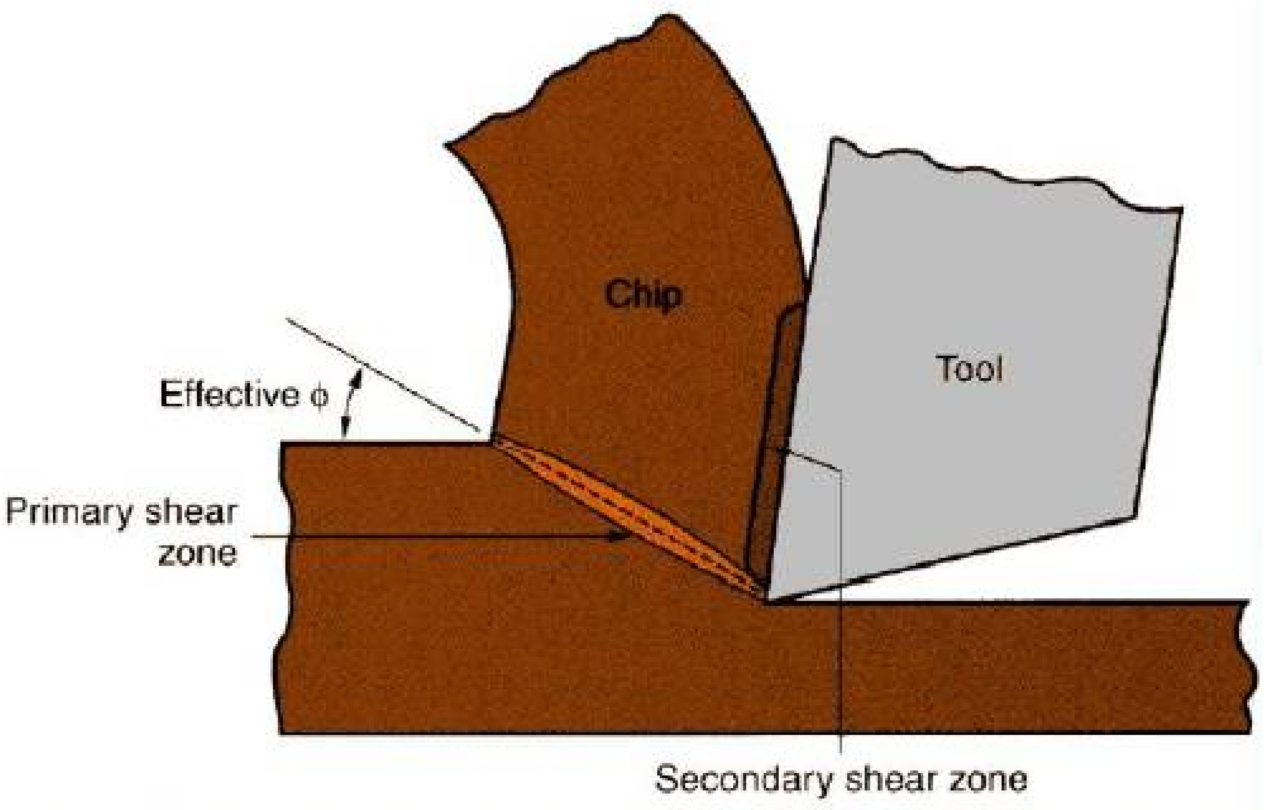
UNIT-II

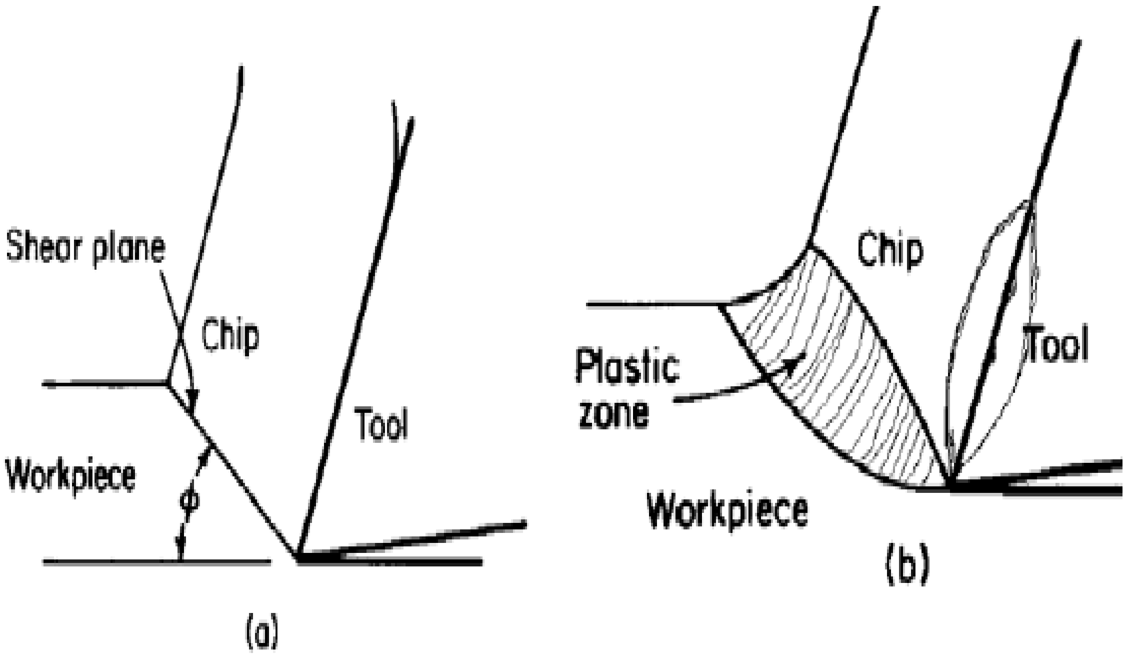
Mechanics of Metal Cutting

Mechanics of Chip Formation



Source:https://www.slideshare.net/manojkumarg1990/metalcutting-140822084807phpapp01

Shear Zone



Source: google images

Mechanics of Chip Formation

- ❖ Figure represents shaping operation, where the w/p remains stationary and tool advances into the w/p towards left

- ❖ Thus, the metal gets compressed (first elastically and then plastically) very severely, causing shear stress
- ❖ This stress is maximum along the plane, called shear plane

- ❖ If material of w/p is ductile, the material flows plastically along the shear plane, forming chip which flows upwards along the face of the tool.

