Unit III – Other Machine Tools

Part A

1. **Mention the differences between shaper and planer. (AU Apr 2011)**

S.NO	SHAPER	PLANER
1	Tool reciprocates and the work is stationary	Tool is stationary and work reciprocates
2	Less accuracy due to overhanging of ram	It gives more accuracy as the tool is rigidly supported during cutting.

2. **What are the differences between drilling and reaming? (AU Apr 2011)**

   Drilling is the operation of producing cylindrical hole in a work piece. It is done by rotating the cutting edge of a cutter known as drill. The work is rotated at high speed.

   Reaming is the operation of finishing and sizing hole which is already drilled while the work is revolved at a very slow speed.

3. **Briefly describe the importance of quill mechanism. (AU Apr 2011)**

   If the taper shank of drill is smaller than the taper in the spindle hole, a sleeve is used. The sleeve with drill is fitted in the hole of the spindle. The sleeve has outside taper surface. This fits into the tapered hole of the spindle**.**

4. **List the types of sawing machines. (AU Dec 2010)** Types of sawing machines are

   (1)Reciprocating saw

   (2)Circular saw

   (3)Band saw

5. **Define the cutting speed, feed and machining time for drilling. (AU Dec 2010)**

   Cutting Speed: It is the peripheral speed of a point on the surface of the drill in contact with the Work piece. It is usually expressed in m/min.

   Feed: It is the distance of a drill moved into the work at each revolution of the spindle. It is expressed in mm/rev.

   Machining time: The time taken to complete the machining process without considering the idle time of machines is called machining time.

6. **What is broaching. (AU Dec 2010) (AU Dec 2009)**

   It is a process of machining a surface with a special multipoint cutting tool called “BROACH” which has successively higher cutting edges in a fixed path.

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7. **What is the difference between up milling and down milling? (AU Apr 2010)**

S.No	Event of operation	Up milling	Down Milling
1	Direction of travel	Cutter rotates against the direction of travel of workpiece	Cutter rotates in the same direction of travel of workpieces
2	Cutting Force	Increases from zero to max per tooth	Decreases from max to zero per tooth.

8. **List four applications of broaching machines. (AU Apr 2010)**

   (i) Straight and helical slots

   (ii) External surfaces of various shape

   (iii) External and internal toothed gears

   (iv) Holes of cross sectional shape

9. **How do you classify milling cutters? (AU Dec 2009)** They are classified based on following factors

   (i) According to the shape of the teeth.

   (ii) According to the type of operation

   (iii) According to the way of mounting on the machine

10. **What do you know about straight fluted drill and fluted drill? (AU Dec 2009)**

    The reamer with helical flutes provides smooth shear cutting action and provides better surface finish .The pitch of the flutes is made uneven to reduce vibration.

11. **What is meant by up milling and down milling? (AU Dec 2008)**

    In up milling, cutter rotates opposite to the direction of feed of the work piece whereas in down milling , the cutter rotates in the same direction of travel of the work piece.

12. **State the differences between a vertical shaper and slotters. (AU Dec 2008)**

S. No	VERTICAL SHAPER	SLOTTER
1	Vertical shapers generally fitted with rotary table to machine curved surfaces	Slides are fitted
2	Rotary table along with tools will move	Slides will move to perform slotting.

13. **Write the differences between drilling and tapping. (AU Dec 2008)**

    Drilling is the operation of producing cylindrical hole in a work piece. It is done by rotating the cutting edge of a cutter known as drill. The work is rotated at high speed.

    Tapping is the process used for making internal threads in a machine component by a tool called “TAP” 2

14. **What is a shell mill? (AU Dec 2007)**

A shell mill is a large type of face or end mil that mounts on to a arbor, rather than having an integral shank. Typically there is a hollow or recess in the centre of the shell mill for mounting hardware on to a separate arbor.

15. **Mention the operations performed by a planner. (AU Dec 2006)**

a. Planning horizontal surface

b. Planning of an angle

c. Planning vertical surface

d. Planning curved surface

16. **Why is sawing a commonly used process. (AU Dec 2006)**

a. Easy handling of machines and spindle construction

b. Fast operation and cost of machinery is less

Part B

1. Explain various milling cutters with neat sketches? **(AU Apr 2012,Apr 13)**

MILLING CUTTERS

Classification of Cutters

These are multi tooth rotary cutting tools generally made of high speed steels or sintered carbides. Milling cutters are classified into different ways.

According to the shape of the tooth, milling cutters are classified as
- (i) Milled tooth cutters.
- (ii) Form relieved cutters.

According to the type of operation.
- (i) Plain milling cutters.
- (ii) Side milling cutters.
- (iii) End mill cutters.
- (iv) Angle milling cutters.
- (v) T-slot milling cutters.
- (vi) Slitting saws.
- (vii) Form milling cutters.
- (viii) Fly cutters.
- (ix) Wood ruff key slot milling cutter.

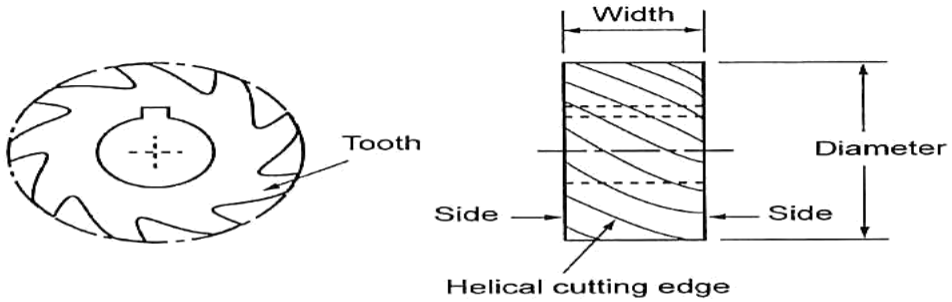
According to the way of mounting on the machine.
- (i) Arbor cutters.
- (ii) Shank cutters.
- (iii) Face cutters.

1. Plain milling cutter

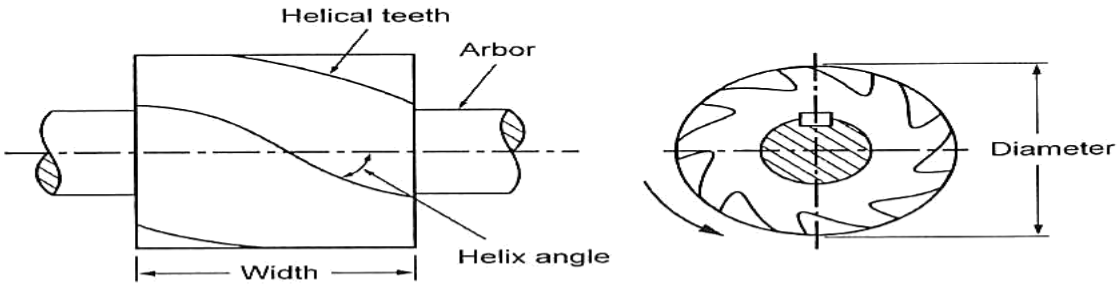
This is also known as a *mill cutter*. It is a disc or cylindrical shaped cutter having teeth on its circumference. It is used to machine flat surface parallel to its axis. There are two types of plain milling cutters commonly used.

- (i) Plain straight teeth cutter.
- (ii) Plain milling helical teeth cutter.

The plain milling cutters having the width more than its diameter is called *slab mill cutter*. This is used for rough machining with coarse feed. The cutter has less number of teeth.



Plain milling cutter



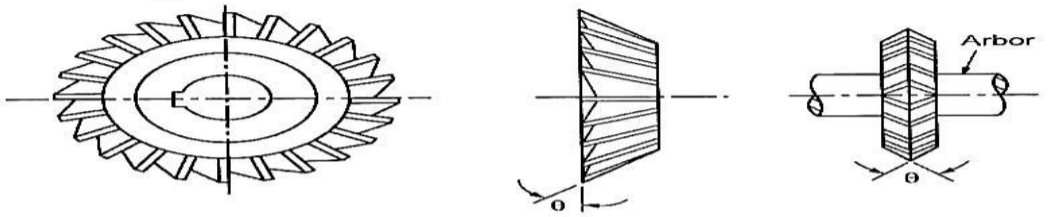
Slab milling cutter

Straight teeth plain milling cutters are used for light operations. Helical teeth cutters are used for heavy cut operations.

Cutters of various diameters and widths are available. Roughing cutters will have less number of teeth. Finishing cutters will have more

4. Angle milling cutters

All cutters which have their cutting teeth at an angle to the axis of rotation are known as *angular cutters*. Their specific use in milling V-grooves, notches, dove tail slots, reamers teeth and other angular surfaces. Angular cutters are classified as single angle cutters and double angle cutters.



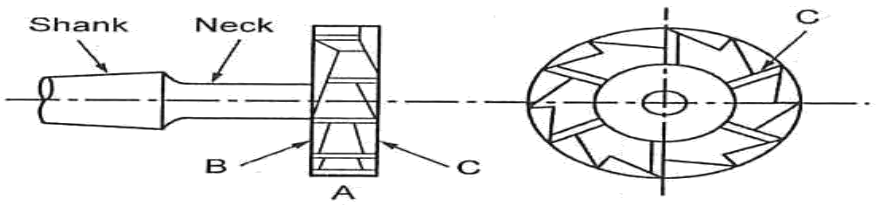
Single angle milling cutter ***Double angle milling cutter***

Single angle cutters may have their teeth either only on the angular face or on both, the angular face and the side. The later type enables milling of both the flanks of the inclined angular groove simultaneously. Their teeth may have an included angle of 45° to 60°.

Double angle cutters differ from single angle cutters in such a way that they have two angular faces which join together to form V-shaped tooth. The included angle of this 'V' is either 45°, 60° or 90°. Angle of both sides should be equal.

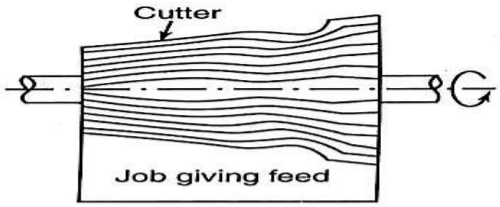
5. T-slot milling cutter

It is a single operation cutter which is used only for cutting T-slots. The arrangement of cutting teeth is similar to that of a side milling cutter. But this cutter has a tapered shank. A neck is formed between the cutting face and the shank. The cutter has cutting edges on its periphery and on its sides.



T - slot milling cutter

Concave milling cutter has teeth curved inwards on its periphery. The cutter will produce a convex semi circular surface on the work piece.



Form milling cutter

Convex milling cutter has teeth curved outward on its periphery. The cutter will produce a concave semi-circular surface on the work piece.

Gear cutters have formed cutting edges. The shape of the cutter teeth is involute. The cutter will produce groove of involute shape. The involute gear tooth is formed between two grooves milled by the cutter. The profile of the gear tooth depends upon the module and the number of teeth on the gears. Therefore, for cutting different number of gear teeth of same module, different cutters are required. Corner rounding cutters are used for milling the edges and corners of the jobs to a required radius.

Fly cutters

It is actually a single point tool which is used in milling machine when standard cutters are not available. It is either mounted on a cylindrical body held in a stub arbor or held in a bar. Screws are used for tightly holding the tool in the above holders. The cutting edge of the tool is ground to the required shape. The cutter removes metal, when it rotates.

2. Discuss various hole making processes. **(AU Apr 2011,Dec 12)**

DRILLING

INTRODUCTION

Drilling is the process of producing hole on the work piece by using a rotating cutter called *drill*. The machine on which the drilling is carried out is called *drilling machines*. The drilling machine some times called *drill press* as the machine exerts vertical pressure to originate a hole. The hole is produced either by giving axial movement to the rotating drill or moving the work axially against the revolving drill. Though drilling may be done in a lathe or a vertical milling machine. It can be done conveniently, quickly and at low cost in drilling machine. Drilling machine can also used for boring, counter-boring, counter-sinking, reaming, tapping and spot facing operations. Drilling machines are used in machine assembly, repair shop, tool room, maintenance work, agricultural machinery etc.

CLASSIFICATION OF DRILLING MACHIENS

The drilling machines are classified as follows:

1. Portable drilling machine.

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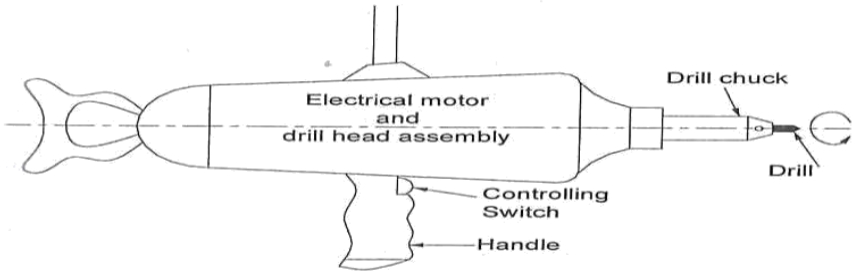
2. Sensitive drilling machine.
   a. Bench type
   b. Floor type
3. Upright drilling machine
   a. Round column type or pillar type
   b. Box column type or square section type.
4. Radial drilling machine
   a. Plain type
   b. Semi-universal type
   c. Universal type
5. Gang drilling machine
6. Multiple spindle drilling machine
7. Automatic drilling machine
8. Deep hole drilling machine

PORTABLE DRILLING MACHINE

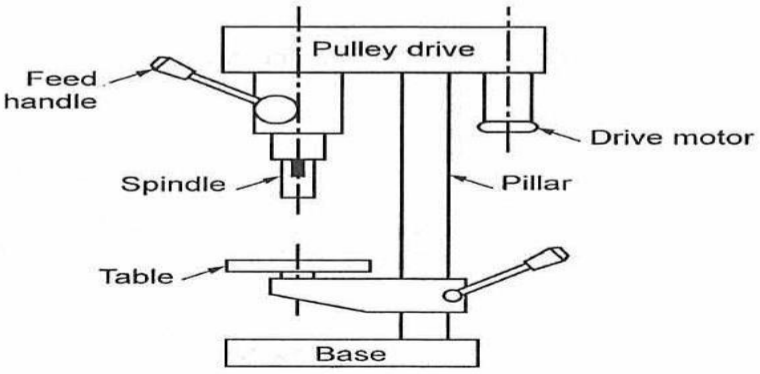


Portable drilling machine

This type of machine is light in weight, compact in a smaller unit and easily handled with respect to the work piece. It is used for making small hole (up to 18*mm*) in large work piece. It is operated by hand power, pneumatic power or electric power. shows the schematic diagram of electrically operated portable *drilling machine*.

SENSITIVE DRILLING MACHINES

Sensitive drilling machines are lightweight, high-speed machines, which are generally bench type drilling machines, but pillar type machines are also available. It is used for light duty work and drill holes up to 15*mm* diameter. There is no power feeding arrangement, feeding is purely on hand control of the operator so that the operator can sense the feeding or can control the feeding. Therefore, the machine is called sensitive drilling machine.



Sensitive drilling machine

The main parts of the sensitive drilling machines are base, column, table, spindle and driving mechanism.

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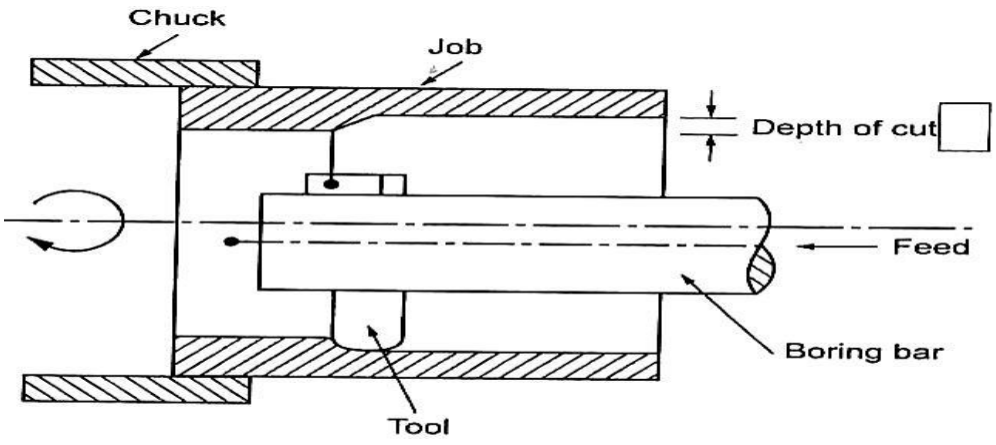
Boring is cutting a hole in wood with a tool called a bit. Holes of 6 mm size or larger are bored. Holes of 6 mm size or smaller are drilled. Boring is the first step in making any kind of shaped opening or making holes.



Boring operation

3. With a neat sketch explain the column and knee type milling machine and name its main parts. **(AU Dec 2010,Apr 11)**

Column and Knee Type Milling Machines

Column and Knee type milling machines are most commonly used for general shop floor work, maintenance work, tool room work, etc. It has a vertical column on its base. The column has machined guide ways on its front face. A knee slides up and down on these ways. The column serves as a housing for speed and feed mechanisms. The Knee carries the saddle and worktable.

There are two types of column and knee type milling machines.

(i) Horizontal type.
(ii) Vertical type.

In horizontal type, the axis of rotation of arbor is horizontal. In vertical type, the axis of rotation of arbor is vertical.

