機械所設計組 R12522615 王邑安 HW\_ID:2

**Introduction to statistical control and optimization**

Homework 10



For reduce defect:

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Surface Defect Data | | | | |
| exp | Top | Center | Bottom | SN |
| 1 | 1 | 0 | 1 | 1.760913 |
| 2 | 1 | 2 | 8 | -13.6173 |
| 3 | 3 | 35 | 106 | -36.1875 |
| 4 | 6 | 15 | 6 | -19.9564 |
| 5 | 1720 | 1980 | 2000 | -65.5946 |
| 6 | 135 | 360 | 1620 | -59.6571 |
| 7 | 360 | 810 | 1215 | -58.7736 |
| 8 | 270 | 2730 | 5000 | -70.3511 |
| 9 | 5000 | 1000 | 1000 | -69.5424 |
| 10 | 3 | 0 | 0 | -4.77121 |
| 11 | 1 | 0 | 1 | 1.760913 |
| 12 | 3 | 1620 | 90 | -59.4325 |
| 13 | 1 | 25 | 270 | -43.8932 |
| 14 | 3 | 21 | 162 | -39.4929 |
| 15 | 450 | 1200 | 1800 | -62.1152 |
| 16 | 5 | 6 | 40 | -27.4325 |
| 17 | 1200 | 3500 | 3500 | -69.3685 |
| 18 | 8000 | 2500 | 3500 | -74.3933 |

For adjusting mean thickness to target value:

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Thickness | | | | | | |
| exp | Top | Center | Bottom | average | standard error | SN |
| 1 | 2029 | 1975 | 1961 | 1988.333 | 35.90728803 | 34.86613 |
| 2 | 5375 | 5191 | 5242 | 5269.333 | 94.99649116 | 34.88096 |
| 3 | 5989 | 5894 | 5874 | 5919 | 61.44102864 | 39.6758 |
| 4 | 2118 | 2109 | 2099 | 2108.667 | 9.504384953 | 46.92168 |
| 5 | 4102 | 4152 | 4174 | 4142.667 | 36.89625094 | 41.00596 |
| 6 | 3022 | 2932 | 2913 | 2955.667 | 58.22656896 | 34.11069 |
| 7 | 3030 | 3042 | 3028 | 3033.333 | 7.571877794 | 52.05433 |
| 8 | 4707 | 4472 | 4336 | 4505 | 187.6885718 | 27.60514 |
| 9 | 3859 | 3822 | 3850 | 3843.667 | 19.29594085 | 45.9856 |
| 10 | 3227 | 3205 | 3242 | 3224.667 | 18.61003314 | 44.77475 |
| 11 | 2521 | 2499 | 2499 | 2506.333 | 12.70170592 | 45.90354 |
| 12 | 5921 | 5766 | 5844 | 5843.667 | 77.50053763 | 37.54761 |
| 13 | 2792 | 2752 | 2716 | 2753.333 | 38.01753981 | 37.1975 |
| 14 | 2863 | 2835 | 2859 | 2852.333 | 15.14375559 | 45.49933 |
| 15 | 3218 | 3149 | 3124 | 3163.667 | 48.68606919 | 36.25572 |
| 16 | 3020 | 3008 | 3016 | 3014.667 | 6.110100927 | 53.86382 |
| 17 | 4277 | 4150 | 3992 | 4139.667 | 142.7807177 | 29.24592 |
| 18 | 3125 | 3119 | 3127 | 3123.667 | 4.163331999 | 57.50447 |



|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  | A | B | C | D | E | F |
| A1 | -18.4144 |  |  |  |  |  |
| A2 | -48.4516 |  |  |  |  |  |
| A3 | -61.6436 |  |  |  |  |  |
| B1 |  | -25.511 |  |  |  |  |
| B2 |  | -42.7772 |  |  |  |  |
| B3 |  | -60.2213 |  |  |  |  |
| C1 |  |  | -36.2434 |  |  |  |
| C2 |  |  | -52.6174 |  |  |  |
| C3 |  |  | -39.6487 |  |  |  |
| D1 |  |  |  | -38.1325 |  |  |
| D2 |  |  |  | -42.1508 |  |  |
| D3 |  |  |  | -48.2262 |  |  |
| E1 |  |  |  |  | -50.1569 |  |
| E2 |  |  |  |  | -36.9623 |  |
| E3 |  |  |  |  | -41.3904 |  |
| F1 |  |  |  |  |  | -45.9108 |
| F2 |  |  |  |  |  | -35.3969 |
| F3 |  |  |  |  |  | -47.2019 |

