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1. $D_0 = 100$ mm $h_0 = 80$ mm $\mu = 0.2$
   $K = 600$ MPa $n = 0.12$,

a) $\epsilon = 0.002$

Y_f (flow stress) $= K\epsilon^n$
$\Rightarrow Y_f = 600 \times (0.002)^{0.12}$
$\Rightarrow Y_f = 284.626$ MPa

Shape factor, $K_f = 1 + \dfrac{0.4\mu D_0}{h_f}$

$\Rightarrow K_f = 1 + \dfrac{0.4 \times 0.2 \times 100}{80}$

$\Rightarrow K_f = 1.1$

Now, Force, $F = K_f Y_f A$

$\Rightarrow F = 1.1 \times 284.626 \times A$

Area, $A = \dfrac{\pi D_0^2}{4} = \dfrac{\pi \times (100)^2}{4} = 7853.98$ mm^2

$\Rightarrow F = 1.1 \times 284.626 \times 7853.98$ N
$= 2458991.6$ N

b) At $h = 60$ mm

Now, strain, $\epsilon = \ln\left(\frac{h_0}{h}\right)$

$$\Rightarrow \epsilon = \ln\left(\frac{80}{60}\right)$$

$$\Rightarrow \epsilon = 0.288$$

$$Y_f = K\epsilon^n$$

$$\Rightarrow Y_f = 600\,(0.288)^{0.12}$$

$$\Rightarrow Y_f = 516.75 \text{ MPa}$$

For Area,

Initial volume $= \frac{\pi D_0^2 h}{4}$

$$\Rightarrow V = \frac{\pi \times 100^2 \times 80}{4}$$

$$\Rightarrow V = 628318.5 \text{ mm}^3$$

$$\Rightarrow \text{Area, } A = \frac{628318.5}{60} = 10471.98 \text{ mm}^2$$

$$\Rightarrow \frac{\pi D^2}{4} = 10471.98$$

$$\Rightarrow D = 115.47 \text{ mm}$$

$$K_f = 1 + \frac{0.4 \mu D}{h}$$

$$\Rightarrow K_f = 1 + \frac{0.4 \times 0.2 \times 115.47}{60}$$

$$\Rightarrow K_f = 1.154$$

$\Rightarrow$ Force, $F = K_f Y_f A$

$= (1.154)(516.75)(10471.98)$

$= 6244750.6$ N

c) $h = 40$ mm

Now, strain, $\epsilon = \ln\left(\frac{h_0}{h}\right)$

$$\Rightarrow \epsilon = \ln\left(\frac{80}{40}\right)$$

$$\Rightarrow \epsilon = 0.693$$

$Y_f = K\epsilon^n$

$\Rightarrow Y_f = 600(0.693)^{0.12}$

$\Rightarrow Y_f = 574.17$ MPa

For Area,

Initial volume, $= \frac{\pi D_o^2 h}{4}$

$\Rightarrow V = \frac{\pi (100)^2 \times 80}{4}$

$\Rightarrow V = 628318.5 \text{ mm}^3$

$\Rightarrow$ Area, $A = \frac{628318.5}{40} = 15707.96 \text{ mm}^2$

$\Rightarrow \frac{\pi D^2}{4} = 15707.96$

$\Rightarrow D = 141.42 \text{ mm}$

$K_f = 1 + \frac{0.4 \mu D}{h}$

$\Rightarrow K_f = 1 + \frac{0.4 \times 0.2 \times 141.42}{40}$

$\Rightarrow K_f = 1.283$

Force, $F = K_f \, Y_f \, A$

$\Rightarrow F = 1.283 \times 574.17 \times 15707.96$

$\Rightarrow F = 11569984.5 \text{ N}$

$\therefore$ Answers $\rightarrow$ a) 2458991.6 N
b) 6244750.6 N
c) 11569984.5 N

2. $l_o = 200$ mm $\quad d_o = 80$ mm
$d_f = 30$ mm $\quad a = 0.8$, $b = 1.5$
$K = 750$ MPa $\quad n = 0.15$