1. Plain or Horizontal milling machine

It is a horizontal column and knee type-milling machine otherwise simply a *horizontal milling machine*. A description of the principle parts of a milling machine is as follows:

(i) Base:

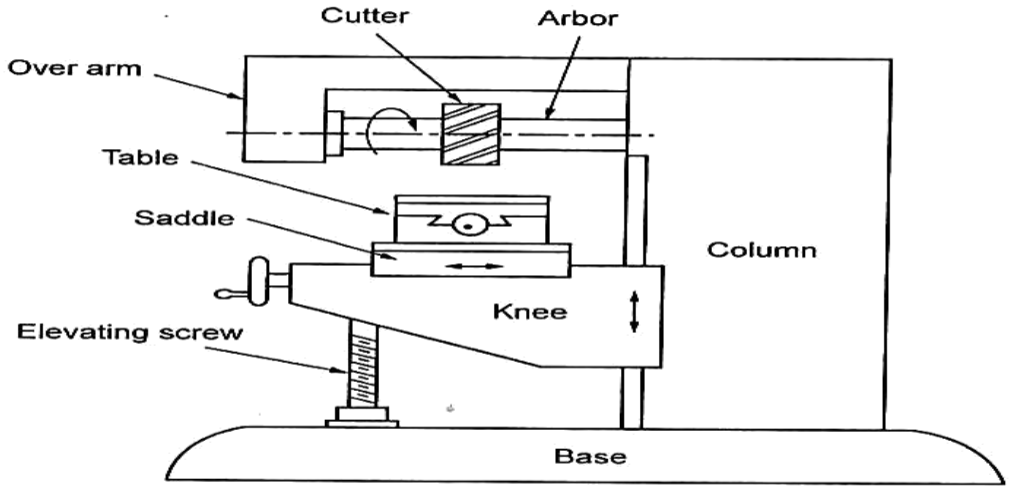
It is the foundation of the machine made of grey cast iron. All other parts are mounted on it. It also serves as a reservoir for cutting fluid.

(ii) Column:

It is the main support of the machine. The motor and other driving mechanisms are housed in it. It supports and guides the knee in its vertical travel.

(iii) Knee:

The knee projects from the column and slides up and down through dove tail guides. It supports saddle and the table. Elevating screw provides its vertical movement (up and down).



Horizontal milling machine

(iv) Saddle:

The saddle supports and carries the table and provides traversed movement.

(v) Table:

The top surface of the table is accurately machined. There are T-slots along the length of the table for holding the work.

The table rests on the guide ways of the saddle and travels longitudinally in a horizontal plane. It supports the work piece, fixtures etc.

(vi) Over arm:

It is mounted on and guided by the top of the column. The over arm is used to hold the outer end of the arbor to prevent it from bending.

(vii) Arbor:

Arbor is an accurately machined shaft. Cutters are mounted on the arbor which is rigidly supported by the over arm, spindle and end braces. It is tapered at one end to fit the spindle nose and has two slots to fit the nose keys for locating and driving it.

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4. Explain hacksaw and band saw with neat sketches. **(AU Apr 2010)**

SAWING MACHINES

SAWING

Sawing is defined as the process of cutting billet or work stock to our requirements. It means, cutting the bar stock to the required length or size for machining to obtain the desired shape and size.

During sawing, the individual tooth cuts the work when either the saw or work feeds. This operation can be controlled by the direction. speed of cutting and number of teeth on the saw. Sometimes, curved cut can also be done. The main thing in sawing process is, the maximum width of cut done on work will be equal to the width of the saw itself.

SAWING MACHINES

Generally, sawing machines are classified according to the various types of power sawing machines.

1. Reciprocating saw
   - (i) Horizontal sawing machine
   - (ii) Vertical sawing machine
2. Circular saw
   - (i) Cold saw
   - (ii) Friction saw
   - (iii) Abrasive disk
3. Band saw
   - (i) Contour hand saw
   - (ii) Friction blade

Reciprocating Saw

This is same lke power hack saw. We can see it in any small size workshop itself. It consists of a frame, work table, vise, supporting base and power source. When the power supply is given, the blade reciprocates back and forth. The metal is cut only in forward stroke called *cutting stroke* as that shaper and planer.

No metal is cut during return stroke. So, depth of cut is given only at the end of return stroke by means of gravity or spring regulated ratchet mechanism or hydraulic drive. Mostly, hydraulic drives are used to lift the hack saw blade on the return stroke. In this operation, work material or stock is held between clamping saws. Sometimes, several stocks are clamped together and cut the same time depending upon the quantity of stock to be cut. By this process, both the straight and angular cuts can be made.

Circular Saw

Circular saws are in the form of revolving disc to cut the stock to the required dimensions. Teeth are formed on its full outer periphery.

1. Cold saw

It has a circular blade. Teeth are inserted on its periphery to cut the stock. Due to large diameter blades, it cuts the stock rapidly. Even it runs at slow speed, it is more powerful. Smooth and accurate cut can be obtained by using this saw. It is equipped with automatic feeding mechanism to cut the stock held in a vise effectively. Coolants may or may not be required.

2. Friction disc

These types of saws have almost no teeth. It is operated at high speeds. Due to this, heat is generated. So, the work becomes softer due to heat generation during cutting. In this case, cutting action is faster but it leaves heavier burr and less accurate.

3. Abrasive disc

In this case, cutting action takes place through abrasive discs by grinding. Resionoid or rubber bonded wheels are rotated at high speeds. In this method also, cutting action is faster and accurate but cutting action will not be true sawing.

Band Saw

A continuous blade having teeth runs over the rotating rim of the two wheels. The work is held between these two rotating wheels. So, the continuous cutting action can take place thereby making more productive.

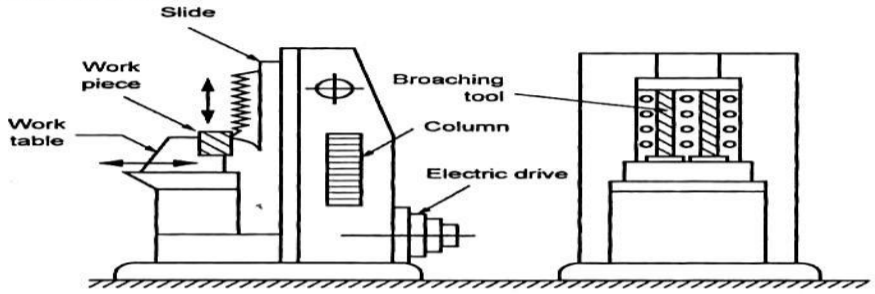
1. Contour saw

It is the most versatile sawing machines in applications. The work can be fed in any direction. According to the feeding of work, the direction of cutting can be oriented to produce required shape. These

5. Discuss push and pull type broaching machines with neat sketches.**(AU Apr 2010,Dec 08)**

Push Down Type Vertical Broaching Machine

The push type vertical broaching machine is used for surface broaching operation. It consists of a box shape column, slide and drive mechanism. Fig. shows the vertical push down type surface broaching machine.



Push down type vertical broaching machine

Broaching tools are mounted on slide which is hydraulically operated and accurately guided on the column ways. Slide with the broaches travels at various speeds which are controlled by the hydraulic drive. Its stroke is adjusted to suit the broaching operation to be performed. The slide is provided with quick return mechanism. In this type, most of the machines are provided with receding table so that the fixture may be loaded and unloaded during its return stroke.

The worktable is mounted on the base in front of the column. The fixture is clamped to the table. The work piece is held in the fixture. After advancing the table to the broaching position, it is clamped and the slide with the broach travels downwards for machining the work piece. Then the table recedes to load a new work piece and the slide returns to its upper position. The cycle is then repeated.

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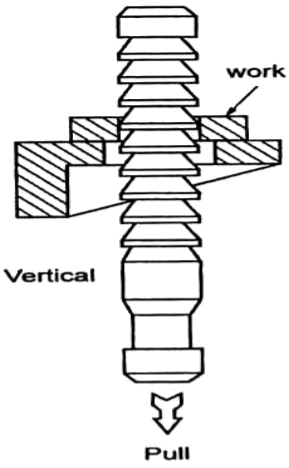
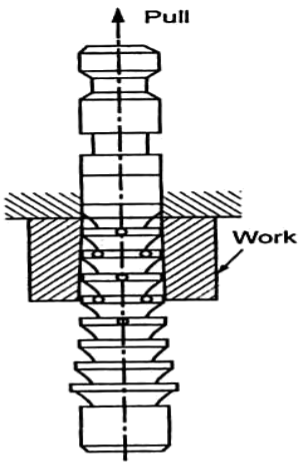
Pull Down Type Vertical Broaching Machine



Pull down type vertical broaching machine



Pull up type vertical broaching machine

These machines are mostly used for internal broaching. Instead of being pushed the broach, it is pulled through the job. This machine has an elevator at the top of the machine.

The pulling mechanism is enclosed in the base of the machine. The work piece is mounted on the table by means of fixture. The tail end of the broach is gripped in the elevator. The broach is lowered through the work piece. The broach is automatically engaged by the pulling mechanism and is pulled down through the job. After the operation is completed, the broach returns to its original position. The operation of this machine is shown in fig.

6. Discuss the principle of operation of a shaper with a neat sketch. **(AU Dec 09)**

PRINCIPLE OF OPERATION

The shaper which is having a reciprocating type of machine tool with single point cutting tool used to produce flat surface. The flat surface may be horizontal, vertical or inclined. It has the three important parts such as

1. Table
2. Tool head
3. Ram

The tool head is fitted on the front end of the ram while the job is rigidly fixed on the table. The tool is mounted on the tool post or head. The ram reciprocates along with the tool to remove the metal in the forward stroke called as *cutting stroke*. The tool does not cut the metal in the return stroke called as *idle stroke*. Therefore, one pass is nothing but the combination one forward and return stroke or one cutting and one idle stroke. So, we are in a position to reduce idle stroke time by increasing the speed of the return stroke. That is, the speed of cutting stroke will be lower than the speed of return stroke. This is done to reduce the time required for one pass. Hence, the overall time required will be reduced drastically. This quick return of the ram during idle stroke is obtained by a quick return mechanism. At the end of each cutting stroke, the feed (depth of cut) is given.

MACHINING VARIOUS TYPES OF FLAT SURFACES

1. The table is moved in a cross-wise direction to machine horizontal surfaces.
2. The tool head is moved perpendicular to the table in down ward direction to machine vertical surfaces.
3. The tool head is fed at an angle to produce inclined surfaces

CLASSIFICATION OF SHAPERS

Generally, shapers are classified as follows.

1. According to the type of driving mechanism
   a. Crank drive type
   b. Whit worth driving mechanism type.
   c. Hydraulic drive type.
2. According to the position of ram.
   a. Horizontal shaper.
   b. Vertical shaper.
   c. Travelling head shaper
3. According to the table design
   a. Standard or plain shaper
   b. Universal shaper
4. According to the type of cutting stroke
   a. Push out type
   b. Draw cut type

PRINCIPLE PARTS OF A SHAPER

The different parts of a shaper are listed and described below.

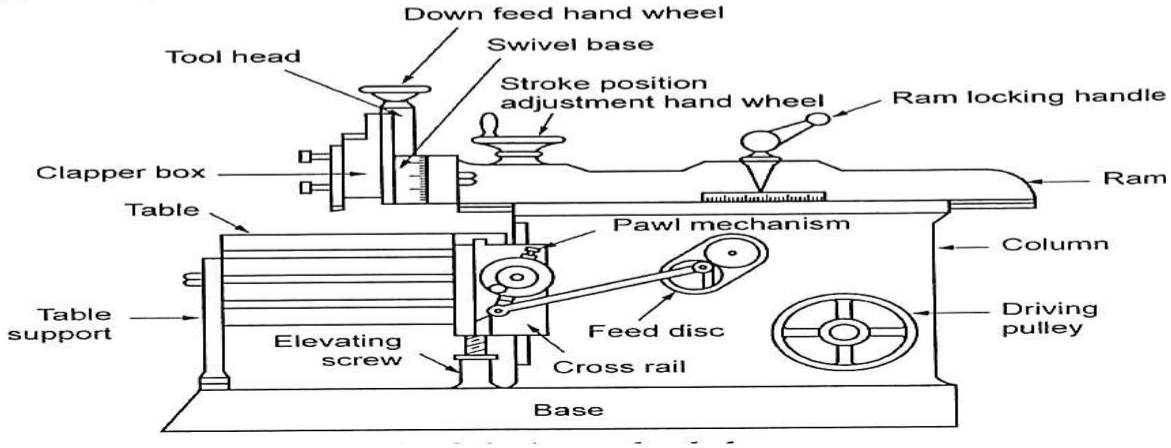
1. Base
2. Column
3. Cross rail
4. Saddle
5. Table
6. Ram
7. Tool head

1. Base

The base is a heavy and robust in construction which is made of cast iron by casting process. It is the only part to support all other parts because all parts are mounted on the top of this base. So, it should be made to absorb vibrations due to load and cutting forces while machining.

2. Column

The column has a box type structure which is made of cast iron. The inside surface is made as hollow to reduce the total weight of the shaper. It is mounted on the base. The ram driving (Quick return) mechanism is housed. The two guide ways are provided on the top. The ram reciprocates on this guide ways. Similarly, there are two guide ways at the front vertical face of the column to move the cross rail along these guide ways.



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3. *Cross rail*

It is also a heavy cast iron construction. It slides on the front vertical ways of the column with two mechanisms. One is for elevating the table and the other one is for cross travel of the table. A saddle slides over two guide ways already provided in the front face of the cross slide. The crosswise movement of the table is obtained by cross feed screw and the vertical movement of the cross rail is obtained by an elevating screw.

4. *Saddle*

It is mounted on the cross rail which holds the table in position on its top without any shake.

5. *Table*

It is also a box type rectangular hollow cast iron block. This table slides along the horizontal guide ways of the cross rail. The work is held in the table. The table has machined surfaces on the top and sides of T-slots for clamping work. It can be moved vertically by the elevating screw. An adjustable table support supports the front face of the table.

6. *Ram*

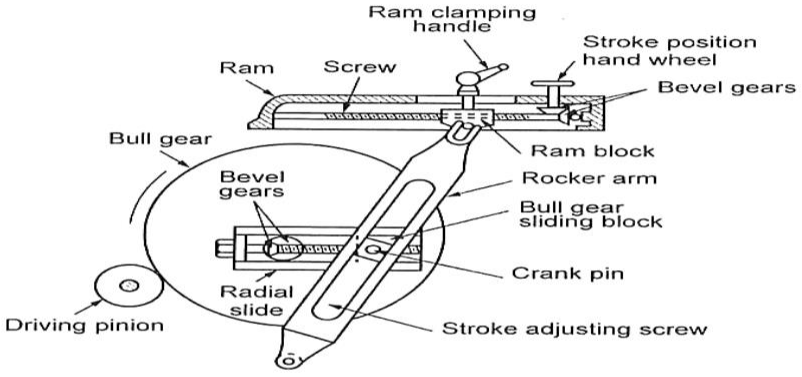
Ram of cast iron has cross ribs for rigidity. Generally, it is a reciprocating type which slides over the guide ways on the top of the column. It is connected to driving mechanism of any one and also it carries the tool head at the front end.

7. *Tool head*

It holds the tool rigidly having swivel base with degree graduation. So, the tool head can be swiveled to any angle as required. The tool head has a vertical slide and apron to provide vertical and angular feed to the tool. A feed screw with graduated dial moves the vertical slide vertically to set the accurate movement.

7. Describe the working of a crank and slotted link mechanism. **(AU Dec 2010,Apr 08)**

In this mechanism, the ram is actuated by gear drives associated with electric motor. First, the electric motor drives the pinion gear. Next, the pinion gear drives the bull gear which rotates in opposite direction due to external gear meshing. A radial slide is provided on the bull gear. A sliding block is assembled on this slide. The block can be positioned in radial direction by rotating the stroke adjustment screw.



Crank and slotted lever mechanism

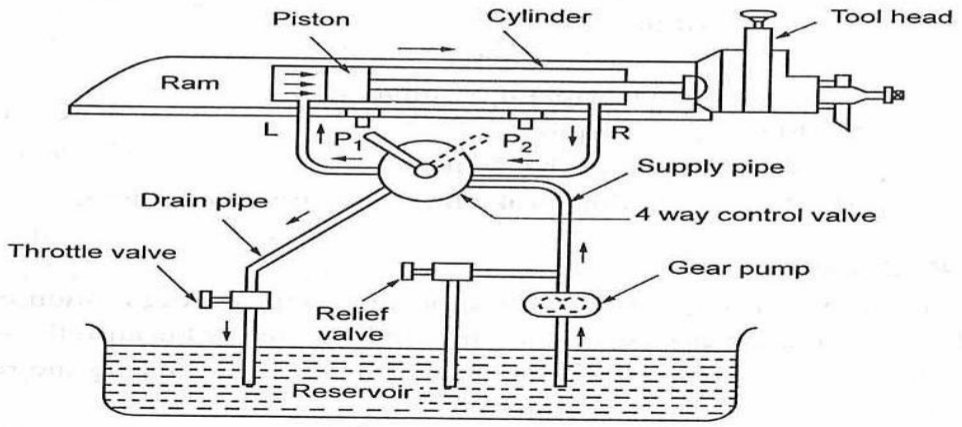
The sliding block has a crank pin. A rocker arm is freely fitted to this crank pin. The rocker arm sliding block slides in the slot provided in the rocker arm called as *slotted link*. The bottom end of the rocker is pivoted and its upper end has fork which is connected to the ram block by a pin.

