Module 5

Abrasive Processes (Grinding)

Lesson 29

Classification of grinding machines and their uses

Instructional Objectives

At the end of this lesson the students would be able to:

(i) recognise various types of basic grinding machines
(ii) illustrate techniques of grinding in these machines
(iii) state various applications of grinding machines

29. Grinding Machines

Grinding Machines are also regarded as machine tools. A distinguishing feature of grinding machines is the rotating abrasive tool. Grinding machine is employed to obtain high accuracy along with very high class of surface finish on the workpiece. However, advent of new generation of grinding wheels and grinding machines, characterised by their rigidity, power and speed enables one to go for high efficiency deep grinding (often called as abrasive milling) of not only hardened material but also ductile materials.

Conventional grinding machines can be broadly classified as:

(a) Surface grinding machine
(b) Cylindrical grinding machine
(c) Internal grinding machine
(d) Tool and cutter grinding machine

29.1 Surface grinding machine:

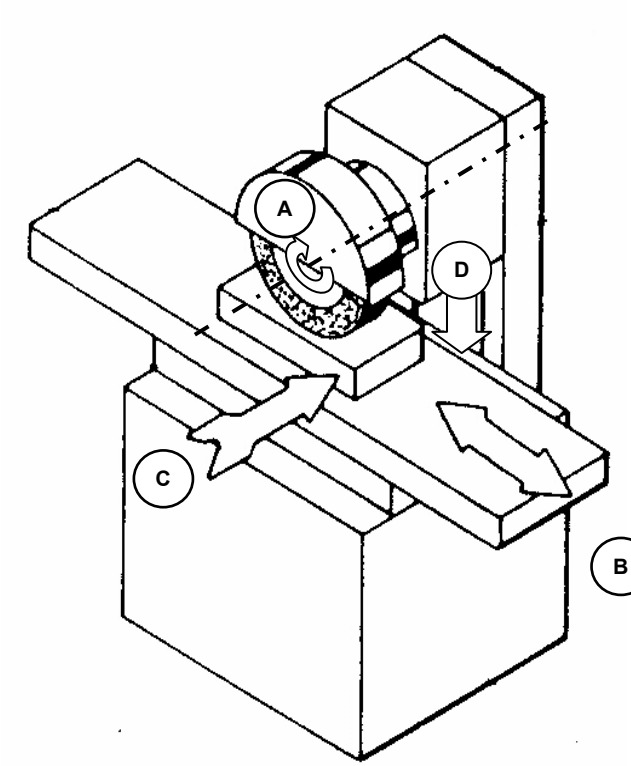
This machine may be similar to a milling machine used mainly to grind flat surface. However, some types of surface grinders are also capable of producing contour surface with formed grinding wheel.

Basically there are four different types of surface grinding machines characterised by the movement of their tables and the orientation of grinding wheel spindles as follows:

- Horizontal spindle and reciprocating table
- Vertical spindle and reciprocating table
- Horizontal spindle and rotary table
- Vertical spindle and rotary table

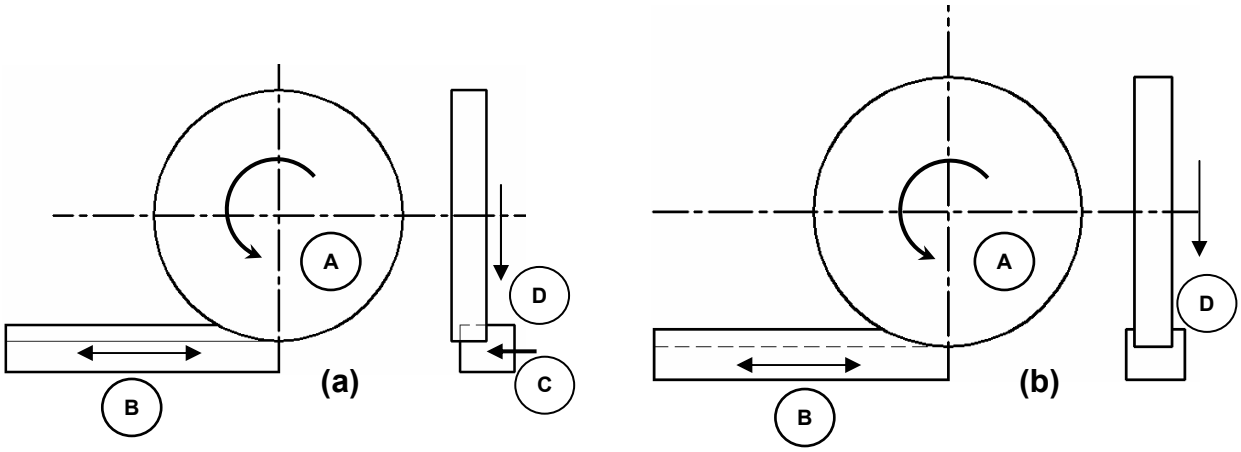
29.1.1 Horizontal spindle reciprocating table grinder

