

# SURVEY RESEARCH ON CONTINUOUS QUALITY IMPROVEMENT SYSTEM\*

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**Abstract:** Continuous quality improvement (CQI) has been promoting progresses of the social, and which is being studied and applied in much more widespread area at present. This paper systematically studies and reports research results of continuous quality improvement, involved in several key viewpoints of CQI such as the background of management and engineering philosophy on CQI, the objectives of CQI, the ways to implement CQI, the objects of CQI based on process. In terms of management methodology, the results of discussion on Benchmarking & CQI, standardization management and its certification & CQI, TQM pyramid & CQI and self-assessment & CQI etc. are reported. In quality engineering field, CQI culture of variation reduction is presented. Actually this paper is a comprehensive research project report of "Continuous Quality Improvement System", supported jointly by NSFC and KOSEF.

**Key words:** Continuous improvement, Quality management, Quality engineering

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## **I. Background of Engineering & Management Philosophy on Continuous Improvement**

Continuous improvement is not only the focus of the research and application of modern quality science, but also the interesting main subject of the quality scholars and engineers. This paper firstly studies the background of engineering & management philosophy on continuous quality improvement, and indicating the relationship between the two of backgrounds.

Engineering background is originated from new Quality Loss Principle. The old or traditional Quality Loss Principle says: "The products/service within the specifications are quality products/service, and the quality loss are zero; only the products/service beyond the specifications just cause quality loss, namely which are defects." The new Quality Loss Principle stems from variation theory, and summarized from engineering practice: Frequent innovations and changes or variations arouse the human being's vigor, and making the human society progresses. However, once these changes (or variations) infiltrate production process, it will become the enemy of quality, and being the root cause of the defects. Therefore we should decrease and control the variation of production processes to improve the quality of the final product/service. The theories and practices of engineering both summarize the new Quality Loss Principle as follows: "It is the variation around the target value (nominal value) that results in quality loss. As long as there exist the variations, quality loss must happen. The greater the variation is, the greater the quality loss is, the ideal status is zero variations, namely, the products or parts just hit the exact value of the designed target". Anyhow, this is only an ideal and remote objective that can never been realized, because the variations are caused by random factors. As it's known, wherever and whenever we are, no matter how advanced the science technology is, it is always impossible to absolutely cancel the random factors. We may only gradually reduce or be blunt the random factors so that the variations could be decreased. We can never thoroughly do away with them. Hence the target of zero variation is only an ideal limitation. In order to improve quality, we should reduce the variation toward to zero variation objective, which is remote, never reached at the zero point. This case leads us continuously to reduce the variation, namely continuous quality

improvement, toward the zero variation, the remote, never realized but ideal objective. This is the engineering background of continuous quality improvement. In terms of CQI, there are several ways, such as quality management, quality engineering, technology innovation, etc. In fact, this kind of quality improvement also contains cost reduction

The management philosophy of CQI is originated from the summons of market competition. The concept of quality has evolved into "Satisfying the customers" from "meeting the specification". This is a revolution in management ideology. People's satisfaction is dynamic. It is this kind of dynamic requirement of customers that enforce the society continuously in progress. Therefore we say that the satisfaction is relative, especially under the condition of current market economic system. Because of the fierce competition and rapid development of advanced technologies, a product/service may satisfy with customers today, but may be discarded by customers tomorrow. The enterprise should satisfy the customers forever to keep and increase the market share or competition edge. In order to satisfy with marketplace or customers forever, continuous quality improvement and reduction of cost both will become the first of all. This is the management philosophy of CQI.

Whatever the origins of engineering or management background of CQI are, the final result must be only one, which must satisfy the customers. The continuous development of human society is based on continuous improvement of all work we have been doing. The target of CQI is to continuously satisfy with the marketplace, and the core of that is to continuously minimize the cost and enhance the quality.

