A survey for research and application of quality science in CHINA*

Jichao Xu
Research Department for Quality Engineering
Zhengzhou Institute of Aeronautics
Zhengzhou, 450052, P. R. China
Tel. 86-371-8986633ext.5011, 86-371-8798129
Fax.86-371-8889638
Email: jxu@zzia.edu.cn

Abstract

Quality science may be defined as the subject promoting both quality and productivity, which may include quality management, quality engineering and technology innovation. The research and application of quality science have been in existence for many years in China. This report first reviews its recent history as well as the analysis of the status quo. Finally, a prospectus and comments section for the future of quality science points out the development trends and its significant effectiveness on China's modern economics.

Key Words : Quality Science, China, Economy Development

1. Introduction

"Total quality" is the target on which quality science has been working, which may be necessary to illustrate the evolution of the quality concept with the "total quality". The meaning of quality has had a couple of break-through, and each time, it has carried forward the development of the society and economy. Traditional definitions of quality says: "Quality, is meeting the specifications or tolerance set by engineering, otherwise the product is defective." Actually this definition originated from an engineering background, referred to as objective quality.

In one of his speeches in Japan in the 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 introduced the concept of subjective quality: "Quality, is to meet the customers' expectations." His ideology encouraged Japanese enterprises to work towards customers' satisfaction throughout the whole processes of

* This report was sopported by National Science Foundation of China No. 79870100 and No. 700072029 and Aeronautics Science Foundation of China No. 97J55002.

management or engineering.

The requirements of customers are exactly the needs of the market. The concept of "Subjective Quality" seems so simple that everybody could easily understand it, but during that period this new concept was quite revolutionary idea. It fitted in with the rule of economic development under the market competition, and as a new concept, it played a key role in Japan's economic prosperity. It is also the reason why the National Quality Award of Japan was named as the Deming Quality Award.

With the rapid development of scientific technology and the market competition, as well as the continuous pursuit of the people's desire, products/service may satisfy customers today, but it would be forgotten tomorrow. Therefore the concept of Dynamic Quality appears "Quality means continuously satisfying the customers" which has become the root of business culture of many world class companies.

To satisfy the customers, quality itself is far away from good enough. With both high quality and a reasonable price, the products should satisfy customers indeed. However, the price depends on the cost. The so-called reasonable price means the price depending on the fully-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 various stages such as foundation 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 the concept of economy. Quality science has been aiming at attaining the objective of Total Quality.

2. The Ways to Total Quality

Total quality reflects the characteristic of an enterprise in terms of micro-view, and also the potential economic feature of the nation from macro-view. A principal part of modern quality science is Continuous Quality Improvement (CQI), or Continuous Total Quality Improvement. In this field, there has been a dispute between quality scholars and engineers for a long time, especially between the theory and the enterprise practice in China. The disputable focus is based on this: which department causes quality improvement, the quality department 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 technology innovation. This division has won general confirmation and approval of international colleagues. 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, re-engineering of various processes.

Technology innovation will doubtlessly bring about a quality leap, usually quality revolution. Generally it belongs to the area of engineering and technology. However, the antecedent condition is high cost or high investment. We should continuously grub potentials by quality management and quality engineering after technology innovation, continuously reduce variation and improve quality. The common character of quality management and quality engineering in quality improvement is low cost or free. Only from this way can we produce competitive products with high quality and low price. The Japanese bought monopolies from the West and then returned the products made in Japan to the Western market. It is because Japanese had paid much more attention to CQI through the tools of the two levels of quality management and quality engineering, and getting products with high quality and low cost. Compared with Japan, the Western countries, including USA, did achieve far less. They spent much more on expensive technology development instead of the application in CQI, the two of cheaper ways.

In fact, technology innovation usually results in breakthrough of quality, a course of qualitative change, while quality management and quality engineering are the principal ways of quality and cost improvement, the course of quantitative change. The infinite cycles of "quantitative change" and "qualitative change" is the right way for business excellence of enterprises.

Since the 1980s, this situation has been 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 especially those joint ventures also awoke. NSFC (National Science Foundation of China) has listed topics of quality management and quality engineering as one of the national key research areas. The slogan, "Quality Prospers the Nation of China", stressed the importance of research and application for quality management and quality engineering again... basically, quality management and quality engineering are long-term methodologies for Total Quality Improvement.

3. Background of Engineering & Management Philosophy on Continuous Improvement

Continuous improvement is the focus of research and application of modern quality science. We firstly study the background of engineering & management philosophy on continuous quality improvement and then show the relationship between the two backgrounds.

The engineering background originates from the 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 is zero; only the products/service beyond the specifications cause quality loss, namely those with defects." See Figure 3.1(a), old quality loss principle.

