CHAPTER 2- ABRASIVE GRINDING PROCESSES.

LEARNING OBJECTIVES

- Understand the types of different grinding machines
- Techniques of grinding
- Various application of grinding machines

Classification of Grinding Processes.

Grinding machines can be best classified according to the type of surfaces they are used to produce. In order to bring the job to the required shape, size and surface finish the surplus stock is removed either by feeding the job against the revolving wheel or by forcing the revolving wheel against the job. Conventional grinding machines can be broadly classified as

- Surface grinding machine
- Cylindrical grinding machine
- Internal grinding machine
- Tool and cutter grinding machine

SURFACE GRINDING MACHINE

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 & reciprocating table
- Vertical spindle & reciprocating table
- Horizontal spindle & rotary table
- Vertical spindle & rotary table

Figure 1: Horizontal spindle and reciprocating table

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Figure 2: a) Transverse Grinding  b) Plunge Grinding

Vertical Spindle reciprocating table grinder

This grinding machine with all working motions is shown in Fig. 3a. 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 3b. 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.

Figure 3a) Vertical spindle reciprocating table surface grinder (SG)  
3b) Surface grinding in vertical spindle reciprocating table SG.
Horizontal Spindle rotary table grinder

Surface grinding in this machine is shown in Fig.4. 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 swiveling the worktable, concave or convex or tapered surface can be produced on individual part.

![Figure 4 Horizontal spindle rotary table surface grinder (SG)](image)

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

Vertical Spindle rotary table grinder

The principle of grinding in this machine is shown in Fig. 5. 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.

![Figure 5 Vertical spindle rotary Table surface grinders (SG)](image)

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

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Creep feed grinding machine

This machine enables single pass grinding of a surface with a larger down feed 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.

<table>
<thead>
<tr>
<th>Creep feed grinding machine</th>
<th>Reciprocating grinding machine</th>
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<tr>
<td>It is characterized by high depths of cut around 2.5mm or more</td>
<td>It is characterized by low depths of cut between 0.005 and 0.03mm and fast reciprocating table movements of around 15 to 30m/min</td>
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<td>These machines require a considerable investment in a sophisticated machine tool and its ancillary equipment such as rotary dressing units, large capacity coolant supply and filtering units.</td>
<td>Reciprocating is a very cost effective method for easy-to-grind materials, low number of work pieces and low stock removals. the initial investment for such a grinder is relatively low</td>
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<td>There are much higher forces and temperatures at play than in reciprocating grinding. A creep-feed machine must be more rigid and powerful with spindle powers between 40 and 80kW (55 to 110hp) and higher. The high resulting temperatures must be counteracted with huge coolant supply units delivering volumes between 250 and 500l/min</td>
<td>The low depths of cut prevent proper chip formation and rapidly lead to wear flats on the abrasive grit resulting in wheel glazing and a high level of friction. This generates excessive levels of heat often causing thermal damage and micro cracking. Low depths of cut result in short arcs of contact.</td>
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**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:

- Plain centre type cylindrical grinder
- Universal cylindrical surface grinder
- Centreless cylindrical surface grinder

Figure 6 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 headstock 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 Figure 7.

![Figure 6: Plain centre type cylindrical grinder.](image)

**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 headstock, wheel head slide and wheel head mount on the wheel head slide.

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This allows grinding of any taper on the workpiece. Universal grinder is also equipped with an additional head for internal grinding as shown in the figure 8.

**External centreless grinder**

This grinding machine is a production machine in which outside 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. 9.
Parts with variable diameter can be ground by Centreless infeed grinding as shown in Fig. 10a. The operation is similar to plunge grinding with cylindrical grinder. End feed grinding shown in Fig. 10b is used for workpiece with tapered surface.

![Figure 10: a) infeed b) end feed grinding](image)

Chucking type internal grinder

Figure 11 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. 11b)

![Figure 11: Internal grinder- chucking type a) traverse feed b) plunge grinding](image)
**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 Figure 12.

![Diagram of Centreless internal grinder](image)

**Figure 12: Internal centreless grinder**

**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.