

Mechanical Workshop

AMEW 101

MILLING

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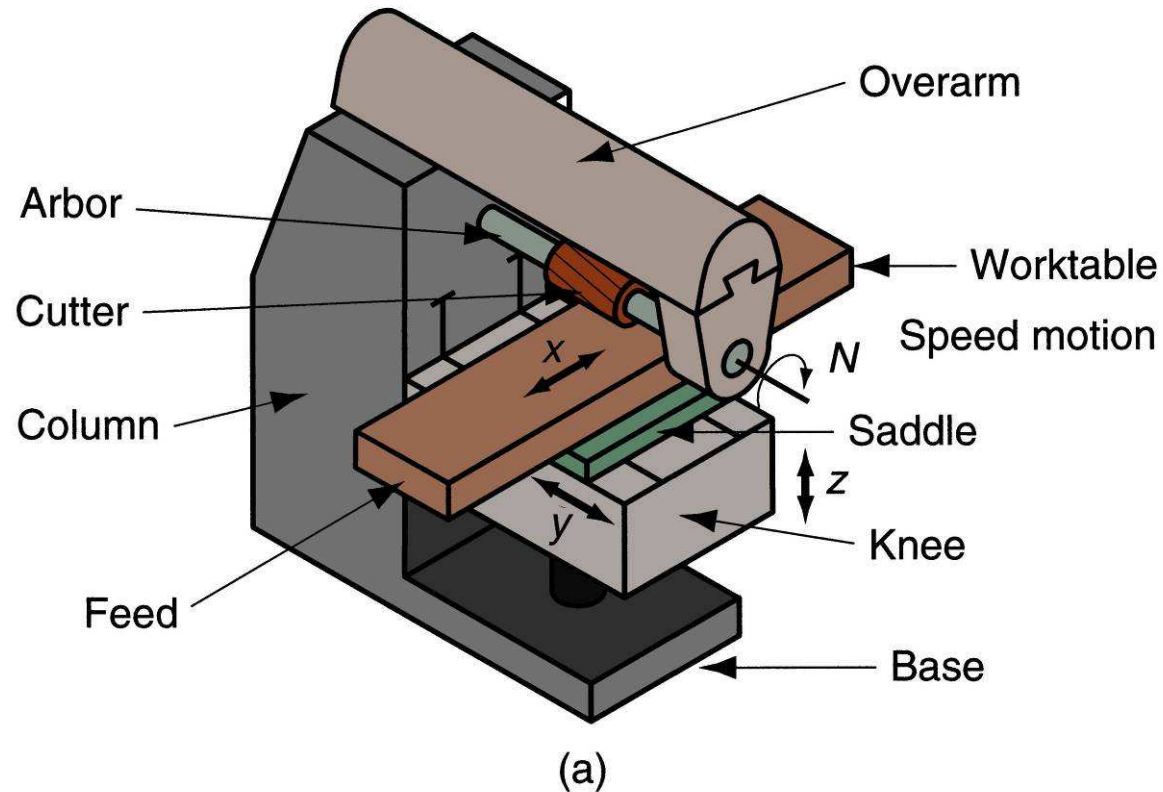
Milling Process

Milling is one of the basic machining processes. Milling is a very versatile process capable of producing **simple two dimensional** flat shapes to **complex three dimensional** interlaced surface configurations.

Milling Process

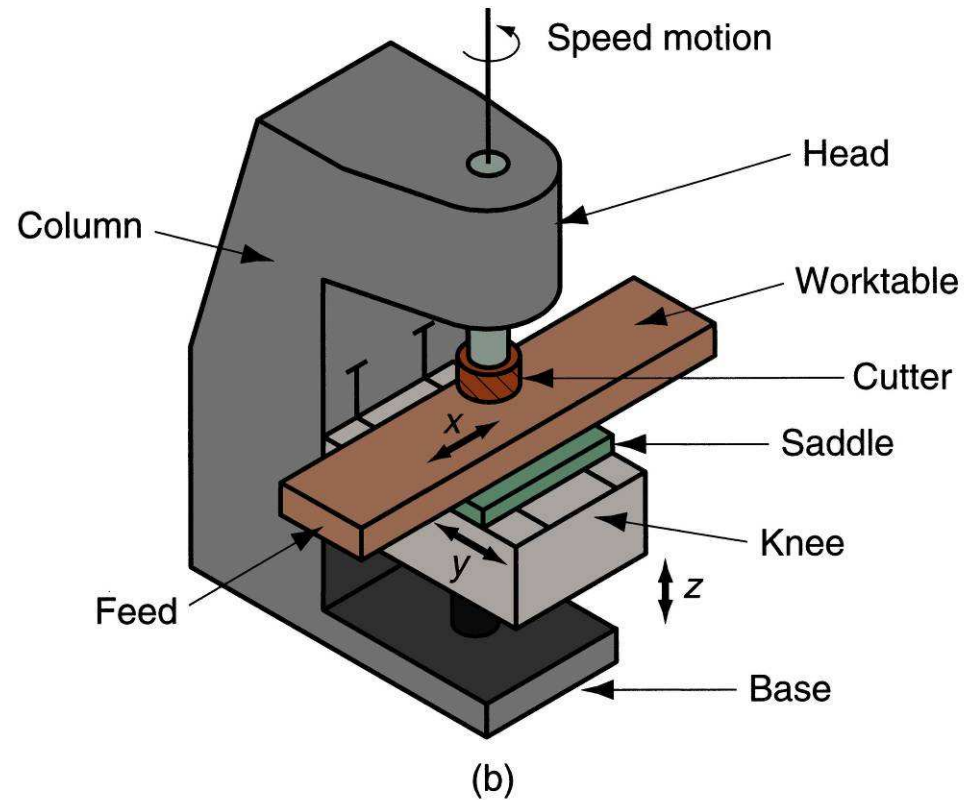
- At all types of milling machines, the cutting tool performs a rotational motion, that is the **cutting motion**. The rotation axis of the tool could be **horizontal** or **vertical**, depending on machine-tool version.
- The **feeding motion** is achieved either by part or tool, or both, usually on three perpendicular directions.

