# Types of Cutting Tools

## Single Point Tools

✓ Tools having only one cutting edge
e.g.- Lathe tools, shaper tools, boring tools, planer tools, etc.

## Multi Point Tools

✓ Tools having more than one cutting edge
✓E.g.- milling cutters, drills, broaches, grinding wheels, etc.

# Types of Cutting Tools-on basis of Motions

**Linear Motion Tools**

e.g.- Lathe, boring, broaching, shaping, planing tools, etc.

**Rotary Motion Tools**

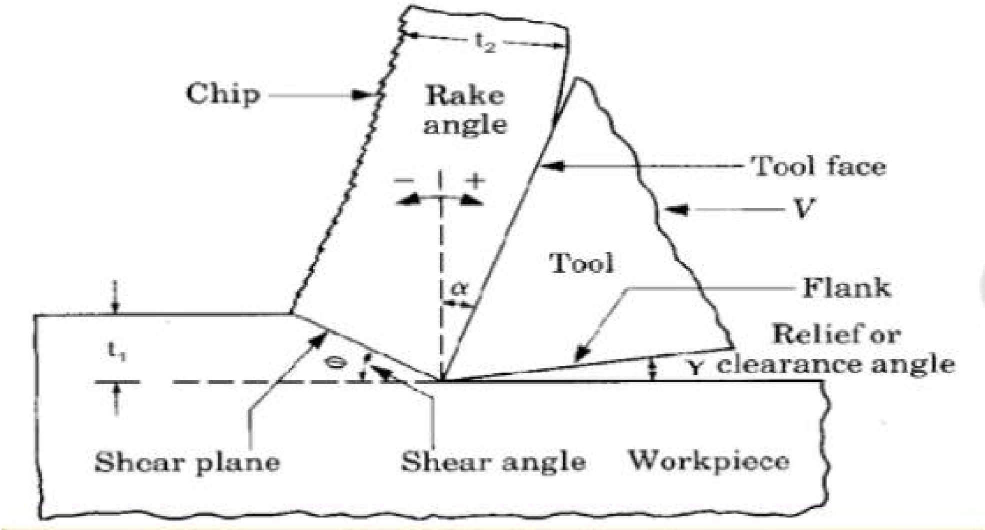
e.g.- Milling cutters, grinding wheels, etc.

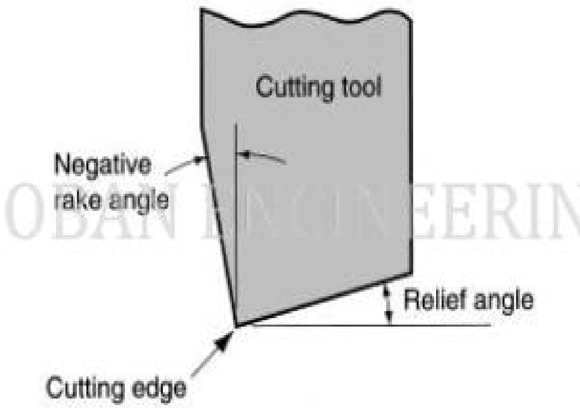
**Linear and Rotary Motion Tools**

e.g.- Drills, honing tools, etc.

# Rake Angle

- Angle between the rake face and normal to the machining direction
- It specifies the ease with which a metal is cut
- Higher the rake angle better is the cutting and less cutting force




**Negative Rake Angle**

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

# Rake Angle

- Increasing rake angle reduces metal backup available at tool rake face

- This reduces strength of the tool tip and heat dissipation through the tool

- Maximum 15˚ for HSS cutting mild steel

- Zero and negative rake angles are used for highly brittle tool materials like carbides or diamond to give extra strength to the tool tip

# Clearance Angle

- Angle between machined surface and the underside of the tool called the flank face

- Tool will not rub or spoil the machined surface

- A very large clearance angle reduces the strength of the tool tip (5 to 6° angle is used)

