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Total Quality Management, Process Analytical Technology, five basic principles and Pharmaceutical Industry: an overview

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Abstract: This article aims to provide good understanding regarding philosophy and teachings of Quality gurus Contribution of three types of Quality Gurus since 1940s for Total Quality Management in industries. Early 1950's Americans who took the messages of quality to Japan, Late 1950's Japanese who developed new concepts in response to the Americans 1970's-1980's Western gurus who followed the Japanese industrial success. The role of FDA inimplementing Process Analytical Technology (PAT) in pharmaceutical Industry is discussed. Based on the various principles of Quality Gurus and FDA-PAT a discussion is made on the formulation of new five basic principles which discusses the Pharmaceutical products/drugs, customer and the implementation of quality in Pharmaceutical industry saving the time of the pharmaceutical Industry as well as the customer.
Key words: Total Quality Management, Process Analytical Technology, Pharmaceutical Industry.

Introduction: Quality

ISO8402-1986 standarddefines quality is "The totality of features and characteristics of a product or service that bears its ability to satisfy stated or implied needs." In manufacturing, a measure of excellence or a state of being free from defects, deficiencies and significant variations. It is brought about by strict and consistent commitment to certain standards and specifications as per the regulatory authorities guidance that achieve uniformity of a product in order to satisfy specific customer or user requirements.

Today, there is no single universal definition of quality. Some people view quality as "performance to standards." Others view it as "meeting the customer's needs" or "satisfying the customer."

Total Quality Management

Total quality management (TQM)[1,2] was developed by William Deming, a management consultant whose work had great impact on Japanese manufacturing.

Investopedia defines TQM as "The continuous process of reducing or eliminating errors in manufacturing, streamlining supply chain management, improving the customer experience and ensuring that employees are up-to-speed with their training. Total quality management aims to hold all parties involved in the production process as accountable for the overall quality of the final product or service."

Contributions of Quality Guru's[3]

Walter A. Shewhart[4] was a statistician at Bell Labs during the 1920s and 1930s. Shewhart studied randomness and recognized that variability existed in all manufacturing processes. He developed quality control charts that are used to identify whether the variability in the process is random or due to an assignable cause, such as poor workers or miss-calibrated machinery. He stressed that eliminating variability improves quality. His work created the foundation for today's statistical process control and he is often referred to as the "grandfather of quality control"

Quality improvement got its starting point in Japan when the Second World War came to end in mid 1940s. **Dr. W. Edwards Deming** who was responsible for the production of Quality war materials in USA during Second World War was invited by the Japanese industrial manufacturers and industrial Engineers to the task of shifting the perception of world towards Japan for its cheap, imitation products to that of innovative quality products. Under the direction of Dr.Deming's,his 14 principles were implemented in Japanese Industries.

1. Create a constancy of purpose
2. Adopt the new philosophy
3. Cease dependence of inspection
4. Do not award business based on price tag alone
5. Improve every process
6. Institute training on the Job
7. Institute leadership
8. Drive out fear
9. Breakdown barriers
10. Eliminate exhortations
11. Eliminate arbitrary numerical targets
12. Permit pride and workmanship
13. Encourage education; and
14. Top management commitment and action

The 14 principles he formulated are universally applicable in all sectors of business such as health-care, education—in fact, to any enterprise one can imagine.

The second American Quality Guru **Joseph M Juran** who was invited to Japan in 1954 by the Union of Japanese Scientists and Engineers (JUSE), visited Japan with his idea of Triology which means

1. Quality planning
2. Quality Improvement ; and
3. Quality Control.

His lectures introduced the management dimensions of planning, organizing, and controlling and focused on the responsibility of management to achieve quality and the need for setting goals.Juran defines quality as fitness for use in terms of design, conformance, availability, safety, and field use. Thus, his concept more closely incorporates the viewpoint of customer. He is prepared to measure everything and relies on systems and problem-solving techniques. Unlike Deming, he focuses on top-down management and technical methods rather than worker pride and satisfaction.

