GOVERNMENT POLYTECHNIC, PANCHKULA

BRANCH: MECHANICAL ENGINEERING

SUBJECT: WORKSHOP TECHNOLOGY - III

SEMESTER: 5th

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3.2 Various elements of grinding wheel – Abrasive, Grade, structure, Bond
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CHAPTER 1

MILLING

INDTRODUCTION

Milling is the cutting operation that removes metal by feeding the work against a rotating, cutter having single or multiple cutting edges. Flat or curved surfaces of many shapes can be machined by milling with good finish and accuracy. A milling machine may also be used for drilling, slotting, making a circular profile and gear cutting by having suitable attachments.

WORKING PRINCIPLE AND SPECIFICATION OF MILLING MACHINE

WORKING PRINCIPLE

The work piece is holding on the worktable of the machine. The table movement controls the feed of work piece against the rotating cutter. The cutter is mounted on a spindle or arbor and revolves at high speed. Except for rotation the cutter has no other motion. As the work piece advances, the cutter teeth remove the metal from the surface of work piece and the desired shape is produced.

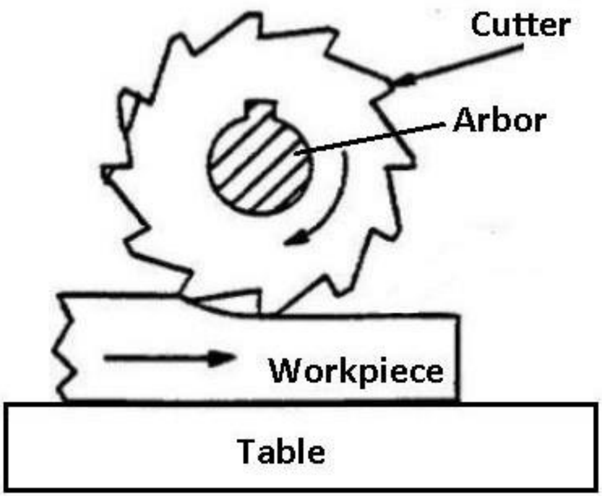


Fig.1.1 Principle of a milling machine

SPECIFICATION

The size of the milling machine is generally specified by the dimensions of work table in mm i.e. length of table X Width of table. The other main specifications which needs due consideration is:

- longitudinal feed
- cross feed
- Vertical feed
- Spindle speed
- Type of drive
- Power of driving motor etc.

CLASSIFICATION, BRIEF DESCRIPTION AND APPLICATIONS OF MILLING MACHINES

CLASSIFICATION AND DESCRIPTION

The milling machine may be classified in a variety of ways as follow:

According to the design, the distinctive classification is as follows:

A. According to drive:

(a) Cone-Pulley belt drive: The cone pulley at the bottom is connected to the electric motor by a V-belt. So the cone pulley at the bottom rotates at a particular speed. The belt is arranged on any of the four steps to obtain different spindle speeds. The spindle speed is increased if the belt is placed on the smaller step of the driven pulley.

(b) Individual motor drive: Milling machines commonly have self-contained electric drive motors, coolant systems, digital readouts, variable spindle speeds, and power-operated table feeds.

B. According to design:

1. Column and Knee Milling Machines:

(a) Horizontal milling machine: Horizontal milling machines feature a similar design in which a spindle containing a rotating cutting tool presses against a work piece to remove material from the work piece as shown in fig.1.2.

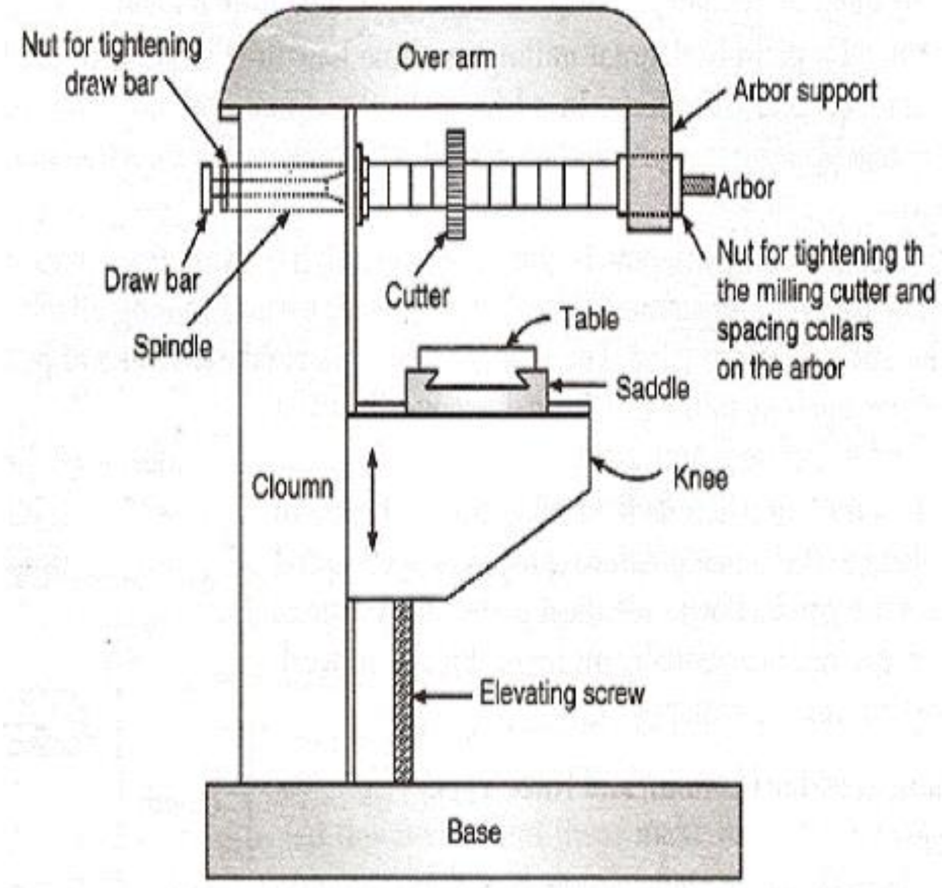


Fig. 1.2 Horizontal Milling Machine

The knee can be moved up and down by elevating screw. Saddle mounted on knee can be moved towards or away from column. Milling table is mounted on the top of saddle to hold the job. This machine is suitable for general milling work such as surface finishing, gear cutting etc.

(b) Vertical milling machine:

Vertical Machining relies on rotary cutters to remove metal from a workpiece. Vertical machining occurs on a vertical machining center (VMC), which employs a spindle with a vertical orientation. With a vertically oriented spindle, tools stick straight down from the tool holder, and often cut across the top of a work piece as shown in fig. 1.3.

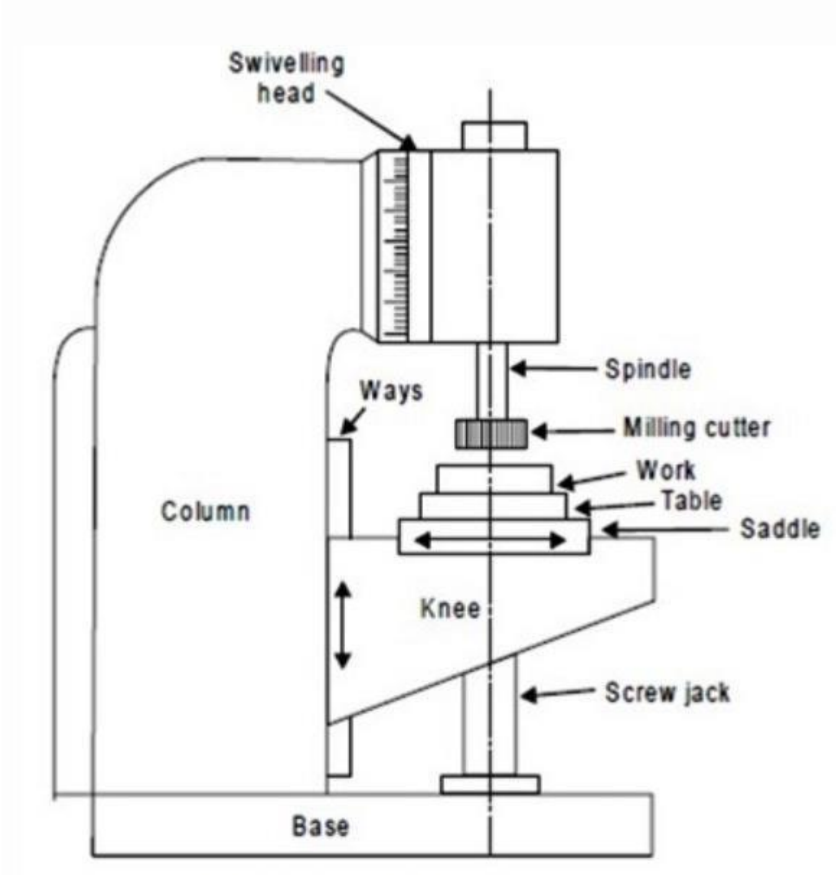


Fig. 1.3 Vertical Milling Machine

The milling head can be swiveled at any oblique position. This machine is usually used for end milling work with end mill cutters.

(c) Universal milling machine: The universal milling machine is similar in appearance in horizontal milling machine. The worktable of this machine is provided with extra swivel movement with a dividing head located at the end of the table. This permits the table to swing up to 45° in either direction for angular and helical milling operations as shown in fig. 1.4.

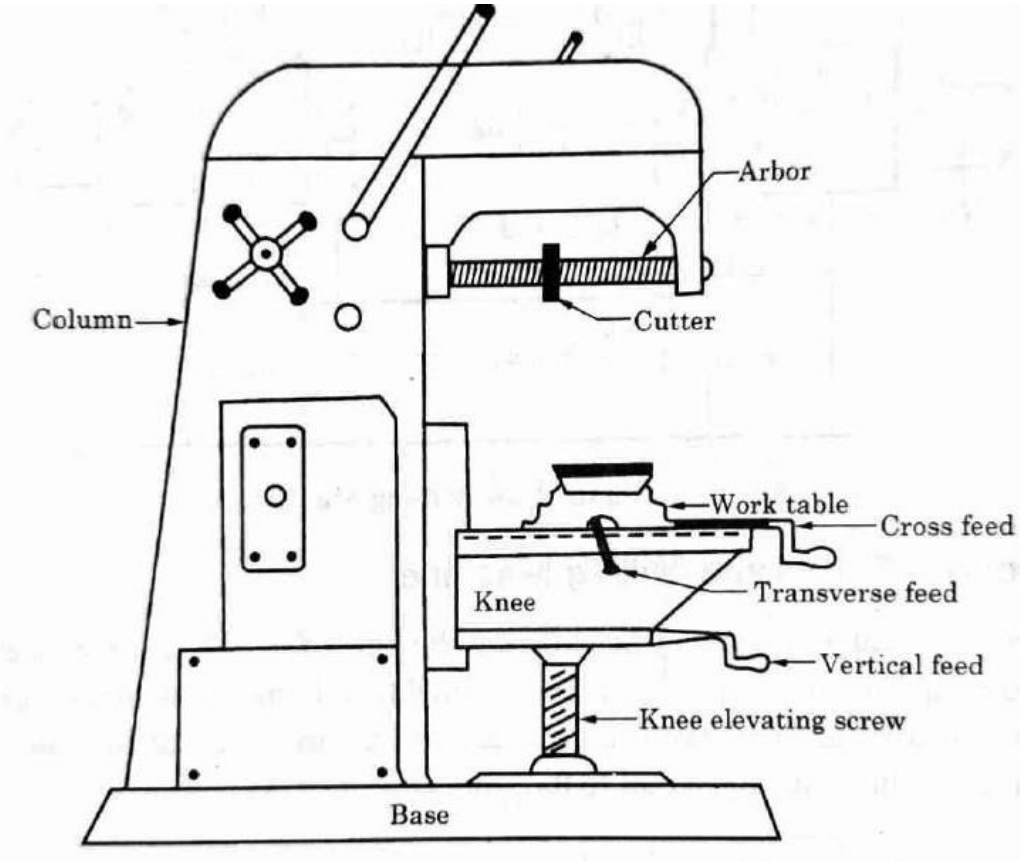


Fig. 1.4 Universal Milling Machine

The universal machine can be fitted with various attachments such as the indexing fixture, rotary table, slotting and rack cutting attachments, and various special fixtures.

(d) Omniversal milling machine: This is the modified form of a horizontal milling machine. It consists of two spindles, one of which is in the horizontal plane while the other is carried by a universal swiveling head. The latter can be set in a vertical position and swiveled up to 45° on both sides.

2. Planer type Milling Machine: The planner milling machine is mostly used for facing operations in mass production. These machines are similar to the bed type mill machine, except it can be mounted with various cutters and spindle heads to the machine. These cutters in the machines can perform the facing operations simultaneously which is a great function.

3. Bed-Type Milling Machine: In this type of machines, the work table is mounted on a fixed bed and it has a longitudinal travel only. It cannot move up, down or crosswise. The adjustable spindle or spindle head attached to a vertical column can move along vertical ways on the column to adjust tool to the work.

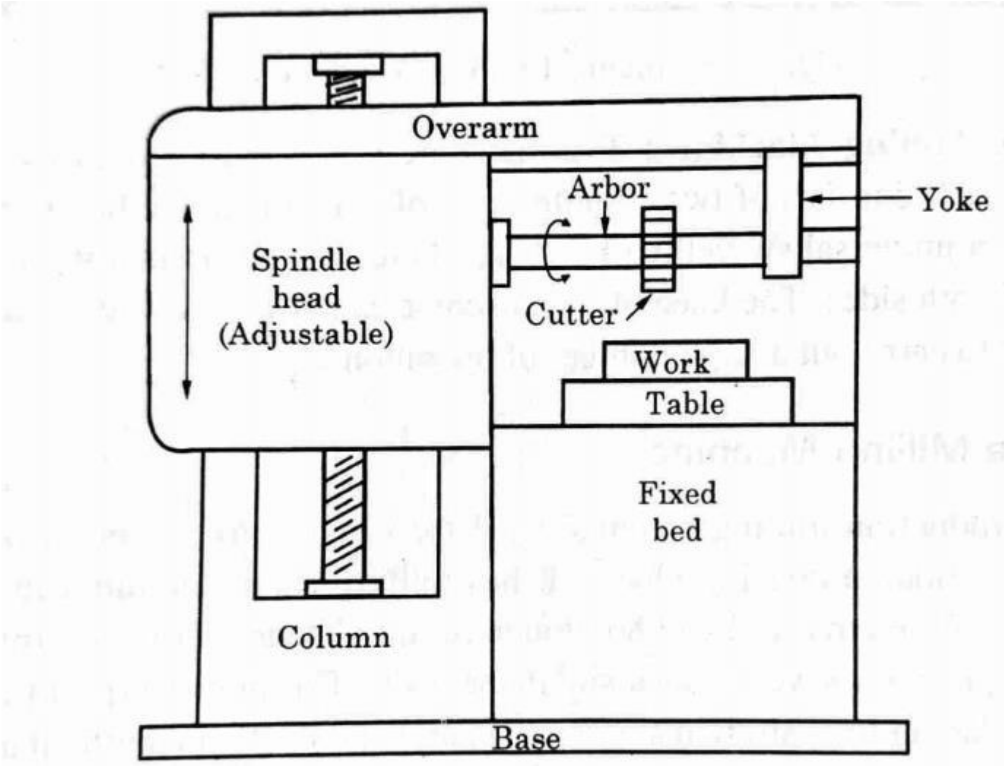


Fig. 1.5 Bed Type Milling Machine

(a) Simplex milling machine: It is a smaller version of planer type milling machine having single adjustable horizontal spindle head.

(b) Duplex milling machine: It is also a smaller version of planer type milling machine having two adjustable horizontal spindle heads each attached to a separate vertical column one each side to the fixed bed as shown in fig.

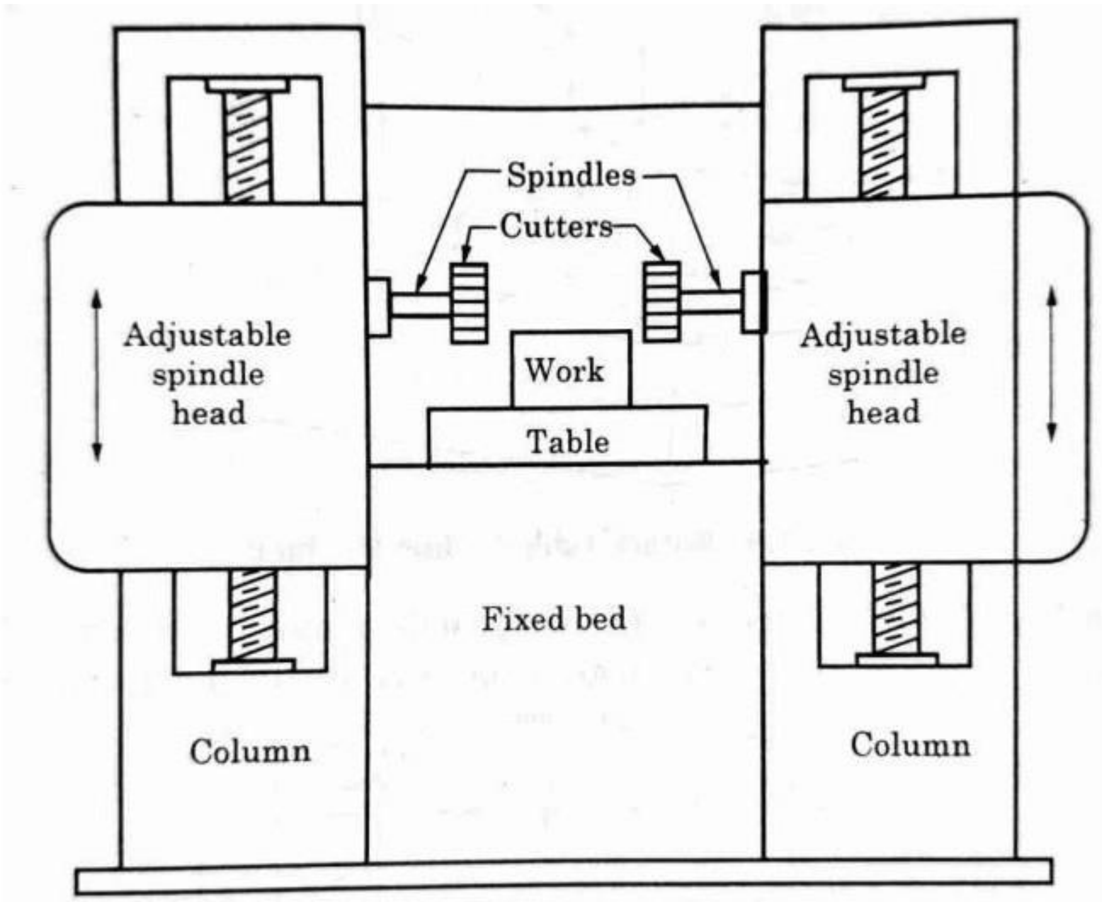


Fig. 1.6 Duplex Milling Machine

(c) Triplex milling machine: It has two adjustable horizontal spindle heads like a duplex milling machine attached to two different columns and one vertical spindle head on a cross rail.

4. Special Purpose Milling Machine: These are machine made for some special work.

(a) Rotary table milling machine: The rotary table milling machine consists of a circular table that rotates in a vertical axis. You need to set multiple cutters at different heights. The machine works with one cutter roughing up the work piece, and the rest of the cutters finishing the surface. The operator can load and unload the work pieces continuously while the machine is working, and that is the most significant advantage of the rotary table milling machine.

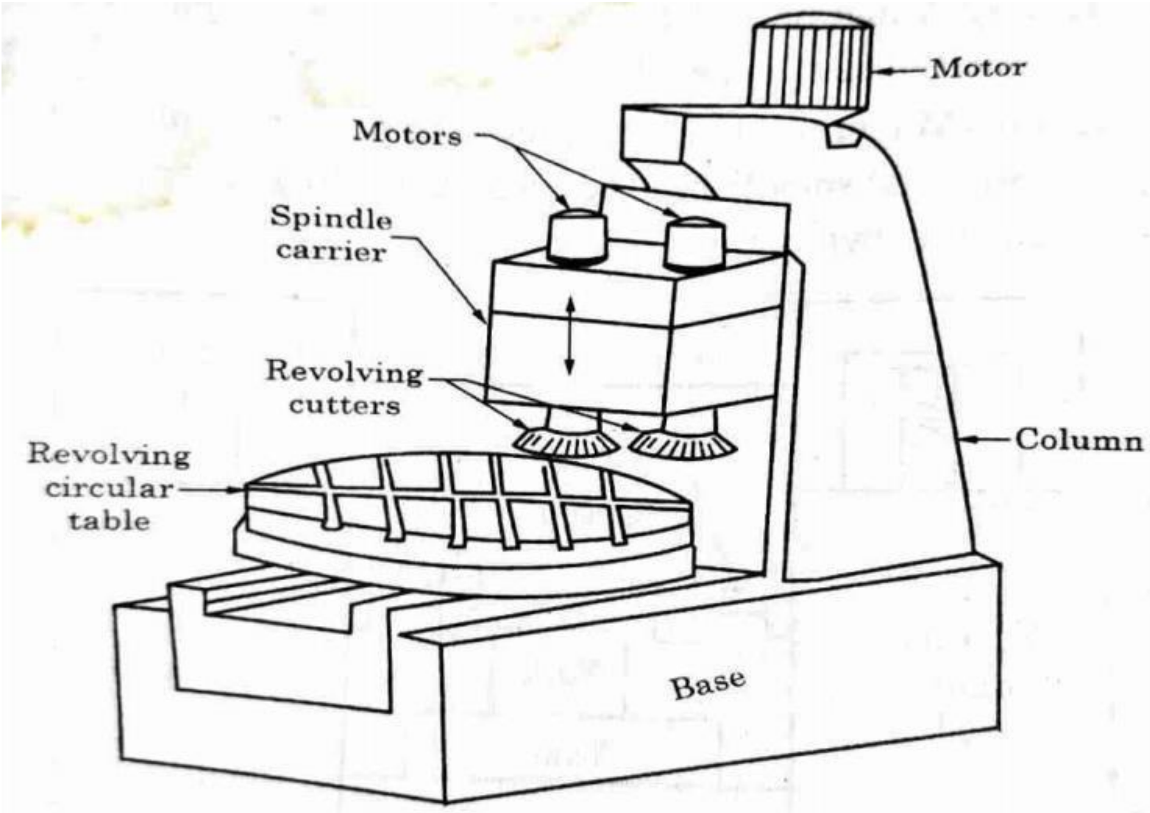


Fig. 1.7 Rotary Type Milling Machine

(b) Drum milling machine: The drum milling machine is just like a rotary table. The only difference is that this machine has a table that supports the work piece and is called a drum, which can only rotate horizontally. To remove the metal, you need to place the work piece on the drum. These cutters have three or four spindle heads. After one complete turn, you need to remove the finished parts and clamp the new one onto it.

(c) Profile milling machine: In appearance, it resembles the vertical spindle machine. It has one to four cutter spindles. The cutter is a small diameter shank type end mill. Its movement is controlled, either by hand or automatically, by the path of a stylus or tracer which has the same diameter and shape as the cutter. In this machine the operation is performed in two dimensions. A good commercial finish and a tolerance of within 0.1 mm can be expected from this machine.

(d) Duplicating milling machine: It is also called by the name of originator, Keller machine, die sinker or automatic tracer controlled miller. In this machine, milling operating can be performed in third dimension also. The template used in this machine must be replica in three dimensions of the work to be performed.

Typical work performed includes the making of forging dies, steel molds for glass, plastic and certain metals, auto body dies, ship propellers and air-craft connecting rods.

(e) Planetary milling machine: It is a unique machine in the sense that the work is held stationary while the revolving cutter or cutters move in a planetary path to finish a circular surface on the work, either internally or externally. Many of the operations would be lathe operations, if the nature of work piece permits. The cutter may be plain, form or thread cutter and may work on either the inside or the outside of the work or inside and outside simultaneously.

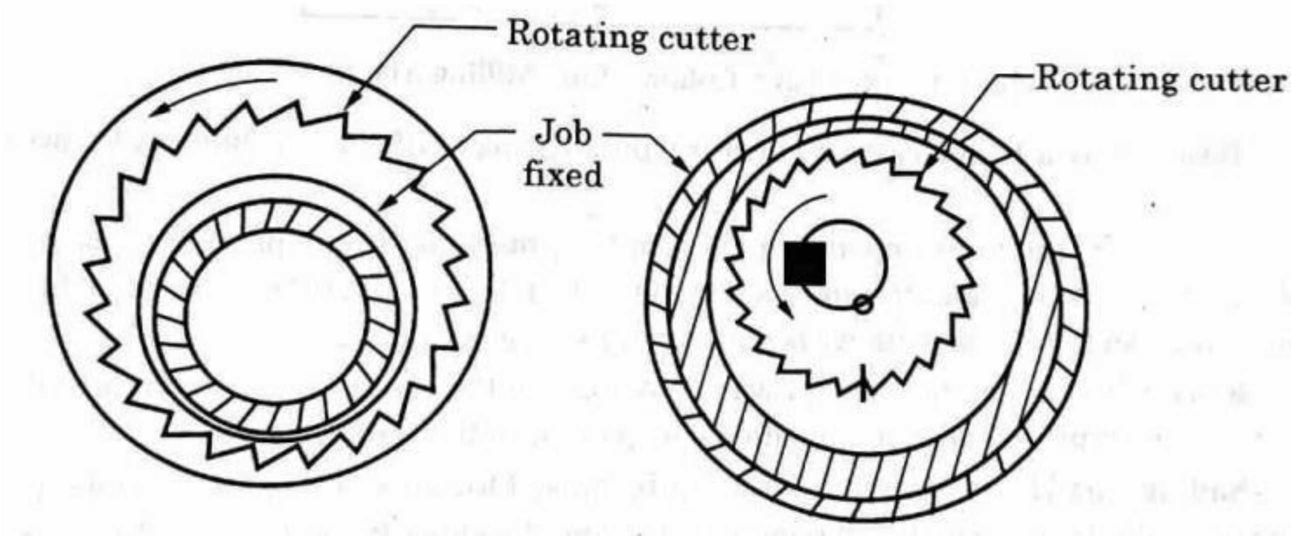


Fig. 1.8 Planetary Milling Machine

APPLICATIONS OF MILLING MACHINES

Milling machines are widely used in the tool and die making industry and are commonly used in the manufacturing industry for the production of a wide range of components. Typical examples are the milling of flat surface, indexing, gear cutting, as well as the cutting of slots and key-ways.

- Milling machines are very versatile. They are usually used to machine flat surfaces, but can also produce irregular surfaces. They can also be used to drill, bore, cut gears, and produce slots.
- A milling machine removes metal by rotating a multi-toothed cutter that is fed into the moving work piece. The spindle can be fed up and down with a quill feed lever on the head.
- The bed can also by feed in the x, y, and z axes manually. In this clip the z axis is adjusted first, then the y, than the x.
- Once an axis is located at a desired position and will no longer be fed, it should be locked into position with the Gibb locks.
- Most milling machines are equipped with power feed for one or more axes. Power feed is smoother than manual feed and, therefore, can produce a better surface finish. Power feed also reduces operator fatigue on long cuts.

COLUMN AND KNEE TYPE MILLING MACHINE

It is low production machine most commonly used machine in view of flexibility and easier setup. The table of this machine is mounted on the knee which is mounted on the vertical column. The knee can be moved up and down to accommodate various heights of works. The knee can be guided on the guide ways provided at the front face of the column.

Principle parts: The principle parts of knee and column type milling machine are shown in fig. 1.9.

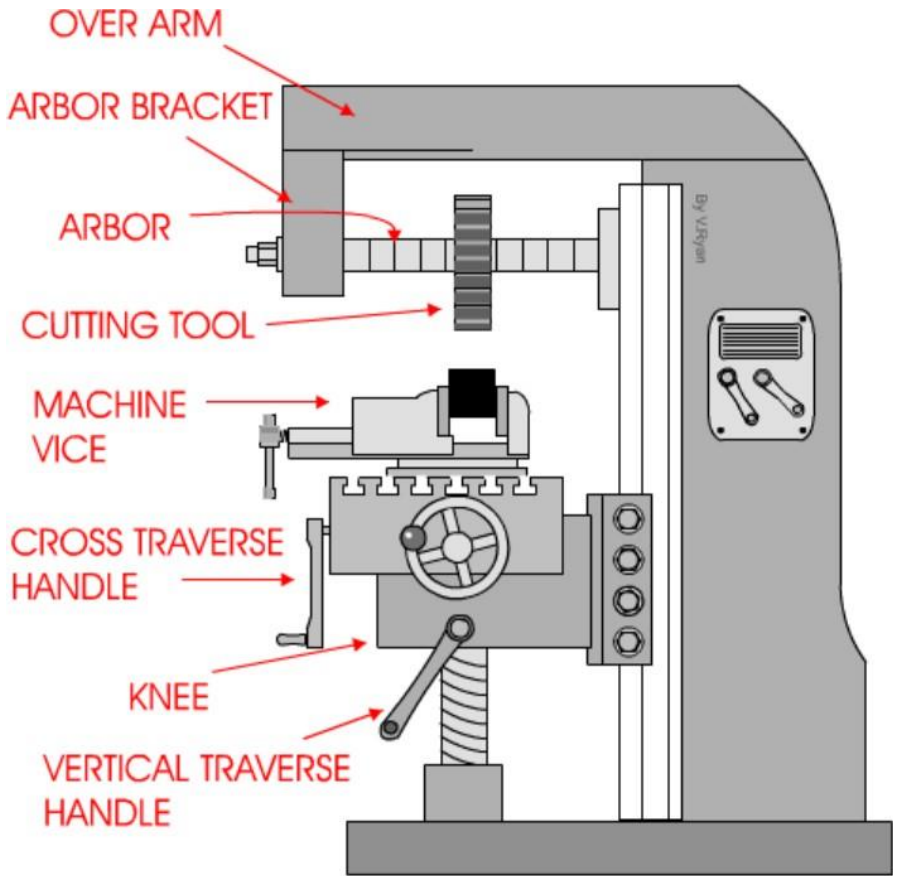


Fig.1.9 Knee and column type milling machine

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

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

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

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

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

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

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

c). Longitudinal (back and forth) motion provided by hand wheel fitted on the side of feed screw.

In addition to the above motions, the table of a universal milling machine can be swiveled 45° to either side of the centre line and thus fed at an angle to the spindle.

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

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

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

MILLING MACHINES ACCESSORIES AND ATTACHMENTS

1. Arbor: Arbor is cutter holding device. An arbor usually made with the taper shank for proper alignment with spindle having taper hole to at its nose. The cutter having a bore at the center is mounted and keyed to arbor.

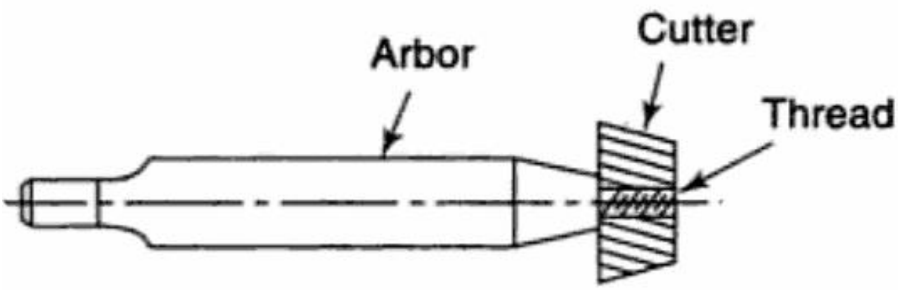


Fig.1.10 Arbor

2. Adaptors: An adaptor is like a collet used on milling machine having standardized spindle end. Cutters having shanks usually mounted on adaptors.

