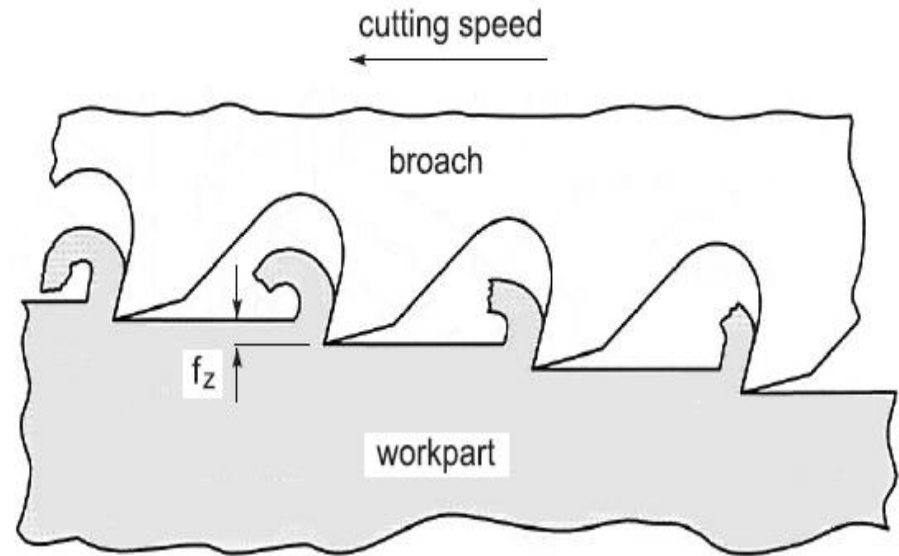


Broaching and Abrasive Processes

BROACHING

Broaching is a machining operation that involves the use of a multiple-tooth cutting tool moved linearly relative to the workpiece in the direction of the tool axis:

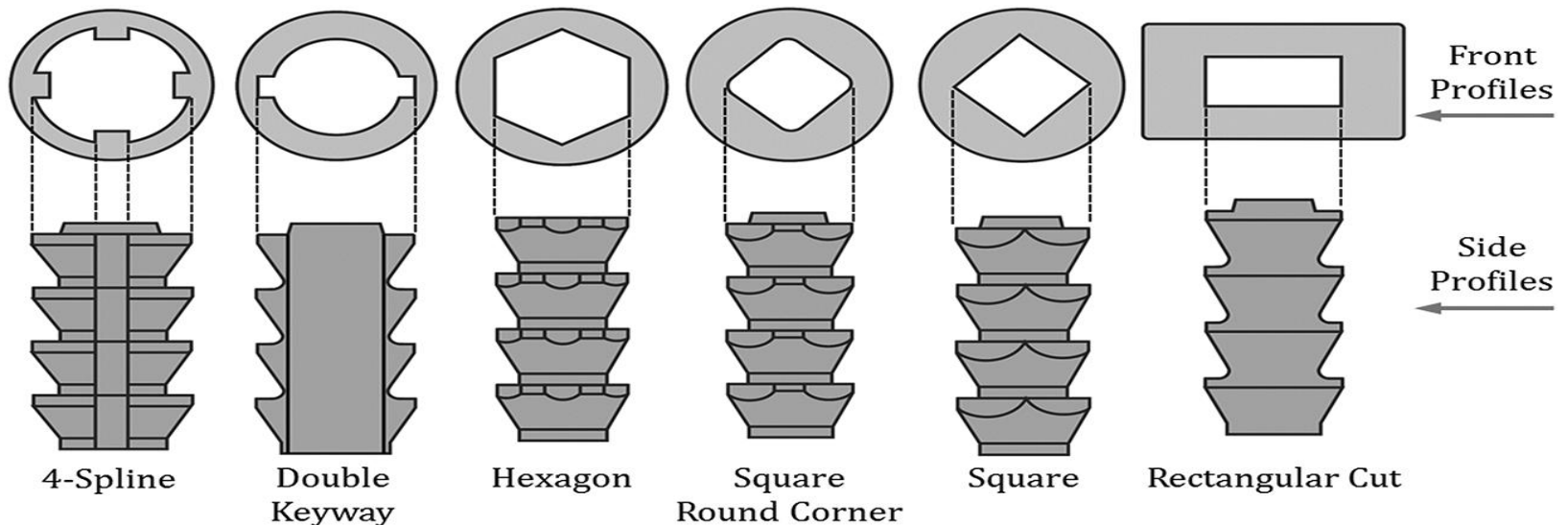


The broaching operation.

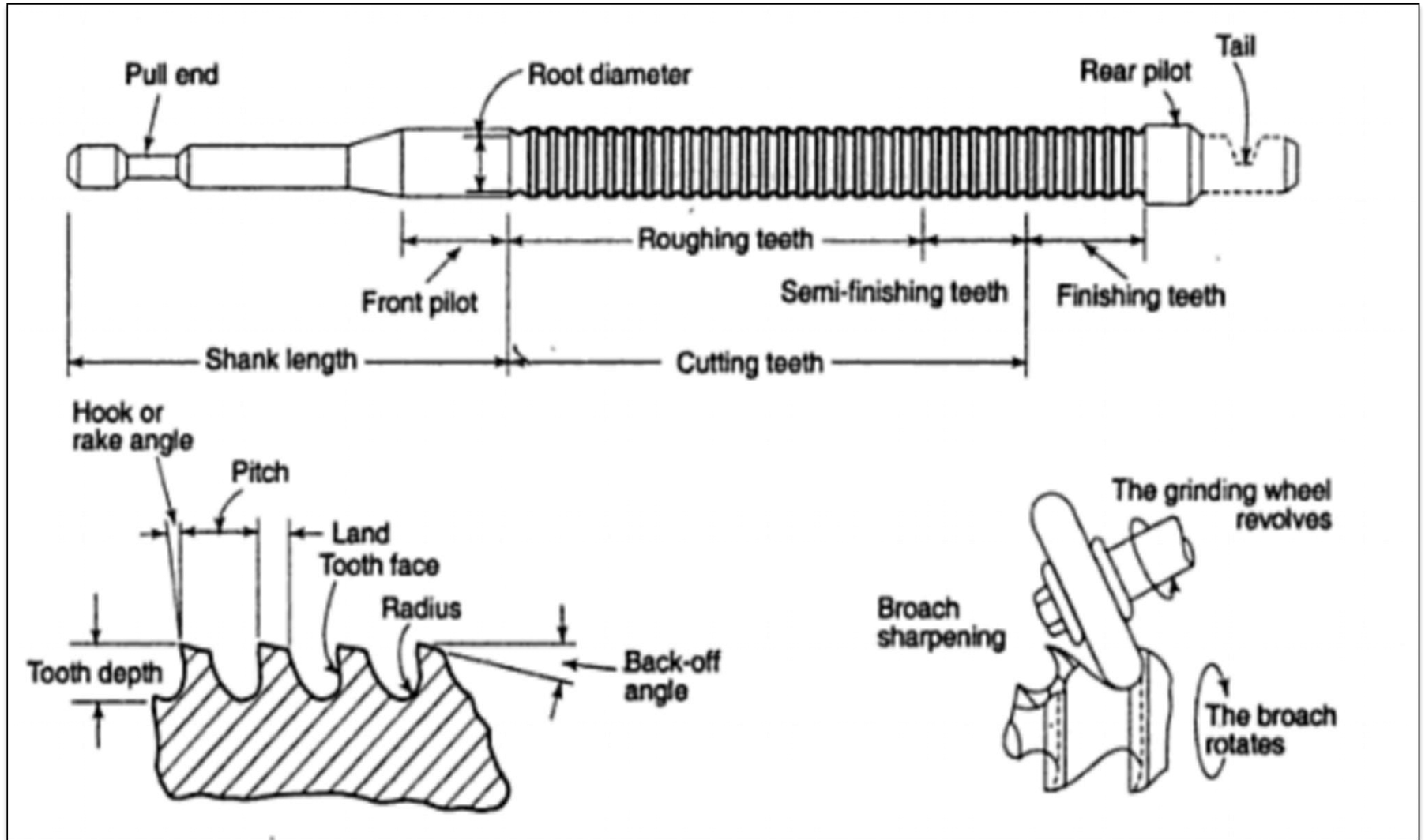
The cutting tool is called a *broach*, and the machine tool is called a *broaching machine*. The shape of the machined surface is determined by the contour of the cutting edges on the broach, particularly the shape of final cutting teeth. Broaching is a highly productive method of machining. Advantages include good surface finish, close tolerances, and the variety of possible machined surface shapes, some of them can be produced only by broaching. Owing to the complicated geometry of the broach, tooling is expensive. Broaching is a typical mass production operation.

