To Study the Quality Assurance & Control of Products in Industries

Author Name: - Jagtar Singh
Guide Name: - Mr. Ashwani Sethi
Guru Nanak College Of Management And Technology, Doomwali
Email Id: - Jagtarsidhu786@Gmail.Com

ABSTRACT

Many quality improvement (QI) programs including six sigma, design for six sigma, and kaizen require collection and analysis of data to solve quality problems. Due to advances in data collection systems and analysis tools, data mining (DM) has widely been applied for QI in manufacturing. Although a few review papers have recently been published to discuss DM applications in manufacturing, these only cover a small portion of the applications for specific QI problems (quality tasks). In this study, an extensive review covering the literature from 1997 to 2007 and several analyses on selected quality tasks are provided on DM applications in the manufacturing industry. The quality tasks considered are; product/process quality description, predicting quality, classification of quality, and parameter optimization. The review provides a comprehensive analysis of the literature from various points of view: data handling practices, DM applications for each quality task and for each manufacturing industry, patterns in the use of DM methods, application results, and software used in the applications are analyzed. Several summary tables and figures are also provided along with the discussion of the analyses and results. Finally, conclusions and future research directions are presented.

Highlights: - *Review, data mining applications, manufacturing, 1997–07, selected quality problems, and typically small, separately stored quality and production data. Increasing use of DM, especially in metal, computer and electronics industries, Common use of artificial neural networks for prediction and design optimization General purpose software preferred over specialized DM software.*

Keywords: -

Knowledge discovery in databases; Data mining; Quality improvement; Six sigma; Design for six sigma; Quality description; Prediction; Classification; Parameter optimization; Data mining software; Manufacturing

INTRODUCTION

Quality management ensures that an organization, product or service is consistent. It has four main components: quality planning, quality control, quality assurance and quality improvement. Quality management is focused not only on product and service quality, but also the means to achieve it. Quality management therefore uses quality assurance and control of processes as well as products to achieve more consistent quality.

There are many methods for quality improvement. These cover product improvement, process improvement and people based improvement. In the following list are methods of quality management and

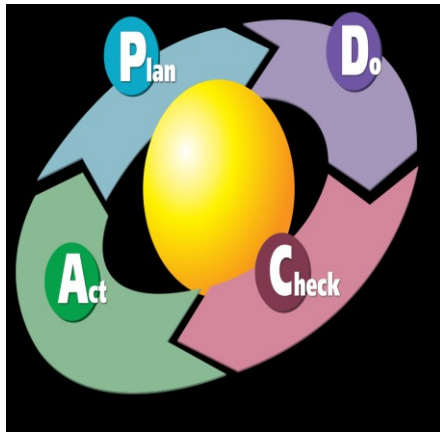techniques that incorporate and drive quality improvement:

Figure 1.1 the PDCA Cycle

- ISO 9004:2008 — guidelines for performance improvement.
- ISO 15504-4: 2005 — information technology — process assessment — Guidance on use for process improvement and process capability determination.
- QFD — quality function deployment, also known as the house of quality approach.
- Kaizen — 改善, Japanese for change for the better; the common English term is continuous improvement.
- Zero Defect Program — created by NEC Corporation of Japan, based upon statistical process control and one of the inputs for the inventors of Six Sigma.
- Six Sigma — 6σ, Six Sigma combines established methods such as statistical process control, design of experiments and failure mode and effects analysis (FMEA) in an overall framework.
- PDCA — plan, do, check, act cycle for quality control purposes. (Six Sigma's DMAIC method (define, measure, analyze, improve, control) may be viewed as a particular implementation of this.)

- Quality circle — a group (people oriented) approach to improvement.
- Taguchi methods — statistical oriented methods including quality robustness, quality loss function, and target specifications.

The Toyota Production System — reworked in the west into lean manufacturing.

- Kansei engineering — an approach that focuses on capturing customer emotional feedback about products to drive improvement.
- TQM — total quality management is a management strategy aimed at embedding awareness of quality in all organizational processes. First promoted in Japan with the Deming prize which was adopted and adapted in USA as the Malcolm Baldrige National Quality Award and in Europe as the European Foundation for Quality Management award (each with their own variations).
- TRIZ — meaning "theory of inventive problem solving"
- BPR — business process reengineering, a management approach aiming at optimizing the workflows and processes within an organization.
- OQRM — Object-oriented Quality and Risk Management, a model for quality and risk management.

Proponents of each approach have sought to improve them as well as apply them for small, medium and large gains. Simple one is Process Approach, which forms the basis of ISO 9001:2008 Quality Management System standards, duly driven from the 'Eight principles of Quality management', process approach being one of them. Thareja writes about the mechanism and benefits: "The process (proficiency) may be limited in words, but not in its applicability. While it fulfills the criteria of all-round gains: in

terms of the competencies augmented by the participants; the organization seeks newer directions to the business success, the individual brand image of both the people and the organization, in turn, goes up. The competencies which were hitherto rated as being smaller are better recognized and now acclaimed to be more potent and fruitful". The more complex Quality improvement tools are tailored for enterprise types not originally targeted. For example, Six Sigma was designed for manufacturing but has spread to service enterprises. Each of these approaches and methods has met with success but also with failures.