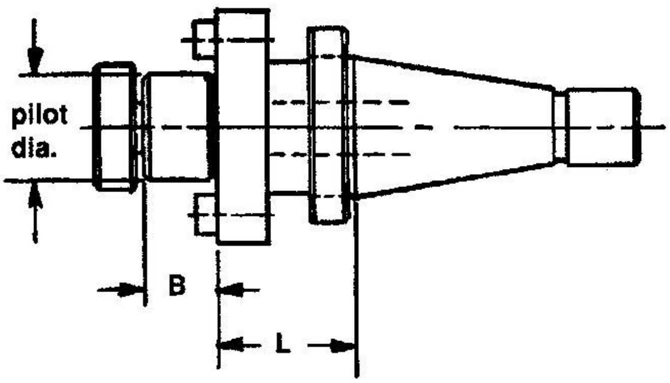


Fig.1.11 Adaptor

3. Collets: A collet is an accurate time saving cutter holding device on milling machines. The most commonly used collet is the spring type collet.

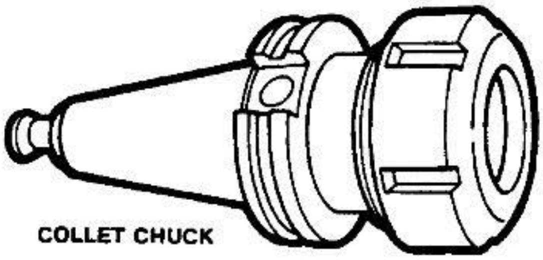


Fig.1.12 Collet

4. Vices: Vices are the most common devices used for holding work on milling machine table due to their quick loading and unloading arrangement.

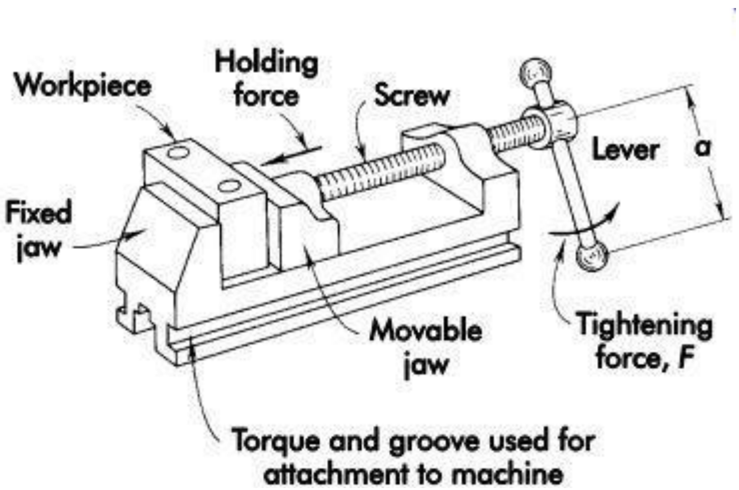


Fig.1.13 Vice

5. Circular table: It is mounted on the machine table used for producing circular surfaces after centralizations for milling circular surfaces.

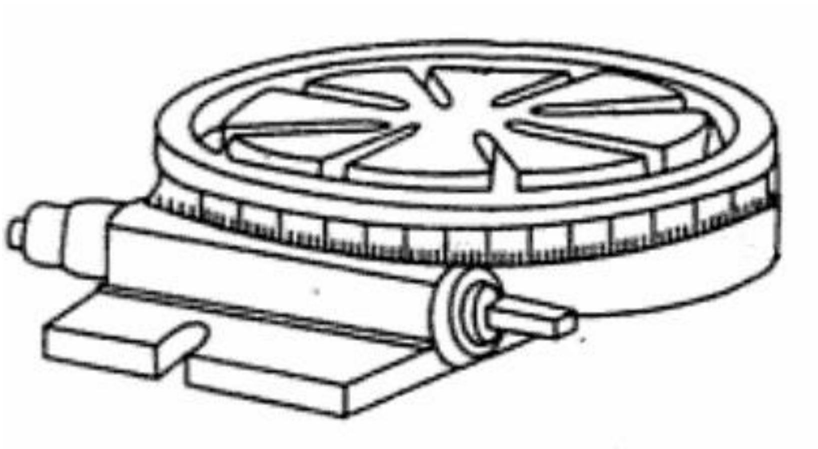


Fig.1.14 Circular Table

6. Indexing head and tail stock: It is used to divide the periphery of circular work piece. It is most common arrangement used in workshops. This is used for holding and dividing the circumference of component for grooving, gear cutting, fluting etc.

7. Vertical milling attachment: It is an attachment used for converting a horizontal milling machine into a vertical milling machine. By orienting the cutting spindle axis from the horizontal to vertical position.

8. Rotary table: It is used for variety of circular milling operations such as segment outlines, splines slotting, segmental milling and dies making jobs.

MILLING METHODS

Based upon the directions of movement of the milling cutter and the feeding directions of the work piece, there are two possible types of milling:

1. Conventional Milling (Up Milling):

In up cut milling, the cutter rotates in a direction opposite to the table feed as illustrated in figure 1.15. It is conventionally used in most milling operations because the backlash between the lead screw and the nut of the machine table can be eliminated.

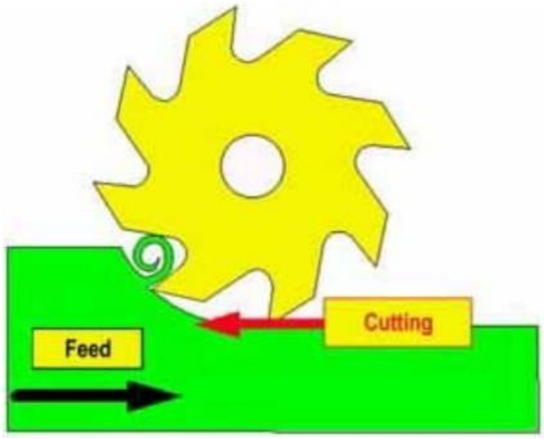


Fig.1.15 up Milling

2. Climb Milling (Down Milling):

In down cut milling, the cutter rotates in the same direction as the table feed as illustrated in figure 1.16. This method is also known as Climb Milling and can only be used on machines equipped with a backlash eliminator or on a CNC milling machine. This method, when properly treated, will require less power in feeding the table and give a better surface finish on the work piece.

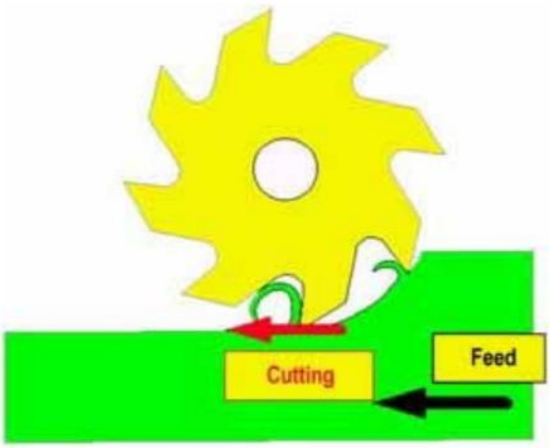


Fig.1.16 Down Milling

DIFFERENT MILLING CUTTERS AND WORKMENDRELS

There are various types of milling cutters. According to purpose or use, there can be classified as follow:

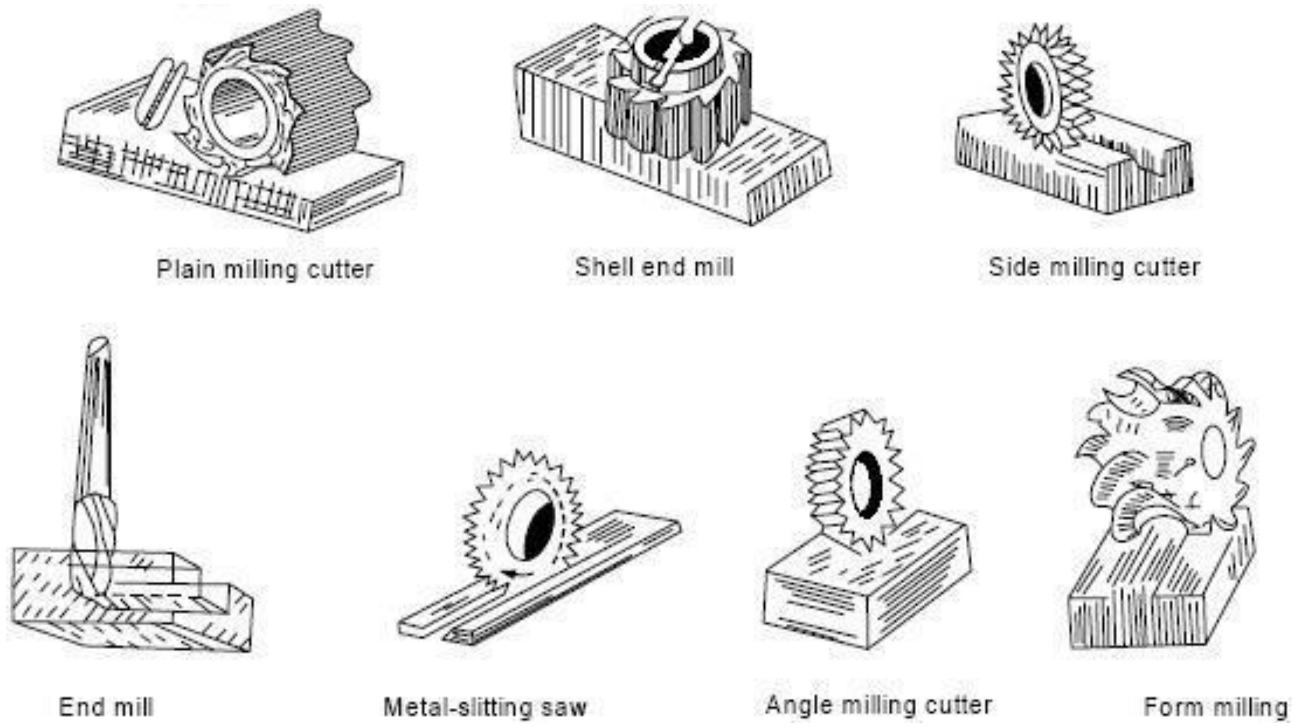


Fig.1.17 Milling Cutters

1. Plain Milling Cutter:

It has straight or helical teeth cut on the periphery of a disc or a cylindrical surface. It may be of solid inserted blade or tipped type, and is usually profile sharpened but may be form relieved also. Generally helical teeth are used if the width of the cutter exceeds 15 mm.

2. Side Milling Cutter:

This cutter is similar to plain cutter except that it has teeth on the side. However, the side milling cutter may have teeth on the periphery and on one or both sides of the tool. These cutters may have straight, spiral or staggered teeth. Further these may be solid, inserted blade or tipped construction, and may be profile sharpened or form relieved.

3. End Mill Cutters:

These cutters have an integral shaft for driving and have teeth on both periphery and ends. These are the cutters with teeth on the periphery and end integral with a shank for holding and driving. These are used to mill flat, horizontal, vertical, bevel, chamfer and slant surfaces, grooves and keyways, and to cut slot and in recess work such as die making etc.

4. Angle Milling Cutters:

Any cutter, angle shaped, comes under this classification. These may have cutters either on only one conical surface (single-angle cutter) or on two conical surfaces (double angle cutter). Angle cutters are used for cutting ratchet wheel, dovetails, flutes on milling cutters and reamers, machining angles and Vs of 30°, 45°, 60° and 90°.

5. T-Slot Cutters:

These are used for milling T-slots in one operation and are available in special sizes for standard T-slots. These resemble plain or side milling cutters which have an integral straight or tapered shaft for driving.

6. Form Milling Cutters:

These have a special curved tooth outline and are used for milling contours of the various shapes. Various other types of form milling cutters are convex milling cutters, concave milling cutters, corner-rounding milling cutters, pocket milling cutters, spindle milling cutters, form milling gang cutters, etc.

WORK HOLDING DEVICES

A work piece must be held securely and rigidly on the table of milling machine for accurate milling operation. The various devices used for this purpose are as follows:

1. T- Bolts and clamps:

Bulky work pieces of irregular shapes are clamped directly on the milling machine table by using T- bolts and clamps. Different types of clamps are used for different patterns of work. The common types of clamps are shown in Fig 10 of chapter 5. All these clamps carry a long hole, through which clamping bolt passes. This hole permits the bolts for adjustment according to the size and shape of the job.

2. Angle plates:

- When work surfaces are to be milled at right angles to another face, angle plates are used for supporting the work.
- The angle plate is made from high-quality material (generally spherical cast iron) that has been stabilized to prevent further movement or distortion.
- Slotted holes or "T" bolt slots are machined into the surfaces to enable the secure attachment or clamping of work pieces to the plate, and also of the plate to the worktable.
- Angle plates also may be used to hold the work piece square to the table during marking-out operations.

Fig.1.18 Angle Plate

3. V block:

The V blocks are used for holding shafts on a milling machine table in which keyways and slots are to be milled.

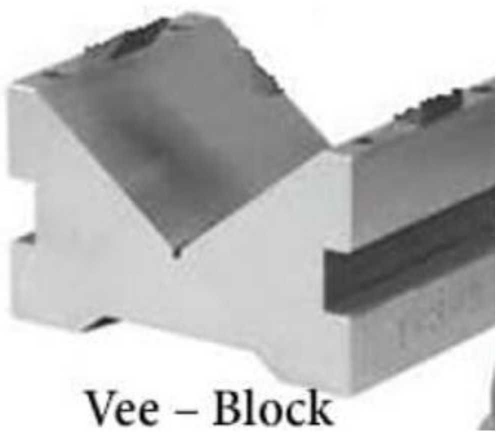


Fig.1.19 V block

4. Vices:

Vices are the most common appliance for holding work on milling machine tables. According to its quick loading and unloading arrangement. Vices are of three types,

(a) Plain Vice

The plain vice is directly bolted on the milling machine table is the most common type of vice used on plain milling operations, which involves heavy cuts, such as in slab milling. Its especially low construction enables the work to remain quite close to the table. This reduces the chance of vibration to a minimum. The base carries slots to accommodate 'T' bolts to fix the vice on the table. Work is clamped between the fixed and movable jaw and for holding work pieces of irregular shape special jaws are sometimes used.

Fig.1.20 Plain Vice

(b) Swivel Vices

The swivel vice is used to mill an angular surface in relation to a straight surface without removing the work from the vice. It has got a circular base graduated in degrees. The base is clamped on the table by means of T- bolts.

(c) Universal Vices

It can be swiveled in a horizontal plane similar to a swivel vice and can also be tilted in any vertical position for an angular cut. The vice is not rigid in construction and is used mainly in tool room work. It enables the milling of various surfaces, at an inclination to one another, without removing the work piece.

Fig.1.21 Universal Vice

5. Dividing Head:

Dividing head or indexing head used to hold the work piece and divide the periphery into the number of divisions required. These are of three types:

(a) Plain dividing head

(b) Universal dividing head

(c) Optical dividing head

6. Special Fixture:

Work directly mounted on table or Special fixtures. Work directly mounted on the table for heavy nature of jobs or odd-shaped jobs which is not possible to hold by other holding devices, with the help of slots, T- bolts, and nuts. The fixtures are special devices designed to hold work for specific operations more efficiently than standard work holding devices. The fixtures are especially useful when large numbers of identical parts are to be manufactured.

MILLING OPERATIONS

The following are the different milling operations performed on the milling machine:

1. Face Milling: Plain Milling, also called Surface Milling or Slab Milling, is milling flat surfaces with the milling cutter axis parallel to the surface being milled. Generally, plain milling is done with the work piece surface mounted parallel to the surface of the milling machine table and the milling cutter mounted on a standard milling machine arbor. The arbor is well supported in a horizontal plane between the milling machine spindle and one or more arbor supports.

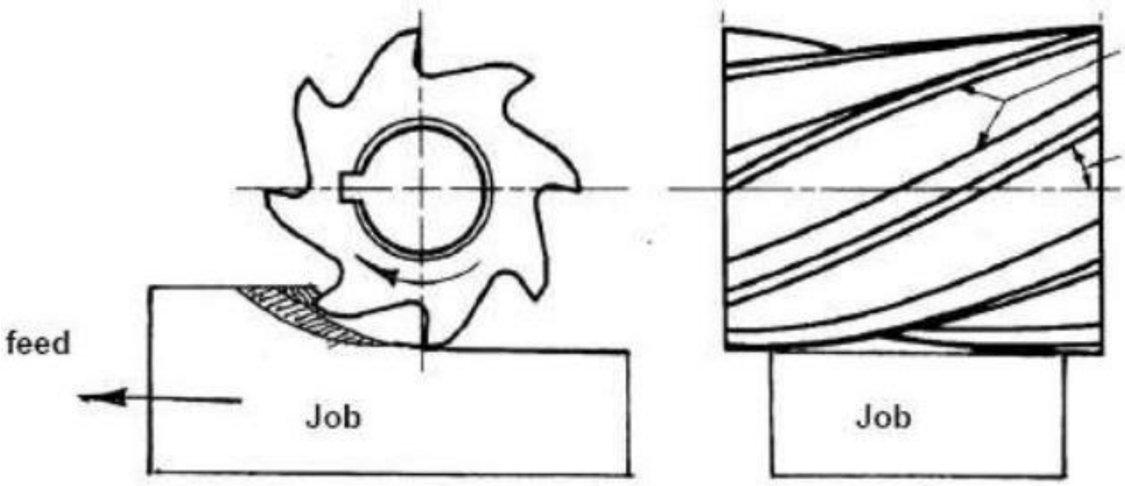


Fig.1.22 Face Milling

2. Angular milling: It is also known as angle milling, refers to milling operations in which the cutting tool's axis of rotation is at an angle relative to the surface of the work piece. The process employs single-angle milling cutters—angled based on the particular design being machined—to produce angular features, such as chamfers, serrations, and grooves. One common application of angular milling is the production of dovetails, which employs 45°, 50°, 55°, or 60° dovetail cutters based on the design of the dovetail.

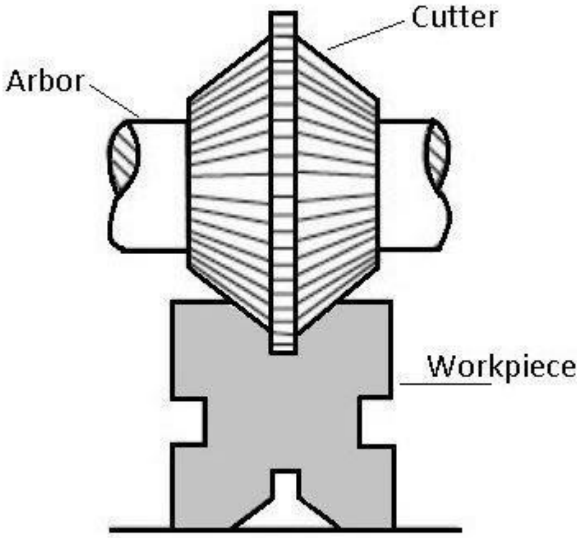


Fig.1.23 Angular Milling

3. Form milling: The process of machining special contours composed of curves and straight lines, or entirely of curves, at a single cut. This is done with formed milling cutters, shaped to the contour to be cut, or with a fly cutter ground for the job. The more common form milling operations involve milling half-round recesses and beads and quarter-round radii on the work pieces. This operation is accomplished by using convex, concave, and corner rounding milling cutters ground to the desired circle diameter.

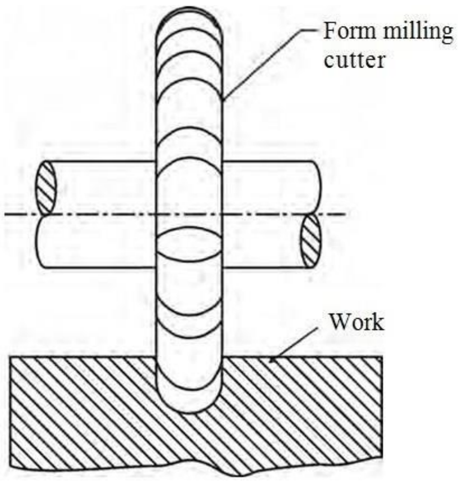


Fig.1.24 Form Milling

4. Straddle milling: When two or more parallel vertical surfaces are machined at a single cut, the operation is called straddle milling. Straddle milling is accomplished by mounting two side milling cutters on the same arbor, set apart so that they straddle the work piece. The diagram below illustrates a typical example of straddle milling. In this case a spline is being cut, but the same operation may be applied when cutting squares or hexagons on the end of a cylindrical work piece.

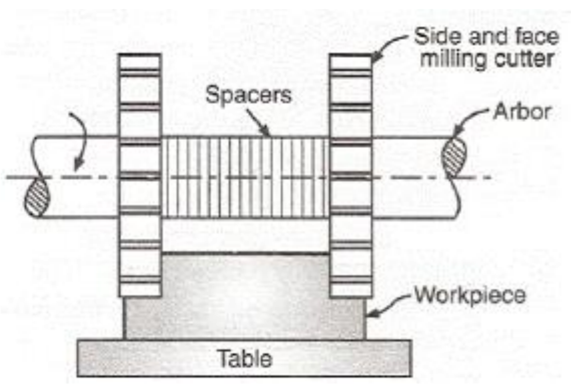


Fig.1.25 Form Milling

5. Gang milling: The term applied to an operation in which two or more milling cutters are used together on one arbor when cutting horizontal surfaces. The usual method is to mount two or more milling cutters of different diameters, shapes and/ or widths on an arbor as shown in the following diagram. The possible cutter combinations are unlimited and are determined in each case by the nature of the job.

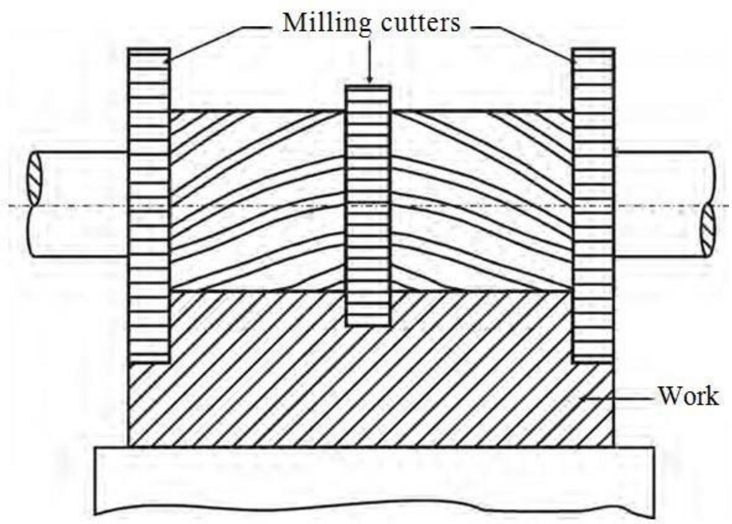


Fig.1.26 Gang Milling

CUTTING SPEED AND FEED

1. Cutting Speed: The cutting speed of milling cutter is its peripheral linear speed resulting from rotation. In simple words, the cutting speed of a milling cutter is the travel of one revolution of one cutting tooth. It is expressed in meter per minute.

Cutting Speed (v) = $(\pi \times D \times n)/1000$ m/min

2. Feed: The feed in a milling machine may be defined as the rate with which the work piece advances under the cutter. The feed is expressed in a milling machine by the following three different methods:

i. Feed per minute
ii. Feed per tooth
iii. Feed per revolution

THREAD MILLING

Thread milling is used to produce internal or external threads by using a single or multiple thread milling cutters. The operation is performed on a special thread milling machine to produce accurate threads in small or large quantities.

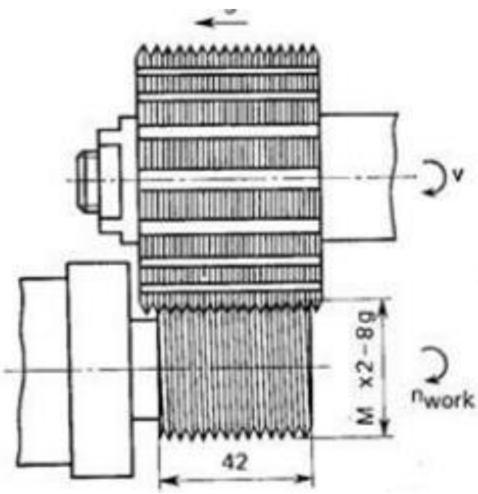


Fig.1.27 Thread Milling

CHAPTER 2

GEAR MANUFACTURING AND FINISHING PROCESS

GEAR HOBBING:

Gear Hobbing is a machining process for gear cutting, cutting splines, and cutting sprockets on a hobbing machine, which is a special type of milling machine. The teeth or splines are progressively cut into the work piece by a series of cuts made by a cutting tool called a hob.

Gear Hobbing uses a hobbing machine with two skew spindles, one mounted with a blank work piece and the other with the hob. The angle between the hob's spindle (axis) and the work piece spindle varies, depending on the type of product being produced. For example, if a spur gear is being produced, then the hob is angled equal to the helix angle of the hob; if a helical gear is being produced then the angle must be increased by the same amount as the helix angle of the helical gear. The two shafts are rotated at a proportional ratio, which determines the number of teeth on the blank; for example, for a single-threaded hob if the gear ratio is 40:1 the hob rotates 40 times to each turn of the blank, which produces 40 teeth in the blank. If the hob has multiple threads the speed ratio must be multiplied by the number of threads on the hob. The hob is then fed up into the work piece until the correct tooth depth is obtained. Finally the hob is fed through the work piece parallel to the blank's axis of rotation.

Often multiple blanks are stacked, and then cut in one operation. For very large gears the blank can be gashed to the rough shape first to make hobbing easier.

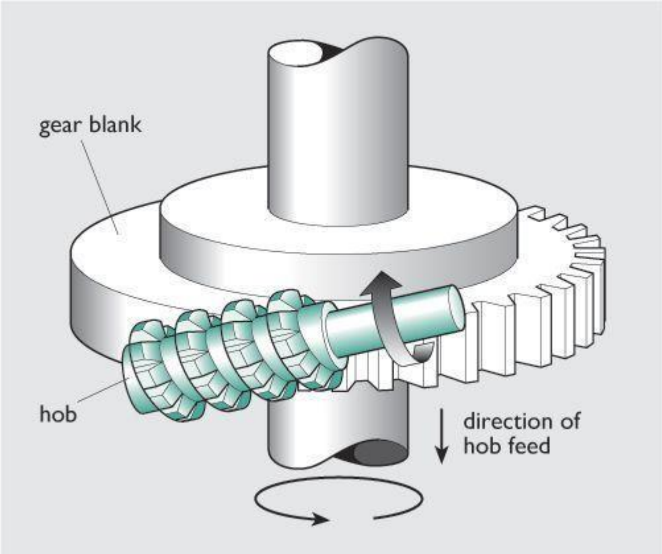


Fig 2.1 Gear Hobbing

Gear Hobbing Machine:

Hobbing machines, also known as hobbers, are fully automated machines that come in many sizes, because they need to be able to produce anything from tiny instrument gears up to 10 ft (3.0 m) diameter marine gears. Each gear hobbing machine typically consists of a chuck and tailstock, to hold the work piece or a spindle, a spindle on which the hob is mounted, and a drive motor.

For a tooth profile which is a theoretical involute, the fundamental rack is straight-sided, with sides inclined at the pressure angle of the tooth form, with flat top and bottom. The necessary addendum correction to allow the use of small-numbered pinions can either be obtained by suitable modification of this rack to a cycloidal form at the tips, or by hobbing at other than the theoretical pitch circle diameter. Since the gear ratio between hob and blank is fixed, the resulting gear will have the correct pitch on the pitch circle, but the tooth thickness will not be equal to the space width. Hobbing machines are characterized by the largest module or pitch diameter it can generate. For example, a 10 in (250 mm) capacity machine can generate gears with a 10 in pitch diameter and usually a maximum of a 10 in face width. Most hobbing machines are vertical hobbers, which mean the blank is mounted vertically. Horizontal hobbing machines are usually used for cutting longer work pieces; i.e. cutting splines on the end of a shaft.

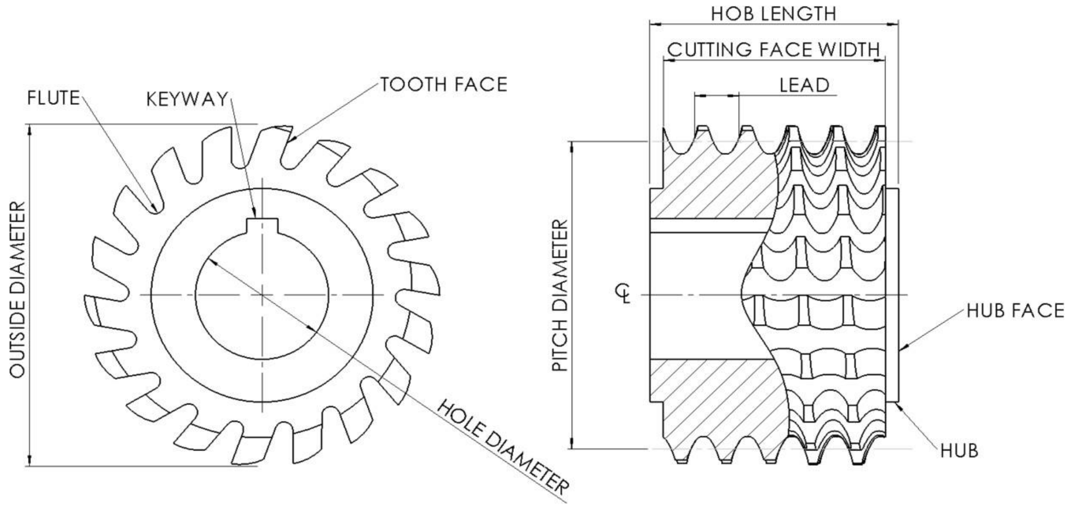


Fig.2.2 Gear Hobbing

GEAR SHAPING

Gear shaping is a machining process for creating teeth on a gear using a cutter. Gear shaping is a convenient and versatile method of gear cutting. It involves continuous, same-plane rotational cutting of gear.

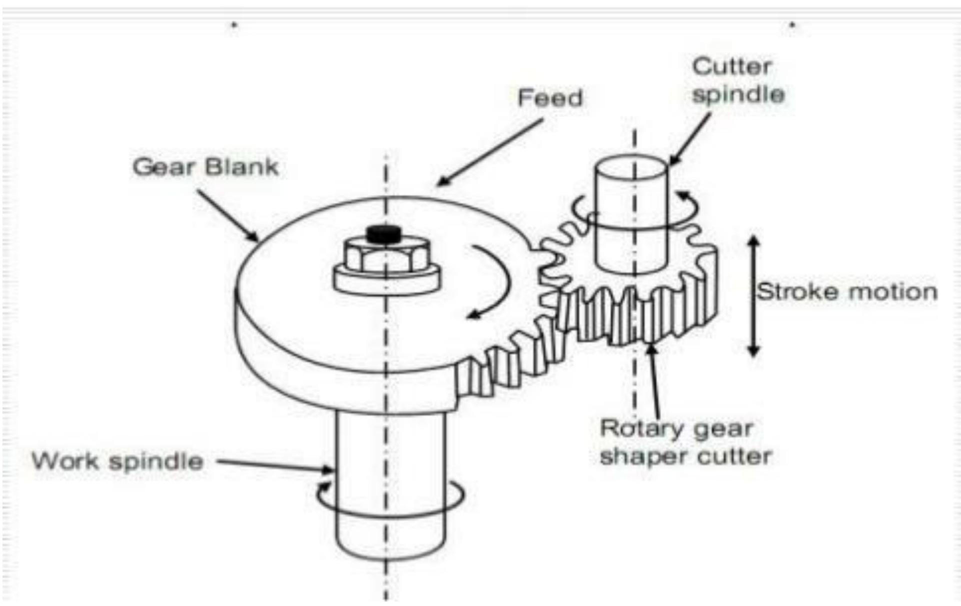


Fig. 2.3 Gear Shaping

The types of cutters used for gear shaping can be grouped into four categories: disk, hub, shank, and helical cutters. The cutters are essentially gears that are used to form the teeth. This method of gear cutting is based on the principle that any two gears will mesh if they are of the same pitch, proper helix angle, and proper tooth depth and thickness.

GEAR FINISHING PROCESSES

The tooth profile of the gear must be accurate and smooth for the efficiently working of the gears. The various finishing operations for gears are explained below:

1. Lapping: The term "lapping" is used to describe a number of various surface finishing operations where loose abrasive powders are used as the grinding agent at normally low speeds. It is a process reserved for products that demand very tight tolerances of flatness, parallelism, thickness or finish.

