Create Partial Factorial Design

Stat-> DOE -> Factorial -> Create Factorial Design

In this example:
5 factors (16 runs -> resolution 5 partial factorial)
Design: 1/2 fraction
No center points
1 replicate
1 block
Factors: name the factors (column headers)
Randomize runs

% Reacted in C10 is entered after running the experiments

Design Summary

Factors:	5	Base Design:	5, 16	Resolution:	V
Runs:	16	Replicates:	1	Fraction:	1/2
Blocks:	1	Center pts (total):	0		

Alias Structure

I + ABCDE
A + BCDE
B + ACDE
C + ABDE
D + ABCE
E + ABCD
AB + CDE
AC + BDE
AD + BCE
AE + BCD
BC + ADE
BD + ACE
BE + ACD
CD + ABE
CE + ABD
DE + ABC

Design Table

Run	Blk	A	B	C	D	E
1	1	-	-	-	-	+

2	1 +	-	-	-	-
3	1 -	+	-	-	-
4	1 +	+	-	-	+
5	1 -	-	+	-	-
6	1 +	-	+	-	+
7	1 -	+	+	-	+
8	1 +	+	+	-	-
9	1 -	-	-	+	-
10	1 +	-	-	+	+
11	1 -	+	-	+	+
12	1 +	+	-	+	-
13	1 -	-	+	+	+
14	1 +	-	+	+	-
15	1 -	+	+	+	-
16	1 +	+	+	+	+

Analyze Partial Factorial Design

Stat-> DOE -> Factorial -> Analyze Factorial Design

Resposnses: % Reacted (ie result)
Terms: Include all up through the level 2
Graphs: Pareto and Normal

RESULTS:
Significant: DE, E, BD, B, D

Coded Coefficients

Term	Effect	Coef	SE Coef	T-Value	P-Value	VIF
Constant		65.25	*	*	*	
feed rate	-2.000	-1.000	*	*	*	1.00
catalyst %	20.50	10.25	*	*	*	1.00
agitation rpm	-0.000000	-0.000000	*	*	*	1.00
temperature C	12.250	6.125	*	*	*	1.00
concentration	-6.250	-3.125	*	*	*	1.00
feed rate*catalyst %	1.5000	0.7500	*	*	*	1.00
feed rate*agitation rpm	0.5000	0.2500	*	*	*	1.00
feed rate*temperature C	-0.7500	-0.3750	*	*	*	1.00
feed rate*concentration	1.2500	0.6250	*	*	*	1.00
catalyst %*agitation rpm	1.5000	0.7500	*	*	*	1.00
catalyst %*temperature C	10.750	5.375	*	*	*	1.00

catalyst %*concentration	1.2500	0.6250	*	*	*	1.00
agitation rpm*temperature C	0.2500	0.1250	*	*	*	1.00
agitation rpm*concentration	2.250	1.125	*	*	*	1.00
temperature C*concentration	-9.500	-4.750	*	*	*	1.00

Model Summary

S	R-sq	R-sq(adj)	R-sq(pred)
*	100.00%	*	*

Analysis of Variance

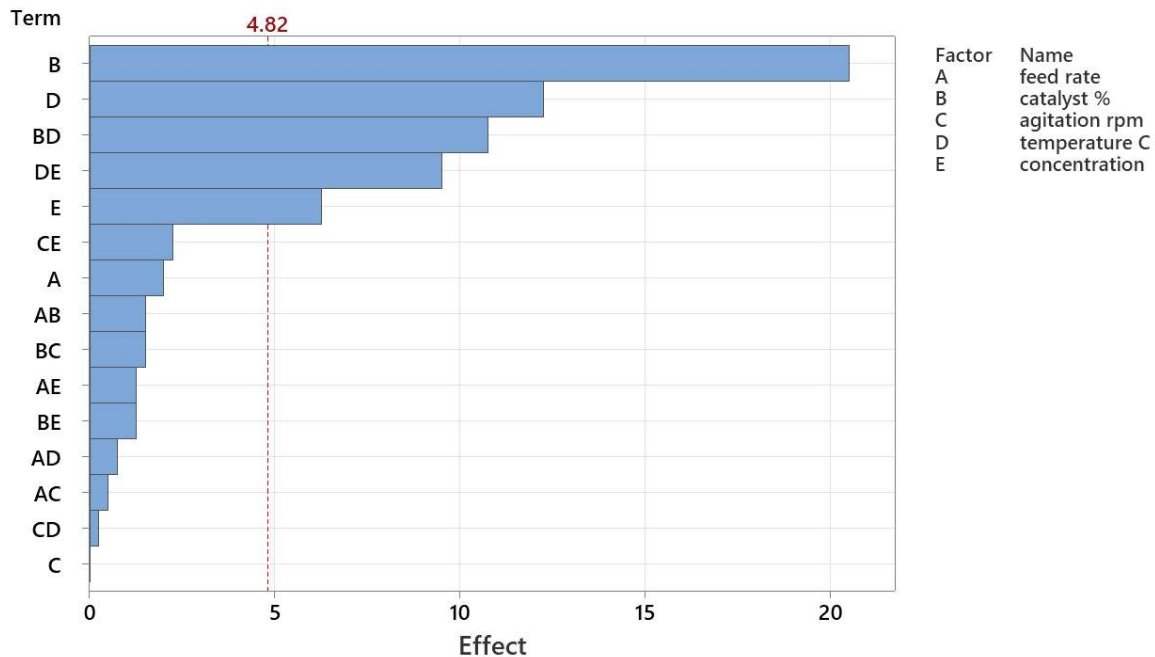| Source	DF	Adj SS	Adj MS	F-Value	P-Value
Model	15	3331.00	222.07	*	*
Linear	5	2453.50	490.70	*	*
feed rate	1	16.00	16.00	*	*
catalyst %	1	1681.00	1681.00	*	*
agitation rpm	1	0.00	0.00	*	*
temperature C	1	600.25	600.25	*	*
concentration	1	156.25	156.25	*	*
2-Way Interactions	10	877.50	87.75	*	*
feed rate*catalyst %	1	9.00	9.00	*	*
feed rate*agitation rpm	1	1.00	1.00	*	*
feed rate*temperature C	1	2.25	2.25	*	*
feed rate*concentration	1	6.25	6.25	*	*
catalyst %*agitation rpm	1	9.00	9.00	*	*
catalyst %*temperature C	1	462.25	462.25	*	*
catalyst %*concentration	1	6.25	6.25	*	*
agitation rpm*temperature C	1	0.25	0.25	*	*
agitation rpm*concentration	1	20.25	20.25	*	*
temperature C*concentration	1	361.00	361.00	*	*
Error	0	*	*		
Total	15	3331.00			

Regression Equation in Uncoded Units

% Reacted = 112.8 - 1.950 feed rate - 93.25 catalyst % - 0.7875 agitation rpm
+ 0.2375 temperature C + 11.67 concentration + 0.6000 feed rate*catalyst %
+ 0.01000 feed rate*agitation rpm - 0.007500 feed rate*temperature C
+ 0.1667 feed rate*concentration + 0.1500 catalyst %*agitation rpm
+ 0.5375 catalyst %*temperature C + 0.8333 catalyst %*concentration
+ 0.000625 agitation rpm*temperature C + 0.07500 agitation rpm*concentration
- 0.1583 temperature C*concentration

Normal Plot of the Effects
(response is % Reacted, α = 0.05)

Effect Type
- Not Significant
- Significant

Factor	Name
A	feed rate
B	catalyst %
C	agitation rpm
D	temperature C
E	concentration

Points labeled: B, D, BD, E, DE

Lenth's PSE = 1.875

Pareto Chart of the Effects
(response is % Reacted, α = 0.05)

4.82

Terms (top to bottom): B, D, BD, DE, E, CE, A, AB, BC, AE, BE, AD, AC, CD, C

Factor	Name
A	feed rate
B	catalyst %
C	agitation rpm
D	temperature C
E	concentration
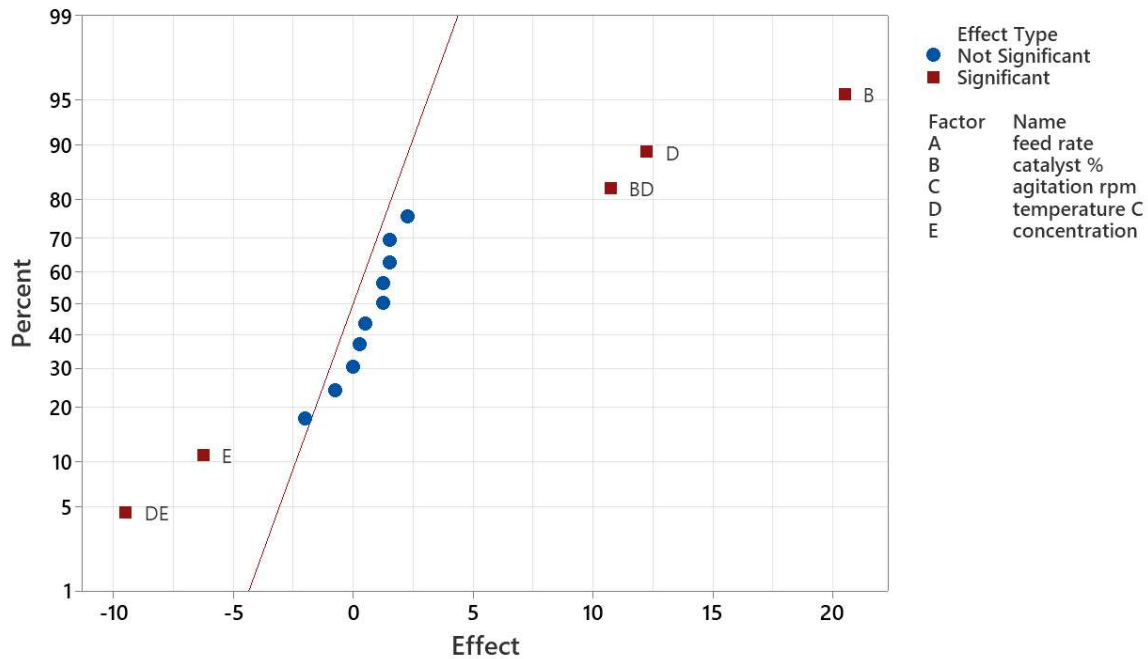
Lenth's PSE = 1.875

Re-Analyze Partial Factorial Design with only significant factors

(CTRL/E to re-edit the entry)
Factors: DE, E, BD, B, D

RESULT:
R2 is over 96% = good
ANOVA P-Value less than 0.05 = confirmed that all factors are significant
Regression equation Y=F(x) transfer function
Residuals are random = good

Catalyst, Temperature, Concentration, Catalyst-Temperature and Temperature-Concentration
Interactions are truly significant and should be included in future experiments.

Coded Coefficients

Term	Effect	Coef	SE Coef	T-Value	P-Value	VIF
Constant		65.250	0.663	98.47	0.000	
catalyst %	20.500	10.250	0.663	15.47	0.000	1.00
temperature C	12.250	6.125	0.663	9.24	0.000	1.00
concentration	-6.250	-3.125	0.663	-4.72	0.001	1.00
catalyst %*temperature C	10.750	5.375	0.663	8.11	0.000	1.00
temperature C*concentration	-9.500	-4.750	0.663	-7.17	0.000	1.00

Model Summary

S	R-sq	R-sq(adj)	R-sq(pred)
2.65047	97.89%	96.84%	94.60%

Analysis of Variance

Source	DF	Adj SS	Adj MS	F-Value	P-Value
Model	5	3260.75	652.15	92.83	0.000
Linear	3	2437.50	812.50	115.66	0.000
catalyst %	1	1681.00	1681.00	239.29	0.000
temperature C	1	600.25	600.25	85.44	0.000
concentration	1	156.25	156.25	22.24	0.001
2-Way Interactions	2	823.25	411.62	58.59	0.000
catalyst %*temperature C	1	462.25	462.25	65.80	0.000
temperature C*concentration	1	361.00	361.00	51.39	0.000
Error	10	70.25	7.03		
Total	15	3331.00			

Regression Equation in Uncoded Units

% Reacted   =   9.9 - 65.5 catalyst % + 0.212 temperature C + 23.25 concentration
                  + 0.5375 catalyst %*temperature C - 0.1583 temperature C*concentration

Fits and Diagnostics for Unusual Observations

Obs	% Reacted	Fit	Resid	Std Resid	
9	69.00	63.63	5.38	2.57	R

R Large residual

Alias Structure

Factor	Name
A	feed rate
B	catalyst %
C	agitation rpm
D	temperature C
E	concentration

Aliases

I + ABCDE

B + ACDE

D + ABCE

E + ABCD

BD + ACE

DE + ABC

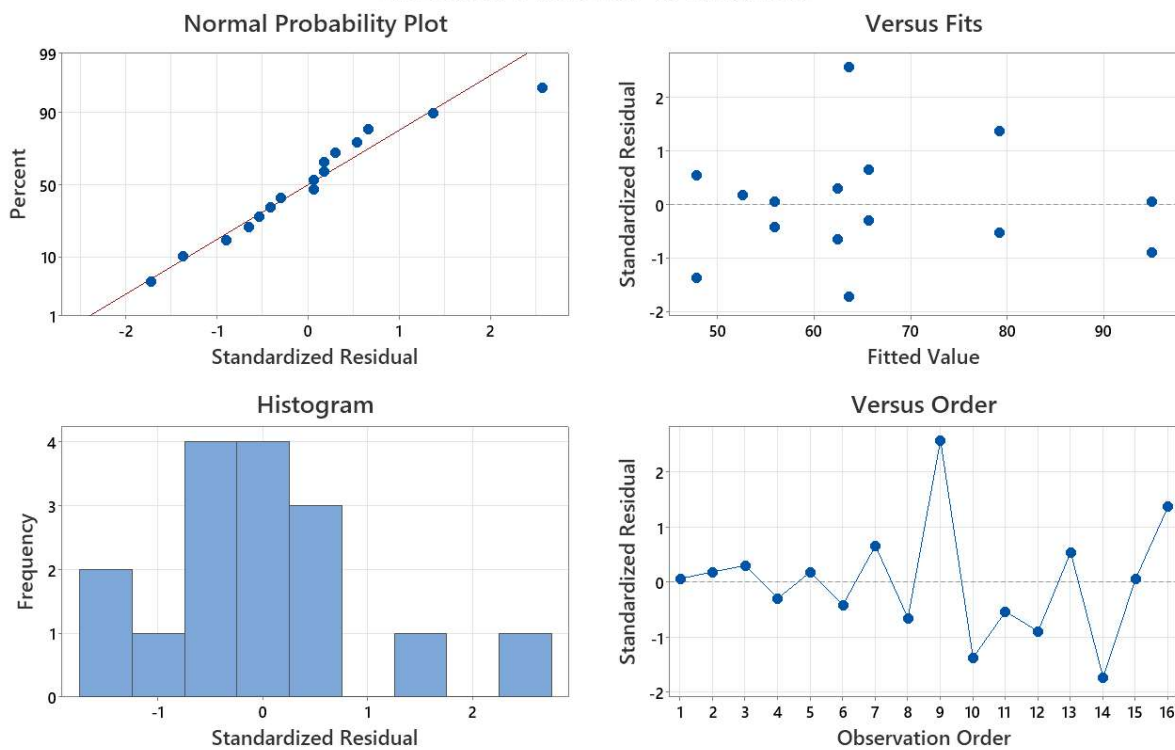
Normal Plot of the Standardized Effects
(response is % Reacted, α = 0.05)