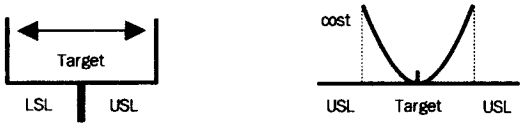

Fig. 3.1(a) Fig. 3.1(b)

Fig. 3.1 Quality Loss Principle

The new Quality Loss Principle stems from variation theory, which is summarized from engineering practice: Frequent innovations and changes or variation create human being' s vigor and promote the human society progress. However, once these changes (or variations) infiltrate production processes, it will become the enemy of quality, and be the root cause of defects. Therefore we should decrease and control the variation of production processes to improve the quality of the final products/ 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 variation exists, quality loss must happen. The greater the variation, the greater the quality loss." Ideal status is zero variation, namely, the products or parts just hit the exact value of the designed target. See Fig. 3.1(b), new quality loss principle. This is only an ideal and remote objective that can never be realized, because the variations are caused by random factors.

As it is well known, wherever and whenever we are, no matter how advanced the science and technology are, it is always impossible absolutely to cancel the random factors. We may only gradually reduce or be blunt the random factors so that the variation could be decreased. We can never thoroughly do away with them. Hence the target of zero variation is only an ideal objective.

In order to improve quality, we should reduce the variation toward the objective of zero variation. We know that we will never reach the zero point. This case leads us continuously to reduce the variation, namely continuous quality improvement, toward the zero variation, the remote, never reached but ideal objective, see Figure 3.2, continuous quality improvement.

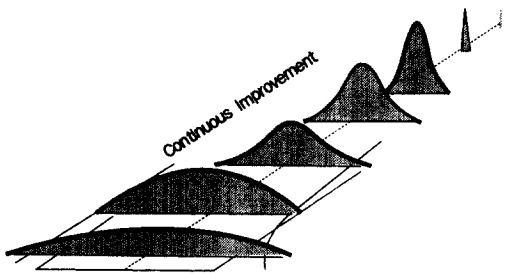

Fig. 3.2 Continuous Variation Reduction

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 from the summons of market competition. The concept of quality has been evolved into from "meeting the specification" to "satisfying the customers". 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 to make 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 be satisfied 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 marketplace or customers forever, both continuous quality improvement and reduction of cost will be considered concurrently. This is the management philosophy of CQI.

Whatever the origins of CQI is engineering or management background, the final result must be 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 continuously to satisfy the customers, and the core of that is to continuously minimize the cost and to 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 the 4th on Far Eastern Economic Review's 200 Asia Leading Companies in 1994, and was ranked by Fortune magazine as the 4th 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. 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.

4. China' s Experience in Quality Management

China, as a developing country, has been learning advanced quality management theory and methods from many developed countries so as to speed up the pace of development. At first, the quality management theory and methods were studied in some industrial areas of China, and especially some regulations, standards, specifications developed by the Department of Defense of United States for quality and reliability management were introduced to China. For example, the military standards of DOD:DODD50001, MIL-Q-9858A, MIL-HDBK-50, DOD-D5000.40, MIL-STD-785B were referred when we amended and built corresponding Chinese quality management systems. On the basis of that the quality management handbook and outline for quality reliability assurance were worked out and strictly carried out in some industries.

We also referred to some quality management systems of Western Europe and the former Soviet Union, and we have especially been heavily affected by successful experience of quality management of Japan. In 1978, a total quality management campaign was commenced all over China.

During this period, many quality circles were organized and the regulations for production process control were forced to be carried out in Chinese enterprises.

In pace with reforming and opening up, China' s government has realized the significance of employing the ISO 9000 family of standards, and it urges enterprises to perform the quality standard systems.

Many famous companies of China are using ISO quality standard, and most of them have passed the standard certification. Some are still making efforts towards the objective of certification. International standard researchers of China think the standard in various enterprises of China should be much stricter than the basic international standard and its implementation criteria adopted for different fields should also be added depending on specific requirements. In the following, we will present some examples of the latest progress in quality management area of China.

5. Processes-Oriented and Continuous Quality Improvement

What is the object of CQI? According to the principle of treatment in upper-stream and prevention CQI must firstly 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 simplified so that in the beginning there are input and suppliers, followed by working activity with output for customers. This is defined as a general process, see Figure 5.1, process and quality process. Any enterprise consists of various processes. While a quality process is a process with lower cost and minimum variation, and any activities in the process must be value-added then the process is called quality process. If CQI could change all the processes, especially key processes into quality processes, the enterprises would be a world-class company.

