GRINDING PROCESS

V.Gunasegaran
Assistant Professor
Department of Mechanical Engineering
School of Mechanical Sciences
BSAU, Chennai - 48

Introduction

- ✓ Some manufacturing processes cannot produce the required dimensional accuracy or surface finish
- ✓ An abrasive is a small, hard particle having sharp edges and an irregular shape
- ✓ Abrasives is removing of small amounts of material from a surface through a cutting process that produces tiny chips
- ✓ Sandpaper or emery cloth can smoothen surfaces and remove sharp corners

Grinding wheels

- ✓ Grinding wheels can sharpen knives and tools
- ✓ Grinding wheels are produced by mixing the appropriate grain size of abrasive with required bond and then pressed into shape
- ✓ The characteristics of the grinding wheel depends on number of variables
- ✓ Specified by dia. of wheel, dia. of spindle hole and face width of wheel

Designation and selection

- Grinding wheels designation and selection have been described by the characteristics of
  - Abrasives
  - Bonds

Abrasives

- ✓ Commonly found in nature are emery, corundum (alumina), quartz, garnet and diamond
- ✓ Abrasives that have been made synthetically:
  - Aluminum oxide (Al_2O_3)
  - Silicon carbide (SiC)
  - Cubic boron nitride (CBN)
  - Diamond

Bonds

- ✓ Common types of bonds:
- ✓ Vitrified:
  - Consist of feldspar and clays
  - Strong, stiff, porous, and resistant to oils acids, and water
- ✓ Resinoid or Synthetic resin:
  - Bonding materials are thermosetting resins
  - These are more flexible than vitrified wheels
- ✓ Shellac
  - Less used bond in grinding wheels
  - Used for getting very high finish

Contd.,

- ✓ Silicate
  - Consist of sodium silicate and harden when at heat
  - It is not strong as vitrified
- ✓ Rubber:
  - Most flexible bond
  - Made by natural / synthetic rubber
  - Strength developed by vulcanization
- ✓ Metal
  - Used for making of CBN and diamond wheels
  - Manufacturing by powder-metallurgy techniques

Other Selection Parameters

- ✓ Grain size
  - Identified by grit size
- ✓ Grade
  - Hardness of wheel
- ✓ Grinding wheel standard marking or Wheel designation system
  - Label includes types of abrasive and bond, grain size, grade, structure and both end with manufacturer's identifications
- ✓ Structure
  - Grain spacing in grinding wheel (dense, medium, open)

Marking of Conventional Grinding wheel

The standard marking system for conventional abrasive wheel can be as follows:

51 A 60 K 5 V 05

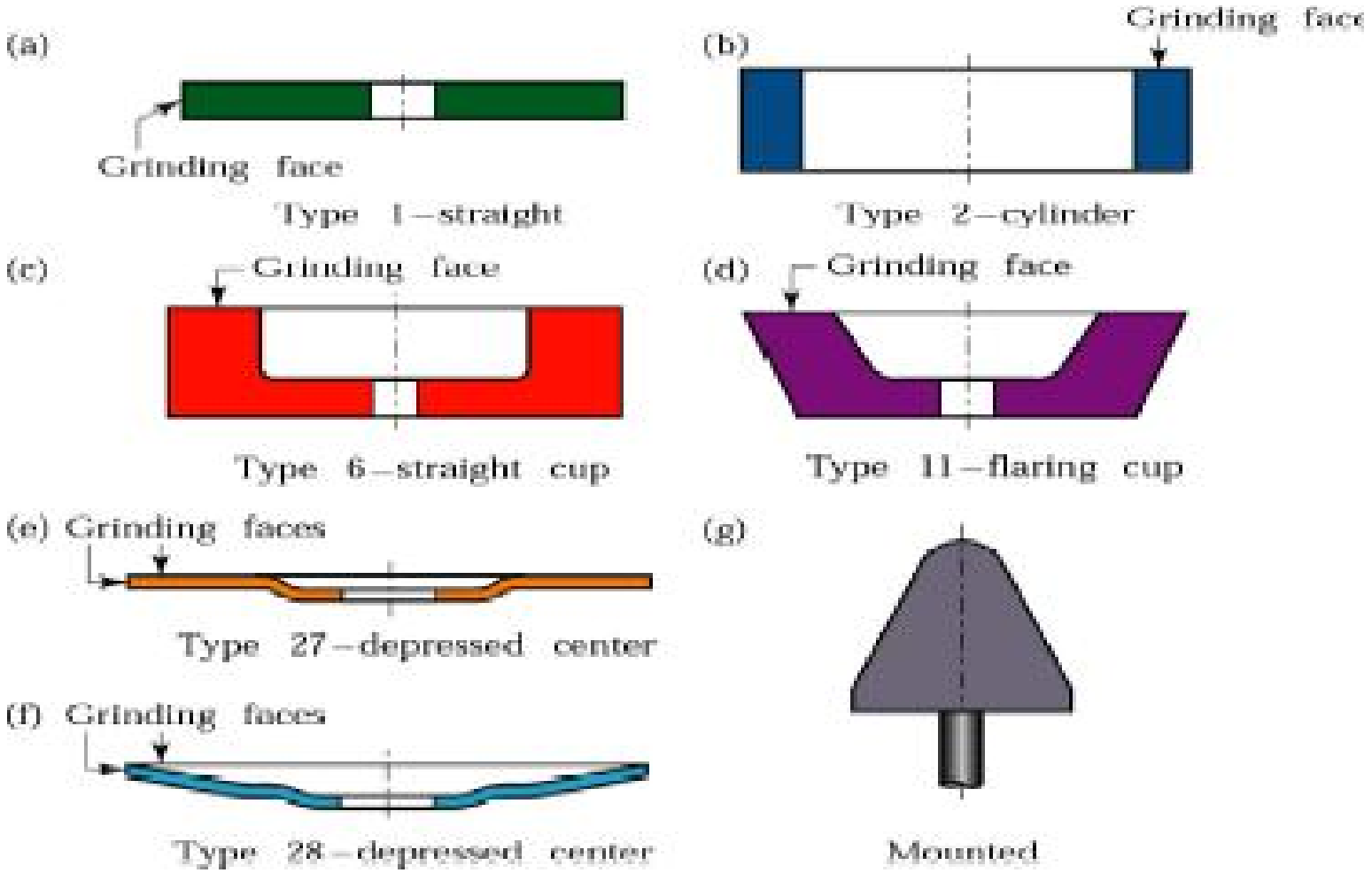
where

- The number '51' is manufacturer's identification number indicating exact kind of abrasive used.
- The letter 'A' denotes that the type of abrasive is Aluminium Oxide (Al_2O_3). In case of Silicon Carbide (SiC) the letter 'C' is used.
- The number '60' specifies the average grit size in inch mesh. For a very large size grit this number may be as small as 6 where as for a very fine grit the number may be as high as 600.
- The letter 'K' denotes the hardness of the wheel. The letter symbol can range between 'A' and 'Z', 'A' denoting the softest grade and 'Z' denoting the hardest one.
- The number '5' denotes the structure or porosity of the wheel. This number can assume any value between 1 to 20, '1' indicating high porosity and '20' indicating low porosity.
- The letter code 'V' means that the bond material used is vitrified.
- The number '05' is a wheel manufacturer's identifier.

