* represent temperature:
* represent pressure:
* represent reaction time:

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Test(m) | x1 | x2 | x3 | y1 | y2 | y3 | average |  |
| 1 | -1 | -1 | -1 | 61.43 | 58.58 | 57.07 | 59.02667 | 4.902033333 |
| 2 | 1 | -1 | -1 | 75.62 | 77.57 | 75.75 | 76.31333 | 1.188633333 |
| 3 | -1 | 1 | -1 | 27.51 | 34.03 | 25.07 | 28.87 | 21.4576 |
| 4 | 1 | 1 | -1 | 51.37 | 48.49 | 54.37 | 51.41 | 8.6448 |
| 5 | -1 | -1 | 1 | 24.8 | 20.69 | 15.41 | 20.3 | 22.1571 |
| 6 | 1 | -1 | 1 | 43.58 | 44.31 | 36.99 | 41.62667 | 16.25723333 |
| 7 | -1 | 1 | 1 | 45.2 | 49.53 | 50.29 | 48.34 | 7.5391 |
| 8 | 1 | 1 | 1 | 70.51 | 74 | 74.68 | 73.06333 | 5.005233333 |

Main effects and interaction effects:

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| E1 | E2 | E3 | E12 | E23 | E13 | E123 |
| 21.46917 | 1.104167 | -8.0725 | 2.1625 | 28.63417 | 1.555833 | -0.46417 |

Assuming all effects are null effect:

Degree of freedom for t-test:

|  |  |  |  |
| --- | --- | --- | --- |
|  |  | t\_16,0.005 | t\_16,0.995 |
| t\_E1 | 15.93300864 | -2.920781622 | 2.920781622 |
| t\_E2 | 0.819440145 | -2.920781622 | 2.920781622 |
| t\_E3 | -5.990880514 | -2.920781622 | 2.920781622 |
| t\_E12 | 1.604865793 | -2.920781622 | 2.920781622 |
| t\_E23 | 21.25040212 | -2.920781622 | 2.920781622 |
| t\_E13 | 1.154637547 | -2.920781622 | 2.920781622 |
| t\_E123 | -0.344474083 | -2.920781622 | 2.920781622 |

Only reject



Assuming effects are normal distribution:

* Rank each effect from 1~7
* The c.d.f. of effect is:
* The normal distribution value of effect:

|  |  |  |  |
| --- | --- | --- | --- |
|  |  | percentile | norm.inv |
| E1 | 21.46916667 | 78.57142857 | 1.066705077 |
| E2 | 1.104166667 | 35.71428571 | -0.493315391 |
| E3 | -8.0725 | 7.142857143 | -1.974350809 |
| E12 | 2.1625 | 64.28571429 | 0.493315391 |
| E23 | 28.63416667 | 92.85714286 | 1.974350809 |
| E13 | 1.555833333 | 50 | 0 |
| E123 | -0.464166667 | 21.42857143 | -1.066705077 |



The significant effects are:



Assuming coefficients are null effect and t-distributed with .

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| b | coefficient | - | + | H\_0 |
| b0 | 49.86875 | 47.90092 | 51.83658 | reject |
| b1 | 10.73458333 | 8.766758 | 12.70241 | reject |
| b2 | 0.552083333 | -1.41574 | 2.519908 | accept |
| b3 | -4.03625 | -6.00408 | -2.06842 | reject |
| b12 | 1.08125 | -0.88658 | 3.049075 | accept |
| b23 | 14.31708333 | 12.34926 | 16.28491 | reject |
| b13 | 0.777916667 | -1.18991 | 2.745742 | accept |
| b123 | -0.232083333 | -2.19991 | 1.735742 | accept |