Pareto Chart of the Standardized Effects
(response is % Reacted, α = 0.05)

Factor	Name
A	feed rate
B	catalyst %
C	agitation rpm
D	temperature C
E	concentration
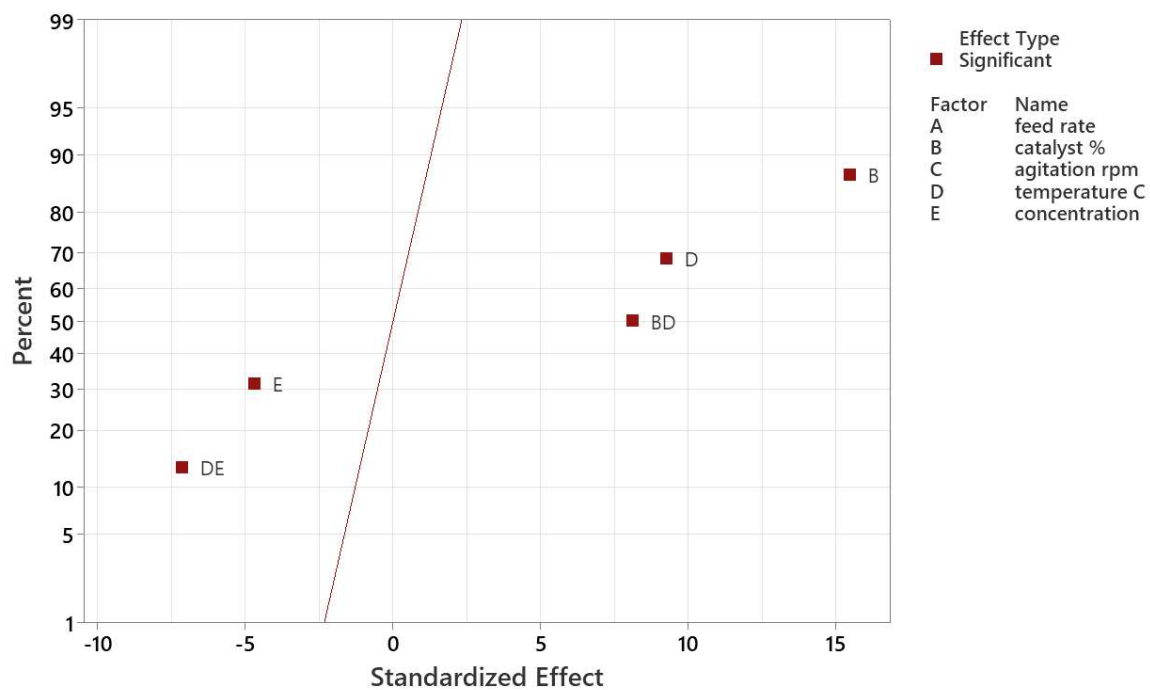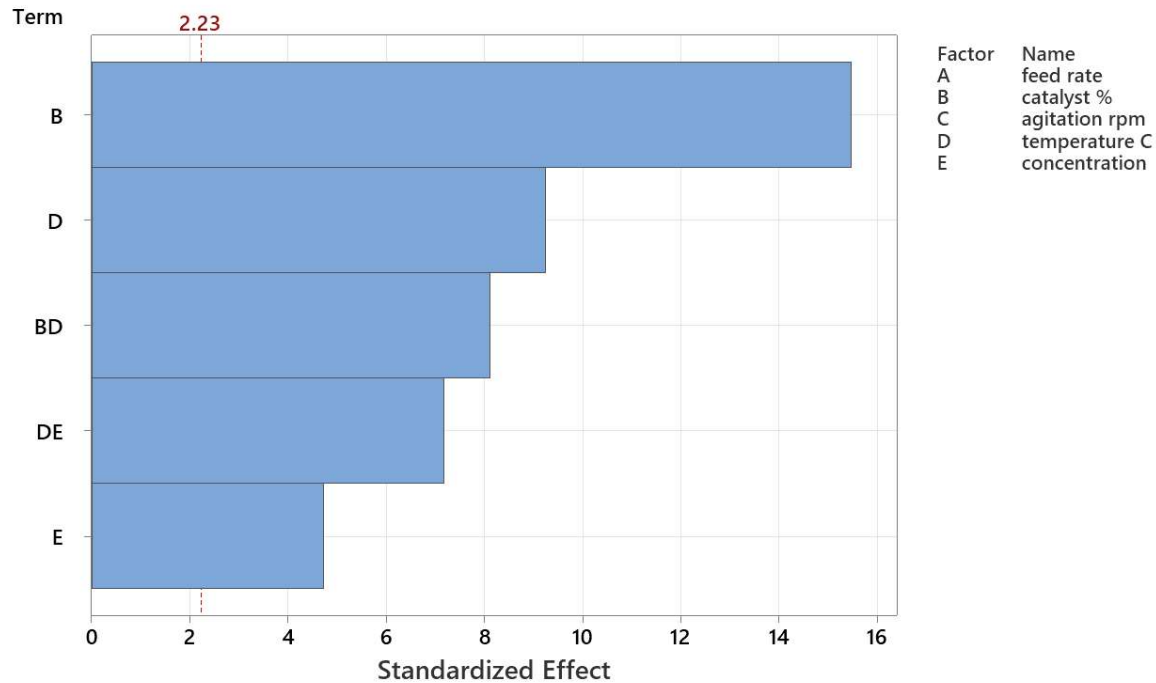
Residual Plots for % Reacted

Normal Probability Plot

Versus Fits

Histogram

Versus Order

Example of Placket-Burman Partial Design

Stat-> DOE -> Screening-> Create Screening Design

Pluckett-Burman
5 factors
Number of runs: 12
Center points replicates: 0
Number of replicates: 1
Factors: list and name them (A,B,C,D,E)
Options: Randomize
Results: Summary Table
% Reacted in C10 is eneterd after runnung the experiments

Design Summary

Factors:	5	Replicates:	1
Base runs:	12	Total runs:	12
Base blocks:	1	Total blocks:	1

Design Table

Run	Blk	A	B	C	D	E
1	1	+	-	+	-	-
2	1	+	+	-	+	-
3	1	-	+	+	-	+
4	1	+	-	+	+	-
5	1	+	+	-	+	+
6	1	+	+	+	-	+
7	1	-	+	+	+	-
8	1	-	-	+	+	+
9	1	-	-	-	+	+
10	1	+	-	-	-	+
11	1	-	+	-	-	-
12	1	-	-	-	-	-

Create Full Factorial Design

Stat-> DOE -> Factorial -> Create Factorial Design (FULL)

2 levels
3 factors
Design: FULL fraction
Center points per block : 2

1 replicate corner points
1 block
Factors: name the factors (column headers Drop rate (%), Bandwidth (Mb), File size (kb))
Randomize runs

% Reacted in C8 is entered after running the experiments (Time (sec))

Design Summary

Factors:	3	Base Design:		3, 8
Runs:	10	Replicates:		1
Blocks:	1	Center pts (total):		2

Analyze FULL Factorial Design

Stat-> DOE -> Factorial -> Analyze Factorial Design

Response: Time (sec) (ie result)
Terms: Include all up through the level 2
Graphs: Pareto and Normal
Include residuals 4 in one plot

RESULTS:
Significant: only C (File size) is significant
Factors do not provide a good valid model

Coded Coefficients

Term	Effect	Coef	SE Coef	T-Value	P-Value	VIF
Constant		5.030	0.483	10.41	0.061	
Drop rate (%)	0.316	0.158	0.483	0.33	0.799	1.00
Bandwidth (Mb)	0.391	0.195	0.483	0.40	0.755	1.00
FIle Size (kb)	9.294	4.647	0.483	9.62	0.066	1.00
Drop rate (%)*Bandwidth (Mb)	0.227	0.113	0.483	0.23	0.853	1.00
Drop rate (%)*FIle Size (kb)	0.266	0.133	0.483	0.28	0.829	1.00
Bandwidth (Mb)*FIle Size (kb)	0.339	0.170	0.483	0.35	0.785	1.00
Drop rate (%)*Bandwidth (Mb)*FIle Size (kb)	0.686	0.343	0.483	0.71	0.607	1.00
Ct Pt		-1.26	1.08	-1.17	0.452	1.00

Model Summary

S	R-sq	R-sq(adj)	R-sq(pred)
1.36633	98.96%	90.62%	*

Analysis of Variance

Source	DF	Adj SS	Adj MS	F-Value	P-Value
Model	8	177.196	22.150	11.86	0.221
Linear	3	173.247	57.749	30.93	0.131
Drop rate (%)	1	0.200	0.200	0.11	0.799
Bandwidth (Mb)	1	0.306	0.306	0.16	0.755
FIle Size (kb)	1	172.741	172.741	92.53	0.066
2-Way Interactions	3	0.475	0.158	0.08	0.959
Drop rate (%)*Bandwidth (Mb)	1	0.103	0.103	0.06	0.853
Drop rate (%)*FIle Size (kb)	1	0.142	0.142	0.08	0.829
Bandwidth (Mb)*FIle Size (kb)	1	0.230	0.230	0.12	0.785
3-Way Interactions	1	0.941	0.941	0.50	0.607
Drop rate (%)*Bandwidth (Mb)*FIle Size (kb)	1	0.941	0.941	0.50	0.607
Curvature	1	2.534	2.534	1.36	0.452
Error	1	1.867	1.867		
Total	9	179.063			

Regression Equation in Uncoded Units

Time (sec) = -1.00 + 0.074 Drop rate (%) + 0.0065 Bandwidth (Mb) + 0.1050 FIle Size (kb)
- 0.00136 Drop rate (%)*Bandwidth (Mb) - 0.00127 Drop rate (%)*FIle Size (kb)
- 0.000086 Bandwidth (Mb)*FIle Size (kb)
+ 0.000034 Drop rate (%)*Bandwidth (Mb)*FIle Size (kb) - 1.26 Ct Pt

Fits and Diagnostics for Unusual Observations

Obs	Time (sec)	Fit	Resid	Std Resid	
1	0.10	0.10	0.00	*	X
2	0.61	0.61	0.00	*	X
3	0.61	0.61	0.00	*	X
4	0.20	0.20	0.00	*	X
5	9.48	9.48	-0.00	*	X
6	9.15	9.15	-0.00	*	X
7	9.29	9.29	0.00	*	X
8	10.79	10.79	-0.00	*	X

X Unusual X

Alias Structure

Factor	Name
A	Drop rate (%)
B	Bandwidth (Mb)
C	FIle Size (kb)

Aliases
I
A
B
C
AB
AC
BC
ABC
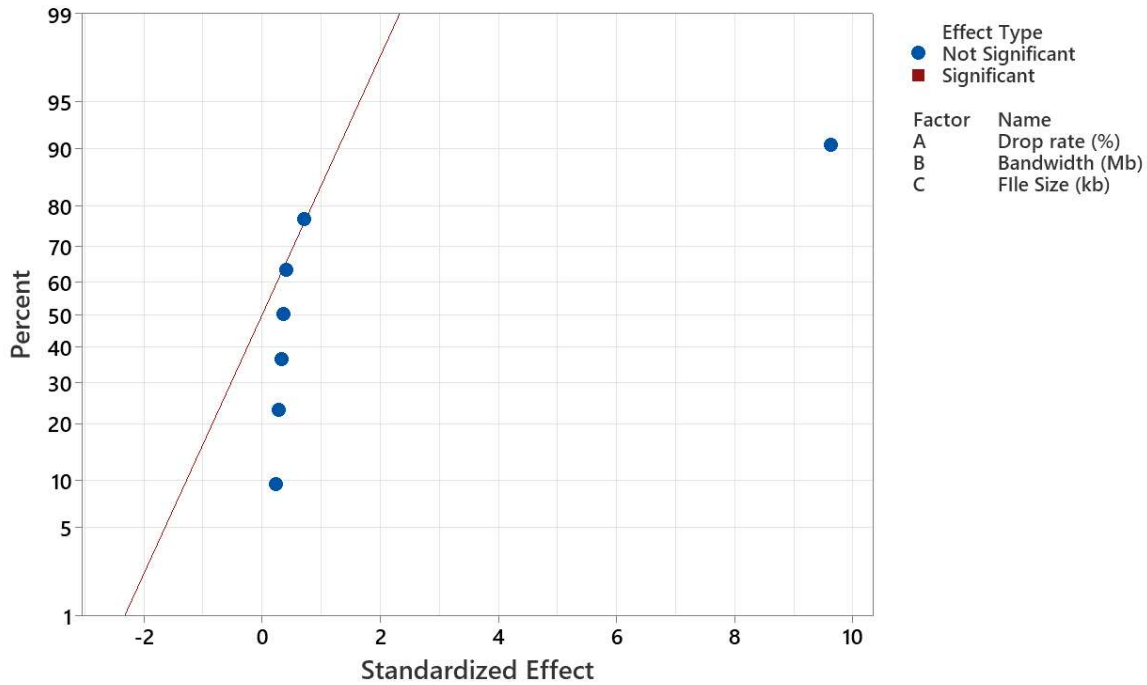
Normal Plot of the Standardized Effects
(response is Time (sec), α = 0.05)

Effect Type
● Not Significant
■ Significant

Factor	Name
A	Drop rate (%)
B	Bandwidth (Mb)
C	FIle Size (kb)