Types of Grinding wheels

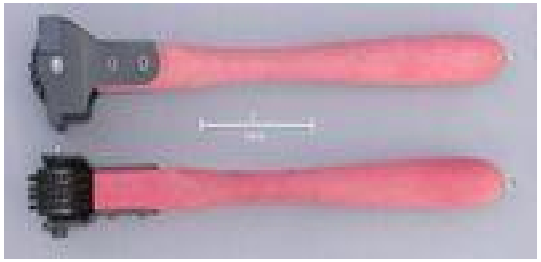
- ✓ The grinding wheels come in variety of shapes and standardised sizes
- ✓ These are to suit various workpiece shapes & sizes and to be used in different types of grinding machines
- ✓ Most common type is straight
- ✓ Flaring type used for tool grinding
- ✓ Cut – off used for parting operations

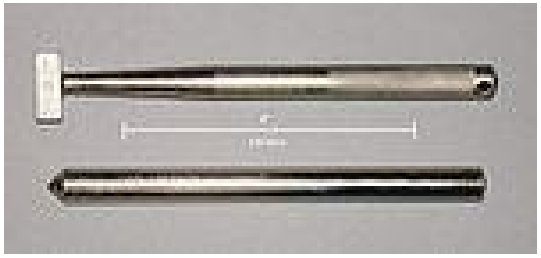
Contd.,


(a)
Grinding face
Type 1—straight
(b)
Grinding face
Type 2—cylinder
(c)
Grinding face
Type 6—straight cup
(d)
Grinding face
Type 11—flaring cup
(e) Grinding faces
Type 27—depressed center
(f) Grinding faces
Type 28—depressed center
(g)
Mounted

Dressing and Truing

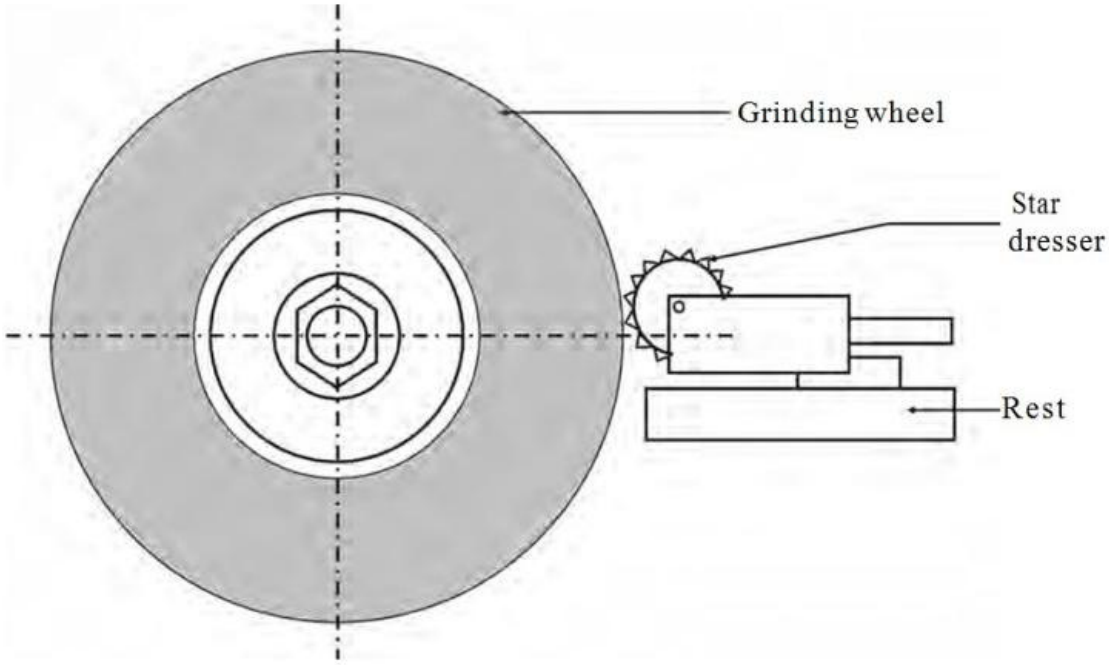
- If the grinding wheels are loaded or gone out of shape, they can be corrected by dressing or truing
- Dressing is the process of breaking away the glazed surface so that sharp particles are again presented to the work
- The common types of wheel dressers are
  - Star dresser
  - Diamond dressers
- This minimizes vibration and improves surface finish





Contd.,

- ✓ The purpose of shaping (making wheel true & concentric) and the grinding wheel is corrected by means of diamond tool dressers known as truing



Dressing of a Grinding Wheel (Star wheel method)

Balancing

- ✓ When mounting the new grinding wheel intense care should be taken for proper balancing
- ✓ Unbalancing wheel may cause vibration and poor surface finish, geometry and dimension
- ✓ For the wheel balancing, wheel balancer can be used
  - Static balancing
  - Dynamic balancing

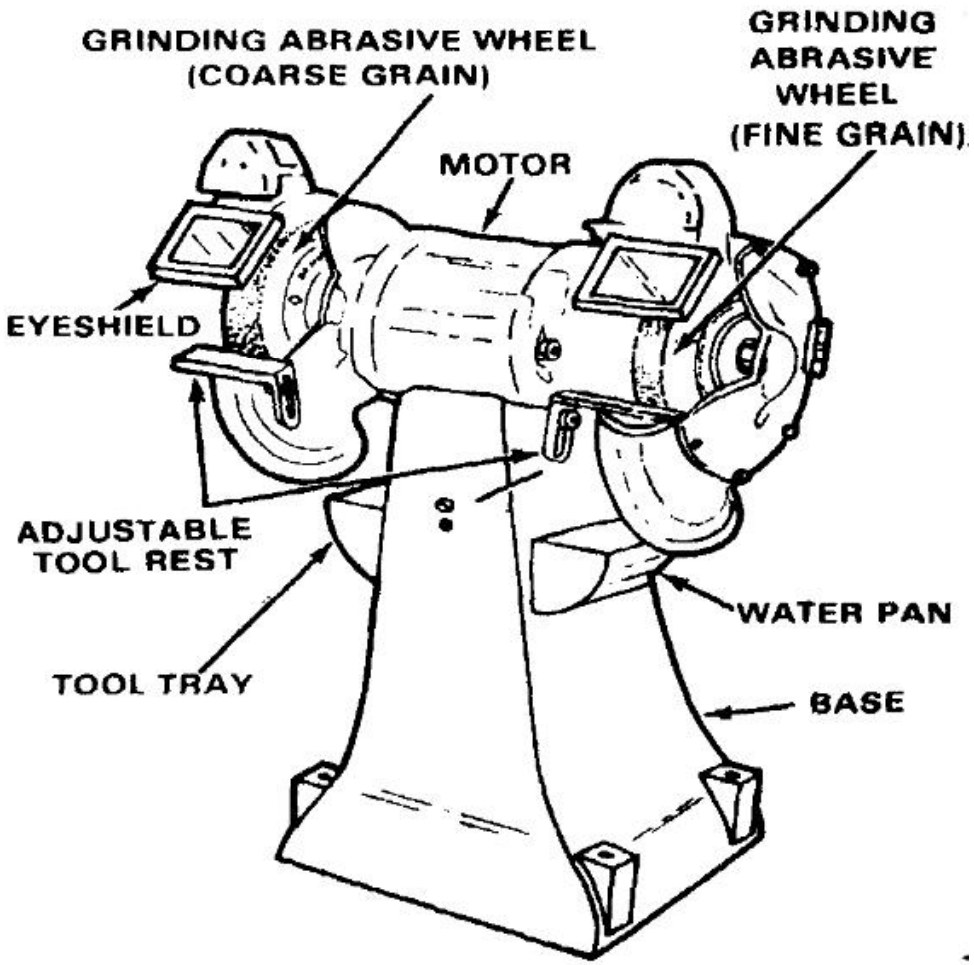
Grinding Fluids

- ✓ The correct selection of grinding fluid can greatly affect the grinding process
- ✓ Grinding fluids serves for
  - Reduce temperature in the work piece
  - Lubricate the contact area between wheel and work piece (prevent chip sticking)
  - Removing common grinding dust which is hazardous to the health of operator

