SHAININ Method: Edge Over Other DOE Techniques

A.K. Verma¹, A. Srividya¹, A.V. Mannikar², V.A. Pankhawala², K.J. Rathanraj³

¹ Reliability Engineering Group, Indian Institute of Technology, Bombay, India

² Automotive Research Association of India (ARAI), Pune, India

³ BMS College of Engineering, Bangalore, India

Abstract— Shainin methods refer to a collection of principles, which make up the framework of a continually evolving approach to quality. After the classical design of experiments (DOE) and Taguchi DOE, the third approach is Shainin DOE, which is a collection of simple, but powerful techniques invented or perfected by Dorian Shainin of the United States. In this paper, three cases of Taguchi experiments have been taken from literature and the above method has been tried to find out whether the authors have got the positive results from their experiment. If not, authors emphasize on the importance of giving the check in the start of the experiment (screening experiment) with minimum number experiments prior to the Taguchi approach.

Keywords— Shainin, Taguchi DOE

I. INTRODUCTION

The Shainin method is gaining popularity now because of the simple tools, which can give substantial good results at low cost and time. In fact, Motorola has a saying: “Without Deming, the U.S would not have had a quality philosophy; without Juran, it would not have had a quality direction; without Shainin, it would not have solved quality problems!” that sums up the contributions of America’s three greatest quality gurus [1]. Unfortunately, like Deming’s approach and Taguchi methods, Shainin techniques have not received the wide publicity and use they deserve.

In this paper, authors would like to emphasize on the screening test or the pilot test, which is being carried out at the start of the experimentation. This will give an initial check to the parameter selection to level selection. Shainin technique gives a tool to check the screening test results so that one can think of going ahead with the full experimentation. This is a limitation of both classical and Taguchi DoE where experiments are to be carried out fully before one could realize that experimental result are of use or not. Thus in this paper, three cases of Taguchi experiments have been taken from literature [2,3,4] and the above method has been tried to find out whether the authors have got the positive results from their experiment. If not, authors emphasize on the importance of giving the check in the start of the experiment (screening experiment) with minimum number experiments prior to the Taguchi approach.

II. SHAININ VARIABLE SEARCH METHOD

According to Bhote [1], the variable search method can be classified into four stages. In the first stage, objective is to determine and to select the right variable and the right levels for each variable for the experiment. Here, after selecting the factors for the experiment, assign two levels to each factor—a best level, which is likely to contribute to a best response/output and a marginal level, indicative of a likely deviation from the best level in day-to-day production with normal maintenance. Once the factors and levels are fixed, two experiments are run, first with all factors at their best levels, second with all factors at their marginal levels. If there is a large difference between the response of the all-best and the all-marginal combinations of factors, it is an early indication that one has captured the right factors. If the difference in response is small, the chances are that one has not captured (1) the right factors; or (2) the right levels of these factors; or that (3) the first dominant cause is being cancelled by a strong second dominant cause; or (4) the first dominant factor is an interaction among an even number of factors. Thus necessary corrective action can be taken if the difference in response is small. If the difference between the responses is large, for confirmation of the response values, two all-best levels of all factors and two more all-marginal levels of all the factors (randomized to avoid bias) can be conducted. Then D/d ratio is found, which must be greater than or equal to a minimum of 1.25. (D is the difference between the median values of the best and the marginal responses and d is the average of two differences (or ranges) within the all-best responses and the all-marginal responses). If D/d ratio value is more than the said value, experiment can be moved to second stage. This also means that right factors have been captured. Subsequent stages are similar to other DOE techniques.

III. CASE STUDIES

A. Case study 1:

According to Srivastava [2], for the optimization of resistance spot-weld process, three main parameters selected were % Heat, weld time and hold time and

levels are fixed as shown below in the Table 1 [ref. 2 pp 47, Table No. 3.1]

TABLE 1
Physical experimental layout

Run No.	M/s Alpha Company Parameters		
	% Heat	Weld Time (cycles)	Hold Time (cycles)
1	75	16	06
2	75	16	10
3	75	18	06
4	75	18	10
5	80	16	06
6	80	16	10
7	80	18	06
8	80	18	10

Results of which are depicted in the Table 2 [ref.2 pp 88 Table 4A], which consists of 20 repetition of each run. Observing the below table and finding the difference among the run 1 and run 8 which are the Marginal levels and the Best levels of the orthogonal array.