2. Honning: Honing is an abrasive machining process that produces a precision surface on a metal work piece by scrubbing an abrasive grinding stone or grinding wheel against it along a controlled path. Honing is primarily used to improve the geometric form of a surface, but can also improve the surface finish.

3. Gear shaving: Gear shaving is a free-cutting gear finishing operation which removes small amounts of metal from the working surfaces of the gear teeth. Its purpose is to correct errors in index, helical angle, tooth profile and eccentricity. The process can also improve tooth surface finish and eliminate, by crowned tooth forms, the danger of tooth end load concentrations in service. Shaving provides for form modifications that reduce gear noise. These modifications can also increase the gear's load carrying capacity, its factor of safety and its service life.

4. Gear Burnishing: Burnishing can be defined as a process in which a smooth but hard tool using sufficient pressure burnishing is rubbed on the surface of the metal. This helps to flatten the high spots by allowing plastic flow of the metal. The edges of the metal can be smoothened by pushing it through a die that will smooth out the burrs and the blanked edge caused by the die break.

5. Super Finishing Process: Super finishing, also known as micromachining, micro finishing, and short-stroke honing, is a metalworking process that improves surface finish and work piece geometry. This is achieved by removing just the thin amorphous surface layer left by the last process with an abrasive stone or tape; this layer is usually about 1 μm in magnitude. Superfinishing, unlike polishing which produces a mirror finish, creates a cross-hatch pattern on the work piece

CHAPTER 3

GRINDING

INTRODUCTION:

Grinding is a subset of cutting, as grinding is a true metal-cutting process. Each grain of abrasive functions as a microscopic single-point cutting edge. Grinding is a process of removing material in the form of small chips by means of rotating abrasive particles bonded together in a grinding wheel to produce flat, cylindrical or other surfaces. A wheel used for grinding various types of surfaces is known as grinding wheel. Example of work is: Sharpening of turning tool and milling cutter, debarring of a lever.

Grinding is the most common form of abrasive machining. It is a material cutting process which engages an abrasive tool whose cutting elements are grains of abrasive material known as grit.

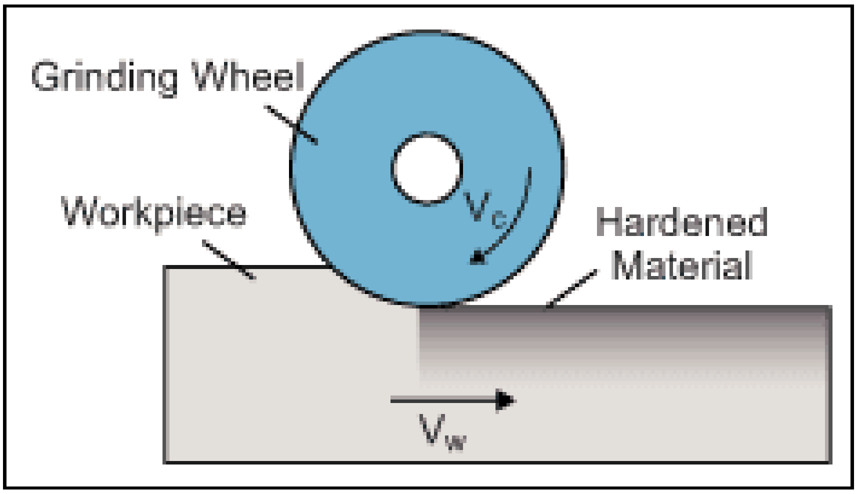


Fig.3.1 Grinding action

When a moving abrasive surface contacts a workpiece, if the force is high enough, material will be removed from the part and the abrasive surface will wear. Those two things will always occur; however, the force level determines how fast the mutual removal rates will be, how rough the remaining surface will be, and whether the workpiece will be metallurgical damaged or not. The purpose of this section is to provide relationships between variables and to illustrate how changes to a system affect its performance

PURPOSES OF GRINDING

1. It is used for sharpening the cutting tools.
2. Cylindrical grinding process is used for grinding the outer surface of cylindrical object
3. Centerless grinding process is used for preparing the transmission bushing, shouldered pins and ceramic shafts for circulator pumps.
4. Internal grinding process is used for finishing the tapered, straight and formed holes precisely.
5. There are few special grinders used for sharpen the milling cutters, taps, other various machine cutting tool cutter and reamers.
6. It is used for grinding thread in order to have close tolerances and better finish.
7. It is used to produce surfaces with a higher degree of smoothness.
8. It is also used for higher metal removal rate.

VARIOUS ELEMENTS OF GRINDING WHEEL

1. Abrasive grain

The abrasive aggregate is selected according to the hardness of the material being cut.

- Aluminum oxide (A)
- Silicon carbide (S)
- Ceramic (C)

- Diamond (D, MD, SD)
- Cubic boron nitride (CBN)

Grinding wheels with diamond or CBN grains are called super abrasives. Grinding wheels with aluminum oxide (corundum), silicon carbide, or ceramic grains are called conventional abrasives.

2. Grain size

From 10 (coarsest) to 600 (finest), determines the average physical size of the abrasive grains in the wheel. A larger grain will cut freely, allowing fast cutting but poor surface finish. Ultra-fine grain sizes are for precision finish work. Generally grain size of grinding wheel in alphabetical A-E = SOFT, F-V = MEDIUM SIZE, W-Z= HARD

3. Wheel grade

From A (soft) to Z (hard), determines how tightly the bond holds the abrasive. A to H for softer structure, I to P for moderately hard structure and Q to Z for hard structure. Grade affects almost all considerations of grinding, such as wheel speed, coolant flow, maximum and minimum feed rates, and grinding depth.

4. Structure

Spacing or structure, from 1 (densest) to 17 (least dense). Density is the ratio of bond and abrasive to air space. A less-dense wheel will cut freely, and has a large effect on surface finish. It is also able to take a deeper or wider cut with less coolant, as the chip clearance on the wheel is greater.

5. Wheel bond

How the wheel holds the abrasives; affects finish, coolant, and minimum/maximum wheel speed.

Bond name	Symbol	Bond description
Vitrified	V	Glass-based; made via vitrification of clays and feldspars
Resinoid	B	Resin-based; made from plants or petroleum distillates
Silicate	S	Silicate-based
Shellac	E	Shellac-based
Rubber	R	Made from natural rubber or synthetic rubber
Metal	M	Made from various alloys
Oxychloride	O	Made from an oxohalide

COMMON WHEEL SHAPE, TYPES OF GRINDING WHEELS AND SPECIFICATION OF GRINDING WHEEL

COMMON WHEEL SHAPE

The shape and size of grinding wheels depends upon the design of the machine, the power of the machine, the operation to be performed, the shape and size of the workpiece and the grinding conditions.

According to shape, the various grinding wheels are shown in the figure

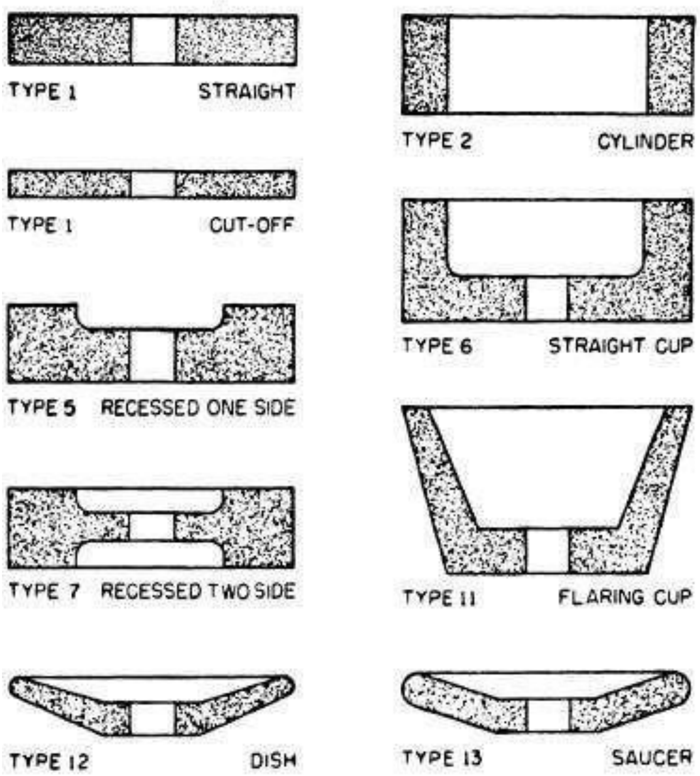


Fig.3.2 Standard grinding wheel shapes

TYPES OF GRINDING WHEELS

1. Built up Wheels

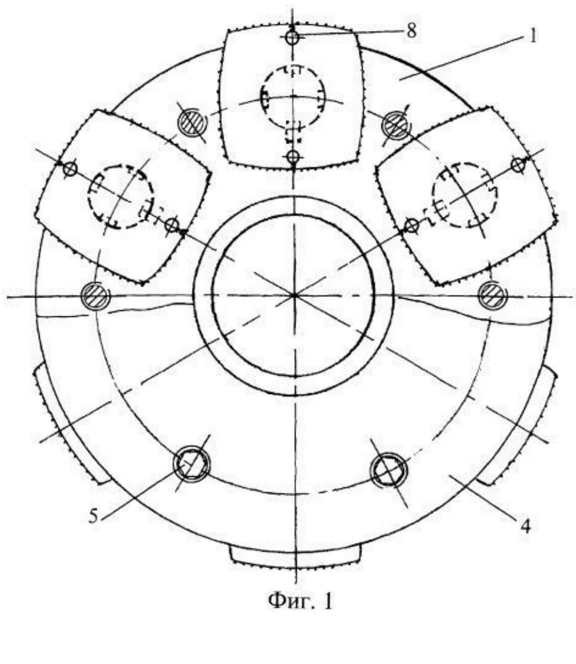


Fig.3.2 Built up Wheel

Grinding wheel includes metallic body supporting segments in the form of tetrahedral inserts. Faces of said inserts are coated with rubber for increasing contact zone with blank, they are stretched with grinding belt and have radius equal to radius of wheel working surface.

2. Cone and Plug Shape Wheels

Cones and plugs are designed for removing burrs and flash and finishing any type of metal surface in a confined area. Cone and plug shaped grinding wheels are typically used for heavy metal removal in various casting industries.

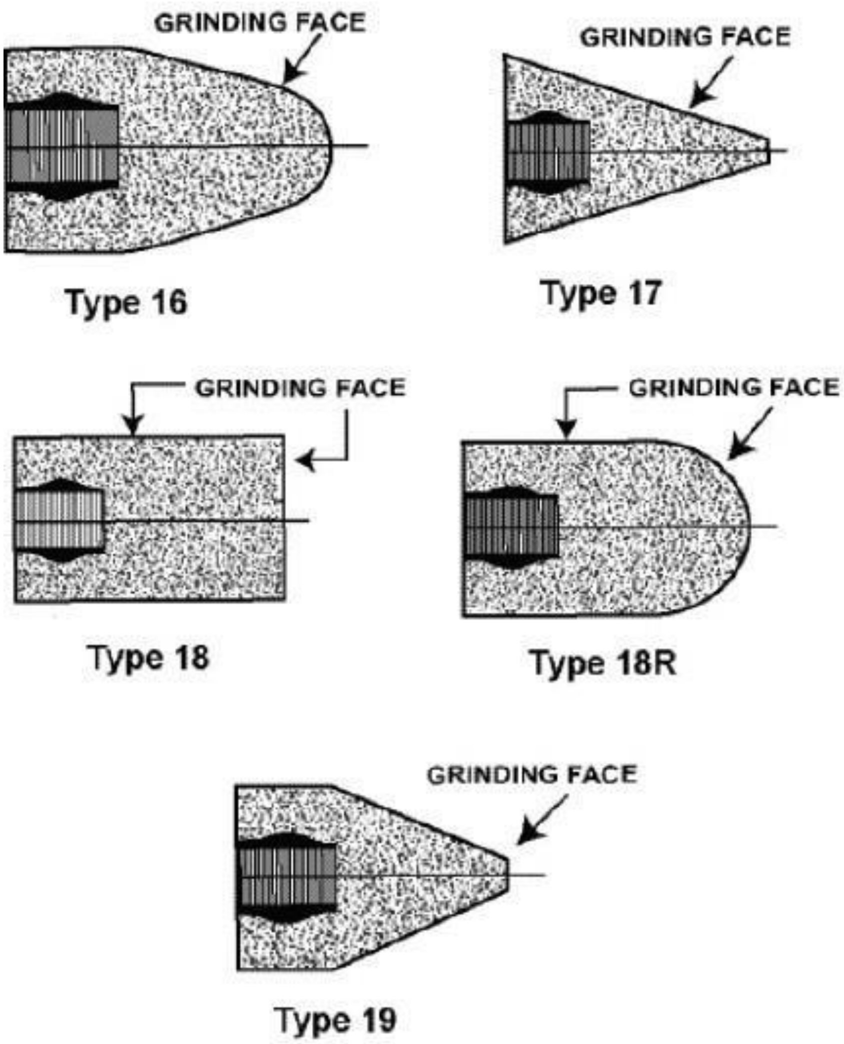


Fig.3.3 Cone and Plug shape wheel

3. Mounted Wheels

A grinding wheel is a wheel composed of an abrasive compound and used for various grinding (abrasive cutting) and abrasive machining operations. Such wheels are used in grinding machines.

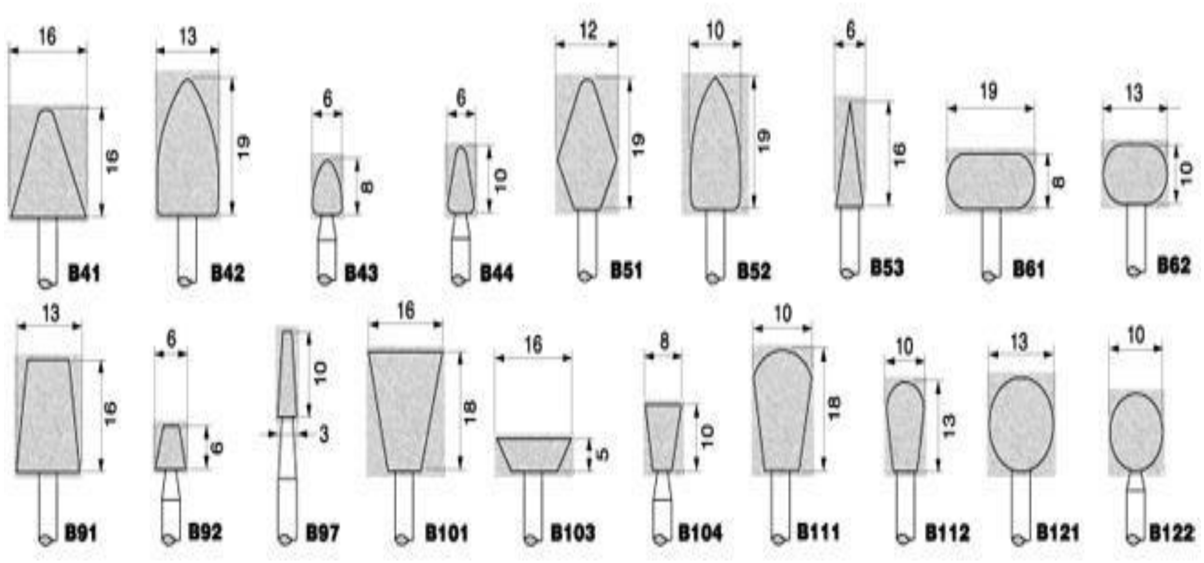


Fig.3.4 Mounted wheels

4. Diamond Wheels

A diamond grinding cup wheel is a metal-bonded diamond tool with diamond segments welded or cold-pressed on a steel (or other metal, such as aluminum) wheel body, which usually looks like a cup.

Fig.3.5 Diamond wheel

SPECIFICATION OF GRINDING WHEEL AS PER B.I.S.

IS: 551-1996 lays down the rules for the making system of grinding wheels. The marking system comprises of following symbols. These are:

1. Type of Abrasives

Abrasive	**Symbol**
Aluminium oxide	A
Silicon Carbide	C
White Aluminium Oxide	WA
Green Grit	GC

2. Grain Size

Grain Size	**Grit Number**
Coarse Grain	8,10,12,14,16,24
Medium Grain	30,36,46,54,60
Fine Grain	80,100,120,150,180
Very Fine Grain	220,240,280,320,400,500,600

3. Grade

Very Soft	A,B,C,D,E
Soft	G,H,I,J,K
Medium	L,M,N,O
Hard	P,Q,R,S
Very Hard	T,U,V,W,X,Y,Z

4. Structure

1 - 8	Dense structure
9 – 15	Open Structure

5. Types of Bond

Vitrified	V
Resinoid	B
Rubber	R
Silicate	S

TRUING, DRESSING, BALANCING AND MOUNTING OF GRINDING WHEEL

TRUING

The grinding wheel becomes worn from its original shape because of breaking away of the abrasive and bond. Sometimes the shape of the wheel is required to be changed for form grinding. For these purposes the shape of the wheel is corrected by means of diamond tool dressers. This is done to make the wheel true and concentric with the bore or to change the face contour of the wheel. This is known as truing of grinding wheels.

Diamond tool dressers are set on the wheels at 15° and moved across with a feed rate of less than 0.02mm. A good amount of coolant is applied during truing.

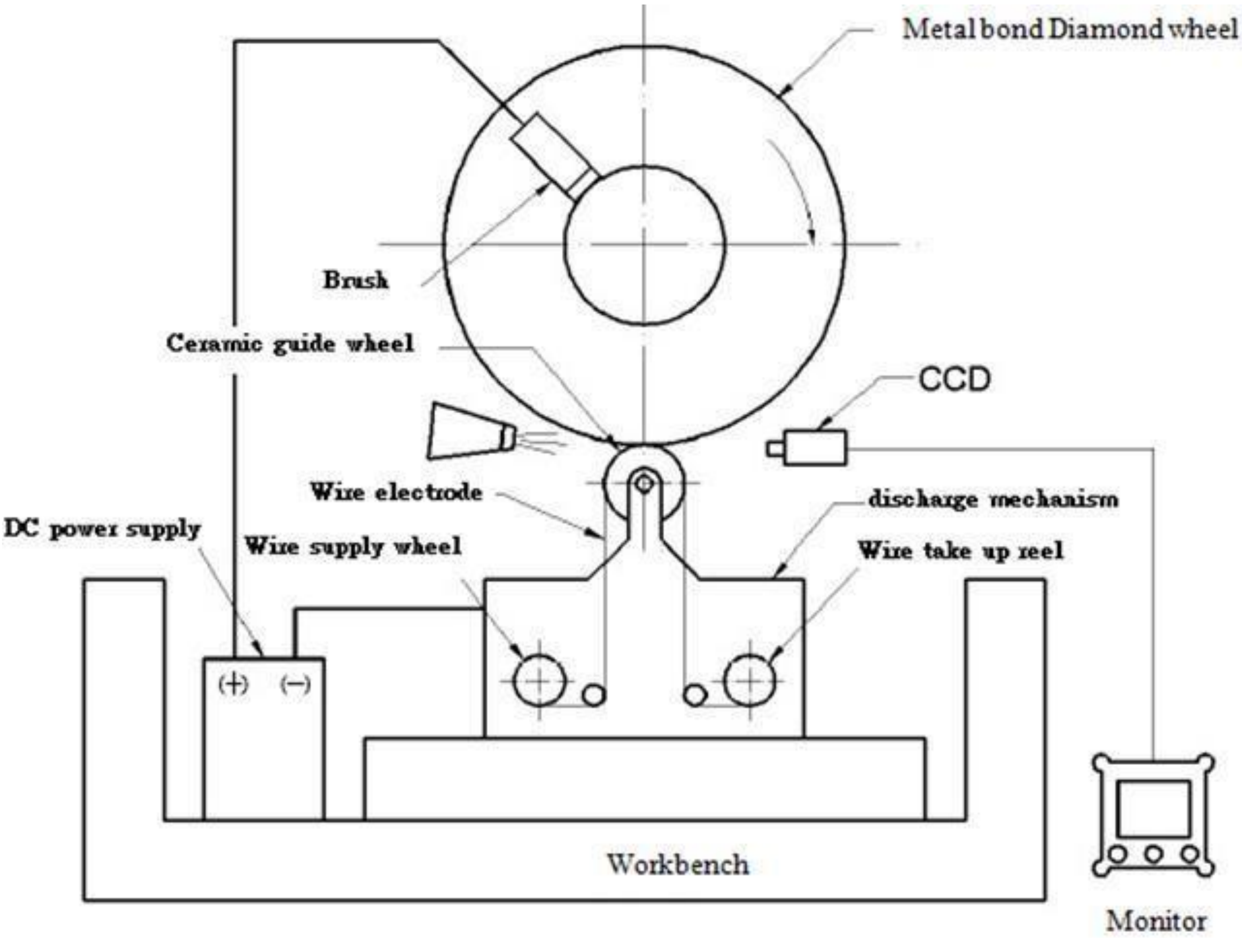


Fig.3.6 Truing

DRESSING

When the sharpness of grinding wheel becomes dull because of glazing and loading, dulled grains and chips are removed (crushed or fallen) with a proper dressing tool to make sharp cutting edges and simultaneously, make recesses for chips by properly extruding to grain cutting edge.

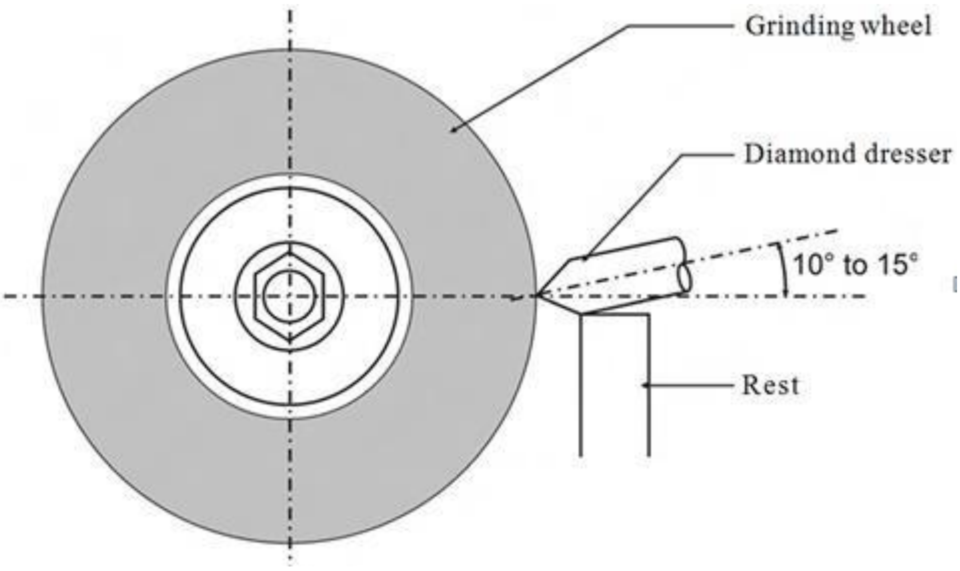


Fig.3.7 Dressing of a grinding wheel

Types of Dressing Tools

1 Wheel Dresser

2 Abrasive Stick Dresser

3 Abrasive Wheel Dresser

1. Wheel Dresser

A long handled tool with a row of free running, hardened and serrated, wavy discs or star-shaped cutters running at right angles to the handle. These are presented to the grinding wheel as it is turned off and slows down. Force is applied to the face of the slowing wheel with the result that the hardened discs match speed with the face of the wheel allowing the fingers or undulating surface of the dresser, to knock the abrasive grains out.

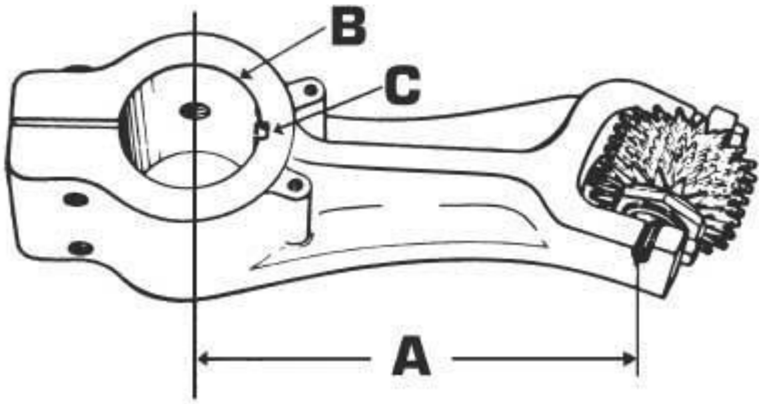


Fig.3.8 Wheel Dresser

2. Abrasive Stick Dresser

CRATEX rubber-bonded silicon carbide dressing stick for grinding wheels is ideal tool for truing, dressing and shaping different types of grinding wheels including CRATEX rubberized abrasive wheels. It is a perfect solution to keep your grinding wheel flat, sharp, clean and running smoothly!

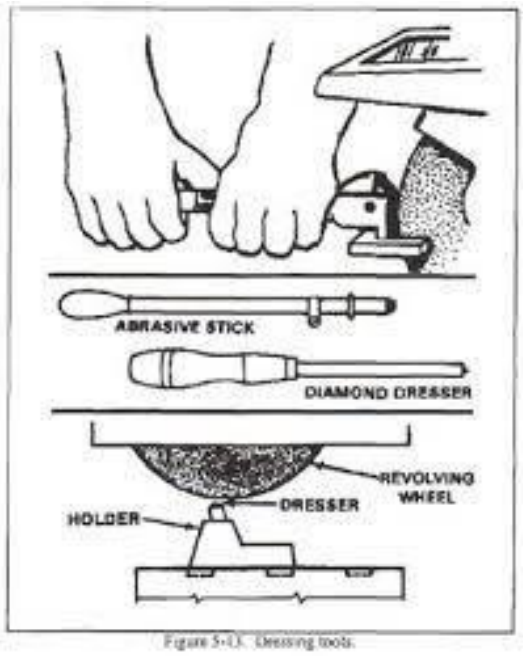


Fig.3.9 Abrasive stick dresser

3. Abrasive Wheel Dresser

A grinding wheel is a wheel composed of an abrasive compound and used for various grinding (abrasive cutting) and abrasive machining operations.

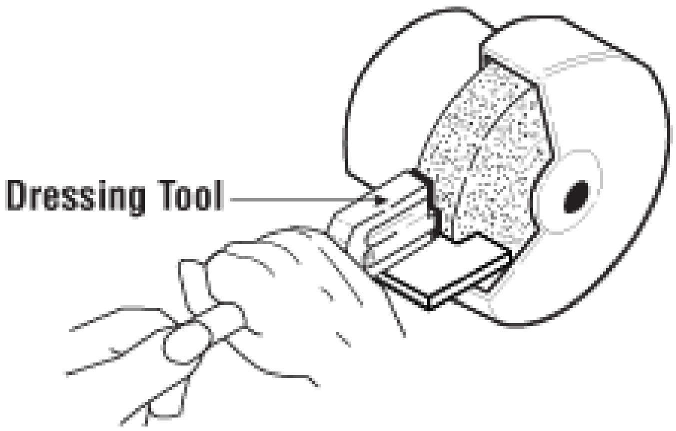


Fig.3.10 Abrasive wheel dresser

BALANCING OF GRINDING WHEEL

The regular and proper dressing of the grinding wheel is important to both reestablish a precise geometry and to create optimal grinding wheel topography. As the balance state changes constantly due to dressing, wear and profiling, the balancing of grinding wheels is essential in spite of dressing them.

Grinding wheels rotate at high speeds. The density and weight should be evenly distributed throughout the body of the wheel. If it is not so, the wheel will not rotate with correct balance.

The grinding wheels are balanced by mounting them on test mandrels. The wheel along with the mandrel is rolled on knife edges to test the balance and corrected.

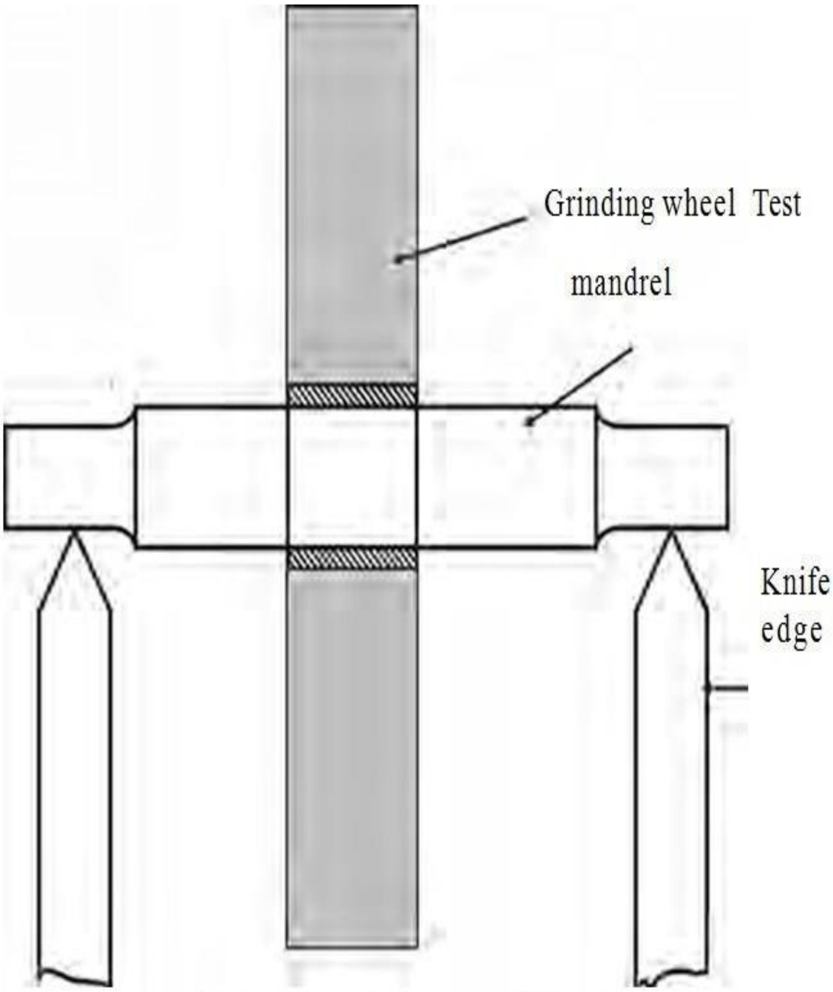


Fig.3.11 Balancing of a grinding wheel

MOUNTING OF GRINDING WHEEL

Great care must be taken in mounting the grinding wheels on the spindle because of high cutting speeds. The following points are important in connection with mounting of grinding wheel.

1. All wheels should be inspected before mounting to make sure that they have not been the wheel is put on an arbor and is subjected to slight hammer blows. A clear, ringing, vibrating sound must be heard.
2. The wheel should not be forced on and they should have an easy fit on the spindle.