Grinding Process

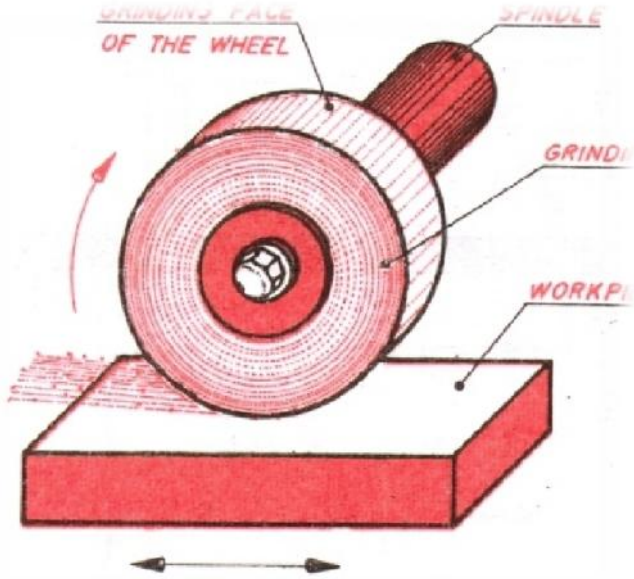
- ✓ Grinding is a surface finishing operation where very thin layer of material is removed in the form of dust particles.
- ✓ Thickness of material removed is in range of 0.25 to 0.50 mm.
- ✓ Tool used is a abrasive wheel
- ✓ Grinding machine is a power operated machine tool where, the work piece is fed against constantly rotating abrasive wheel to remove thin layer of material from work.

Grinding Machine



Working Principle

- ✓ Work piece is fed against the rotating abrasive wheel.
- ✓ Due to action of rubbing or friction between the abrasive particles and work piece material is removed.

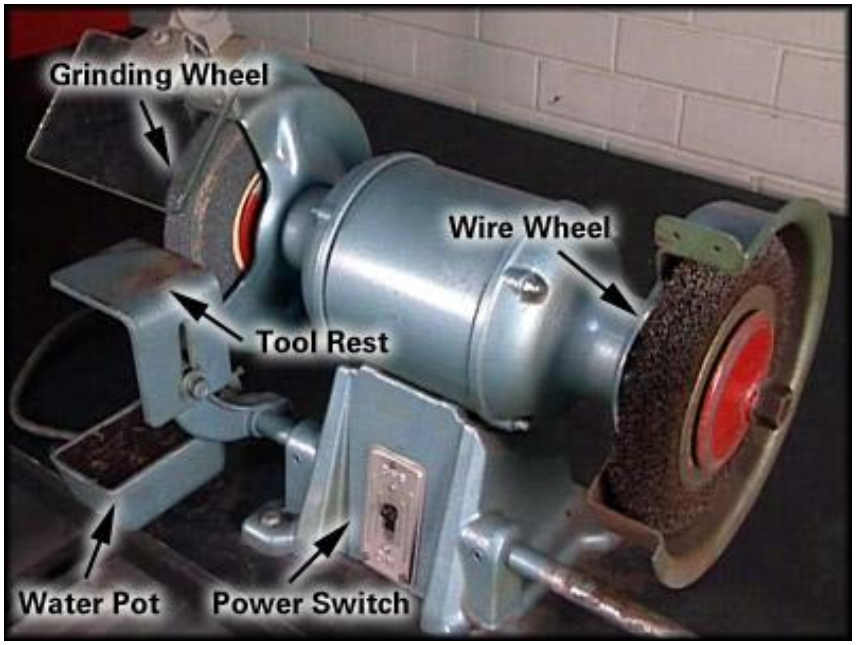


Classification of grinding machine

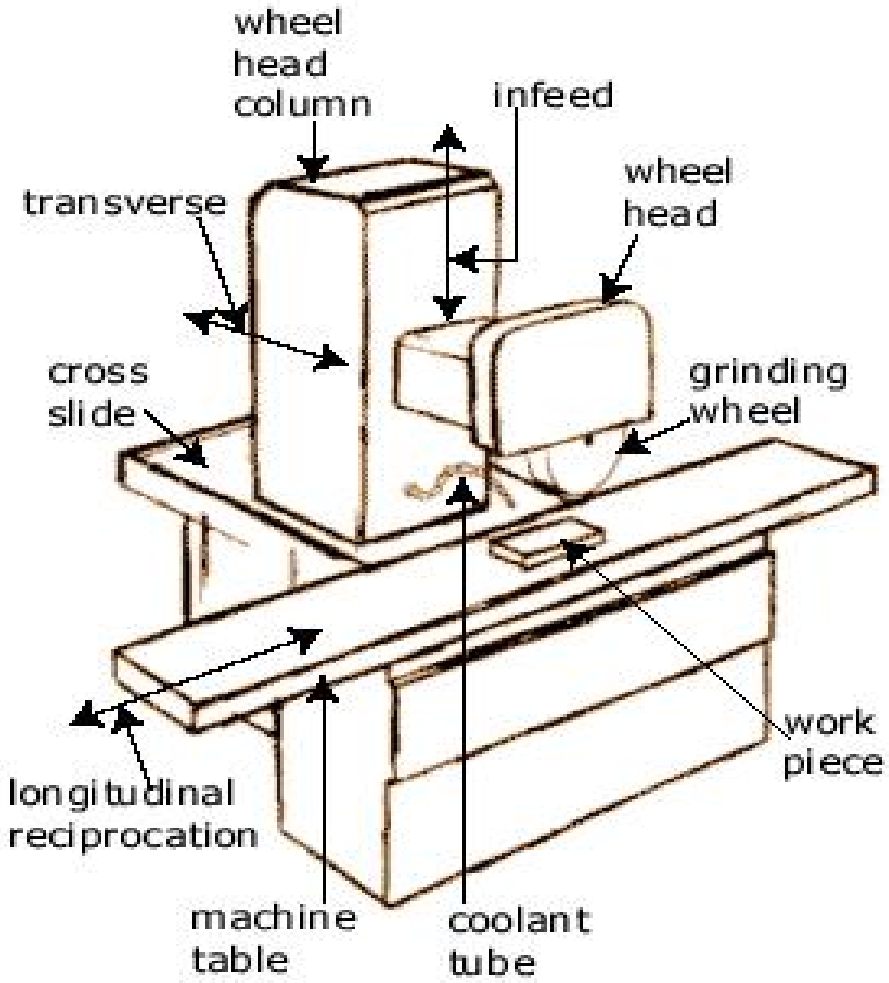
- ✓ Bench grinding machine
- ✓ Surface grinding machine
- ✓ Cylindrical grinding machine
- ✓ Center less grinding machine
- ✓ Internal grinding machine
- ✓ Special purpose grinding machine

Bench grinder

- ✓ Two wheels of different grain sizes for roughing and finishing operations and is secured to a workbench.



