ME 312
Manufacturing Technology II

Shrikrishna N. Joshi (SNJ)
E-mail: snj@iitg.ac.in
Phone: 2678
Office: D 203

Course syllabus

- **Metal Cutting:** mechanics, tools (material, temperature, wear, and life considerations), geometry and chip formation, surface finish and machinability, optimization
- **Machine tool:** generation and machining principles, Setting and Operations on machines: lathe, milling (including indexing), shaping, slotting, planing, drilling, boring, broaching, grinding (cylindrical, surface, centre-less), thread rolling and gear cutting machines
- **Tooling:** jigs and fixtures, principles of location and clamping

Course syllabus

- **Batch production:** capstan and turret lathes; CNC machines
- **Finishing:** micro-finishing (honing, lapping, super-finishing)
- **Unconventional methods:** electro-chemical, electro-discharge, ultrasonic, LASER, electron beam, water jet machining
- **Rapid prototyping and rapid tooling**

Course syllabus

Texts:

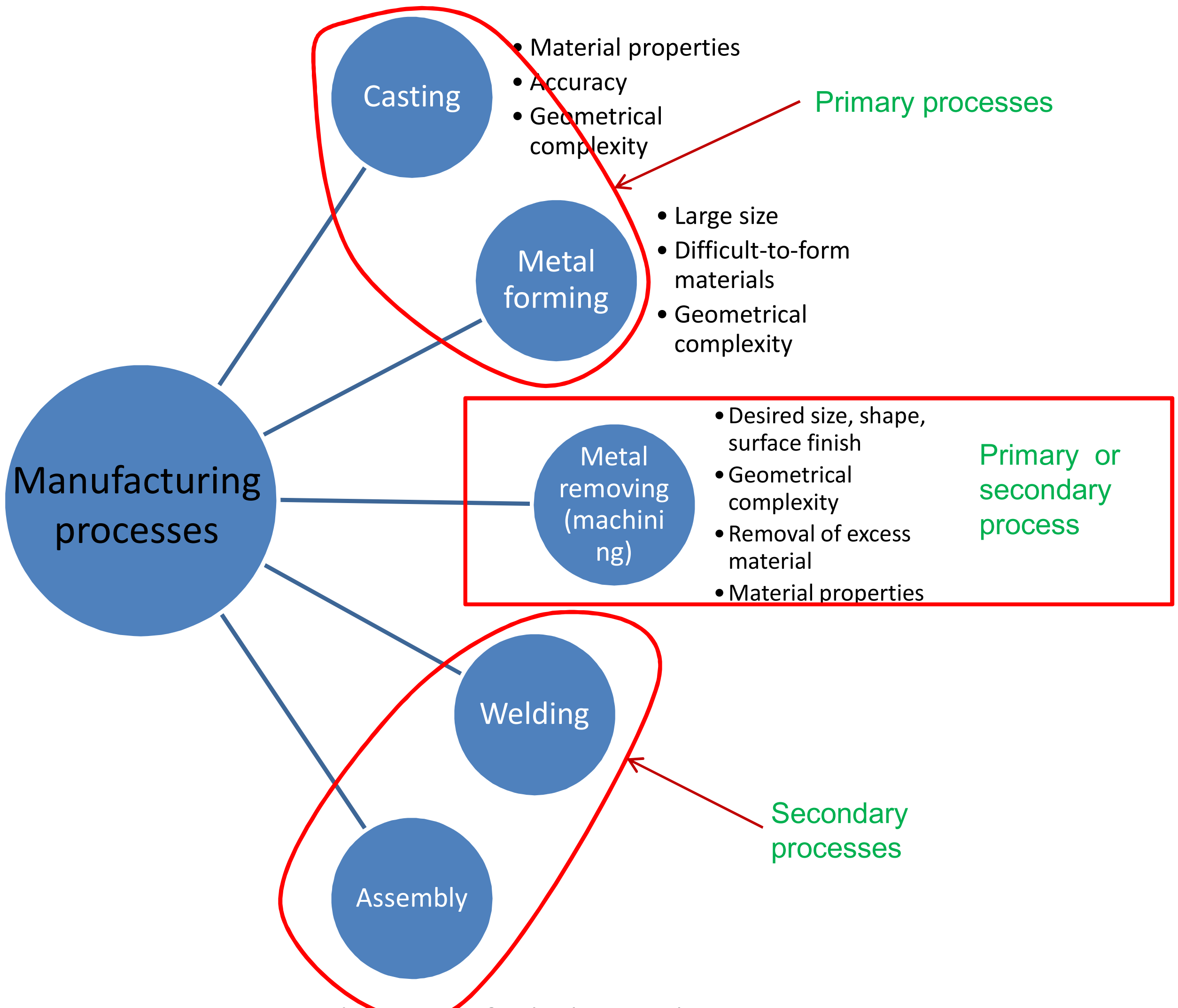
1. G Boothroyd, *Fundamentals of Metal Cutting Machine Tools*, Tata McGraw Hill, 1975.
2. A Ghosh and A K Mallik, *Manufacturing Science*, Wiley Eastern, 1986.
3. P C Pandey and C K Singh, *Production Engineering Sciences*, Standard Publishers Ltd. 1980.
4. M C Shaw, *Metal Cutting Principles*, 2^{nd} Edition, OUP New York, 2005.
5. G K Lal, *Introduction to Machining Science* , New Age, New Delhi, 1996.

References:

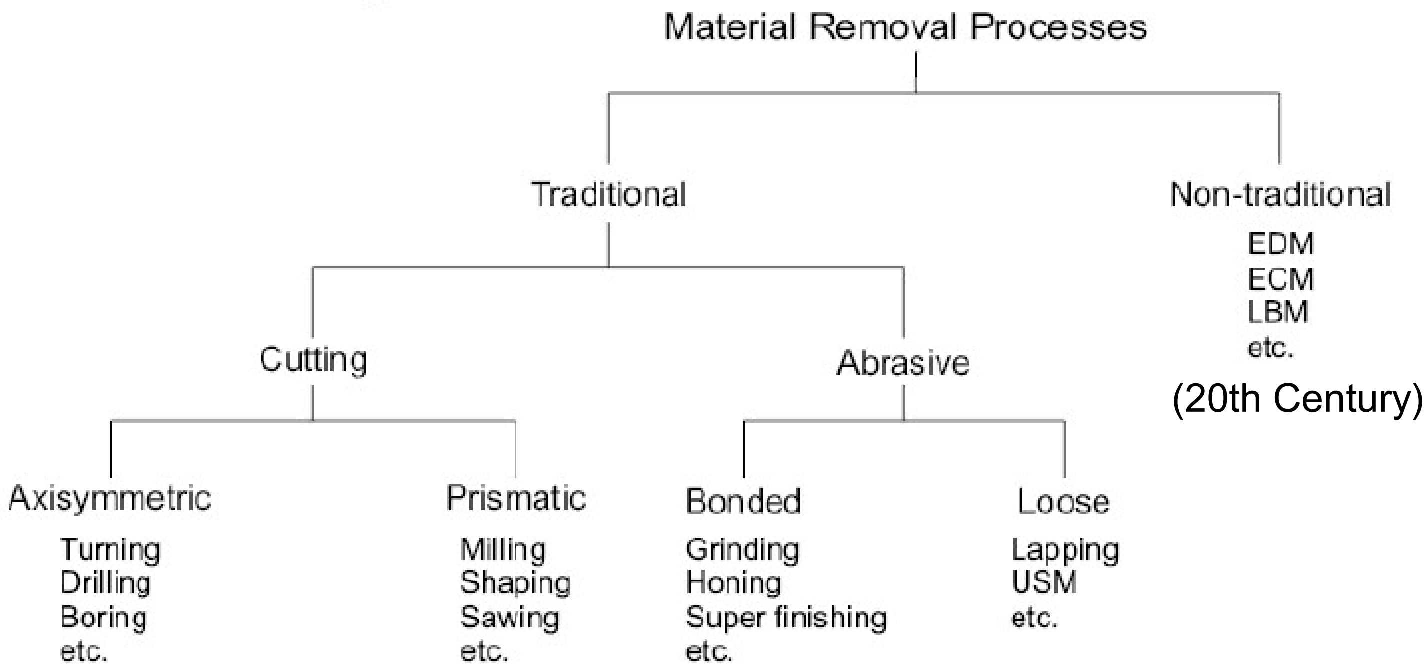
6. R A Walsh, *MGH Machining and Metalworking Handbook*, McGraw Hill, New York, 1994.
7. J Brown, *Advanced Machining Technology Handbook*, McGraw Hill, New York, 1994.
8. *Production Technology*, H M T Publication Tata McGraw Hill, 1980

Course evaluation

- Quizzes and project: 25%
- Mid-sem: 35%
- End-sem: 40%


Manufacturing processes
Casting
Material properties
Accuracy
Geometrical complexity
Metal forming
Large size
Difficult-to-form materials
Geometrical complexity
Primary processes
Metal removing (machining)
Desired size, shape, surface finish
Geometrical complexity
Removal of excess material
Material properties
Primary or secondary process
Welding
Assembly
Secondary processes

Material removal processes



Machining

INDISPENSABLE

- Machining of materials
  – Higher surface finish
  – Close tolerances
  – Complex geometric shapes
- Metal cutting: expensive one
  – Substantial amount of work removal from workpiece
  – Lot of energy will be expended

Machine tools

- Cutting tool: the body which removes the excess material by direct mechanical contact
- Machine tool : provides the necessary relative motions between cutting tool and workpiece
- Machining in 21^{st} Century: Micro-electronics technology- CNC technology, advanced methods

