

第5.3節 實驗誤差的統合

Pooling of Errors

- 5.3-1 實例：瓷磚製程實驗 (Example: Tile Experiments)
- 5.3-2 S/N比平方和及自由度計算公式 (Formula for S/N Ratios)
- 5.3-3 實例：煞車組件設計 (Example: Brake Design)

實驗誤差的統合

- 當某些控制因子被判定為不重要時，它們的因子效應被認為只是_____造成的變異現象，亦即與_____無異。
- 此時，這些因子效應向量應該被合併到_____中。這表示_____必須重新計算，先前被判定為重要的因子必須以_____重新測試。
- 經重新測試後若有因子重新被判定為不重要時，則必須重複誤差合併的步驟，直到所有不重要的因子效應都被合併到誤差向量為止。
- 以上程序稱為誤差的_____。

5.3-1 實例：瓷磚製程實驗 (Tile Experiments)

表5.3-1 瓷磚製程實例中對品質特性的初步變異分析表

Factor	SS	DOF	Var	F	Confidence	Significance*
A	0.1264	1	0.1264	12.8	99.9%	
B	0.1642	2	0.0821	8.3	100.0%	
C	0.0165	2	0.0083	0.8	56.5%	
D	0.0143	2	0.0072	0.7	51.4%	
E	0.1378	2	0.0689	7.0	99.9%	
F	0.6005	2	0.3003	30.5	100.0%	
G	0.0361	2	0.0181	1.8	83.5%	
H	0.4421	2	0.2211	22.4	100.0%	
Others	0.0343	2	0.0172	1.7	82.0%	
Error	1.0640	108	0.0099	S = 0.0993		
Total	2.6363	125	*At least 99% confidence			

表5.3-2 瓷磚製程實例中對品質特性的最後變異分析表

Factor	SS	DOF	Var	F	Confidence	Significance*
A						
B						
C						
D						
E						
F						
G						
H						
Others						
Error						
Total	2.6363	125	*At least 99% confidence			

對S/N比的變異分析

表5.3-3 瓷磚製程實例中S/N比的數據及因子反應表

Exp.	A	B	C	D	E	F	G	H	S/N
1	1	1	1	1	1	1	1	1	
2	1	1	2	2	2	2	2	2	42.19
3	1	1	3	3	3	3	3	3	43.65
4	1	2	1	1	2	2	3	3	40.34
5	1	2	2	2	3	3	1	1	37.74
6	1	2	3	3	1	1	2	2	50.03
7	1	3	1	2	1	3	2	3	46.34
8	1	3	2	3	2	1	3	1	43.21
9	1	3	3	1	3	2	1	2	43.13
10	2	1	1	3	3	2	2	1	36.04
11	2	1	2	1	1	3	3	2	42.88
12	2	1	3	2	2	1	1	3	37.05
13	2	2	1	2	3	1	3	2	38.46
14	2	2	2	3	1	2	1	3	43.15
15	2	2	3	1	2	3	2	1	37.69
16	2	3	1	3	2	3	1	2	40.23
17	2	3	2	1	3	1	2	3	36.60
18	2	3	3	2	1	2	3	1	43.48

Ave = 41.31

	A	B	C	D	E	F	G	H
Level 1	43.10	40.52	40.45	40.32	44.53	41.11	40.44	
Level 2	39.51	41.24	40.96	40.88	40.12	41.39	41.48	
Level 3		42.16	42.50	42.72	39.27	41.42	42.00	

表5.3-4 瓷磚製程實例中對S/N比的初步變異分析表

Factor	SS	DOF	Var
A			
B			
C			
D			
E			
F			
G			
H			
Others			
Total			

- At this moment, can we evaluate the experimental error? Why?
- What should we do next?

表5.1-1 瓷磚製程實驗的數據 (上表) 及因子反應表 (下表)