3. The hole of grinding wheel is mostly lined with the lead liner bushes should not project beyond the side of wheels.

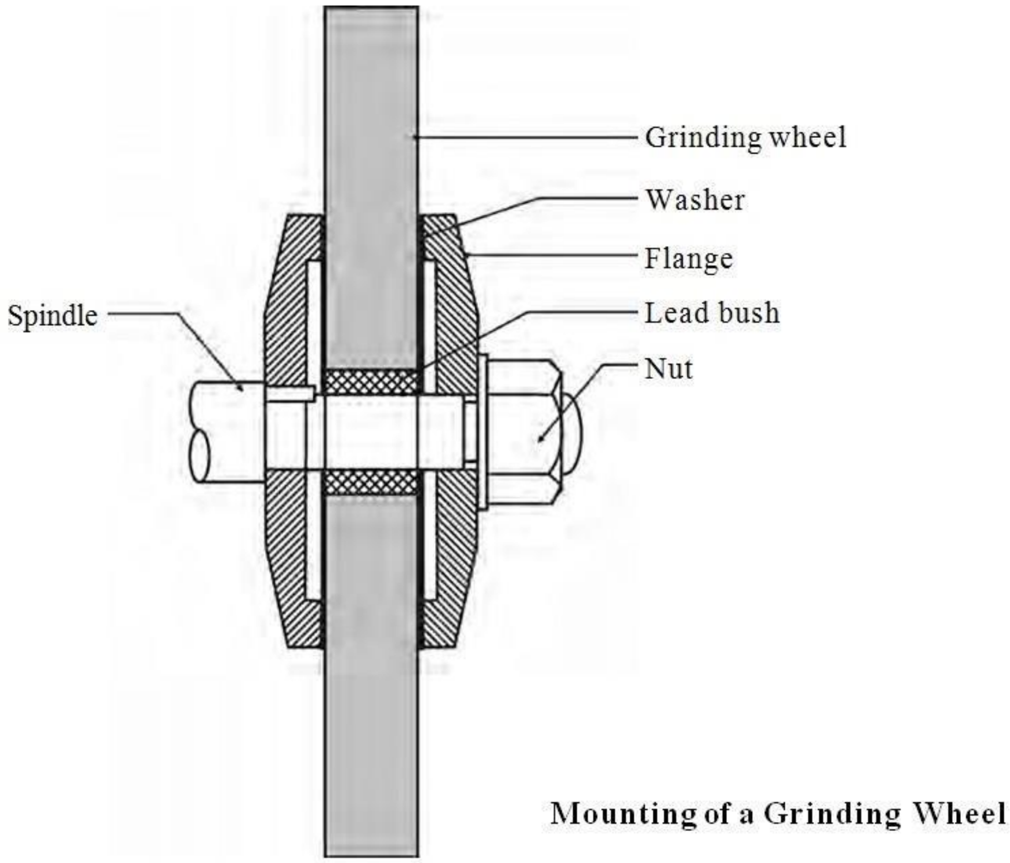


Fig.3.12 Mounting of a grinding wheel

4. There must be a flange on each side of the flange must be large enough to hold the wheel properly, at least the flange diameter must be equal to the half of the grinding wheel diameter. Both the flanges should be of same diameter.
5. The sides of the wheel and the flanges should be Flanges contact the wheel only with the annular clamping area.
6. Washers of compressible materials such as cardboard, leather, rubber, not over 1.5 mm thick should be fitted between the wheel and its flanges. The diameter of washers may be normally equal to the diameter of the flanges.

7. The inner flange should be keyed to the spindle, whereas the outer flange should have an easy sliding fit on the spindle so that it can adjust itself tightly to give a uniform bearing on the wheel and the compressible washers.
8. The nut should be tightened to hold the wheel firmly. Undue tightness is unnecessary and undesirable as excessive clamping strain is liable to damage the wheel.
9. The wheel guard should be placed and tightened before the machine is started.
10. After mounting the wheel, the machine is The grinding wheel should be allowed to idle for a period of about 10 to 15 minutes. Grinding wheels must be dressed and trued before any work can be started.

GRINDING METHODS

1. Surface Grinding

Surface grinding is used to produce a smooth finish on flat surfaces. It is a widely used abrasive machining process in which a spinning wheel covered in rough particles (grinding wheel) cuts chips of metallic or nonmetallic substance from a workpiece, making a face of it flat or smooth.

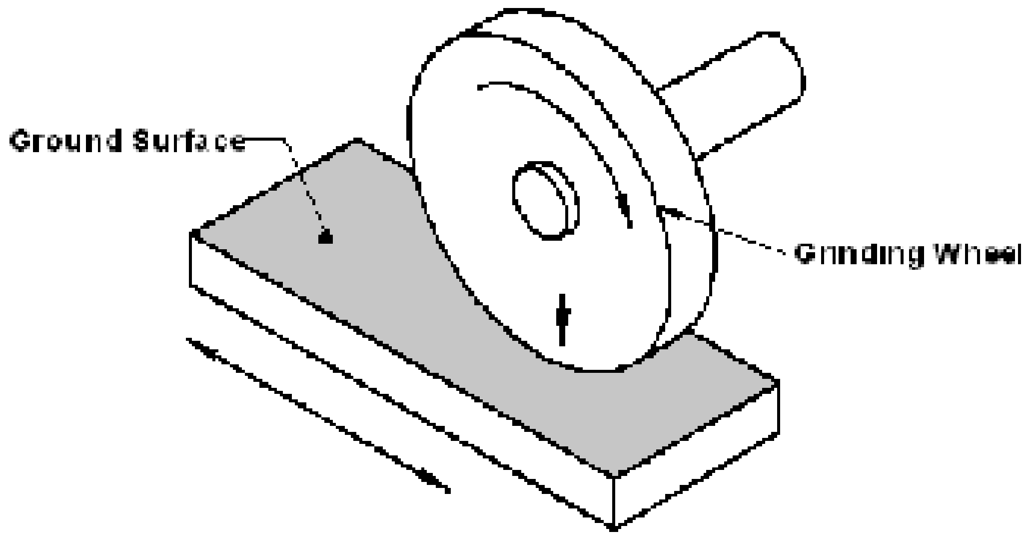


Fig.3.13 Surface Grinding

2. Cylindrical Grinding

Cylindrical Grinder Operation provides a detailed overview of the steps needed to perform the various types of operations possible on a cylindrical grinder. Operations performed on the cylindrical grinder include plunge, traverse, center-type, chucking-type, ID, profile, and taper grinding. Different steps and considerations must be taken in order to perform each type of operation; including setting the grinding variables and using the appropriate machine components and controls.

In order to perform successful cylindrical grinding operations, operators must have a solid foundational knowledge of proper grinding methods. This class provides the practical steps and considerations for cylindrical grinding various workpieces from start to finish, which gives operators an understanding of grinding before ever turning on the machine.

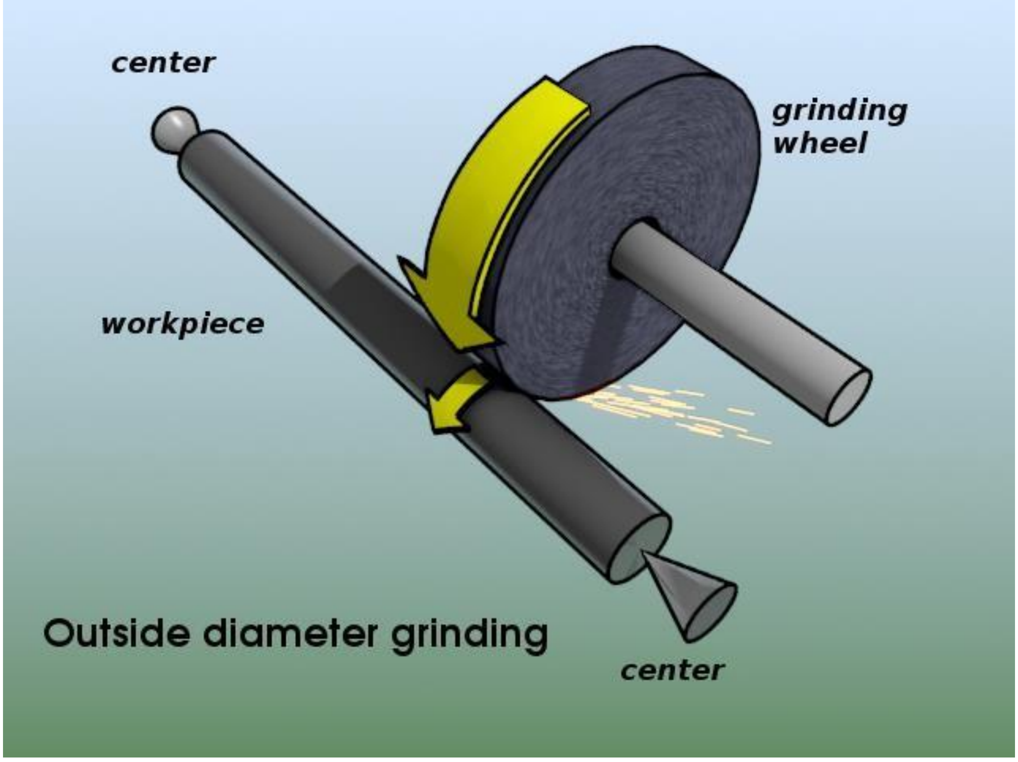


Fig.3.14 Cylindrical grinding

3. Centre less Grinding

Centre less Grinding is a form of grinding where there is no collet or pair of centers holding the object in place. Instead, there is a regulating wheel positioned on the opposite side of the object to the grinding wheel.

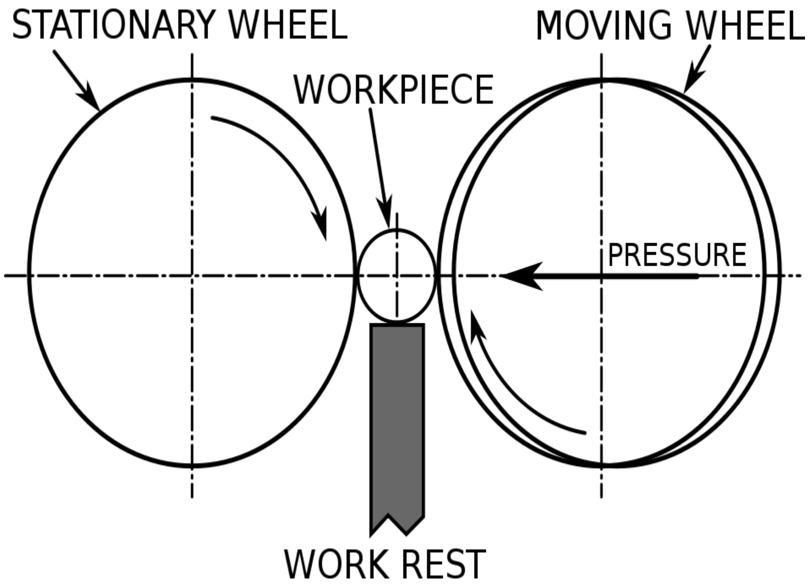


Fig.3.15 Centerless grinding

A work rest keeps the object at the appropriate height but has no bearing on its rotary speed. The work blade is angled slightly towards the regulating wheel, with the workpiece centerline above the centerlines of the regulating and grinding wheel; this means that high spots do not tend to generate corresponding opposite low spots, and hence the roundness of parts can be improved. Centerless grinding is much easier to combine with automatic loading procedures than centered grinding; through feed grinding, where the regulating wheel is held at a slight angle to the part so that there is a force feeding the part through the grinder is particularly efficient.

GRINDING MACHINE

A grinding machine, often shortened to grinder, is any of various power tools or machine tools used for grinding, which is a type of machining using an abrasive wheel as the cutting tool. Each grain of abrasive on the wheel's surface cuts a small chip from the work piece via shear deformation.

1. Cylindrical Grinding Machine

The cylindrical grinder is a type of grinding machine used to shape the outside of an object. The cylindrical grinder can work on a variety of shapes; however the object must have a central axis of rotation. This includes but is not limited to such shapes as a cylinder, an ellipse, a cam, or a crankshaft.

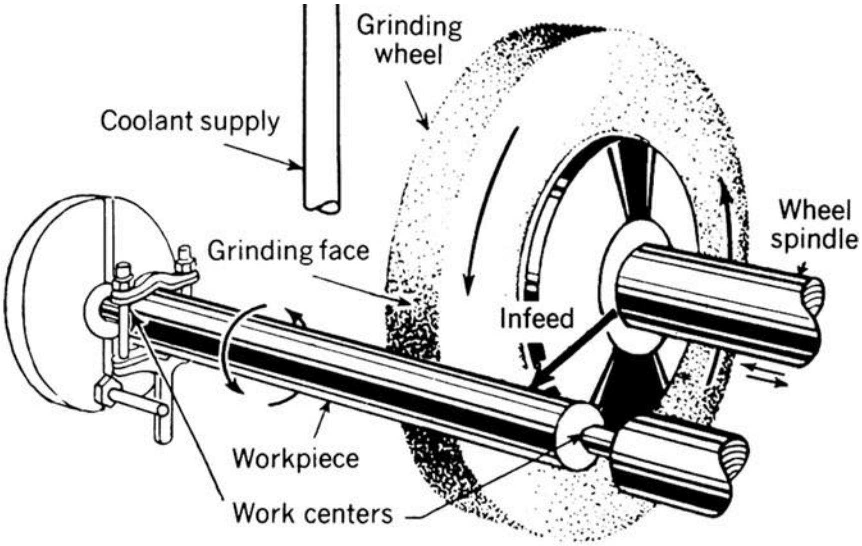


Fig.3.16 Cylindrical Grinding Machine

2. Centreless Grinding Machine

Centreless grinding is a machining process that uses abrasive cutting to remove material from a workpiece. Centreless grinding is an outer diameter grinding process. In difference from other cylindrical processes, where the work piece is held in the grinding machine, while grinding between centers, the work piece is not mechanically constrained during centreless grinding. Therefore the parts to be ground on a centreless grinder do not need center holes, drivers or work head fixtures at the ends. Instead, the work piece is supported in the grinding machine on its own outer diameter by a work blade and by the regulating wheel. The work piece is rotating between a high speed grinding wheel and a slower speed regulating wheel with a smaller diameter.

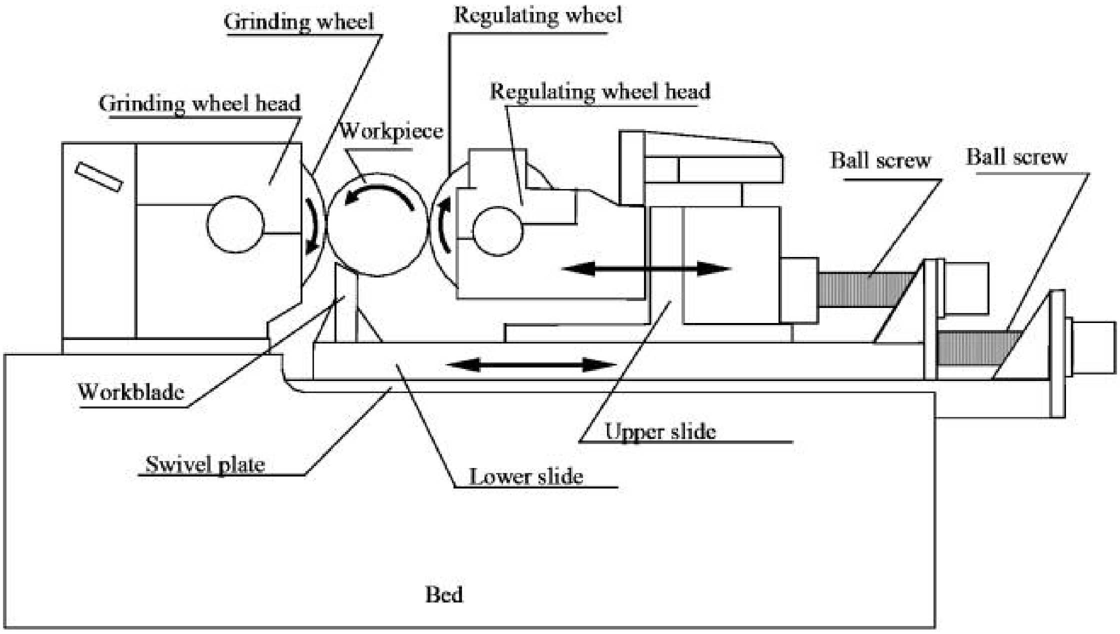


Fig.3.17 Centerless Grinding Machine

The blade of the grinding machine is usually positioned in a way that the center of the work piece is higher than the virtual line between the centers of the regulating wheel and the grinding wheel. Also the blade is designed with an angle in order to ensure that the work piece is fixed between the blade and the regulating wheel. The regulating wheel consists of soft material like rubber and can contain some hard grain material to achieve good traction between work piece and regulating wheel.

3. Tool and Cutter Grinder

A tool and cutter grinder is used to sharpen milling cutters and tool bits along with a host of other cutting tools. It is an extremely versatile machine used to perform a variety of grinding operations: surface, cylindrical, or complex shapes.

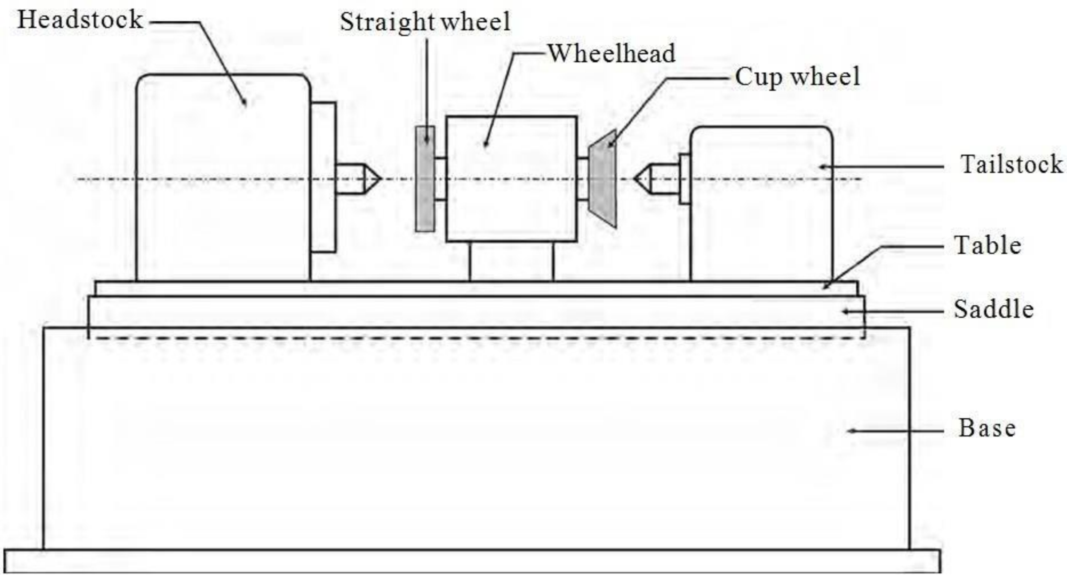


Fig.3.18 Tool and Grinder Machine

4. SURFACE GRINDING MACHINE

This machine may be similar to a milling machine used mainly to grind flat surface. However, some types of surface grinders are also capable of producing contour surface with formed grinding wheel. Basically there are four different types of surface grinding machines characterized by the movement of their tables and the orientation of grinding wheel spindles as follows:

1. Horizontal spindle and reciprocating table
2. Vertical spindle and reciprocating table
3. Horizontal spindle and rotary table
4. Vertical spindle and rotary table

1. Horizontal spindle and reciprocating table

A disc type grinding wheel performs the grinding action with its peripheral surface. Both traverse and plunge grinding can be carried out in this machine.

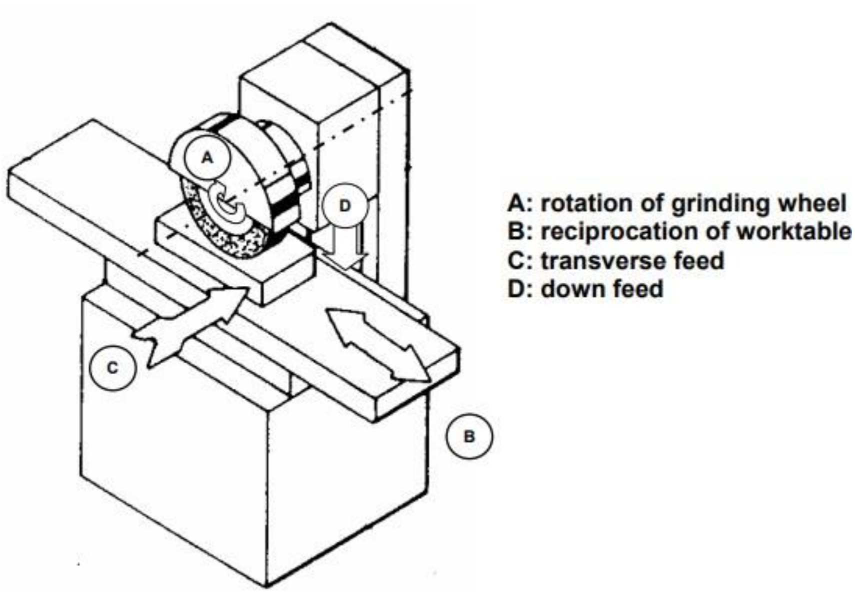


Fig.3.19 Horizontal spindle and reciprocating table

2. Vertical spindle and reciprocating table

This grinding machine with all working motions. The grinding operation is similar to that of face milling on a vertical milling machine. In this machine a cup shaped wheel grinds the work piece over its full width using end face of the wheel.

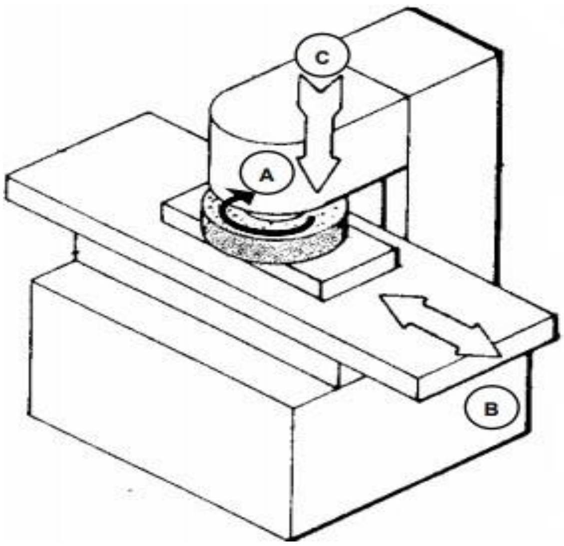


Fig.3.20 Vertical spindle and reciprocating table

5. INTERNAL GRINDING MACHINE

This machine is used to produce internal cylindrical surface. The surface may be straight, tapered, grooved or profiled. Internal grinding machine is employed for finishing an accurate hole in a hardened part and also, when it is possible to apply other methods of finishing an accurate hole. Depending upon the shape of the work piece two grinding methods have been used:

1. Grinding of work piece which can rotate.
2. Grinding of work piece which cannot rotate.

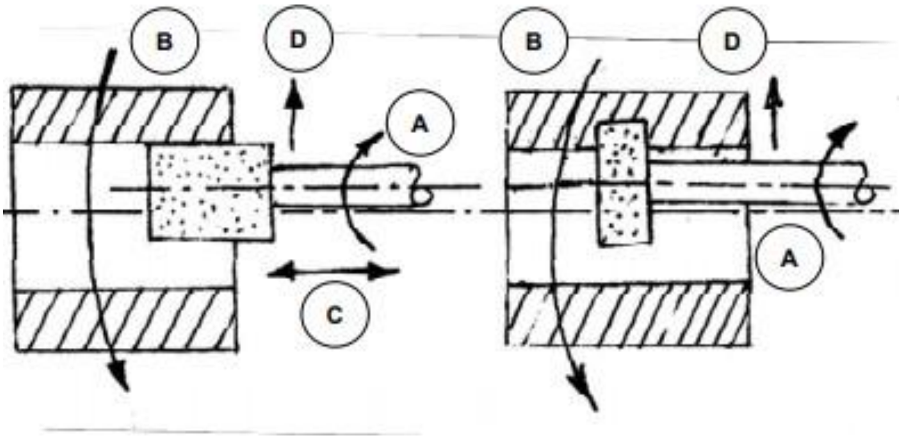


Fig.3.21 Internal Grinding Machine

SELECTION OF GRINDING WHEEL

1. Size and shape

Nine standard grinding wheel shapes have been established by the Grinding Wheel Manufacturers' Association. These are shown in Fig. 1. The dimensional sizes have also been standardized.

Although these standard shapes represent the group most used in grinding operations, there are many special shapes which are used less frequently or in highly specialized grinding operations.

2. Abrasive

There are two main types of abrasive.

- Silicon carbide: This is very sharp and extremely hard, but its use as an abrasive is limited to some extent by its brittleness. Silicon carbide should be used in the grinding of low tensile strength materials such as grey cast-iron, chilled iron, bronze, aluminium, copper, brass and non-metallic materials. A special form of silicon carbide, green in colour, is used to grind carbide-tipped tools.
- Aluminium oxide*:* This is slightly softer than silicon carbide but is much tougher. It should be used in the grinding of high tensile-strength materials such as alloy steel, annealed malleable iron and strong bronzes. There is also another form of aluminium oxide which is white in colour as opposed to the normal brown variety. This white alumina tends to fracture more readily than the regular (brown) aluminium oxide, and more and sharper cutting edges are therefore presented to the work. Grinding wheels of white alumina should be selected when grinding hardened tool steels or for use in general tool room grinding.

3. Grit size

In general, coarse grit wheels are used for fast removal of material. Fine grit wheels are used where finish is considered important. Coarse wheels may be used for soft materials, but a fine grit should generally be used for hard and brittle materials.

4. Bond

The bond material holds the abrasive particles in the form of a wheel. When these particles become blunt or break down completely, the bond material releases the blunt grains and thereby exposes new, sharp particles to continue the work. This action occurs because of the increase in grinding pressures resulting from the particles of grit becoming dull. The four principal bond types are vitrified, shellac, resinoid and rubber.

5. **Grade**

Grade is a measure of “holding power” for the abrasive grains, which determines the degree of hardness or softness of a grinding wheel. Most manufacturers indicate the grade of wheel by a letter. Although standards vary since grade is not an exact value, the grade letters generally increase in hardness from E to Z. The selection of correct wheel grade for specific grinding applications is discussed later in this article, but hard wheels are usually recommended for soft materials and soft wheels for hard materials.

6. **Structure**

This refers to the spacing of the grit or grains and indicates the number of cutting edges per unit area of wheel face.

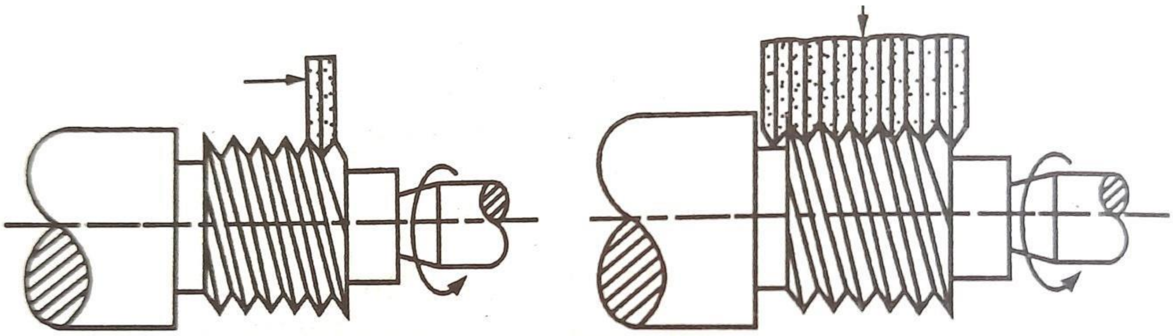
The structure to use depends mainly on the physical properties of the material to be ground and the type of finish required. Soft, ductile materials require greater chip clearance and, therefore, a wide spacing of the grit. A fine finish requires a wheel with a close spacing of the abrasive particles.

THREAD GRINDING

This process is employed as a finishing/forming operation on a number of screw threads. It is used in the following manners:

1. Single wheel grinding method: This used is utilized for blanks of larger lengths. In this method, a thin disc type grinding wheel is used and threads are finished in single pass of grinding wheel.

2. Plunge cut grinding method: This used is utilized for blanks of smaller lengths. The length of grinding wheel is larger than that of the thread to be ground.



(a) Single Wheel Grinding (b) Plunge Cut Grinding

Fig.3.22 Thread Grinding

Subject : Workshop Technology-III

Semester : 5th

Branch : Mechanical Engineering

CONTENT

4. **Modern Machining Processes**

   Mechanical Process - Ultrasonic machining (USM): Introduction, principle, process, advantages and limitations, applications

   Electro Chemical Processes - Electro Chemical Machining (ECM) – Fundamental principle, process, applications

   Electrical Discharge Machining (EDM) - Introduction, basic EDM circuit, Principle, metal removing rate, dielectric fluid, applications

   Laser Beam Machining (LBM) – Introduction, machining process and applications

   Plasma Arc Machining (PAM) and welding – Introduction, principle process and applications

CONTENT

5. Metallic Coating Processes

Metal spraying – Wire process, powder coating process, applications

Electro plating, anodizing and galvanizing

Organic Coatings- oil base paint, rubber base coating

CONTENT

6. Metal Finishing Processes

Purpose of finishing surfaces.
Surface roughness-Definition and units
Honing Process, its applications
Description of hones.
Brief idea of honing machines.
Lapping process, its applications.
Description of lapping compounds and tools.
Brief idea of lapping machines.
Polishing
Buffing.
Burnishing

UNIT- 4
MODERN MACHINING PROCESSES

INTRODUCTION

Types of Manufacturing Processes:

- Manufacturing processes can be broadly divided into two groups

1. Primary manufacturing processes
2. Secondary manufacturing processes.

- The Primary manufacturing process provides *basic shape* and size to the material as per designer's requirement. For example: Casting, forming, powder metallurgy processes provide the basic shape and size.
- The Secondary manufacturing processes provide the *final shape* and size with tighter control on dimension, surface characteristics etc. Most of Material removal processes are mainly the secondary manufacturing processes.

INTRODUCTION

Material removal processes can be further divided into mainly two groups

1. Conventional Machining Processes
2. Non-Traditional Manufacturing Processes

Examples of conventional machining processes are turning, boring, milling, shaping,

broaching, slotting, grinding etc.

Examples of non conventional (or also called non traditional or unconventional) are

1. Ultrasonic Machining (USM),
2. Electro-discharge Machining (EDM) ,
3. Electro Chemical Machining (ECM) etc.

COMPARISON

	Conventional	Non Conventional
Chip Formation	Generally macroscopic chip formation by shear deformation.	Material removal may occur with chip formation or even no chip formation may take place. For example in case of Electrochemical machining material removal occurs due to electrochemical dissolution at atomic level
Tool	There may be a physical tool present. for example a cutting tool in a Lathe Machine,	There may or may not be a physical tool present. For example in laser jet machining, machining is carried out by laser beam. However in Electrochemical Machining there is a physical tool that is very much required for machining.

COMPARISON

	Conventional	Non Conventional
Tool Contact	Conventional machining involves the direct contact of tool and work –piece	Whereas unconventional machining does not require the direct contact of tool and work piece.
Surface Finish	Lower accuracy and surface finish.	Higher accuracy and surface finish.

