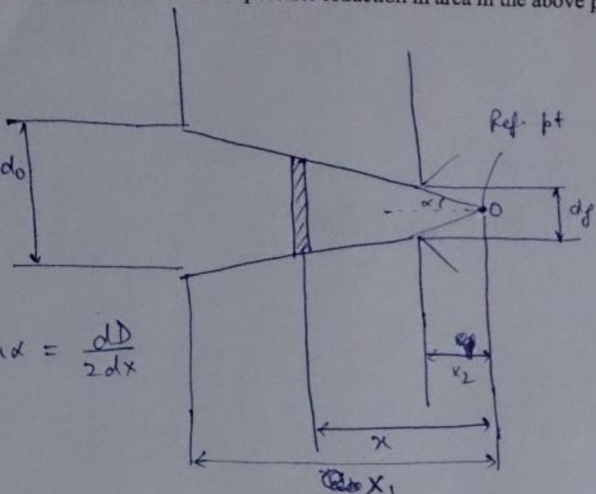
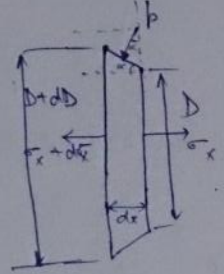
ANSHUL GOYAL

4. a) Neglecting friction, derive an expression for the draw stress in a wire drawing process through a conical die with semi die angle α to reduce the diameter of a wire from d_0 to d_f at room temperature. σ_0 is the uniaxial flow stress of the material. (8)

b) Calculate the maximum possible reduction in area in the above process. (2)

(a)





$$\tan\alpha = \frac{dD}{2dx}$$

~~Radial~~ pressure, p acts on $(\pi D)\left(\frac{dx}{\cos\alpha}\right)$

Balancing forces in x - direction

$$(\sigma_x + d\sigma_x)\frac{\pi}{4}(D+dD)^2 - (\sigma_x)\frac{\pi}{4}D^2 + p\times(\pi D)\left(\frac{dx}{\cos\alpha}\right)\times\sin\alpha = 0$$

$$(\sigma_x + d\sigma_x)(D^2 + 2DdD) - \sigma_x D^2 + 4p\cancel{D}\left(\frac{dx}{\cos\alpha}\right)\sin\alpha = 0$$

$$\Rightarrow \cancel{\sigma_x D} + 2\sigma_x dD + D d\sigma_x - \cancel{\sigma_x D} + 4p\frac{dx}{\cos\alpha}(\sin\alpha) = 0$$

$$\Rightarrow 2\sigma_x dD + D d\sigma_x + 4p\frac{dD}{2\tan\alpha}\frac{(\sin\alpha)}{\cos\alpha} = 0$$

$$\Rightarrow 2\sigma_x dD + D d\sigma_x + \frac{2p\, dD}{\sin\alpha} = 0$$

$$\Rightarrow \left(2\sigma_x + \frac{2p}{\sin\alpha}\right)dD = -D\, d\sigma_x$$

$$\Rightarrow \frac{d\sigma_x}{2\left(\sigma_x + \frac{p}{\sin\alpha}\right)} = \frac{-dD}{D}$$

Integrating

$$\Rightarrow \cancel{\tfrac{1}{2}} \ln\left(\cancel{\sigma_x + \frac{p}{\sin\alpha}}\right) = \cancel{-}\ln D \cancel{+} \cancel{\ln} C$$

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MEL 234 METAL FORMING AND MACHINING

Minor Test – 2 (II Sem 2013-14)   Time : 1 hour   Max marks: 30

1. Tensile properties of a 1.2mm thick sheet are: YS = 320 MPa, UTS = 445 MPa, Total elongation = 22%.

   a) Determine whether a cup of outer diameter 50 mm and height 40 mm can be deep drawn in a single stage using a circular blank cut from the above sheet. Assume efficiency of the process to be 85% and neglect thickness changes. If yes, calculate the force required for deep drawing. (5)

   b) Estimate the optimum blank holding force for the above deep drawing process. (2)

   c) Show the variation of total force in deep drawing as a function of punch travel. (1)

   d) Determine the minimum possible bend radius of the above sheet. State the assumption used. (2)

(a) $H = 40\ mm$ $\eta = 0.85$

$$D_p = (50 - 2 \times 1.2)_{mm} = 47.6\ mm$$

$$D_0 \approx \sqrt{D_p^2 + 4 D_p H} \approx 99.41\ mm$$

Now LDR $\frac{(D_0)_{max}}{D_p} = \exp(\eta)$

$$\Rightarrow (D_0)_{max} \approx 111.37\ mm$$

As $D_0 < (D_0)_{max} \Rightarrow$ The cup can be drawn.

