**SCM 517 – HW #4**

Q1) A process engineer is trying to improve the life of a cutting tool. He ran a 23 experiment using cutting speed (*A*), metal hardness (*B*), and cutting angle (*C*) as the factors. The data from two replicates are shown in Table below:

|  |  |  |
| --- | --- | --- |
| Run | Replicate | |
| I | II |
| (1) | 221 | 311 |
| *a* | 325 | 435 |
| *b* | 354 | 348 |
| *ab* | 552 | 472 |
| *c* | 440 | 453 |
| *ac* | 406 | 377 |
| *bc* | 605 | 500 |
| *abc* | 392 | 419 |

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| StdOrder | RunOrder | CenterPt | Blocks | A | B | C | Results |
| 2 | 1 | 1 | 1 | 1 | -1 | -1 | 325 |
| 15 | 2 | 1 | 1 | -1 | 1 | 1 | 605 |
| 3 | 3 | 1 | 1 | -1 | 1 | -1 | 354 |
| 10 | 4 | 1 | 1 | 1 | -1 | -1 | 435 |
| 16 | 5 | 1 | 1 | 1 | 1 | 1 | 392 |
| 11 | 6 | 1 | 1 | -1 | 1 | -1 | 348 |
| 14 | 7 | 1 | 1 | 1 | -1 | 1 | 406 |
| 1 | 8 | 1 | 1 | -1 | -1 | -1 | 221 |
| 9 | 9 | 1 | 1 | -1 | -1 | -1 | 311 |
| 13 | 10 | 1 | 1 | -1 | -1 | 1 | 440 |
| 8 | 11 | 1 | 1 | 1 | 1 | 1 | 419 |
| 6 | 12 | 1 | 1 | 1 | -1 | 1 | 377 |
| 12 | 13 | 1 | 1 | 1 | 1 | -1 | 552 |
| 5 | 14 | 1 | 1 | -1 | -1 | 1 | 440 |
| 7 | 15 | 1 | 1 | -1 | 1 | 1 | 500 |
| 4 | 16 | 1 | 1 | 1 | 1 | -1 | 472 |

1. Do any of the three factors affect tool life?

* Yes b(metal hardness) and c(cutting angle) will affect tool life since p-value of b and c are less than 0.05.

1. What combination of factor levels produces the longest tool life?

|  |  |
| --- | --- |
| a(cutting speed) | -1 |
| b (metal hardness) | 1 |
| c(cutting angle) | 1 |

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A graph of a graph of a line

Description automatically generated with medium confidence

A graph with blue dots and lines

Description automatically generated

From the above graph we can say that to get the longest tool life the best combination is when we have metal hardness(B) and cutting angles high(C) and low cutting speed(A)

1. Is there a combination of cutting speed and cutting angle that always gives good results regardless of metal hardness?

* A screenshot of a graph

  Description automatically generated

From the above analysis we can say combination of cutting speed and cutting angle will give the good result regardless of metal hardness because metal hardness does not have the significant effect on our model since p value for a and c is 0.001.

Q2) Four factors are thought to possibly influence the taste of a soft-drink beverage: type of sweetener (*A*), ratio of syrup to water (*B*), carbonation level (*C*), and temperature (*D*). Each factor can be run at two levels, producing a 24 design. At each run in the design, samples of the beverage are given to a test panel consisting of 20 people. Each tester assigns a point score from 1 to 10 to the beverage. Total score is the response variable, and the objective is to find a formulation that maximized total score. Two replicates of this design are run, and the results are shown in Table below. Analyze the data and draw conclusions.

|  |  |  |
| --- | --- | --- |
| Treatment  Combination | Replicate | |
| I | II |
| (1) | 188 | 195 |
| *a* | 172 | 180 |
| *b* | 179 | 187 |
| *ab* | 185 | 178 |
| *c* | 175 | 180 |
| *ac* | 183 | 178 |
| *bc* | 190 | 180 |
| *abc* | 175 | 168 |
| *d* | 200 | 193 |
| *ad* | 170 | 178 |
| *bd* | 189 | 181 |
| *abd* | 183 | 188 |
| *cd* | 201 | 188 |
| *acd* | 181 | 173 |
| *bcd* | 189 | 182 |
| *abcd* | 178 | 182 |