Figure 29.1 illustrates this machine with various motions required for grinding action. 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 as shown in Fig. 29.2



A: rotation of grinding wheel
B: reciprocation of worktable
C: transverse feed
D: down feed

Fig.29.1*: Horizontal spindle reciprocating table surface grinder*



A: rotation of grinding wheel **B: reciprocation of worktable**
C: transverse feed **D: down feed**

Fig. 29.2 *Surface grinding (a) traverse grinding (b) plunge grinding*

29.1.2 Vertical spindle reciprocating table grinder

This grinding machine with all working motions is shown in Fig. 29.3. The grinding operation is similar to that of face milling on a vertical milling machine. In this machine a cup shaped wheel grinds the workpiece over its full width using end face of the wheel as shown in Fig. 29.4. This brings more grits in action at the same time and consequently a higher material removal rate may be attained than for grinding with a peripheral wheel.

A: rotation of grinding wheel B: reciprocation of worktable
C: down feed of grinding wheel

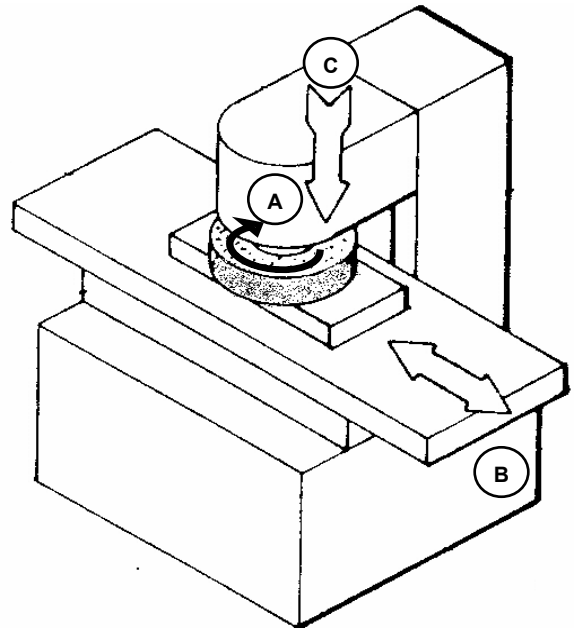


Fig. 29.3 *Vertical spindle reciprocating table surface grinder*

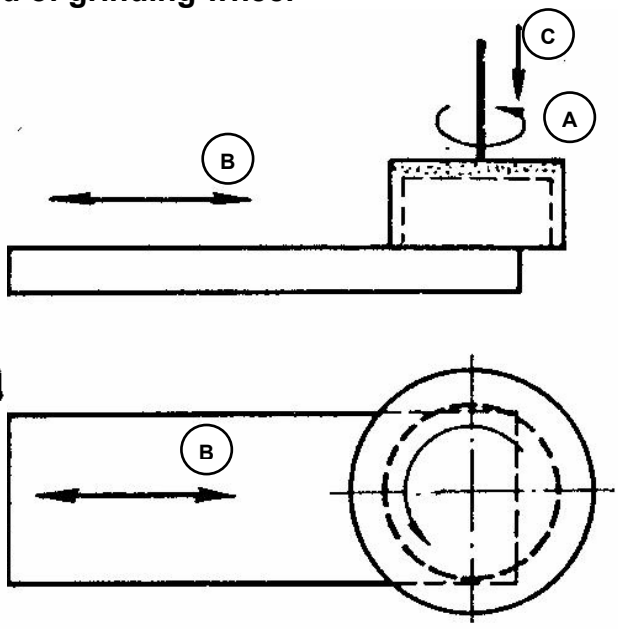
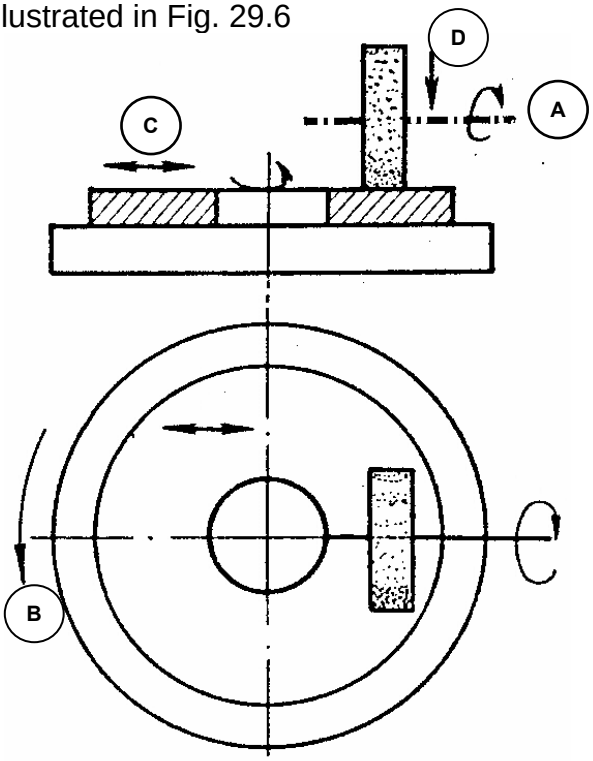