Horizontal Milling Machine



Horizontal knee-and-column milling machine.

Vertical Milling Machine

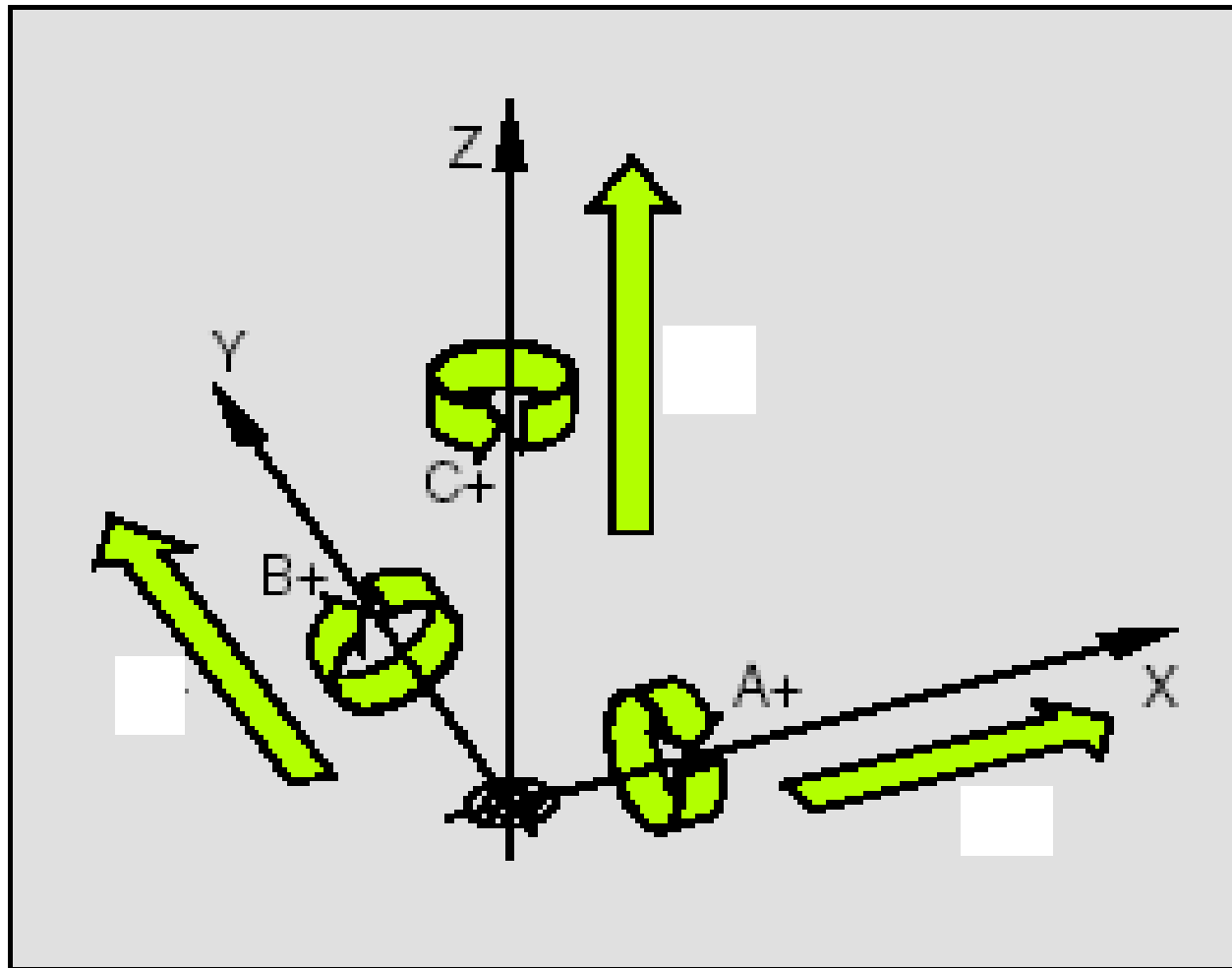


Vertical knee-and-column milling machine.