COMPARISON

	Conventional	Non Conventional
Material Economy	Suitable for every type of material economically.	Not Suitable for every type of material economically
Tool Life	Tool life is less due to high surface contact and wear.	Tool life is more
Material Wastage	Higher waste of material due to high wear.	Lower waste of material due to low or no wear.
Noise Level	Noisy operation mostly cause sound pollutions	Quieter operation mostly no sound pollutions are produced.
Cost	Lower capital cost	Higher Capital Cost

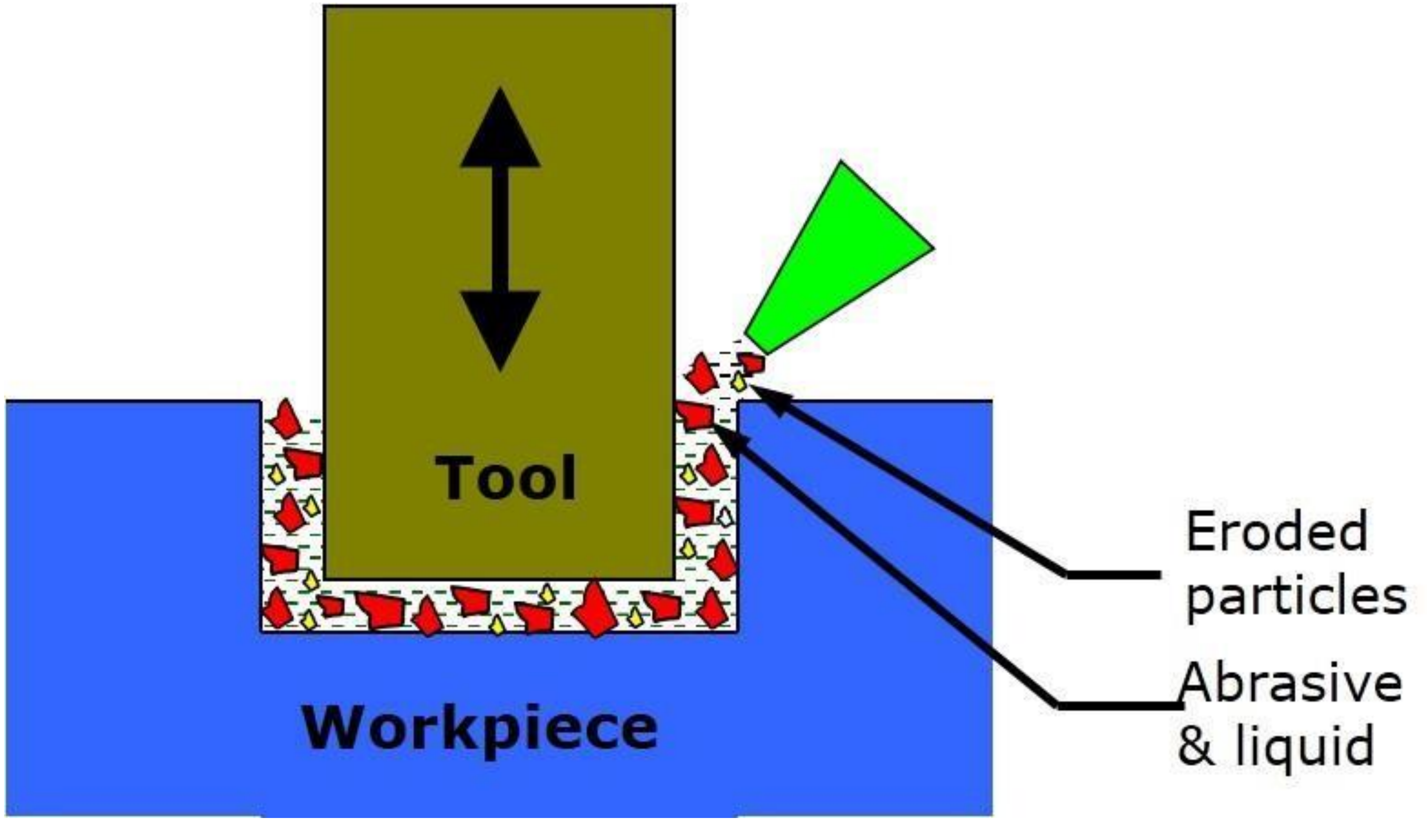
ULTRASONIC MACHINING

INTRODUCTION

- Ultrasonic machining is a non-traditional mechanical means of uniform stock material removal process
- It is applicable to both conductive and non conductive materials.
- Particularly suited for very hard and/or brittle materials such as graphite, glass, carbide, and ceramics.

PRINCIPLE

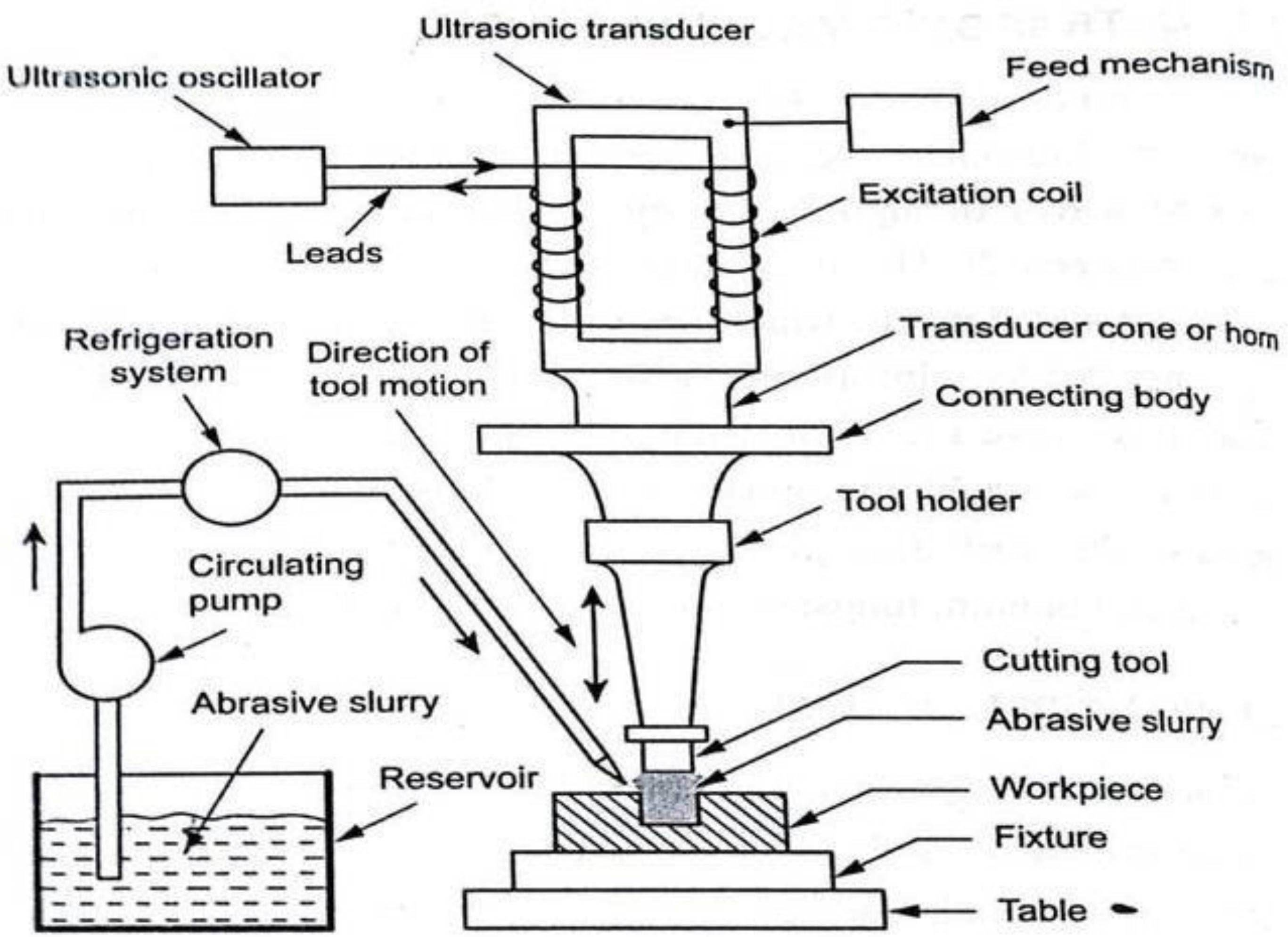
- The machining zone (between the tool and the work piece) is flooded with hard abrasive particles generally in the form of water based slurry.
- As the tool vibrates over the work piece, abrasive particles acts as indenter and indent both work and tool material .
- Abrasive particles , as they indent , the work material would remove the material from both tool and work piece.
- It uses formed tools, vibrations of high frequency and a suitable abrasive slurry mix.
- Ultrasonic range is possible with the help of piezoelectric materials.
- Frequency > 20,000 Hz.



- Ultrasonic range is possible with the help of piezoelectric materials.
- Frequency > 20,000 Hz.

ELEMENTS

1. Generator.
2. Transducer.
3. Concentrator.
4. Abrasive.
5. Tool.

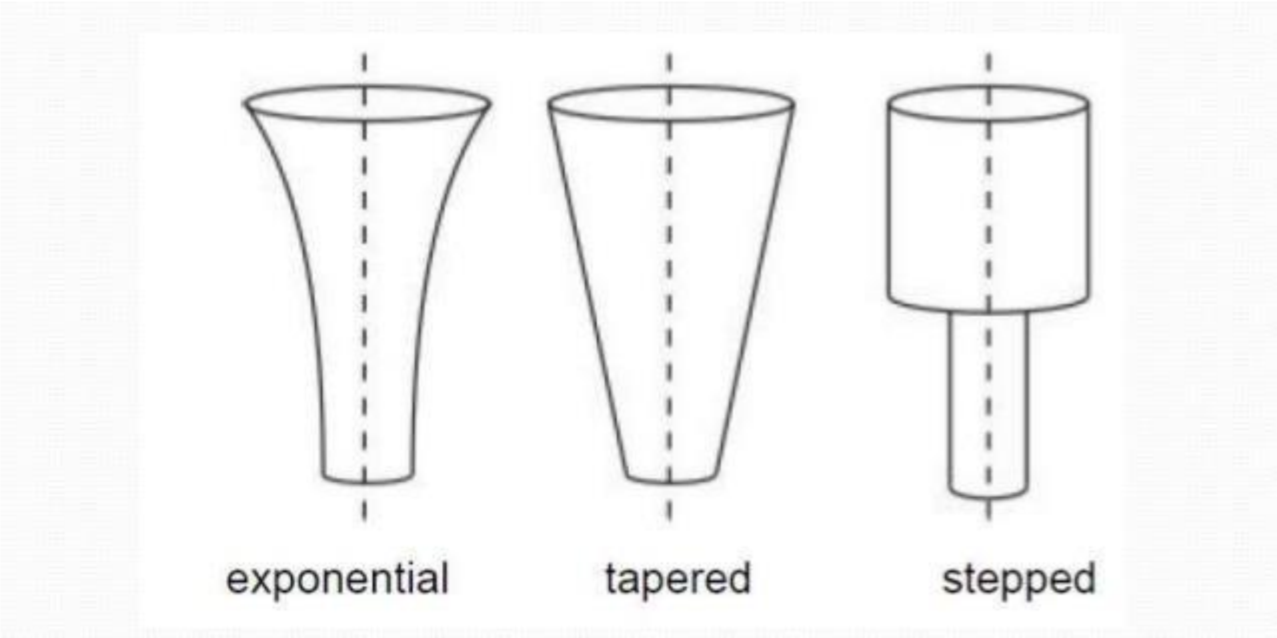


ELEMENTS

1. **Generator :** This unit converts low frequency (50 Hz) electrical po were to high frequency (20kHz) electrical power.
2. **Transducer:** The high frequency electrical signal is transmitted to traducer which converts it into high frequency low amplitude vibration. Essentially transducer converts electrical energy to mechanical vibration.
3. **Abrasive :** Common types of abrasive are : Boron carbide, Silicon carbide (SiC), Diamond etc. It is supplied at high pressure using pump through nozzle at the cutting zone.

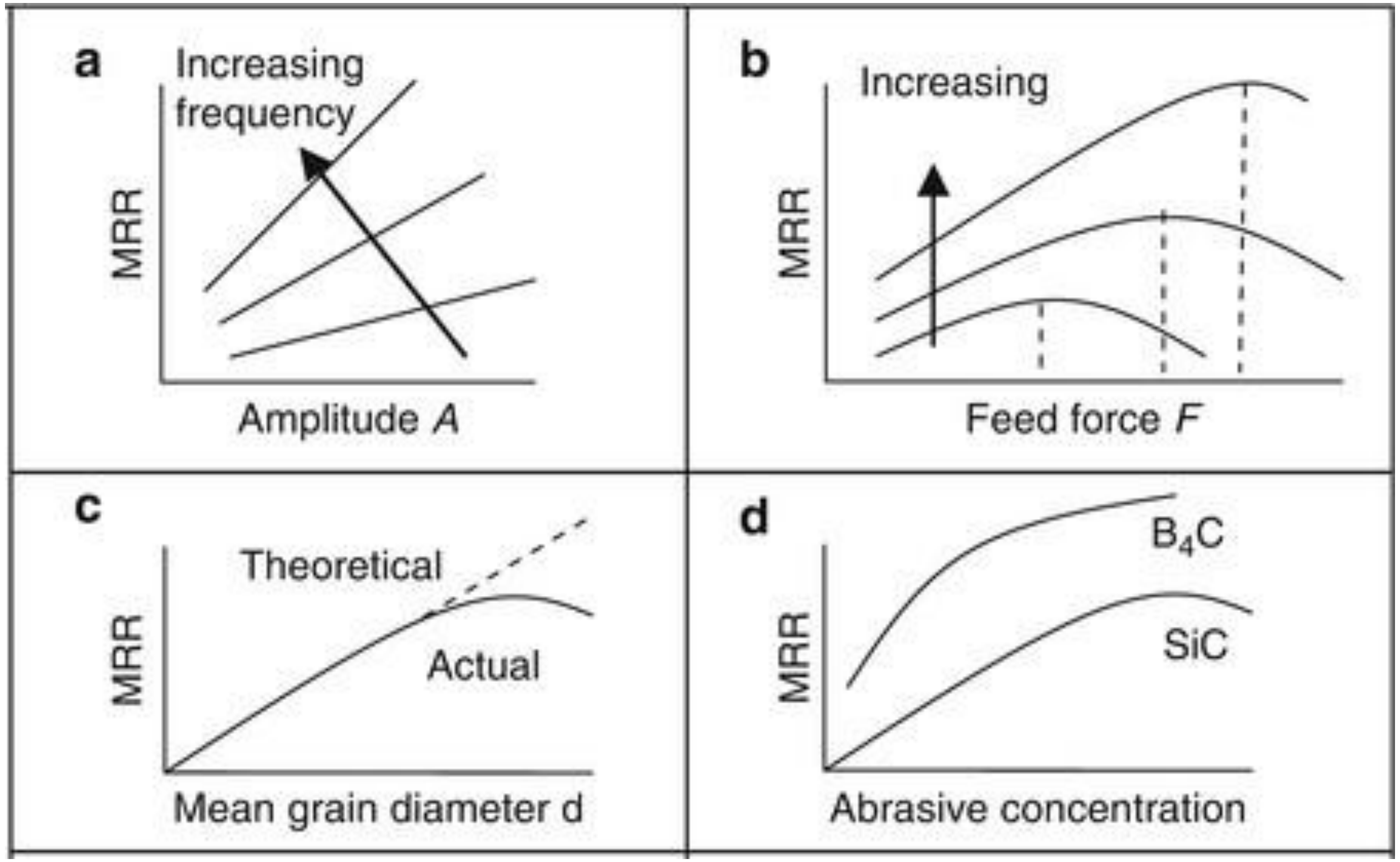
4. **Tool :** Tools are made of relatively ductile materials like Brass, Stainless steel or Mild steel so that Tool wear rate (TWR) can be minimized.

5. **Concentrator :** Tool cone focuses the mechanical energy produced by the transducer to the workpiece in such a manner that its utilization is optimum.



Material Removal Rate in USM

USM parameters such as frequency, abrasive size, contact load, amplitude of vibration etc influences the rate of metal removal and surface finish.



APPLICATIONS

- Machining of cavities in electrically non-conductive ceramics
- Used for multistep processing for fabricating silicon nitride turbine blades
- Large number of holes of small diameter could be machined.
- Used for machining hard, brittle metallic alloys, semiconductors, glass, ceramics, carbides etc.
- Used for machining round, square, irregular shaped holes and surface impressions.
- Used in machining of dies for wire drawing, punching and blanking operations
- USM can perform machining operations like drilling, grinding and milling operations on all materials which can be treated suitably with abrasives.

ADVANTAGES

- It can be used machine hard, brittle, fragile and non conductive material
- No heat is generated in work, therefore no significant changes in physical structure of work material
- Non-metal (because of the poor electrical conductivity) that cannot be machined by EDM and ECM can very well be machined by USM.
- It is burr less and distortion less processes.
- It can be adopted in conjunction with other new technologies like EDM,ECG,ECM.

DISADVANTAGES

- Low Metal removal rate.
- It is difficult to drill deep holes, as slurry movement is restricted.
- Tool wear rate is high due to abrasive particles. Tools made from brass, tungsten carbide, MS or tool steel will wear from the action of abrasive grit with a ratio that ranges from 1:1 to 200:1.
- USM can be used only when the hardness of work is more than 45 HRC.

ELECTRO CHEMICAL MACHINING

INTRODUCTION

- Electrochemical machining (ECM) is a method of removing metal particules by an electrochemical process instead of standard machining methods.
- To process complex materials which standard machining methods are insufficient.
- Also for processing extreme hard and brittle materials with high sensivity.

PRINCIPLE

- Electrochemical machining (ECM) is an electrolytic material removal process involving a negatively charged shaped electrode (cathode), a conductive fluid (electrolyte), and a conductive workpiece (anode).
- ECM is characterized as "reverse electroplating." The tool must be properly shaped, and provision for waste removal must be made.
- ECM is an electrolytic process and its basis is the phenomenon of electrolysis, whose laws were established by Faraday in 1833.

PROCESS

- In ECM one employs a cathode electrode shaped to provide the complementary structure in an anode work piece.
- A highly conductive electrolyte stream separates the cutting tool from the work piece, and metal removal is accomplished by passing a dc current of up to 100A/cm^2 through the salt solution cell.
- The pressurized electrolyte passes at high speed (10 to 60 m/s) through the gap (about 0.1 to 0.6 mm) between the work piece and the tool to prevent metal ions from plating onto the cathode tool and to remove the heat that is generated as a result of the high current flow.
- The rate of material removal is the same for hard or soft materials, and surface finishes are between 0.3 and 1 µm.

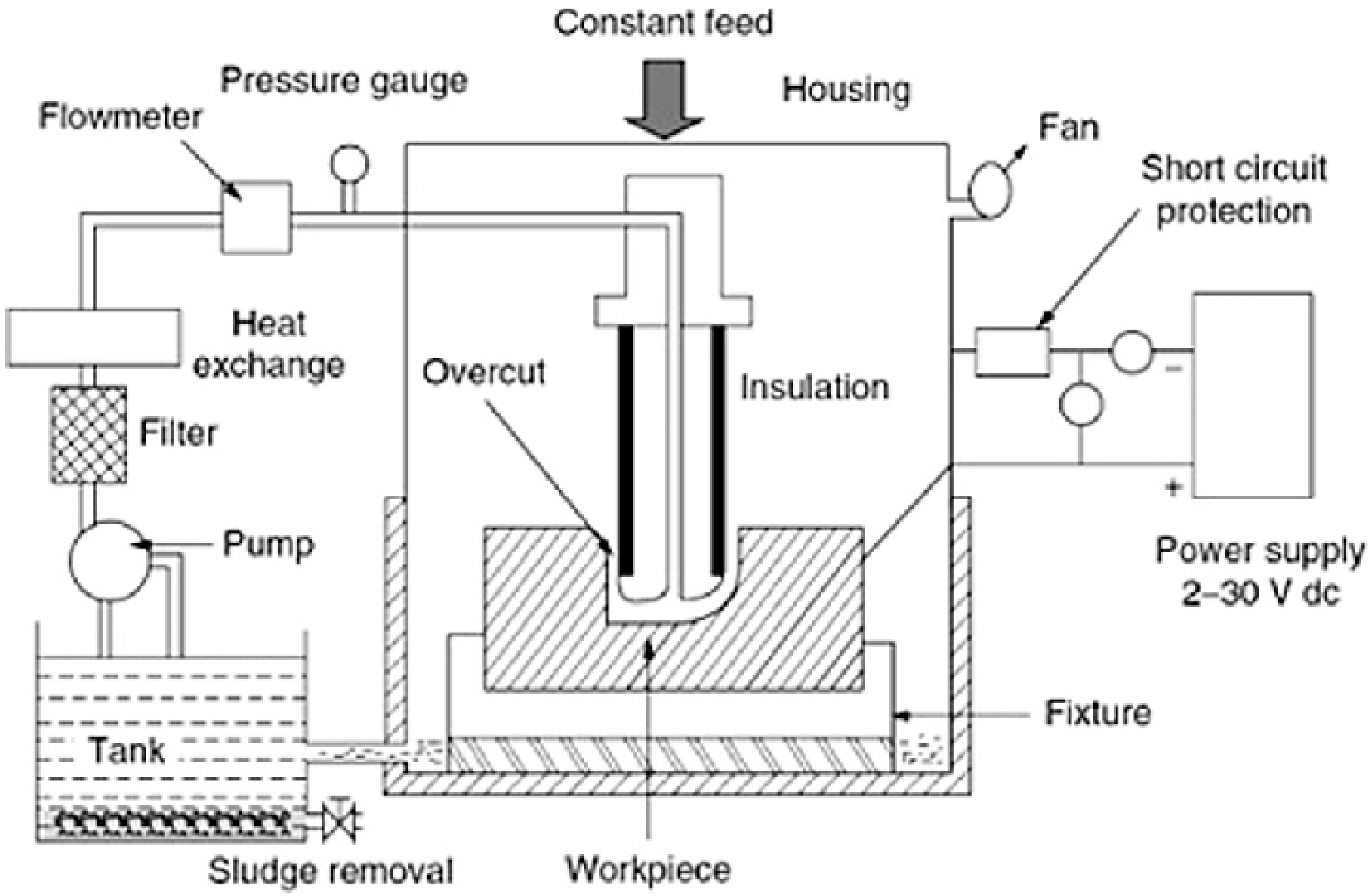


Fig. Electrochemical Machine

PROCESS

- The cathode is advanced into the anode work piece at a rate matching the dissolution rate, which is between 0.5 and 10 mm/min. The supply voltage commonly used in ECM ranges from 5 to 20 V, the lower values being used for finish machining (creating of a final smooth surface) and the higher voltages for rough machining.
- The cathode tool must have these four characteristics: be machinable, rigid (high Young's modulus), be a good conductor and have good corrosion resistance. The three most common cathode materials used are copper, brass, and stainless steel.
- Because there is no actual contact between the tool and the work, the tool does not have to be harder than the work, as in traditional machining methods. Hence, this is one of the few ways to machine very hard material; another is spark-discharge machining.

ADVANTAGES

- Components are not subject to either thermal or mechanical stress.
- There is no tool wear in ECM.
- Non-rigid and open work pieces can be machined easily as there is no contact between the tool and workpiece.
- Complex geometrical shapes can be machined repeatedly and accurately
- ECM is a time saving process when compared with conventional machining
- During drilling, deep holes can be made or several holes at once.
- Fragile parts which cannot take more loads and also brittle material which tend to develop cracks during machining can be machined easily in ECM

DISADVANTAGES

- More expensive than conventional machining.
- Need more area for installation.
- Electrolytes may destroy the equipment.
- Not environmentally friendly (sludge and other
- waste)
- High energy consumption.
- The danger of a burn in the case of a short circuit between the positive and negative leads.

APPLICATIONS

- The most common application of ECM is high accuracy duplication. Because there is no tool wear, it can be used repeatedly with a high degree of accuracy.
- It is also used to make cavities and holes in various products.
- It is commonly used on thin walled, easily deformable and brittle material because they would probably develop cracks with conventional machining.
- Applications are valid for highly sensitive working areas like; electronic, air and space industries.
- It has also contains many benefices that in great industries like telecommunication, automotive and defence industries.

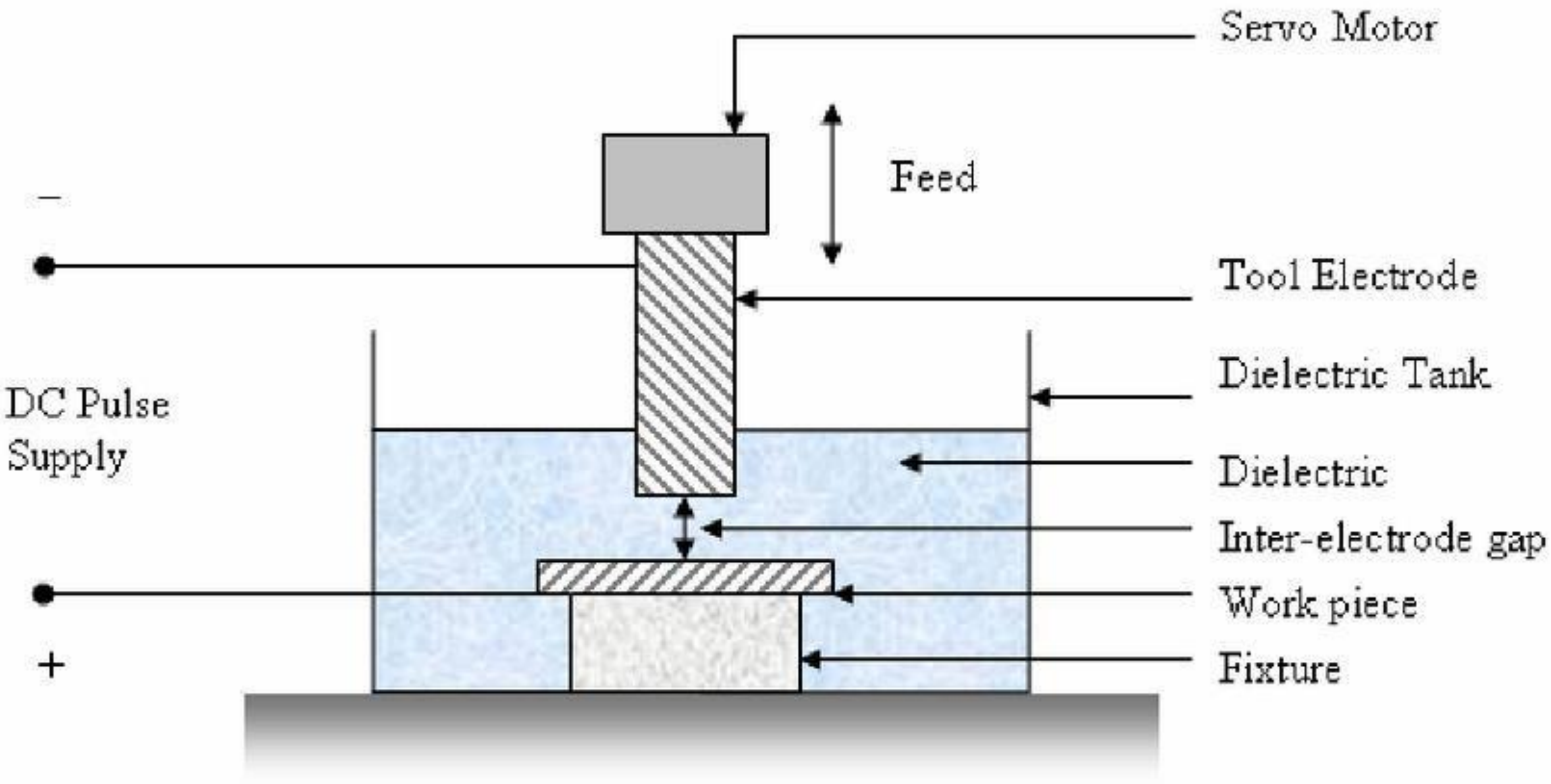
ELECTRIC DISCHARGE MACHINING

INTRODUCTION

- Sometimes it is referred to as spark machining, spark eroding. Its a manufacturing process whereby a desired shape is obtained using electrical discharges (sparks).
- Material is removed from the workpiece by a series of rapidly recurring current discharges between two electrodes, separated by a dielectric liquid and subject to an electric voltage
- EDM can be used on any material that is an electrical conductor
- Uses an electrode that sends out the sparks which erodes the metal
- Uses dielectric fluids for cooling and flushing of the material

PRINCIPLE

- Electrical Discharge Machining (EDM) is a controlled metal-removal process that is used to remove metal by means of electric spark erosion.
- In this process an electric spark is used as the cutting tool to cut (erode) the workpiece to produce the finished part to the desired shape.
- The metal-removal process is performed by applying a pulsating (ON/OFF) electrical charge of high-frequency current through the electrode to the workpiece. This removes (erodes) very tiny pieces of metal from the workpiece at a controlled rate.



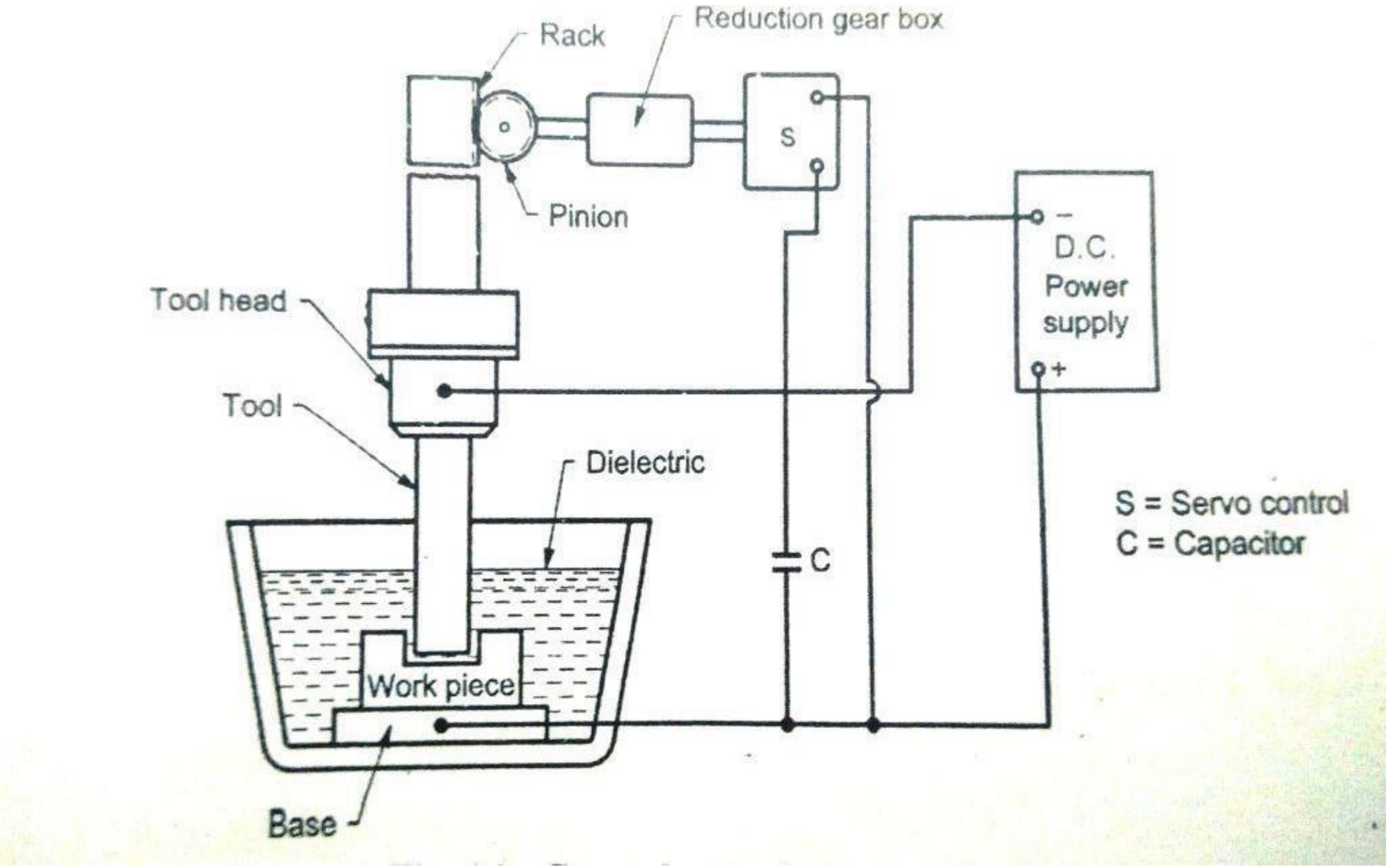
- One of the electrode is known as or "tool" or "electrode" and other electrode is workpiece.
- As distance between the two electrodes is reduced, the current intensity becomes greater than the strength of the dielectric (at least in some points) causing it to break.

Process

1. The main elements of EDM are:
2. Electric power supply
3. Dielectric medium
4. Work piece & tool
5. Servo control unit

- When a voltage of 50V to 450V is applied by the circuit, electron starts following from the tool (cathode) due to electric field and the gap is ionised.
- Due to this, there is drop in resistance and electric energy which results in electrical breakdown.

Process



Rack
Reduction gear box
S
Pinion
–
D.C.
Power
supply
+
Tool head
Tool
Dielectric
C
S = Servo control
C = Capacitor
Work piece
Base

Process

- As the temperature is very high, the metal gets melt and some portion of it may be vaporized also. These vaporised or melted particles of the metal are thrown away by the flowing dielectric.
- The machining speed of this process is mentioned in terms of an amount of metal removal.
  Specification:
  Tool material used - The tool (electrode) used is made of materials like brass, copper, cast iron, tungsten, graphite, steel, etc.
  Because these materials have properties like ;
- High wear resistance.
- High MRR
- Good conductor of electricity
- Easy to machine ability

Material Removal Rate

The metal removing rate is proportional to the working current value. The figures given below shows the variation of different parameter with meta removal rate.