Brief history of machine tools

- 1774 - John Wilkinson- Horizontal Boring Machine

Courtesy: JR Walker and B Dixon, Machining Fundamentals, G-W Publishers, 2010

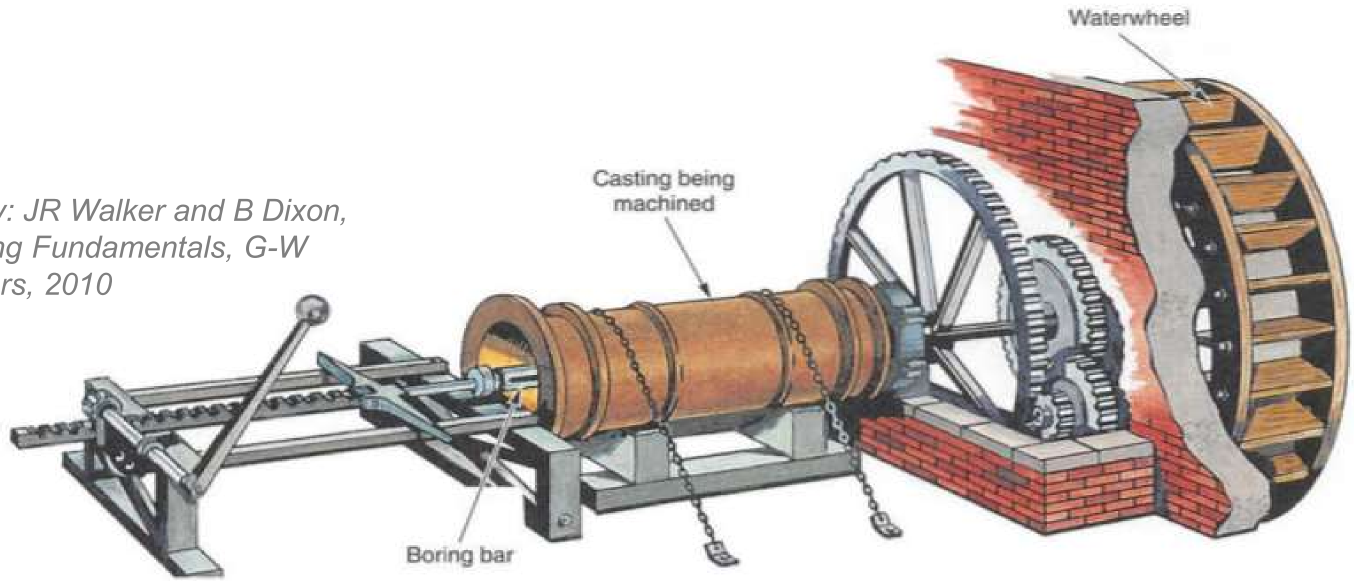


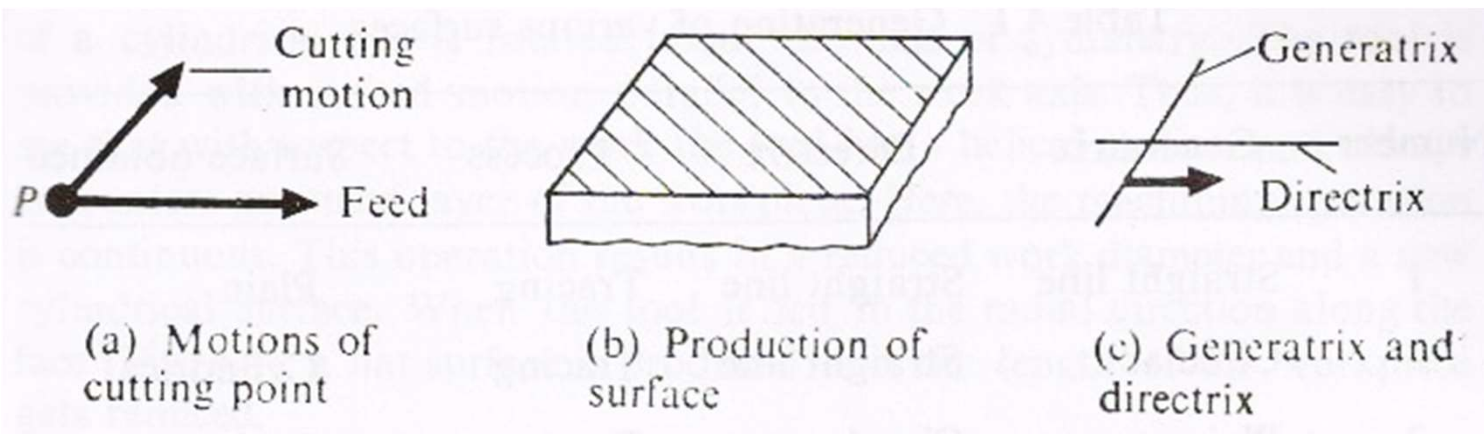
Figure 1-2. The first true machine tool is thought to be the boring mill invented by John Wilkinson in 1774. It enabled James Watt to complete the first successful steam engine. The boring bar was rigidly supported at both ends and was rotated by waterpower. It could bore a 36" diameter cylinder to an accuracy of less than 1/16".

Brief history of machine tools

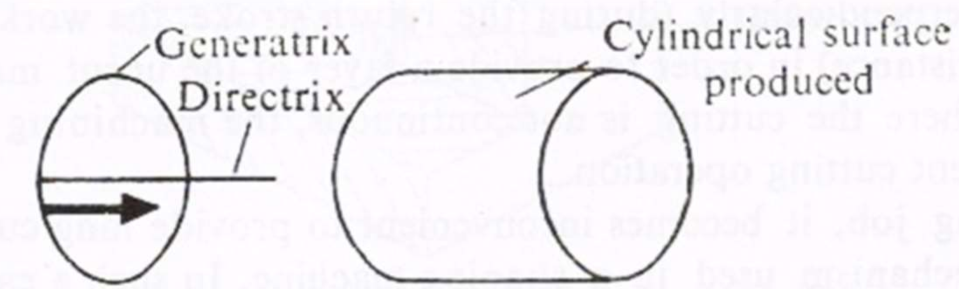
- 1774 - John Wilkinson- Horizontal Boring Machine
- 1794 - Henry Maudsley - Engine Lathe
- 1817 – Roberts – Planer Machine
- 1818 - Eli Whitney - Milling Machine
- 1840 - John Nasmyth - Drill Press
- 1845 - Stephen Fitch - Turret Lathe
- 1869 - Christopher Spencer - Automatic Turret Lathe
- 1880 - Surface Grinder
- 1952 - John Parson, MIT and US Air Force - Numerical Control - CNC

Relative motion between tool and work

- Primary or cutting motion: responsible for cutting action
- Secondary or feed motion: responsible for gradually feeding the uncut portion

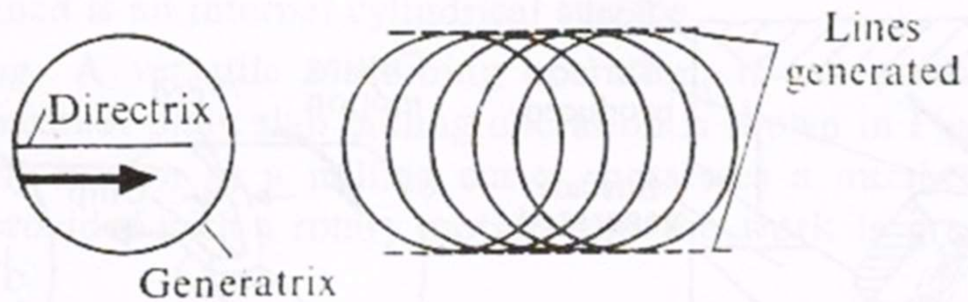


Relative motion between tool and work



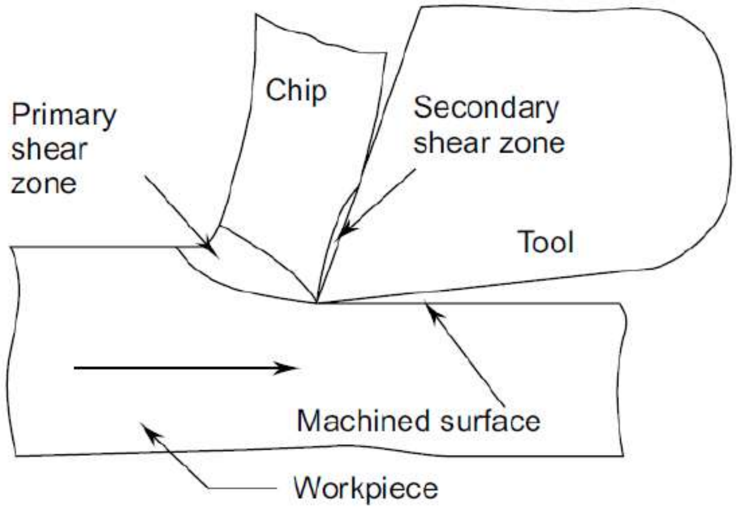
(a) Directrix perpendicular to plane of generatrix

