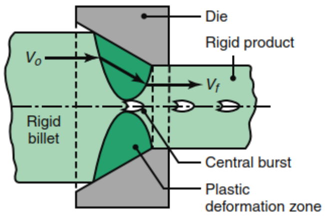
Indian Institute of Technology, Bombay / Department of Mechanical Engineering
ME 206 – Manufacturing Processes - I

Time:45 mins QUIZ - III Total Marks: 35 (5 x 4 + 3 x 5)

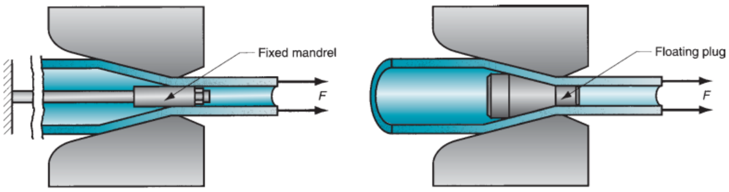
1. *"Center-burst" is a common defect in extrusion and following picture shows it schematically. State in three to four points how or why does this defect occur in extrusion.*



The center of the extruded product can develop cracks, called center cracking, center-burst, arrowhead fracture, or chevron cracking.

- Attributed to a state of hydrostatic tensile stress at the centerline in the deformation zone in the die.
- Increases if the two plastic zones do not meet, with increasing die angle, with increasing amount of impurities.
- Decreases with increasing extrusion ratio and friction.

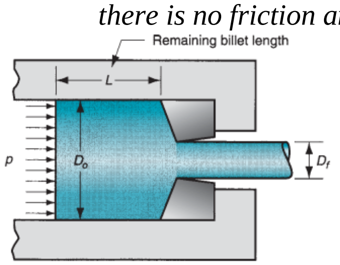
2. *Drawing of tubes is commonly done using either a fixed or a floating mandrel as shown below. Explain in four to five points the basic working principle for each and their relative merits / demerits.*



- Involves the process of pulling the tube to reduce either diameter or thickness with a fixed internal mandrel.
- Also, known as stationary mandrel drawing
- Slow process
- Gives the best inner surface finish

➢ The mandrel is held in by the friction forces between the mandrel and the tube.
➢ No external control on mandrel
➢ May change its position if the frictional condition changes, so tube thickness changes.
➢ Can be used for long length

3. *Following picture shows schematically the direct extrusion process. Explain in four to five points how can you derive the ram pressure required for extrusion in this case assuming ideal deformation (i.e. there is no friction and no redundant work).*



➢ Ideal deformation (no friction and no redundant work)
➢ True strain $\epsilon = \ln\left(\frac{A_0}{A_f}\right) = 2\ln\left(\frac{D_0}{D_f}\right)$
➢ Average flow stress during deformation $\bar{Y}_f$
➢ Ram pressure = $2\,\bar{Y}_f \ln\left(\frac{D_0}{D_f}\right)$

4. *What would be the maximum possible reduction in one pass in wire drawing operation if the workpiece material is assumed to be perfectly plastic (i.e. no strain hardening) and there is no friction between die and workpiece material and there is no redundant work?*

The expression for the *drawing force, F*, under *ideal and frictionless* conditions is given by the equation $F = Y_{avg} A_f \ln\left(\frac{A_0}{A_f}\right)$, Drawing stress $\sigma_d = Y_{avg} \ln\left(\frac{A_0}{A_f}\right)$

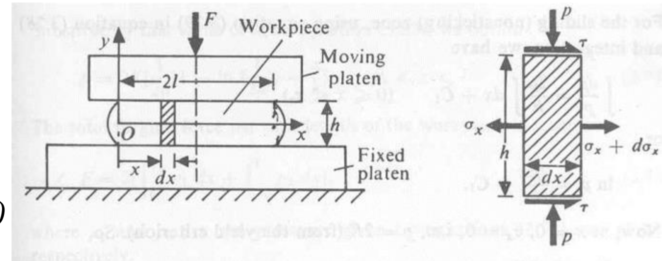
For perfectly plastic, $\sigma_d = Y_{avg}$, so $\ln\left(\frac{A_0}{A_f}\right) = 1,\ \frac{A_0}{A_f} = e$

Maximum possible reduction $R_{max} = \frac{A_0 - A_f}{A_0} = 1 - \frac{A_f}{A_0} = 1 - \frac{1}{e} = 63\%$

5. *For a typical open-die forging operation as shown below, the forging pressure in the sticking region (p_{st}) and sliding region (p_{sl}) are derived and given below. You should be able to figure out the meaning of each variable in the expressions and the drawing given.*

$$p = 2\tau_Y e^{\frac{2\mu x}{h}} \quad \textit{(pressure in sticking region)}$$

$$p = 2\tau_Y\left[\exp\left(\frac{2\mu x_s}{h}\right) + \frac{x - x_s}{h}\right] \quad \textit{(pressure in sliding region)}$$



(a) *State all the assumptions that are required to derive the expressions for forging pressure and add one point to explain the contribution of each assumption (why it is important or needed).*

(b) *Find out the expression for the sticking length (x_s).*

(c) *A strip of an alloy with initial dimensions 50 mm x 50 mm x 150 mm is forged between two flat dies to a final size of 25 mm x 100 mm x 150 mm. If the coefficient of friction between the workpiece and the dies is 0.20, determine the maximum forging force. The average yield stress of the alloy is 20 N/mm^2.*

(a) Assumptions:

- The forging force F attains maximum value at the end of the operation. This assumption gives a gradual increase in the load and reduces the effect of impact.
- The coefficient of friction μ between the workpiece and the dies is constant. This assumption is taken to avoid the non linearity in the solution.
- The thickness of the workpiece is small as compared to with its other dimensions, and the variation of the stress field along the y-direction is negligible. This assumption gives a 2D stress analysis.
- The length of the strip is much more than the width. This assumption makes the problem plane strain type.
- The entire workpiece is in the plastic state during the process. This assumption is taken to avoid the effect of elastic stress.

(b) If $p = p_s \ at\ x = x_s,\ then\ p_s = 2\tau_Y e^{\frac{2\mu x_s}{h}}$,

At $x = x_s, \tau = \mu p_s = \tau_Y$ $(as\ \tau = \mu p\ \ for\ 0 \le x \le x_s\ and\ \tau = \tau_Y\ for\ x_s \le x \le l)$

Hence $\mu p_s = \mu 2\cancel{\tau_Y} e^{\frac{2\mu x_s}{h}} = \cancel{\tau_Y}$

So $\frac{2\mu x_s}{h} = \ln\frac{1}{2\mu}$ $\quad Sliding\ length\ (x_s) = \frac{h}{2\mu}\ln\left(\frac{1}{2\mu}\right)$

(c) Shear yield stress $\tau_y = \frac{\sigma_y}{\sqrt{3}} = \frac{20}{\sqrt{3}} = 11.55\ \frac{N}{mm^2}$

Sliding length $x_s = \frac{25}{2 \times 0.20}\ln\left(\frac{1}{2 \times 0.20}\right) = 57.27\ mm$

Since x_s is more than l , the entire zone is sliding. So $p = 2\tau_Y e^{\frac{2\mu x}{h}}$ $(0 \le x \le 50)$

Force per unit length $F = 2\left[\int_0^l p\ dx\right] = 2\left[\int_0^{50} 2 \times 11.55 e^{\frac{2\times 0.20 \times x}{25}}\ dx\right] = 3538.75\frac{N}{mm}$

Since the length of the strip is 150 mm, the total forging force is 150x3538.75 = 5.3x10^5 N