A historical perspective of Quality Control is presented in the schematic way as below

Table 2.1 : *Historical Perspective of Quality Control*

S.No.	Period	Q.C. Strategies
1.	*Before Industrial Revolution*	**Craftsmanship** The craftsman or the master craftsman was responsible for quality control. In doing so he was using his own judgement and experience.
2.	*During Industrial Revolution*	**Supervisory Practices** Quality control was exercised through checks and supervision of workers by following inspection techniques generally visual in nature.
3.	*Dawn of the 20th century*	**Inspection Techniques** The emergence of mass production led to the development and sophistication in inspection techniques. Emphasis was still on the finished products.
4.	*After the World War*	**Statistical Quality Control (SQC)** Basic statistical principles were employed to develop sophisticated techniques of quality control. It led to the introduction of the 'Sampling Tables' and 'Control Charts'. It was used to control the quality of products during the manufacturing stages. Statistical analysis was used as a feedback to bring appropriate changes in process and also for controlling the process.
5.	*Modern Era*	**Quality as an Emergent Property** The concepts like Total Quality Control (TQC) Quality Assurance, Company Wide Quality and Creativity [CWQC], and zero defect quality control are developed. Inspection oriented approach is changed to prevention oriented approach, by identifying problems before they occur and solving them.

2.3 CONCEPT OF TOTAL QUALITY MANAGEMENT (TQM)

Total Quality Management has been accepted throughout the world these days. Many orgnaisations are trying to adopt TQM as a way of life. In fact TQM is the need of all modern organisations, which was realised first in Japan. TQM is an organisation wide quality focussed culture. It is a system approach to quality management and a journey to achieve excellence in all aspects of orgaisation's activity. The quality standards do not remain the same for ever. They are to be modified or changed to meet the changing requirements of the customers and to make use of new technology. The launching of ISO : 9000 series standards is an attempt to help the industrial organisations in adopting TQM to improve their quality and productivity.

Definitions

TQM has been defined in number of ways. The following are some of the definitions of TQM :

1. TQM refers to the total involvement of staff in an organisation together, which includes suppliers, distributors and even customers in brining about quality satisfaction by promoting quality cultures through quality circles, job enrichment and effective purchasing. Workers and supervisors have to be trained to solve the problems in product/process variations.

2. **According to Prof. Leopald S. Vasin,**

   "TQM is the control of all transformation processes of an organisation to best satisfy customer's needs in the most economical manner".

3. TQM is a management approach of orgnaisation, centred on quality, based on the participation of all its members and aiming at long term success through customer satisfaction and benefits to the members of orgnaisation and society (ISO : 8402/IS 13999).

   Total in TQM standards for an overall integrated approach to all aspects of quality, hardware/software and even management commitments.

4. **According to Sashkin and Kiser,**

   "TQM may be defined as creating an organisational culture committed to the continuous improvement of skills, teamwork, processes, product and service quality and customer satisfaction."

   Thus, TQM is a continuous customer-centred employee driven improvement.

5. "TQM is a combination of socio-technical process towards doing the right things (externally), everything right (internally), first time and all the times with economic viability considered at each stage of each process."

6. **Bently (1987) mentions that,**

   "TQM is a systematic approach to education, management and operations designed to focuss and co-ordinate the efforts of all employees in an organisation to perform certain activities to :

   - ❒ Know and meet requirements of their jobs.
   - ❒ Prevent problems which may cause defects.
   - ❒ Understand the cost of not meeting the requirements and,
   - ❒ Strive to reduce the cost on a continuous basis".

7. **Atkinson (1990) describes**

   TQM as a strategic approach to produce the best product and services possible through constant innovation.

8. **According to Price and Chen (1993),**

   TQM is a management system, not a series of programmes. It is a system that puts customer satisfaction before profit. It is a system that comprises a set of integrated philosophies, tools and processes used to accomplish business objectives by creating delighted customers consistently meeting or exceeding their expectation and creating happy employees.

9. TQM is a style of working of management to achieve customer satisfaction by boostin quality through continuous improvement and by motivating employees towards quality. Th goal of TQM is to achieve complete lack of defects *i.e.*, zero defects. It is applicable to bot products and services.

10. TQM, therefore, can be viewed as the process wherein the top management alongwith the people in the organisation ensure improvement in the product quality and work environment continuously at all stages and levels, with the aim of improving customer's and employee's satisfaction. It is a process of examining every critical system in an organisation establishing base line measures of performance and then constantly working to improve them.