Fig. 29.4 *Surface grinding in Vertical spindle reciprocating table surface grinder*

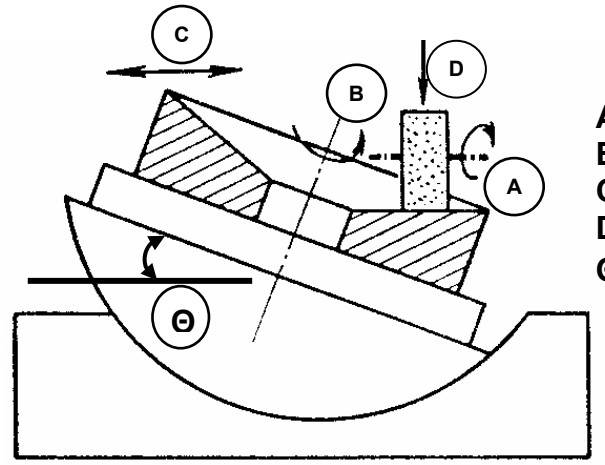
29.1.3 Horizontal spindle rotary table grinder

Surface grinding in this machine is shown in Fig.29.5. In principle the operation is same as that for facing on the lathe. This machine has a limitation in accommodation of workpiece and therefore does not have wide spread use. However, by swivelling the worktable, concave or convex or tapered surface can be produced on individual part as illustrated in Fig. 29.6



A: rotation of grinding wheel
B: table rotation
C: table reciprocation
D: down feed of grinding wheel

Fig. 29.5 *Surface grinding in Horizontal spindle rotary table surface grinder*

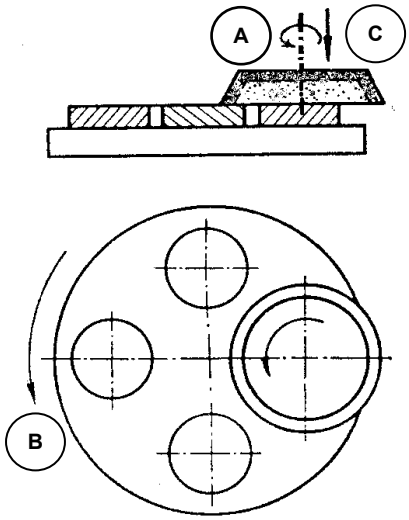


A: rotation of grinding wheel
B: table rotation
C: table reciprocation
D: down feed of grinding wheel
Θ: swivel angle

Fig. 29.6 *Grinding of a tapered surface in horizontal spindle rotary table surface grinder*

29.1.4 Vertical spindle rotary table grinder

The principle of grinding in this machine is shown in Fig. 29.7. The machine is mostly suitable for small workpieces in large quantities. This primarily production type machine often uses two or more grinding heads thus enabling both roughing and finishing in one rotation of the work table.