Some of the common differentiators between success and failure include commitment, knowledge and expertise to guide improvement, scope of change/improvement desired (Big Bang type changes tend to fail more often compared to smaller changes) and adaption to enterprise cultures. For example, quality circles do not work well in every enterprise (and are even discouraged by some managers), and relatively few TQM-participating enterprises have won the national quality awards.

There have been well publicized failures of BPR, as well as Six Sigma. Enterprises therefore need to consider carefully which quality improvement methods to adopt, and certainly should not adopt all those listed here.

It is important not to underestimate the people factors, such as culture, in selecting a quality improvement approach. Any improvement (change) takes time to implement, gain acceptance and stabilize as accepted practice. Improvement must allow pauses between implementing new changes so that the change is stabilized and assessed as a real improvement, before the next improvement is made (hence continual improvement, not continuous improvement).

Improvements that change the culture take longer as they have to overcome greater resistance to change. It is easier and often more effective to work within the existing cultural boundaries and make small improvements (that is Kaizen) than to make major transformational changes. Use of Kaizen in Japan was a major reason for the creation of Japanese industrial and economic strength.

On the other hand, transformational change works best when an enterprise faces a crisis and needs to make major changes in order to survive. In Japan, the land of Kaizen, Carlos Ghosn led a transformational change at Nissan Motor Company which was in a financial and operational crisis. Well organized quality improvement programs take all these factors into account when selecting the quality improvement methods.

PROBLEM FORMULATION

Before developing research we keep following things in mind so that we can develop powerful and quality research.

3.1 PROBLEM FORMULATION

3.1.1 QUALITY REQUIREMENTS

Whatever the approach to development may be, the final program must satisfy some fundamental properties. The following properties are among the most relevant:

➢ Reliability: how often the results of a program are correct. This depends on conceptual correctness of algorithms, and minimization of programming mistakes, such as mistakes in resource management (e.g., buffer overflows and race conditions) and logic errors (such as division by zero or off-by-one errors).

➢ Robustness: how well a program anticipates problems due to errors (not bugs). This includes situations such as incorrect, inappropriate or

To Study the Quality Assurance & Control of Products in Industries *Jagtar Singh*

corrupt data, unavailability of needed resources such as memory, operating system services and network connections, user error, and unexpected power outages.

- ➢ Usability: the ergonomics of a program: the ease with which a person can use the program for its intended purpose or in some cases even unanticipated purposes. Such issues can make or break its success even regardless of other issues. This involves a wide range of textual, graphical and sometimes hardware elements that improve the clarity, intuitiveness, cohesiveness and completeness of a program's user interface.
- ➢ Portability: the range of computer hardware and operating system platforms on which the source code of a program can be compiled/interpreted and run. This depends on differences in the programming facilities provided by the different platforms, including hardware and operating system resources, expected behavior of the hardware and operating system, and availability of platform specific compilers (and sometimes libraries) for the language of the source code.
- ➢ Maintainability: the ease with which a program can be modified by its present or future developers in order to make improvements or customizations, fix bugs and security holes, or adapt it to new environments. Good practices during initial development make the difference in this regard. This quality may not be directly apparent to the end user but it can significantly affect the fate of a program over the long term.
- ➢ Efficiency/performance: the amount of system resources a program consumes (processor time, memory

space, slow devices such as disks, network bandwidth and to some extent even user interaction): the less, the better. This also includes careful management of resources, for example cleaning up temporary files and eliminating memory leaks.

3.1.2 Readability of source code

In computer programming, readability refers to the ease with which a human reader can comprehend the purpose, control flow, and operation of source code. It affects the aspects of quality above, including portability, usability and most importantly maintainability.

Readability is important because programmers spend the majority of their time reading, trying to understand and modifying existing source code, rather than writing new source code. Unreadable code often leads to bugs, inefficiencies, and duplicated code. A study found that a few simple readability transformations made code shorter and drastically reduced the time to understand it.

Following a consistent programming style often helps readability. However, readability is more than just programming style. Many factors, having little or nothing to do with the ability of the computer to efficiently compile and execute the code, contribute to readability. Some of these factors include:

Different indentation styles (whitespace)

- ➢ Comments
- ➢ Decomposition
- ➢ Naming conventions for objects (such as variables, classes, procedures, etc.)

Various visual programming languages have also been developed with the intent to resolve readability concerns by adopting non-traditional approaches to code structure and display.

3.1.3 Algorithmic complexity

The academic field and the engineering practice of computer programming are both largely concerned with discovering and implementing the most efficient algorithms for a given class of problem. For this purpose, algorithms are classified into orders using so-called Big O notation, which expresses resource use, such as execution time or memory consumption, in terms of the size of an input. Expert programmers are familiar with a variety of well-established algorithms and their respective complexities and use this knowledge to choose algorithms that are best suited to the circumstances.

3.1.4 Methodologies

The first step in most formal software development processes is requirements analysis, followed by testing to determine value modeling, implementation, and failure elimination (debugging). There exist a lot of differing approaches for each of those tasks. One approach popular for requirements analysis is Use Case analysis. Many programmers use forms of agile software development where the various stages of formal software development are more integrated together into short cycles that take a few weeks rather than years. There are many approaches to the Software development process.

