品質與可靠度工程實驗室
Quality and Reliability Engineering Lab.

田口方法-Minitab案例說明

實驗室網址 永久：http://campusweb.yuntech.edu.tw/~qre/index.htm
目前：http://140.125.88.116/QRE

塑膠射出成型品之融合強度

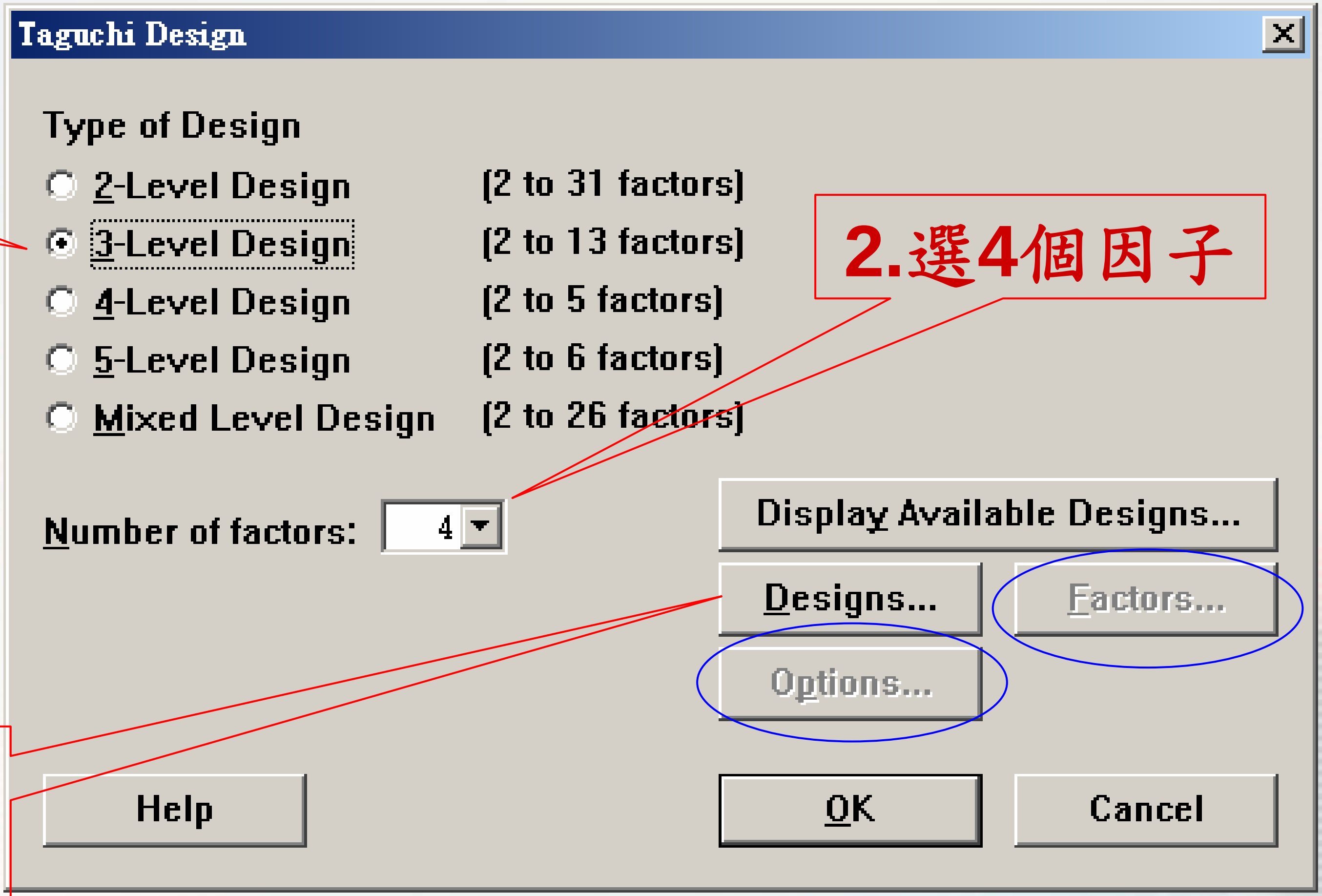
- 品質特性：抗拉強度（望大品質特性）
- 水準2為初始使用的製程參數

因子	說明	水準1	水準2	水準3
A	膠溫	150℃	170℃	190℃
B	射速	50%	70%	190%
C	保壓壓力	25kg/cm²	50kg/cm²	75kg/cm²
D	模溫	30℃	40℃	50℃

- 選用L9直交表進行部份因子實驗

塑膠射出成型品之融合強度

- 開啟Minitab選Stat=>DOE=>Taguchi=>Create Taguchi Design



Taguchi Design

Type of Design

○ 2-Level Design (2 to 31 factors)
● 3-Level Design (2 to 13 factors)
○ 4-Level Design (2 to 5 factors)
○ 5-Level Design (2 to 6 factors)
○ Mixed Level Design (2 to 26 factors)

Number of factors: 4

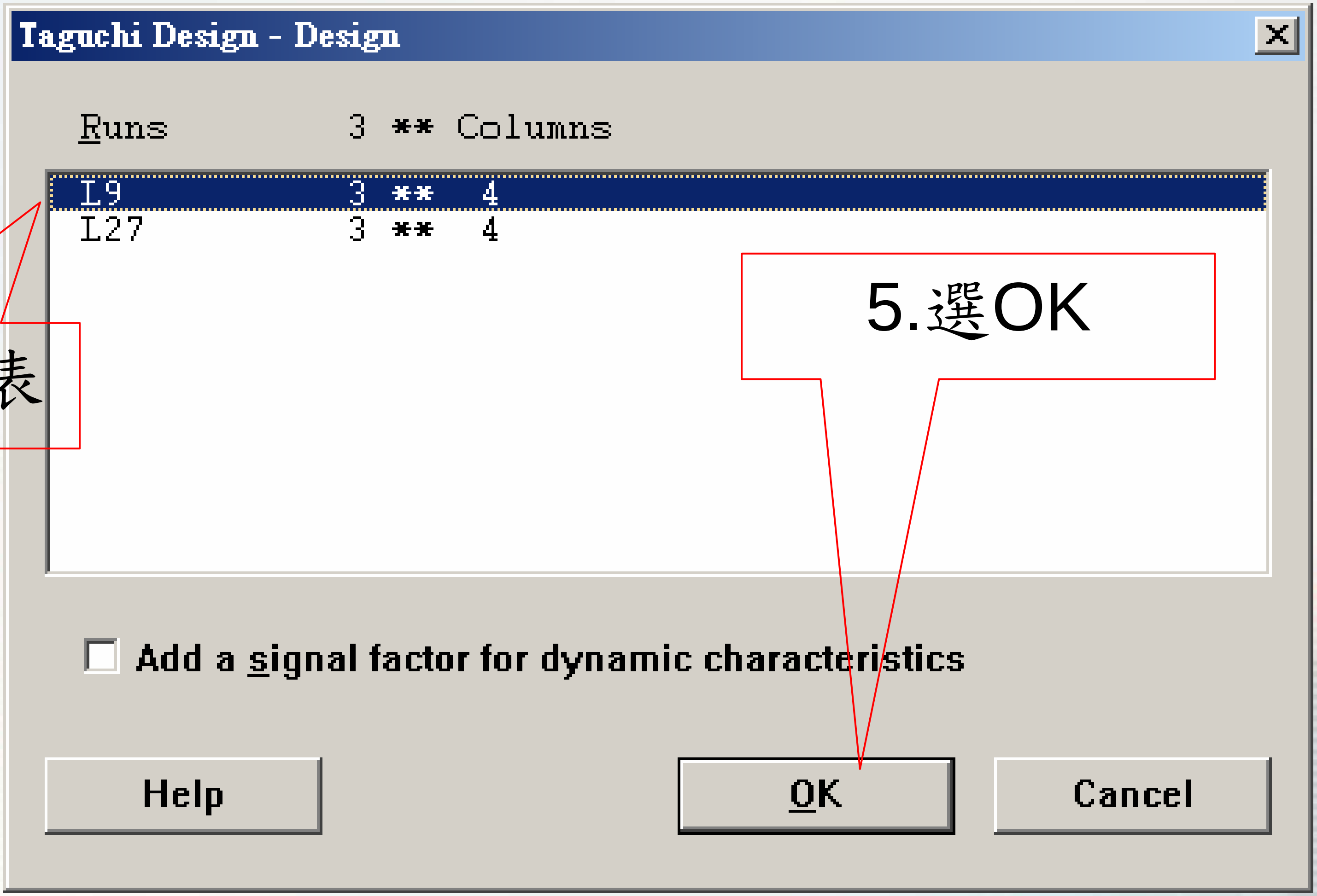
Display Available Designs...
Designs...
Factors...
Options...
Help
OK
Cancel

1.選3個水準

2.選4個因子

3.選Designs選擇直交表

塑膠射出成型品之融合強度



Taguchi Design - Design

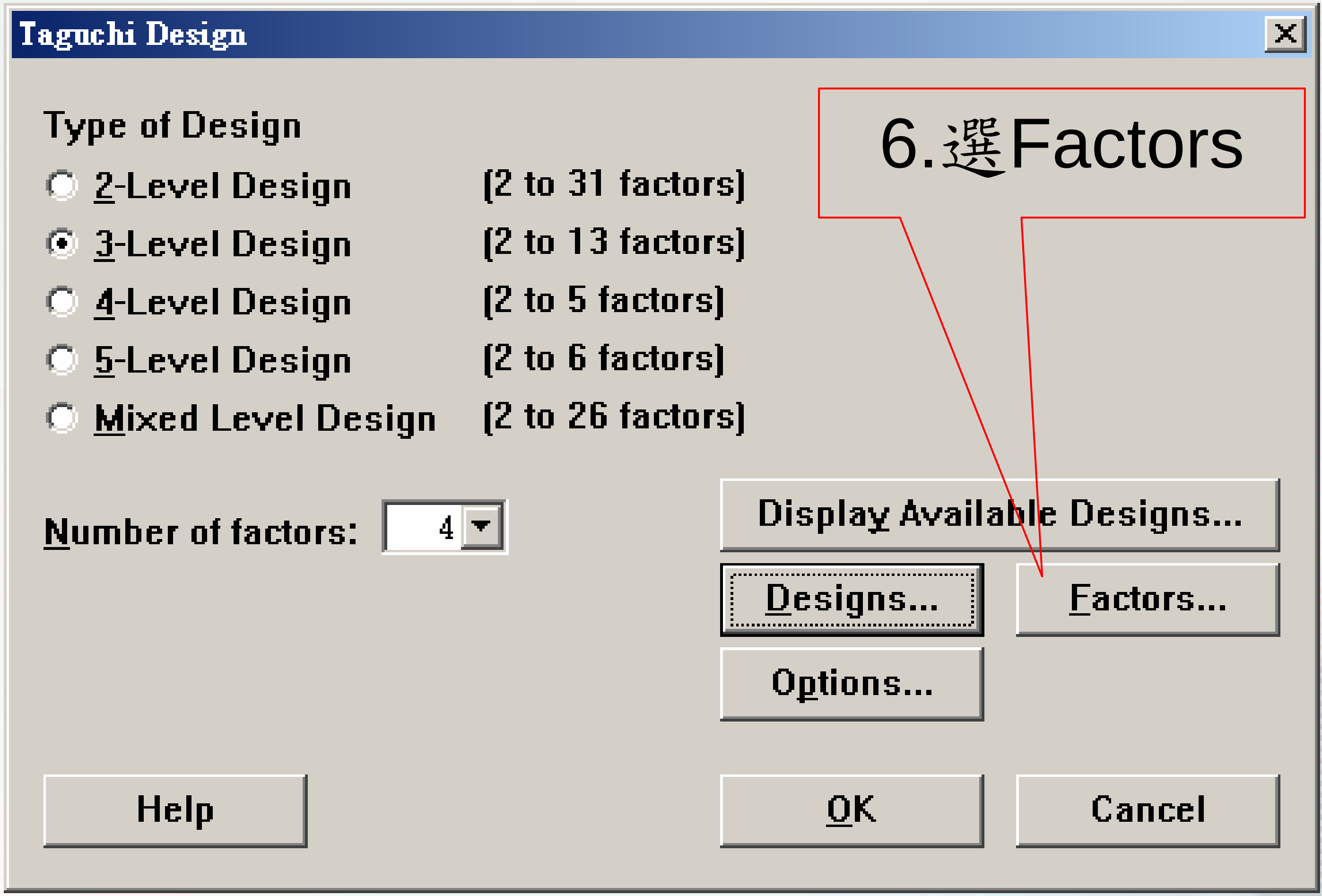
Runs	3 ** Columns
L9	3 ** 4
L27	3 ** 4

☐ Add a signal factor for dynamic characteristics

4.選L9直交表

5.選OK

塑膠射出成型品之融合強度



Taguchi Design

Type of Design

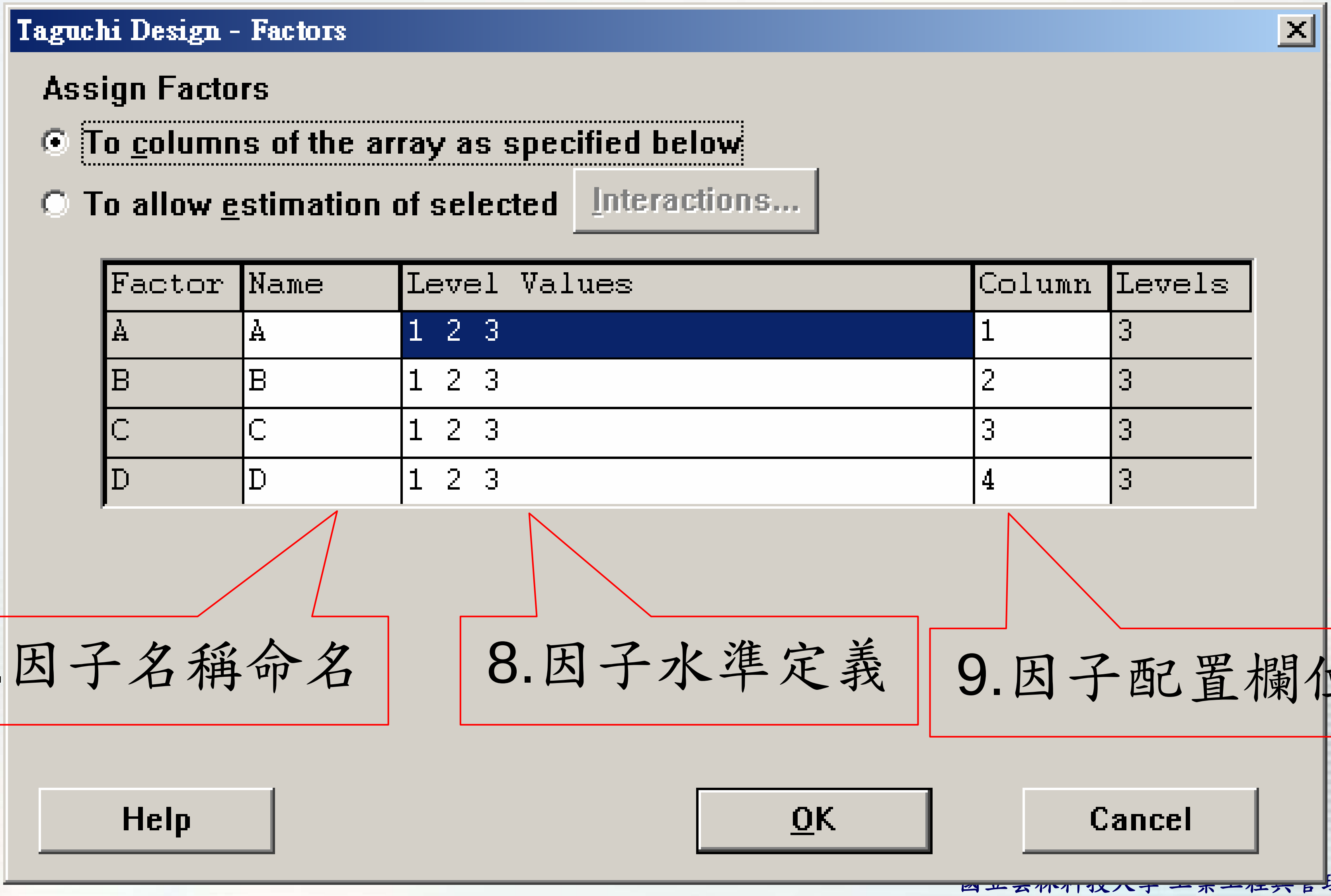
○ 2-Level Design [2 to 31 factors]
● 3-Level Design [2 to 13 factors]
○ 4-Level Design [2 to 5 factors]
○ 5-Level Design [2 to 6 factors]
○ Mixed Level Design [2 to 26 factors]

Number of factors: 4

Display Available Designs...
Designs...
Factors...
Options...
Help
OK
Cancel

6.選Factors

塑膠射出成型品之融合強度


Taguchi Design - Factors
Interactions...
Help
OK
Cancel

Assign Factors

● To columns of the array as specified below

○ To allow estimation of selected

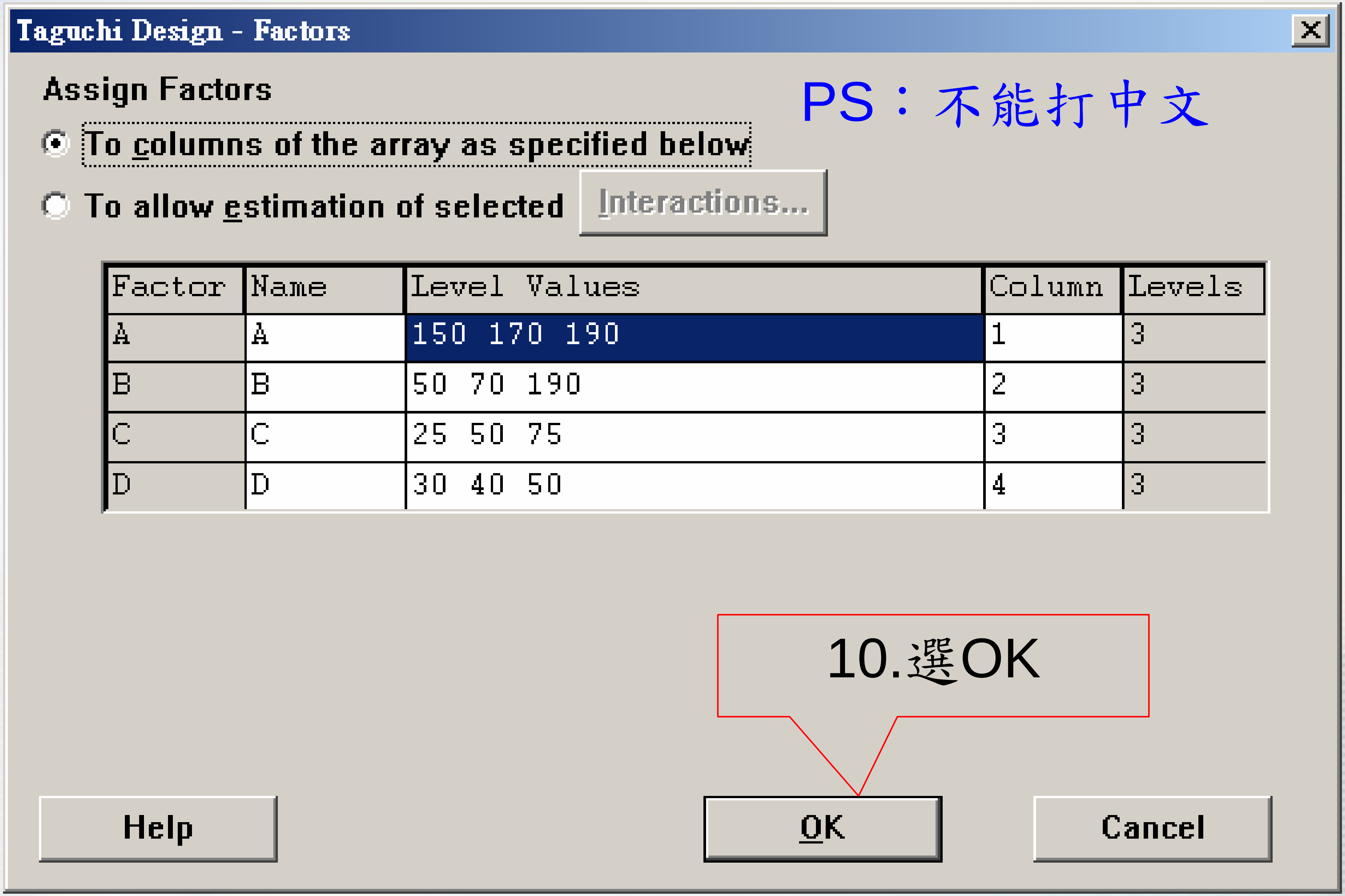
Factor	Name	Level Values	Column	Levels
A	A	1 2 3	1	3
B	B	1 2 3	2	3
C	C	1 2 3	3	3
D	D	1 2 3	4	3

7.因子名稱命名

8.因子水準定義

9.因子配置欄位

塑膠射出成型品之融合強度



Taguchi Design - Factors

Assign Factors

● To columns of the array as specified below

○ To allow estimation of selected

Interactions...