(a) Extrusion ratio, $r_x = \left(\frac{A_o}{A_f}\right)$

$$\Rightarrow r_x = \left(\frac{d_o^2}{d_f^2}\right)$$

$$\Rightarrow r_x = \left(\frac{80^2}{30^2}\right)$$

$$\Rightarrow r_x = 7.111$$

(b) True strain, $\epsilon = \ln(r_x)$

$$\Rightarrow \epsilon = \ln(7.111)$$
$$\Rightarrow \epsilon = 1.962$$

(c) Extrusion strain, $\epsilon_x = a + b\ln(r_x)$

$$\Rightarrow \epsilon_x = 0.8 + 1.5\ln(7.111)$$

$$\Rightarrow \epsilon_x = 3.742$$

d) Ram pressure, $p = K_x \bar{Y}_f \epsilon_x$

Average flow stress, $\bar{Y}_f = \dfrac{K\epsilon^n}{1+n}$

$$\Rightarrow \bar{Y}_f = \frac{750(1.962)^{0.15}}{1.15}$$

$$\Rightarrow \bar{Y}_f = 721.55 \text{ MPa}$$

Now, for die angle $90°$, pressure would be maximum,

$$\Rightarrow p = (721.55)(3.742)$$
$$= 2700.04 \text{ MPa}$$

e) Ram force, $F = pA_0$

$$A = \frac{\pi d_0^2}{4}$$

$$\Rightarrow A = \frac{\pi (80)^2}{4} = 5026.55 \text{ mm}^2$$

$$\Rightarrow F = (2700.04)(5026.55)$$

$$\Rightarrow F = 13571886.06 \text{ N}$$

3. $t_0 = 80$ mm $\quad t_f = 60$ mm

$V_0 = 16$ m/min $\quad V_r = 18.5$ rev/min

$R = 600$ mm

Maximum draft, $d_{max} = \mu^2 R$

Now, $d = t_0 - t_f = 80 - 60 = 20$ mm

$$\Rightarrow 20 = \mu^2 \times 600$$

$$\Rightarrow \mu = 0.183$$

Scanned with CamScanner

b) Now, plate widens by 2%

Now, we know that,

$$t_0 w_0 V_0 = t_f w_f V_f \quad -①$$

$$w_f = w_0 + \frac{2 w_0}{100}$$

$$\Rightarrow w_f = w_0 (1.02)$$

Substituting w_f in ①

$$\Rightarrow 80 \times w_0 \times 16 = 60 \times (1.02) w_0 \times V_f$$

$$\Rightarrow V_f = \frac{80 \times 16}{60 \times 1.02}$$

$$\Rightarrow V_f = 20.92 \text{ m/min}$$

c) Roll speed $V_r = 2\pi R \times 18.5$

$$\Rightarrow V_r = 2 \times \pi \times 0.6 \times 18.5$$

$$\Rightarrow V_r = 69.74 \text{ m/min}$$

$\Rightarrow$ Forward slip = $\dfrac{V_f - V_r}{V_r}$

$\Rightarrow$ Forward slip = $\dfrac{20.92 - 69.74}{69.74}$

$\Rightarrow$ Forward slip = -0.7

1. $d_o = 3$ mm $\quad d_f = 2.5$ mm

a) Area reduction, $r = \dfrac{A_o - A_f}{A_o}$

$$A_o = \frac{\pi d_o^2}{4} = 7.07 \text{ mm}^2$$

$$A_f = \frac{\pi d_f^2}{4} = 4.91 \text{ mm}^2$$

$$\Rightarrow r = \frac{7.07 - 4.91}{7.07}$$

$$= 0.3055$$

b) Draw stress, $\sigma_d = Y_f \left(1 + \dfrac{\mu}{\tan\alpha}\right) \phi \ln \dfrac{A_o}{A_f}$

$$\phi = 0.88 + \frac{0.12 D}{L_c}$$

$$D = \frac{d_o + d_f}{2} \qquad L_c = \frac{d_o - d_f}{2 \sin\alpha}$$

$$\Rightarrow D = 2.75 \qquad L_c = 0.966$$

$$\Rightarrow \phi = 0.88 + \frac{0.12 \times 2.75}{0.916}$$

$$\Rightarrow \phi = 1.222$$

$$\overline{Y_f} = \frac{K \epsilon^n}{1+n}$$

$$\epsilon = \ln\left(\frac{A_o}{A_f}\right) = 0.365$$

$$\Rightarrow \overline{Y_f} = \frac{500 \times (0.365)^{0.3}}{1.3}$$

$$\overline{Y_f} = 284.2$$

$$\Rightarrow \sigma_d = (284.2)\left[1 + \frac{0.07}{\tan 15^\circ}\right](1.222)(0.365)$$

$$\Rightarrow \sigma_d = (284.2)(1.26)(1.222)(0.365)$$

$$\Rightarrow \sigma_d = 159.72 \text{ MPa}$$

c) Draw force, $F = A_f \sigma_d$

$$\Rightarrow F = (4.91)(159.72)$$

$$\Rightarrow F = 784.22 \text{ N}$$

5. $H = U_m V$

Volume, $V = \frac{\pi d_o^2 h}{4}$

$$V = \frac{\pi \times 6^2 \times 4.5}{4}$$

$$\Rightarrow V = 127.23 \text{ mm}^3$$

$$\Rightarrow H = 10 \times 127.23 \text{ J}$$

$$= 1272.3 \text{ J}$$

Required heat, $H_2 = 1272.3 \times 3$

$$\Rightarrow H_2 = 3816.9$$

Now, $H_2 = I^2 R t$

$$\Rightarrow I = \sqrt{\frac{H}{Rt}} = \sqrt{\frac{3816.9}{125 \times 10^{-6} \times 0.2}}$$

$$\Rightarrow I = 12356.2 \text{ A}$$