Juran's 10 steps to quality improvement are:

1. Build awareness of opportunity to improve.
2. Set-goals for improvement.
3. Organize to reach goals.
4. Provide training
5. Carryout projects to solve problems.
6. Report progress.
7. Give recognition.

8. Communicate results.
9. Keep score.
10. Maintain momentum by making annual improvement part of the regular systems and processes of the company.

Armand V. Feigenbaumis the founder and president of General Systems Company that designs, implements and installs total quality control systems.He has written a very good book entitled 'Total Quality Control', in 1961. He stressed in his book that quality of products and services is directly influenced by 'Nine Ms' viz.; Markets, Money, Management, Men, Motivation, Materials, Machines and Mechanization, Modern information methods and Mounting product requirements.

Armand V. Feigenbaumwas the first to consider that quality should be considered at all the different stages of the process and not just within the manufacturing function. In his words, "The underlying principle of the total quality view and its basic difference from all other concepts is that it provides genuine effectiveness."

Feigenbaum's philosophy is explained in his "Three steps to quality".

These are explained as under:

1. **Quality Leadership:**
   Management should take the lead in enforcing quality efforts. It should be based on sound planning.
2. **Management Quality Technology:**
   The traditional quality programmes should be replaced by the latest quality technology for satisfying the customers in future.
3. **Organisational Commitment:**
   Motivation and continuous training of the total work force tells about the organisational commitment towards the improvement of the quality of the product and the services.

Prof. Kaoru Ishikawa was a Japanese organizational theorist, Professor at the Faculty of Engineering at the University of Tokyo, noted for his quality management innovations led the concept and use of *Quality Circles*. The intended purpose of a Quality Circle is to;

a. Support the improvement and development of the company
b. Respect human relations in the workplace and increase job satisfaction
c. Draw at employee potential

He believed quality must be company wide – including the product, service, management, the company itself and the people. Quality improvement must be companywide in order to be successful and sustainable. His major contribution stands in his name as Ishikawa diagram is also known as the "*fishbone diagram*" or "*cause and effect diagram*" and is a problem-solving tool used in Quality Circles.

Many, including Juran and Crosby, consider Kaoru Ishikawa's teachings to be more successful in Japan than in the West. Quality circles are effective when management understand statistical quality management techniques and are committed to act on their recommendations. The Quality circle movement was started in Japan by **Prof. IshiKawa**who is known as " The father of Quality circle movement" The contribution of the Quality circles in making Japan an Economic Super power has led many countries to adopt the concept. In India Quality circle forum was started in 1980 with Headquarters at Hyderabad. Quality circle is defined as "it a small group comprising of 6 to 12 employees doing similar work together voluntarily on a regular basis for identifying improvements in their respective work areas. Their aim is to achieve and so also to sustain excellence towards mutual upliftment of employees as well as the organisation.

Genichi Taguchi provided a whole new way to evaluate the quality of a product. Traditionally, product quality has been a correlation between loss and market size for the product. Actual quality of the product was thought of as an adherence to product specifications. Loss due to quality has usually only been thought of as additional costs in manufacturing (i.e. materials, re-tooling, etc.) to the producer up to the time of shipment or sale of the product. It was believed that after sale of the product, the consumer was the one to bear costs due to quality loss either in repairs or the purchase of a new product. It has actually been proven in most cases that in the end the manufacturer are the one to bear the costs of quality loss due to things like negative feedback from

customers. Taguchi changed the perspective of quality by correlating quality with cost and loss in dollars not only at the manufacturing level, but also to the customer and society in general.