Popular modeling techniques include Object-Oriented Analysis and Design (OOAD) and Model-Driven Architecture (MDA). The Unified Modeling Language (UML) is a notation used for both the OOAD and MDA.

A similar technique used for database design is Entity-Relationship Modeling (ER Modeling).

Implementation techniques include imperative languages (object-oriented or

procedural), functional languages, and logic languages.

3.1.5 Measuring language usage

It is very difficult to determine what are the most popular of modern programming languages. Some languages are very popular for particular kinds of applications (e.g., COBOL is still strong in the corporate data center,[citation needed] often on large mainframes, FORTRAN in engineering applications, scripting languages in Web development, and C in embedded applications), while some languages are regularly used to write many different kinds of applications. Also many applications use a mix of several languages in their construction and use. New languages are generally designed around the syntax of a previous language with new functionality added (for example C++ adds object-orientedness to C, and Java adds memory management and bytecode to C++, and as a consequence loses efficiency and the ability for low-level manipulation).

Methods of measuring programming language popularity include: counting the number of job advertisements that mention the language, the number of books sold and courses teaching the language (this overestimates the importance of newer languages), and estimates of the number of existing lines of code written in the language (this underestimates the number of users of business languages such as COBOL).

3.1.6 Debugging

Debugging is a very important task in the software development process since having defects in a program can have significant consequences for its users. Some languages are more prone to some kinds of faults because their specification does not require compilers to perform as much checking as other languages. Use of a static code

analysis tool can help detect some possible problems.

Debugging is often done with IDEs like Eclipse, Kdevelop, NetBeans, Code::Blocks, and Visual Studio. Standalone debuggers like gdb are also used, and these often provide less of a visual environment, usually using a command line

OBJECTIVE

3.2 OBJECTIVE

Quality Assurance (QA) is a way of preventing mistakes or defects in manufactured products and avoiding problems when delivering solutions or services to customers. QA is applied to physical products in pre-production to verify what will be made meets specifications and requirements, and during manufacturing production runs by validating lot samples meet specified quality controls. QA is also applied to software to verify that features and functionality meet business objectives, and that code is relatively bug free prior to shipping or releasing new software products and versions.

Quality Assurance refers to administrative and procedural activities implemented in a quality system so that requirements and goals for a product, service or activity will be fulfilled. It is the systematic measurement, comparison with a standard, monitoring of processes and an associated feedback loop that confers error prevention. This can be contrasted with quality control, which is focused on process output.

Two principles included in Quality Assurance are: "Fit for purpose", the product should be suitable for the intended purpose; and "Right first time", mistakes should be eliminated. QA includes management of the quality of raw materials, assemblies, products and components, services related to

production, and management, production and inspection processes.

Suitable quality is determined by product users, clients or customers, not by society in general. It is not related to cost, and adjectives or descriptors such as "high" and "poor" are not applicable. For example, a low priced product may be viewed as having high quality because it is disposable, where another may be viewed as having poor quality because it is not disposable.

3.2.1 QUALITY ASSURANCE IN SOFTWARE DEVELOPMENT

Software Quality Assurance consists of a means of monitoring the software engineering processes and methods used to ensure quality. The methods by which this is accomplished are many and varied, and may include ensuring conformance to one or more standards, such as ISO 9000 or a model such as CMMI.

RESEARCH METHODOLOGY

4.1 RESEARCH METHODOLOGY

Methodology is the systematic, theoretical analysis of the methods applied to a field of study. It comprises the theoretical analysis of the body of methods and principles associated with a branch of knowledge. Typically, it encompasses concepts such as paradigm, theoretical model, phases and quantitative or qualitative techniques.

A methodology does not set out to provide solutions - it is, therefore, not the same thing as a method. Instead, it offers the theoretical underpinning for understanding which method, set of methods or so called "best practices" can be applied to specific case, for example, to calculate a specific result.

It has been defined also as follows:

"The analysis of the principles of methods, rules, and postulates employed by a discipline";

- "The systematic study of methods that are, can be, or have been applied within a discipline";

- "The study or description of methods"

4.2 RELATIONSHIP BETWEEN METHODOLOGY, THEORY, PARADIGM, ALGORITHM AND METHOD

The Methodology is the general research strategy that outlines the way in which a research project is to be undertaken and, among other things, identifies the methods to be used in it. These Methods, described in the methodology, define the means or modes of data collection or, sometimes, how a specific result is to be calculated. Methodology does not define specific methods, even though much attention is given to the nature and kinds of processes to be followed in a particular procedure or to attain an objective.

When proper to a study of methodology, such processes constitute a constructive generic framework and may therefore be broken down into sub-processes, combined, or their sequence changed.

A Paradigm is similar to a methodology in that it is also a constructive framework. In theoretical work, the development of paradigms satisfies most or all of the criteria for methodology. An Algorithm, like a paradigm, is also a type of constructive framework, meaning that the construction is a logical, rather than a physical, array of connected elements.

Any description of a means of calculation of a specific result is always a description of a method, and never a description of a methodology. It is thus important to avoid using methodology as a synonym for method or body of methods. Doing this shifts it away from its true epistemological meaning and reduces it to being the procedure itself, the set of tools or the instruments that should have been its outcome. A methodology is the design process for carrying out research or the development of a procedure and is not in itself an instrument, or method, or procedure for doing things.