Broaching

- Method of removing extra metal from external or internal surfaces of a work piece by using an elongated tool having a series of multiple cutting teeth positioned in tandem.
- Each successive tooth is slightly higher than its predecessor such that each tooth takes a cut when broach is reciprocated past work piece.



Broach tool nomenclature



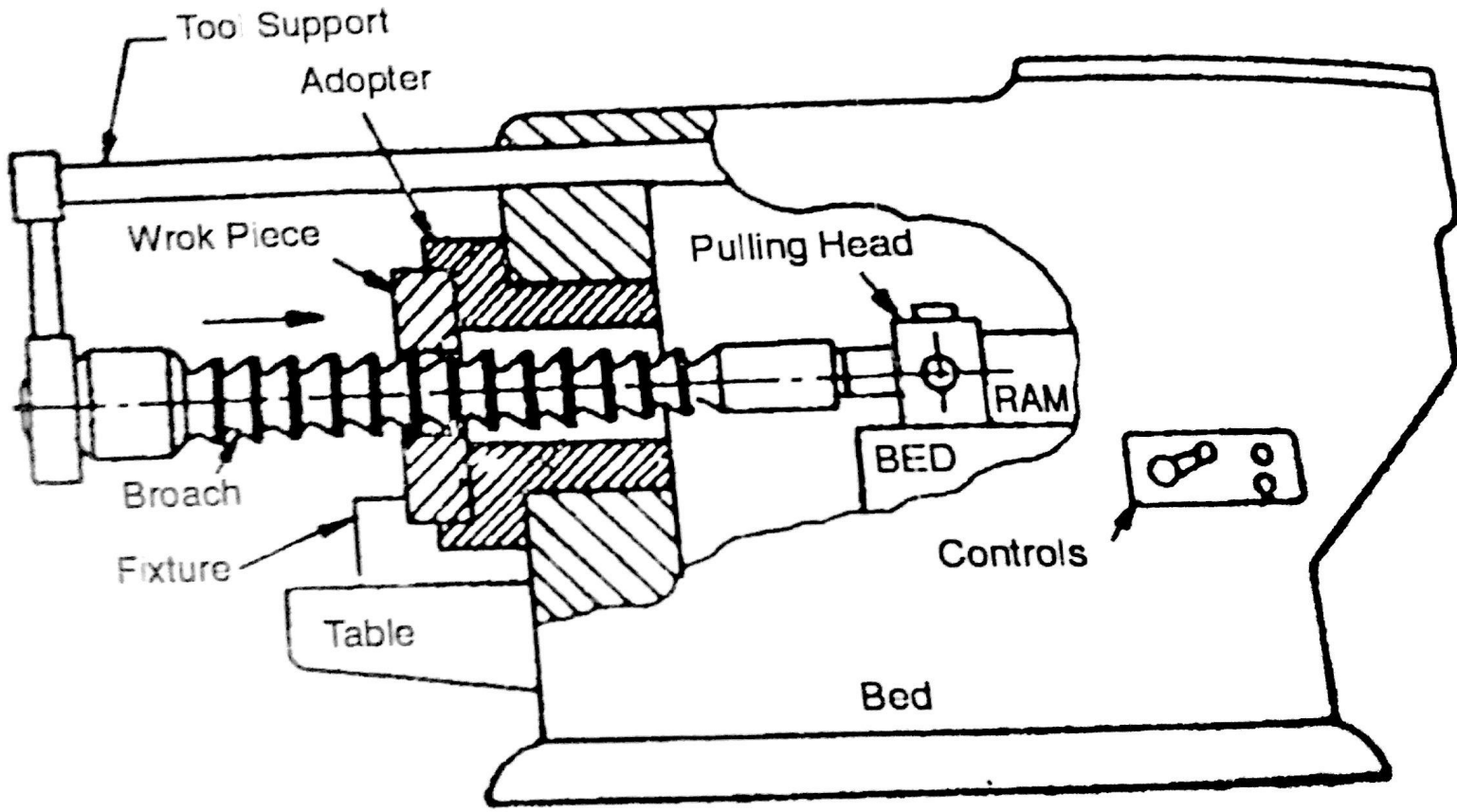
- **Pull end-** connected to pulling head of broaching machine.
- **Front pilot-** this locates the broach centrally with the hole to be broached.
- **Roughing teeth and semi finished teeth-** used for removing most of metal in broaching.
- **Finishing teeth-** meant for finishing the hole to the size and shape.
- **Rear pilot-** meant for giving support to the broach after the last tooth leaving the work piece.
- **Land-** top portion of teeth.
- **Clearance or back off angle-** back of the tooth sloped to give clearance angle.
- **Rake or face angle-** angle made by sloping the front face of tooth. Depends upon workpiece material.
- **Pitch-** linear distance between one tooth to the next tooth.

It is more in roughing teeth than finishing teeth.

Types of broaching machines

- According to **direction of cutter**
 - Horizontal cutter
 - Vertical cutter
- According to **method of cutting**
 - Pull type
 - Push type
 - Continuous type
- According to **type of drive**
 - Mechanical drive
 - Hydraulic drive
- According to **number of pull heads**
 - Single head
 - Multiple pull head
- According to **type of operation**
 - External type
 - Internal type

Horizontal broaching machine

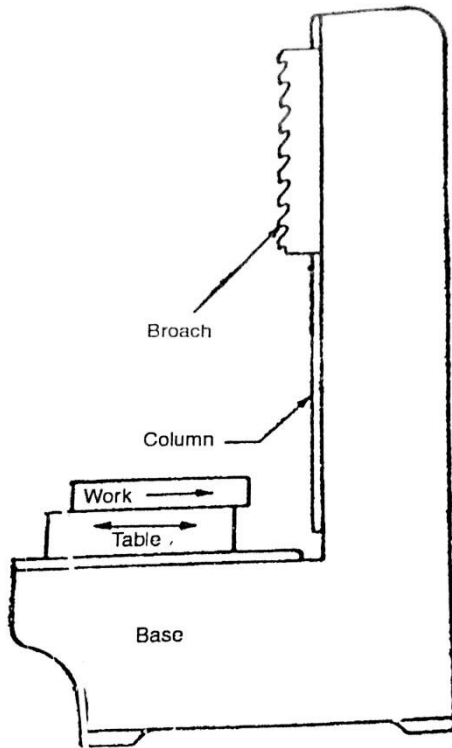


- Mostly all are **pull type**.
- Both internal and external broaching can be done.
- Consists of a **box type bed** having length is twice the length of stroke.
- All modern machines are provided with **hydraulic drive** housed in the bed.
- Job located in the **adapter** which is fitted on front vertical face.
- Small end is connected to hole of the job, then connected to pulling end which is mounted on front end of ram.
- Ram is connected to hydraulic drive.
- Rear end is supported by guide.

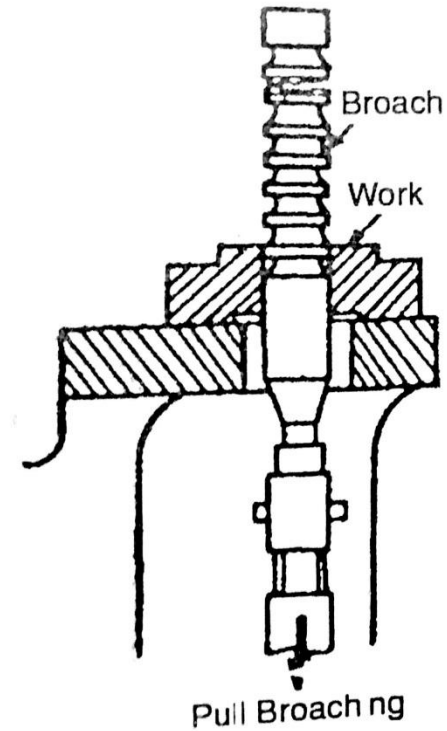
- Cutting speed- 4 to 15 mpm.
- Return speed- 35 mpm.
- Automatic stops are provided to control the stroke of ram.
- Used for small works like key ways splines, gun barrel refilling, cutting internal and external gears with helix angle less than 15°