Shigeo Shingo - The Japanese Industrial Engineer regarded as one of the most important figures in the history of manufacturing of Japan to the contributions to improving manufacturing processes, Shigeo Shingo has been described and an 'Engineering genius'. He has authored several books including A study of the Toyota Production System; A Revolution in Manufacturing; The Single Minute Exchange of Die (SMED), a process-based innovation system; Zero Quality Control; Source Inspection and the Poka-yoke System; the use of process or design feature. The use of process or design features to prevent errors or their negative impact also known as Poka yoke, Japanese slang for "avoiding inadvertent errors" which was formalized by Shigeo Shingo. A good Poko yoke definition is simply 'mistakeproofing'of note the term Poka yoke is one of the handfulof the more commonly used Japanese terms that have become mainstream in industrial circle. : The Shingo System for Continuous Improvement.

Then came **Philip Crosby,** in 1979 Crosby published a book "Quality is free".The book became popular at that time because of the crisis in North American Quality in products. During late 1970s and1980s North American manufacturers were losing market share to Japanese products largely due to the superior quality of the Japanese goods. Crosby framed four Major principles viz.,

1. The definition of quality is conformance to requirements (requirements meaning both the product and the customer's requirements,
2. The system quality is prevention
3. The performance standard is Zero defects
4. The measurement of quality is the price of nonconformance

His belief was that an organization that establishes good Quality management principles will see savings returns that will be more than pay for the cost of quality system "Quality is free" It is less expensive to do it right at the first time than to pay for rework and repairs at a later time.

USA facing the competition from the resurgent Japanese Economy during 8os became conscious of quality and adopted the approach and called it as total quality service, strategic Quality management, Quality initiative, Quality first are some of the titles for TQM.

David A. Garvin[5] **i**s the Professor of Business Administration at the Harvard Business School. He strongly believed that "If quality is to be managed, it must first be understood." By his experiments David Garvin identified his "eight dimensions of quality" which he maintained covered the meaning of quality to managers, operators and customers

1. Performance: Main operating characteristics such as power, sound, speed etc.
2. Features: The extras that supplement the main characteristics
3. Reliability: How often it breaks down
4. Conformance: How close it is to the design specification or service to the customer's experience.
5. Durability: Length of life, toughness in use, service frequencyetc.
6. Serviceability: Ease, cost and friendliness of service.
7. Aesthetics: Appearance and impression.
8. Perceived quality: The feel, finish and manner in which the customer is dealt with.

Harvard professor David Garvin, in his book *Managing Quality* summarized five principal approaches to define quality.

1. Transcendent
2. Product based
3. User based
4. Manufacturing based
5. Value based

Tom Peters identified leadership as being central to the quality improvement process, discarding the word "Management" for "Leadership". The new role is of a facilitator, and the basis is "Managing by walking about" (MBWA), enabling the leader to keep in touch with customers, innovation and people, the three main

areas in the pursuit of excellence. He believes that, as the effective leader walks, at least 3 major activities are happening:

a. Listening suggests caring
b. Teaching values are transmitted; and
c. Facilitating able to give on-the-spot help

Process Analytical Technology[6,7]

The quality in the pharmaceutical industry has become a very important. Since the world has gathered together to harmonize its practices and guides and the launching of the FDA current good manufacturing practices – the cGMP; for the 21st century – there has been a growing awareness for the significance of the quality of the pharmaceutical products.