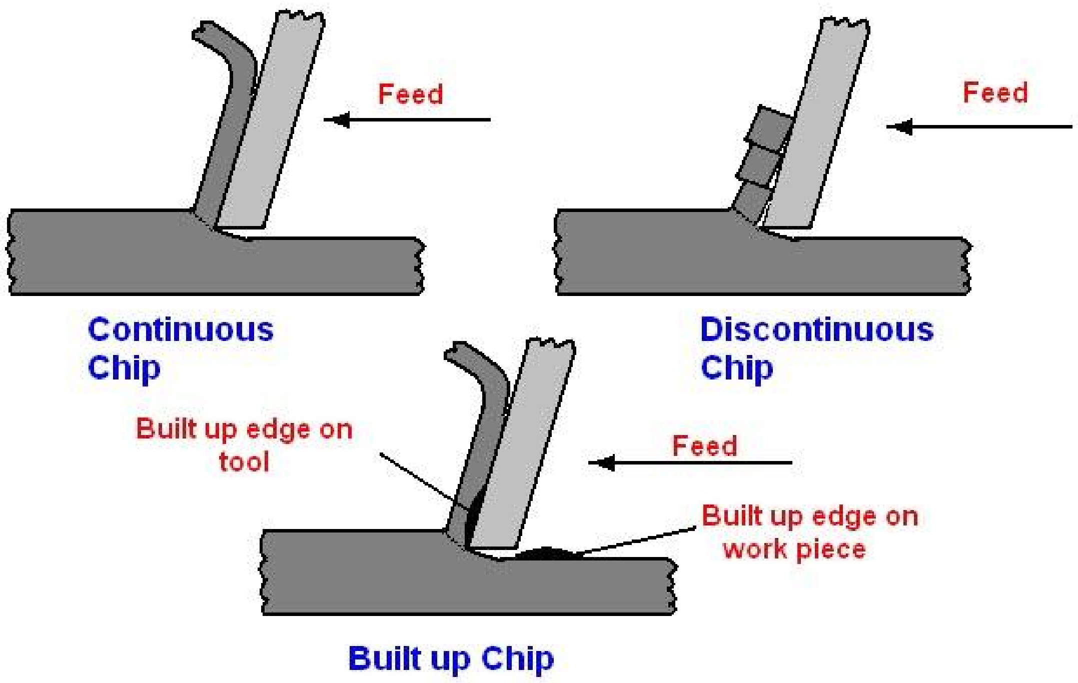
Mechanics of Chip Formation

The tool will cut or shear off the metal provided by:-

- ✓ The tool is harder than the work metal
- ✓ Tool is properly shaped so that its edge can be effective in cutting
- ✓ Relative motion between tool and w/p, to make cutting possible

Types of Chips

1. Continuous Chips
2. Discontinuous Chips or Segmental Chips
3. Built up edge Chips



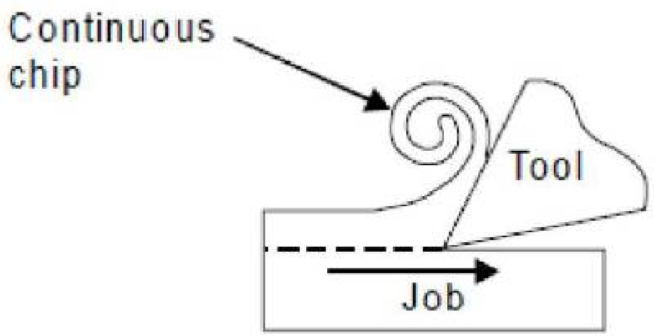
Source: http://engineeringhut.blogspot.com/2010/11/types-of-chips.html

Types of Chips

Continuous Chips

Continuous plastic deformation of metal ahead of the tool, chip moving smoothly up the tool face

- ✓ While machining *ductile material* at *high cutting speed* and *low friction* at chip tool interface (polishing, coolant)
- ✓ Large rake angle
- ✓ Small depth of cut
- ✓ Low feed rate
- ✓ Sharp cutting edge



Pic Source: Google images

Types of Chips

Continuous Chips

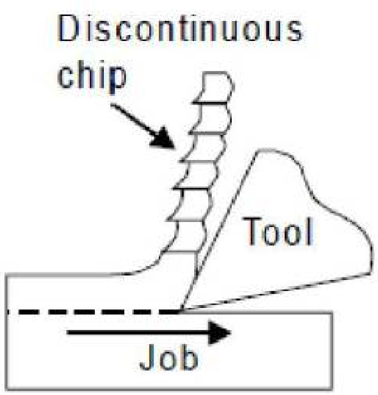
Advantages

- ✓ Better surface finish to the ductile material.
- ✓ Less heat generation due to minimum friction between the tool face and chip.
- ✓ Low power consumption.
- ✓ Long tool life due to less wear and tear

Types of Chips

Discontinuous Chips

- ✓ While machining *brittle material* like Cast iron and bronze
- ✓ Chips produced in form of small segments
- ✓ Also produced in ductile materials while machining at low speeds and adequate lubricant is not provided
- ✓ This causes excessive friction between chip and tool face leading to fracture of chip into small segments
- ✓ Smaller rake angle
- ✓ Higher depth of cut
- ✓ Easy Disposal



