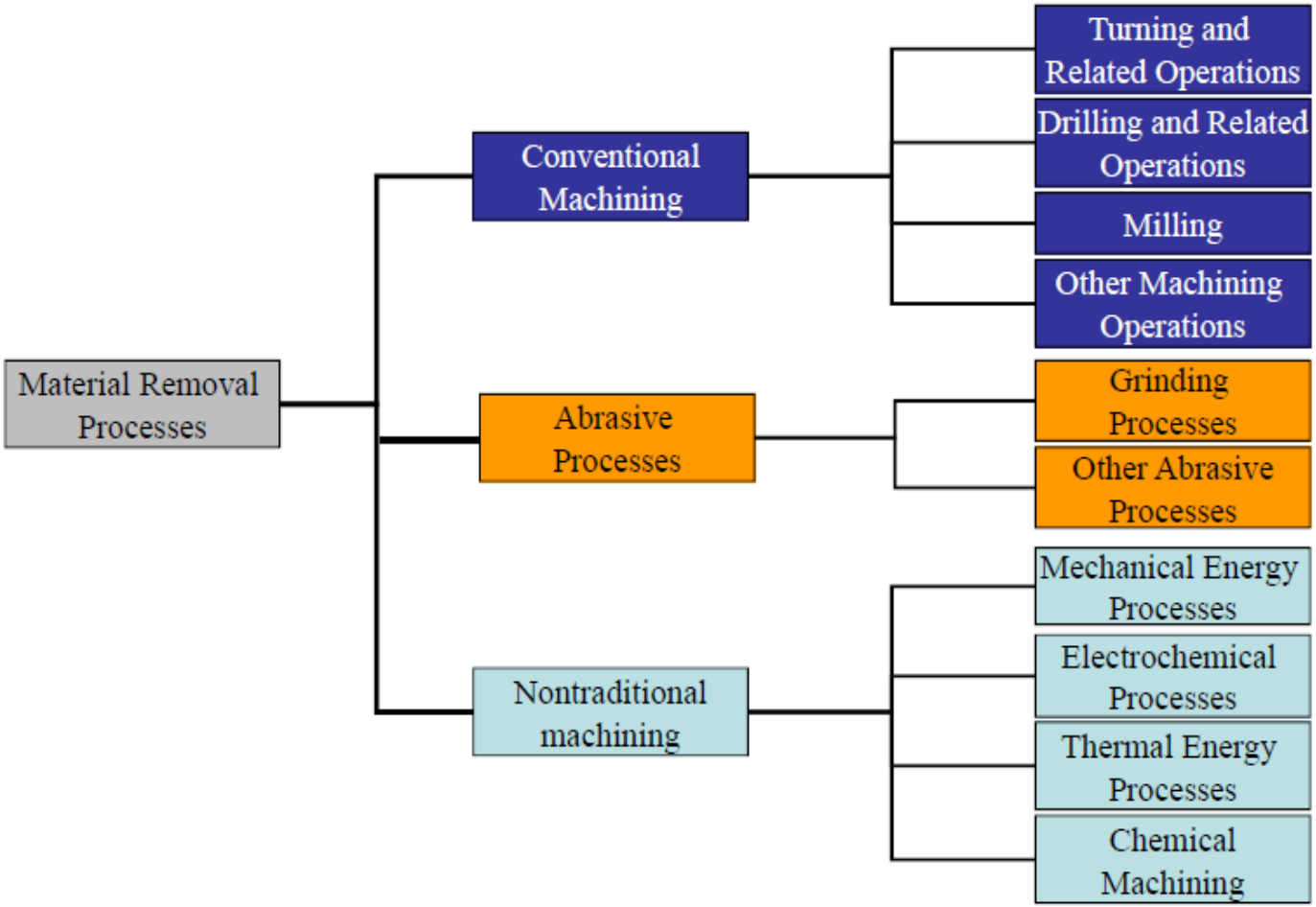
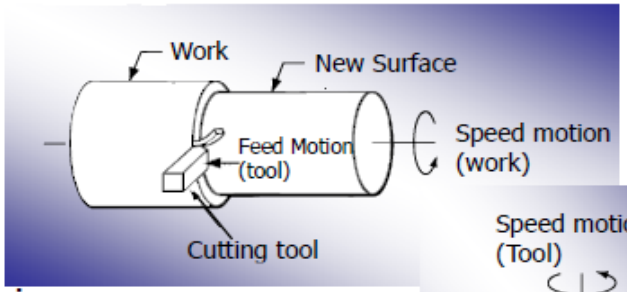
Theory of Metal Machining

