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Optimization of Static Problem (Static Design) By Taguchi Method (Taguchi Design) Using Minitab

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Abstract
A process to be optimized has several control factors which directly decide the target or desired value of the output. The optimization then involves determining the best control factor levels so that the output is at the target value. Such a problem is called as a "STATIC PROBLEM".

Key words: *static design , Taguchi design ,S/N ratio, SMALLER-THE-BETTER, LARGER-THE-BETTER, NOMINAL-THE-BEST*

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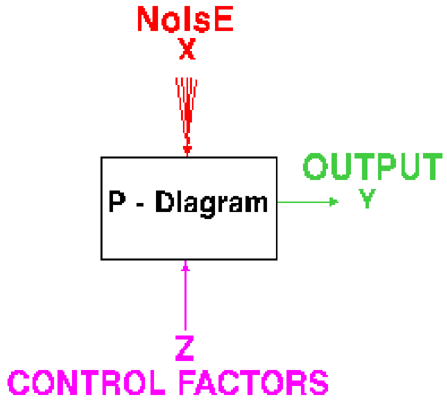
I. Introduction



P - Diagram for STATIC problems

This is best explained using a P-Diagram which is shown below ("P" stands for Process or Product). Noise is shown to be present in the process but should have no effect on the output! This is the primary aim of the Taguchi experiments - to minimize variations in output even though noise is present in the process. The process is then said to have become ROBUST.

The method is applicable over a wide range of engineering fields that include processes that manufacture raw materials, sub systems, products for professional and consumer markets. In fact, the method can be applied to any process be it engineering fabrication, computer-aided-design, banking and service sectors etc. Taguchi method is useful for 'tuning' a given process for 'best' results.

STATIC PROBLEM (BATCH PROCESS OPTIMIZATION) **:**

There are 3 Signal-to-Noise ratios of common interest for optimization of Static Problems;

- **SMALLER-THE-BETTER :**

$n = -10 \text{ Log}_{10}$ [mean of sum of squares of measured data]

This is usually the chosen S/N ratio for all undesirable characteristics like " defects " etc. for which the ideal value is zero. Also, when an ideal value is finite and its maximum or minimum value is defined (like maximum purity is 100% or maximum Temperature is 92K or minimum time for making a telephone connection is 1 sec) then the difference between measured data and ideal value is expected to be as small as possible. The generic form of S/N ratio then becomes,

n = -10 Log_{10} [mean of sum of squares of {measured - ideal}]

- **LARGER-THE-BETTER :**

n = -10 Log_{10} [mean of sum squares of reciprocal of measured data]

This case has been converted to SMALLER-THE-BETTER by taking the reciprocals of measured data and then taking the S/N ratio as in the smaller-the-better case.

- **NOMINAL-THE-BEST :**

$$n = 10\ \text{Log}_{10}\ \frac{\text{square of mean}}{\text{variance}}$$

This case arises when a specified value is MOST desired, meaning that neither a smaller nor a larger value is desirable.

Examples are;

(i) most parts in mechanical fittings have dimensions which are nominal-the-best type.

(ii) Ratios of chemicals or mixtures are nominally the best type.

e.g. Aqua 1:3 of HNO3:HCL
Ratio of Sulphur, KNO3 and Carbon in gun powder

(iii) Thickness should be uniform in deposition /growth /plating /etching..

ANALYSIS OF STATIC PROBLEM (static design)

In this static problem I also used same problem as previous used . only for better result and graph .

An engineer for a golf equipment manufacturer wants to design a new golf ball that has better flight distance. The engineer has identified four control factors (core material, core diameter, number of dimples, and cover thickness) and one noise factor (type of golf club). Each control factor has 2 levels. Because there is no signal factor, the engineer creates a static Taguchi design.

Minitab displays a summary of the L8 design, which includes 4 factors and 8 runs.
The Minitab worksheet shows the settings for each factor for all 8 experimental runs.

Taguchi Design
Design Summary

Taguchi Array L8(2^4)
Factors: 4
Runs: 8

Columns of L8(2^7) array: 1 2 4 7

C1	C2	C3	C4
A	**B**	**C**	**D**
1	1	1	1
1	1	2	2
1	2	1	2
1	2	2	1
2	1	1	2
2	1	2	1
2	2	1	1
2	2	2	2

II. Results

An engineer for a golf equipment manufacturer wants to design a new golf ball to maximize ball flight distance. The engineer has identified four control factors (core material, core diameter, number of dimples, and cover thickness) and one noise factor (type of golf club). Each control factor has 2 levels. The noise factor is two types of golf clubs: driver and a 5-iron. The engineer measures flight distance for each club type, and records the data in two noise factor columns in the worksheet.

