

Homework #5 Design for Additivity

Due Date: Thursday, June 18, 1:05, 4-149

Objectives:

- Explore the effect of the choice of system response on the accuracy of an additive model of a system
- Reinforce material from earlier sessions

Assignment

The figure below depicts a side view of an electronic package. The ribbon leads are formed in a die into a leg shape (the industry uses a set of anthropomorphic terms as defined in Figure 1). The problem is that the yield strength of the leads varies by $\pm 10\%$ about its nominal value of 200MPa. This tends to make the spring-back of the ribbon lead during the forming process inconsistent and hence the air gap is inconsistent. This is a problem as the air gap is filled with thermally conductive material. If the air gap is too small, the fill material will overflow from the bottom of the package and foul the contacts. If the air gap is too great, there will be insufficient area covered by conductive material. You have been given the task of making this process more robust to the variation in yield strength of the lead material and thereby reducing quality problems. See the next page for details.

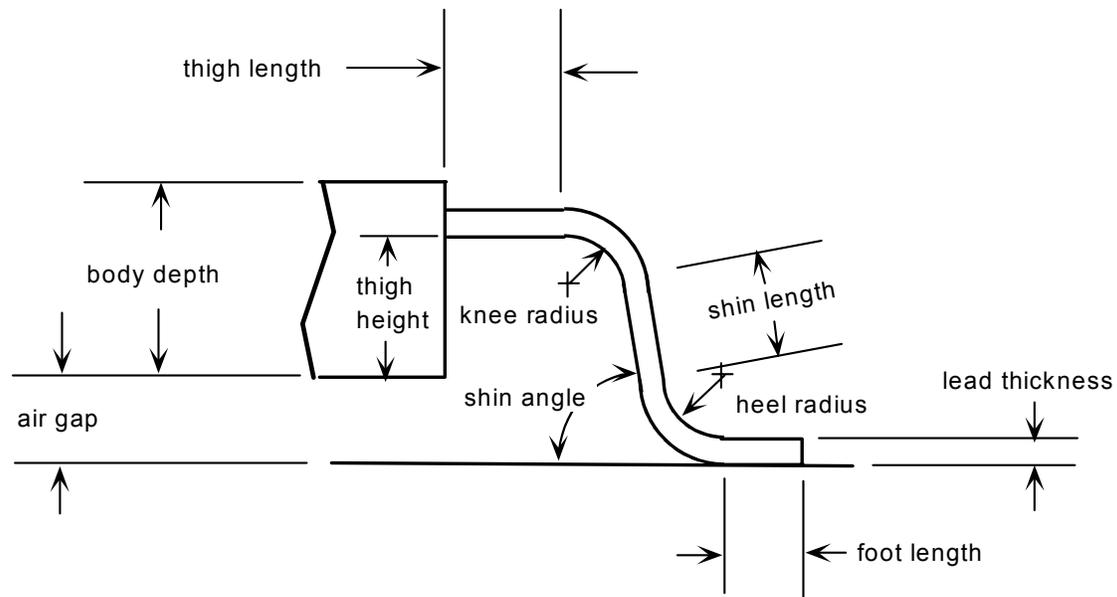


Figure 1 -- Terminology for ribbon leads.

You have been told that **you may vary** the following parameters within the following ranges:

Thickness of the lead material $t = 0.1\text{mm}$ to 0.2mm

Initial radius of the knee bend $R_i = 1\text{mm}$ to 2mm

Initial knee angle $\Theta_o = 80^\circ$ to 120° (see Fig. 2 below)

Elastic modulus of the lead material $E = 90\text{Gpa}$ to 110Gpa

Shin length = 1mm - 4mm

The other parameters of the problem are **fixed**:

Air gap (desired) = $0.5\text{ mm} \pm 0.2\text{mm}$ ($\Delta_o=0.2\text{mm}$)

Cost to rework a ribbon lead $A_o=\$0.50$

Thigh length = 2mm

Body depth = 2mm

Thigh height = 2mm

Foot length = 2 mm

Shin angle is always equal to knee angle

Heel radius is always equal to knee radius

To simplify your analysis, you may wish to neglect the spring-back in the heel bend and focus on only the spring-back in the knee. You may assume that the springback of the knee bend is governed by the equation

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

- Estimate the quality loss in the system if each control factor is at the middle of its allowable range.
- Evaluate the significance of interaction between the control factors t and R_i if **variance in air gap** is defined as the response of the system.
- Evaluate the significance of interaction between the control factors t and R_i if **percent conforming to air gap specification** is defined as the response of the system.
- Evaluate the significance of interaction between the control factors t and R_i if **20 log(mean air gap/variance in air gap)** is defined as the response of the system.
- How does the choice of initial knee angle affect the robustness of this system? Support your conclusion with some common sense engineering reasoning or a more formal model of the system.
- Which control factor settings will you choose.
- What is the quality loss in the system at your chosen settings.

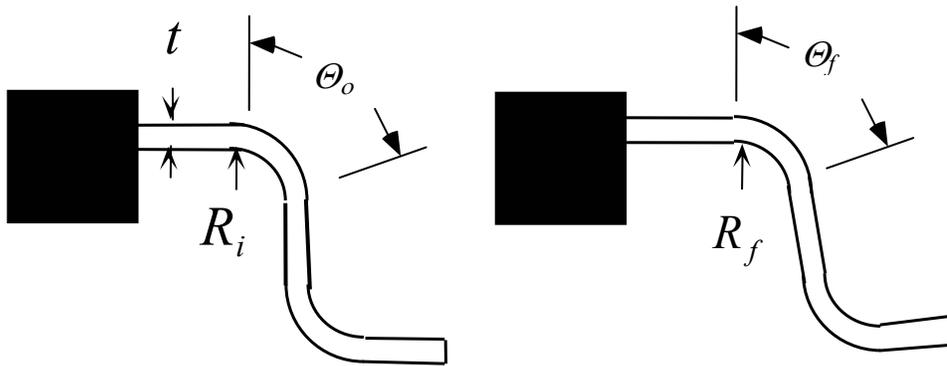


Figure 2 -- Spring-back in the knee bend of a ribbon lead.