Usually, processes 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 also even much more effective and significant. If all the processes, especially the core processes are quality processes, the enterprise will be an excellent business. This is why processes are emphasized so much on

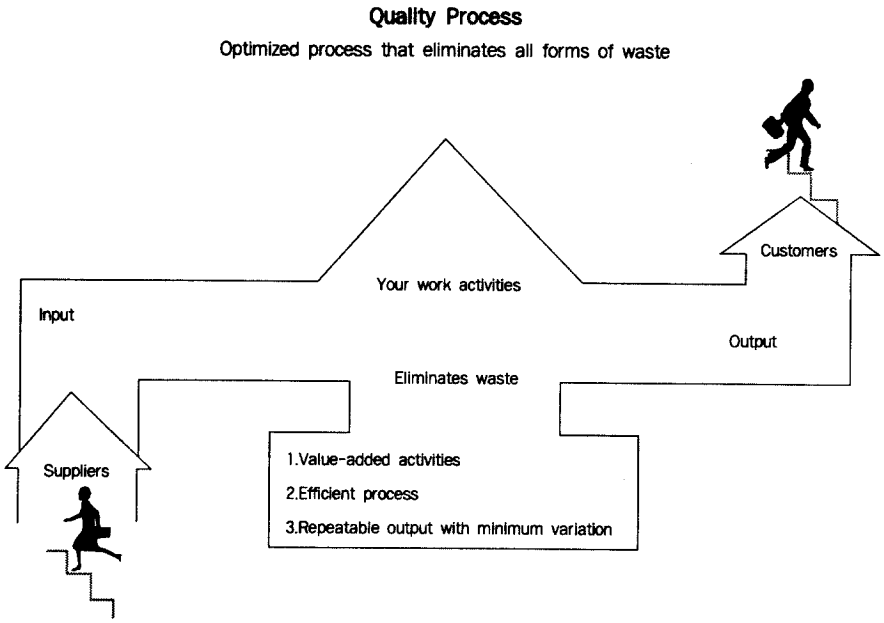

Fig. 5.1 Process & Quality Process

the National Quality Award models and in the new ISO 9000 family. CQI is mainly focussed on the process!

6. Benchmarking and Continuous Quality Improvement

Benchmarking is a method of continuous quality improvement focussed on processes with the aim for total quality. There are various techniques to improve the quality through information exchange and various comparisons by 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 " In war, if you know both your enemy, and yourself, you don' t fear the action of 100 of them"

American Productivity Center gives the 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 criteria for comparing. One is quality, and the other is productivity, namely, to some extent, cost. Processes are usually the objects of the comparison and improvement. The quality index may be described as the number of defectives or defects, the degree of variation, and so on.

Productivity index or cost index may be chosen as storage period, labor hour and space used, 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. Some enterprises of China are following Benchmarking regulations to improve their business.

7. Standardization Management and Its Certification

Standardization systems is a summarization of the successful experience, it is also the base for further improvement, one important part of quality management. The ISO 9000 family is of significant importance on a world wide basis. Many enterprises were certified by the ISO 9000 family. A number of quality certification bodies are founded in the 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 own management standardization systems. Some world-class companies such as Boeing have innovated

their system as D1-9000 by adding (AQS) Advanced Quality System to the previous D1-8000A systems so as .to enhance competitive edge. Boeing enacts this standard for its suppliers all over the world, which is very much similar to ISO 9002.

Ford, GM, Daimler Chrysler etc. regulated QS-9000 for automobile industry, while D1-9000 and AS-9000 are mainly used for Aviation and Aerospace industry and ISO 9000 family is generally used in various areas. All of these are based on the same in principle, but different fields require different features. Japan is very well known for its specialty in management, therefore almost each Japanese venture has its own standardization system, which is not worse than the ones of Europe and America. Why did they also adopt ISO 9000? The Standardization Association of Japan explained that they adopted ISO 9000 mainly to satisfy market requirements in the world, especially in Europe.

Since ISO 9000 can be used in all kinds of businesses, it has been proven that ISO 9000 must be generic and broadly documented as details and supplements of the business features are quite necessary for the company to be certified. It' s absolutely wrong for some companies to regard their products as internationally advanced products as long as they pass certification of ISO9000. Having acquired ISO 9000 certification can only show that you' ve done the basics in quality management. As shown Figure 7.1, The Basis of TQM.

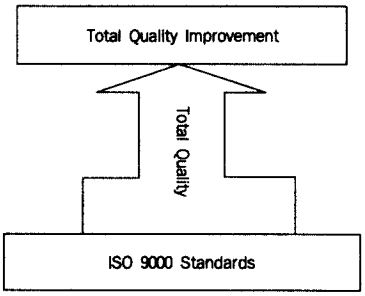

Fig. 7.1 Basis of TQM

For 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 being certified. Perhaps through adoption of the 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.

