The Selection of Manufacturing Engineering Processes

By

Dr. Saied Darwish

(Prof. Industrial Engineering Department, KSU)

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CHAPTER SEVEN

GRINDING OPERATION

CONTENTS

7.1 Grinding operation

- Grinding is a material removal process in which abrasive particles are bonded to form a grinding wheel that operates at very high surface speeds.
- The grinding wheel is precisely balanced for high rotational speeds.
- Grinding may be linked to the milling process: Cutting occurs on either the periphery or the face of the grinding wheel, similar to peripheral milling and face milling. Figure 7.1

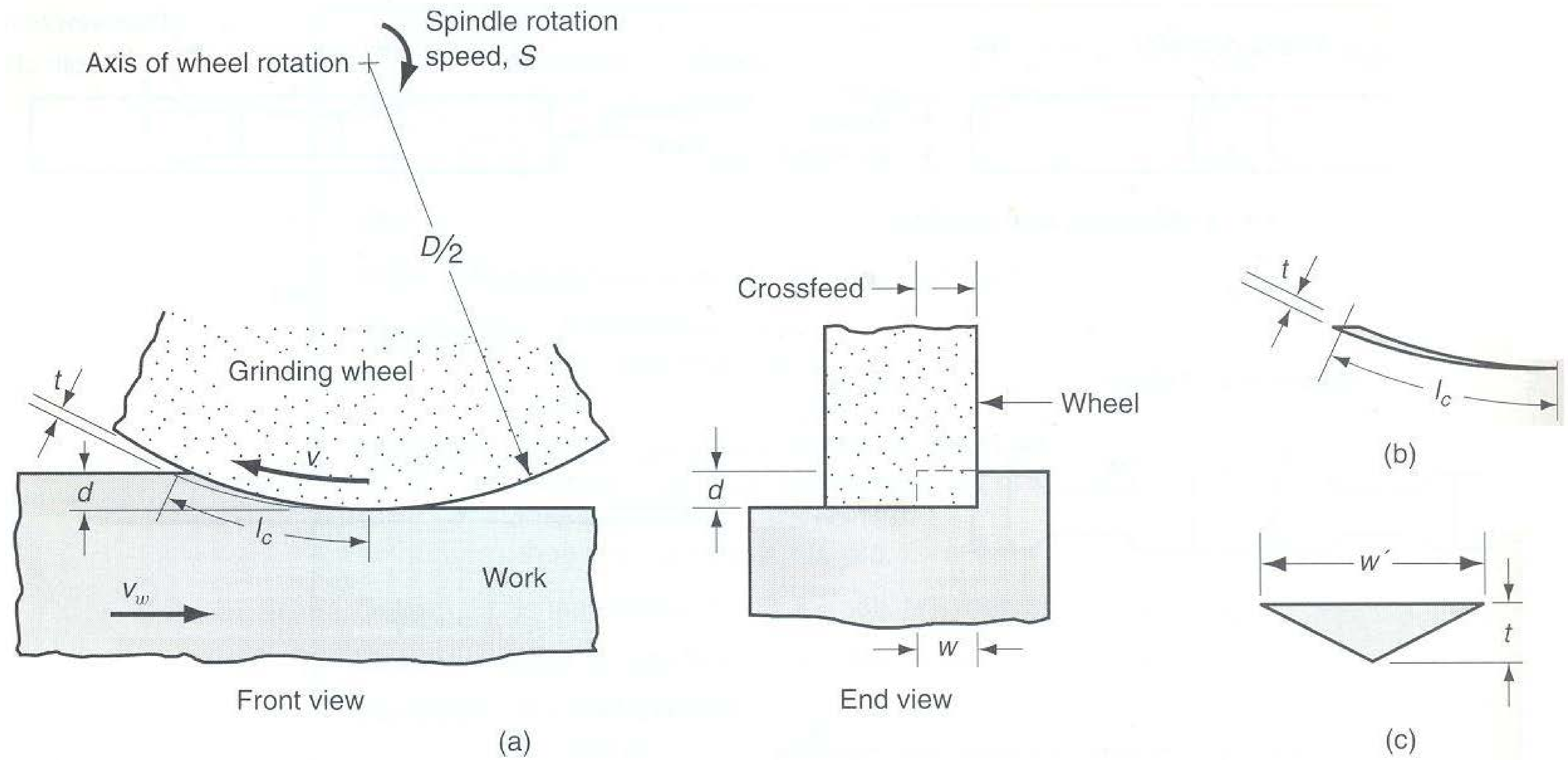

Figure 7.1: (a) The geometry of surface grinding, showing cutting conditions; (b) assumed longitudinal shape and (c) cross-section of a single chip.

7.2 Significant differences between grinding and milling

- The abrasive grains in the wheel are much smaller than the teeth on the milling cutter.
- Cutting speeds in grinding are much higher than in milling.
- A grinding wheel is self sharpening (as the wheel wears, the abrasive particles become dull and either fracture to create fresh cutting edges or are pulled out of the surface of the wheel to expose new grains).

7.3 The grinding wheel

- The grinding wheel consists of abrasive particles and bonding materials.
- The bonding material holds particles in place and establishes the structure and shape of the wheel.

7.4 Abrasive material

General properties of an abrasive material used in grinding wheels include high hardness, wear resistance, and toughness.

The abrasive materials of greatest commercial importance are:

1. Aluminum oxide (Al_2O_3)
2. Silicon carbide (SiCa)
3. Cubic boron nitride (CBN)
4. Diamond (natural and synthetic)

7.5 Grain size

There are two main grain sizes available:

- Small grain size: suitable for grinding hard materials, with better surface finish.
- Large grain size is suitable for grinding soft materials with high material removal rate.