# Shear Angle Relationship

In traingle OAP, $OP = t_1/\sin\Phi$

In traingle OBP, $OP = t_2/\cos(\Phi-\alpha)$

So, $t_1/\sin\Phi = t_2/\cos(\Phi-\alpha)$

$t_1/t_2 = \sin\Phi/\cos(\Phi-\alpha)$

$r = \sin\Phi/(\cos\Phi.\cos\alpha + \sin\Phi.\sin\alpha)$

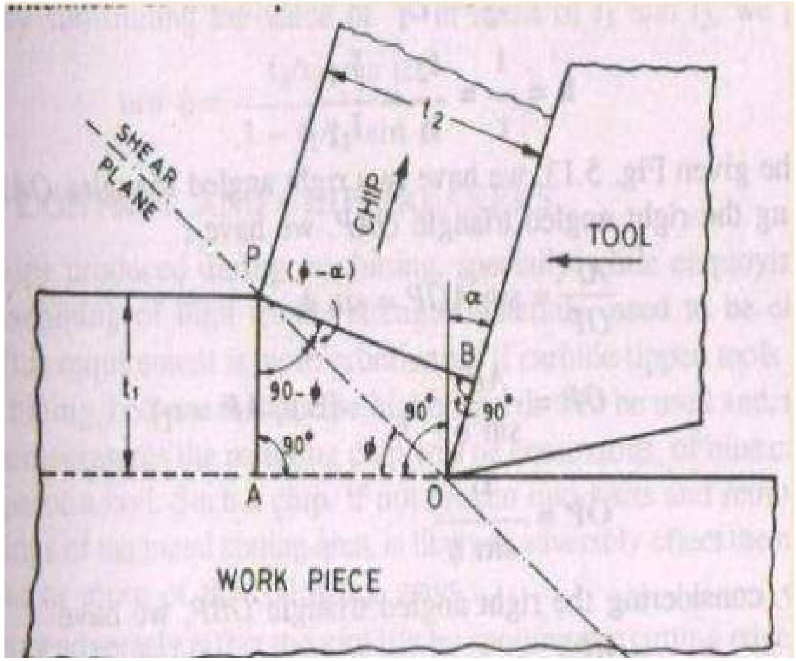
$r = 1/(\cot\Phi.\cos\alpha + \sin\alpha)$

$r\cos\alpha/\tan\Phi + r\sin\alpha = 1$

$r\cos\alpha/\tan\Phi = 1 - r\sin\alpha$

$\tan\Phi = r\cos\alpha/(1 - r\sin\alpha)$

(r = chip thickness ratio)




Pic Source: Google Images

# Merchant Cutting Force Circle

**Assumptions**

- Cutting velocity always remains constant
- Cutting edge of tool remains sharp throughout the cutting
- Only continuous chip is produced
- There is no built-up edge
- No consideration is made of the inertia force of the chip

- The behaviour of the chip is like that of a free body which is in state of stable equilibrium under the action of 2 resultant forces which are equal, opposite and collinear

# Merchant Cutting Force Circle

**$F_s$**= Shear force, acts along shear plane
is the resistance to shear of the metal
in forming the chip

**$F_n$**= Force acting normal to the shear plane, is
the backing up force on the chip provided by the w/p

**F**=Frictional resistance of the tool acting against the
Motion of the chip as it moves upward along the tool

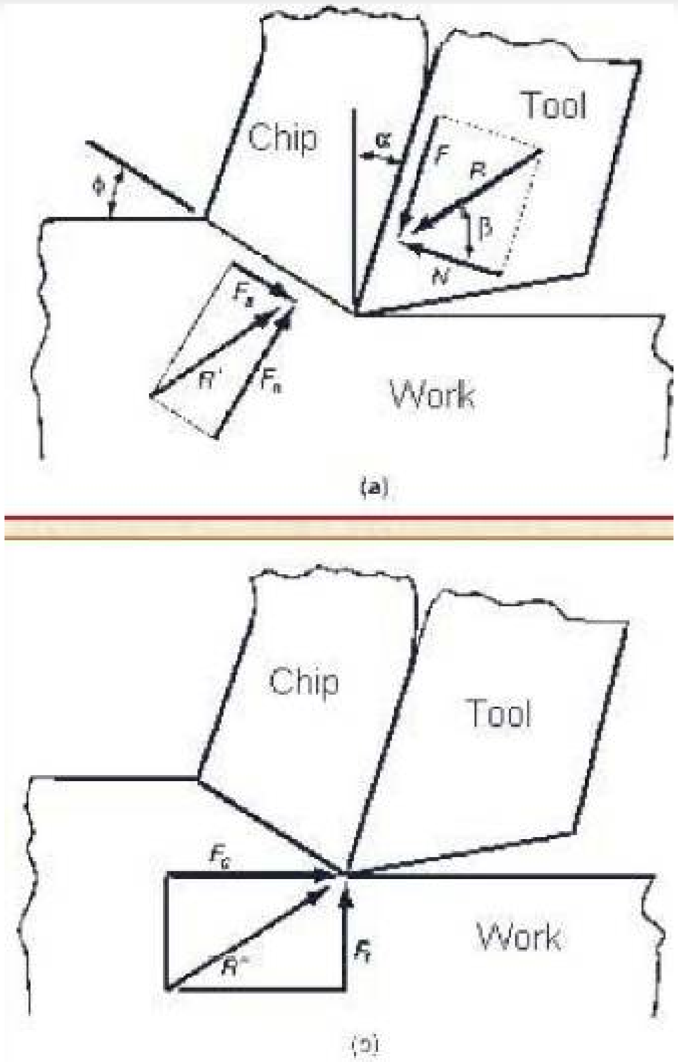
**N**=Normal to the chip force, is provided by the tool

