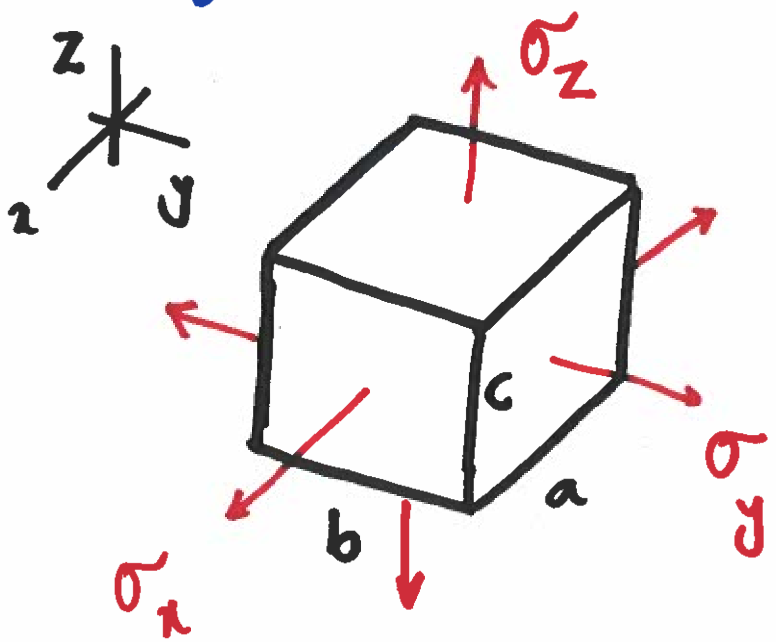
Review)

change in the volume of a part, subjected to stresses:



$+$ tens.

$-$ comp.

$$V_0 = abc$$

$$V = (a+\delta_x)(b+\delta_y)(c+\delta_z)$$

$$= abc\left(1+\frac{\delta_x}{a}\right)\left(1+\frac{\delta_y}{b}\right)\left(1+\frac{\delta_z}{c}\right)$$

$$= abc(1+\varepsilon_x)(1+\varepsilon_y)(1+\varepsilon_z)$$

$$= abc(1+\varepsilon_x+\varepsilon_y+\varepsilon_z)$$ ignoring the higher terms

$$\Delta V = V - V_0$$

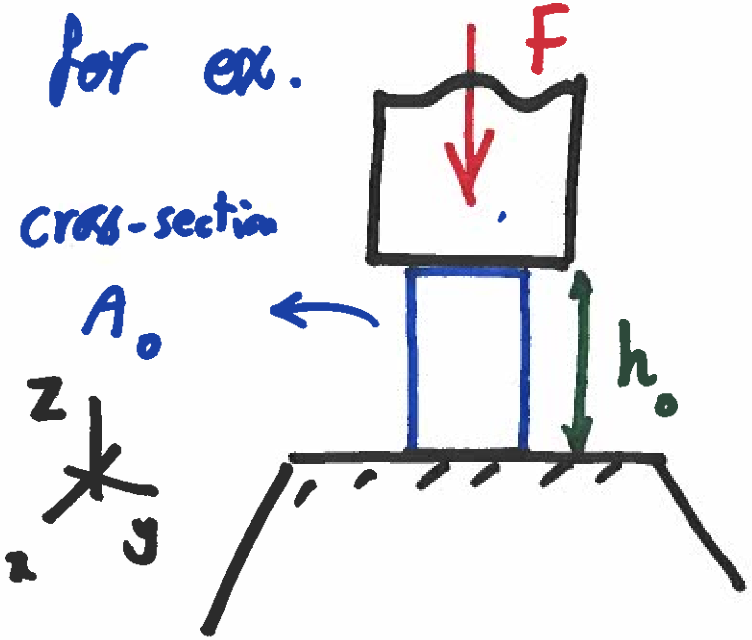
$$\frac{\Delta V}{V_0} = \varepsilon_x+\varepsilon_y+\varepsilon_z = \frac{1-2\nu}{E}(\sigma_x+\sigma_y+\sigma_z)$$