Conventional pharmaceutical manufacturing is generally accomplished using batch processing with laboratory testing conducted on collected samples to evaluate quality. This conventional approach has been successful in providing quality pharmaceuticals to the public. However today significant opportunities were available for improving pharmaceutical development manufacturing and quality assurance through innovation in product and process development, process analysis and process control. Pharmaceuticals continue to have an increasingly prominent role in health care. It is high time that pharmaceutical manufacturing will need to employ innovation, utilising the scientific and engineering knowledge along with the best principles of Quality Management to respond to the challenges of new discoveries (e.g ., novel drugs and nanotechnology) and ways to doing business (e.g., individualised therapy, genetically tailored treatment). Regulatory policies must also rise to the challenge. In the recent years regulatory authorities like United States Food and Drug Administration(USFDA) has been rather reserved in the cases of new technology implementation in order to uphold the safety of the patients. Their focus was rather much more that drugs were supposed to be produced exactly according to specifications with proved and established devices. Governments of various countries including India exercise a significant degree of regulatory control over the manufacturing process. In order to ensure the patient safety the manufacturing process has to be validated extensively. Deviation in the process involves time consuming and expensive approval process. Number of disadvantages are there in manufacturing drugs in this method. Quality assurance is performed after the product has been made, so products are sequestered for as much as a month after the production, while testing of samples are completed. If irregularities are found it is too late to adjust the process parameters and the irregularities must be identified and explained in a time consuming investigation or the out of specification material must be thrown out or reworked. It is also against the principle of**Genichi Taguchi.** Loss due to quality has usually only been thought of as additional costs in manufacturing (i.e. materials, re-tooling, etc.) to the producer up to the time of shipment or sale of the product. It is also against the principles of **Joseph M Juran**that it is less expensive to do it right the first time than to pay for rework and repairs at a later time. The final result of this situation is that the Pharmaceutical industry is lagging behind other related industries in implementing new manufacturing technologies which have the potential to improve product consistency reduce delays in product release and cut overall manufacturing costs.

Recently change has been appeared in the thought process and FDA now pushing the pharmaceutical industries across the world to improve the quality standards and implement innovative manufacturing and testing methods. FDA came forward and published a guideline, which describes new technological concept to quality which are summarized under the name “Process Analytical Technology” Process Analytical Technology (PAT) is a system designing, analyzing and controlling the manufacturing process. PAT enables Right – first Time manufacturing . In this way post –process testing will be reduced or eliminated because products result from a tightly controlled process designed to yield good output. Moreover online quality monitoring will reduce off- specification production which in turn reduces the manufacturing costs. FDA has also stated that the goal of PAT is to develop a basic understanding of the manufacturing process and control it accordingly. PAT aims to ensure that all variability affecting a process must be identified explained and managed.

PAT-Frame work[8,9,10]

PAT is intended to support innovation and efficiency in pharmaceutical development manufacturing and quality assurance. The frame work has two components

1. A set of scientific principles and tools supporting innovation;and
2. A strategy for regulatory implementation that will accommodate innovation

The implantation of PAT in pharmaceutical manufacturing brings about several advantages which can be classified into three categories, scientific, benefits, regulatory and business profits. One of the highest costs, when bringing a new drug to market are the development costs which can add up to 30-35% of the total costs. Thus the implementation of PAT during product development can be of enormous value if time to market is influenced. Further benefits of implementing PAT result not only in reduced cycle times and facilitating continuous processing, but also in omission of laborious end products testing's in favour of release based on in-process documentation. PAT is considered to be both strategic and tactical because it supports establishment of plans to achieve company goals and defines projects aligned with these plans, key performance indication of operational performance could be improved and produce time to market could be shortened. However adoption of process analytical technology in the pharmaceutical industry continue to face a number of barriers, which can be broadly classified into three categories, real and perceived technological barriers, lack of economic incentive and regulatory disincentives. Moreover PAT is sometimes considered to as a labor-reductive which may be perceived as a risk by the operating personnel. This is unlikely but new personal skills and capabilities may be required.

Five Basic Principles of Pharmaceutical Industry

To ensure quality and safe products, pharmaceutical companies build their quality approach around Good Manufacturing Practices (GMP), Good Laboratory Practices (GLP), Good Clinical Practices (GCP) and their In- house Standard Operating Procedures (SOPs).

Thus quality is important for pharmaceutical companies due to: Stringent Regulatory requirements; Competitive market; Global competition; Technological advances and Emergence of generic product. History tells us that many drugs approved by US FDA was withdrawn from the market due to safety reasons.

Having studied all the principles of various Total Quality Management Gurus and their difference in their opinion about total quality management and FID's contribution of PAT it is now possible to come to the conclusion that the following five principles may be good for the Pharmaceutical industry namely

1. Products/drugs are for the customer's use
2. Customer based product/drug,
3. Product/drug based on its customer
4. Time of the customer/industry is precious; and
5. Pharmaceutical Industry/organisation/Institution is a growing organism.