Pareto Chart of the Standardized Effects
(response is Time (sec), α = 0.05)

Term

12.71

Factor	Name
A	Drop rate (%)
B	Bandwidth (Mb)
C	FIle Size (kb)
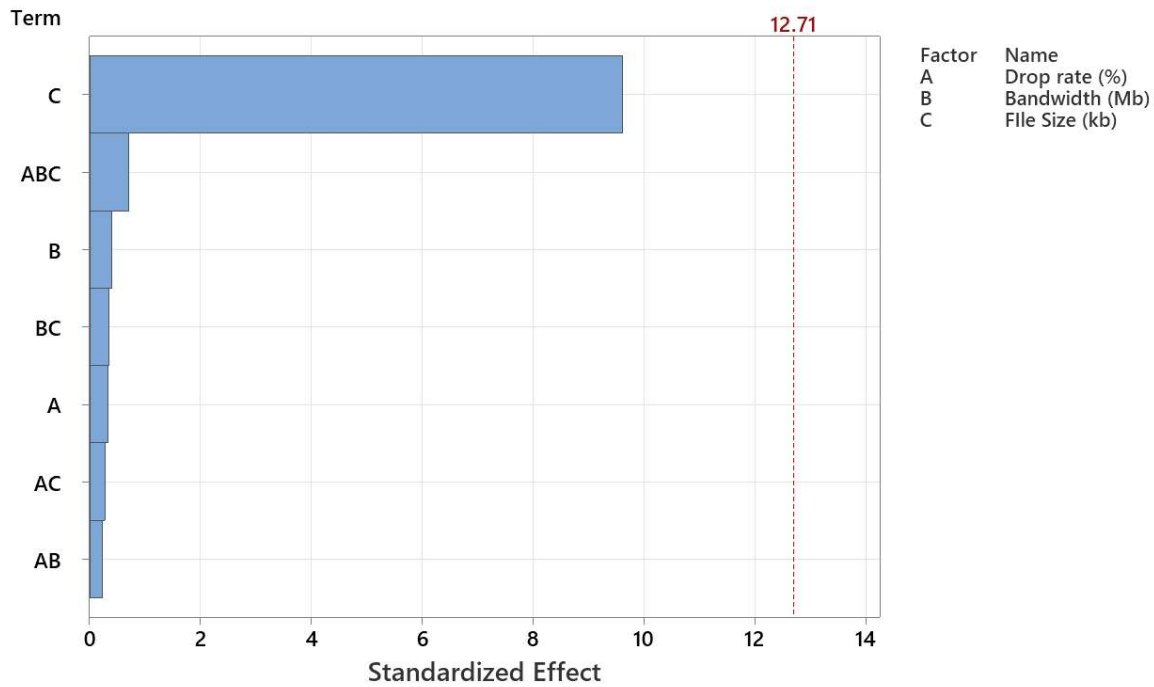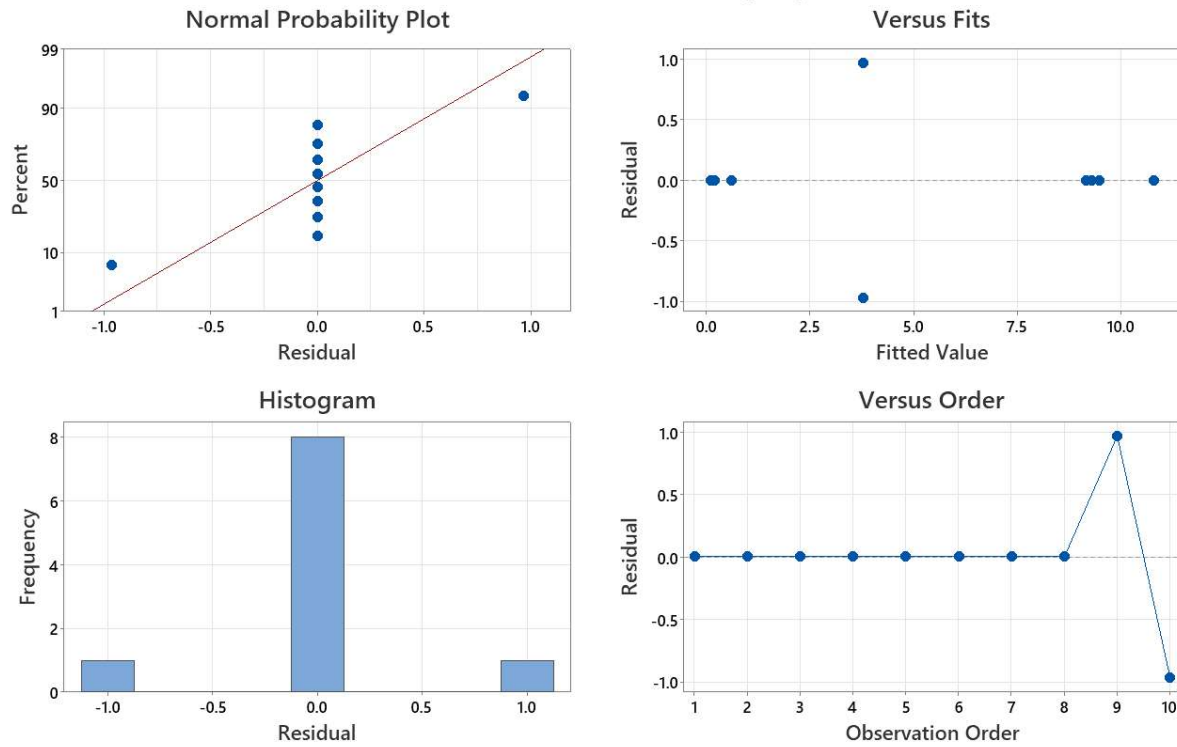
Factorial Plots

Stats -> DOE -> Factorial -> Factorial Plots

Main Effects Plot for Time (sec)
Fitted Means
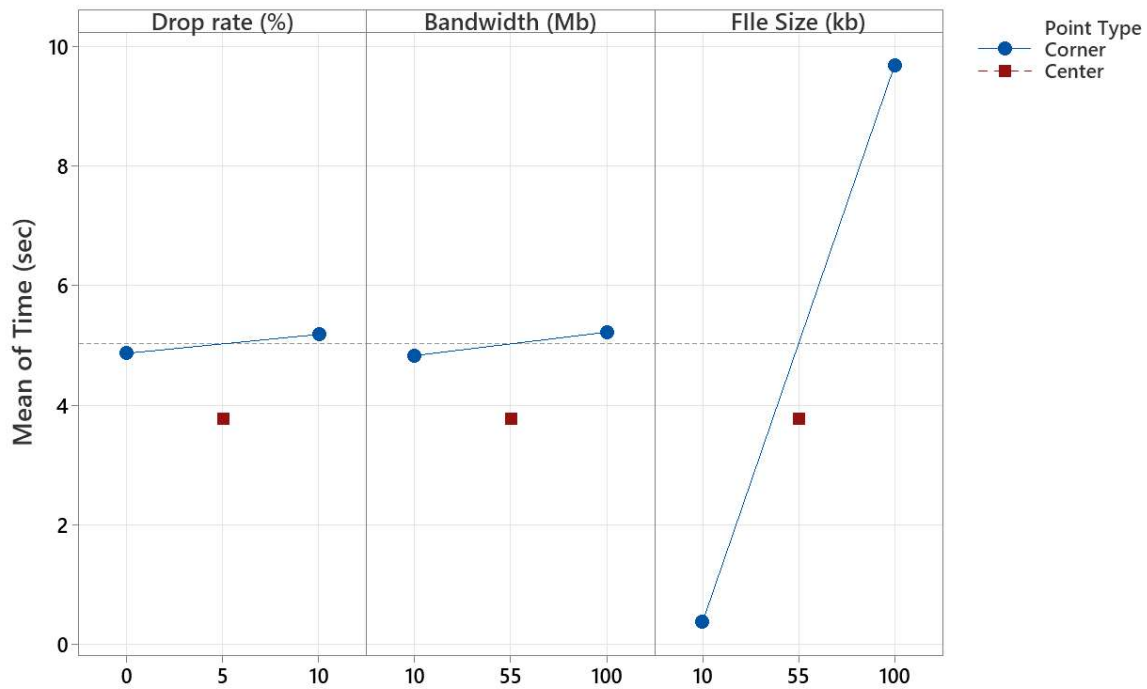
Interaction Plot for Time (sec)
Fitted Means

Stats -> DOE -> Factorial -> Cube Plot

Cube Plot (fitted means) for Time (sec)

⊕ Centerpoint
● Factorial Point

9.2938   10.7890

0.6133   0.2038
100

⊕
3.7711

Bandwidth (Mb)   9.4762   9.1463
100

FIle Size (kb)

0.1024   0.6116
10   10

0   Drop rate (%)   10
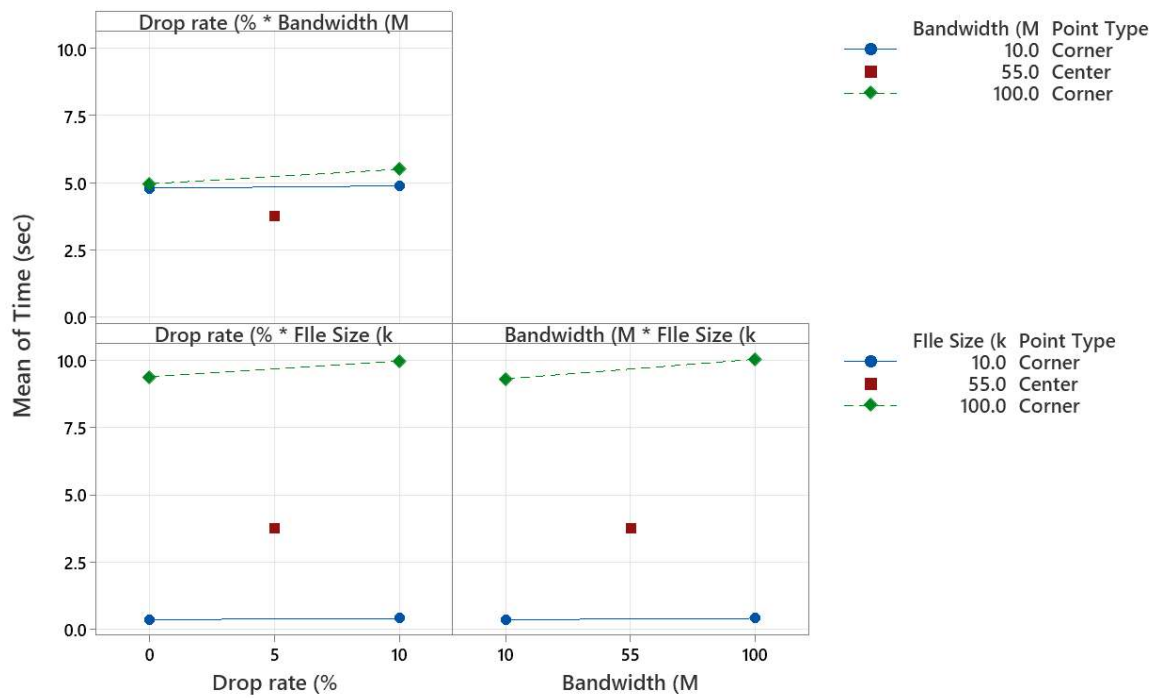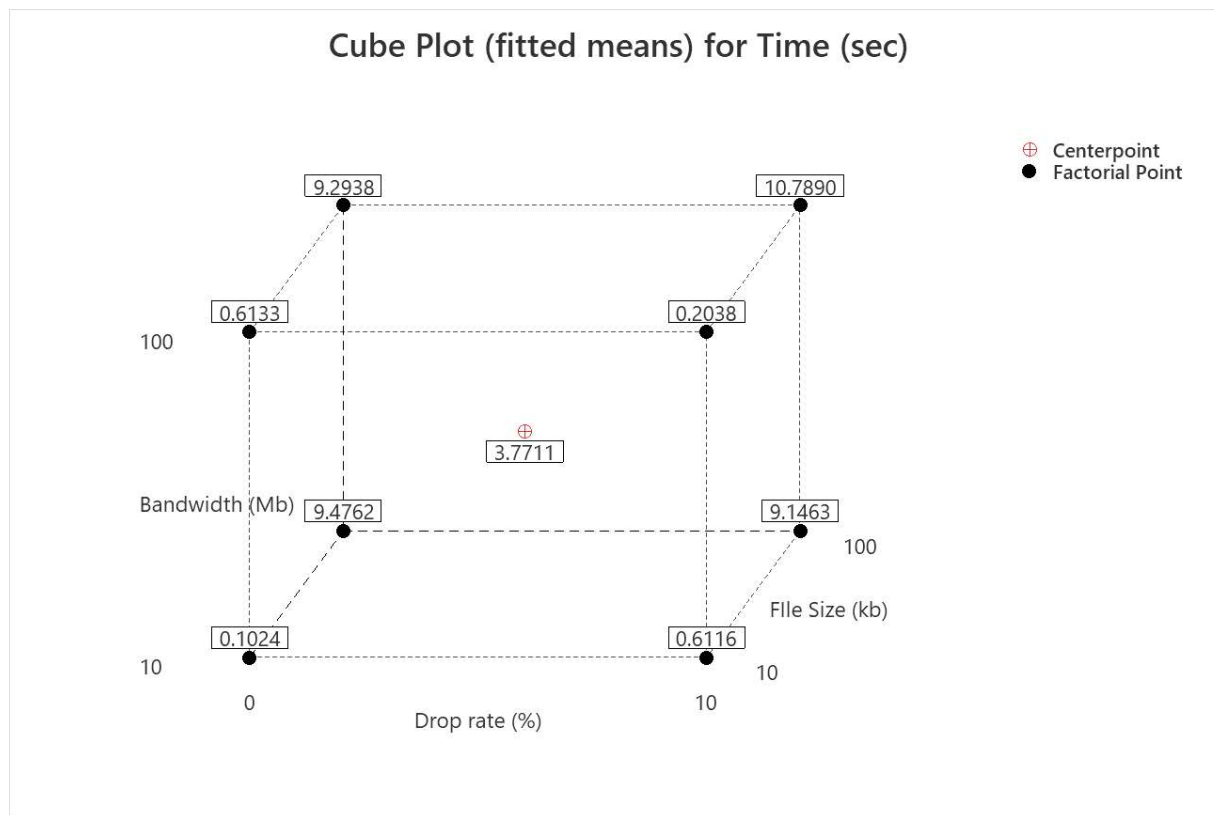
Factorial (Curvature, 5 center points) - Create Factorial Design

