Full Factorial Design with Zero–point Information

GOAL: Optimize the bonding process for an assembly by using JMP IN software to design, analyze, and interpret a full factorial experiment with zero-point information. Generate a model equation using the significant factors and interactions as input.

Objective: To test the hypothesis that tensile strength of the bond is a function of resin, percent input, die gap and neck height.

Introduction: We will use the designed two level full factorial experiment from Lab 4 and add zero-point information. The response of interest is the tensile strength of a bond between two parts for an assembly. The input factors that will be investigated are percent input of material used, die gap during bonding, and neck height on part.

The model equation will be of the form:

\[ Y = C_0 + C_1 X_1 + C_2 X_2 + C_3 X_1 X_2 + C_4 X_3 + \ldots \]

The constant term \( C_0 \) is the overall average of all the response data from the experiment. For a 2-level design the coefficients (\( C_1, C_2, C_3, C_4, \ldots \)) are the half-effects of each significant factor or interaction when the model equation is “design unit based” where the factors are set to –1 or 1. Only significant components go into the model equation. The coefficient is zero for non-significant components.

In Lab4 the full factorial design did not include any zero-point information or a response with the factors at their mid-level settings. Zero-point information results in a more accurate predictor equation and can be used to generate the initial estimator for residual.

The experimental space of interest is:
- Resin material – current or test
- Percent input – 15 to 35 in %
- Die gap – 0.120 to 0.160 in millimeters
- Neck height – 20.0 to 40.0 in micrometers

The tensile strength in MPa for each of the experimental runs will be entered into the DOE table and evaluated.

Procedure:

Start up JMP IN.
The following is a table of the responses for the experimental settings (in design units) given:

<table>
<thead>
<tr>
<th>Neck</th>
<th>Die</th>
<th>Per</th>
<th>Resin</th>
<th>Tensile Strength (MPa)</th>
</tr>
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<td>-1</td>
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<td>-1</td>
<td>-1</td>
<td>6.2</td>
</tr>
<tr>
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<td>1</td>
<td>-1</td>
<td>5.4</td>
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<td>1</td>
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<td>0</td>
<td>-1</td>
<td>6.0</td>
</tr>
</tbody>
</table>

Enter the responses into your DOE table. **NOTE: The design units must match to the response.** Or you will have problems with the analysis and conclusions.

Save your new DOE table.

Select Analyze, Fit Model. The Model Specification will open for your DOE. The default for Model Effects is the single effects and two effect interactions. Add the three effect interactions.

The four effect interaction is very unlikely to be statistically significant. It and the zero-point information will be used to calculate the estimator of residual.

Now Run Model. Review the analysis information. Is the model statistically significant? Use an alpha = 0.05. Discuss with class.

Remove the effects and/or interactions that are not significant.

Now Run Model. Review the analysis information and include this in report. Is the model statistically significant? Use an alpha = 0.05.
Note: The resin input factor is not significant. Thus the experimental model uses all the data for analysis and treats the runs for each setting of resin as replicates. Discuss this with the class.

Review the Parameter Estimates. These are the half-effects for each component and are the coefficients to use for the model equation. Note that the leverage plots use these half-effects. Does there appear to be any non-linear behavior of the response?

Write out the model equation in design unit space.

Write out the model equation in physical space (actual units input for the process.)

Include comments on Lack of Fit.

What input values will give an optimum process? What is the predicted output at those settings?

The Report for the LAB Full Factorial and this lab can be submitted as one report.

The Report should contain all of the sections as per the guidelines. Be sure to include a cover page, Goal and Objective statements for the experiment, Explanation and assumptions for the Design Of Experiment used, analysis of data, discussion of results (include the model equations) and Conclusions.