7.6 Bonding materials

- The bonding material must be able to withstand centrifugal forces and high temperatures.
- Following are some common bonding materials:

1. Vitrified bond (clay and ceramic materials)
2. Silicate bond (sodium silicate)
3. Rubber bond
4. Metallic bond (usual bond)

7.6 Cont. Bonding materials

Marking system for conventional grinding wheels

The grinding wheels come with the following marking system.

A	46	H	6	V	xx
(Abrasive type)	(Grain size)	(Grade)	(structure)	(Bond type)	(Manufacturer's record)

7.7 Standard grinding wheel shapes

Grinding wheels are available in different shapes, in figure some standard grinding wheel shapes are shown.

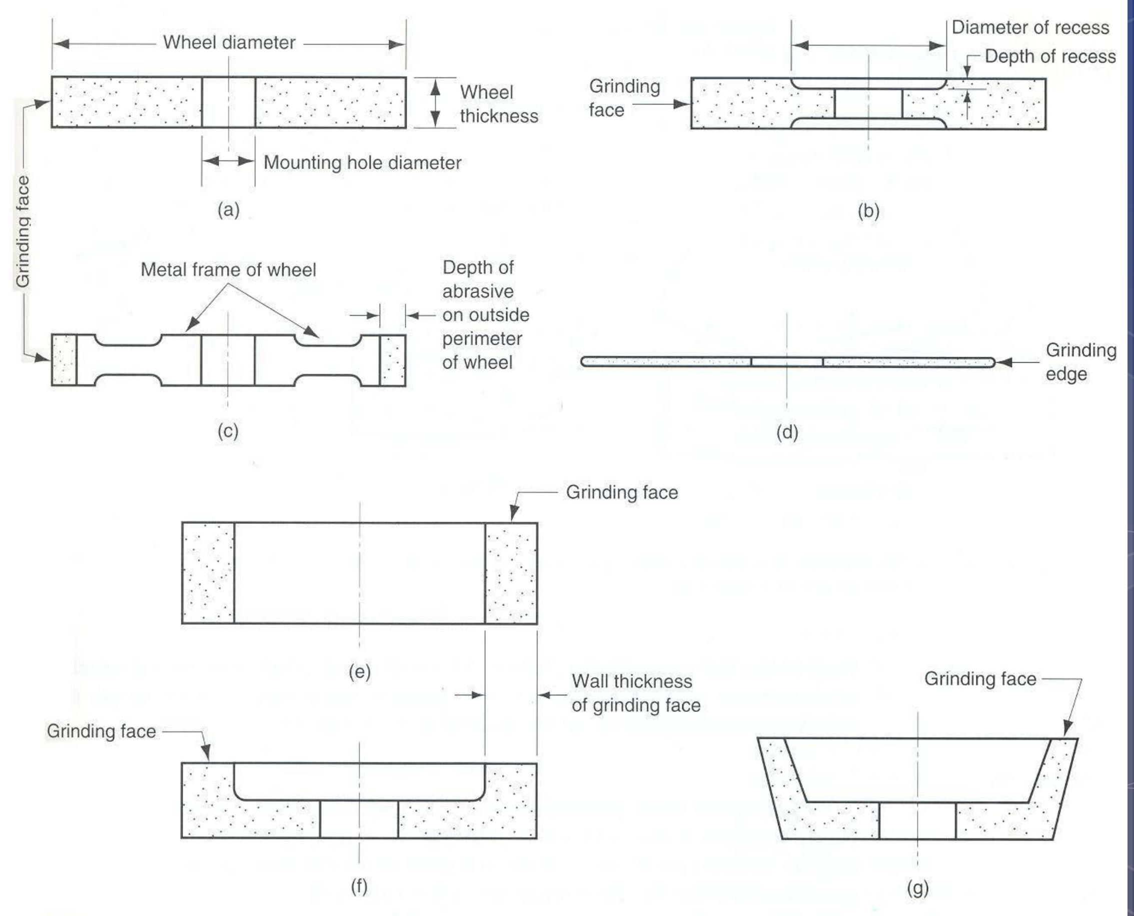

Figure 7.2: Some standard grinding wheel shapes: (a) straight, (b) recessed two sides, (c) metal wheel frame with abrasive bonded to outside circumference, (d) abrasive cutoff wheel, (e) cylinder wheel, (f) straight cup wheel, and (g) flaring cup wheel

7.8 Dressing of grinding wheel

As the wheel is used, there is a tendency for the wheel to become loaded with metallic chips and the grains become dull or glaze. To improve the condition of the wheel a process termed “wheel dressing” is used as shown in figure 7.3.