Stat-> DOE -> Factorial -> Create Factorial Design (FULL)

In this example:
2 factors
Design: FULL fraction
Center points per block : 5
1 replicate corner points
1 block
Factors: name the factors (Mixture %,from 3 to 5, Temperature C, from 160 to 100)
Randomize runs

Design Summary

Factors:	2	Base Design:	2, 4
Runs:	9	Replicates:	1
Blocks:	1	Center pts (total):	5

Design Table

Run	Blk	A	B
1	1	-	-
2	1	+	-
3	1	-	+
4	1	+	+
5	1	0	0
6	1	0	0
7	1	0	0
8	1	0	0
9	1	0	0

Factorial (Curvature, 5 center points) - Analyze Factorial Design

Stat-> DOE -> Factorial -> Analyze Factorial Design

Response: Time (sec) (ie result)
Terms: Include all up through the level 2
Graphs: Pareto and Normal
Include residuals 4 in one plot

RESULTS:
Significant: only C (File size) is significant
Factors do not provide a good valid model

Coded Coefficients

Term	Effect	Coef	SE Coef	T-Value	P-Value	VIF
Constant		86.250	0.195	441.90	0.000	
Mixture %	-5.500	-2.750	0.195	-14.09	0.000	1.00
Temperature C	3.510	1.755	0.195	8.99	0.001	1.00
Mixture %*Temperature C	-6.530	-3.265	0.195	-16.73	0.000	1.00
Ct Pt		6.234	0.262	23.81	0.000	1.00

Model Summary

S	R-sq	R-sq(adj)	R-sq(pred)
0.390359	99.65%	99.29%	*

Analysis of Variance

Source	DF	Adj SS	Adj MS	F-Value	P-Value
Model	4	171.573	42.8932	281.49	0.000
Linear	2	42.570	21.2850	139.68	0.000
Mixture %	1	30.250	30.2500	198.52	0.000
Temperature C	1	12.320	12.3201	80.85	0.001
2-Way Interactions	1	42.641	42.6409	279.83	0.000
Mixture %*Temperature C	1	42.641	42.6409	279.83	0.000
Curvature	1	86.362	86.3617	566.75	0.000
Error	4	0.610	0.1524		
Total	8	172.182			

Regression Equation in Uncoded Units

% Yeild   =   -154.6 + 52.76 Mixture % + 1.4815 Temperature C - 0.3265 Mixture %*Temperature C
+ 6.234 Ct Pt

Fits and Diagnostics for Unusual Observations

Obs	% Yeild	Fit	Resid	Std Resid	
1	83.980	83.980	0.000	*	X
2	85.010	85.010	0.000	*	X
3	94.020	94.020	0.000	*	X
4	81.990	81.990	0.000	*	X

X Unusual X

Alias Structure

Factor	Name
A	Mixture %
B	Temperature C

Aliases
I
A
B
AB

Normal Plot of the Standardized Effects
(response is % Yeild, α = 0.05)

Effect Type
■ Significant

Factor	Name
A	Mixture %
B	Temperature C

Pareto Chart of the Standardized Effects
(response is % Yeild, α = 0.05)

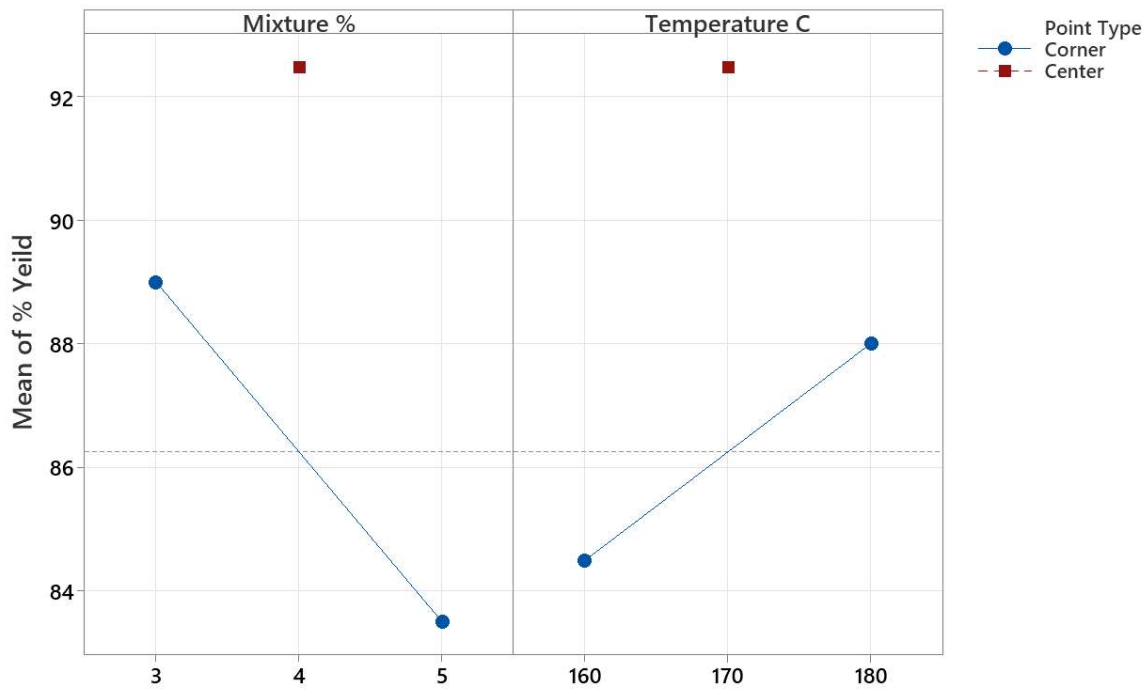| Factor	Name
A	Mixture %
B	Temperature C
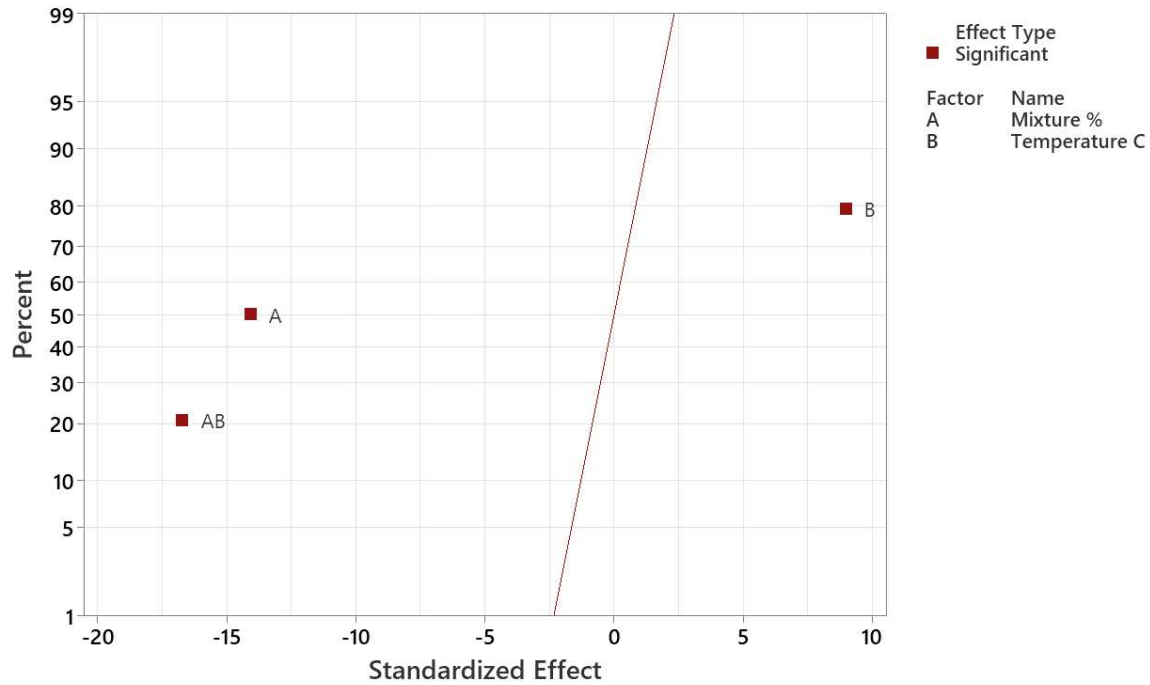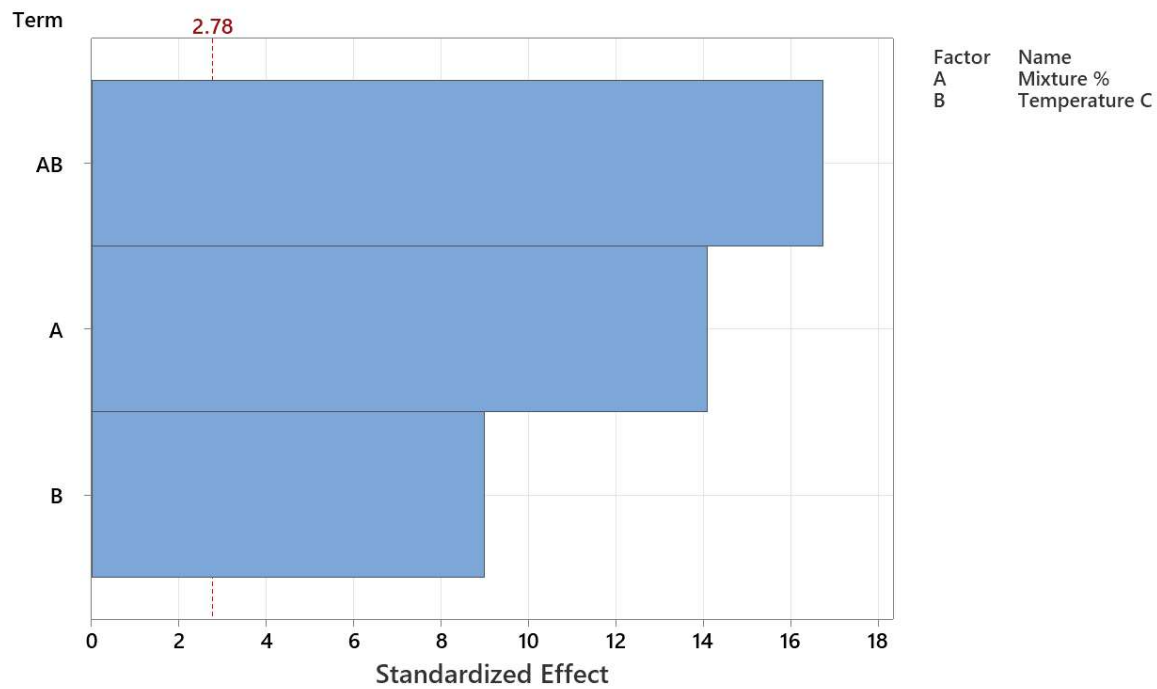
Residual Plots for % Yeild
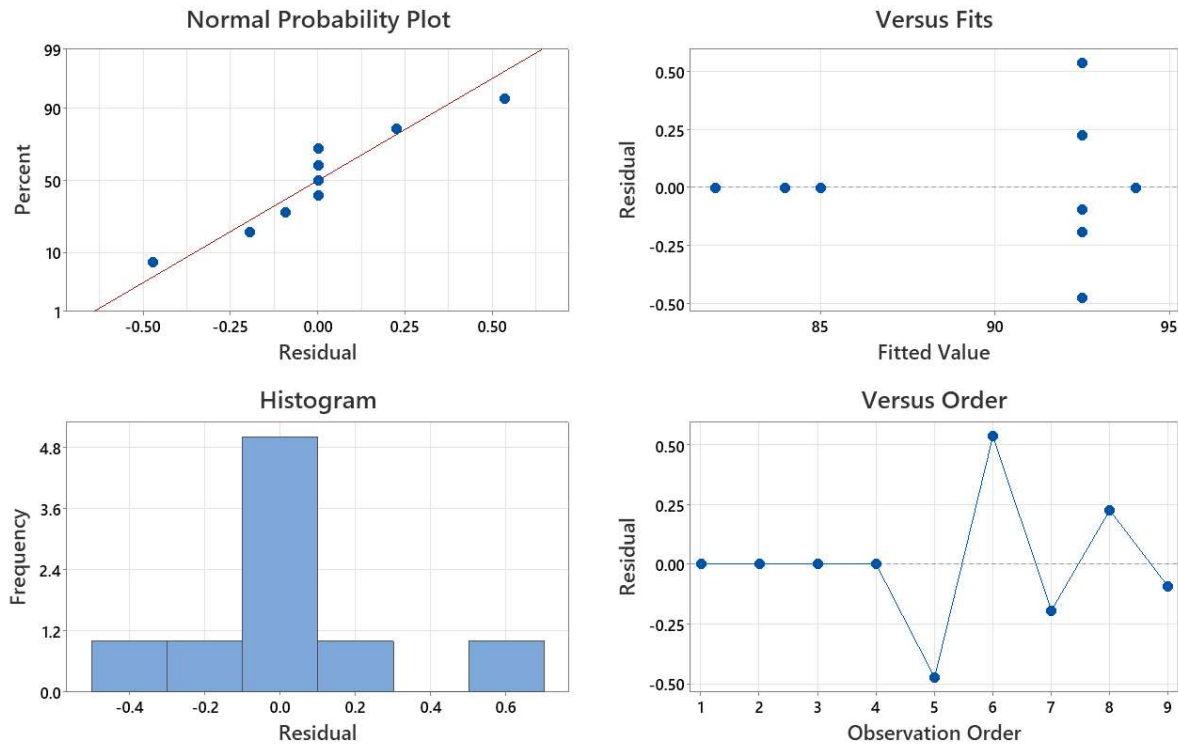
Stats -> DOE -> Factorial -> Factorial Plots

Note that the middle point is not on the straight line (ie, it is curve).