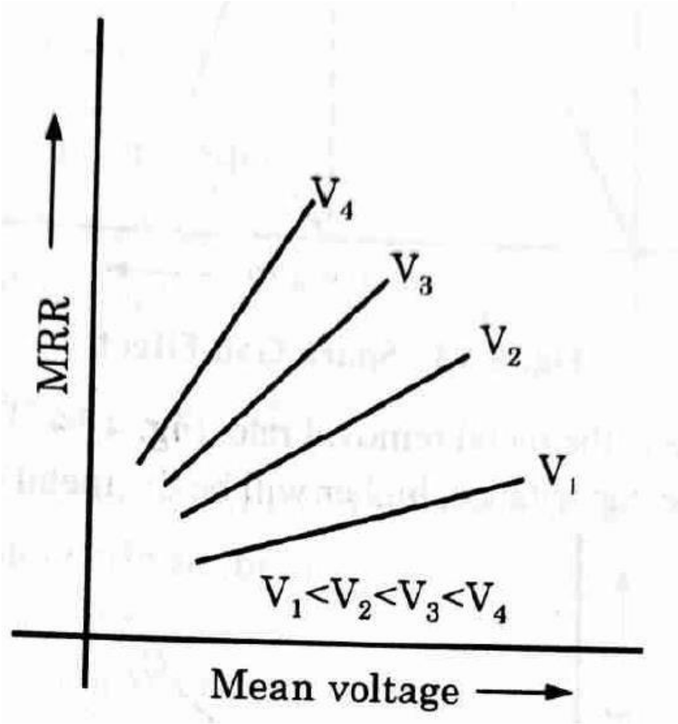


Fig. Voltage Effect

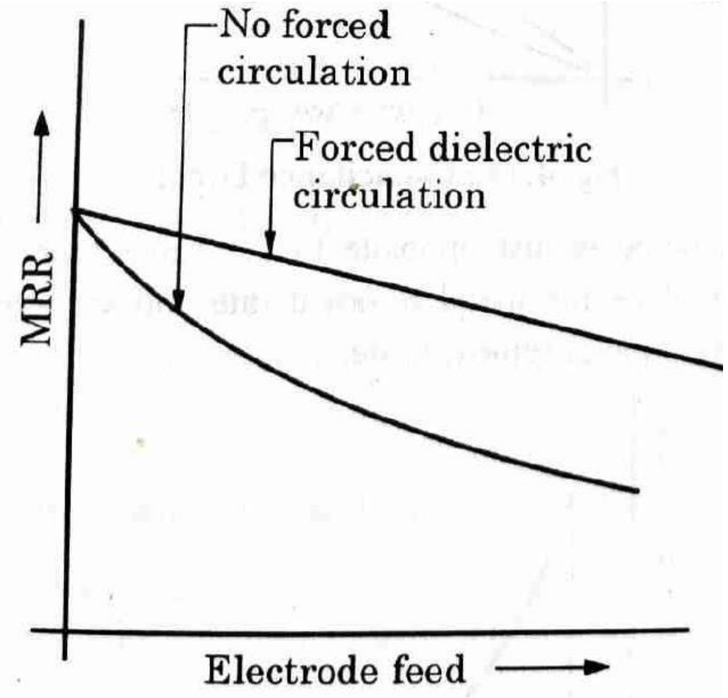


Fig. Dielectric Force Effect

MATERIAL REMOVAL RATE

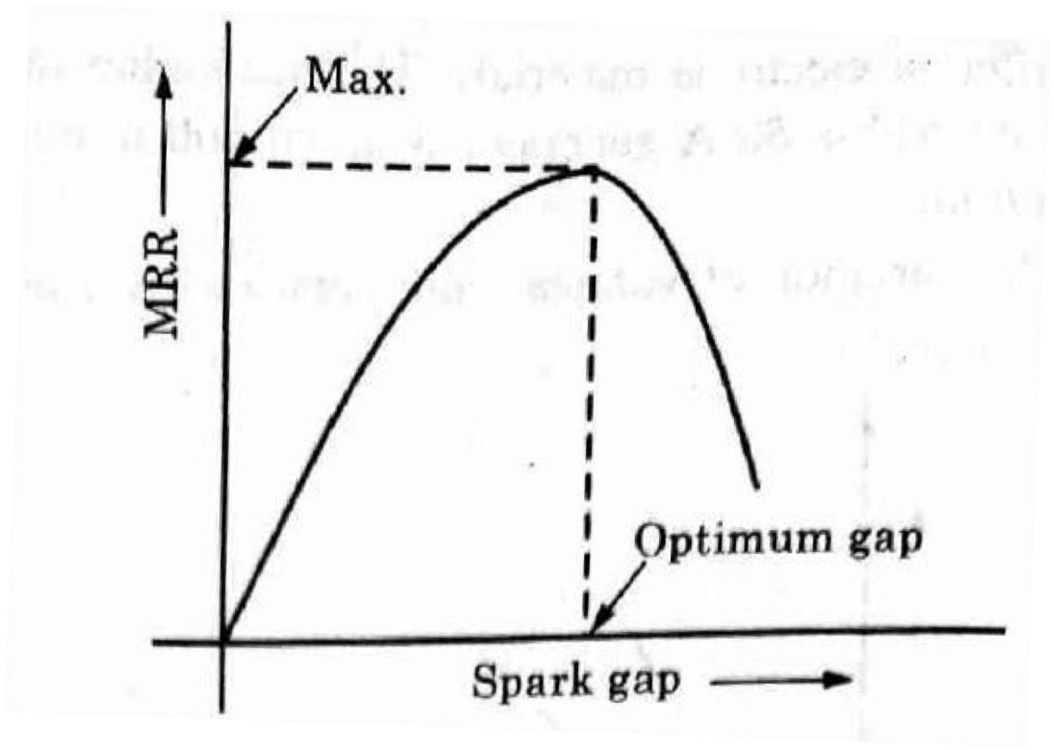


Fig. Spark Gap Effect

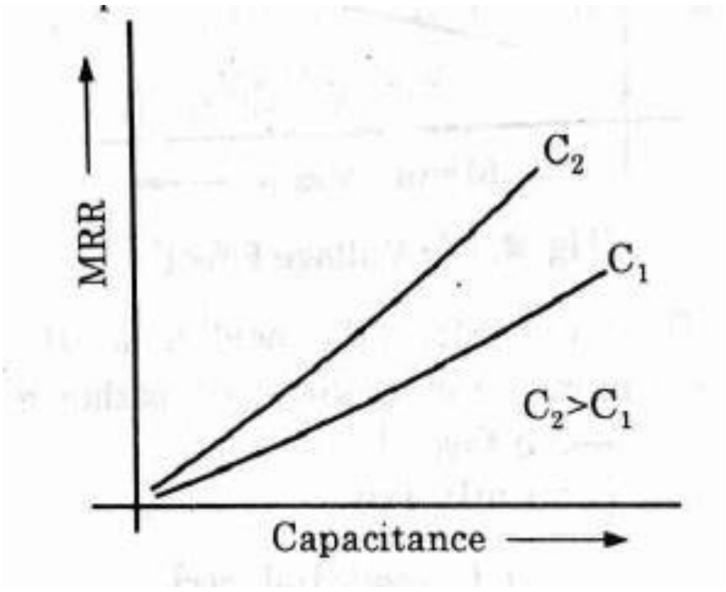


Fig. Capacitance Effect

APPLICATIONS

- Mainly EDM is used in tool and die manufacturing because in EDM process hardened materials can be machined easily.
- EDM is also used in automobile industries.
- Internal threads and internal gears can be cut in harden materials.
- Cuttings of slots in diesel fuel injector nozzles.
- It is used for resharpening of cutting tools and broaches.

ADVANTAGES

- As in EDM process there is no direct contact between tool and workpiece, hence highly complicated sections and weak materials can be machined without distortion.
- Any shape which is on the tool surface can be easily reproduced on the workpiece.
- It can be used for any hard material and even in heated treated conditions.
- Fine holes can be easily drilled.
- High degree of surface finish and accuracy.

DISADVANTAGES

- Only small workpiece can be machined easily.
- Materials which are only good conductor of electricity can be machined.
- EDM is having low MRR.
- Power required to drive the machine is high.
- Sharp corners cannot be produced by this process.
- Surface cracking may take place in some materials

LASER BEAM MACHINING

INTRODUCTION

- LASER stands for Light Amplification by Stimulated Emission of Radiation.
- LBM uses the light energy (focused coherent beam of monochromatic light) to remove material by vaporization and ablation (evaporation or melting of a surface through heating by friction).
- Laser beam can very easily be focused using optical lenses as their wavelength ranges from half micron to around 70 microns.

PRINCIPLE

- Key principle behind the operation of laser was first published in 1917 by Albert Einstein.
- He hypothesized that under the proper conditions light energy of a particular frequency could be used to stimulate the electrons in an atom to emit additional light exactly with the same characteristics as the original stimulating light source.
- Energy densities of the order of 100,000 kW/cm2.

PROCESS

- The workpiece is held in work holding device below the laser mechanism.
- As the xenon filled lamp is fired by discharging of a large capacitor through it, intense radiation from lamp excite the fluorescent impurity atom to a higher energy level.
- When the atom falls back to original energy level, an intense beam of visible light is emitted.
- When this light is reflected back again and again, more atoms are excited and stimulated to return to ground level.
- The stimulated light is transmitted through the reflective coating and this light focused at spot of workpiece with high energy density which melt and vaporize the metal.

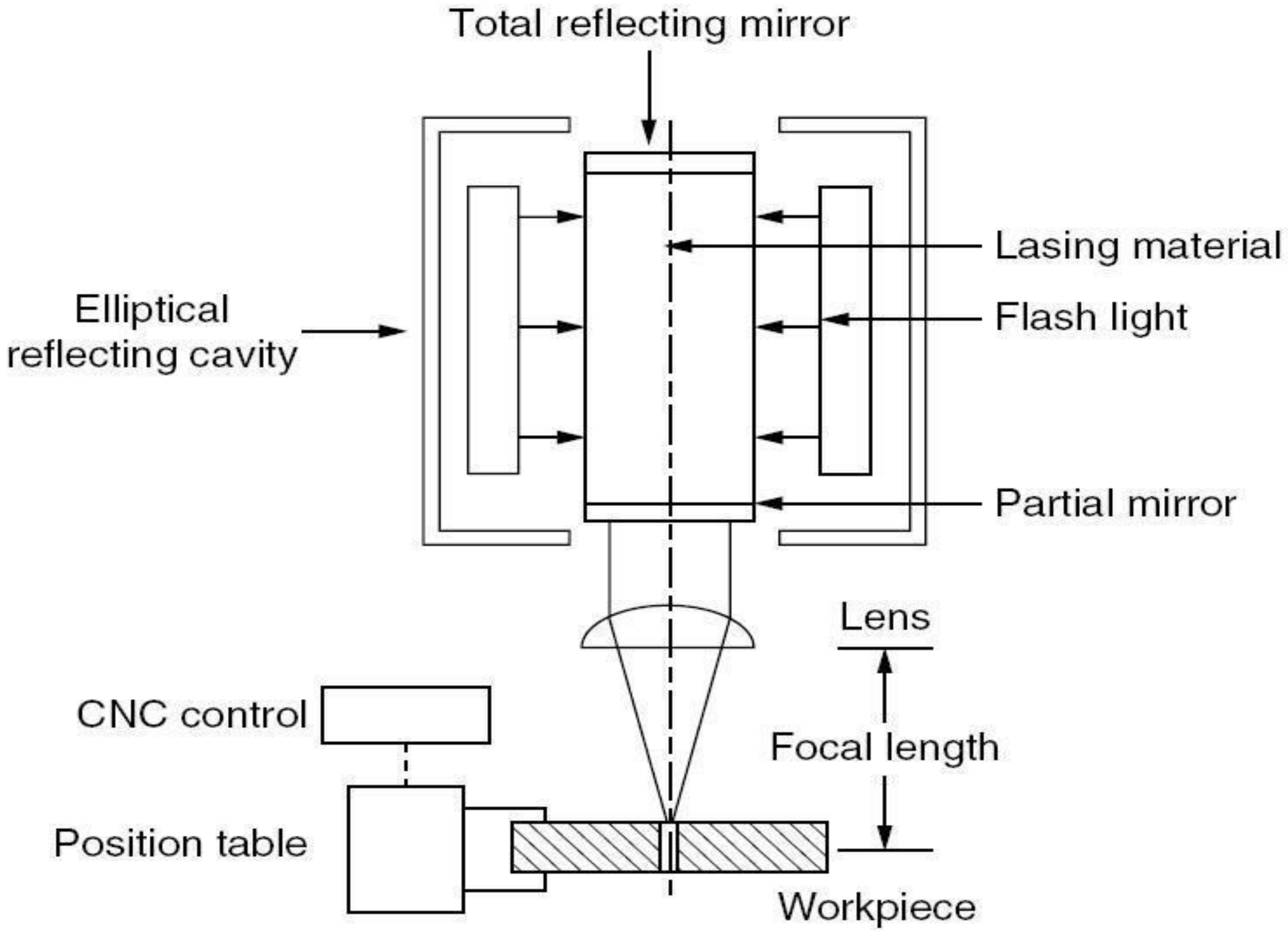


Fig. Laser Beam Machining

ADVANTAGES

- There is no mechanical contact between the tool and work.
- LBM could be used to drill micro holes with very large depth to diameter ratio (L/D aspect ratio).
- Large mechanical forces are not exerted upon the work piece.
- Laser operates in any transparent environment, including air, inert gas, vacuum and ever certain liquids.
- No burrs are produced in this process, so the cut is clean.
- Any metal or non-metal can be machined. E.g. tungsten, ceramics,hastealloy, zirconium, wood, paper etc.

DISADVANTAGES

- Currently, it cannot be used to cut metals that have high heat conductivity or high reflectivity. For eg. Aluminium, copper and their alloys cannot be cut satisfactorily.
- The machined area can be irregular due to off-axis modes that may be generated during laser action.
- The least diameter to which laser beam can be focused depends upon the laser beam divergence.
- Output energy from laser is difficult to control precisely.
- The metal removal rate of 0.0065 cm3/hr in LBM is among the slowest as compared to other machining processes

APPLICATIONS

- LBM is again a micromachining method which can be used for a wide range of metal processing applications such as metal removal, drilling, trepanning, metal shaping, cutting etc.
- Most of the LBM drilling applications are in small hole drilling such as fuel filters, carburetor nozzles etc.
- Round holes with diameter ranging from 0.127 to 1.27mm can be produced with L/D ration of 100:1.
- Laser beam can be used for making or engraving so as to produce controlled surface pattern on a workpiece.
- For vaporizing foreign material clogged in electron microscope apertures.

PLASMA ARC MACHINING AND WELDING

PLASMA ARC MACHINING

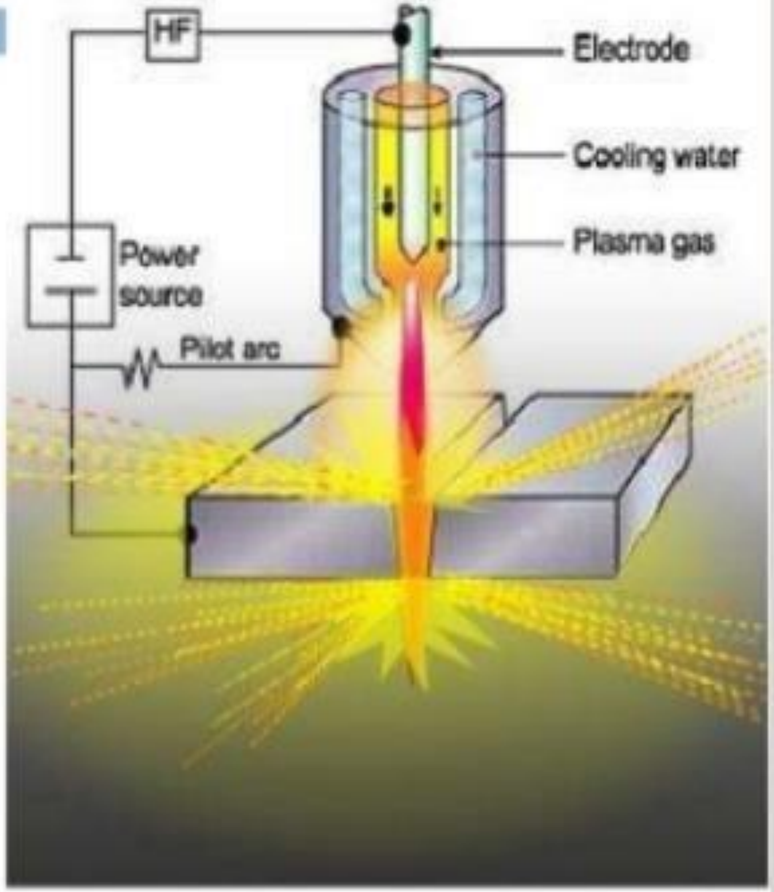
- The plasma arc machining process was introduced to the industries in 1964 as a method of bringing better control to the arc welding process in lower current ranges.

- Plasma-arc machining (PAM) employs a high-velocity jet of high-temperature gas to melt and displace material in its path.

- Today, plasma retains the original advantages it brought to industry by providing an advanced level of control and accuracy.

PRINCIPLE OF PAM

- Gases are heated and charged to plasma state.
- Plasma state is the superheated and electrically ionized gases at approximately 5000ºC.
- These gases are directed on the workpiece in the form of high velocity stream.



PROCESS DESCRIPTION OF PAM

- PLASMA GUN
- POWER SUPPLY
- COOLING MECHANISM
- WORK PIECE

PLASMA GUN

- The plasma gun consists of a tungsten electrode fitted in the chamber.
- The electrode is given negative polarity and nozzle of the gun is given positive polarity.
- A strong arc is established between the two terminals anode and cathode.
- There is a collision between molecules of gas and electrons of the established arc.
- Gas molecules get ionized and plasma state is formed.
- Plasma is directed to the workpiece with high velocity.

POWER SUPPLY

- Power supply (DC) is used to develop two terminals in the plasma gun.
- A tungsten electrode is inserted to the gun and made cathode and nozzle of the gun is made anode.
- Heavy potential difference is applied across the electrodes to develop plasma state of gases.

COOLING MECHANISM

- Hot gases continuously comes out of nozzle so there are chances of its over heating.

- A water jacket is used to surround the nozzle to avoid its overheating.

WORK PIECE

- Work piece of different materials can be processed by PAM process.
- Ex: aluminium, magnesium, stainless steels and carbon and alloy steels.

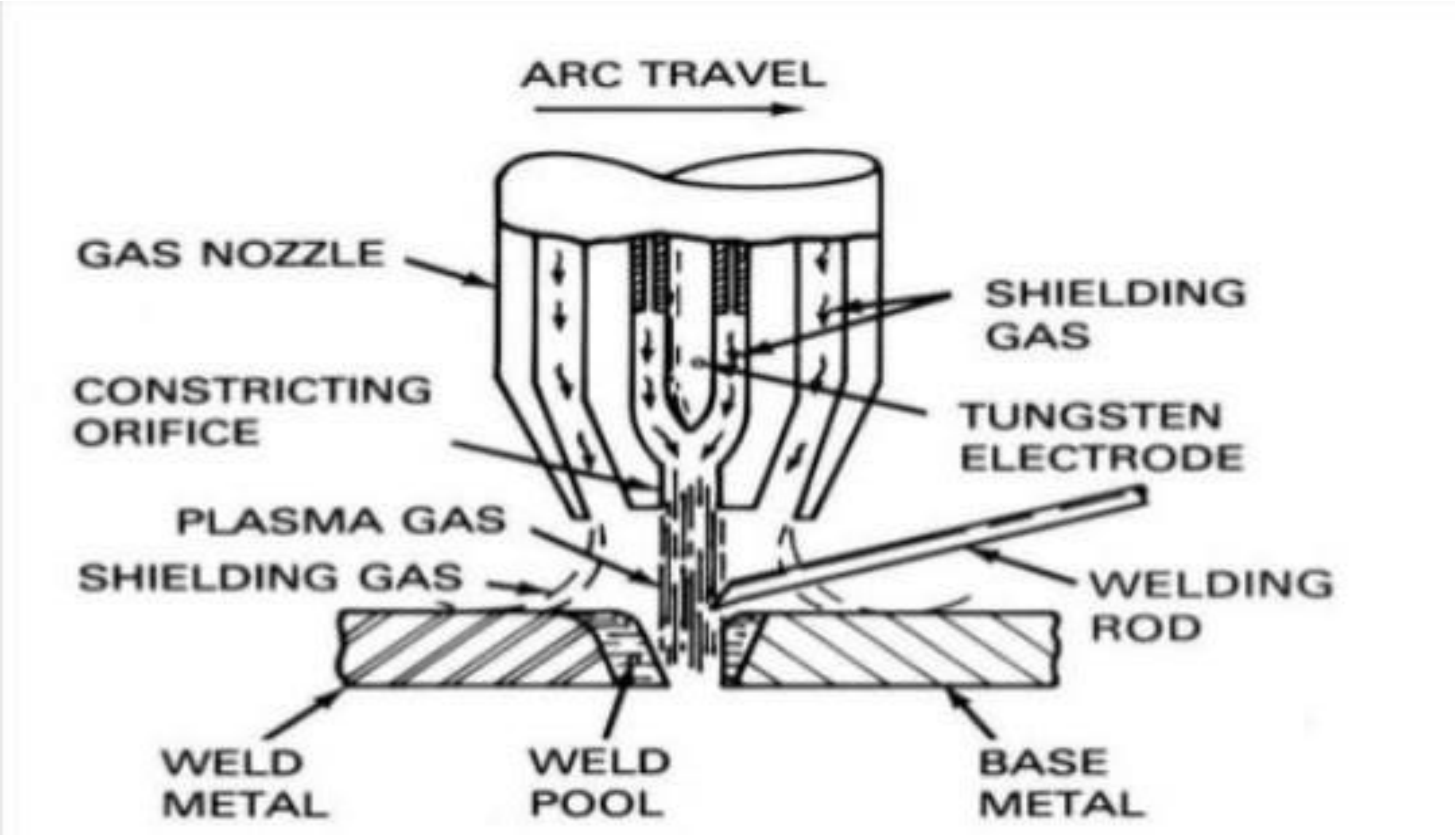
APPLICATIONS OF PAM

- In tube mill application.
- Welding of cryogenic, aerospace and high temperature corrosion resistant alloys.
- Nuclear submarine pipe system.
- Welding steel Rocket motor case.
- Welding of stainless steel tubes.
- Welding titanium plates up to 8mm thickness.

PLASMA ARC WELDING

- Arc welding process that produces coalescence of metals by heating them with a constricted arc between an electrode and the work piece (transferred arc) or between the electrode and the water-cooled constricting nozzle (non transferred arc) .
- Plasma: A gaseous mixture of positive ions, electrons and neutral gas molecules.

PRINCIPLE OF PAW



PROCESS OF PAW

- Gas which is heated to an extremely high temperature and ionized so that it becomes electrically conductive.
- PAW process uses this plasma to transfer an electric arc to the work piece.
- The metal to be welded is melted by the intense heat of the arc and fuses together.

APPLICATIONS OF PAM

- Aerospace Industries
- Cryogenics
- Foodstuff and Chemical Industries
- Machine and Plant Construction
- Automobiles and Railways
- Ship Construction
- Tank Equipment and Pipeline Construction etc.

UNIT- 5

METAL COATING PROCESSES

INTRODUCTION

- A metallic coating forms a corrosion resistant protective layer that can withstand harsh environmental conditions by changing the surface properties of the material on which it is applied.
- Metallic coatings contain a metallic element or alloy. Metallic coatings can be applied by using a sprayer, electrochemically, chemically or mechanically.
- Metallic coatings are applied on equipment requiring a shiny or glossy appearance and protection from sunlight, corrosion and oxidation.

METAL SPRAYING

INTRODUCTION

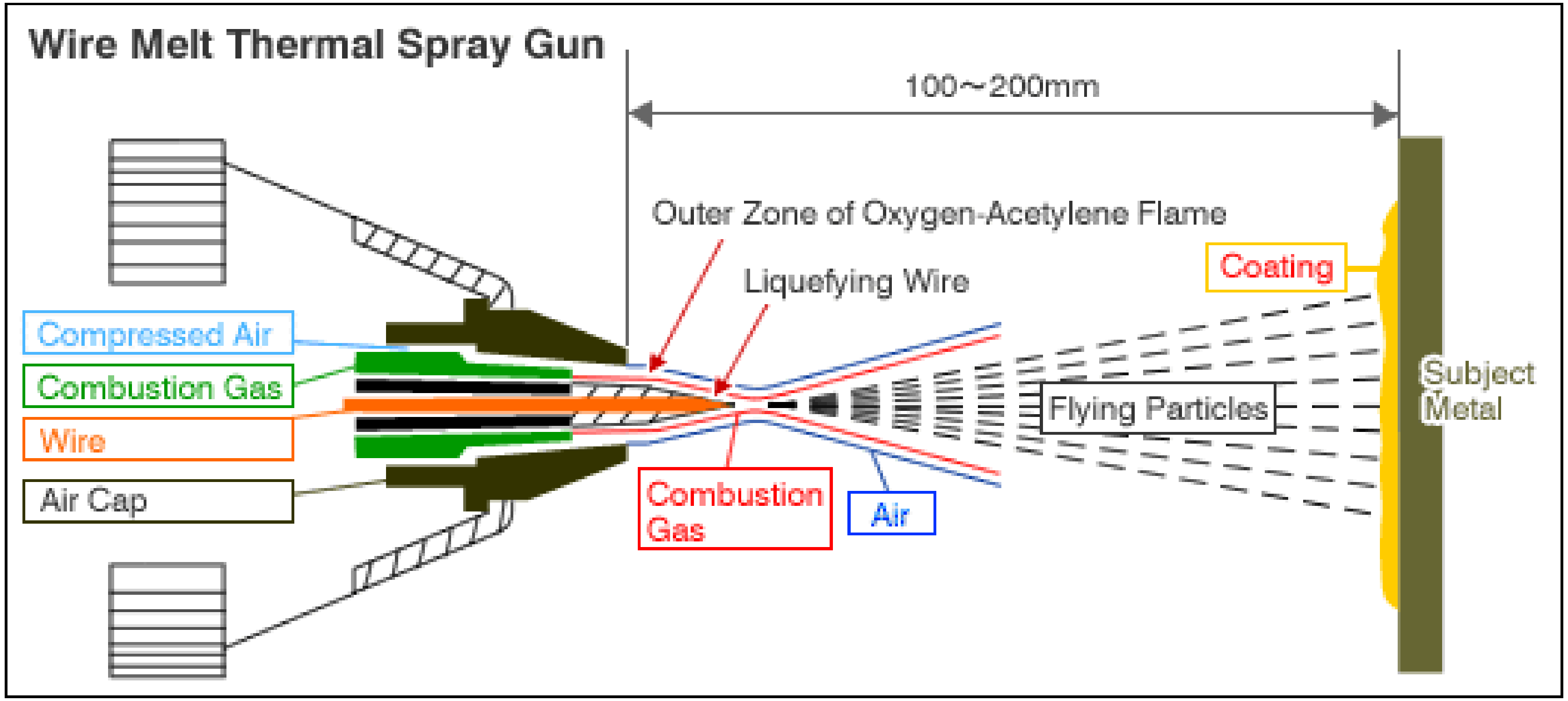
- It is also know as **Thermal Spraying** involves covering a diverse range of surfaces with a metallic coating using a spray of molten particles.
- The spraying technique will depend on a number of different factors including the application you are using, as well as your budget, operational timeframe, and preferred finish.
- The surface to be metallized should be properly cleaned before metallizing to ensure perfect deposition of metal.

The followings are two common methods of metal spraying”

1. Wire Gun Method.
2. Powder Metal Method.

1. Wire Gun Method:

- The Combustion Wire Thermal Spray Process is basically the spraying of molten metal onto a surface to provide a coating.
- Material in wire form is melted in a flame (oxy-acetylene flame most common) and atomised using compressed air to form a fine spray.
- When the spray contacts the prepared surface of a substrate material, the fine molten droplets rapidly solidify forming a coating



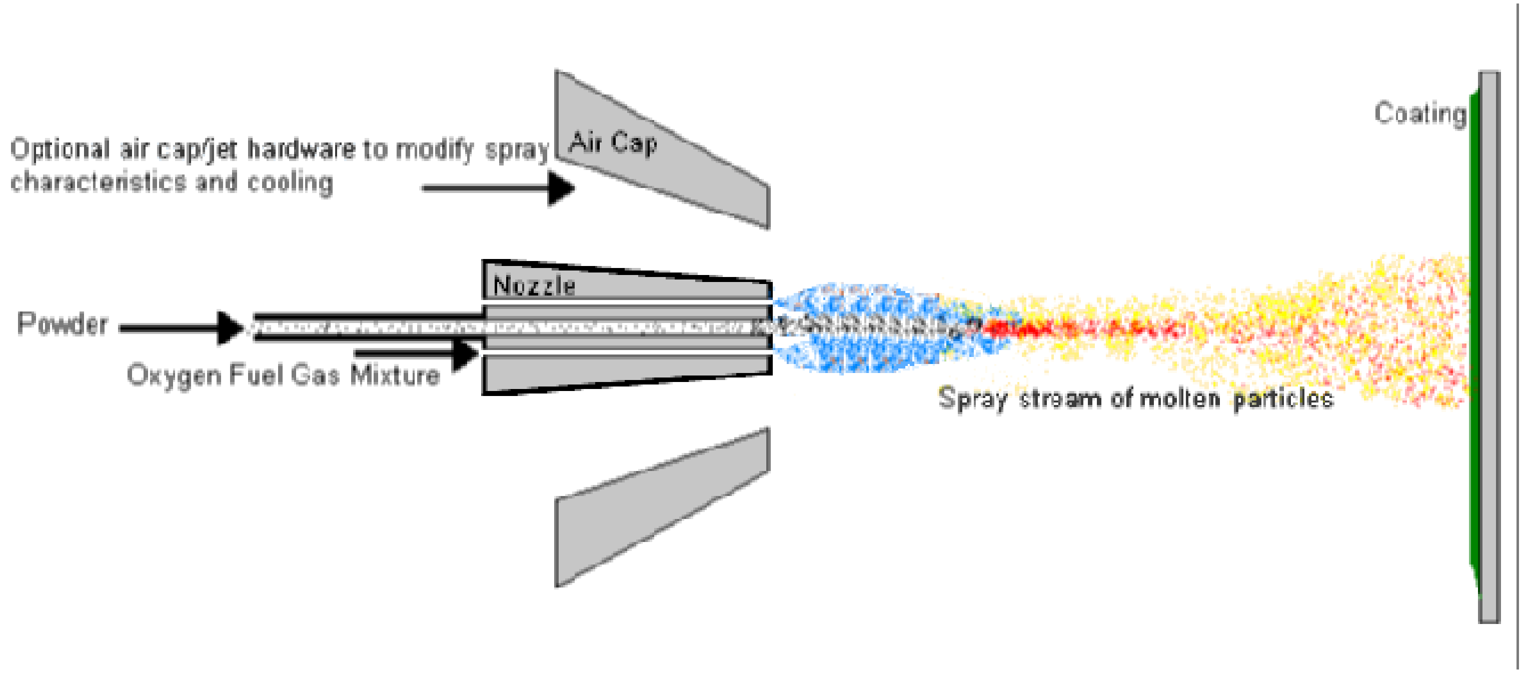
- The substrate temperature can be kept low during processing avoiding damage.
- This flame spray process has been extensively used in the past and today for machine element work and anti-corrosion coatings.
- Ceramics and cermets can be used in rod or composite wire form.

ADVANTAGES:

- Low capital investment
- Simple to operate
- Wire form cheaper than powder
- Deposit efficiency very high

2. Powder Gun Method:

- This process is basically the spraying of molten material onto a surface to provide a coating.
- Material in powder form is melted in a flame (oxy-acetylene or hydrogen most common) to form a fine spray.
- When the spray contacts the prepared surface of a substrate material, the fine molten droplets rapidly solidify forming a coating.



- The substrate temperature can be kept low during processing avoiding damage.
- The main advantage of this flame spray process over the similar Combustion wire spray process is that a much wider range of materials can be easily processed into powder form giving a larger choice of coatings.