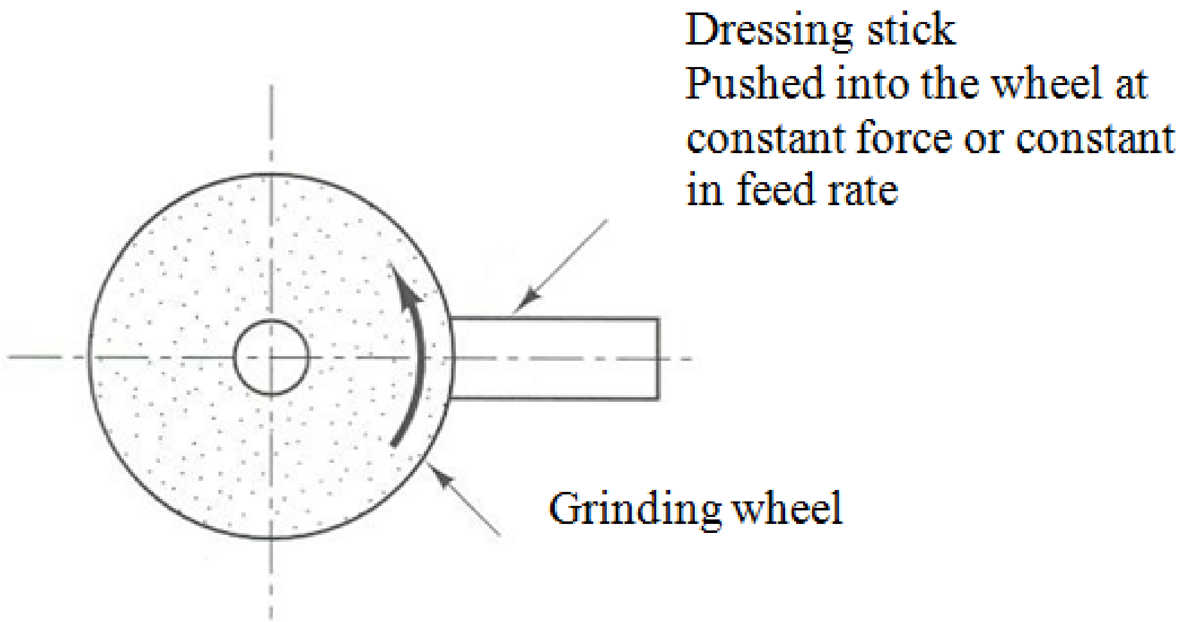

Figure7.3: Schematic arrangement of stick dressing.

7.9 Truing of grinding wheel

Grinding wheels lose their geometry during use. Truing operation restores the original shape. A single point diamond tool is used to true the wheel as shown in figure 7.4.

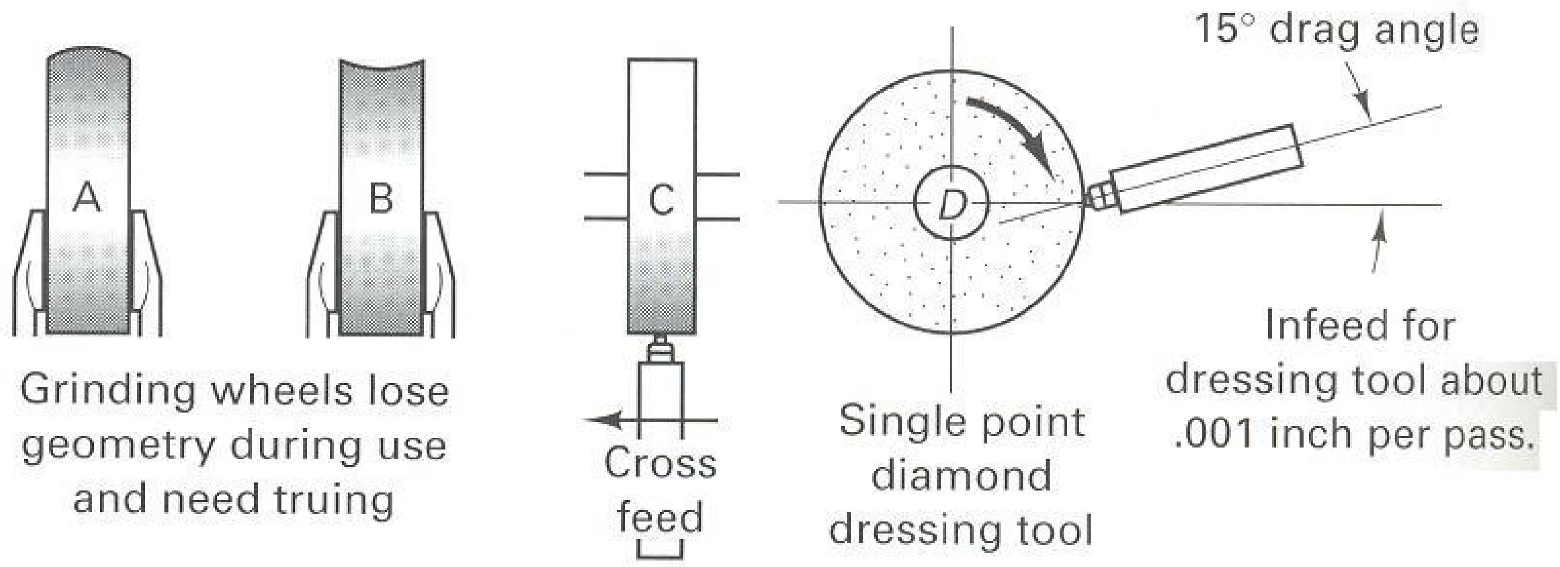

Figure 7.4: Diamond nibs may be used for truing wheels in batch operations

7.10 Grinding operations and grinding machines

7.10.1 Cylindrical grinding:

Cylindrical grinding as its name suggests, is used for rotational parts. These grinding operations are divided into two basic types.

A. External cylindrical grinding which is similar to external turning. The grinding machine used for these operations closely resemble a lathe in which the tool post has been replaced by a high speed motor to rotate the grinding wheel.

B. Internal cylindrical grinding operates somewhat like a boring operation. The workpiece is usually held in a chuck and rotated to provide surface speed. The wheel is fed in either of two ways: (1) traverse feed or (2) plunge feed