**$F_c$**=Horizontal cutting force exerted by the tool on w/p

**$F_t$**=Vertical or tangential force, helps in holding the
Tool in position and acts on the tool nose

$$\boxed{\vec{R}' = \vec{N} + \vec{F}} \quad \text{and} \quad \boxed{\vec{R} = \vec{F}_S + \vec{F}_N}$$

$$\boxed{\vec{R} = \vec{R}'} \quad \text{For equilibrium}$$

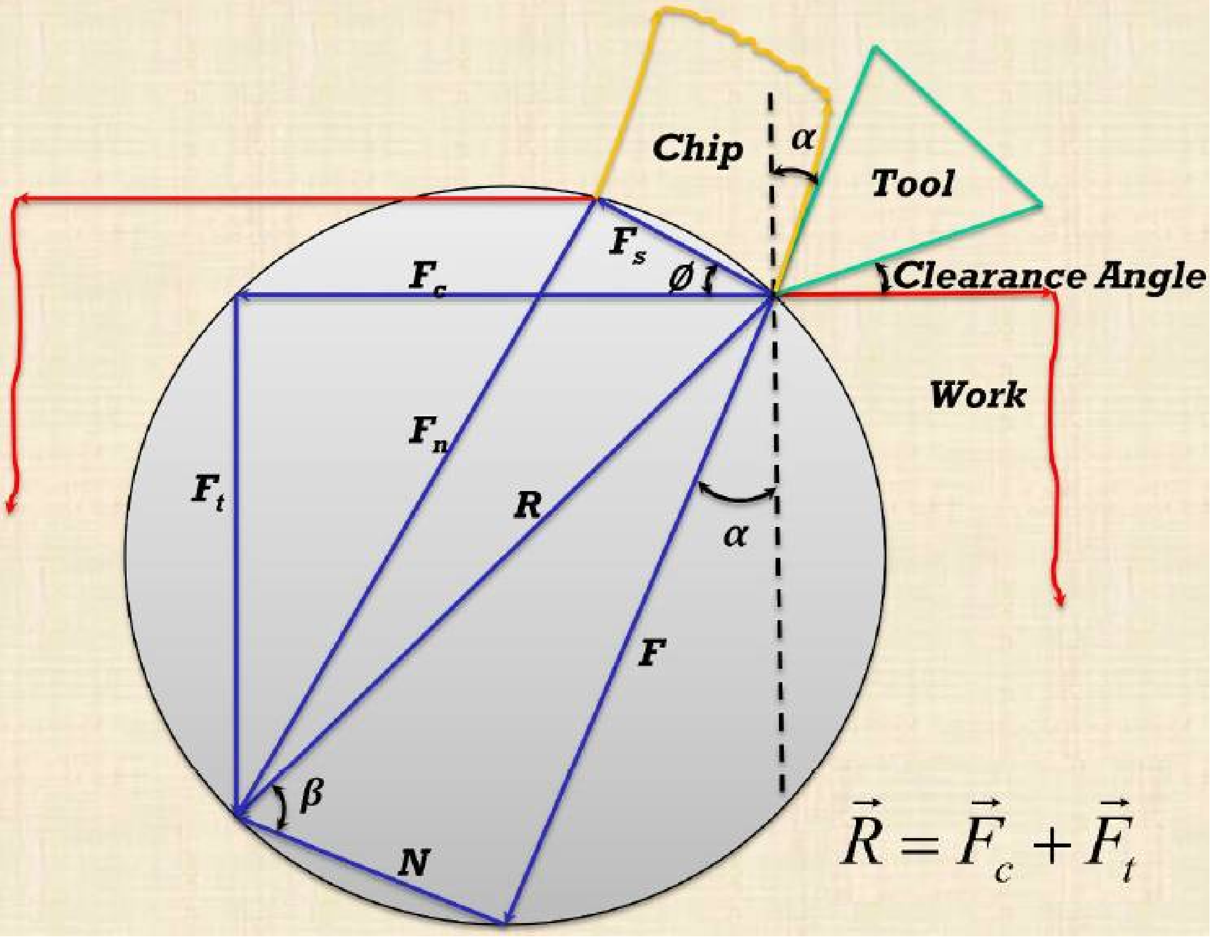



Pic Source: Google Images

# Merchant Cutting Force Circle

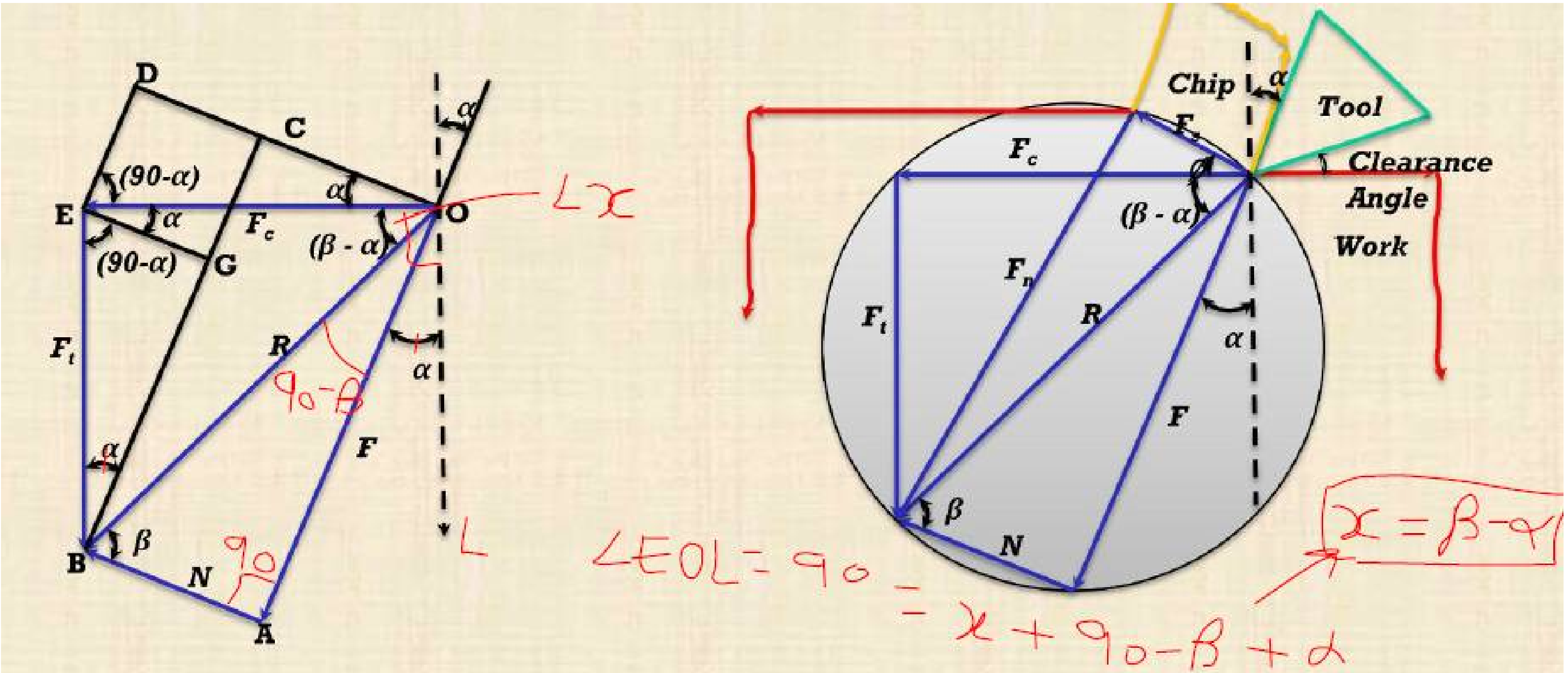
- It is useful to determine the relation between the various forces and angles
- In the diagram 2 force triangles have been combined, also R and R' together have been replaced by R
- The force R can be resolved into 2 components $F_c$ and $F_t$
- $F_c$ and $F_t$ can be determined by force dynamometers
- Rake angle can be measured from the tool and then forces F and N can be determined
- Shear angle can be obtained from it's relation with chip thickness ratio
- Then, $F_s$ and $F_n$ can be determined