Pic Source: Google Images

Types of Chips

Continuous Chips with Built up edge

- ✓ While machining ductile materials, when high friction exists at chip-tool interface results in continuous chips with built up edge
- ✓ Normal reaction of chip on tool face is quite high
- ✓ It is maximum at cutting edge and nose of the tool
- ✓ Give rise to high temperature and compressed metal *(chip particles)* adjacent to nose gets welded to it
- ✓ Extra metal welded to nose of the tool is called built-up edge

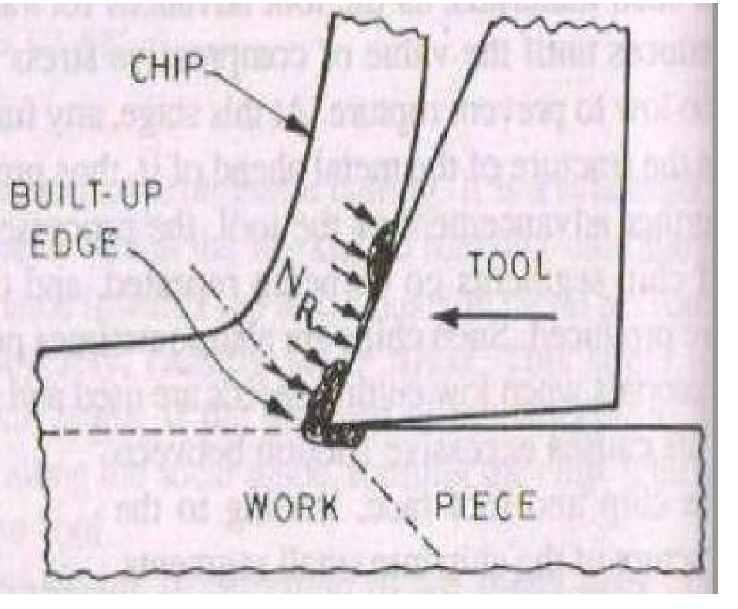
Built-Up Edge

Metal in built-up edge is highly strain hardened and brittle

During the chip flow up the tool, it gets broken and carried away by the chip

The rest of the built up edge is adhere to the surface of the work piece and makes it rough.

✓The small rake angle of the tool.
✓Low cutting speed.
✓Lack of coolant



Pic Source: Google Images

Built-Up Edge

Advantages

✓ it protects the tool from getting damaged since cutting is done by built up edge
✓hence the tool life increases

Disadvantages

✓ rough surface finish
✓change in the rake angle and cutting forces
✓fluctuating cutting force, causing vibrations in cutting tool
✓chances of carrying away some material from the tool causing tool wear