Methodology and method are not interchangeable but, in recent years, there has been a tendency to use methodology as a "pretentious substitute for the word method". Using methodology as a synonym for method or set of methods, leads to confusion and misinterpretation, and undermines the proper analysis that should go into designing research.

4.3 THE EVOLUTION OF QUALITY IMPROVEMENT METHODOLOGY SELECTION

Lately, practitioners are integrating two or more QIM into a more powerful and effective hybrid QIM, addressing many of the weaknesses and retaining most of the strengths of each strategy. The proposed combined framework integrates tools and techniques within the methodology to enhance the bottom-line results and win customer loyalty. Implementation of such proposed framework shows dramatic improvement in the key metrics (such as defect per unit, process capability index, mean and standard deviation of casting density, yield, and overall equipment effectiveness) and a substantial financial savings is generated by the organization. Furthermore, this new approach of integrating and and/or aligning two or more QIMs creates awareness to organizations to adopt "another" potential QIM which may

suit an organization better and provide the best fit for a company. A comprehensive literature reviews highlighted the degree of alignment and integration in various combinations of QIM. The globalized world and emerging technologies are imposing an enormous impact on organization's operation routine causing an exponential upsurge of stress and burden while prompting stiff competition in the market place. The shift of CMM/CMM-I, ISO, ITIL, PSP and Six Sigma is among the QIM integrated with other QIM. These different combinations of integrated QIM can help generate business results that are at once concrete, consistent, measurable, and sustainable. This approach of combined methodology not only provides a framework for implementation but also enables business leaders to quantify the risk of failures by focusing purely on a single methodology in an evolving and unpredictable time frame of reaching maturity. Moreover, the time frames to transform a conventional organization to an integrated QIM vary tremendously across industries, and even across firms in the same industry. Even the metrics used to gauge a firm's progress toward an integrated QIM vary widely. Therefore, it is necessary to create awareness among IT management teams to think forward of a new mandate approach in IT quality management without having to drop existing QIM for a new face-lift migration to cope with business objectives. In most cases, the existing QIM which serves well in the day-to-day operational and procedural business activities should be maintained and retained as it has already become part of the organization's culture. It is important to explore other QIMs which address existing weaknesses and limitations in view of continuous improvement. This method of migration approach integrating and aligning other QIM not only retained existing cultures and norms, but the organization moves forward and achieve a higher level of maturity in QM through

focusing on a different set of demanding user expectations and user requirements. In short, organizations should move their development from narrowly-focused, traditional QIMs to a lifecycle approach of integrating/aligning with other QIMs which enforces "continuous improvement". Below are some reviewed evidences from the practitioners of integrating and aligning different combinations of QIMs to better manage and control the quality of IT processes/products/services:

1) Antony revealed that Six Sigma and CMM are complimentary and mutually supportive and Six Sigma could be an enabler to launch CMM depending on current organizational or individual circumstances. MIMOS Software Production Process has successfully integrated Six Sigma and CMM-I to establish a Defect Prediction Model for system test phase in early prediction of functional defects in PLC rather than capturing ample defects at the later stage of the testing phase.

2) Seow has undertaken a qualitative research study in a food and beverage SME organization in Malaysia exploring how customizing and alignment of Lean-Six Sigma deployment has improved equipment reliability, made positive significant savings in lead times and customer delivery, and winning of new supermarket contracts. When Lean principles are integrated with Six Sigma practices, their success rate grows; and most importantly, improvements become embedded in daily work life on a continuing basis.

3) A battery company (Baxter Battery) instituted the blend of Six Sigma methodology in conjunction with Lean solution, and dramatically reduced its capital cost ($20 million) while streamlining its manufacturing process (specifically in lead

To Study the Quality Assurance & Control of Products in Industries *Jagtar Singh*

plates used to build batteries), as well as improving its customer satisfaction levels.

4) Byrne being the Americas Group Lean-Six Sigma Leader for IBM revealed some leading companies (e.g. Caterpillar Inc.,) implemented operations strategies based on Lean Six Sigma management techniques with the objective of establishing disciplined working environments focused on customer needs, detailed data analysis and facts, not theories. The author sees Lean Six Sigma approach focusing not just on efficiency but also on growth, it can serve as a foundation for innovation throughout an organization. The Lean-Six Sigma program is not just about "doing things better", it is a way of "doing better things". Furthermore, if Lean-Sigma is used effectively, it can enhance innovations in products, services, markets and even a company's underlying business model, as well as improve operations.

5) On the other hand, a number of researchers are aligning ITIL-Six Sigma with the objective that Six Sigma techniques can be applied to ITIL in bringing the engineering approach to ITIL's framework. The reason behind this is that ITIL itself is not a transformation method, nor does it offer one. ITIL does not provide usable methods that are "out of the box" to measure customer satisfaction like Six Sigma does. Chan supports the adoption of Six Sigma principles into ITIL as this new combination helps IT to focus on their customer and the business strategy is more proactively based on facts and reinforces collaboration across the enterprise.

6) Another good example would be GE engaged in the IT Solution Enterprise Planning & Strategy consulting group to develop a process improvement methodology, combining ITIL and Six Sigma to migrate from the current state to "measurable, ITIL-Sigma compatible processes" for its' ITSM system.