RESULT: Full factorial design was not able to discover the relationship. Response surface model is

Main Effects Plot for % Yeild
Fitted Means

Interaction Plot for % Yeild
Fitted Means
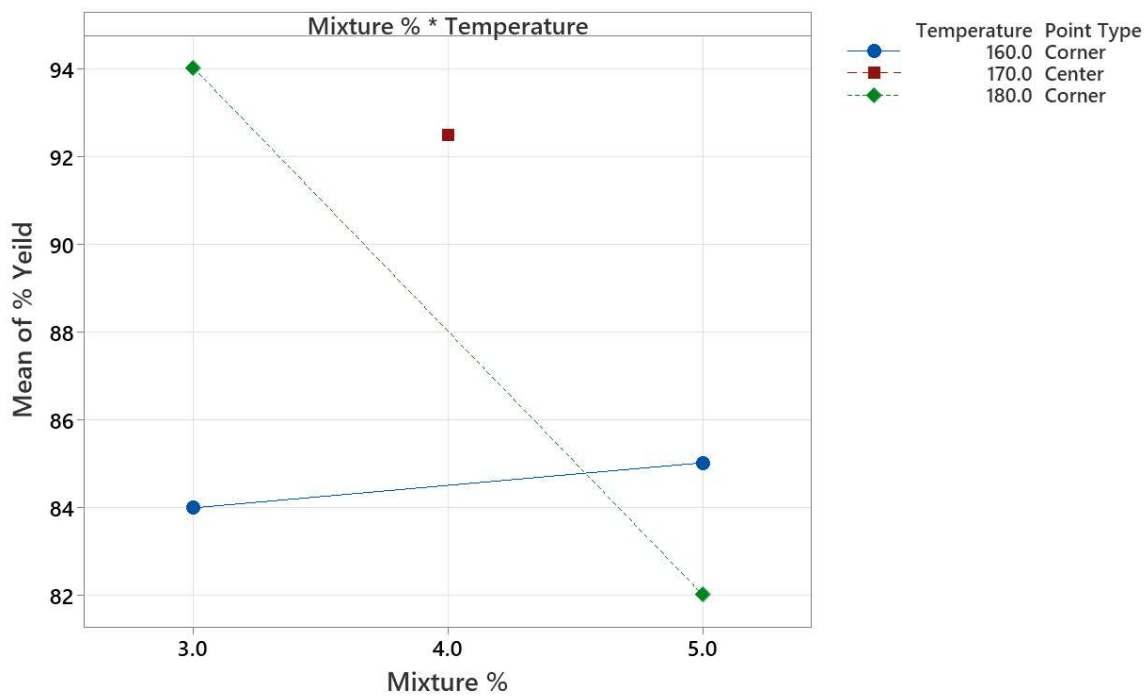
Create Response Surface Design

Stat ->DOE -> Response Surface -> Create Response Surface Design

Response surface is not limited to linear relationship

Central Composite
Number of factors: 2
Number of categorical factors: 0
Full 13 runs, 1 block, 0 cube, 0 axial
Factors: Mixture % from 3 to 5 , Temperature from 160 to 180
Randomize runs

Design Summary

Factors:	2	Replicates:	1
Base runs:	13	Total runs:	13
Base blocks:	1	Total blocks:	1

Point Types

Cube points:	4
Center points in cube:	5
Axial points:	4
Center points in axial:	0

Analyze Response Surface Design

Stat -> DOE -> Response Surface -> Analyze Response Surface Design

Responses: % Yield
Terms: Full quadratic
Plots: Pareto, Residuals Four in One.

RESULTS: All terms are significant, including quadratic terms (see P-Value <0.05)

Coded Coefficients

Term	Coef	SE Coef	T-Value	P-Value	VIF

Constant	92.484	0.252	366.39	0.000	
Mixture %	-3.143	0.200	-15.75	0.000	1.00
Temperature	1.940	0.200	9.72	0.000	1.00
Mixture %*Mixture %	-3.178	0.214	-14.85	0.000	1.02
Temperature*Temperature	-3.175	0.214	-14.84	0.000	1.02
Mixture %*Temperature	-3.265	0.282	-11.57	0.000	1.00

Model Summary

S	R-sq	R-sq(adj)	R-sq(pred)
0.564427	99.20%	98.63%	95.51%

Analysis of Variance

Source	DF	Adj SS	Adj MS	F-Value	P-Value
Model	5	275.940	55.1880	173.23	0.000
Linear	2	109.122	54.5612	171.26	0.000
Mixture %	1	79.016	79.0159	248.03	0.000
Temperature	1	30.107	30.1066	94.50	0.000
Square	2	124.177	62.0884	194.89	0.000
Mixture %*Mixture %	1	70.242	70.2421	220.49	0.000
Temperature*Temperature	1	70.132	70.1316	220.14	0.000
2-Way Interaction	1	42.641	42.6409	133.85	0.000
Mixture %*Temperature	1	42.641	42.6409	133.85	0.000
Error	7	2.230	0.3186		
Lack-of-Fit	3	1.621	0.5402	3.54	0.127
Pure Error	4	0.610	0.1524		
Total	12	278.170			

Regression Equation in Uncoded Units

% Yield = -1118.4 + 77.78 Mixture % + 12.295 Temperature - 3.178 Mixture %*Mixture %
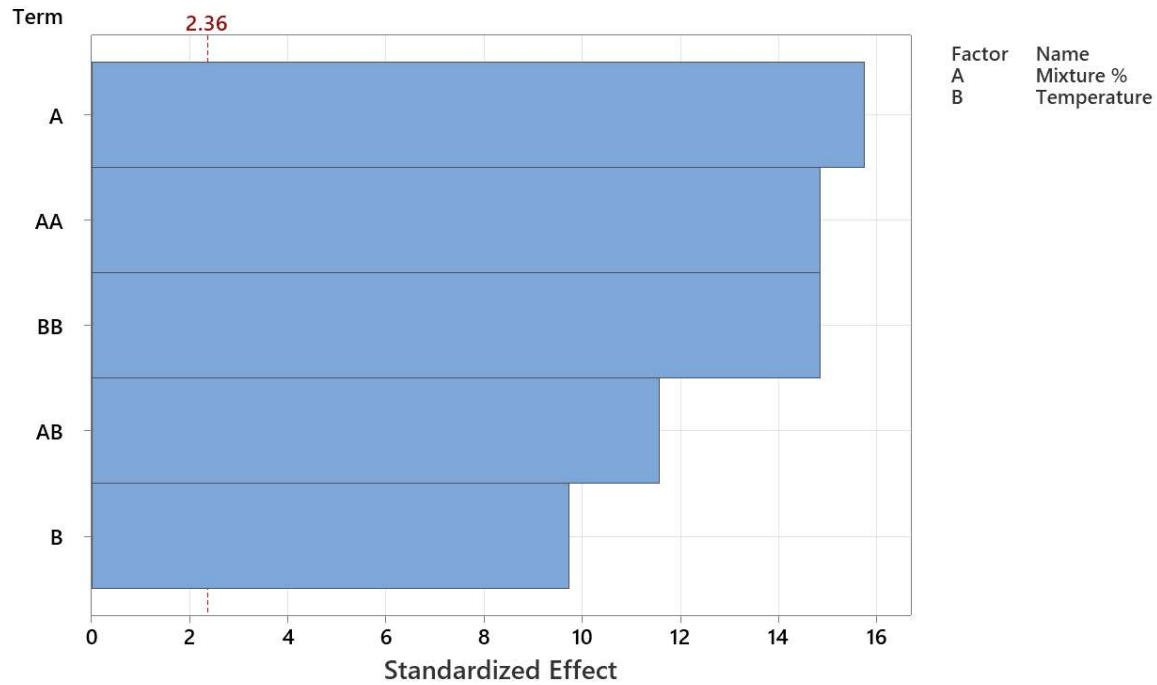- 0.03175 Temperature*Temperature - 0.3265 Mixture %*Temperature

Fits and Diagnostics for Unusual Observations
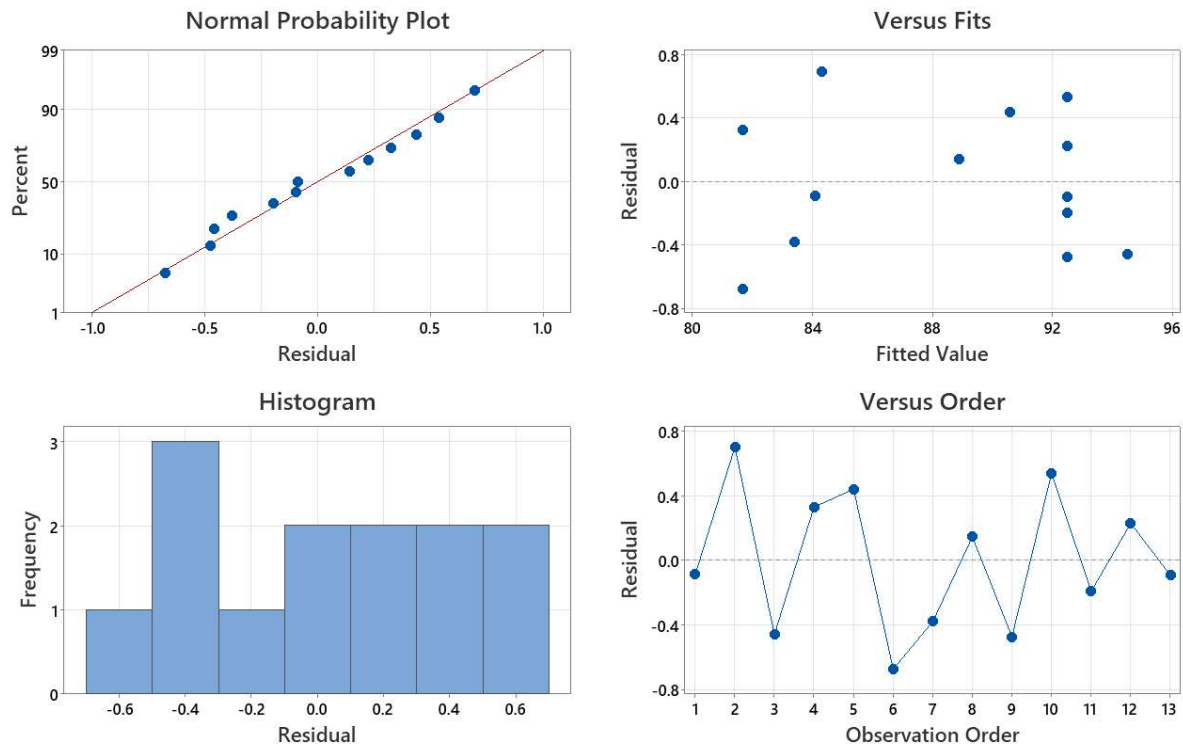
Obs	% Yield	Fit	Resid	Std Resid	
2	85.010	84.314	0.696	2.01	R

R Large residual

Pareto Chart of the Standardized Effects
(response is % Yield, α = 0.05)

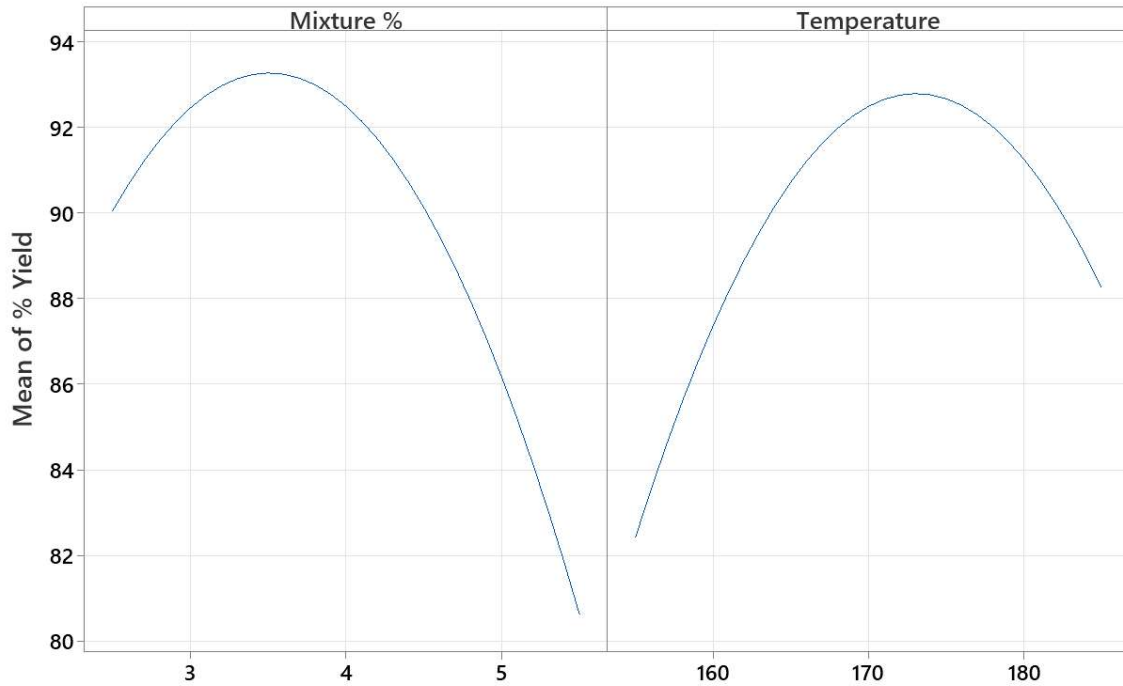| Factor	Name
A	Mixture %
B	Temperature

Residual Plots for % Yield

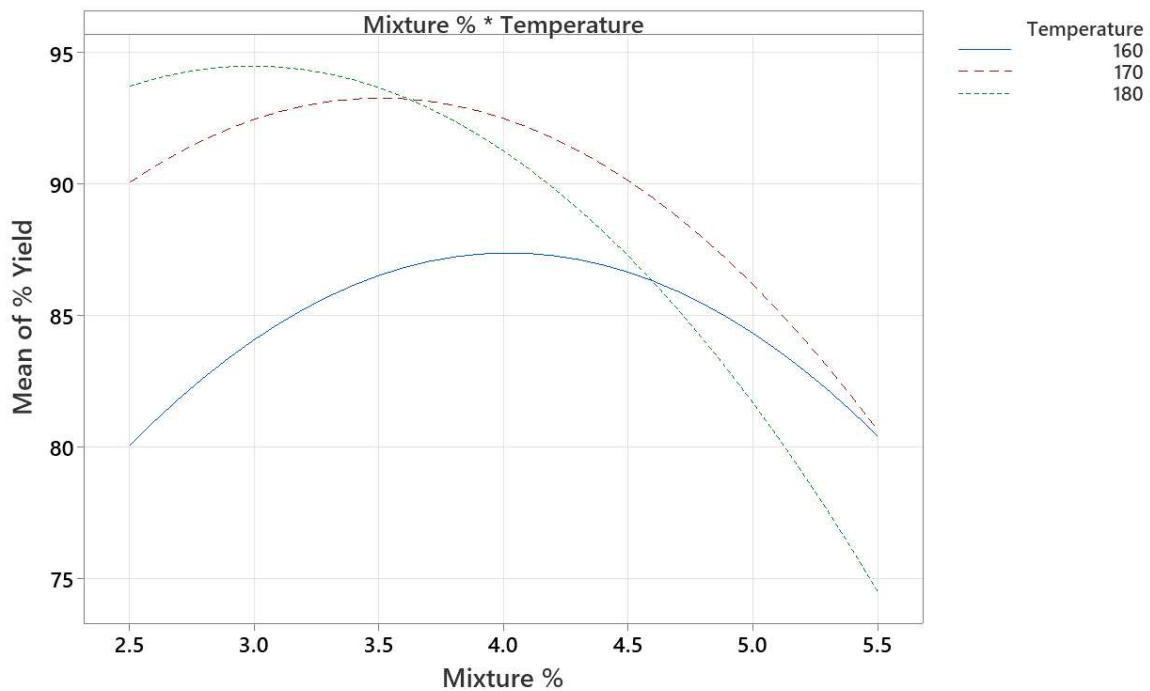**Stats -> DOE -> REsponse Surface -> Factorial Plots**