Built-Up Edge

How to avoid built-up edge

✓ friction at chip-tool interface should be minimized by polishing the tool face

✓Adequate supply of coolant

✓Large rake angle

✓High cutting speeds and low feeds

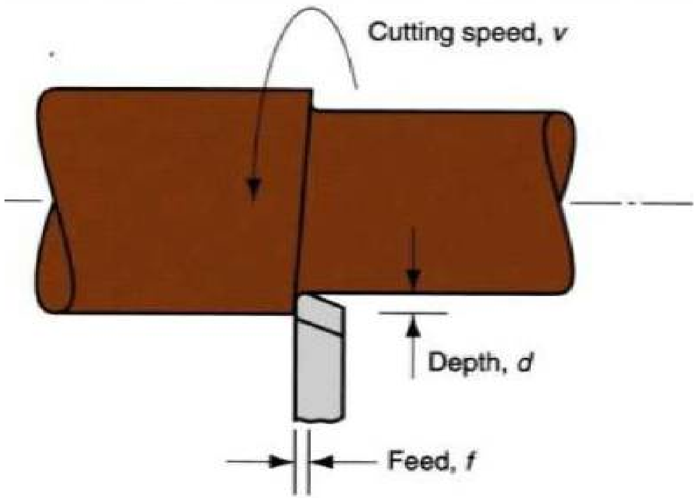
Types of Cutting

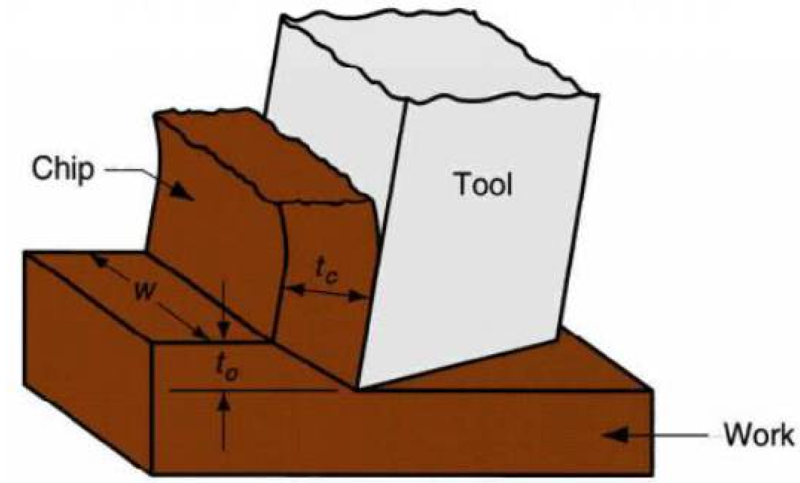
Orthogonal Cutting (2-D Cutting)

✓ Cutting edge is straight, parallel to original plane surface on the w/p

✓and perpendicular to direction of cutting

e.g.- Lathe cut off operation, straight milling (slot cutting), broaching etc.





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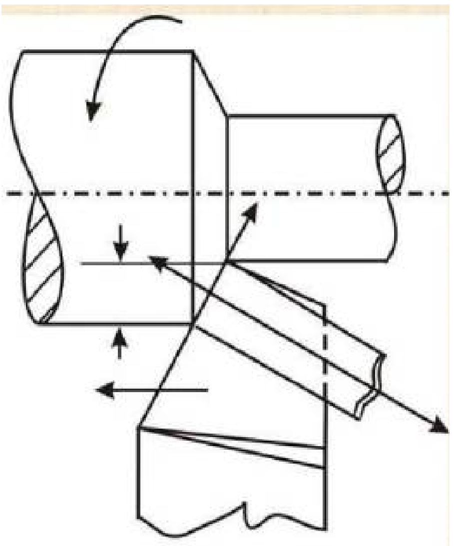
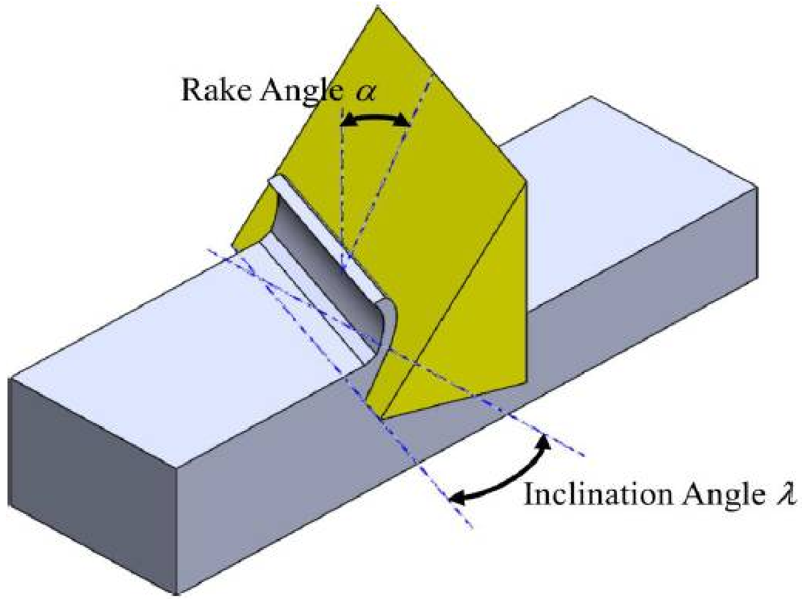
Types of Cutting