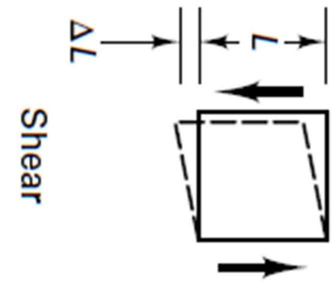
Direct tracing by generatrix



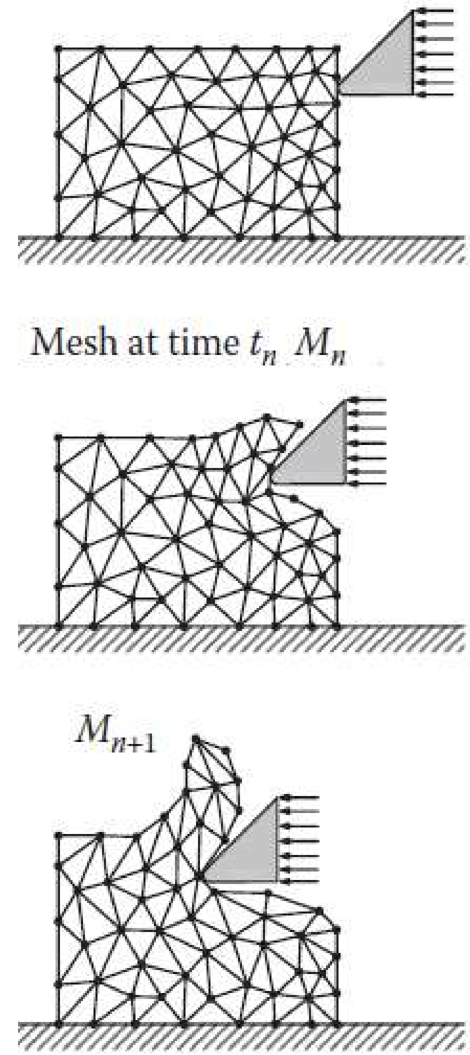
(b) Directrix in the plane of generatrix

Envelope of generatrices: Generation





Mechanism of chip formation



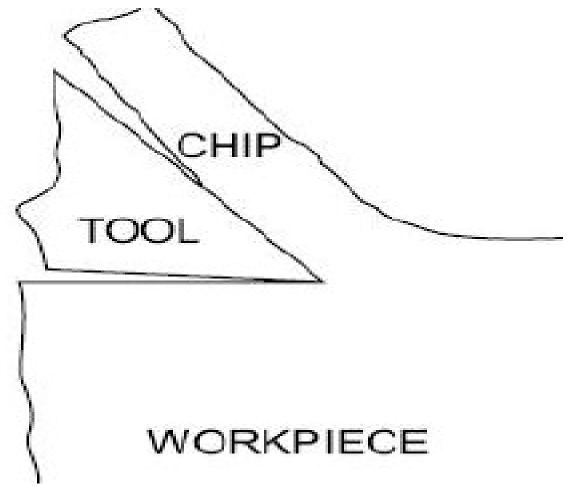
- Metal in front of the tool rake face gets immediately compressed first elastically and then plastically.
- Actual separation of the metal starts as a yielding or fracture, depending upon the cutting conditions, starting from the cutting tool tip.
- The chip, after sliding over the tool rake face, would be lifted away from the tool, and the resultant curvature of the chip is termed “**chip curl”**.

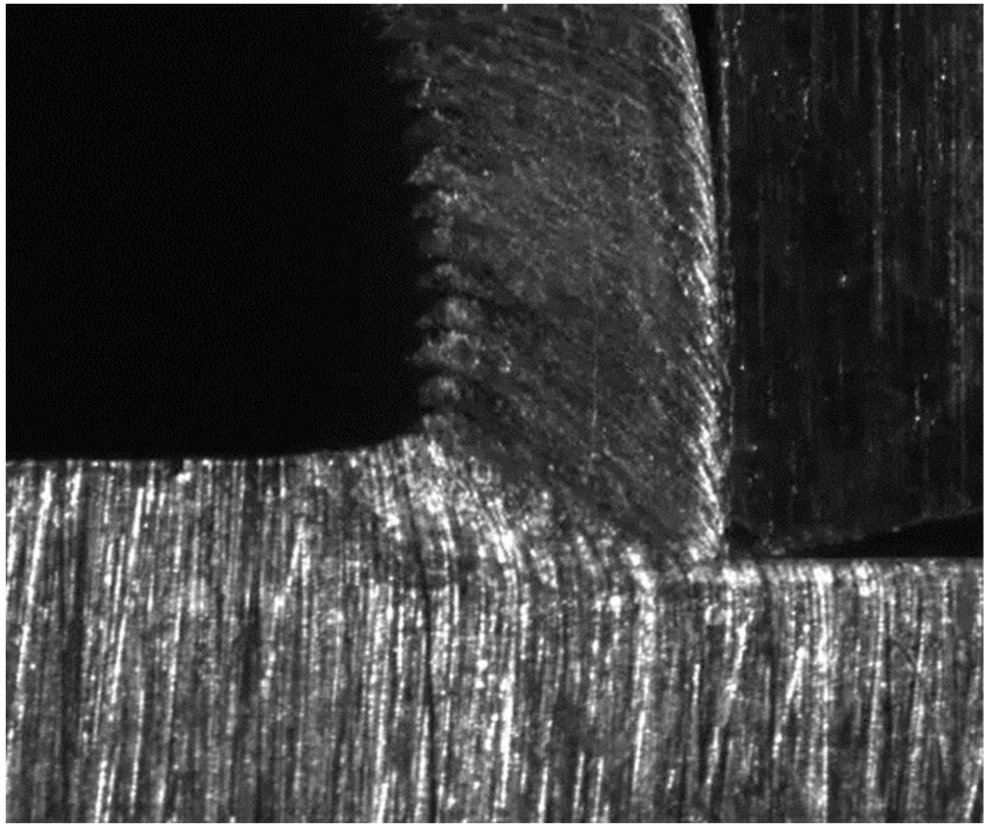
Types of chips

- Continuous chips
- Discontinuous chips
- Continuous chips with built-up-edge (BUE)

Continuous chip

- Machining steel or ductile metals at high cutting speeds (1.0 m/s).
- Ductility of metal flows along the shear plane instead of rupture.
- Sharp cutting edge
- Small uncut chip thickness (low depth of cut)
- Large rake angle
- Less friction : efficient lubrication

