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DISCUSSION

A Review on Taguchi's Technique of forming Orthogonal Arrays

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ABSTRACT

Prediction and utilization of right parameters in any fabricating process is the first and foremost step that is essential to maintain the quality of any fabricated product. Quality of fabricated commodities by the industrialists should not be a drawback, instead that should be a main asset for the development of any industry. General algorithm, artificial neural networks, trial and error method, Design of Experimentation (DOE) are some of the optimizing techniques applied in the fabrication processes, among which DOE method framing orthogonal arrays proposed by Dr. Genechi Taguchi is the simplest and widely executed quality control technique. Maintaining the quality without creating loss to the society is the primary motto of this methodology. According to him, consistency of performance of a product means showing its standard, and inconsistency means lack of its quality. Taguchi's approach of quality control using 'parameter design phase' of three quality engineering activities such as parameter phase, tolerance phase and design phase not only minimizes the number of experiments to be conducted but also reduces the time, expenditure and in the end, it gives us a set of appropriate parameters that are desired during final fabrication of products. The present paper speaks about the steps that are to be followed for selection of number of parameters and number of level for forming orthogonal arrays.

Keywords: Orthogonal arrays, Taguchi's approach, General algorithm, Artificial neural networks, Design of experimentation.

1. INTRODUCTION

Before we manufacture a product or conduct an experiment on it one should know the need of required parameters and number of trails that are to be conducted necessary for execution. Dr.Taguchi's method of forming the orthogonal array's can be considered as the best possible method to the industrialists and to the research scholars to overcome the wastage problem of MMT (machinery, material and time), by selecting the essential set of parameters during manufacturing and research. Dr. Genechi Taguchi proposed design of experimentation forming orthogonal arrays in nine simplified steps among which 1-6 steps are the initial steps and 6-9 steps are the final steps of the planning phase for conducting any kind of experimentation [1]. One to nine steps involved in the Taguchi's methodology are,

1. Stating the problem (or) concern: In this step a statement is made which clearly and concisely describes what the real problem is, not the symbols of the problem.
2. The second step in design of experimentation is stating the objective of experiment where a brief description and determination of the experiment is discussed which involves selection of the number of required parameters and criteria of when to start and stop the experiment.
3. Genechi Taguchi states quality as "consistency of performance" of a product. Lack of quality causes loss to

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the society [2]. A formula to quantify the amount of loss based on deviation from the target performance is given in equation (1.1),

$$L = k(Y - Y_0)^2 \tag{1.1}$$

So, the correct selection of quality characteristics and measurements are to be made.

4. Influence of selected parameters on quality characteristics: This step is the most important step of the DOE which reveals out the important factors that are left out unknowing which will affect the information gained from the experimentation and in the end, C-E diagram is conducted based on the application of parameters, and processes in the right order using Brain storming or flow chart,

An example flow chart in welding process is shown in figure 1.

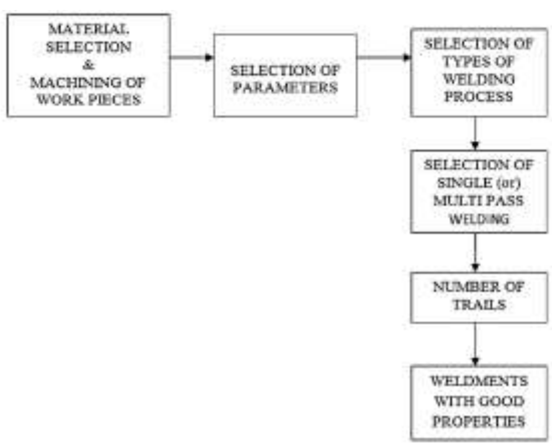


Figure 1.Flow chart in welding process

1.1. C-E (Cause Effect diagram)

Example casting: The problem observed in the casting is that a percentage of casting produces in the end are cracked at various locations. C-E structure begins with the basic effect of the process and progresses throughout the causes of the effect [3]. The structure is branched with primary, secondary and sometimes with tertiary effects such that the factors that are affecting the quality characteristics of the product can be verified and at the end a quality product can be achieved. The cause effect diagram is shown in figure 2.

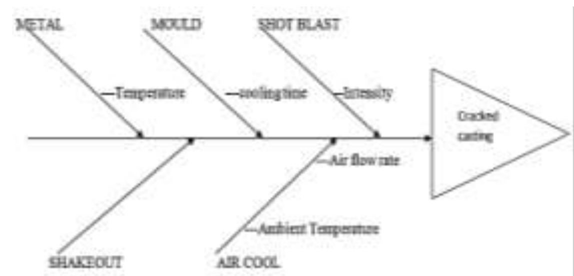


Figure 2.Cause effect diagram

1.2. Brain storming

It is nothing but a group of people sit together to discuss regarding the important factors that are likely to affect the quality of the product after manufacturing, and the timings about the starting and halting of the process for necessary correction in changing the parameters if required any.