Because the goal of the experiment is to maximize flight distance, the engineer uses the larger-is-better signal-to-noise ratio (S/N). The engineer also wants to test the interaction between core material and core diameter.

In Taguchi experiments, you always want to maximize the S/N ratio. In this example, the ranks indicate that core diameter (B) has the most influence on both the S/N ratio and the mean. For S/N ratio, cover thickness (D) has the next largest influence, followed by core material (A) and dimples (C). For means, core material (A) has the next largest influence, followed by dimples (C) and cover thickness (D).

For this problem, because the goal is to increase ball flight distance, the engineer wants the factor levels that produce the highest mean. The levels averages in the response tables show that the S/N ratios and the means are maximized at the Level 1 value for each factor, which corresponds with the following factor settings.

- Liquid core (A)
- Core diameter (B) = 118
- Dimples (C) = 392
- Cover thickness (D) = 0.06
- The main effects plots and the interaction plots confirm these results. The interaction plots show that, with the liquid core, the flight distance is maximized when the core diameter is 118.
- To continue this analysis, the engineer can use Predict Taguchi Results to determine the predicted S/N ratios and means at these factor settings

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Linear Model Analysis: SN ratios versus Material, Diameter, Dimples, Thickness

Estimated Model Coefficients for SN ratios

Term                          Coef  SE Coef.  T       P
Constant                    38.181   0.4523  84.418  0.000
Material Liquid              3.436   0.4523   7.596  0.017
Diameter 118                 3.967   0.4523   8.772  0.013
Dimples 392                  2.982   0.4523   6.593  0.022
Thicknes 0.03               -3.479   0.4523  -7.692  0.016
Material*Diameter Liquid 118   1.640   0.4523   3.625  0.068

Model Summary

    S    R-Sq  R-Sq(adj)
1.2793  99.21%     97.23%

Analysis of Variance for SN ratios

Source             DF   Seq SS   Adj SS   Adj MS     F      P
Material            1   94.427   94.427   94.427  57.70  0.017
Diameter            1  125.917  125.917  125.917  76.94  0.013
Dimples             1   71.133   71.133   71.133  43.47  0.022
Thickness           1   96.828   96.828   96.828  59.17  0.016
Material*Diameter   1   21.504   21.504   21.504  13.14  0.068
Residual Error      2    3.273    3.273    1.637
Total               7  413.083


Linear Model Analysis: Means versus Material, Diameter, Dimples, Thickness

Estimated Model Coefficients for Means
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Term                         Coef  SE Coef       T      P
Constant                   110.40    8.098   13.634   0.005
Material Liquid              36.86    8.098   4.552   0.045
Diameter 118                 51.30    8.098   6.335   0.024
Dimples 392                  23.25    8.098   2.871   0.103
Thicknes 0.03               -22.84    8.098   -2.820  0.106
Material*Diameter Liquid 118   31.61    8.098   3.904   0.060

Model Summary

     S    R-Sq  R-Sq(adj)
22.9035  97.88%     92.58%

Analysis of Variance for Means

Source            DF   Seq SS   Adj SS   Adj MS      F      P
Material           1   10871   10871   10870.8   20.72   0.045
Diameter           1   21054   21054   21053.5   40.13   0.024
Dimples            1    4325    4325   4324.5   8.24     0.103
Thickness          1    4172    4172   4172.4   7.95     0.106
Material*Diameter   1    7995    7995   7994.8   15.24   0.060
Residual Error      2    1049    1049    524.6
Total              7   49465

Response Table for Signal to Noise Ratios
Larger is better

Level   Material   Diameter   Dimples   Thickness
1         41.62     42.15    41.16      34.70
2         34.75     34.21    35.20      41.66
Delta      6.87      7.93     5.96       6.96
Rank         3        1        4         2