Vertical broaching machine

Push down type vertical machine



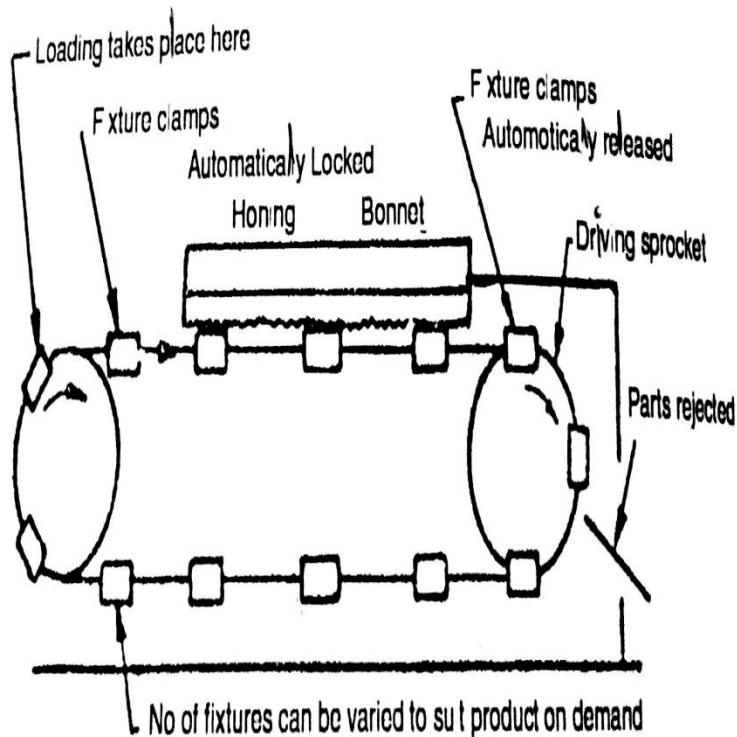
Pull down type



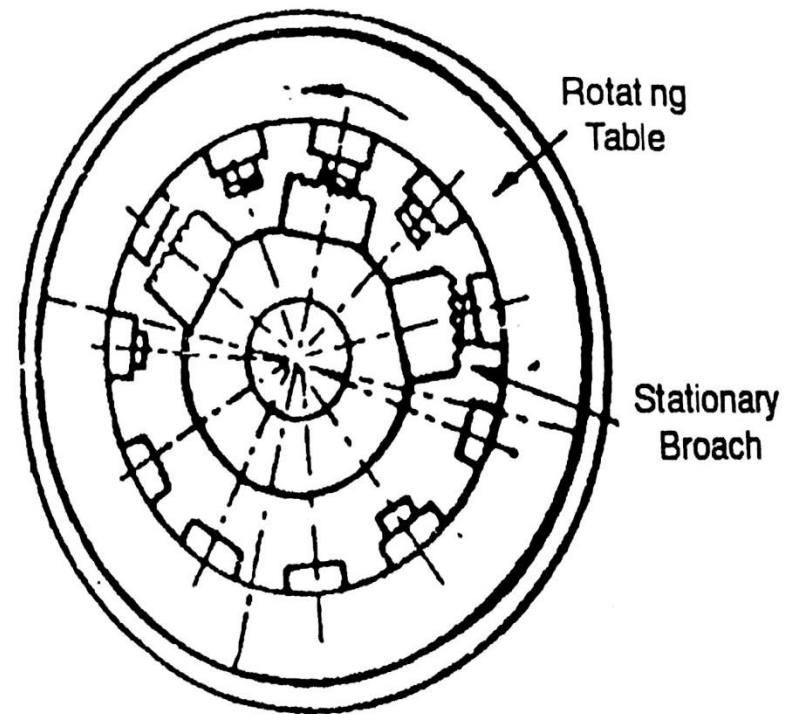
- Three types
 - Push down type
 - Pull down type
 - Pull up type
- **Applications**
- Connecting rods, connecting rods capes.
- Broaching of holes and splines in gears, bushes etc..

Continuous broaching machine

Horizontal continuous broaching machine



Rotary table continuous broaching machine



Classification of broaches

- According to **method of operation**
 - Push broach
 - Pull broach
- According to **king of operation**
 - Internal broach
 - External broach
- According to their **construction**
 - Solid broach
 - Built up of replaceable section
 - Inserted tooth broach
 - Overlapping teeth broach
 - Progressive cut broach
- According to **function**
 - Keyway, surface, round hole, spline, spiral, burnishing broach etc..

Broaching operation

- Surface broaching
- Hole broaching
- Keyway broaching
- Spline broaching

Specifications of broaching machine

- The size of broaching machine is given by **length of stroke of ram** in millimeters and **pressure applied on broach** in kilograms or tones.
- Other specifications of machine are:
 - Power of the motor and its speed
 - Length of bed
 - Length of slide stroke
 - Rated pulling force
 - Cutting stroke speed
 - Number of speeds
 - Return stroke speed
 - Maximum size of cut
 - Weight of machine
 - Size and floor area

Advantages of broaching

- **Roughing and finishing operations** in machining a job are often completed in a **single stroke** of broach, giving high rate of production.
- Any form that can be achieved on a broaching tool can be reproduced effectively on work piece.
- External or internal finishing can be done maintaining tolerances 0.0075mm needed for interchangeable production.
- Manufacturing sequence for obtaining varieties of shapes on a work piece is often simplified by using multiple type broaches to work one after other in same stroke of machine.
- Simple and automated.

Grinding

- It is a process of removing material by **abrasive action** of revolving wheel on surface of a work piece in order to bring it to required shape and size.

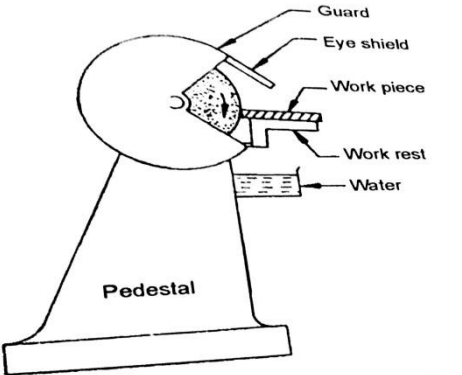
Types of grinding machines

- Rough grinders
- Precision grinders
- Rough grinders
 - Floor stand and bench grinders
 - Portable and flexible shaft grinders
 - Swing frame grinders
 - Abrasive belt grinders

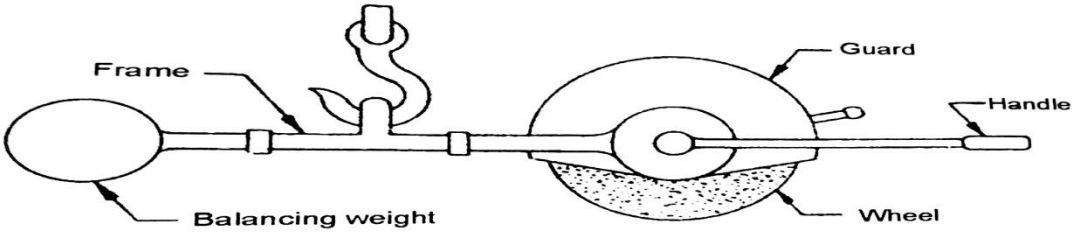
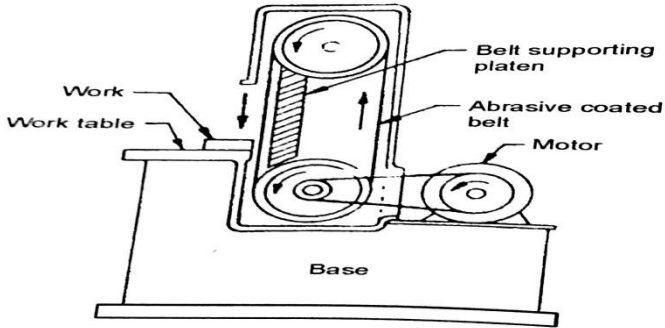
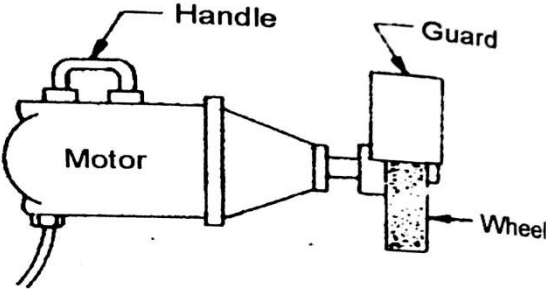
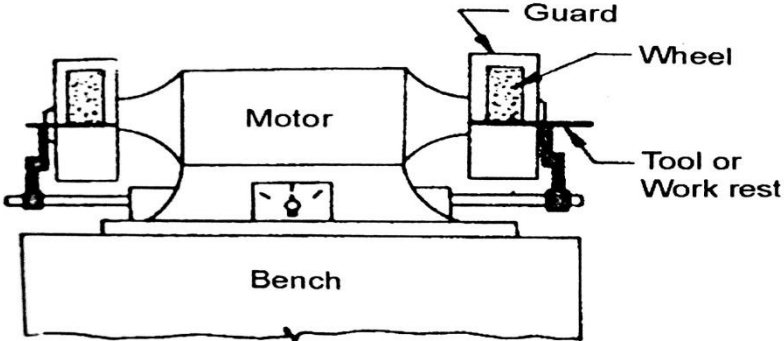
- Precision grinders
 - Cylindrical grinders
 - Centre-type(plain)
 - Centre-type(Universal)
 - Centre-less
 - Internal grinders
 - Chucking
 - Plain
 - Universal
 - Planetary
 - Centre-less
- surface grinders
 - Reciprocating table
 - Horizontal spindle
 - Vertical spindle
 - Rotating table
 - Horizontal spindle
 - Vertical spindle

- Tool and cutter grinders
 - Universal
 - Special
- Special grinding machines.