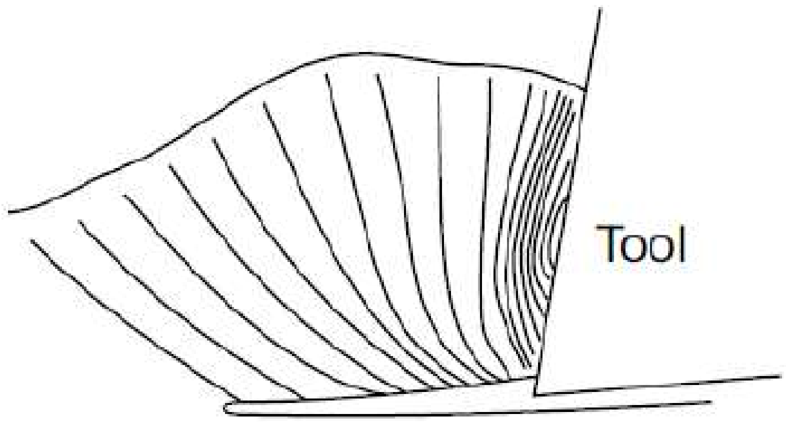




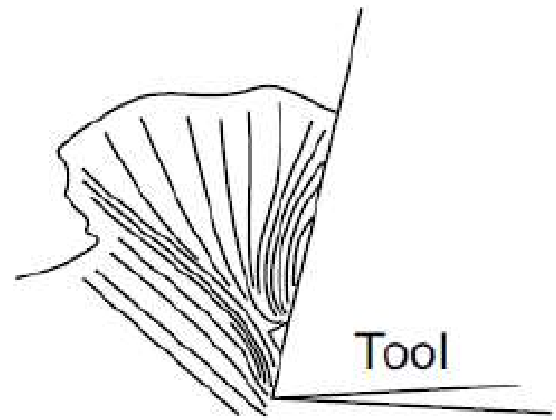
Continuous Chips

Rake angle = 0 degree; V = 1 mm/s; brass Y. Guo, W.D. Compton, S. Chandrasekar. In situ analysis of flow dynamics and deformation fields in cutting and sliding of metals. Proceedings of the Royal Society A 471, 20150194 (2015).

Discontinuous chips



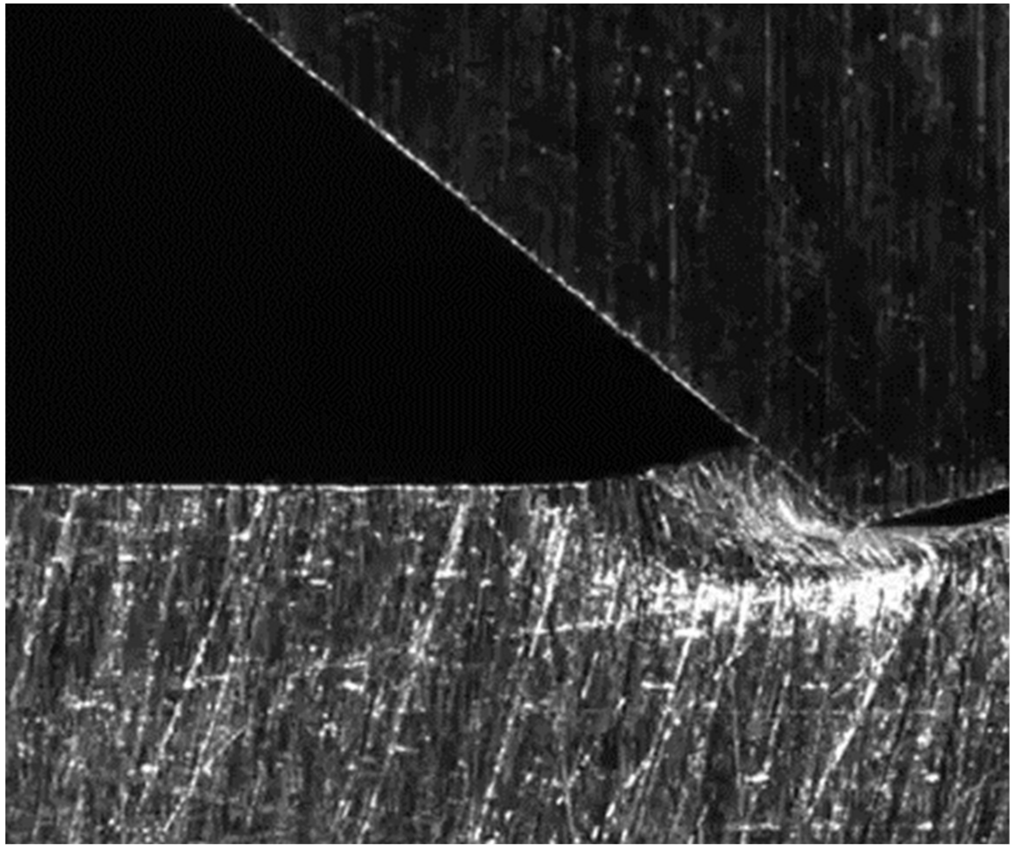
(a) Tear type



(b) Shear type

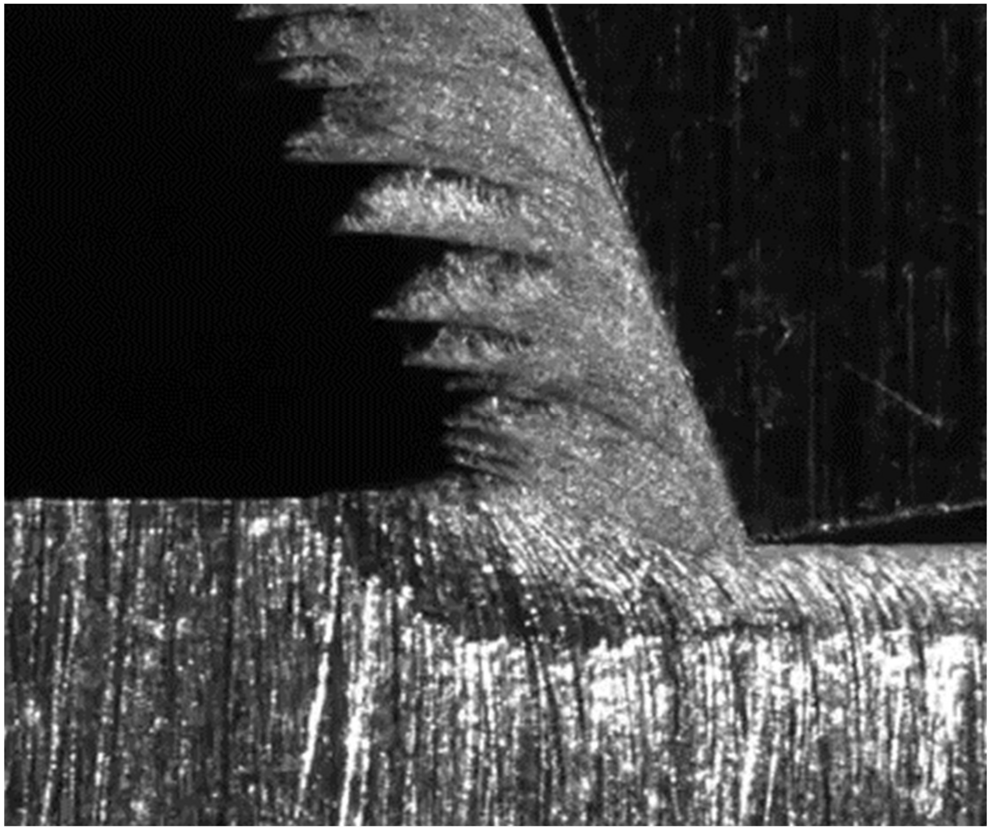
- Machining of brittle materials like cast iron
- Deformation by fracture
- Chips in the form of discontinuous segments