Exp.	A	B	C	D	E	F	G	H	y ₁	y ₂	y ₃	y ₄	y ₅	y ₆	y ₇	y ₈	y ₉	y ₁₀	\bar{y}	S
1	1	1	1	1	1	1	1	1	10.18	10.18	10.12	10.06	10.02	9.98	10.20	10.106	10.106	10.106	0.0870	
2	1	1	2	2	2	2	2	2	10.03	10.01	9.98	9.96	9.91	9.89	10.12	9.986	9.986	10.12	9.986	0.0776
3	1	1	3	3	3	3	3	3	9.81	9.78	9.74	9.74	9.71	9.68	9.87	9.761	9.761	10.024	9.761	0.0641
4	1	2	1	1	2	2	3	3	10.09	10.08	10.07	9.99	9.92	9.88	10.14	10.024	10.024	10.024	10.024	0.0964
5	1	2	2	2	3	3	1	1	10.06	10.05	10.05	9.89	9.85	9.78	10.12	9.971	9.971	10.12	9.971	0.1293
6	1	2	3	3	1	1	2	2	10.20	10.19	10.18	10.17	10.14	10.13	10.22	10.176	10.176	10.176	10.176	0.0321
7	1	3	1	2	1	3	2	3	9.91	9.88	9.88	9.84	9.82	9.80	9.93	9.866	9.866	10.024	9.866	0.0476
8	1	3	2	3	2	1	3	1	10.32	10.28	10.25	10.20	10.18	10.18	10.36	10.253	10.253	10.253	10.253	0.0709
9	1	3	3	1	3	2	1	2	10.04	10.02	10.01	9.98	9.95	9.89	10.11	10.000	10.000	10.000	10.000	0.0698
10	2	1	1	3	3	2	2	1	10.00	9.98	9.93	9.80	9.77	9.70	10.15	9.904	9.904	10.15	9.904	0.1563
11	2	1	2	1	1	3	3	2	9.97	9.97	9.91	9.88	9.87	9.85	10.05	9.929	9.929	10.05	9.929	0.0713
12	2	1	3	2	2	1	1	3	10.06	9.94	9.90	9.88	9.80	9.72	10.12	9.917	9.917	10.12	9.917	0.1392
13	2	2	1	2	3	1	3	2	10.15	10.08	10.04	9.98	9.91	9.90	10.22	10.040	10.040	10.22	10.040	0.1199
14	2	2	2	3	1	2	1	3	9.91	9.87	9.86	9.87	9.85	9.80	10.02	9.883	9.883	10.02	9.883	0.0687
15	2	2	3	1	2	3	2	1	10.02	10.00	9.95	9.92	9.78	9.71	10.06	9.920	9.920	10.06	9.920	0.1295
16	2	3	1	3	2	3	1	2	10.08	10.00	9.99	9.95	9.92	9.85	10.14	9.990	9.990	10.14	9.990	0.0973
17	2	3	2	1	3	1	2	3	10.07	10.02	9.89	9.89	9.85	9.76	10.19	9.953	9.953	10.19	9.953	0.1473
18	2	3	3	2	1	2	3	1	10.10	10.08	10.05	9.99	9.97	9.95	10.12	10.037	10.037	10.12	10.037	0.0673

Ave = 9.984

對S/N比的變異分析

表5.3-5 瓷磚製程實例中對S/N比的第二次變異分析表

Factor	SS	DOF	Var	F	Confidence	Significance*
A						
B						
C						
D						
E						
F						
G						
H						
Others						
Error						
Total	229.22	17	*At least 99% confidence			

表5.3-6 瓷磚製程實例中對S/N比的最後變異分析表

Factor	SS	DOF	Var	F	Confidence	Significance*
A						
B						
C						
D						
E						
F						
G						
H						
Error						
Total	229.22	17	*At least 90% confidence			

5.3-2 S/N比平方和及自由度計算公式

- 當_____時，5.1-12式至5.1-15式可以簡化為：

$$DOF_T = n - 1 \quad (5.3-1式)$$

$$SS_T = \left(\sum_{i=1}^n \eta_i^2 \right) - n \times \bar{\eta}^2 = \text{SUMSQ}(\eta_i - \bar{\eta}) \quad (5.3-2式)$$

$$DOF_P = L_P - 1 \quad (5.3-3式)$$

$$SS_P = \frac{n}{L_P} \sum_{k=1}^{L_P} (\bar{\eta}_{Pk} - \bar{\eta})^2 = n \times \text{VARP}(\bar{\eta}_{P1}, \bar{\eta}_{P2}, \dots, \bar{\eta}_{PL_P}) \quad (5.3-4式)$$

5.3-3 實例：煞車組件設計 (Brake Design)

對S/N比的變異分析

表5.3-7 煞車組件實例中對S/N比的初步變異分析表

Factor	SS	DOF	Var
A	33.1	1	33.1
B	0.1	2	0.0
C	27.6	2	13.8
D	58.3	2	29.1
E	11.4	2	5.7
F	0.1	2	0.1
G	58.7	2	29.3
H	192.0	2	96.0
Others	0.3	2	0.2
Total	381.5	17	

- At this moment, can you evaluate the experimental error?
What is your reason?
- What should we do next?

表5.3-8 煞車組件實例中對S/N比的最後變異分析表

Factor	SS	DOF	Var	F	Confidence	Significance*
A						
B						
C						
D						
E						
F						
G						
H						
Others						
Error						
Total	381.5	17				*At least 99% confidence

對 β 的變異分析

表5.3-9 煞車組件實例中對 β 的初步變異分析表

Factor	SS	DOF	Var
A	3113.3	1	3113.3
B	823.9	2	412.0
C	10405.4	2	5202.7
D	206.2	2	103.1
E	3633.5	2	1816.8
F	10982.7	2	5491.3
G	38070.2	2	19035.1
H	44039.3	2	22019.7
Others	2952.7	2	1476.4
Total	114227.2	17	

- At this moment, can we evaluate the experimental error? Why?
- What should we do next?

表5.3-10 煞車組件實例中對 β 的第二次變異分析表

Factor	SS	DOF	Var	F	Confidence	Significance*
A						
B						
C						
D						
E						
F						
G						
H						
Others						
Error						
Total	114227.2	17				*At least 95% confidence

- Can we stop the ANOVA now? Why?

表5.3-11 煞車組件實例中對 β 的最後變異分析表

Factor	SS	DOF	Var	F	Confidence	Significance*
A						
B						
C						
D						
E						
F						
G						
H						
Others						
Error						
Total	114227.2	17				*At least 95% confidence