ME 206
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HW#5 (For practice only to be submitted by folks needing extra credit)

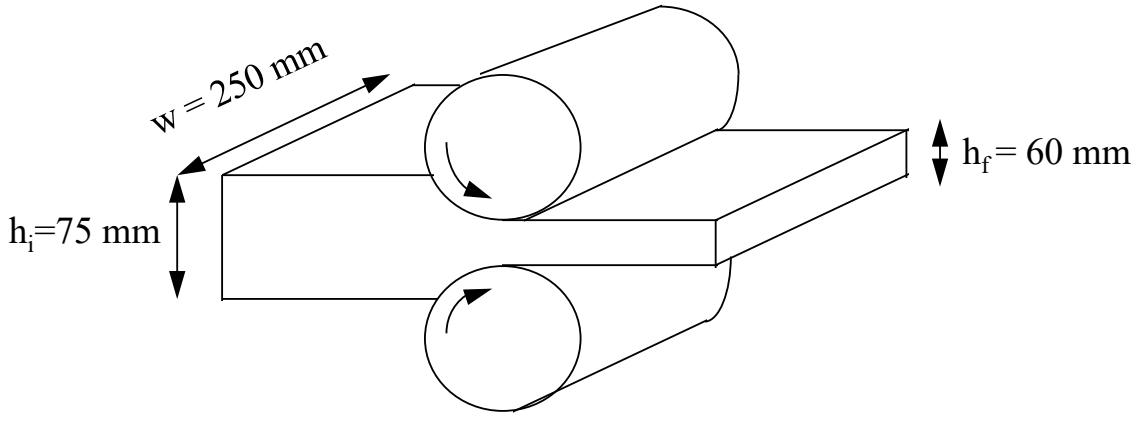
Rolling

1. 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 Q2 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,

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

2. 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 $\mu = \mu_{min}$

3. 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 μ = 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?



Sheet Metal Forming

4. Why is the bending force in $P_{max} = \frac{kYLT^2}{W} \approx k\frac{(UTS)LT^2}{W}$ proportional to t^2. Show from bending stress equations.
5. A cylindrical cup is drawn from the sheet metal that has a normal anisotropy of 3. Estimate the maximum ratio of cup height to cup diameter that can be successfully drawn in single draw. Assume that the thickness of the sheet throughout the cup remains the same as the original blank thickness.
6. Find the maximum bending force required for a 1/8" thick and 12" wide Ti-5Al-2.5Sn Titanium alloy in a V-die with a width of 6".
7. For the material mentioned problem 3, estimate the force required for deep drawing with a blank diameter of 10" and a punch diameter of 9".

Polymer Processing

8. An extruder has a barrel with an inside diameter of 30 mm and rotates at 50 rpm (for simplicity, assume that the barrel rotates). The screw has a channel depth of 4 mm, a channel width of 20 mm, and a flight angle of 18 degrees. The pumping section of the screw is 1.25 m long, and is used to extrude a flat polyethylene sheet. When melted, the polyethylene has a viscosity of 80 N-s/m^2. The die has a thickness of 2 mm, a width of 75 mm and is 25 mm long. In other words, the resulting sheet is 2 mm thick and 75 mm wide. Determine the speed of the sheet through the die.
9. An injection molding machine has a barrel diameter of 25 mm and rotates at 75 rpm (for simplicity, assume the barrel rotates). The reciprocating screw has a channel depth of 5 mm, a channel width of 20 mm, and a flight angle of 18 degrees. The pumping section of the screw is 1 m long. Determine the back pressure required to make a shot with a volume of 20 cm^3 in 10 seconds for a polymer with a viscosity of 150 N-s/m^2.