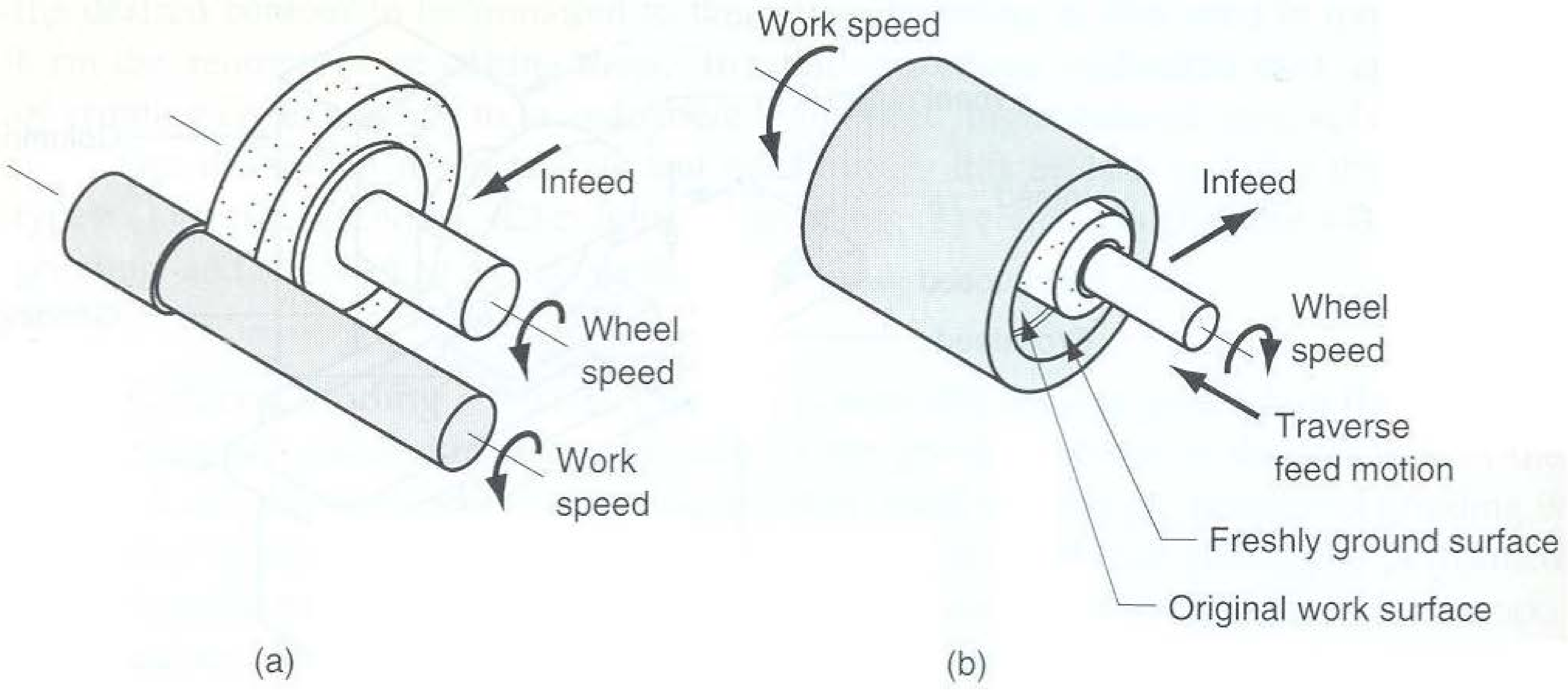

Figure 7.5: Two types of cylindrical grinding: (a) external and (b) internal

7.10 Grinding operations and grinding machines

7.10.1 Cylindrical grinding:

(1) traverse feed: grinding wheel is fed in a direction parallel to the axis of rotation of the workpiece