-A screenshot of a computer

Description automatically generated

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **A** | **B** | **C** | **D** | **Result** |
| -1 | 1 | -1 | 1 | 181 |
| -1 | 1 | -1 | -1 | 179 |
| 1 | -1 | 1 | 1 | 181 |
| -1 | -1 | 1 | -1 | 175 |
| 1 | 1 | -1 | -1 | 185 |
| -1 | 1 | 1 | -1 | 190 |
| 1 | -1 | 1 | -1 | 183 |
| 1 | 1 | 1 | 1 | 178 |
| 1 | 1 | 1 | -1 | 175 |
| 1 | -1 | -1 | -1 | 172 |
| -1 | 1 | -1 | -1 | 187 |
| 1 | -1 | 1 | 1 | 173 |
| -1 | 1 | 1 | 1 | 189 |
| -1 | -1 | -1 | -1 | 188 |
| -1 | -1 | -1 | -1 | 195 |
| -1 | 1 | 1 | 1 | 182 |
| -1 | 1 | -1 | 1 | 189 |
| -1 | -1 | 1 | 1 | 188 |
| 1 | 1 | 1 | -1 | 168 |
| 1 | 1 | -1 | -1 | 178 |
| 1 | 1 | 1 | 1 | 182 |
| 1 | 1 | -1 | 1 | 188 |
| -1 | 1 | 1 | -1 | 180 |
| -1 | -1 | 1 | 1 | 201 |
| 1 | 1 | -1 | 1 | 183 |
| 1 | -1 | -1 | 1 | 178 |
| -1 | -1 | 1 | -1 | 180 |
| -1 | -1 | -1 | 1 | 200 |
| 1 | -1 | -1 | 1 | 170 |
| -1 | -1 | -1 | 1 | 193 |
| 1 | -1 | -1 | -1 | 180 |
| 1 | -1 | 1 | -1 | 178 |

* For the value d as high and a , b and c as low we will get the optimized maximum result for the total score.

Q3) An engineer has performed an experiment to study the effect of four factors on the surface roughness of a machined part. The factors (and their levels) are *A* = tool angle (12, 15), *B* = cutting fluid viscosity (300, 400), *C* = feed rate (10, 15 in/min), and *D* = cutting fluid cooler used (no, yes). The data from this experiment (with the factors coded to the usual +1, -1 levels) are shown in Table below:

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Run | *A* | *B* | *C* | *D* | Surface  Roughness |
| 1 | - | - | - | - | 0.00340 |
| 2 | + | - | - | - | 0.00362 |
| 3 | - | + | - | - | 0.00301 |
| 4 | + | + | - | - | 0.00182 |
| 5 | - | - | + | - | 0.00280 |
| 6 | + | - | + | - | 0.00290 |
| 7 | - | + | + | - | 0.00252 |
| 8 | + | + | + | - | 0.00160 |
| 9 | - | - | - | + | 0.00336 |
| 10 | + | - | - | + | 0.00344 |
| 11 | - | + | - | + | 0.00308 |
| 12 | + | + | - | + | 0.00184 |
| 13 | - | - | + | + | 0.00269 |
| 14 | + | - | + | + | 0.00284 |
| 15 | - | + | + | + | 0.00253 |
| 16 | + | + | + | + | 0.00163 |

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Run** | ***A*** | ***B*** | ***C*** | ***D*** | **SR** |
|  |  |  |  |  |  |
| 1 | -1 | -1 | -1 | -1 | 0.0034 |
| 2 | 1 | -1 | -1 | -1 | 0.00362 |
| 3 | -1 | 1 | -1 | -1 | 0.00301 |
| 4 | 1 | 1 | -1 | -1 | 0.00182 |
| 5 | -1 | -1 | 1 | -1 | 0.0028 |
| 6 | 1 | -1 | 1 | -1 | 0.0029 |
| 7 | -1 | 1 | 1 | -1 | 0.00252 |
| 8 | 1 | 1 | 1 | -1 | 0.0016 |
| 9 | -1 | -1 | -1 | 1 | 0.00336 |
| 10 | 1 | -1 | -1 | 1 | 0.00344 |
| 11 | -1 | 1 | -1 | 1 | 0.00308 |
| 12 | 1 | 1 | -1 | 1 | 0.00184 |
| 13 | -1 | -1 | 1 | 1 | 0.00269 |
| 14 | 1 | -1 | 1 | 1 | 0.00284 |
| 15 | -1 | 1 | 1 | 1 | 0.00253 |
| 16 | 1 | 1 | 1 | 1 | 0.00163 |

1. Estimate the factor effects. Plot the effect estimates on a normal probability plot and select a tentative model. You can assume that the high order interaction (4way) is negligible and use it towards the estimation of error – The Sparsity of effect principle

* A graph with red and blue dots

  Description automatically generated
* Factors A , B , C and AB will affect the model significantly.

1. Fit the model identified in part (a) and analyze the residuals. Is there any indication of model inadequacy?

* A graph of residual plots for surface

  Description automatically generated
* From the above graph we can say that residuals are not normally distributed which is inadequacy, to get the accurate final model.