Vertical Milling Machining center



Rotational axis of motion

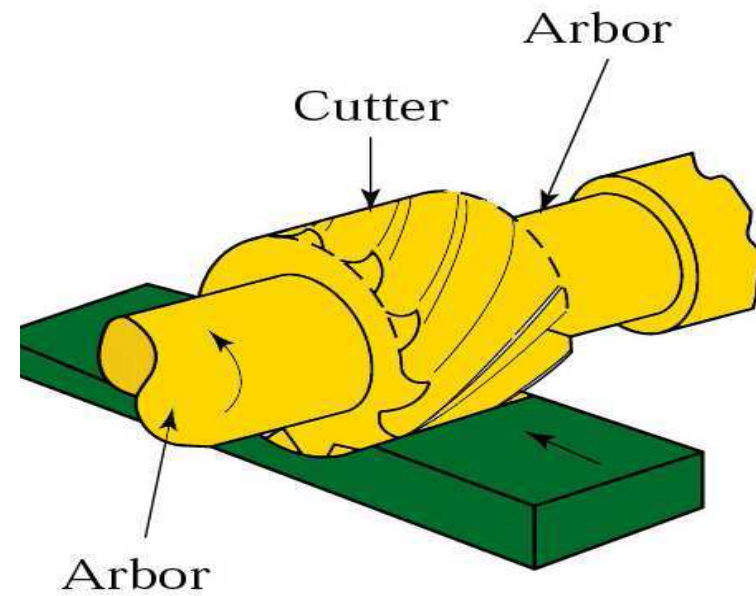
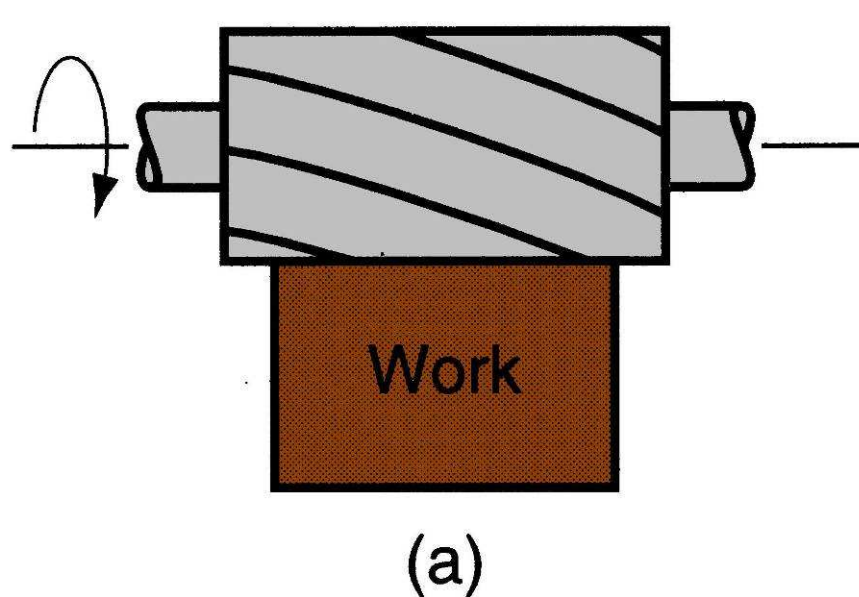


Milling



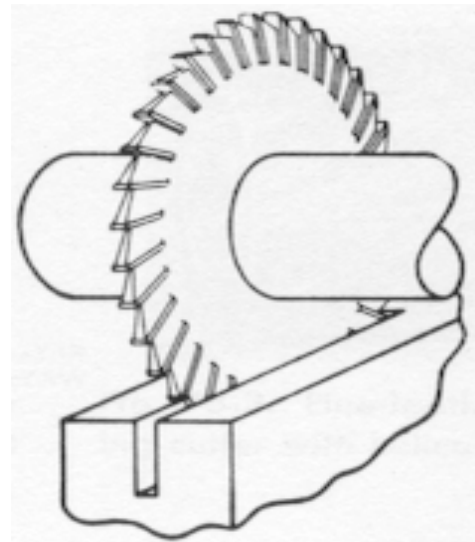
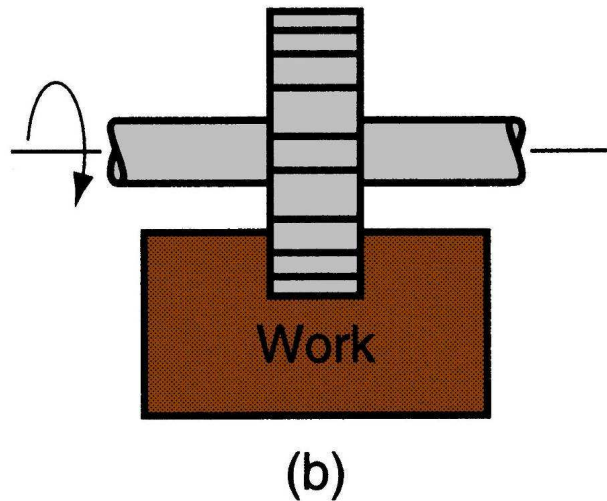
Milling Operations on a Horizontal Milling Machine

- Slab milling: Cutter width extends beyond the work piece on both sides



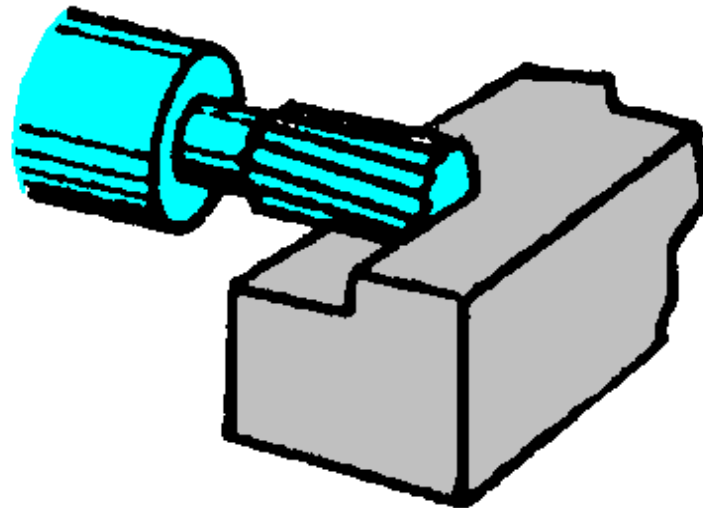
Milling Operations on a Horizontal Milling Machine

- Slot milling: Cutter width is less than the work piece width, creating a slot. If the cutter is very thin, it can be used to cut a work part into two, called saw milling.