- Cutting force becomes unstable
- Higher depths of cut (large chip thickness)
- Low cutting speeds (0.02 m/s)
- Small rake angles



Discontinuous Chips

Rake angle = -50 degree; V = 1 mm/s; 70-30 brass Y. Guo, W.D. Compton, S. Chandrasekar. In situ analysis of flow dynamics and deformation fields in cutting and sliding of metals. Proceedings of the Royal Society A 471, 20150194 (2015).

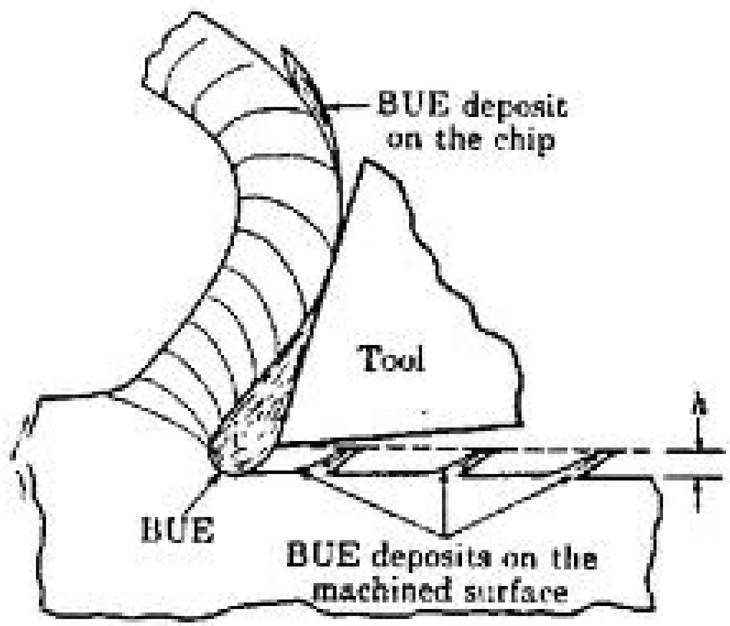


Segmented Chips

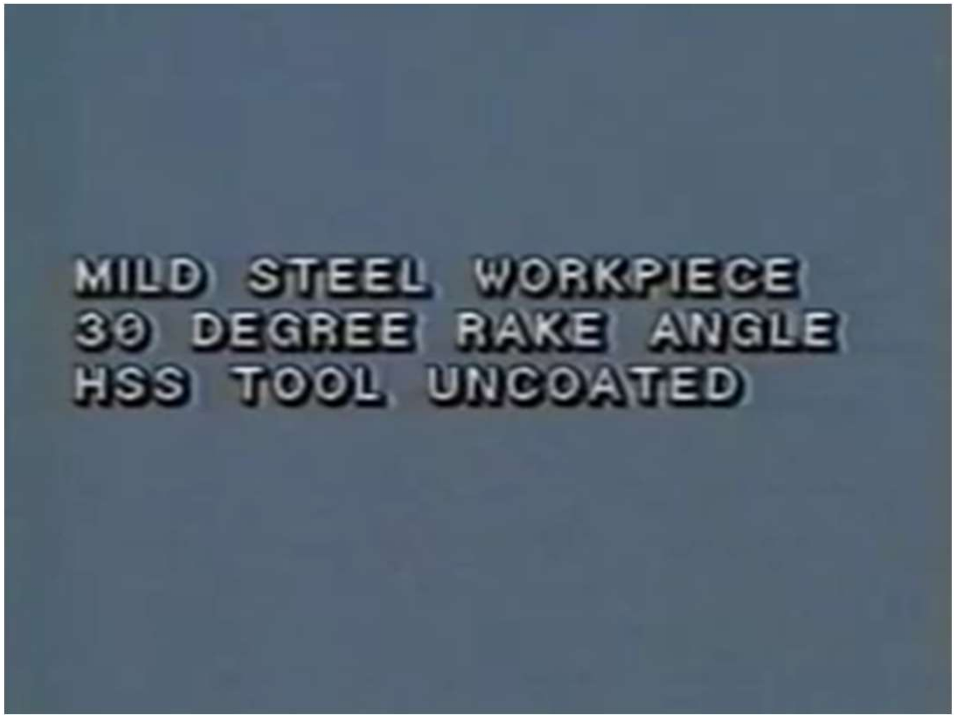
Rake angle = -20 degree; V = 1 mm/s; 70-30 brass Y. Guo, W.D. Compton, S. Chandrasekar. In situ analysis of flow dynamics and deformation fields in cutting and sliding of metals. Proceedings of the Royal Society A 471, 20150194 (2015).

Continuous chip with built-up edge (BUE)

- Friction between tool and chip is high while machining ductile materials, some particles of chip adhere to the tool rake face near the tool tip.
- When such sizeable material piles up on the rake face, it is termed as built up edge (BUE).
- As the size of BUE grows larger, it becomes unstable and parts of it gets removed while cutting. The removed portions of BUE partly adheres to the chip underside and partly to the machined surface.

