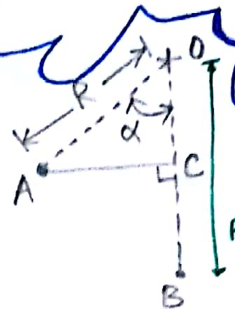
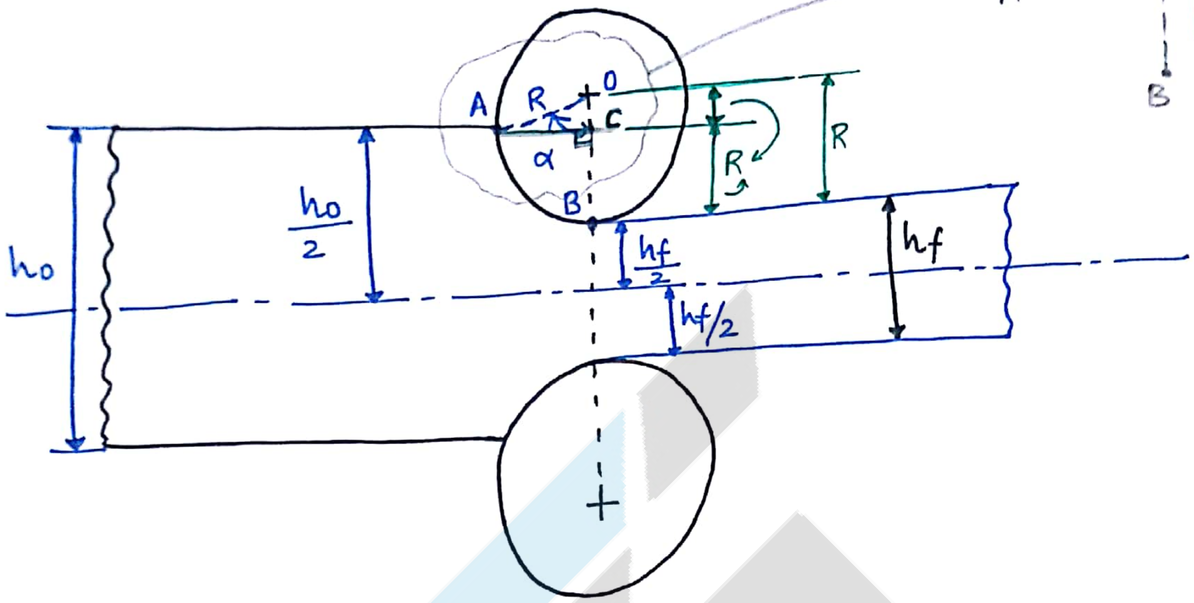
ROLLING

Refer these notes with SK Mondal SIR pdf 2019 production ↑ metal cutting + metal forming + ...etc



Important for Numericals →

GEOMETRY OF ROLLING PROCESS →



→ Reduction / Draft $= \Delta h = h_o - h_f = D(1-\cos\alpha)$

→ Point A → contact starts & Point B → contact ends

→ AB = arc of contact $= R\alpha$ → (Radian में)

→ α → angle of Bite

→ $BC = \frac{h_o}{2} - \frac{h_f}{2} = \frac{\Delta h}{2}$

→ $OC = R - BC = R - \frac{\Delta h}{2}$

→ $\cos\alpha = \frac{OC}{OA} = \frac{R - \Delta h/2}{R} = 1 - \frac{\Delta h}{2R} = 1 - \frac{\Delta h}{D}$

Gate 2017 → the thickness of a metallic sheet is reduced from an initial value of 16 mm to a final value of 10 mm in one single pass rolling with a pair of cylindrical rollers each of diameter of 400 mm. The bite angle in degree will be ?

Sol → $\cos\alpha = 1 - \frac{\Delta h}{D}$ → $\alpha = 9.936$ ✓

Gate 2012 (PI) → In a single pass rolling process using 410 mm diameter steel rollers, a strip of width 140 mm and thickness 8 mm undergoes 10% reduction of thickness. The angle of bite in radius is ?