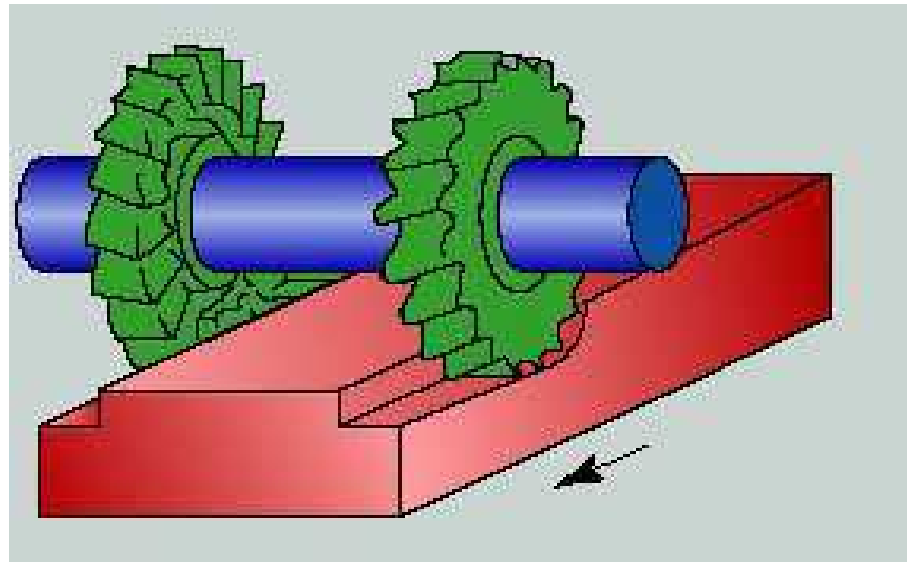
Milling Operations on a Horizontal Milling Machine

- Side milling: Cutter, machines the side of the work piece.



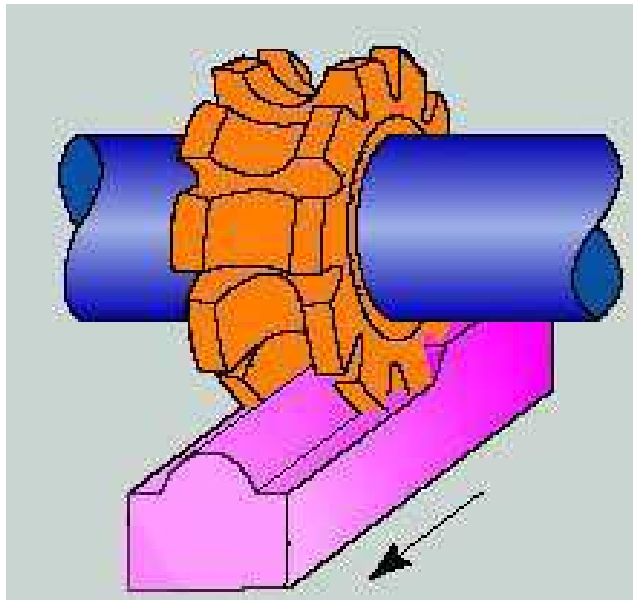
Milling Operations on a Horizontal Milling Machine

- Straddle milling: Similar to side milling, but cutting takes on both sides of the work part simultaneously.

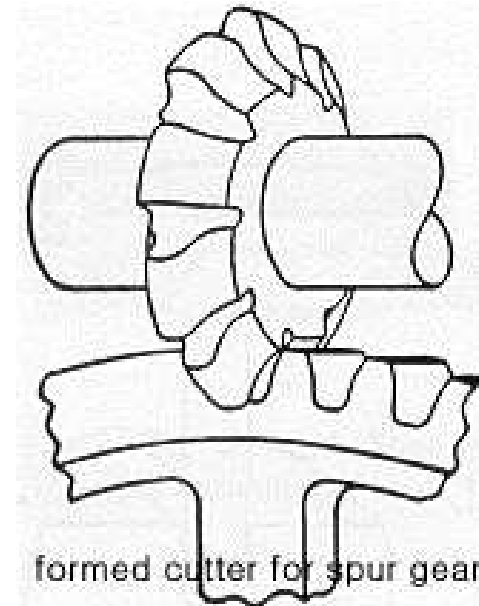


Milling Operations on a Horizontal Milling Machine

- Form milling: The cutter has the desired form of the part



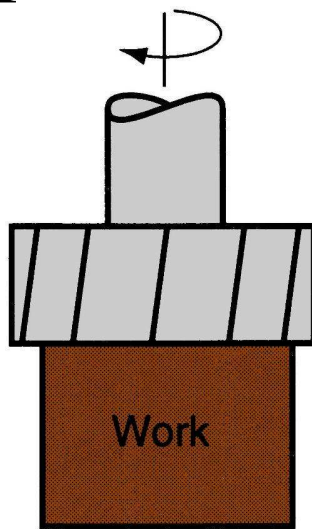
Milling of a concave half circle



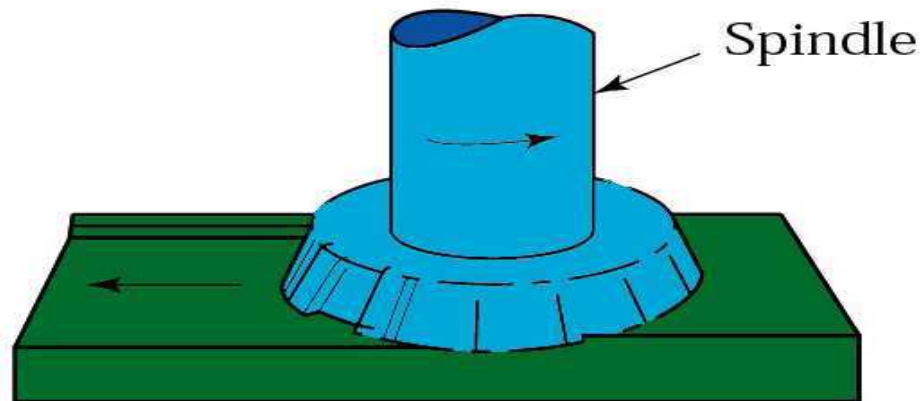
Milling of a gear

Milling Operations on a Vertical Milling Machine

- Face milling: The cutter with a relatively large diameter removes a layer from the upper side of the part

