UNIT IV TQM TOOLS & TECHNIQUES II 9

Quality circles – Quality Function Deployment (QFD) – Taguchi quality loss function –TPM Concepts, improvement needs – Cost of Quality – Performance measures.

Quality Function Deployment(QFD)

- Quality Function Deployment is a planning tool used to fulfill customer expectations.
- Quality Function Deployment focuses on customer expectations or requirements, often referred to as voice of the customer.

QFD TEAM :

There are two types of teams namely

1. Team for designing a new product
2. Team for improving an existing product

BENEFITS OF QFD :

1. Improves Customer satisfaction
   - Creates focus on customer requirements
   - Uses competitive information effectively
   - Prioritizes resources
   - Identifies items that can be acted upon

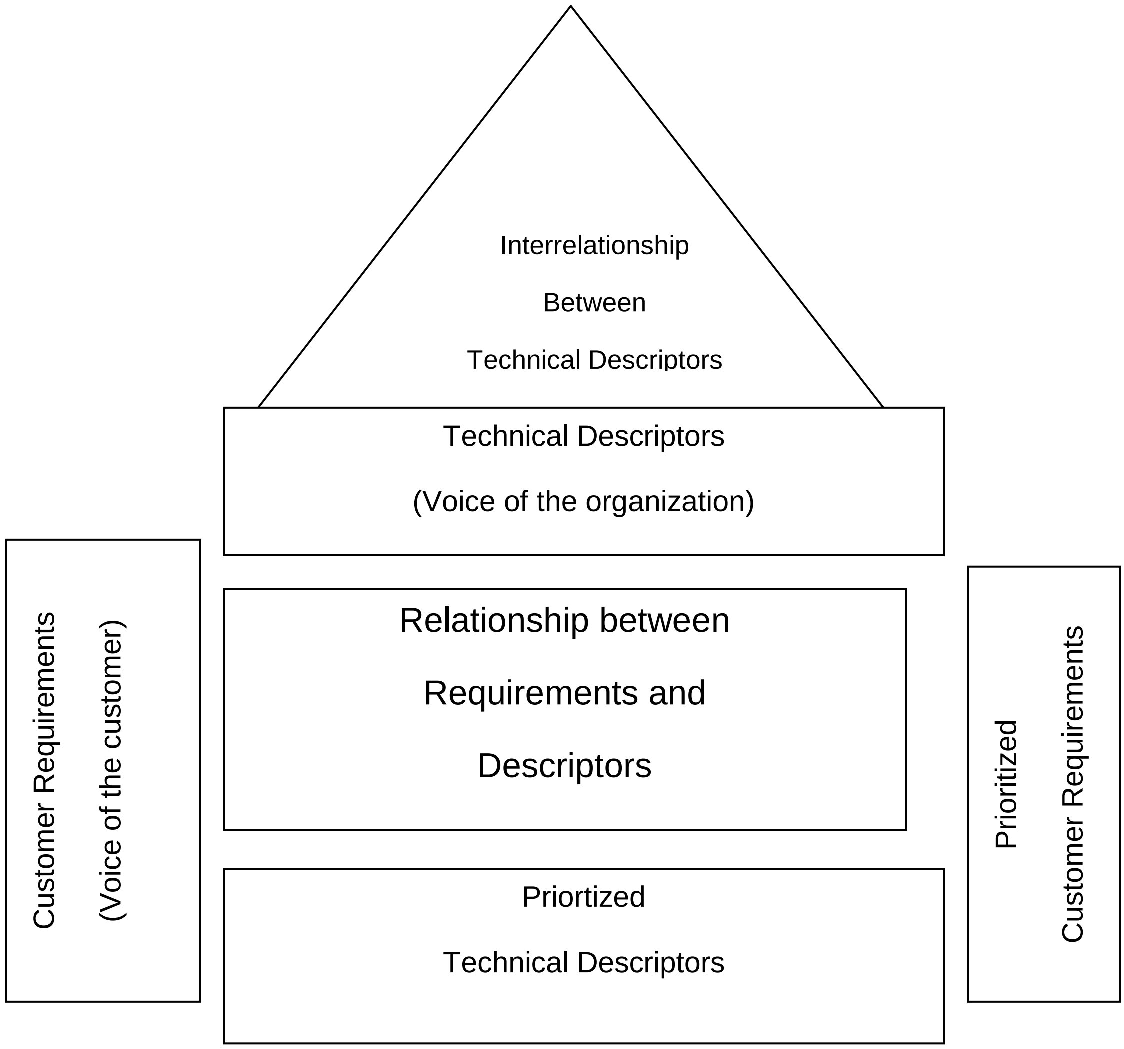
2. Reduces Implementation Time
   - Decreases midstream design changes
   - Limits post introduction problems
   - Avoids future development redundancies