8. Continuous Quality Improvement and the 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 early 1980s, 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 no alternative. Because the cause of failure is due to yourself, your companies are based on Taylor Model; the worst thing is to rely on standards set by 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 further said, " We are beyond the Taylor Model, as we very much know that the current environment of business is very complicated, in the competitive circumstance the survival and development of the companies must rely on aggregating a bit of intelligence of employees and utilizing that. For us, the core of management is just to collect all intelligence of all employees to contribute to the company. For the challenge of new technology, we know that much more than what you know, which could not be successful only depending on a few capable persons in the company, although they appeared quite smart some time. Only that company who makes an effort to aggregate intelligence of all their employees is going to progress and survive well. 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 controls the middle level much like the military system, the same applies from the middle to the lower level. The old management pattern is not good at communication within the various levels, or information exchanging nor at motivating the employee. If the top level does not hold enough information and data, it will be difficult for leaders to make right decision-making. The new one is very different from the old model, which is a service mode of management, and is very easy for the management to collect sufficient information at various levels and motivate ardor of employees, aggregating intelligence so that the management make correct decisions, which it will be of significance for quality improvement and the continuous reduction of costs. Regardless of the Taylor or service mode, the structure consists of a tower with several levels known as the Quality Management Pyramid, in quality circles, as illustrated at Figure 8.1, new & old management pyramid. Dr Jens J. Dahlgaard, an European expert of quality management proposed the Total Quality Management Pyramid, see Figure 8.2, total quality management pyramid, in which the five key elements of total quality management are placed, based on the type of service mode. They are: Leadership, all inclusive participation, focus on facts, continuous improvement and focus on customers. The leadership is located at the

bottom of the pyramid, which indicates the innovation mode of management, the other four of elements are put on the four side faces, which express the close and reasonable combination of the innovation mode and total quality management. In the following section the position of continuous improvement will be discussed.

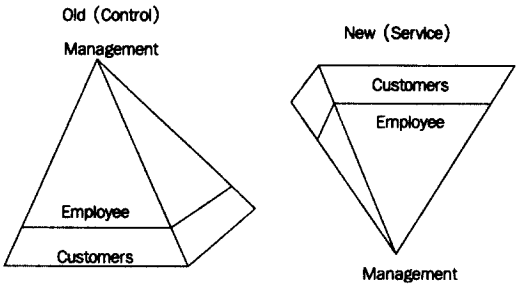

Fig. 8.1 New & Old Quality Pyramid

China's system of socialist marketing economics must depend on marketplace, focusing on customers and satisfying customers. In the intense competition environment of marketing together with the rapid development of technology, the requirement of customers have been changing with the dynamic society. In order to satisfy the customers continuous improvement must be maintained to develop a competitive edge in the global market. How do we sustain continuous quality improvement? The first step is to focus on facts and data used in continuous improvement so as to satisfy-customers.

Both in collecting data and improving quality, everybody should participate in those activities. Every employee involved in improvement of, either an engineering process or management process, needs to strive for less variation and less waste so as to make it a value added activity.

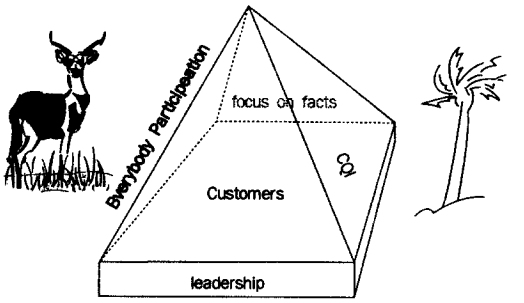

Fig. 8.2 Pyramid of TQM

Each employee will need to play an important role in continuous improvement of the processes. To implement a continuous improvement system, the assurance of leadership must be a key factor. From the above discussion, continuous improvement is the most significant position in a TQM pyramid.

9. Continuous Improvement and Diagnostic System Based on the Quality Evaluation Models

There is a close relationship between evaluation of quality systems and evaluation for continuous improvement. Especially for business performance improvement of the whole company, the evaluation mode is very important. One way of evaluating systems is

for a quality award model. Almost all countries established their national quality award; especially those developed countries, such as the Deming Prize of Japan, Malcolm Baldridge National Quality Award of the United States and the European Quality Award as well as the various national quality awards of each country in Europe.

Quality Awards can play a very important role in reducing both cost and variation, 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 exists some misunderstanding in basic problems, which not only happens to enterprises, but also to some extent in academic circles and government departments.

Since the national quality award existed, we can see, the framework of them are almost the same because of communication and learning from each other. For example, the European Quality Award consists of nine blocks, as indicated at Fig. 9.1. Five of these elements are system factors. In the conditions to cause success for the enterprise are leadership, people, policy and strategy, resource and, the results part of people satisfaction, customer' s satisfaction, and effect on society and business results will also be rated. Actually any quality award can be divided into two or three parts, the one part covers conditions and the other part covers the results. The third part is the process part, which in fact functions as a transformation bridge from conditions to results. It is for that reason that the process is emphasized on both the Quality Award Models and the ISO9000 standard family.