Surface grinder



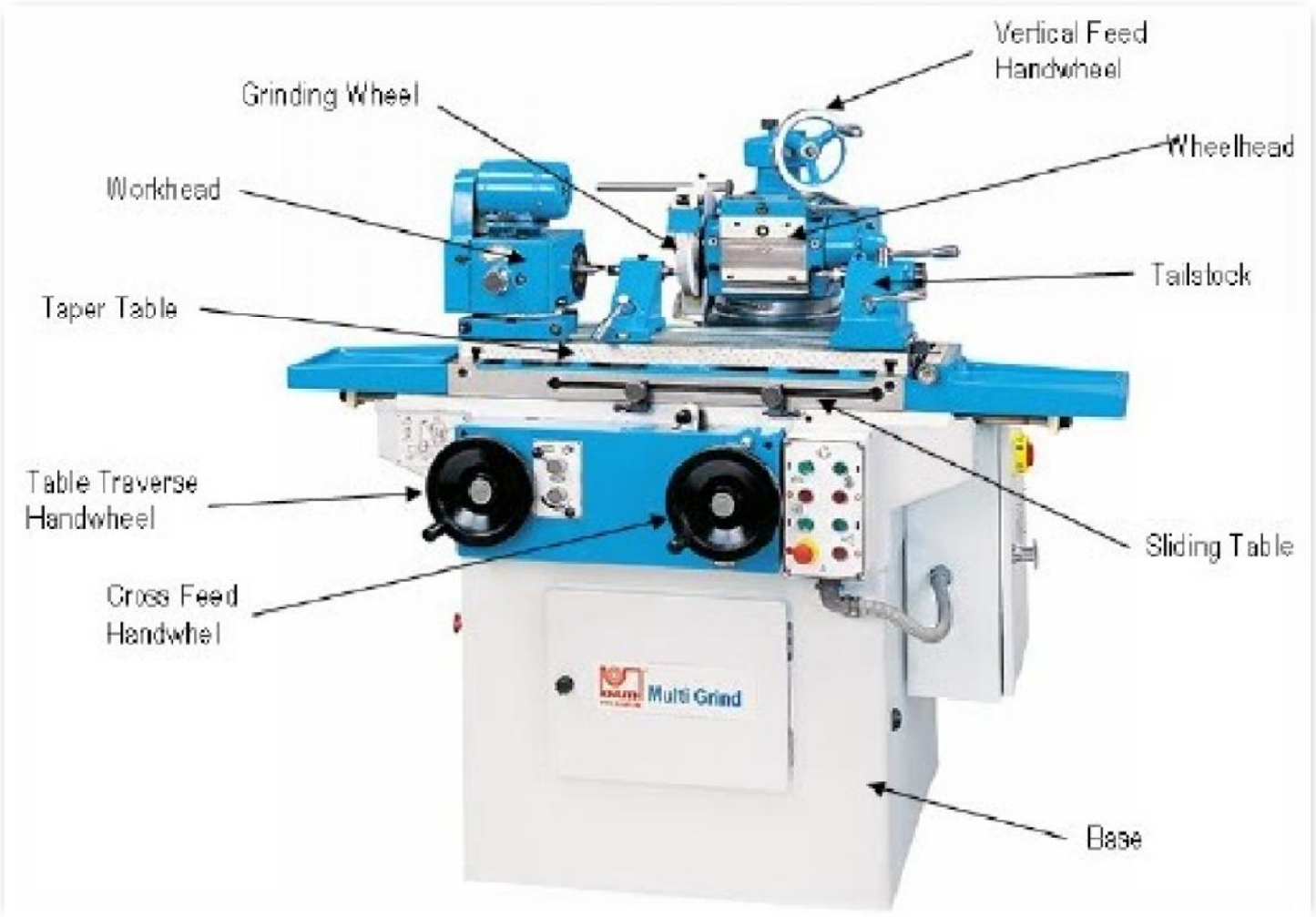
Contd.,

- Surface grinder which includes the wash grinder
- A surface grinder has a "head" which is lowered, and the work piece is moved back and forth past the grinding wheel on a table that has a permanent magnet for use with magnetic stock
- Surface grinders can be manually operated or have CNC controls

Contd.,

- ✓ Rotary surface grinders or commonly known as "Blanchard" style grinders, the grinding head rotates and the table usually magnetic moves in the opposite direction, this type machine removes large amounts of material and grinds flat surfaces with noted spiral grind marks
- ✓ Used to make and sharpen; burn-outs, metal stamping die sets, flat shear blades, fixture bases or any flat and parallel surfaces

Cylindrical grinder



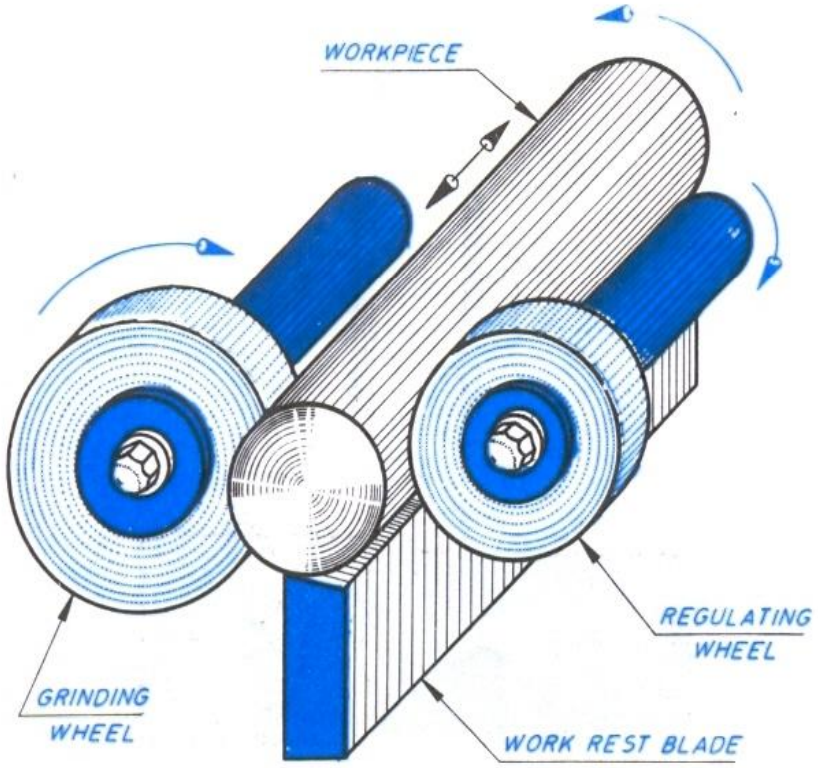
Contd.,

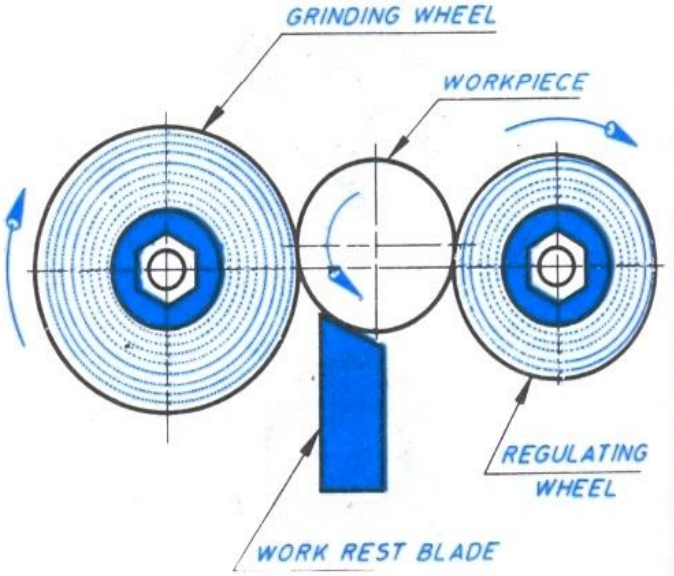
- ✓ Cylindrical grinder, which includes both the types that use centers and centerless types
- ✓ A cylindrical grinder may have multiple grinding wheels
- ✓ Work piece holding by chucks and centers
- ✓ The work piece is rotated and fed past the wheel(s) to form a cylinder
- ✓ It is used to make precision rods, tubes, bearing races, bushings, and many other parts