When the pinion gear rotates along with bull gear, the crank will also rotate. Due to this, the rocker arm sliding block also rotates in the same circle. Simultaneously, the sliding block slides up and down in the slot. This movement is transmitted to the ram which reciprocates. Hence, the rotary motion is converted into reciprocating motion by this.

8. Sketch and explain the hydraulic drive of a horizontal shaper.**(AU Dec 2010, Dec 2009)**

Hydraulic drive

A piston reciprocates inside the hydraulic cylinder. A piston rod is connected between the piston and ram. So, the ram reciprocates along with the piston. Two parts or entries are provided near the each end of the cylinder. A four-way control valve connects these two entries with the reservoir. The reservoir connects the value through a drain pipe and a supply pipe.

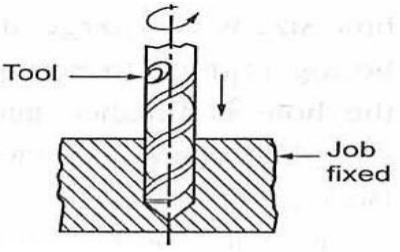


Hydraulic drive

9. What are the operations performed on a drilling machine? **(AU Apr 2010)**

DRILLING OPERATIONS

The various operations done in a drilling machine are explained as follows.

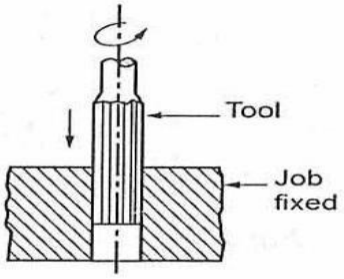


Drilling

Drilling

Drilling is the operation of cutting a round hole by a rotating tool called *drill*. Before drilling, the center of the hole is located on the work piece. For this, two lines at right angles to each other are drawn. A center punch is used to mark the center point at the intersection of two lines. The rotating drill is pressed at the center point marked on the work piece to produce the hole.

Drilling does not produce an accurate hole. The internal surface produced by drilling will be rough. The hole is lightly larger than the size of the drill used. This is because of the vibration of the drill.



Reaming

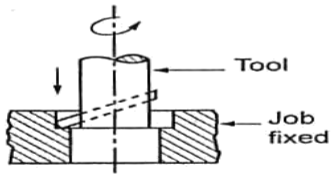
Reaming

Reaming is the process of sizing and finishing the already drilled hole.

The tool used for reaming is known as a *reamer*. Reamer is a cylindrical tool having many cutting edges. Reamer cannot produce a hole. It simply follows the path of an already drilled hole. It removes a very small amount of metal. The amount of metal removed in reaming is about 0.375*mm*. In reaming, the spindle speed is half that of drilling.

Boring

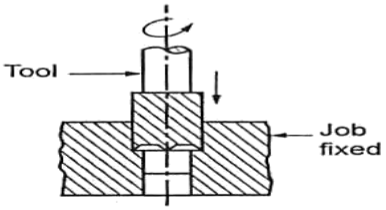
Boring is an operation of enlarging a hole by a single point cutting tool. Boring is done where suitable size drill is not available. If the hole size is very large, it cannot be drilled. Then boring is done to enlarge the hole. By boring, the hole is finished accurately to the required size. The internal surface of a hole in a casting is machined by boring. Boring corrects the out of roundness of a hole. The cutter is held in a boring bar. The boring bar has a tapped shank to fit into spindle hole. Boring is a slow process.



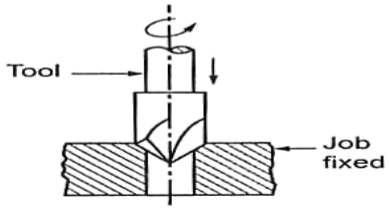
Boring

Counter Boring

The operation of enlarging the end of a hole cylindrically is known as *counter boring*.



Counter boring



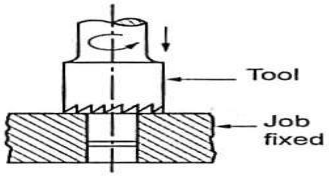
Counter sinking

Counter Sinking

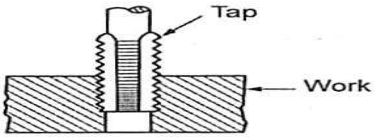
The operation of making a cone-shaped enlargement of the end of a hole is known as *countersinking*.

Spot Facing

The operation of squaring and smoothing the surface around a hole is known as *spot facing*. Fig. illustrates the process of spot facing.



Spot facing



Tapping

Tapping

Tapping is an operation of cutting internal threads in a hole by using a cutting tool called *tap*. A tap has cutting edges in the shape of threads. When the tap is screwed into the hole, it will remove metal and cut internal threads.

The drilled hole will be smaller than the tap size.

Tap drill size = 0.8 × Outside diameter of the thread.

Trepanning

The operation of producing a large hole (diameter over 50*mm*) by removing metal along the circumference of a hollow cutting tool is known as *trepanning*. There is a pilot inside the trepanning tool which enters the small previously drilled hole to produce the larger hole concentric. It is used for the diameter more than capacity of particular machine and where hole depth is much more in comparison with normal work.

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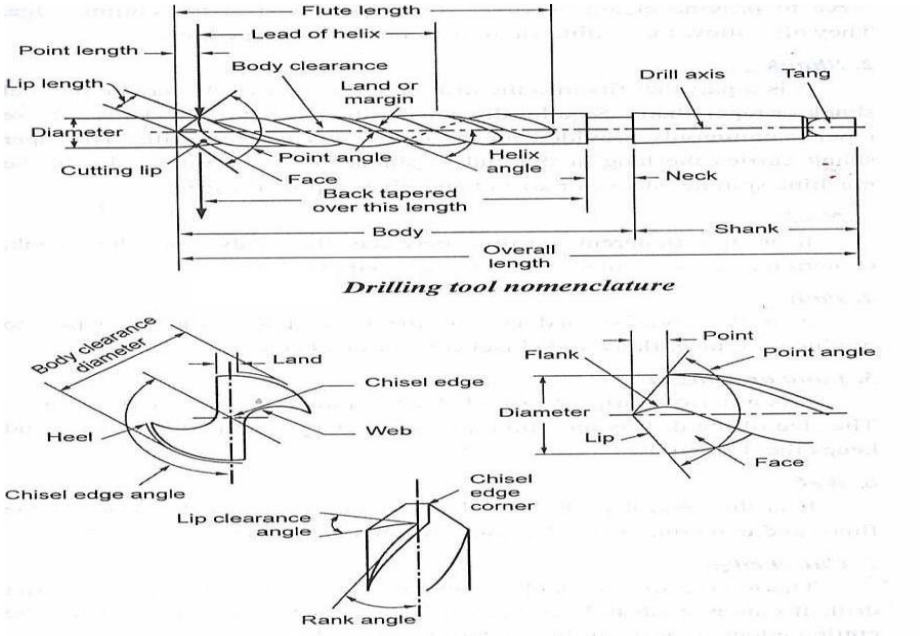
10. Sketch a twist drill and explain **(AU Dec 08, Dec 09)**



Drilling tool nomenclature

11. Explain different types of milling cutters. **(AU Dec 2009)**

These are multi tooth rotary cutting tools generally made of high speed steels or sintered carbides. Milling cutters are classified into different ways.

According to the shape of the tooth, milling cutters are classified as

(i) Milled tooth cutters.
(ii) Form relieved cutters.

According to the type of operation.

(i) Plain milling cutters.
(ii) Side milling cutters.
(iii) End mill cutters.
(iv) Angle milling cutters.
(v) T-slot milling cutters.
(vi) Slitting saws.
(vii) Form milling cutters.
(viii) Fly cutters.
(ix) Wood ruff key slot milling cutter.

According to the way of mounting on the machine.

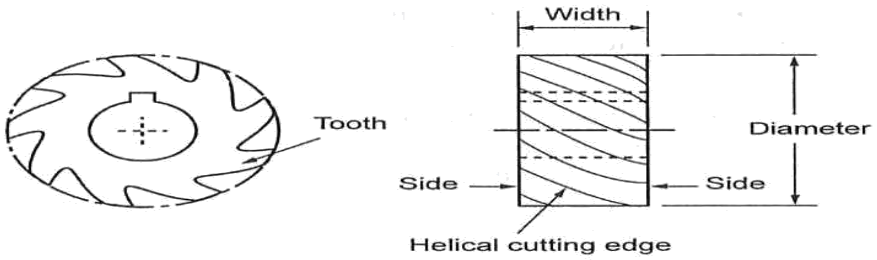
(i) Arbor cutters.
(ii) Shank cutters.
(iii) Face cutters.

1. Plain milling cutter

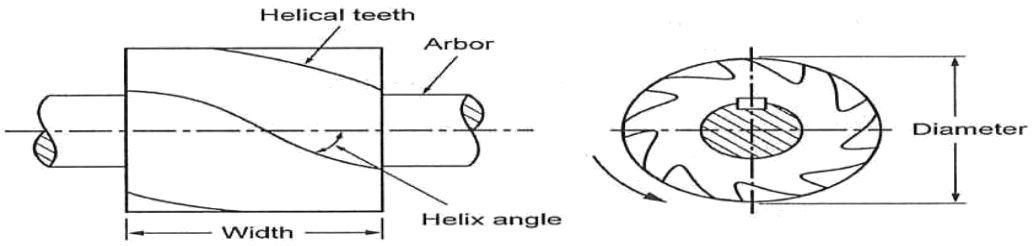
This is also known as a *mill cutter*. It is a disc or cylindrical shaped cutter having teeth on its circumference. It is used to machine flat surface parallel to its axis. There are two types of plain milling cutters commonly used.

(i) Plain straight teeth cutter.
(ii) Plain milling helical teeth cutter.

The plain milling cutters having the width more than its diameter is called *slab mill cutter*. This is used for rough machining with coarse feed. The cutter has less number of teeth.



Plain milling cutter



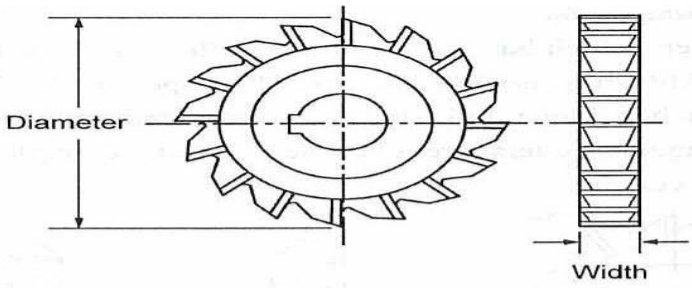
Slab milling cutter

Straight teeth plain milling cutters are used for light operations. Helical teeth cutters are used for heavy cut operations.

Cutters of various diameters and widths are available. Roughing cutters will have less number of teeth. Finishing cutters will have more number of teeth for the same diameter.

2. Side milling cutter

It has cutting edges on its periphery and also on the sides. This cutter is used for removing metal from the side of the work pieces. It is also used for cutting slots. These cutters may have plain, helical or

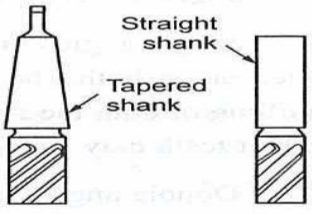


Side milling cutter

staggered teeth. Among these three, helical cutters are preferred on milling machines since they require less power for machining. And also it provides smoother operation as more than one tooth performs a milling operation at a time.

3. End milling cutters

The end milling cutters have cutting teeth on the end as well as on the periphery of the cutter. The peripheral teeth may be straight or helical. It is similar in construction to a twist drill or reamer. These cutters are generally provided with a shank on one end. The shank may be of straight or tapered. Tapered shank cutters are fitted to the spindle using adapters. Straight shank cutters are fitted to the spindle using collets.



End milling cutter

End mills are commonly used for vertical milling operations. They are used for light milling operations like cutting slots, machining accurate holes and profile milling.

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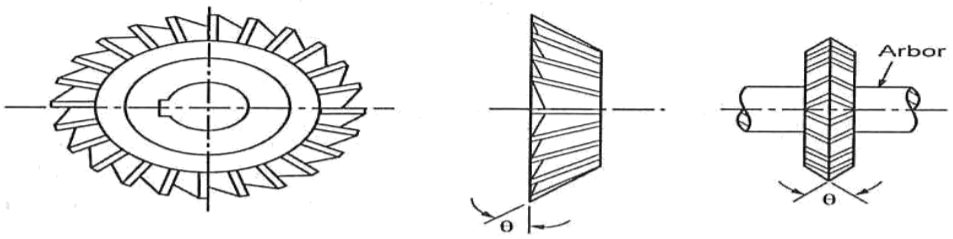
4. Angle milling cutters

All cutters which have their cutting teeth at an angle to the axis of rotation are known as *angular cutters*. Their specific use in milling V-grooves, notches, dove tail slots, reamers teeth and other angular surfaces. Angular cutters are classified as single angle cutters and double angle cutters.



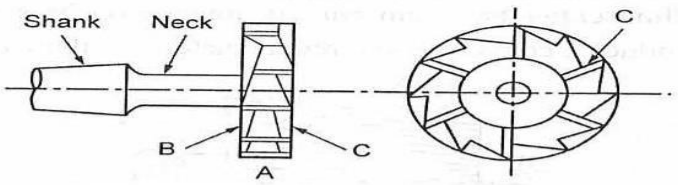
Single angle milling cutter *Double angle milling cutter*

Single angle cutters may have their teeth either only on the angular face or on both, the angular face and the side. The later type enables milling of both the flanks of the inclined angular groove simultaneously. Their teeth may have an included angle of 45° to 60°.

Double angle cutters differ from single angle cutters in such a way that they have two angular faces which join together to form V-shaped tooth. The included angle of this 'V' is either 45°, 60° or 90°. Angle of both sides should be equal.

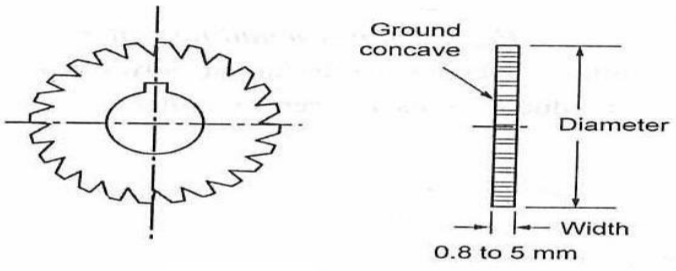
5. T-slot milling cutter

It is a single operation cutter which is used only for cutting T-slots. The arrangement of cutting teeth is similar to that of a side milling cutter. But this cutter has a tapered shank. A neck is formed between the cutting face and the shank. The cutter has cutting edges on its periphery and on its sides.



T - slot milling cutter

6. Slitting saws



Slitting saw

These are very thin cutters in varying thickness from 0.5 to 5*mm*. They are used for cutting deep slots and parting off materials into pieces. These cutters are thinner at the centre than at the edges to provide clearance and reduce friction.

7. Form milling cutter

The cutters which are designed to cut definite shapes are known as *form milling cutters*. These cutters can be classified according to their shape as convex or concave cutters, gear cutters, flute cutters and corner rounding cutters.

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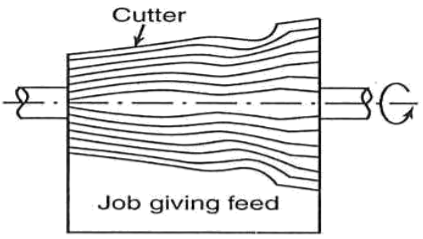
Concave milling cutter has teeth curved inwards on its periphery. The cutter will produce a convex semi circular surface on the work piece.



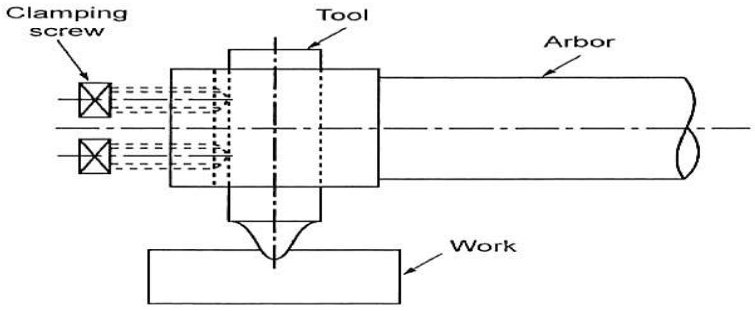
Form milling cutter

Convex milling cutter has teeth curved outward on its periphery. The cutter will produce a concave semi-circular surface on the work piece.

Gear cutters have formed cutting edges. The shape of the cutter teeth is involute. The cutter will produce groove of involute shape. The involute gear tooth is formed between two grooves milled by the cutter. The profile of the gear tooth depends upon the module and the number of teeth on the gears. Therefore, for cutting different number of gear teeth of same module, different cutters are required. Corner rounding cutters are used for milling the edges and corners of the jobs to a required radius.