Recently China is introduced a new quality award model., which is to similar models of other countries. In some developed countries, the quality award model operated well, in that it really helped to promote national economic growth. Obviously the quality awards were regarded as a quality improvement model in these countries and thus it become an efficient and effective tool for comprehensive improvement of business behavior of companies. In China, some people misunderstood the quality award to be a gold medal for reputation. In the quality

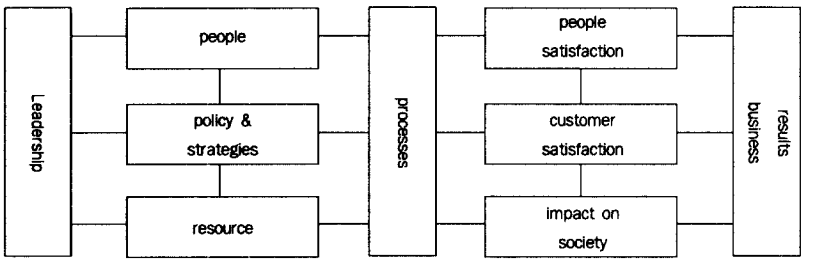

Fig. 9.1 Quality Award Model

award, some aspects are much more effective compared with the ISO9000 family.

ISO9000 stresses very much the process element. The quality award not only focuses on the process but also pays much more attention to business results.

It is our suggestion that quality awards should be regarded as a quality improvement model and enterprises should take the quality award criteria as an improvement tool to reduce cost and enhance quality. Whether you apply for a Quality Award or not, you may frequently make good use of the quality award model to do self-assessments and diagnostics. In that way you can continuously improve the potentials of your enterprise, and ultimately meet the requirements of the Quality Award Model.

10. A Review *of* Quality Engineering In China

The term Quality Engineering (QE) has been well known in China since the late 1970s. The implication of QE, however, has been changing. Initially, the meaning of QE in China was the same as in Japan, which referred to Dr. Taguchi' s system design, parameter design and tolerance design. For a long time, Chinese scholars and engineers had adopted the concept of QE originated by Dr. Taguchi. Up to the mid-1980s, the concept of QE had been renewed due to the influence from the Americans and the Europeans. A very well-known Journal of the United States, Quality Engineering, broadened Taguchi' s QE to a much more generalized level that contains all quality technology including the Taguchi methods and all other quality techniques. As such QFD, the new and old seven tools, even the 8th and the10th tools, and so on, will be included in QE. Even today, there still exist different opinions related to the concept of QE among Chinese researchers and engineers, but the mainstream determined that QE is the summation of all quality technology. More and more major departments of the Chinese government such as the Aerospace Industry, the Quality and Reliability Research Center under COSTIND etc. are all employing the generalized QE concept and apply it on the "Ninth and Tenth Five-year Plan of Quality Engineering Research". Hereafter, we would like to use the generalized quality engineering terminology in the rest of this report.

In the 1960s, some experts and professors working in the operations research field proposed the 0.618-optimization method and orthogonal experiment design techniques, and these optimization techniques were popularized as quality control and improvement measures in China' s enterprises. Most of the workers in the workshops also knew the above two methods of optimization well. After that, in early

1970s, various control charts based on Shewhart' s original idea were introduced to China, for use in monitoring process variation. From then on, we commenced the study and application of statistical process control techniques. Many monograph and research papers on SPC were published in Chinese. At the same time, a specific National Standard for SPC was worked out by the Chinese Association for Quality Control. SPC courses were set up in some universities of China. A lot of workers and engineers have since been trained on SPC as well as TQM.

As time went on, in about the early 1980s, Taguchi Methods called "Three Times of Design" were presented in China. Taguchi Methods were widely spread in partial areas of China industry such as China North Industry Group. From the early 1980s, Dr. Taguchi visited in person the China North Industry Group almost every year, and gave a series of lectures and comments on achievements presented by Chinese engineers in Taguchi symposiums. Due to his great contribution to both China' s industry and friendship, Dr. Taguchi was honored with a title of 'distinguished foreign experts' . For his outstanding contribution to China he was received by the Chinese government and met by China' s top leaders in October 1994. The Taguchi method has been effectively applied to China' s industry and hundreds of successful case studies were published or presented at conferences. In addition, Taguchi' s series of "Quality Engineering" was published in Chinese, and a lot of training classes were held on the Taguchi methods. Also some computer software on Taguchi methods in Chinese has been put on the market.