ADVANTAGES:

- It can be applied to large and irregularly shaped objects.
- It can be applied to fabricated structure and there is no possibility of damage to the coating.
- It can be applied to non metallic objects also.

ELECTROPLATING

- Electroplating is basically the ***process of plating a metal onto the other by hydrolysis*** mostly to prevent corrosion of metal or for decorative purposes.
- The process uses an electric current to reduce dissolved metal cations to develop a lean coherent metal coating on the electrode.

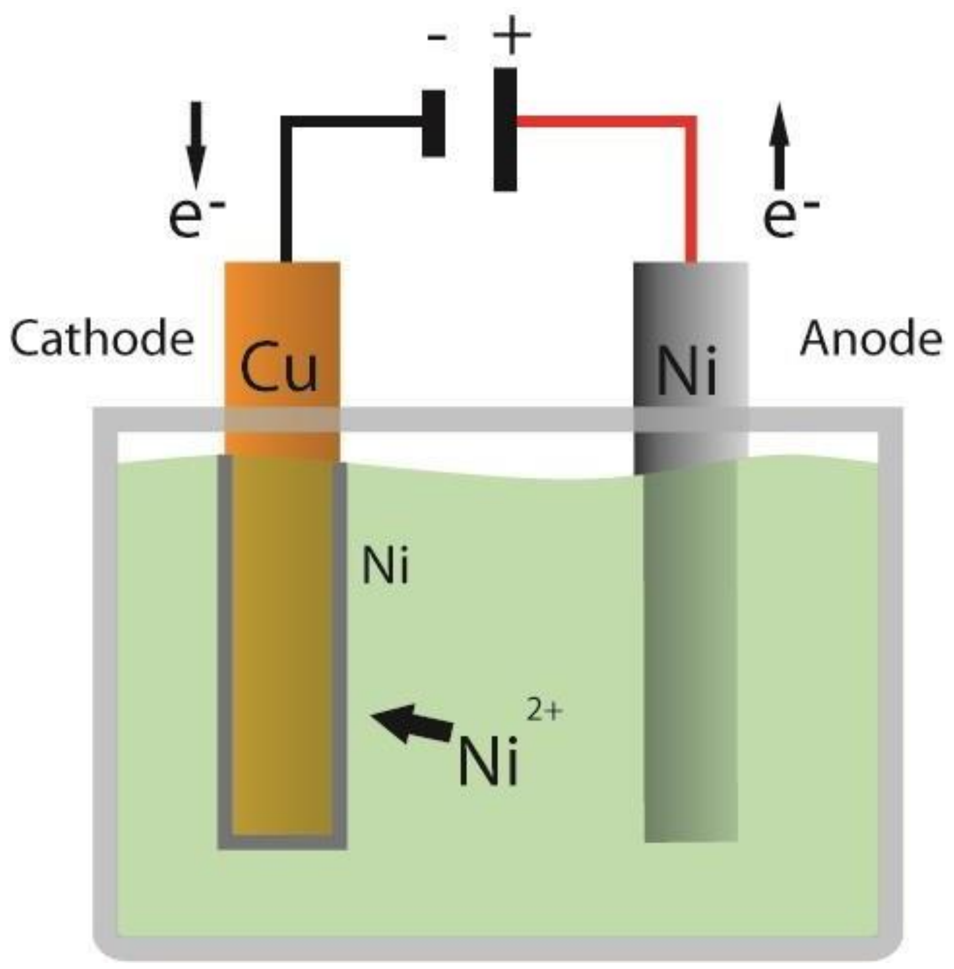
- An electrochemical process where metal ions are transferred from a solution and are deposited as a thin layer onto surface of a cathode.

- The setup is composed DC circuit with an anode and a cathode sitting in a bath of solution that has the metal ions necessary for coating or plating

- Electroplating can enhance;
  - Chemical properties---increase corrosion resistance
  - Physical properties---increase thickness of part
  - Mechanical properties---increase tensile strength & hardness

Uses of Electroplating

- mproving wear resistance.
- Improving the thickness of the metal surface.
- Enhancing the electrical conductivity like plating a copper layer on an electrical component.
- Minimizing Friction.
- Improving surface uniformity.



ANODIZING COATING

- Anodizing is an electrochemical process that converts the metal surface into a decorative, durable, corrosion-resistant, anodic oxide finish.
- Aluminum is ideally suited to anodizing, although other nonferrous metals, such as magnesium and titanium, also can be anodized.
- Anodizing is accomplished by immersing the aluminium into an acid electrolyte bath and passing an electric current through the medium.
- A cathode is mounted to the inside of the anodizing tank; the aluminium acts as an anode, so that oxygen ions are released from the electrolyte to combine with the aluminium atoms at the surface of the part being anodized.

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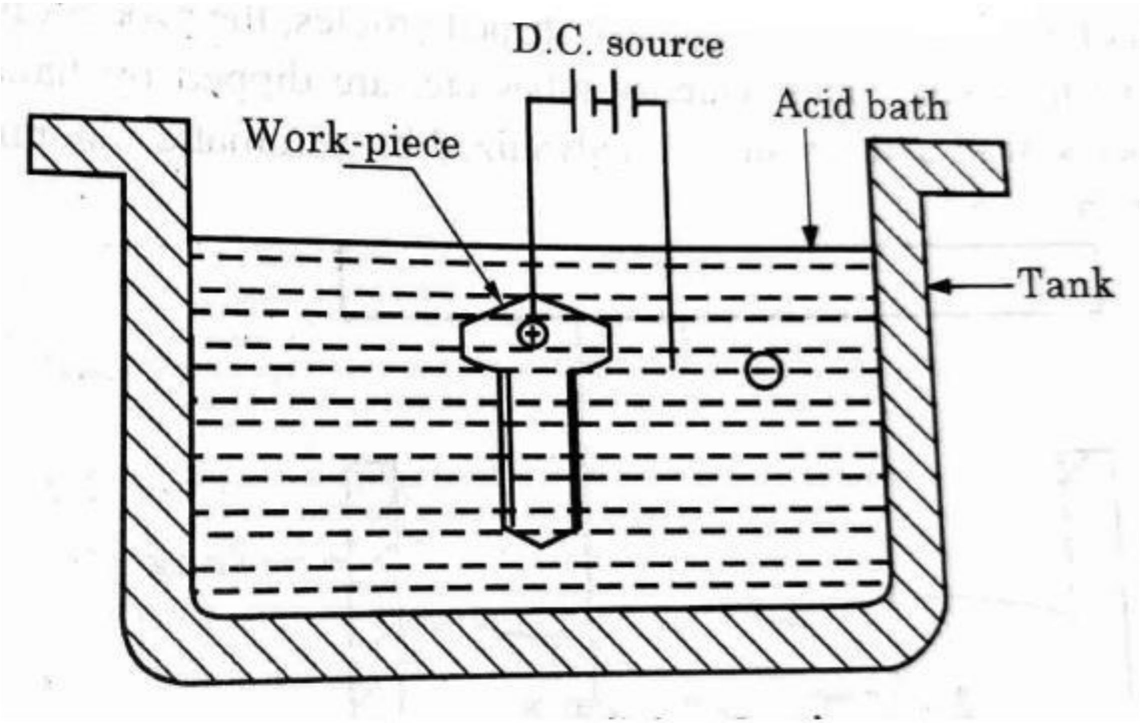
PROCESS

- When an electric current (generally DC) is supplied to electrolyte, hydrogen is produced at the cathode and oxygen at the nozzle.
- Oxygen instantly tries to combine with any material brought in contact with it.



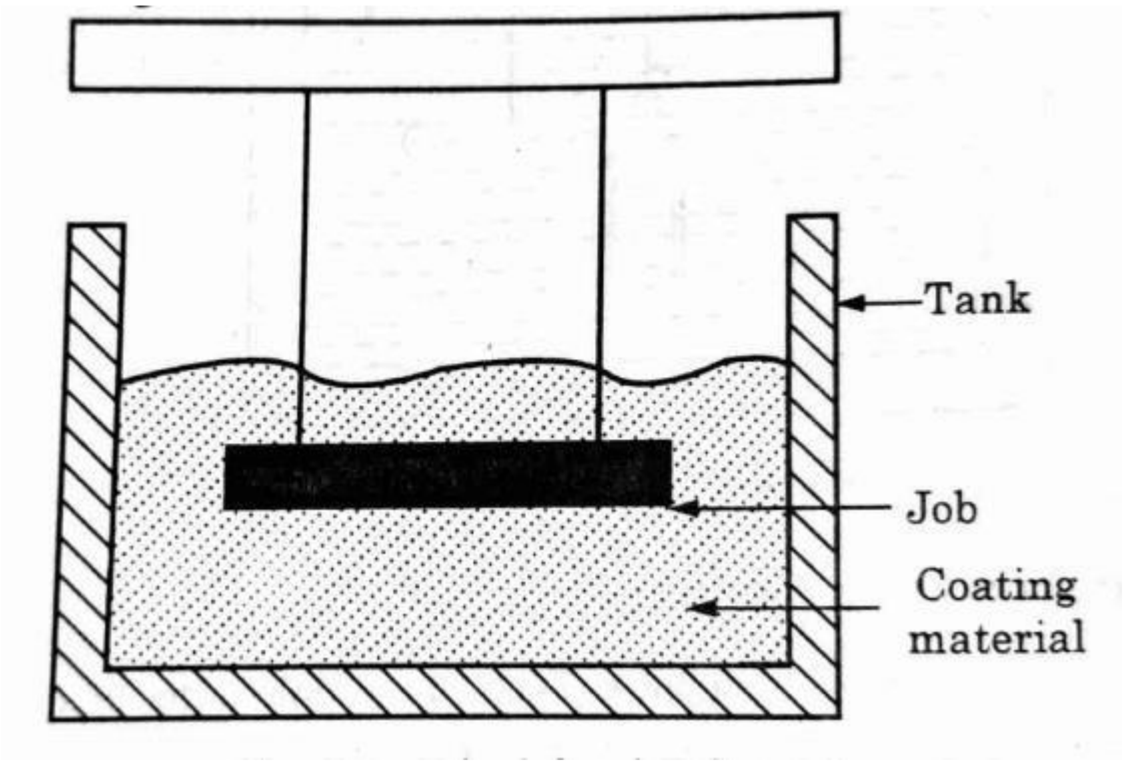
GALVANIZING

- Galvanization is the process of applying a protective zinc coating to steel or iron, in order to prevent rusting.
- The protection is two fold: Physical protection from moisture and air and Electrochemical cathodic protection.

PROCESS

- **Surface Preparation:** During the surface preparation stage, material going through degreasing/caustic cleaning, pickling, and fluxing.
- **Degreasing/Caustic Cleaning:** A hot alkali solution, mild acidic bath, or biological cleaning bath removes contaminants from the steel such as dirt, grease and oil.
- **Pickling:** To remove mill scale and iron oxides, the steel goes through a diluted solution of heated sulfuric acid or ambient hydrochloric acid.

- **Fluxing:** Any remaining oxides are removed in a zinc ammonium chloride solution and a protective layer is deposited on the steel to prevent any further oxides from forming prior to galvanizing.
- **Galvanizing:** Following surface preparation, the steel will be immersed in a bath of molten zinc. The zinc kettle contains at least 98% pure zinc and is maintained at a temperature between 815º-850º F (435º-455º C).



ORGANIC COATINGS

- Durable protective coating applied to a substrate for decorative or specific technical properties.
- The main component responsible for the creation of well-adhering adhering film (membrane) are organic compounds: polymers, oligomers, monomers, or mixtures thereof.

The types of organic coatings:

- **Primers:** Adhesion to the substrate, corrosion protection, paint adhesion.
- Adhesive cements: Materials with a suitable consistency coatings used for surfacing.
- Topcoats with high resistance to external factors:
  - **Varnish** : solution of film-forming substance in an organic solvent, for example: colorless varnish.

- Enamel - solution of film-forming substance, pigments (colorants), modifiers, additives in an organic solvent
- Paints - solution of film-forming substance, pigments (colorants), modifiers, inorganic anti-corrosion additives in an organic solvent.

- OIL BASE PAINTS

  PAINT • Paint is any liquid, liquefiable, or mastic composition that, after application to a substrate in a thin layer, converts to a solid film.
- It is most commonly used to protect, color, or provide texture to objects.
- Paint can be made or purchased in many colors—and in many different types, such as watercolor, synthetic, etc.
- Paint is typically stored, sold, and applied as a liquid, but most types dry into a solid.

COMPOSITON OF PAINT

- pigment - prime pigments to impart colour and opacity
- Bnder (resin) - a polymer, often referred to as resin, forming a matrix to hold the pigment in place
- Extender - larger pigment particles added to improve adhesion, strengthen the film and save binder
- Solvent (sometimes called a thinner) - either an organic solvent or water is used to reduce the viscosity of the paint for better application. Water-borne paints are replacing some paints that use volatile organic compounds such as the hydrocarbons which are harmful to the atmosphere.
- Additives - used to modify the properties of the liquid paint or dry film

RUBBER BASE COATING

- It is one of the most widely used processes of coating in various applications.
- Such protective coating is applied onto or impregnated into a substrate or an object for protective, decorative or functional purposes.
- Rubber coating medium is a very important consideration in the selection of coating material.
- This type of coating is used on many elastomeric components like seals, gaskets, o-rings, stoppers and plungers etc.

Rubber as a Coating Material-

- Rubber is a preferred material for coating application because of two reasons:
  - Rubber is resisted to mechanical wear and tear.
  - Rubber is resisted to the influence of strong aggressive environment.
- Natural and synthetic rubber coating both are done in various applications. However, synthetic rubber coating is more prevalent than natural coating.
- As natural rubber can not be used directly for coating purpose, most of the time latex concentrate that contains roughly 60% rubber are used for the purpose.
- Due to their versatile nature, synthetic rubber coatings, mostly made of liquid rubber, can be easily sprayed onto any surface for long term sealing, insulation and protection against moisture, dust and other air borne materials preventing leakages etc.

UNIT- 6

METAL FINISHING PROCESSES

PURPOSE OF FINISHING SURFACE

Surface finishing is a broad range of industrial processes that alter the surface of a manufactured item to achieve a certain property.

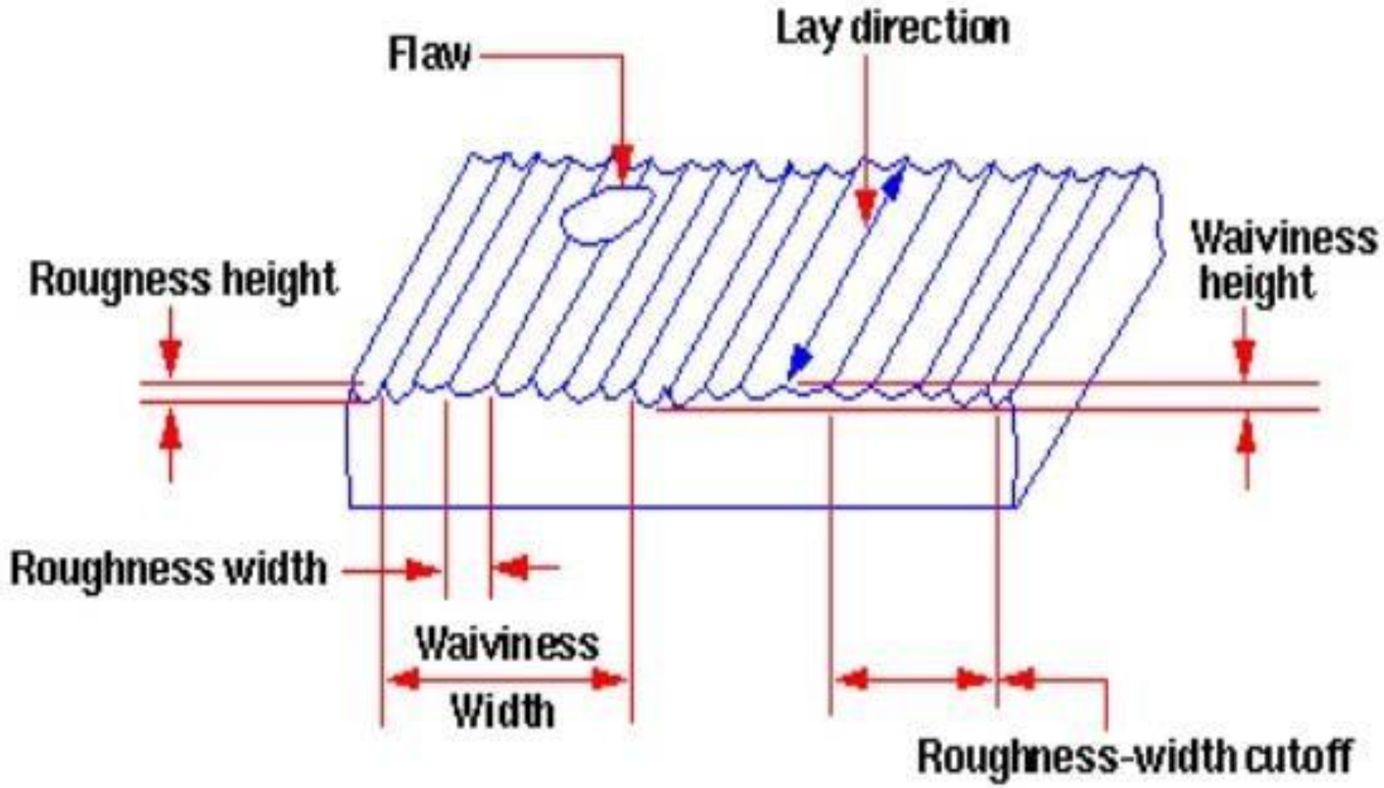
- To improve appearance
- To reduce friction and surface roughness and increase surface finsih
- To resist against corrosion and chemical reaction
- To reduce wear and tear
- To increase the hardness and toughness
- To remove burrs and other surface flaws, and control the surface friction
- To restore original dimensions to salvage or repair an item

SURFACE ROUGHNESS

- Repetitive or random deviations from the normal surface which form the pattern of the surface.
- Surface texture include roughness, waviness, lay and flows.
- every part's surface is made up of texture and roughness which varies due to manufacturing techniques and the part structure itself.

IMPORTANT TERMS

- **Ideal Surface :** Hypothetical perfect surface without any micro irregularity.
- **Roughness Height :** It is the height of the irregularities with respect to a reference line. It is measured in millimeters or microns or micro inches.
- **Roughness Width :** The distance between two adjacent peaks and valleys.

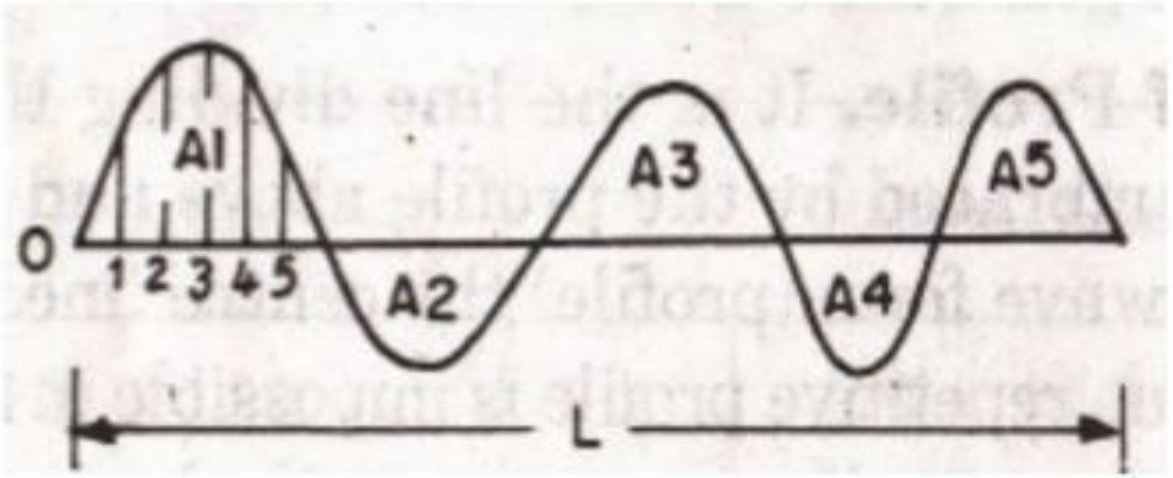


- **Waviness:** The surface irregularity in the form of waves having larger wave length.
- **Lay:** Lay is the primary direction of surface pattern produced by tool marks.
- **Flaws:** Irregualrity such as blow holes, scartches, cracks etc. occur on the surface.

Measurement of Surface Roughness

1. Centre line Average (C.L.A. Method)

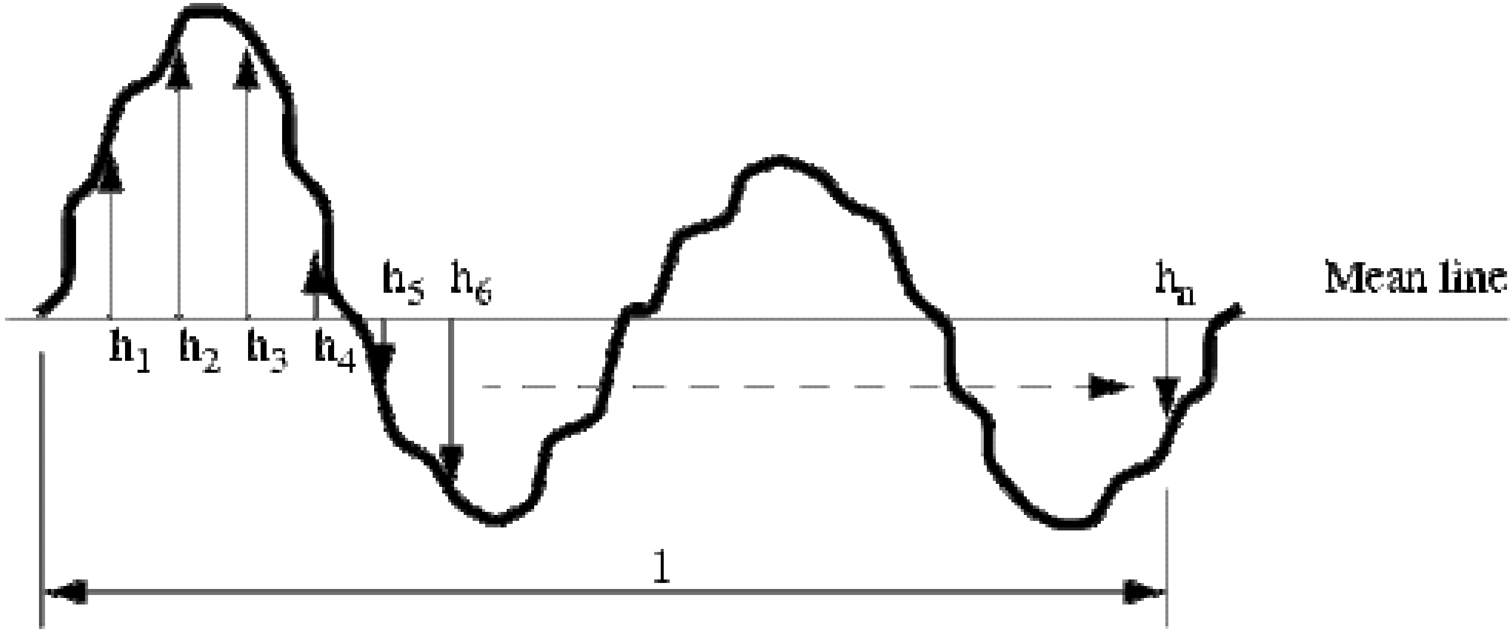
- Surface roughness is measured as the average deviation from nominal surface. It is defined as average value of the ordinates from mean line, regardless of the arithmetic sign of ordinates.



$$C.L.A.Value = \frac{h1 + h2 + h3 + \cdots . + hn}{n}$$

2. Root Mean square Method

- Surface roughness is measured as the average deviation from nominal surface. It is defined as square root of arithmetic mean of values of square of ordinates of the surfaces measured from mean line.



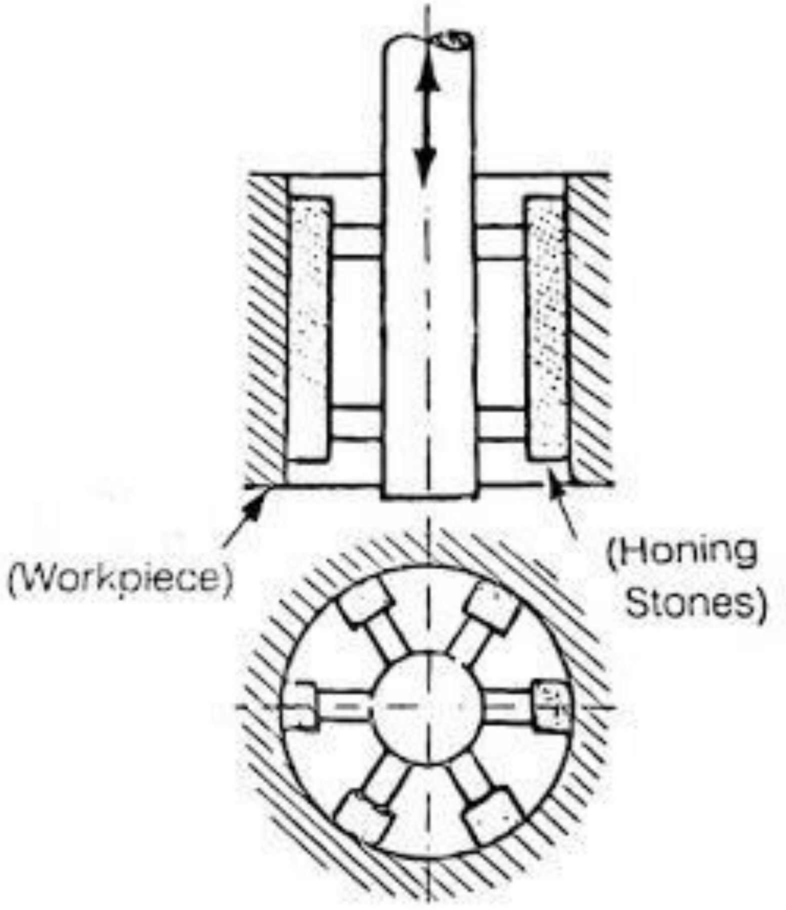
$$RMS = R_q = \sqrt{\frac{h_1^2 + h_2^2 + h_3^2 + \dots + h_n^2}{n}}$$

HONING

- Honing is an abrasive machining process that produces a precision surface on a metal work piece by scrubbing an abrasive stone against it along a controlled path.
- Honing is primarily used to improve the geometric form of a surface, but may also improve the surface texture.
- Typical applications are the finishing of cylinders for internal combustion engines, air bearing spindles and gears.
- There are many types of hones but all consist of one or more abrasive stones that are held under pressure against the surface they are working on.
- The hone is composed of abrasive grains that are bound together with an adhesive.
- Generally, honing grains are irregularly shaped and about 10 to 50 micrometers in diameter.

HONING PROCESS

- Work piece is clamped rigidly on the work table.
- The abrasive sticks of aluminium oxide or silicon carbide are mounted on a mandrel or fixture.
- Pressure of tool on work piece is equally distributed on all sides.
- The honing tool is given slow reciprocating motion with rotating speed of 10 to 30 m/s.
- The hole to be honed is flooded with a lubricant like paraffin to carry away heat and flushes the chips.



APPLICATIONS OF HONING

- Gears and connecting rods
- Cylinder blocks and liners
- Diesel engine cylinder
- Hydraulic Cylinders
- Refrigerator compressor
- Roller bearing races
- Bores of cannons
- Bores in rocker arms
- Airplane and automobile cylinder tapper valve guide bushes

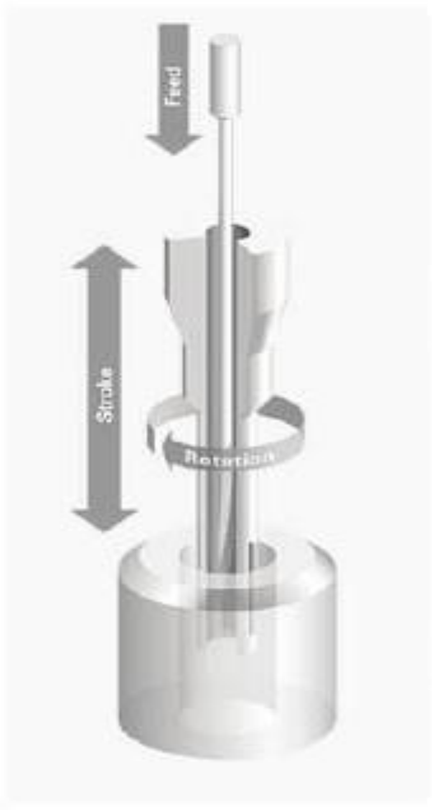
HONES

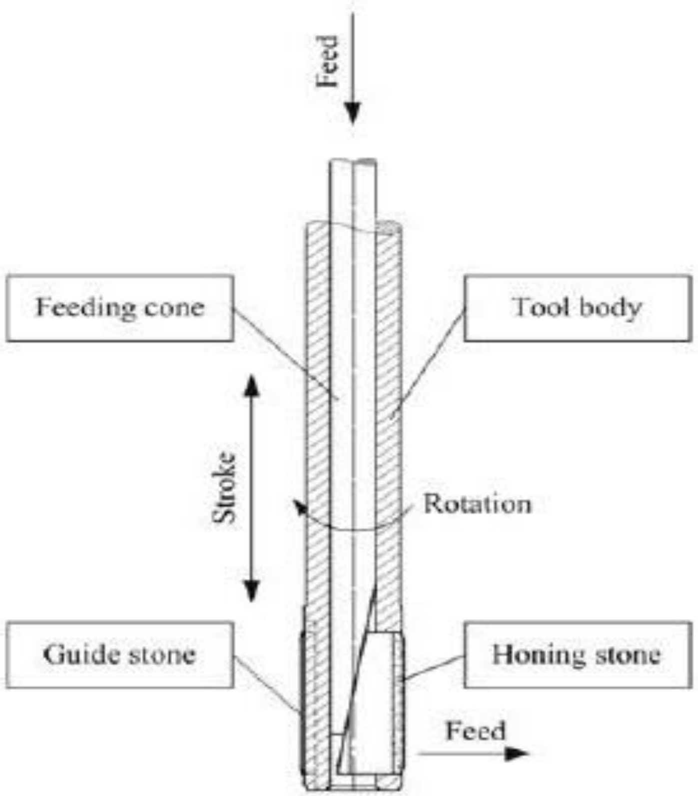
Hone is a metal frame which holds the abrasive sticks during honing operation. It is also known as honing tool. Hones may be of two types.

1. Internal Hones
2. External Hones

INTERNAL HONES

- When a hone is used to finish an internal cylindrical surface.
- It is carried with the help of abrasive stick which are mounted on the expanding head or hone in the holder.
- The hone is connected with the spindle of machine through universal joint.

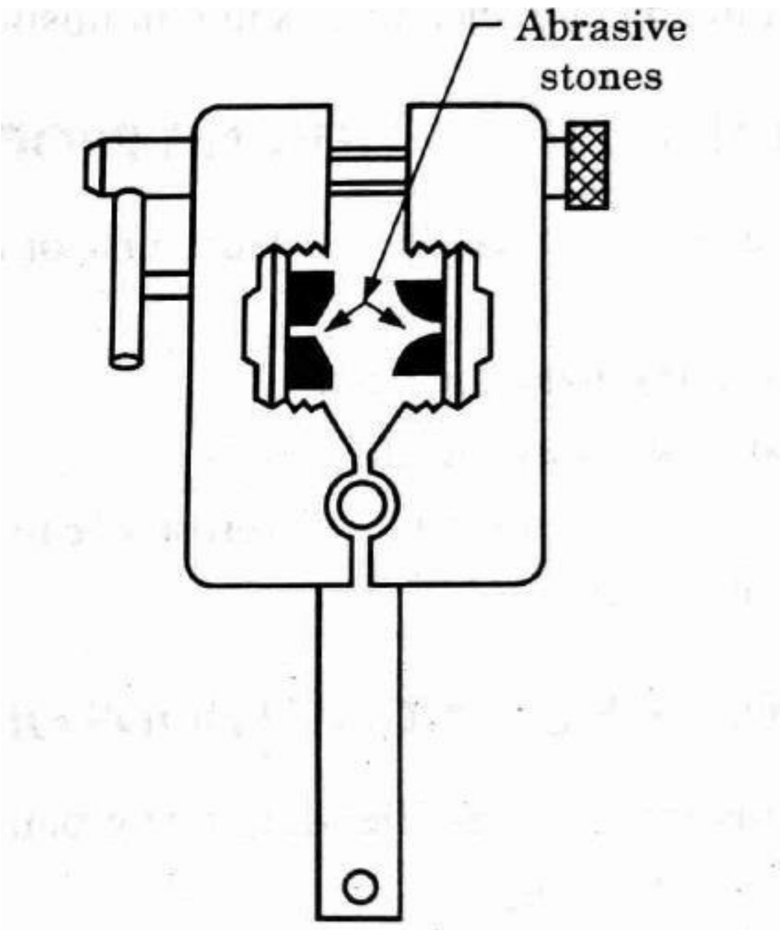




- This method is hone is mostly used for finishing automobile cylinders.
- Hones are built in a wide range of sizes.