|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 摘要輸出 | |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |
| 迴歸統計 | |  |  |  |  |  |  |  |
| R 的倍數 | 0.989446032 |  |  |  |  |  |  |  |
| R 平方 | 0.979003449 |  |  |  |  |  |  |  |
| 調整的 R 平方 | 0.969817459 |  |  |  |  |  |  |  |
|  | 標準誤(s\_p) | 3.300601 |  |  |  |  |  |  |
|  | 觀察值個數 | 24 |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |
| ANOVA |  |  |  |  |  |  |  |  |
|  | 自由度 | SS | MS | F | 顯著值 |  |  |  |
| 迴歸 | 7 | 8127.225 | 1161.032 | 106.5757 | 3.2E-12 |  |  |  |
| 殘差 | 16 | 174.3035 | 10.89397 |  |  |  |  |  |
| 總和 | 23 | 8301.529 |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |
|  | 係數 | 標準誤 | t 統計 | P-值 | 下限 95% | 上限 95% | 下限 99.0% | 上限 99.0% |
| 截距 | 49.86875 | 0.673732 | 74.01864 | 1.02E-21 | 48.4405 | 51.297 | 47.90092 | 51.83658 |
| x1 | 10.73458333 | 0.673732 | 15.93301 | 3.08E-11 | 9.306335 | 12.16283 | 8.766758 | 12.70241 |
| x2 | 0.552083333 | 0.673732 | 0.81944 | 0.424574 | -0.87617 | 1.980332 | -1.41574 | 2.519908 |
| x3 | -4.03625 | 0.673732 | -5.99088 | 1.88E-05 | -5.4645 | -2.608 | -6.00408 | -2.06842 |
| x1x2 | 1.08125 | 0.673732 | 1.604866 | 0.128077 | -0.347 | 2.509499 | -0.88658 | 3.049075 |
| x2x3 | 14.31708333 | 0.673732 | 21.2504 | 3.75E-13 | 12.88883 | 15.74533 | 12.34926 | 16.28491 |
| x1x3 | 0.777916667 | 0.673732 | 1.154638 | 0.265193 | -0.65033 | 2.206165 | -1.18991 | 2.745742 |
| x1x2x3 | -0.232083333 | 0.673732 | -0.34447 | 0.734976 | -1.66033 | 1.196165 | -2.19991 | 1.735742 |



(100-yield) is a smaller-the-better performance measure. The SN ratio will be:

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| test | x1 | x2 | x3 | y1 | y2 | y3 | SN |
| 1 | -1 | -1 | -1 | 61.43 | 58.58 | 57.07 | -32.2585 |
| 2 | 1 | -1 | -1 | 75.62 | 77.57 | 75.75 | -27.4962 |
| 3 | -1 | 1 | -1 | 27.51 | 34.03 | 25.07 | -37.0533 |
| 4 | 1 | 1 | -1 | 51.37 | 48.49 | 54.37 | -33.7415 |
| 5 | -1 | -1 | 1 | 24.8 | 20.69 | 15.41 | -38.0393 |
| 6 | 1 | -1 | 1 | 43.58 | 44.31 | 36.99 | -35.3381 |
| 7 | -1 | 1 | 1 | 45.2 | 49.53 | 50.29 | -34.2713 |
| 8 | 1 | 1 | 1 | 70.51 | 74 | 74.68 | -28.6268 |



Main effects and interaction effects:

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| E1 | E2 | E3 | E12 | E23 | E13 | E123 |
| 4.104921 | -0.14022 | -1.43147 | 0.373203 | 5.379859 | 0.067893 | 1.098439 |

Assuming all effects are null effects, and estimated standard error by the lowest three effects.

The lowest three effects are:

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  |  |  |  |  |  |  |
| 17.58073 | -0.60055 | -6.13076 | 1.59837 | 23.04109 | 0.290776 | 4.704441 |

Only reject



Assuming effects are normal distribution:

* Rank each effect from 1~7
* The c.d.f. of effect is:
* The normal distribution value of effect:

|  |  |  |  |
| --- | --- | --- | --- |
|  | effect | percentile | norm.inv |
| E1 | 4.104921 | 78.57143 | 0.18484 |
| E2 | -0.14022 | 21.42857 | -0.18484 |
| E3 | -1.43147 | 7.142857 | -0.34212 |
| E12 | 0.373203 | 50 | 0 |
| E23 | 5.379859 | 92.85714 | 0.342117 |
| E13 | 0.067893 | 35.71429 | -0.08548 |
| E123 | 1.098439 | 64.28571 | 0.085482 |



The significant effects are:



There are two objective functions:

“Solver Options” in Excel can be used to find the optimal values in those functions:

|  |  |  |  |
| --- | --- | --- | --- |
| x1 | x2 | x3 |  |
| 1 | -1 | -1 | 78.95667 |

|  |  |  |  |
| --- | --- | --- | --- |
| x1 | x2 | x3 |  |
| 1 | -1 | -1 | -27.895 |

Both of the result show that (x\_1,x\_2,x\_3 )=(1,-1,-1) can achieve the highest and stable yield. This is similar to the result in HW#11 3(h).