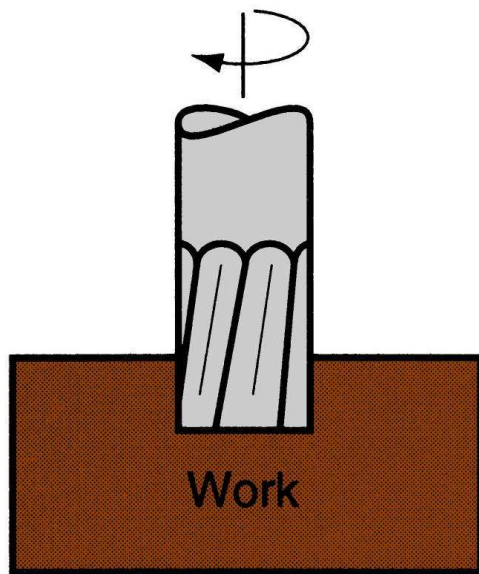


(a)

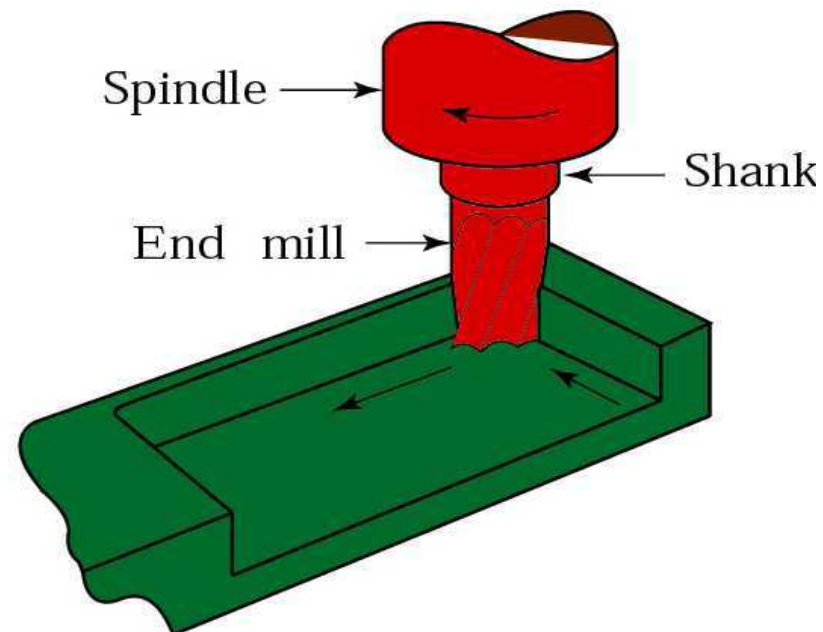


Milling Operations on a Vertical Milling Machine

- End milling: Cutters diameter is less than the work part's width

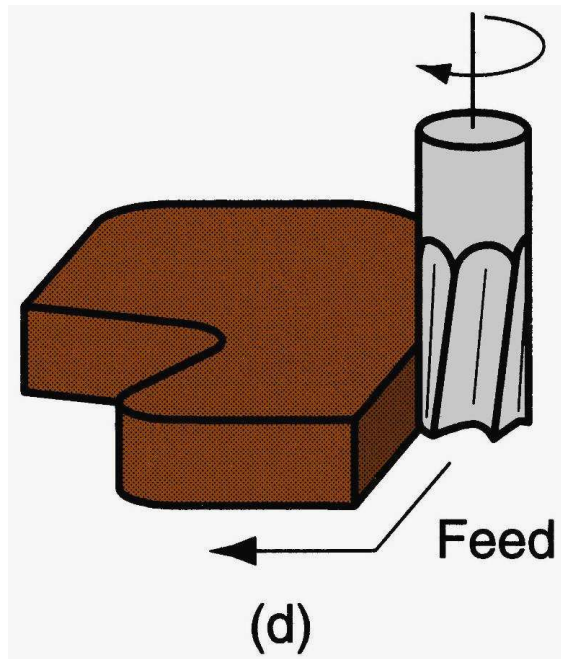


(c)



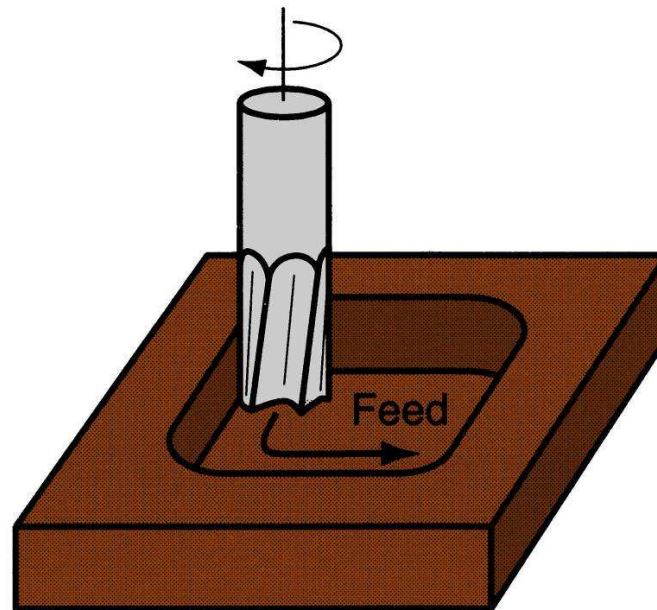
Milling Operations on a Vertical Milling Machine

- Profile milling (also contouring or shaping):
Outside periphery of flat part is cut



Milling Operations on a Vertical Milling Machine

- Pocket milling: The cutter removes material creating a cavity (rectangular, circular etc.)