5. Specifying the control and noise factors S/N ratio: Some examples of control factors are material, speed, feed, diameter, temperature etc. Noise factors are ambient temperature, ambient humidity, road surface, vehicle speeds, assembly person etc.
6. Selection of levels for the factors: For the starting of the experiment, a low level factor should be used. If the result at the end is positive, a high level order of the experiments can be conducted. For a low level, a 2-level and for higher order a 3-level or 4-level can be selected. Once the level is fixed, number of variables can be varied accordingly.

Full factorial experiments are:

3 factors at 2 levels 2^3=8

4 factors at 2 levels 2^4=16

7 factors at 2 levels 2^7=128

15 factors at 2 levels 2^{15}=32,768

7. Orthogonal arrays: An orthogonal array states about how many experiments have to be conducted for finding out the best

suitable factors further during manufacturing or designing a product. The factors selected can be of two types:

- Continuous factors
- Discontinuous factors

The first one implies towards temperature, pressure, thickness, speed, feed etc. whereas the later implies about type of container to be used, supplier, material etc. Standard notation for orthogonal array is given under equation (1.2).

$$Ln(X^y) \qquad (1.2)$$

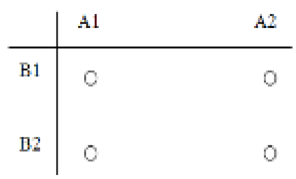
where, L=Latin symbol

n=number of experiments

X=number of level

y=number of factors

One simple way to select the number of experiments to be conducted using Taguchi technique is:



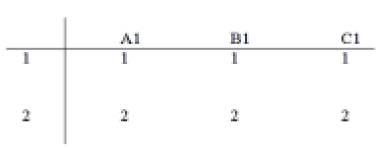
From the above, there are 2 factors and 2 levels and the numbers of experiments to be conducted are four and it can be stated as follows:

A1B1 A2B2 A1B2 A2B2

or

2^2= 4 experiments

If three factors are considered at 2 levels, then 8 experiments are required.



A1B1C1	A1B1C2	A2B2C2	A2B1C1
B1A2C1	A1B2C2	A1B2C2	A2B2C1

or

2^3=2*2*2=8

Arrangement of experiments for the above example can be given as:

S. No	A	B	C
1	1	1	1
2	1	1	2
3	1	2	1
4	1	2	2
5	2	1	1
6	2	1	2
7	2	2	1
8	2	2	2

8. Selection of interactions that may influence the selected quality characteristics: This step can be performed when any additional information i.e., the factors to be added in the experiment is required; we need to move back to step four where the selection of parameters is conducted.
9. At last an assessment or assignment can be made over all the steps for any necessary correction before and after modifying the DOE.

After all the steps making a trail run can be conducted with the selected parameters and the results are analysed. The set of factors that gives us the quality product is selected for mass production.

The orthogonal arrays for different levels and different number of variables are given as:

P= Parameters L=Level

P=2, L=3

1	1	1
2	1	2
3	1	3
4	2	1
5	2	2
6	2	3
7	3	1
8	3	2
9	3	3

P=3, L=3

1	1	1	1
2	1	2	2
3	1	3	3
4	2	1	2
5	2	2	3
6	2	3	1
9	3	3	2

P=4, L=3

1	1	1	1	1
2	1	2	2	2
3	1	3	3	3
4	2	1	2	3
5	2	2	3	1
6	2	3	1	2
7	3	1	3	2
8	3	2	1	3
9	3	3	2	1

P=5, L=3

1	1	1	1	1	1
2	1	2	2	2	2
3	1	3	3	3	3
4	2	1	1	2	2
5	2	2	2	3	3
6	2	3	3	1	1
7	3	1	2	1	3
8	3	2	3	2	1
9	3	3	1	3	2
10	1	1	3	3	2
11	1	2	1	1	3
12	1	3	2	2	1
13	2	1	2	3	1
14	2	2	3	1	2
15	2	3	1	2	3
16	3	1	3	2	3
17	3	2	1	3	1
18	3	3	2	1	2

P=2, L=4

1	1	1
2	1	2
3	1	3
4	1	4
5	2	1
6	2	2
7	2	3
8	2	4
9	3	1
10	3	2
11	3	3
12	3	4
13	4	1
14	4	2
15	4	3
16	4	4