(2) plunge feed: plunge cut, the grinding wheel is fed radially into the work

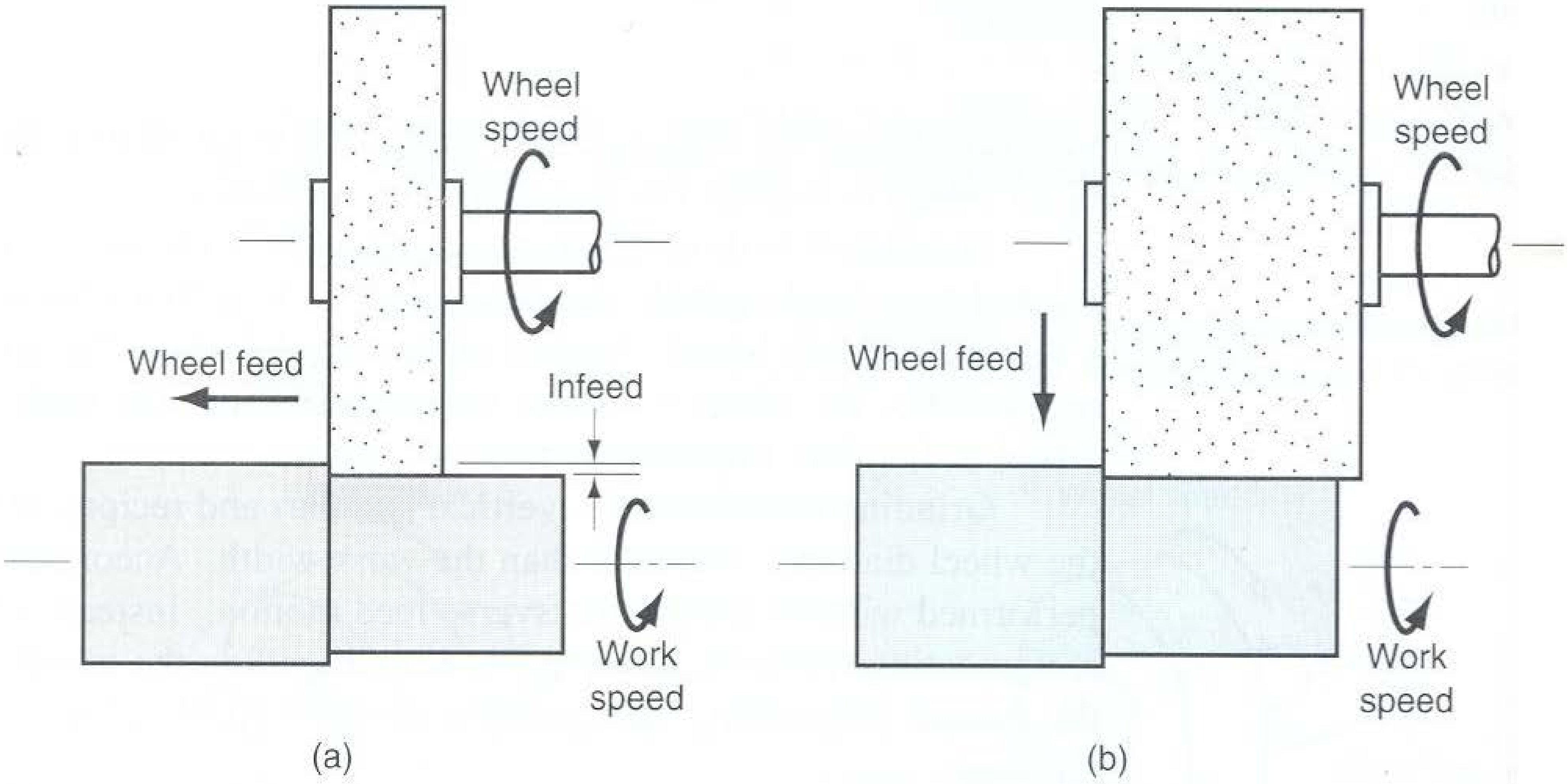

Figure 7.6: Two types of feed motion in external cylindrical: (a) traverse feed and (b) plunge-cut.

7.10.2 Surface grinding

Surface grinding is normally used to grind plain flat surfaces. It is performed using either the periphery of the grinding wheel or the flat face of the wheel.

Four types of surface grinding machines are used in surface grinding operation.

A. horizontal spindle with reciprocating worktable

B. horizontal spindle with rotating worktable

C. vertical spindle with reciprocating worktable

D. vertical spindle with rotating worktable.

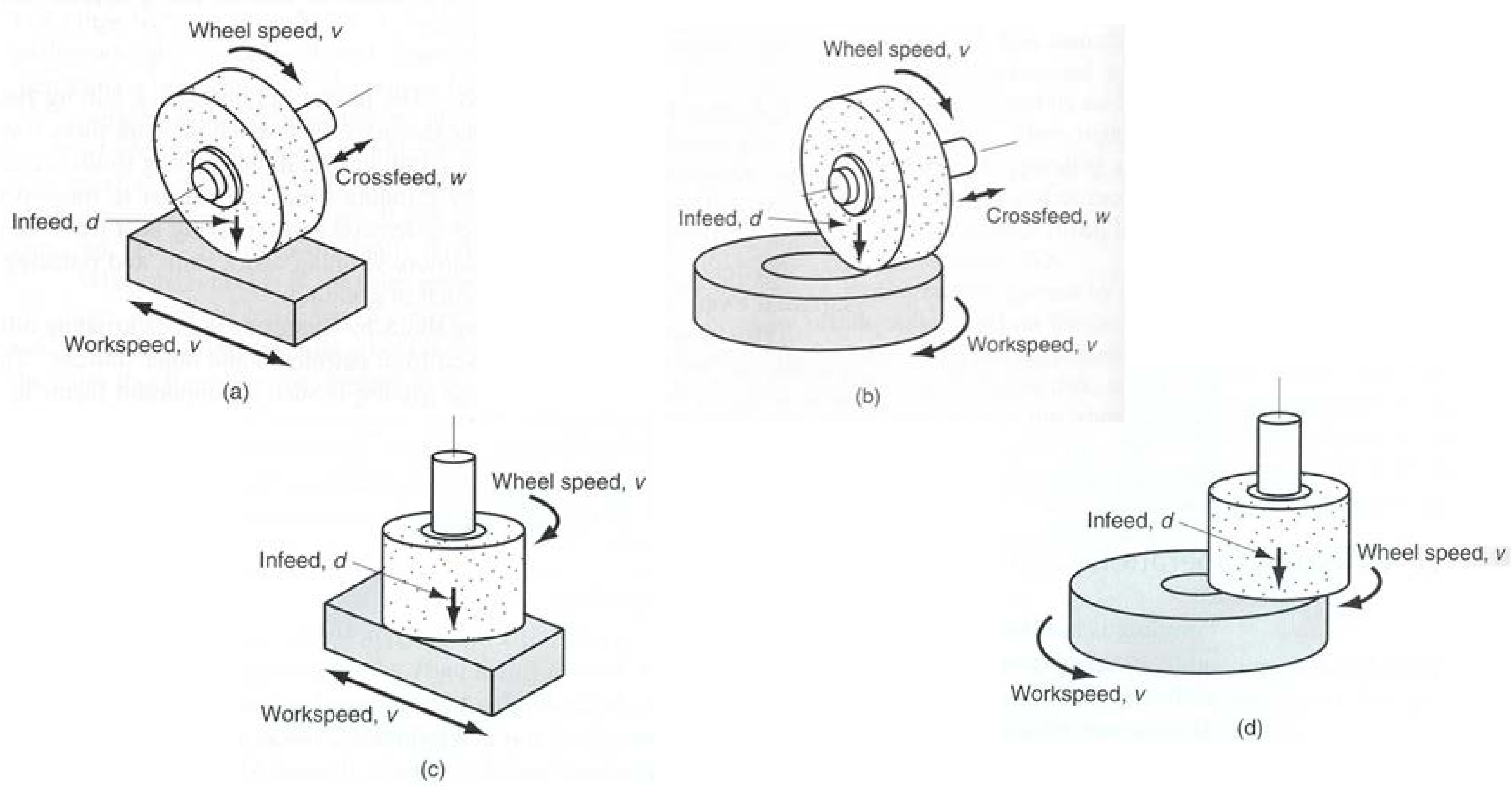

Figure 7.7: Four types of surface grinding: (a) horizontal spindle with reciprocating worktable, (b) horizontal spindle with rotating worktable, (c) vertical spindle with reciprocating worktable, and (d) vertical spindle with rotating worktable.

7.10.3 Centerless grinding

Centerless grinding has a number of advantages over cylindrical grinding.