Centre less grinding machine

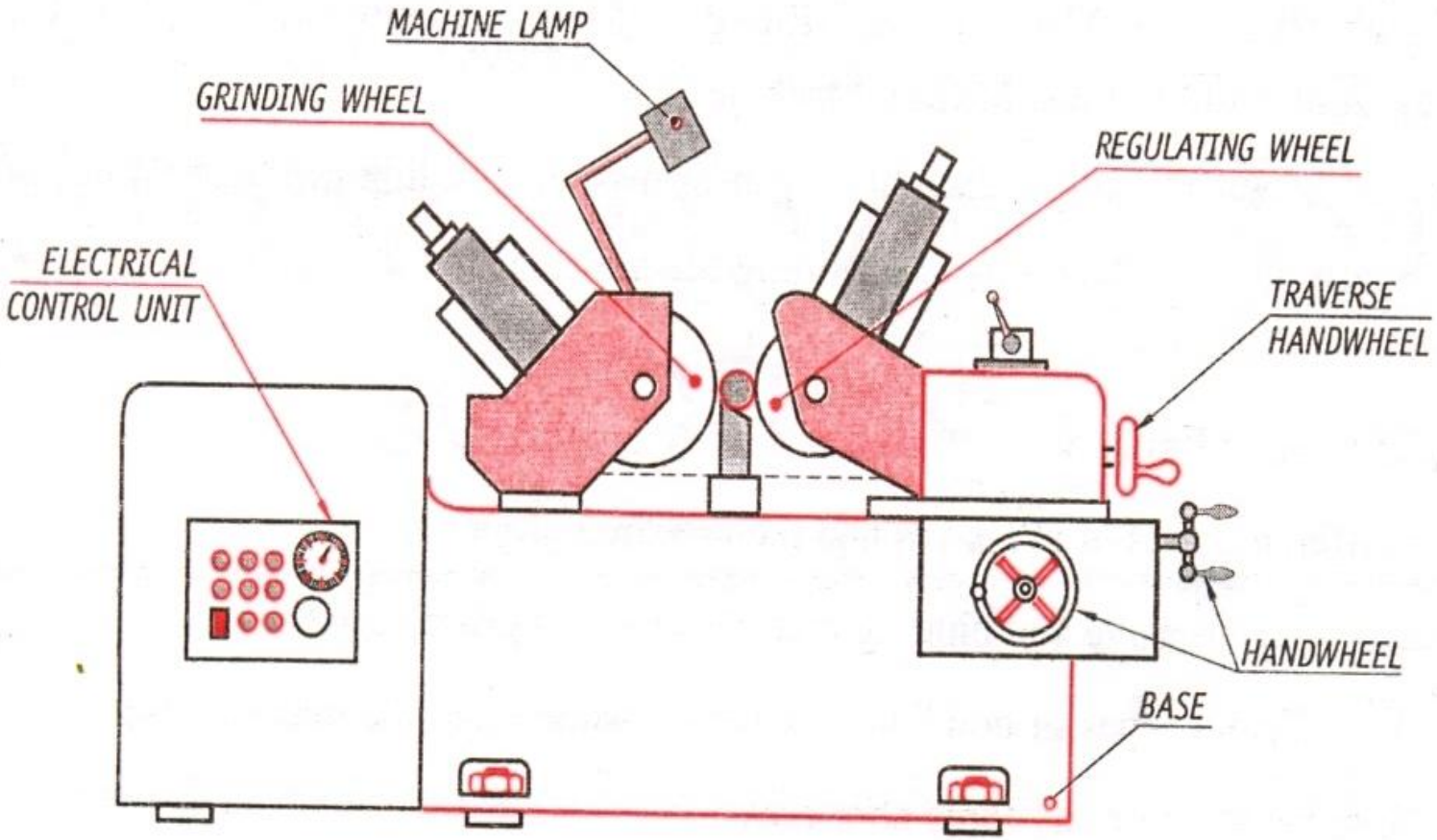
- ✓ It is used to grind curved surface work piece which are long and slender.
- ✓ Work piece rests on a work-rest blade and is backed by a second wheel called as regulating wheel.
- ✓ Grinding wheel pushes the work piece down the work-rest blade against the regulating wheel.

Contd.,


WORKPIECE
GRINDING WHEEL
REGULATING WHEEL
WORK REST BLADE


GRINDING WHEEL
WORKPIECE
REGULATING WHEEL
WORK REST BLADE

Contd.,


MACHINE LAMP
GRINDING WHEEL
REGULATING WHEEL
ELECTRICAL
CONTROL UNIT
TRAVERSE
HANDWHEEL
HANDWHEEL
BASE

How Centerless Grinders Works

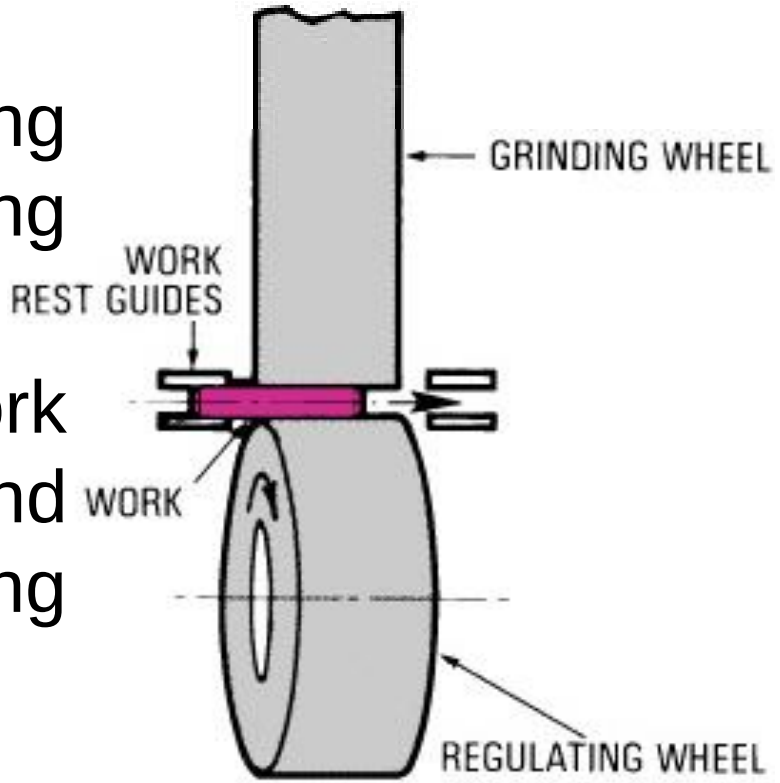
- ✓ Work supported on work rest blade equipped with suitable guides
- ✓ Rotation of grinding wheel forces work onto rest blade against regulating wheel
- ✓ Regulating wheel controls speed of work and longitudinal feed movement
  - – Set at slight angle (angle controls rate of feed)
- ✓ Centers fixed – diameter of work controlled by distance between wheels and height of work rest blade