   Promotes Team Work

   - Based on consensus
   - Creates communication
   - Identifies actions

3. Provides Documentation
   - Documents rationale for design
   - Adds structure to the information
   - Adapts to changes (a living document)

House of Quality



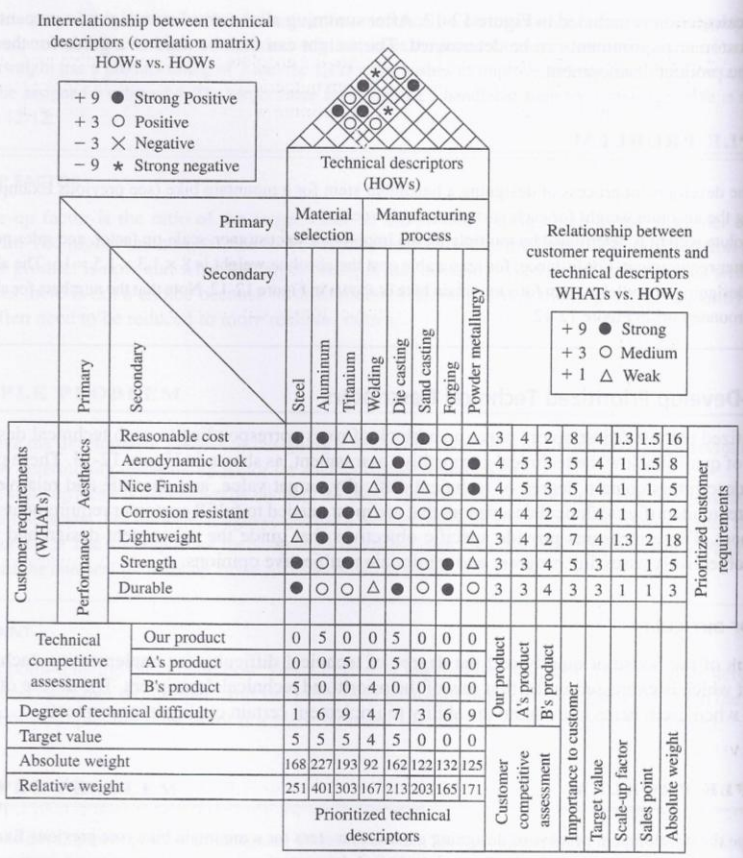


Figure 12-13 Adding Prioritized Technical Descriptors to the House of Quality

EXAMPLE PROBLEM

Continue the development process of designing a handlebar stem for a mountain bike (see previous Examples) by determining the target value for each technical descriptor.

The target value for each technical descriptor is determined in the same way that the target value was determined for each customer requirement (see appropriate Example). The target value for designing a handlebar stem for a mountain bike is shown in Figure 12-13.

THE STEPS IN BUILDING A HOUSE OF QUALITY ARE :

1. List Customer Requirements (WHAT's)

2. List Technical Descriptors (HOW's)

3. Develop a Relationship Matrix Between WHAT's and HOW's

4. Develop an Inter-relationship Matrix between HOW's

5. Competitive Assessments
   a. Customer Competitive Assessments
   b. Technical Competitive Assessments

6. Develop Prioritized Customer Requirements

7. Develop Prioritized Technical Descriptors

TAGUCHI QUALITY LOSS FUNCTION

INTRODUCTION

Taguchi Methods is a statistical methods developed largely by GENICHI TAGUCHI to improve quality of manufactured goods.

The philosophy of off-line quality control.

Innovations in the design of experiments.

Taguchi Loss Function Definition

Taguchi defines Quality as "the *loss imparted by the product to society from the time the product is shipped."*

LOSS = Cost to operate, Failure to function, maintenance and repair cost, customer satisfaction, poor design.