Main Effects Plot for % Yield
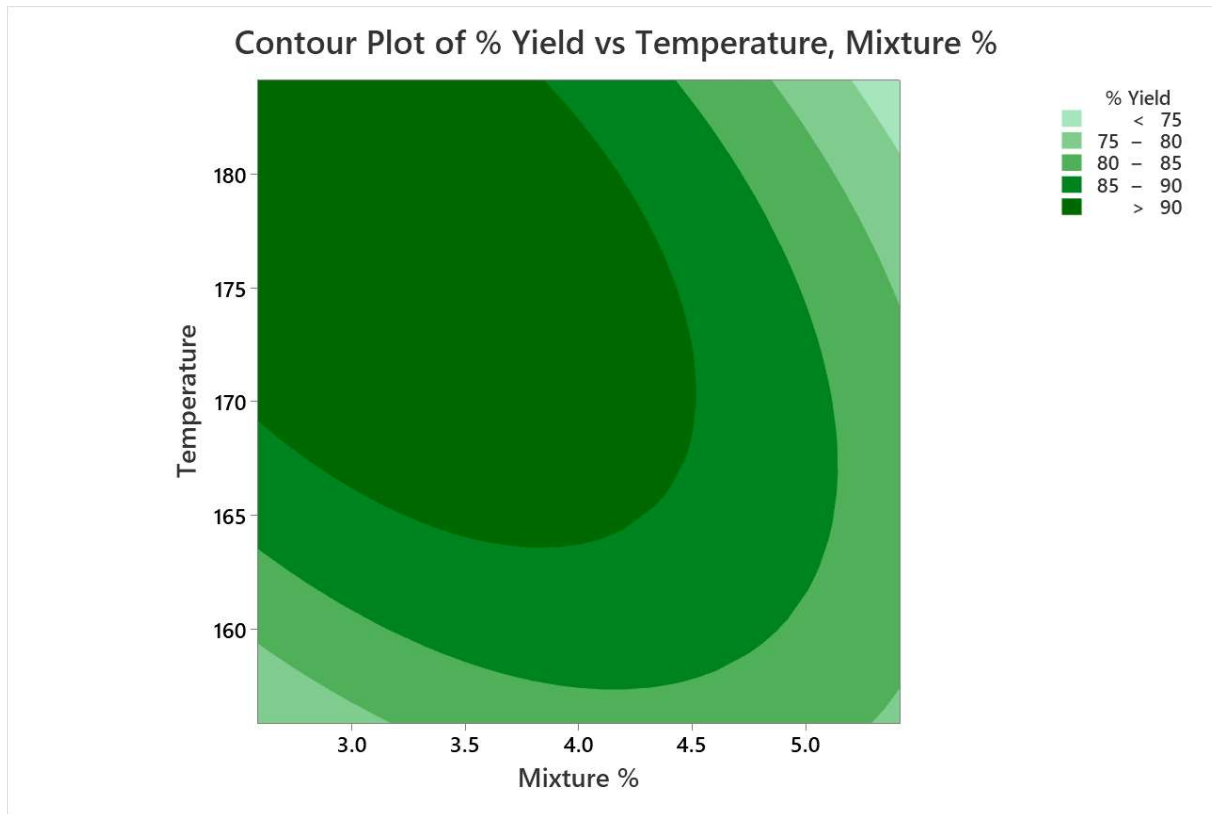Fitted Means

Interaction Plot for % Yield
Fitted Means

Stats -> DOE -> Response Surface -> Contour Plots
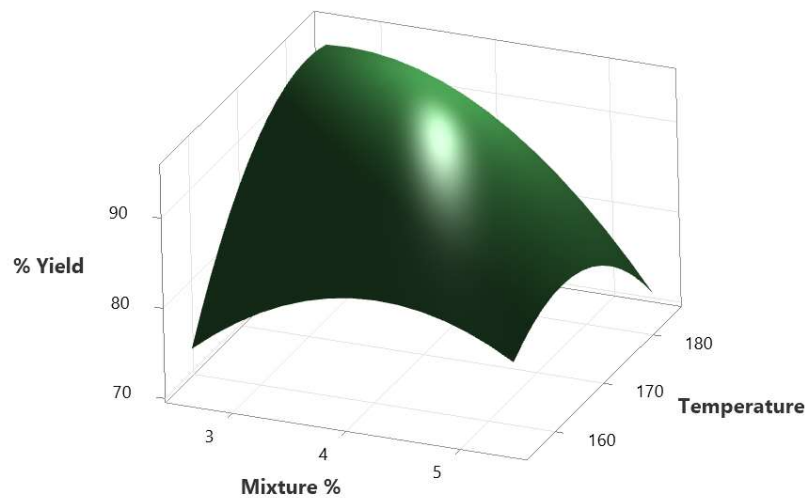Response % Yield
Variables: Generate plots for all pairs of continuous variables
In separate panels of the same graph

Stats -> DOE -> Response Surface -> Surface Plots

Surface Plot of % Yield vs Temperature, Mixture %

Response Optimizer

Stat -> DOE -> Response Surface -> Response Optimizer

Maximize % Yield
Options: select constraingts of production system (ie select operational range)

Parameters

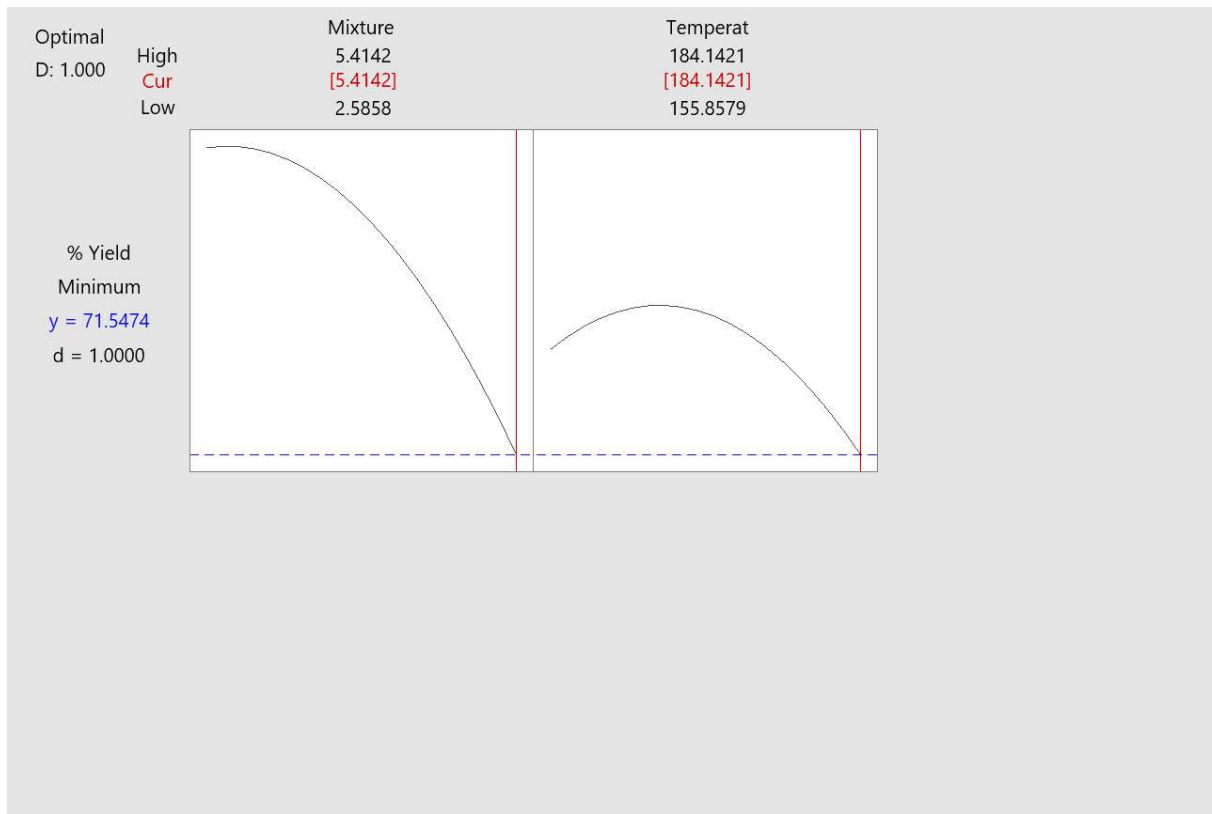| Response	Goal	Lower	Target	Upper	Weight	Importance
% Yield	Minimum		81.01	94.02	1	1

Solution

Solution	Mixture %	Temperature	% Yield Fit	Composite Desirability

1	5.41421	184.142	71.5474	1

Multiple Response Prediction

Variable	Setting
Mixture %	5.41421
Temperature	184.142

Response	Fit	SE Fit	95% CI	95% PI
% Yield	71.547	0.837	(69.568, 73.527)	(69.160, 73.935)

Optimal
D: 1.000

	Mixture	Temperat
High	5.4142	184.1421
Cur	[5.4142]	[184.1421]
Low	2.5858	155.8579

% Yield
Minimum
y = 71.5474
d = 1.0000

Real World Exercise

Company has defective box springs.
Results of 2^3 factorial experiment determined 3 factors

Low-High settings for each factor:
Oven Temperature: 788C - 871C
Carbon Concentration : 0.5% - 0.7%
Quench Temperature: 21C - 49C

Create DOE worksheet for 2^3 full factorial experiment. No replicates. No ceter points. 8 runs total.

RESULTS:

In initial analysis A and AC were significant. Re-analysis must include all the lower order effects, therefore A,B,C and AC were included in re-analysis.

Conclusion: Oven Temperature(A) and Oven+Quench Temperature (AC) are

Design Summary

Factors:	3	Base Design:	3, 8
Runs:	8	Replicates:	1
Blocks:	1	Center pts (total):	0

Design Table

Run	Blk	A	B	C
1	1	-	-	-
2	1	+	-	-
3	1	-	+	-
4	1	+	+	-
5	1	-	-	+
6	1	+	-	+
7	1	-	+	+
8	1	+	+	+

Coded Coefficients

Term	Effect	Coef
Constant		71.25
Oven Temperature, C	23.00	11.50
Carbon Concentration, %	-5.000	-2.500
Quench Temperature, C	1.5000	0.7500
Oven Temperature, C*Carbon Concentration, %	1.5000	0.7500
Oven Temperature, C*Quench Temperature, C	10.000	5.000
Carbon Concentration, %*Quench Temperature, C	-0.000000	-0.000000
Oven Temperature, C*Carbon Concentration, %*Quench Temperature, C	0.5000	0.2500

Term	SE Coef	T-Value	P-Value
Constant	*	*	*
Oven Temperature, C	*	*	*
Carbon Concentration, %	*	*	*
Quench Temperature, C	*	*	*
Oven Temperature, C*Carbon Concentration, %	*	*	*
Oven Temperature, C*Quench Temperature, C	*	*	*
Carbon Concentration, %*Quench Temperature, C	*	*	*
Oven Temperature, C*Carbon Concentration, %*Quench Temperature, C	*	*	*

Term	VIF
Constant	
Oven Temperature, C	1.00
Carbon Concentration, %	1.00
Quench Temperature, C	1.00

Oven Temperature, C*Carbon Concentration, %	1.00
Oven Temperature, C*Quench Temperature, C	1.00
Carbon Concentration, %*Quench Temperature, C	1.00
Oven Temperature, C*Carbon Concentration, %*Quench Temperature, C	1.00

Model Summary

S	R-sq	R-sq(adj)	R-sq(pred)
*	100.00%	*	*

Analysis of Variance

Source	DF	Adj SS	Adj MS
Model	7	1317.50	188.21
Linear	3	1112.50	370.83
Oven Temperature, C	1	1058.00	1058.00
Carbon Concentration, %	1	50.00	50.00
Quench Temperature, C	1	4.50	4.50
2-Way Interactions	3	204.50	68.17
Oven Temperature, C*Carbon Concentration, %	1	4.50	4.50
Oven Temperature, C*Quench Temperature, C	1	200.00	200.00
Carbon Concentration, %*Quench Temperature, C	1	0.00	0.00
3-Way Interactions	1	0.50	0.50
Oven Temperature, C*Carbon Concentration, %*Quench Temperature, C	1	0.50	0.50
Error	0	*	*
Total	7	1317.50	

Source	F-Value	P-Value
Model	*	*
Linear	*	*
Oven Temperature, C	*	*
Carbon Concentration, %	*	*
Quench Temperature, C	*	*
2-Way Interactions	*	*
Oven Temperature, C*Carbon Concentration, %	*	*
Oven Temperature, C*Quench Temperature, C	*	*
Carbon Concentration, %*Quench Temperature, C	*	*
3-Way Interactions	*	*
Oven Temperature, C*Carbon Concentration, %*Quench Temperature, C	*	*
Error		
Total		

## Regression Equation in Uncoded Units

% Acceptable = 119.4 - 0.04217 Oven Temperature, C - 49.98 Carbon Concentration, %
- 4.943 Quench Temperature, C
+ 0.03012 Oven Temperature, C*Carbon Concentration, %
+ 0.006024 Oven Temperature, C*Quench Temperature, C
- 3.569 Carbon Concentration, %*Quench Temperature, C
+ 0.004303 Oven Temperature, C*Carbon Concentration, %*Quench Temperature, C