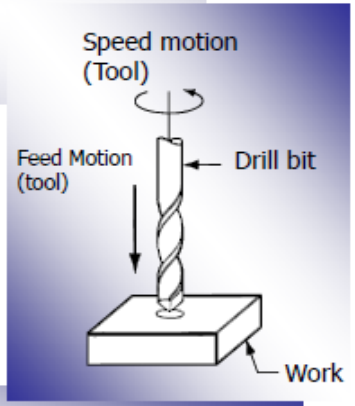
Classification

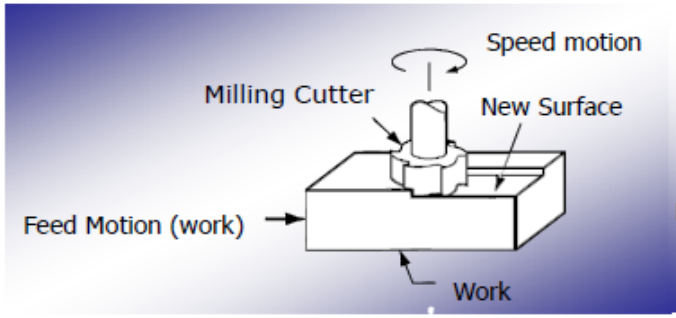


Machining Overview

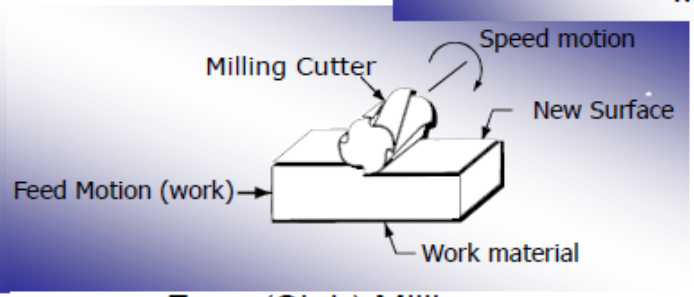
- Types
  - Turning - Lathe
  - Drilling – Drill press
  - Milling – Milling Machine
    - Peripheral
    - Face
- Cutting Tool







Peripheral (End) Milling



Face (Slab) Milling

Machining

A material removal process in which a sharp cutting tool is used to mechanically cut away material so that the desired part geometry remains

- Most common application: to shape metal parts
- Most versatile of all manufacturing processes in its capability to produce a diversity of part geometries and geometric features with high precision and accuracy
  - Casting can also produce a variety of shapes, but it lacks the precision and accuracy of machining

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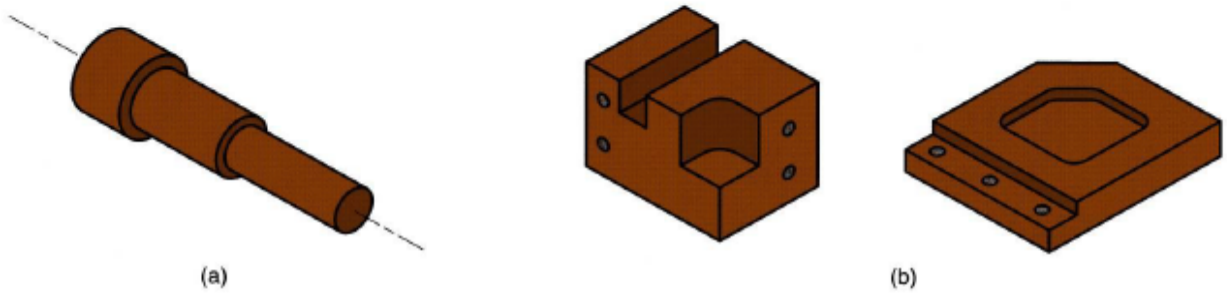
Classification of machined parts

- Rotational - cylindrical or disk-like shape
- Nonrotational (also called prismatic) - block-like or plate-like



Machined parts are classified as: (a) rotational, or (b) nonrotational, shown here by block and flat parts.

