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EGR 7050 Design and Analysis of Engineering experiments

Homework 10

1. *Problem 6.36 describes a study of resistivity in silicon wafers. The full factorial, 24 design for 4 factors would have 16 runs, as shown in Table P6.10. Suppose that only 8 runs could be made in this process.*
    a. *Create the data table for a 2^{4-1} design with D = AC as the design generator (show the 8 rows). Fill in the appropriate 8 observations from Problem 6.36. You won't use all of the data in Table P6.10.*

	A	B	C	D=AC	Resistivity
1	-	-	-	+	1.6
2	+	-	-	-	11.28
3	-	+	-	+	1.16
4	+	+	-	-	5.75
5	-	-	+	-	2.13
6	+	-	+	+	9.11
7	-	+	+	-	1.03
8	+	+	+	+	5.3

    b. *Find the alias structure for this 2^{4-1} design (with D = AC as the design generator). What is the resolution of this design?*

    This is a 2^{4-1} design. The aliases are found using each of these generators with the main effects and 2^{nd} order interactions:

A	(ACD)	CD
B	(ACD)	ABCD
C	(ACD)	AD
D	(ACD)	AC
AB	(ACD)	BCD
BC	(ACD)	ABD
BD	(ACD)	ABC
ACD	(ACD)	I

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The design generator has three letters, hence this is a resolution 3 design. Also, no main effect is aliased with any other main effect and some main effects are aliased with 2 factor interactions.

c. *Analyze the data from the 2^{4-1} data table from part a. and estimate the factor effects using a combination of the Normal plot of effects and an ANOVA analysis. (You don't need to include your residual analysis or show connecting letters report in your submission for this problem.)*

Response Resistivity

Summary of Fit

RSquare	0.920561
RSquare Adj	0.814643
Root Mean Square Error	1.67864
Mean of Response	4.67
Observations (or Sum Wgts)	8

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio
Model	4	97.96170	24.4904	8.6912
Error	3	8.45350	2.8178	Prob > F
C. Total	7	106.41520		0.0533

Parameter Estimates

Term	Estimate	Std Error	t Ratio	Prob>|t|
Intercept	4.67	0.593489	7.87	0.0043*
A[-]	-3.19	0.593489	-5.37	0.0126*
B[-]	1.36	0.593489	2.29	0.1058
C[-]	0.2775	0.593489	0.47	0.6720
D=AC[-]	0.3775	0.593489	0.64	0.5699

Main effect regression coefficients are given here. The effect estimate can be calculated from this.

Effect Tests

Source	Nparm	DF	Sum of Squares	F Ratio	Prob > F
A	1	1	81.408800	28.8906	0.0126*
B	1	1	14.796800	5.2511	0.1058
C	1	1	0.616050	0.2186	0.6720
D=AC	1	1	1.140050	0.4046	0.5699

The main effect A is less than 0.05 and appears to be statistically significant

Effect Screening

The parameter estimates have equal variances.

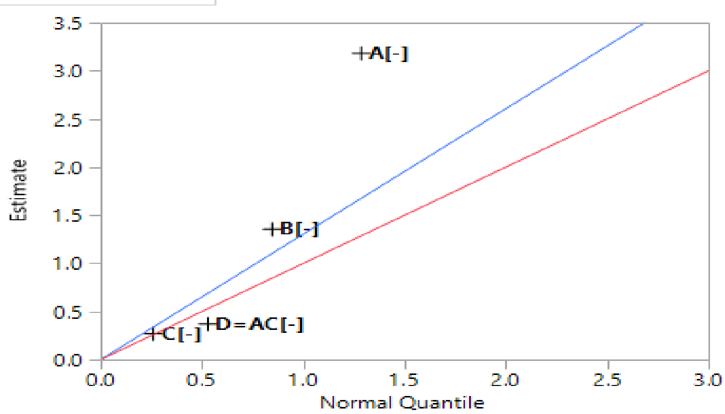
The parameter estimates are not correlated.

Lenth PSE

1.303125

Normal Plot

Half Normal Plot



Blue line has slope equal to Lenth's PSE.

Red line has slope 1.

Factor A appear to be significant. A is aliased with CD.

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d. *Considering the limitations in the design you discovered in part b., what conclusions can you draw about significant effects?*

   Except A no other main effect appears to be significant. A is aliased with CD alone. Leaving the other effects might result in an inconsistent model.

e. Is there a better design in Table 8.14 that you would recommend? If so, why?

   D = ABC could be a better design. It could result in a design with better resolution.

