Written Manufacturing
Doctoral Qualifying Examination

May 2003

Instructions:

This is an Open Book Examination.

Please state all assumptions and write clearly.

Please be to-the-point. This exam can be completed within an hour if you keep things simple and budget time carefully.

Good luck!
Question 1: Cutting

a. What are the SI units of specific energy of cutting? Describe the physical basis of specific energy. How is it related to other material properties. How is specific energy related to hardness (and why)?

b. You are required to cut 10 mm thick discs of diameter 400 mm out of 10 mm plate-stock which has been pre-cut to 500 mm by 500 mm squares as shown below.

![Diagram of 400 mm diameter circle within a 500 mm square]

i) Say you need one part. Come up with a plan for machining the discs out of the stock on a CNC machine tool, and one alternative process plan on any other machine/process you can think of. The process plans must include hand-sketches of fixturing, including how you might fixture the part.

ii) Assuming any material constants you think deem necessary in symbolic form ($E$, $Y$, etc., you define them) compare the energies required per part for each of the two processes.

iii) Now, say you need 100 parts. Which plan would you chose?

iv) Now, say that the finish that we require on the circumference is relatively high. Which plan would you prefer? Would you consider some third machine or process?

Question 2: Bending

Consider bending. You are given a rectangular strip of 6061 T6 Aluminum with dimensions 150 mm x 10 mm x 2 mm. You are asked to bend the right half of the strip, including the very end of the strip, into a curve of radius 20 mm. The dimensions are given to you for a sense of scale – you don’t actually need them to solve the problem below.

i. Sketch out a process plan.
ii. A persnickety professor claims that it is difficult to bend the end of a beam, \( i.e., \)
to impart a curvature. Using basic beam bending analysis, explain why this might 
be the case.

iii. How does the above thinking change the process plan?

iv. increase or decrease when the yield strength increases? Why? (One sentence 
physical intuition)

Question 3: Variation

Explain in a couple of paragraphs what the underlying thinking is behind statistical process 
control. Specifically, why is a mean shift more tolerable than variation? How would you go 
about fixing either of the problems? Where does random variation come from?