Machining Operations and Machine tools

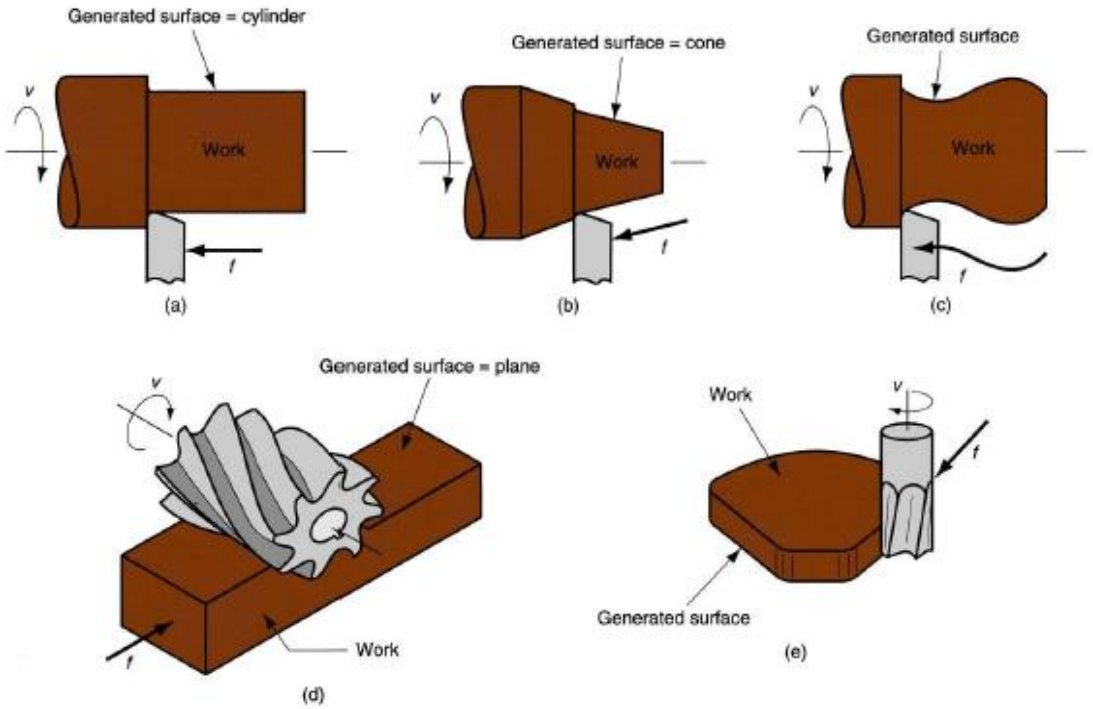
1. Turning and Related Operations
2. Drilling and Related Operations
3. Milling
4. Machining Centers and Turning Centers
5. Other Machining Operations

Machining Operations and Part Geometry

Each machining operation produces a characteristic part geometry due to two factors:

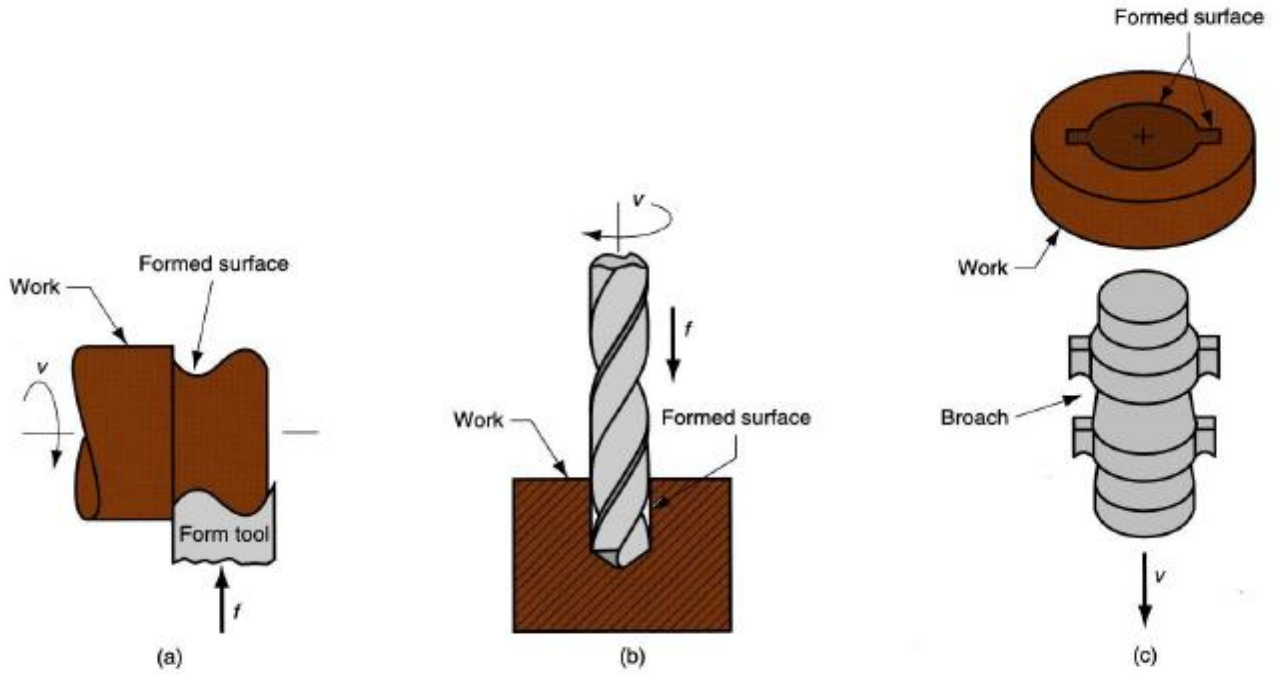
1. Relative motions between tool and workpart
   - *Generating* – part geometry determined by feed trajectory of cutting tool
2. Shape of the cutting tool
   - *Forming* – part geometry is created by the shape of the cutting tool

