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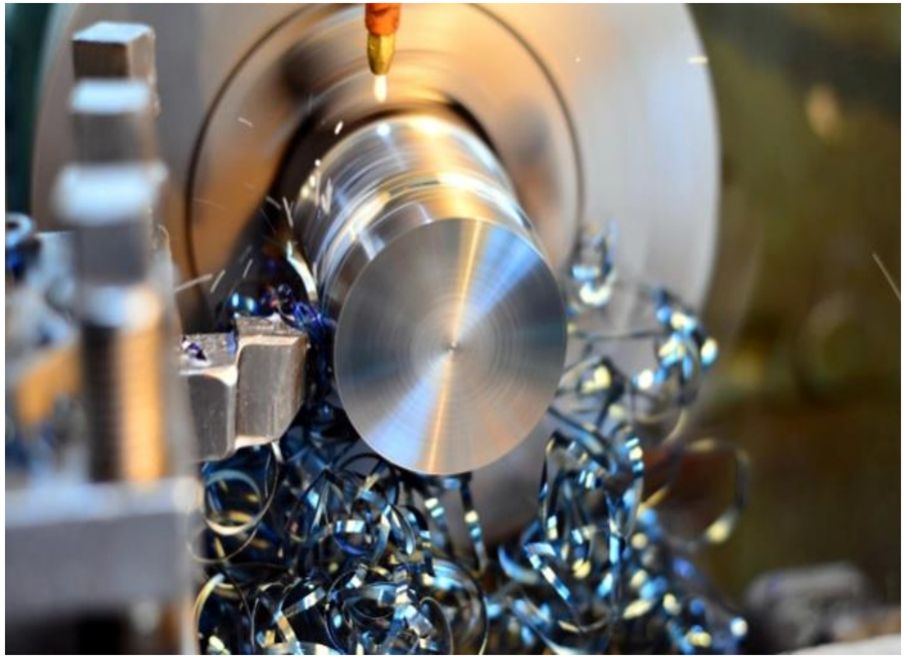
MECHANICAL ENGINEERING LECTURE BY SUBODH KUMAR

Machinability

- Machinability is the ease with which a metal can be cut (machined) permitting the removal of the material with a satisfactory finish at low cost.

- Materials with good machinability (free machining materials) require little power to cut, can be cut quickly, easily obtain a good finish, and do not wear the tooling much.



Marchant circle diagram:

The assumptions of merchant circle are given below.

- Tool is perfectly sharp and contact the chip on its front or rake face.
- Cutting is orthogonal
- There is no side flow of the chip.
- Continuous chip with out BUE.
- Uncut chip thickness is constant.
- Work move with a uniform velocity.
- Material is perfectly plastic.

Fig 1 shows the forces acting on the tool in orthogonal cutting. The cutting force FC acts in the direction of the cutting speed V,and supplies the energy required for cutting the thrust force, Ft acts in the direction normal to cutting velocity, that is perpendicular to the workpiece.

These two forces produce the resultant force (R) ,the resultant force can be resolved into two component on the tool face. First is a friction force F, along the tool –chip interface and a normal force N, perpendicular to the interface.

