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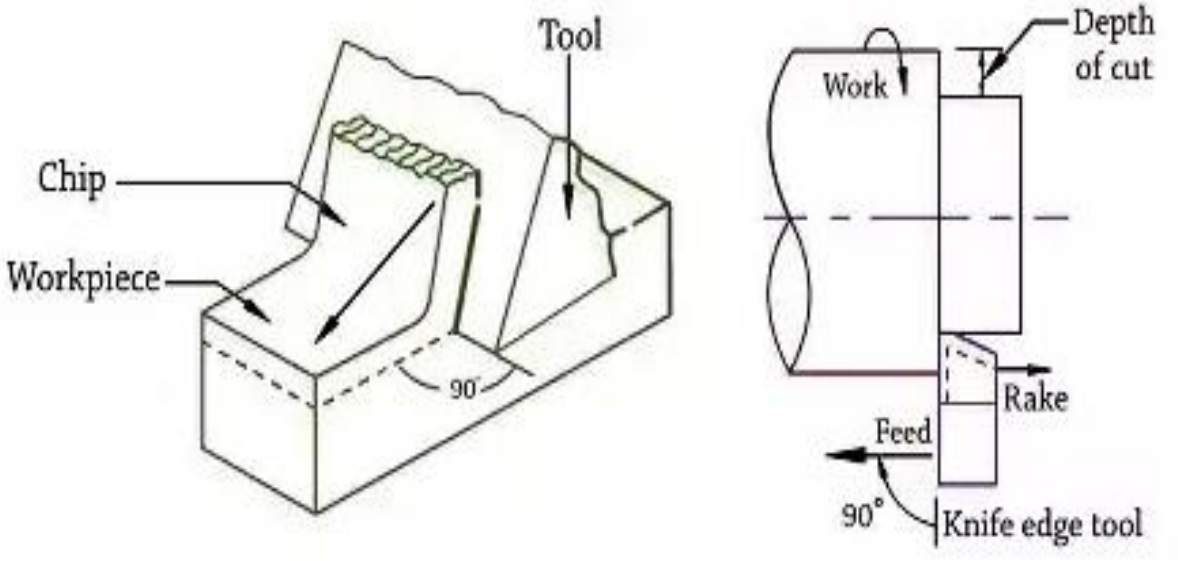
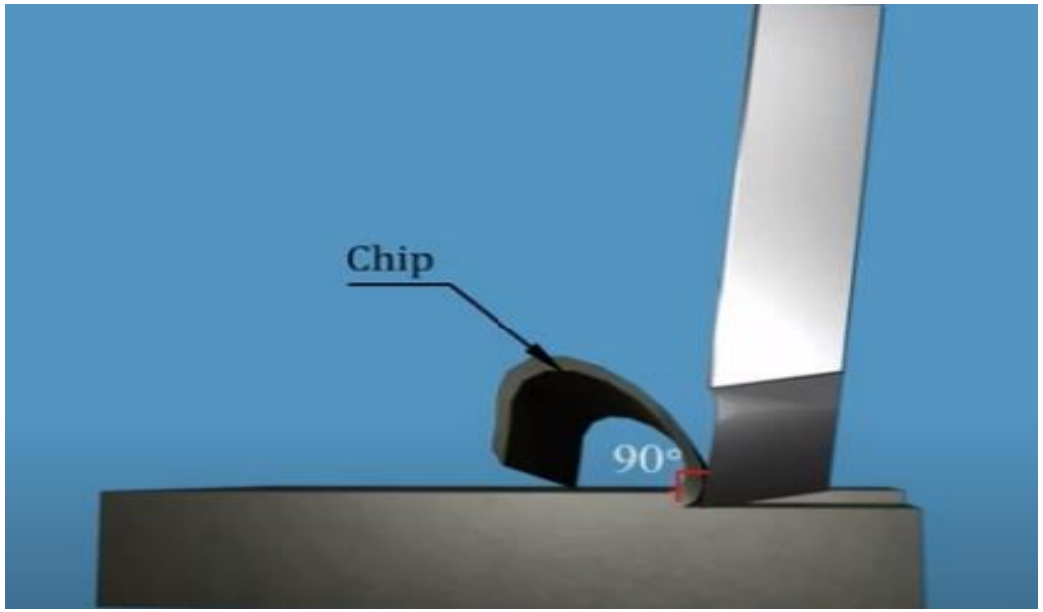
(1) Orthogonal Cutting

- Cutting edge of the tool is perpendicular to the direction of cutting velocity.
- The chip generated flows on along the rake face of the tool till it curves off or breaks up.
- For orthogonal cutting inclination angle (i) should be zero and entering angle (λ) should be 90^o

$$i = 0 \text{ and } \lambda = 90^o$$

- Here only two components of forces are acting ,cutting force & thrust force .So the metal cutting may be considered as a two dimensional (2D) cutting.