Alias Structure

Factor	Name
A	Oven Temperature, C
B	Carbon Concentration, %
C	Quench Temperature, C

Aliases

I
A
B
C
AB
AC
BC
ABC

Normal Plot of the Effects
(response is % Acceptable, α = 0.05)

Effect Type
● Not Significant
■ Significant

Factor	Name
A	Oven Temperature, C
B	Carbon Concentration, %
C	Quench Temperature, C

Lenth's PSE = 2.25

Pareto Chart of the Effects
(response is % Acceptable, α = 0.05)

Factor	Name
A	Oven Temperature, C
B	Carbon Concentration, %
C	Quench Temperature, C
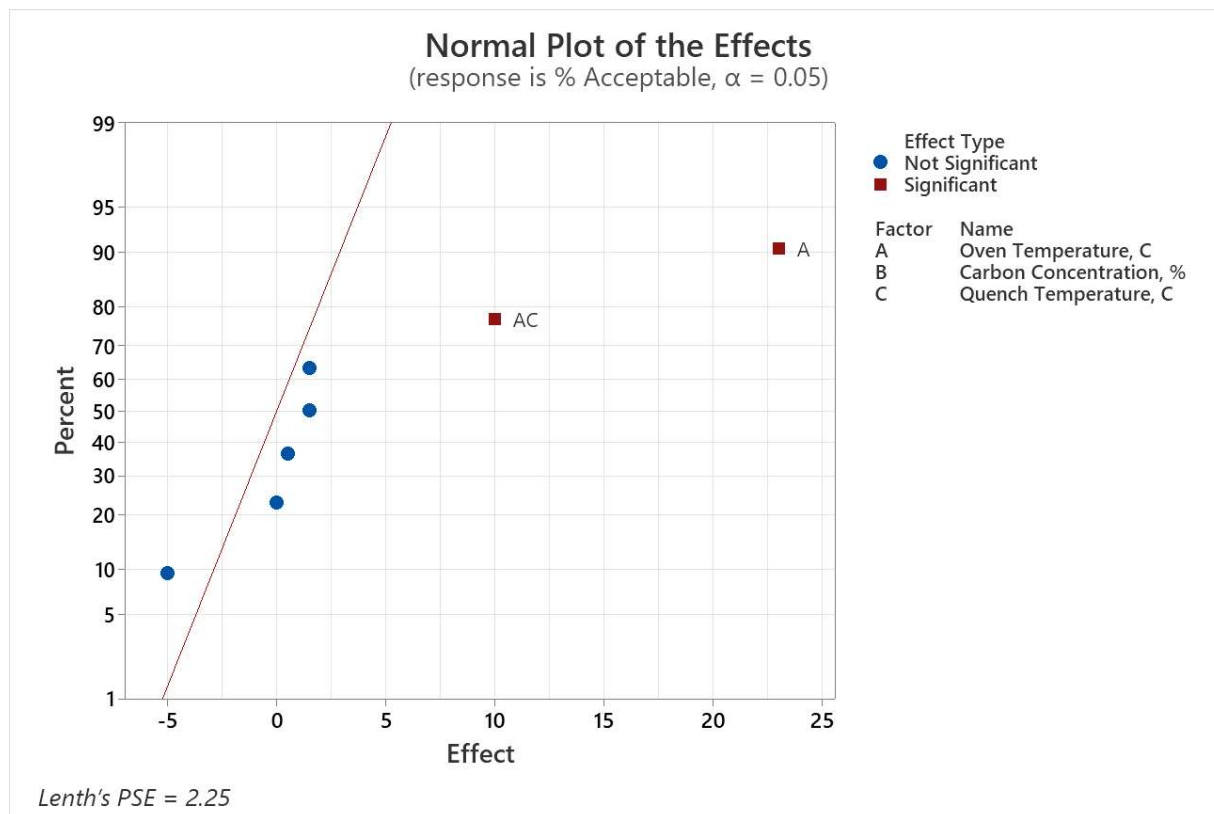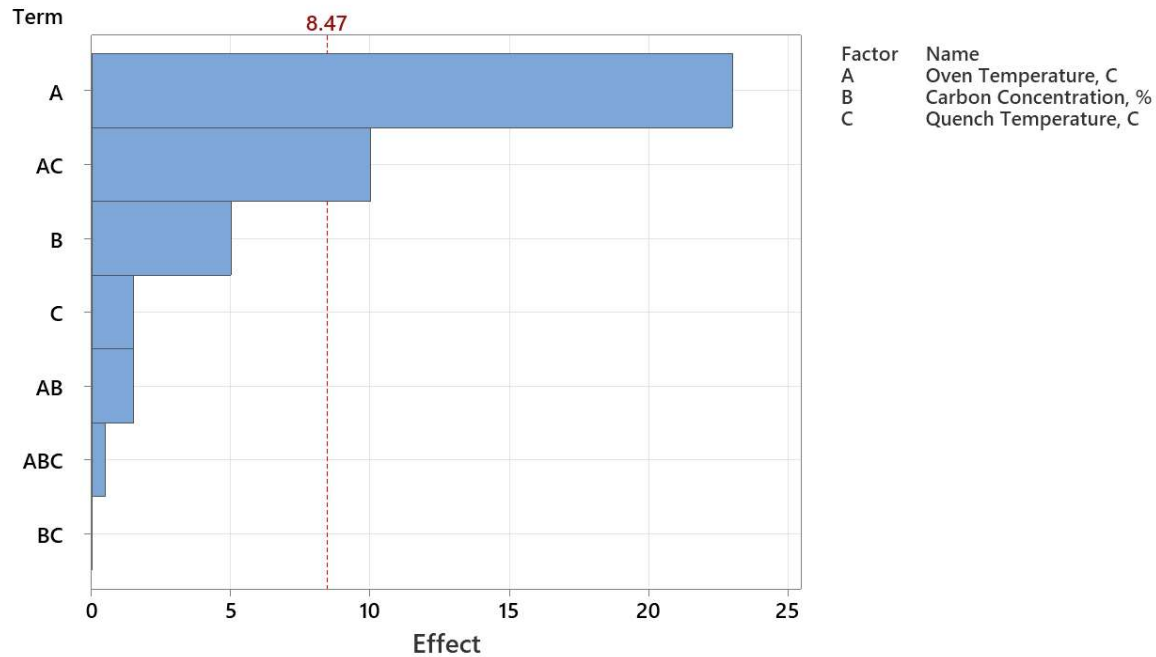
Lenth's PSE = 2.25

Coded Coefficients

Term	Effect	Coef	SE Coef	T-Value	P-Value	VIF
Constant		71.250	0.456	156.10	0.000	
Oven Temperature, C	23.000	11.500	0.456	25.20	0.000	1.00
Carbon Concentration, %	-5.000	-2.500	0.456	-5.48	0.012	1.00
Quench Temperature, C	1.500	0.750	0.456	1.64	0.199	1.00
Oven Temperature, C*Quench Temperature, C	10.000	5.000	0.456	10.95	0.002	1.00

Model Summary

S	R-sq	R-sq(adj)	R-sq(pred)
1.29099	99.62%	99.11%	97.30%

Analysis of Variance

Source	DF	Adj SS	Adj MS	F-Value	P-Value
Model	4	1312.50	328.13	196.88	0.001
Linear	3	1112.50	370.83	222.50	0.001
Oven Temperature, C	1	1058.00	1058.00	634.80	0.000
Carbon Concentration, %	1	50.00	50.00	30.00	0.012
Quench Temperature, C	1	4.50	4.50	2.70	0.199
2-Way Interactions	1	200.00	200.00	120.00	0.002
Oven Temperature, C*Quench Temperature, C	1	200.00	200.00	120.00	0.002
Error	3	5.00	1.67		

Total   7   1317.50

Regression Equation in Uncoded Units
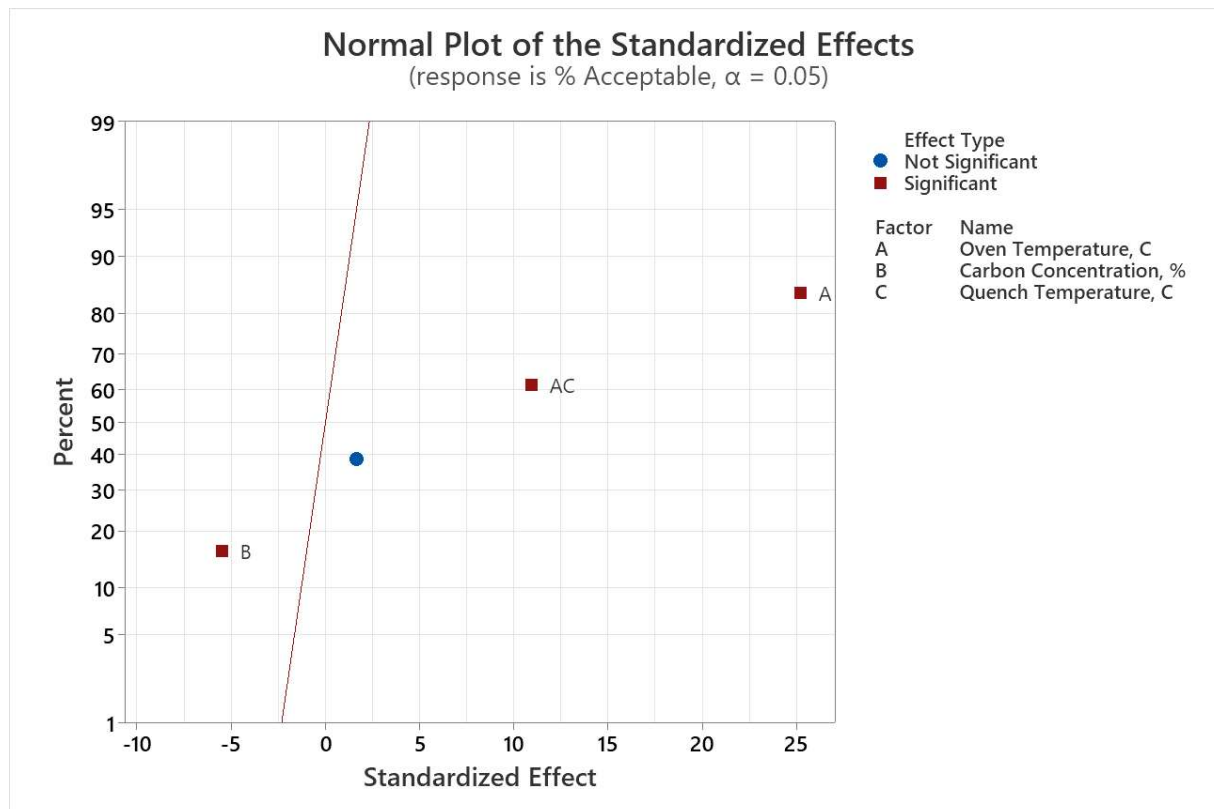
% Acceptable   =   104.4 - 0.0241 Oven Temperature, C - 25.00 Carbon Concentration, %
                    - 7.085 Quench Temperature, C
                    + 0.008606 Oven Temperature, C*Quench Temperature, C

Alias Structure

Factor	Name
A	Oven Temperature, C
B	Carbon Concentration, %
C	Quench Temperature, C

Aliases

I
A
B
C
AC

Normal Plot of the Standardized Effects
(response is % Acceptable, α = 0.05)

Pareto Chart of the Standardized Effects
(response is % Acceptable, α = 0.05)