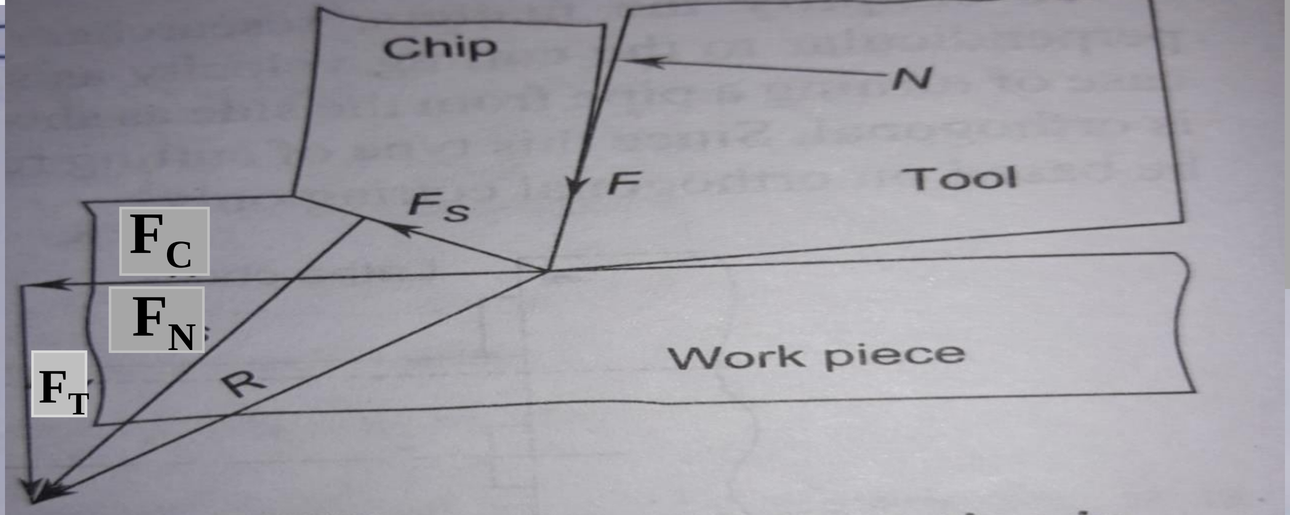
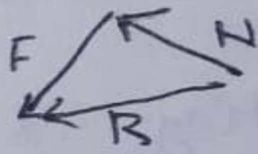


FIG. 2.13 *Various forces acting in orthogonal cutting*

Fig. (1)



F_c = cutting force

V = cutting velocity

F_T = Thrust force

F_s = Shear Force

F_N = Normal Shear force

F = Friction Force

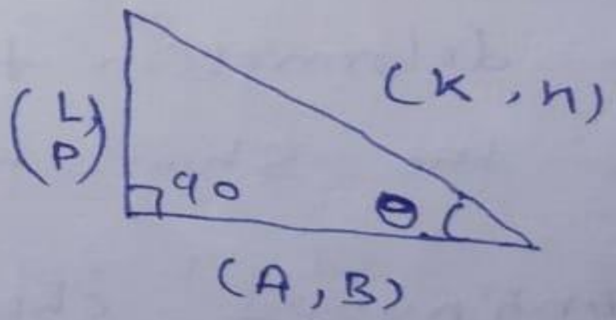
N = Normal Force.