A: rotation of grinding wheel
B: work table rotation
C: down feed of grinding wheel

Fig. 29.7 *Surface grinding in vertical spindle rotary table surface grinder*

29.1.5 Creep feed grinding machine:

This machine enables single pass grinding of a surface with a larger downfeed but slower table speed than that adopted for multi-pass conventional surface grinding. This machine is characterised by high stiffness, high spindle power, recirculating ball screw drive for table movement and adequate supply of grinding fluid. A further development in this field is the creep feed grinding centre which carries more than one wheel with provision of automatic wheel changing. A number of operations can be performed on the workpiece. It is implied that such machines, in the view of their size and complexity, are automated through CNC.

29.1.6 High efficiency deep grinding machine:

The concept of single pass deep grinding at a table speed much higher than what is possible in a creep feed grinder has been technically realized in this machine. This has been made possible mainly through significant increase of wheel speed in this new generation grinding machine.

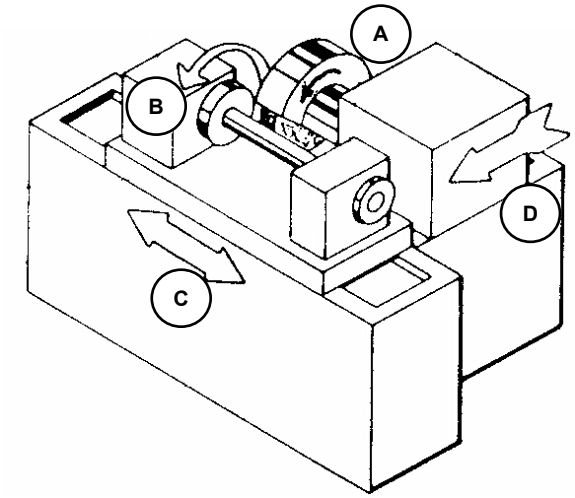
29.2 Cylindrical grinding machine

This machine is used to produce external cylindrical surface. The surfaces may be straight, tapered, steps or profiled. Broadly there are three different types of cylindrical grinding machine as follows:

1. Plain centre type cylindrical grinder
2. Universal cylindrical surface grinder
3. Centreless cylindrical surface grinder

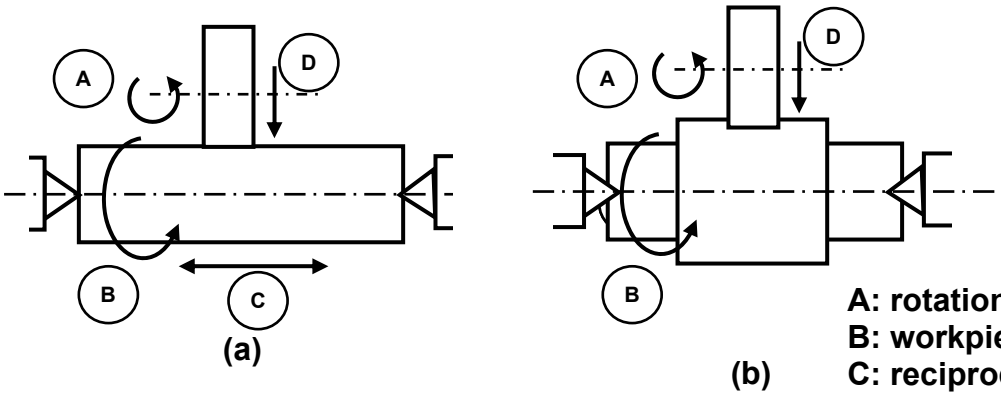
29.2.1 Plain centre type cylindrical grinder

Figure 29.8 illustrates schematically this machine and various motions required for grinding action. The machine is similar to a centre lathe in many respects. The workpiece is held between head stock and tailstock centres. 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 as shown in Fig.29.9.