Rough grinders

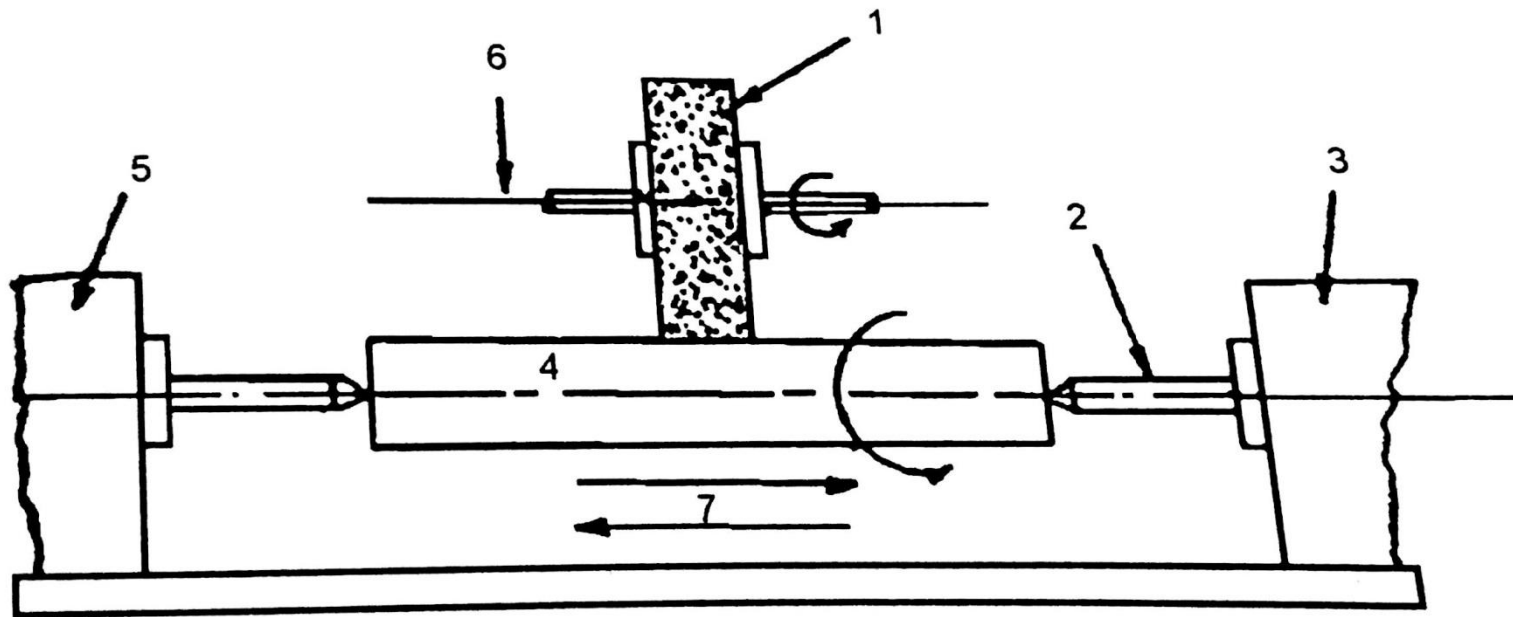


Pedestal Grinder



Precision grinders

- Cylindrical grinders

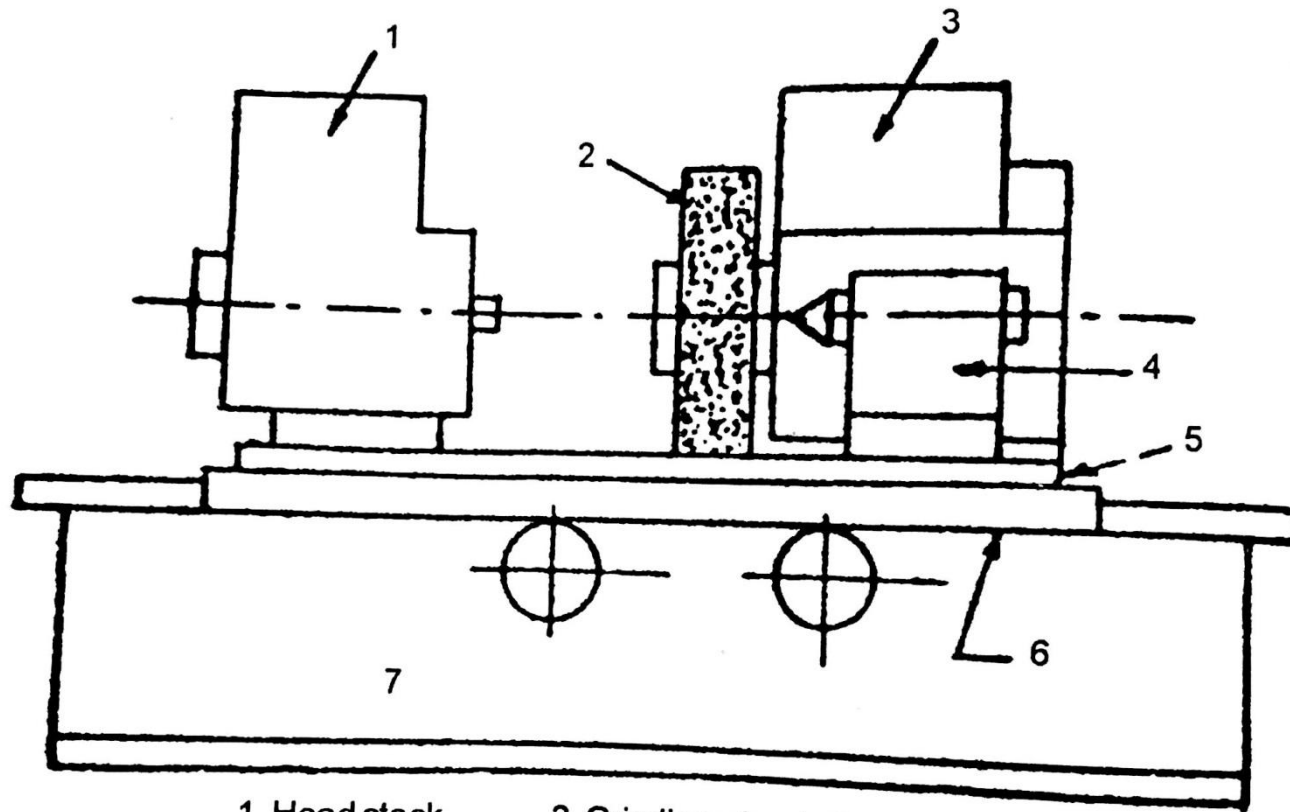


1. Grinding wheel
4. Work piece

2. Dead centre
5. Head stock
7. Work Traverse

3. Tail stock
6. Wheel feed

Plain centre type cylindrical grinding machine

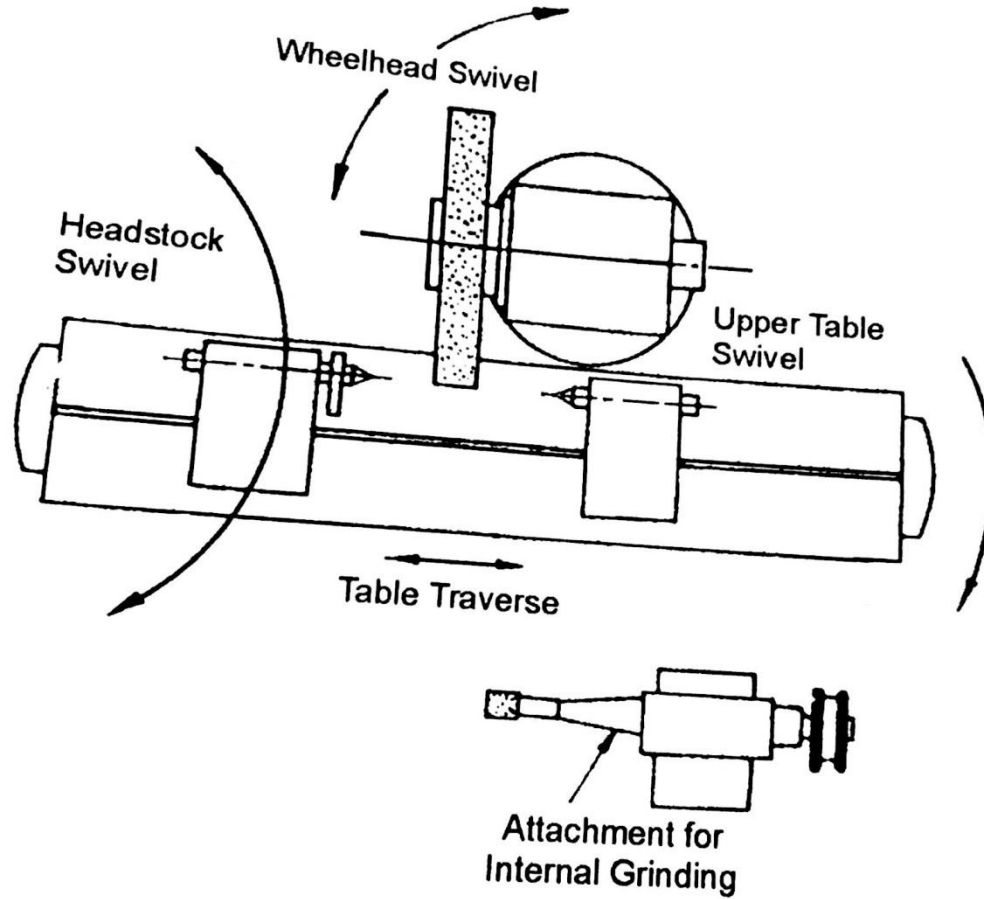