Generating Shape



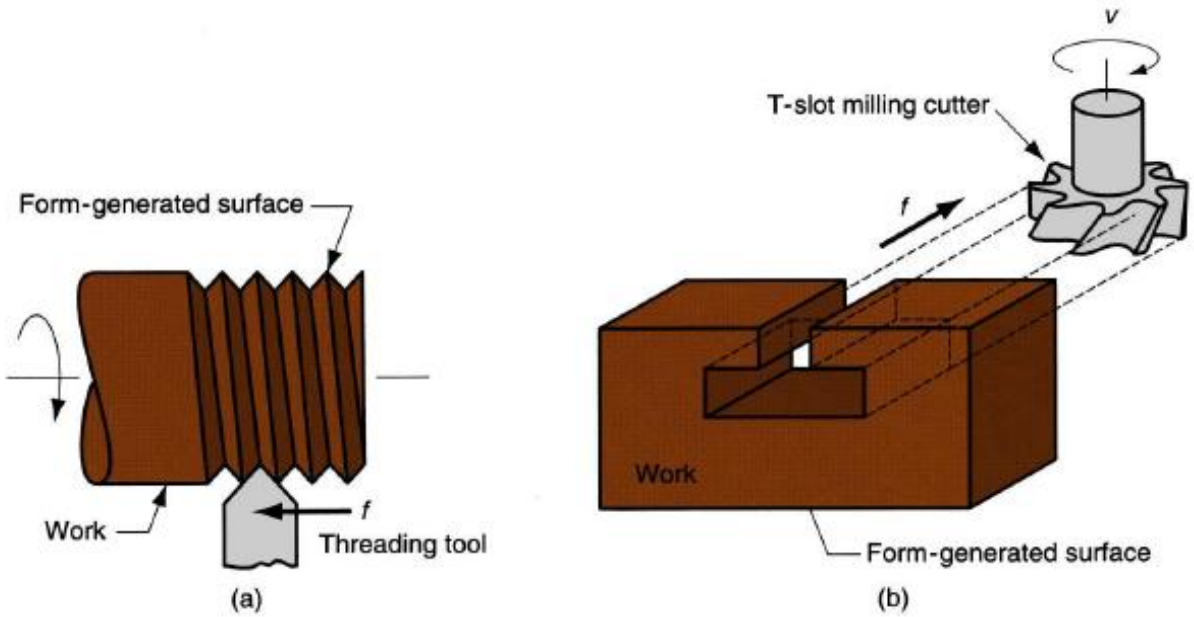
Generating shape: (a) straight turning, (b) taper turning, (c) contour turning, (d) plain milling, (e) profile milling.

Forming to Create Shape



Forming to create shape: (a) form turning, (b) drilling, and (c) broaching.