Many world-class companies have made CQI as the foundation of their corporate cultures, such as Motorola, GE, Boeing, etc. As one of the world's leading providers of electronic components, systems and services, Motorola ranked 4<sup>th</sup> on Far Eastern Economic Review's 200 Asia Leading Companies in 1994, and ranked by Fortune magazine as the 4<sup>th</sup> most admired in the USA in 1995. They won other quality awards against the toughest competitors in the industry. Its business truth is that "CQI is everybody's responsibility. Quality means everything." Quality is a daily priority and a personal obligation for everyone at Motorola. The pursuit of quality has become the most important part of the corporate

culture. Unless everyone can point to his or her own personal improvements in quality the company hasn't reached the level of commitment that's absolutely essential for success. Only through Empowered, Cross-Functional Teamwork can achieve continuous success, and continuously strives to Streamline their operations and eliminate Non-Value-Added Processes.  $6\sigma$  (six sigma) is a basic target based on zero defects per million manufactured parts. At present they are hitting 99.9996%, which is so close to perfection that they are now using a parts-per-billion measure for defects. According to Motorola's management philosophy, perfection is measured only by the limits they continuously set upon themselves.

Among the five elements of Total Quality Management (TQM), CQI takes the No.1 position and has become the focus of the idea and method of quality management as well as quality engineering technology.

## **II. The Target of Continuous Quality Improvement**

To clarify that total quality is the target of CQI, it will be necessary to illustrate the evolution process of the quality concept. The concept of quality has experienced a couple of breaking-through, and each time has carried forward the development of the society and economics. Traditional definition of quality says: "meeting the specifications or tolerance of the engineering, otherwise defectives." Actually this definition is originated from engineering background, which is called objective quality. In one of his speeches in Japan at early 1950s, Dr. Deming, who was from Operations Research Center of Massachusetts Institute of Technology, USA, initially introduced Statistical Quality Control Technology to Japan. What's more, he brought the Japanese the concept of Subjective Quality: "Quality is to meet the customers' expectations." His theory encouraged that all the Japan enterprises had been working toward the customers' satisfaction throughout the whole processes of management or engineering. The requirements of customers are exactly the needs of market. The concept of "Subjective Quality" seems so simple that everybody could easily understand it, but as to those years, this new concept was a really

revolutionary idea. It fits in with the rule of economic development under the market competition. This new concept plays a key role for Japan's economic prosperity. It is also the reason why the National Quality Award of Japan was named as Deming quality Award. With the rapid development of scientific technology and market competition, as well as the continuous pursuit of the people's desire, a products/service may satisfy customers currently, but it would be forgotten tomorrow. Therefore the concept of Dynamic Quality appears "Quality means continuously satisfying the customers." which has become the root source of CQI corporate of many world class companies culture. To satisfy the customers, quality itself is far away from enough. Only with both high quality and reasonable price can the products satisfy customers indeed. However, the price depends on the cost. The so-called reasonable price means the price depending on the full-utilized practical cost. European experts called this kind of quality under low cost as "Total Quality". To be worth declaiming, Total Quality is not the result of summation with the quality of basic research, R&D, design, manufacturing, after-sale service and other aspects of the whole process, instead of the simultaneous combination of high quality and low cost. Total quality emphasizes on the concept of economics.

### **III. The Ways of Continuous Quality Improvement To The Total Quality**

Continuous quality improvements are essential to any company's future development and survival. Total quality reflects business potential character of the enterprise in terms of micro-view, and also economic potential quality of the nation from macro-view. Principal part of modern quality science is CQI, or Total Quality Improvement with minimized cost. In the field of quality improvement, there has been a dispute between quality scholars and engineers for a long time, especially between the theories and enterprise practices in China. The disputable focus is that: Which department causes quality improvement, the quality or the engineering? This problem brings about fussiness in the research of related subjects, and even the problem of resource allocation. Hence we put forward the three levels theory of quality improvement, namely quality management, quality engineering and technologies

innovation. This division has won general confirmation and approval of international colleagues from Europe and USA. The theory analyzes in detail the different contributions that quality department and engineering fields have accordingly made in CQI. Technology revolution or innovation means introducing new energy and new materials, developing the latest advanced technologies, reengineering of various processes, reforming of manufacturing organization structures by such concurrent engineering. Reengineering itself is a reflection of technology revolution. Technology revolution or innovation will doubtlessly bring about quality leap, usually quality revolution. Generally it belongs to the area of engineering. However, the antecedent condition is high cost or investment. We should continuously grab potentials by quality management and quality engineering techniques after technology innovation, continuously reduce variation and improve quality. The common character of quality management and quality engineering technology in quality improvement is low cost or free. Only from this way can we produce competitive products with high quality and low price. Japanese bought monopolies from the West, and then return the products made in Japan to the Western market. It is because Japanese had paid much attention to CQI by the tools of the two levels of quality management and quality engineering, and at last got products with high quality and low cost. Compared with Japan, the Western countries including USA did less. They spent more on expensive technology development instead of the application in CQI of the two cheaper ways. In fact, technology innovation is a breakthrough of quality, a course of qualitative change, while quality management and quality engineering are the gradual improvement of the quality and cost, the courses of quantitative change. The infinite cycles of "quantitative change" and "qualitative change" is the way to the excellent enterprises.