Product to be produced "being within specification"

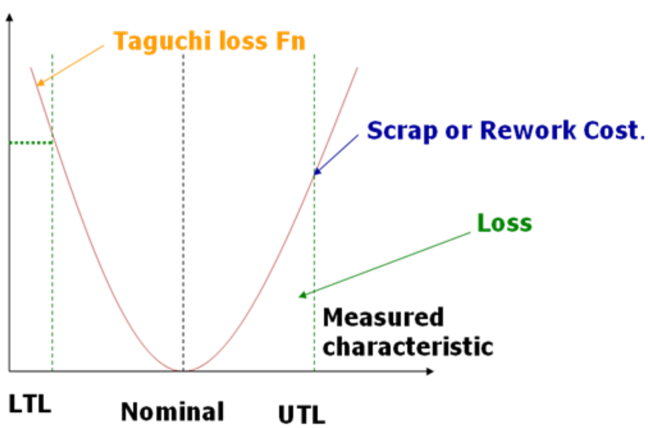
Taguchi's Vs Traditional Approach

Taguchi's Quadratic Quality Loss Function

Quality Loss Occurs when a product's deviates from target or nominal value.

Deviation Grows, then Loss increases.

Taguchi's U-shaped loss Function Curve.



Taguchi uses Quadratic Equation to determine loss Curve

$$\mathbf{L(x) = k(x-N)^2}$$

Where **L (x)** = Loss Function,

k = C/d² replaced: $\mathbf{k = C/d^2}$ = Constant of proportionality, where **C** – Loss associated with sp limit

d - Deviation of specification from target value

x = Quality Features of selected product,

N = Nominal Value of the product and

(x-N) = Tolerance

<u>Problem</u>

A part dimension on a power tool is specified as 32.25±0.25.Company records show±0.25 exceeded & 75% of the returned fo replacement. Cost of replacement is Rs.12,500.Determine **k** & QLF.

Solution : Expected Cost of repair

C = 0.75(12500) = Rs 9,375

k = C/d² = 9375/(90.25)² = Rs 1,50,000

QLF =L (x) 1,50,00(x-N)

Quality Loss Function II

$$L(y) = k(y\text{-}m)^2$$

$L(y)$ = Loss

k = constant = $\frac{\text{cost to correct}}{\text{tolerance}^2}$

y = reported value

m = mean value (average)

(Taguchi On Robust Technology p. 22)

Taguchi's Quality Loss Function concept combines cost, target and variation in one metric with specifications being of secondary importance.

Taguchi has defined quality as the loss imparted to society from the time a product is shipped. Societal losses include failure to meet customer requirements, failure to meet ideal performance and harmful side effects.

- CUSTOMERS PERCEIVE QUALITY AS MEETING THE TARGET RATHER THAN JUST MEETING THE SPECIFICATIONS.

There are three common quality loss functions

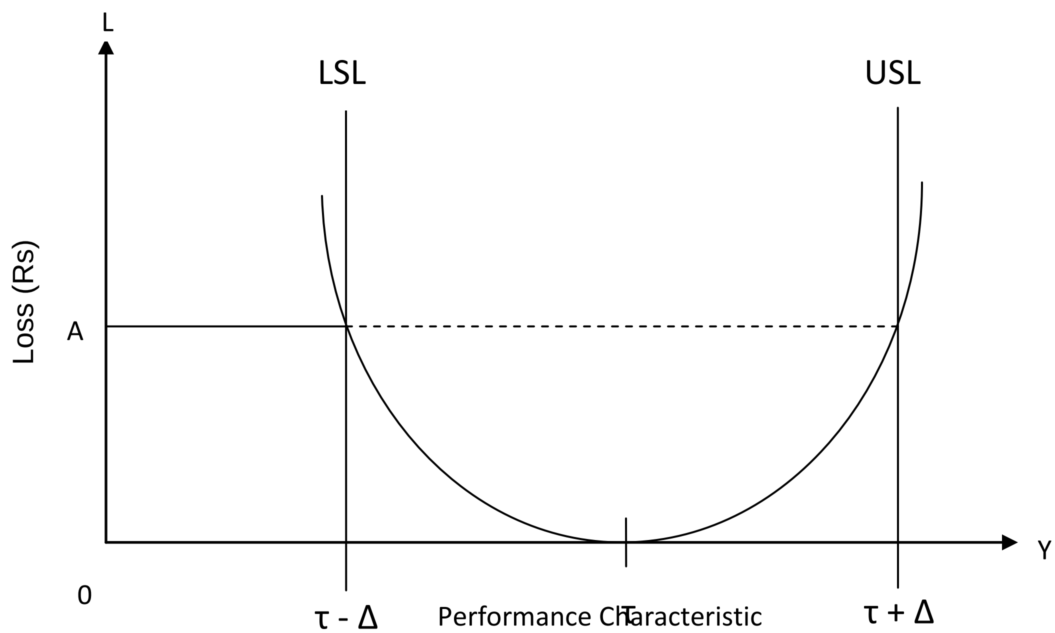
1. Nominal - the - best.

