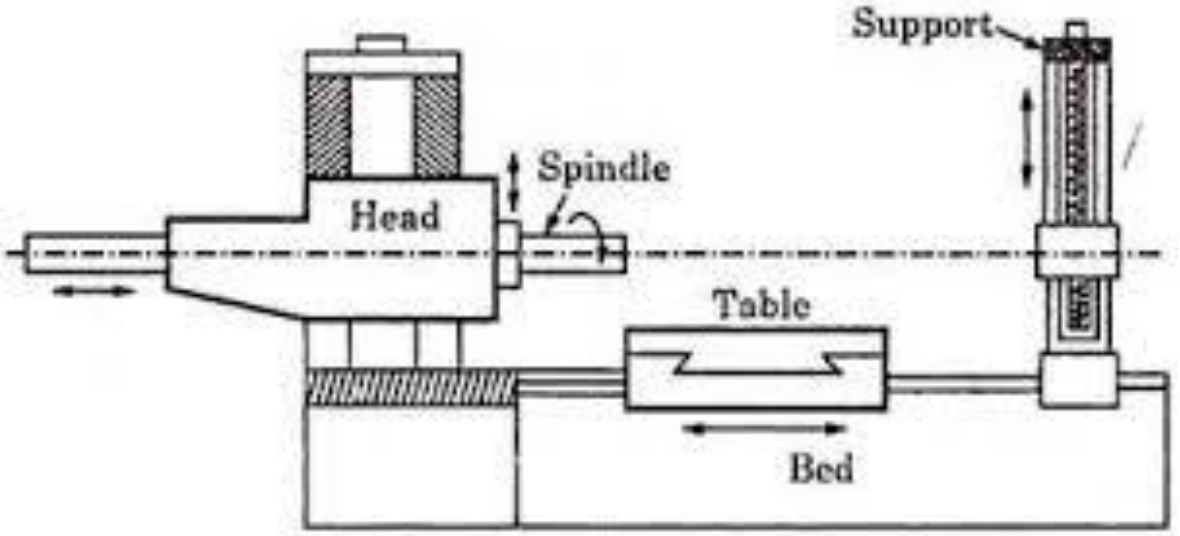


Fig. 18.40. Horizontal Boring Machine.

Double Column/Standard Vertical Boring m/c

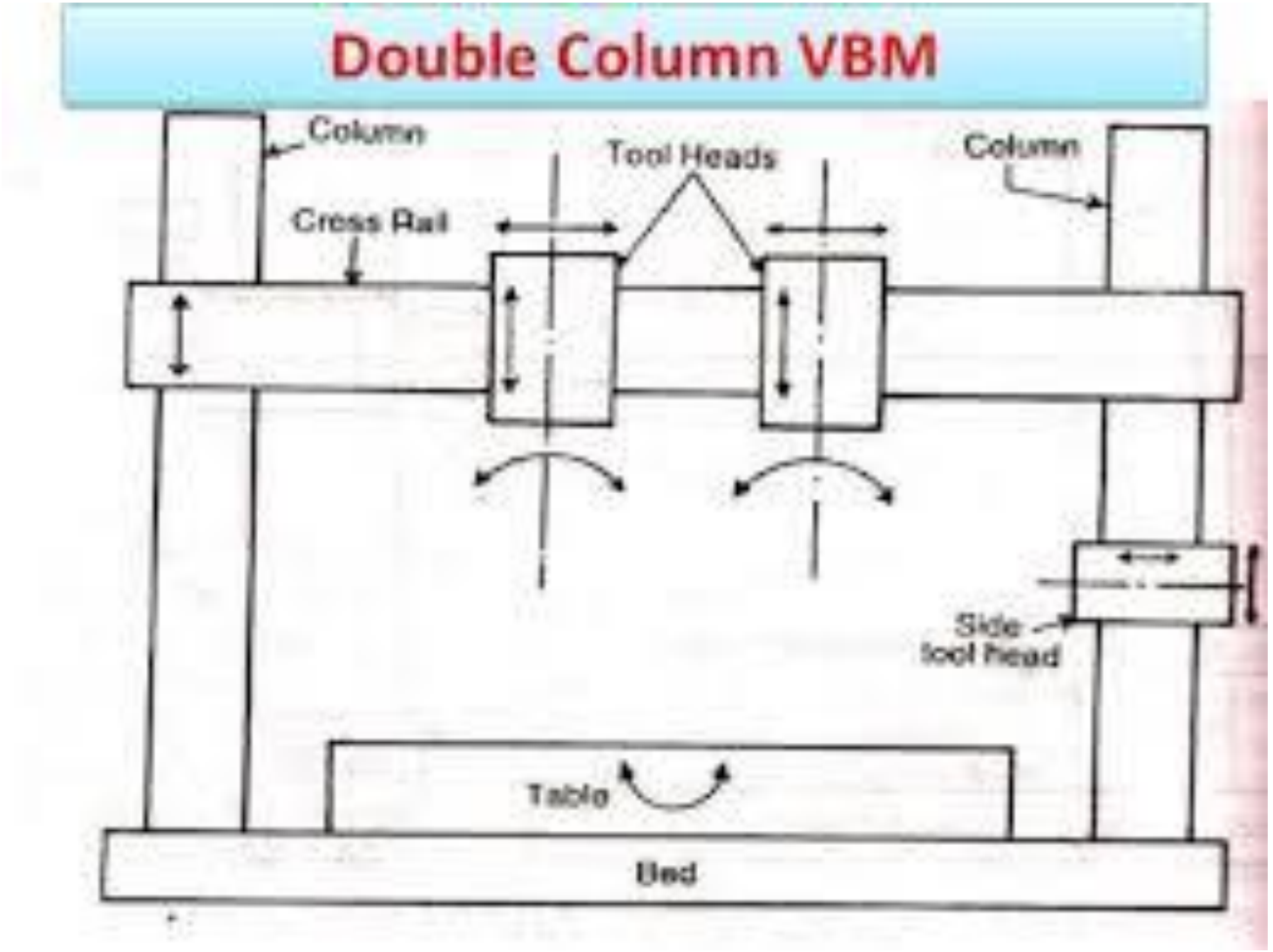
Vertical column: The m/s consists of two columns, one on each side of the bed. The column are bridged together by means of a cross rail. The column is usually made of hollow in order to accommodate different mechanisms for transmitting power to the cross rail, worktable, etc.