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  | A | B | C | D | E | F |
| A1 | 39.60813 |  |  |  |  |  |
| A2 | 40.16514 |  |  |  |  |  |
| A3 | 44.37655 |  |  |  |  |  |
| B1 |  | 44.94637 |  |  |  |  |
| B2 |  | 37.35681 |  |  |  |  |
| B3 |  | 41.84665 |  |  |  |  |
| C1 |  |  | 39.8631 |  |  |  |
| C2 |  |  | 43.36514 |  |  |  |
| C3 |  |  | 40.92159 |  |  |  |
| D1 |  |  |  | 44.98975 |  |  |
| D2 |  |  |  | 39.51249 |  |  |
| D3 |  |  |  | 39.64759 |  |  |
| E1 |  |  |  |  | 33.42883 |  |
| E2 |  |  |  |  | 45.9278 |  |
| E3 |  |  |  |  | 44.79319 |  |
| F1 |  |  |  |  |  | 40.33536 |
| F2 |  |  |  |  |  | 41.99035 |
| F3 |  |  |  |  |  | 41.82411 |



|  |  |
| --- | --- |
| Optimal factor | reason |
| A1 | Compromise the thickness but reduce the surface defect dramatically. |
| B1 | Has the best performance on both surface defects and thickness. |
| C1 | Compromise the thickness but reduce the surface defect mostly |
| D1 | Has the best performance on both surface defects and thickness. |
| E2 | Has the best performance on both surface defects and thickness. |
| F2 | Has the best performance on both surface defects and thickness. |



|  |  |  |
| --- | --- | --- |
| starting | | |
| setting | surface defect | thickness |
| A2 | -48.45155873 | 40.16514 |
| B2 | -42.77724028 | 37.35681 |
| C1 | -36.2434415 | 39.8631 |
| D3 | -48.2262285 | 39.64759 |
| E1 | -50.15689951 | 33.42883 |
| F1 | -45.91075026 | 40.33536 |
| overal mean | -42.83651755 | 41.38327 |
|  | -57.58353102 | 23.88045 |

|  |  |  |
| --- | --- | --- |
| optimal | | |
| setting | surface defect | thickness |
| A1 | -18.41443397 | 39.60813 |
| B1 | -25.51098367 | 44.94637 |
| C1 | -36.2434415 | 39.8631 |
| D1 | -38.13251124 | 44.98975 |
| E2 | -36.96225315 | 45.9278 |
| F2 | -35.39692395 | 41.99035 |
| overal mean | -42.83651755 | 41.38327 |
|  | 23.52204029 | 50.40912 |



For reduce defect:

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Surface Defect Data | | | | |
| exp | Top | Center | Bottom | SN |
| 1 | 1 | 1 | 0 | 1.760913 |
| 2 | 126 | 3 | 1 | -37.2389 |
| 3 | 315 | 50 | 180 | -46.5039 |
| 4 | 15 | 40 | 18 | -28.5512 |
| 5 | 2020 | 360 | 13 | -61.4718 |
| 6 | 2500 | 270 | 35 | -63.2388 |
| 7 | 1800 | 720 | 315 | -61.092 |
| 8 | 9999 | 225 | 1 | -75.2301 |
| 9 | 3000 | 2800 | 2000 | -68.4178 |
| 10 | 1 | 0 | 1 | 1.760913 |
| 11 | 1 | 0 | 1 | 1.760913 |
| 12 | 270 | 8 | 3 | -43.8604 |
| 13 | 225 | 3 | 0 | -42.2732 |
| 14 | 63 | 15 | 39 | -32.7989 |
| 15 | 1890 | 180 | 25 | -60.798 |
| 16 | 14 | 1 | 1 | -18.1954 |
| 17 | 9999 | 600 | 8 | -75.2435 |
| 18 | 5000 | 2000 | 2000 | -70.4139 |

For adjusting mean thickness to target value:

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Thickness | | | | | | |
| exp | Top | Center | Bottom | average | standard error | SN |
| 1 | 1952 | 1941 | 1949 | 1947.333 | 5.686241 | 50.6923 |
| 2 | 5323 | 5307 | 5091 | 5240.333 | 129.5737 | 32.13684 |
| 3 | 6077 | 5943 | 5962 | 5994 | 72.50517 | 38.34696 |
| 4 | 2149 | 2130 | 2111 | 2130 | 19 | 40.99252 |
| 5 | 5031 | 5040 | 5032 | 5034.333 | 4.932883 | 60.17682 |
| 6 | 2934 | 2875 | 2841 | 2883.333 | 47.0567 | 35.74547 |
| 7 | 3709 | 3671 | 3687 | 3689 | 19.07878 | 45.72716 |
| 8 | 5073 | 4898 | 4599 | 4856.667 | 239.688 | 26.13384 |
| 9 | 4110 | 4067 | 4110 | 4095.667 | 24.82606 | 44.34834 |
| 10 | 3599 | 3591 | 3535 | 3575 | 34.87119 | 40.21619 |
| 11 | 2551 | 2552 | 2570 | 2557.667 | 10.69268 | 47.57515 |
| 12 | 5691 | 5777 | 5743 | 5737 | 43.31282 | 42.44137 |
| 13 | 2765 | 2786 | 2773 | 2774.667 | 10.59874 | 48.35913 |
| 14 | 2891 | 2844 | 2841 | 2858.667 | 28.04164 | 40.1672 |
| 15 | 3241 | 3189 | 3197 | 3209 | 28 | 41.18423 |
| 16 | 3235 | 3162 | 3140 | 3179 | 49.72927 | 36.11357 |
| 17 | 4593 | 4298 | 4219 | 4370 | 197.1218 | 26.91494 |
| 18 | 4120 | 4088 | 4138 | 4115.333 | 25.32456 | 44.21726 |

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  | A | B | C | D | E | F |
| A1 | -20.3867 |  |  |  |  |  |
| A2 | -48.1886 |  |  |  |  |  |
| A3 | -61.4321 |  |  |  |  |  |
| B1 |  | -24.4317 |  |  |  |  |
| B2 |  | -46.7037 |  |  |  |  |
| B3 |  | -58.8721 |  |  |  |  |
| C1 |  |  | -38.2481 |  |  |  |
| C2 |  |  | -52.725 |  |  |  |
| C3 |  |  | -39.0344 |  |  |  |
| D1 |  |  |  | -37.337 |  |  |
| D2 |  |  |  | -43.979 |  |  |
| D3 |  |  |  | -48.6915 |  |  |
| E1 |  |  |  |  | -49.6809 |  |
| E2 |  |  |  |  | -39.2766 |  |
| E3 |  |  |  |  | -41.05 |  |
| F1 |  |  |  |  |  | -44.0653 |
| F2 |  |  |  |  |  | -37.9339 |
| F3 |  |  |  |  |  | -48.0083 |

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  | A | B | C | D | E | F |
| A1 | 41.90147 |  |  |  |  |  |
| A2 | 44.43756 |  |  |  |  |  |
| A3 | 37.24252 |  |  |  |  |  |
| B1 |  | 43.68348 |  |  |  |  |
| B2 |  | 38.8508 |  |  |  |  |
| B3 |  | 41.04727 |  |  |  |  |
| C1 |  |  | 41.95125 |  |  |  |
| C2 |  |  | 45.50976 |  |  |  |
| C3 |  |  | 36.12054 |  |  |  |
| D1 |  |  |  | 44.02076 |  |  |
| D2 |  |  |  | 36.5004 |  |  |
| D3 |  |  |  | 43.06039 |  |  |
| E1 |  |  |  |  | 38.38117 |  |
| E2 |  |  |  |  | 40.34639 |  |
| E3 |  |  |  |  | 44.85398 |  |
| F1 |  |  |  |  |  | 43.77011 |
| F2 |  |  |  |  |  | 40.71308 |
| F3 |  |  |  |  |  | 39.09836 |

|  |  |
| --- | --- |
| Optimal factor | reason |
| A1 | Compromise the thickness but reduce the surface defect dramatically. |
| B1 | Has the best performance on both surface defects and thickness. |
| C1 | Compromise the thickness but reduce the surface defect mostly. |
| D1 | Has the best performance on both surface defects and thickness. |
| E3 | Increase a little amount of surface defect but has the best thickness performance. |
| F2 | Compromise the thickness but reduce the surface defect dramatically |