A: rotation of grinding wheel
B: work table rotation
C: reciprocation of worktable
D: infeed

Fig. 29.8 *Plain centre type cylindrical grinder*

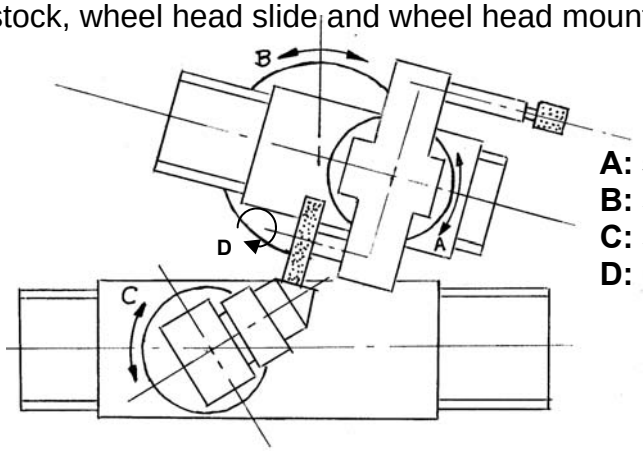


A: rotation of grinding wheel
B: workpiece rotation
C: reciprocation of worktable
D: infeed

Fig. 29.9 *cylindrical (a) traverse grinding and (b) plunge grinding*

29.2.2 Universal cylindrical surface grinder

Universal cylindrical grinder is similar to a plain cylindrical one except that it is more versatile. In addition to small worktable swivel, this machine provides large swivel of head stock, wheel head slide and wheel head mount on the wheel head slide.



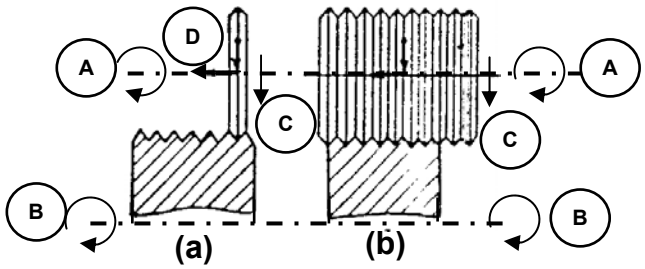
A: swivelling wheel head
B: swivelling wheel head slide
C: swivelling head stock
D: rotation of grinding wheel

Fig. 29.10 *important features of universal cylindrical grinding machine*

This allows grinding of any taper on the workpiece. Universal grinder is also equipped with an additional head for internal grinding. Schematic illustration of important features of this machine is shown in Fig.29.10.

29.2.3 Special application of cylindrical grinder

Principle of cylindrical grinding is being used for thread grinding with specially formed wheel that matches the thread profile. A single ribbed wheel or a multi ribbed wheel can be used as shown in Fig. 29.11.

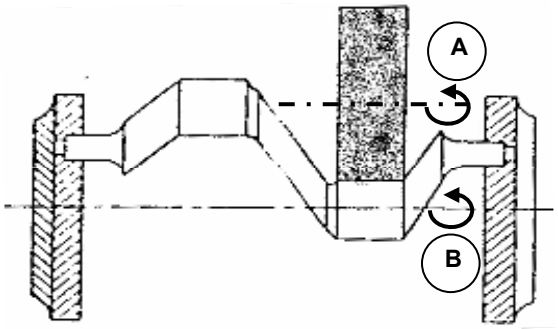


A: rotation of grinding wheel
B: rotation of workpiece
C: Downfeed
D: Longitudinal feed of wheel

Fig. 29.11 *Thread grinding with (a) single rib (b) multi-ribbed wheel*

Roll grinding is a specific case of cylindrical grinding wherein large workpieces such as shafts, spindles and rolls are ground.

Crankshaft or crank pin grinders also resemble cylindrical grinder but are engaged to grind crank pins which are eccentric from the centre line of the shaft as shown in Fig. 29.12. The eccentricity is obtained by the use of special chuck.