Hooke's law: $\varepsilon_x = \frac{1}{E}(\sigma_x - \nu(\sigma_y+\sigma_z))$

$$\frac{\Delta V}{V_0} = \frac{1-2\nu}{E}(\sigma_x + \sigma_y + \sigma_z)$$

$\sigma_x = 0$, $\sigma_y = 0$

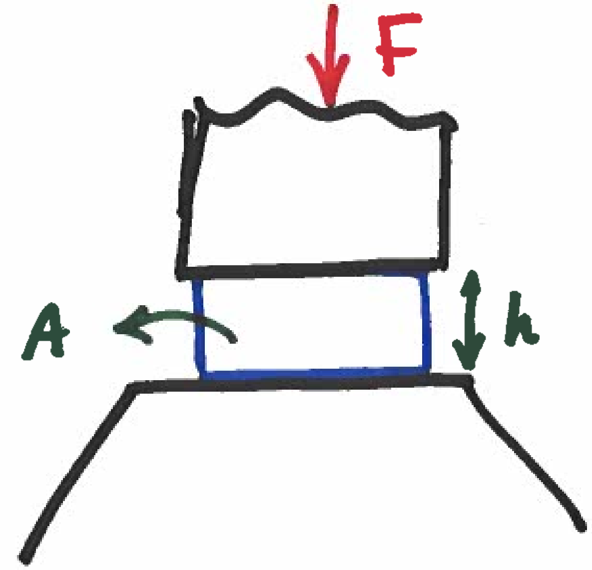
for ex.



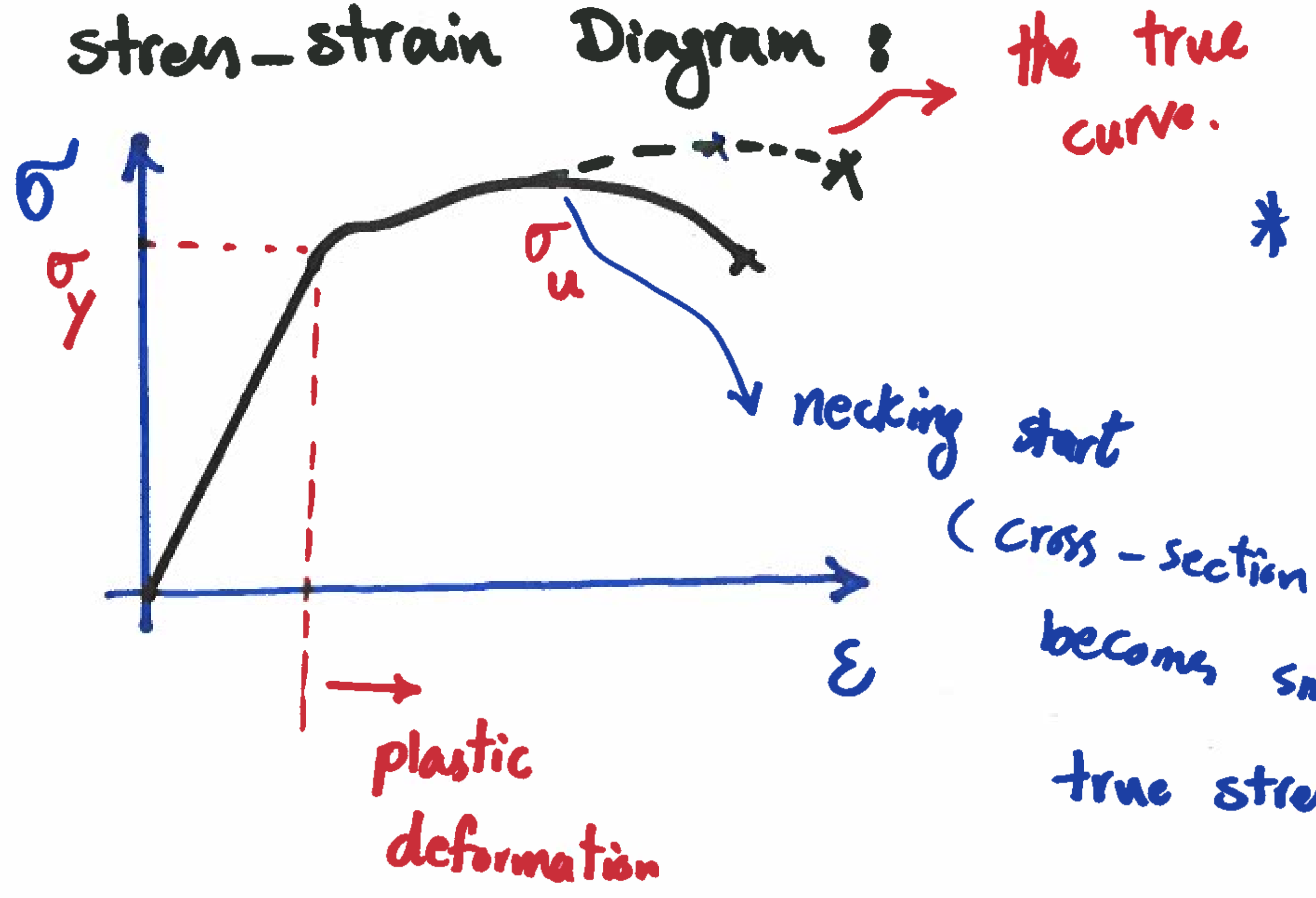
$$\frac{\Delta V}{V_0} = \frac{1-2\nu}{E}\left(-\frac{F}{A}\right)$$