|  |  |  |
| --- | --- | --- |
| starting | | |
| setting | surface defect | thickness |
| A2 | -48.1886461 | 44.43756 |
| B2 | -46.7037336 | 38.8508 |
| C1 | -38.24810216 | 41.95125 |
| D3 | -48.69154344 | 43.06039 |
| E1 | -49.68085787 | 38.38117 |
| F1 | -44.06533208 | 43.77011 |
| overal mean | -43.33584073 | 41.19385 |
|  | -58.89901162 | 44.48204 |

|  |  |  |
| --- | --- | --- |
| optimal | | |
| setting | surface defect | thickness |
| A1 | -20.38674825 | 41.90147 |
| B1 | -24.43166052 | 43.68348 |
| C1 | -38.24810216 | 41.95125 |
| D1 | -37.33697182 | 44.02076 |
| E3 | -41.05002876 | 44.85398 |
| F2 | -37.93387102 | 40.71308 |
| overal mean | -43.33584073 | 41.19385 |
|  | 17.29182109 | 51.15477 |



Two 2-level factors:

|  |  |  |
| --- | --- | --- |
| exp NO. | A | B |
| 1 | 1 | 1 |
| 2 | 1 | 2 |
| 3 | 2 | 1 |
| 4 | 2 | 2 |

Ten 3-level factors:

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| exp NO. | A | B | C | D | E | F | G | H | I | J |
| 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 2 | 1 | 1 | 1 | 1 | 2 | 2 | 2 | 2 | 2 | 2 |
| 3 | 1 | 1 | 1 | 1 | 3 | 3 | 3 | 3 | 3 | 3 |
| 4 | 1 | 2 | 2 | 2 | 1 | 1 | 1 | 2 | 2 | 2 |
| 5 | 1 | 2 | 2 | 2 | 2 | 2 | 2 | 3 | 3 | 3 |
| 6 | 1 | 2 | 2 | 2 | 3 | 3 | 3 | 1 | 1 | 1 |
| 7 | 1 | 3 | 3 | 3 | 1 | 1 | 1 | 3 | 3 | 3 |
| 8 | 1 | 3 | 3 | 3 | 2 | 2 | 2 | 1 | 1 | 1 |
| 9 | 1 | 3 | 3 | 3 | 3 | 3 | 3 | 2 | 2 | 2 |
| 10 | 2 | 1 | 2 | 3 | 1 | 2 | 3 | 1 | 2 | 3 |
| 11 | 2 | 1 | 2 | 3 | 2 | 3 | 1 | 2 | 3 | 1 |
| 12 | 2 | 1 | 2 | 3 | 3 | 1 | 2 | 3 | 1 | 2 |
| 13 | 2 | 2 | 3 | 1 | 1 | 2 | 3 | 2 | 3 | 1 |
| 14 | 2 | 2 | 3 | 1 | 2 | 3 | 1 | 3 | 1 | 2 |
| 15 | 2 | 2 | 3 | 1 | 3 | 1 | 2 | 1 | 2 | 3 |
| 16 | 2 | 3 | 1 | 2 | 1 | 2 | 3 | 3 | 1 | 2 |
| 17 | 2 | 3 | 1 | 2 | 2 | 3 | 1 | 1 | 2 | 3 |
| 18 | 2 | 3 | 1 | 2 | 3 | 1 | 2 | 2 | 3 | 1 |
| 19 | 3 | 1 | 3 | 2 | 1 | 3 | 2 | 1 | 3 | 2 |
| 20 | 3 | 1 | 3 | 2 | 2 | 1 | 3 | 2 | 1 | 3 |
| 21 | 3 | 1 | 3 | 2 | 3 | 2 | 1 | 3 | 2 | 1 |
| 22 | 3 | 2 | 1 | 3 | 1 | 3 | 2 | 2 | 1 | 3 |
| 23 | 3 | 2 | 1 | 3 | 2 | 1 | 3 | 3 | 2 | 1 |
| 24 | 3 | 2 | 1 | 3 | 3 | 2 | 1 | 1 | 3 | 2 |
| 25 | 3 | 3 | 2 | 1 | 1 | 3 | 2 | 3 | 2 | 1 |
| 26 | 3 | 3 | 2 | 1 | 2 | 1 | 3 | 1 | 3 | 2 |
| 27 | 3 | 3 | 2 | 1 | 3 | 2 | 1 | 2 | 1 | 3 |