Example 13.11

- A. Create Factorial Design
 - 1. Stat>DOE>Factorial>Create Factorial Design

_ [2]	
]	
	C14
	014

3. Select Designs

Create Factorial Design - Designs						
<u>D</u> esigns	Runs	Resolution	2**(k-p)			
1/16 fraction	8	III	2**(7-4)			
1/8 fraction	16	IV	2**(7-3)	2^{7-3}		
1/4 fraction 1/2 fraction	32 64		2 ** (7-2) 2 ** (7-1)			
Full factorial	128	Full	2**7			
Number of <u>c</u> enter poin	its: 0	(per b	lock)	s 1		
Number of <u>b</u> locks:	1	•				
Help		<u>O</u> K	Ok Cancel			

4. You could key the data in column 12.

<mark>) М</mark> І	MINITAB - Untitled - [Worksheet 2 ***]												
⊞ Elle Edit Manip Calc Stat Graph Editor Window Help													
<u></u>										*C			
÷	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11	C12	T
	StdOrder	RunOrder	CenterPt	Blocks	Α	В	С	D	E	F	G		
1	10	1	1	1	1	-1	-1	1	1	1	-1		
2	9	2	1	1	-1	-1	-1	1	-1	1	1		
3	5	3	1	1	-1	-1	1	-1	1	1	1		
4	3	4	1	1	-1	1	-1	-1	1	1	-1		
5	4	5	1	1	1	1	-1	-1	-1	1	1		
6	11	6	1	1	-1	1	-1	1	1	-1	1		
7	8	7	1	1	1	1	1	-1	1	-1	-1		
8	1	8	1	1	-1	-1	-1	-1	-1	-1	-1		
9	2	9	1	1	1	-1	-1	-1	1	-1	1		
10	12	10	1	1	1	1	-1	1	-1	-1	-1		
11	16	11	1	1	1	1	1	1	1	1	1		
12	14	12	1	1	1	-1	1	1	-1	-1	1		
13	13	13	1	1	-1	-1	1	1	1	-1	-1		
14	6	14	1	1	1	-1	1	-1	-1	1	-1		
15	15	15	1	1	-1	1	1	1	-1	1	-1		
16	7	16	1	1	-1	1	1	-1	-1	-1	1		
17													

B. Factorial Plots

Stat>DOE>Factorial> Factorial Plots

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E	le <u>E</u> dit <u>M</u> anip <u>C</u> alc	<u>S</u> tat <u>G</u> raph E <u>d</u> itor <u>W</u>	indow <u>H</u> elp						_ <u>-</u>
È	🖬 🎒 👗 🖻 🕻	<u>B</u> asic Statistics <u>R</u> egression	; 📓 🛤	<u>a</u>		28	*		
÷	C5	ANOVA	•	C8	C9	C10	C11	C12	C13 C 🔺
	temperature(A) s	<u>D</u> OE	▶ <u>F</u> actorial	۱.	Create Factorial Design		holding pressure(G)	Observed Shrinkage	
1	-1	Control Charts	<u>R</u> esponse	e Surface 🕨	Define Custom Factorial De	esign	-1	6	
2	1	Quality Tools	 Mixture Tagushi 		Analyze Factorial Design		1	10	
3	-1	Multivariate			Eactorial Plots		-1	32	
4	1	Time Series	Modify D	esign	Contour/Surface (Wirefram	ne) Plots	1	60	
5	-1	<u>T</u> ables	Display D	esign	Overlaid Contour Plot		1	4	
6	1	Nonparametrics	1		Response Optimizer		-1	15	
7	-1	Power and Sample Size	1	-1	-1	-1	1	26	
8	1	1	1	-1	1	-1	-1	60	
9	-1	-1	-1	1	-1	1	1	8	
10	1	-1	-1	1	1	1	-1	12	
11	-1	1	-1	1	1	-1	1	34	
12	1	1	-1	1	-1	-1	-1	60	
13	-1	-1	1	1	1	-1	-1	16	
14	1	-1	1	1	-1	-1	1	5	
15	-1	1	1	1	-1	1	-1	37	
16	1	1	1	1	1	1	1	52	
17									
18									
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Take "Main Effects –setup" as example

Factorial Plots - Main Effects		×
C1 StdOrder C2 RunOrder C3 CenterPt C4 Blocks C12 Observed Shrink	Responses: 'Observed Shrinkage' Factors to Inclu Available:	ide in Plots <u>Selected:</u> <u>A:temperature(</u> B:screw speed() C:holding time D:cycle time(D E:moisture con F:gate size(F)
Select Help	<u><</u> << <u>Q</u>	G:holding press Options K Cancel