2.4 TQM PHILOSOPHIES

As a philosophy of modern business TQM will probably carry on evolving and introducing new concepts and principles. However, the fundamental principles which have been developed by Quality Gurus like Deming, Juran, Philip B. Crosby and others will still play a crucial role in creating a quality culture in the organisation and determining the degree of success in business competition.

The various philosophies are described in brief as below.

Deming's Approach to TQM

Deming proposed 14 principles of quality management, which focus on the role of management and a participating work force. These principles are aimed at creating an organisational climate in which statistical methods can be implemented for quality improvement. He advocated the 'Deming Cycle' *i.e.*, Plan, Do, Check and Act (PDCA) for action by managers. His views on improving quality contain fourteen point-approach as follows :

1. Create constancy of purpose – towards improvement of product and service, with an aim to become competitive, stay in business and provide jobs.
2. Adopt the new philosophy – for making the accepted levels of defects, delays or mistakes unwanted.
3. Cease dependence on mass inspection – Eliminate the need for inspection on a mass basis by building quality into the product in the first place.
4. Minimise total cost – try to stop awarding business with respect to the price.
5. Improve constantly and forever the system of production and service, to improve quality and productivity and this constantly decreases cost.
6. Institute modern methods of training – for all employees, including manager to make better use of all employees.
7. Institute leadership. The aim of supervision should be to help people and machines and gadgets to do a better job.
8. Drive out fear – so that every one may work effectively for the company.
9. Break down the barriers between departments – so that every one can work as a team member.
10. Eliminate slogans, exhortations and targets for the workforce that ask for zero defects and new levels of productivity.
11. Aim to eliminate work standards on the factory floor prescribing numeric quotas.

12. Remove barriers to pride of workmanship.
13. Institute a vigorous programme of education and self-improvement.
14. Establish companywide quality improvement. Put everybody in the company to work to accomplish the transformation.

Deming's philosophy on corporate quality management can be characterised as follows :

- It is management led.
- Everyone in the organisation has to take part.
- It is based on a continuous process of improvement.
- It is scientifically-based
- It aims at serving the customer better all the time.

Juran's Ten Steps to Quality Improvement

Juran proposes that three managerial processes are necessary for the structured implementation of a total quality programme : planning, control and improvement. Juran argues that the planning process is crucial for improvement to become a continuous activity. Planning has to be conducted with a long term view rather than on a project by project basis. He advocated *ten* steps to quality improvement as follows :

1. Start with building awareness of the need and opportunity for improvement.
2. Set realistic goals for improvement.
3. Organise to reach the goals by methods to establish a quality council, identify problems, select projects, appoint teams, designate facilities.
4. Provide training.
5. Carry out projects to solve problems.
6. Report progress.
7. Give recognition to any body who achieves.
8. Communicate results to all concerned.
9. Keep score by being quantitative.
10. Maintain a regular momentum by making annual improvement in part of the systems and process of the company.

Juran's Triology : (Quality Planning, Quality Control, Quality Improvement)

Juran estimated that about 15 percent of quality problems (variations) in a company are due to special causes which means that they may involve workers. In his view, 85% or more are due to management dealing with the system. He stressed that the most important thing to upgrading quality is not technology but quality management. The long term health of the business is determined by a structural approach to quality which is planned, implemented and controlled according to the mission of the business concerned.

Juran proposes *three* managerial (basic quality related) processes which are necessary for the structural implementation of total quality programmes : (*i*) Quality planning (*ii*) Quality control and (*iii*) Quality improvement. These processes have become known as Juran's triology.

Quality Planning

The planning component begins with external customers. Once quality goals are estimated, marketing determines the external customer, and all organisational personnel (managers, members or multi-functional teams or work groups) determine the internal customers.

External customers may be numerous, where there are numerous customers a Pareto diagram might be useful to determine the vital few. Once the customers are determined, their needs are discovered. Customer's needs are then translated to requirements that are understandable to the organisation and its suppliers.

The next step in the planning process is to develop product and/or service features that respond to customer needs, meet the needs of the organisation and its suppliers, are competitive and optimize the cost of all stake holders. This step typically is performed by a multi-functional Team-Quality Function Deployment, Taguchi's quality engineering and quality by design are some of the approaches that can be used.

The next step is to develop the process able to produce the product and/or service features: Activities include determining the necessary facilities, training and operation, control and maintenance of the facilities. Additional activities include process capability evaluation and process control type and location.