Sol → $\cos\alpha = 1 - \frac{(0.8)}{410} \times \left(\frac{\pi}{180}\right)$

$\alpha = 0.062$ radian ✓

Alternative → $h_f = 90\%\ h_o$

$= 0.9 \times 8$

$h_f = 7.2\text{mm}$

ROLL STRIP CONTACT LENGTH

$L = R\alpha \rightarrow$ radian

Grate 2004 → In a rolling process, sheet of 25mm diameter is rolled to 20mm thickness. Roll is of diameter 600 mm and it rotates at 100 rpm. The roll strip contact length will be?

Sol → $\cos\alpha = 1 - \frac{\Delta h}{D} = 1 - \frac{5}{600} = 0.13$ rad

$L = R \cdot \alpha = 300 \times 0.13 = 39$ mm ✓

[redacted]

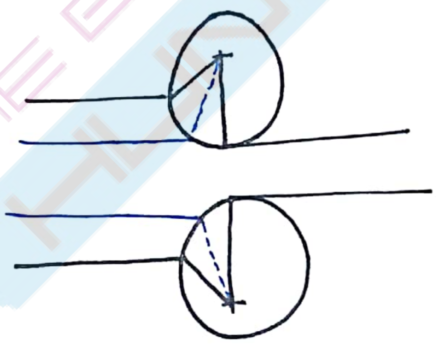
FOR UNAIDED ENTRY

$\mu \geq \tan\alpha$

[redacted]

$\boxed{\uparrow \cos\alpha = 1 - \frac{\Delta h \uparrow}{D}}$

Reduction↑, α↓



Limit of Reduction → $\boxed{\mu \geq \tan\alpha}$

↳ workpiece घूमेगा नहीं

→ for max^m. reduction, $\boxed{\mu = \tan\alpha}$

$\boxed{\Delta h_{max} = \mu^2 R}$

$\Delta h_{max} = \mu^2 R \longrightarrow$ (previous page)

$\rightarrow h_0 - h_{f(min)} = \mu^2 R$

Example $\rightarrow$ 50 mm Billet $\longrightarrow$ 5 mm

How many pairs

$(\Delta h)_{max} = \mu^2 R = 5mm$

45

$5 \times \underline{9}$

pass

Grate 2016 $\rightarrow$ A 300 mm thick slab is being colled rolled using roll of 600 mm diameter. If the coefficient of friction is 0.08, the maximum possible reduction (in mm) is ____

Sol $\rightarrow$ $(\Delta h)_{max} = \mu^2 R = 1.92$ ✓

Grate 2015 $\rightarrow$ In a rolling operation using rolls of diameter 500 mm, if a 25 mm thick plate cannot be reduced to less than 20 mm in one pass, the coefficient of friction between the roll and the plate is ____

Sol $\rightarrow$ (cannot be reduced than $<$ 20 mm)

$\rightarrow h_0 - h_{f min} = \mu^2 R$

Gate 2015 → In a slab rolling process operation, the maximum thickness reduction $(\Delta h)_{max}$ is given by $(\Delta h)_{max} = \mu^2 R$, where R is the radius of the roll and μ is the coefficient of friction between the roll and the sheet. If $\mu = 0.1$, the maxm. angle subtended by the deformation zone at the centre of the roll (bite ∠ in degrees) is ____

Sol → $\Delta h_{max} = 0.1^2 R$

$\Delta h_{max} = 0.01 R$

or

$\boxed{\mu = \tan\alpha}$ ✓

5.71

MINIMUM POSSIBLE THICKNESS → $h_0 - h_{f_{min}} = \mu^2 R$

Gate 2006 → A 4mm thick sheet is rolled with 300 mm diameter rolls to reduce thickness without any change in its width. The friction coefficient at the work-roll interface is 0.1. The minimum possible thickness of the sheet that can be produced in a single pass is ____

Sol → Use above formulae → 2.5 ✓

NUMBER OF PASSES NEEDED

$$n = \frac{\Delta h_{required}}{\Delta h_{max}}$$

Gate - 2011 (PI) → The thickness of a plate is reduced from 30 mm to 10 mm by successive cold rolling process using identical rolls of diameter 600 mm. Assume that there is no change in width. If the coefficient of friction b/w the rolls and the workpiece is 0.1, the minm. no. of passes required is ____

$$\Delta h_{max} = h_0 - h_{f\,min} = \mu^2 R = 3\ mm$$

Sol →

$$n = \frac{\Delta h_{req.}}{\Delta h_{max}} = \frac{20}{3} = \frac{30-10}{3} \approx 7 \text{ passes}$$