Forming and Generating

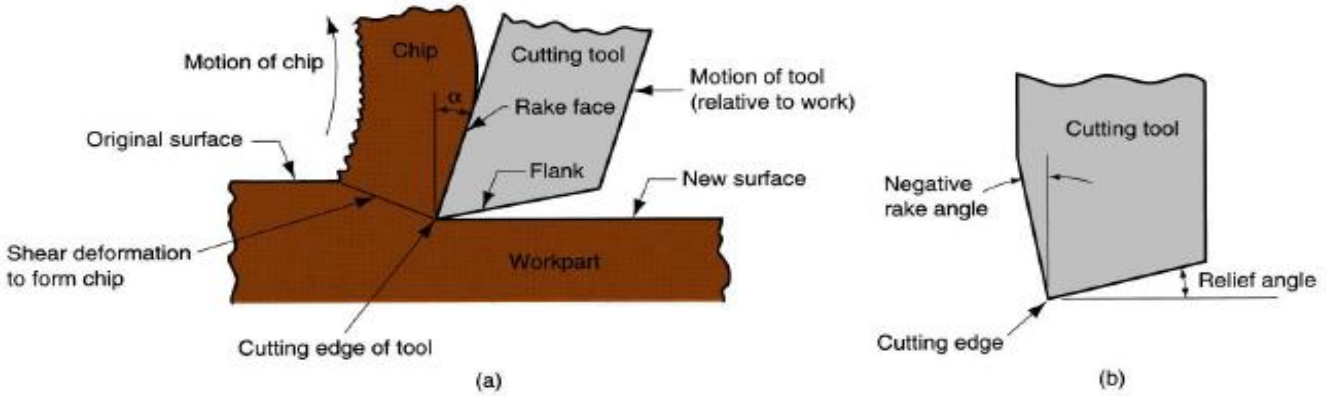


Combination of forming and generating to create shape: (a) thread cutting on a lathe, and (b) slot milling.

Machining

Cutting action involves shear deformation of work material to form a chip

- As chip is removed, new surface is exposed



(a) A cross-sectional view of the machining process, (b) tool with negative rake angle; compare with positive rake angle in (a).

Why Machining is Important

- Variety of work materials can be machined
  - Most frequently used to cut metals
- Variety of part shapes and special geometric features possible, such as:
  - Screw threads
  - Accurate round holes
  - Very straight edges and surfaces
- Good dimensional accuracy and surface finish

Disadvantages of Machining

- Wasteful of material
  - Chips generated in machining are wasted material, at least in the unit operation
- Time consuming
  - A machining operation generally takes more time to shape a given part than alternative shaping processes, such as casting, powder metallurgy, or forming

Machining in Manufacturing Sequence

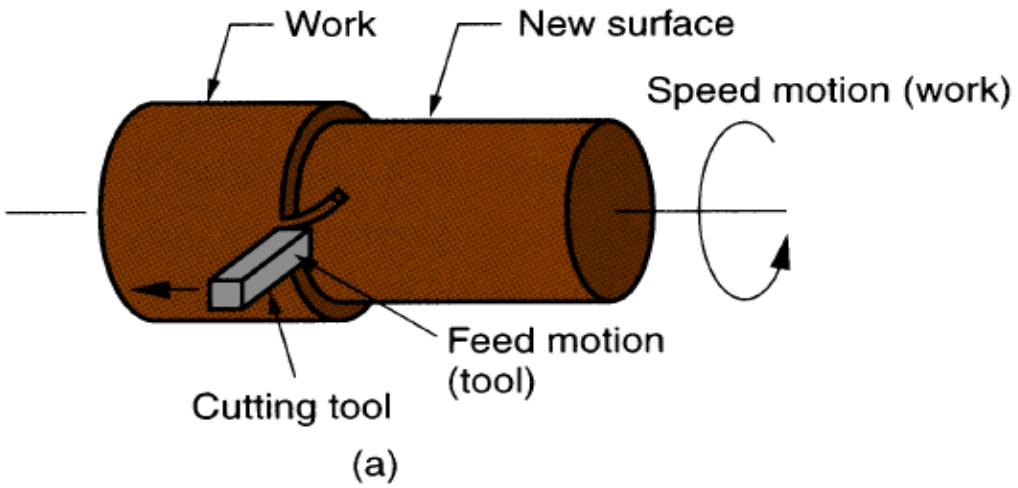
- Generally performed after other manufacturing processes, such as casting, forging, and bar drawing
  - Other processes create the general shape of the starting workpart
  - Machining provides the final shape, dimensions, finish, and special geometric details that other processes cannot create