7) Even PSP has been likened to applying Six Sigma toward Software Development. Both PSP and Six Sigma are emerging as efficient tools to improve software processes with PSP-Six Sigma being one of the mutually complementing software process improvement methods. Deploying PSP in conjunction with Six Sigma can provide the quantitative analysis capabilities to identify high leverage activities, evaluate the effectiveness of process changes, quantify cost and benefits, and control process performance. In short, despite the fact that PSP and Six Sigma can be utilized independently, there is a definite and significant synergy between them.

The reason why there is a need to create awareness and to explore the potentials alignment and/or integration of existing QIM with other QIM(s) is to have a focused-extension in both QA and QC, and to handle demanding customers. Although this move requires much effort, time, resources and culture changes; the potential benefits derived is long-term and there are attractive long run market opportunities.

4.4 QUALITY MANAGEMENT SOFTWARES

Quality Management Software is a category of technologies used by organizations to manage the delivery of high quality products. Solutions range in functionality; however, with the use of automation capabilities they typically have components for managing internal and external risk, compliance, and the quality of processes and products. Pre-configured and industry-specific solutions are available and generally require integration with existing IT architecture applications such as ERP, SCM, CRM, and PLM.

Quality Management Software Functionalities

- Non-Conformances/Corrective and Preventive Action
- Compliance/Audit Management
- Supplier Quality Management
- Risk Management
- Statistical Process Control
- Failure Mode and Effects Analysis
- Complaint Handling
- Advanced Product Quality Planning
- Environment, Health, and Safety
- Hazard Analysis & Critical Control Points
- Production Part Approval Process

Enterprise Quality Management Software

The intersection of technology and quality management software prompted the emergence of a new software category: Enterprise Quality Management Software (EQMS). EQMS is a platform for cross-functional communication and collaboration that centralizes, standardizes, and streamlines quality management data from across the value chain. The software breaks down functional silos created by traditionally implemented standalone and targeted solutions. Supporting the proliferation and accessibility of information across supply chain activities, design, production, distribution, and service, it provides a holistic viewpoint for managing the quality of products and processes.

4.5 FUNDAMENTAL OF SIX SIGMA

- Six Sigma's aim is to eliminate waste and inefficiency, thereby increasing customer satisfaction by delivering what the customer is expecting.
- Six Sigma is a highly disciplined process that helps us focus on developing and delivering near-perfect products and services.

- Six Sigma follows a structured methodology, and has defined roles for the participants.
- Six Sigma is a data driven methodology, and requires accurate data collection for the processes being analyzed.
- Six Sigma is about putting results on FINANCIAL Statements.
- Six Sigma is a business-driven, multi-dimensional structured approach to:
  - ✓ Improving Processes
  - ✓ Lowering Defects
  - ✓ Reducing process variability
  - ✓ Reducing costs
  - ✓ Increasing customer satisfaction
  - ✓ Increased profits

The word Sigma is a statistical term that measures how far a given process deviates from perfection.

The central idea behind Six Sigma is that if you can measure how many "defects" you have in a process, you can systematically figure out how to eliminate them and get as close to "zero defects" as possible and specifically it means a failure rate of 3.4 parts per million or 99.9997% perfect.

Key Concepts of Six Sigma

At its core, Six Sigma revolves around a few key concepts.

- Critical to Quality: Attributes most important to the customer.
- Defect: Failing to deliver what the customer wants.
- Process Capability: What your process can deliver.
- Variation: What the customer sees and feels.
- Stable Operations: Ensuring consistent, predictable processes to

improve what the customer sees and feels.

- Design for Six Sigma: Designing to meet customer needs and process capability.

Our Customers Feel the Variance, Not the Mean. So Six Sigma focuses first on reducing process variation and then on improving the process capability.

Myths about Six Sigma:

There are several myths and misunderstandings about Six Sigma. Few are given below:

- Six Sigma is only concerned with reducing defects.
- Six Sigma is a process for production or engineering.
- Six Sigma cannot be applied to engineering activities.
- Six Sigma uses difficult-to-understand statistics.
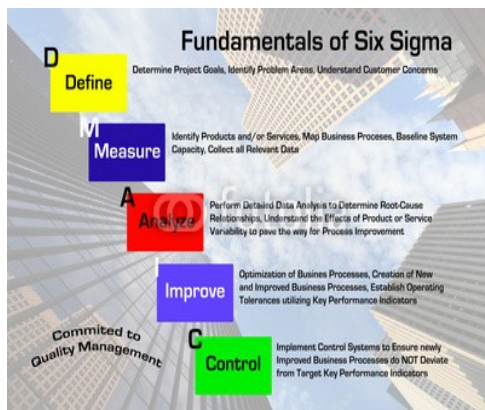- Six Sigma is just training.

Figure 4.1 Fundamental of Six Sigma

The Benefits of Six Sigma

There are following six major benefits of Six Sigma that attract companies.

Six Sigma:

- Generates sustained success.

- Sets a performance goal for everyone.
- Enhances value to customers.
- Accelerates the rate of improvement.
- Promotes learning and cross-pollination.
- Executes strategic change.

Origin of Six Sigma

Six Sigma originated at Motorola in the early 1980s in response to achieving 10X reduction in product-failure levels in 5 years.