2. An article in Soldering & Surface Mount Technology ("Characterization of a Solder Paste Printing Process and Its Optimization," 1999, Vol. 11, No. 3, pp. 23‐26) describes the use of a 28_3 fractional factorial experiment to study the effect of eight factors on two responses; percentage volume matching (PVM) ‐ the ratio of the actual printed solder paste volume to the designed volume; *and non-conformities per unit (NPU) ‐ the number of solder paste printing defects determined by visual inspection (20_ magnification) after printing according to an industry workmanship standard. The factor levels are shown below and the test matrix and response data are shown in Table P8.9.*

Parameters	Levels	
	Low(-)	High (+)
A. Squeegee pressure, MPa	0.1	0.3
B. Printing speed, mm/s	24	32
C. Squeegee angle, deg	45	65
D. Temperature, deg C	20	28
E. Viscosity, kCps	1100-1500	1250-1300
F. Cleaning interval, stroke	8	15
G. Separation speed, mm/s	0.4	0.8
H. Relative humidity, %	30	70

a. *Verify that the generators are I = ABCF, I = ABDG, and I = BCDEH for this design.*

The below table s generated by using F=ABC, G=ABD, H=BCDE generators. The runs obtained correspond to the table given in the question.

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8

	A	B	C	D	E	F=ABC	G=ABD	H=BCDE	runs
1	-	-	-	-	-	-	-	+	h
2	+	-	-	-	-	+	+	+	afgh
3	-	+	-	-	-	+	+	-	bfg
4	+	+	-	-	-	-	-	-	ab
5	-	-	+	-	-	+	-	-	cf
6	+	-	+	-	-	-	+	-	acg
7	-	+	+	-	-	-	+	+	bcgh
8	+	+	+	-	-	+	-	+	abcfh
9	-	-	-	+	-	-	+	-	dg
10	+	-	-	+	-	+	-	-	adf
11	-	+	-	+	-	+	-	+	bdfh
12	+	+	-	+	-	-	+	+	abdgh
13	-	-	+	+	-	+	+	+	cdfgh
14	+	-	+	+	-	-	-	+	acdh
15	-	+	+	+	-	-	-	-	bcd
16	+	+	+	+	-	+	+	-	abcdfg
17	-	-	-	-	+	-	-	-	e
18	+	-	-	-	+	+	+	-	aefg
19	-	+	-	-	+	+	+	+	befgh
20	+	+	-	-	+	-	-	+	abeh
21	-	-	+	-	+	+	-	+	cefh
22	+	-	+	-	+	-	+	+	acegh
23	-	+	+	-	+	-	+	-	bceg
24	+	+	+	-	+	+	-	-	abcef
25	-	-	-	+	+	-	+	+	degh
26	+	-	-	+	+	+	-	+	adefh
27	-	+	-	+	+	+	-	-	bdef
28	+	+	-	+	+	-	+	-	abdeg
29	-	-	+	+	+	+	+	-	cdefg
30	+	-	+	+	+	-	-	-	acde
31	-	+	+	+	+	-	-	+	bcdeh
32	+	+	+	+	+	+	+	+	abcdefgh

b. *What are the aliases for the main effects and two factor interactions? You can ignore all interactions of order three and higher.*

I = ABCF, I = ABDG, and I = BCDEH

This is a 2^{8-3} *design. The aliases are found using each of these generators.*

A	*(ABCF)*	=BCF	A	*(ABDG)*	=BDG	A	(BCDEH)	=ABCDEH	A=BCF=BDG=ABCDEH
B	*(ABCF)*	=ACF	B	*(ABDG)*	=ADG	B	(BCDEH)	=CDEH	B=ACF=ADG=CDEH
C	*(ABCF)*	=ABF	C	*(ABDG)*	=ABCDG	C	(BCDEH)	=BDEH	C=ABF=ABCDG=BDEH
D	*(ABCF)*	=ABCDF	D	*(ABDG)*	=ABG	D	(BCDEH)	=BCEH	D=ABCDF=ABG=BCEH

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E	(*ABCF)*	=ABCEF	E	(*ABDG)*	=ABDEG	E	(BCDEH)	=BCDH	E=ABCEF=ABDEG=BCDH
F	(*ABCF)*	=ABC	F	(*ABDG)*	=ABDFG	F	(BCDEH)	=BCDEFH	F=ABC=ABDFG=BCDEFH
G	(*ABCF)*	=ABCFG	G	(*ABDG)*	=ABD	G	(BCDEH)	=BCDEGH	G=ABCFG=ABD=BCDEGH
H	(*ABCF)*	=ABCFH	H	(*ABDG)*	=ABDGH	H	(BCDEH)	=BCDE	H=ABCFH=ABDGH=BCDE
AB	(*ABCF)*	=CF	AB	(*ABDG)*	=DG	AB	(BCDEH)	=ACDEH	AB=CF=DG=ACDEH
CF	(*ABCF)*	=AB	CF	(*ABDG)*	=ABCDFG	CF	(BCDEH)	=BFDEH	CF=AB=ABCDFG=BFDEH
DG	(*ABCF)*	=ABCDFG	DG	(*ABDG)*	=AB	DG	(BCDEH)	=BCEGH	DG=ABCDFG=AB=BCEGH