ϕ = Shear ~~plane~~ angle

α = rake angle

$\frac{LAL}{KKA}$,

$\frac{PBP}{HHB}$

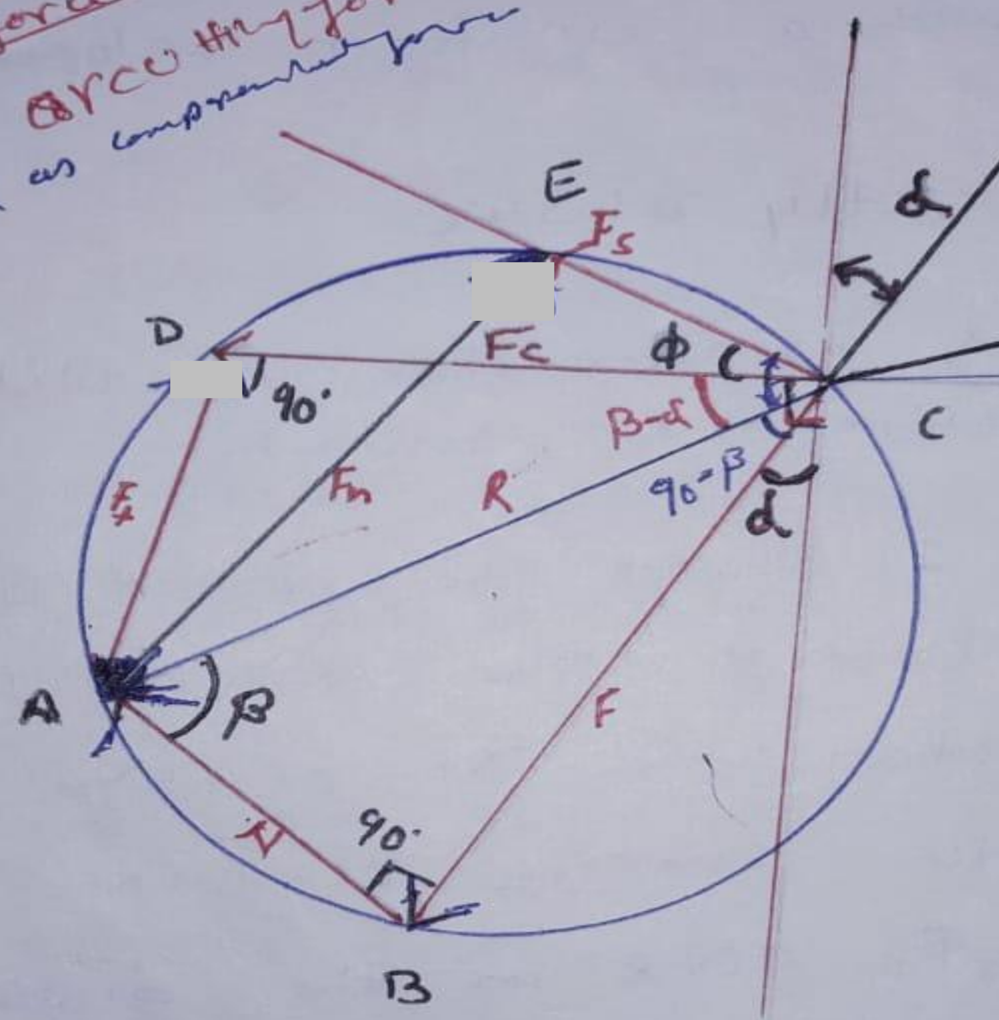


F_f or Feed force

Tangential force cutting force

N will work as compressive force

$\tan\phi = \frac{r\cos\alpha}{1 - r\sin\alpha}$



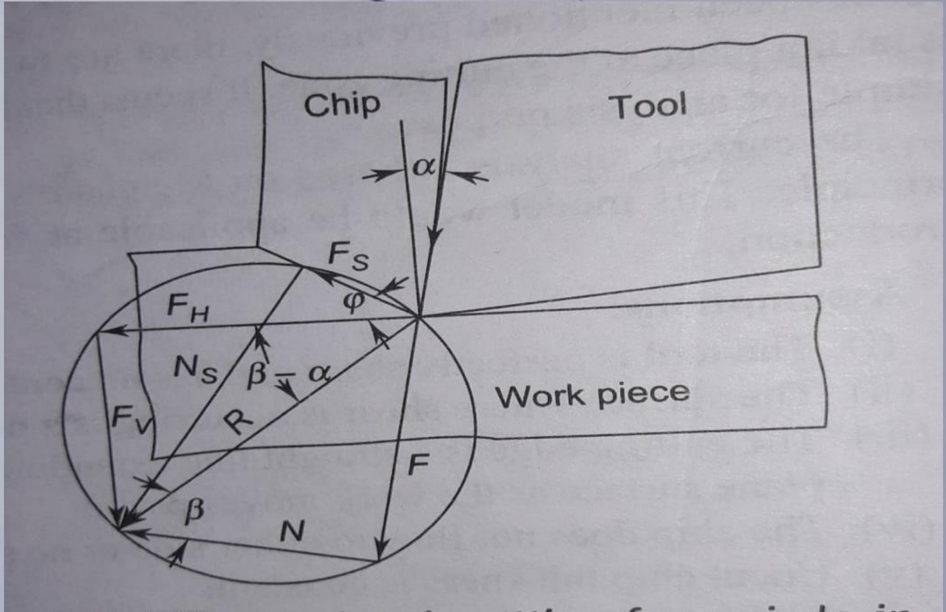


FIG. 2.15 Merchant's cutting force circle in orthogonal cutting

ΔABC

$\angle C = ?$

$\angle C + \beta + 90 = 180$

$\angle C = -\beta - 90 + 180$

$\angle C = 90 - \beta$

$90 - [(90-\beta)+\alpha]$

$\cancel{90} - \cancel{90} + \beta - \alpha$

$\beta - \alpha$

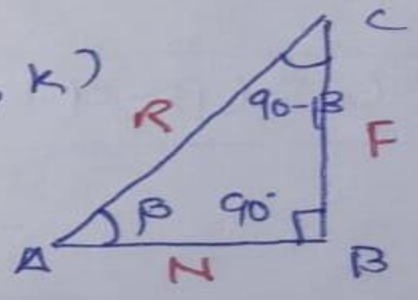
$\underline{\underline{\Delta ABC}}$ $\tan\beta = \frac{P}{B}$