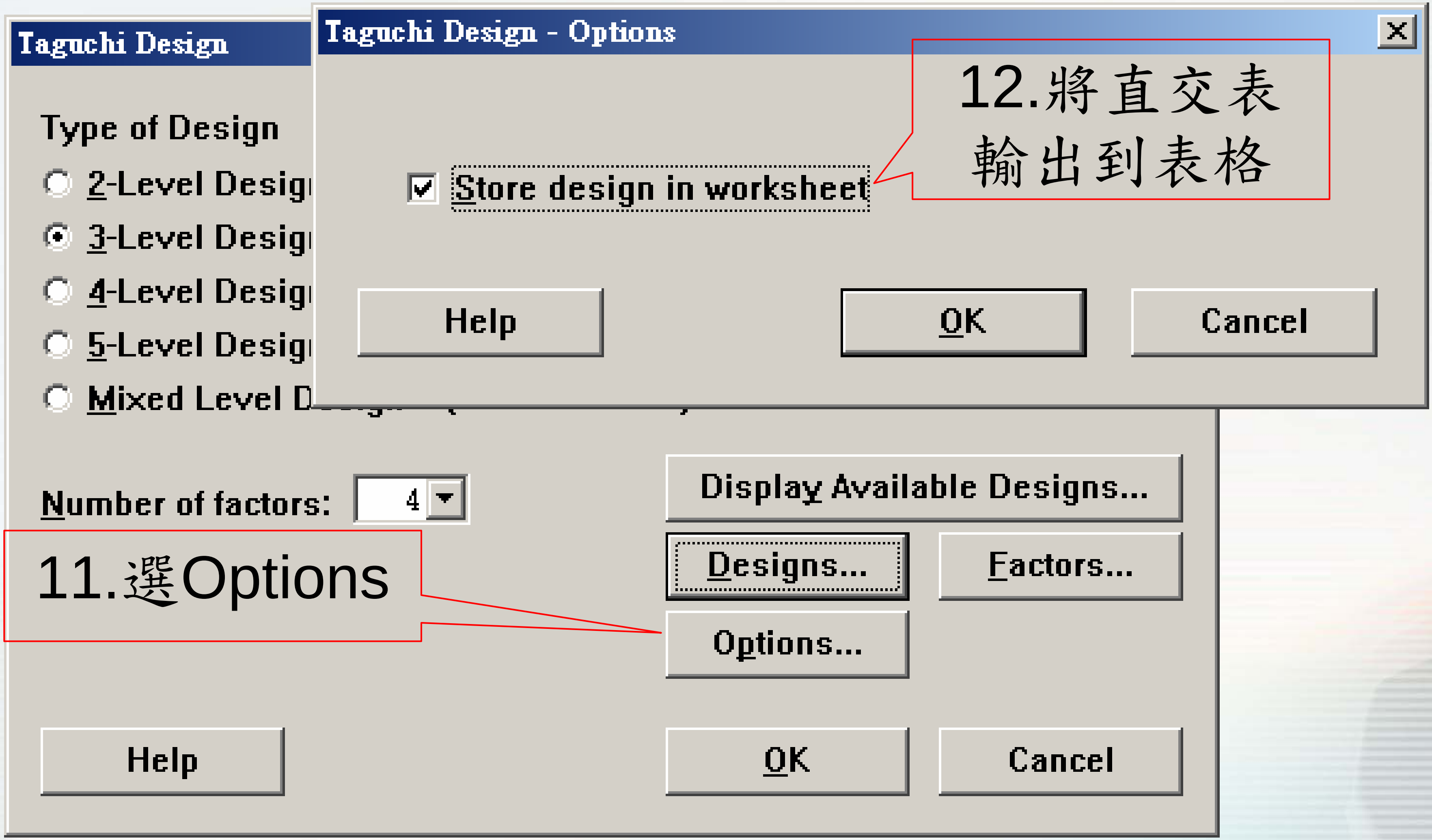
Factor	Name	Level Values	Column	Levels
A	A	150 170 190	1	3
B	B	50 70 190	2	3
C	C	25 50 75	3	3
D	D	30 40 50	4	3

Help
OK
Cancel

PS：不能打中文

10.選OK

塑膠射出成型品之融合強度



Taguchi Design

Type of Design

○ 2-Level Desig

● 3-Level Desig

○ 4-Level Desig

○ 5-Level Desig

○ Mixed Level D

Number of factors: 4

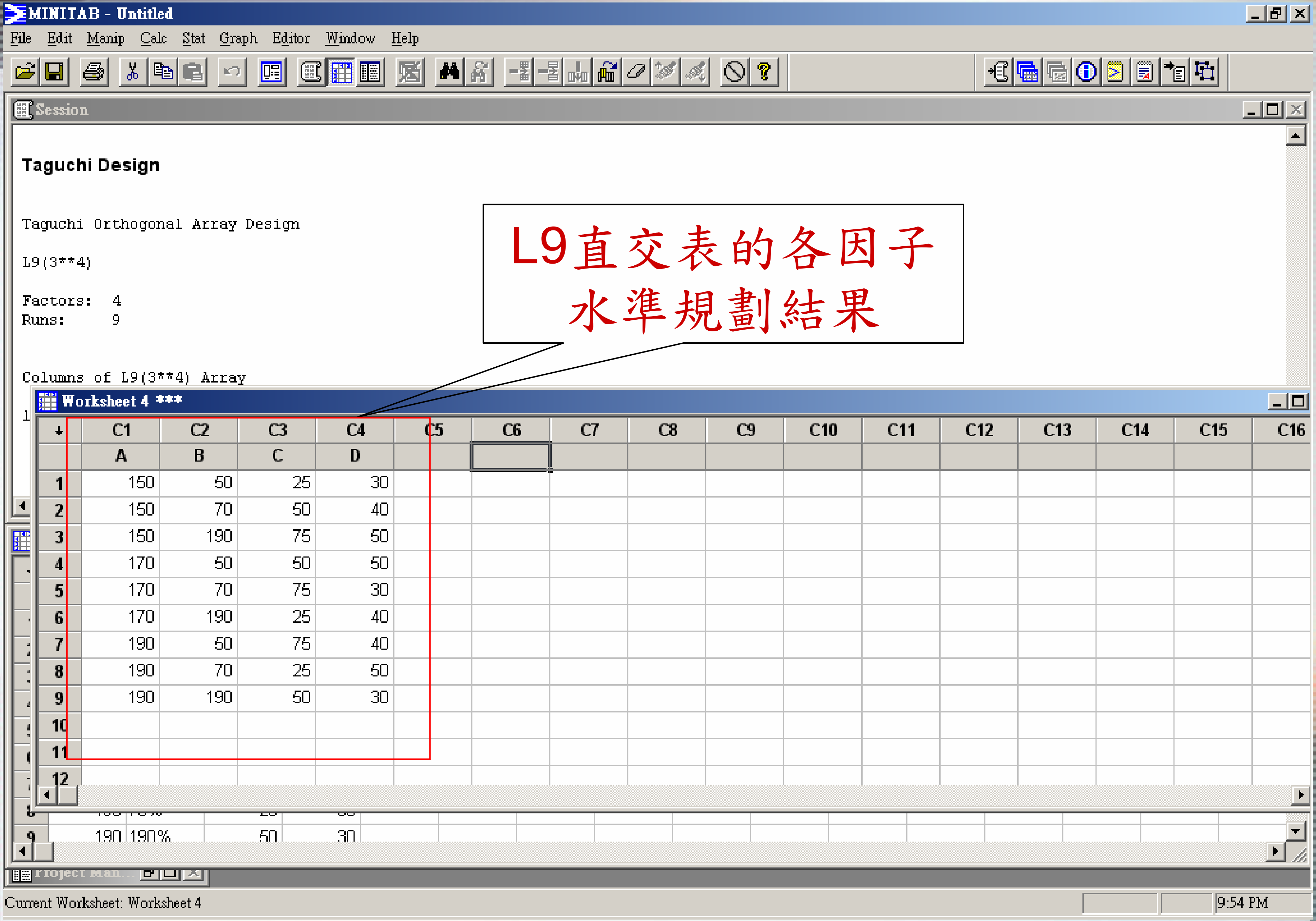
Taguchi Design - Options

☑ Store design in worksheet

Help
OK
Cancel
Display Available Designs...
Designs...
Factors...
Options...
Help
OK
Cancel

11.選Options

12.將直交表輸出到表格

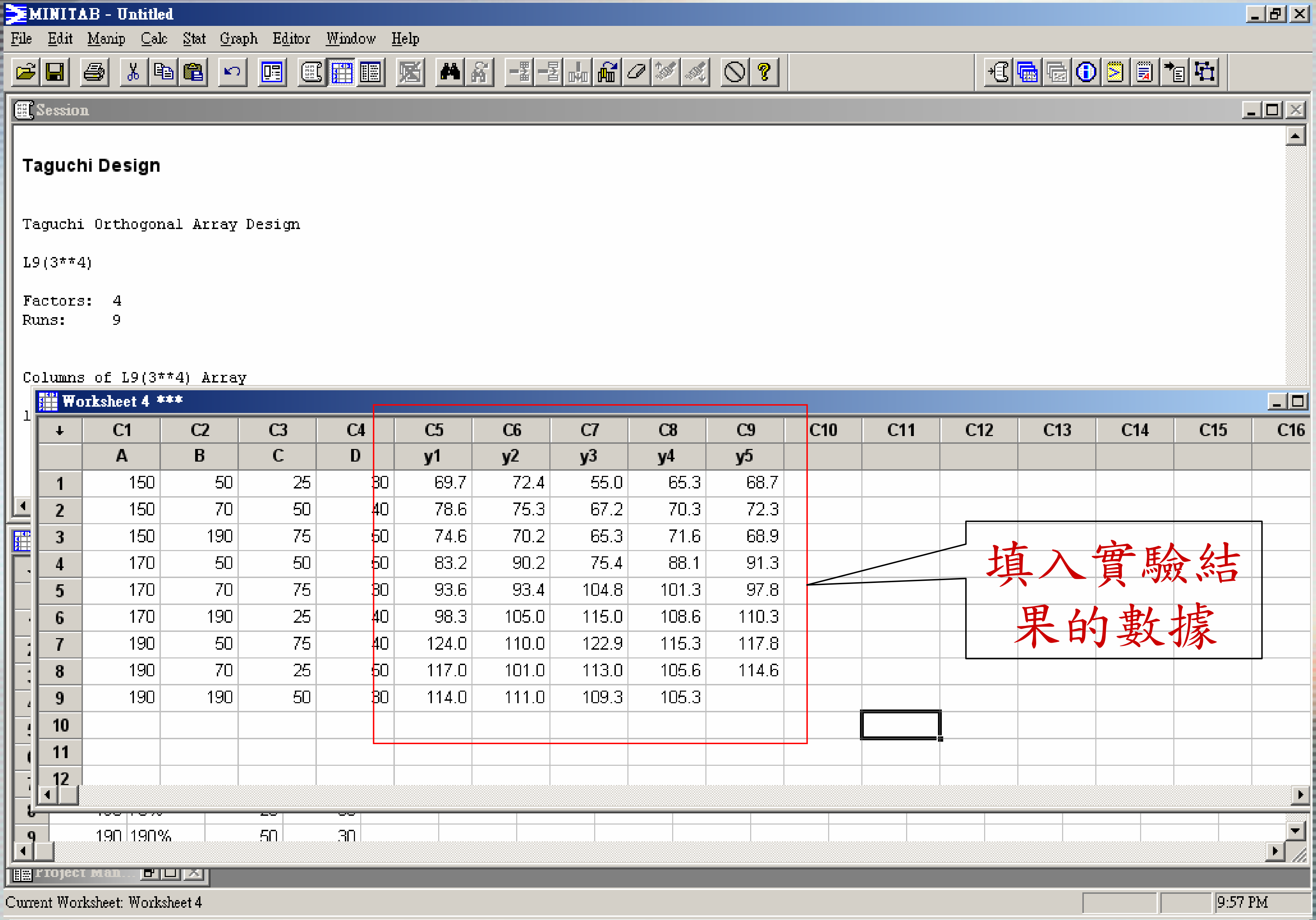

MINITAB - Untitled
File Edit Manip Calc Stat Graph Editor Window Help
Session
Worksheet 4 ***

```
Taguchi Design

Taguchi Orthogonal Array Design

L9(3**4)

Factors:   4
Runs:      9


Columns of L9(3**4) Array
```

	C1	C2	C3	C4	C5	C6
	A	B	C	D		
1	150	50	25	30		
2	150	70	50	40		
3	150	190	75	50		
4	170	50	50	50		
5	170	70	75	30		
6	170	190	25	40		
7	190	50	75	40		
8	190	70	25	50		
9	190	190	50	30		
10						
11						
12						

L9直交表的各因子
水準規劃結果

Current Worksheet: Worksheet 4　9:54 PM


MINITAB - Untitled
File Edit Manip Calc Stat Graph Editor Window Help
Session
Worksheet 4 ***
Project Man...
Current Worksheet: Worksheet 4
9:57 PM

Taguchi Design

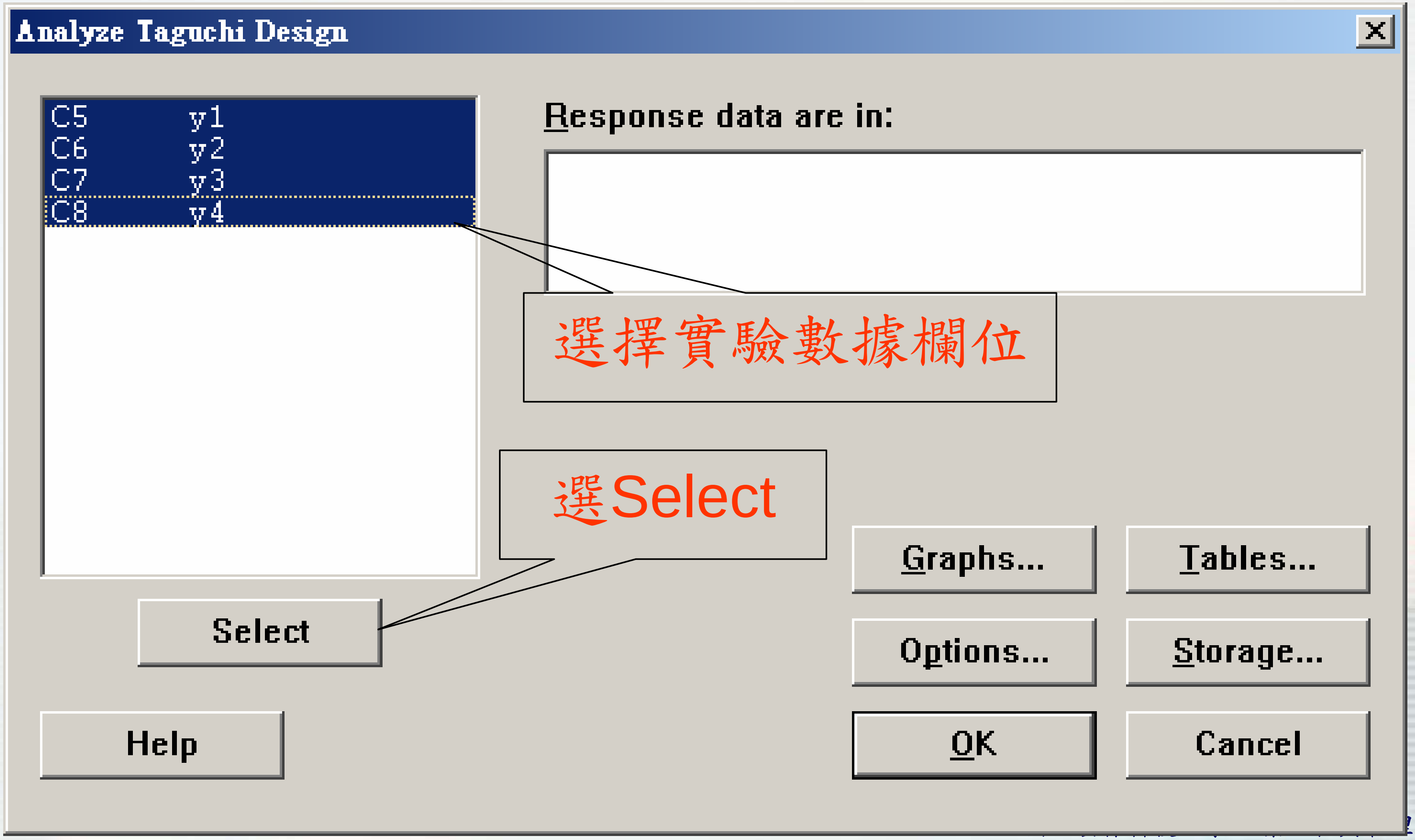
```
Taguchi Orthogonal Array Design

L9(3**4)

Factors:  4
Runs:     9


Columns of L9(3**4) Array
```

↓	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11	C12	C13	C14	C15	C16
	A	B	C	D	y1	y2	y3	y4	y5							
1	150	50	25	30	69.7	72.4	55.0	65.3	68.7							
2	150	70	50	40	78.6	75.3	67.2	70.3	72.3							
3	150	190	75	50	74.6	70.2	65.3	71.6	68.9							
4	170	50	50	50	83.2	90.2	75.4	88.1	91.3							
5	170	70	75	30	93.6	93.4	104.8	101.3	97.8							
6	170	190	25	40	98.3	105.0	115.0	108.6	110.3							
7	190	50	75	40	124.0	110.0	122.9	115.3	117.8							
8	190	70	25	50	117.0	101.0	113.0	105.6	114.6							
9	190	190	50	30	114.0	111.0	109.3	105.3								
10																
11																
12																

填入實驗結果的數據

塑膠射出成型品之融合強度

- 選Stat=>DOE=>Taguchi=>Analyze Taguchi Design



Analyze Taguchi Design

C5	y1
C6	y2
C7	y3
C8	y4

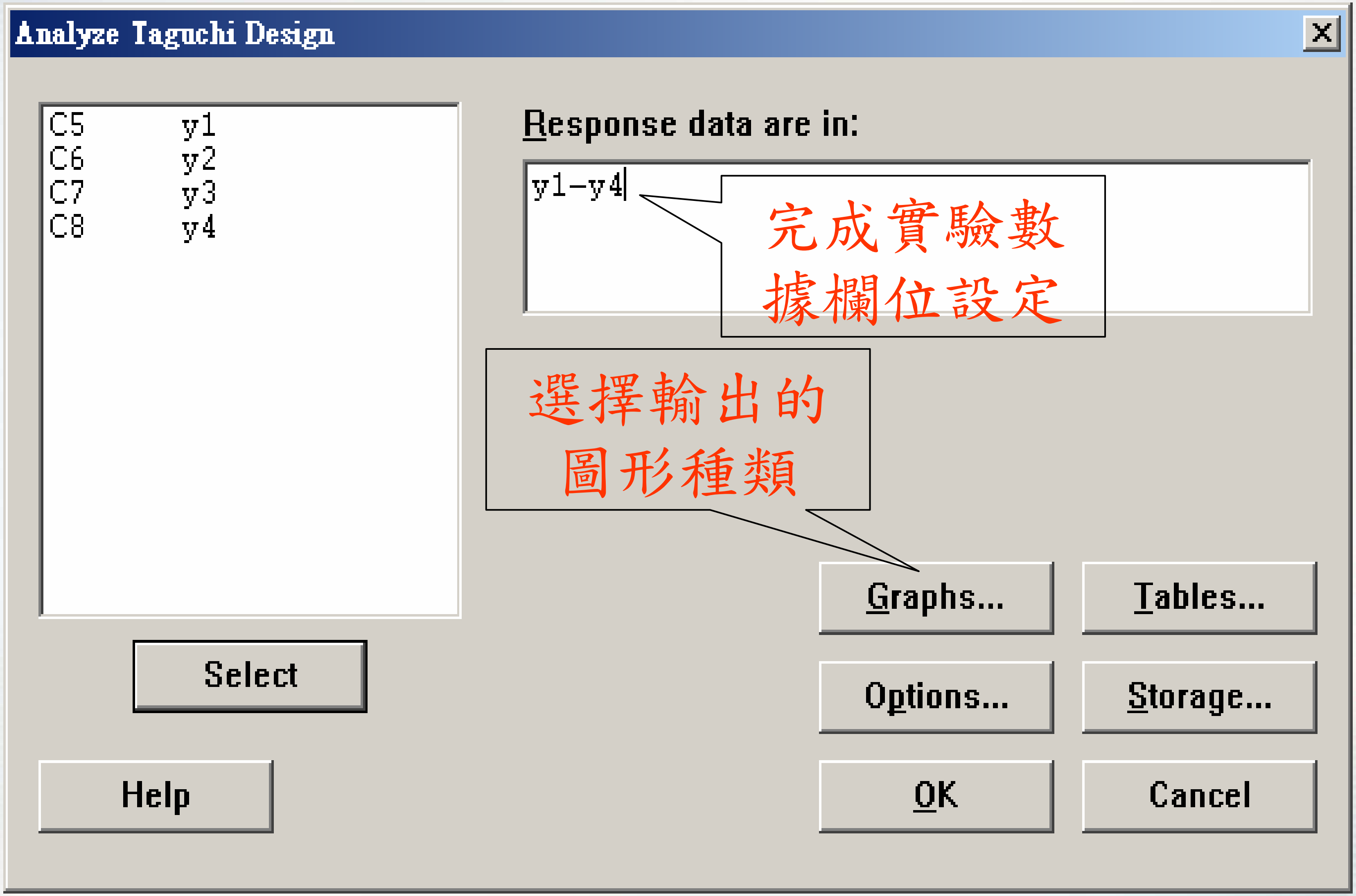
Response data are in:

選擇實驗數據欄位

選Select

Select
Graphs...
Tables...
Options...
Storage...
Help
OK
Cancel

塑膠射出成型品之融合強度

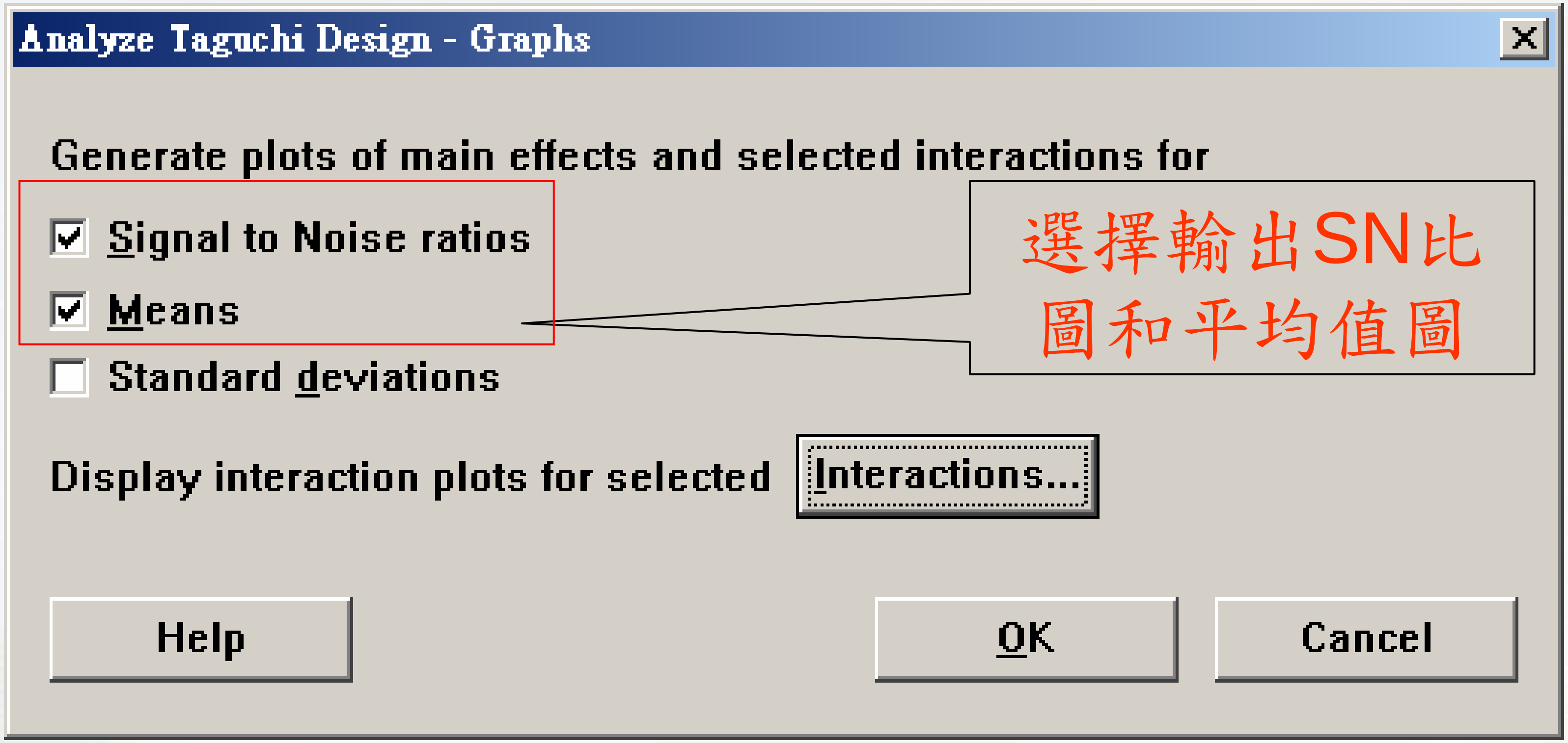

Analyze Taguchi Design
C5 y1
C6 y2
C7 y3
C8 y4
Response data are in:
Select
Help
Graphs...
Tables...
Options...
Storage...
OK
Cancel

y1-y4

完成實驗數據欄位設定

選擇輸出的圖形種類

塑膠射出成型品之融合強度



Analyze Taguchi Design - Graphs

Generate plots of main effects and selected interactions for

☑ Signal to Noise ratios

☑ Means

☐ Standard deviations

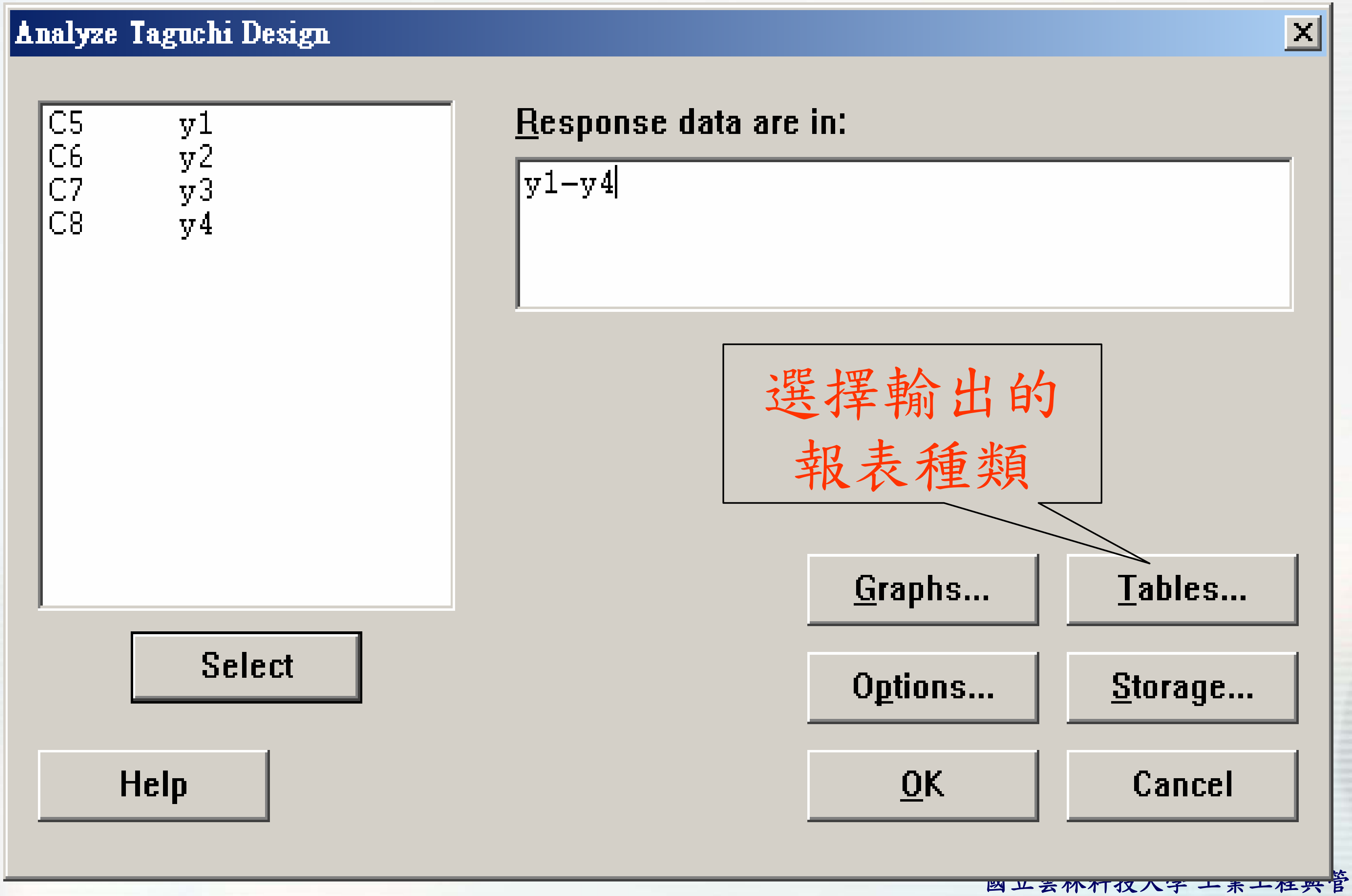
Display interaction plots for selected

Interactions...

Help
OK
Cancel

選擇輸出SN比圖和平均值圖

塑膠射出成型品之融合強度

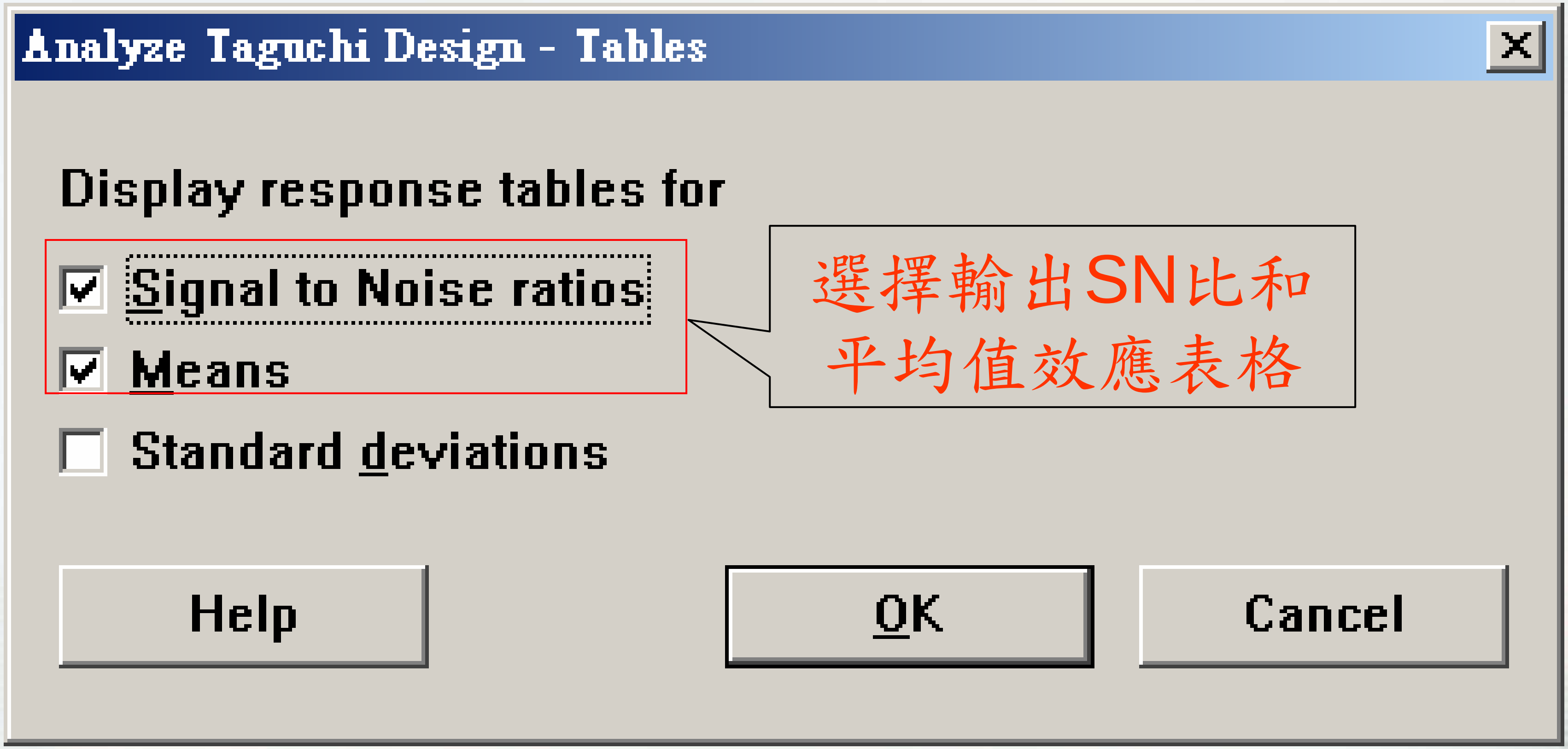

Analyze Taguchi Design
Select
Help
Graphs...
Tables...
Options...
Storage...
OK
Cancel

C5 y1
C6 y2
C7 y3
C8 y4

Response data are in: y1-y4

選擇輸出的
報表種類

塑膠射出成型品之融合強度



Analyze Taguchi Design - Tables

Display response tables for

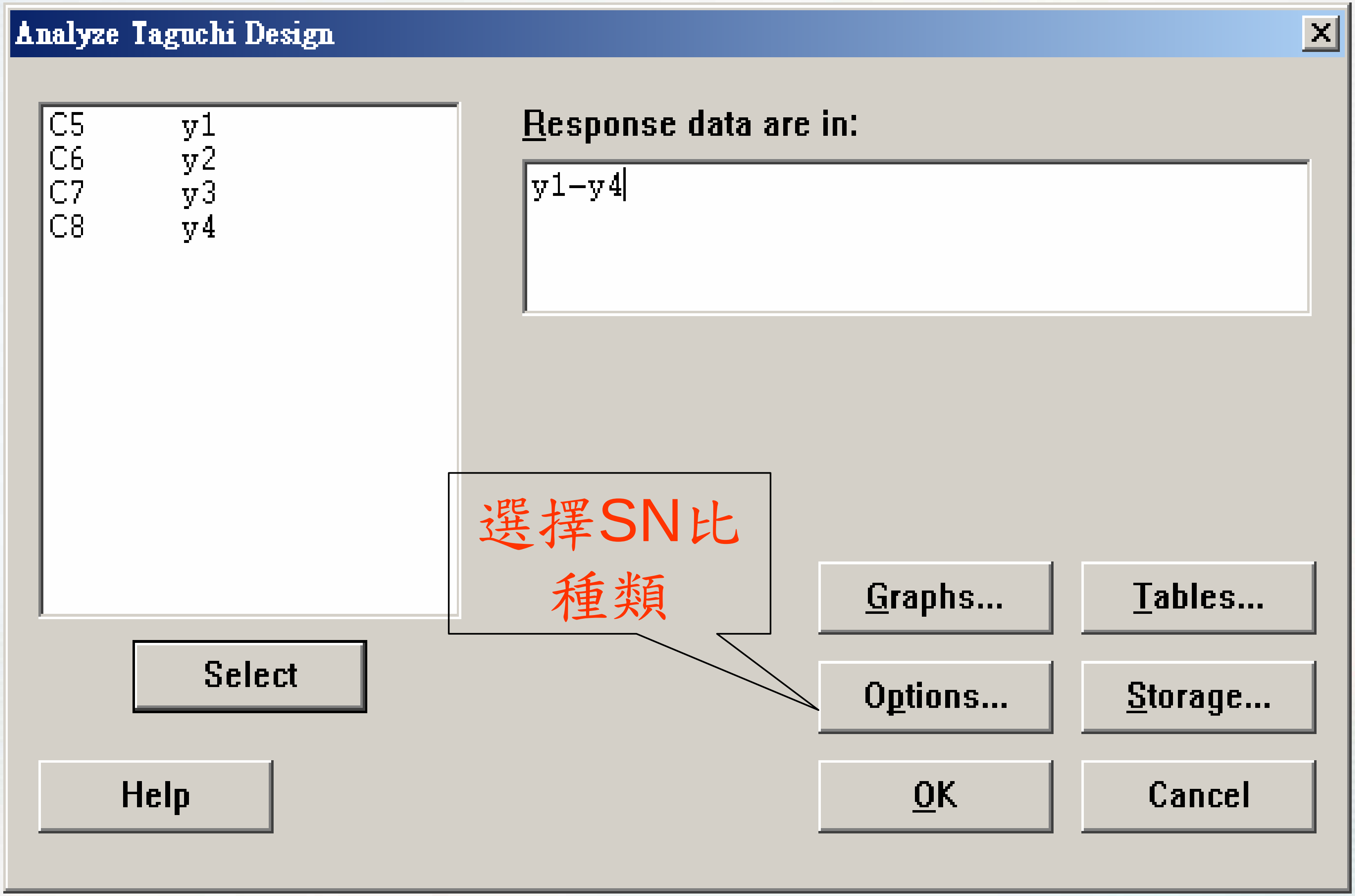
☑ Signal to Noise ratios

☑ Means

☐ Standard deviations

選擇輸出SN比和平均值效應表格

塑膠射出成型品之融合強度



Analyze Taguchi Design

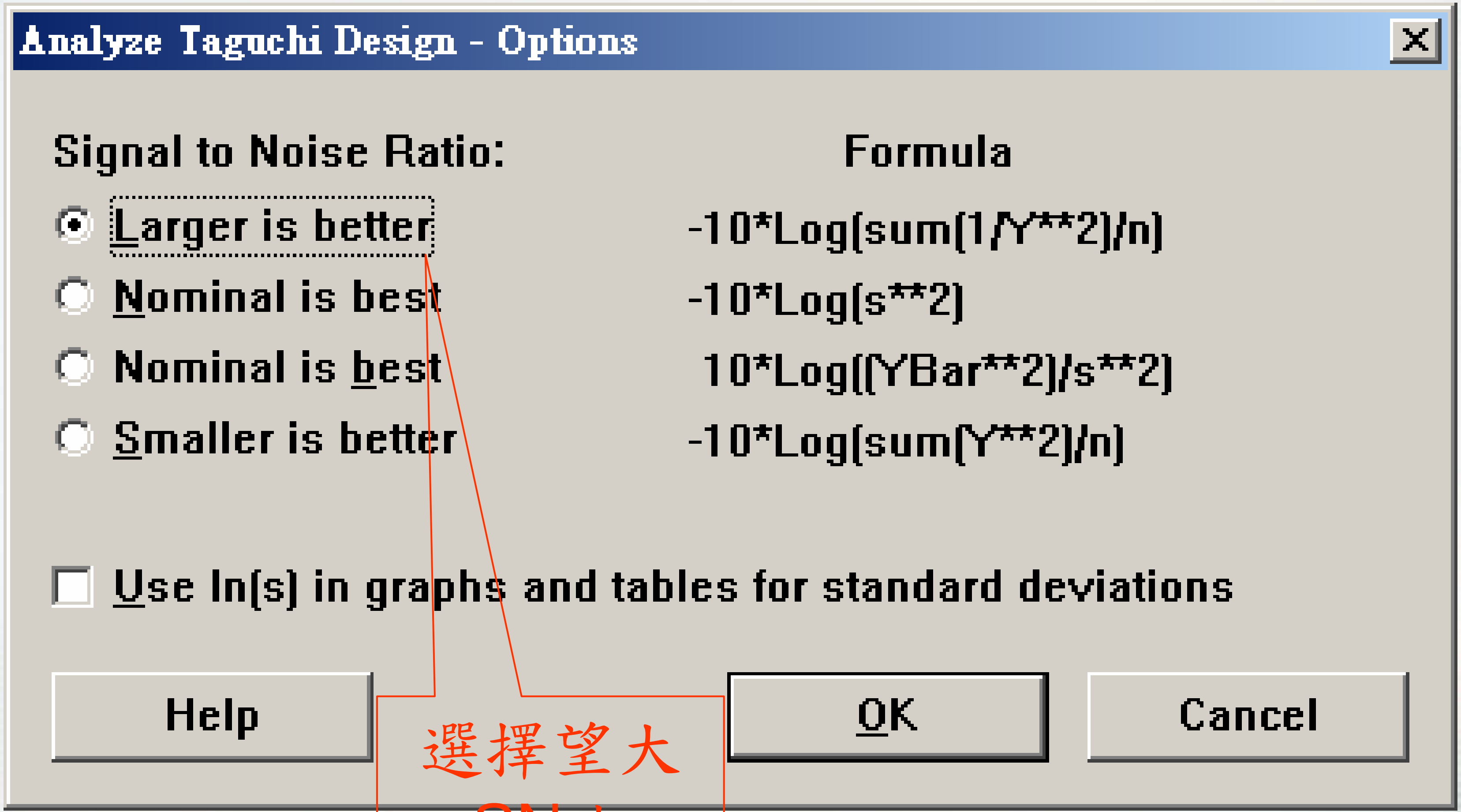
C5	y1
C6	y2
C7	y3
C8	y4

Response data are in: y1-y4

Select
Help
Graphs...
Tables...
Options...
Storage...
OK
Cancel

選擇SN比種類

塑膠射出成型品之融合強度



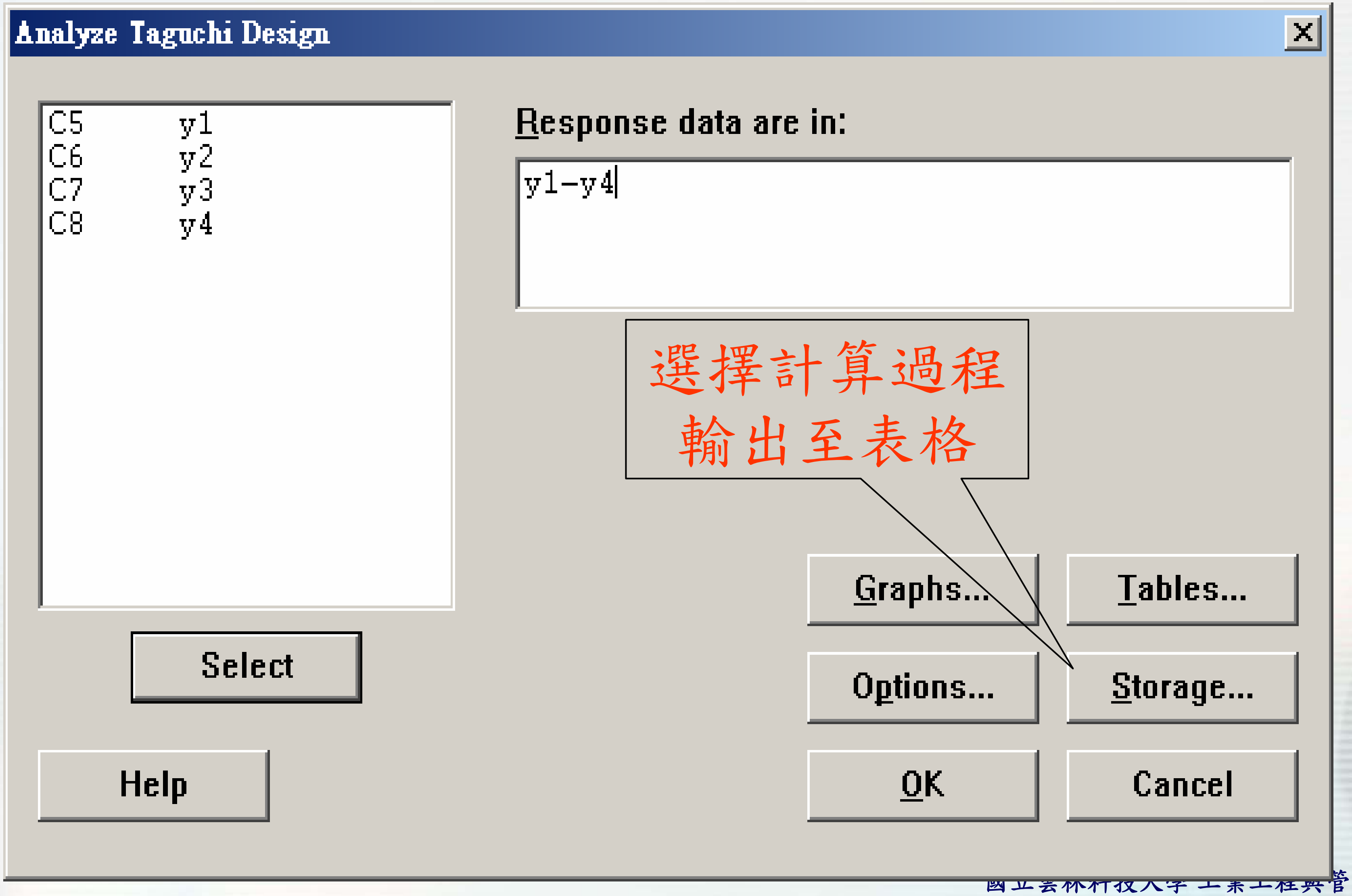
Analyze Taguchi Design - Options

Signal to Noise Ratio:	Formula
● Larger is better	-10*Log(sum(1/Y**2)/n)
○ Nominal is best	-10*Log(s**2)
○ Nominal is best	10*Log((YBar**2)/s**2)
○ Smaller is better	-10*Log(sum(Y**2)/n)