$$F_{dr} = 1.3 \times \frac{2}{\sqrt{3}} \times \bar{\sigma}_0 \times \epsilon \times Area$$

$\ln\left(\frac{D_0}{D_p}\right)$

$$\epsilon = \ln(1+e) = \ln(1+0.22) = 0.1988$$

$Area = \pi * D_p * H$

Taking $\bar{\sigma}_0 = \frac{YS + UTS}{2} = 382.5\ MPa$

4

$$F_{dr} = 1.3 \times \frac{2}{\sqrt{3}} \times \frac{382.5\ N}{mm^2} \times 0.1988 \times \pi\ 47.6\ mm \times 40\ mm$$

$$\approx 682.43\ kN$$

(b) Optimum Blank Holding Force

$$= 0.17 \times F_{dr}$$

$$= 116.01\ kN$$

0

$\frac{A_0 - A_f}{A_0} = \lambda \Rightarrow 1 - \frac{A_f}{A_0} = \lambda \Rightarrow 1-\lambda = \frac{l_0}{l_f}$

2. The cross sectional area of a bar of length 1m is reduced by successive extrusions through seven dies of decreasing size. The reduction in area in each of the seven dies is 35%. Calculate a) total true strain, b) total engineering strain, c) extrusion ratio in each pass and d) final length of the bar. (4)

$\frac{l_1}{l_0} = \frac{1}{1-\lambda}$ $\frac{l_2}{l_1} = \frac{1}{1-\lambda}$ $\frac{l_n}{l_{n-1}} = \frac{1}{1-\lambda}$ $\frac{l_n}{l_0} = \frac{l_n}{l_{n-1}} \times \frac{l_{n-1}}{l_{n-2}} \times \cdots \frac{l_2}{l_1} \times \frac{l_1}{l_0}$

$= \frac{l_7}{l_6} \times \frac{l_6}{l_5} \times \frac{l_5}{l_4} \times \frac{l_4}{l_3} \times \frac{l_3}{l_2} \times \frac{l_2}{l_1} \times \frac{l_1}{l_0}$

$\lambda = 0.35$

$= \left(\frac{1}{1-\lambda}\right)^7$

(a) Total True Strain $= 7 \times \ln\left(\frac{1}{1-\lambda}\right) = 3.02$

(b) $\ln(1+e) = 3.02 \Rightarrow$ Total engg. strain $= 19.49$

(c) Extrusion Ratio $= \frac{A_0}{A_f} = \frac{1}{1-\lambda} = 1.538$

4

(d) Final length of the bar $= 20.4$ m

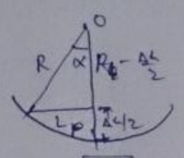
3. a) In a hot rolling operation, the thickness of a 80mm thick slab is to be reduced in a single pass using 600mm diameter rolls without any change in width. Determine the minimum possible exit thickness of the slab if i) $\mu = 0.4$ and ii) $\mu = 0$.

32.11mm 80mm

(4)

b) Show the variation of roll pressure along the arc of contact in cold rolling of strips and friction hill. (2)

(a) $h_0 = 80$ mm $R = 300$ mm, $\varepsilon_w = 0$



(i) $(\tan\alpha)_{max} = \mu$

if $\Delta h << R$

$\left[\frac{L_p}{R}\right]_{max} = \mu$ $L_p = \sqrt{R\Delta h}$ if $\Delta h << R$

$\Rightarrow \left(\sqrt{\frac{\Delta h}{R}}\right)_{max} = \mu \Rightarrow (\Delta h)_{max} = \mu^2 R$

$\Rightarrow 80mm - (h_f)_{min} = 48mm$ but we had assumed $\Delta h << R$

$\Rightarrow \boxed{(h_f)_{min} = 32mm}$ ×

(ii) $\mu = 0 \Rightarrow$ No Rolling

$(h_f)_{min} = 80$ mm

$\frac{R^2 - \left(R - \frac{\Delta h}{2}\right)^2}{\left(R - \frac{\Delta h}{2}\right)^2} = \mu^2$

$\Rightarrow \frac{R^2}{\left(R - \frac{\Delta h}{2}\right)^2} = 1 + \mu^2 = 1.16$

$\frac{R}{R - \frac{(\Delta h)_{max}}{2}} = 1.077$

b)