In late 1980s, Quality Function Deployment (QFD) techniques were introduced to China. Some researchers and engineers were studying and trying to apply it to the development process of products. Up to now, case studies based on QFD are very limited in China' s industry, but many related departments of the Chinese government were encouraging researchers and engineers to develop QFD and popularize its application in industry.

11. Status Quo on Quality Engineering

New View for Quality Engineering in the 90s.: In the past thirty years, many quality technology and management methods have been studied and introduced in China, and most of them have been put into industry practice. The understanding of quality technology and management methods has been gradually evolved and enhanced. However, an important breakthrough of ideology for quality engineering occurred in early 1990s. The breakthrough can be described by two points as follows: The first

is that the root cause of quality problems is the variation around the target; secondly, potential quality is much more important than performance quality, and the potential quality comes from standardization management.

Since the 1990s, some researchers and engineers in China have realized that various kinds of excessive variation of quality characteristics around target value results in poor quality of products or processes. Imagine if there would be no variation around the target value in the whole production process, then each product would be perfect. So, the focus that we are working on in quality control and improvement is just on reducing or eliminating various variations. Reduction and controlling variation is being performed in the following different stages discussed below: Technology development, product and process design, monitoring control, calibration of measurement systems, sampling examination and so on. Another new viewpoint in quality engineering is that quality work should be treated as early as possible in the original streams of contract review and Quality planning. Some practical lessons from several companies in China' s Aerospace Industry indicate the significance of quality lever theory, see Figure 11.1. The traditional viewpoint of "fire fighting" or "curing the head for a headache and curing the foot for a footache" in quality engineering has been commonly criticized. The focus of quality work must be on prevention. This has become the main objective in the quality engineering field.

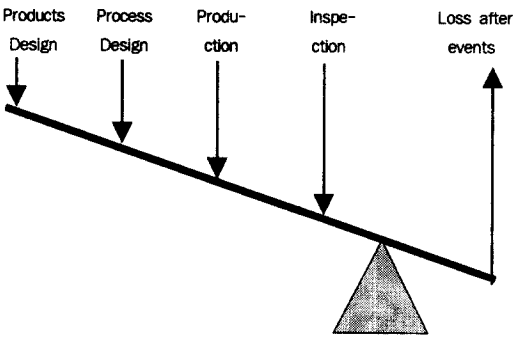

Fig. 11.1 Quality Lever

Potential quality is often used to rate the substantial quality level of the whole company. It is a very different concept from performance quality which is employed to evaluate quality of products. The usual criteria often used to rate performance quality are the rejection rate, percentage of defectives, etc. Potential quality reflects quality assurance ability of the company, which, however, can not be depicted by the quality of individual product. For example, a supplier always delivers the products which are really within specification limits, but we can not conclude that the supplier has a satisfactory potential quality level. Perhaps a lot of defectives were discarded before delivery of products to the buyer, so a qualified company in potential quality should have a much lower quality loss.

Potential quality can be evaluated by quality management level, which usually depends on standardization of all quality work to ISO 9000.

In the China Aviation Industry, the two Airplane Manufacturing Corporations of Xian and Shengyang were operating Dl-9000 Quality Systems developed by the Material Division of Boeing Commercial Airplane Group, because they are all suppliers of Boeing. How can the potential quality of the two corporations be evaluated? The main evaluation criteria adopted by Boeing both of them was for implementation level of Dl-9000 Quality system and not the rejection rate. Boeing had approved both on D1-9000 quality systems in 1993. In recent years, some European Companies were trying to rate their partners in China by the European Quality Model, which may be said to be an advanced system of quality improvement, to indicate the potential character of companies. An outlook for potential quality held by Chinese researchers, engineers and top leaders are pushing standardization and continuous improvement work of quality management.

Also in the near future, the certification work for basic and advanced quality systems will be commence.

Quality activities are usually divided into several stages, such as R&D, design of products or processes, manufacturing as well as calibration of measurement system etc. It is said that the definition of R&D in some countries including the United States and China has wrongly excluded the issue of quality. Thankfully, the paradigm has begun to change. Within each stage of the above we have now a corresponding quality technique. At present, the researchers and engineers of China have discovered that there exists a close relationship among these quality techniques. For instance, within the three techniques used in reducing variation, control chart methods monitoring the variation eg. robust design, as well as calibration of gauges, there is some relationship in the use of these techniques. These relations indicate that the related quality techniques form an organic system. So we should jointly utilize all techniques, this is known as quality system engineering.

The use of quality system engineering is a great leap for Chinese engineers and researchers in cognition and application of quality techniques.