B. Analysis data

1. Stat>DOE>Factorial>Analyze Factorial Design

MINITAB - Untitled - [example 12_11.MTW ***]								- 8 ×	
🛗 Ei	e <u>E</u> dit <u>M</u> anip <u>C</u> al	c <u>S</u> tat <u>G</u> raph E <u>d</u> itor <u>W</u> indo	ow <u>H</u> elp					E	- 8 ×
B	. 5 1	Basic Statistics	<u> </u>		9 ?	*		1 1	
Ŧ	C5	ANOVA +	C8	C9	C10	C11	C12	C13	C 🔺
	temperature(A)	s <u>D</u> OE ►	Eactorial >	Create Factorial Design		holding pressure(G)	Observed Shrinkage		
1	-1	Control Charts	Response Surface	Define Custom Factorial D	esign	-1	6		
2	1	Quality loois	Taguchi	Analyze Factorial Design		1	10		
3	-1	Multivariate		Eactorial Plots		-1	32		
4	1	Time Series	Modity Design	Contour/Surface (Wirefram	ne) Plots	1	60		
5	-1	Tables •		Qverlaid Contour Plot,		1	4		
6	1	Nonparametrics	1	Response Optimizer		-1	15		
7	-1	Power and Sample Size	1 -1	-1	-1	1	26		
8	1	1	1 -1	1	-1	-1	60		
9	-1	-1	-1 1	-1	1	1	8		
10	1	-1	-1 1	1	1	-1	12		
11	-1	1	-1 1	1	-1	1	34		
12	1	1	-1 1	-1	-1	-1	60		
13	-1	-1	1 1	1	-1	-1	16		
14	1	-1	1 1	-1	-1	1	5		
15	-1	1	1 1	-1	1	-1	37		
16	1	1	1 1	1	1	1	52		
17									
18									

2. Analyze Factorial Design



2-2. Term

Analyze Factorial Design - Te	erms X	
Include terms in the mo	odel up through order: 7	Select all possible terms
<u>A</u> vailable Terms:	<u>S</u> elected Terms:	
A:temperature(B:screw speed(C:holding time D:cycle time(D E:moisture con F:gate size(F) G:holding pres	> A: temperatur B:screw spee C:holding ti: D:cycle time E:moisture c K F:gate size() G:holding pr AB AC Default AF AG	
\Box Include <u>b</u> locks in the	e model	
🗖 Include center points	s in the model	
Help	<u>OK</u> Cancel Press ok	

2-3. Graph

Analyze Factorial Design - Graphs	×
C1 StdOrder C2 RunOrder C3 CenterPt C4 Blocks C5 temperature(A) C6 screw speed(B) C7 holding time(C) C8 cycle time(D) C9 moisture conter C10 gate size(F) C11 holding pressur C12 Observed Shrink	Effects Plots ✓ Normal ✓ Pareto Alpha: 0.01 Residuals for Plots: ○ Regular ○ Standardized ○ Deleted Residual Plots ○ Histogram ○ Normal plot ○ Residuals versus fits ○ Residuals versus order ○ Residuals versus yariables:
Select Help	Press ok <u>O</u> K Cancel

Output 1



Select A, B, AB, AD, G, D (To include the interaction "AD", term D must be selected.)



You will see step "2. Analyze Factorial Design"

2-2 Terms (Select A, B, AB, AD, G, D)



2-4. Press ok

Output 2

Fractional Factorial Fit: Observed Shr versus temperature(, screw speed(, ...

Estimated Effects a	nd Coeffic	cients for	Observed (co	oded unit	(3)	
Term	Effect	Coef	SE Coef	Т	P	
Constant		27.313	0.4607	59.29	0.000	
temperat	13.875	6.937	0.4607	15.06	0.000	
screw sp	35.625	17.812	0.4607	38.66	0.000	
cycle ti	1.375	0.688	0.4607	1.49	0.170	
holding	-4.875	-2.437	0.4607	-5.29	0.000	
temperat*screw sp	11.875	5.938	0.4607	12.89	0.000	
temperat*cycle ti	-5.375	-2.688	0.4607	-5.83	0.000	
Analysis of Varianc	e for Obse	erved (code	ed units)			
Source	DF	Seq SS	Adj SS	Adj MS	F	P
Main Effects	4	5949.25	5949.25	1487.31	437.98	0.000
2-Way Interactions	2	679.63	679.63	339.81	100.07	0.000
Residual Error	9	30.56	30.56	3.40		
Total	15	6659.44				
Alias Structure						
I						
temperat						
screw						
cycle						
holding						
temperat*screw						
temperat*cycle						

Delete D and AD (Only A, B, G, AB), since p_value of factor D is larger than significant level 0.01.