All best level – Run 1: median value = 6.20

All marginal level –Run 8: median value = 6.185

Therefore, $D = 6.20 - 6.185 = 0.015$

$d = \text{Average lack of repeatability in each assembly}$
 $= ((6.28-6.13)+(6.320-5.987))/2 = 0.2415$

$D/d = 0.015/0.2415 = 0.062$, which is less than 1.25:1.

This implies that the other experiments between Run 2 to Run 7 were not required to be conducted.

One can observe that there is a large difference within the replications than the Run 1 and Run 8. There is no substantial success achieved out of this experiment in identifying the influence of variations in weld parameters. The Shainin technique uses the fundamentals of the Analysis of variance that ratio of the difference between the group variability and variability within must be significant otherwise the experiment will not achieve the intended result.

B. Case study 2:

Kusiak and Feng [3], considered the tolerance design problem for the machining dimensional chain and each dimension includes a nominal value and the tolerance. Assuming that the nominal values have been selected, tolerances are to be allocated so that the manufacturing cost is minimized. In Tolerance synthesis problem (TSP), the unit of tolerance is μm , and there is no unit for cost as it is a relative value. The robust TSP is to assign a tolerance stackup so that the tolerance stackup is not greater than an upper limit ($20 \mu m$) and the total cost manufacturing does not exceed a preset limit.

From the Table 3 and applying the screening test of Shainin method:

All best level - Level 0: median value = -1.57

All marginal level -Level 1: median value = -0.41

TABLE 2
Response values in kN of M/s Alpha Co.

S. No.	Run Number							
	1	2	3	4	5	6	7	8
1	6.24	6.29	6.314	6.367	6.369	6.172	6.392	6.175
2	6.20	6.30	6.324	6.399	6.359	6.175	6.395	6.250
3	6.19	6.302	6.328	6.354	6.361	5.978	6.381	6.185
4	6.13	6.298	6.311	6.398	6.372	6.124	6.395	5.998
5	6.20	6.258	6.325	6.354	6.412	6.198	6.455	5.987
6	6.19	6.274	6.311	6.374	6.392	6.178	6.325	6.311
7	6.21	6.301	6.298	6.382	6.352	6.185	6.339	6.302
8	6.28	6.302	6.367	6.352	6.355	6.198	6.395	6.185
9	6.19	6.254	6.328	6.333	6.385	6.261	6.339	6.179
10	6.15	6.271	6.319	6.323	6.410	6.302	6.345	6.182
11	6.128	6.292	6.258	6.351	6.398	6.295	6.478	6.189
12	6.154	6.259	6.298	6.382	6.399	6.179	6.411	6.179
13	6.245	6.264	6.259	6.375	6.268	6.180	6.382	6.201
14	6.23	6.289	6.278	6.366	6.358	6.279	6.395	6.176
15	6.182	6.269	6.259	6.367	6.362	6.258	6.382	6.320
16	6.19	6.299	6.287	6.329	6.365	6.179	6.402	6.181
17	6.254	6.298	6.316	6.399	6.389	6.182	6.399	6.179
18	6.271	6.298	6.298	6.342	6.339	6.179	6.385	6.178
19	6.248	6.295	6.314	6.352	6.398	6.175	6.391	6.180
20	6.195	6.289	6.324	6.369	6.350	6.201	6.389	6.182
Mean	6.2039	6.2851	6.3058	6.3634	6.3697	6.1939	6.3888	6.186
S.D	0.0438	0.0167	0.0273	0.0224	0.0321	0.0695	0.0358	0.081

TABLE 3
The data of a 2^{4-1} experiment with 5 replicates of the TSP [3]