Cross-Rail: It is horizontal member connecting the two vertical columns of the m/c. it carries spindle head/s & can slide up & down on the vertical guideways of the two columns by means of elevating screws & can be clamped to any desired position. The cross-rail is provided with guideways at its front for the tool head/s to move left or right. The tool head is designed to be swiveled to a certain angle of taking angular cuts.

Worktable: It is mounted on the bed of the m/s & rotates about its vertical axis. The workpiece is fastened to the revolving table, while the cutting tool which are stationary, advance vertically into the revolving workpiece.

Bed: It is a rigid structure, usually cylindrical in shape & together with the columns forming a single casting. The bed supports the worktable & houses in it various mechanisms for rotation of the worktable to take place,

Double Column/Standard Vertical Boring m/c

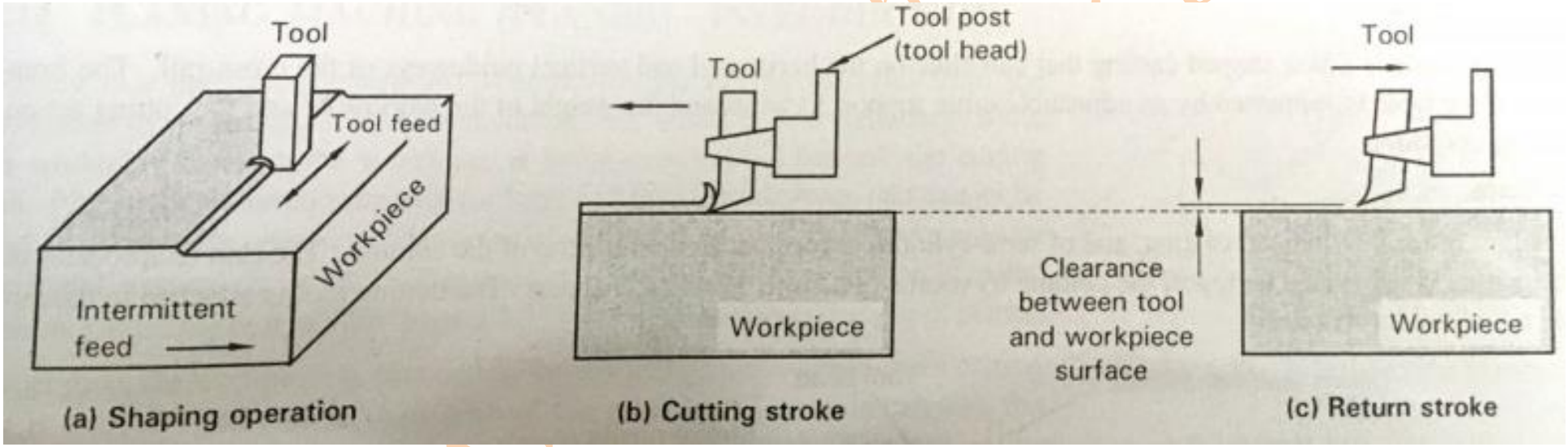


Shaping Machine

Shaping: It is a machining process of removing excess material from the workpiece by means of single point cutting tool held in reciprocating ram. The process of employed to produce flat surfaces (Horizontal. Vertical or inclined), grooves, T-slots, dovetails & may also be used to produce contoured surfaces with the use of copying attachments. The m/c used for performing the operation is called shaping m/c or shaper.

Working: In operation, the workpiece is clamped rigidly on the m/s table, & a single point cutting tool is held in the tool post mounted on the arm of the shaping m/c. the arm reciprocates the tool to & fro across the workpiece as shown. Hence the ram makes to strokes during the cutting process. These two strokes are called cutting stroke & return stroke as shown. During cutting stroke, the tool moves in the forward direction, during which it cuts a small thin strip of metal from the workpiece as shown. No cutting of material takes place during the return stroke of the ram and hence, this stroke is called idle stroke. During return stroke, the tool is lifted clear of the workpiece, reducing the cutting action to one direction only. The workpiece is given an indexed feed (equal amount after each cut) in a direction perpendicular to the line of action of the cutting tool.