# Procedure to construct Merchant Circle




Pic Source: Theory of metal cutting and machine tools- By Thella babu Rao

# Frictional Force System




$$F = OA = CB = CG + GB = ED + GB$$

$$\Rightarrow F = F_C \sin\alpha + F_t \cos\alpha$$

$$N = AB = OD - CD = OD - GE$$

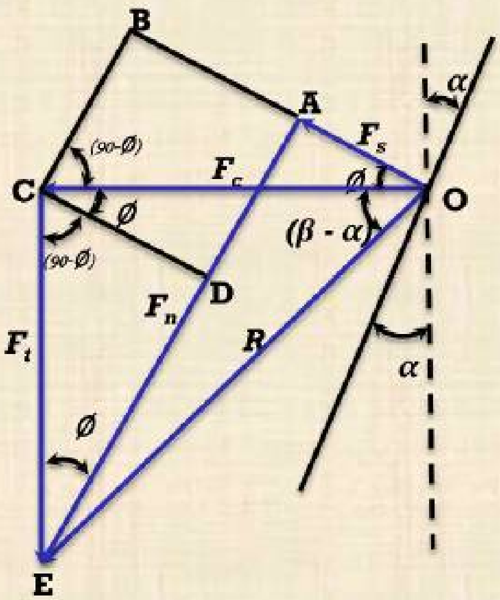
$$\Rightarrow N = F_C \cos\alpha - F_t \sin\alpha$$

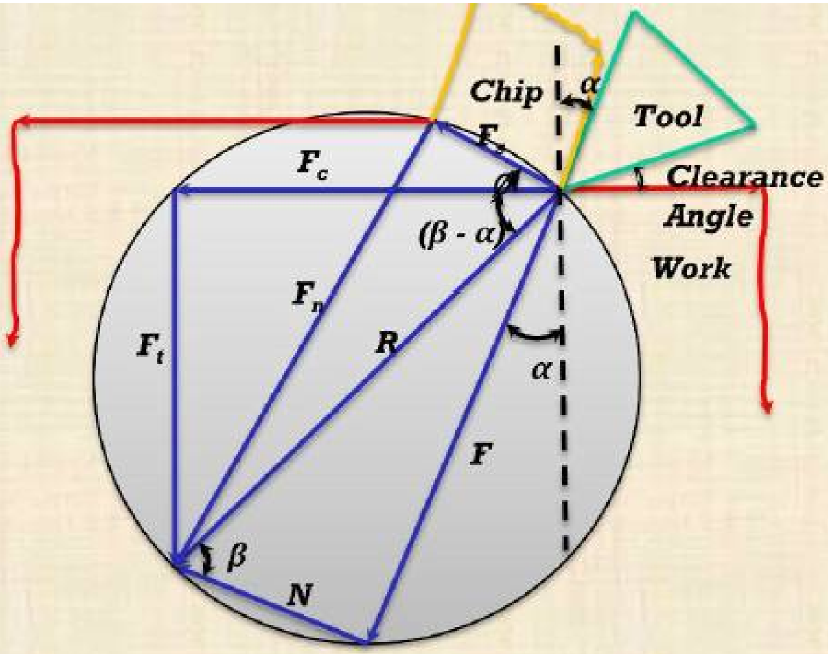
*The coefficient of friction*

$$\mu = \tan\beta = \frac{F}{N}$$

*Where* $\beta$ = *Friction angle*

# Shear Force System




$$F_S = OA = OB - AB = OB - CD$$

$$\Rightarrow F_S = F_C \cos\phi - F_t \sin\phi$$

$$F_N = AE = AD + DE = BC + DE$$

$$\Rightarrow F_N = F_C \sin\phi + F_t \cos\phi$$

Also:

$$F_N = F_S \tan(\phi + \beta - \alpha)$$

# Relationship of Various Sources

$$F = F_C \sin\alpha + F_t \cos\alpha$$

$$N = F_C \cos\alpha - F_t \sin\alpha$$

$$F_S = F_C \cos\phi - F_t \sin\phi$$

$$F_N = F_C \sin\phi + F_t \cos\phi$$

$$F_N = F_S \tan(\phi + \beta - \alpha)$$


THANK YOU