The technology development of quality was presented to China by Dr. Taguchi. Since the robust method in technology development stage has many advantages, such as technology readiness, flexibility and reproducibility. Chinese scholars and engineers have been studying it and trying to apply it to the practical process of R&D. In terms of technology development, some of researchers still feel a little confused. For example, the generic function of Dr. Taguchi

can always be revealed by the linearity relation $Y=\beta M$, where Y is the quality characteristic, M is a signal factor which is a constant. Even if engineers and researchers working on the project sufficiently understand the internal structure of the project, can they be sure to find out the ideal function described by the linearity relation? The current work that we are doing around robust technology development is twofold. The first, and the foremost is that some experts and professors are trying to find out the solutions for the ideal function expressed by $Y=\beta M$ for general technology development problems. This is still an open problem.

Secondly, some practitioners were simulating Dr. Taguchi to determine the linearity $Y=\beta M$ in case studies. In the application field, some of the cases were successful and some of them were not. The main focus in research on Robust Technology Development is that people are trying to make it much more perfect in both theory and application.

Robust design should imply various methods, but we only mean the parameter design with unlinearity principle, see Figure 11.2. For instance, changing new parts or using advanced material can also reduce variation to improve the quality, but these methods will not be included in quality engineering. In theory, since the Americans influenced some Chinese scholars, they have some arguments with Taguchi' s implementation techniques for parameter design. These are mainly reflected at three aspects: interaction, S/N ratio, and choice of quality characteristic. Especially, the point that selection of quality characteristics can avoid the interaction is criticized.

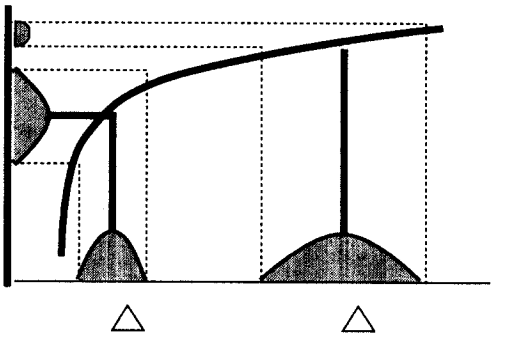

Fig. 11.2 Robust Design Principle

Statistical process control technology based on Shewhart' s original idea has been used in some industries of China for more than thirty years. Before the 1990s, one always thought that SPC is the most important tool in the quality control field. In the process control field for short run, Boeing Company has proposed a proportional chart and target chart, which appeared in D1-9000 quality system and were not published in any quality journal, but applicable areas of these methods are very limited due to assumption of the same or proportional of targets.

General short run control charts were studied by a transformation technique, called standardization transformation chart for short run. This technique can be applied to much more extensive area not limited by targets. These short run methods have been

used in process control of Boeing 737-doors produced by the China Shengyang Airplane Manufacturing Company, who is a supplier of Boeing Company. The effectiveness is very significant.

Sampling examination is a traditional quality control technique. For many years, the methods have been popularized in China and it is still considered as the major and effective measure of quality control.

Sampling examination are still in use, although, as we know, the USA is trying to stop the research and application of sampling examination. This indicates that the focus of quality control is going to be on prevention instead of examination after events.

The lessons for China' s companies in quality activities show that the measurement system is very important for quality assurance of products. Historically, some quality problems in a Chinese airplane manufacturing company just happened due to the poor accuracy of measurement instruments. Usually, purchasing a new gauge or measurement instrument with a much higher accuracy is extremely expensive. So calibration and improvement of old measurement instruments becomes very necessary. In fact, measurement system analyses is also a process in which controllable factors could be found. In China, some robust design technology has successfully been applied to quality improvement of measurement systems. It seems that this is a new achievement in quality improvement of measurement system in China. This method is going to be wide spread in the near future in China.

QFD is a powerful cross-functional tool deploying the voice of the customer into design requirement, part characteristics, process planning and production planning. It was initially developed in Japan by Dr. Shigeru Mizuno and Prof. Akao (known as the father of QFD). Only a few years ago, attention to QFD was paid in China. Since 1991, the Quality and Reliability Center under COSTIND has been setting up research projects of QFD and encouraging researchers and engineers to do study and practice in the aspect of QFD. In China, some engineers have approached and applied QFD, but the significant achievements produced by QFD need to be evaluated in the near future. Whatever happens, QFD as a special methodology for transferring customer' s requirements into the process of development, and manufacturing must be popularized sooner or later in China.

12. Prospects for Quality Science in China

Presently, the quality management ideology and quality engineering technology both have been widely spread in China' s

industry. The application effect of the quality science, however, is not yet so significant as in developed countries. The main causes may be as follows: Although the top leaders of the Chinese government put forward the slogan of "Quality prosper the Nation", the leaders do not clearly realize the effect of quality science on the goal. Quality may be improved in several ways. For example, Purchasing of new and expensive materials, and advanced equipment etc. can effectively enhance the quality of products. Here the quality engineering and management efforts required for improvement is therefore eliminated to a great extent. The lever of socialism market economy has not yet worked well for marketplace competition, so most of the leaders of Chinese companies do not yet recognize the importance of quality and cost in obtaining and keeping the marketplace share.