☐ Use ln(s) in graphs and tables for standard deviations

選擇望大
SN比

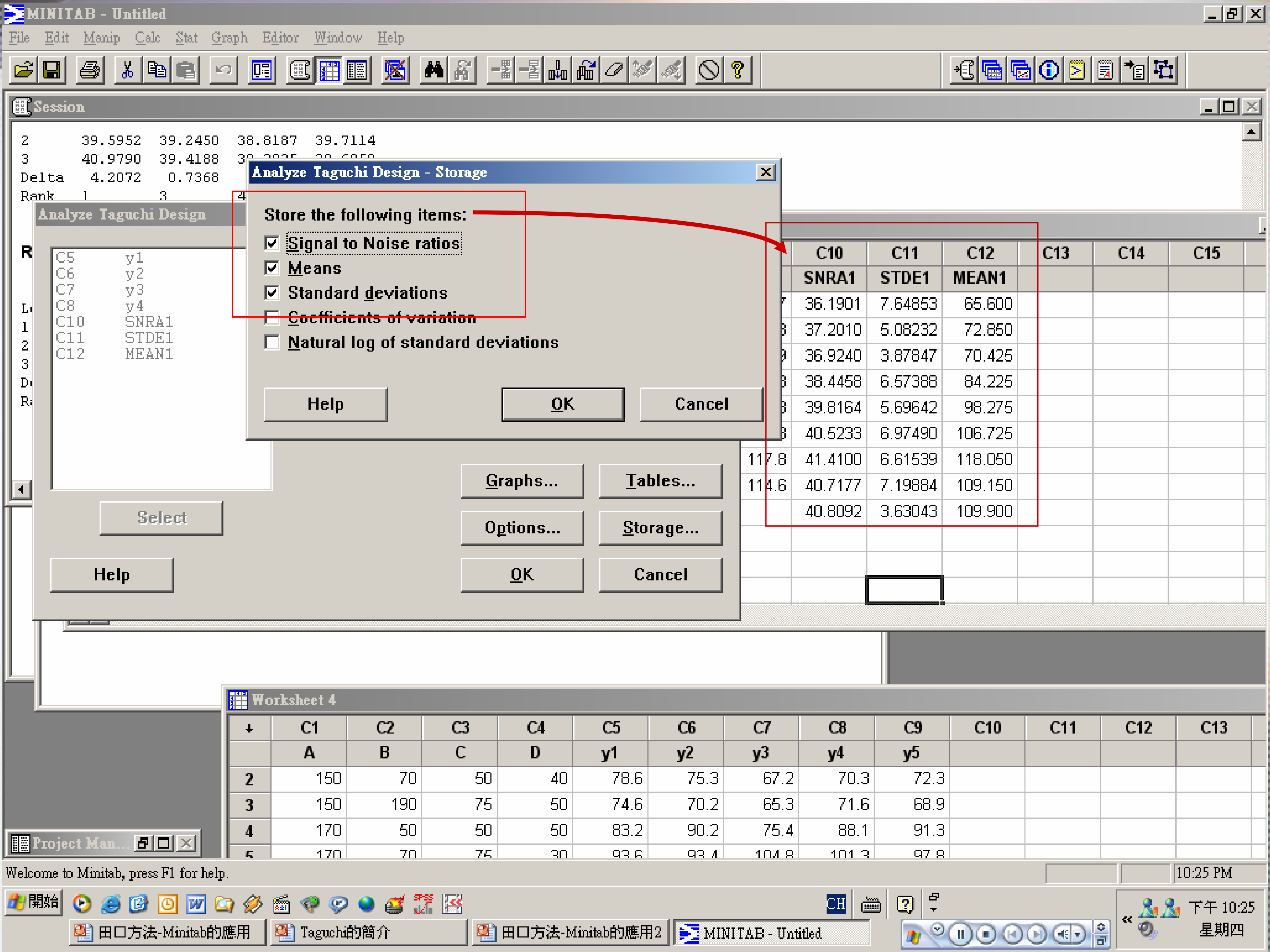
塑膠射出成型品之融合強度


Analyze Taguchi Design
Select
Help
Graphs...
Tables...
Options...
Storage...
OK
Cancel

C5 y1
C6 y2
C7 y3
C8 y4

Response data are in: y1-y4

選擇計算過程
輸出至表格


MINITAB - Untitled
File
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Graph
Editor
Window
Help
Session
Analyze Taguchi Design
Project Man...
Worksheet 4

```
2       39.5952  39.2450  38.8187  39.7114
3       40.9790  39.4188
Delta    4.2072   0.7368
Rank     1        3
```

Analyze Taguchi Design - Storage

Store the following items:

☑ Signal to Noise ratios
☑ Means
☑ Standard deviations
☐ Coefficients of variation
☐ Natural log of standard deviations

Help
OK
Cancel

Analyze Taguchi Design

```
C5    y1
C6    y2
C7    y3
C8    y4
C10   SNRA1
C11   STDE1
C12   MEAN1
```

Select
Help
Graphs...
Tables...
Options...
Storage...
OK
Cancel

C10	C11	C12	C13	C14	C15
SNRA1	STDE1	MEAN1			
36.1901	7.64853	65.600			
37.2010	5.08232	72.850			
36.9240	3.87847	70.425			
38.4458	6.57388	84.225			
39.8164	5.69642	98.275			
40.5233	6.97490	106.725			
41.4100	6.61539	118.050			
40.7177	7.19884	109.150			
40.8092	3.63043	109.900			

Worksheet 4

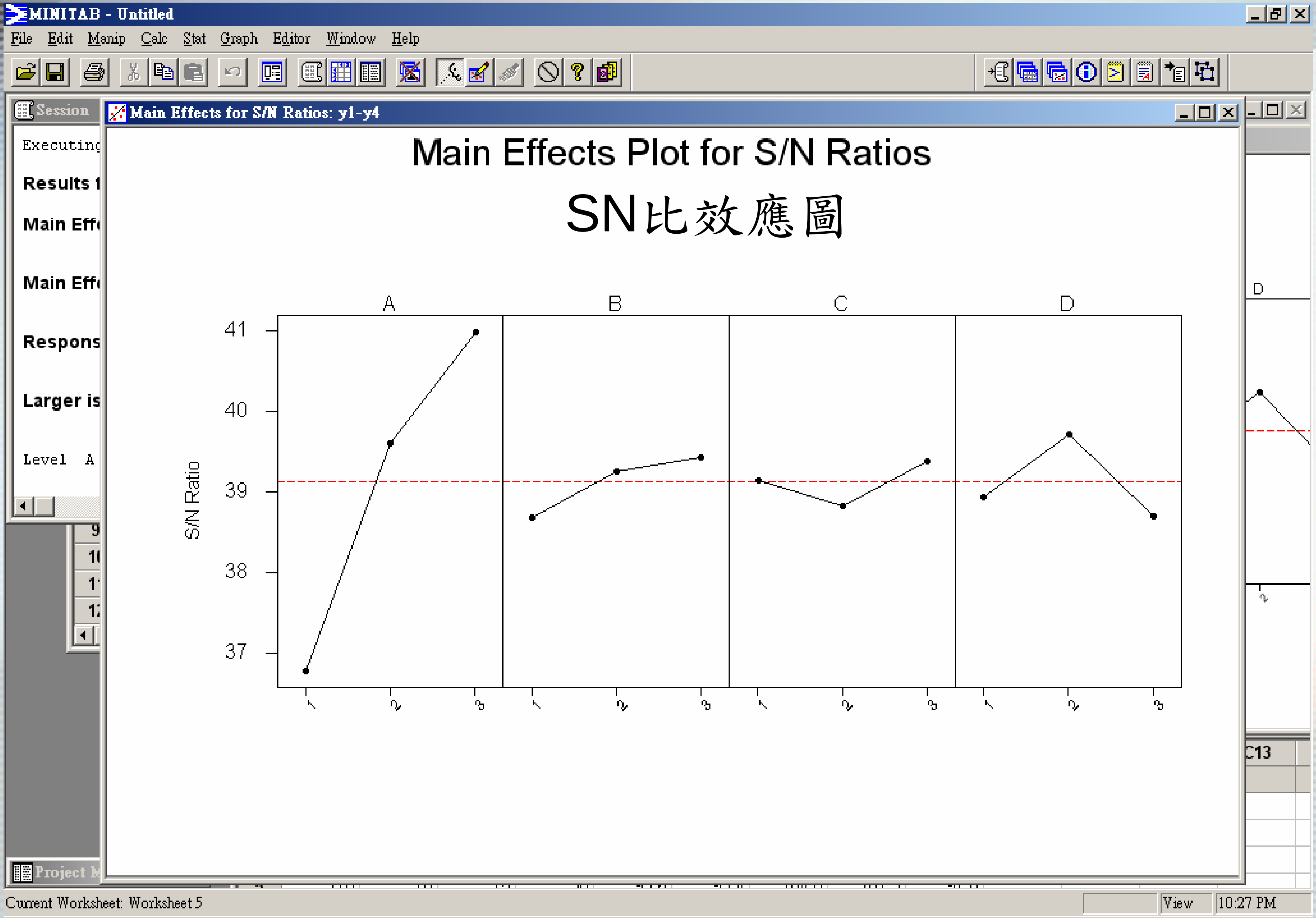
↓	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11	C12	C13
	A	B	C	D	y1	y2	y3	y4	y5				
2	150	70	50	40	78.6	75.3	67.2	70.3	72.3				
3	150	190	75	50	74.6	70.2	65.3	71.6	68.9				
4	170	50	50	50	83.2	90.2	75.4	88.1	91.3				
5	170	70	75	30	93.6	93.4	104.8	101.3	97.8				

Welcome to Minitab, press F1 for help.

10:25 PM

開始
田口方法-Minitab的應用
Taguchi的簡介
田口方法-Minitab的應用2
MINITAB - Untitled
CH
下午 10:25
星期四

SN比效應圖


MINITAB - Untitled
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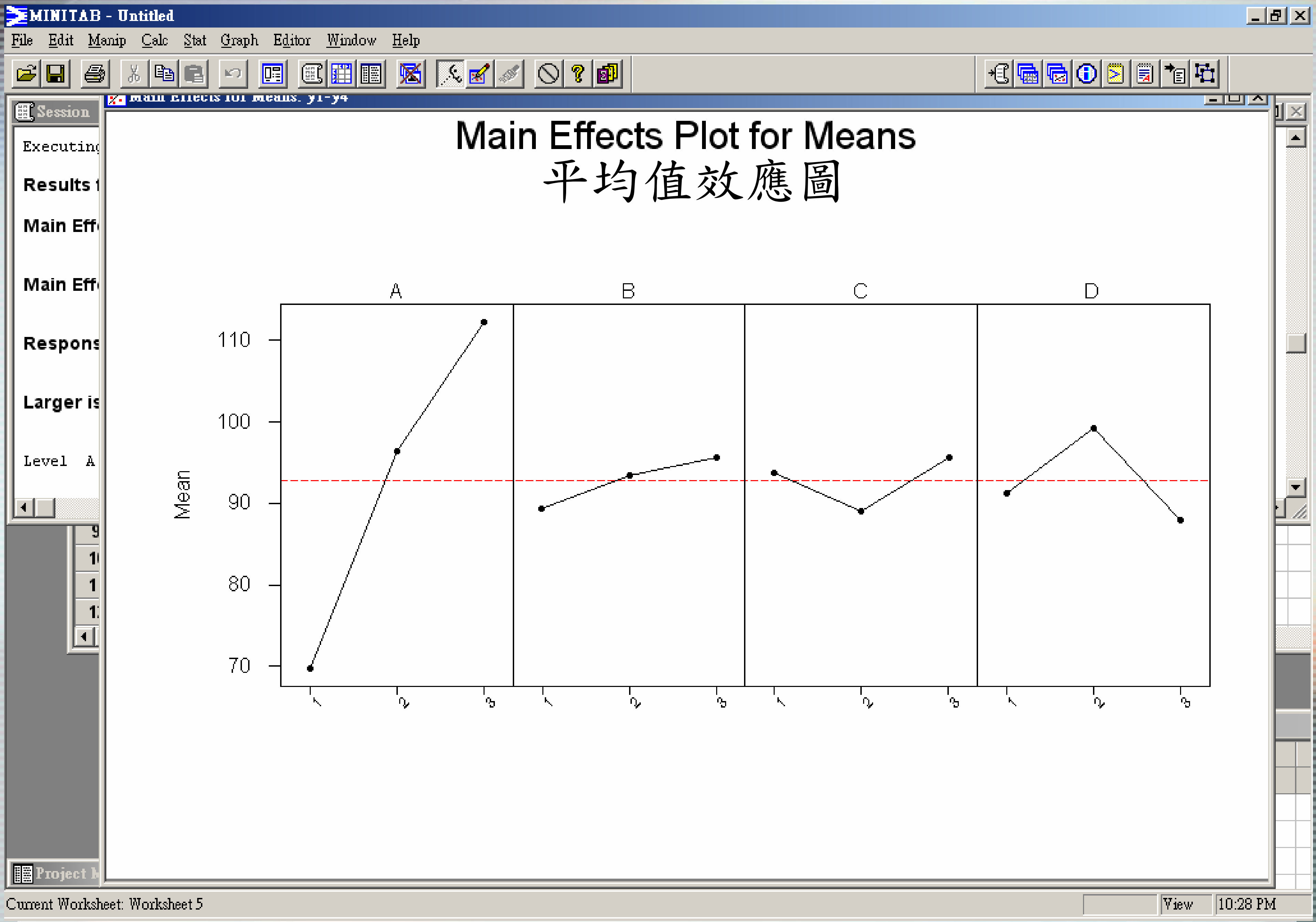
Executing
Results f
Main Eff
Main Eff
Respons
Larger is
Level A
Main Effects for S/N Ratios: y1-y4
Main Effects Plot for S/N Ratios
A
B
C
D
S/N Ratio
41
40
39
38
37
1
2
3
1
2
3
1
2
3
1
2
3
C13
Project M
Current Worksheet: Worksheet 5
View
10:27 PM



MINITAB - Untitled
File
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Manip
Calc
Stat
Graph
Editor
Window
Help
Session
Project

Main Effects for Means: y1-y4

Main Effects Plot for Means
平均值效應圖

A
B
C
D
Mean
110
100
90
80
70
1
2
3
1
2
3
1
2
3
1
2
3

Executing

Results f

Main Eff

Main Eff

Respons

Larger is

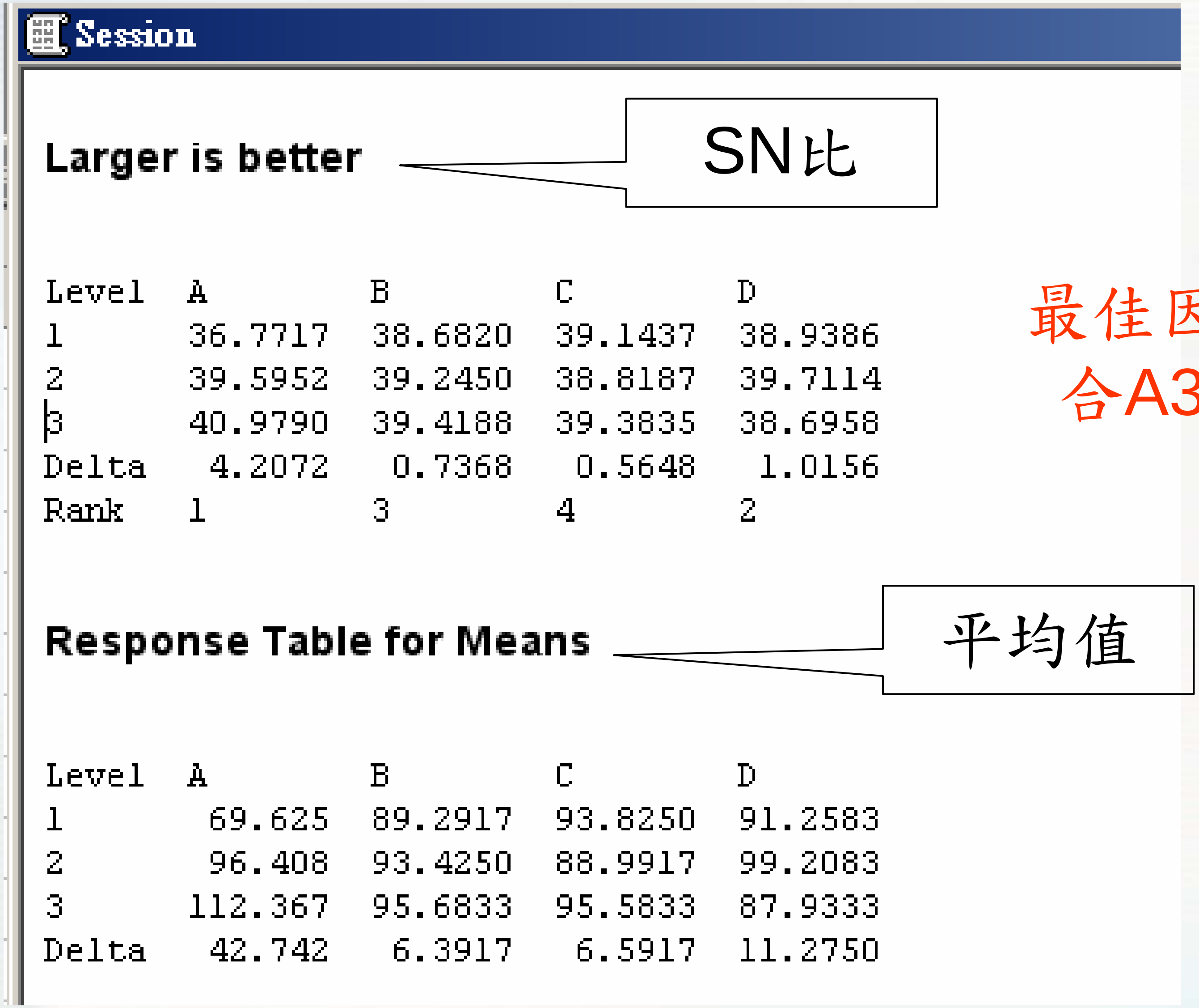
```
Level  A
```

Current Worksheet: Worksheet 5

View

10:28 PM

塑膠射出成型品之融合強度



SN比

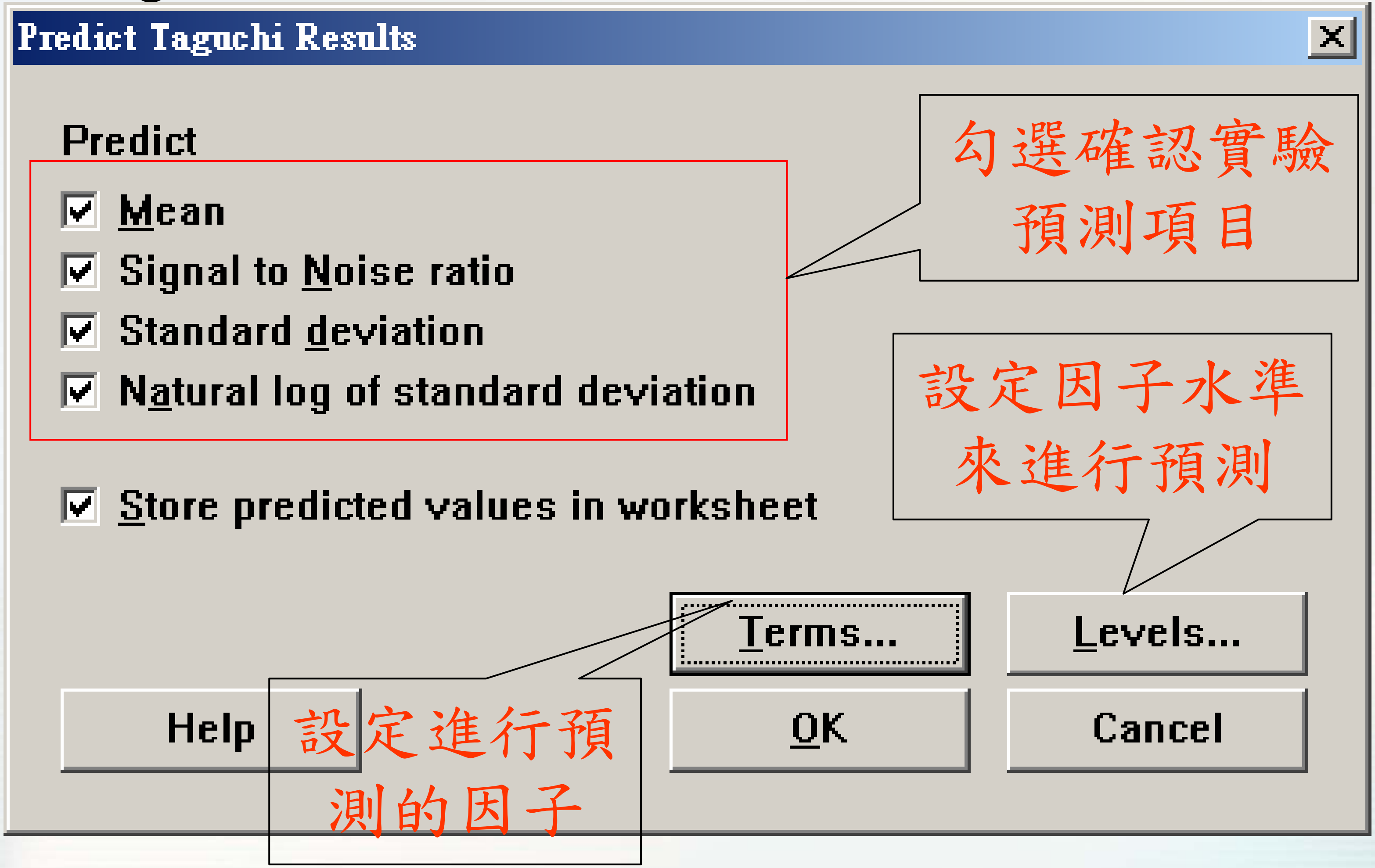
平均值

```
Larger is better

Level   A        B        C        D
1       36.7717  38.6820  39.1437  38.9386
2       39.5952  39.2450  38.8187  39.7114
3       40.9790  39.4188  39.3835  38.6958
Delta    4.2072   0.7368   0.5648   1.0156
Rank    1        3        4        2


Response Table for Means

Level   A        B        C        D
1        69.625  89.2917  93.8250  91.2583
2        96.408  93.4250  88.9917  99.2083
3       112.367  95.6833  95.5833  87.9333
Delta    42.742   6.3917   6.5917  11.2750
```

