Applied Mechanics and Materials
ISSN: 1662-7482, Vols. 599-601, pp 1021-1024
doi:10.4028/www.scientific.net/AMM.599-601.1021

Submitted: 2014-06-04
Accepted: 2014-06-05
Online: 2014-08-11

Optimization of Reliability Test on the Shell of Portable Electronic Products Based on Taguchi Method

Xue Mei Du[1, a], Wei Lei[1,b], Nai Jia Wang[1,c] and Jin Yu Ding[1,d]

[1]School of Economics and Management, Tongji University, 1239 Siping Road, Shanghai, P.R. China

[a]xuemei.du@163.com, [b]leiwei_90@foxmail.com, [c]wangnaijia0726@163.com,[d]djy3481164@163.com

Keywords: Reliability test; Taguchi Method; Portable electronic products

Abstract. Traditional reliability test of electronic products has the feature of many contents, long cycle and rising test fees. This paper analyzes the feasibility of combination of Taguchi method and reliability test. Then, the process of optimizing reliability test is proposed with emphasis on use of Taguchi method such as orthogonal table and signal-to-noise ratio (SNR). Finally, the process is applied to the reliability test on the shell of a new type of portable electronic product developed by C Company, verifying that the new process is operable and can reduce test numbers, time and cost while guaranteeing effectiveness of reliability test compared with the traditional approach.

1. Introduction

Reliability test exposes products in natural or artificial conditions to evaluate their performance to ensure that the products can meet the consumer's demand for the reliability with the minimum risk. Nowadays the consumer's demand for product's reliability is more and more demanding in portable electronic industry. The content of the reliability test includes drop resistance, compression, waterproof and dustproof, etc. Besides, test field is widened and test period is lengthened with a rising cost. Enterprises gradually begin to face the fact that how to balance the accuracy and expenditure of reliability test. Therefore, to carry out the test economically and rapidly, it is urgent to propose an improved process.

2. Literature Review

Some research fruits were acquired by scholars in optimization of the reliability test. However, few studies were done specifically on the combination of Taguchi method and reliability test. Lim C.T. and Low Y.J. designed a specific process of drop test of electronic products which attributes drop surfaces to the three axis-X, Y, Z to reduce test times and cost [1]. Chung - Li Hwan, Meng-Ju Lin researched on phone drop test and designed an orthogonal experiment by using Taguchi method to select suitable material of cell phone's LCD screen to enhance its drop-resistance feature [2]. Zheng Chengde, Han Zhijun compared the differences between Taguchi method and reliability test with respect to design ideas, the relationship between quality and cost, design methods and then illustrated the feasibility of combining Taguchi method and reliability test [3].

In all, the study of the combination of Taguchi method and reliability test is not sufficiently discussed. Thus, this paper aims to explore theoretical research and case analysis on the optimization of reliability test based on Taguchi method.

3. Reliability Test Based on Taguchi Method

3.1 Feasibility analysis on combining Taguchi methods and reliability test. Taguchi method uses orthogonal table to arrange experiments. By using SNR as index measuring stability of product quality, we can find out stable and reliable plan to obtain the effect of the lowest cost and minimum quality loss. Furthermore, SNR reflects the stability of the product output characteristic, which reflects product reliability. Therefore, SNR and reliability have much in common. By reference to the orthogonal matrix test method, we can ignore the invalid "noise" to make reliability test leaner. In this way, test cost and test time can be reduced and the effectiveness and accuracy of the reliability test can be ensured. Therefore, Taguchi method and reliability test can be combined.

3.2 Optimized process of reliability test based on Taguchi method.

The process of optimizing reliability test is proposed to include six steps as shown in Fig. 1.

(1) Selecting quality characteristics. Quality characteristics means the the product's function features, which is the indexes to be evaluated.

(2) Finding out all factors affecting quality characteristics. This step is to determine which stress to be tested. Commonly brainstorming method is used to find out the affecting factors.

(3) Arranging test plan.This step is to choose the stress leavels and their conbination.

(4) Executing the test and collecting data.

(5) Analyzing data. One purpose of this step is to measure the growth of product reliability. The other one is to measure whether the stress parameters are proper. Finally, we refine new control factors and level numbers analyzed by SNR.

(6) Confirming the new test plan. By data analysis, we can confirm the optimum combination of new control factors and conduct tests to validate the effectiveness and efficiency of the new test .

