**APPENDIX A**

This Appendix provides the layout for the Design of Experiment and its related output that was conducted in Minitab 8 statistical software analysis.

Factorial Regression: G1C versus Offset, Exp-time, Ar-Flow, CenterPt

Stepwise Selection of Terms

Candidate terms: Offset, Exp-time, Ar-Flow, Offset\*Exp-time, Offset\*Ar-Flow,  
     Exp-time\*Ar-Flow, Offset\*Exp-time\*Ar-Flow, Ct Pt

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  | -----Step 1---- | | -----Step 2---- | | -----Step 3---- | |
|  | Coef | P | Coef | P | Coef | P |
| Constant | 13.684 |  | 13.684 |  | 13.684 |  |
| Exp-time | 1.589 | 0.031 | 1.589 | 0.024 | 1.589 | 0.015 |
| Ar-Flow |  |  | 0.206 | 0.757 | 0.206 | 0.736 |
| Exp-time\*Ar-Flow |  |  | -1.453 | 0.037 | -1.453 | 0.024 |
| Offset |  |  |  |  | -1.393 | 0.030 |
|  |  |  |  |  |  |  |
| S |  | 3.40245 |  | 3.21485 |  | 2.94774 |
| R-sq |  | 17.32% |  | 32.09% |  | 45.39% |
| R-sq(adj) |  | 14.01% |  | 23.23% |  | 35.46% |
| R-sq(pred) |  | 3.44% |  | 6.24% |  | 18.13% |
| Mallows’ Cp |  | 8.90 |  | 7.20 |  | 4.07 |

*α to enter = 0.05, α to remove = 0.05  
The stepwise procedure added terms during the procedure in order to maintain a hierarchical  
     model at each step.*

Analysis of Variance

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Source | DF | Adj SS | Adj MS | F-Value | P-Value |
| Model | 4 | 158.871 | 39.718 | 4.57 | 0.008 |
| Linear | 3 | 108.179 | 36.060 | 4.15 | 0.018 |
| Offset | 1 | 46.548 | 46.548 | 5.36 | 0.030 |
| Exp-time | 1 | 60.617 | 60.617 | 6.98 | 0.015 |
| Ar-Flow | 1 | 1.014 | 1.014 | 0.12 | 0.736 |
| 2-Way Interactions | 1 | 50.692 | 50.692 | 5.83 | 0.024 |
| Exp-time\*Ar-Flow | 1 | 50.692 | 50.692 | 5.83 | 0.024 |
| Error | 22 | 191.162 | 8.689 |  |  |
| Curvature | 1 | 6.039 | 6.039 | 0.69 | 0.417 |
| Lack-of-Fit | 3 | 21.800 | 7.267 | 0.80 | 0.510 |
| Pure Error | 18 | 163.323 | 9.074 |  |  |
| Total | 26 | 350.034 |  |  |  |

Model Summary

|  |  |  |  |
| --- | --- | --- | --- |
| S | R-sq | R-sq(adj) | R-sq(pred) |
| 2.94774 | 45.39% | 35.46% | 18.13% |

Coded Coefficients

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Term | Effect | Coef | SE Coef | T-Value | P-Value | VIF |
| Constant |  | 13.684 | 0.567 | 24.12 | 0.000 |  |
| Offset | -2.785 | -1.393 | 0.602 | -2.31 | 0.030 | 1.00 |
| Exp-time | 3.179 | 1.589 | 0.602 | 2.64 | 0.015 | 1.00 |
| Ar-Flow | 0.411 | 0.206 | 0.602 | 0.34 | 0.736 | 1.00 |
| Exp-time\*Ar-Flow | -2.907 | -1.453 | 0.602 | -2.42 | 0.024 | 1.00 |

Regression Equation in Uncoded Units

|  |  |  |
| --- | --- | --- |
| G1C | = | 13.58 - 0.928 Offset + 0.1571 Exp-time + 0.1242 Ar-Flow - 0.00433 Exp-time\*Ar-Flow |

Alias Structure

|  |  |
| --- | --- |
| Factor | Name |
| A | Offset |
| B | Exp-time |
| C | Ar-Flow |

|  |
| --- |
| Aliases |
| I |
| A |
| B |
| C |
| BC |

Fits and Diagnostics for Unusual Observations

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Obs | G1C | Fit | Resid | Std Resid |  |
| 15 | 20.837 | 15.418 | 5.419 | 2.06 | R |

*R  Large residual*



Figure A-1: Normal probability plot of all the factors and its significance



Figure A-3: Pareto chart distribution of all the factors with significance level of 5%



Figure A-4: Residual plots for all the observations

Response Optimization: G1C

Parameters

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Response | Goal | Lower | Target | Upper | Weight | Importance |
| G1C | Maximum | 8.042 | 22 |  | 1 | 1 |

Solution

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Solution | Offset | Exp-time | Ar-Flow | G1C Fit | Composite Desirability |
| 1 | 3 | 50 | 8 | 17.9135 | 0.707226 |

Multiple Response Prediction

|  |  |
| --- | --- |
| Variable | Setting |
| Offset | 3 |
| Exp-time | 50 |
| Ar-Flow | 8 |

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Response | Fit | SE Fit | 95% CI | 95% PI |
| G1C | 17.91 | 1.33 | (15.15, 20.67) | (11.21, 24.62) |



Figure A-5: Maximum ILSS and its related settings