Response Table for Means

Level   Material   Diameter   Dimples   Thickness
1        147.26    161.70   133.65      87.56
2         73.54     59.10    87.15     133.24
Delta     73.73    102.60    46.50      45.68
Rank         2        1        3         4
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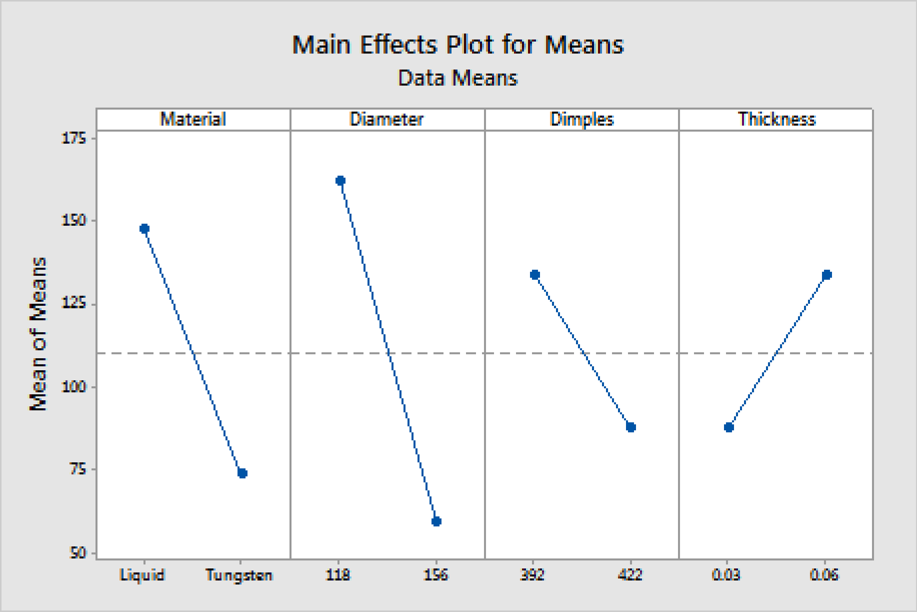
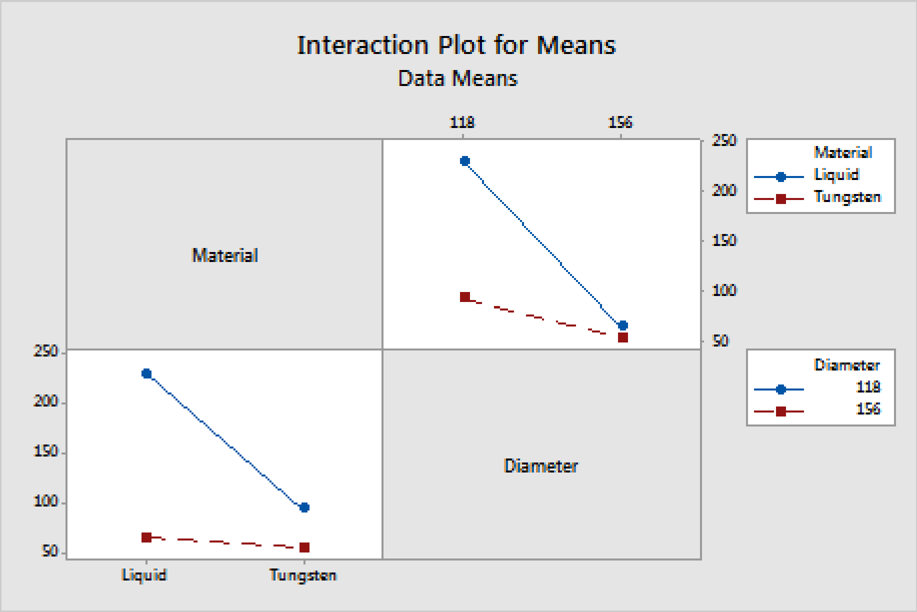
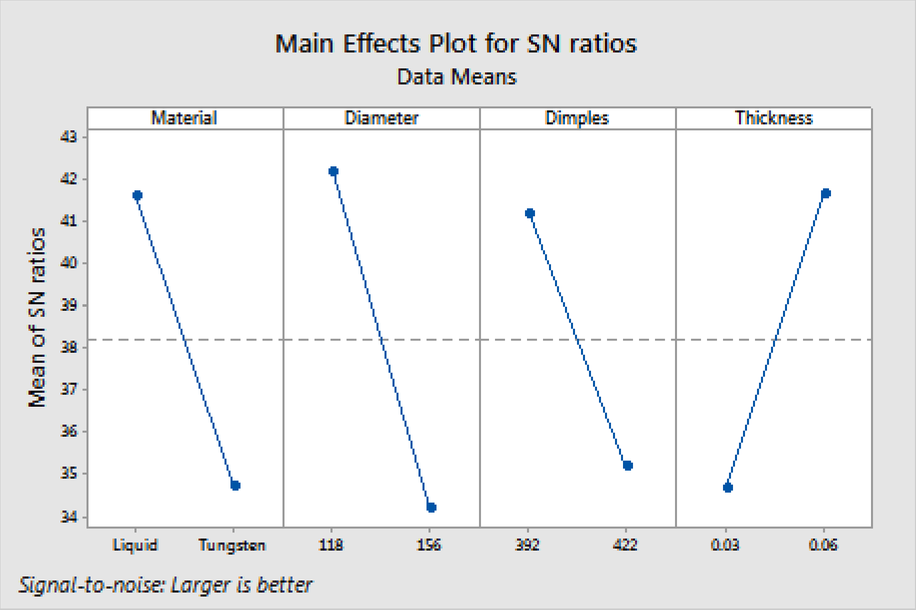
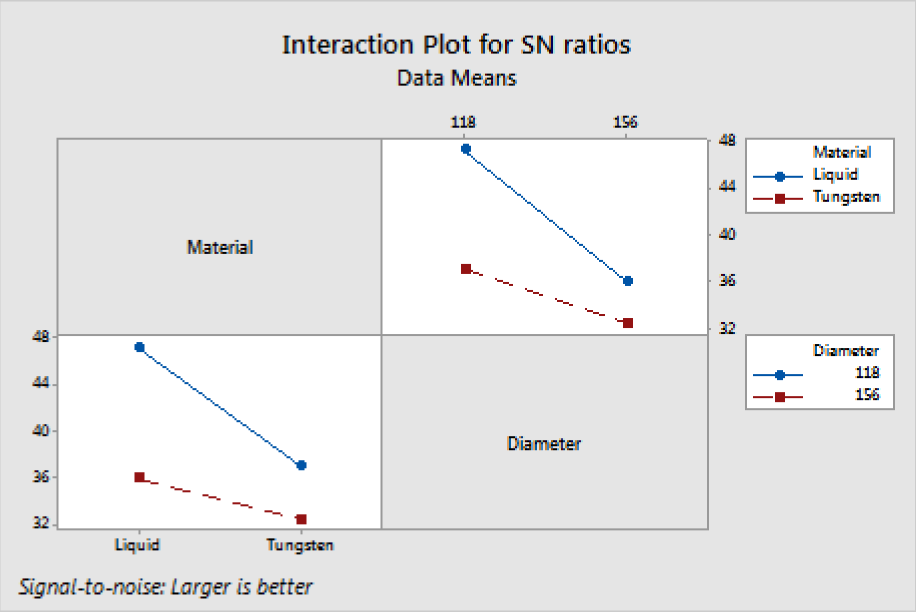
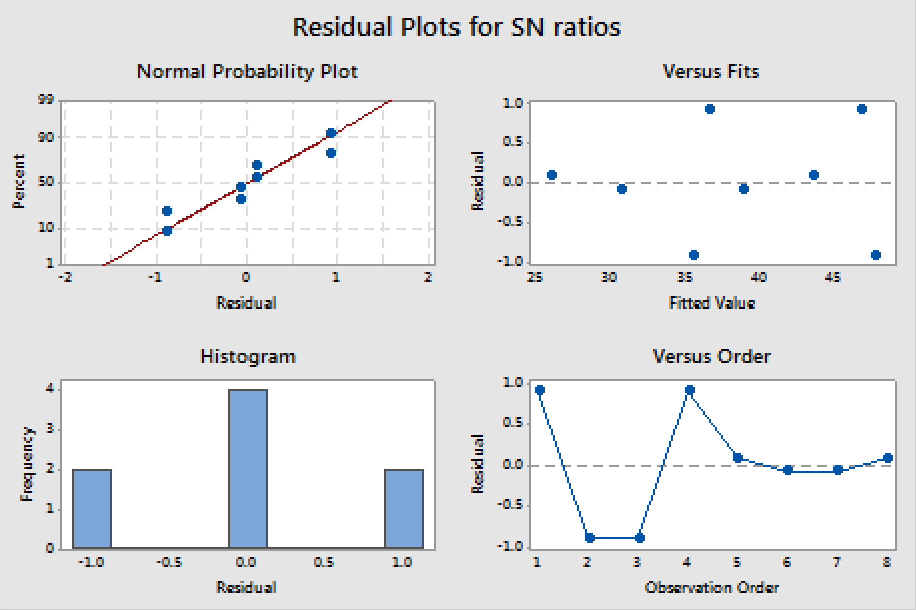
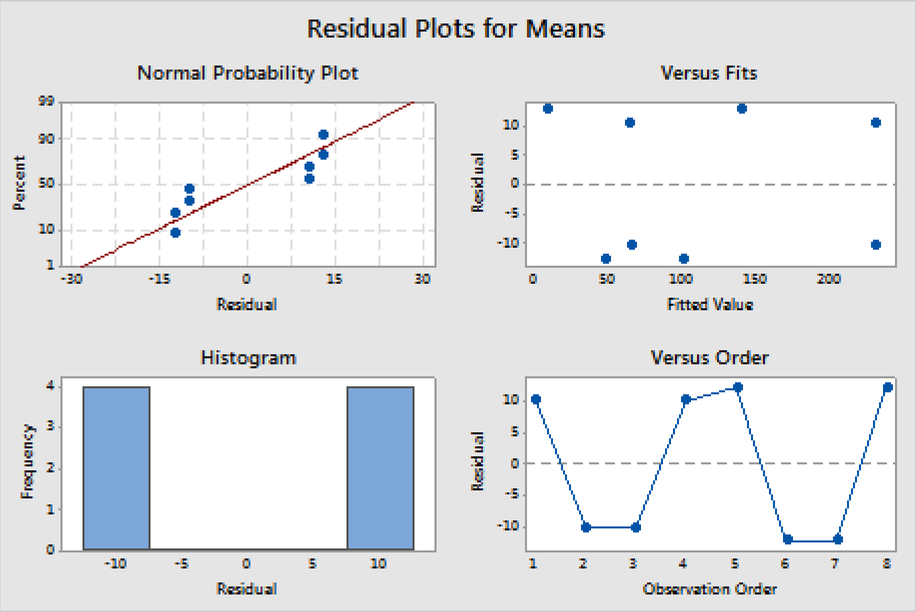