It is self-centering, the stock removal rate is higher, and the work is firmly held by the support plate and control or regulating wheel, which results in better dimensional accuracy

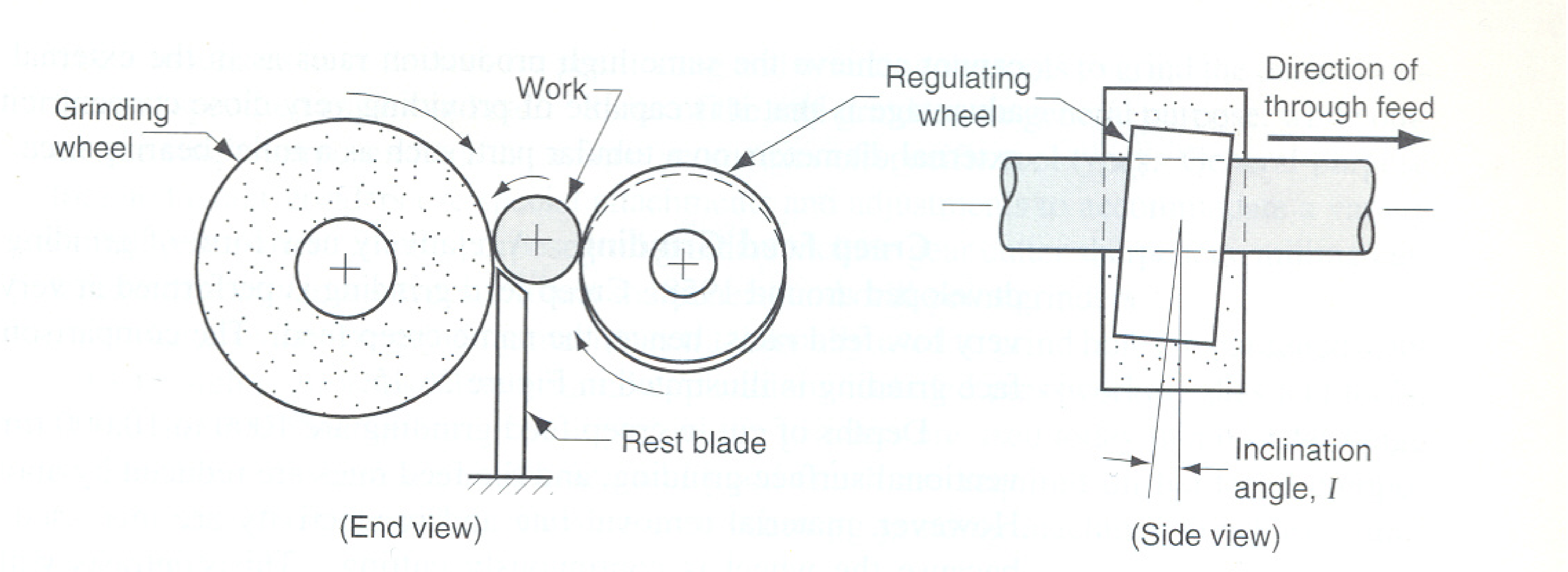

Figure 7.8: External centerless grinding

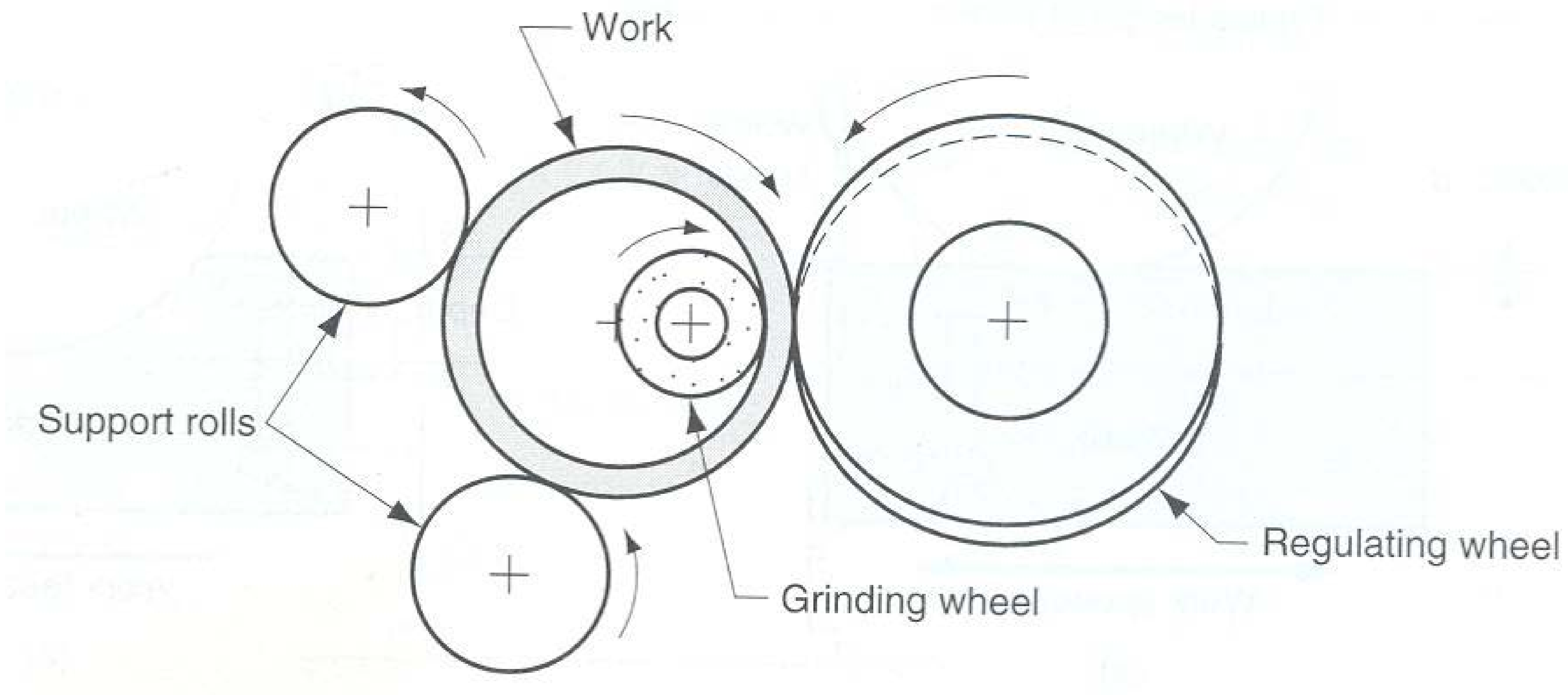

Figure 7.9: Internal centerless grinding.

