SUPPLEMENTARY DATA

Response 1 Filling Level (Paddle wheel with flat rods)

ANOVA for Response Surface Reduced Quadratic Model Analysis of variance table [Partial sum of squares - Type III]

Source	Sum of Squares	df	Mean Square	F Value	p-value Prob > F	
Model	381.12	5	76.22	318.66	< 0.0001	significant
A-Powder mass	59.75	1	59.75	249.79	< 0.0001	
B-Paddle wheel speed	7.31	1	7.31	30.54	< 0.0001	
C-Pos. of monitoring	256.42	1	256.42	1071.97	< 0.0001	
BC	56.12	1	56.12	234.61	< 0.0001	
C^2	1.53	1	1.53	6.38	0.0155	
Residual	9.81	41	0.24			
Lack of Fit	9.76	39	0.25	10.95	0.0871	not significant
Pure Error	0.046	2	0.023			
Cor Total	390.93	46				

The Model F-value of 318.66 implies the model is significant. There is only a 0.01% chance that a "Model F-Value" this large could occur due to noise.

Values of "Prob > F" less than 0.0500 indicate model terms are significant. In this case A, B, C, BC, C++2+- are significant model terms. Values greater than 0.1000 indicate the model terms are not significant. If there are many insignificant model terms (not counting those required to support hierarchy), model reduction may improve your model.

The "Lack of Fit F-value" of 10.95 implies there is a 8.71% chance that a "Lack of Fit F- value" this large could occur due to noise. Lack of fit is bad -- we want the model to fit. This relatively low probability (<10%) is troubling.

Std. Dev.	0.49	R-Squared	0.9749
Mean	7.32	Adj R-Squared	0.9719
C.V. %	6.68	Pred R-Squared	0.9654
PRESS	13.53	Adeq Precision	71.751

The "Pred R-Squared" of 0.9654 is in reasonable agreement with the "Adj R-Squared" of 0.9719.

"Adeq Precision" measures the signal to noise ratio. A ratio greater than 4 is desirable. Your ratio of 71.751 indicates an adequate signal. This model can be used to navigate the design space.

Factor	Coefficient Estimate	df	Standard Error	95% CI Low	95% CI High	VIF
Intercept	7.08	1	0.12	6.84	7.32	
A-Powder mass	1.41	1	0.089	1.23	1.59	1.00
B-Paddle wheel speed	-0.57	1	0.10	-0.78	-0.36	1.00
C-Pos. of monitoring	2.92	1	0.089	2.74	3.10	1.00
BC	1.93	1	0.13	1.68	2.19	1.00
C^2	0.38	1	0.15	0.075	0.68	1.00

Final Equation in Terms of Coded Factors:

FL Flatrod =

+7.08

+1.41 * A

-0.57 * B

+2.92 * C

+1.93 * B * C

+0.38 * C^2

Final Equation in Terms of Actual Factors:

FL Flatrod =

+6.39311

+0.17641 * Powder mass

-0.21803 * Paddle wheel speed

-0.22428 * Position of monitoring

+3.45403E-003 * Paddle wheel speed * Position of monitoring

+1.91410E-003 * Position of monitoring^2

The Diagnostics Case Statistics Report has been moved to the Diagnostics Node. In the Diagnostics Node, Select Case Statistics from the View Menu.

Proceed to Diagnostic Plots (the next icon in progression). Be sure to look at the:

1) Normal probability plot of the studentized residuals to check for normality of residuals.
2) Studentized residuals versus predicted values to check for constant error.
3) Externally Studentized Residuals to look for outliers, i.e., influential values.
4) Box-Cox plot for power transformations.

If all the model statistics and diagnostic plots are OK, finish up with the Model Graphs icon.

Response 2 Filling Level (Paddle wheel with round rods)

ANOVA for Response Surface Reduced 2FI Model Analysis of variance table [Partial sum of squares - Type III]

Source	Sum of Squares	df	Mean Square	F Value	p-value Prob > F	
Model	232.29	5	46.46	144.67	< 0.0001	significant
A-Powder mass	46.58	1	46.58	145.07	< 0.0001	
B-Paddle wheel speed	2.55	1	2.55	7.93	0.0074	
C-Pos. of monitoring	147.12	1	147.12	458.12	< 0.0001	
AC	1.43	1	1.43	4.46	0.0409	
BC	34.61	1	34.61	107.78	< 0.0001	
Residual	13.17	41	0.32			
Lack of Fit	13.17	39	0.34	4308.60	0.0002	significant
Pure Error	1.567E-004	2	7.835E-005			
Cor Total	245.46	46				

The Model F-value of 144.67 implies the model is significant. There is only a 0.01% chance that a "Model F-Value" this large could occur due to noise.

Values of "Prob > F" less than 0.0500 indicate model terms are significant. In this case A, B, C, AC, BC are significant model terms. Values greater than 0.1000 indicate the model terms are not significant. If there are many insignificant model terms (not counting those required to support hierarchy), model reduction may improve your model.

The "Lack of Fit F-value" of 4308.60 implies the Lack of Fit is significant. There is only a 0.02% chance that a "Lack of Fit F-value" this large could occur due to noise.

Significant lack of fit is bad -- we want the model to fit.

Std. Dev.	0.57	R-Squared	0.9464
Mean	7.73	Adj R-Squared	0.9398
C.V. %	7.33	Pred R-Squared	0.9263
PRESS	18.09	Adeq Precision	49.188

The "Pred R-Squared" of 0.9263 is in reasonable agreement with the "Adj R-Squared" of 0.9398. "Adeq Precision" measures the signal to noise ratio. A ratio greater than 4 is desirable. Your ratio of 49.188 indicates an adequate signal. This model can be used to navigate the design space.

