ME-206
HW#3
Instructor: Prof. Ramesh Singh

Assigned March 22, 2022
Due March 29, 2022

1. Find the expression of the average forging pressure and forging force for plane strain forging of blocks having initial height h to a final height of h/2. There are two cases shown in the Fig.1. Assume all sliding conditions and coefficient of friction as μ. Also check the results with approximate average pressure formula for pure sliding. Which one is higher? Please provide a physical explanation.

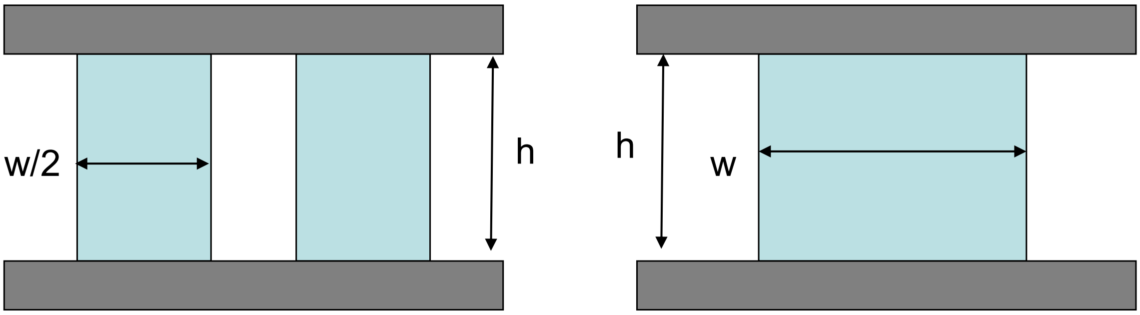

Fig. 1. Dimensions of the blocks for forging

2. Ball bearing balls are formed cold from wire stock in a closed-die (see Fig. 2). Consider a ball of 0.2 in. in diameter made from wire having an initial diameter of 0.15 in. The variation in length of the wire slug sheared from the rod is ± 3%. This gives rise to the variation in flash. The slug length is adjusted so that at its maximum length, the cavity is just filled and maximum flash thickness is 0.005 in.
   a. Find the maximum flash length
   b. If the average flow stress, τ_{flow} = 60,000 psi and a coefficient of friction is 0.1, estimate the maximum forging force.

   State all your assumptions in solving the problem.

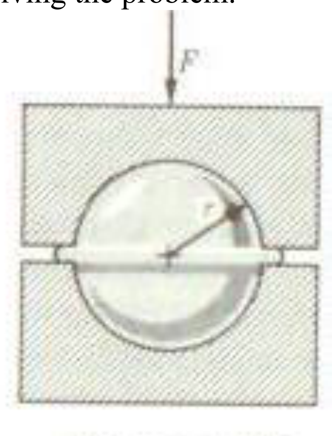

Fig. 2. Ball forging

3. You are cold upset forging a cylinder of steel that has K = 250 MPa and n = 0.13. The initial cylinder is 25 mm in height and 600 mm in diameter. It is being reduced to half its height between flat dies.

a. Derive the expression for the sticking-sliding transition and write the pressure equations in both the zones. Plot the pressure profile on the cylinder.
b. Determine the maximum force required, if the coefficient of friction is 0.4.
c. Determine the extra force required over what would be needed if no friction were present.
d. Compute the average pressure and force required when it is all sticking.
e. If the process takes 3 seconds, and the efficiency is 40 percent, determine the power required for part (a).

4. Given that for hot forging the flow stress relationship is $Y_f = C\left(\dot{\varepsilon}\right)^m$. Use $\dot{\varepsilon}$ = V/h where V is the velocity and h is the final height. You are hot forging a piece of steel (C = 45 MPa, m = 0.1). Its initial size is 1 m (height) by 300 mm (width), by 2 m (long, i.e. into the paper). Its final height is 200 mm. The platens move at 10 m/min. The coefficient of friction is 0.15.
   a. Check for sliding or sticking condition and is there any transition.
   b. Determine the forging force and power.
   c. For a safety factor of 3, determine the yield strength of the die.

5. If there is a sticking/sliding transition in plane strain forging, how will you account for it? Show the pressure distribution plot in sliding and sticking region. Explain how you will get the forging loads with the equations. Do not do the integration just write the pressure equation for both the regions with the limits.

6. Starting from drawing stress for large die angle α given in slide 15, derive the equation for small die angles.

7. A round wire made of perfectly plastic material with a yield stress of 30,000 psi is drawn from 0.1" to 0.07" in a draw die of 15^0. Let the coefficient of friction be 0.1. Use ideal deformation approximation and the drawing stress equation to estimate the drawing forces. Comment on any differences in your answer.

8. You are cold, forward extruding a metal from an initial diameter of 75 mm to a final diameter of 20 mm. The initial length of the billet is 2 m. The metal has K = 965 MPa, and n = 0.19. The die angle is 90 degrees.

- Determine the maximum power for an extrusion velocity of 1.5 m/s.
- The die can be used until its diameter wears 10%. Determine how this will affect your answer.

9. A round wire is drawn from 2.5 mm to 1.8 mm under ideal deformation conditions i.e. without any friction and redundant work. The **average flow (yield) stress** of a linearly hardening material is given by: $\overline{Y_f}(N/mm^2) = 207 + 414\varepsilon$
   a. Determine the actual flow stress of the material
   b. Estimate the ideal drawing force for the linearly hardening material and maximum allowable reduction per pass for the linearly hardening material. Is the maximum allowable reduction for this material higher than a perfectly plastic material? If yes, why?

10. For the conditions mentioned in Q. 10, if the actual flow stress of the material is given by: $Y_f(N/mm^2) = 207 + 414\varepsilon$,
    a. Find the average flow stress

b. Find the ideal drawing and maximum allowable reduction per pass
c. Find the drawing stress and maximum allowable reduction accounting for friction (Note: you may need to use Mathematica or a numerical technique to solve it)
d. Find the drawing stress and maximum allowable reduction accounting for friction and redundant work (Note: you may need to use Mathematica or a numerical technique to solve it)