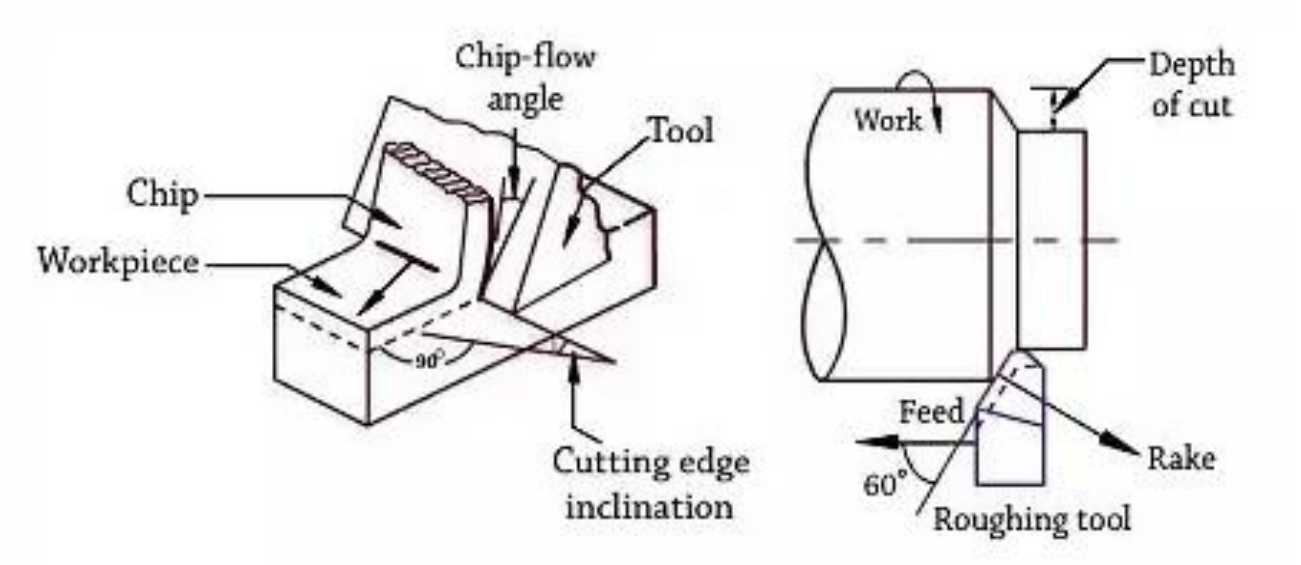
- As shown in fig. after being produce ,the chip slides up the tool face for a certain distance and curves away. When the chip slides on the tool face under the pressure caused by the cutting force, it overcomes the friction force and thus generate heat.

- The chip contacts the tool from the tip to where it leaves the tool ,this distance is called the tool chip contact length or contact length . A longer contact length leads to a greater accumulation of heat in the tool. If the contact length can be shortened then friction force and heat will be reduce.

Oblique cutting

- Oblique cutting condition

$$i \neq 0 \ , \lambda \neq 90^{o}$$



- In this type cutting ,the cutting edge and the cutting motion are usually not perpendicular to each other.

- This type of cutting occurs when the major cutting edge of the tool is presented to the work piece at angle acute to the direction of feed motion.

- The workpiece material approaches the tool at a velocity V and leaves the surface (as a chip) with velocity V_C and Shear velocity is V_S .

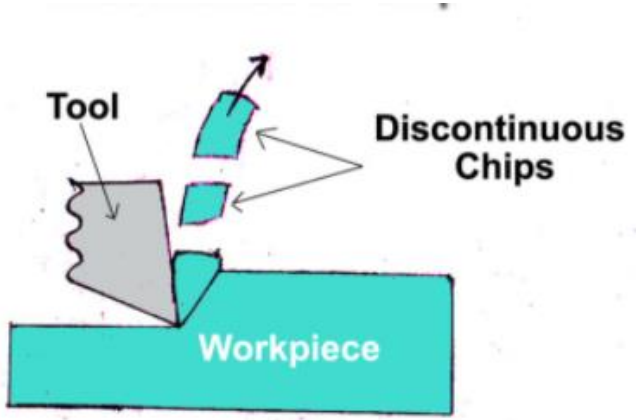
- Here three component of forces are acting cutting force, Thrust force and radial force so metal cutting may be considered as a 3-dimensional (3D) cutting.