Training of Chinese workers is much poorer in a general sense. In many developed countries, such as Japan and U.S., many workers and technicians are also able to employ basic quality technology as such DOE, Taguchi' s method, SPC etc. to enhance the quality of products. In China, only researchers or senior engineers with specialist training could do these kinds of work. So those quality improvement techniques are very difficult to popularize in the whole company.

As socialism market economy and re-entry to the General Agreement of Tariff and Trade/World Trade Organizations go on, the above problems need to be settled very soon.

The search for increased marketing share through quality and price (cost), really forces Chinese leaders and companies to study and apply quality engineering and quality management more extensively. In fact, some managers being of superior foresight and vision have paid great attention to the research and application of quality engineering and quality science. Especially, some suppliers of foreign companies and joint ventures have been smoothly applying quality engineering/ quality management to assure the quality of their products. Those managers who only consider the production task without quality or those who are only concerned about quality without cost considerations will be discarded by the market economics law. The new generation of managers in Chinese companies are now promoting quality engineering and quality management to a much higher degree than before, because quality science cannot only improve the quality of product and service but also reduce the cost simultaneously.

Reference

1. Aguayo, R.(1990), "Dr Deming-The Man Who Taught the Japanese about Quality", *Carol Publishing Group, Inc*, New York.
2. Abraham, B and Mackay J.(1990), "Designed Experiments for Reduction of Variation",

Research Reports, RR-90-04, The Institute for Improvement in Quality and Productivity, University of Waterloo.

3. Bergman, B. and Klefsjo, B.(1994), "Quality from Customer Needs to Customer Satisfaction" *Student Literature*, Lund.
4. Crosby, P.(1979), "Quality is Free", *McGraw Hill*, New York .
5. Conti Tito(1993), "Building Total Quality", Chapman & Hall.
6. Chong, P.S. and Kukalis, S.(1991) "How Does American Top Management View Quality?", *Omega*, Vol.19, pp.506-510.
7. Dahlgaard J. Jens, K. Kristensen, G. K. Kanji (1994), "The Quality Journey without End-Advances in Total Quality Management", International *Periodical Publishers*.
8. Deming, W. E.(1986), "Out of the Crisis", *MIT, Center for Advanced Engineering Study*.
9. Deming, W.E.(1982), "Quality, Productivity and Competitive Position", *MIT, Center for Advanced Engineering Study*.
10. Juran, J.M.(1978), "Japanese and Western Quality-a Contrast", *International Conference on Quality Control*, JUSE, Tokyo.
11. Kanji, G.K.(1990a), "Total Quality Management: the Second Industrial Revolution", *Total Quality Management*, Vol.1, pp.3-12.
12. Koiper Kant F (1991), "Defect Reduction and process Improvement", *Boeing Commercial Airplane Group for Boeing Suppliers*, Vol.11, No.1.
13. Park Sung H., Jichao Xu (1998), "A Study on Process Capability Indices for Non-Normal", Proceedings of 12th Asia Quality Management Symposium, Seoul, Korea, pp.144-146.
14. Phadke, M.S(1989), "Quality Engineering Using Robust Design", *Prentice Hall*, New Jersey.
15. Material Division of Boeing Commercial Airplane Group(1991), "Advanced Quality System for Boeing Suppliers", *Boeing*.
16. Taguchi, G.(1986), "Introduction to Quality engineering", *Asian Productivity Organization*, Tokyo, Japan.
17. Vigayan, N. Nair(1992), "Taguchi's Parameters Design: A Panel Discussion," *Technometrics*, Vol. 34, No.2.
18. Xu, Jichao(1996), "Variability Detection and Robustness Design in Complicated production System", Computers and ind. Engng. , Vol. 31, No. 4 , pp.775-778.
19. Xu, Jichao, Sung H. Park(1998), "Survey Research on Continous Quality Improvement System", Proceedings of 12th Asia Quality Management Symposium, Seoul, Korea.
20. Xu, Jichao(1998), "Quality Science Today", Journal of Shanghai Quality, Vol. 10, No.4.
21. Xu, Jichao, Yumin Liu(1995), "The same Distribution principle in Short Run SPC and Its Implementing methods", The proceedings of the Second Asia-Pacific Quality and Reliability Conference, Beijing, pp315-317.
22. Xu, Jichao, Yumin Liu(1992), "Information Model for the Process Control with Multivariate", System Engineering, Vol.13, No.1, pp.33-41.
23. Xu, Jichao, Yizhong Ma(1999), "Measuring of Variation and Robust Design for Multivariate Process", System Engineering, Vol. 18, No.4.