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

$\frac{LAL}{KKA}$, $\frac{PBP}{HHB}$

$\tan\beta = \mu$

$\boxed{\beta = \tan^{-1}(\mu)}$ — ①



(P, L)

(B, A)

β = frictional angle

$\sin\beta = \frac{F}{R}$

$\boxed{F = R\sin\beta}$ — ②

μ = coefficient of friction
β = Frictional angle
F = Friction force
R = Resultant
N = Normal force

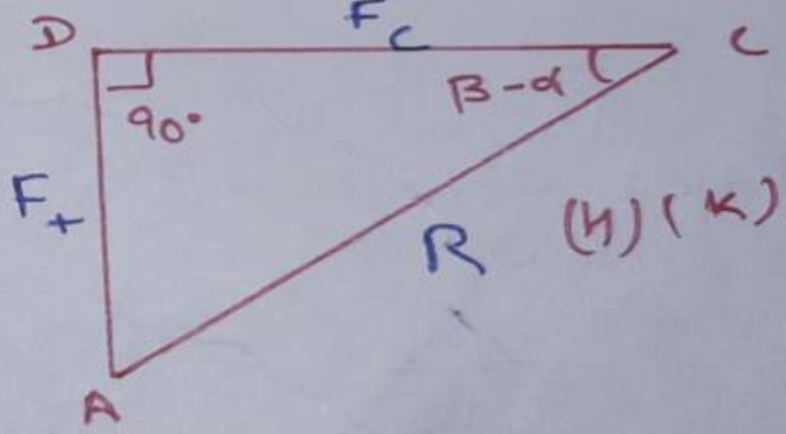
$$\cos\beta = \frac{N}{R}$$

$$\boxed{N = R\cos\beta} - (3)$$

a friction force, F, along the tool-chip interface and a normal force, N, perpendicular to the interface.

(β, α)

ΔADC



(L) (P)

(H) (K)

$$\sin(\beta-\alpha) = \frac{F_t}{R}$$

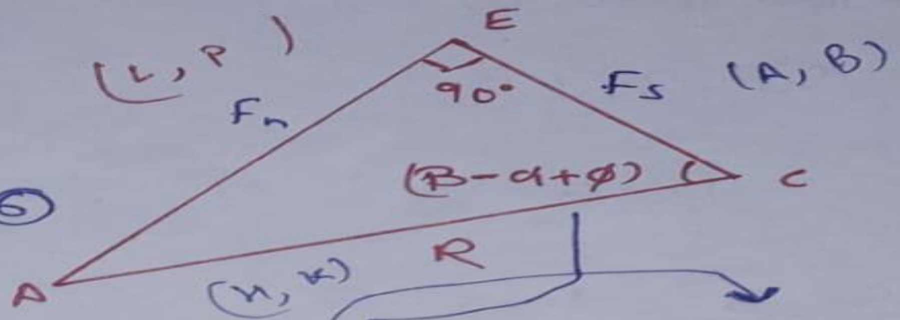
$$\boxed{F_t = R\sin(\beta-\alpha)} - (4)$$