The First Principle

Products/drugs are for the customer's use

Drugs which are manufactured after following many regulatory guidelines and specifications also sometimes fails and causes the ill effects on the human beings. Drugs must give quality assurance to the level of quality life for the customers. Drugs must be used in a proper way under the guidance of proper physicians and the customer also should follow the time limit and time table of the drugs to come out of the ailment for which it was prescribed by the Physician.

From the various principles it is well known that one of the key elements of TQM is

Customer care and Quality products.In the field of Pharmaceutical Industry customer means not only the patients but also the Physicians.

The second and third principles viz.,

2. Customer based product/drug,
3. Product/drug based on its customer;

focuses on customer tailored made products for the individual customers. Once before the introduction of mass production of drugs by the pharmaceutical companies, pharmacist used to prepare the drugs for the individual customers/patient based on their disease and ailment.

The first, and overriding, feature of TQM is the company's focus on its customers. Quality is defined as meeting or exceeding customer expectations. The goal is to first identify and then meet customer needs. TQM recognizes that a perfectly produced product has little value if it is not what the customer wants. Therefore, we can say that quality is customer driven. However, it is not always easy to determine what the customer wants, because tastes and preferences change. Also, customer expectations often vary from one customer to the next. Companies need to continually gather information by means of focus groups, market surveys, and customer interviews in order to stay in tune with what customers want. They must always remember that they would not be in business if it were not for their customer.

The fourth principle

Time of the customer/industry is precious;

Also insists on time of the Pharmaceutical Industry and customer.

Many Guru's of TQM speaks about the production of the product with the "Zero error" at the first time itself in order to avoid redoing the whole process at latter stage when quality or specification are not up to the expected standard. PAT emphasis on in-line quality at-quality control in order to create a "Quality free" product. PAT reduces cycle time considerably for the benefit of the Pharmaceutical Industry. PAT speaks the following use which are exactly applicable to the fourth principle.

- Reduce/eliminate deviations
- Improve customer service (product availability)
- Reduce cycle times (operational efficiency)
- Reduce inventory levels
- Reduce costs (reworks, resample, retesting, etc)
- Improve capacity utilization
- Improve compliance (reduce deviation reports)
- Improve assurance of quality

The fifth principle

Pharmaceutical Industry/Organisation/Institution is a growing organism.

Speaks about the growth of the Pharmaceutical Industry in manifold directions. The quality improvement and infrastructure facilities are to be improved based on the market feedback from the customers. Another concept of the TQM philosophy is the focus on continuous improvement. Traditional systems operated on the assumption that once a company achieved a certain level of quality, it was successful and needed no further improvements. The Japanese believe that the best and most lasting changes come from gradual improvements. Continuous improvement, called "Kaizen" by the Japanese, requires that the company continually strive to be better through learning and problem solving. Because we can never achieve perfection, we must always evaluate our performance and take measures to improve it. Product quality is rapidly becoming an important competitive issue. Several surveys have voiced customer's dissatisfaction with the existing levels of quality of the products/drugs marketed.

Conclusion

Pharmaceutical Industry must follow and imbibe within itself all the Total Quality Management Gurus' principles and FDA- PAT, when embarking on, or continuing along, a quality journey within Pharmaceutical Industry. Quality Gurus insights into quality management provide a good understanding of quality management

principles. An example of one such proposition is: quality is a responsibility of the whole organization, rather than of the quality department. It is advisable to take note of the messages from all of the prominent quality gurus, who have most influenced the path of quality in the last 50 – 60 years. Pharmaceutical Industries must keep the five basic principles as a slogan to attain the quality products/drugs which are discussed to reach the Indian pharmaceutical industry in the international market a leader as asupplier of good quality, low cost generic bulk and formulation.

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