Factors				Replicate of tolerance stack up					Cost	T	σ_T
A	B	C	D	1	2	3	4	5	y		
0	0	0	0	2.41	3.25	-3.00	-1.57	-6.04	379	0.990	4.425
1	0	0	1	-2.15	0.53	-1.42	5.70	-0.20	475	0.492	3.088
0	1	0	1	-3.71	1.02	-2.69	2.25	-5.01	521	1.628	3.284
1	1	0	0	5.58	0.54	-1.74	3.73	-5.16	471	0.590	3.645
0	0	1	1	-3.83	-0.27	-1.66	-1.74	-5.43	487	2.586	3.510
1	0	1	0	5.46	-0.75	-0.71	-0.26	-5.59	437	0.370	3.656
0	1	1	0	3.89	-0.27	-1.98	-3.71	-10.4	483	2.494	3.900
1	1	1	1	-0.66	-2.98	-0.41	3.56	-4.56	579	1.509	2.171

So $D = -1.57 \sim (-0.41) = 1.16$

$d = \text{Average lack of repeatability in each assembly}$
 $= (9.29 + 8.12)/2 = 8.71$

$D/d = 1.16/8.71 = 0.13$, which is less than 1.25:1. So this experiment might have not yielded significant result.

One can observe that there is a large difference within the replications than the level 0 and level 1. There might be an improvement in the form of cost reduction and tolerance. But one can say that it is not substantial.

C. Case study 3:

Table 4 below from Lin [4] that is a four factor two level experiments, which discusses about Taguchi's concept of orthogonal arrays. Looking at the below orthogonal array one can make out the Run 1 which has all level at -1 and Run 8 which has all level at 1 can be considered All-best and All-marginal level. Applying the screening test of Shainin method to below Table 4:

All best level -Level -1: Average value = 32.27

(As min. three values are not available to consider the median value)

All marginal level -Level 1: Average value = 14.8

So $D = 32.27 \sim 14.8 = 17.47$

$d = \text{Average lack of repeatability in each assembly}$
 $= (1.64 + 0.8)/2 = 1.22$

$D/d = 17.47/1.22 = 14.31$, which is greater than 1.25:1. So this experiment is a success.

IV. CONCLUSION

In this paper, three case studies have been discussed to show that how screening test of Shainin method can be applied on the Taguchi's orthogonal array to assess the adequacy of the experiment. It is observed that case 1 and case 2 show D/d ratio less than 1.25 and therefore it can be concluded that the experimentation result be successful in identifying the influence of variations in parameters. In fact, it goes to assert adequacy of tolerance levels (i.e. the tolerance variations are not influencing the quality). However analysis of these two case studies do emphasis that the additional experiments conducted were not really required and could have been eliminated using Shainin variable search method at screening stage only. While case 3 shows higher ratio of D/d and hence it can be concluded that the experimentation might give significant result. Thus the Shainin variable search method can be effectively used to find and fix the few important factors as well as its levels by conducting minimum number of experiments in the screening test.

TABLE 4
Simulated data using the L_8 array [4]

Run	1	2	3	4	5	6	7	Observations	
	A	B	AB	C	AC	e	D	y_i	
1	-1	-1	-1	-1	-1	-1	-1	33.09	31.45
2	-1	-1	-1	1	1	1	1	21.13	19.26
3	-1	1	1	-1	-1	1	1	13.59	13.55
4	-1	1	1	1	1	-1	-1	18.68	24.69
5	1	-1	1	-1	1	-1	1	12.95	16.39
6	1	-1	1	1	-1	1	-1	5.61	3.74
7	1	1	-1	-1	1	1	-1	3.43	2.42
8	1	1	-1	1	-1	-1	1	14.40	15.20

REFERENCES

- [1] Keki R. Bhote, Adi K. Bhote, "World Class Quality: using Design of Experiments to make it happen", 2nd edition, *American Management Association*, New York, 2000.
- [2] Srivastava, Bipin B., "Reliability studies on resistance spot weld process parameters in automobile components" *Ph.D thesis, IIT, Bombay*, Mumbai, 2000.
- [3] Kusiak A., Chang-Xue Feng, "Robust Tolerance Design for Quality" *Journal of Engineering for Industry, Transactions of the ASME*, Vol.118, Feb 1996, pp 166-169.
- [4] Dennis K. J. Lin, "Making full use of Taguchi's orthogonal arrays" *Quality and Reliability Engineering International*, Vol.10, 1994, pp 117-121.