MIT 2.810 Manufacturing Processes and Systems

Fall 2013

Homework 8

November 6, 2013

Problem 1 [adapted from Montgomery, Introduction to Statistical Quality Control, 7th edition]
Process Capability

We are studying two processes for machining a part. Process A produces parts which have a mean length of 100 and a standard deviation of 3. Process B produces parts which have a mean length of 105 and standard deviation 1. The design specifications for the part are 100 ± 10. Calculate:

1. C_p for each process,
2. C_{pk} for each process,
3. The percentage of parts which are out of specification limits for each process. State the assumptions you need to make to estimate this percentage.

Problem 2 [adapted from Montgomery, Introduction to Statistical Quality Control, 7th edition]
Process Capability and Tolerance Stack-up

Suppose that 20 parts manufactured by the processes in problem 1 were assembled so that their dimensions were additive. That is,

$$L = L_1 + L_2 + \ldots + L_{20}$$

The specifications on the final length are 2000 ± 200. Which process would you prefer to produce the parts? Why? Do the process capability indices provide any guidance in selecting the process?

Problem 3
Interchangeable Parts

A shaft and bearing pair that are assembled into a single unit are manufactured as follows. The shaft has diameter that is normally distributed with mean 1.0 in. and standard deviation 0.003 in.

The bearing has inside diameter normally distributed with mean 1.01 in. and standard deviation 0.004 in.

1. If the bearing and shaft that are to be assembled are selected at random, what is the probability that they will not fit?
2. If instead we want a fit with at least 0.002 in. clearance, how must the standard deviation of the bearing change such that 99% of the assemblies will succeed?

Problem 4 [adapted from Montgomery, Introduction to Statistical Quality Control, 7th edition]
Control Charts

We are monitoring a process by plotting x-bar and S charts. Table 1 shows the measurement data from 25 samples, each of size 6. Plot x-bar and S charts for this data[1]. Is the process in control?

Sample Number	Observation					
	1	2	3	4	5	6
1	1.324	1.413	1.674	1.457	1.691	1.515
2	1.431	1.359	1.608	1.467	1.611	1.478
3	1.428	1.487	1.493	1.432	1.567	1.471
4	1.503	1.635	1.384	1.283	1.551	1.434
5	1.560	1.274	1.527	1.436	1.644	1.412
6	1.596	1.545	1.357	1.328	1.420	1.410
7	1.627	1.506	1.837	1.418	1.514	1.587
8	1.419	1.430	1.664	1.607	1.552	1.567
9	1.388	1.728	1.536	1.518	1.369	1.594
10	1.404	1.670	1.509	1.463	1.522	1.547
11	1.416	1.767	1.428	1.593	1.418	1.596
12	1.582	1.336	1.578	1.391	1.756	1.435
13	1.286	1.411	1.445	1.640	1.193	1.498
14	1.495	1.404	1.589	1.646	1.497	1.546
15	1.359	1.286	1.600	1.250	1.547	1.379
16	1.575	1.530	1.517	1.184	1.866	1.410
17	1.368	1.727	1.396	1.501	1.445	1.541
18	1.416	1.386	1.306	1.621	1.557	1.438
19	1.580	1.419	1.654	1.512	1.725	1.528
20	1.711	1.441	1.236	1.382	1.760	1.353
21	1.437	1.505	1.349	1.567	1.488	1.474
22	1.474	1.594	1.658	1.497	1.472	1.583

[1] Standard tables for estimating the necessary factors can be found here: http://onlinelibrary.wiley.com/doi/10.1002/0471790281.app6/pdf

23	1.592	1.433	1.555	1.530	1.687	1.506
24	1.640	1.524	1.571	1.556	1.553	1.550
25	1.580	1.366	1.624	1.373	1.689	1.455

Table 1: Sample data for problem 4

Problem 5
Tolerance Stack-up

A certain product requires assembling 5 blocks in series. Each block is 100 mm in length. We are considering two processes – milling and sand casting – for manufacturing each 100 mm block. Assume that for each process, the variation is mean centered with $C_p = 1$.
Estimate:

1. Mean length and variance of the length of the final part assuming the lengths are uncorrelated,
2. Mean length and variance of the length of the final part assuming the lengths are correlated.

Hint: Estimate the dimensional tolerances for a part of 100 mm size produced by each process.