Engineer Bill Smith invented Six Sigma, but died of a heart attack in the Motorola cafeteria in 1993 never knowing the scope of the craze and controversy he had touched off.

Six Sigma is based on various quality management theories (e.g.: Deming's 14 point for management, Juran's 10 steps on achieving quality).

RESULT

EXPERIMENTAL RESULTS

5.1 TAGUCHI METHODS

Taguchi methods (Japanese: 田口方法) are statistical methods developed by Genichi Taguchi to improve the quality of manufactured goods, and more recently also applied to engineering, biotechnology, marketing and advertising. Professional statisticians have welcomed the goals and improvements brought about by Taguchi methods, particularly by Taguchi's development of designs for studying variation, but have criticized the inefficiency of some of Taguchi's proposals.

Taguchi's work includes three principal contributions to statistics:

- A **specific loss function**

- The philosophy of **off-line quality control**; and
- Innovations in the **design of experiments**.

5.1.1 LOSS FUNCTIONS

Loss functions in statistical theory
Traditionally, statistical methods have relied on mean-unbiased estimators of treatment effects: Under the conditions of the Gauss-Markov theorem, least squares estimators have minimum variance among all mean-unbiased estimators. The emphasis on comparisons of means also draws (limiting) comfort from the law of large numbers, according to which the samples means converge to the true mean. Fisher's textbook on the design of experiments emphasized comparisons of treatment means.

Taguchi's use of loss functions

Taguchi knew statistical theory mainly from the followers of Ronald A. Fisher, who also avoided loss functions. Reacting to Fisher's methods in the design of experiments, Taguchi interpreted Fisher's methods as being adapted for seeking to improve the mean outcome of a process. Indeed, Fisher's work had been largely motivated by programmers to compare agricultural yields under different treatments and blocks, and such experiments were done as part of a long-term programmed to improve harvests. In Figure we show the diagram of Man Machines Materials Fishbone: -
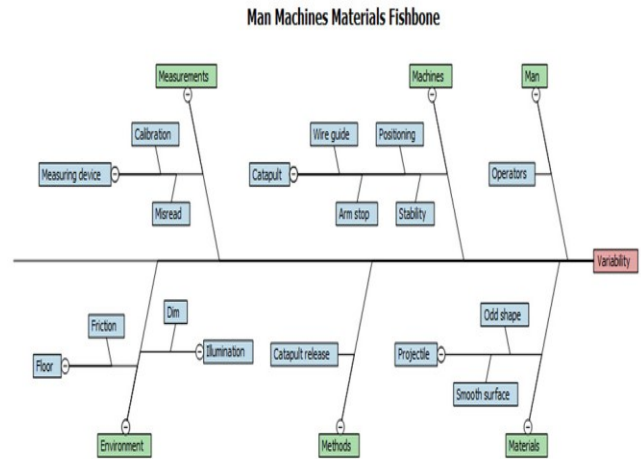

Figure 5.1 Man Machines Materials Fishbone

However, Taguchi realized that in much industrial production, there is a need to produce an outcome on target, for example, to machine a hole to a specified diameter, or to manufacture a cell to produce a given voltage. He also realized, as had Walter A. Shewhart and others before him, that excessive variation laid at the root of poor manufactured quality and that reacting to individual items inside and outside specification was counterproductive.

He therefore argued that quality engineering should start with an understanding of quality costs in various situations. In much conventional industrial engineering, the quality costs are simply represented by the number of items outside specification multiplied by the cost of rework or scrap. However, Taguchi insisted that manufacturers broaden their horizons to consider cost to society. Though the short-term costs may simply be those of non-conformance, any item manufactured away from nominal would result in some loss to the customer or the wider community through early wear-out; difficulties in interfacing with other parts, themselves probably wide of nominal; or the need to build in safety margins. These losses are externalities and are usually ignored by

manufacturers, which are more interested in their private costs than social costs. Such externalities prevent markets from operating efficiently, according to analyses of public economics. Taguchi argued that such losses would inevitably find their way back to the originating corporation (in an effect similar to the tragedy of the commons), and that by working to minimize them, manufacturers would enhance brand reputation, win markets and generate profits.

Such losses are, of course, very small when an item is near to negligible. Donald J. Wheeler characterized the region within specification limits as where wedeny that losses exist. As we diverge from nominal, losses grow until the point where losses are too great to deny and the specification limit is drawn. All these losses are, as W. Edwards Deming would describe them, unknown and unknowable, but Taguchi wanted to find a useful way of representing them statistically. Taguchi specified three situations:

- Larger the better (for example, agricultural yield);
- Smaller the better (for example, carbon dioxide emissions); and
- On-target, minimum-variation (for example, a mating part in an assembly).

The first two cases are represented by simple monotonic loss functions. In the third case, Taguchi adopted a squared-error loss function for several reasons:

- It is the first "symmetric" term in the Taylor series expansion of real analytic loss-functions.
- Total loss is measured by the variance. For uncorrelated random variables, as variance is additive the total loss is an additive measurement of cost.

- The squared-error loss function is widely used in statistics, following Gauss's use of the squared-error loss function in justifying the method of least squares.

