2019 Spring – SPC&O HW#10

1. A 2^2 factorial design has produced the following model relating machined part surface finish (y) to feed rate (x_1) and nose radius (x_2) of the tool (x_1, x_2 are in coded units of ± 1):

$$\hat{y} = 90 + 10x_1 - 15x_2 + 5x_1x_2$$

   (a) What is the average surface finish across the experiment?

   (b) What are the values for E_1, E_2, and E_{12} as obtained from the experiment?

   (c) Use Excel to sketch the 3D or contour response surface in the x_1, x_2, y coordinate space.

   (d) Explain the meaning of the interaction effect.

   (e) If a surface finish of 100 is desired, what values of feed rate and nose radius (coded units) should be used? Identify the possible values of the feed rate and the nose radius to achieve the desired surface finish on the response surface in (c).

2. Give an example where a dependent variable (output) y is affected by two independent variables x_1 and x_2 with interaction effect. Explain why there exists the interaction effect.

3. For the problem of "Glove Box Door Alignment" experiment to achieve parallelism equal to zero,

   (a) Calculate the SN ratios of the parallelisms of the experimental results;

   (b) Plot the effect plot and build an additive model;

   (c) Use the effect plot to determine the optimal setting for the process and use the additive model to predict the optimal parallelism;

   (d) Calculate all the main factor and two-factor interaction effects on the SN ratio and build a regression predictive model; and

   (e) Use the regression model to determine the optimize setting and predict the resulting optimal parallelism. Compare the results with (c).

4. The yield (as large as possible with the maximum at 100%) of a semiconductor fabrication process has been studied as a function of three factors, at the following experimental levels:

Variable	Low Level	High Level
1. Temperature ($^\circ$C)	80	120
2. Pressure (psi)	50	70
3. Reaction time (min)	5	15

A 2^3 factorial design was performed. Each test, or unique combination of the three variables, was performed three times. The table provides the results of the tests.

				Trial			
Test	**Temperature**	**Pressure**	**Time**	**1**	**2**	**3**	**Average**
1	80	50	5	61.43(14)	58.58(18)	57.07(16)	59.03
2	120	50	5	75.62(6)	77.57(11)	75.75(2)	76.31
3	80	70	5	27.51(21)	34.03(1)	25.07(19)	28.87
4	120	70	5	51.37(10)	48.49(15)	54.37(9)	51.41
5	80	50	15	24.80(3)	20.69(7)	15.41(5)	20.30
6	120	50	15	43.58(17)	44.31(22)	36.99(13)	41.63
7	80	70	15	45.20(24)	49.53(12)	50.29(20)	48.34
8	120	70	15	70.51(8)	74.00(4)	74.68(23)	73.07

(a) Estimate the variance of the noises.

(b) Estimate the variance of effects.

(c) With *t* test statistics and α=0.05, which effects are statistically significant?

(d) Use the significant effects to construct a mathematical prediction model.

(e) Use Excel's regression analysis to build the regression model and compare it to (c).

(f) Calculate all the main and interaction effects on the SN ratio.

(g) Build a predictive model for the SN Ratio.

(h) Suggest an optimum setting for the process to achieve the highest, stable yield based on results of (d) and (g).