2. Smaller - the - better.

3. Larger - the - better.

NOMINAL – THE – BEST :

Although Taguchi developed so many loss functions, many situations are approximated by the quadratic function which is called the **Nominal – the – best** type.



Quadratic Loss Function

The quadratic function is shown in figure. In this situation, the loss occurs as soon as the performance characteristic, y, departs from the target τ.

At τ, the loss is Rs. 0.

At LSL (or) USL, the loss is Rs. A.

The quadratic loss function is described by the equation $L = k (y - \tau)^2$.

Where,

L = cost incurred as quality deviates from the target.

y = Performance characteristic

τ = target

k = Quality loss coefficient.

The loss coefficient is determined by setting $\Delta = (y - \tau)$, the deviation from the target. When Δ is the USL (or) LSL, the loss to the customer of repairing (or) discarding the product is Rs. A.

Thus,

$$K = A / (y - \tau)^2 = A / \Delta^2 .$$

<u>SMALLER – THE – BETTER :</u>

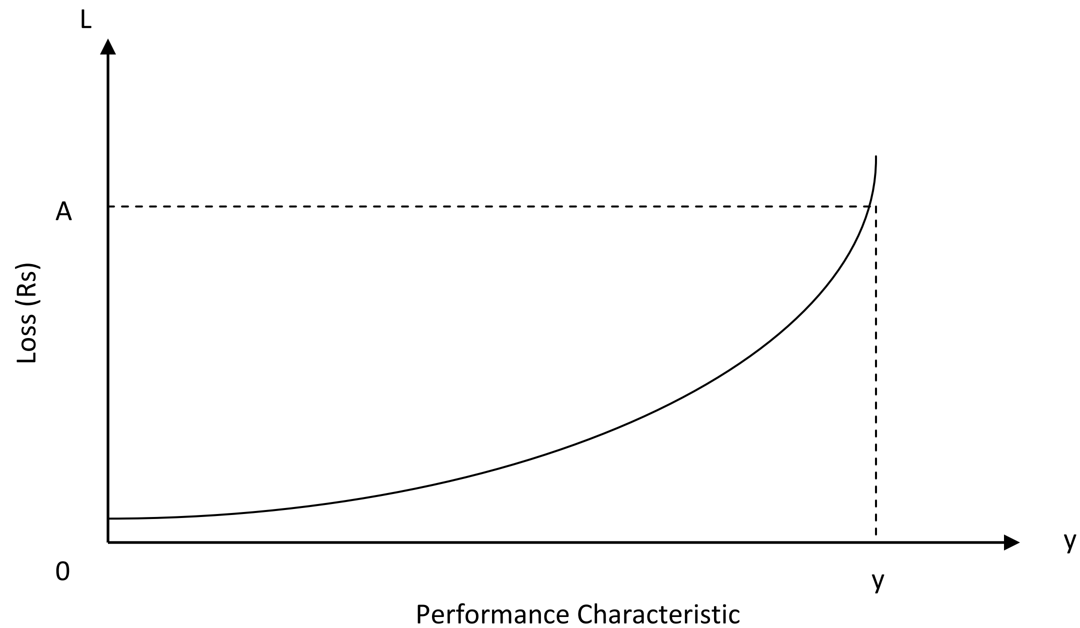
The following figure shows the smaller – the – better concepts.

The target value for **smaller – the – better** is 0. There are no negative values for the performance characteristic.

The radiation leakage from a microwave appliance, the response time for a computer, pollution from an automobile, out of round for a hole etc. are the performance characteristics for this concept.

<u>LARGER – THE – BETTER :</u>

The following figure shows the concept of the Larger – the – better.



TOTAL PRODUCTIVE MAINTENANCE (TPM)

TPM(Total Productive Maintenance).

Total Productive Maintenance (TPM) is defined as keeping the running plant and equipment at its highest productive level with the co-operation of all areas of the organization.