$$\cos(\beta-\alpha) = \frac{F_c}{R}$$

$$\boxed{F_c = R\cos(\beta-\alpha)} - (5)$$

Δ AEC

$\frac{LAL}{KKA}$, $\frac{PBP}{HHB}$



$$\sin(\beta-\alpha+\phi) = \frac{F_n}{R}$$

$$\boxed{F_n = R \sin(\beta-\alpha+\phi)} \quad -\ (6)$$

$$\cos(\beta-\alpha+\phi) = \frac{F_s}{R}$$

$$\boxed{F_s = R\cos(\beta-\alpha+\phi)} \quad -\ (7)$$

area of shear plane $A_s = \frac{wt}{\sin\phi}$

$$\tau = \frac{F_s}{A_s}$$

$$F_s = \tau \times A_s$$

$$\boxed{F_s = \frac{\tau\, wt}{\sin\phi}} \quad -\ (8)$$

τ = shear stress in shear plane
w = width of cut
t = uncut chip thickness

Take equation (5) & (7) and 5 ÷ (7)

$$\frac{F_c}{F_s} = \frac{\cancel{R}\cos(\beta-\alpha)}{\cancel{R}\cos(\beta-\alpha+\phi)}$$

$$\boxed{F_c = F_s\left[\frac{\cos(\beta-\alpha)}{\cos(\beta-\alpha+\phi)}\right]} \quad -\ (10)$$

$$\Rightarrow \sigma = \frac{F_n}{A_s}$$

$$F_n = \sigma A_s$$

$$\boxed{F_n = \sigma \times \frac{wt}{\sin\phi}} \quad -\ (9)$$

Value of eqn (8) put in eqn (10)

$$F_c = \tau wt \cos(\beta-\alpha)$$

Value of eqn (8) put in eqn (10)

$$\boxed{F_c = \frac{\tau w t \cos(\beta - \alpha)}{\sin\phi \cos(\phi + \beta - \alpha)}}$$

— (11)

$$\boxed{F_n = \sigma \times \frac{wt}{\sin\phi}}$$

— (9)

Take equation (4) and (7) and equation (4) ÷ (7)

$$\frac{F_t}{F_s} = \frac{\cancel{R} \sin(\beta - \alpha)}{\cancel{R} \cos(\beta - \alpha + \phi)}$$

$$F_t = F_s \left[\frac{\sin(\beta - \alpha)}{\cos(\beta - \alpha + \phi)}\right] \quad \text{--- (12)}$$

Put the value of F_s from eqn (8) in eqn (12)

$$\boxed{F_t = \frac{\tau w t \sin(\beta - \alpha)}{\sin\phi \cos(\phi + \beta - \alpha)}} \quad \text{--- (13)}$$