A: rotation of wheel
B: rotation of crank pin

Fig. 29.12 *Grinding of crank pin*

Cam and camshaft grinders are essentially subsets of cylindrical grinding machine dedicated to finish various profiles on disc cams and cam shafts. The desired contour on the workpiece is generated by varying the distance between wheel and workpiece axes. The cradle carrying the head stock and tail stock is provided with rocking motion derived from the rotation of a master cam that rotates in synchronisation with the workpiece. Newer machines however, use CNC in place of master cam to generate cam on the workpiece.

29.2.4 External centreless grinder

This grinding machine is a production machine in which out side diameter of the workpiece is ground. The workpiece is not held between centres but by a work support blade. It is rotated by means of a regulating wheel and ground by the grinding wheel.

In through-feed centreless grinding, the regulating wheel revolving at a much lower surface speed than grinding wheel controls the rotation and longitudinal motion of the workpiece. The regulating wheel is kept slightly inclined to the axis of the grinding wheel and the workpiece is fed longitudinally as shown in Fig. 29.14.

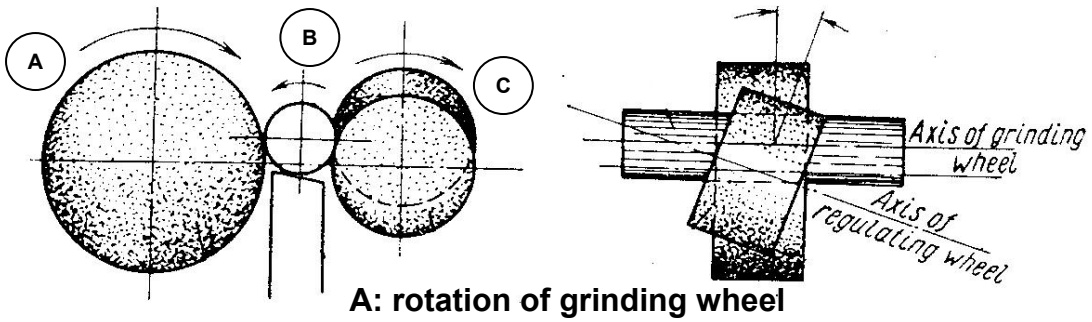


Fig.29.14*: Centreless through feed grinding*

Parts with variable diameter can be ground by Centreless infeed grinding as shown in Fig. 29.15(a). The operation is similar to plunge grinding with cylindrical grinder. End feed grinding shown in Fig. 29.15 (b) is used for workpiece with tapered surface.

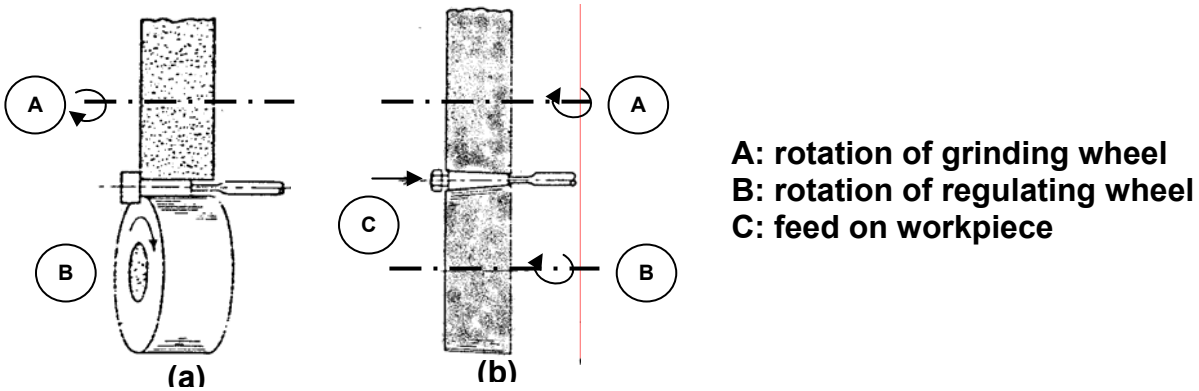


Fig. 29.15 *Centreless (a) infeed and (b) end feed grinding*

The grinding wheel or the regulating wheel or both require to be correctly profiled to get the required taper on the workpiece.