EXTERNAL HONES

- When a hone is used to finish an external cylindrical surface
- It is accomplished by mounting four sticks held in holders on contracting yoke.
- The work piece is rotated while the sticks envelop the work piece.
- Only a little pressure is applied on the stick.

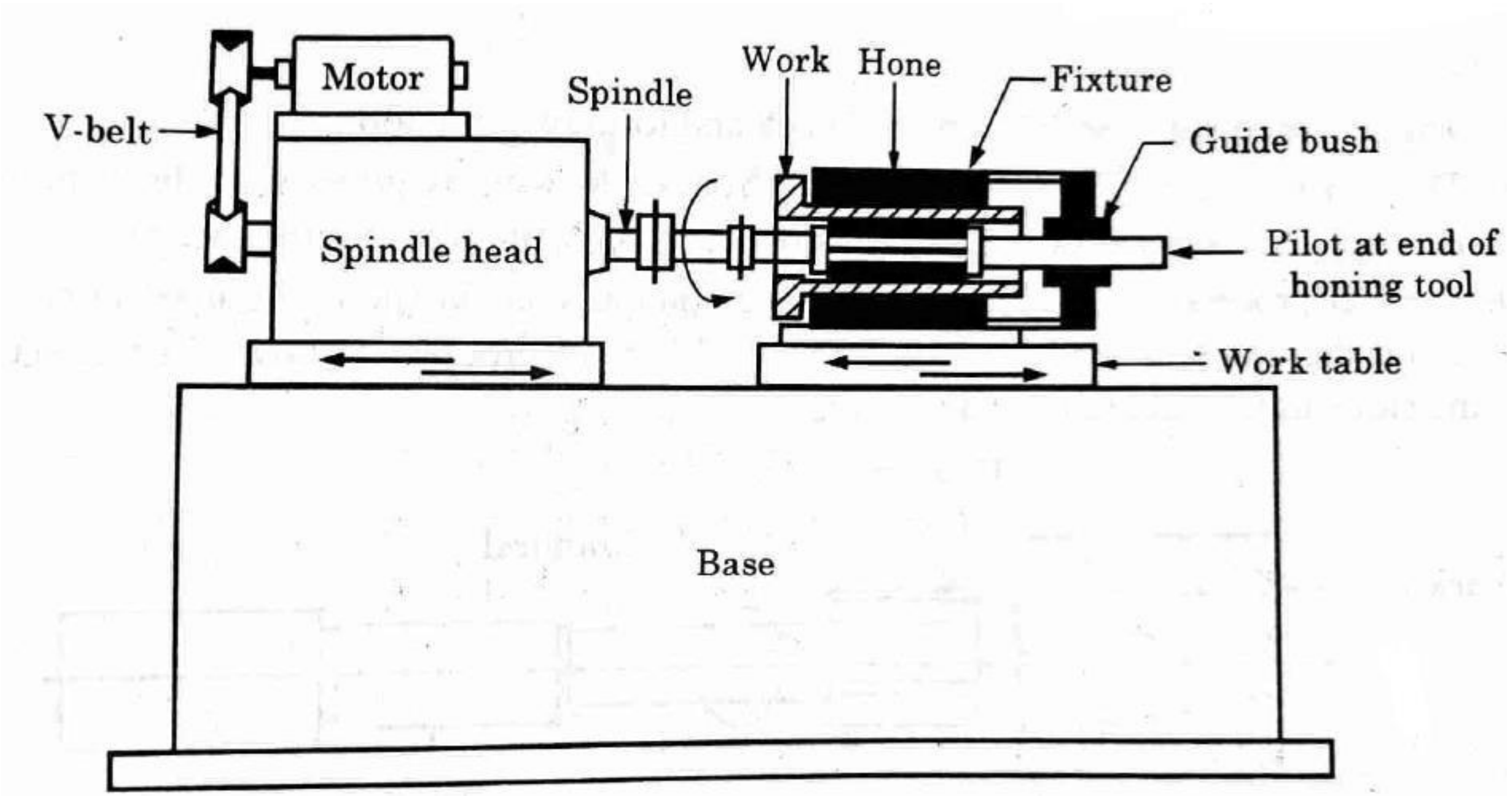


HONING MACHINES

- The honing process can be done on many general purpose machine such as lathe and drilling machines.
- It is done where large production is required.
- Two types of honing machines are used:

1. Horizontal honing machine

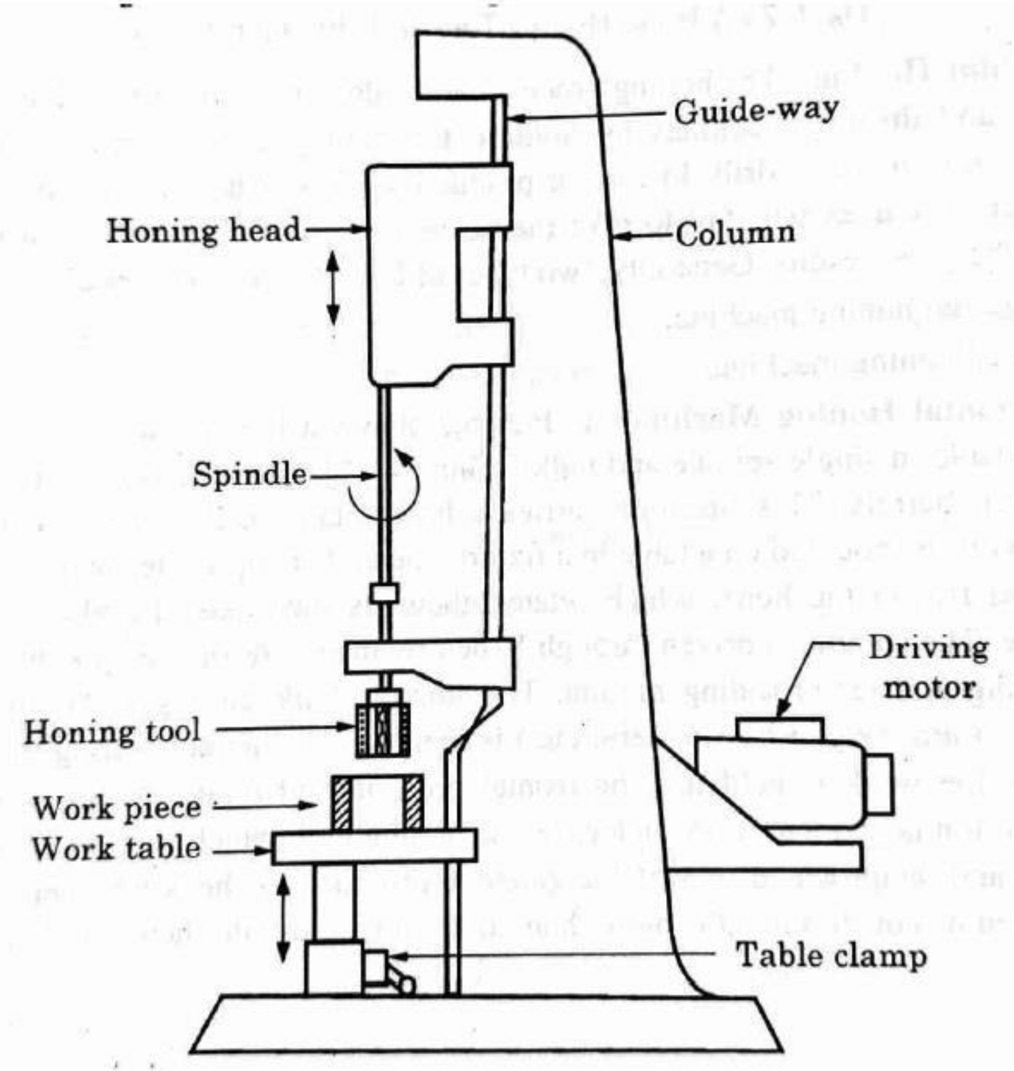
- It has single spindle and multi spindle and used for longer mounded.
- The machine carries a horizontal spindle on which honing tool is mounted
- The work is mounted on a table in a fixture, the table reciprocate to an fro on the hone.
- The spindle is driven through v belt by the motor.
- The supply of cutting fluid is regularly maintained during the operations.



- Job lengths more than 2000mm are usually honed in horizontal honing machines.
- A suitable gauge is provided to check the whether the correct size has been achieved or not.

2. Vertical honing machine

- In this honing tool is held in chuck and is rotated as well as reciprocated up and down.
- The work as well as tool is held in vertical positions.
- The table may be raised or lowered in front of the column to any position.
- The job lengths upto 2000mm are usually honed in vertical honing machines.



LAPPING PROCESS

- **Lapping** is a machining process in which two surfaces are rubbed together with an abrasive between them, by hand movement or using a machine.
- The tool used for lapping process is known as lap.
- Lapping improves surface finish by reducing peaks & valleys on a surface finish of 0.2 µ Ra
- Lapping involves a softer material such as ceramic for the lap, which is "charged" with the abrasive.
- The lap is used to cut a harder material. The abrasive embeds within the softer material, which holds it and permits it to score across and cut the harder material.

APPLICATIONS OF LAPPING PROCESS

- Jigs and fixtures brushes.
- Holes and pins
- Tapered surface of plug cocks.
- Pump parts.
- Ball and roller bearing races
- Refrigerator compressor parts
- Spray nozzle
- Bores in rocker arms
- Hub holes in gears of gear boxes.

LAPPING COMPOUNDS AND TOOL

LAP

- A lap is a solid rectangular, cylindrical or circular block of soft metal charged with abrasive powder or compound and is used for obtaining extremely accurate and finished surfaces.
- The lap is held over the work piece under a controlled pressure and it forces the abrasives to remove the metal in the same fashion as in grinding.
- The material used for the body of lap are lead, copper, soft cast iron, etc.
- The abrasive powder or compound is embedded in the lap by rubbing or rolling is called charging.

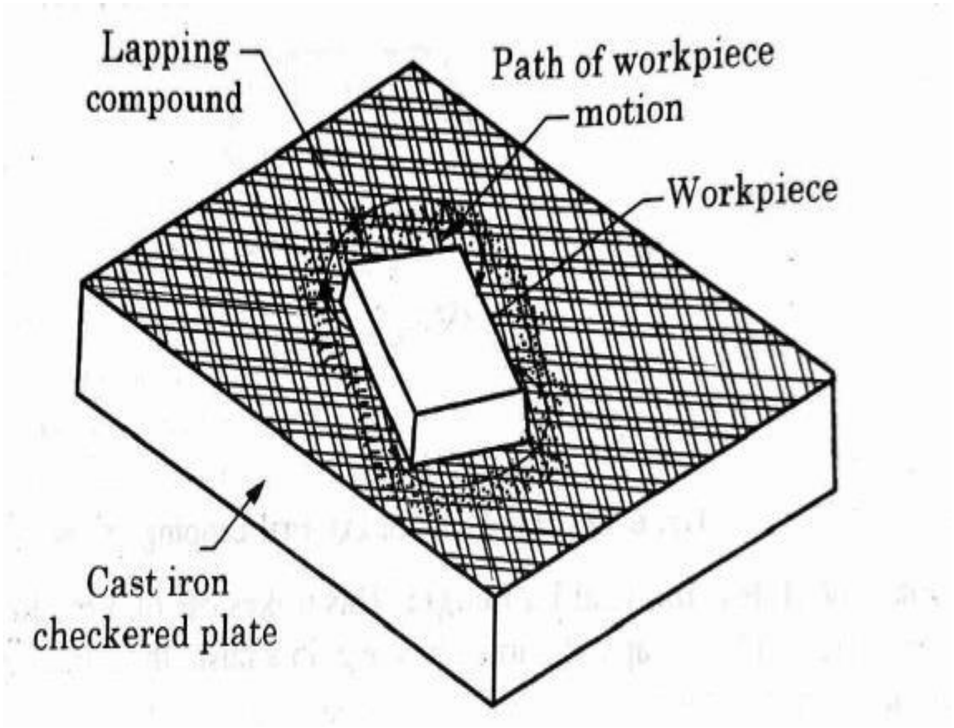
MATERIALS USED IN LAPPING PROCESS

1. **Material of lap:** The body of lap is made of any soft material such as brass, soft cast, iron, lead, copper etc.
2. **Abrasive particles:** Lapping powders and compounds are mostly used as abrasives during the lapping process. Silicon carbide, aluminium oxide, diamond dust, boron carbide etc are used as abrasive material powder.
3. **Holding Material:** Abrasive are mixed with carrier medium called vehicle. Its purpose is to suspend abrasive and keep grains separated as well as to lubricate the work and prevent scoring.

LAPPING PROCESS

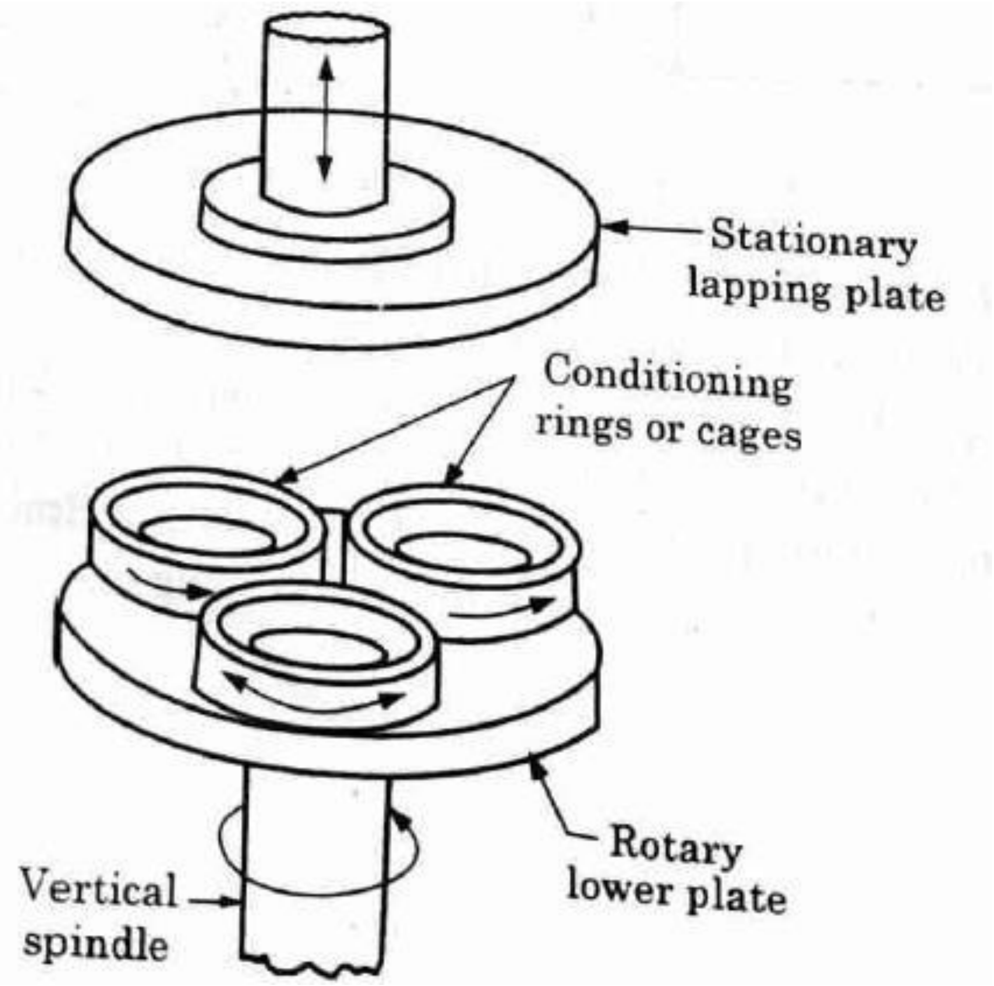
1. **Hand Lapping:**

- It is carried out by the operator himself. Operator can hold the small work piece in one hand and by another hand, he can do the lapping.
- Fixtures can be used for large sized work piece.
- It is used for lapping press work dies, dies and metallic moulds for casting, engine valves, piston rings etc.



2. Machine Lapping:

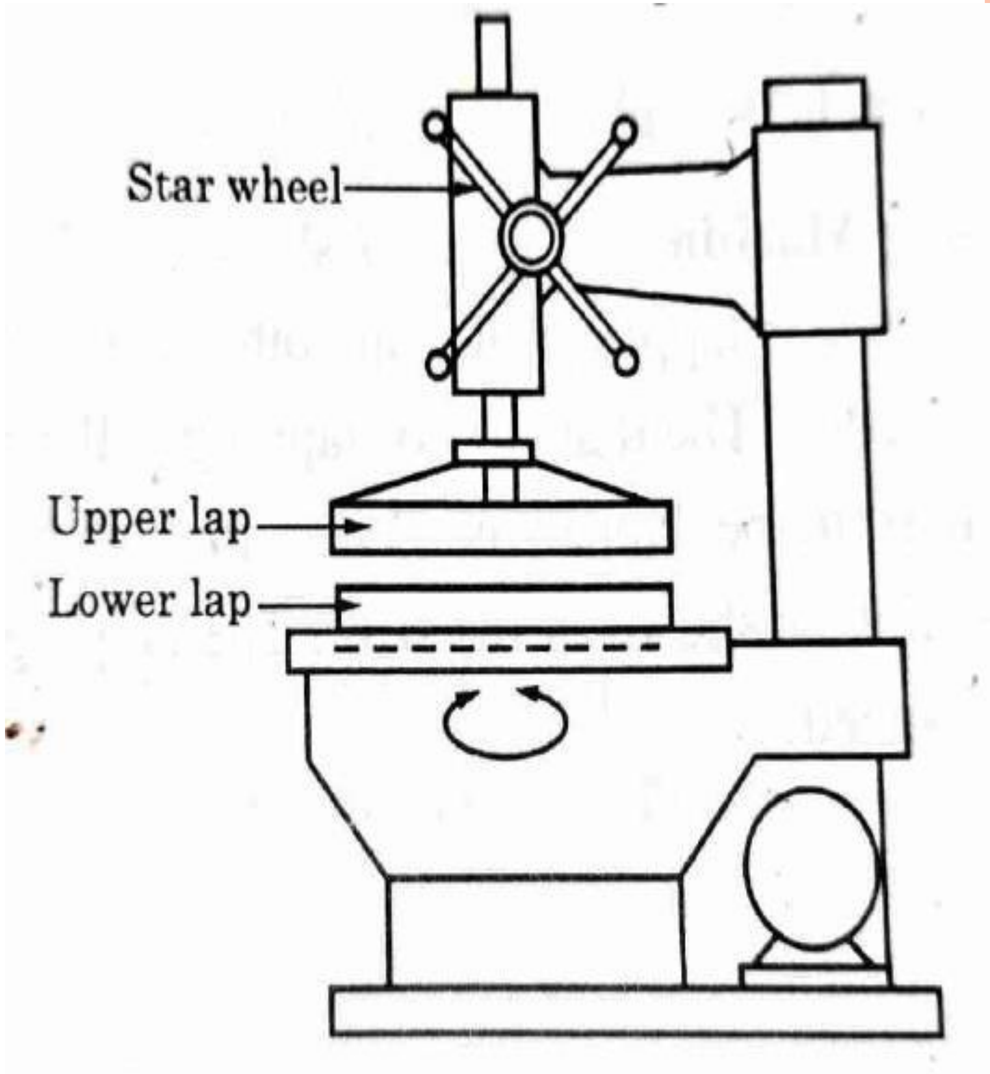
- Rotation to the work piece or tool is given by the machine.
- It uses a motor driven lap and is used to obtain highly finished sufaces on races of ball and roller bearings, worm gears, cam shafts, piston pins etc.
- It consist of two plats(wheels) one above the other.
- The workpiece to be lapped is placed between these two plates and loose abrasive grains with vehicle is fed.



LAPPING MACHINES

1. **Vertical Axis Lapping Machine:**

- This type of lapping machine consists of two opposed, heavy east iron or bonded abrasive circular plates held in vertical spindles.
- When cast iron laps are used, the lower lap drive the work pieces when the former is rotated at a speed of not more than 100m/min. the upper lap is held stationary but is free to float in the vertical direction .
- It rest upon the work during the lapping operation, thus applying the constant pressure.

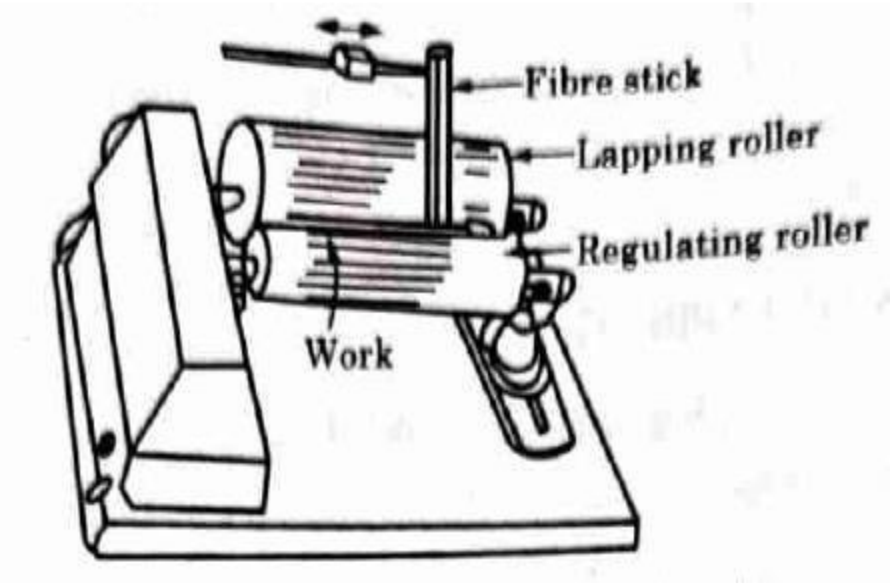


2. Centre less Axis Lapping Machine:

- A center less lapping machine works on same principle as that of center less grinding machine.
- The lapping machine is constructed to produce very high roundness accuracy and fine surface finish.
- The bonded abrasive lapping and regulating wheels are much wider than those used for centerless grinding to allow the work to remain longer in abrading contact and to receive final finish.
- The lapping wheels speed vary from 175m/min to650m/min, depending upon the surface finish and production requirement.

3. Roller type Lapping Machine:

- Roller type lapping machine is designed for processing a single piece at time, and it is used for lapping plug gauges, measuring wires, and similar straight or taper cylindrical objects.
- The machine consists of two cast iron rolls and a reciprocating device for holding down the work piece and controlling the size.
- The diameter of larger roller, known as lapping roller, is twice that of regulating roller.



4. Abrasive Belt Lapping Machine

- This machine is used for lapping of crakpins, crankshaft, aeroplane engine cams etc,
- It is a horizontal axis machine and has horizontal spindle.
- It neither uses embeded abrasive laps nor the bonded wheels.

5. Sperical Lapping Machine

- It is used for spherical surface lapping and works similar to drill press.
- A crankpin connected by crankshaft is connected to lap through ball joint which laps the work surface of similar shape.
- The axis of crankshaft and workpiece are aligned before lapping.

POLISHING

- Polishing is one finishing loose abrasive process, used to generate surfaces with very high tolerances in geometry, surface integrity, and roughness characteristics.
- It is still one of the most important finishing methods. Polishing particles remove small elements of a surface and make them smooth.
- This smoothness is obtained by rubbing the surface with the polishing particles with a rotating disk.

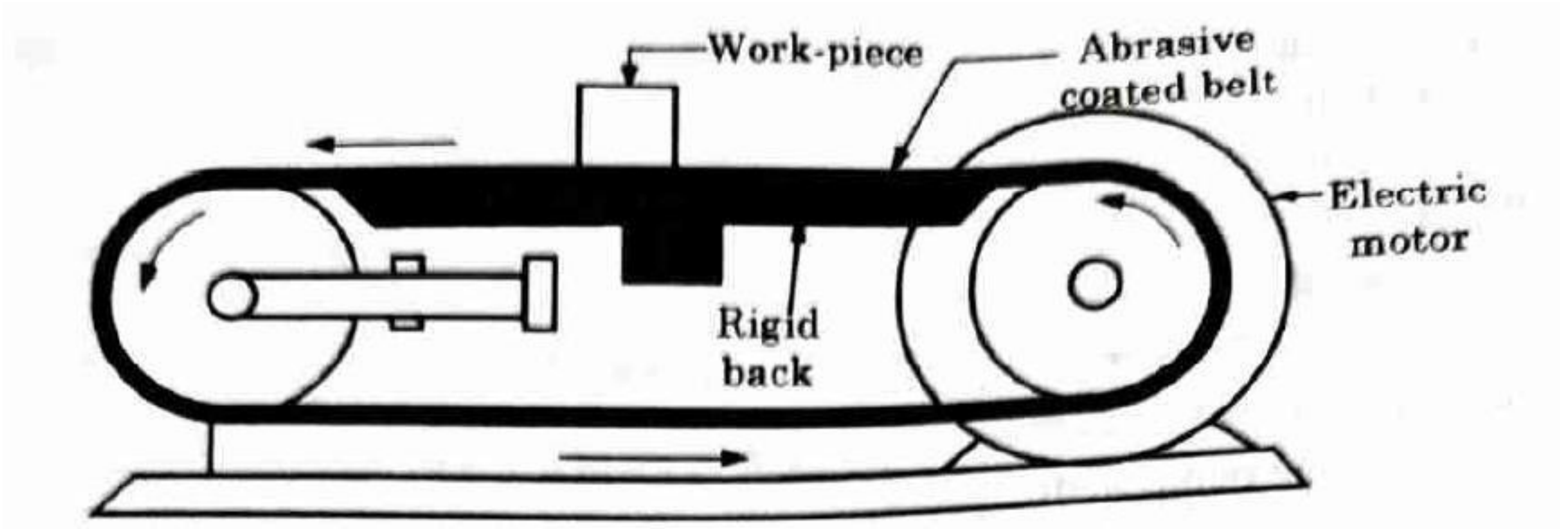
Purpose of Polishing

- To remove scratches, nicks, discolouration, surface defect etc.
- To produce more uniform surface.
- To make metal smoother.
- To make lustrous appearance.

Method of Polishing

1.Polishing with coated abrasive belt

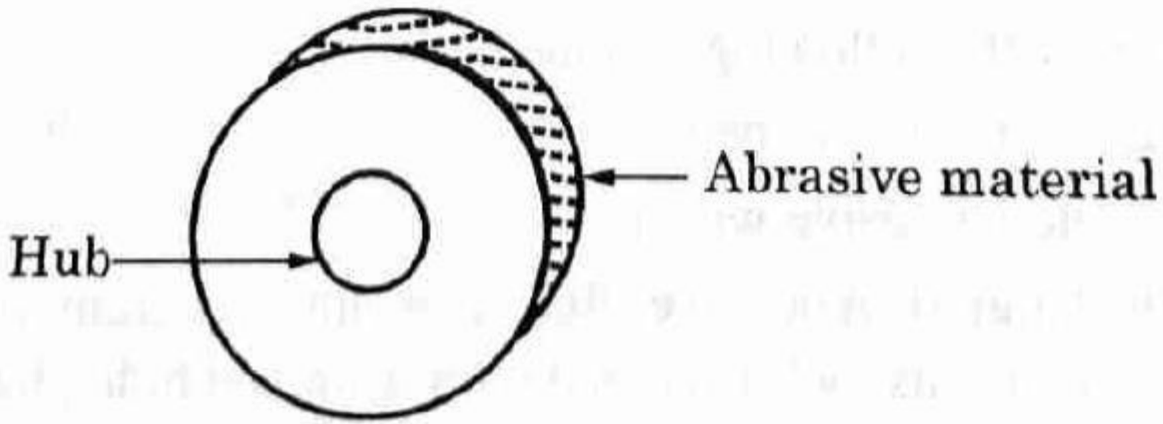
- Belt is coated with resin and hide glue followed by abrasives (Aluminium oxide, silicon carbide etc).
- The belt is driven by the electric motor and rotate over the rollers.
- The work piece may be held in hand or in a fixture and forces against the rotating belt to obtain a polished surface.



Method of Polishing

2. Polishing with coated abrasive wheel

- This operation is performed by means of a coated wheel.
- Coated abrasive wheel is made up of hundreds of small abrasive strip mounted on hub.
- Polishing wheels are made of leather, paper, canvas, felt or wool.

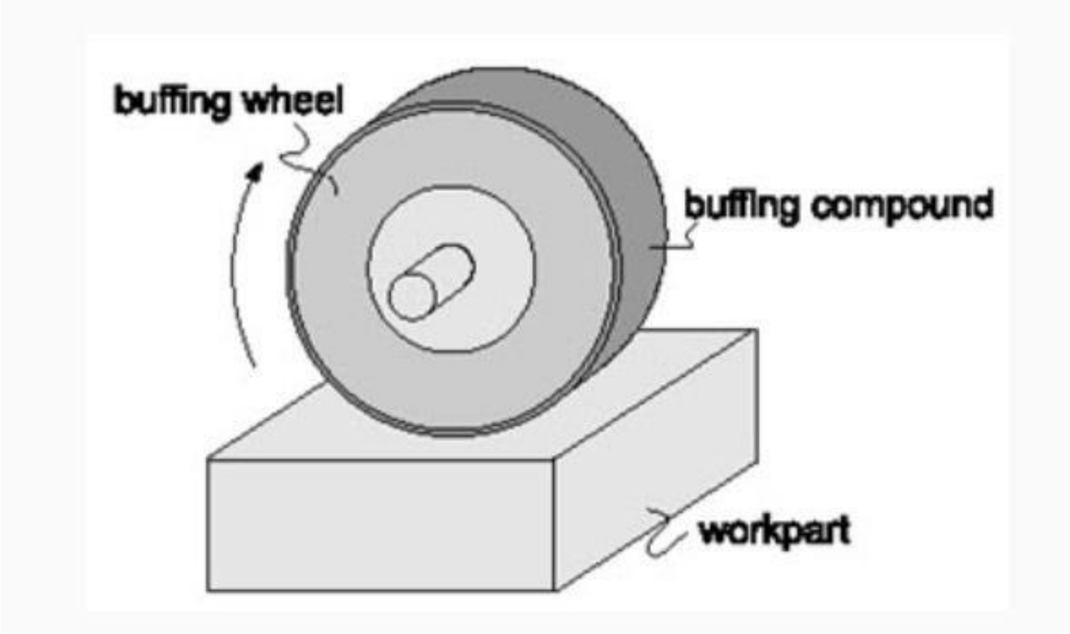


Applications of Polishing

- Stainless steel utensils
- Surgical instruments
- Wrenches
- All the parts to be electroplating are usually polished before electroplating.

BUFFING

- Buffing is a smoothening and brightening process on a surface by the rubbing action of fine abrasive in a lubricating binder applied intermittently to a moving wheel of wood, cotton, fabric, felt or cloth.
- It is a polishing operation in which the work piece is bought in contact with a revolving cloth buffing wheel has been charged with very fine abrasives.



Burnishing

- It is a process by which a smooth hard tool (using sufficient pressure) is rubbed on the metal surface.
- This process flattens the high spots by causing plastic flow of the metal.
- The edges of sheet metal can be smoothed out by pushing the sheet metal through a die that will exert a compressive force to smooth out the blanked edge and the burrs caused by the die break.