Go to 2-2 Terms (Select A, B, G, AB)

Analyze Factorial Design - T Include terms in the m	ferms odel up throug	x h order: 3 -
<u>A</u> vailable Terms:		Selected Terms:
A:temperatur B:screw spee C:holding ti: D:cycle time E:moisture c F:gate size(: G:holding pr AC AD AE AF AG BC PD	>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>	A:temperature(B:screw speed() G:holding pres AB
\Box Include <u>b</u> locks in th	e model	
☐ Include center point	ts in the mode	I
Help	<u>0</u> K	Cancel

Output 3

Fractional Factorial Fit: Observed Shr versus temperature(, screw speed(, ...

Estimated Effects and Coefficients for Observed (coded units)

Term	Effect	Coef	SE Coef	Т	Р	
Constant		27.313	0.9345	29.23	0.000	
temperat	13.875	6.937	0.9345	7.42	0.000	
screw sp	35.625	17.812	0.9345	19.06	0.000	
holding	-4.875	-2.438	0.9345	-2.61	0.024	
temperat*screw sp	11.875	5.938	0.9345	6.35	0.000	
Analysis of Variance	for Obs	erved (code	ed units)			
Source	DF	Seq SS	Adj SS	Adj MS	F	P
Main Effects	3	5941.69	5941.69	1980.56	141.76	0.000
2-Way Interactions	1	564.06	564.06	564.06	40.37	0.000
Residual Error	11	153.69	153.69	13.97		
Lack of Fit	3	2.19	2.19	0.73	0.04	0.989
Pure Error	8	151.50	151.50	18.94		
Total	15	6659.44				
Alias Structure						

I temperat screw holding temperat*screw Delete G (Only A, B, AB), because p_value of D is larger than 0.01

Go to 2-2 Terms (Select A, B, AB)

Analyze Factorial Design - Terms						
<u>A</u> vailable Terms:		Selected Terms:				
A:temperatur B:screw spee C:holding ti D:cycle time E:moisture c F:gate size(G:holding pr AC AD AE AF AG BC	>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>	A:temperature(B:screw speed(AB				
\Box Include <u>b</u> locks in the	ne model					
□ Include center points in the model						
Негр	<u>0</u> K	Cancel				

Output 4

Fractional Factorial Fit: Observed Shr versus temperature(, screw speed(

Estimated Effects and	Coeffic	cients for (Observed (co	oded unit	ts)	
Term	Effect	Coef	SE Coef	Т	Р	
Constant		27.313	1.138	24.00	0.000	
temperat	13.875	6.937	1.138	6.09	0.000	
screw sp	35.625	17.812	1.138	15.65	0.000	
temperat*screw sp	11.875	5.938	1.138	5.22	0.000	
Analysis of Variance for Observed (coded units)						
Source	DF	Seq SS	Adj SS	Adj MS	F	Р
Main Effects	2	5846.6	5846.6	2923.31	141.02	0.000
2-Way Interactions	1	564.1	564.1	564.06	27.21	0.000
Residual Error	12	248.7	248.7	20.73		
Pure Error	12	248.8	248.8	20.73		
Total	15	6659.4				
Alias Structure						
I						
temperat						
screw						
temperat*screw						

The fitting model for predicted shrinkage (See textbook to get more details)

 $\hat{y} = 27.313 + 6.937x_1 + 17.812x_2 + 5.938x_1x_2$

Residual analysis

(After you select the final model, you must analyze residuals.)

Go to 2-3. Graph

Analyze Factorial Design - Graphs	×
C1 StdOrder C2 RunOrder C3 CenterPt C4 Blocks C5 temperature(Å) C6 screw speed(B) C7 holding time(C) C8 cycle time(D) C9 moisture conter C10 gate size(F) C11 holding pressur C12 Observed Shrink	Effects Plots Normal Pareto Alpha: 0.01 Residuals for Plots: Regular ⊙ Standardized ⊙ Deleted Residual Plots Histogram Normal plot Residuals versus fits Residuals versus order Residuals versus yariables: 'temperature(A)' 'screw speed(B)'
Select	
Help	<u>O</u> K Cancel

Output 5