?

$$A_0 h_0 = Ah - \Delta V$$



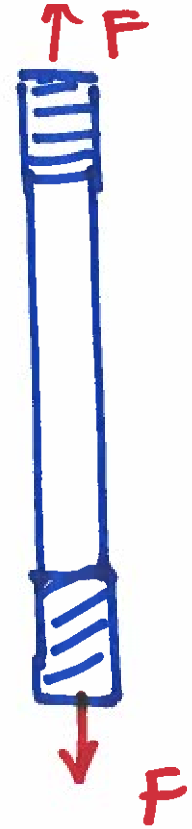
stress – strain Diagram :



$*\ \sigma = \frac{F}{A}$

$\varepsilon = \frac{\delta}{L_0}$

true stress $\sigma = \frac{F}{A_{actual}}$

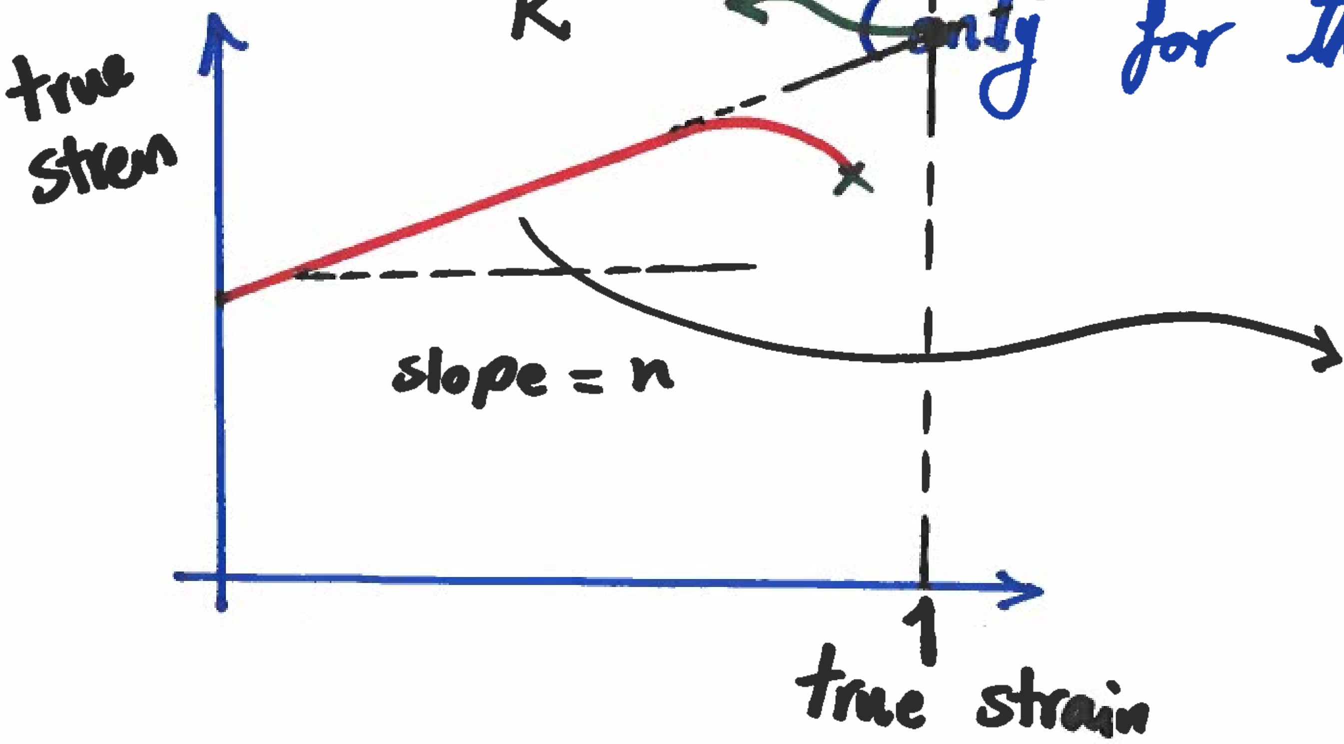


based on the true stress, the strength of material increases, as the strain increases. $\Rightarrow$ this property is called, strain - hardening & (work - hardening)

