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Section 1

MANE 6313

Subsection 1

Week 9, Module F

Student Learning Outcome

- Select an appropriate experimental design with one or more factors,
- Select an appropriate model with one or more factors,
- Evaluate statistical analyses of experimental designs,
- Assess the model adequacy of any experimental design, and
- Interpret model results.

Module Learning Outcome

Analyze an 1/8 Fraction design.

One eighth Fraction – Problem 8.37

8.37 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 2^{8-3} 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 nonconformities 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, *°C*	20	28
E. Viscosity, *kCps*	1,100-1,150	1,250-1,300
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.

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

(c) Analyze both PVM and NPU responses.

(d) Analyze the residual for both responses. Are there any problems with model adequacy?

(e) The ideal value of PVM is unity and the NPU response should be as small as possible. Recommend suitable

■ **TABLE P8.9**
The Solder Paste Experiment

Run Order	Parameters								PVM	NPU (%)
	A	*B*	*C*	*D*	*E*	*F*	*G*	*H*		
4	−	−	−	−	−	−	−	+	1.00	5
13	+	−	−	−	−	+	+	+	1.04	13
6	−	+	−	−	−	+	+	−	1.02	16
3	+	+	−	−	−	−	−	−	0.99	12
19	−	−	+	−	−	+	−	−	1.02	15
25	+	−	+	−	−	−	+	−	1.01	9
21	−	+	+	−	−	−	+	+	1.01	12
14	+	+	+	−	−	+	−	+	1.03	17
10	−	−	−	+	−	−	+	−	1.04	21
22	+	−	−	+	−	+	−	−	1.14	20
1	−	+	−	+	−	+	−	+	1.20	25
2	+	+	−	+	−	−	+	+	1.13	21
30	−	−	+	+	−	+	+	+	1.14	25
8	+	−	+	+	−	−	−	+	1.07	13
9	−	+	+	+	−	−	−	−	1.06	20
20	+	+	+	+	−	+	+	−	1.13	26
17	−	−	−	−	+	−	−	−	1.02	10
18	+	−	−	−	+	+	+	−	1.10	13
5	−	+	−	−	+	+	+	+	1.09	17
26	+	+	−	−	+	−	−	+	0.96	13
31	−	−	+	−	+	+	−	+	1.02	14
11	+	−	+	−	+	−	+	+	1.07	11
29	−	+	+	−	+	−	+	−	0.98	10
23	+	+	+	−	+	+	−	−	0.95	14
32	−	−	−	+	+	−	+	+	1.10	28
7	+	−	−	+	+	+	−	+	1.12	24
15	−	+	−	+	+	+	−	−	1.19	22
27	+	+	−	+	+	−	+	−	1.13	15
12	−	−	+	+	+	+	+	−	1.20	21
28	+	−	+	+	+	−	−	−	1.07	19
24	−	+	+	+	+	−	−	+	1.12	21
16	+	+	+	+	+	+	+	+	1.21	27

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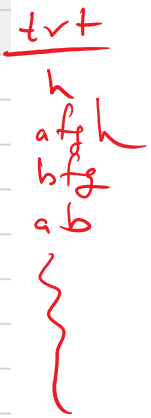
C5	C6	C7	C8	C9	C10	C11	C12
A	B	C	D	E	F	G	H
-1	-1	-1	-1	-1	-1	-1	1
1	-1	-1	-1	-1	1	1	1
-1	1	-1	-1	-1	1	1	-1
1	1	-1	-1	-1	-1	-1	-1
-1	-1	1	-1	-1	1	-1	-1
1	-1	1	-1	-1	-1	1	-1
-1	1	1	-1	-1	-1	1	1
1	1	1	-1	-1	1	-1	1
-1	-1	-1	1	-1	-1	1	-1
1	-1	-1	1	-1	1	-1	-1
-1	1	-1	1	-1	1	-1	1
1	1	-1	1	-1	-1	1	1
-1	-1	1	1	-1	1	1	1
1	-1	1	1	-1	-1	-1	1
-1	1	1	1	-1	-1	-1	-1
1	1	1	1	-1	1	1	-1
-1	-1	-1	-1	1	-1	-1	-1
1	-1	-1	-1	1	1	1	-1