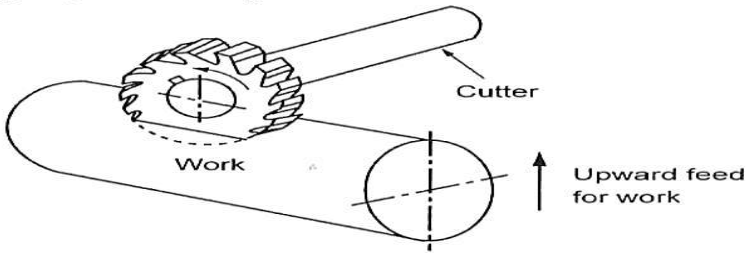
8. Fly cutters

It is actually a single point tool which is used in milling machine when standard cutters are not available. It is either mounted on a cylindrical body held in a stub arbor or held in a bar. Screws are used for tightly holding the tool in the above holders. The cutting edge of the tool is ground to the required shape. The cutter removes metal, when it rotates.



Fly cutter

9. Woodruff key slot milling cutter



Woodruff key slot milling cutter

It is a small type of end milling cutter which is similar to plain and side mills. It has a taper shank and a neck. The cutter may have straight or staggered teeth. The sides of the cutter are ground concave. This provides clearance for the cutter movement. It is used to cut woodruff key slot in a shaft.

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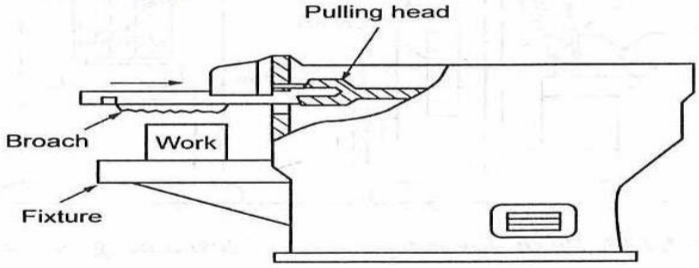
12. With the help of a neat sketch, discuss the working of a surface broaching machine. **(AU Apr 2010)**

Horizontal Type Surface Broaching Machine

Fig. shows the horizontal type surface-broaching machine. Here, the broach is pulled over the top surface of the work piece held in the fixture on the worktable. The cutting speed ranges from 3 to 12*mpm* with a return speed up to 30*mpm*.



Horizontal type surface broaching machine

When the surface broaching is done, the broaches are always permanently connected to the draw head.

13. Sketch the Quill mechanism .write its main parts and their functions? **(AU Apr 2010)**

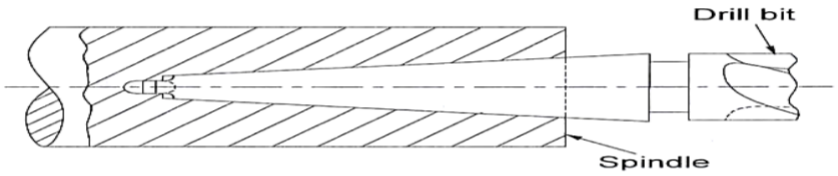
MOUNTING THE DRILL TOOL

Both taper shank and straight shank drills can be mounted on the drilling machine spindle in a number of ways. They are:

1. Fitting directly in the spindle.
2. By using a sleeve.
3. By using a socket.
4. By means of chucks.

Fitting Directly In The Spindle

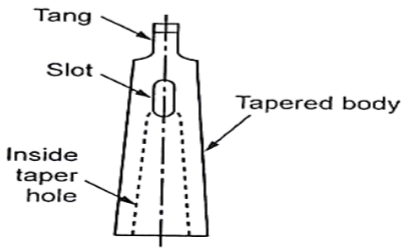
The drill is directly held in the spindle by friction. The spindle of the drilling machine and the shank of the drill has a standard tapered bore. The taper shank of the drill is forced into it. To get a positive drive, (without slipping) the tang of drill fits into a slot at the end of taper bore in the spindle. To remove the drill from the spindle, a tapered wedge called *drift* is forced into the slotted hole in the spindle referred in fig.



Drill fitted in the spindle

By Using a Sleeve

If the taper shank of drill is smaller than the taper in the spindle hole, a sleeve is used. The sleeve with drill is fitted in the hole of the spindle. The sleeve has outside taper surface. This fits into the tapered hole of the spindle. The inside taper of the sleeve can hold the drill or a smaller sleeve. In this sleeve also, there is a tang which is used for the same manner as explained in previous case.



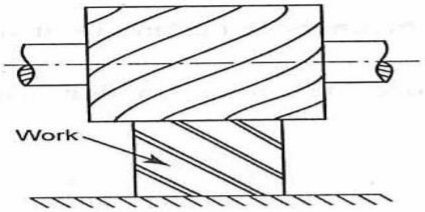
Drill sleeve

14. How will you cut the following types of surfaces on milling machines? **(AU Apr 2010)**

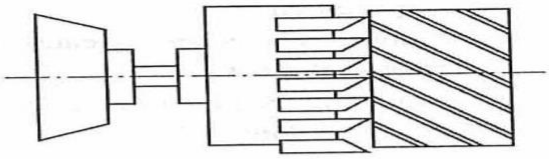
(a) Flat surfaces (b)Slots and splines

Plain or Slab Milling

Plain or slab milling is the operation of producing flat horizontal surface parallel to the axis of the cutter using a plain or slab milling cutter as shown in fig.



Plain milling.



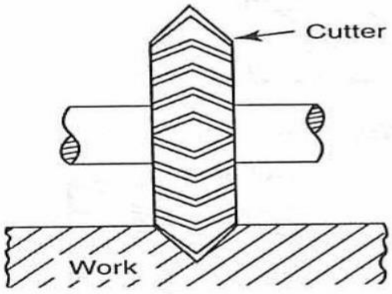
Face milling

Face Milling

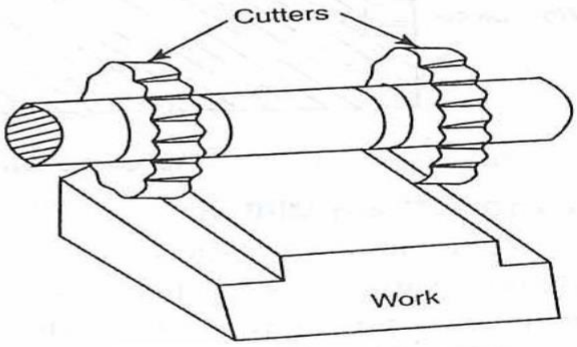
Face milling is the operation of producing flat surface on the face of the work piece which is at right angle to the axis of rotation of the face milling cutter. Refer fig.

Angular or Bevel Milling

It is the operation of machining a flat surface at an angle, other than right angle to the axis of the revolving cutter. The cutter used may be a single or double angle cutter, depending upon whether a single surface is to be machined or two mutually inclined surfaces simultaneous.



Angular milling



Straddle milling

Straddle Milling

Straddle milling operation is the production of two vertical flat surfaces on both sides of the job by using two side milling cutters which are separated by collars. Straddle milling is very commonly used for milling square and hexagonal surfaces.

Gang Milling

Gang milling is the production of many surfaces of a job simultaneously by feeding the table against a number of required cutters. Fig. shows a gang of three side milling cutters and two plain milling cutters which are fitted to the arbor. The two plain milling cutters have helical teeth of opposite hands. This method of operation saves machining time and hence it is widely used in mass production.

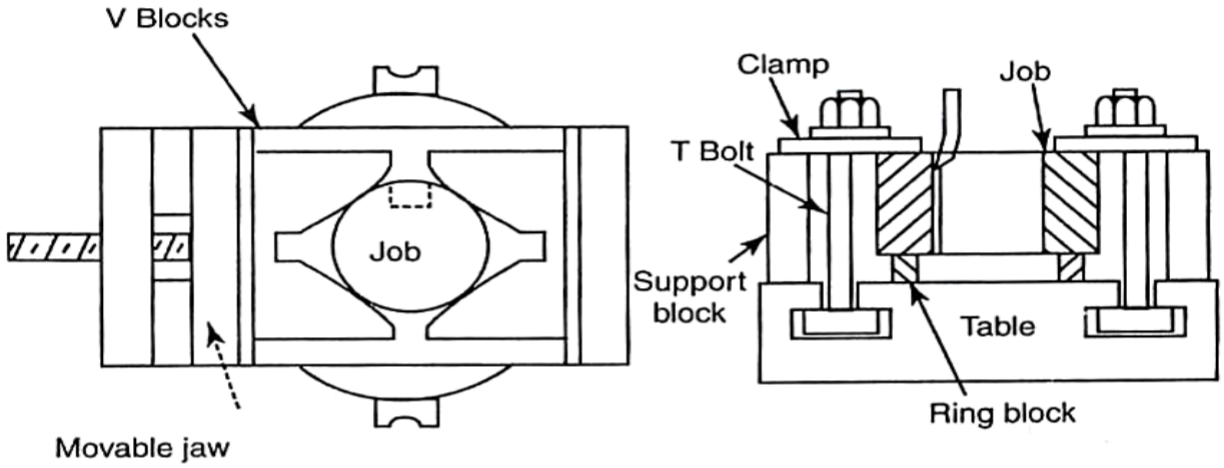
15. Make a note on different types of work holding devices used in a slotting machine. **(AU Dec 2008)**

WORK HOLDING DEVICES

The work is held on a slotter table by a vice, using 'T' bolts and clamps or by special fixtures. The work is placed above the parallel or packing pieces. This permits the over travel of tool. Fig. illustrates the method of holding a work (gear) on the slotter table for cutting internal keyway. The gear is placed on a ring block.

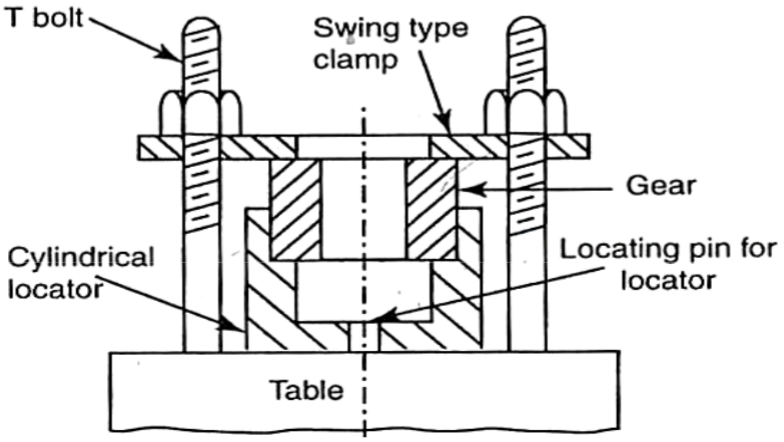
The axis of gear is aligned with the axis of the rotary table. It is clamped by using 'T' bolts and clamps.

Cylindrical jobs can be held in a vice by using 'V' block as shown in the fig. The vice is clamped in the table.



Job in vice

Special fixtures can be used as shown in fig. . In this, a gear blank is located by a cylindrical locator. The cylindrical locator is located by a pin at the center of table. Hence, axis of gear is located at the center of table. The clamping plate and T bolts are used to clamp the work.



Slotting fixture

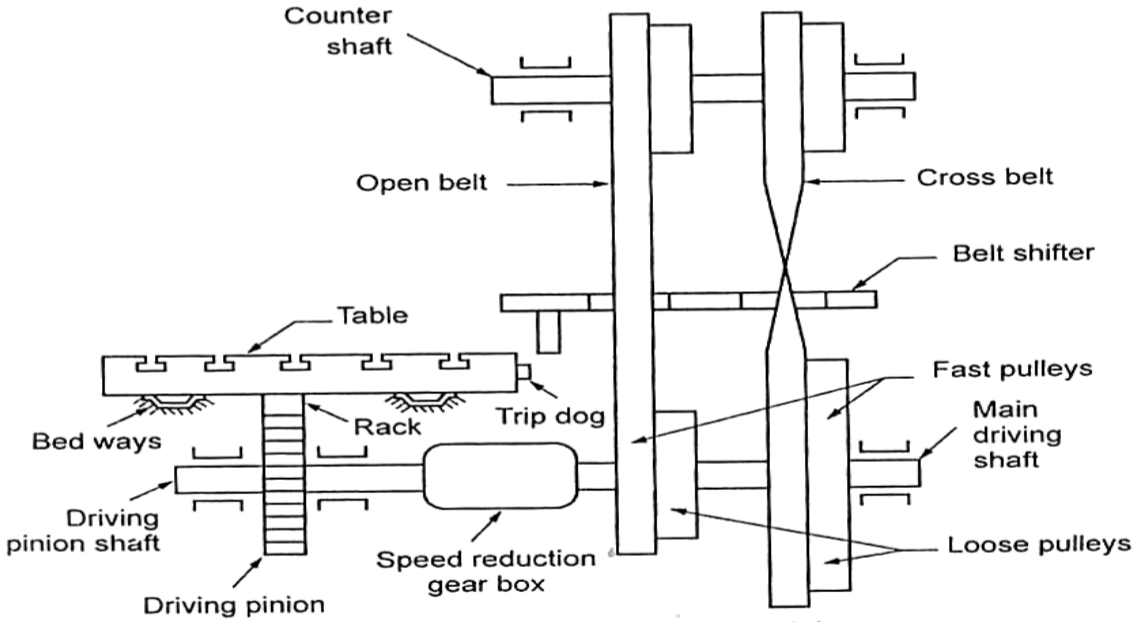
16. Explain the different types of table drive and feed mechanisms in a planning machine . **(AU Dec 2008)**

The following various types of quick return mechanism are used in planer as described below:

Open and Cross Belt Drive

A counter shaft is driven by electric motor. This shaft carries two wide faced pulleys of equal diameter. One pulley drives the open belt. Another pulley drives the cross belt.The main driving shaft is placed below the bed. One end of the shaft carries a set of two large pulleys and two small pulleys.

One of the larger pulley and one of the smaller pulleys are keyed to the shaft. They are called *fast pulleys*. The other two pulleys rotate freely on the shaft. They are called *loose pulleys*. The large pulleys are connected to the counter shaft pulleys by cross belt. The small pulleys are connected to the counter shaft pulleys by open belt. The speed of the main driving shaft is reduced through a speed reduction gearbox. From this gearbox, the drive is transmitted to the driving pinion. This pinion meshes with the rack at the bottom of the table.



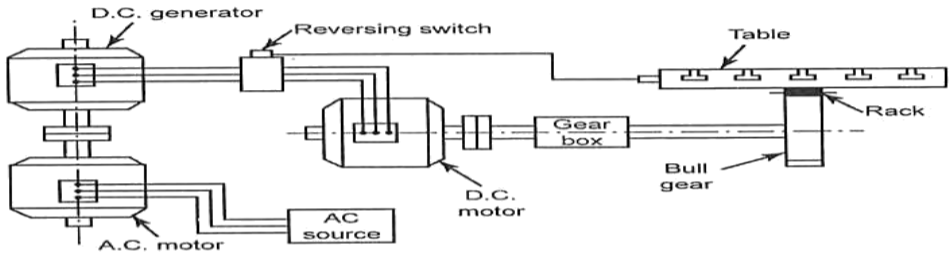
Open and cross belt drive

Referring to the figure , the cross belt connects the larger loose pulley. No drive is transmitted by it to be main shaft. But the open belt connects the smaller fast pulley. So the drive is transmitted to the main shaft through the open belt. The return stroke of the table takes place. At the end of the return stroke, the trip dog pushes the belt shifter. The belt shifter shifts both the belts to the right. The cross belt is shifted to the larger fast pulley. The open belt is shifted to the smaller loose pulley. So, the drive is transmitted to the main shaft through the belt on the larger fast pulley. The direction of rotation of the main shaft is reversed. Because of the larger diameter of the pulley, the main shaft rotates at a

slow speed. So, the cutting stroke takes place at slow speed. No drive takes place through the open belt.

The quick return motion is obtained. At the end of the cutting stroke, the belts will be shifted to the left by another trip dog. The length and position of the stroke may be adjusted by adjusting the position of trip dogs.

Electric Drive



Electric drive

In this drive, four electrical machines are used in which one is D.C. motor with variable speed reversible motor. The D.C. motor shaft is connected to the table through gears rack and pinion. This D.C. motor receives power from a D.C. generator. This D.C. generator is again coupled with one more A.C. motor.

Working principle

When the A.C. motor runs, the D.C. motor will receive power from the D.C. generator. At that time, the table moves in forward direction. At the end of this stroke, a trip dog actuates an electrical reversing switch. Due to this action, it reverses the direction of current in D.C. generator with increased current strength. Now, the motor rotates in reverse direction with higher speed. So, the table moves in reverse direction to obtain quick return motion.

Advantages

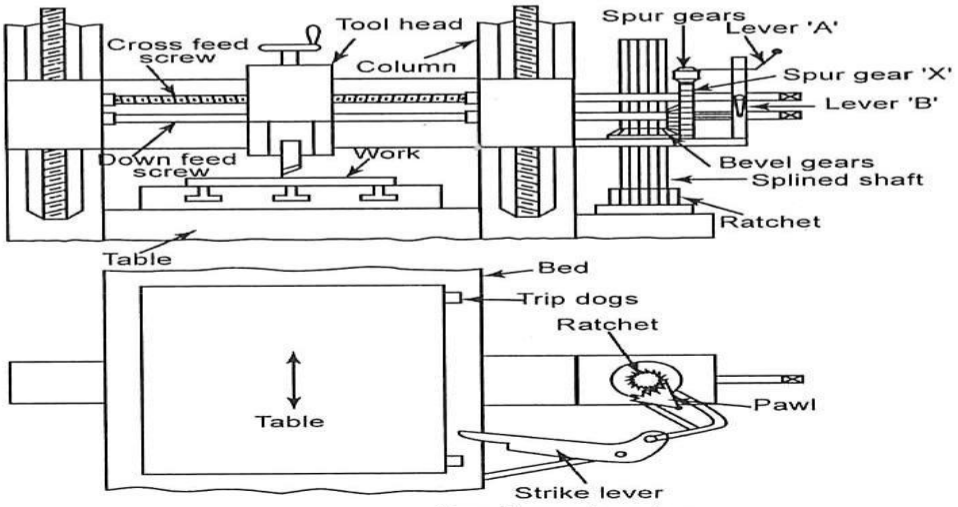
1. Operation is smooth.
2. More number of cutting speeds and returns speeds can be obtained.
3. Quick and accurate control are possible.
4. Cutting speed, stroke length and stroke position can be adjusted without stopping the machine.