Predictive and Preventive maintenance are essential to building a foundation for a successful TPM environment. **Predictive Maintenance** is the process of using data and statistical tools to determine when a piece of equipment will fail. **Preventive Maintenance** is the process of periodically performing activities such as lubrication on the equipment to keep it running.

OBJECTIVES OF TPM :

1. To maintain and improve equipment capacity.

2. To maintain equipment for life.

3. To use support from all areas of the operation.

4. To encourage input from all employees.

5. To use teams for continuous improvement.

TPM PHILOSOPHY – CONCEPT OF TPM :

Total Productive Maintenance (TPM) is an extension of the Total Quality Management (TQM) philosophy to the maintenance function.

TPM has the following steps:

1. Management should learn the new philosophy of TPM.

2. Management should promote the new philosophy of TPM.

3. Training should be funded and developed for everyone in the organization.

4. Areas of needed improvement should be identified.

   Loss measurements to identify improvement needs are

   - Down time losses
   - Reduced speed losses
   - Poor quality losses

5. Performance goals should be formulated.

6. An implementation plan should be developed.

7. Autonomous worth groups should be established.

ELEMENTS OF QUALITY COSTS

The cost of quality (COQ) can be classified into the following four categories.

- Cost of prevention
- Cost of appraisal
- Cost of internal failures, and
- Cost of external failures.

Cost of Prevention

- ***Prevention costs*** are the costs that are incurred on preventing a quality problem from arising.
- Prevention costs relate to efforts to prevent failures.

- ***Cost of prevention includes:***
- ***Cost of quality planning :*** It includes the costs associated with creating an overall quality plan, the cost of market research and product development, inspection plan, reliability plan, etc.

- ***Cost of documenting:*** It includes cost of preparation of required documents such as manuals, procedures, policies, etc.

- ***Process control cost:*** It is the cost associated with implementing the quality plans and procedures to achieve the stated purpose.

- ***Cost of training:*** It includes the costs of conducting training programmes.

- ***Costs associated with preventing recurring defects:*** It is the engineering, technical and supervisory costs for preventing the reoccurring defects.

- Costs of investigation, analysis and correction of causes of defects by quality control and engineering departments.

- Cost of quality awareness programme.

Cost of Approval

a) ***Appraisal costs*** are the costs that are incurred in assessing that the products / services conform to the requirements.

b) Appraisal costs relate to testing, execution, and examination to assess whether specified quality is being maintained.

c) ***Cost of appraisal includes :***

   a. Cost of receiving test and inspection.
   b. Cost of laboratory acceptance testing.
   c. Cost of installation testing.
   d. Cost of installation and commissioning.
   e. Cost of maintenance and calibration of testing and inspecting equipments.

f. Cost of test equipment depreciation.
g. Cost of analysis of reporting of tests and inspection results.
h. Cost of line quality engineering.
i. Cost of vendor rejects,

Cost of Internal Failures

- ***Internal failure costs*** arise due to internal failures.
- These costs are linked to correcting mistakes before delivery of the product, such as : scrap, rejects, adjustments, downtime of equipment, labour sitting idle while waiting for repairs, and sales discounts for inferior products.

- ***Cost of internal failure includes:***

1. Cost associated with scrap and rejects.
2. Cost of repair and rework.
3. Cost of design changes.
4. Cost of trouble-shooting or defect failure analysis.
5. Cost of reinspection and retesting.
6. Cost of sales discounts for inferior products.
7. Cost of downgrading.
8. Cost of downtime.

Cost of External Failures

1. ***External failure costs*** arise from the rejection of the products / services by the customers due to poor quality.
2. These costs are associated with the adjustments of malfunctions after delivery of the product, such as : repair costs, travel and lodging expenses, replacement costs, stock spare parts, lost goodwill of customer, guarantee and warranty costs, and dispatchment costs.

