2.810 - Solutions
Fall 2013, revised Oct 23, 2013
Homework: Sheet Forming Problems 1 & 2

1a
Burr height increases with increasing clearance and increasing ductility of the metal. Tools with dull edges are also a major factor in burr formation. To reduce burrs, one should make sure that the clearance is minimized and that the tools are sharp. In addition, since ductility has an effect, shearing at high speeds or low temperatures will decease burr formation.

1b
Scissors cut by a shearing process, which is why they are sometimes referred to as hears. The material being cut is subjected to shear stresses at the intersection of the two blades of the scissors. Because shearing takes place in a small localized region, low forces are required to cut with scissors. The shearing process involves surface cracks propagating through the material until separation occurs. The clearance between the two blades is important or else the material may merely by pulled into the gap between the two blades.

1c
The punch force, P, is basically the product of the shear strength of the sheet-metal and the cross-sectional area being sheared. However, friction between the punch and the workpiece can substantially increase this force. An approximate empirical formula for calculating the maximum punch force is given by

$$P = 0.7(UTS)(t)(L)$$

Where UTS is the material's ultimate tensile strength, t is part thickness, and L is the total length of the sheared edge.

1d
Recall the result for springback in bending as given below. The first term on the rhs is the max springback, and the second term is a correction that reduces springback to less than the max.

$$\left[\frac{1}{R_0}-\frac{1}{R_1}\right]=3\frac{Y}{hE}-4R_0^2\left(\frac{Y}{hE}\right)^3$$

Hence springback increases with increasing Y/hE and decreases with increasing Ro.

1e
Circles in the plane of the sheet which undergo deformation will become ellipses. The major axis of the ellipse as compared to the original circle diameter will indicate the major engineering strain, and the minor axis as compared to the original diameter will

give the minor engineering strain. The smaller the circle diameter, the more one can concentrate in a narrow region of the formed sheet-metal part. Thus, better accuracy is obtained in calculating the strains involved and in the use of forming-limit diagrams.

1f

The beads are placed to restrict metal flow in the areas where it flows most easily. Generally, the sheet metal will flow in more easily along the edges of the die rather than at the corners.

1g

This is from observations in mechanics of solids; the bending stress formula in beams is $\sigma = \frac{Mc}{I}$, where I is the moment of inertia and is proportional to T^3, and c = T/2. Thus, for a material of certain strength σ, the bending force, P, is proportional to T^3.

1h

(a) Aluminum foil – produced by rolling two sheets at once as evidenced by the difference in the two surface finish; one surface is shiny (roll side), the other is dull (facing the other sheet). The foil can be cut to desired widths and lengths in slitting lines.

(b) Housing for appliances such as refrigerators, washers, an dryers – produced by rolled sheet stock, then leveled and slit to desired dimensions.

(c) Baking pans – rolled stock, then drawn or stamped to final dimensions, edges trimmed and turned in.

Problem 2 Spring back is larger for materials with larger values of Y/E.

Materials ranked in terms of their Spring Back behavior

	E[GPa]	Y[MPa]	Y/E
Ti	105	862	8.2×10^{-3}
Mg	43	218	5.1×10^{-3}
Steel	195	965	5.0×10^{-3}
Cu	128	588	4.6×10^{-3}
Al	74	293	4.0×10^{-3}
Ni	197	653	3.3×10^{-3}
Mo	345	1075	3.1×10^{-3}
W	375	620	1.7×10^{-3}
Pb	14	14	1.0×10^{-3}

Note: The values in this Table are averaged and therefore can deviate considerably.

Example: Mild Steel can have a yield strength of approx. 350MPa, which leads to a Y/E ratio of 1.53. 10^{-3} a value even smaller than the one for Tungsten (W).