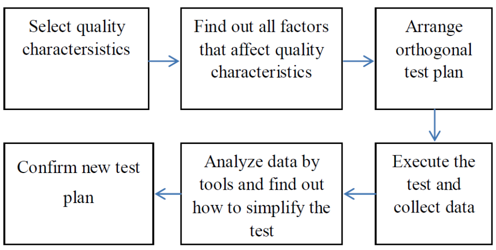

Fig. 1 Optimization flow chart of reliability test

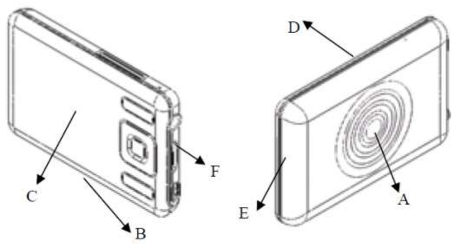

Fig. 2 Drop surfaces in drop test

4. Case Study

This paper takes the reliability test on the shell of a new type portable electronic product developed by C company as an example to validate the feasibility of the new process.

4.1 Selecting quality characteristics. Based on the after-sales service data and product's reliability demand obtained by QFD, drop resistance and compression resistance are selected as quality characteristics. Thus, drop and hydrostatic test are used to conduct reliability test.

4.2 Finding out impact factors. Drop surface, drop height, the pressure value and the indenter size are chosen as the impact factors of the experiment initiatorily.

According to national standards and investigation, we choose 40, 75, 100 and 120 centimeter as drop height. In order to simplifies the test, we only choose six drop surfaces, respectively marked as A, B, C, D, E and F(see Fig. 2). As for the hydrostatic test, the diameters of indenter respectively are 5, 9, 12 millimeter and pressures are 7 kg/F, 12 kg/F and 15 kg/F. Then we combine different drop surfaces with different heights, different indenter sizes with pressure values respectively to test reliability. These tests are conducted 33 times. Each time we selected 10 samples randomly, marked as N=10. When each time's test ends, we count the total sample numbers that don't pass the test because of broken touch screen and so on, marked as Nd. Then survival rate, marked as ω is calculated in each time's test. The test is finished in 3 days and the results are shown in Table 1.

$$\omega = Nd/N \quad (1)$$

Table 1 Results of traditional shell reliability test

Test Number	drop surface	drop height	Drop tests results		Test Number	Indenter size	Pressure value	Hydrostatic tests results	
			Nd	Survival rate				Nd	Survival rate
1	A	40	0	100%	25	5	7	4	60%
2	A	75	1	90%	26	5	12	5	50%
3	A	100	1	90%	27	5	15	6	40%
…	…	…	…	…	…	…	…	…	…
24	F	120	5	50%	33	12	15	9	10%

The results show that survival rate is affected by drop surface, drop height, indenter size and pressure value. Hence, we convince that all of them are impact factors.

4.3 Arranging orthogonal test plan. In this case, different stress levels are considered as external noises. By attributing the "noise" of drop surface to the X, Y, and Z axis, three stress factors are reduced. Survival rates of the 40 cm drop height are all 100%, hence numbers of drop height, as "noises", can be reduced to three. Combining with the orthogonal table, we find that the new test just meet the configuration conditions of orthogonal table$L_9(3^4)$. Furthermore, the paper lists the configuration of every stress factors in the drop test and hydrostatic test. Then the new reliability test matrix is obtained and orthogonal test is arranged.

Table 2 Results of orthogonal test

Test Number	Dropping surface	Dropping height	Indenter size	Pressure value	Tests result	
	A	B	C	D	Nd	Passing rate
1	X	75	5	7	0	100. 00%
2	X	100	9	12	1	90. 00%
3	X	120	12	15	8	20. 00%
4	Y	75	9	15	9	10. 00%
5	Y	100	12	7	4	60. 00%
6	Y	120	5	12	6	40. 00%
7	Z	75	12	12	5	50. 00%
8	Z	100	5	15	9	10. 00%
9	Z	120	9	7	5	50. 00%

Table 3 Mean response table

Level	Drop surface	Drop height	mdenter size	Pressure value
Level 1	0. 7000	0. 5333	0. 5000	0. 7000
Level 2	0. 3667	0. 5333	0. 5000	0. 6000
Level 3	0. 3667	0. 3667	0. 4333	0. 1333
Delta	0. 3333	0. 1667	0. 0667	0. 5667
Ranking	2	3	4	1

Table 4 Passing rates of normal test under various stress levels

Level	Drop surface	Drop height	mdenter size	Pressure value
Level 1	0. 7167	0. 5500	0. 4667	0. 7500
Level 2	0. 4000	0. 5000	0. 5167	0. 5667
Level 3	0. 3500	0. 3333	0. 4167	0. 1667