最佳因子水準組合A3B3C3D2

塑膠射出成型品之融合強度

- 選Stat=>DOE=>Taguchi=>Predict Taguchi Results



Predict Taguchi Results

Predict

☑ Mean

☑ Signal to Noise ratio

☑ Standard deviation

☑ Natural log of standard deviation

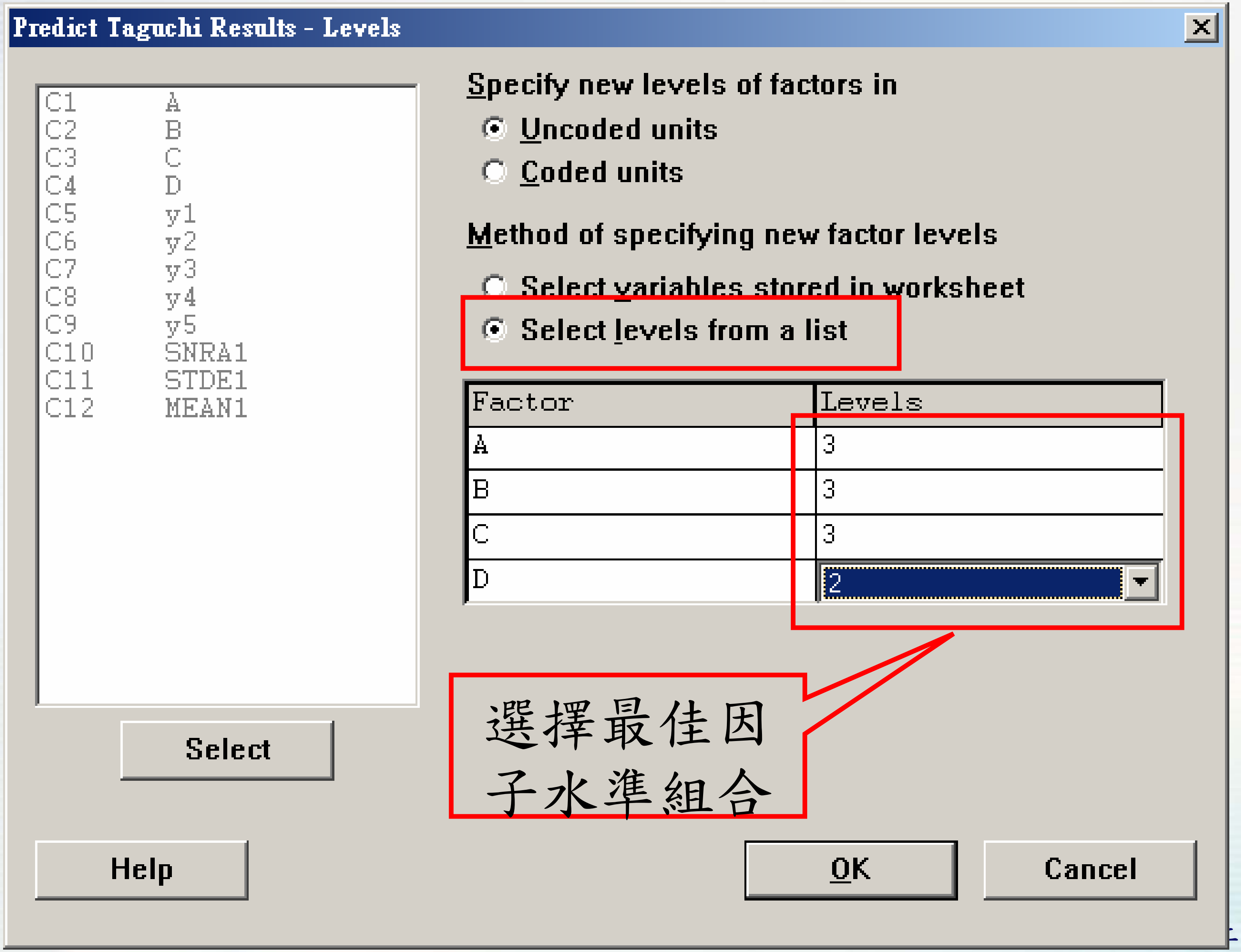
☑ Store predicted values in worksheet

勾選確認實驗預測項目

設定因子水準來進行預測

設定進行預測的因子

塑膠射出成型品之融合強度



Predict Taguchi Results - Levels

C1 A
C2 B
C3 C
C4 D
C5 y1
C6 y2
C7 y3
C8 y4
C9 y5
C10 SNRA1
C11 STDE1
C12 MEAN1

Specify new levels of factors in
● Uncoded units
○ Coded units

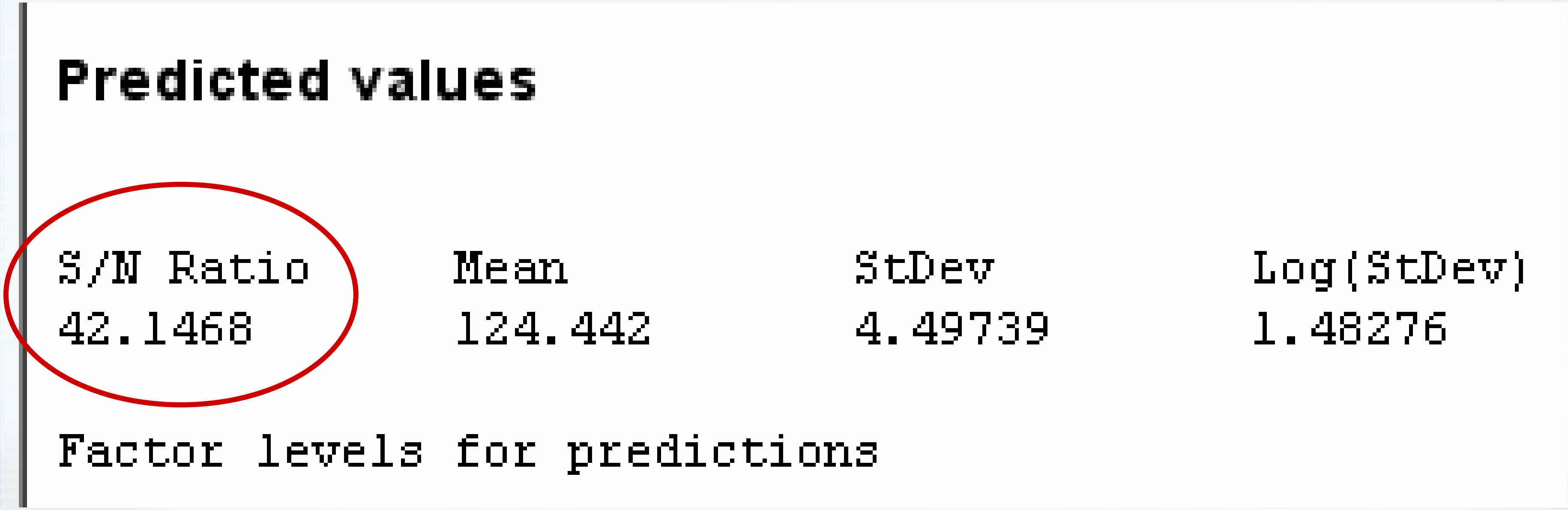
Method of specifying new factor levels
○ Select variables stored in worksheet
● Select levels from a list

Factor	Levels
A	3
B	3
C	3
D	2

選擇最佳因子水準組合

塑膠射出成型品之融合強度

- 確認實驗預測結果



Predicted values

```
S/N Ratio      Mean        StDev      Log(StDev)
42.1468        124.442     4.49739    1.48276

Factor levels for predictions
```

]

波霸奶茶涼度實驗

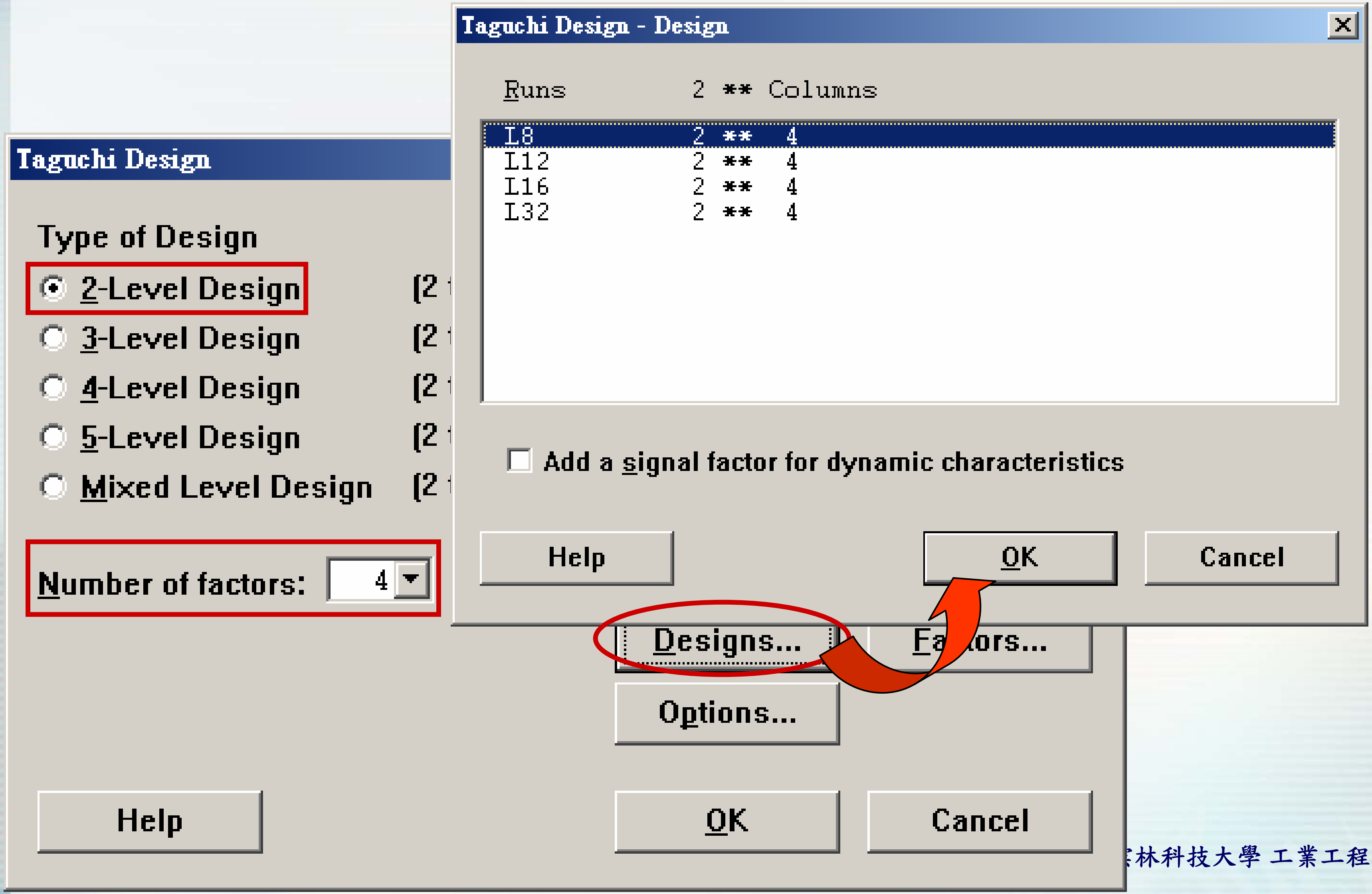
- 某波霸奶茶老闆，接到顧客抱怨奶茶不夠冰，這老闆想改善奶茶的涼度。
- 品質特性：涼度（望小品質特性）

因子符號	說明	水準1	水準2
A	冰塊種類	2個冰塊	碎冰
B	混合方式	未攪動	攪動10秒
C	溫度量測位置	底部	表面
D	杯子種類	紙杯	保麗龍杯

- 因子A和B有交互作用，A和C有交互作用，B和C有交互作用，選用L8直交表進行實驗

波霸奶茶涼度實驗

- 選Stat=>DOE=>Taguchi=>Create Taguchi Design



Taguchi Design

Type of Design

● 2-Level Design [2

○ 3-Level Design [2

○ 4-Level Design [2

○ 5-Level Design [2

○ Mixed Level Design [2

Number of factors: 4

Designs...
Factors...
Options...
Help
OK
Cancel

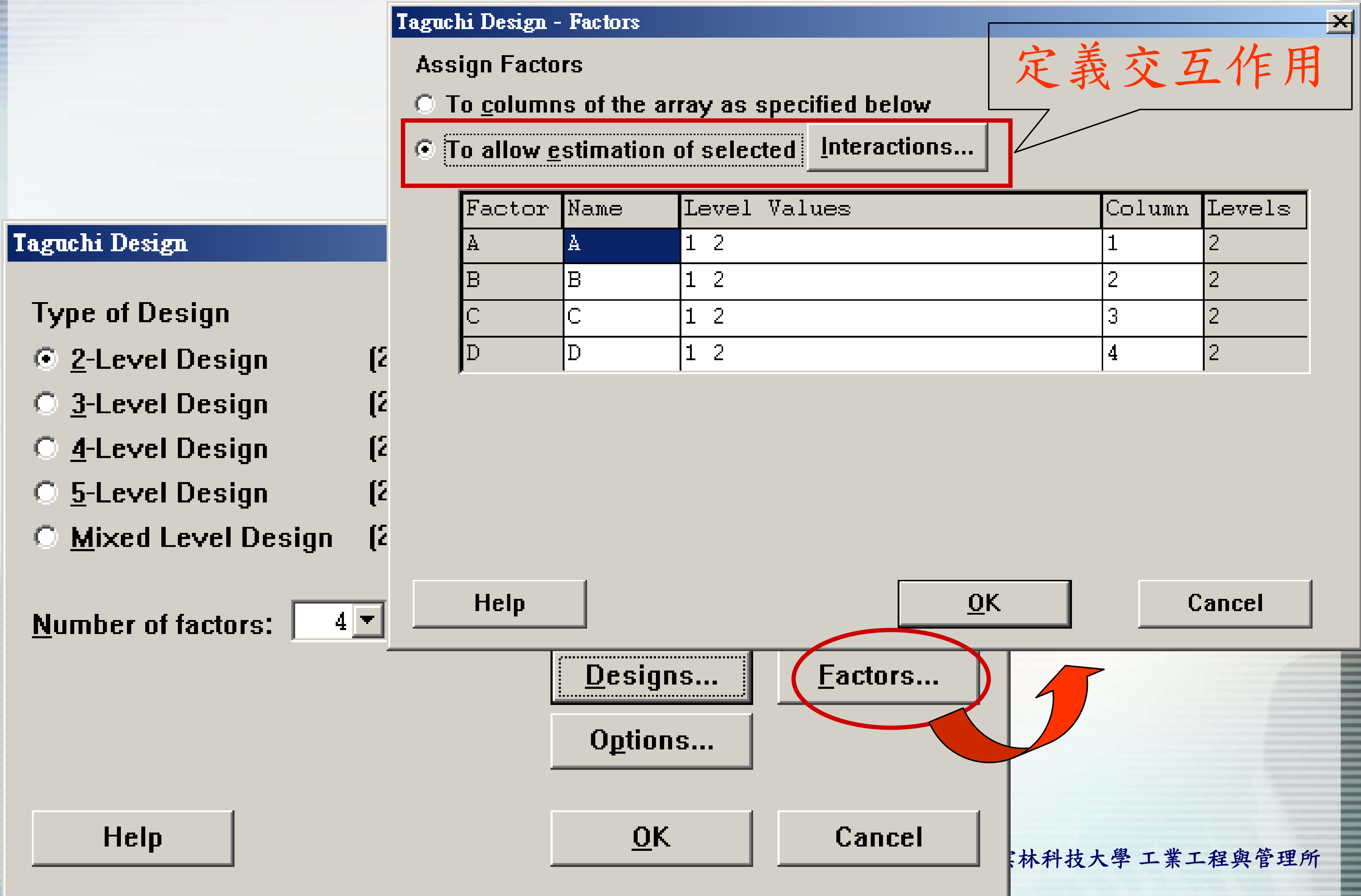
Taguchi Design - Design

Runs	2 ** Columns
L8	2 ** 4
L12	2 ** 4
L16	2 ** 4
L32	2 ** 4

☐ Add a signal factor for dynamic characteristics

Help
OK
Cancel

波霸奶茶涼度實驗



Taguchi Design - Factors

Assign Factors

○ To columns of the array as specified below

● To allow estimation of selected

Interactions...

Factor	Name	Level Values	Column	Levels
A	A	1 2	1	2
B	B	1 2	2	2
C	C	1 2	3	2
D	D	1 2	4	2

Help
OK
Cancel

定義交互作用

Taguchi Design

Type of Design

● 2-Level Design

○ 3-Level Design

○ 4-Level Design

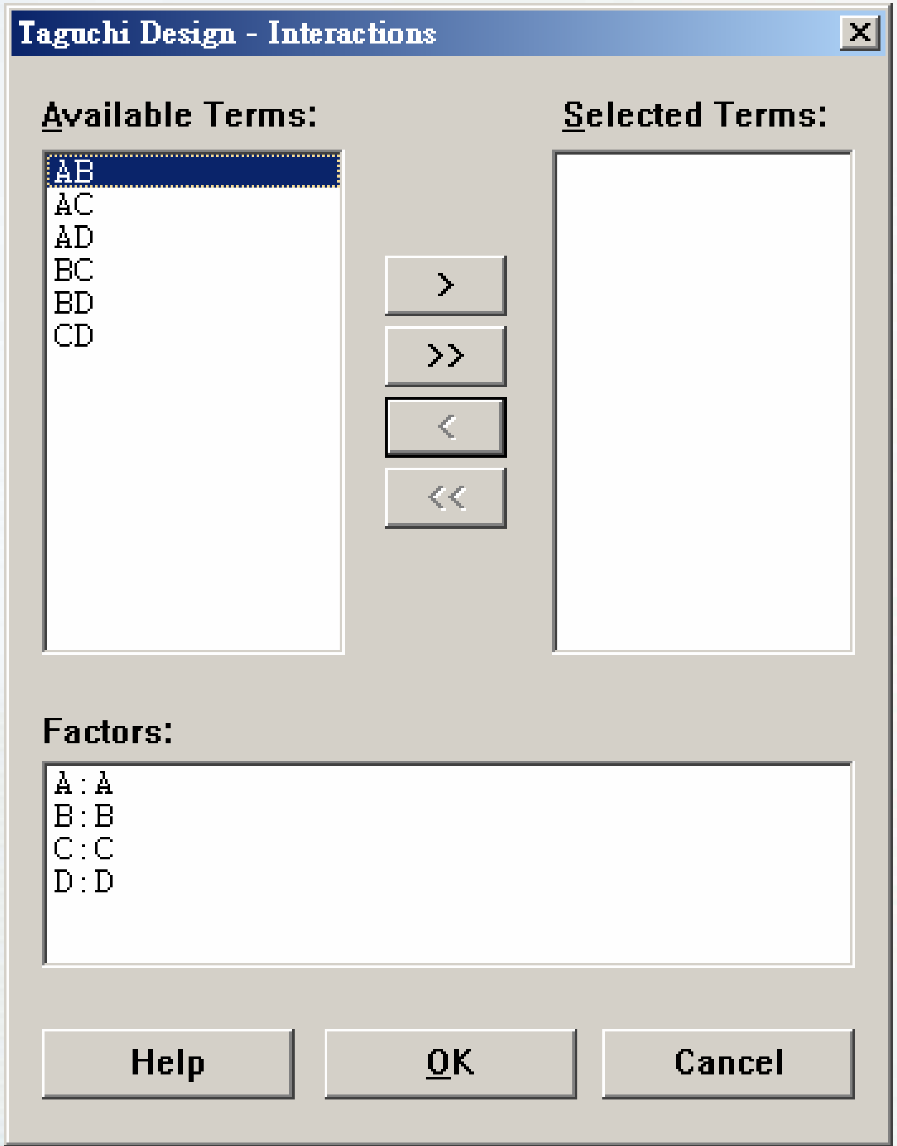
○ 5-Level Design

○ Mixed Level Design

Number of factors: 4

Designs...
Factors...
Options...
Help
OK
Cancel

波霸奶茶涼度實驗



Taguchi Design - Interactions

Available Terms:

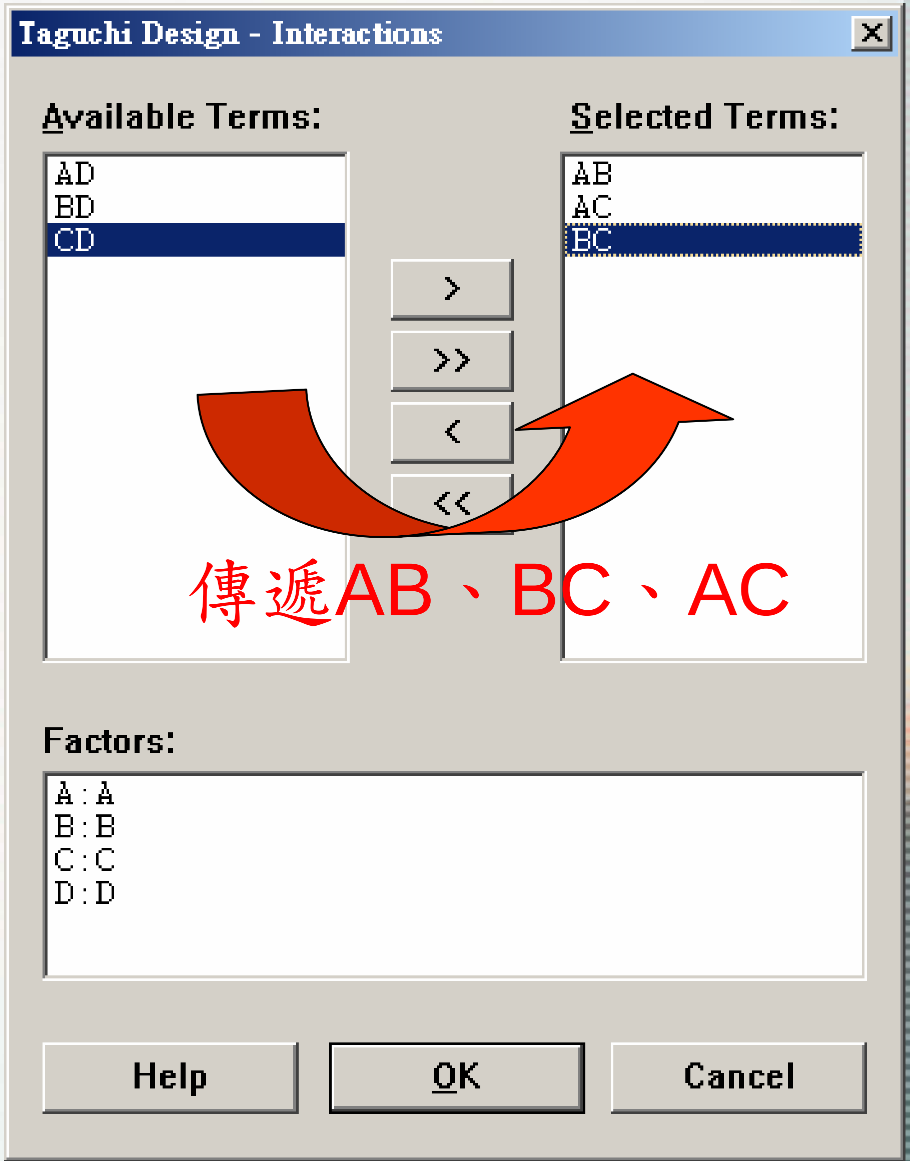
AB
AC
AD
BC
BD
CD

Selected Terms:

Factors:

A:A
B:B
C:C
D:D

>
>>
<
<<
Help
OK
Cancel



Taguchi Design - Interactions

Available Terms:

AD
BD
CD

Selected Terms:

AB
AC
BC

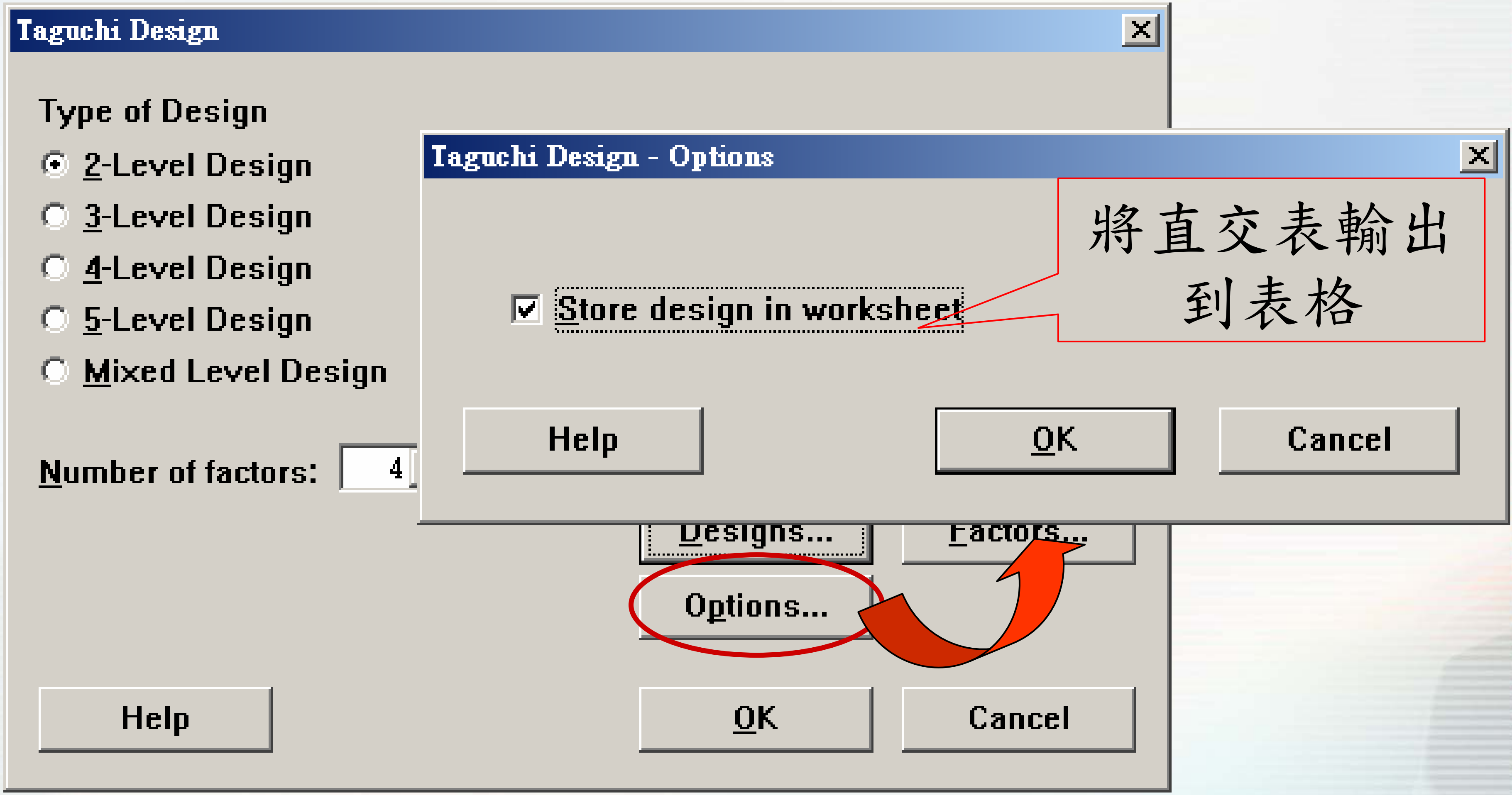
Factors:

A:A
B:B
C:C
D:D

>
>>
<
<<
Help
OK
Cancel

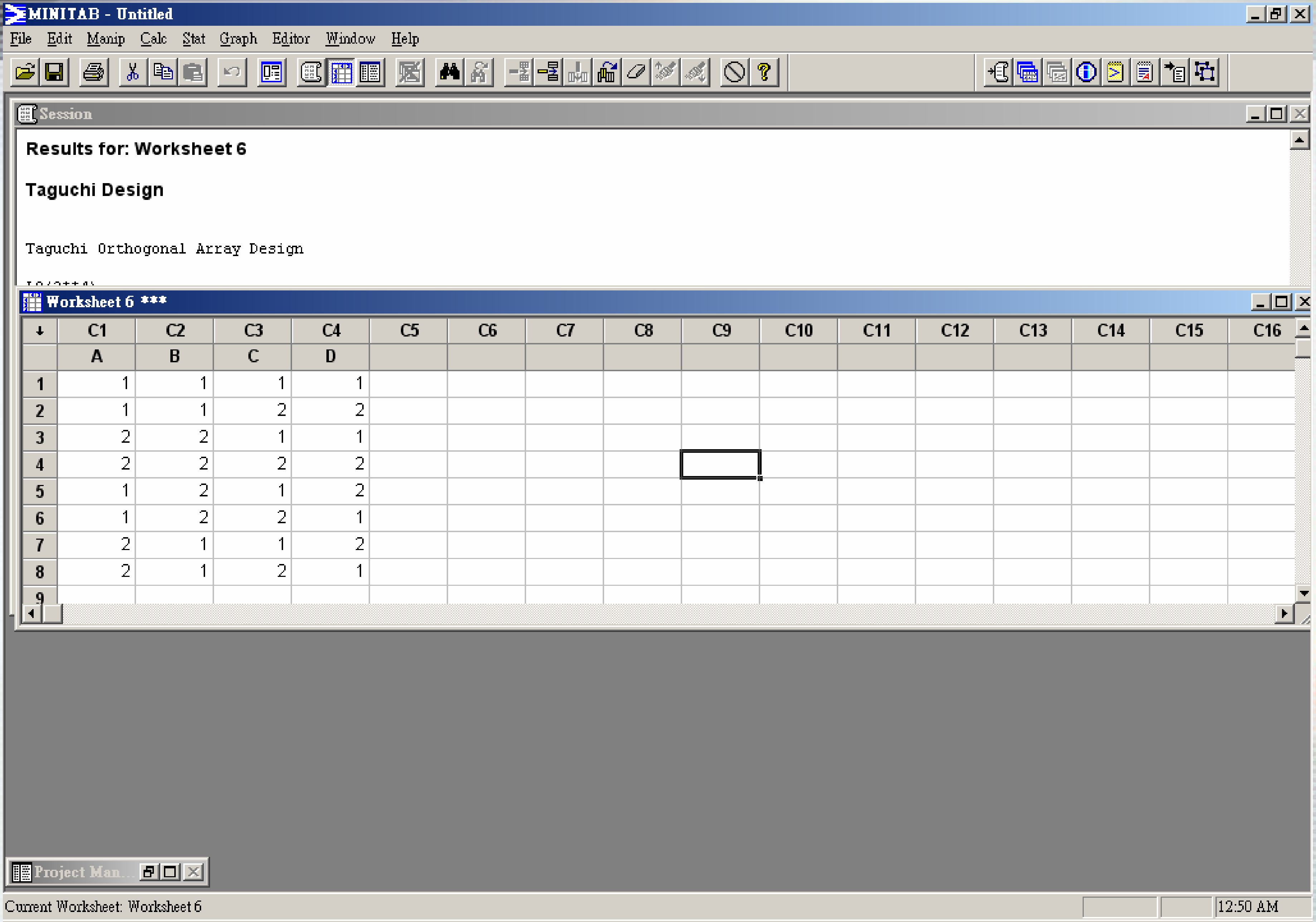
傳遞AB、BC、AC

波霸奶茶涼度實驗


Taguchi Design
Type of Design
● 2-Level Design
○ 3-Level Design
○ 4-Level Design
○ 5-Level Design
○ Mixed Level Design
Number of factors: 4
Designs...
Factors...
Options...
Help
OK
Cancel
Taguchi Design - Options
Help
OK
Cancel

☑ Store design in worksheet

將直交表輸出到表格


MINITAB - Untitled
File
Edit
Manip
Calc
Stat
Graph
Editor
Window
Help
Session
Worksheet 6 ***
C5
C6
C7
C8
C9
C10
C11
C12
C13
C14
C15
C16
Project Man...
12:50 AM

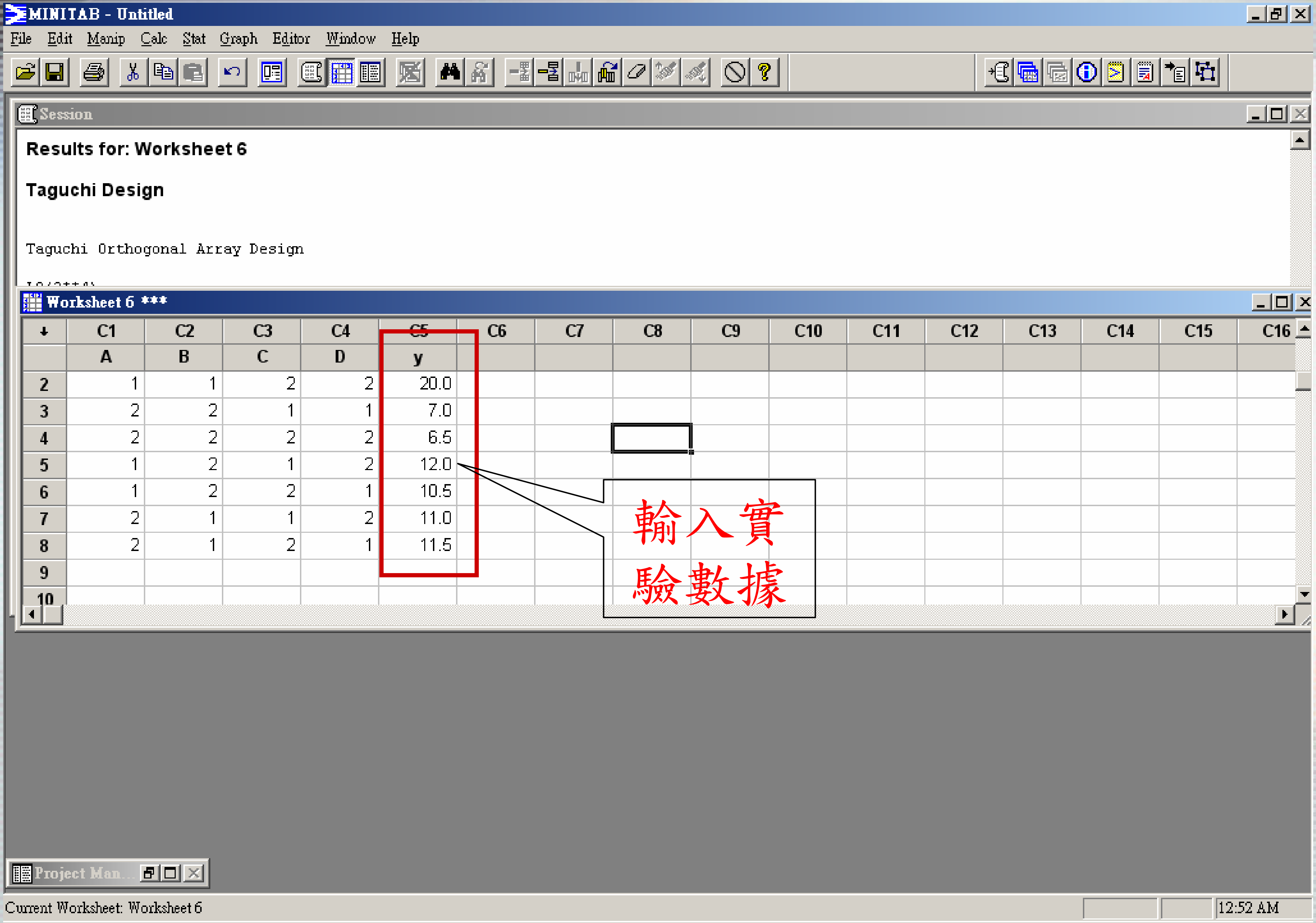
Results for: Worksheet 6

Taguchi Design

```
Taguchi Orthogonal Array Design

L8(2**4)
```

↓	C1	C2	C3	C4
	A	B	C	D
1	1	1	1	1
2	1	1	2	2
3	2	2	1	1
4	2	2	2	2
5	1	2	1	2
6	1	2	2	1
7	2	1	1	2
8	2	1	2	1
9				

Current Worksheet: Worksheet 6


MINITAB - Untitled
File Edit Manip Calc Stat Graph Editor Window Help
Session
Worksheet 6 ***
Project Man...
Current Worksheet: Worksheet 6
12:52 AM

Results for: Worksheet 6

Taguchi Design

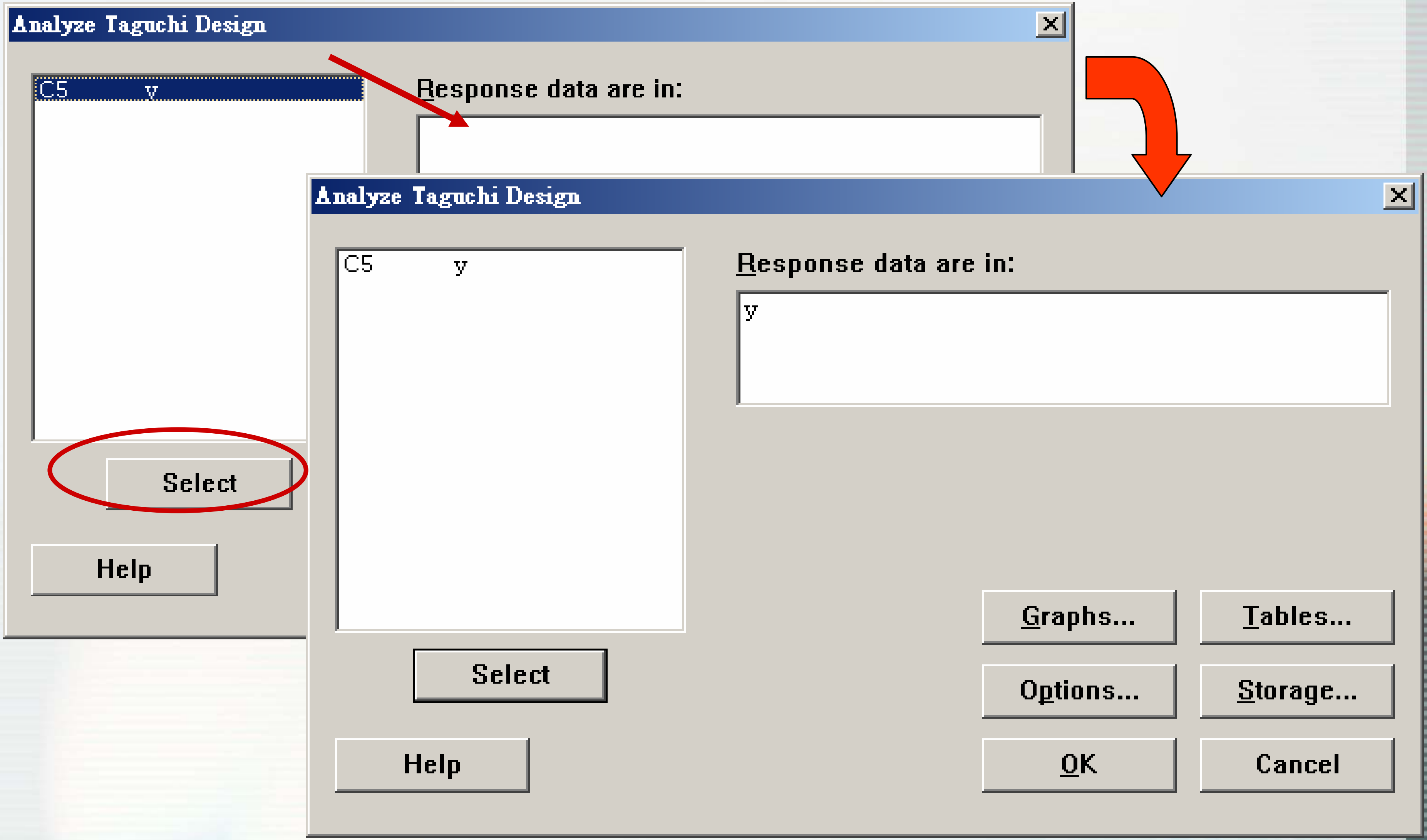
```
Taguchi Orthogonal Array Design
```

↓	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11	C12	C13	C14	C15	C16
	A	B	C	D	y											
2	1	1	2	2	20.0											
3	2	2	1	1	7.0											
4	2	2	2	2	6.5											
5	1	2	1	2	12.0											
6	1	2	2	1	10.5											
7	2	1	1	2	11.0											
8	2	1	2	1	11.5											
9																
10																

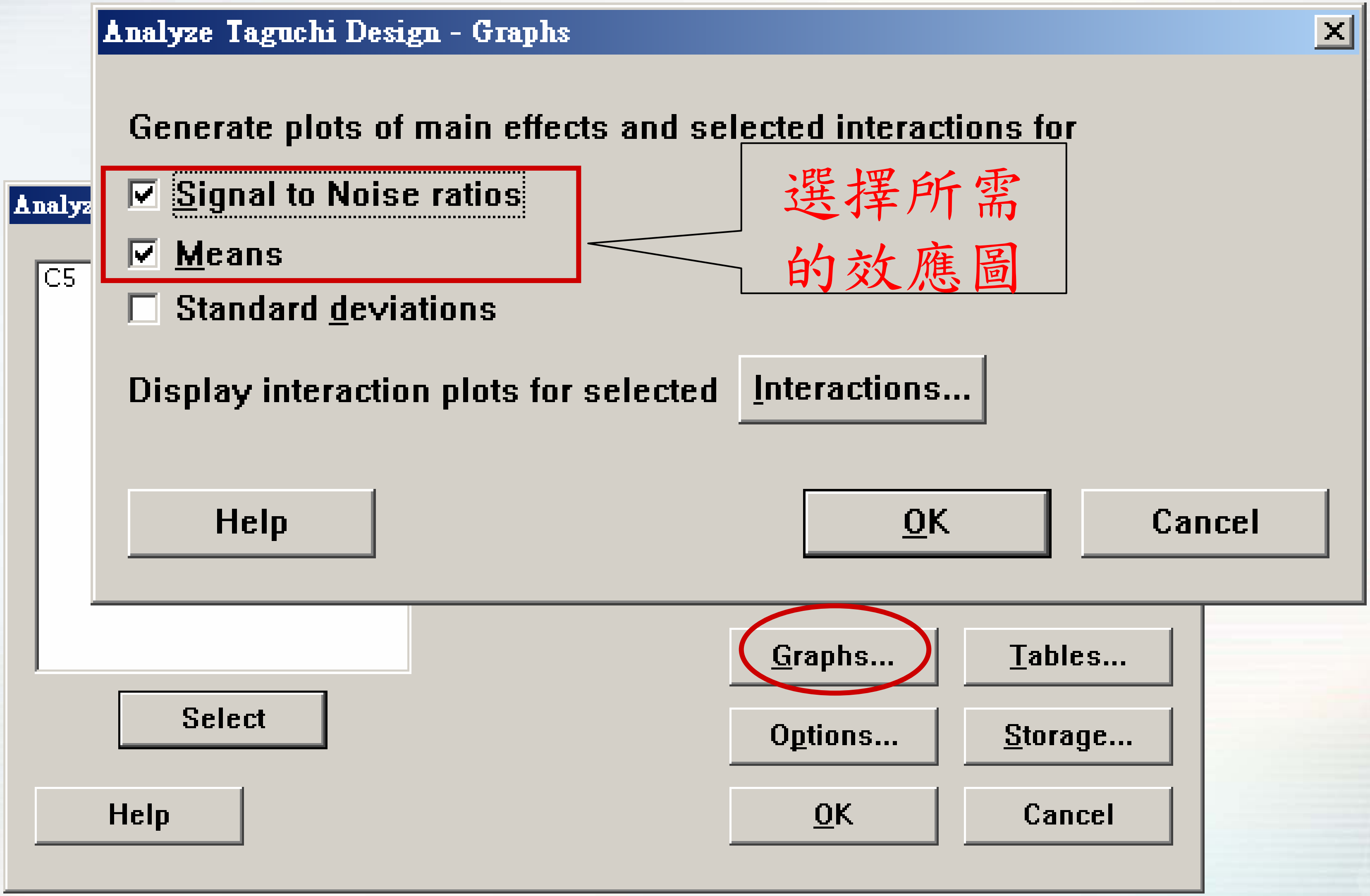
輸入實驗數據

波霸奶茶涼度實驗

- 選Stat=>DOE=>Taguchi=>Analyze Taguchi Design


Analyze Taguchi Design
C5 y
Response data are in:
Select
Help
Analyze Taguchi Design
C5 y
Response data are in:
y
Select
Help
Graphs...
Tables...
Options...
Storage...
OK
Cancel