IES 2001 → A strip is to be rolled from a thickness of 30 mm to 15 mm using a two-high mill having rolls of diameter 300 mm. The coefficient of friction for unaided bite should nearly be ____

Sol → $\mu \geq \tan\alpha \longleftarrow$ unaided bite

$$\cos\alpha = 1 - \frac{\Delta h}{D} = 0.95$$

or

$$\mu = \tan\alpha$$

$$(\Delta h)_{max} = \mu^2 R$$

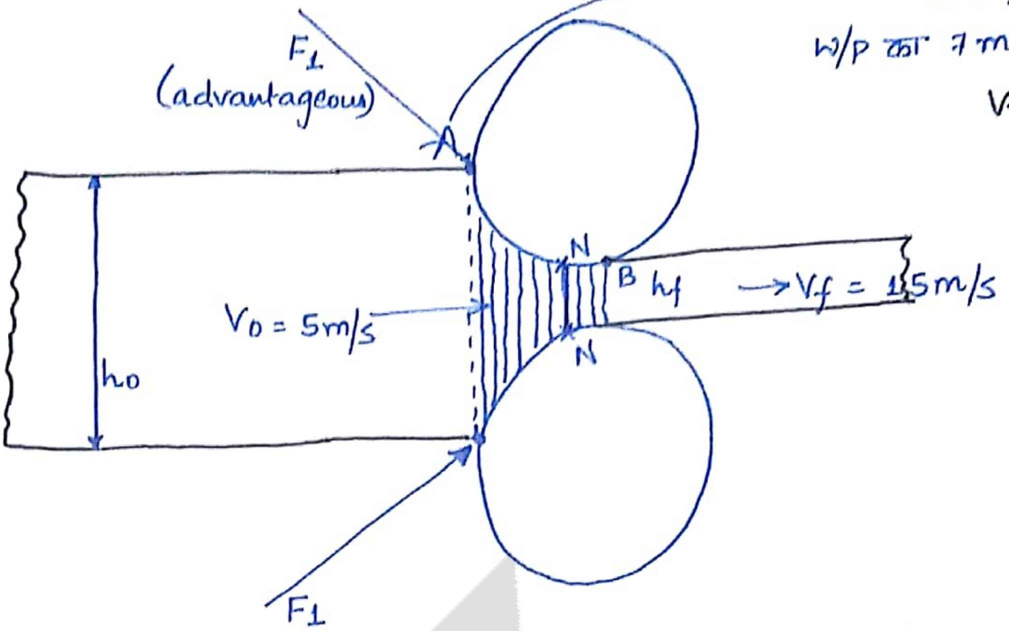
$$15 = \mu^2 \times 150$$

$$\mu = 0.33\ldots\ldots$$

NEUTRAL POINT & NEUTRAL PLANE

roller का 10 m/s,
w/p का 7 m/s

$V_r = \frac{\pi D N}{60}$ (m/s)



N → neutral point → no-slip point

at N,

$\boxed{V_r = V_{workpiece}}$

Roller

Why → Both contacted → R and W/P → Relative motion → slip

at point A → Roller $V = 10$ m/s $= V_R$

W/P $V = 5$ m/s $= V_0$

if W/P → 5 m/s → Backward

at point B → $V_{w/p} = 15$ m/s

$V_r = 10$ m/s

So forward slip

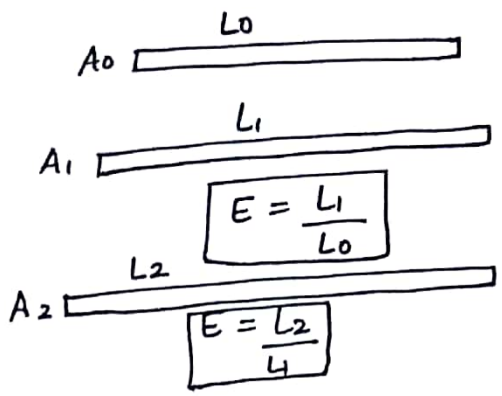
A to N	N to B
slip Backward	slip forward

