Super Strict Quality Requirements of the 21st Century and Its Influence on the Industry of CHINA

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Abstract

The famous US quality management expert J. M. Juran pointed out on the American Quality Congress of ASQC in 1994, that the 20th century is a century of productive force and the 21st century would be a century of quality. In the past dozens of years, science and technology have made rapid progress. Take electronic products for example, the non-conformity rate has dropped from 1%(10^{-2}) and 1%(10^{-3}) to ppm (parts per million, 10^{-6}), even to ppb (parts per billion, 10^{-9}). Such a low non-conformity rate can be called the super strict quality requirements of products of the 21st Century. Super strict quality requirements can cause a series of new changes: Therefore, super strict quality requirements are unavoidable to produce significant influences to the industry of the 21st century. This paper analyzed these influences and pointed out that which quality sciences must be paid attention to first.

1. Introduction

Mankind has gained giant achievements in the 20th century, productive force has made remarkable progress and product quality and service quality have been continuously improved. Just as US quality management expert J. M. Juran said on the American Quality Congress of ASQC in 1994, the 20th century will be recorded in history as the century of productive force, and the coming 21st century is the century of quality. Quality will become the theme of the new 21st century, and we must meet its challenge. So that J. M. Juran can make this scientific thesis has its scientific foundation.

In the past dozens of years, science and technology have made more rapid progress. For example, the non-conformity rate of electronic products has dropped from the past 1%(10^{-2}) and 1%(10^{-3}) to ppm (parts per million, 10^{-6}), even to ppb (parts per billion, 10^{-9}). The 3σ Control Principle was implemented in the past, under the state in

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statistical control, its non-conformity rate was 2.7×10^{-3}. Now, we put forward the 6σ Control Principle, under the state in statistical control, its non-conformity rate is 2ppb = 2×10^{-9}, that is, the non-conformity rate has dropped 1.35 million times ($2.7 \times 10^{-3} / 2 \times 10^{-9} = 1.35 \times 10^{6}$), compared with the past! Such strict quality requirements can be called the Super strict Quality Requirements of the 21st Century. Note, recently the Motorola Company advocated the 8σ Principle. But, according to the authors' calculation, it means that the non-conformity rate will again drop 1.61 million times compared with the case of 6σ Control Principle. It is impossible to be realized technologically now, hence the advocating of 8σ Principle is only a psychological call.

Super strict quality requirements caused the following new changes:

1. Quality sciences themselves also need reforming to meet the development of a new quality situation as follows:

(1) Since the 1990s, quality sciences had produced a new branch, that is, the SPC and SPD for near zero non-conformity process.

(2) Modern quality control and diagnosis require more and more precise control and diagnosis, thus more and more stress was paid on MSPC(Multivariate Statistical Process Control) and MSPD (Multivariate Statistical Process Diagnosis), and the application of other advanced statistical methods.

2. We must make great efforts to advocate the application of quality sciences. For example, in the production process, we must stress the application of SPC and SPD, as well as MSPC and MSPD, otherwise, the super strict quality needs cannot be met.

Therefore, the function of quality experts and technological personnel, not only quality management personnel are stressed on the spot. This is a new characteristic under the new quality situation which we must pay full attention to.

3. Under the new quality situation, we cannot only be satisfied on documentarized requirements in the establishment of a quality system but require more to stress its scientification and we need the application of scientific and statistical methods to assure its realization. Particularly, we must implement SPC and SPD, as well as MSPC and MSPD to assure the realization of the prevention principle.

The above-mentioned super strict quality requirements will unavoidably influence the industry of China in the 21st century. This paper will analyze the influence brought by the super strict quality requirements and quality sciences which may be adopted.

2. Influence Brought by Super strict Quality Requirements on the Industry of China in the 21st Century

The important influence brought by super strict quality requirements on the industry of China in the 21st century are concretely shown as follows:

1. First, the technological development of national defense, astronautics, micro-electronics, precise instrument and meter, fine chemical engineering, aircraft industries and other sophisticated scientific and technological departments themselves require the realization of super strict quality requirements.