Shaping Machine



Classification of Shaping Machine

- Design of work table
  - Standard shaper
  - Universal shaper
- Driving mechanism
  - Crank shaper
  - Geared shaper
  - Hydraulic shaper
- Design of travel ram
  - Horizontal shaper
  - Vertical shaper
  - Traveling head shaper
- Nature of cutting stroke
  - Push cut shaper
  - Draw cut (pull type)shaper

Horizontal Shaping Machine

Base: It is a heavy CI body that supports the entire weight of the machine parts, and also the forces generated during the machining process. The base is secured rigidly to the floor with the help of foundation bolts & nuts.

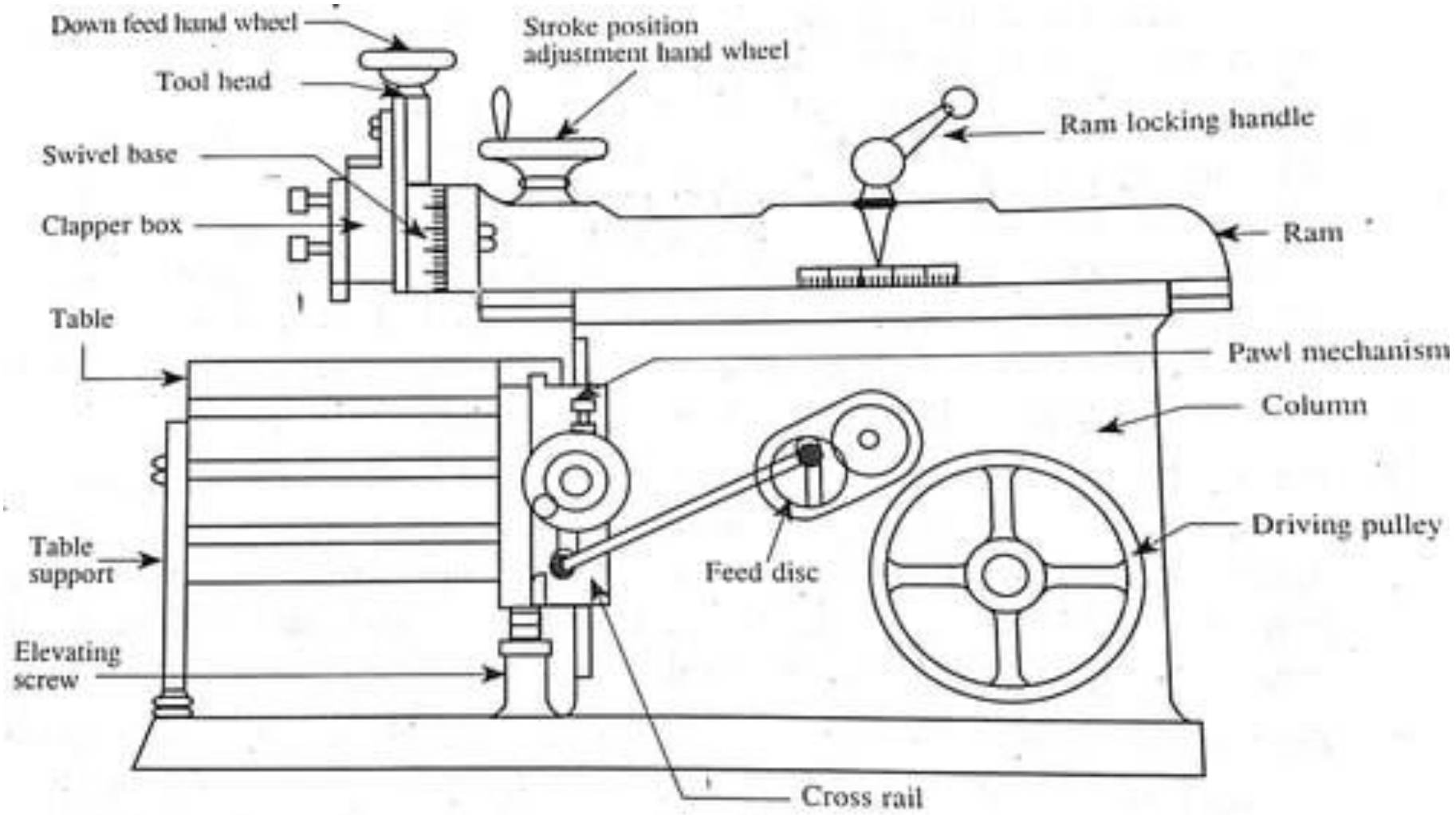
Column: It is a rigid hollow casting mounted on the base. It houses the driving motor, control devices and the mechanism for driving the ram & the worktable. The column carries horizontal guideways at its top on which the ram reciprocates and vertical guideways at its front face on which the cross-rail slides.

Cross-Rail: It is mounted on the front vertical guideways of the column can be raised up & down by means of an elevating screw to accommodate workpiece of different heights. The cross-rail is provided on its front face with horizontal guideways, which is perpendicular to the ram movement.