1. Head stock
4. Tail stock
7. Base

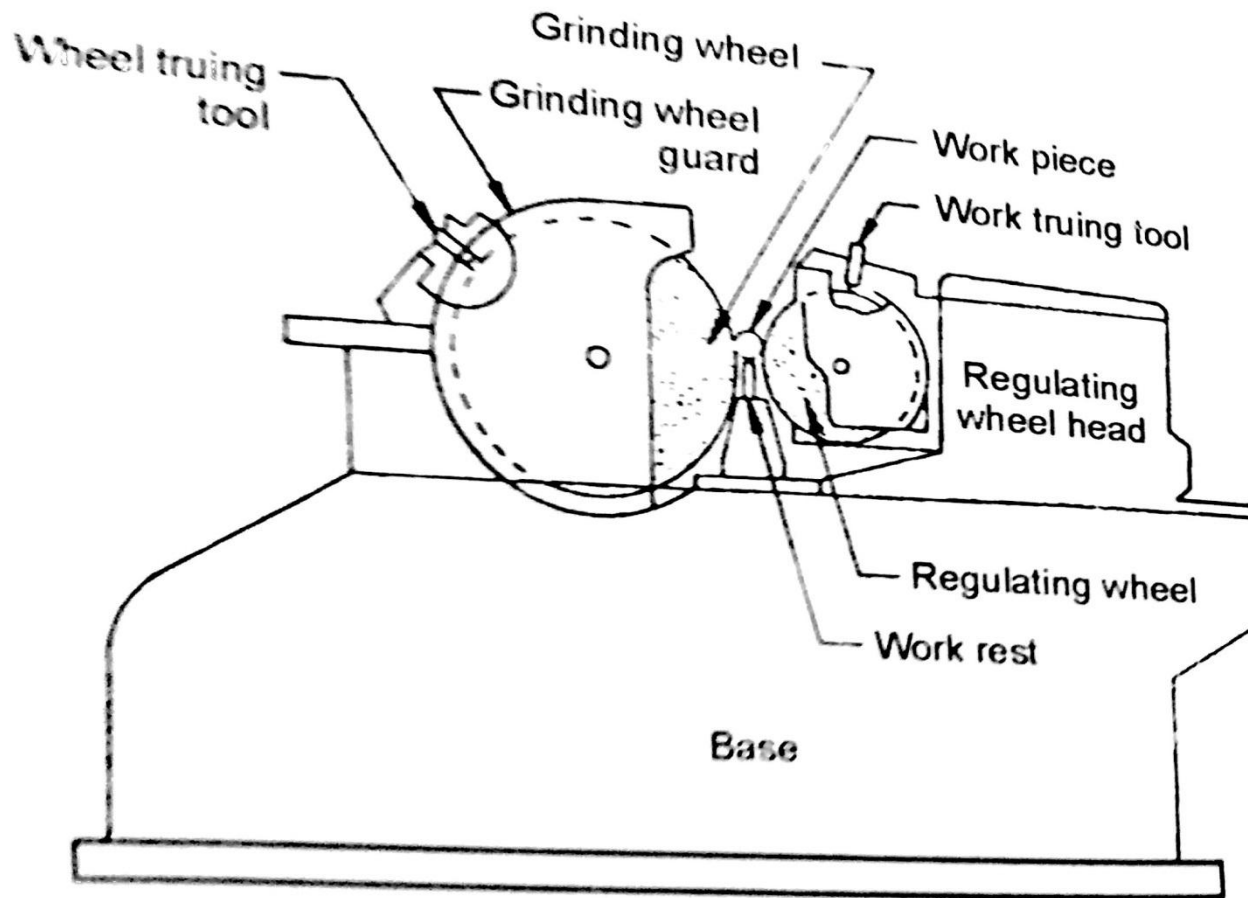
2. Grinding wheel
5. Uppertable

3. Wheel head
6. Lower table

Centre type universal grinder

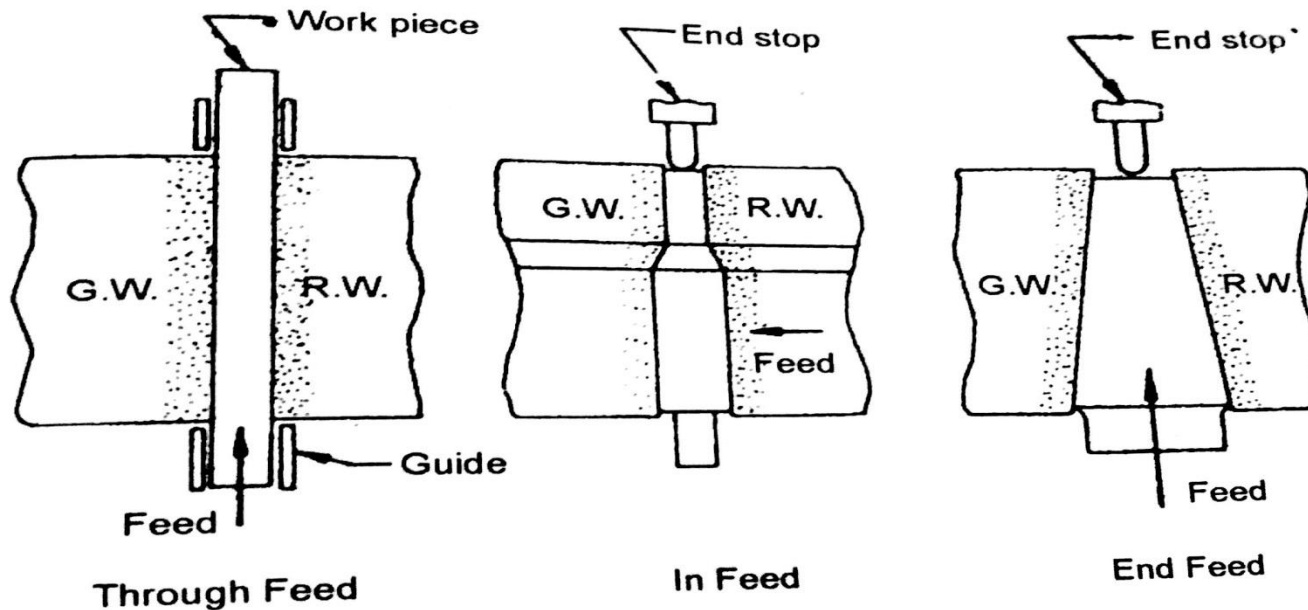


Centreless grinders



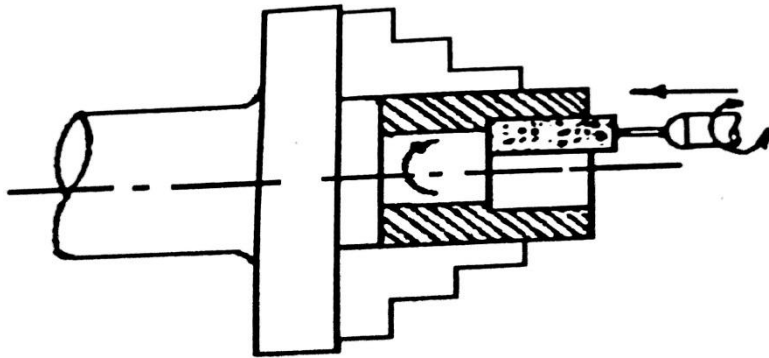
- In centreless grinding, the work piece is fed in following methods