5.1.2 OFF – LINE QUALITY CONTROL

Taguchi's rule for manufacturing

Taguchi realized that the best opportunity to eliminate variation is during the design of a product and its manufacturing process. Consequently, he developed a strategy for quality engineering that can be used in both contexts. The process has three stages:

- System design
- Parameter (measure) design
- Tolerance design

System design

This is design at the conceptual level, involving creativity and innovation. We show the continual improvement of the quality management system in this figure.
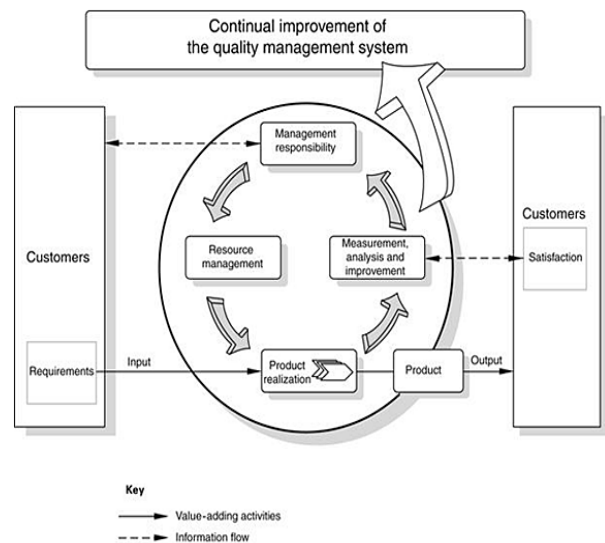

Figure 5.2 continual improvement of the quality management system

Parameter design

Once the concept is established, the nominal values of the various dimensions and design parameters need to be set, the detail design phase of conventional engineering. Taguchi's radical insight was that the exact choice of values required is under-specified by the performance requirements of the system. In many circumstances, this allows the parameters to be chosen so as to minimize the effects on performance arising from variation in manufacture, environment and cumulative damage. This is sometimes called robustification. Robust parameter designs consider controllable and uncontrollable noise variables; they seek to exploit relationships and optimize settings that minimize the effects of the noise variables.

Tolerance design

With a successfully completed parameter design, and an understanding of the effect that the various parameters have on performance, resources can be focused on reducing and controlling variation in the critical few dimensions.

5.1.3 DESIGN OF EXPERIMENTS

Taguchi developed his experimental theories independently. Taguchi read works following R. A. Fisher only in 1954. Taguchi's framework for design of experiments is idiosyncratic and often flawed, but contains much that is of enormous value He made a number of innovations.

Outer Array

Taguchi's designs aimed to allow greater understanding of variation than did many of the traditional designs from the analysis of variance (following Fisher). Taguchi contended that conventional sampling is

inadequate here as there is no way of obtaining a random sample of future conditions. In Fisher's design of experiments and analysis of variance, experiments aim to reduce the influence of nuisance factors to allow comparisons of the mean treatment-effects. Variation becomes even more central in Taguchi's thinking.

Taguchi proposed extending each experiment with an "outer array" (possibly an orthogonal array); the "outer array" should simulate the random environment in which the product would function. This is an example of judgmental sampling. Many quality specialists have been using "outer arrays".

Later innovations in outer arrays resulted in "compounded noise." This involves combining a few noise factors to create two levels in the outer array: First, noise factors that drive output lower, and second, noise factors that drive output higher. "Compounded noise" simulates the extremes of noise variation but uses fewer experimental runs than would previous Taguchi designs.

Management of Interaction

Many of the orthogonal arrays that Taguchi has advocated are saturated arrays, allowing no scope for estimation of interactions. This is a continuing topic of controversy. However, this is only true for "control factors" or factors in the "inner array". By combining an inner array of control factors with an outer array of "noise factors", Taguchi's approach provides "full information" on control-by-noise interactions, it is claimed. Taguchi argues that such interactions have the greatest importance in achieving a design that is robust to noise factor variation. The Taguchi approach provides more complete interaction information than typical

To Study the Quality Assurance & Control of Products in Industries *Jagtar Singh*

fractional factorial designs, its adherents claim.

- Followers of Taguchi argue that the designs offer rapid results and that interactions can be eliminated by proper choice of quality characteristics. That notwithstanding a "confirmation experiment" offers protection against any residual interactions. If the quality characteristic represents the energy transformation of the system, then the "likelihood" of control factor-by-control factor interactions is greatly reduced, since "energy" is "additive".

Inefficiencies of Taguchi's designs
- Interactions are part of the real world. In Taguchi's arrays, interactions are confounded and difficult to resolve.

Statisticians in response surface methodology (RSM) advocate the "sequential assembly" of designs: In the RSM approach, a screening design is followed by a "follow-up design" that resolves only the confounded interactions judged worth resolution. A second follow-up design may be added (time and resources allowing) to explore possible high-order univariate effects of the remaining variables, as high-order univariate effects are less likely in variables already eliminated for having no linear effect. With the economy of screening designs and the flexibility of follow-up designs, sequential designs have great statistical efficiency. The sequential designs of response surface methodology require far fewer experimental runs than would a sequence of Taguchi's designs.

Analysis of Experiments

Taguchi introduced many methods for analyzing experimental results including

novel applications of the analysis of variance and minute analysis.