The Force relations –

$$F = F_c \sin\alpha + F_t \cos\alpha \quad \text{--- (14)}$$

$$N = F_c \cos\alpha - F_t \sin\alpha \quad \text{--- (15)}$$

$$F_n = F_c \sin\phi + F_t \cos\phi \quad \text{--- (16)}$$

$$F_s = F_c \cos\phi - F_t \sin\phi \quad \text{--- (17)}$$

$$\phi + 90 + \angle 0 = 180$$

$$\angle 0 = 180 - 90 - \phi$$

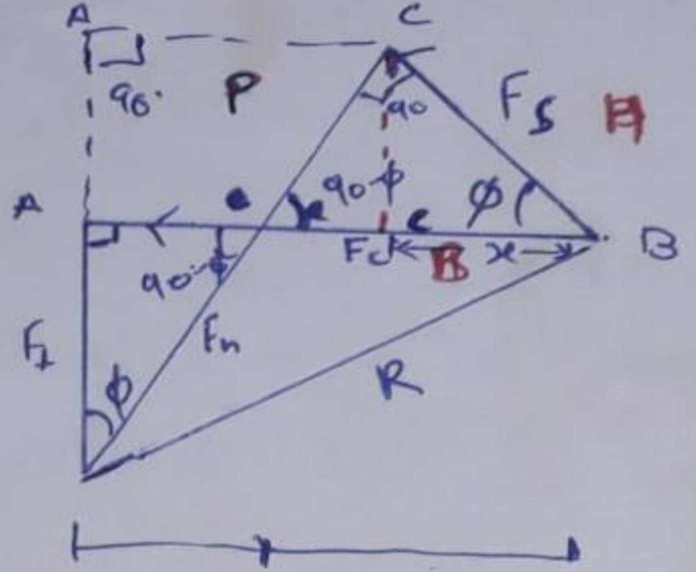
$$\boxed{\angle 0 = 90 - \phi}$$

$$F_c = F_s \cos\phi + F_n \sin\phi \quad \text{--- (18)}$$

$$F_t = F_n \cos\phi - F_s \sin\phi \quad \text{--- (19)}$$

LAL / KKA PBP / MHB

(P) ∟



$F_c = \cancel{AC + CB}\ DE' + E'C$

$\Delta EE'C$

$E'C = ?$

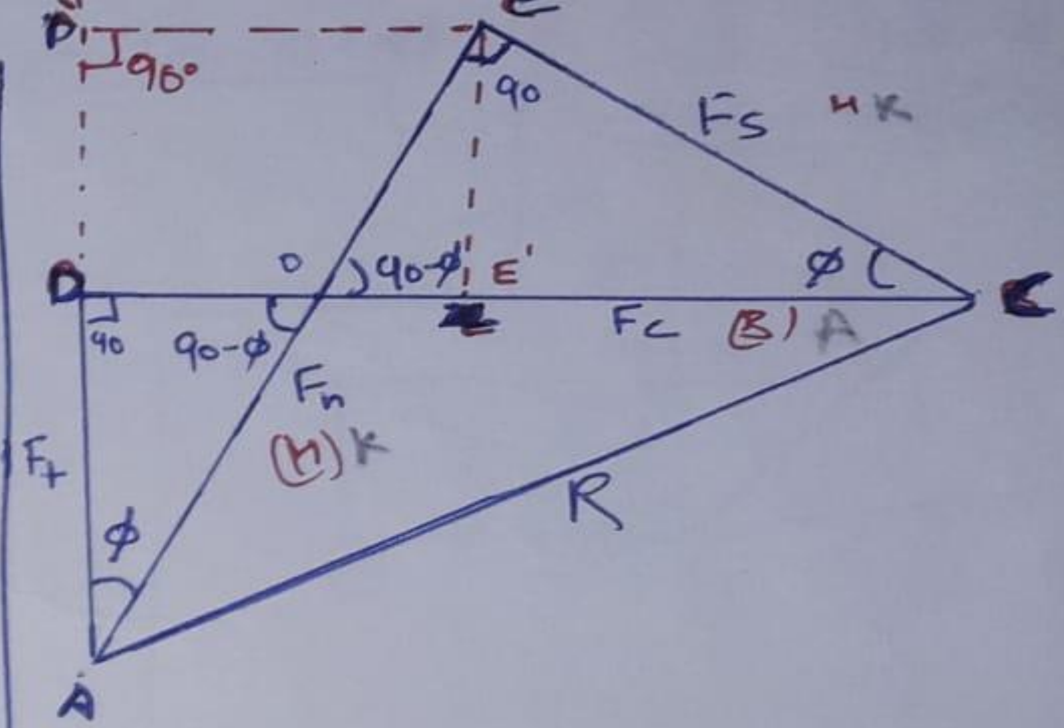
$\cos\phi = \frac{E'C}{F_s}$

$\boxed{E'C = F_s \cos\phi}$

$\Delta AD'E$

$D'E = ?$ $(D'E = DE')$

$\sin\phi = \frac{D'E}{F_n}$



$\boxed{D'E = F_n \sin\phi}$

or DE'

$F_c = E'C + DE'$

$\boxed{F_c = F_s \cos\phi + F_n \sin\phi}$

THANKYOU