7.11 Forces and power in grinding

There are three force components involved in the grinding operation

Pr = Radial force, Pa = Axial force, Ps = Main cutting force (Tangential force).

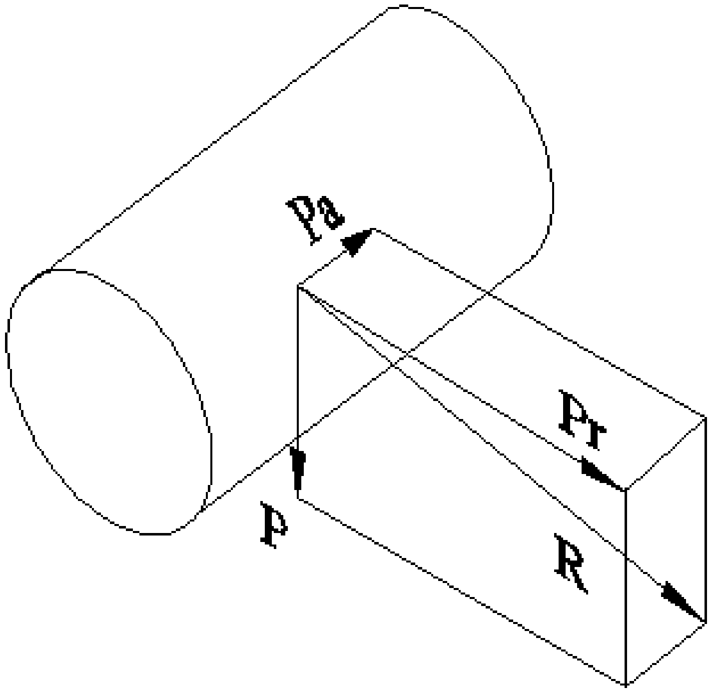

Figure 7.10: Force components in grinding.

The power can be calculated from the following formula.

$$N_s = \frac{P_s \times V}{102 \times 60} \qquad \text{(kW)}$$

7.12 Related abrasive processes

7.12.1 Honing

Honing is an abrasive process performed by a set of bonded abrasive sticks.

A common application is to finish the bores of internal combustion engines, other applications

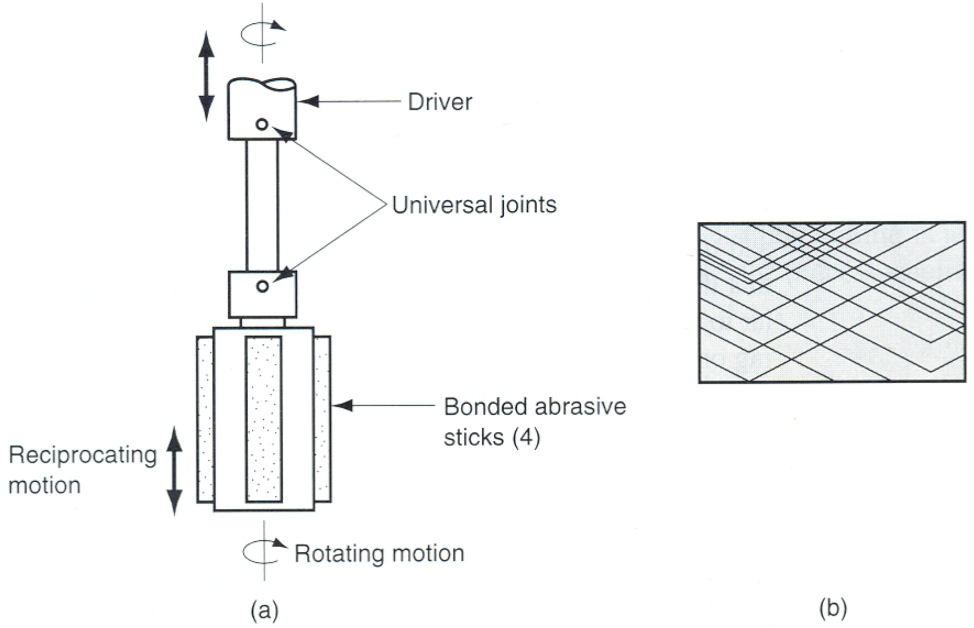

Figure 7.11: The honing process: (a) the honing tool used for internal bore surfaces (b) cross hatched surface pattern created by the action of the honing tool.