5.2 ASSESSMENT

Genichi Taguchi has made valuable contributions to statistics and engineering. His emphasis on loss to society, techniques for investigating variation in experiments, and his overall strategy of system, parameter and tolerance design have been influential in improving manufactured quality worldwide. Although some of the statistical aspects of the Taguchi methods are disputable, there is no dispute that they are widely applied to various processes. A quick search in related journals, as well as the World Wide Web, reveals that the method is being successfully implemented in diverse areas, such as the design of VLSI; optimization of communication & information networks, development of electronic circuits, laser engraving of photo masks, cash-flow optimization in banking, government policymaking, runway utilization improvement in airports, and even robust eco-design.

CONCLUSION AND FUTURE WORK

This chapter is based upon the conclusion of what we have done so far and how the system can be further enhanced with an increase in requirements.

6.1 TRANSFORMING THE FUTURE OF QUALITY

Quality's new dimension requires professionals to go beyond the core skills and practices that were used in the1980s. They must develop and better use more strategic thinking skills to adapt to the four key forces of change that are influencing organizational strategies and business results. These trends are:
- Globalization
- Customer sophistication

- Talent management and leadership issues
- Environmental concerns and social responsibility

Identified by The Conference Board Quality Council, these trends effectively mirror the seven forces of change that are shaping the future of quality as reported in the 2008 ASQ Futures Study. Interestingly, similar to those defined by the Quality Council, all are examples of forces or trends that are outside the organization or company:
1) Globalization, 2) Social Responsibility, 3) New Dimensions for Quality, 4) Aging Population, 5) Healthcare, 6) Environmental Concern, and 7) 21stCentury Technology

6.2 CONCLUSION

The quality executive is a revenue-generator and revenue protector, as well as a cost-cutter—vital roles in holding the line in a down economy while positioning the organization to take advantage of growth opportunities during a recovery. Ideally, business and organizational leaders must naturally apply quality tools and techniques to drive their business. The customer demands it. A culture must be created where the tenets of quality are embedded in the organization's DNA and that they are designed to meet the business challenges while delivering predictable, sustainable business results in good economic times and in bad. To achieve these goals, quality professionals must continue to acquire skills that allow them to become strategic business partners to their company's senior leadership team. The result: More engaged employees, more loyal customers, better bottom line performance, and improved top-line growth.

REFERENCES

[1]. Hung-Che Wu, Ching-Chan Cheng "A hierarchical model of service quality in the airline industry" Third International Symposium on Date of Conference: 19 Sept. 2013, Pages 13-22)

[2]. Ying-guo Lü, Jie Chen, Xue-qin Li, Lu Ren "Study on processing and quality improvement of frozen noodles" LWT - Food Science and Technology, Volume 59, Issue 1, Date of Conference: Nov 2013, Pages 403 - 410 Vol. 1)

[3]. Chee-Cheng Chen, "Application of quality function deployment in the semiconductor industry: A case study" Computers & Industrial Engineering, Volume 58, Issue 4, Date of Conference: May. 2010, Pages: 672 – 679

[4]. C.K.H. Lee, K.L. Choy, G.T.S. Ho, K.S. Chin, K.M.Y. Law, Y.K "A hybrid OLAP-association rule mining based quality management system for extracting defect patterns in the garment industry" Expert Systems with Applications, Volume 40, Issue 7,Publication Date: 1 Jun 2013, Pages 2435-2446

[5]. Trent A. Kroeger, Neil J. Davidson, Stephen C. Cook; "Understanding the characteristics of quality for software engineering processes: A Grounded Theory investigation" Information and Software Technology, Volume 56, Issue 2 Publication Date: Feb 2014, Pages 252 – 271)

[6] Gulser Koksal; "A review of data mining applications for quality improvement in manufacturing industry" Volume 38, Issue 10 Publication Date: 15 Sept 2011, Pages 13448 – 13467)

[7] Cebrail Çiflikli, Esra Kahya-Özyirmidokuz; "Implementing a data mining solution for enhancing carpet manufacturing productivity" Volume 23, Issue 8 Publication Date: Dec 2010, Pages 783 – 788)

[8] Jia – Lang Seng, T.C Chen; "An analytic approach to select data mining for business decision" Volume 37, Issue 12 Publication Date: Dec 2010, Pages 8042 – 8057)

[9] John H. Heinrichs, Jeen-Su Lim; "Integrating web-based data mining tools with business models for knowledge management" Volume 35, Issue 1 Publication Date: Apr 2003, Pages 103 – 112)

[10] N. Ur-Rahman, J.A. Harding; "Textual data mining for industrial knowledge management and text classification: A business oriented approach" Volume 39, Issue 5 Publication Date: Apr 2012, Pages 4729 – 4739)

[11] Andrew Kusiak, Matthew Smith; "Data mining in design of products and production systems" Volume 31, Issue 1 Publication Date: 9 Apr 2007, Pages 147 – 156)

[12] Niyati Aggarwal, Amit Kumar, Harsh Khatter, Vaishali Aggarwal; "Analysis the effect of data mining techniques on database" Volume 47, Issue 1 Publication Date: 2 Feb 2012, Pages 164 – 169)

To Study the Quality Assurance & Control of Products in Industries *Jagtar Singh*