P=3, L=4

1	1	1	1
2	1	2	2
3	1	3	3
4	1	4	4
5	2	1	2
6	2	2	1
7	2	3	4
8	2	4	3
9	3	1	3
10	3	2	4
11	3	3	1
12	3	4	2
13	4	1	4
14	4	2	3
15	4	3	2
16	4	4	1

P=4, L=4

1	1	1	1	1
2	1	2	2	2
3	1	3	3	3
4	1	4	4	4
5	2	1	2	3
6	2	2	1	4
7	2	3	4	1
8	2	4	3	2
9	3	1	3	4
10	3	2	4	3
11	3	3	1	2
12	3	4	2	1
13	4	1	4	2
14	4	2	3	1
15	4	3	2	4
16	4	4	1	3

P=5, L=4

1	1	1	1	1	1
2	1	2	2	2	2
3	1	3	3	3	3
4	1	4	4	4	4
5	2	1	2	3	4
6	2	2	1	4	3
7	2	3	4	1	2
8	2	4	3	2	1
9	3	1	3	4	2
10	3	2	4	3	1
11	3	3	1	2	4
12	3	4	2	1	3
13	4	1	4	2	3
14	4	2	3	1	4
15	4	3	2	4	1
16	4	4	1	3	2

P=2, L=5

1	1	1
2	1	2

3	1	3
4	1	4
5	1	5
6	2	1
7	2	2
8	2	3
9	2	4
10	2	5
11	3	1
12	3	2
13	3	3
14	3	4
15	3	5
16	4	1
17	4	2
18	4	3
19	4	4
20	4	5
21	5	1
22	5	2
23	5	3
24	5	4
25	5	5

P=3, L=5

1	1	1	1
2	1	2	2
3	1	3	3
4	1	4	4
5	1	5	5
6	2	1	2
7	2	2	3
8	2	3	4
9	2	4	5
10	2	5	1
11	3	1	3
12	3	2	4
13	3	3	5
14	3	4	1
15	3	5	2
16	4	1	4
17	4	2	5
18	4	3	1
19	4	4	2
20	4	5	3
21	5	1	5
22	5	2	1
23	5	3	2
24	5	4	3
25	5	5	4

P=4, L=5

1	1	1	1	1
2	1	2	2	2
3	1	3	3	3
4	1	4	4	4
5	1	5	5	5
6	2	1	2	3
7	2	2	3	4
8	2	3	4	5
9	2	4	5	1
10	2	5	1	2
11	3	1	3	5
12	3	2	4	1
13	3	3	5	2
14	3	4	1	3
15	3	5	2	4
16	4	1	4	2
17	4	2	5	3
18	4	3	1	4
19	4	4	2	5
20	4	5	3	1
21	5	1	5	4
22	5	2	1	5
23	5	3	2	1
24	5	4	3	2
25	5	5	4	3

P=5, L=5

1	1	1	1	1	1
2	1	2	2	2	2
3	1	3	3	3	3
4	1	4	4	4	4
5	1	5	5	5	5
6	2	1	2	3	4
7	2	2	3	4	5
8	2	3	4	5	1
9	2	4	5	1	2
10	2	5	1	2	3
11	3	1	3	5	2
12	3	2	4	1	3
13	3	3	5	2	4
14	3	4	1	3	5
15	3	5	2	4	1
16	4	1	4	2	5
17	4	2	5	3	1
18	4	3	1	4	2
19	4	4	2	5	3
20	4	5	3	1	4
21	5	1	5	4	3
22	5	2	1	5	4
23	5	3	2	1	5
24	5	4	3	2	1
25	5	5	4	3	2

1.2. Taguchi's vs. goal post philosophy

The goal post philosophy by Philip B Crosby states that the permitted tolerances is of high quality. But this embraced only the designers and makers and the stage is called as "Goal Post syndrome" [4, 5]. The statement made by the Crosby is missing the customers' satisfaction.

An example that can be coated at this point which is missing the customer satisfaction given by the Crosby is when customer buys a T.V. with better picture quality which may not the one that necessarily meet other specification like sound, make, size etc.

2. CONCLUSION

General algorithm, artificial neural networks, trial and error method are some of the quality finding methods that are used by the industrialists. Apart from the quality control, the methods what we use should ease its use in conducting less number of experiments and giving better results than any other methodology. From the literature survey conducted on design of experimentation forming orthogonal arrays, the design proposed by Dr. Genechi Taguchi can be considered as the best quality control technique among all the techniques and is the most implemented technique by the industrialists.

Formation and application of orthogonal arrays gives well defined results in regard to the right parameters selection and number of experiments conducted before manufacturing or fabricating a component, such that time and the investment made on the material and wastage of the material can be reduced and quality products can be produced.

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