* represent RH cowl fore/aft movement:
* represent Center brace attachment sequence:

* represent Plenum gasket:
* represent Evaporator case setup, fore/aft:
* Experiment results under the same conditions should be similar to each other. This indicates the better performance in parallelism. Therefore, the SN ratio will be: =

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| test | x1 | x2 | x3 | x4 | Run1 | Run2 | mean | var | SN |
| 1 | -1 | -1 | -1 | -1 | -1.44 | -0.08 | -0.76 | 0.9248 | -2.04421 |
| 2 | 1 | -1 | -1 | -1 | -1.79 | -1.01 | -1.4 | 0.3042 | 8.090969 |
| 3 | -1 | 1 | -1 | -1 | 0.39 | 0.17 | 0.28 | 0.0242 | 5.105007 |
| 4 | 1 | 1 | -1 | -1 | -0.5 | -0.24 | -0.37 | 0.0338 | 6.074867 |
| 5 | -1 | -1 | 1 | -1 | -0.2 | 0.17 | -0.015 | 0.06845 | -24.8319 |
| 6 | 1 | -1 | 1 | -1 | -0.79 | -0.64 | -0.715 | 0.01125 | 16.5746 |
| 7 | -1 | 1 | 1 | -1 | 1.22 | 0.28 | 0.75 | 0.4418 | 1.048968 |
| 8 | 1 | 1 | 1 | -1 | 0.21 | 0.28 | 0.245 | 0.00245 | 13.89166 |
| 9 | -1 | -1 | -1 | 1 | -0.4 | -0.65 | -0.525 | 0.03125 | 9.454686 |
| 10 | 1 | -1 | -1 | 1 | -0.63 | -1.19 | -0.91 | 0.1568 | 7.227367 |
| 11 | -1 | 1 | -1 | 1 | 0.47 | 0.44 | 0.455 | 0.00045 | 26.6281 |
| 12 | 1 | 1 | -1 | 1 | -0.01 | -0.03 | -0.02 | 0.0002 | 3.0103 |
| 13 | -1 | -1 | 1 | 1 | 1.29 | 0.64 | 0.965 | 0.21125 | 6.442579 |
| 14 | 1 | -1 | 1 | 1 | -1.17 | 0.14 | -0.515 | 0.85805 | -5.09898 |
| 15 | -1 | 1 | 1 | 1 | 0.48 | 1.06 | 0.77 | 0.1682 | 5.471555 |
| 16 | 1 | 1 | 1 | 1 | 0.4 | 0.34 | 0.37 | 0.0018 | 18.81131 |

Main effects and interaction effects:

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| E1 | E2 | E3 | E4 | E12 | E13 | E14 | E23 |
| 5.163413 | 8.028334 | -3.90466 | 6.004621 | -4.27979 | 8.848435 | -11.1751 | 3.505968 |
| E24 | E34 | E123 | E124 | E134 | E234 | E1234 |
| 0.94557 | -1.26883 | 3.359163 | 5.152495 | -1.93761 | -1.01024 | 8.208787 |



Assuming all effects are null effects:



Assuming the main effects and second order interaction effects are null effects:

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| effects | E1 | E2 | E3 | E4 | E12 | E13 | E14 | E23 | E24 | E34 |
|  | 5.163413 | 8.028334 | -3.90466 | 6.004621 | -4.27979 | 8.848435 | -11.1751 | 3.505968 | 0.94557 | -1.26883 |
| t-test | 1.100887 | 1.711715 | -0.83251 | 1.28024 | -0.91249 | 1.886568 | -2.38264 | 0.747505 | 0.201604 | -0.27053 |
| p-value | 0.321099 | 0.14763 | 0.443055 | 0.256636 | 0.403363 | 0.117878 | 0.062958 | 0.488402 | 0.848172 | 0.797567 |

All of the p-value of main or second order interaction effects are bigger than α=0.01. The result show that there isn’t any statistically significant effect on the SN ratio.



Assuming the main and two-factor interaction effects are normal distribution:

* Rank each effect from 1~10
* The c.d.f. of effect is:
* The normal distribution value of effect:

|  |  |  |  |
| --- | --- | --- | --- |
|  |  | percentile | norm.inv |
| E1 | 5.163413 | 65 | 1.807241 |
| E2 | 8.028334 | 85 | 4.86111 |
| E3 | -3.90466 | 25 | -3.16351 |
| E4 | 6.004621 | 75 | 3.163512 |
| E12 | -4.27979 | 15 | -4.86111 |
| E13 | 8.848435 | 95 | 7.714741 |
| E14 | -11.1751 | 5 | -7.71474 |
| E23 | 3.505968 | 55 | 0.589381 |
| E24 | 0.94557 | 45 | -0.58938 |
| E34 | -1.26883 | 35 | -1.80724 |



Since the plot of 99% confidence intervals for all effects suggest that there isn’t any statistically significant effect, the 90% confidence intervals of main effects and interaction effects were plotted.

The results show that E14 rejects H\_0, indicating it has a significant effect on parallelism. Additionally, the confidence intervals for E2, E13, and E1234 are marginally close to the rejection region. Therefore, these effects are also considered significant.

The regression model for SN ratio:



There are two objective functions:

“Solver Options” in Excel can be used to find the optimal values in those functions:

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| x1 | x2 | x3 | x4 |  |
| -1 | 1 | -1 | 1 | 24.1214 |