- Through feed
- In feed
- End feed

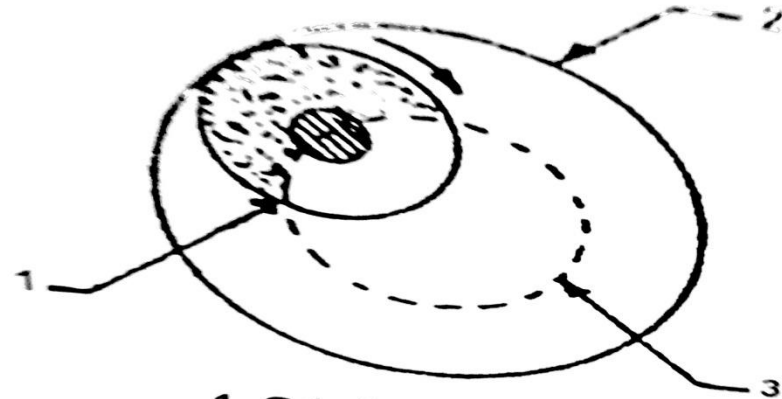


Internal grinders

Chucking

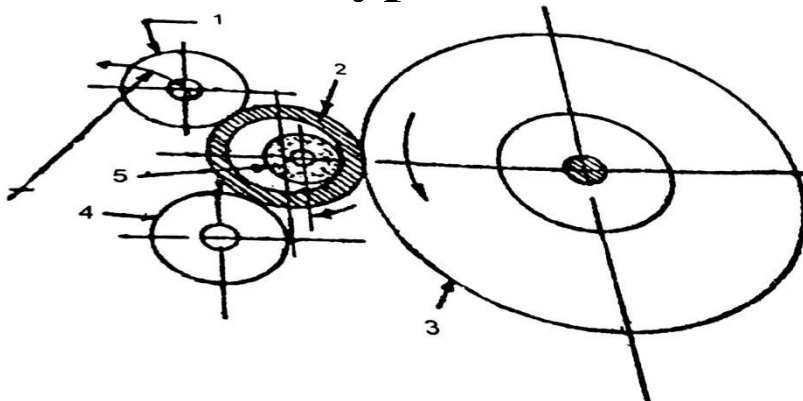


Planetary



- 1. Grinding wheel
- 2. Cylinder bore
- 3. Path of grinding wheel

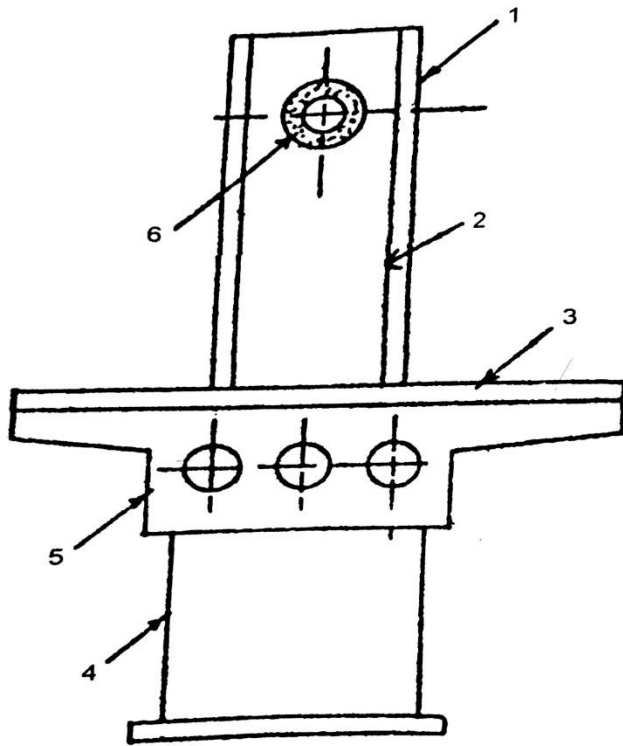
- **Centreless type internal**



- 1. Pressure Roll 2. Work 3. Regulating Roll
- 4. Support Roll 5. Grinding wheel

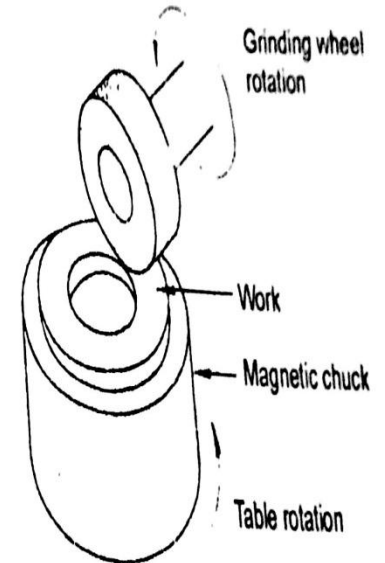
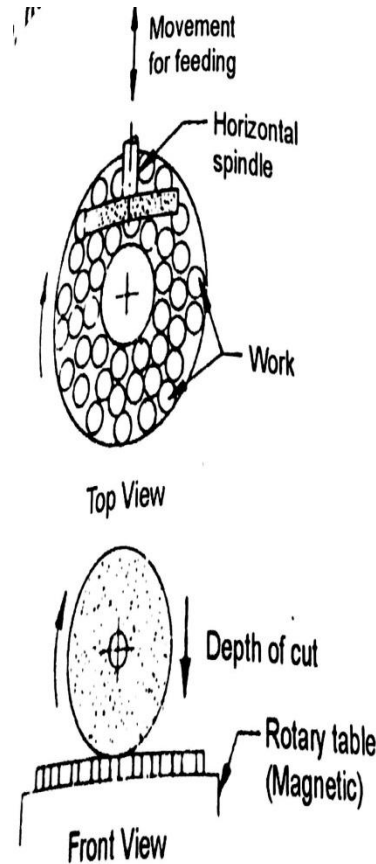
Surface grinder

Horizontal spindle reciprocating table type



1. Column 2. Wheel head 3. Table 4. Base
5. Saddle 6. Grinding wheel

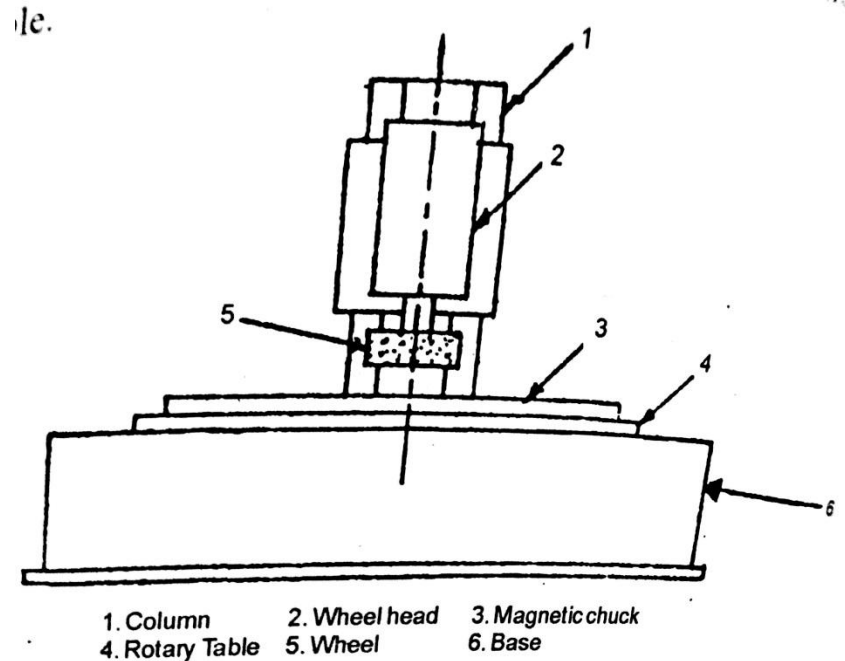
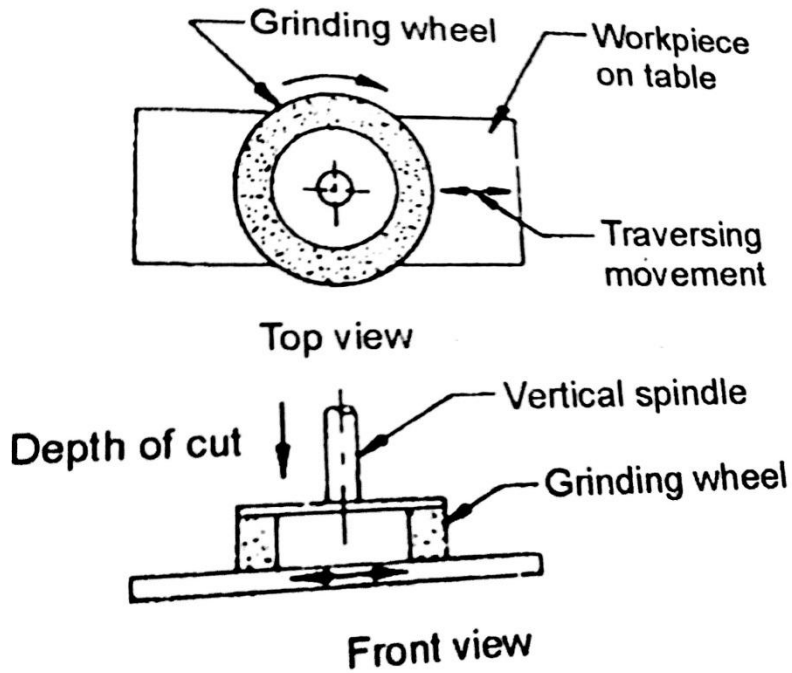
Horizontal spindle rotary table type