Main Effects Plot for Means
Data Means
Material
Diameter
Dimples
Thickness
Mean of Means
175
150
125
100
75
50
Liquid
Tungsten
118
156
392
422
0.03
0.06


Interaction Plot for Means
Data Means
118
156
250
200
150
100
50
Material
Material
Liquid
Tungsten
Diameter
118
156
250
200
150
100
50
Diameter
Liquid
Tungsten


Main Effects Plot for SN ratios
Data Means
Material
Diameter
Dimples
Thickness
Mean of SN ratios
43
42
41
40
39
38
37
36
35
34
Liquid
Tungsten
118
156
392
422
0.03
0.06
Signal-to-noise: Larger is better


Interaction Plot for SN ratios
Data Means
118
156
48
44
40
36
32
Material
Liquid
Tungsten
Material
Diameter
118
156
Diameter
48
44
40
36
32
Liquid
Tungsten
Signal-to-noise: Larger is better





III. CONCLUSION

➢ In the above discussion, for S/N ratios, all the factors have a p-value less than 0.05 and are statistically significant at a significance level of 0.05. Frequently, a significance level of 0.10 is used for evaluating terms in a model.

➢ The interaction is statistically significant at a significance level of 0.10. For means, core material ($p = 0.045$) and core diameter ($p = 0.024$) are statistically significant at a significance level of 0.05, and the interaction of material with diameter ($p = 0.06$) is statistically significant at a significance level of 0.10.

➢ Minitab prominently provides an estimated regression coefficients table for each response characteristic that you select. In this above problem, the engineer chose two response characteristics — the signal-to-noise ratio (S/N) and the means. Use the p-values to determine which factors are statistically significant and use the coefficients to determine each factor's relative importance in the model.

REFERENCES:

[1]. https://iopscience.iop.org/article/10.1088/1757-899X/1112/1/012009/pdf (1.10.2021)
[2]. ng.libretexts.org/Bookshelves/Industrial_and_Systems_Engineering/Book%3A_Chemical_Process_Dynamics_and_Controls_(Woolf)/14%3A_Design_of_Experiments/14.01%3A_Design_of_Experiments_via_Taguchi_Methods_-_Orthogonal_Arrays (2.10.2021)
[3]. https://eko.staff.uns.ac.id/files/2014/09/Buku-Alternatif.pdf (4.10.2021)
[4]. https://www.mne.psu.edu/simpson/courses/ie466/ie466.robust.handout.PDF(5.10.2021)
[5]. https://www.hindawi.com/journals/isrn/2013/462174/(6.10.221)