Methods of Centerless Grinding

- ✓Three methods
  - Thru-feed
  - Infeed
  - Endfeed

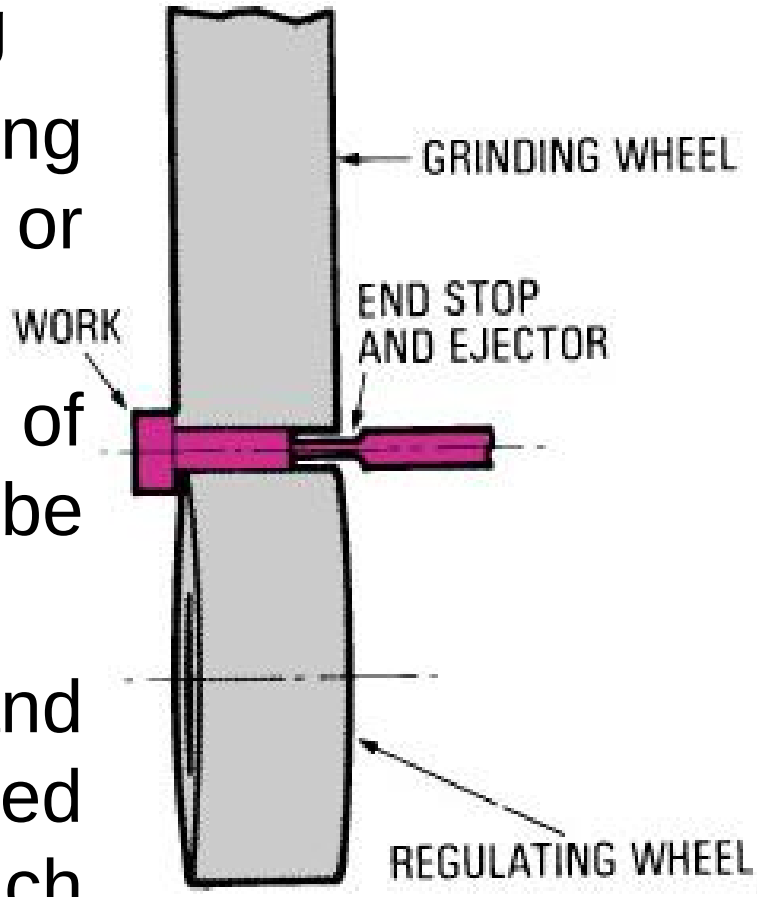
Thru-Feed Centerless Grinding

- ✓ Consists of feeding work between grinding and regulating wheels
- ✓ Work fed by regulating wheel past grinding wheel
- ✓ Speed of feeding work controlled by speed and angle of regulating wheel



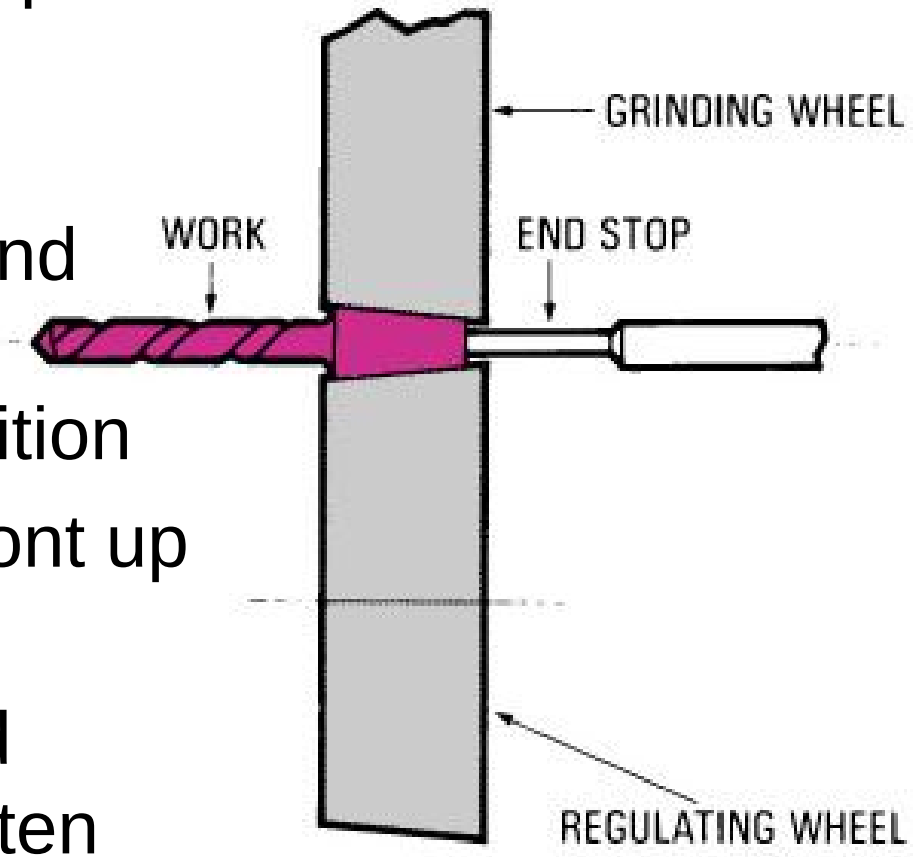
Infeed Centerless Grinding

- ✓ Form of plunge grinding
- ✓ Used when work being ground has shoulder or head
- ✓ Several diameters of workpiece may be finished simultaneously
- ✓ Work rest blade and regulating wheel clamped in fixed relation to each other



Endfeed Centerless Grinding

- ✓ Used for grinding tapered work
- ✓ Grinding wheel, regulating wheel, and work rest remain in fixed position
- ✓ Work fed in from front up to fixed stop
- ✓ Grinding wheel and regulating wheel often dressed to required taper



Advantages of Centerless Grinding

- ✓ There is no need for having and maintaining centres and centre holes
- ✓ Workpiece can be loaded and unloaded from the machine rapidly
- ✓ Productivity is high
- ✓ No limit to length of work being ground
- ✓ Work is supported rigidly, since no chatter or deflection of work
- ✓ Less skill is needed
- ✓ Less wheel wear and less grinding time required because there is less stock to be removed

Limitations

- ✓ The setup time for centerless grinding is usually large
- ✓ This process is useful only for large volume production
- ✓ Work with several diameters cannot be handled well (Not suitable for large size)

Special Types

- ✓ Tool and Cutter
  - Tool and cutter grinder and the D-bit grinder. These usually can perform the minor function of the drill bit grinder, or other specialist tool room grinding operations

Contd.,

- Jig Grinder
  - Jig grinder, which as the name implies, has a variety of uses when finishing jigs, dies, and fixtures. Its primary function is in the realm of grinding holes and pins. It can also be used for complex surface grinding to finish work started on a mill.

Contd.,

- ✓ Gear grinder
  - Gear grinder, which is usually employed as the final machining process when manufacturing a high-precision gear. The primary function of these machines is to remove the remaining few thousandths of an inch of material left by other manufacturing methods (such as gashing or hobbing).

Applications of Grinding

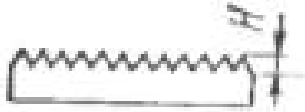
- ✓ It is used for finishing of flat ,conical and cylindrical surfaces
- ✓ Finishing internal cylinders or bores
- ✓ Forming and sharpening cutting tools
- ✓ Snagging or removing rough projections from castings and stampings

SUPER FINISHING PROCESSES

Introduction

- ✓ Parts worn out during finishing process due to defects of grinding operation
- ✓ The defects are chatter marks, helical type scratches, surface cracks, etc.,
- ✓ In certain circumstances high surface quality is required
- ✓ Hence for removing grinding defects, to obtain desired surface finish and to improve the geometrical shape finishing processes are used

Surface roughness produced by various processes

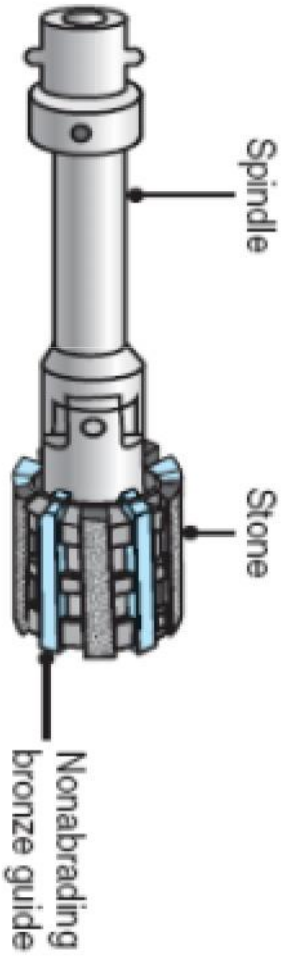
Process	Diagram of resulting surface	Height of micro irregularity (μm)
Precision Turning		1.25-12.50
Grinding		0.90-5.00
Honing		0.13-1.25
Lapping		0.08-0.25
Super Finishing		0.01-0.25

Super Finishing Processes

- ✓ With material removal
  - Honing, lapping and super finishing
- ✓ Without (very less) material removal
  - Glazing, sand blasting, tumbling, abrasive belt grinding, polishing and buffing