波霸奶茶涼度實驗



Analyze Taguchi Design - Graphs

Generate plots of main effects and selected interactions for

☑ Signal to Noise ratios

☑ Means

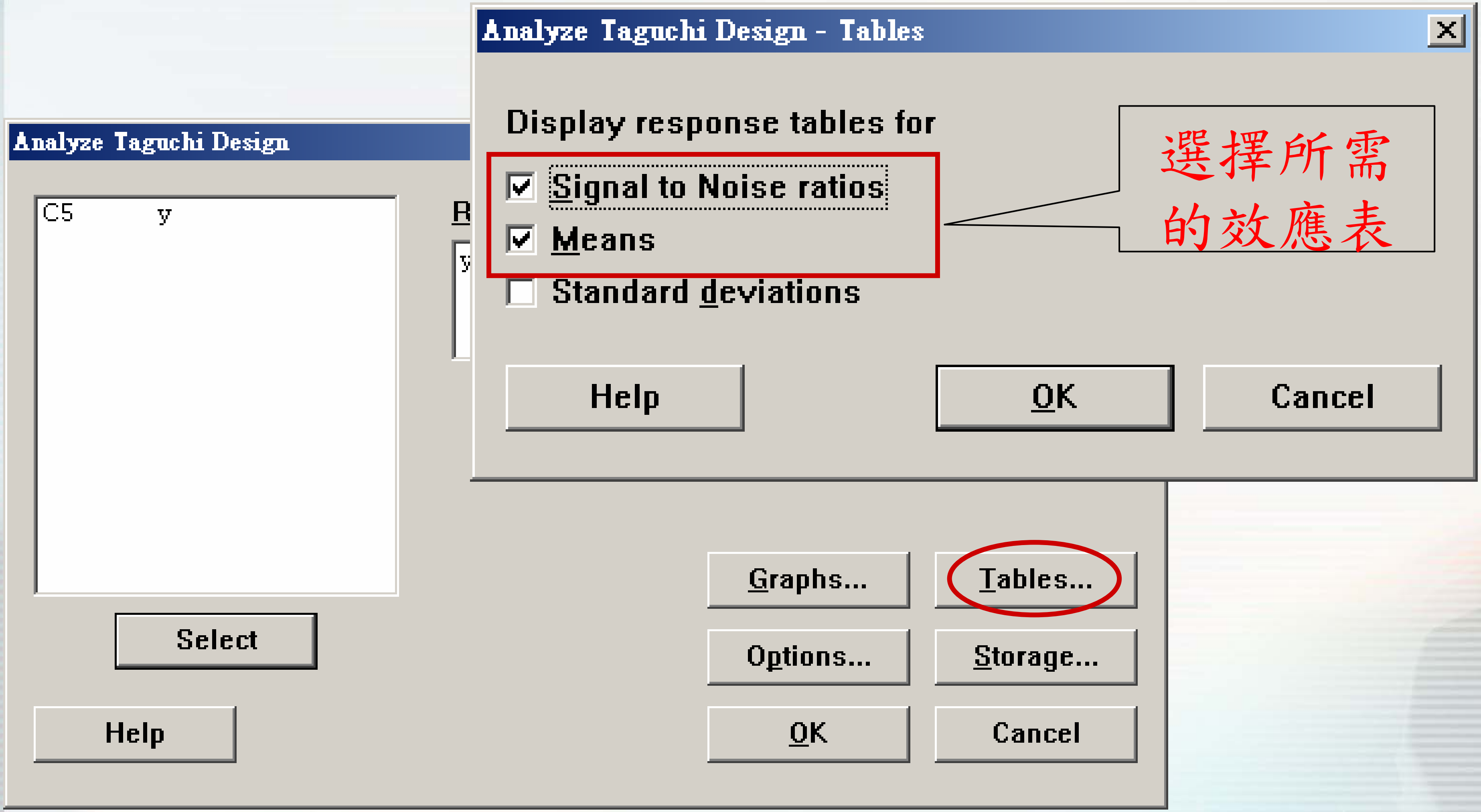
☐ Standard deviations

Display interaction plots for selected

Interactions...
Help
OK
Cancel
Analyz
C5
Graphs...
Tables...
Select
Options...
Storage...
Help
OK
Cancel

選擇所需的效應圖

波霸奶茶涼度實驗



Analyze Taguchi Design - Tables

Display response tables for

☑ Signal to Noise ratios

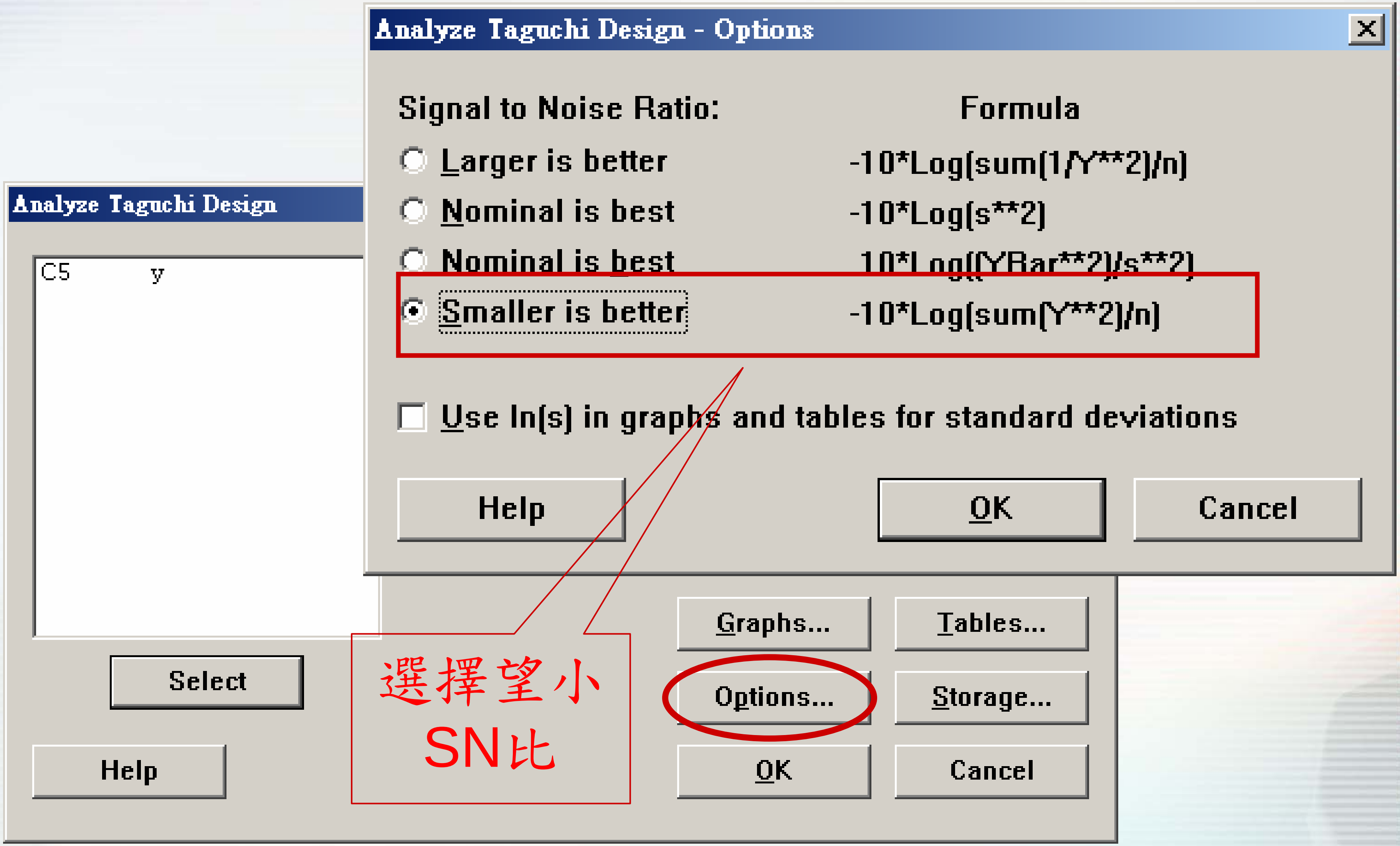
☑ Means

☐ Standard deviations

選擇所需的效應表

Help
OK
Cancel
Analyze Taguchi Design
C5 y
Select
Help
Graphs...
Tables...
Options...
Storage...
OK
Cancel

波霸奶茶涼度實驗



Analyze Taguchi Design - Options

Signal to Noise Ratio: Formula

○ Larger is better -10*Log(sum(1/Y**2)/n)

○ Nominal is best -10*Log(s**2)

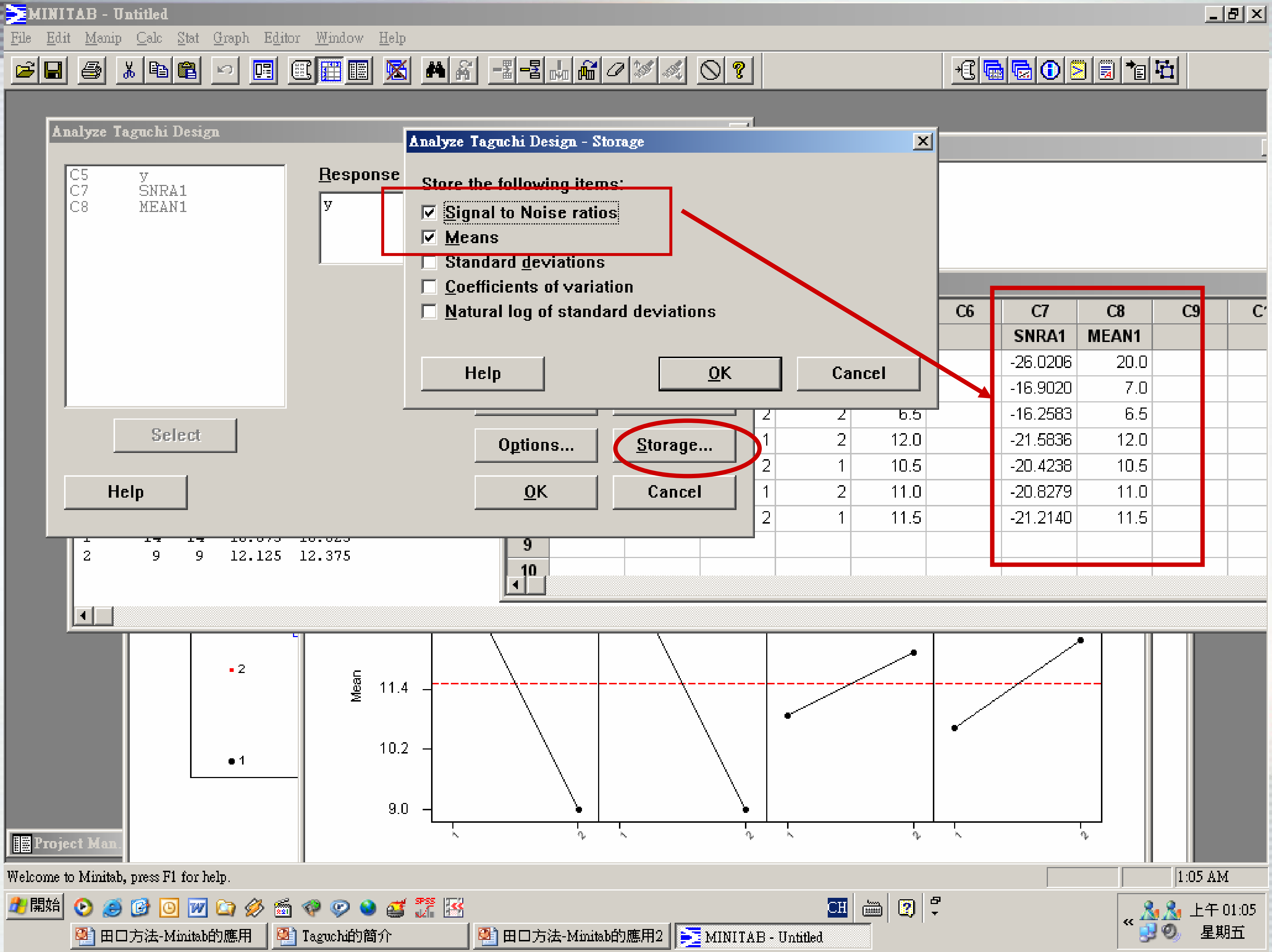
○ Nominal is best 10*Log((YBar**2)/s**2)

● Smaller is better -10*Log(sum(Y**2)/n)

☐ Use ln(s) in graphs and tables for standard deviations

Help
OK
Cancel
Analyze Taguchi Design
C5 y
Select
Help
Graphs...
Tables...
Options...
Storage...
OK
Cancel

選擇望小
SN比


MINITAB - Untitled
File Edit Manip Calc Stat Graph Editor Window Help

Analyze Taguchi Design

C5 y
C7 SNRA1
C8 MEAN1

Response: y

Select
Help
Options...
Storage...
OK
Cancel

Analyze Taguchi Design - Storage

Store the following items:

☑ Signal to Noise ratios
☑ Means
☐ Standard deviations
☐ Coefficients of variation
☐ Natural log of standard deviations

Help
OK
Cancel

			C6	C7 SNRA1	C8 MEAN1	C9
				-26.0206	20.0	
				-16.9020	7.0	
2	2	6.5		-16.2583	6.5	
1	2	12.0		-21.5836	12.0	
2	1	10.5		-20.4238	10.5	
1	2	11.0		-20.8279	11.0	
2	1	11.5		-21.2140	11.5	

```
1        14    14   10.875   10.625
2         9     9   12.125   12.375
```

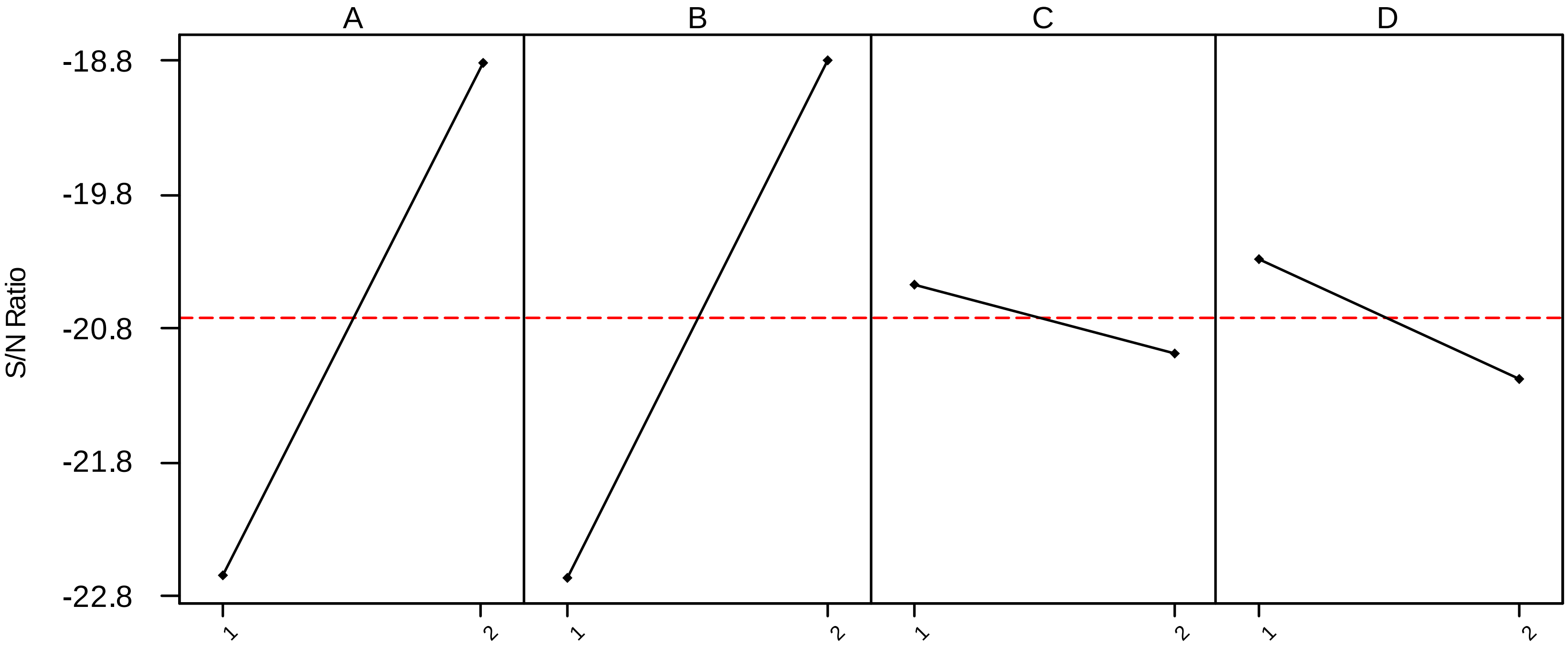
2
1
Mean
11.4
10.2
9.0
1
2
1
2
1
2
1
2
Project Man...

Welcome to Minitab, press F1 for help.