29.2.5 Tool post grinder

A self powered grinding wheel is mounted on the tool post or compound rest to provide the grinding action in a lathe. Rotation to the workpiece is provided by the lathe spindle. The lathe carriage is used to reciprocate the wheel head.

29.3 Internal grinding machine

This machine is used to produce internal cylindrical surface. The surface may be straight, tapered, grooved or profiled.
Broadly there are three different types of internal grinding machine as follows:

1. Chucking type internal grinder
2. Planetary internal grinder
3. Centreless internal grinder

29.3.1 Chucking type internal grinder

Figure 29.16 illustrates schematically this machine and various motions required for grinding action. The workpiece is usually mounted in a chuck. A magnetic face plate can also be used. A small grinding wheel performs the necessary grinding with its peripheral surface. Both transverse and plunge grinding can be carried out in this machine as shown in Fig. 29.17.

A: rotation of grinding wheel **B: workpiece rotation**
C: reciprocation of worktable **D: infeed**

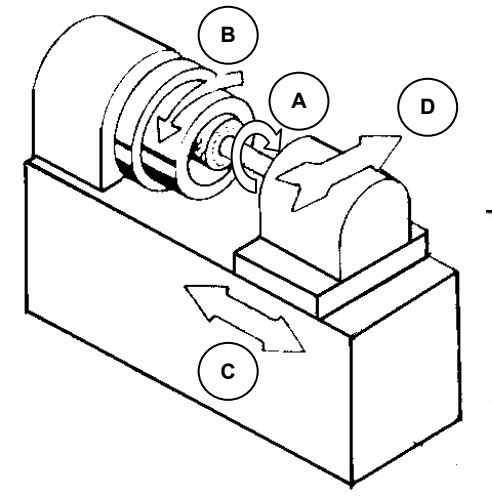


Fig. 29.16 *Internal centreless grinder*

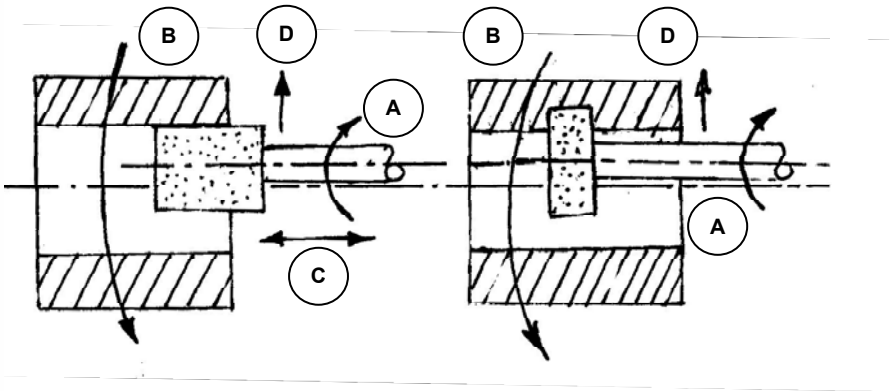
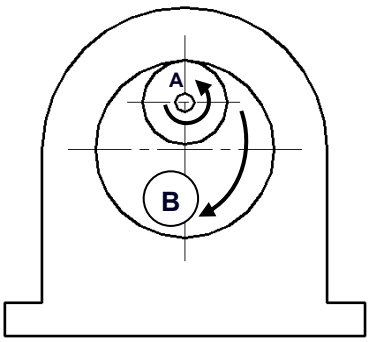


Fig. 29.17 *Internal (a) traverse grinding and (b) plunge grinding*

29.3.2 Planetary internal grinder

Planetary internal grinder is used where the workpiece is of irregular shape and can not be rotated conveniently as shown in Fig. 29.18. In this machine the workpiece

does not rotate. Instead, the grinding wheel orbits the axis of the hole in the workpiece.