FEED MECHANISM

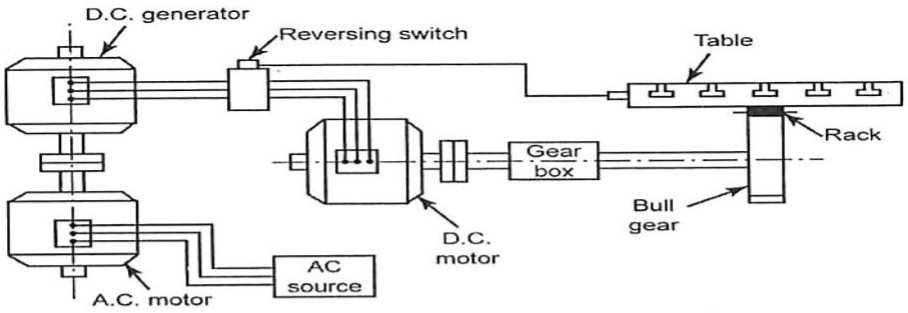
Hand Feed

The cross feed screw passes through a nut in the tool head. When this cross feed screw rotates, the tool will move in horizontal direction to obtain cross feed.

Automatic Feed



17. State the advantages of Ward-Leonard drive. **(AU Dec 2007)**



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In this drive, four electrical machines are used in which one is D.C. motor with variable speed reversible motor. The D.C. motor shaft is connected to the table through gears rack and pinion. This D.C. motor receives power from a D.C. generator. This D.C. generator is again coupled with one more A.C. motor.

Working principle

When the A.C. motor runs, the D.C. motor will receive power from the D.C. generator. At that time, the table moves in forward direction. At the end of this stroke, a trip dog actuates an electrical reversing switch. Due to this action, it reverses the direction of current in D.C. generator with increased current strength. Now, the motor rotates in reverse direction with higher speed. So, the table moves in reverse direction to obtain quick return motion.

Advantages

1. Operation is smooth.
2. More number of cutting speeds and returns speeds can be obtained.
3. Quick and accurate control are possible.
4. Cutting speed, stroke length and stroke position can be adjusted without stopping the machine.

18. Explain with a sketch “Fast and loose pulleys” quick return mechanism of a planer table. **(AU Dec 2007)**

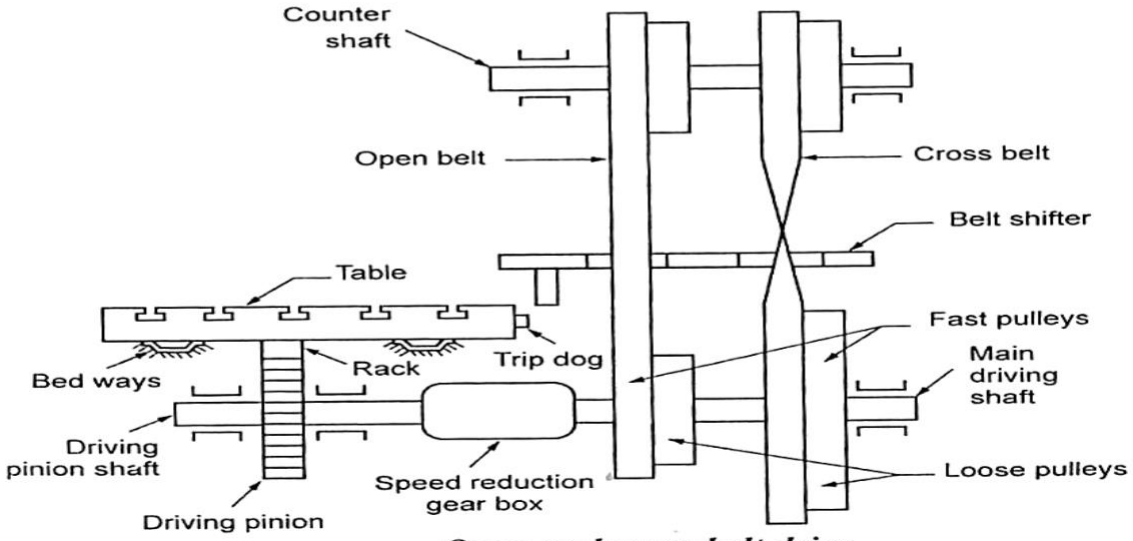
The following various types of quick return mechanism are used in planer as described below:

Open and Cross Belt Drive

A counter shaft is driven by electric motor. This shaft carries two wide faced pulleys of equal diameter. One pulley drives the open belt. Another pulley drives the cross belt.The main driving shaft is placed below the bed. One end of the shaft carries a set of two large pulleys and two small pulleys.

One of the larger pulley and one of the smaller pulleys are keyed to the shaft. They are called *fast pulleys*. The other two pulleys rotate freely on the shaft. They are called *loose pulleys*. The large pulleys are

connected to the counter shaft pulleys by cross belt. The small pulleys are connected to the counter shaft pulleys by open belt. The speed of the main driving shaft is reduced through a speed reduction gearbox. From this gearbox, the drive is transmitted to the driving pinion. This pinion meshes with the rack at the bottom of the table.



Open and cross belt drive

Referring to the figure , the cross belt connects the larger loose pulley. No drive is transmitted by it to be main shaft. But the open belt connects the smaller fast pulley. So the drive is transmitted to the main shaft through the open belt. The return stroke of the table takes place. At the end of the return stroke, the trip dog pushes the belt shifter. The belt shifter shifts both the belts to the right. The cross belt is shifted to the larger fast pulley. The open belt is shifted to the smaller loose pulley. So, the drive is transmitted to the main shaft through the belt on the larger fast pulley. The direction of rotation of the main shaft is reversed. Because of the larger diameter of the pulley, the main shaft rotates at a slow speed. So, the cutting stroke takes place at slow speed. No drive takes place through the open belt.

The quick return motion is obtained. At the end of the cutting stroke, the belts will be shifted to the left by another trip dog. The length and position of the stroke may be adjusted by adjusting the position of trip dogs.

19. Sketch and explain the working principle of upright drilling machine. **(AU Dec 2006,08)**

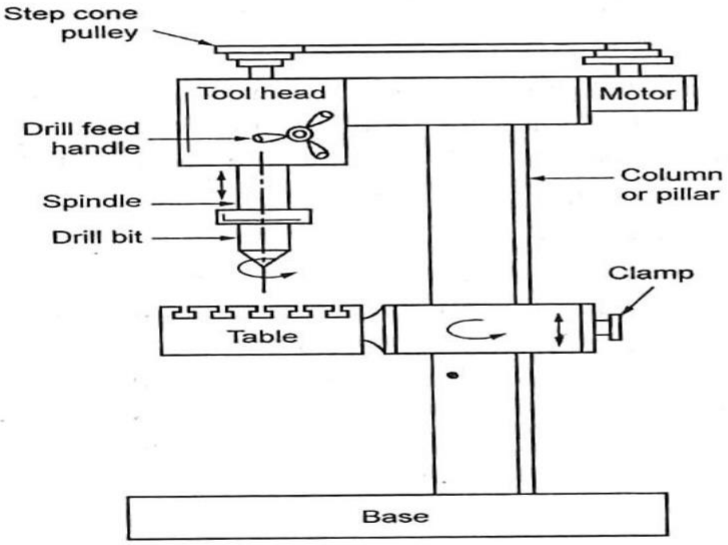
UPRIGHT OR PILLAR DRILLING MACHINE

Upright drilling machine is a higher capacity version of sensitive drilling machine. It is stationary floor mounted drilling machine. It is used for medium sized work pieces and having medium speed. The spindle head and the drive arrangement in this machine are similar to a sensitive drilling machine. But in this case, power-feeding arrangements are available. The main parts of the machine are base, column, work table and spindle head.

1. Base

It is a supporting member on which all the parts of the machine are mounted. It is generally made of cast iron.

The top surface of the base is accurately machined. The base has 'T'-slots which is used for mounting large work piece directly on it.



Up-right drilling machine

2. Column

It is a vertical member mounted on the base and carries table, spindle and pulley drive mechanism. It should be very strong to take the heavy cutting forces. It may be of round type or box type.

In a round type, the column is round in section also named as *pillar*. The table holding work piece can be rotated 360° about the column for locating work piece under the spindle. Drill upto 50*mm* diameter is possible in this type.

In a box type, the column is square in section, heavier, more strengthy and rigid than round type. It can only be raised or lowered by an elevator screw and will not rotate. Drill diameter more than 50*mm* and upto 75*mm* is possible by this type.

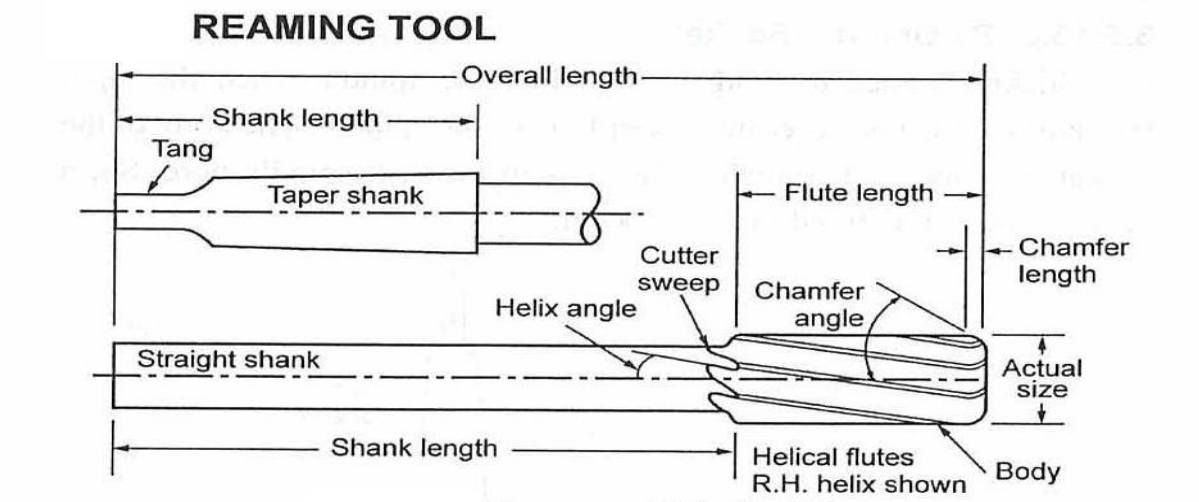
3. Table

The worktable is attached to the column by means of clamping screw. It has T-slots on the surface to hold work pieces. It can move vertically along the column and can be adjusted radially about the column. As already stated, the column may be rotated about its own axis only in round column type.

4. Spindle head and drive mechanism

The spindle head is mounted on the top of the vertical column. It is driven by a motor through belt and step cone drive. Sensitive hand feed is available. A quick traverse hand feed is also available to bring down the drill quickly to the hole location and withdrawn after drilling. The different spindle speeds are obtained by using a step cone pulley arrangement.

20. Write short notes on expanding hand reamers and adjustable machine reamers. **(AU Dec 2006)**



Reamer with helical flutes

A reamer is a multi-tooth cutter which rotates and moves linearly into an already existing hole. It is used to give smooth surface as well as close tolerance on the already drilled or bored hole.

Reamer is more like a form tool, since the cylindrical shape and size of the reamer is reproduced in the hole. At the bottom of the reamer, the flutes are made slightly tapered to facilitate its entry into the

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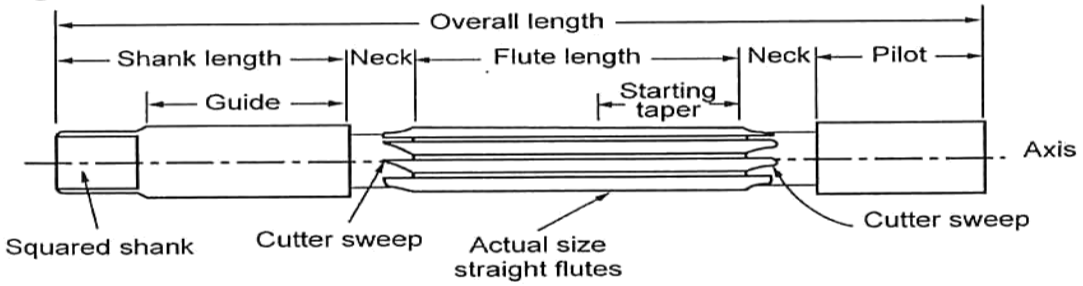
existing hole. Generally, the reamer is expected to cut from the sides not from the end. Reamer is usually manufactured with two or more peripheral grooves of flutes either parallel to the axis or as a right-angled helix as shown in fig



Reamer straight flutes

The reamer with helical flutes provides smooth shear cutting action and provides better surface finish. The pitch of the flutes is made uneven to reduce vibration. Small size reamers are made with straight shank whereas large size reamers are made with taper shank. There are different kinds of reamers for different applications. Shell reamers are used for reaming larger holes. For better dimensional control, adjustable reamers are used. Taper reamers are used for reaming holes to receive taper pins.

Since the reamer follows the already existing hole, any misalignment present in the hole is likely to break the reamer, if mounted in conventional spindle. Hence, a floating reamer is used between the machine spindle and the reamer to adjust for any small misalignment between the spindle axis and the hole axis.

Reamers are operated at lower speeds and higher feeds than drills of the corresponding diameter. Generally, speeds of reaming will be approximately 60 to 70% of that for drilling the same material.

21. Sketch and explain the main parts of a band saw. **(AU Dec 2006,Apr 08)**

Band Saw

A continuous blade having teeth runs over the rotating rim of the two wheels. The work is held between these two rotating wheels. So, the continuous cutting action can take place thereby making more productive.

1. Contour saw

It is the most versatile sawing machines in applications. The work can be fed in any direction. According to the feeding of work, the direction of cutting can be oriented to produce required shape. These

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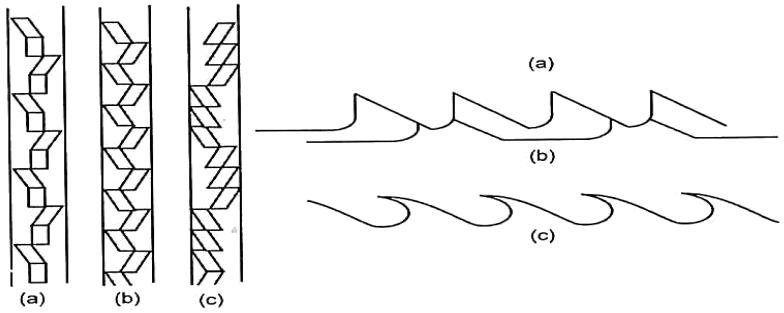
sawing machines are mainly used to make dies and other contour shapes in a work.

2. Friction band saw

The operating principle of the friction disk is same as that of friction saw. But dull blades remove small work that too softened particles. Friction between work and saw is more.

SELECTION OF BLADE FOR SAWING MACHINE

1. Generally, according to the type of work to be cut.standard carbon, high speed steel and bimetallic high speed steel are selected.



Tooth pattern and tooth form

2. Among raker, alternate and wavy tooth pattern, the required one is choosen.
3. Similarly, any one of tooth form is selected among standard, skip and hook.

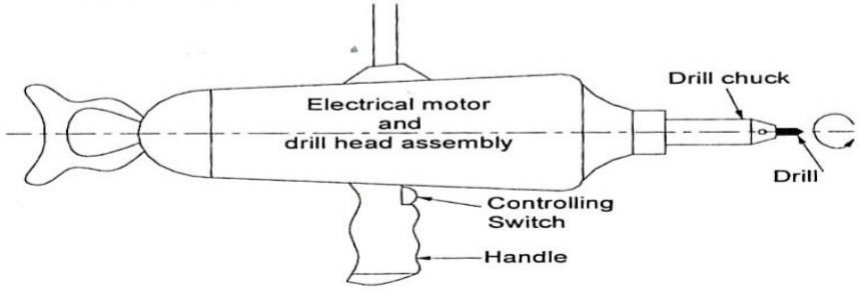
22. Explain different types of drilling machines with their special features? **(AU Apr 2010,Dec 09)**

CLASSIFICATION OF DRILLING MACHINE

The drilling machines are classified as follows:

1. Portable drilling machine.
2. Sensitive drilling machine.
   a. Bench type
   b. Floor type
3. Upright drilling machine
   a. Round column type or pillar type
   b. Box column type or square section type.
4. Radial drilling machine
   a. Plain type
   b. Semi-universal type
   c. Universal type
5. Gang drilling machine
6. Multiple spindle drilling machine
7. Automatic drilling machine
8. Deep hole drilling machine

PORTABLE DRILLING MACHINE



Portable drilling machine

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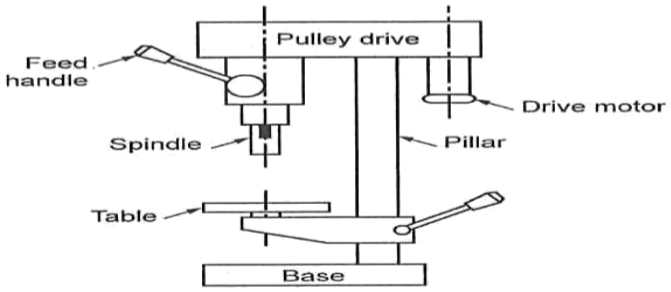
This type of machine is light in weight, compact in a smaller unit and easily handled with respect to the work piece. It is used for making small hole (up to 18*mm*) in large work piece. It is operated by hand power, pneumatic power or electric power. Fig. shows the schematic diagram of electrically operated portable *drilling machine*.