2. Next the civil departments. Many civil-run trades in China have the trend to gradually enter the scope of super strict quality requirements. For example, the international level of non-conformity rate of compressors, important components of air-conditioners and refrigerators is 200ppm. The highest level is 34ppm for Brazilian EMBRACO Co. At present, although there is a certain difference with the quality of compressors in China, since it needs to take part in the international market competition, it must make efforts in this direction and adopt modern quality sciences to assure product quality.

To sum up, obviously, the 21st century, this quality century will be a challenge for industrial circles in China. Whoever wants to hold his ground on international markets, must meet the needs of super strict quality and produce products reaching world level quality, otherwise it will be difficult to get a foothold on international markets.

3. Super Strict Quality Requirements and Quality Sciences

To meet the super strict quality requirements, we must start from two aspects: one, we start from technology. Take for example, Brazilian EMBRACO, in order to improve the quality of compressors, apart from adopting the most advanced compressor technology, it also completely uses the computer to control the whole processing process to assure that the processing operation is absolutely correct. The other, in order to assure the realization of super strict quality requirements, it must also use advanced quality sciences. For example, in the processing process, use the SPC and SPD for near zero non-conformity process, as well as MSPC and MSPD and other quality sciences to assure product quality. Now we introduce them briefly as follows.

First, take the SPC and SPD for near zero non-conformity process. This is a new quality science just born in the 1990s. Now electronic science is making rapid progress. The non-conformity rate of electronic part requires even as low as 20ppb (2×10^{-9}). For such a low non-conformity rate, a normal SPC technology has not been suitable and requires developing to SPC and SPD of near zero non-conformity process. This newest

branch of quality science is now in the preliminary development stage of SPC and is not yet mature. Dr. Jing Sun have already been engaged in this research work and obtained certain achievements. For example, Dr. Jing Sun had proposed the criterion of statistical control and the criterion of abnormality for the near zero non-conformity process, the geometric CUSUM chart control method and geometric EWMA chart control method and the universal adjusted p chart etc.

Next, there are relatively many achievements in the MSPC, but very few in the MSPD, particularly fewer in theories to be able to solve practical on-the-spot problems. In 1996, Prof. Gongxu Zhang proposed the multivariate diagnosis theory with two kinds of quality which have solved the MSPC and MSPD problems of multi-operation and multi-index system . Prof. Gongxu Zhang also developed the Software DTTQ2000 according to the above theory and it has been put to use. The Xinhua Pharmaceutical Co. Ltd. in Shandong Province, the Dongguan Shengyi Laminate Copper Plate Co. Ltd. and Bubugao in Guangdong Province and other units have adopted this software to implement on-the-spot computer quality control and diagnosis. According to statistics of the Xinhua Pharmaceutical Co. Ltd., one diagnosis only takes 1 to 2 minutes. The diagnosis is not only correct, but also greatly shortens the time for training on-the-spot diagnosis personnel. Only one kind of analgin medicine can increase the benefit of 36000 US dollars per year. In 1998, Prof. Gongxu Zhang again proposed a new multivariate diagnosis theory of regressive uni-factor method, which not only greatly simplifies the multivariate control and diagnosis, but also makes a series of multivariate diagnoses problems easy to be solved.

Some practical case studies using the software DTTQ 2000 will be shown in the following paragraph.

4. Practical Case Studies Using the Multivariate Diagnostic Software DTTQ 2000

Case Study 1: Assembly-Type Enterprise

In an electronic switch factory, the electronic switch has 14 parameters, which are checked and recorded automatically by a computer. Since the quality of the product is very good, it sells very well on market. But, the quality manager of this factory is much worried about this point, since the quality of the electronic switch is so good that he technical engineers of this factory cannot find out non-conforming ones from their products, and all products are sold out on market. Thus, if there is any problem, it must be happened in their user's place, i.e. in a factory. On 13th of June 1999, the