Worktable: It is a box shaped casting that can slide on the horizontal & vertical guideways of the cross-rail. The front face of the table is supported by an adjustable table to support the weight of the workpiece & the cutting action during operation.

Ram: It is rigidly braced casting, & of semi cylindrical form located on the top of the column. The ram reciprocates on the guideways provided on top of the column by means of a slotted link mechanism. The cutting tool is attached to the ram via a tool holder and head.

Horizontal Shaping Machine



Shaper

Planing Machine

Planing: It is a machining operation of removing the excess material from the workpiece by means of single point cutting tool, which is held stationary while the worktable carrying the workpiece is being reciprocated beneath the cutting tool. Planing is preferred for large and heavy workpieces that cannot be worked by shaping operation. The type of surface machined by planing may be horizontal, vertical or inclined. The machine used for planing operation is called planing machine or planner.

Working: in operation, the workpiece is clamped on te worktable, and a single point cutting tool is secured rigidly in the tool head of the machine. The table carrying the workpiece is reciprocated beneath the stationary cutting tool. The tool is given feed ion the transverse direction, i.e., perpendicular to the direction of motion of the table, and also in the vertical direction for obtaining the required depth of cut. The tool is fed only when the workpiece is moving in the return stroke.

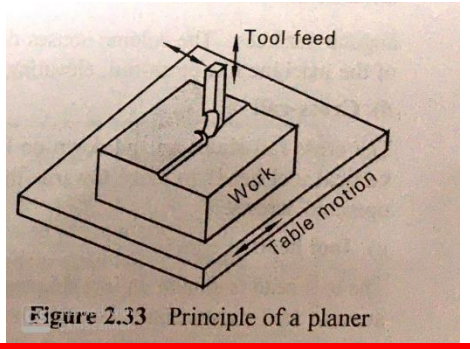


Figure 2.33 Principle of a planer

Standard or Double Planer

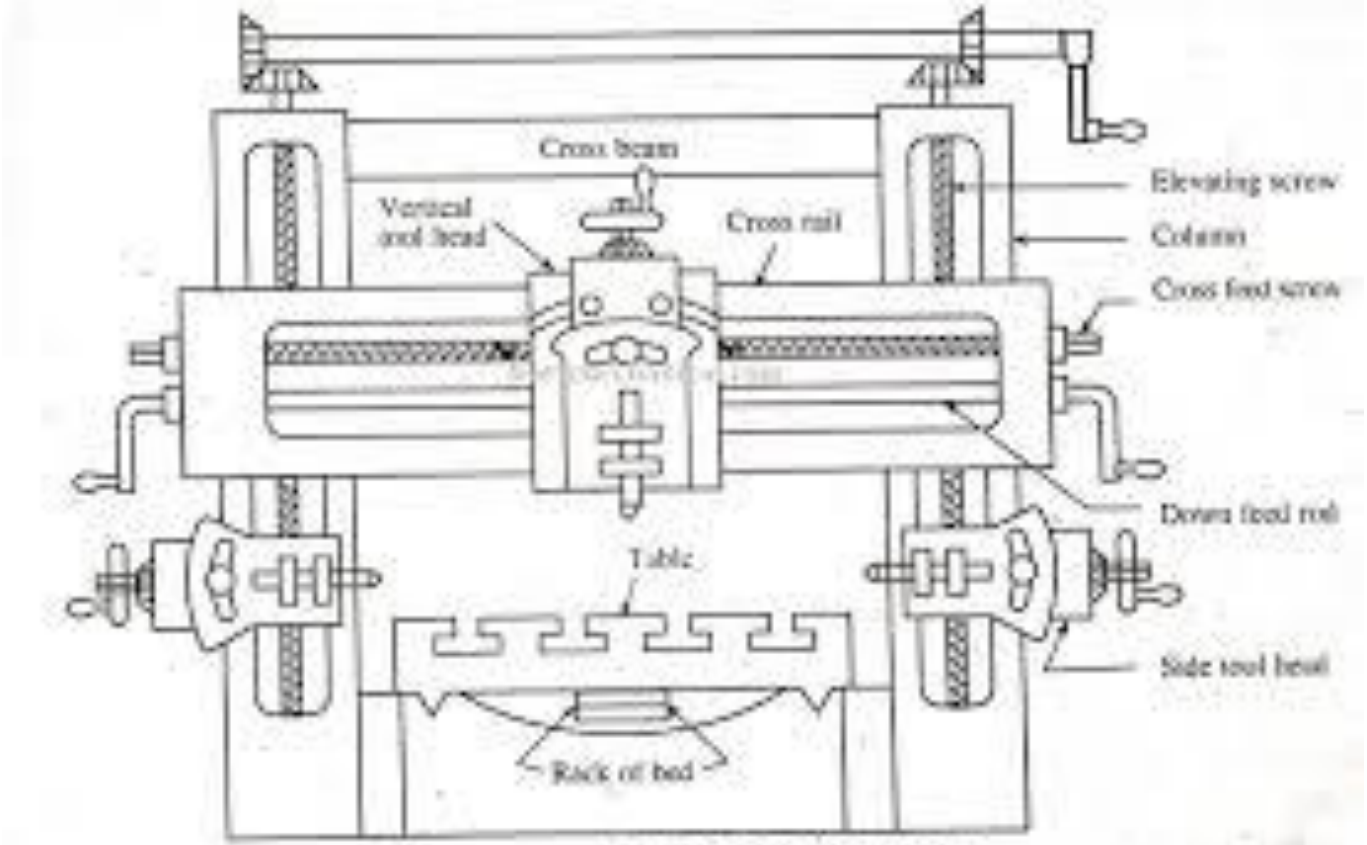
Bed: It is a large casting made of CI & provided with cross ribs for additional strength & rigidity. It forms the foundation of the m/s and other parts are attached or supported by the bed. The bed carries either V-ways or flat ways to support & guide the worktable. The length of the bed will be twice as that of the table.