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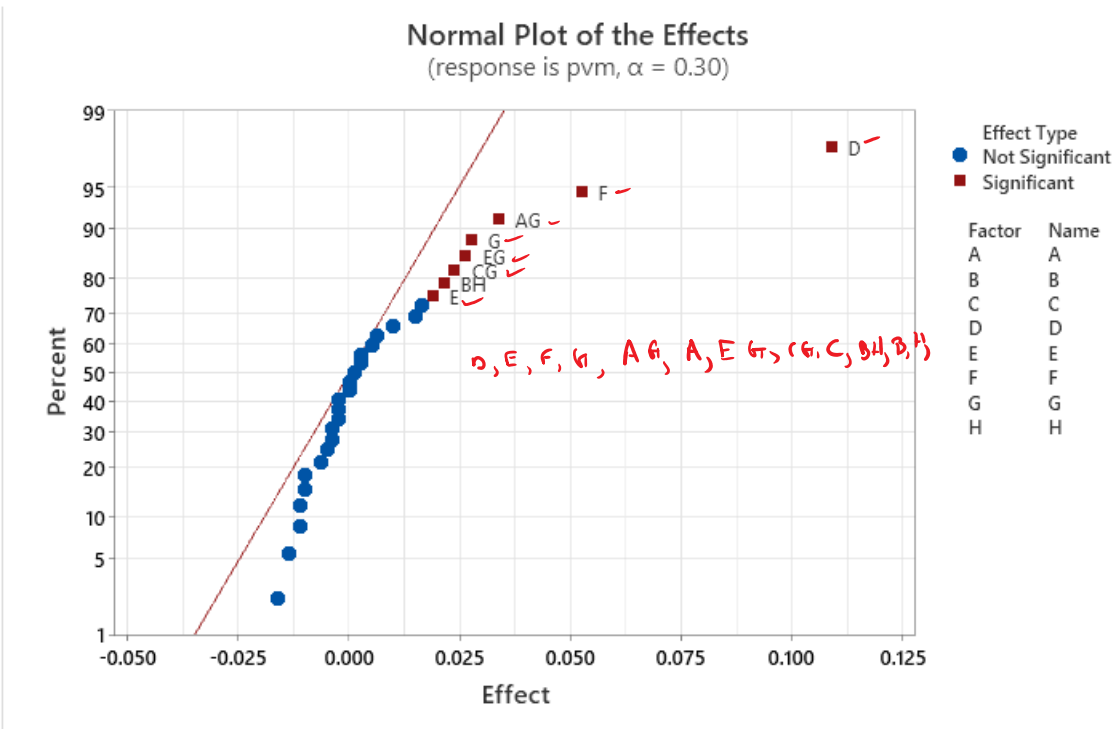

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2nd model

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Analysis of Variance

Source	DF	Adj SS	Adj MS	F-Value	P-Value
Model	12	0.151562	0.012630	23.56	0.000
Linear	8	0.128812	0.016102	30.03	0.000
A	1	0.000113	0.000113	0.21	0.652
B	1	0.000050	0.000050	0.09	0.763
C	1	0.001012	0.001012	1.89	0.185
D	1	0.094612	0.094612	176.46	0.000
E	1	0.002813	0.002813	5.25	0.034
F	1	0.022050	0.022050	41.12	0.000
G	1	0.006050	0.006050	11.28	0.003
H	1	0.002112	0.002112	3.94	0.062
2-Way Interactions	4	0.022750	0.005687	10.61	0.000
A*G	1	0.009112	0.009112	17.00	0.001
B*H	1	0.003613	0.003613	6.74	0.018
C*G	1	0.004512	0.004512	8.42	0.009
E*G	1	0.005513	0.005513	10.28	0.005
Error	19	0.010188	0.000536		
Total	31	0.161750			

→ final model

All statistically significant

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