MAE 212: Spring 2001

HW 9

Due Thursday, April 12, 2001

Problem 1

A material with a true stress-true strain curve of $\bar{\sigma} = 10,000\ \bar{\epsilon}^{0.5}$ psi is used in wire drawing. Assuming that friction and redundant work comprise a total of 40% of the ideal work of deformation, calculate the maximum reduction in cross-sectional area per unit pass that is possible.

Problem 2

Your company is planning a wire-drawing operation and you have been asked to determine how many drawing passes are required to reduce copper wire from 0.025 inches to 0.010 inches in diameter.

The dependence of deformation efficiency, η, on reduction per pass has been determined from laboratory experiments using the same die angle and lubrication that will be used in production. It is given as follows:

$$\eta = 0.333\epsilon_f + 0.683 \tag{1}$$

where ϵ_f is the final obtained strain per pass.

To be sure that no drawing failures occur, assume that the efficiency in production is 75% of that measured in the laboratory, and design the reduction schedule such that the drawing stress never exceeds 60% of the flow stress. Neglect work hardening.

Problem 3

A material with a true stress-true strain relation $\bar{\sigma} = 5,000 + 25,000\ \bar{\epsilon}$ psi is being drawn into a wire. If the original diameter of the wire is 0.2 in, what is the minimum possible diameter at the die exit? Assume no redundant work and that the frictional work is 25% of the ideal work of deformation.

Problem 4

A billet of an aluminum alloy is being hot extruded from a 4 inch diameter to a 1 inch diameter in a single stroke, as shown in the sketch. If the yield stress of the metal remains constant at 10 ksi (i.e., no work hardening) during the operation and the process efficiency, η, is 0.50,

1. What is the magnitude of the pressure needed to perform the operation?
2. Calculate the lateral pressure felt by the wall of the container (see sketch).
3. What is the minimum wall thickness, t, needed to prevent yielding of the container walls if the container is made of a metal whose yield strength is 100 ksi?

Problem 5

A coil of steel, 10 in wide by 1/8 in thick is to be drawn through dies of semi-angle 8^o to a final thickness of 0.100 in by a single pass. The outlet speed of the drawn strip is 50 ft/min, μ is about 0.06 and the average yield stress is $50,000$ psi. If any spreading of the width is negligible, determine the power required to make this reduction.

Problem 6

Plot the force versus reduction in height curve in open die forging of a cylindrical annealed copper specimen 1 in high and 1 in. in diameter, up to a reduction of 75% for the case of: (a) no friction between the flat dies and the specimen, (b) $\mu = 0.2$ and (c) $\mu = 0.4$.

Ignore barreling. For annealed copper, it is given that for a power law material model $K = 315$ MPa=$46,000$ psi and $n = 0.54$.

Problem 7

Consider axially symmetric wire drawing of a non-hardening material through a conical converging die. For small semi-die angles α, we can assume that inside the deformation zone the radial, circumferential and axial axes are fixed principal axes. To emphasize that σ_r is a compressive stress, we use the notation $\sigma_r = -p \leq 0$, where p =pressure.

1. Assume that the yield stress in tension is given as Y. Using the approximation $\sigma_r = \sigma_\theta$, show that according to the Mises criterion, yielding is initiated when

$$\sigma_r + p = Y \tag{2}$$

2. Analyze a slab of material in the deformation zone and using equilibrium of axial forces and the result of the previous question, show that:

$$\frac{dD}{D} = \frac{d\sigma_x}{2B\sigma_x - 2Y(1+B)} \tag{3}$$

3. Apply proper boundary conditions and calculate the drawing stress σ_d in terms of the homogeneous strain $\epsilon_h = 2\ell n\frac{D_o}{D_f}$.

4. Show that you results in the question above coincide with those of the ideal work method in the case of negligible friction.

5. Derive an analytical expression for the die pressure in wire drawing, without friction or redundant work, as a function of the diameter in the deformation zone.

Problem 8

What is the value of the die pressure at the exit when an ideal drawing operation is being carried out at the maximum theoretical reduction per pass?

Problem 9

Give an approximate plot of the individual contributions of ideal, w_i, frictional, w_f, and redundant work, w_r, during drawing versus the semi-die angle α. Then show the influence of the semi-die angle on the actual work, $w_a = w_i + w_f + w_r$.