Worktable: It is a heavy rectangular casting that travels along the guideways of the bed. The top surface of the table is provided with T-slots to facilitate clamping of the workpiece or vices & other special fixtures. The table is driven by hydraulic means or by pinion gear driving a rack, which is fastened under the center of the table.

Column/Housing: The m/c consists of two vertical columns or housings, one on each side of the bed. The columns are fastened together at the top with a cross beam, and also at the bottom to the m/c in order to create a very strong and a rigid structure for machining large & heavy workpieces. The front face of the column is provided with guideways for the cross-rail to slide up & down. Two side tool heads, holding the cutter tools are mounted on each of the vertical column & can move up & down on the column ways, and also can be fed horizontally onto the job or ay any desired inclination for machining angular surfaces. The column houses different mechanism for transmitting power from the main drive to the upper parts of the m/c like cross-rail, elevating screws, etc.

Cross-Rail: It slides up & down on the vertical columns. It is provided with horizontal guideways at its front for the vertical tool head to move towards the left or right of the m/c. the cross-rail is controlled by hand or power operated screws.

Tool Head: It is similar as that of shaping m/c, holding the cutting tool & imparting the tool, the necessary vertical & horizontal feed movements. The tool head includes a clapper box similar to that in a shaping m/c, which allows the cutting tool to lift during the return stroke thereby preventing the scratching of the tool on the job.



Double housing planner

Slotting Machine

Slotting: It is a machining process for producing slots, splines, keyways & for creating internal & external forms or profiles in work parts. The process is similar to that carried out on a shaper, however the cutting tool during slotting reciprocates in a vertical direction across the rigidly held workpiece as shown. The workpiece mounted on the worktable is fed either parallel or perpendicular to the cutting edge or in a circle. Slotting is carried out on a slotting m/c as shown. The slotting m/c also called slotter is considered as a vertical shaper.

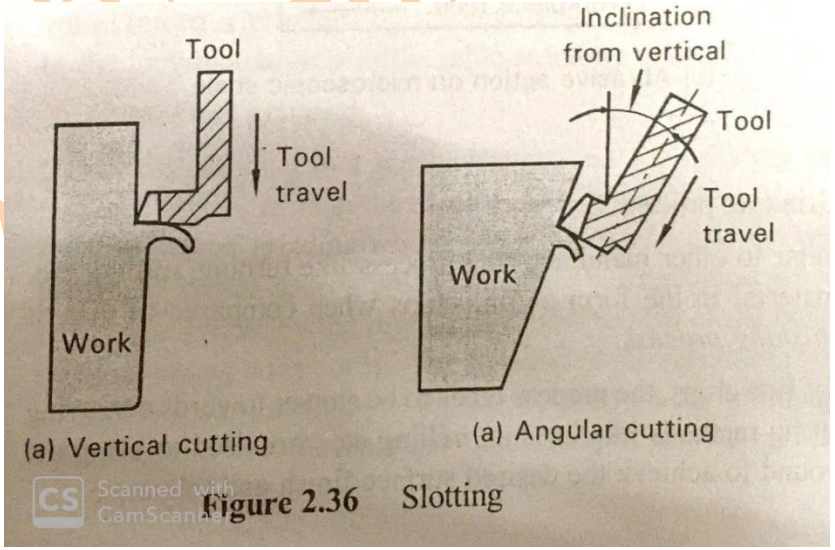


Figure 2.36 Slotting

Slotting Machine

bed (BASE): The bed made from CI material forms a rigid base to all the parts of the slotting m/c. the top of the bed carries horizontal guideways along which the saddle can transvers.

Column: The column is integrally cast with the base & houses various driving mechanism. The front face of the vertical column is provided with guideways along which the ram slides up & down.

Saddle: It is mounted on the guide ways & can move towards or away from the column. The saddle is precisely finished to give guideways for the cross-slide.

Worktable: The rotary worktable on the cross-slide supports & holds the workpiece in position & is adjustable in longitudinal & cross-wise (transverse) direction. The table can also be rotated about its centre. The angular graduation on the table make it easy for the work to machined at angles.

Ram: It reciprocates vertically up & down on the vertical guideways of the column. The ram at it bottom carries the cutting tool & moves vertically or at angles to the worktable.