Continuity Equation → $h_0 b_0 V_0 = h_f b_f V_f$

$$A_1 V_1 = A_2 V_2$$

Elongation factor/coefficient → $E = \dfrac{L_1}{L_0} = \dfrac{A_1}{A_0}$ (for single pass)

$$E^n = \frac{L_n}{L_0} = \frac{A_0}{A_n}\text{, for n-pass,}$$



$$E \times E = \frac{\cancel{L_1}}{L_0} \times \frac{L_2}{\cancel{L_1}}$$

$$E^2 = \frac{L_2}{L_0}$$

Note → In theory of Plasticity, poisson's ratio is always 0.5 and Volumetric strain is always 0, therefore volume remains constant.

$$\epsilon_v = \epsilon_1 + \epsilon_2 + \epsilon_3 = 0$$

Initial Volume $A_0 L_0 = A_1 L_1 = \text{- - - - - - - - -} = A_n L_n$

$$\frac{L_1}{L_0} = \frac{A_0}{A_1}$$

$$\frac{L_n}{L_0} = \frac{A_0}{A_n}$$

Q → Grate 1992 / PI → If the elongation factor during rolling of an ingot is 1.22, the minimum number of passes needed to produce a section 250mm x250mm from an ingot of 750mm x750mm are

Sol → $\cancel{\frac{1.22}{L_0} = \frac{750\times750}{250\times250}}$ ← mistake ☺

$$E^n = \frac{A_0}{A_n}$$

$$1.22^n = \frac{750\times750}{250\times250}$$

$$n = 11.04$$

$$n = 12$$

ANALYSIS OF ROLLING → for IES conventional only

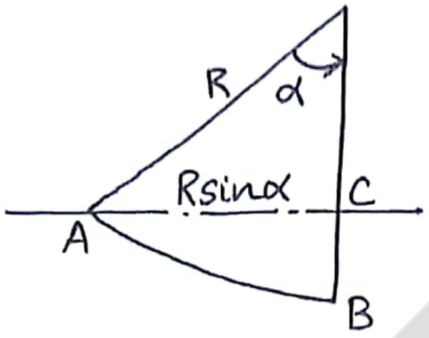
↳ if μ → given → then

FORCE, TORQUE and POWER

$$\sigma_y \le \sigma_0 \le \sigma_{ult} \rightarrow \text{Break}$$

σ_y → yield stress → failure starts from here

σ_0 → flow stress ↳ metal को plastic deformation के लिए



Good formulae......

But approximate Value = $R\sin\alpha = \sqrt{R\Delta h}$ (mm)

Gate 2016 → In a single-pass rolling operation, a 200mm wide metallic strip is rolled from a thickness 10mm to a thickness 6mm. The Roll Radius is 100mm and it rotates at 200 rpm. The roll-strip contact length is a function of roll radius and, initial and final thickness of the strip. If the average flow stress in plain strain of the strip material in the roll gap is 500 MPa. the roll separating force (in kN) is ?

Gate 2008 → In a single pass rolling operation, a 20mm thick plate with plate width of 100 mm, is reduced to 18 mm. The roller radius is 250mm and rotational speed is 10rpm. The average flow stress for the plate material is 300 MPa. The power required for the rolling operation in kW is closest to

a) 15.2 b) 18.2 c) 30.4 d) 45.6

KN में बदलना

Sol → $F = \sigma_0 \sqrt{R\Delta h}\ b = 300 \times \sqrt{250 \times 2} \times 100\,N = \_\_\_\_\ (KN)$

assume hot working if not given

forging ; Rolling

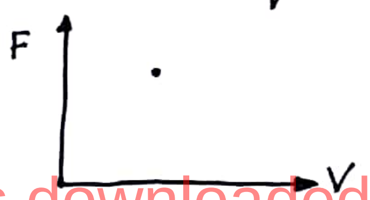
$a = \lambda L_p = 0.5\sqrt{250 \times 2}\ (mm)$

$T = Fa$

$\text{Power} = 2T\,\frac{2\pi N}{60} = 15.7\,kW$

KN · mm = N · m → JUGAAD (mondal sir का)

Note → In Rolling, $\boxed{\text{Force} \times V = \text{Power}}$ formula is not applicable because direction of force and direction of velocity are not same.



The end
Rolling