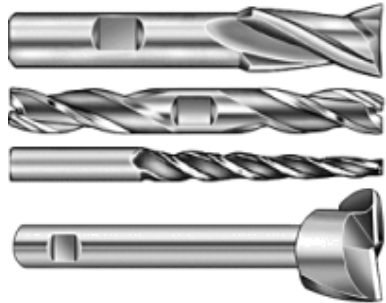


(e)

Milling Machine Capabilities

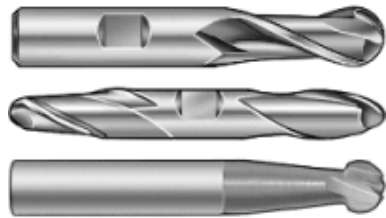
- **Surfacing**
- **Shaping - Contouring**
- **Pockets**
- **Slots**
- **Hole Patterns**
- **Simple and Complex Angles**
- **Boring**

Mill Bits

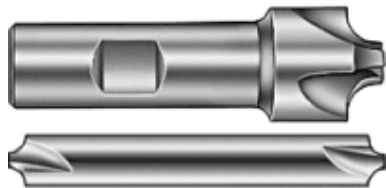


square **end-mills** are the workhorse bits:

- pockets
- slots
- edge trim
- facing



ball-end mills make rounded pockets or spherical pockets; also fillets



corner-rounders form rounded corners!



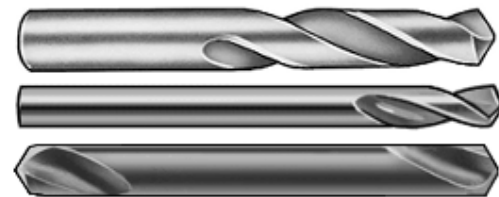
conical end-mill for chamfers

graphics from McMaster Carr online catalog: www.mcmaster.com

Drills and Reamers



standard “**jobber**” drill: will flex/walk, follow pilot



stub drill for less walk/greater rigidity



center drill establishes hole position with *no walk*



reamers (straight or spiral)
finish off hole (last several thousandths)
precise hole diameter
for insertion of dowel pins, bearings, etc.
plunge while spinning, extract still