Since 1980s, This situation has changed. Western countries learned quality management and quality engineering from the Eastern Asian countries, and changed their direction from general technology innovation to total aspects including statistical control, quality management, quality engineering and technology innovation. China's academic circle and enterprises area especially those joint companies also awoke. NSFC (National Science Foundation of China) has listed quality management and quality engineering as one of the national key

and important projects. The Slogan, "Quality Prosper Nation", stressed the importance of research and application of quality management and quality engineering again... In a word, quality management and quality engineering are long-term methodology to the Total Quality Improvement.

#### **IV. Processes-Oriented and Continuous Quality Improvement**

What's the object of CQI? According to the principle of treatment in upper-stream and prevention at first, CQI must be based on the production processes. An enterprise is a complicated system engineering. Anyhow, any enterprise is composed of various processes. These processes may be abstracted that is to say, in the beginning part there are input and suppliers, and then working activity with the output and customers, which is defined as general process. Any enterprises consists of various processes. While the quality process is the process with lower cost and minimum variation, and any activities in the process must be value-added. CQI will change all the process especially key processes into the quality process. The enterprises would be world-class company. Usually the process can be divided into two categories: one is management process, and the other is engineering process. Generally the quality improvement on engineering process is of much more intuition. But the improvement on management process is much more effective and significant. If all the processes especially the core processes are the quality ones, the enterprise will get an excellent business behavior. This is why process is emphasized so much on the National Quality Award models and ISO 9000 family. CQI focus mainly on the process!

#### **V. Benchmarking and Continuous Quality Improvement**

Benchmarking is a method of continuous quality improvement based on process with the aim at total quality. There are various techniques to improve the quality, among which the information exchanging and various comparisons focusing on two key characteristics, quality and productivity or cost are the most effective ways. Benchmarking

is originated from Rank Xerox in 1960s with a philosophy of Sunzu's war arts book. The core idea is "if you know your enemy and know yourself both, you don't fear the results of one hundreds of the war".

American productivity Center gives it a definition as: Systematically measure yourself and your competitor, and make effective improvement and competition strategy based on the information acquired. In the process of benchmarking, there are two basic indexes for comparing. One is quality comparison, and the other is productivity, namely, to some extent, cost. Processes are usually the objects of the comparison and improvement. Quality index may be described as the number of defectives or defects, the degree of variations, and so on. Productivity index or cost index may be chosen as storage period, labor hour and space to be taken, etc. Comparison in processes would use various indexes of quality and cost. It depends. The core of Benchmarking is to find out the root cause of the poor quality and high cost, and then improve that corresponding to the cause, which is a recycling and unlimited process of continuous improvement.

## **VI. Standardization Management and Its Certification, The Milestone of Continuous Quality Improvement**

Standardization family is a summarization of the successful experience, and also the base of further improvement, one important part of quality management. The ISO 9000 family is of significant affection in the world wide, and many of enterprises were certified with the ISO 9000 family. A number of quality certification bodies are founded in Mainland of China and Hong Kong. However, academic circle and government departments should understand ISO 9000 correctly and completely, so that they can guide certification and further quality improvement to enterprises. Firstly, ISO 9000 is not a unique quality standard system. In fact, almost each world class enterprise has its management standardization systems. Some world-class companies such as Boeing has innovated its system as D<sub>1</sub>-9000 by adding (AQS) Advanced Quality System to the previous D<sub>1</sub>-8000A systems so as .to get competitive edge with the Air Bus. Boeing enacts this standard for its suppliers of all over the world, similar to ISO 9002. Recently Ford, GM



