Plastic Deformation, Forging & Rolling

1. Kalpakjian & Schmid Prob. 2.47 (5th Ed). This is the same as Prob. 2.53 in the 4th Edition, except change wire diameter from 1.25 mm to 1.20 mm.

2. Take a cubic piece of metal with a length of the sides of $l_0$ and deform it plastically to the shape of a rectangular parallelepiped of dimensions $l_1$, $l_2$ and $l_3$. Assuming that the material is rigid, perfectly plastic, show that volume constancy requires that the following expression be satisfied:

$$
\epsilon_1 + \epsilon_2 + \epsilon_3 = 0
$$

3. Show that the effective strain for a plastically deformed material in a state of plane strain is:

$$
\epsilon_e = \frac{2}{\sqrt{3}} \epsilon_1
$$

*Hint:* You will need to apply the result of Problem 2.

4. A 25 mm diameter, 25 mm high solid bar of AISI 4135 annealed steel is reduced to a height of 20 mm in an open die forging process. We will make all estimates below by assuming the forging process to be frictionless.

   (a) What is the *engineering* strain?
   (b) What is the *true* strain?
   (c) What is the final diameter of the forged bar?
   (d) Estimate the maximum forging force (assuming power law strain hardening).
   (e) Estimate the total work.

5. A 0.5 m wide sheet of 5052-O aluminum is reduced in thickness from 6 mm to 4 mm in two passes through a rolling mill. The thickness is reduced 1.0 mm during each pass. The roll diameter is 250 mm. The initial sheet is 1 m long. We will neglect the effects of friction in our rolling model.

   (a) Estimate the roll separating force on the first pass.
   (b) Estimate the roll separating force on the second pass.
   (c) Estimate the length of the 4 mm thick sheet.