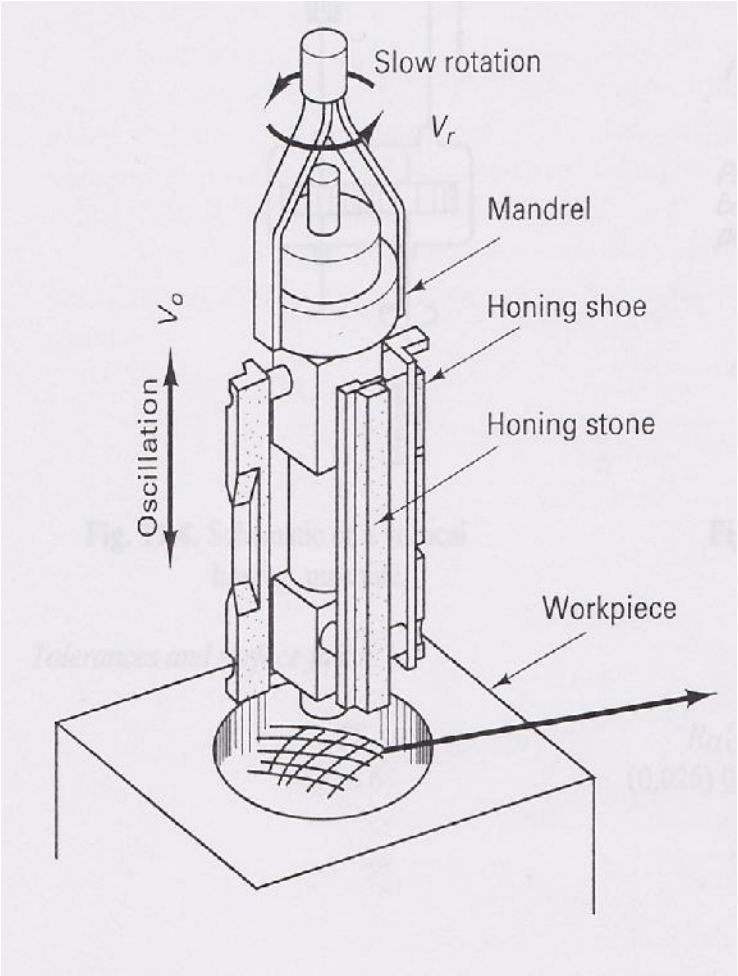
Honing

- ✓ Honing is a low abrading process
- ✓ Used to improve the surface finish of holes
- ✓ Stock removing from metallic and non-metallic surfaces
- ✓ Tool has a reciprocating axial motion and produces a crosshatched pattern on the surface of the hole
- ✓ In this process bonded abrasive sticks/abrasive stone is used
- ✓ The dimension to an accuracy of 0.005 mm can be obtained



Contd.,

- ✓ Honing is wet cutting process
- ✓ 6 to 8 honing sticks are held together and metal is removed by rotating or reciprocating the holder
- ✓ Honing tool is rotated at a speed of 0.5 - 2.5 m/s and reciprocates at a speed of 0.2 – 0.5 m/s



Advantages of Honing

- ✓ Correction of Geometrical accuracy
  - – Out of roundness
  - – Taper
  - – Axial distortion
- ✓ Dimensional accuracy
- ✓ Required surface finish

Application of Honing

- ✓ It can be used for both external (cylindrical and flat surfaces) and internal surfaces (common)
- ✓ Honing of automobile cylinder
- ✓ Honing is also used for repair work

Lapping

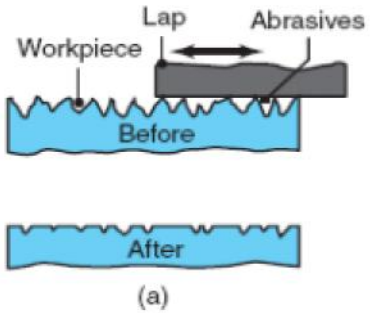
- ✓ Finishing operation done with loose abrasive grains
- ✓ Used for finishing flat, cylindrical, or curved surfaces
- ✓ The *lap* is soft & porous and is made of cast iron, copper, leather or cloth
- ✓ The abrasive particles are embedded in the lap or carried in a slurry
- ✓ Machine lapping process is carried out for gauge blocks, piston pin, ball bearings and engine valves

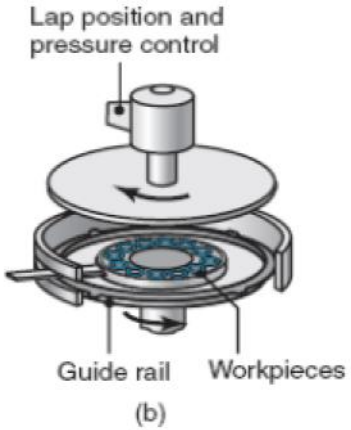
Contd.,

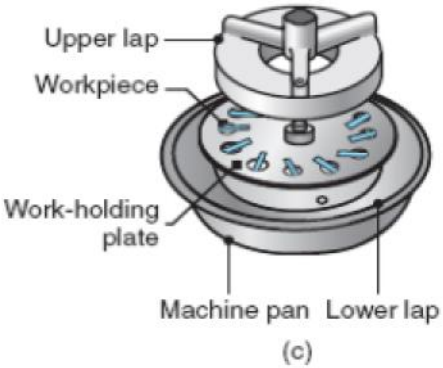

Parameters of the Experiment
Parameters of the Experiment

Contd.,

- ✓ Process employed to get:
  - Extreme accuracy of dimension
  - Correction of minor imperfection of shape
  - Refinement of the surface finish
  - Close fit between mating surfaces





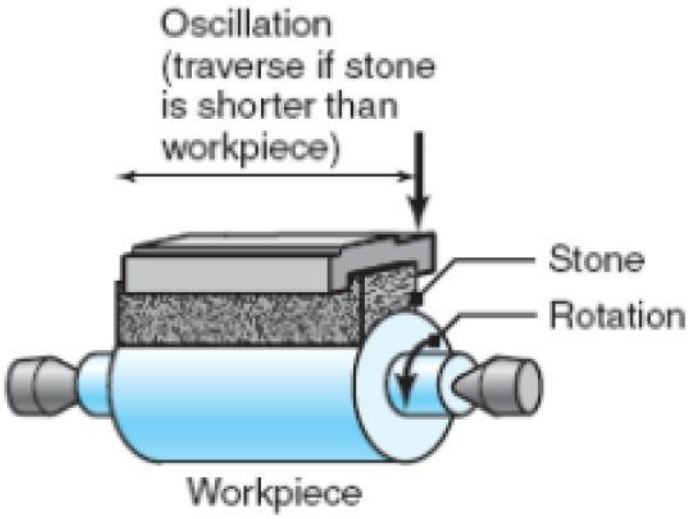


Super Finishing

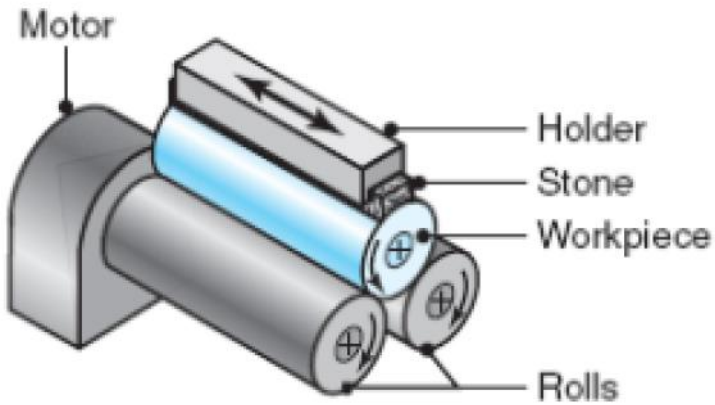
- ✓ Super finishing is another abrasive process which utilises either bonded abrasive like honing for cylindrical surfaces or a cup wheel for flat surfaces
- ✓ Produces a high wear resistant surface on any object which is symmetrical
- ✓ Surfaces are: Cylindrical, conical, spherical and flat
- ✓ The contact surface is large and tool maintains a rotary contact with workpiece while oscillating

Contd.,

- ✓ Light pressure (0.1-0.3 MPa) is applied and the motion of the honing stone has a short stroke (1-5mm)
- ✓ Small heat generation, hence there is no metallurgical alteration of the work.



