THE UNIVERSITY OF UTAH

ME 3000 Design of Mechanical Elements **Prof. B. Raeymaekers**

Homework #2: Material selection **Spring 2016**

Instructions

*This homework was **assigned on 01/22/16** and your hard-copy solution is **due on 01/29/16** at 5 pm in the ME front office. Show your work, no credit will be given for the solution only. Include a print out of your Matlab code if applicable (with comments).*

PROBLEM 1:

Your material supplier has provided you with data on three materials that you wish to evaluate for use in a product. The three .txt files "LE1.txt", "LE2.txt", and "LE3.txt" contain the load-extension information. The first column of each text file contains the displacement in mm, whereas the second column contains the load in kN. The original length and diameter of all test specimens used by your material supplier to obtain this data is L_0 = 200 mm, and D_0 = 20 mm.

a) Plot the load-extension curves of the three materials in one graph. Properly format the figure following the guidelines outlined in Problem 1 of HW1, and identify the different curves in the graph corresponding to the respective .txt file number.
b) Derive the engineering stress-strain curves from the load-extension information. Plot the engineering stress-strain curves of the three materials in one graph.
c) Calculate the Young's modulus, the ultimate tensile strength, the toughness modulus, and the resilience modulus for each of the three materials, and summarize them in a table. *Hint: To calculate the modulus of toughness and resilience, use a trapezoidal integration in Matlab ("trapz" function), to compute the appropriate area underneath the stress-strain curve.*

Hand in:

- One properly formatted graph with three load-extension curves.
- One properly formatted graph with three stress-strain curves.
- Values of the requested metrics listed in a table.
- Include your Matlab code.

PROBLEM 2:

Consider a rod of 1144 annealed steel. The rod is 500 mm long, and has a circular cross-section with a diameter of 20 mm.

a) Calculate the yield stress and the ultimate strength if 2.5% cold work is applied to the rod? How long is the rod after applying 2.5% cold work?

Hand in:

- Yield stress and ultimate strength after cold work, length of rod after cold work.

b) What is the minimum amount of cold work that must be applied to the material to obtain strain hardening?

Hand in:

- Minimum amount of cold work calculation.

c) Use Matlab to plot a graph that displays yield stress (y-axis) versus amount of cold work (x-axis), for $\varepsilon_i \leq m$

Hand in:
- Graph.
- Matlab code.

d) What is the yield stress that is obtained after cold working this rod with $\varepsilon_i = m$? How much cold work does that state correspond to?

Hand in:
- Yield stress for $\varepsilon_i = m$.
- Amount of cold work W.

PROBLEM 3:

Consider a plate of 304 stainless steel measuring W = 20 mm, L = 40 mm and 5 mm thick (McMaster Part ID 5378T15).

a) If the plate is axially loaded with 15,000 N, what is the implied safety factor of this design?

Hand in:
- Implied safety factor of the original design.

b) How much cold work must be applied to this material, such that the safety factor is doubled?

Hand in:
- Amount of cold work that must be performed on the specimen to double the original safety factor.

c) If no cold work is performed on the plate, which 304 stainless steel plate would you purchase from McMaster to achieve a safety factor that is equal or higher than the one used in (b)? (but only as high as necessary, i.e., minimize the cost).

Hand in:
- Product ID of alternate part without cold work.

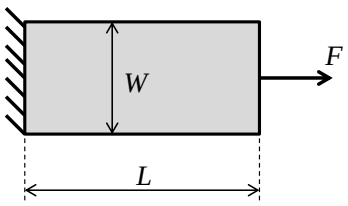

Figure 2: Axially loaded plate

Hint: If conflicting information about material properties exists (different sources/tables), you always use the properties listed in the catalogue of the materials you will purchase/use.