questions

Wednesday, April 17, 2024 9:39 AM

Rolling

17.1 A 42.0-mm-thick plate made of low carbon steel is to be reduced to 34.0 mm in one pass in a rolling operation. As the thickness is reduced, the plate widens by 4%. The yield strength of the steel plate is 174 MPa and the tensile strength is 290 MPa. The entrance speed of the plate is 15.0 m/min. The roll radius is 325 mm and the rotational speed is 49.0 rev/min. Determine (a) the minimum required coefficient of friction that would make this rolling operation possible, (b) exit velocity of the plate, and (c) forward slip.

$t_o = 42mm \quad t = 34mm$

$w \to 4\% \quad \sigma_Y = 174 MPa$

$TS = 290 MPa \quad v_o = 15 m/min$

$R = 325mm \quad N = 49 rev/min$

a) $d_{max} = \mu^2 R$

$d = t_o - t_f = 42 - 34 = 8$

$8 = \mu^2 \times 325$ $\quad \boxed{\mu = 0.16}$

* In two drafts?

$\frac{8}{2} = 4 \quad d_{max} = 4 = \mu^2 \times 325$

$\boxed{\mu = 0.11}$

b) $t_o w_o v_o = t_f w_f v_f$

$\boxed{w_f = 0.04 w_o + w_o}$

$42 \times w_o \times 15 = 34 \times 1.04 w_o \times v_f$

$v_f = 17.81 \ m/min$

17.3 A series of cold rolling operations are to be used to reduce the thickness of a plate from 50 mm down to 25 mm in a reversing two-high mill. Roll diameter = 700 mm and coefficient of friction between rolls and work = 0.15. The specification is that the draft is to be equal on each pass. Determine (a) minimum number of passes required, and (b) draft for each pass?

$t_o = 50mm \quad t = 25mm$

$d = 700mm \quad \mu = 0.15$.

a) $d = t_o - t_f = 50 - 25 = 25mm$

$d_{max} = \mu^2 R = 0.15^2 \times 350 = 7.875$

$\frac{d_{tot}}{d_{max}} = \frac{25}{7.875} = 3.17 \simeq 4$.

b) $\frac{d_{tot}}{4} = \frac{25}{4} = 6.24 \ mm/pass$

17.7 A plate that is 250 mm wide and 25 mm thick is to be reduced in a single pass in a two-high rolling mill to a thickness of 20 mm. The roll has a radius = 500 mm, and its speed = 30 m/min. The work material has a strength coefficient = 240 MPa and a strain hardening exponent = 0.2. Determine (a) roll force, (b) roll torque, and (c) power required to accomplish this operation.

$W_o = 250mm \quad t_o = 25mm \quad t = 20mm$

$R = 500mm \quad v_o = 30 m/min$

$K = 240 MPa. \quad n = 0.2$

a) $F = \bar{Y}_f wL = 148.17 \times 250 \times 50 = 1852125 N$

$L = \sqrt{R(t_o - t)} = \sqrt{500(25-20)}$

$\bar{Y}_f = \frac{K\varepsilon^n}{1+n} = \frac{240 \times 0.22^{0.2}}{1+0.2} = 148.17 \ MPa$

$\varepsilon = \ln \frac{t_o}{t} = \ln \frac{25}{20} = 0.22$

b) $T = 0.5FL = 185\,2125 \times 0.5 \times 50 = 46\,303125$ N.m

c) $P = 2\pi N F L = 2\pi \times \frac{9.55 \text{ mm/min}}{60} \times 1.85\text{ MN} \times 0.05\text{ m} = 0.0925$ MW

$N = \frac{V}{2\pi R} = \frac{30 \times 10^3}{2\pi \times 500} = 9.55$ mm/min.

Forging

17.14 A cylindrical part is warm upset forged in an open die. The initial diameter is 45 mm and the initial height is 40 mm. The height after forging is 25 mm. The coefficient of friction at the die-work interface is 0.20. The yield strength of the work material is 285 MPa, and its flow curve is defined by a strength coefficient of 600 MPa and a strain-hardening exponent of 0.12. Determine the force in the operation (a) just as the yield point is reached (yield at strain = 0.002), (b) at a height of 35 mm, (c) at a height of 30 mm, and (d) at a height of 25 mm. Use of a spreadsheet calculator is recommended.