Oblique Cutting (3-D Cutting)

✓ Cutting edge is inclined to line normal to the cutting direction

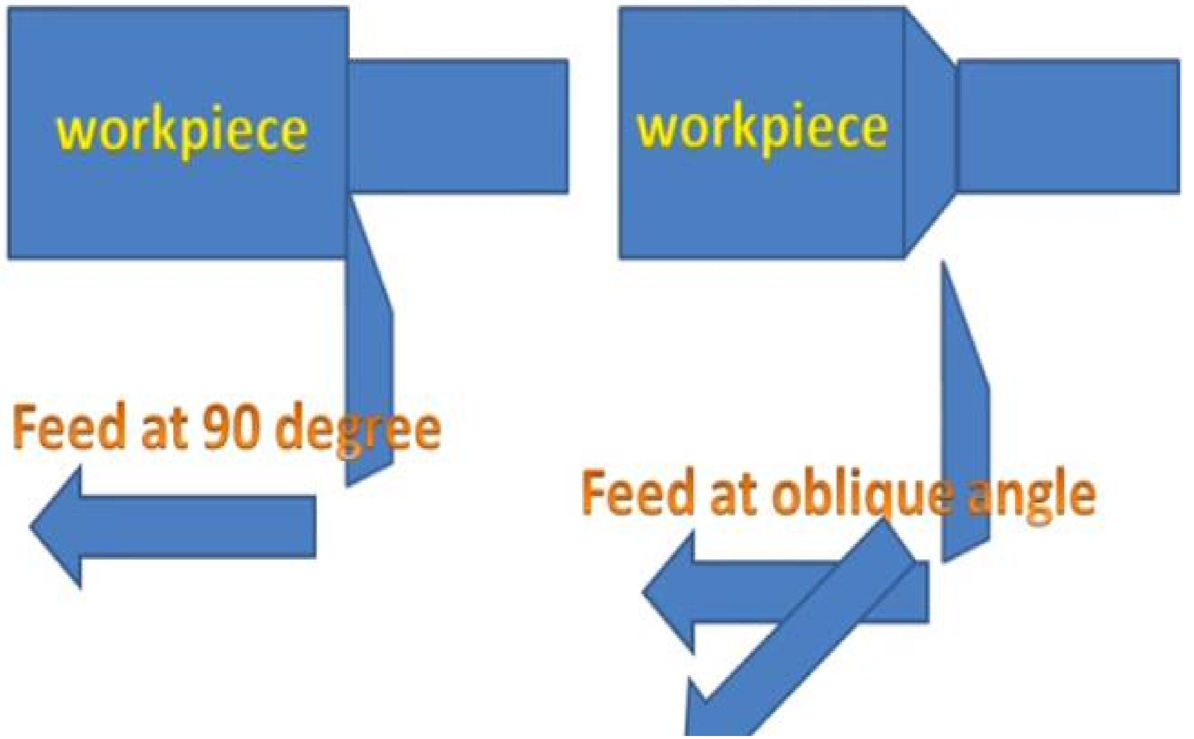
Cutting operations are oblique cutting like turning, milling etc.