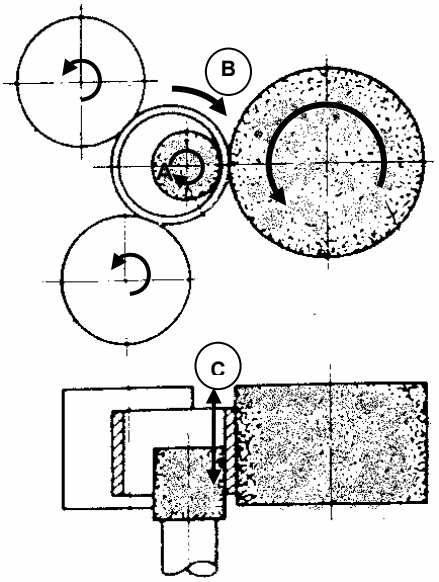


A: rotation of grinding wheel
B: orbiting motion of grinding

Fig. 29.18 *Internal grinding in planetary grinder*

29.3.3 Centreless internal grinder

This machine is used for grinding cylindrical and tapered holes in cylindrical parts (e.g. cylindrical liners, various bushings etc). The workpiece is rotated between supporting roll, pressure roll and regulating wheel and is ground by the grinding wheel as illustrated in Fig. 29.19



A: grinding wheel rotation
B: workpiece rotation
C: wheel reciprocation

Fig. 29.19 *Internal centreless grinding*

29.4 Tool and cutter grinder machine

Tool grinding may be divided into two subgroups: tool manufacturing and tool resharpening. There are many types of tool and cutter grinding machine to meet these requirements. Simple single point tools are occasionally sharpened by hand on bench or pedestal grinder. However, tools and cutters with complex geometry like milling cutter, drills, reamers and hobs require sophisticated grinding machine commonly known as universal tool and cutter grinder. Present trend is to use tool and cutter grinder equipped with CNC to grind tool angles, concentricity, cutting edges and dimensional size with high precision.

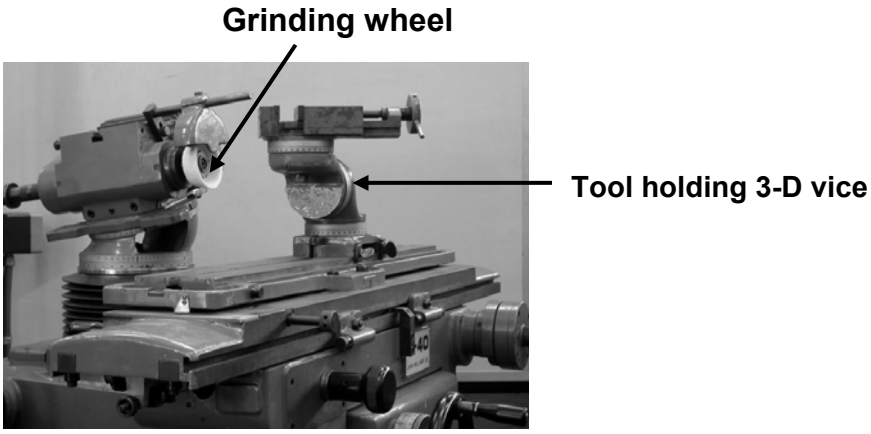


Fig. 29.20 *Pictorial view of a tool and cutter grinder*

Exercise 29

Q1. State the basic advantage of a creep feed grinder over a conventional surface grinder.
Q2. State the specific application of a planetary internal grinder.
Q3. What are the characteristic features of a universal cylindrical grinder?
Q4. State the disadvantages of centreless cylindrical grinding machine?
Q5. Is transverse feed provided in vertical spindle reciprocating table surface grinder?

Answer of the questions given in Exercise 29

Ans. to Q1.
Productivity is enhanced and life of the grinding wheel is extended.

Ans. to Q2.
Planetary internal grinders find application for grinding holes in workpieces of irregular shape or large heavy workpieces.

Ans. to Q3.
Characteristic features of a universal cylindrical grinder not possessed by plain cylindrical grinder are:

- Swivelling wheel head
- Swivelling wheel head slide
- Swivelling head stock

Ans. to Q4.
Disadvantages of a centreless cylindrical grinder are:

- It does not grind concentrically with centres.
- Large diameter short workpiece are difficult to control in the process
- It may not improve workpiece perpendicularity.

Ans to Q5.
Usually no transverse feed is provided in such machine. The wheel diameter is kept larger than the width of the workpiece surface to be ground.