

From Exam in TMA4260 Industrial Statistics, december 2003, Exercise 2

A company decides to investigate the hardening process of a ballbearing production.

The following four factors are chosen:

A: content of added carbon

B: Hardening temperature

C: Hardening time

D: Cooling temperature.

Row	StdOrder	A	B	C	D	Hardhet
1	1	-1	-1	-1	1	15.32
2	2	1	-1	-1	-1	18.24
3	3	-1	1	-1	-1	17.18
4	4	1	1	-1	1	16.90
5	5	-1	-1	1	-1	15.95
6	6	1	-1	1	1	17.52
7	7	-1	1	1	1	14.26
8	8	1	1	1	-1	18.59

a) What is the generator and the defining relation of the design, and what is the design's resolution? Write down the alias structure.

Find the estimates of the main effect of A and the interaction effect AC.

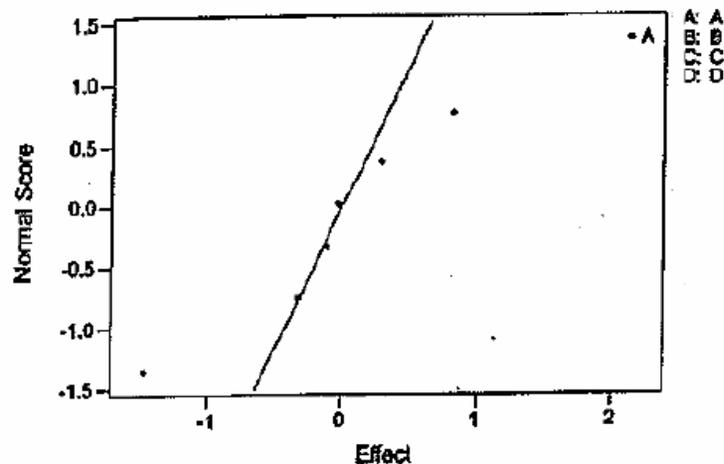
b) What is the variance of the main effect A and the interaction AC?

Assume that the st deviation sigma has been estimated from other experiments, by $s = 0.312$ with 9 degrees of freedom (in the exam, this had been done in Ex 1. Use this estimate to find out whether the interaction AC is significantly different from 0 (i.e. "active") Use 5% significance level. What is the conclusion of the experiment so far?

Estimated Effects and Coefficients
for Hardhet (coded units)

Term	Effect	Coef
Constant		16.7450
A	2.1350	1.0675
B	-0.0250	-0.0125
C	-0.3300	-0.1650
D	-1.4900	-0.7450
A*B	-0.1100	-0.0550
A*C	0.8150	0.4075
A*D	0.2850	0.1425

Normal Probability Plot of the Effects
(response is Hardhet, Alpha = .05)



Analysis of Variance for Hardhet (coded units)

Source	DF	Seq SS	Adj SS	Adj MS	F	P
Main Effects	4	13.776	13.776	3.4439	*	*
2-Way Interactions	3	1.515	1.515	0.5050	*	*
Residual Error	0	0.000	0.000	0.0000		
Total	7	15.291				

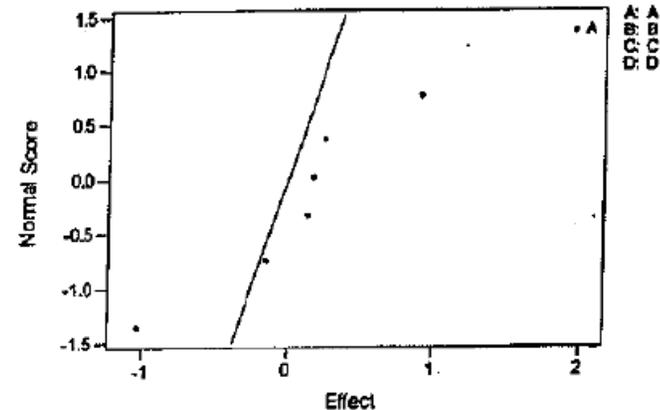
The company is well satisfied with the results so far and they decide to carry out also the other half fraction. The result of the other half fraction is given below.

Row	StdOrder	A	B	C	D	Hardhet
1	1	-1	-1	-1	-1	16.57
2	2	1	-1	-1	1	16.72
3	3	-1	1	-1	1	15.76
4	4	1	1	-1	-1	17.69
5	5	-1	-1	1	1	14.59
6	6	1	-1	1	-1	18.63
7	7	-1	1	1	-1	16.18
8	8	1	1	1	1	17.86

Estimated Effects and Coefficients for
Hardhet (coded units)

Term	Effect	Coef
Constant		16.7500
A	1.9500	0.9750
B	0.2450	0.1225
C	0.1300	0.0650
D	-1.0350	-0.5175
A*B	-0.1450	-0.0725
A*C	0.9100	0.4550
A*D	0.1650	0.0825

Normal Probability Plot of the Effects
(response is Hardhet, Alpha = .05)



Analysis of Variance for Hardhet (coded units)

Source	DF	Seq SS	Adj SS	Adj MS	F	P
Main Effects	4	9.901	9.901	2.4753	*	*
2-Way Interactions	3	1.753	1.753	0.5842	*	*
Residual Error	0	0.000	0.000	0.0000		
Total	7	11.654				

Use this to find unconfounded estimates for the main effects and the two-factor interactions.

Assume that one would like to estimate the variance of the effects from the Higher order interactions. Explain how this can be done, and find the estimate. Is it wise to include the four-factor interaction in this calculation? Why (not)?

Later, one of the operators that participated in the experiments asked whether one could have carried out the first half fraction in (a) in two blocks. This would, he said, have simplified considerably the performance of the experiments. What answer would you give to the operator?

From Exam in SIF 5066 Experimental design and..., May 2003, Exercise 1

A company making ballbearings experienced problems with the lifetimes of the products. In an experiments that they carried out they considered the factors

A: type of ball – standard (-) or modified (+)

B: type of cage - standard (-) or modified (+)

C: type of lubricate - standard (-) or modified (+)

D: quantity of lubricate – normal (-) or large (+)

The repsonse was the lifetime of the ballbearing in an accelerated life testing experiment. The results are given on the next page.

Forsøk	A	B	C	D	Y
1	-	-	-	-	0.31
2	-	+	+	-	0.92
3	+	+	+	+	2.57
4	+	-	-	+	1.38
5	+	+	-	-	2.17
6	-	+	-	+	0.73
7	-	-	+	+	0.95
8	+	-	+	-	1.37

A: type of ball
 B: type of cage
 C: type of lubricate
 D: quantity of lubricate

- a) What type of experiment is this? What is the defining relation? What is the resolution? Calculate estimates of the main effect of A and the two-factor interaction AB.
- b) Estimated contrasts for B,C,D,AC,AD are, respectively, 0.60, 0.31, 0.22, -0.11, -0.01. What can you say about the estimated effects for CD, BD, BC, BCD, ACD, ABD,ABC?
- Assume that factors C and D do not influence the response. Explain why this is then a 2^2 experiment with replicate. Calculate an estimate for the variance of the effects, and find out whether A, B and AB are now significant.
- c) Give an interpretation of the results. The experiment was in fact carried out in two blocks, where experiments 1-4 was one block and 5-8 the other. How is this blocking constructed? How will we need to modify the analysis of significance in (b)? (Assume again that C,D do not influence the response)