(a)

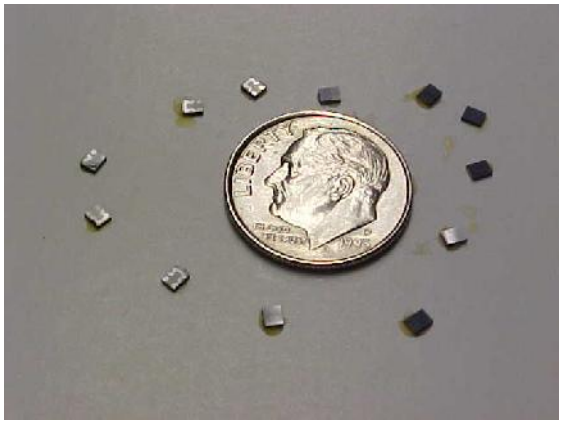


(b)

Polishing and Buffing

- ✓ A process that produces a smooth, glossy surface finish
- ✓ Softening and smearing of surface layers by frictional heating and fine scale abrasive removal from the workpiece surface
- ✓ In buffing the abrasive grains in a suitable carrying medium such as grease are applied at suitable intervals to the buffing wheel
- ✓ Negligible amount of material is removed

Contd.,



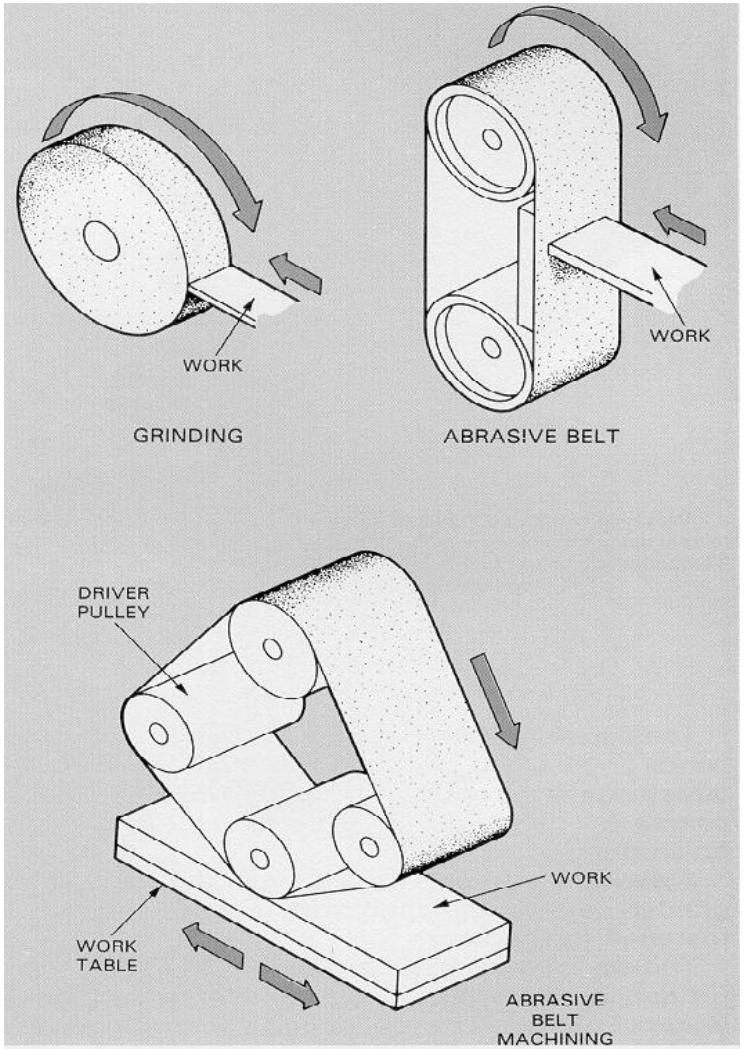
Contd.,

- ✓ Abbrasive material is bond to a tool (disc, belt) or it will be as media (paste) between tool (textile disc, belt) and part
- ✓ Polishing and Buffing operations produces shiny appearance without affecting dimensional accuracy

Abrasive Belt Grinding

- ✓ Used as *belts* for high-rate material removal with good surface finish
- ✓ Replace conventional grinding operations
- ✓ Micro-replication perform more consistently than conventional coated abrasives and the temperatures involved are lower

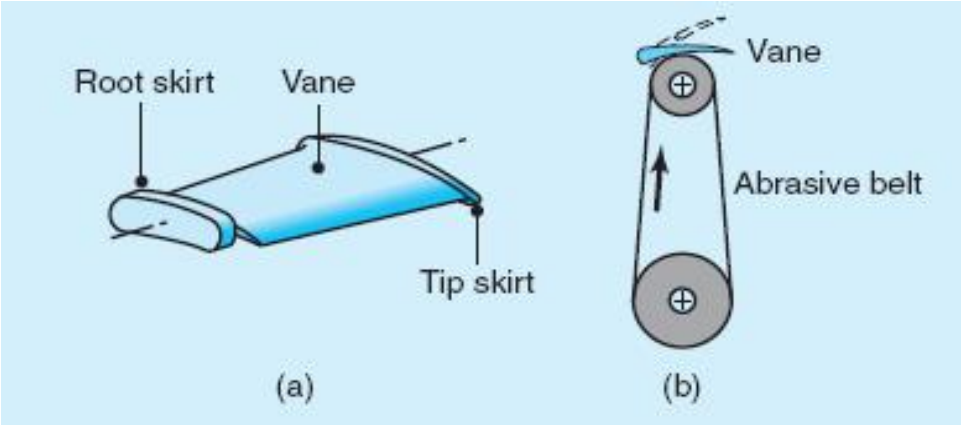
Contd.,


WORK
GRINDING
WORK
ABRASIVE BELT
DRIVER PULLEY
WORK
WORK TABLE
ABRASIVE BELT MACHINING

Contd.,

Belt Grinding of Turbine Nozzle Vanes

- ✓ Turbine nozzle vanes shown
- ✓ The vanes were mounted on a fixture and ground dry at a belt surface speed of 1,800 m/min



Abrasive Jet Grinding

In this process, abrasive particles are used for grinding. The abrasive particles carried by high pressure gas of air, are forced on the work piece through a nozzle. These particles act as cutting tools and the cutting force is provided by the high kinetic energy of the carrier gas. Fig. 4.47 shows the schematic arrangement of the abrasive grinding process. *The process parameters are given below:*

- Velocity of the abrasive 200 - 400 m/sec.
- Inside diameter of the nozzle 0.075 - 0.4 mm.
- Stand off distance 0.7 - 1 mm.
- Size of abrasive particles 10 - 50 microns.
- Abrasives used Al_2O_3, SiC.
- Carrier gas CO_2, Air, N_2.

Merits **-** no heat is generated, pressure exerted on the work is less, it has no wheel wear and high MRR.
Demerits **-** cost is high, power consumption is high and skilled labor is required.
Applications - mainly used in grinding hardened steel and cemented carbides, used in resharpening and reconditioning of carbide tools and used in grinding thin-wall tube without leaving burr or distortion which are difficult to grind in any other processes.