SENSITIVE DRILLING MACHINES

Sensitive drilling machines are lightweight, high-speed machines, which are generally bench type drilling machines, but pillar type machines are also available. It is used for light duty work and drill holes up to 15*mm* diameter. There is no power feeding arrangement, feeding is purely on hand control of the operator so that the operator can sense the feeding or can control the feeding. Therefore, the machine is called sensitive drilling machine.



Sensitive drilling machine

The main parts of the sensitive drilling machines are base, column, table, spindle and driving mechanism.

1. Column

The column vertically stands on its base. It is a cylindrical post. It supports the table, the spindle head, motor and the driving mechanism.

2. Table

The job on which the hole to be produced is mounted on the table. It can be moved vertically along the column and clamped in any position. It can also be adjusted radially around the column. It has T-slots for clamping work piece or work holding device.

3. Spindle and driving mechanism

It is mounted at the top of the column. It has an electrical drive motor on one-side whereas it has the spindle assembly on the other side. The motor drives the spindle through cone pulley and V-belt arrangement. The belt can be shifted to different sets of pulleys to get different spindle speeds. The spindle is fed into the work piece manually using a hand lever. The spindle has a Morse taper bore at its bottom end to hold the drill chuck. Drill chuck holds the drill bit.

UPRIGHT OR PILLAR DRILLING MACHINE

Upright drilling machine is a higher capacity version of sensitive drilling machine. It is stationary floor mounted drilling machine. It is used for medium sized work pieces and having medium speed. The spindle head and the drive arrangement in this machine are similar to a sensitive drilling machine. But in this case, power-feeding arrangements are available. The main parts of the machine are base, column, work table and spindle head.

1. Base

It is a supporting member on which all the parts of the machine are mounted. It is generally made of cast iron.

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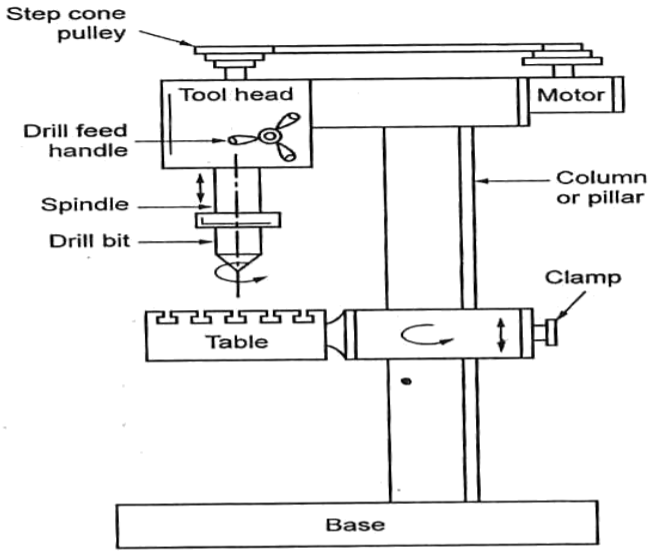
The top surface of the base is accurately machined. The base has T-slots which is used for mounting large work piece directly on it.



Up-right drilling machine

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RADIAL DRILLING MACHINE

This type of machine is mounted on floor and suitable for drilling medium to large and heavy work pieces. The most significant feature of this machine is a radial arm which can swing about a column. The arm can also be moved up and down with respect to the column which can be locked at any desired position as per job size. Fig. shows the radial drilling machine.

The main parts of the machine are base, column, radial arm, drill head, spindle speed and feed mechanism.

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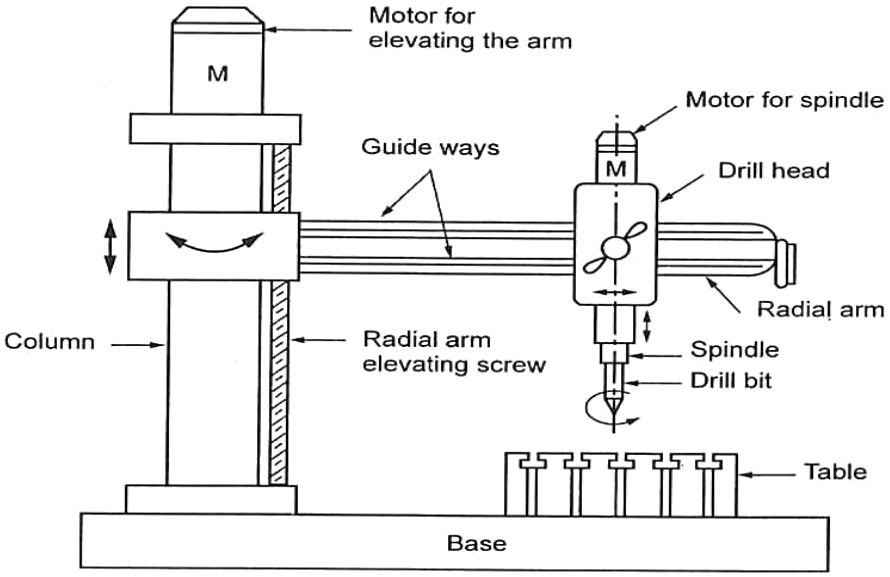

Radial drilling machine

1. Base

It is a large rectangular casting. It supports the vertical column and table. The top surface of the base is accurately machined with T-slots to mount the large size work pieces.

2. Column

Column is a cylindrical casting mounted on the base. It supports radial arm, drill head and motor. The column face should be accurately machined to slide the radial arm up and down. An elevating screw is provided on the side of the column to move the radial arm up and down. The elevating screw is rotated by the motor.

3. Radial arm

It is a heavy casting mounted on the column. The drill head is mounted on the radial arm. It has guide ways to move the drill head.

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23. List the difference between shaper and planner. **(AU Dec 2006, Apr 09)**

Planer	*Shaper*
1. Tool is stationary and work reciprocates.	Tool reciprocates and the work is stationary.
2. This machine is used for machining large and heavy work pieces.	This machine is used for machining medium and small work pieces.
3. It gives more accuracy as the tool is rigidly supported during cutting.	Less accuracy due to the over hanging of ram.
4. Production time is more since it has single tool head.	Production time is less since it has two or four tool heads.
5. Work setting requires more skill.	Work setting is easier.
6. Heavy cut can be given as it has rigid base and uses strong tools.	Heavy cut cannot be given.

UNIT - IV

→ Introduction to Resistance Welding - The various welding Processes described so far, are fusion [only heat] welding Processes like gas welding, Arc welding etc. but in Resistance welding, it consist of both "heat and Pressure" on Joint but no filler metal (or) flux is added. The heat necessary for the melting of Joint is obtained by heating effect of the electrical resistance of the Joint so that it is called as Resistance welding. The quality of the Resistance welding is depends on 3 things. i.e.

1. Magnitude of current 2. Pressure exerted by electrode
3. Surface conditions of Metal to be welded.

Principle of Resistance welding:- Here the heat is generated by "Resistance of the work Metals to the flow of electric current". it consists of low voltage (nearly 1V) [1-25V] and high current (nearly 15000A) [1000-100000A] is passed through the Joint within the short time [nearly 0.3 Sec].

The amount of ~~cur~~ heat generated can be given by

$$H = KI^2Rt$$

Where K = heat loss constant = 0.238

I = current, amperes

R = Resistance at Joint, ohms

t = time during which the current is flowing, Sec.

In the fig of Principle of Resistance welding, we can observe that the two electrodes are connected to the transformer. The high amount of heat is generated at the interface directly in line with the electrodes. At heat time melting is done until the current is off and electrode Pressure is still maintained until the molten metal solidifies to form welded Joint.

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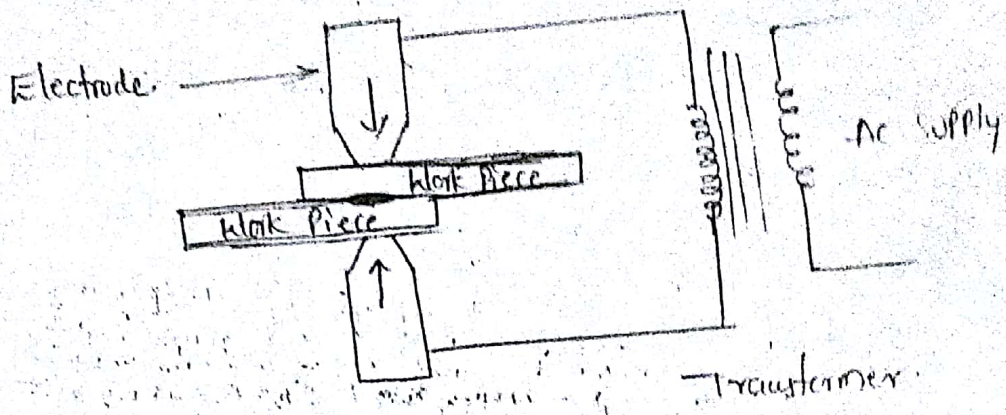
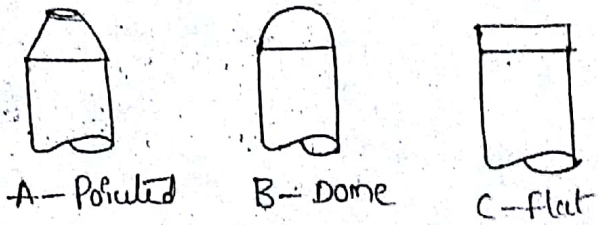


Fig: Principle of Resistance Welding.

→ Types of electrodes In Resistance Welding:-

Somany varities of electrodes are used in Resistance Welding. but the main function of any type of electrode is, to carry high mechanical force and current. Some of the electrode tipe are



→ Pointed linked design of electrodes are used for Ferrous Metals

→ Dome shaped electrodes are applicable for Non-ferrous Metals

→ Flat shaped electrodes are used for Projection Welding.

→ Advantages:- (1) No need to Require Skilled Operator.
(2) Easy to operate and Maintain.
(3) Dissimilar metals can be Welded
(4) different thickness of metal can be Welded
(5) There is no Consumables used in this Process.

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Disadvantages :- (1) Equipment cost is high ①

(2) High thickness of Metals are will not be Joined Properly. ②

(3) Large capacity M/c need more sophisticated controls.

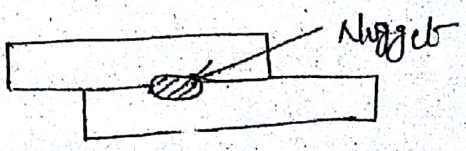
→ Applications :- These are widely used in Join thin sheets in Automobile and aircraft industries and fabrication works of chemical Plant.

→ Types of Resistance Welding Processes :-

The various Welding (Resistance Welding) Processes are

* (1) Spot Welding
* (2) Seam Welding
* (3) Projection Welding
(4) Upset butt Welding
(5) Flash butt Welding
(6) High frequency resistance Welding.

(1) Spot Welding :- This is one of the simplest type of Resistance Welding. Spot Welding is widely applicable for Join two sheet metal in lap Joint forming a small nugget at the interface of 2 Plates. In the fig we can observe that it consists of 2 electrodes one is movable and other is fixed, which are connected to the electric Power supply [Transformer]. In between the electrodes the work Pieces are Placed. here we are using a low voltage with high current.



Working :- When we start the working of Spot Welding firstly we can on the Power supply so that the electricity is passes through through the electrode which are made with copper Material

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after that our required sheet metals which are to be arranged are placed in between 2 electrodes, at that time we can press the foot switch which is linked with "Rocker Arm". [To provide mechanical advantage i.e gives pressure] so that the work pieces are ligluted in between 2 electrodes at that particular time " the electric current supply helps to release heat from electrode it just sufficient to melt the joint interface and finally the nugget [joint] is formed under pressure." these entire process is done within a short span of time i.e [0.06 to 3 sec] after completion of process we can release the work pieces from machine.

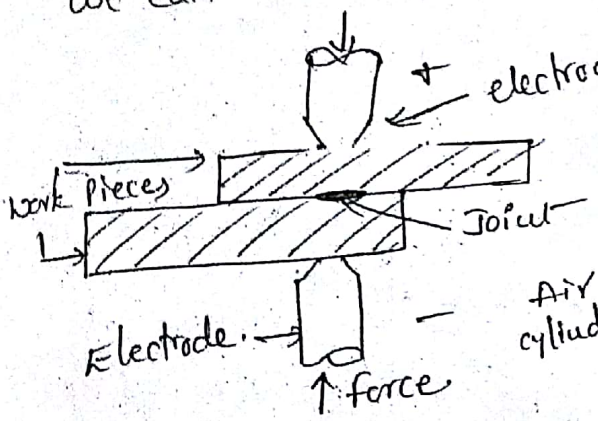

fig: Principle

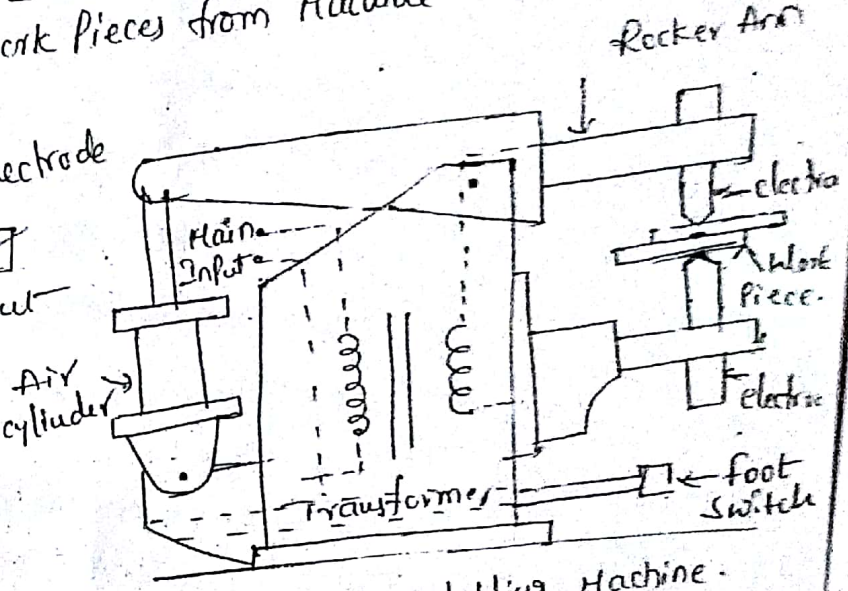

fig: Spot Welding Machine.

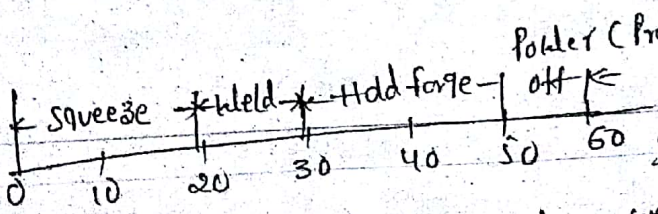

fig: Simple electric resistance welding schedule.

→ Advantages:- (1) Simplest Method, suitable for any type of Metal
(2) Easily handled and maintained
(3) high Production rate is obtained within short time

→ Limitations:- (1) It is suitable for only Lap Joints
(2) Limited size of metals is required i.e not ... sticker metals

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(20)

Applications :- It is widely used in Automobile body works, Refrigerator shells, chemical plant works, boilers, containers and tubes production, aircraft industry etc.

2 Resistance seam Welding :-

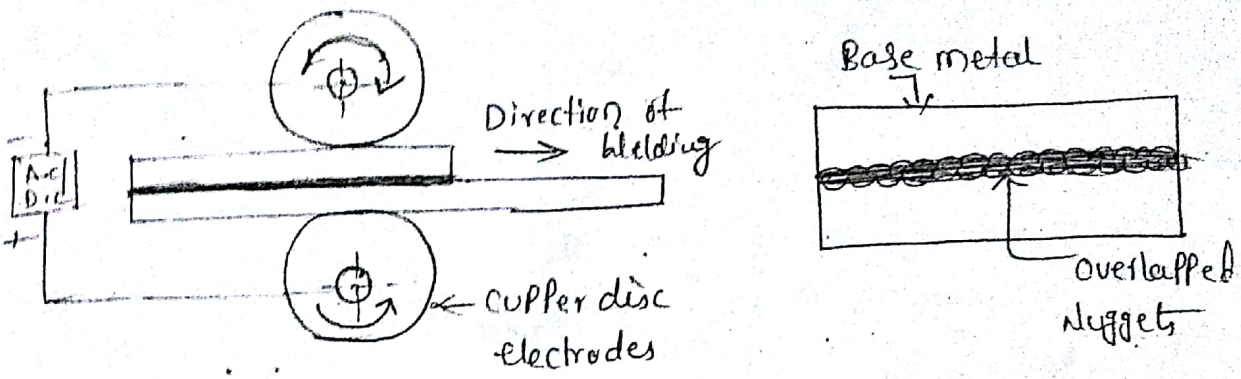

fig:- Seam Welding

Resistance Seam Welding is the advanced process of Spot Welding. In spot Welding only a single spots are form with help of electrodes, but in Seam welding continous spots of joints are occured with helps of cylindrical (or) disc electrodes.