Slotting Machine

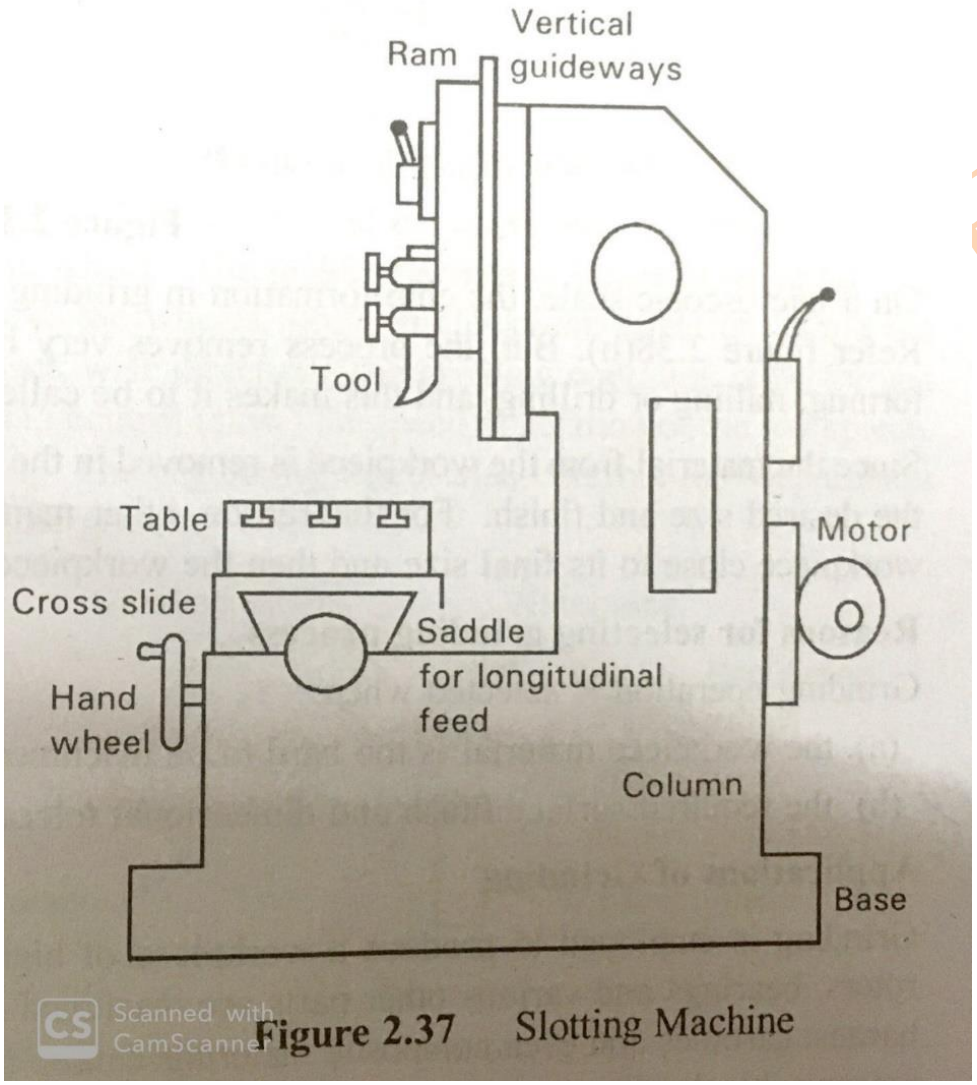


Figure 2.37 Slotting Machine

Grinding

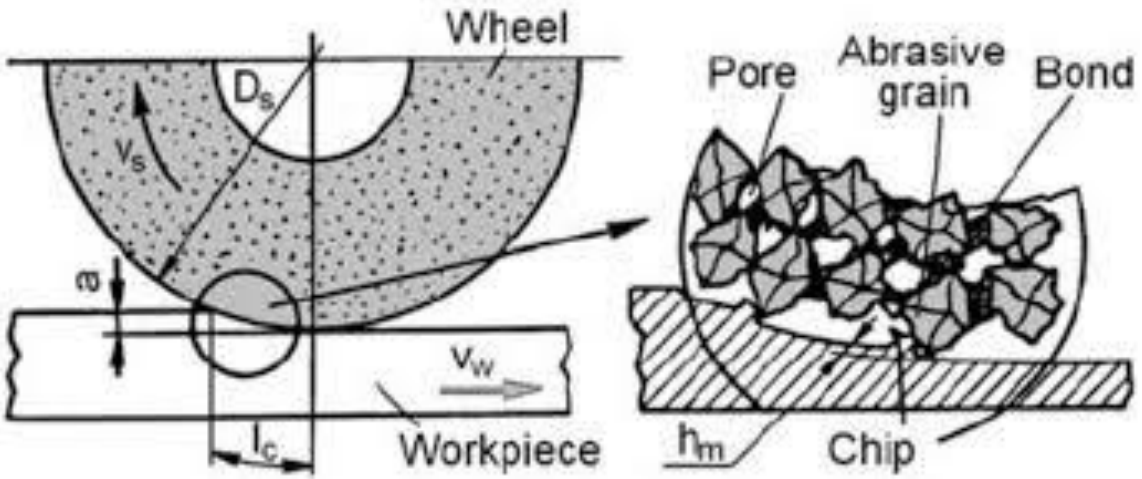
Grinding: It is a process of removing excess material from the workpiece by the mechanical action of abrasive particles that are held together by a adhesive, generally in the form of a solid wheel.