Surface grinder

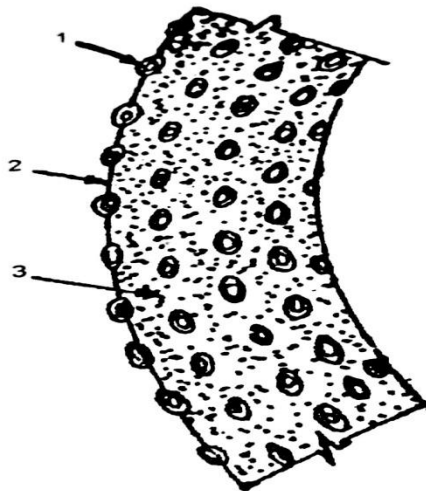
Vertical spindle rotary table surface grinder

Vertical spindle reciprocating table surface grinder



Wheel materials

- A grinding wheel essentially consists of following two materials
- **Abrasives**: It is material of grinding wheel which does cutting action.
- **Bond**: it is material of grinding wheel which acts as binder to hold abrasive grains together.



1. Abrasive particles

2. Wheel face

3. Bonding Material

Abrasives

- Two types
 - Natural abrasives
 - Artificial abrasives
- **Natural abrasives**
 - Sandstone or solid quartz
 - Emery(50-60% crystalline Al_2O_3 + iron oxide)
 - Corundum(75-90% crystalline Al_2O_3 + iron oxide)
 - Diamonds
 - Garnet
- **Artificial abrasives**
 - **Silicon carbide**
 - Variety of colours, bluish green, grinding tipped tools. Carborandum, crystolon, Electroton. Denoted by “S”.
 - **Aluminium oxide**
 - Tool steels, Aloxite, Alundum, Borolon. Denoted by “A”
 - **Boron carbide**
- Efficiency – depends on purity, uniformity in composition, hardness, toughness, sharpness of fracture.

Bonds

- Adhesive substance used to hold abrasive grains together in grinding wheel.
- **Vitrified bond (V)**
 - Clay and abrasive grains with water, 700⁰C, not affected by acids and alkaline.
- **Silicate bond (S)**
 - Abrasive grains with silicate of soda, 250⁰c, water proof, grinding of cutting tools, cutting blades.
- **Resinoid bond (B)**
 - Abrasive grains with synthetic resin. 200⁰c, rough grinding of iron and steel castings.
- **Rubber bond (R)**
 - Abrasive grains with liquid rubber and sulphur.
- **Shellac bond (E)**
 - Abrasive grains with shellac. 150⁰c, finishing iron castings and steel rolls.
- **Oxychloride bond (O)**
 - Abrasive grains with magnesium chloride and magnesium oxide.
 - Used for making disc shaped wheels.

Grit, grade and structure of grinding wheels

- **Grit or grain** - indicate size of abrasive grains.

Types of grit	Grain size or grit number
Coarse	8,10,12,14,16,20,24 (8 to 24)
Medium	30,36,46,54,60 (30 to 60)
Fine	80,100,120,150,180 (80 to 180)
Very fine	220,240,280,320,400,500,600 (220 to 600)

- **Grade or strength of bond**- hardness with which the bond holds the abrasive grains.

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

- **Structure or Grain Spacing** – number of cutting edges per unit area of wheel face as well as the number and size of void spaces between grains.

Dense	1,2,3,4,5,6,7,8
Open	9,10,11,12,13,14,15

Standard marking system for grinding wheels

- Used to specify various characteristic of grinding wheel.
- Following details are indicated in marking system.
 - **Types of abrasives**
 - **Grain size or grit number.**
 - **Grade of wheel.**
 - **Structure.**
 - **Type of bond**
 - **Manufacturers code-prefix and suffix.**

