* 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:
* The objective of the experiment is to achieve parallelism equal to 0. Therefore, the SN ratio will be:

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| test | X1 | X2 | x3 | x4 | Run1 | Run2 | SN |
| 1 | -1 | -1 | -1 | -1 | -1.44 | -0.08 | -0.17033 |
| 2 | 1 | -1 | -1 | -1 | -1.79 | -1.01 | -3.24714 |
| 3 | -1 | 1 | -1 | -1 | 0.39 | 0.17 | 10.43351 |
| 4 | 1 | 1 | -1 | -1 | -0.5 | -0.24 | 8.130437 |
| 5 | -1 | -1 | 1 | -1 | -0.2 | 0.17 | 14.62811 |
| 6 | 1 | -1 | 1 | -1 | -0.79 | -0.64 | 2.866355 |
| 7 | -1 | 1 | 1 | -1 | 1.22 | 0.28 | 1.060164 |
| 8 | 1 | 1 | 1 | -1 | 0.21 | 0.28 | 12.12894 |
| 9 | -1 | -1 | -1 | 1 | -0.4 | -0.65 | 5.357341 |
| 10 | 1 | -1 | -1 | 1 | -0.63 | -1.19 | 0.426322 |
| 11 | -1 | 1 | -1 | 1 | 0.47 | 0.44 | 6.835055 |
| 12 | 1 | 1 | -1 | 1 | -0.01 | -0.03 | 33.0103 |
| 13 | -1 | -1 | 1 | 1 | 1.29 | 0.64 | -0.15716 |
| 14 | 1 | -1 | 1 | 1 | -1.17 | 0.14 | 1.584841 |
| 15 | -1 | 1 | 1 | 1 | 0.48 | 1.06 | 1.694113 |
| 16 | 1 | 1 | 1 | 1 | 0.4 | 0.34 | 8.607508 |

Main effects and interaction effects:

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| E1 | E2 | E3 | E4 | E12 | E13 | E14 | E23 |
| 2.978344 | 7.576463 | -2.29533 | 1.441035 | 7.48524 | -0.98774 | 4.496561 | -6.43432 |
| E24 | E34 | E123 | E124 | E134 | E234 | E1234 |
| 3.157445 | -6.1796 | -0.48476 | 1.584175 | -2.15947 | 0.137379 | -5.99896 |



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 |
|  | 2.978344 | 7.576463 | -2.29533 | 1.441035 | 7.48524 | -0.98774 | 4.496561 | -6.43432 | 3.157445 | -6.1796 |
| t-test | 1.01075 | 2.571196 | -0.77896 | 0.489039 | 2.540238 | -0.33521 | 1.525981 | -2.18359 | 1.071531 | -2.09715 |
| p-value | 0.35852 | 0.049963 | 0.471245 | 0.64551 | 0.051879 | 0.751076 | 0.187537 | 0.080746 | 0.332904 | 0.090079 |

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 | 2.978344 | 55 | 0.370282 |
| E2 | 7.576463 | 95 | 4.846838 |
| E3 | -2.29533 | 25 | -1.9875 |
| E4 | 1.441035 | 45 | -0.37028 |
| E12 | 7.48524 | 85 | 3.054025 |
| E13 | -0.98774 | 35 | -1.13541 |
| E14 | 4.496561 | 75 | 1.987498 |
| E23 | -6.43432 | 5 | -4.84684 |
| E24 | 3.157445 | 65 | 1.135412 |
| E34 | -6.1796 | 15 | -3.05403 |



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 reject , indicating they have significant effects on parallelism.

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 |  |
| -0.07781 | 0.094459 | 0.07588 | 8.72E-08 |

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

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| x1 | x2 | x3 | x4 |  |
| 1 | 1 | -1 | 1 | 23.28656 |

The result shows that the optimal variables are different. Furthermore, actually, there are infinity solutions in the first objective function if the optimization variables follow the equation:

Where is belong to the first objective function.

Therefore, the first objective function can be written as a restriction in the second objective function.

Excel result:

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| x1 | x2 | x3 | x4 |  |
| 0.030778 | 1 | -0.94004 | 1 | 16.36824 |

The result shows that the optimal variables make door parallelism become zero and maximize the SN ratio.