Working: The grinding wheel is rotated at high speeds, and when the surface of the rotating wheel is brought in contact with the workpiece, material is removed in the from of fine chips. The depth of cut is obtained by the downward movement of the grinding wheel or in some m/c's the worktable carrying the workpiece is raised towards the grinding wheel.

On a microscopic scale, the chip formation is grinding is similar to another manufacturing process like turning, milling etc. but, the process removes very little material in the form of fine chips when compared to that of turning, milling, drilling etc., & this makes it to be called finishing process.

Since the material from the workpiece is removed in the form of fine chips, the process tends to be slower towards achieving the desired size & finish. For this reason, other manufacturing methods like turning, milling etc., are used to bring the workpiece close to its final size & then the workpiece is ground to achieve the desired surface finish & tolerance.

Grinding



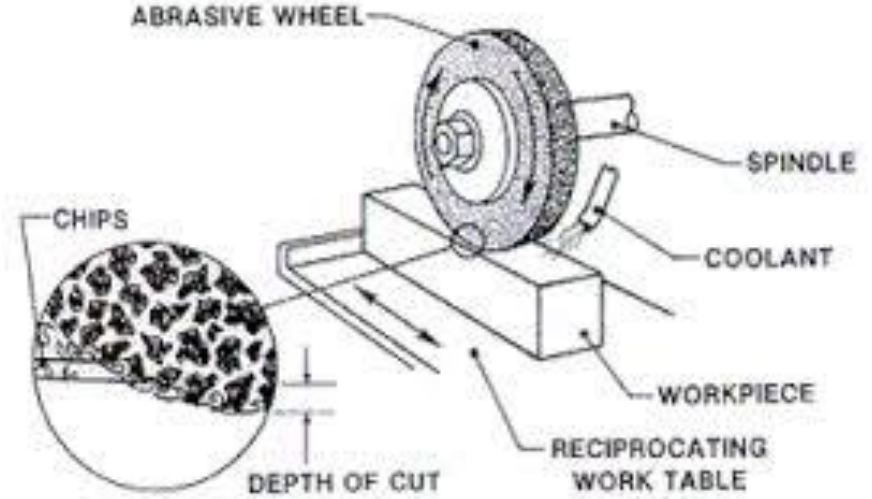


Fig. 1 Elements of a grinding process

Grinding Processes

Surface Grinding: It is a machining process primarily carried out to produce flat surfaces of desired finish as shown. However, with the use of special fixtures & form dressing devices, angular & formed (curved) surfaces can also be finished. In operation the workpiece is fixed on the worktable by means of magnetic chuck/vice and the grinding wheel is brought in contact with the surface of the workpiece. The abrasive action of the grinding wheel on the surface of the workpiece causes material to be removed from it in the from of fine chips. Longitudinal feed to the workpiece is given by reciprocating the worktable and after each longitudinal feed, cross-feed is given so as to finish the workpiece all along its width.

Plane Cylindrical Grinding: It is a machining process for grinding external cylindrical surfaces of single & multi-diameter shafts as shown. The cylindrical workpiece to be ground is held & rotated b/w two centers of the m/c. The grinding wheel is made to rotate at a comparatively higher speed, in a direction opposite to that of the workpiece. The workpiece is given longitudinal feed by the reciprocating the worktable, while in feed is provided by moving the grinding wheel head at right angles to the longitudinal axis of the table resulting in depth of cut.

Grinding Processes

Center-less Grinding: It is a machining process for grinding surfaces of long, slender rods that cannot be held & rotated b/w centers as in case of plane cylindrical grinding. The workpiece is supported by the combination of grinding wheel, work rest blade and rectangular wheel. The grinding wheel is larger in diameter & rotates at high speeds when compared to regulating wheel. Both the wheels rotate in clockwise direction while the workpiece is driven by the regulating wheel which rotates in counter-clock-wise direction. The grinding operation is performed by the grinding wheel only. The function of the regulating wheel is to control the speed of rotation of the workpiece, so that it does not rotate st the same speed as the grinding wheel. The regulating wheel also controls the longitudinal motion of the workpiece or rate of feeding of the workpiece past the grinding wheel.