Transferring plans to operations is the final step of the planning process. Process validation is necessary to ensure with a high degree of assurance that the process will consistently produce the product or service meeting requirements.

Quality Control

Control is used by operating forces to meet the product, process, and service requirements. It uses feedback loop and consists of the following steps :

1. Determine items/subjects to be controlled and their units of measure.
2. Set goals for the controls and determine what sensors need to be put in place to measure the product, process or service.
3. Measure actual performance.
4. Compare actual performance to goals.
5. Act on the difference.

Statistical Process Control (SPC) is the primary technique for achieving control. The basic tools are Pareto diagrams, flow diagram, cause-effect analysis, check sheets, histograms, control charts and scatter diagrams. In addition, process capability information such as C_p and C_{pk} are used to determine if the process is capable and centered.

Quality Improvement

The third part of the triology aims to attain levels of performance that are significantly higher than current levels. Process improvements begins with the establishment of an effective infrastructure such as quality council. The improvement is continuous and never ending.

Juran Triology diagram Fig. 2.3) provides an example of how the three continuous improvement processes inter-relate. In the figure, Juran provides a distinction between sporadic waste and chronic waste. The sporadic waste can be identified and corrected through quality control. The chronic waste requires an improvement process.

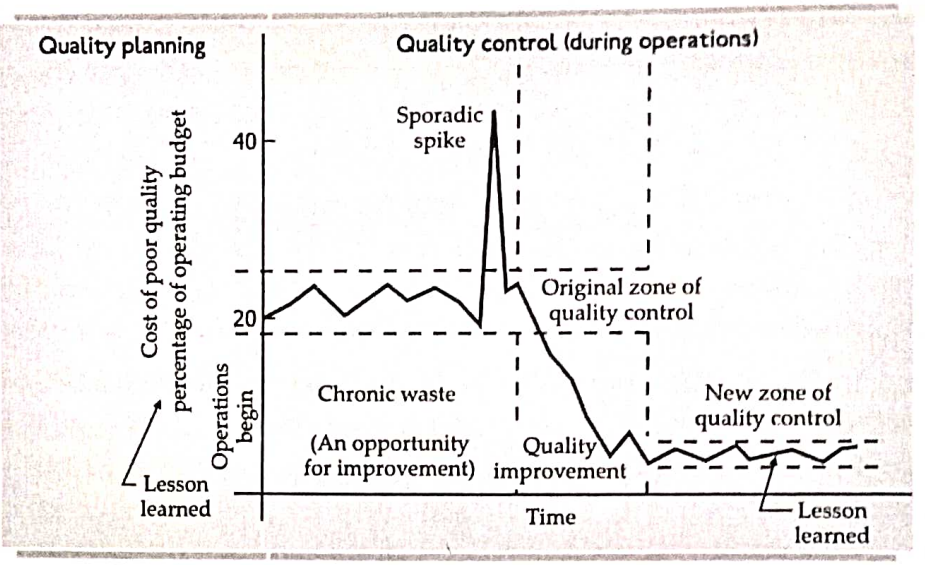

Fig. 2.3 The Juran Triology

As a solution is found through the improvement lessons learned are brought back to the quality planning process so that need goals for the organisation may be established.

There are four primary improvement strategies : *repair, refinement, renovation* and *reinvention.* Choosing the right strategy for the right situation is critical. It is also true that proper integration of the strategies will produce never ending improvement.

Juran draws a fine parallel between his triology process and financial processes in which quality planning equates to budgeting, quality control to cost control or expense control and quality improvement to cost reduction or profit improvement.

Financial Processes

Process	*Some elements*
Financial planning	Budgeting
Financial control	Expense measurement
Financial improvement	Cost reduction

Juran's triology can be represented in a tabular form as below :

Table 2.2 : *Juran's Triology*

	Quality planning	*Quality control*	*Quality improvement*
1.	Establish quality goals	Choose control subjects	Prove the need for improvement
2.	Identify customers	Choose units of measure	Identify specific projects for improvement
3.	Discover customer needs	Set goals	Organise project teams
4.	Develop product features	Create sensor	Diagnose the causes
5.	Develop process features	Measure actual difference	Provide remedies, prove that the remedies are effective
6.	Establish process controls	Take action on the difference	Deal with resistance to change
7.	Transfer to operations		Provide for control to hold gains.