1:05 AM
開始
CH
田口方法-Minitab的應用
Taguchi的簡介
田口方法-Minitab的應用2
MINITAB - Untitled
上午 01:05
星期五

波霸奶茶涼度實驗

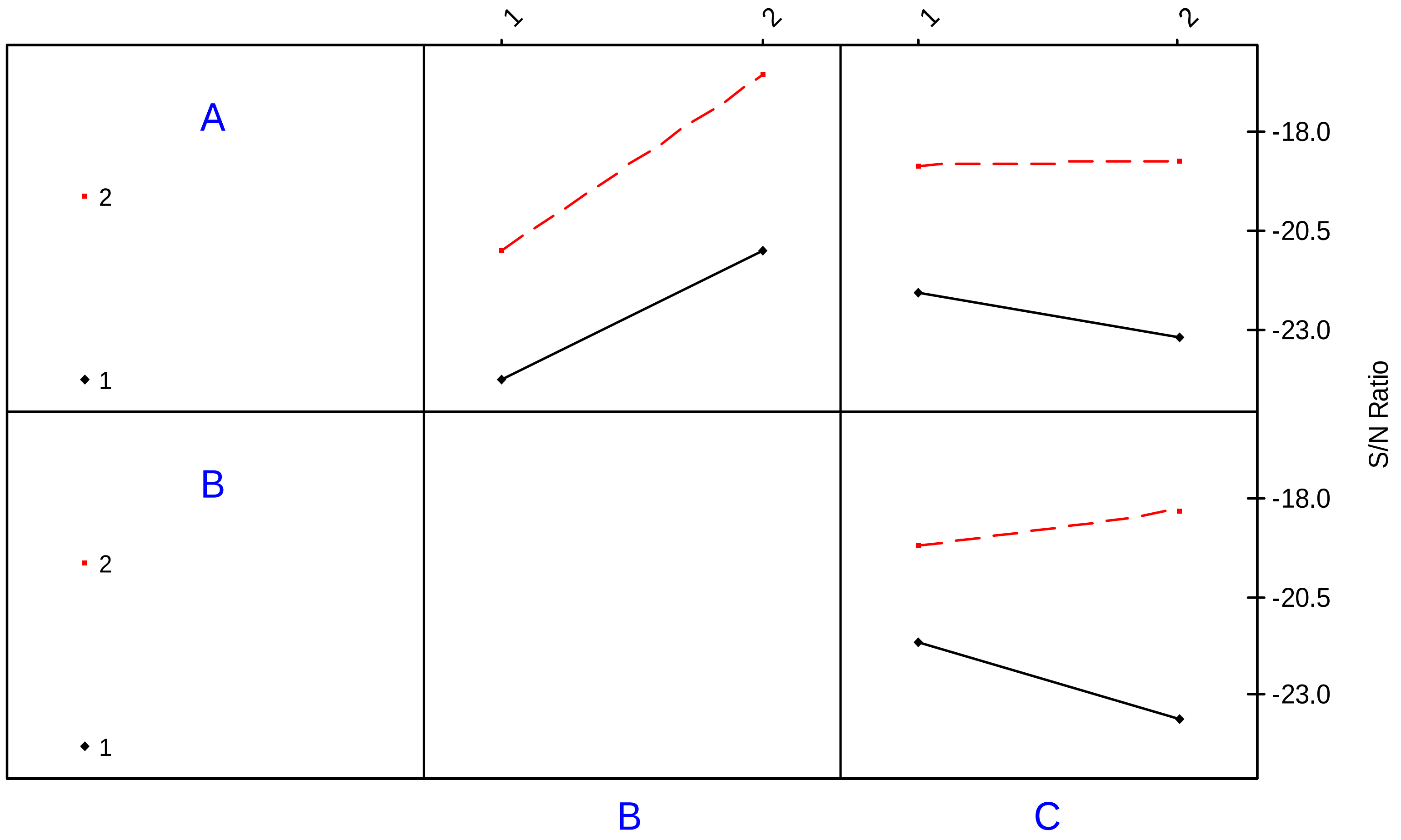
Main Effects Plot for S/N Ratios
主效應因子SN比圖



波霸奶茶涼度實驗

Interaction Plot for S/N Ratios

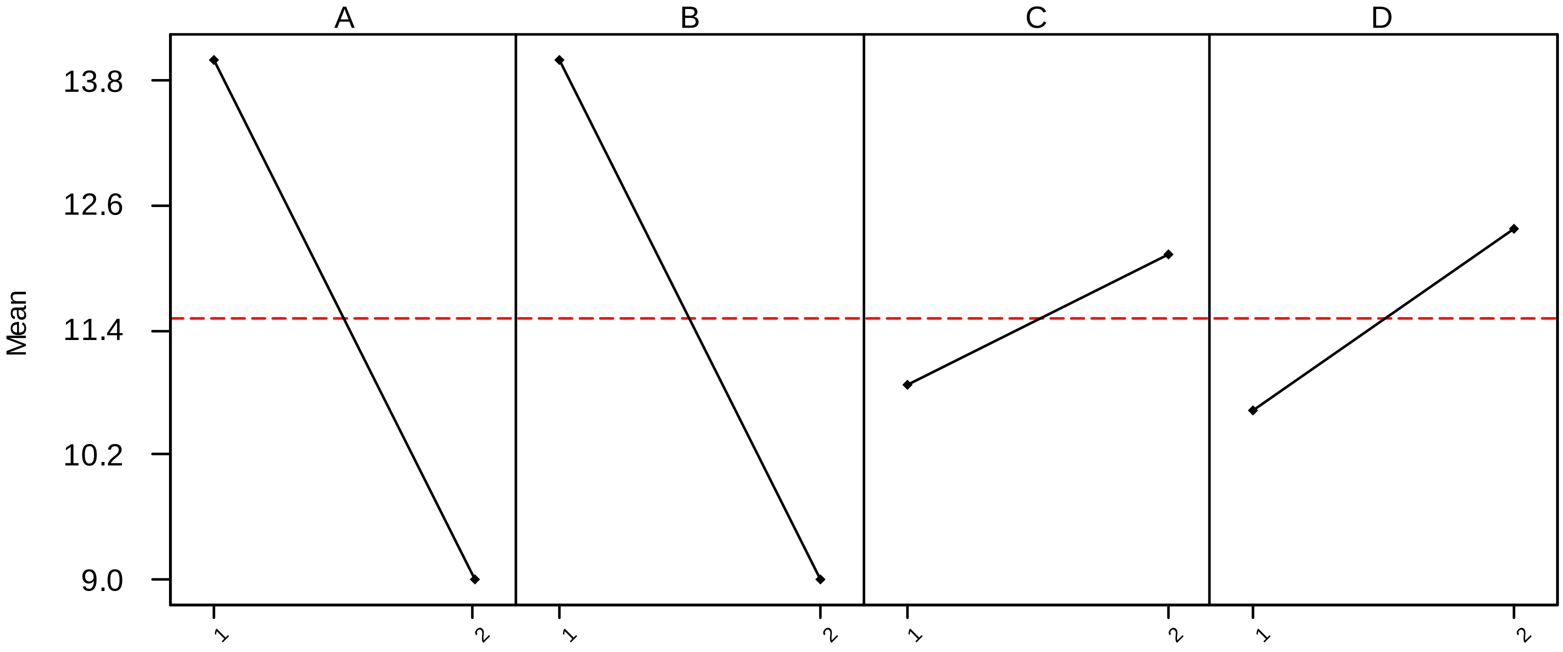
交互作用因子SN比圖



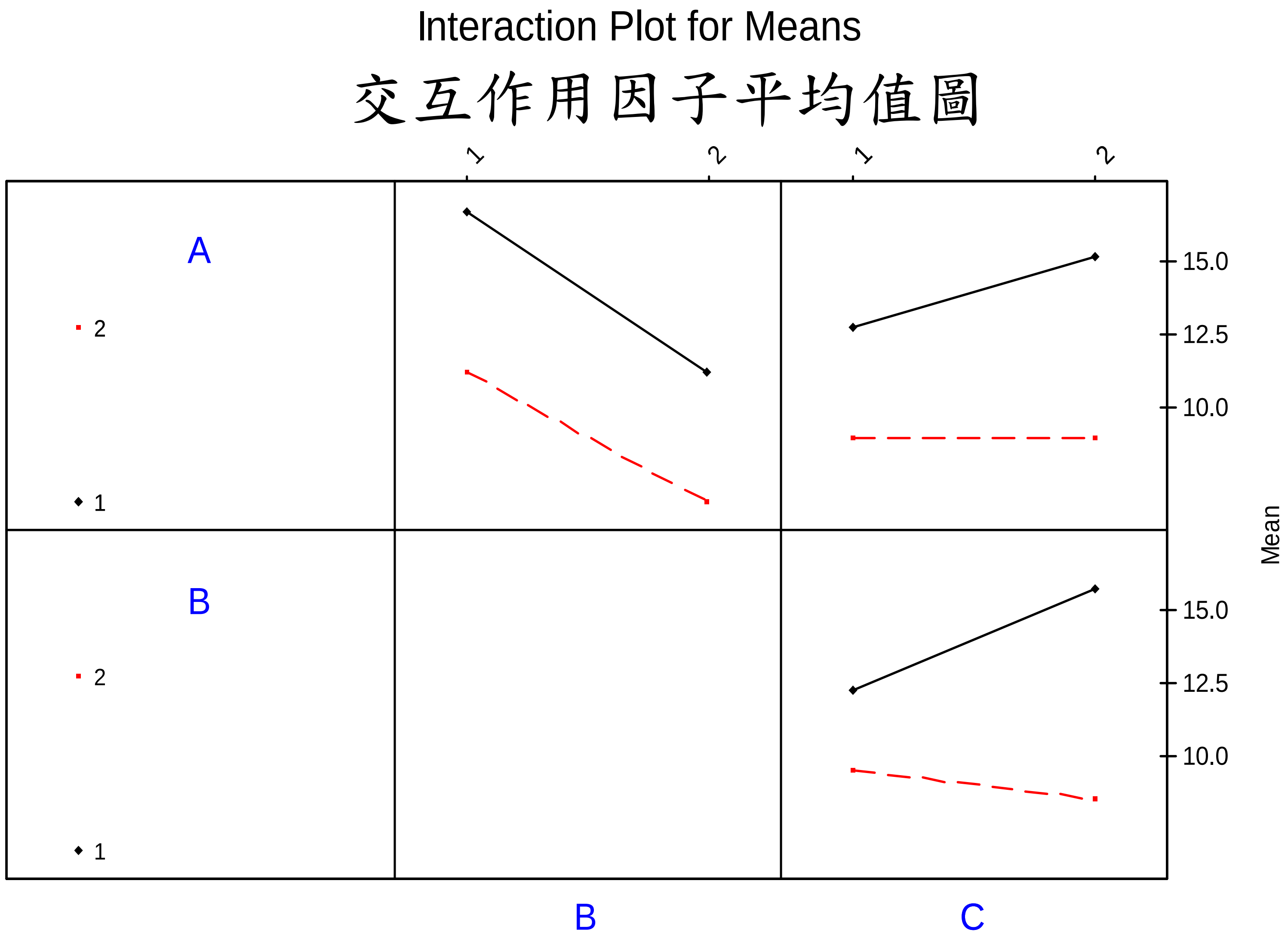
波霸奶茶涼度實驗

Main Effects Plot for Means

主效應因子平均值圖



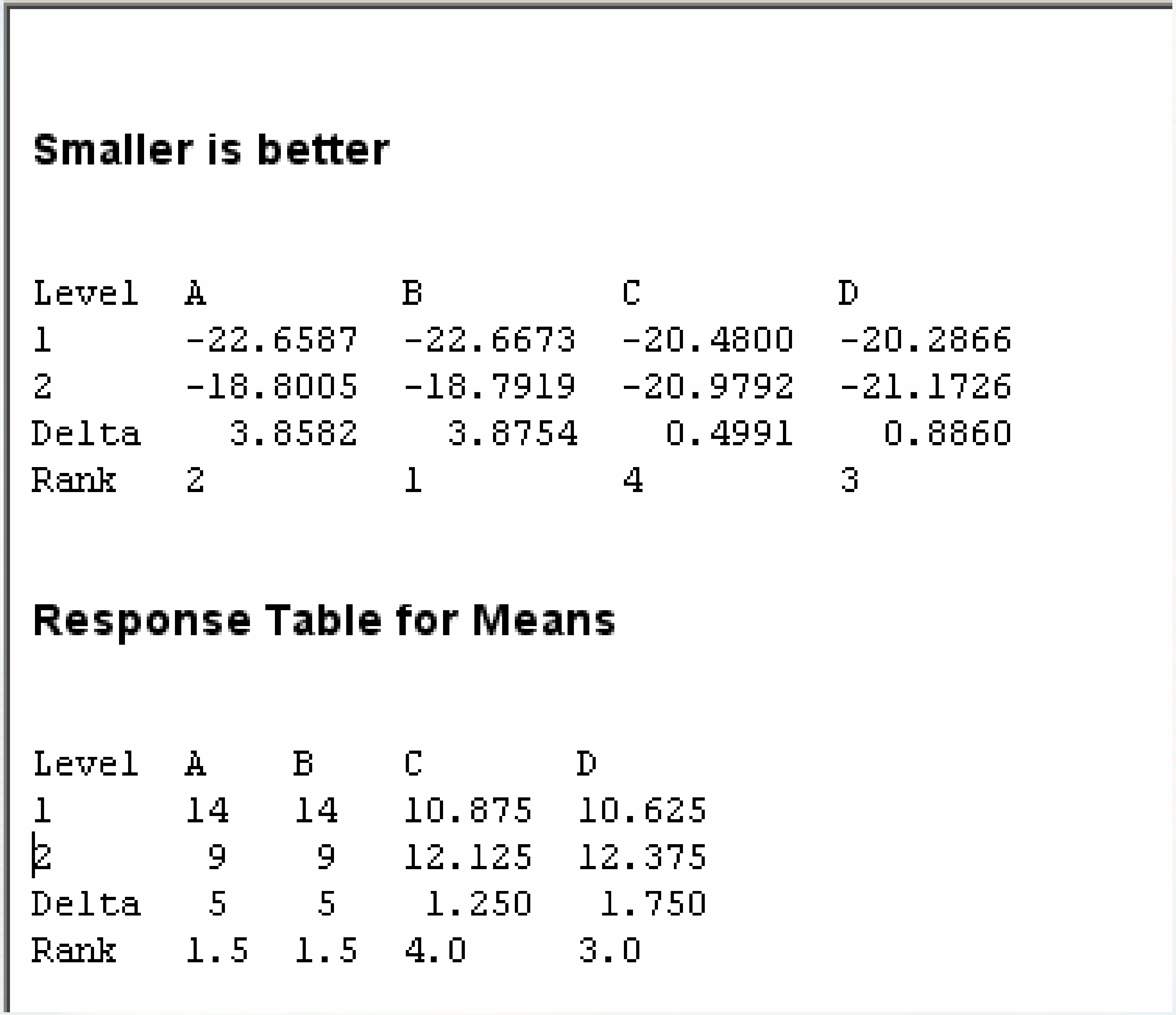
波霸奶茶涼度實驗



交互作用因子平均值圖

波霸奶茶涼度實驗

最佳因子水準組合A2B2C2D1



Smaller is better

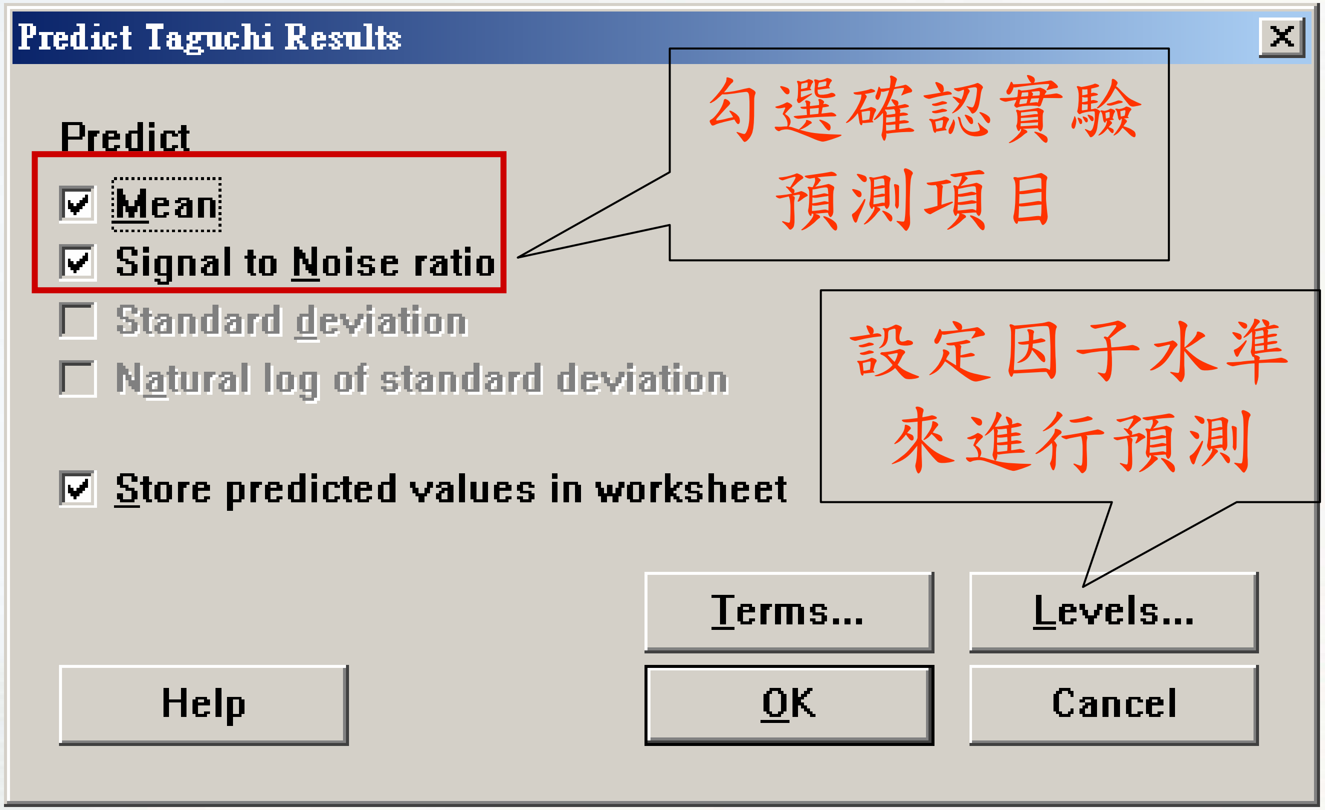
```
Level   A         B         C         D
1       -22.6587  -22.6673  -20.4800  -20.2866
2       -18.8005  -18.7919  -20.9792  -21.1726
Delta     3.8582    3.8754    0.4991    0.8860
Rank    2         1         4         3
```

Response Table for Means

```
Level   A    B    C       D
1       14   14   10.875  10.625
2        9    9   12.125  12.375
Delta    5    5    1.250   1.750
Rank    1.5  1.5  4.0     3.0
```

波霸奶茶涼度實驗

- 選Stat=>DOE=>Taguchi=>Predict


Predict Taguchi Results
Terms...
Levels...
Help
OK
Cancel

Predict

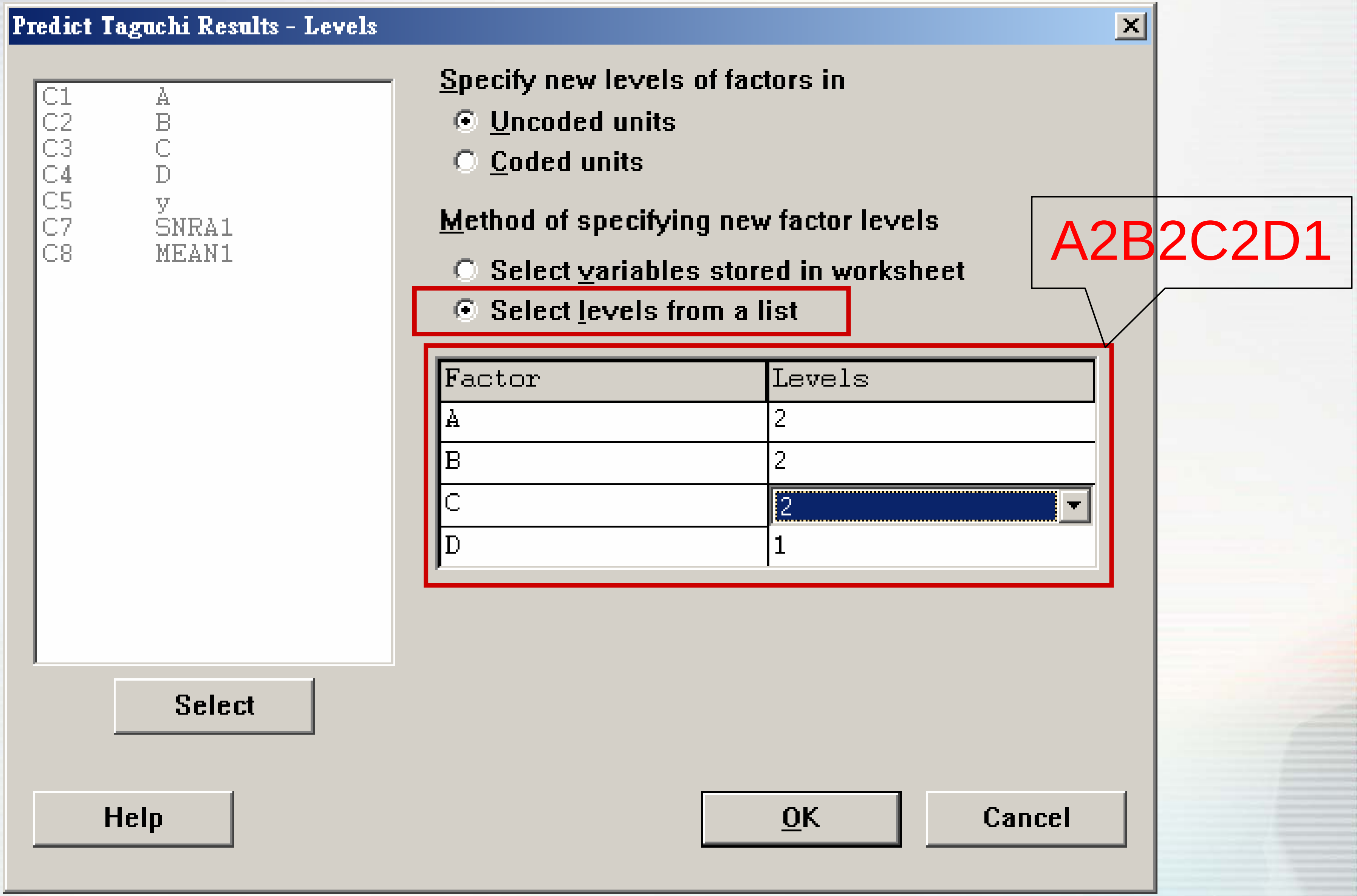
☑ Mean
☑ Signal to Noise ratio
☐ Standard deviation
☐ Natural log of standard deviation

☑ Store predicted values in worksheet

勾選確認實驗預測項目

設定因子水準來進行預測

波霸奶茶涼度實驗



Predict Taguchi Results - Levels

C1	A
C2	B
C3	C
C4	D
C5	y
C7	SNRA1
C8	MEAN1

Specify new levels of factors in

● Uncoded units

○ Coded units

Method of specifying new factor levels

○ Select variables stored in worksheet

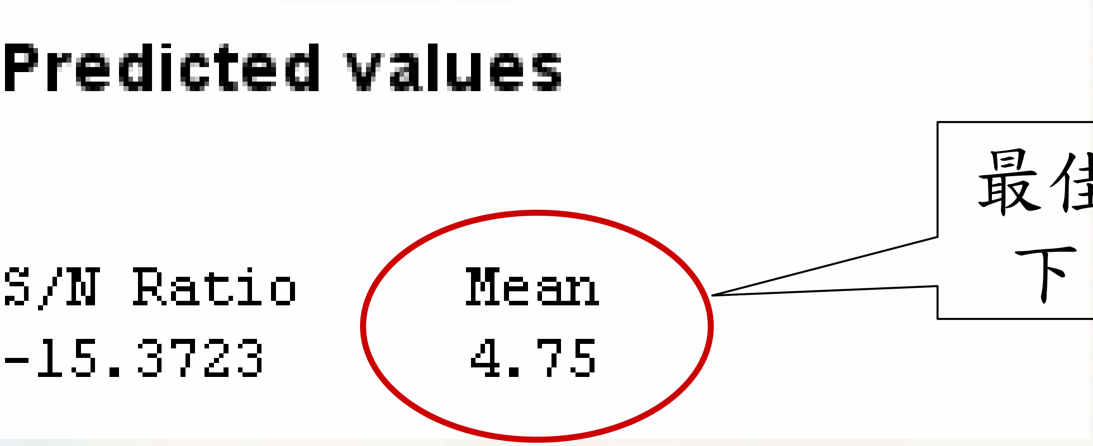
● Select levels from a list

Factor	Levels
A	2
B	2
C	2
D	1

A2B2C2D1

波霸奶茶涼度實驗

- 確認實驗分析結果



```
Predicted values

S/N Ratio       Mean
-15.3723        4.75
```

最佳因子水準組合
下的最低溫度值