countersink: for screw heads & deburring hole

graphics from McMaster Carr online catalog: www.mcmaster.com

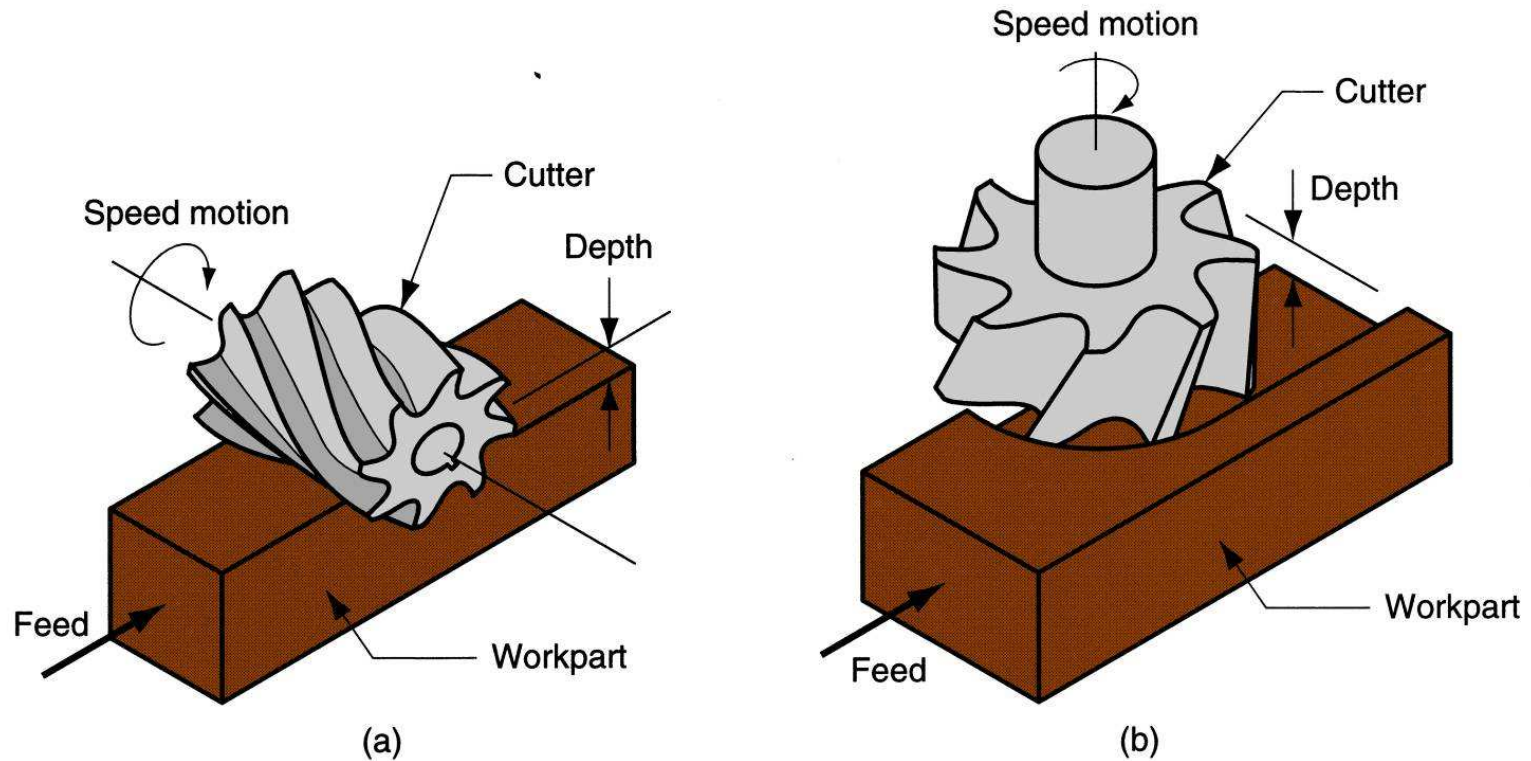
Workholding Devices

- Vise
- Chucks
- Rotating tables
- Special fixtures
- Universal dividing head

Classifications

- Milling operations are classified into two major categories:
 - Peripheral (side)
 - Generally in a plane parallel to the axis of the cutter
 - Face
 - Generally at right angles to the axis of rotation of the cutter

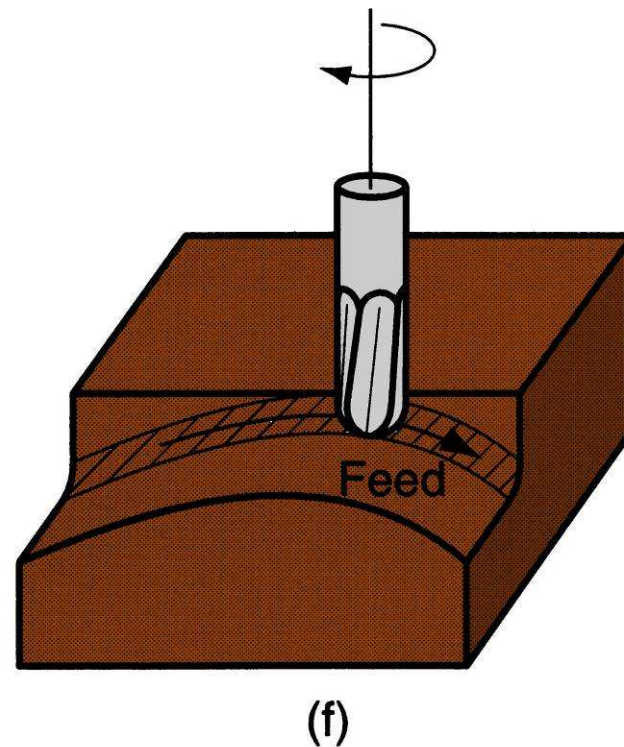
Two Forms of Milling



Two forms of milling: (a) peripheral milling, and (b) face milling.