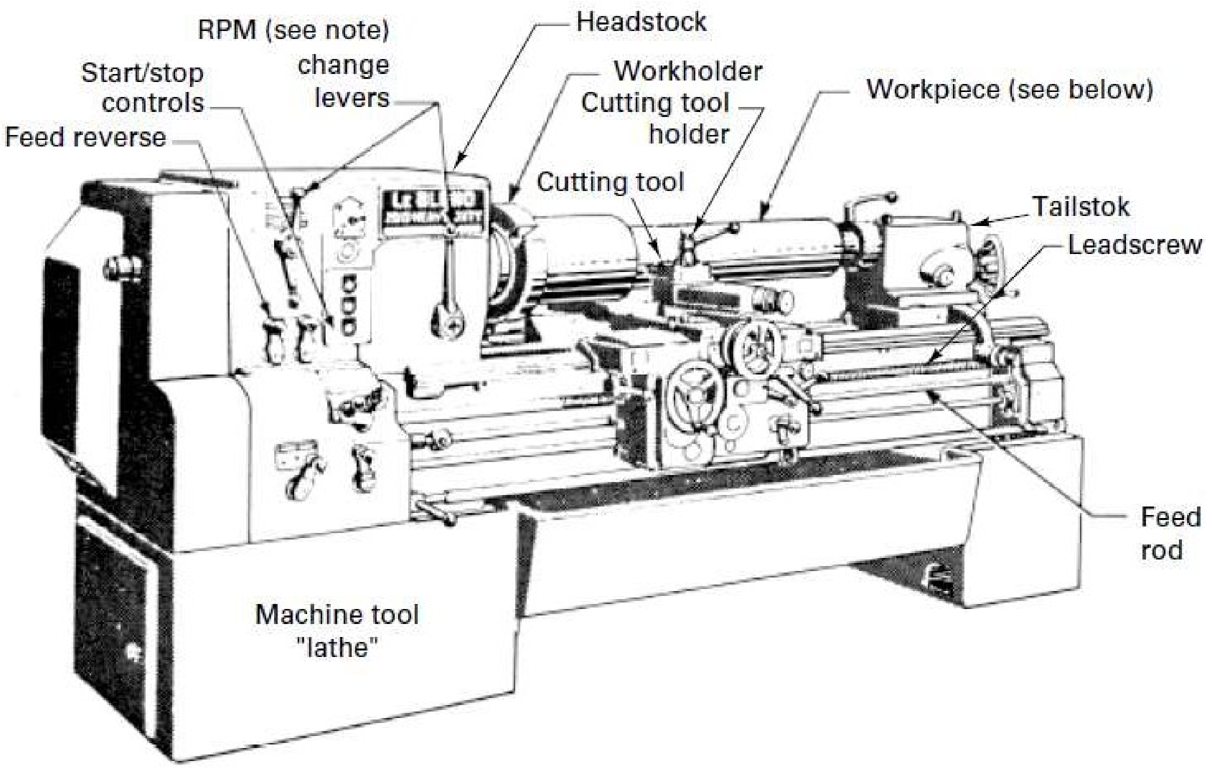


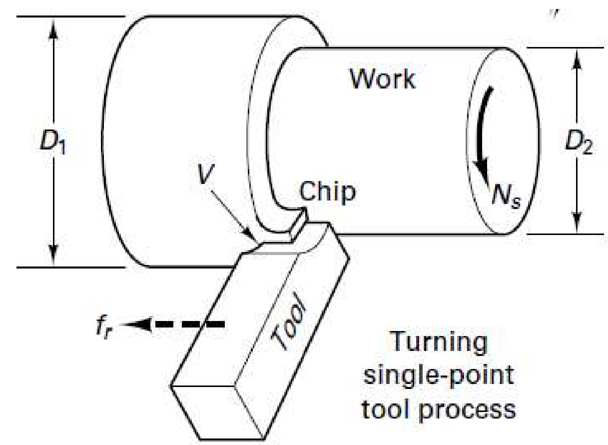
- Medium speed (about 0.3 m/s), high feed rate, low rake angle
- Hardenability