and another company from U.S.A. regulated a QS-9000 for automobile industry, while D1-9000 and AS-9000 are mainly used for Aviation and Aerospace industry, and ISO 9000 family are generally used various areas. All of these are the same in principle, but different fields result in different features. Japanese is very well known for their specialty in management, therefore almost each Japanese venture have its own standardization system, which is not worse than Europe and America. Why did they also adopt ISO 9000? The Standardization Association of Japan explained that they adapt ISO 9000 mainly for the development and maintenance of the market share in the world, especially in Europe. Since ISO 9000 can be used in all kinds of businesses, it is proved that ISO 9000 must be abstract and rough. Details and supplements to the business features are quite necessary for the companies to be certified. It's absolutely wrong for some companies to regard their products as internationally advanced products as long as they finished the certification of ISO9000. Having acquired ISO 9000 certification can only show that you've done the basic jobs in quality management. For the further total quality improvement, there are still a great number of detailed jobs to do. ISO 9000 is generally regarded as the new starting point of the journey of quality management. Those companies still have to continuously improve quality after certified by TQM philosophy and methods as well as quality engineering techniques. Certification does not mean the termination of quality management but a new start of continuous quality improvement at a higher level. In fact, we still need to enrich and improve the certified standard after acquiring and summarizing new experience.

## **VII. Continuous Quality Improvement and TQM Pyramid**

TQM Pyramid depicts the most important five elements, and also indicates the innovation of the current management principle, in which the element, continuous quality improvement, is of the most significant position.

In the 1980s earlier, the former president of Panasonic, Konosuke Matsushita, answered the reporters of the Western world "we are going to win the Western industry, you must lose out, there is nothing for that.

Because the failure cause is

Due to yourself, your companies are based on Taylor Model; the worst thing is to establish on the heads of the bosses. The employee has to do things according to the thinking of the bosses, and you believe that what you are doing is correct." He still said" we are beyond the Taylor Model, as we very much know, the current environment of business is very complicated, in the competitive circumstance the survival and development of the companies must rely on aggregating of a bit intelligence of employee and utilizing of that, for us, the core

Of management is just to collect all intelligence of total employee to contribute to the company. For the challenge of new technology, we know that much more what you know, which could not be successful only depending on few of capable persons in company, although they are appeared quite smart some time. Only are the company to aggregate the all intelligence of the whole employee to make effort for the company, the company is going to survive well, and getting the opportunity made in progress." Actually the Taylor model belongs to the ruler or control type, which is divided into three levels, such as the upper, middle

And lower levels, the top level strictly control middle level something like military system, the same way is transferred from the middle to the lower. The old management pattern is not good at communication of various levels, and information exchanging as well as motivating to employee. If top level do not hold enough information and data, it will be difficult for leader to make right decision. The new one is very different from the old model, which is service mode of management, and which is very easy for the management collect sufficient information of various levels and motivate ardor of employee, aggregating intelligence so that the management make correct decision, in which it will be of significance that quality is improved and the cost is reduced continuously. Regardless of the Taylor or service mode, the structure is of several levels with a tower, so quality circle calls that Quality Management Pyramid. Some European quality management experts proposed the total quality management pyramid, in which the five key elements of total quality management are put on, based on the type of service mode.

The five key elements of total quality management are as follows: leadership, everybody participation, focus on facts, continuous

improvement, focus on customers. The leadership is located in bottom of the pyramid, which indicate the innovation mode of the management, the other four of elements are put on the four of side faces, which express the close and reasonable combination of the innovation mode and total quality management, in the following phase the position of continuous improvement will be discussed.

China's systems of socialist marketing economic must depend on marketplace, namely focusing on customers and satisfying customers. In the intense competition environment of marketing with the rapid development of technology, the requirement of customers have been changing with the dynamic society, in order to satisfy the customers, the continuous improvement must be requested to keep or develop the competition edge of marketing. How do we perform the continuous quality improvement? The first one is to **focus on facts** and data used in continuous improvement so as to **satisfy customers**. In both collecting data and improving quality, **everybody** should **participate** those activities. Every employee are involved in certain process, either engineering process or management process, all of the processes hope to become the quality processes, which means less variation and without waste as well as adding-value activities, each employee will play an important role in **continuous improvement** of the process. In terms of the above everything to implement continuous improvement, the assurance of **leadership** must be key factor. From the above discussion, the continuous improvement is of the most significance in TQM pyramid.