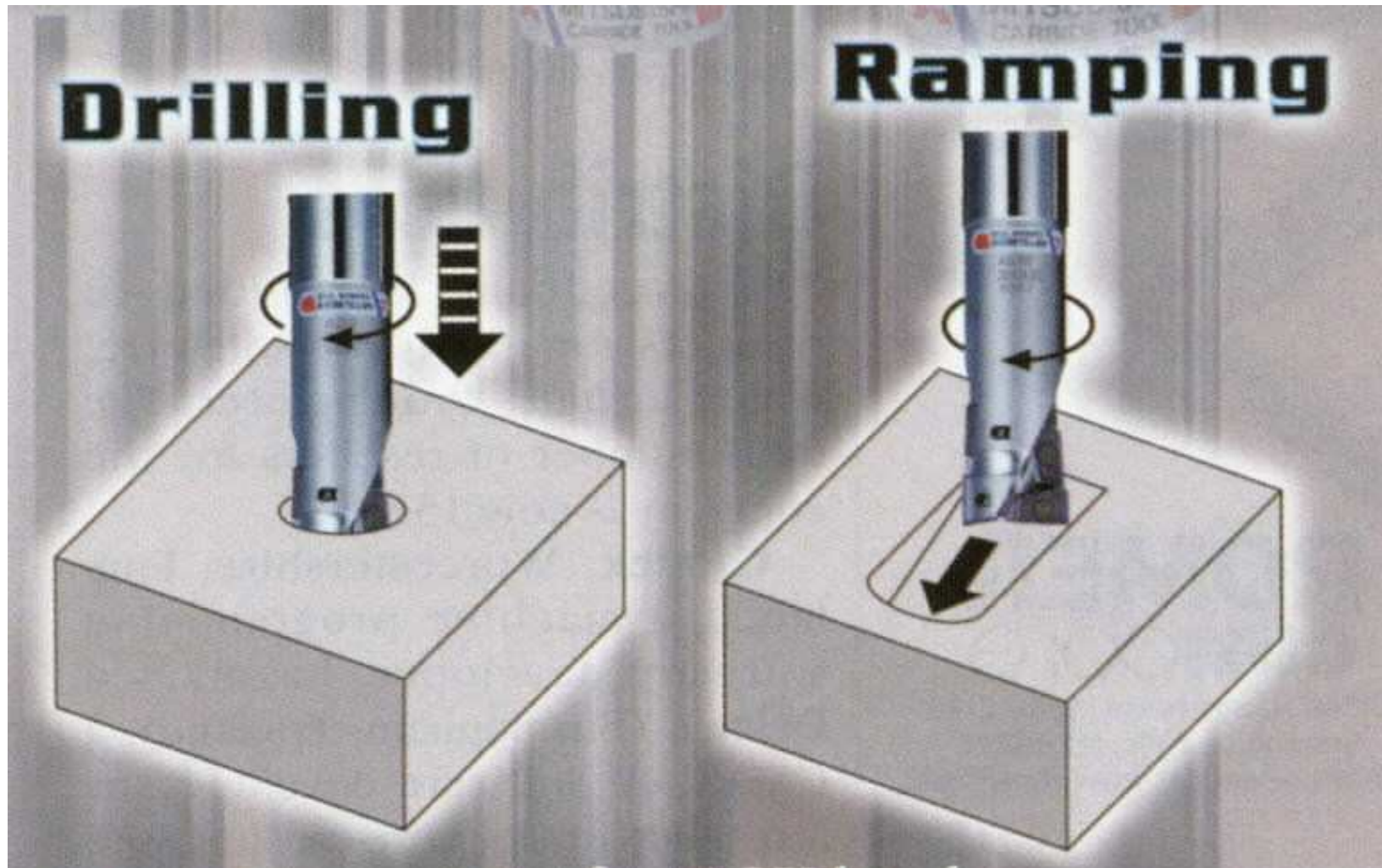
Variations on Face Milling

- Ball-nose cutter fed back and forth across work along a curvilinear path at close intervals to create a three dimensional surface form

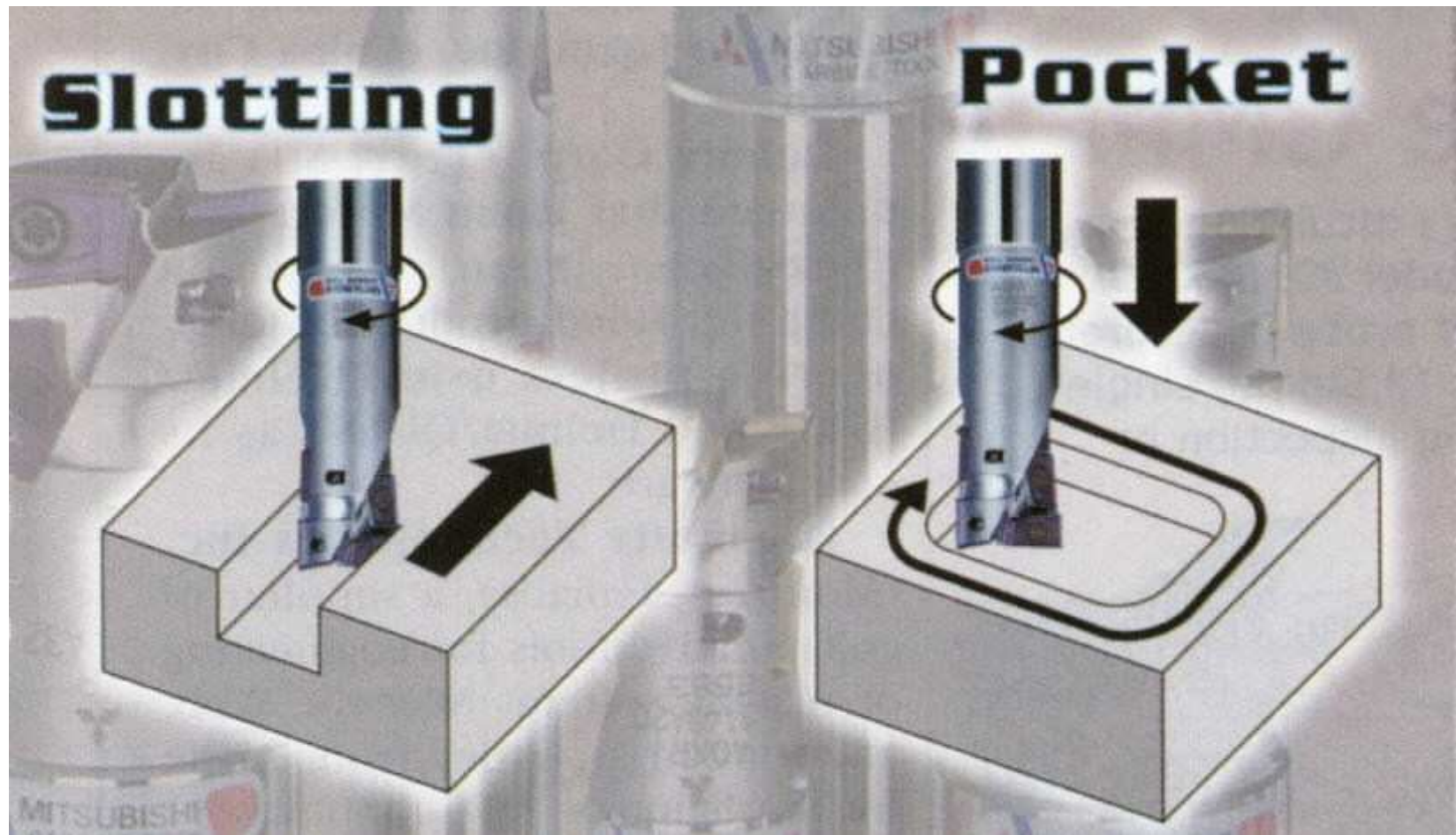


(f) surface contouring

More...



End of More



Operating Parameters

- Spindle speed:
Rpm (Rotations per minute)
- Feed rate
mm/min

Variation of Machines

- CNC
 - Horizontal, Vertical, and Planner (up to 5 axis)