In the above fig we can observed that the Sheets are allowed to pass b/w 2 wheel shaped electrodes. actually these electrodes are run by motor and the work is moved between them and high current is supplied. So that heat will be comes from electrodes which helps to make the metal plastic and pressure from electrodes completes the weld to produce better joints.

→ Advantages
1. Leak Proof joints are Produced
2. High Production rate occurs within less time

→ Disadvantages
1. Low hardenability rating present
2. Limited thickness metals are used [2mm–5mm]

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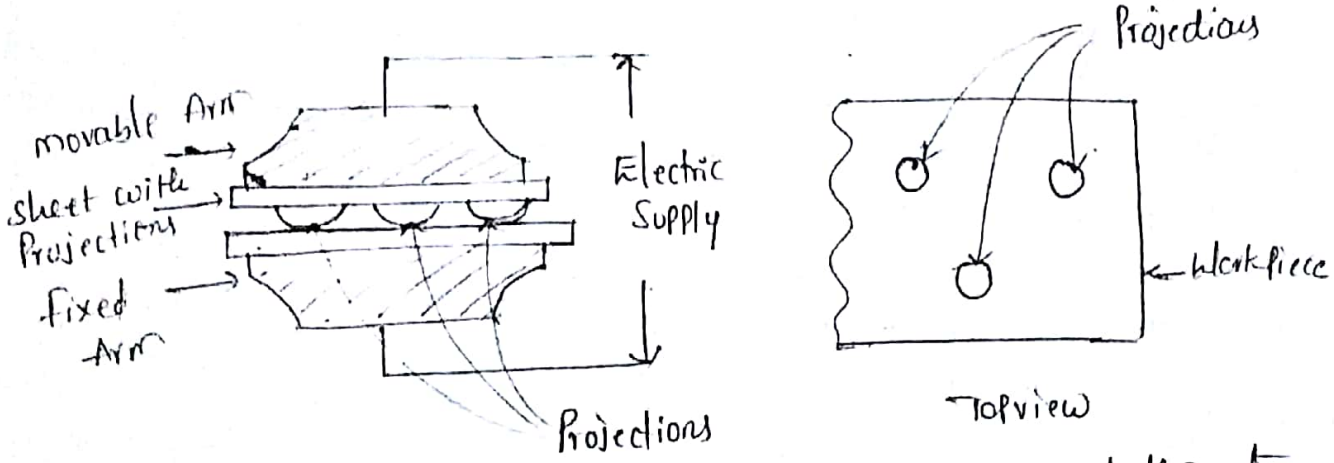
Applications :- This is widely applicable for continuous tanks, (4) automobile fuel tanks, milk storage tanks and barrels etc.

(3) Resistance Projection Welding :-



In previous welding processes, the current concentration at the interface is achieved by electrodes. but in Projection welding, the weld is occur by Projections raised on the surface of one of sheets. when we start the operation the overlaped pieces are placed inbetween Arms, the 2 sheets joint only at the point of projections. It is more applicable compared to the other Resistance processes.

→ Applications :- (1) It is possible to weld more than one spot at a given time.

(2) This is applicable in Car bodies, domestic equipments and also Office furniture works.

(3) This is suitable for Galvanic iron, Carbon steels and stainless steel Materials.

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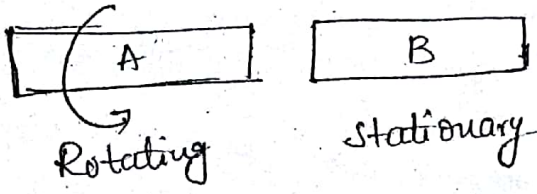
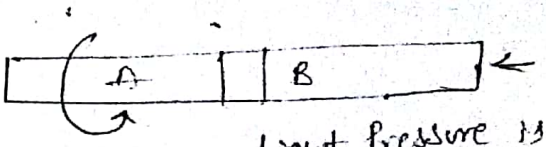
Solid-State Welding

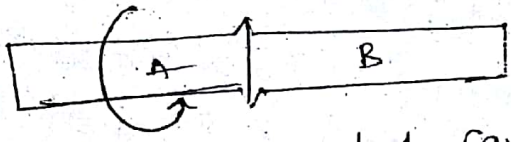
In Solid-State Welding the Joint is formed between the two solid surfaces with help of Pressure and heat [~~below~~ above or below Crystallization temperature and below melting point].

(1) Friction Welding:- This welding is done with help of heat which is created by friction [Rubbing].





Light Pressure is applied to make Contact



Pressure is increased to cause friction & heat generated on the faces of Pieces

Heavy Pressure is applied and stops the rotation so that Joint is formed.

In the above fig we can observe the working of friction Welding. Initially the 2 Pieces are aligned, In the 2 Pieces one is stationary and other is movable part after that the movable part is continously rotated [3000 rev/m] so that the rubbing heat is created at the faces of 2 Piece [750-1300c] at that time the faces become Plastic. finally stop the rotation of Piece and upsetting force is applied immediately to cause deformation and to form a Joint.

(2) Friction stir Welding:- Here, the Joint is made with help of 'Rotating tool', which is moved to contact the Surface between 2 Parts. When we start the working, this Tool is rotated and helps to creates frictional fore [Rubbing] on Surface of base, ... heat is generated which helps to attain

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...ding heat. During transverse motion along weld line joint is formed by thrust force.

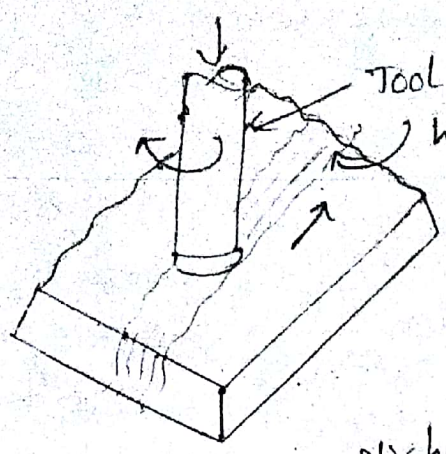
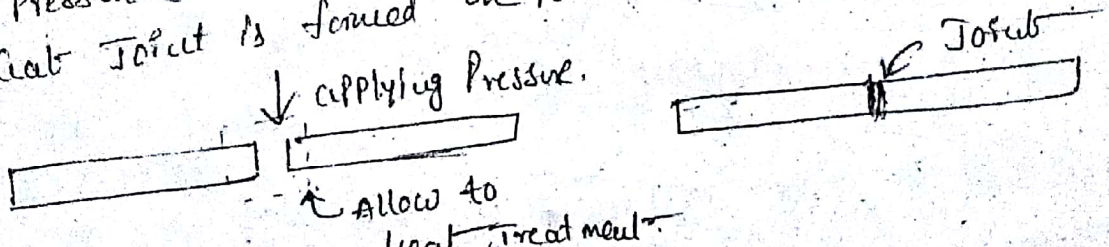


fig: friction stir welding.

③ Forge welding:— This is one of the oldest joining process. In this process, the ends of pieces to be joined by heating and Pressure applied. Firstly the end part of work pieces are allowed to heat treatment which is having above recrystallization temp and below melting point. after complition of heat treatment, the Pressure (or) hammer blow is applied on particular joint. so that joint is formed on particular part.



④ Explosive welding:—

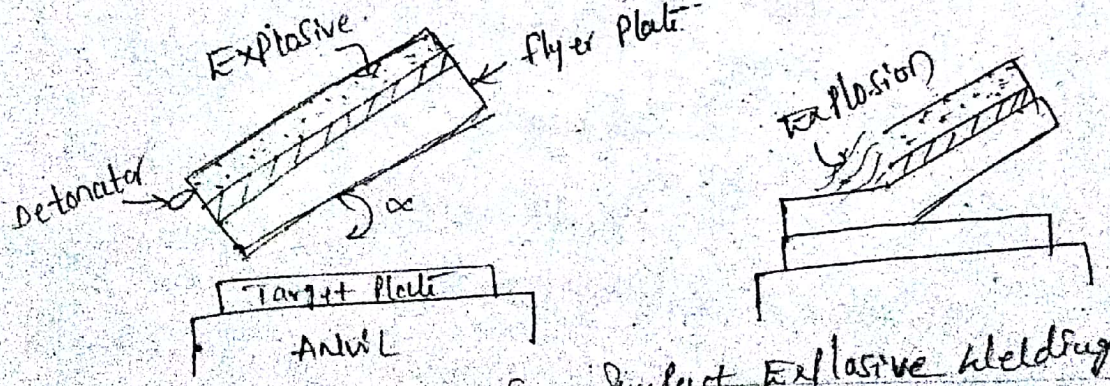


fig: Inclined Explosive welding

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In this welding, we are using detonation of Explosives is used to accelerate a part to move towards the other part at faster rate so that the impact creates the joint as shown in fig. It consist of 2 plate one is Target plate and flyer plate. The explosive is placed on the flyer plate and also detonater is attached to explosive. when we start the operation, a small spark is given to the detonator, at that time the explosive is completed fired, so that the heat is generated - with help of this heat the joint is formed. for higher thicker metal cladding rods are also used for better joint.

Note:- usage of explosive is dangerous.. so that we must take permission from concerned government.

Special Welding Processes

(1) Thermit Welding:-

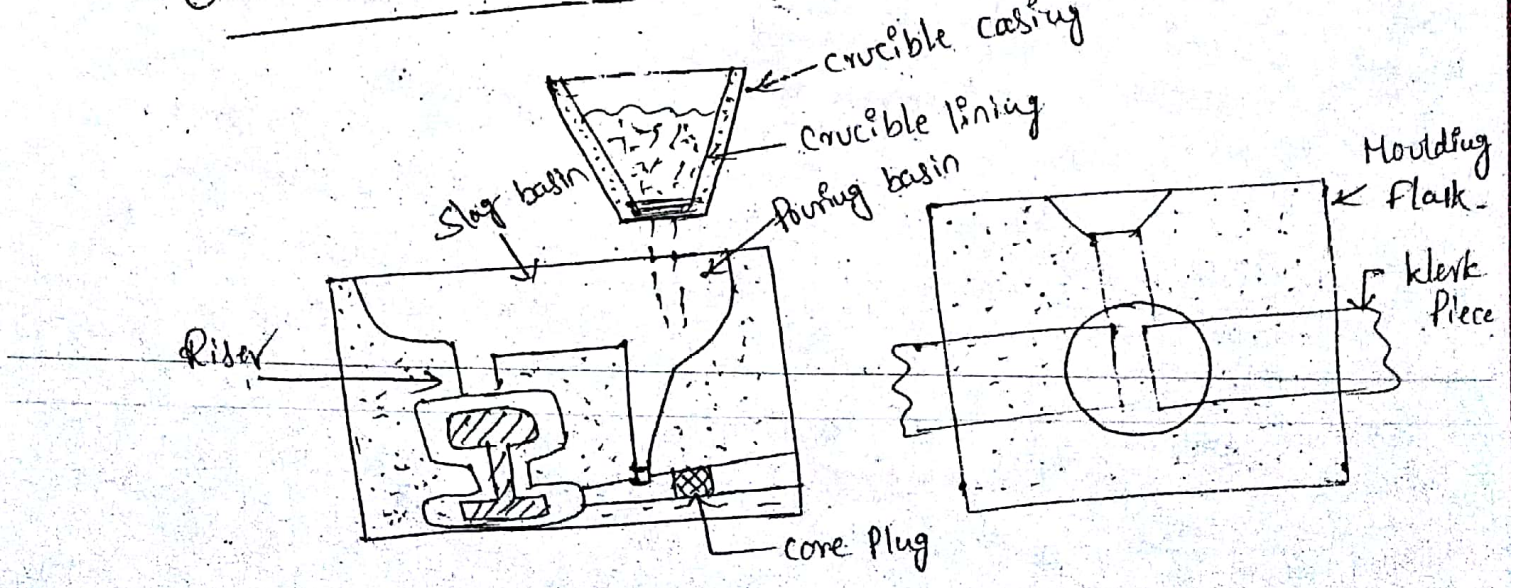

fig: Thermit Welding

In thermit welding, the heat generated for welding is done by "exothermic reaction" - so that it is called as thermit thermit welding.

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Typical reaction in Thermit Welding is

$$3Fe_3O_4 + 8Al \longrightarrow 9Fe + 4Al_2O_3 + Heat \quad [3000^{\circ}C]$$

If a mixture of Iron oxide and Aluminium Powder is ignited, then the two materials would react exothermically. Once it starts, the reaction is rapid and continous until all O_2 from iron oxide is absorbed by aluminium. Thermit Welding is non-explosive and completed in 1min irrespective of quantity. The molten metal obtained by thermit reaction is poured into mould cavity through Pouring basin. The 2 Pieces to be Joined are properly cleaned and the edge is Prepared. The molten metal (wax) is poured into the Joint so that a pattern is formed where the weld is to be obtained. If any excess metal placed in cavity, that can be entered into the riser.

→ Advantages:-
1. It is fast and Provides strong Joint
2. The process is considered safe due to thermit reaction is non-explosive.

→ Disadvantages:-
1. Process is complex due to Preparation of mould
2. Not economical for thin Sections.

→ Applications: It is widely used for Joining thick Sections and repairing of large castings and steel structures. It is especially used for rails (Railway tracks) and crankshafts etc....

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(2) Electron Beam Welding :- [EBW]

This is one of the most special form of fusion welding which is commercially feasible. This welding consists of beam of electrons which are highly accelerated. The kinetic energy of electrons is converted into heat energy when electrons are bombared (strikes) the work piece.

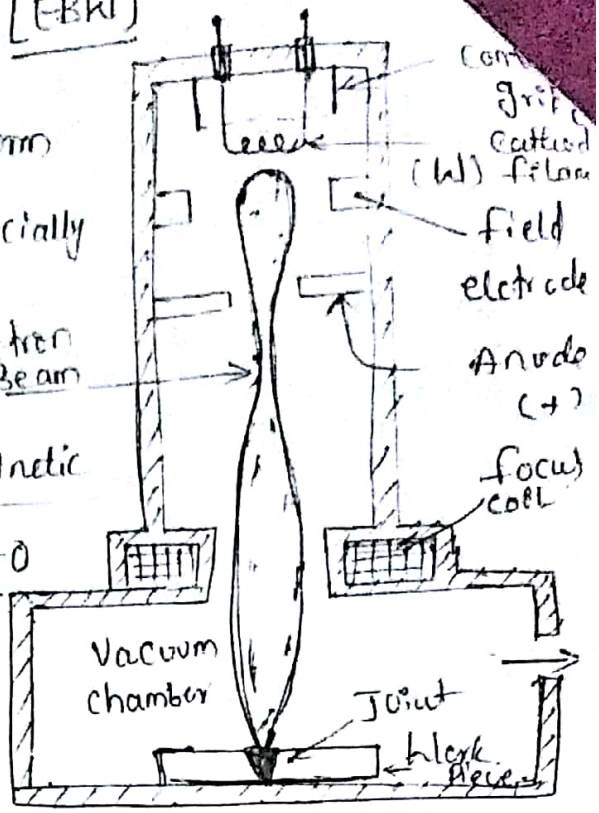

fig electron Beam Welding

In the fig. we can observe the working of EBW. here the electrons are emitted by hot cathode (-) moves towards the anode (+) into vacuum chamber. the diaphrams and focus coils are helps to focus the electron beam into the work piece. so that when the electron beam strikes work piece heat energy will be generates, with help of this heat energy welding is done.

→ Advantages:- ① No flux or shielding gas is required.
② high accurate of Joints are Produced.
③ less shrinkage & distortion Result.

→ Disadvantages:- ① obstrucle Joints cant be welded
② Joints with curvatures not be welded.

→ Applications:- This is widely used for fabrication of structures, high pressure vessels, Parts of IC engine and parts of turbines, aerospace, nuclear, automotive and instrumentation Industries.

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Laser Beam Welding:-

LASER Means light amplification by Stimulated emission of radiation.

Here the welding is done with help of highly of monochromatic beam of light [laser beam]. In the fig we can observe that a Solid State laser (Ruby laser) employs ruby crystal which consists of ruby rod with its ends Polished and then Silvered to obtain fully reflected surface at one end and Partially reflected other end which Provides laser beam. When the crystal is fired with intense light from xenon tube [flash tube), the electrons in the ruby get Stimulated and reach a high energy level. when these electrons return to their normal energy level, they release energy of a Constant wave length. the energy is focussed by lens on the work Piece by welding. after some time this kinetic energy of electrons will be converted into the heat energy. with help of this heat energy the welding will be done.