Difference between orthogonal cutting and oblique cutting

Orthogonal Cutting	Oblique Cutting
① Chip flow in a direction perpendicular to the cutting edge	Chip flow at an angle to cutting edge.
② Chip get coiled in a spiral fasion.	Chip flow in side any direction in widely area thus less concentration of he
③ Tool life is less	Tool life is more
④ There are two component of forces (no radial force)	⑤ there are three component of force
⑤ Surface finish is poor	Surface finish is good
⑥ It is used in Slotting, Parting, grooving, Pipe cutting.	It is used in turning, milling, drilling, grinding.
⑦ Chip flow angel is zero 	Chip flow angle is more than zero

Three Basic Types of Chip in Machining

1. Discontinuous chip
2. Continuous chip
3. Continuous chip with Built-up Edge (BUE)

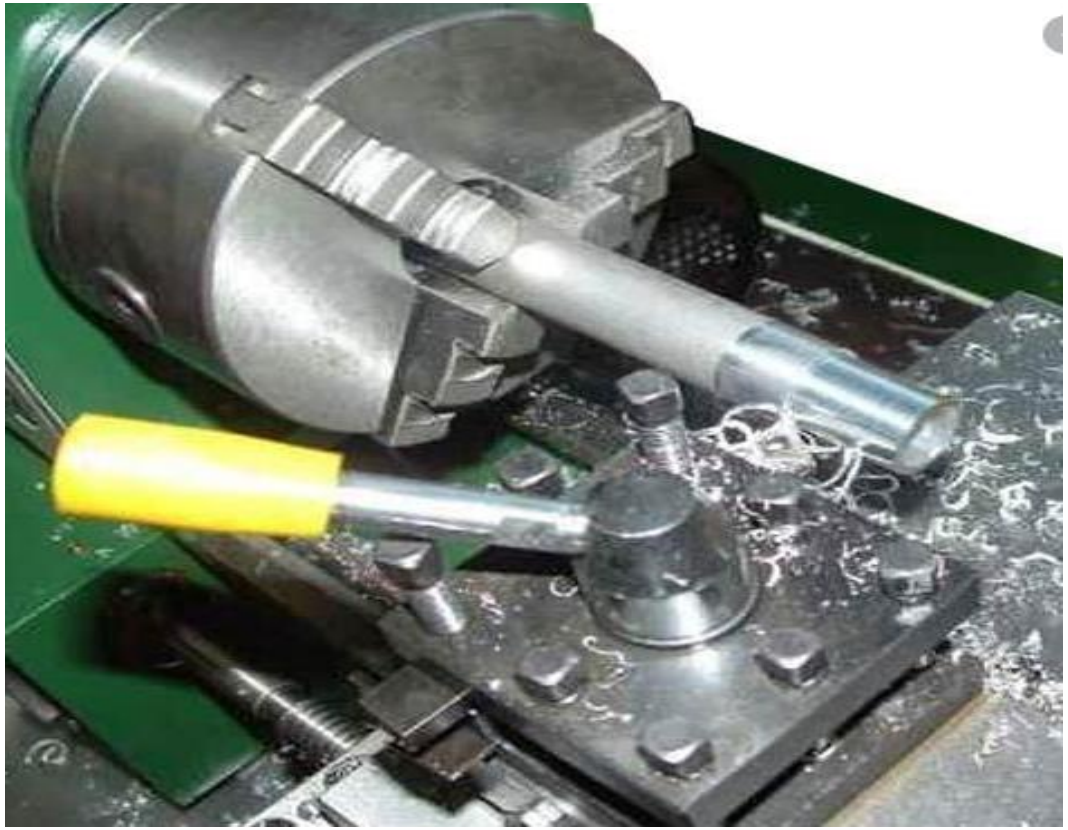


1. Discontinuous chip

- These chips occur when machining hard brittle materials such as cast iron
- Brittle failure takes place along the shear plane before any tangible plastic flow occurs.
- As the point of cutting tool contacts the metal ,some compression occurs and the chip begins flowing along the chip-tool interface.
- As more stress is applied to the brittle metal by the cutting action ,the metal compresses until it reaches a point where rupture occurs and the chip separates from the unmachined portion .
- Rupture of each segment occur on the shear plane.
- As a result of these successive rupture a poor surface is produced on the workpiece.