True strain : $\varepsilon = \int \frac{dL}{L}$ $\rightarrow$ true strain $\varepsilon = \ln \frac{L}{L_0}$

let's plot true stress - true strain on a log-log scale:

(only for the plastic portion)



The slope of this line is called the strain hardening exponent. (n)

we define the true stress as: $\sigma = K \varepsilon^{n}$

K is called the strength coefficient and it is equal to the true stress when the strain is 1.

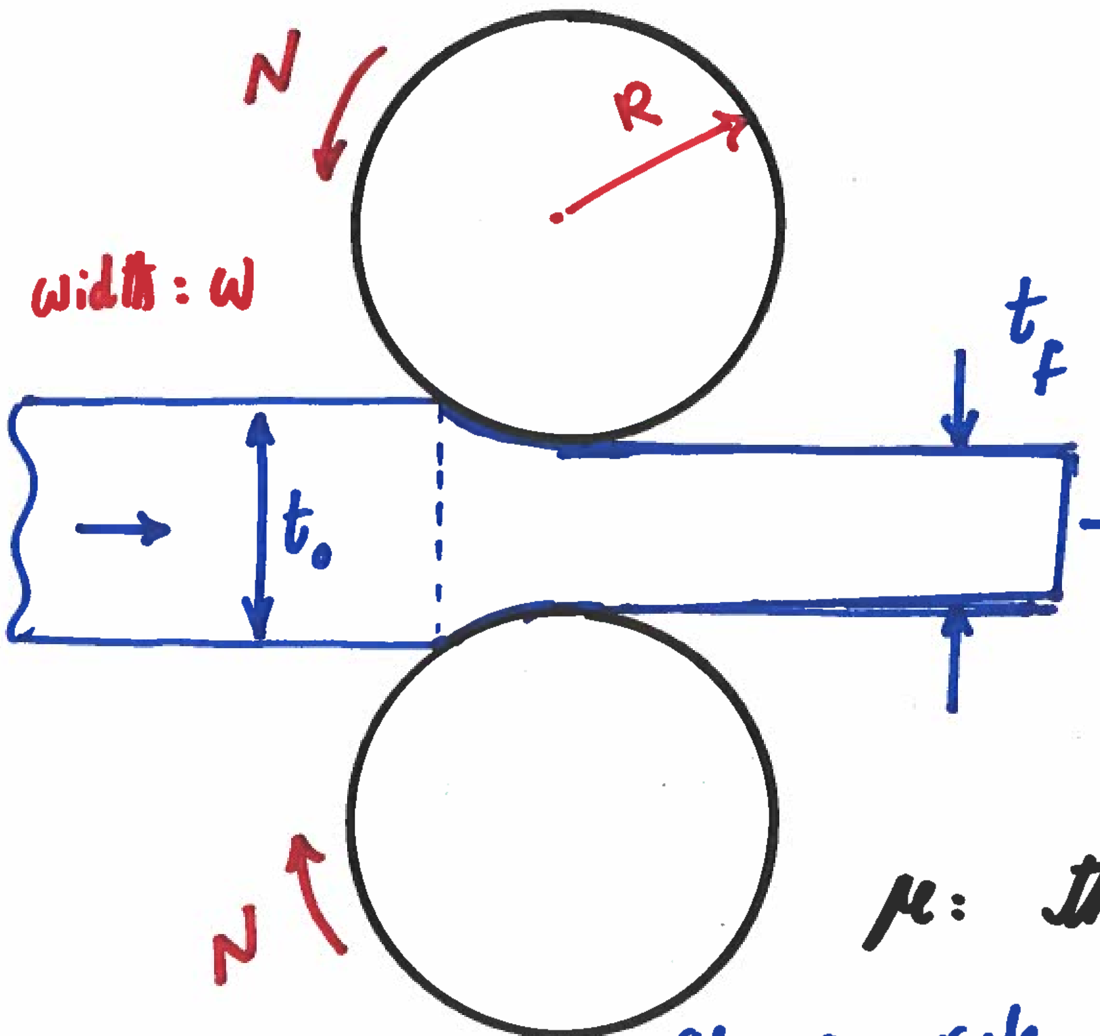
K & n are the main parameters in analyzing bulk deformation process.

