

## Solution Homework #5: Springback

2.008 Design and Manufacturing II  
Spring 2004

Out: March 31<sup>st</sup>  
Due: April 07<sup>th</sup>

### Problem 1

As demonstrated in class, springback is a problem which must be addressed when bending sheet metal. It occurs because there is always an elastic region (albeit, sometimes very small) within the sheet which wants to return to its original state after the bending operation. The springback of the bent sheet can be approximated using the expression

$$\frac{R_i}{R_f} = 4 \left( \frac{R_i Y}{ET} \right)^3 - 3 \left( \frac{R_i Y}{ET} \right) + 1 \quad (1)$$

where, as shown in Figure 1,  $R_i$  and  $R_f$  are the initial and final bend radii,  $Y$  is the yield strength and  $E$  is the elastic modulus of the metal, and  $T$  is the thickness of the sheet. As illustrated in Figure 1, the main effects of springback are that the final radius of curvature is larger than the initial radius and the final bend angle,  $\alpha_f$ , is smaller than the initial angle,  $\alpha_i$ . One approach to compensate for springback is to overbend the part (i.e., bend the sheet more than you want, hoping that it will spring back to the desired shape). Consider the bending of an aluminium sheet (Al 1200-O) with  $Y=5075$  psi,  $E=10^6$  psi, and  $T=1/8$  in.

- Which case will result in more springback:  $R_i = 1$  in or  $R_i = 2$  in? Why?
- You are given a sketch of the setup for bending operation as shown in Figure 2. The target angle for the bend is  $90^\circ$  and  $R_i = 2$  in. The process engineers aren't certain how much of an angle to specify for the initial bend. After assuming that the length of the bent region of the sheet,  $s$ , stays constant and doing some geometry, they used Eq. 1 to find that the difference between the initial and final bend angles will be approximately  $2^\circ$ . What value should they specify for  $\theta$ ?

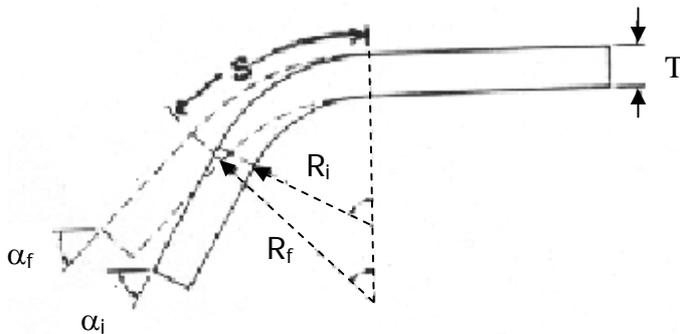


Figure 1: schematic of springback bending

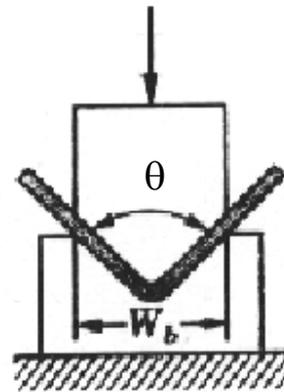


Figure 2: sketch of V-die bending

## Solution

a)

$$R_i = 1 \text{ in: } \frac{R_i}{R_f} = 4 \left( \frac{R_i Y}{ET} \right)^3 - 3 \left( \frac{R_i Y}{ET} \right) + 1 = 0.88$$

$$R_i = 2 \text{ in: } \frac{R_i}{R_f} = 4 \left( \frac{R_i Y}{ET} \right)^3 - 3 \left( \frac{R_i Y}{ET} \right) + 1 = 0.76$$

Calculating the ratio of the initial and final radii reveals that springback increases with increased  $R_i$ . From looking at the equation we see that increasing  $R_i$  (while keeping everything else constant) has the same effect as increasing  $Y$  (Yield Strength) or decreasing  $E$  (Young's Modulus), which will clearly lead to a greater springback. This makes sense because a bigger initial radius means that the stress in the material due to bending will be lower and therefore the ratio plastic deformation vs. elastic deformation will be smaller which leads to a greater springback.

β)

We want to overbend the part to compensate for the springback. Thus  $\theta$  should be  $88^\circ$ .