The following table (Table 2.3) shows the end result of Juran's triology processes :

Table 2.3 : *The end result of Juran's triology processes*

	Triology process	End result
1.	*Quality planning.* The process for preparing to meet quality goals.	A process capable of meeting quality goals under operating conditions.
2.	*Quality control.* The process for meeting quality goals during operations.	Conduct of operations in accordance with the quality plan.
3.	*Quality improvement.* The process for breaking through to unprecedented levels of performance.	Conduct of operations at levels of quality distinctly superior to planning performance.

For the triology of quality process to be successful framework for achieving quality objectives, it is necessary that the process rests on a foundation of inspirational leadership and environment and practices strongly supportive to quality. Without such a quality "Culture" the triology of quality processes cannot be fully effective.

2.5 TAGUCHI PHILOSOPHY

Concept of Parameter Design and Robust Design

There are *three* product development states : *product design, process design,* and *production.* The sources of variation during these stages are noise *i.e.,* environmental variables, product deterioration, and production variations. The counter measures against all these sources of variation are possible only at the product design stage.

To achieve desirable product quality by design Dr. Taguchi recommends a *three* stage process :

- System design
- Parameter design
- Tolerance design

The corner stone of Taguchi's philosophy is robust design. Fig. 2.4 illustrates the three design components ; *system design, parameter design* and *tolerance design,* with robust design encompassing the latter two.

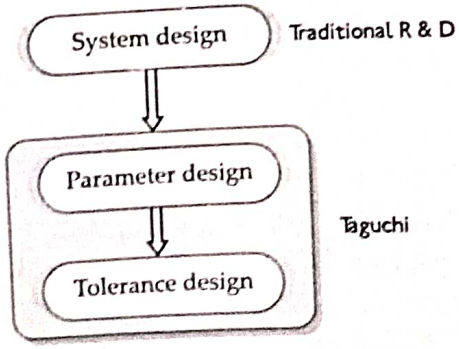

Fig. 2.4 Robust design is the corner stone of Taguchi's philosophy.

System design is the development of the prototype. It uses engineering and scientific knowledge to define initial setting of product and process parameter.

To create the desired output, engineers use engineering principles to combine inputs of materials, parts, components, assemblies, sub-assemblies etc. For each of these inputs, the engineer identifies parameters and specifies numerical values to achieve the required output of the product. For each parameter, the specifications state a target (or nominal) value and a tolerance range around the target. The process is called parameter and tolerance design.

In setting these values, it is useful to set value so that the performance of the product in the field is not affected by variability in manufacturing or field conditions. Then the design is said to be "robust". Robust designs provide optimum performance simultaneously with variation in manufacturing and field conditions.

Taguchi (1978) has developed a method for determining the optimum values of product and process parameters which will minimize the variations while keeping the mean value or target, so that products are robust. Tolerance design is a step used to fine tune the results of parameter design by tightening the tolerance of factors with significant influence on the product. Such steps will normally lead to identifying the need for better materials, buying newer equipment, spending more money for inspection etc.

Taguchi's parameter design and tolerance design concept is founded on three fundamental concepts. These concepts are :

1. ***Quality should be designed and built into the product and not inspected into it.*** Taguchi believed that quality improvement starts at the very beginning *i.e.*, during the design stages of a product or process, and continues through the production phase.

He observed that poor quality cannot be improved by the process of inspection, screening and salvaging. Therefore, quality concepts should be based upon and developed around the philosophy of prevention. He proposed an "off line" strategy for developing quality improvement.

2. ***Quality is best achieved by minimising the deviation from the target.*** His second concept deals with actual method of affecting quality. He stated that quality is directly related to deviation of a design parameter from the target value, not to conformance to some fixed specifications.

By specifying a target value for the critical property and developing manufacturing processes to meet the target value with little deviation, the life expectancy of the product may be improved considerably.

3. ***The cost of quality should be measured as a function of deviation from the standard and losses should be measured system wide.*** His third concept calls for measuring deviations from a given design parameter in terms of overall life cycle costs of the product. These costs would include the cost of scrap, rework, inspection, returns, warranty, service calls and/or product replacement. These costs provide guidance regarding the major parameters to be controlled.

Taguchi's method incorporates the use of statistical techniques. These statistical methods are intended as a trouble shooting/problem-solving tool in the early stages of the product development cycle. Besides control variables which are dealt with by statistical process control (SPC), Taguchi methods enable engineers/designers to identify 'noise variables' which if not controlled can affect product manufacture and performance.