$d_o = 45$ mm $\quad h_o = 40$ mm $\quad h_f = 25$ mm

$\mu = 0.2 \quad \sigma_y = 285$ MPa

$K = 600$ MPa $\quad n = 0.12$

a) $F = K_f Y_f A =$ $\qquad$ 8.8 N

$K_f = 1 + \frac{0.4 \mu D_y}{h_y} = 1 + \frac{0.4 \times 0.2 \times 45.05}{39.8} = 1.091$

an important thing to remember is that ε at yield $= 0.002$

$\varepsilon = 2\ln \frac{d_f}{d_o} = 2 \times \ln \frac{d_y}{45} = 0.002$

$\frac{d_y}{45} = 1.001$ $\qquad$ $d_y = 45.05$ mm

$\varepsilon = \ln \frac{h_o}{h_f} = 0.002 = \ln \frac{40}{h_y}$ $\qquad$ $h_y = 39.8$ mm

$Y_f = K \varepsilon^n$

$600 \times 0.002^{0.12} = 284.63$ MPa.

$A =$ at yield $\frac{\pi}{4} \times 45.05^2 = 1593.97$ mm².

$F = 1.091 \times 284.63 \times 1593.97 = 494976$ N.

b) $h_f = 35\text{ mm}$

$$K_f = 1 + \frac{0.4\mu D}{h} = \frac{1 + 0.4 \times 0.2 \times 48.1}{35} = 1.11$$

$$\varepsilon = 2\ln\frac{d_f}{d_o} \rightarrow 2 \times \ln\frac{d_f}{45} = 0.134 \qquad \boxed{d_f = 48.1\text{ mm}}$$

$$\varepsilon = \ln\frac{h_o}{h_f} = \ln\frac{40}{35} = 0.134$$

$$Y_f = K\varepsilon^n = 600 \times 0.134^{0.12} = 471.42\text{ MPa}.$$

$$A = \frac{\pi}{4} \times 48.1^2 = 1817.11\text{ mm}^2.$$

$$F = 471.42 \times 1817.11 \times 1.11 = 950847.8\text{ N}.$$

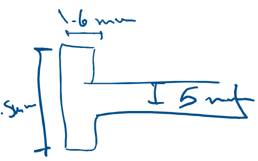
(c) and (d) same technique as (b)

Determine the plot of force vs. work height. Use of a spreadsheet calculator is recommended.

17.17 A cold heading operation is performed to produce the head on a steel nail. The strength coefficient for this steel is 600 MPa, and the strain hardening exponent is 0.22. Coefficient of friction at the die-work interface is 0.14. The wire stock out of which the nail is made is 5.00 mm in diameter. The head is to have a diameter of 9.5 mm and a thickness of 1.6 mm. The final length of the nail is 120 mm. (a) What length of stock must project out of the die in order to provide sufficient volume of material for this upsetting operation? (b) Compute the maximum force that the punch must apply to form the head in this open-die operation.

$K = 600\text{ MPa}$ $n = 0.22$ $\mu = 0.14$ $d_o = 5.00\text{ mm}$

$d_f = 9.5\text{ mm}$ $t_f = 1.6\text{ mm}$ $L_f = 120\text{ mm}$



a) $V_o = V_f$

$$A_o L_o = A_f L_f$$

$$\pi \times \left(\frac{5}{2}\right)^2 \times L_o = \pi \times \left(\frac{9.5}{2}\right)^2 \times 1.6$$

$$L_o = 5.776\text{ mm}.$$

b) $F = K_f Y_f A$

$K_f = 1 + \frac{0.4 \mu D}{h} = 1 + \frac{0.4 \times 0.14 \times 9.5}{1.6} = 1.33$ after yield

$Y_f = K \varepsilon^n = 600 \times 1.28^{0.22} = 633.89$

$\varepsilon = 2 \ln \frac{d_f}{d_0} = 2 \times \ln \frac{9.5}{5} = 1.28$

$A = \frac{\pi}{4} \times 9.5^2 = 70.88$

$= 1.33 \times 633.89 \times 70.88 = 59758.91$ N

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F =