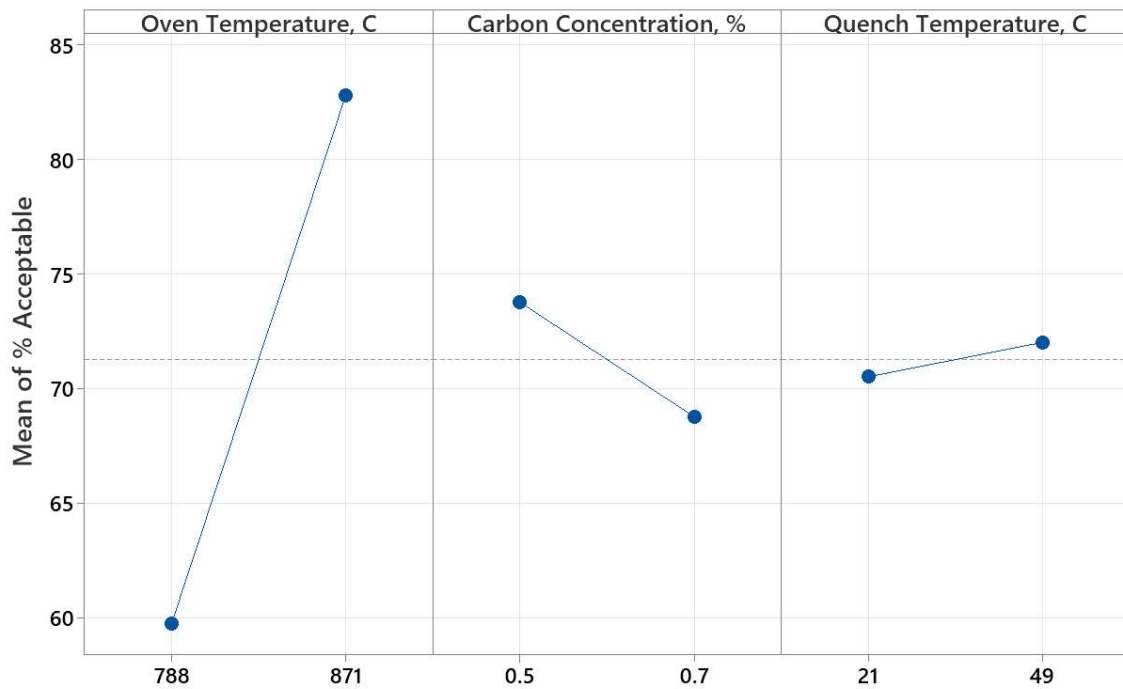| Factor	Name
A	Oven Temperature, C
B	Carbon Concentration, %
C	Quench Temperature, C
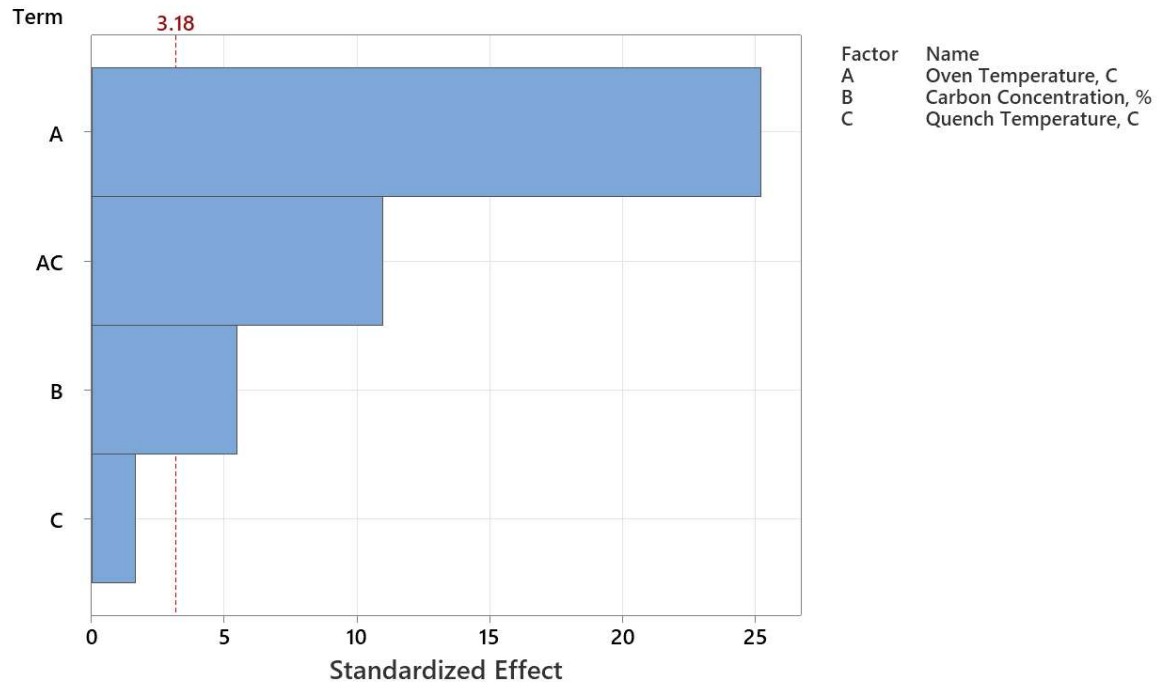
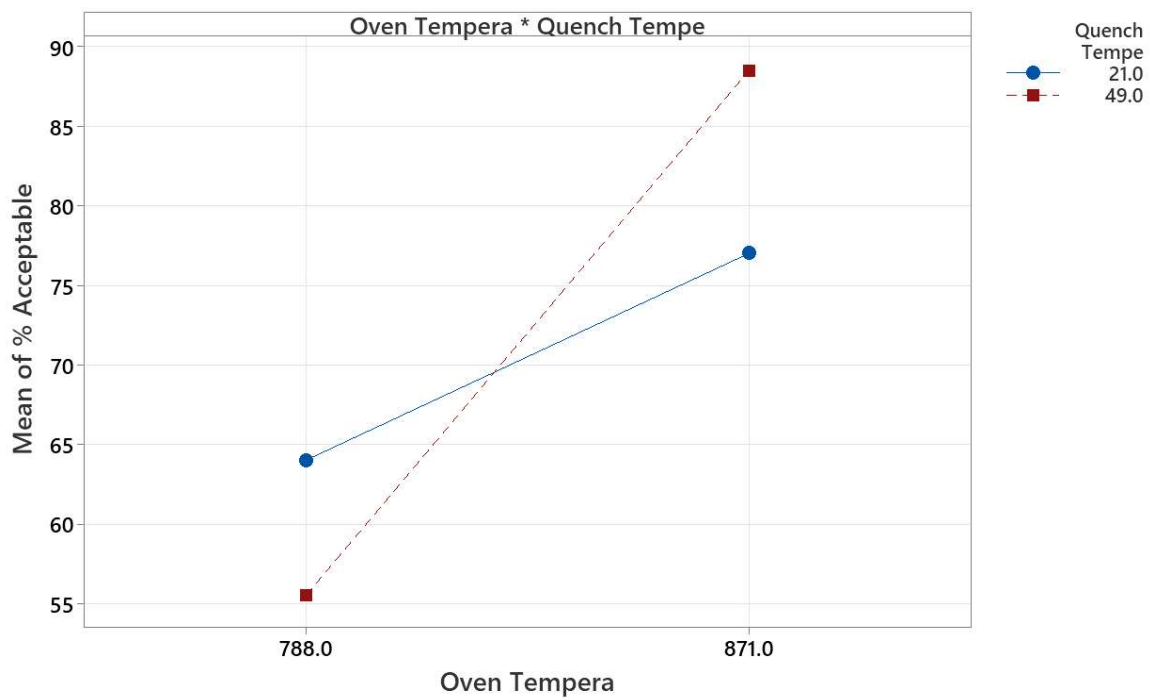# Residual Plots for % Acceptable
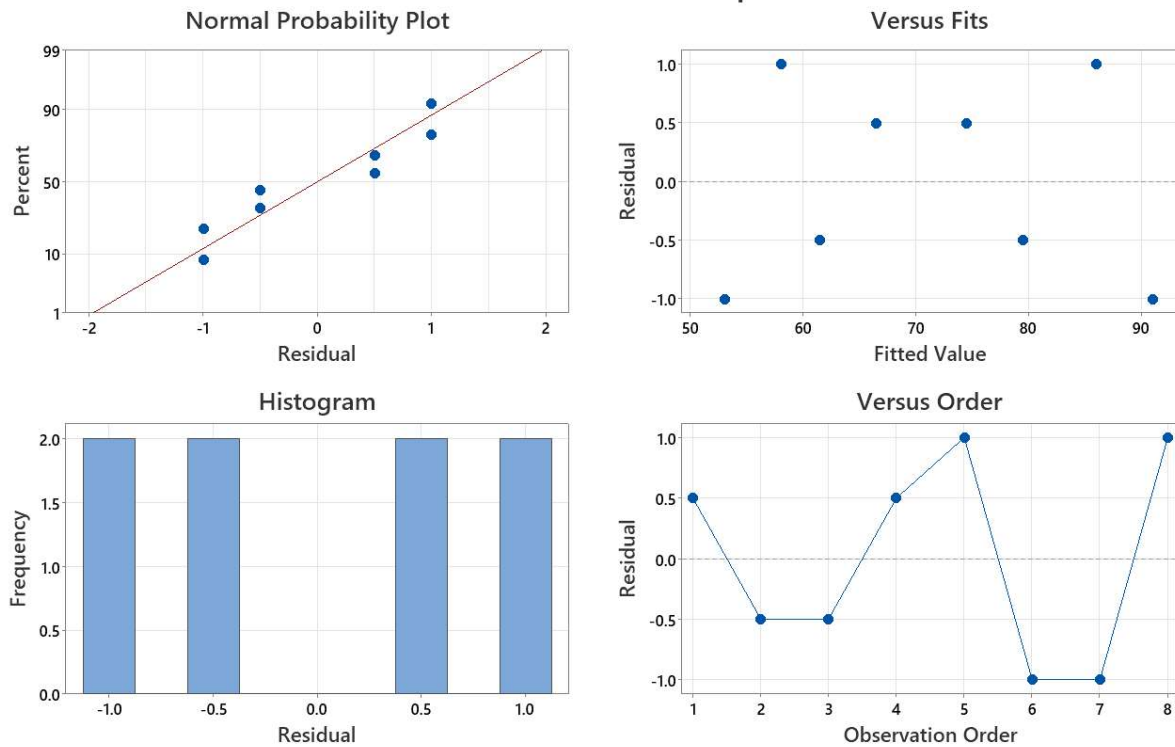
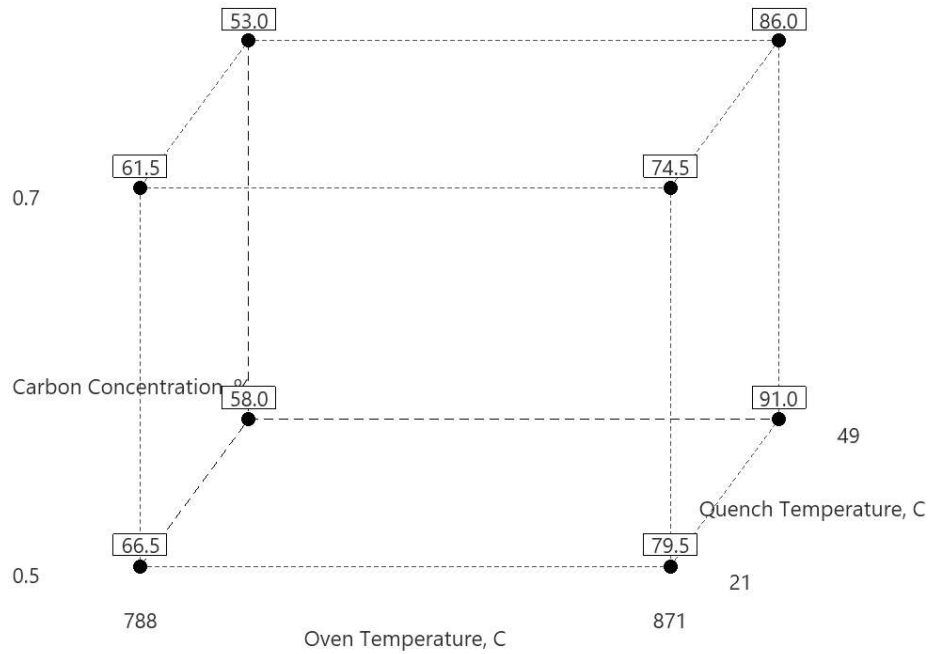**Main Effects Plot for % Acceptable**
Fitted Means
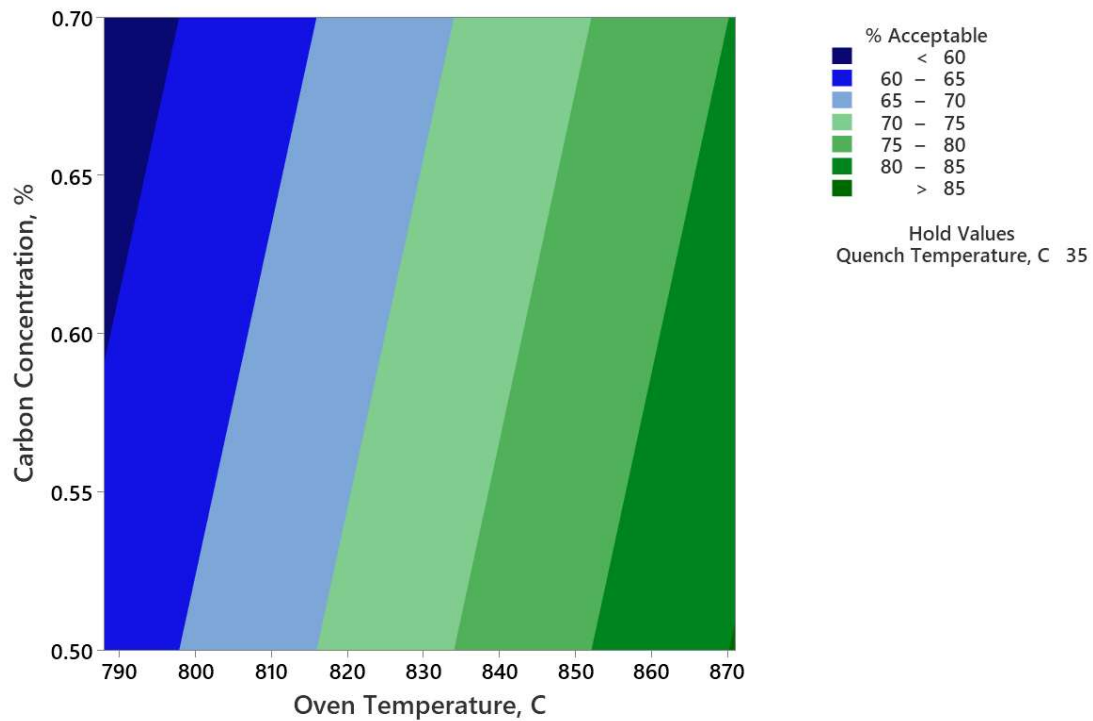

Interaction Plot for % Acceptable
Fitted Means

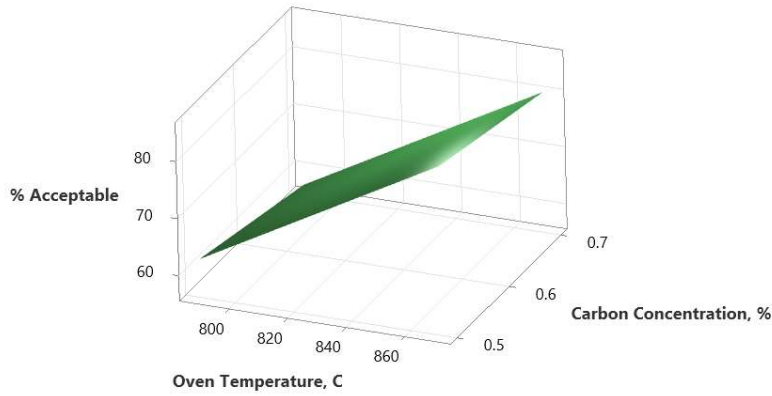## Cube Plot (fitted means) for % Acceptable

Contour Plot of % Acceptable vs Carbon Concentration, %, Oven Temperat

Surface Plot of % Acceptable vs Carbon Concentration, %, Oven Temperat

Hold Values
Quench Temperature, C   35

Parameters

Response	Goal	Lower	Target	Upper	Weight	Importance
% Acceptable	Maximum	52	90		1	1

Solution

Solution	Oven Temperature, C	Carbon Concentration, %	Quench Temperature, C	% Acceptable Fit	Composite Desirability
1	871	0.5	49	91	1

Multiple Response Prediction

Variable	Setting
Oven Temperature, C	871
Carbon Concentration, %	0.5
Quench Temperature, C	49

Response	Fit	SE Fit	95% CI	95% PI
% Acceptable	91.00	1.02	(87.75, 94.25)	(85.76, 96.24)

Optimal		Oven Tem	Carbon C	Quench T
D: 1.000	High	871.0	0.70	49.0
	Cur	[871.0]	[0.50]	[49.0]
	Low	788.0	0.50	21.0

% Accept

Maximum

y = 91.0

d = 1.0000