7.12.2 Lapping

Lapping is an abrasive process used to produce surface finish of extreme accuracy and smoothness. It is used in the production of optical lenses, metallic bearing surfaces and gauges

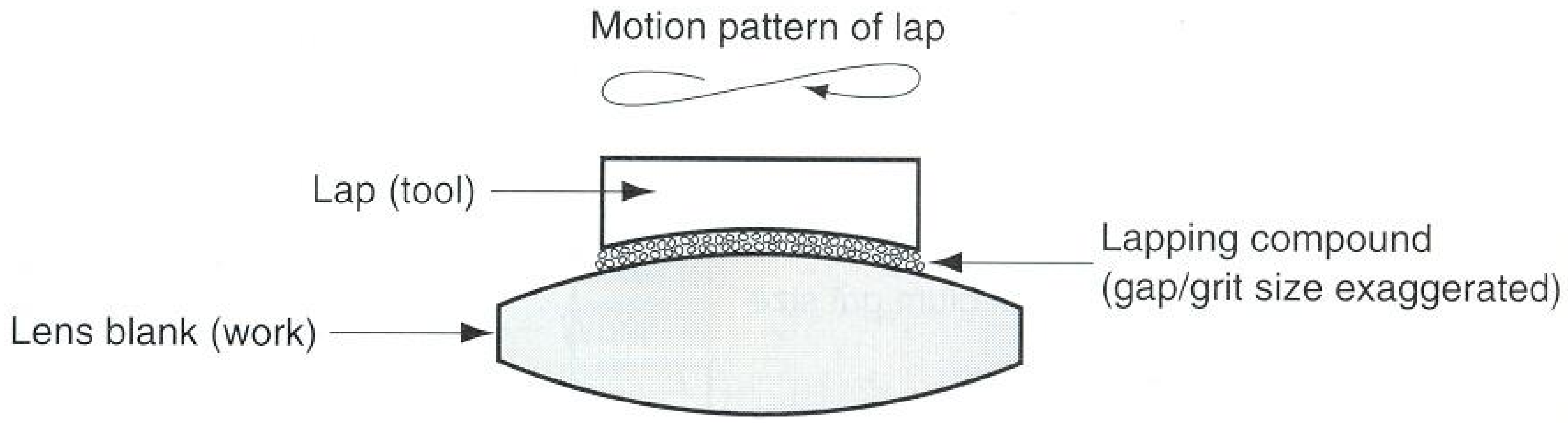

Figure 7.12: The lapping process in lens making.

7.12.3 Super finishing

Super finishing is an abrasive process similar to honing. Super finishing differ from honing in the following aspects:

1. The strokes are shorter.
2. High frequencies are used.
3. Lower pressure is applied between the tool and surface.
4. The grit size are smaller.
5. Workpiece speed is slower.

The result of these conditions is mirror like finishes. This process can be used to finish flat and external cylindrical surfaces, as shown in figure 7.13.

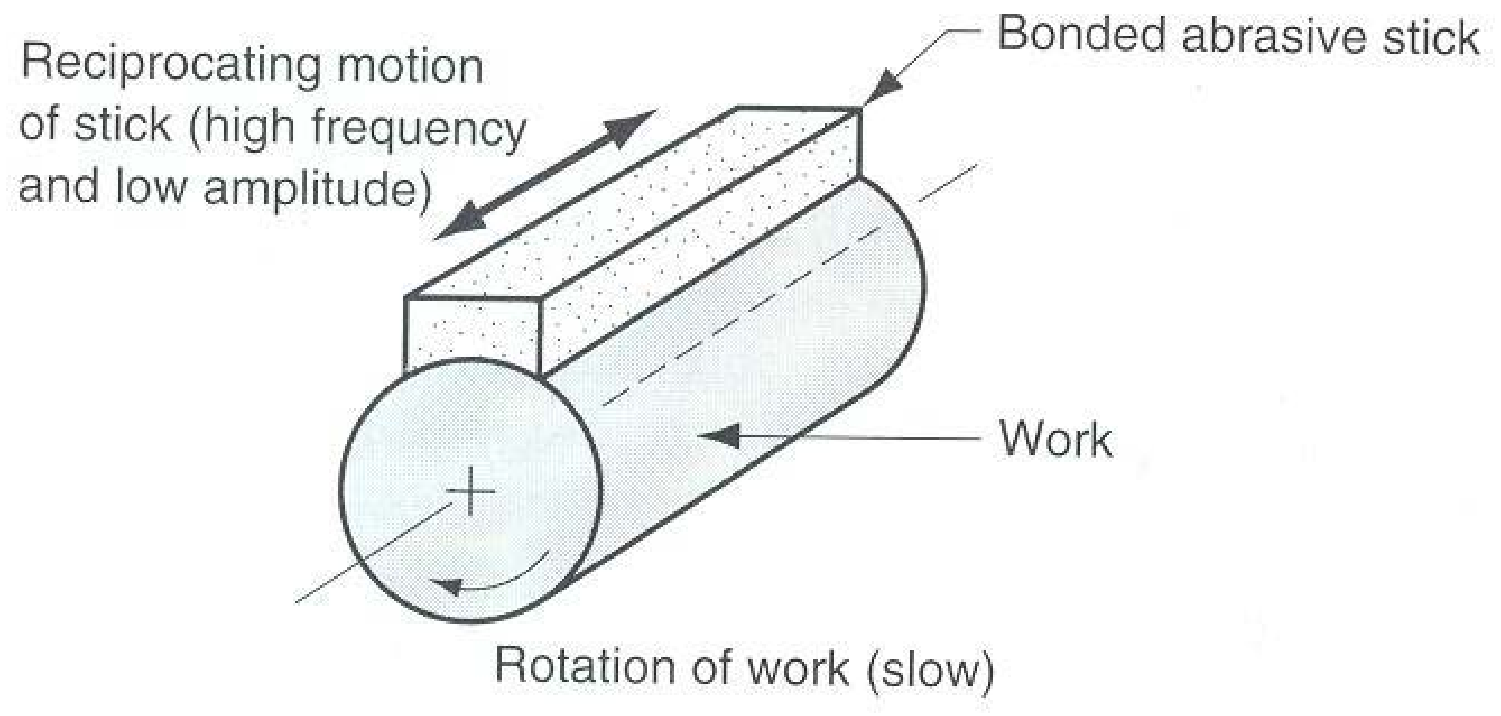

Figure 7.13: Super finishing on an external cylindrical surface.