Machining Operations

- Most important machining operations:
  - Turning
  - Drilling
  - Milling
- Other machining operations:
  - Shaping and planing
  - Broaching
  - Sawing

Turning

Single point cutting tool removes material from a rotating workpiece to form a cylindrical shape

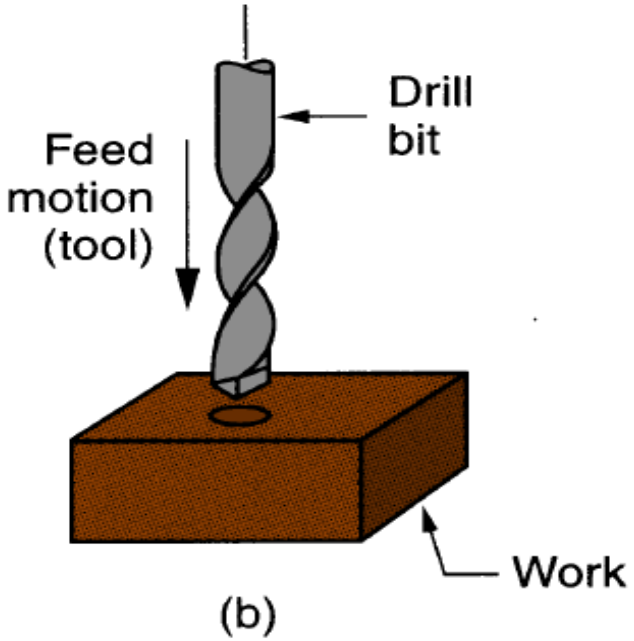


Three most common machining processes: (a) turning,

Drilling

Used to create a round hole, usually by means of a rotating tool (drill bit) with two cutting edges

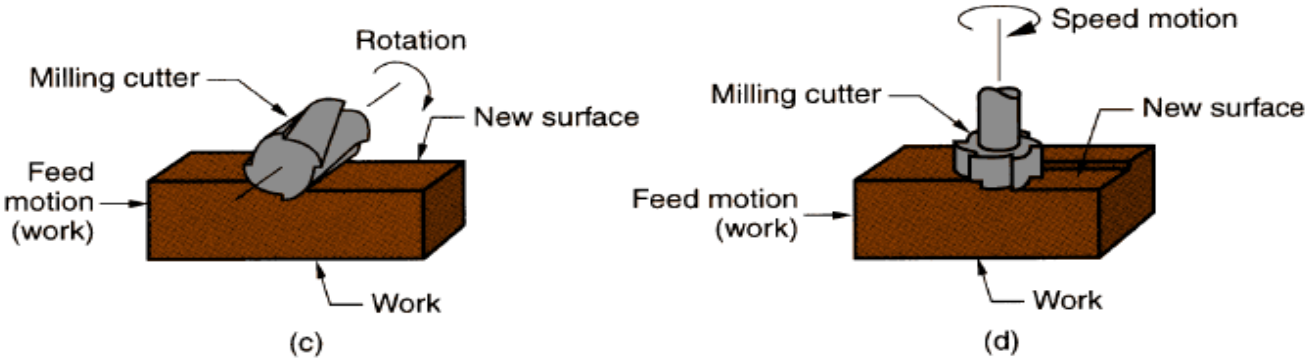
(b) drilling,



Milling

Rotating multiple-cutting-edge tool is moved across work to cut a plane or straight surface

