ME-230

HW#2 (Drawing, Rolling and Extrusion)

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Assigned: Feb 13, 2026

Due: Feb 20, 2026

1. 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.

2. Find the drawing stresses if the same process given in with a die angle of 5^0. Compare the solutions of the slab method (accounting for friction and redundant work) for general solution and small dies given on Slide 16.

3. A round wire is drawn from 2.5 mm to 1.8 mm in a draw die of 15°. The coefficient of friction be 0.1. Use ideal deformation approximation and the drawing stress obtained via a slab method (accounting for friction and redundant work) to estimate the drawing forces for conditions given in a and b.
   a. Perfectly plastic material with a yield stress of 207 MPa
   b. If the yield stress is given by $Y_f = 207 + 414\ \varepsilon$
   c. Find the maximum allowable reduction per pass for $Y_f = 207 + 414\ \varepsilon$

4. 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.

5. 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?

6. 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 maximum allowable reduction per pass and drawing stress.
   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)

7. Derive the approximate solution for average pressure, roll separation force, torque and power rolling based on open die forging. Assume that the material is perfectly plastic and use numbers given in Q7 to compare it with exact forces, torque and power by integrating the solutions in entry and exit zones.
Use Mathematica or Matlab if you have access to it. You can also use plain old excel to do numerical integration if you do not access to these on your computer. Assume instantaneous height h in the deformation zone is given by,

$$h = h_f + R \cdot \phi^2$$

8. A 5 mm thick Al-alloy strip is rolled to a thickness of 4 mm using steel rollers of radius 100 mm. The tensile yield stress of the material is 0.28 KN/mm^2 Determine:
- The minimum coefficient of friction μ_{min} between the strip and the rolls for an unaided bite to be possible
- The angle subtended by the contact zone at the roll center
- The location of neutral point with $\mu = \mu_{min}$

9. A 75 mm thick by 250 mm wide slab of AISI 4135 steel is being **cold-rolled** to a thickness of 60 mm **in a single pass**. Assume the coefficient of friction $\mu = 0.2$. Is the desired reduction feasible without any external force? A two-high non-reversing rolling mill (shown below) with 750 mm diameter rolls made of tool steel is available for this task. The rolling mill has a power capacity of 5 MW per roll. The rolls rotate at a constant angular speed of 100 rpm. The steel work material has the following flow curve at the rolling temperature: $\sigma_t = 800\varepsilon_t^{0.14}$ MPa. Is the available rolling mill adequate for the desired operation?