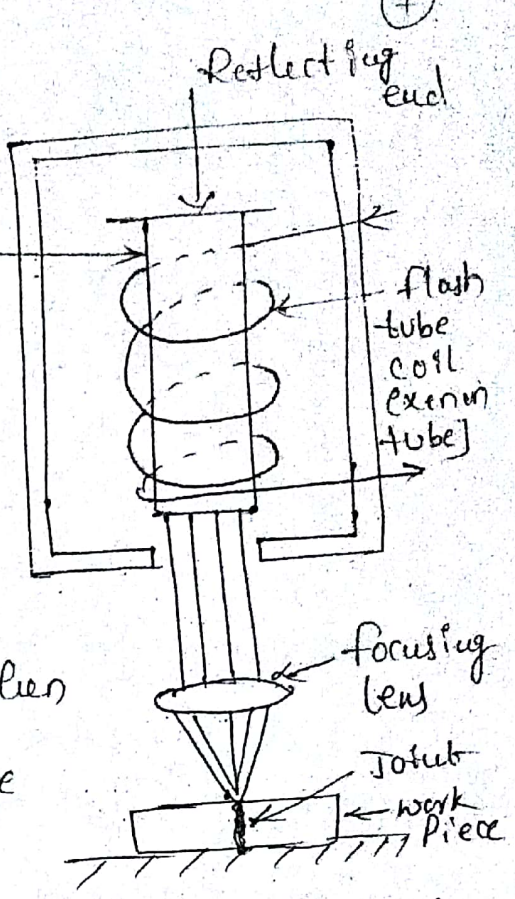

fig: Laser Beam Welding.

Advantages:-

1. No vacuum chamber is required as in case of electron beam welding
2. Laser beam welding Produce high quality of welds.

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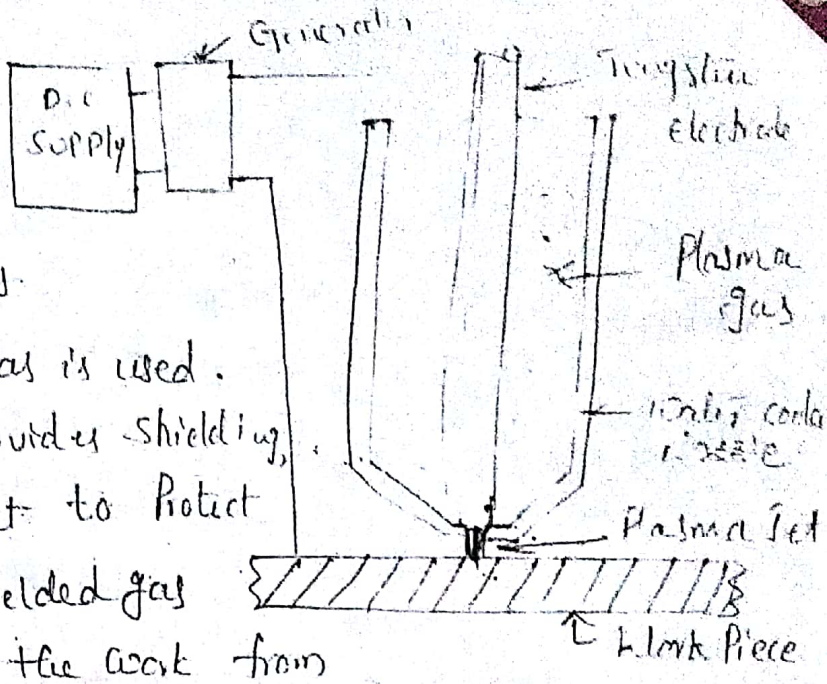
(4) Plasma Arc Welding – (or) Plasma Welding – [PAW]



When an Inert gas is subjected with electricity, it Produce some form of ionised gas i.e Plasma gas.

In this Welding Plasma gas is used. The Plasma gas itself Provides shielding, but it may not be Sufficient to Protect the weld metal. The shielded gas is often used to Protect the work from oxidation. The filled metal if required is used as in TIG Welding.

In the above fig we can notice the working of PAW. Initially the Inert gas is filled into the nozzle / Torch. The Power Supply System consists of 2 Cables one is connected to work table and other is connected to the electrode. When we start the working, automatically the current is passes through the electrode at that time the inert gas mixes with electricity, so that Plasma gas is releases. with help of Plasma gas the arc is created on workPiece, and heat is created by arc. when the torch moves away from the Joint the metal cools and solidifies.

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Soldering and Brazing

Soldering and brazing is also called as Solid-Liquid Welding because the base metal is not melted, but the joint is obtained by filler metal heat is added in liquid state. In these two processes the filler metal is distributed in between the 2 workpieces by capillary action".

Soldering:- It is a process of joining metals [similar / dissimilar] by filler metal whose liquidus temperature is below 450°C. The filler metal used in soldering is an alloy of lead (Pb) and tin (Sn).

Process:- Before we perform soldering operation, the workpiece is completely cleaned with help of flures (or) emery paper. after that we can arrange the soldering torch and solder [filler material] on our required portion of workpiece. The soldering iron is connected to power supply. So that when we start the work, the heat is coming out from torch with help of electricity at that time the solder is touches the torch so that the solder is melted with help of heat and this melted solder is placed on required place of workpiece. Soldering is widely used in "electrical works" like circuit board.

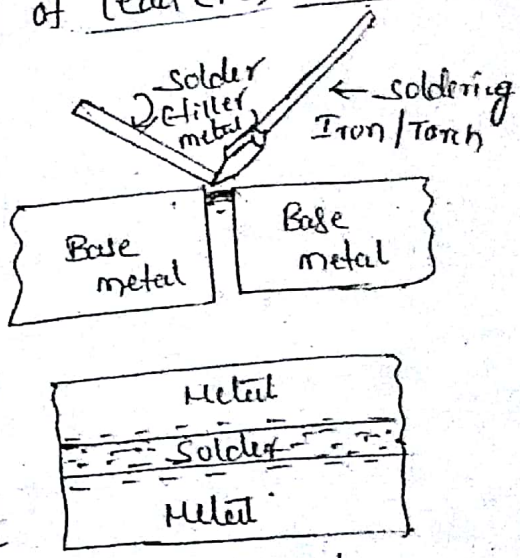

Fig: Principle

Advantages:-
1. Simple and faster operation.
2. Strong enough for sheet metal works & electrical components.

Disadvantages:-
1. Joints are weak and cannot withstand high temperature.

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Brazing :- The Process of joining similar (or) dissimilar m
with help of filler metal, whose liquidus temperature is above 450
The material of filler metal is Non-ferrous alloys, [Copper zinc
alloy]. The working of brazing is similar to the soldering.

In the fig, the speller (filler rod) and also Torch is arranged on the work piece. When the flame is coming out from the Torch, the speller is melts and this melted speller is settle on the required zone on workpiece.

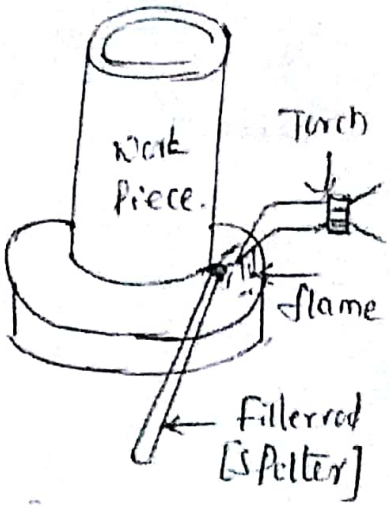

Fig Torch brazing.

→ Types of Brazing :-

1. Torch brazing
2. Furnace brazing
3. Induction brazing
4. Resistance brazing
5. Dip / Immersion brazing

① Torch brazing :- In Torch brazing, the work-piece is brazed by heat which is come from oxy-acetylene flame. The above fig indicates to show the working of Torch brazing

② Furnace brazing :- The parts are brazed are located to temperature under controlled atmosphere in a furnace which is run by electricity (or) gas (or) oil.

③ Induction Brazing :- The parts are brazed is located in a Induction coil, carrying high frequency alternating current.

④ Resistance Brazing :- The Joint of work piece is obtained by resistance of interface. A high electrical current at low voltage is passed.

⑤ Immersion brazing :- The parts to be brazed are located by dipping the assembly into a bath of molten filler metal.

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Difference between Soldering and brazing:-

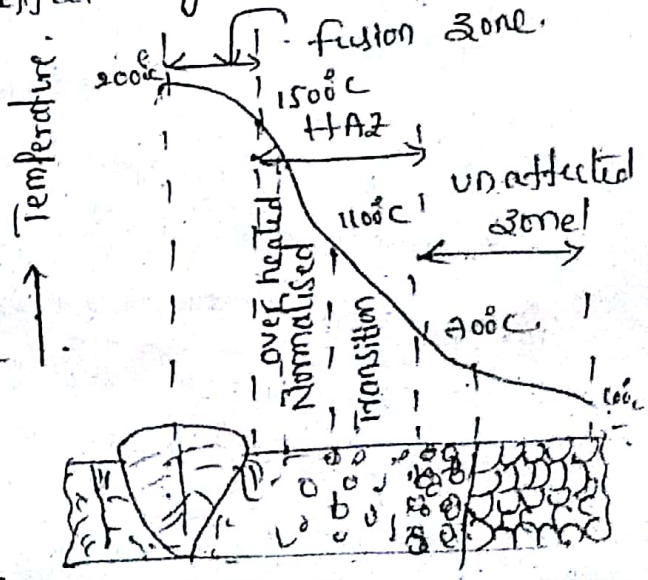
Soldering	brazing
(1) The liquidus Temperature used in soldering is below 450°c.	(1) The liquidus Temperature used in brazing is above 450°c.
(2) The filler metal is called as Solder	(2) The filler metal is called as Spelter
(3) The material of solder is alloy of lead and tin [Pb+Sn]	(3) The Material of Spelter is Copper – Zinc (brass) alloy.
(4) soldering gives less strength Joint than brazing.	(4) brazing gives strength Joint than soldering.

→ **Heat Affected Zone [HAZ]**:- The Portion of base metal that is not melted, but metallurgically affected by heat is called heat affected zone. In the fig we can observe 3 zones ① fusion ② HAZ ③ un affected zone.

→ The region where the base metal melts is called fusion zone.

→ The Portion of ~~base metal~~ adjacent to fusion zone is called HAZ

→ The Portion which is unaffected by heat is called un affected zone.



→ **Pre-heating**:- The heat treatment applied on workpiece before welding is called as Pre-heating. The moisture content of workpiece is reduced by Pre-heating.

→ **Post-heating**:- The heat treatment applied on workpiece after welding is called Post-heating. The residual stress is reduced by Post-heating.

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→ Weldability of metals:-

Weldability means the ability of material which is Welda Welding is suitable for both metals and Alloys.

(a) Welding of Plain Carbon steel:- Steel is a ferrous metal which consists of nearly 2% of carbon (or) [>2%] and less amount of Si, Mg, S, P. Carbon has a strong influence on quality of weld. Welds of highest quality can be made in low carbon steels with Proper selection of Welding conditions and by Providing Proper shield against oxidation.

Plain-Carbon steels are divided into 3 types

① Low-Carbon Steels (<0.3%) ② Medium-Carbon steel [C = 0.3-0.55%]

③ High-Carbon steel [C = 0.55 - 1.45%]

(b) Welding of Cast Iron:- It is a ferrous alloy which consists of more than 2% of carbon. Welding of C.I may be carried with either an electric arc or gas flame. For oxyacetylene welding of cast Iron, a Preheat of work around 650°C will be required. The weld should be made with neutral or slightly carburising flame.

(c) Welding of Aluminium, Copper brass:-

• Al and its alloys can be welded by arc and gas flame Welding Processes. Al has a low M.P (659°C), but its oxide has higher M.P (1938°C). it has high thermal conductivity, and further it doesnot give any indication of change in temperature.

• Cu and its alloys can be successfully welded by fusion Welding. because of high thermal conductivity. it is necessary to Pre heat (500-600°C) the base metal to ensure correct amount of fusion

• Brass is alloy of Cu & Zn. Melting point of Zn is 419°C. Oxy-acetelyne welding is suitable for brass. but the Problem is vaporisation is occurs.

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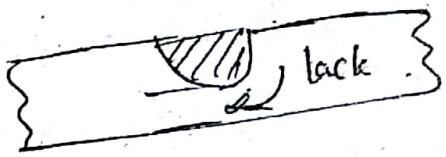
Welding Defects and Remedies

Most of the times the defects are rises due to impurities present on workpiece, Power supply system problems, improper position of torch and filler metals. Some of the welding defects are

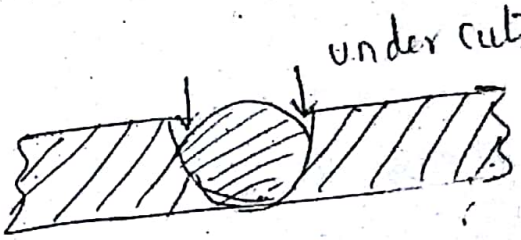
1. Lack of Penetration
2. undercut
3. Slag Inclusion
4. Porosity
5. Spatter
6. Weld crack
7. Poor fusion
8. Warping & distortion.

(1) Lack of Penetration:- This problem is raised by too long arc length, welding speed is too rapid and insufficient welding current.



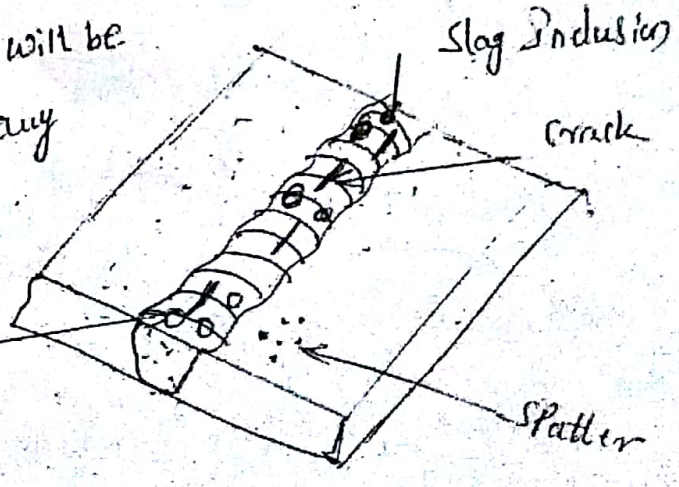
Remedy:- We should maintain the proper power supply and correct speed of welding.

(2) Undercut:- undercuts are formed due to Excessive current, wrong electrode position.



Remedy:- Reduce welding current (or) arc length.

(3) Slag Inclusion:- This problem will be raises due to entrapment of slag (or) any foreign material inside the weld metal.



Remedy:- Properly cleaned the base metal with flux before welding.

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④ Porosity:- Porosity will be raises due to entrapment of gas in weld metal. and the flux coating of electrode or on the surface of the metal and wrong type of electrode.

Remedy:- Use Proper electrode, dry electrode and clean metal. for gas welding keep nozzle above weld metal.

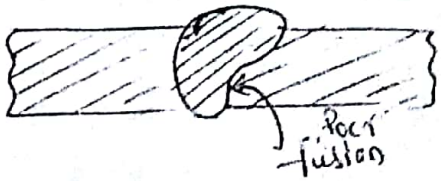
⑤ Spatter:- Globules of metal expelled from an electrode and deposited on the work piece. it is caused by improper heat output of welding.

Remedy:- To maintain exact welding position and heat o/p.

⑥ Weld crack:- crack is nothing but Discontinuity of weld zone. it is caused by contraction and expansion of stress in welding process.

Remedy:- using filler metal which match the base metal composition

⑦ Poor fusion:- It raises due to lack of complete mixing the filler metal and base metal.



Remedy:- Use Proper welding conditions and improved welding techniques.

⑧ Warping & distortion:- caused by imbalance in the stress set up during expansion and contraction of weld metal.

Remedy:- use proper welding fixtures; avoid long runs.

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Testing and Inspection of Welds

If any defects are raised in the welding, the effectiveness and efficiency of weld joint is reduced. so that we can improve the efficiency of joint, those are checked by destructive and Non-destructive Tests.

① Destructive Tests:- ① Tensile Test
② Bend Test
③ Hardness Test
④ Impact Test

② Non Destructive Tests:- ① Visual Inspection
② Radiography test
③ Ultrasonic Test
④ Magnetic Test
⑤ Liquid-Penetrant Test

① Visual Inspection:- This Inspection helps to Inspect the defects such as undercuts, surface blow holes, cracks. visual Inspection means the defects on workpiece was observed by with our eyes.

② Radiography Test:- It is based on different absorption of Radiation [x-rays (or) γ-rays] passing through the work. If any defects are present on work piece, that are observed by Radiation. Actually blow holes are easily observed by Radiography Test

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(3) Ultrasonic Test :- This method is used to locate minute internal flaws in the large weldments. In this test the ultrasonic waves are passed through the work. The waves reflected back from the defect and the opposite face produce the electrical impulse which are fed into a cathode ray oscilloscope to study the defect.

(4) Magnetic Test :- This test reveals the surface defects due to dispersion of magnetic flux at the defect. This causes the attraction of magnetic powder at the edge of crack.

(5) Liquid - Penetrant Test :- This test is used to reveal fine cracks. The part is cleaned by flux after that it is wiped dry and it is kept in a metallic powder. The powder adheres at the places where liquid appears i.e. over the crack.

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