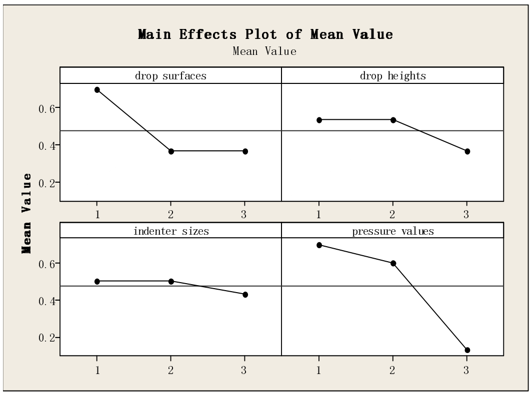

Fig. 3 Main effect diagram of stress factor

4.4 Making the orthogonal test. The test is made 9 times in normal temperature and humidity. Each time we randomly select 10 samples and each sample is made firstly drop test first and then hydrostatic test according to test arrangements in Table 1. Tests are made under the conditions of switching on. When each time's test ends, we count the numbers that don't pass the test and calculate the survival rates. The tests are finished in 1 day and results are shown in Table 2.

4.5 Analyzing data. Because the S/N value is not suitable for calculation from the aspect of survival rate, we use mean value for analysis. The mean response table of stress factors is shown in Table 3; the main effect diagram of mean value of stress factors is shown in Fig. 3. At last, Analysis of Variance (ANOVA) on orthogonal test is calculated. Because all columns of the orthogonal table are occupied, we can use the row in ANOVA table which has the minimum Sum of Squares of Deviations (SSD) as the approximate estimation of error, and the result is shown in Table 5.

According to the classification of orthogonal test, the average survival rate of every impact factors under 3 stress levels in normal test is shown in Table 4. Compared with Table 3, there are small differences in the survival rates of every impact factors under different stress levels between two tests, which prove that the orthogonal experiment has sufficient validate and measure abilities.

According to Table 3 and Table 5, the factor of the static pressure value affects the survival rates most significantly, which is followed by drop surface. While the indenter size and drop height have insignificant influences. By analyzing Fig. 3, we conclude that with the static pressure value increases from 7KG / F to 12KG / F, the mean value of survival rates is not significantly affected. However, when it increases to 15KG / F, the survival rate is greatly reduced.

Table 5 ANOVA table

Variance	SSD	Df	Average of SSD	F	Critical values	Significance	Prefer option
Dropping surface	0.222222	2	0.111111	25	$F_{0.05}(2,2)=19$	*	Y,Z
Dropping height	0.055556	2	0.027778	6.25			
Indentersize	0.008889	2	0.004444	—	$F_{0.0}(2,2)= 9$		
Pressure value	0.548889	2	0.274444	61.75		*	15[KG/F]

4.6 Confirming the new design numbers and test plan. According to the analysis above, we can simplify the test by reducing stress levels of the indenter size and drop height to the highest level, because those two factors have insignificant influence on survival rates. And we can also reduce the stress level of drop surface from 3 to 2 to simplify the test when the new test is designed.

Compared with traditional test, the reliability test based on Taguchi method reduces test numbers, time and cost while effectiveness is guaranteed. The optimized test has appropriate stress intensity and makes enough external noise on samples to guarantee the accuracy of results.

5. Conclusion and Prospect

This paper proposes an optimized process of reliability test based on Taguchi method. And the reliability test on the shell of a new type portable electronic product developed by C Company is taken as an example to validate the effectiveness and operability of the new process.

However, this paper does not consider the application of Taguchi method to reliability test with complex system and the combination of other quality tools in Taguchi method with reliability test. We will do further research in the future.

References

[1] Lim, C.T. and Low, Y.J. Investigating of drop impact of portable electronic products. Electronic Components and Technology Conference. San Diego, CA, USA, pp. 28－31 May, 2002，1270－1274.

[2] Hwan, Chung-Li, et al. Drop tests and impact simulation for cell phones. J. Journal of the Chinese Institute of Engineers 34.3 (2011): 337-346.

[3] Cheng De Zheng, Zhi Jun Han, Taguchi method and reliability design in the development and design of products, J. China Quality, 04 (1999), 29-31.

[4] Juan Xue. Using Taguchi methods to avoid cut-off damage of thin LCD panel, J. Jiangsu Science & Technology Information, 01(2012), 91-92..

[5] Genichi Taguchi, An Introduction to Quality Engineering, China Translation And Publishing Corporation, Beijing, 1985.

[6] Zhi Feng Fan, Xin Lin Qi and Bin Lei，Review of Accelerated Reliability Tests, J. Equipment Environmental Engineering, 02(2008), 37-40.