Selection of grinding wheels

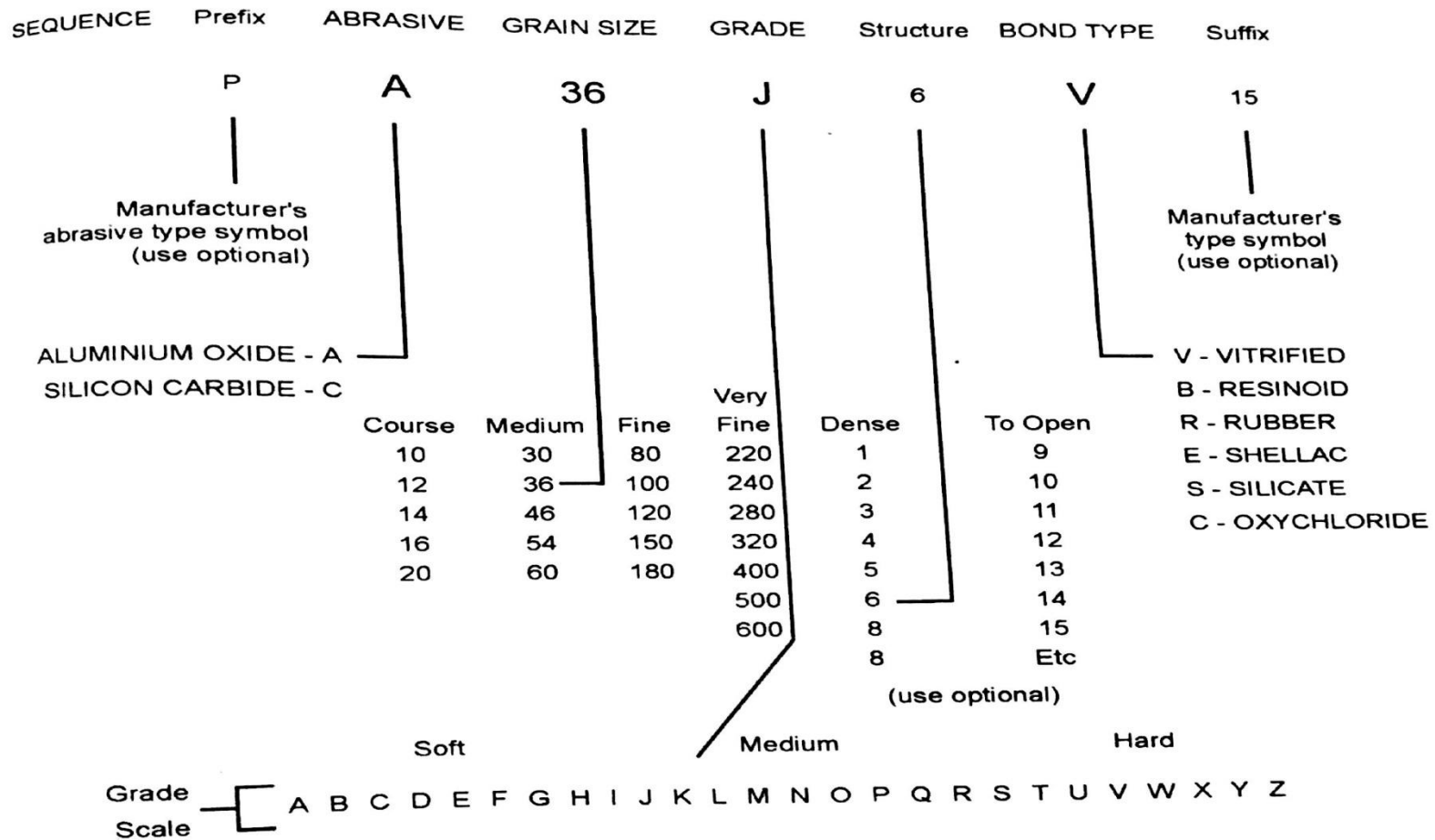


Figure 6.27 Standard Making System for Grinding Wheel

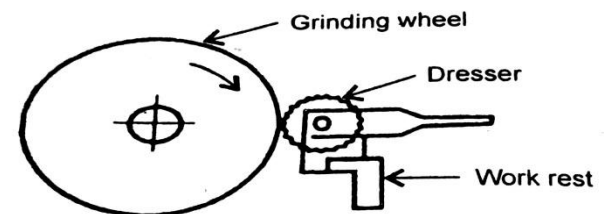
- In selecting a grinding wheel, following factors are considered
 - Material to be grind
 - The amount of stock to be removed
 - Area of contact of wheel with work piece
 - Type of grinding machine and its condition.
 - Wheel speed and work speed.

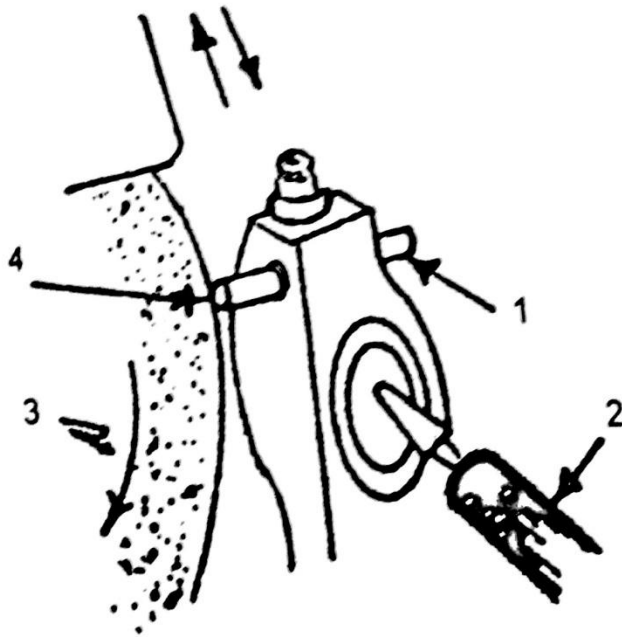
Glazing

- When abrasive grains become dull and stop cutting, the wheel is said to be glazed.
- Glazing takes place when a wheel is too hard or revolves at too fast a speed.
- The remedy for glazing is to decrease speed or to use a softer wheel.

Dressing and truing

- **Dressing**
- Process of removing leading and breaking away glazed surface so that fresh abrasive particles are again presented to work for efficient cutting.
- Done with various types of dressing tools
 - Star dressing tool
 - Used to **dress coarse grain abrasive wheels** used for rough snagging work.
 - Round abrasive sticks
 - Used to dress wheels where a **fair degree of finish is required**.
 - Diamond dressing tool
 - For **high precision and high finish grinding**.





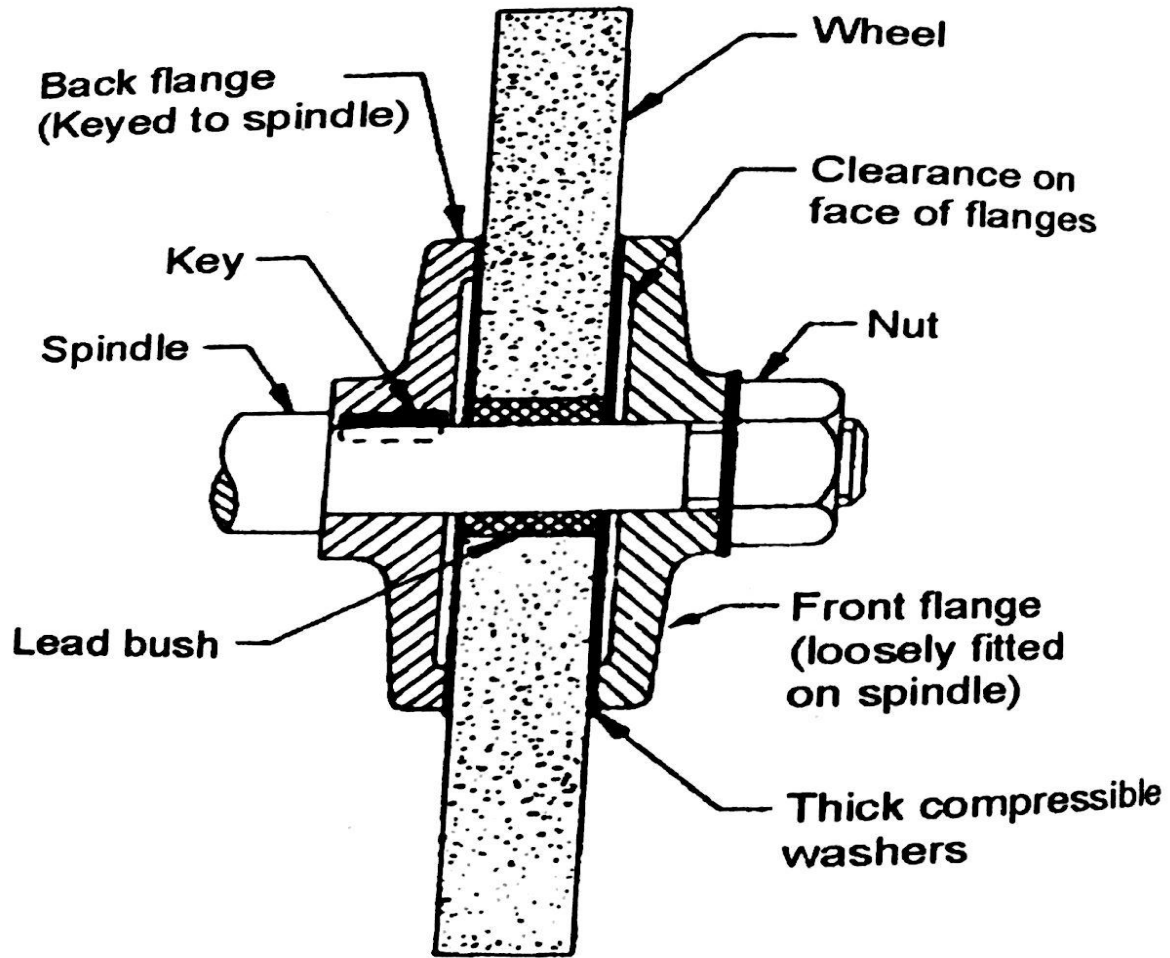
1. Movement of Diamond
2. Tail stock
3. Grinding wheel
4. Diamond
5. Movement of Diamond

- **Truing**

- Process of **changing shape of grinding wheel** as it becomes worn from an original shape, owing to breaking away of abrasive and bond.

Mounting of wheels

- While mounting wheels, following points are considered,
 - The abrasive wheels should have a **sliding fit on spindle**. The wheel should not be forced on spindle.
 - A **linear lead bush** is used in bore of wheel. The bush should not project beyond wheel face.
 - **Flanges of equal diameter** are fitted at both sides of wheel. The flange diameter must be atleast equal to half of wheel diameter.
 - The **side of wheel and flange** should be perfectly **flat**.
 - Flanges should have **clearances** only on their laces.



- The **inner fixed flange** is keyed to **spindle**, the **outer flange** has a **sliding fit with spindle**.
- **Thick compressive washers** are placed on both sides between wheel faces and flanges. This helps proper gripping of flanges on wheel.
- The **nut** should be tightened firmly enough to hold the wheel.
- **Wheel guards** should be placed in position before starting grinder.

Specifications of grinding machines

- Largest size of work piece that can be held in machine.
- For cylindrical grinder- the diameter and length of largest work piece that can be held.
- For internal cylindrical grinder- the maximum diameter of work piece that can be held in chuck.
- Maximum stroke length of wheel.
- For surface grinders- the table area, length of the table, width of table or diameter of rotary table.
- Maximum longitudinal and cross feed movements.