authors were just training the engineers of this electronic switch factory, at last, the authors suggested the quality manager to check their products by using the multivariate diagnostic software DTTQ 2000. To their astonishment, the authors found out 6 electronic switches abnormal from 98 electronic switches (the nonconforming rate is 6.1%!) recently produced checked by using DTTQ 2000. Why did the authors can find out so many abnormal electronic switches while the technical engineers of this factory cannot? The reason is not difficult to understand, the software DTTQ 2000 checks the electronic switches according to a multivariate viewpoint considering the correlation between parameters of the electronic switches while the technical engineers of the factory check the parameters of the electronic switches only one by one, thus they cannot consider the correlation between parameters. To discuss this problem more concretely, in order to check an electronic switch, the technical engineer checks 14 parameters of the electronic switch only one by one, i.e. he checks only 14 averages (μ_i, i = 1, 2, Λ14).

But, the software DTTQ 2000 will check 14 averages, 14 standard deviations (σ_i, i = 1, 2, Λ, 14) and 91(14 13/2=91) covariances (S_{ij}, i ≠ j, i, j = 1, 2, Λ, 14), i.e. checks altogether 119 (14+14+91=119) parameters.

Comparing the number of parameters checked by the DTTQ 2000, 119 and the number of parameters checked by the technical engineer, 14, it is 8.5 times (119 14=8.5), especially, the 91 parameters of s_{ij} reflecting the correlation between parameters are not checked by the technical engineer even by one, this is the reason why the DTTQ 2000 can find 6 abnormal ones from 98 electronic switches while the technical engineers cannot find any one abnormal. Figure 1 shows that 6 abnormal electronic switches found by the DTTQ 2000, and Table 1 shows the diagnoses that which one or which ones of the 14 parameters caused the abnormalities of the abnormal electronic switches.

This case study has a general meaning that

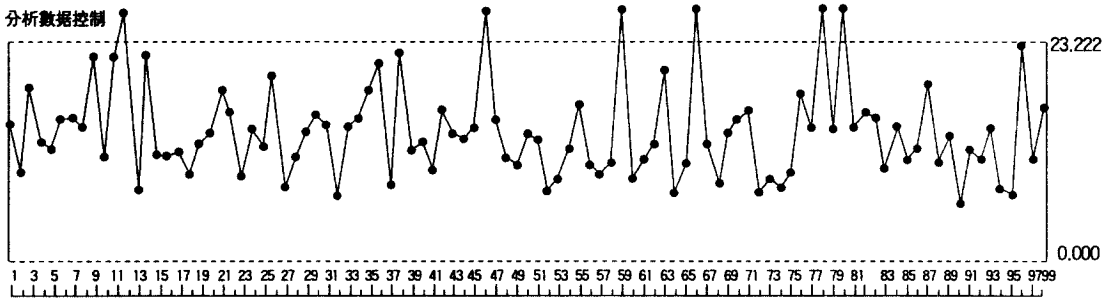

Fig. 1 Diagnosis of electronic switch with DTTQ 2000

Table 1 Diagnosis of abnormal electronic switch with DTTQ 2000

No. of Electronic Switch	Diagnosis of parameters which caused the abnormality of the electronic switch	Note
#12	#12	
#46	#2	
#59	#12	
#66	#11	It is an assignable cause about correlation
#78	#14 #8	This abnormal electronic switch has two assignable causes about correlation simultaneously.
#80	#7	

Note: The assignable cause about correlation denotes that the variation of this cause cannot maintain the variation among parameters during the state in statistical control.