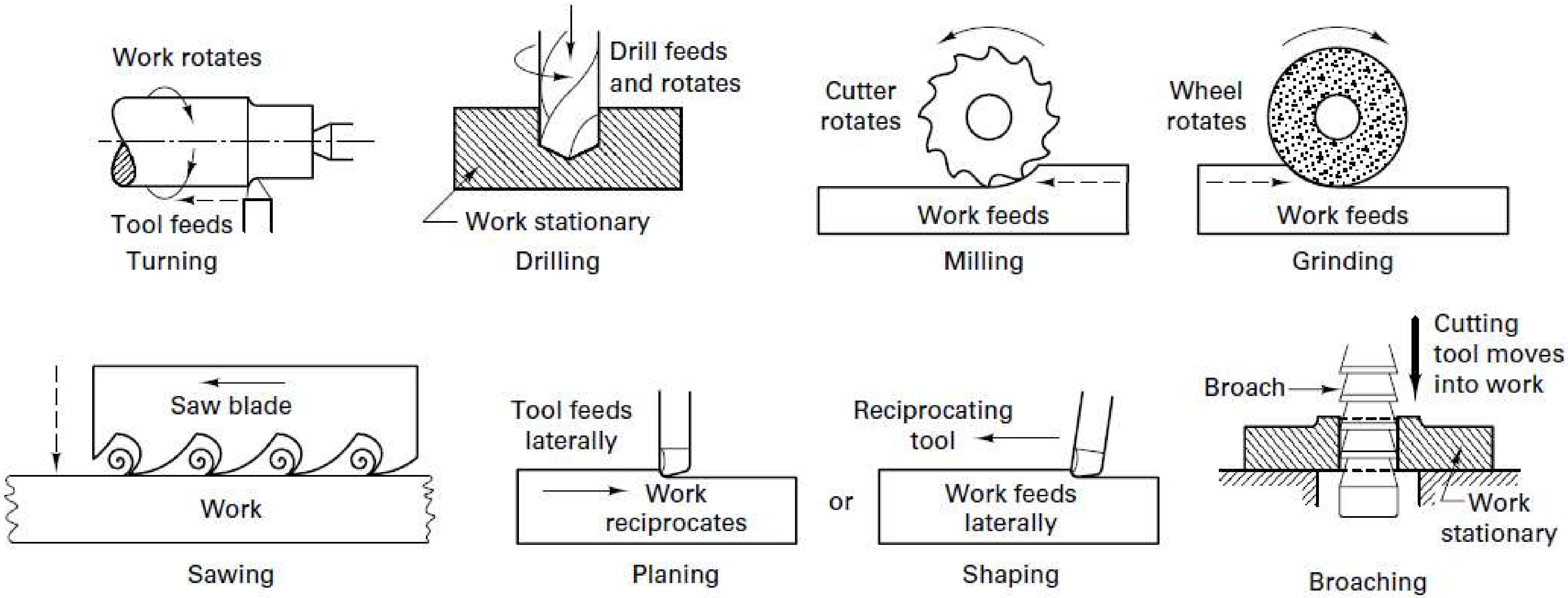
Continuous chips with built-up edge

Turning operation

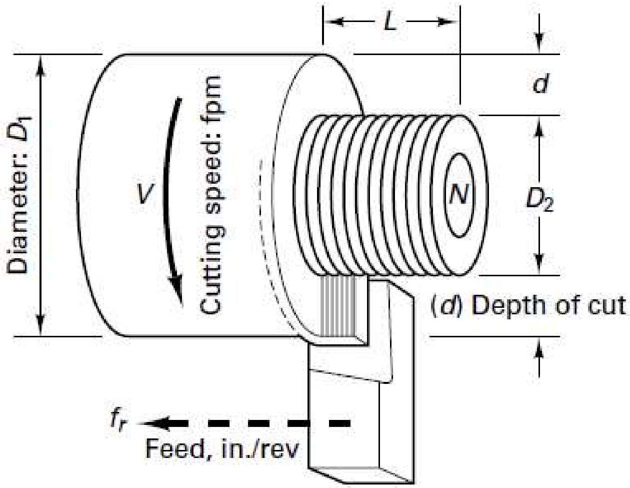


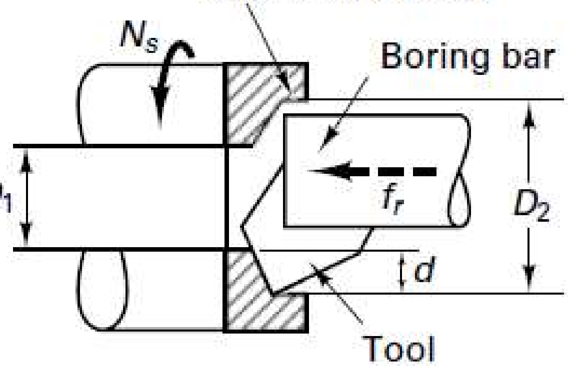


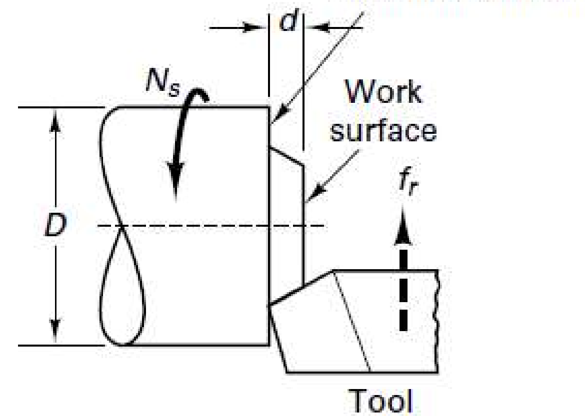
Basic machining operations



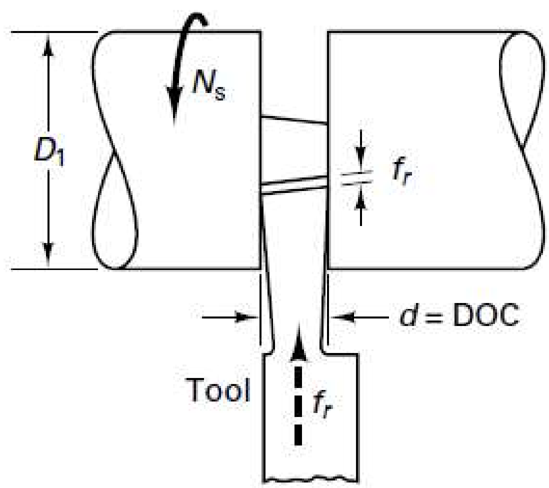
Turning







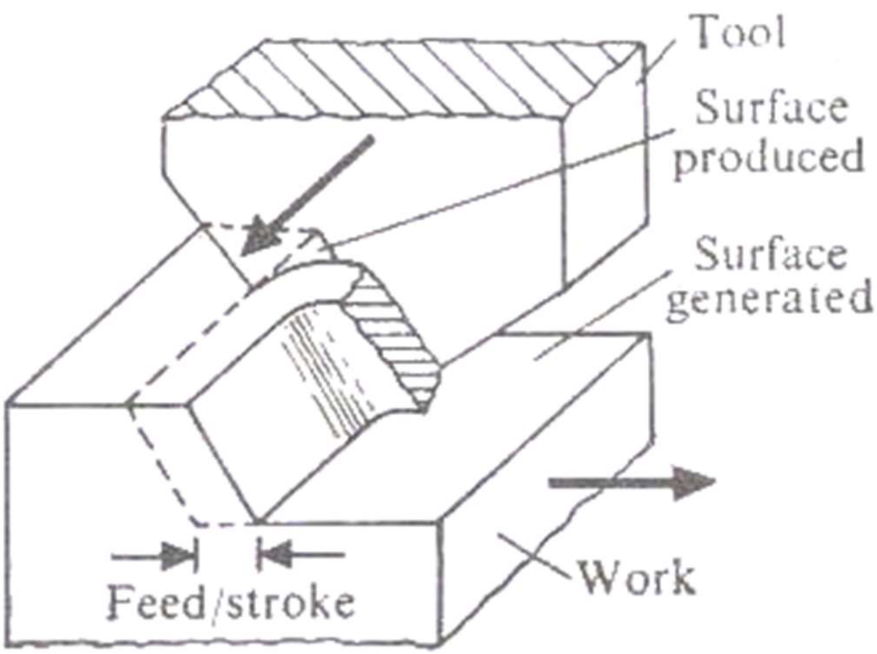
Facing

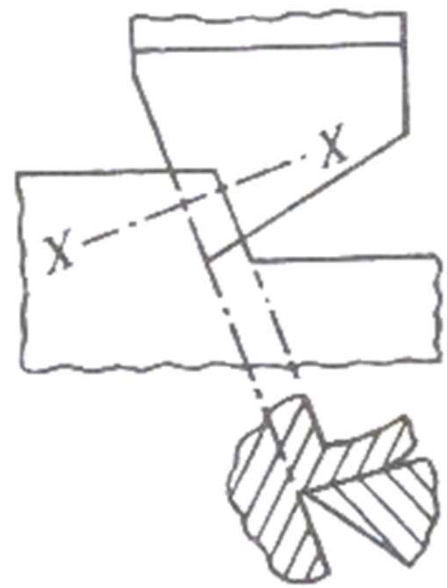


Grooving, parting, or cutoff

Shaping and planing

Intermittent cutting operation





(a) Shaping