Factor	Coefficient Estimate	df	Standard Error	95% CI Low	95% CI High	VIF
Intercept	7.73	1	0.083	7.56	7.90	
A-Powder mass	1.25	1	0.10	1.04	1.46	1.00
B-Paddle wheel speed	-0.34	1	0.12	-0.58	-0.095	1.00
C-Position of monitoring	2.21	1	0.10	2.01	2.42	1.00
AC	0.27	1	0.13	0.012	0.52	1.00
BC	1.52	1	0.15	1.22	1.81	1.00

Final Equation in Terms of Coded Factors:

FL Roundrod =

+7.73

+1.25 * A

-0.34 * B

+2.21 * C

+0.27 * A * C

+1.52 * B * C

Final Equation in Terms of Actual Factors:

FL Roundrod =

+7.82377

+0.014821 * Powder mass

-0.16845 * Paddle wheel speed

-0.11446 * Position of monitoring

+2.38888E-003 * Powder mass * Position of monitoring

+2.71253E-003 * Paddle wheel speed * Position of monitoring

The Diagnostics Case Statistics Report has been moved to the Diagnostics Node. In the Diagnostics Node, Select Case Statistics from the View Menu.

Proceed to Diagnostic Plots (the next icon in progression). Be sure to look at the:

1) Normal probability plot of the studentized residuals to check for normality of residuals.

2) Studentized residuals versus predicted values to check for constant error.

3) Externally Studentized Residuals to look for outliers, i.e., influential values.

4) Box-Cox plot for power transformations.

If all the model statistics and diagnostic plots are OK, finish up with the Model Graphs icon.

Design Matrix Evaluation for Response Surface Quadratic Model

3 Factors: A, B, C (A = Powder mass, B = Paddle wheel speed, C = Position of monitoring)

No aliases found for Quadratic Model Aliases are calculated based on your response selection, taking into account missing datapoints, if necessary. Watch for aliases among terms you need to estimate.

Degrees of Freedom for Evaluation

Model	9
Residuals	37
Lack Of Fit	35
Pure Error	2
Corr Total	46

A recommendation is a minimum of 3 lack of fit df and 4 df for pure error. This ensures a valid lack of fit test. Fewer df will lead to a test that may not detect lack of fit.

Power at 5 % alpha level to detect signal/noise ratios of

Term	StdErr**	VIF	Ri-Squared	0.5 Std. Dev.	1 Std. Dev.	2 Std. Dev.
A	0.18	1.00	0.0000	26.6 %	76.0 %	99.9 %
B	0.21	1.00	0.0000	21.1 %	63.7 %	99.6 %
C	0.18	1.00	0.0000	26.6 %	76.0 %	99.9 %
AB	0.26	1.00	0.0000	15.6 %	47.1 %	96.5 %
AC	0.22	1.00	0.0000	19.3 %	58.6 %	99.2 %
BC	0.26	1.00	0.0000	15.6 %	47.1 %	96.5 %
A^2	0.31	1.01	0.0100	35.8 %	89.1 %	99.9 %
B^2	0.35	1.01	0.0083	28.9 %	80.0 %	99.9 %
C^2	0.31	1.01	0.0100	35.8 %	89.1 %	99.9 %

**Basis Std. Dev. = 1.0

Standard errors should be similar within type of coefficient. Smaller is better.

Ideal VIF is 1.0. VIFs above 10 are cause for alarm, indicating coefficients are poorly estimated due to multicollinearity.

Ideal Ri-squared is 0.0. High Ri-squared means terms are correlated with each other, possibly leading to poor models.

If the design has multilinear constraints multicollinearity will exist to a greater degree, thus increasing the VIFs and the Ri-squareds, rendering these statistics useless. Use FDS instead.

Power is an inappropriate tool to evaluate response surface designs. Use precision-based metrics provided in this program via fraction of design space (FDS) statistics. Click on the Graphs button at the top of this screen, look for the [?] button on the FDS Tool for detailed instructions.

Be sure to set the Model (on previous screen) to be an estimate of the terms you expect to be significant.

Measures Derived From the (X'X)^-1 Matrix

Std	Leverage	Point Type
1	0.3661	Unknown
2	0.2134	Unknown
3	0.1927	Unknown
4	0.2134	Unknown
5	0.3661	Unknown
6	0.2537	Unknown
7	0.1412	Unknown
8	0.1338	Unknown
9	0.1412	Unknown
10	0.2537	Unknown
11	0.3661	Unknown
12	0.2134	Unknown
13	0.1927	Unknown
14	0.2134	Unknown
15	0.3661	Unknown
16	0.2537	Unknown
17	0.1412	Unknown
18	0.1338	Unknown
19	0.1412	Unknown
20	0.2537	Unknown
21	0.1775	Unknown
22	0.1051	Unknown
23	0.1111	Unknown
24	0.1051	Unknown
25	0.1775	Unknown
26	0.2537	Unknown
27	0.1412	Unknown
28	0.1338	Unknown
29	0.1412	Unknown
30	0.2537	Unknown
31	0.3661	Unknown
32	0.2134	Unknown
33	0.1927	Unknown

34	0.2134	Unknown
35	0.3661	Unknown
36	0.2537	Unknown
37	0.1412	Unknown
38	0.1338	Unknown
39	0.1412	Unknown
40	0.2537	Unknown
41	0.3661	Unknown
42	0.2134	Unknown
43	0.1927	Unknown
44	0.2134	Unknown
45	0.3661	Unknown
46	0.1111	Unknown
47	0.1111	Unknown

Average = 0.2128

Watch for leverages close to 1.0. Consider replicating these points or make sure they are run very carefully.