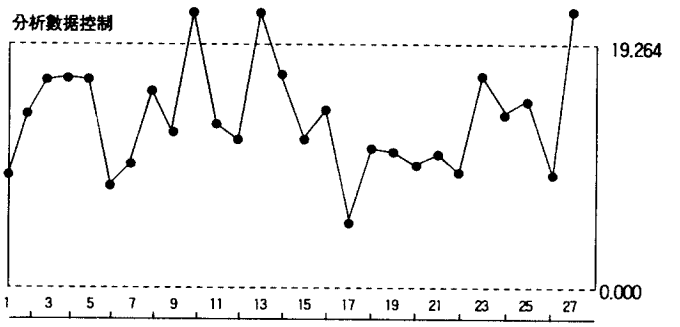

Fig. 2 Diagnoses of the weaving operation using DTTQ 2000 (there are 3 points plotted outside UCL denoting 3 abnormal lots)

Table 2 Diagnoses of assignable causes causing the abnormal lots using DTTQ 2000

No. of abnormal lot	#10	#13	#27
Lot number of production	970128	970208	970325
Assignable causes diagnosed by DTTQ 2000	The sixth parameter of the current operation is an assignable cause.	The third parameter of the current operation is an assignable cause about correlation.	The second parameter of the preceding operation is an assignable cause about correlation.

any assembly type enterprise can follow this case study to check their finished product or semi-product using the multivariate diagnostic software DTTQ 2000.

Case Study 2: Flow-Type Enterprise

This is a multivariate diagnosis of the weaving operation of a glass fiber factory.

There are 7 parameters of the weaving

operation and 7 parameters of the preceding operation. Fig. 2 and Table 2 show the diagnoses of the weaving operation.

This case study also has a general meaning that any flow-type enterprise can follow this case study to use the multivariate diagnostic software DTTQ 2000 to diagnose its abnormalities conveniently.

4. Conclusion

To sum up, we may come to the following conclusions:

1. The 21st century will be a century of quality, which puts forward super strict quality requirements. This is a challenge whether to industrial circles in China or the world.

2. In order to meet the super strict quality requirements, undoubtedly, we should first adopt the most advanced related technology and next, at the same time, adopt the most advanced quality science. Advanced technology and advanced quality sciences, these two are like two wheels of a motorcycle. In order to reach the super strict quality requirements, either of these two wheels should not be short.

3. In the 21st century, quality sciences will be greatly developed. These are the requirements of the quality century. We may anticipate that the following quality sciences will make rapid progress and we may give priority to develop them first:

(1) SPC and SPD for near zero non-conformity process.

(2) MSPC and MSPD.

(3) Combination of APC(Automatic Process Control) and SPC. This also belongs to the so-called SPA (Statistical Process Control Adjustment which is also called ASPC in western countries) stage. Thus, SPC, SPD and SPA together constitute a closed cycle, it can circulate along this cycle again and again, By each cycle means that we improve the quality once.

References

1. Zhang, Gongxu (1992): *Cause-Selecting Control Charts and Diagnosis*, The Aarhus School of Business, Denmark.
2. Zhang, Gongxu (1998): "70 Years of Quality control and Diagnosis", in Chinese, *Taiwan Quality control Monthly*, 5, 1998.
3. Zhang, Gongxu et al (1998): "50 years of Multivariate Quality Control and Diagnosis", in Chinese, *Shanghai Quality*, issue 5-6, 1998.
4. Sun, Jing and Zhang, Gongxu (1998): "Criterion of Statistical Control and Criterion of Abnormality for Near Zero Non-Conformity Process", in Chinese, *Journal of Beijing University of Science and Technology*, 4, 1998.
5. Sun, Jing (1998): "Geometric CUSUM Chart Control", in Chinese, to be published in *China Quality* in 1998.
6. Sun, Jing (1998): "Geometric EWMA Chart Control", in Chinese, *Quality and Reliability*, No. 12, 1998.
7. Sun, Jing (1998): "Universal Adjusted p Control Chart", in Chinese, *Shanghai Quality*, 12, 2000.
8. Jing Sun and Gongxu Zhang (2000), "Control

Charts Based on the Number of Consecutive Conforming Items between Two Successive Nonconforming Items for the Near Zero-Nonconforming Processes", Total Quality Management 2000, Vol. 11, No. 2, pp. 235-250. Quoted by *Quality Control and Applied Statistics* and indexed by SSCI.

9. Sun, Jing and Zhang, Gongxu (2000): "Standards of Conventional Control Charts and its Applications", in Chinese, China Standards Publisher, 2000.