Bread Wrapper Experiment

*Three factors (A: Seal Temperature; B: Cooling Bar Temperature; and C: % Polyethylene) each at two levels.

Summary

*Increasing seal temperature tends to decrease strength a lot.
*Increasing cooling bar temperature tends to increase strength a little.
*Increasing % polyethylene tends to increase strength a lot.

Interactions

*All 2-way interaction plots show some indication of interaction.
*The A: Seal Temperature*C:% Polyethylene showing the largest interaction effect.

Center Points

*n = 4
*Mean = 9.9 g/in
*Std Dev = 0.3742
*Variance = 0.14

Center Points

*Because the data at the center points are replication of the current operating conditions, they provide an idea of the natural variation in the current process.

Fisher Condition

*One of the Fisher conditions is that the variation at each combination of factor levels should be the same. If we assume this condition is met then the variation at the center points can be used as an estimate of random error variation.
Lecture 39: Analysis using Center Points

**MS\text{Error}**

- **MS\text{Error} = 0.14**, the sample variance at the center points.
- **Std Error Dif = \sqrt{MS\text{Error}} \frac{r}{\sqrt{n}}**
- **Std Error Dif = \sqrt{0.14} \frac{2}{\sqrt{8}} = 0.2646**

**A: Seal Temperature**

- \(225^\circ F\): Mean = 8.525 g/in
- \(285^\circ F\): Mean = 6.775 g/in
- Difference in means = –1.75
  - \(t = \frac{-1.75}{0.2646} = -6.61\)
  - P-value = 0.0070

**B: Cooling Bar Temperature**

- \(46^\circ F\): Mean = 7.375 g/in
- \(64^\circ F\): Mean = 7.925 g/in
- Difference in means = 0.55
  - \(t = \frac{0.55}{0.2646} = 2.08\)
  - P-value = 0.1292

**C: % Polyethylene**

- \(0.5\%\): Mean = 6.875 g/in
- \(1.7\%\): Mean = 8.425 g/in
- Difference in means = 1.55
  - \(t = \frac{1.55}{0.2646} = 5.86\)
  - P-value = 0.0099

**Comment**

- If we test at a significance level of 1%, then A: Seal Temperature and C: % Polyethylene are statistically significant because their P-values are less than 0.01.

**Interactions?**

- None of the interactions turn out to be statistically significant at the 1% level.
The easiest way to get JMP to analyze this type of data is to use coded factor levels.

- Low level: –1
- High level: +1

**JMP Data Table**

<table>
<thead>
<tr>
<th>XA</th>
<th>XB</th>
<th>XC</th>
<th>Strength</th>
<th>Center</th>
</tr>
</thead>
<tbody>
<tr>
<td>–1</td>
<td>–1</td>
<td>–1</td>
<td>6.6</td>
<td>0</td>
</tr>
<tr>
<td>+1</td>
<td>–1</td>
<td>–1</td>
<td>6.9</td>
<td>0</td>
</tr>
<tr>
<td>–1</td>
<td>+1</td>
<td>–1</td>
<td>7.9</td>
<td>0</td>
</tr>
<tr>
<td>+1</td>
<td>+1</td>
<td>–1</td>
<td>6.1</td>
<td>0</td>
</tr>
<tr>
<td>0</td>
<td>0</td>
<td>0</td>
<td>9.9</td>
<td>1</td>
</tr>
</tbody>
</table>

**Fit Model**

- Y: Strength
- Highlight XA, XB, XC; Macros – Full Factorial.
- Add Center

**Analysis of Variance**

<table>
<thead>
<tr>
<th>Source</th>
<th>df</th>
<th>SS</th>
<th>MS</th>
<th>F</th>
</tr>
</thead>
<tbody>
<tr>
<td>Treatment</td>
<td>7</td>
<td>14.94</td>
<td>2.13</td>
<td>15.24</td>
</tr>
<tr>
<td>Center</td>
<td>1</td>
<td>13.50</td>
<td>13.50</td>
<td>96.43</td>
</tr>
<tr>
<td>Error</td>
<td>3</td>
<td>0.42</td>
<td>0.14</td>
<td></td>
</tr>
<tr>
<td>C. Total</td>
<td>11</td>
<td>28.86</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Significant Effects?**

- A: Seal Temperature
  - F = 43.75, P-value = 0.0070
- C: % Polyethylene
  - F = 34.32, P-value = 0.0032
- AC Interaction
  - F = 14.32, P-value = 0.0325
Lecture 39: Analysis using Center Points

Parameter Estimates

* Intercept: 7.65
* XA: –0.875
* XC: +0.775
* XA*XC: –0.500

Prediction Equation

* Predicted Strength = 7.65 – 0.875*XA + 0.775*XC – 0.500*XA*XC

Comment

* The prediction equation will give you reasonable predictions for the treatment combinations.

Curvature?

* Comparing the Intercept (the mean for the treatment combinations) to the mean at the center points can tell you something about a curved relationship between the factors and the response.

Test for Curvature

\[
t = \frac{(\bar{Y}_F - \bar{Y}_C)}{\sqrt{MS_{Error} \left[ \frac{1}{n_F} + \frac{1}{n_C} \right]}}
\]

(7.65 – 9.90) = \frac{-2.25}{0.2291} = -9.82

Test for Curvature

* \(t = -9.82\), P-value = 0.0022
* The small P-value indicates that there is statistically significant curvature between one of the factors and response.