2.830J / 6.780J / ESD.63J Control of Manufacturing Processes (SMA 6303)
Spring 2008

Massachusetts Institute of Technology

Department of Mechanical Engineering
Department of Electrical Engineering and Computer Science

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Assignment 2
Out 2/14/2008; due Tuesday 2/26/2008

Problem 1

This is an exercise to reinforce the process-modeling ideas introduced so far in the course, and to help you to start thinking about possible topics for the term project.

Either

Write approximately a page describing a manufacturability or process-control challenge that you've encountered during your professional or research activities. As far as any confidentiality commitments allow, describe the process(es) and its/their sources of variation. Use the framework of the process model set out in Lecture 3. Discuss any approaches that you took to aid manufacturability, such as (i) modeling variation in the process(es), (ii) tackling sources of variation, (iii) refining the process(es) to make them more robust to input variations, or (iv) actively controlling the process(es). What, if any, are the remaining questions surrounding variability of the output? It would be helpful to describe also the extent and nature of any relevant data to which you have access.

Or

Peruse one of the following journals — or another of your choice — and select an article addressing a manufacturability or process-control challenge that interests you. Write about a page discussing the process(es) used in the work and its/their sources of variation. Use the framework of the process model set out in Lecture 3. Assess any approaches that were taken by the authors to (i) model the process(es) and their variation, (ii) tackle sources of variation, (iii) make the process(es) more robust to variation, or (iv) actively control the process(es). If you had been doing the research, would you have tried any alternative approaches?

Possible sources include:
IEEE Transactions on Semiconductor Manufacturing;
Materials and Manufacturing Processes (Taylor and Francis);
International Journal of Advanced Manufacturing Technology (Elsevier).

Points to consider, whether you choose to write about your own experience or about other published research:

a) What are the key 'quality' characteristics of the output from the process(es)?
b) Categorize the process(es) used by their transformation mode (addition, deformation…), the relevant energy domain (mechanical, chemical…), and whether the material–equipment interaction is 'serial' or 'parallel'.
c) What are the key process parameters? Give equipment states/properties and material states/properties. For equipment and material *states*, list the appropriate power and energy variables.
d) What variable(s) are typically used to control the process(es)?
e) What variables cause variation in the output and why?
f) How were the process(es) controlled to achieve the desired geometry/final physical properties?
g) Draw a block diagram of the equipment and material, showing the inputs, parameters, energy transfer and output(s).

Problem 2

May and Spanos problem 4.3

Problem 3

May and Spanos problem 4.5

Problem 4

This problem is related to data taken in an earlier year's lab. To become familiar with that lab, please first view a short video overview of the lab. This video is labeled `2-4.rm' and is entitled 'Control Lab Video'. The video, along with an Excel file containing data from the lab (`2-4.xls'), can be found under the 'Problem Sets' heading in the 'Materials' section of the website.

For two of the processes — sheet shearing and injection molding — we are interested in answering a few questions.

For the sheet shearing data:

a) Are the data well described by a normal distribution? (To determine this, please include a frequency histogram, a measure of the skewness and kurtosis of the data, and a qq or normal probability plot*.)
b) Is there any evidence of a consistent taper in the parts?
c) Does the process appear stationary?

For the injection molding, where the data span a number of different machine settings:

d) Is the entire dataset well described by a normal distribution? (To determine this, again please include a frequency histogram, a measure of the skewness and kurtosis of the data, and a qq or normal probability plot.)
e) If instead we consider datasets from each of the four process settings, do the data look more or less normal than in part d)? (Be sure to determine the sample mean and variance for each condition as well as performing the normality tests.)
f) Looking at the two extremes of low hold–low velocity and high hold–high velocity, what evidence have you of a significant difference in the mean output between these two operating points?

* These functions are all available in the MATLAB Statistics Toolbox. All but the qq-plot are in Excel, and may also be found in Minitab or JMP.