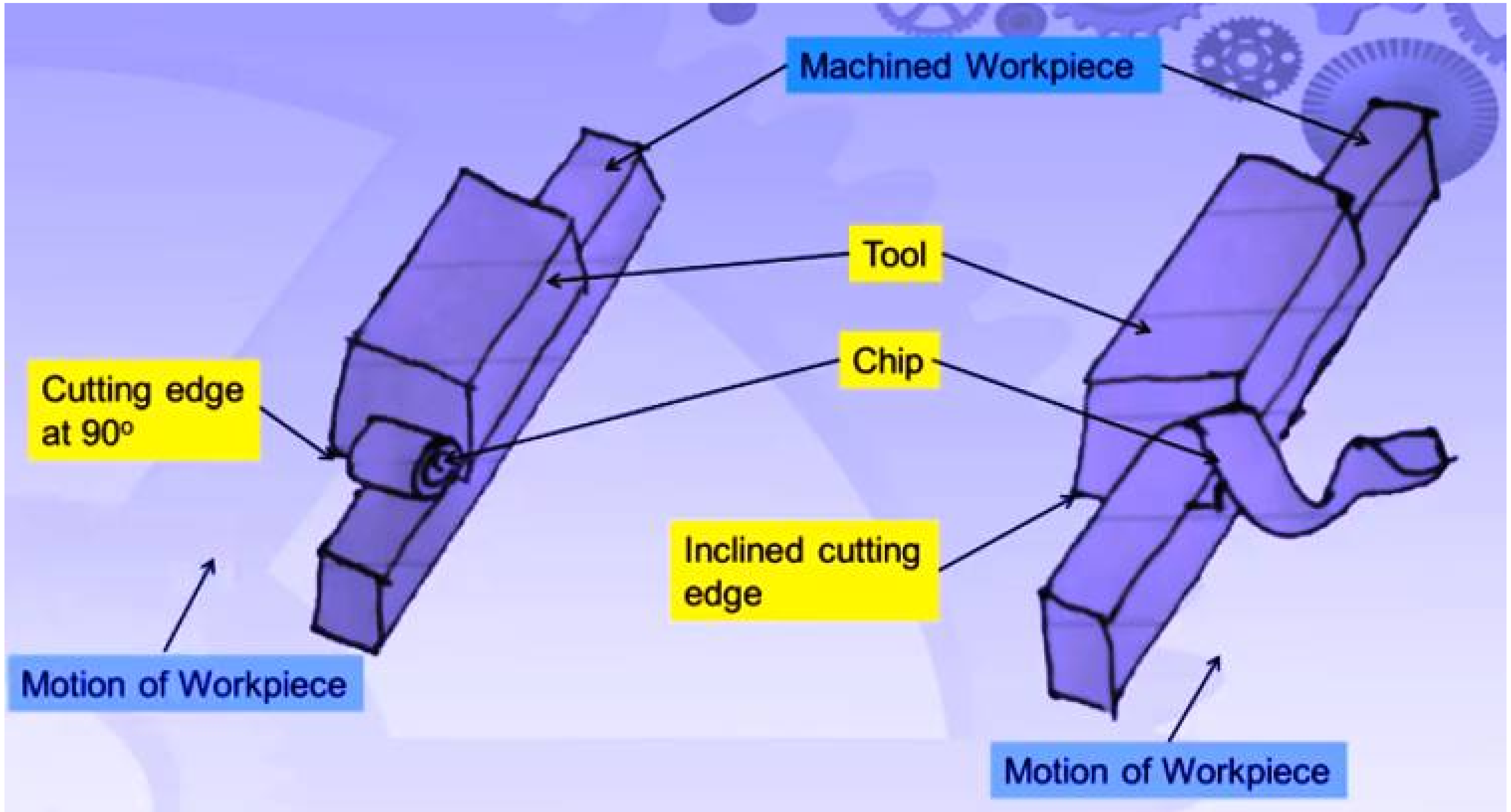


Pic Source: Google Images

Orthogonal vs Oblique



Orthogonal vs Oblique



Pic Source: https://www.youtube.com/watch?v=y_uwqLcwtSM

Orthogonal vs Oblique

Orthogonal Cutting	Oblique Cutting
Cutting edge make right angle to direction of motion	Cutting edge does not make right angle to direction of motion
Chip flows over the tool	Chip flows along side ways
More friction between chip and tool ,more heat generated	Less friction between chip and tool, less heat produced
Lesser tool life	Higher tool life
2 mutually perpendicular cutting force components act on w/p (Cutting force, thrust force)	3 mutually perpendicular cutting force components act on w/p (Cutting force, thrust force, radial force)
Surface finish is poor	Surface finish is good

Pic Source: Google Images