## **VIII Continuous Improvement and Diagnostic System Based on Quality Evaluation Model**

There is close relationship between evaluation systems of quality and continuous improvement, especially for business performance improvement of the whole company, the evaluation mode is much more important. The typical mode of the evaluation systems is the quality award model. Almost all countries established their national level quality award; especially those of developed countries such as Deeming Award of Japan, Beluga Award of US and European Quality Award as

well as the various national quality award of each country in Europe. Quality Award is of very important role in reducing cost and variation both, and also speeding up National Economics growth. However China's National Quality Award has experienced a difficult history. What is the reason? Generally speaking there exist some misunderstanding in basic problems, which not only happen to enterprises, but there exist some problems to some extent in academic circle and government department. From the national quality award existed, we can see, the framework of them almost are the same because of communication and learning each other. For example, The European Quality Award consists of nine blocks, which are leadership, people, policy and strategy, resource and processes, in which those five of elements form the conditions or cause of enterprises success, or system factors. Based on the system factors, the results of people satisfaction, customer's satisfaction, and effect on society and business results will be rated. Actually any quality award can be divided into two parts, the one of that is conditions, and the other is result part. Of cause it could be regarded as three parts with the process part, which in fact function a transformation bridge from conditions to results. It is just reason that the process is emphasized on Quality Award Models and ISO9000 standardization family both. Recently China is regulating new quality award mode, and also refers to ready model of other countries. In some developed countries, the quality award model were utilized and operated well, which really promoted national economic growth, obviously the quality awards was regarded as a quality assurance model in these countries and really become a efficient and effective tool for comprehensive improvement of business behavior of companies. In China, some related people misunderstood that the quality award is a golden medal and reputation, that is wrong way. In terms of the quality award, some aspects are much more effective comparing with ISO9000 family, ISO9000 stressed on very much process element, instead the quality award not only focus on the process but also pay much attention to business results and comprehensively consider effect-factor systems of an enterprise, which is big difference from ISO9000 family. It is our suggestion that quality award should be regarded as a quality assurance model, enterprises should take quality award as an improvement criteria to reduce cost and enhance quality, whether you apply for that or not, you may frequently make use of quality award model to do self-

assessment and the diagnostic, continuously improve your potential character of enterprises, finally meet the standard awarded with the quality award model.

## **IX Role of Quality Engineering in Continuous Quality Improvement**

A effective way to implement total quality improvement is quality engineering, which is recently arose new area, and proposed by Dr. Taguchi, but too narrow meaning from him, only involved in Taguchi Method. Today the concept of that has been spread and generalized, we may say that quality engineering is located within between quality management and engineering technology. The main stream of quality engineering is control and reduce the variation in the whole process of the made products, which is determined by new quality loss principle. Traditional quality loss principle thinks “ only the products beyond the specifications just result in quality loss, any products falling within the tolerance lose zero”. The theory and practice of engineering all prove that” as long as deviate from the nominal value, the loss of quality must be caused, and the greater the quality loss is, the farther the deviation is from nominal value, only the products which exactly hit target value are of zero loss .” The new quality loss principle indicate that variation must be reduced as maximum as possible so as to reduce cost and enhance quality. Therefore the variation reduction become an alternate alias of quality improvement. The 6  $\sigma$  culture of Motorola company is just based on this new quality loss principle. 6  $\sigma$  means the output of the process almost all fall within the Tolerance, the defectives rate is less than 0.00018/ PPM, usually almost all hit, at least very near, target value. Therefor the 6  $\sigma$  suppliers will not be inspected. The 6  $\sigma$  culture are not only used in engineering processes but also very successfully employed in management processes, in which the achievements in management process much more significant comparing with engineering processes. Many companies are studying the 6  $\sigma$  culture of Motorola, as such GE company. Boeing Company has been performing the continuous improvement culture exceeding 6  $\sigma$  in

theory. Obviously the variation of the process with  $6\sigma$  has been enough less, but the objective variation of continuous quality improvement is going to be zero, that is,  $\sigma=0$ , in other words exact 100% measurements hit the target value. The continuous quality improvement culture of Boeing can be described: the remote target of Boeing is that variation=0, as long as possibility exists, every people should make effort to reduce variation continuously toward to zero objective. How do we reduce the variation to improve quality and reduce cost? The technology, we are employing, for continuous quality improvement is called robust design, which is main body of quality engineering. The principle of robust design is as follows: by adjusting the parameters of the process, the output of process will be insensitive to random factors, and then the variation is going to be lessened. In this field, many research achievements have been obtained.

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