Grinding Processes

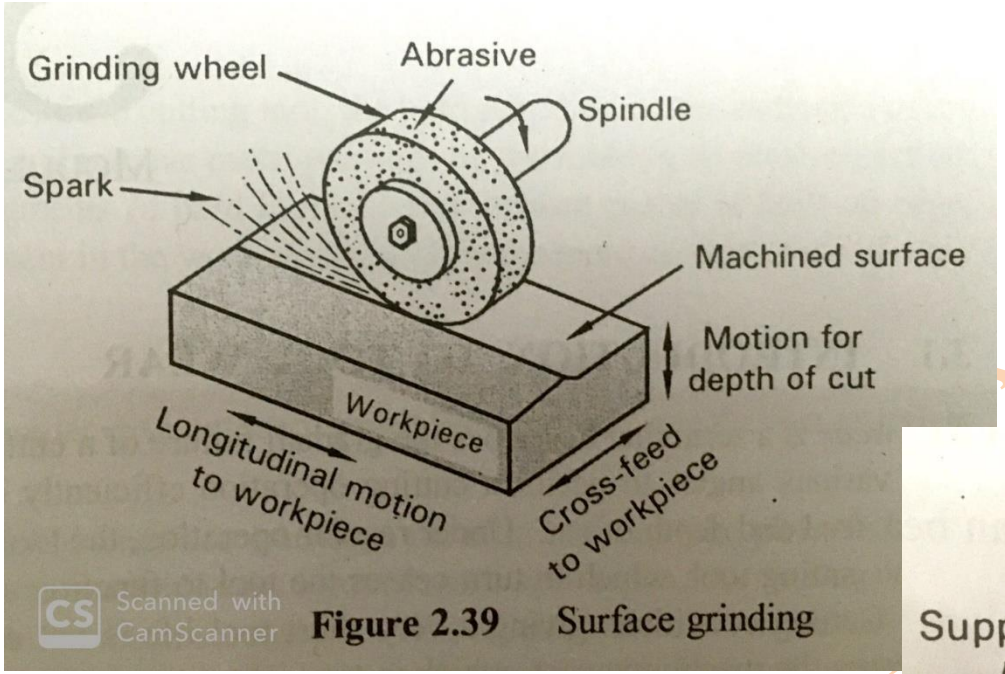


Figure 2.39 Surface grinding

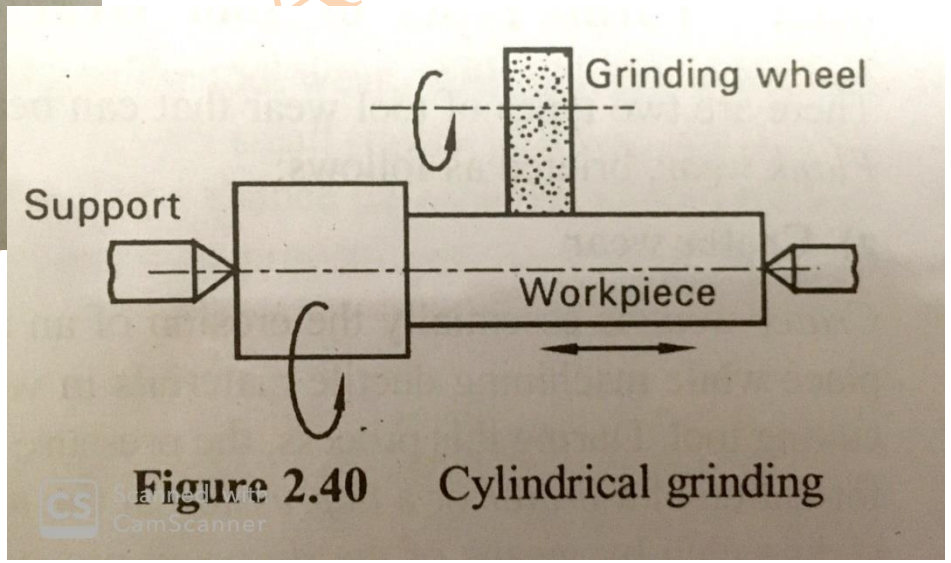


Figure 2.40 Cylindrical grinding

Grinding Processes

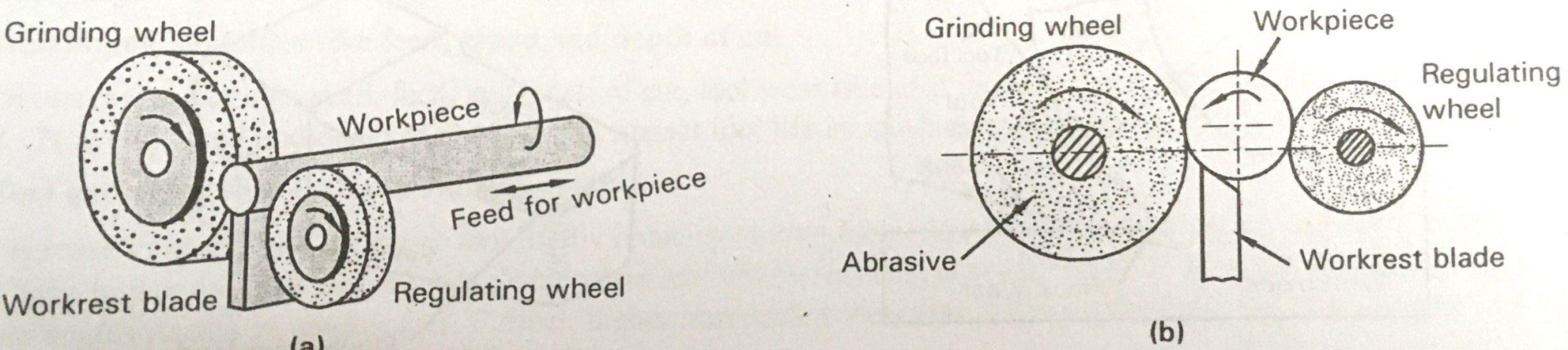


Figure 2.41 Centerless grinding

THANK YOU