- Two forms: peripheral milling and face milling

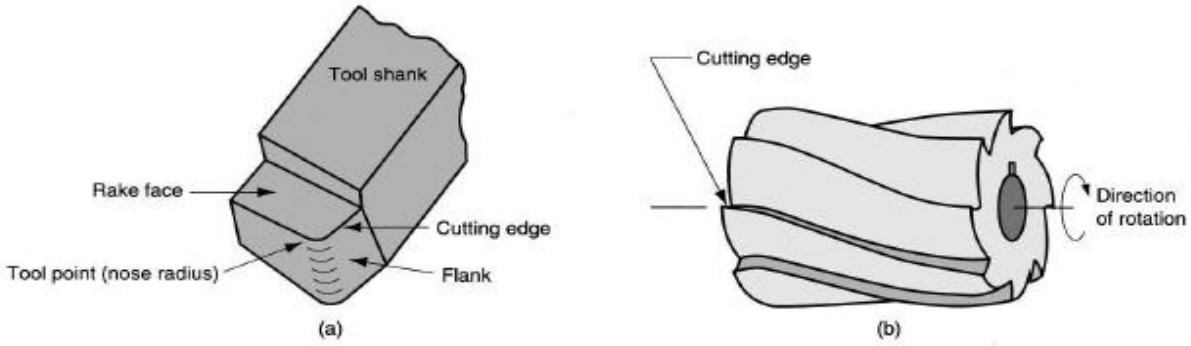


(c) peripheral milling, and (d) face milling.

Cutting Tool Classification

1. Single-Point Tools
   - One dominant cutting edge
   - Point is usually rounded to form a nose radius
   - Turning uses single point tools
2. Multiple Cutting Edge Tools
   - More than one cutting edge
   - Motion relative to work achieved by rotating
   - Drilling and milling use rotating multiple cutting edge tools

Cutting Tools



(a) A single-point tool showing rake face, flank, and tool point; and (b) a helical milling cutter, representative of tools with multiple cutting edges.

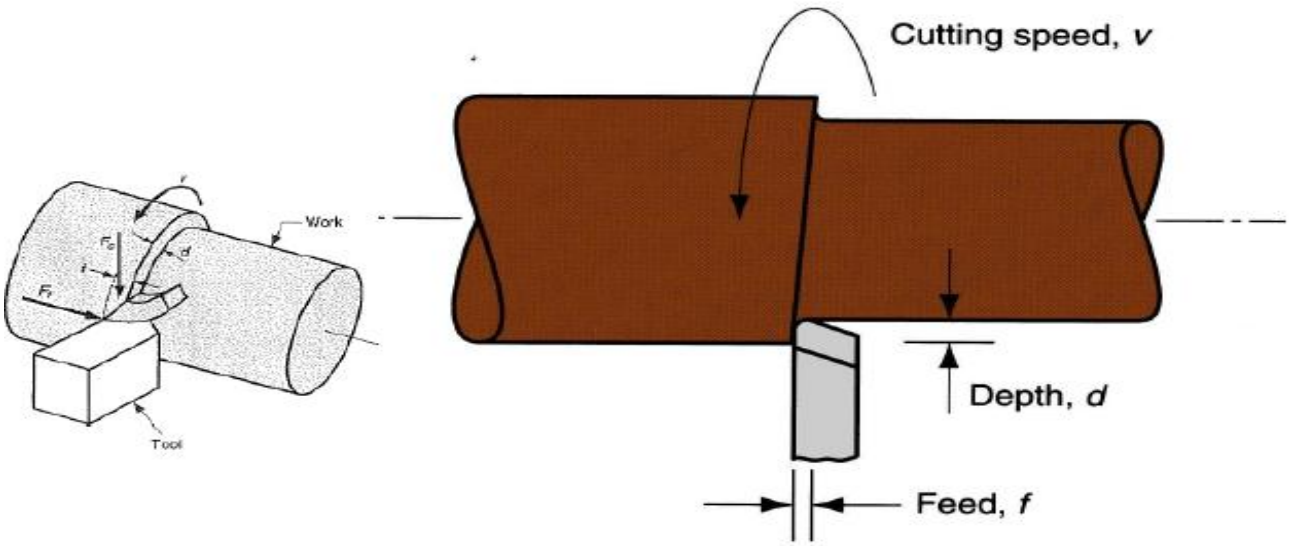
Cutting Conditions in Machining

- Three dimensions of a machining process:
  - Cutting speed v – primary motion
  - Feed f – secondary motion
  - Depth of cut d – penetration of tool below original work surface
- For certain operations, material removal rate can be computed as

$$R_{MR} = v\, f\, d$$

where v = cutting speed; f = feed; d = depth of cut

Cutting Conditions for Turning



Speed, feed, and depth of cut in turning.

Roughing and Finishing

In production, several roughing cuts are usually taken on the part, followed by one or two finishing cuts

- Roughing - removes large amounts of material from starting workpart
  - Creates shape close to desired geometry, but leaves some material for finish cutting
  - High feeds and depths, low speeds
- Finishing - completes part geometry
  - Final dimensions, tolerances, and finish
  - Low feeds and depths, high cutting speeds