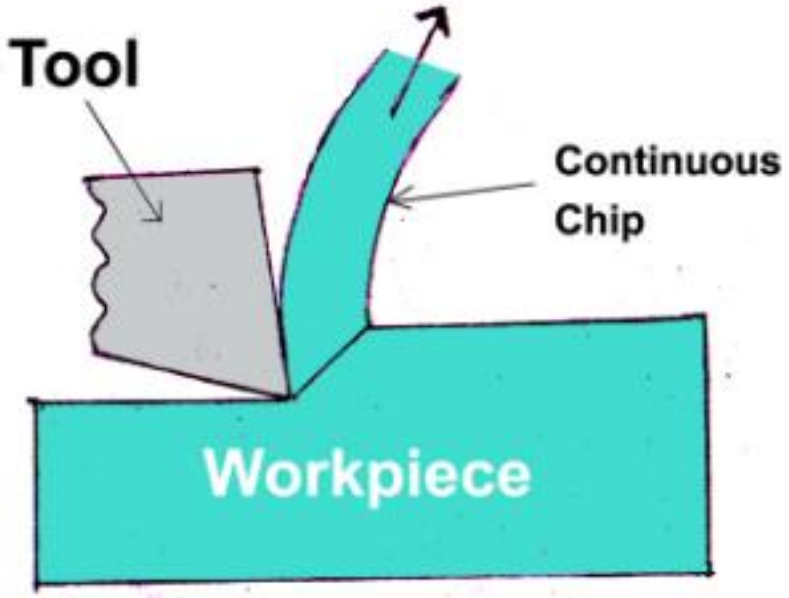
Condition for discontinuous chip

1. Brittle work piece materials
2. Work piece materials that contain hard inclusions and impurities.
3. Very low or very high cutting speeds.
4. Large depths of cut.
5. Low rake angles.
6. Lack of an effective cutting fluid.



(2) Continuous chip:

- Continuous chips are usually formed with ductile materials or soft materials such as aluminium ,copper etc.
- This type of chip is a continuous ribbon produced , and continuous ribbon chip is considered ideal for efficient cutting action because it result in better finishes.
- A disadvantage of continuous chips is the fact that they can become very long . the problem can be overcome by the use of chip –breakers.

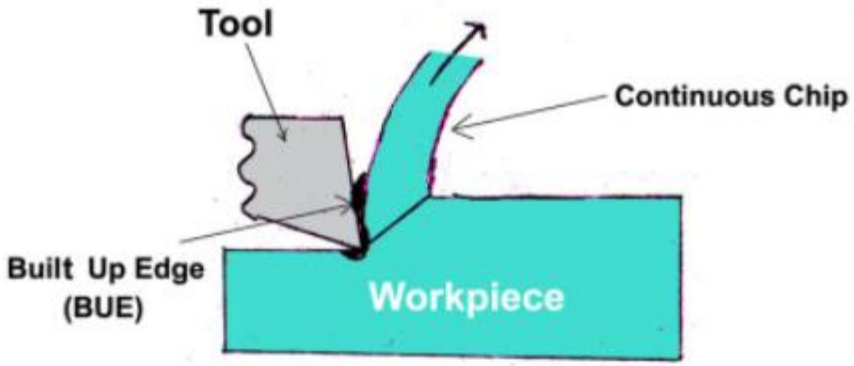


Continuous chips usually form under the following conditions:

- Sharp cutting edge
- Large rake angle
- High cutting speed
- Ductile work materials
- Less friction between chip tool interface through efficient lubrication
- Low depth of cut.

(3) Continuous chip with Built-Up Edges (BUE)

- It is obtained by machining on ductile material, in this condition of high local temperature and extreme pressure in the cutting and high friction in the tool chip interference, may cause the work material to adhere or weld to the cutting edge of the tool.



Condition for this type of chip formation

- Ductile material
- High depth of cut
- Low speed
- Insufficient cutting fluid
- Long chip tool contact length.

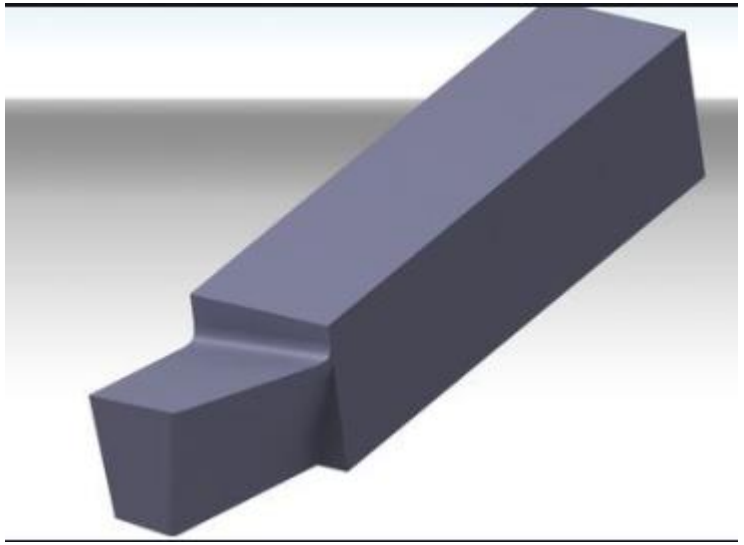
The tendency for a BUE to form is reduced by any of the following practices:

1. Increase the cutting speeds
2. Decreasing depth of cut
3. Increasing the rake angle
4. Using a sharp tool
5. Using an effective cutting fluid

6.Use a cutting tool that has lower chemical affinity for the work piece material.

Harmful effect of BUE

- Poor surface finish
- Increasing the cutting forces
- Induce vibration



THANKYOU