For ex.

	K (MPa)	n
Al. alloy	400	0.1
St.	750	0.25
Strainless-st.	1200	0.4

Some ball park numbers; see your notes for accurate numbers

Rolling :



for each pass there is a limit in how much we can reduce the thickness :

$$d = t_o - t_f$$

speed $\to v_f$ form

draft

$$\boxed{d_{max} = \mu^2 R} \; *$$

μ: the friction coeff.

as a rule of thumb : $\mu \nearrow 0.1$ in cold rolling, $\searrow 0.4$ " hot "

Required power :

$$P = \frac{2\pi N}{60} \times R \times (t_o - t_f)(w)\left(\frac{K\varepsilon^{n}}{1+n}\right)$$

N (rpm); w: initial width

$$\varepsilon = \ln \frac{t_o}{t_f}$$

Forging Analysis :

$$F = K_f \cdot K \cdot \varepsilon^n \cdot A_o$$

the required force to forge from h_o to h

forging factor

Area befor form

$$\varepsilon = \ln \frac{h_o}{h}$$

open-die

$\rightarrow K_f = 1 + \dfrac{0.4 \mu D_o}{h_o}$

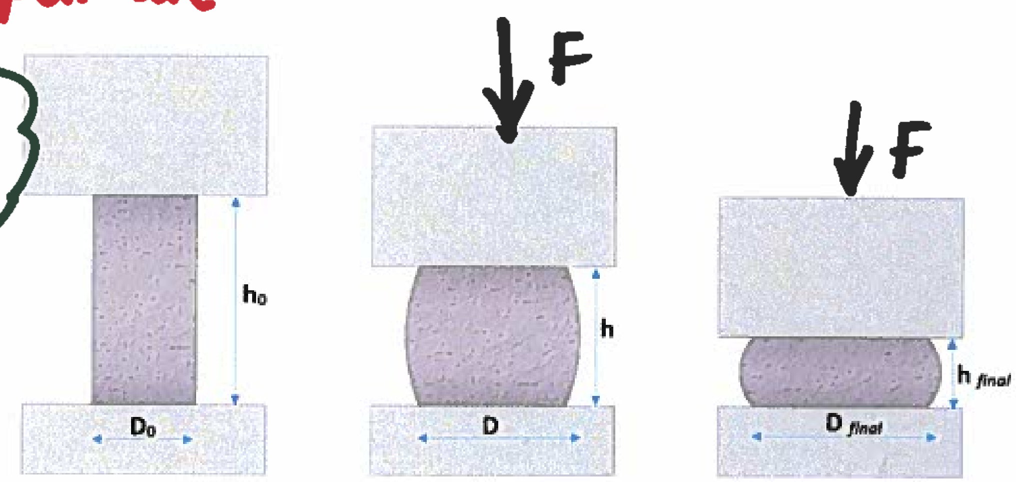
Impres. - die

$\rightarrow K_f = \begin{cases} 6 & \text{Simple Geometry} \\ 8 & \text{Complex} \end{cases}$

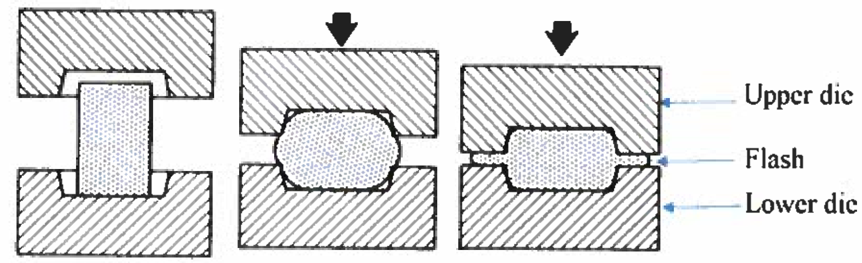
close - die

$\rightarrow K_f = \begin{cases} 6 & \text{coining} \\ 8 & \text{others} \end{cases}$

open-die



Impression - die



close - die