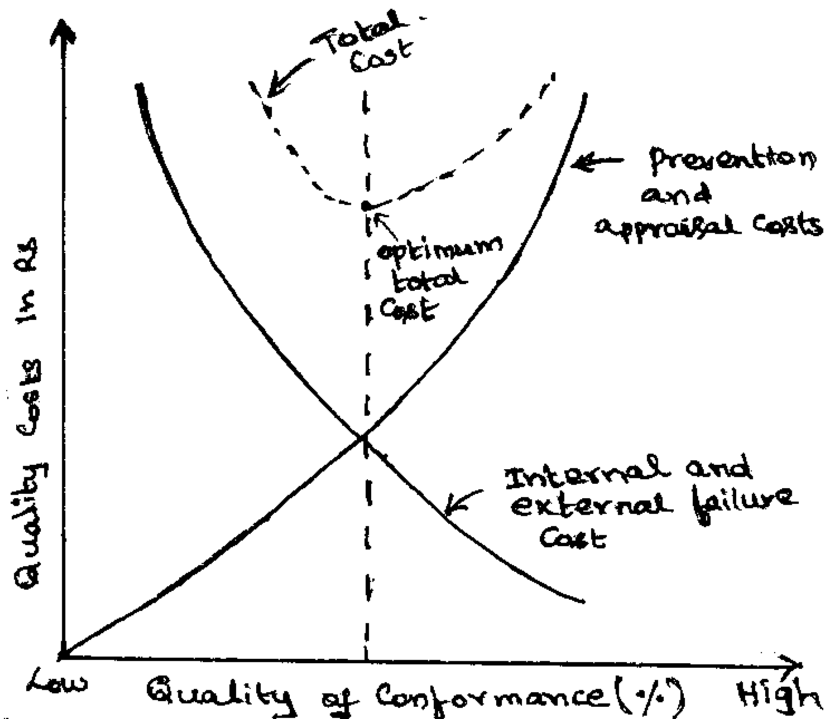
3. ***Cost of external failures include :***

1. Cost of processing complaints from customers.
2. Cost of commissioning failure.
3. Cost of servicing or replacing the defective items.
4. Cost of guarantee and warranty claims.

5. Cost of lost goodwill of customer.
6. Cost of product reliability compensation (voluntary or legal).
7. Cost of loss of sales.
8. Cost of concessions offered to customers (due to substandard products being accepted by customers).

OPTIMUM COST OF PERFORMANCE

The relationship between various cost categories is depicted in Figure. It is understood that the sum of the prevention and appraisal costs rises from zero to infinity as perfection is approached. Thus the optimum total cost point lie between two infinities, as shown in figure



From the figure, it is clear that to achieve a reduction in failure costs, it is necessary to increase prevention and appraisal costs.

4. Discuss the various Analysis techniques involved for Quality Costs.

ANALYSIS OF COQ FOR IMPROVEMENT

Management should use the COQ data to identify and prioritize improvement opportunities. The first priority is to eliminate external failures and then internal failures. Thereafter inspection can be reduced gradually. By spending more money on prevention all these can be achieved. A typical case study is given in Table.

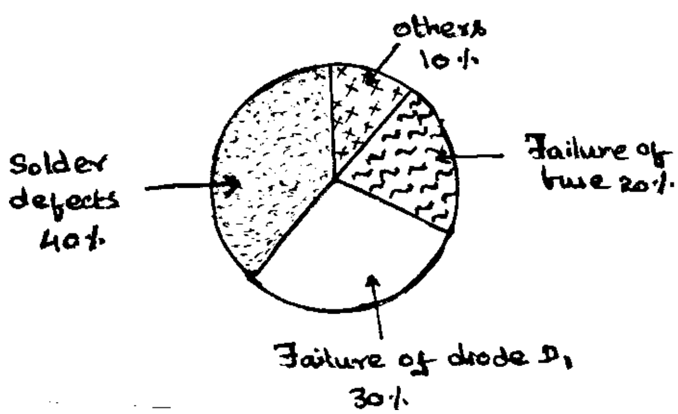
Cost of Quality as a Percentage of Total Manufacturing Cost

Year	External	Internal	Appraisal	Prevention	Total COQ
1995	3	1.5	1	0.5	6
1997	1.5	2.5	1.5	0.5	6
1999	0.5	1	1.5	1	4
2001	0.1	0.2	0.5	1.2	2

During 1997, increasing appraisal without increasing prevention increased internal failures but reduced external failures. However, the total COQ did not change. This is certainly an improvement because external failures affect business very badly. During 1997, the organization decided to get into ISO 9000 and focus on prevention. During 1999 when prevention was stepped up, keeping the same level of inspection, the failures and overall COQ came down. In 1999, the CEO decided to adopt TQM. Vigorous efforts were made to improve quality further and do things right, the first time and every time. Hence in the year 2001, appraisal could be brought down drastically. However, the result is much better as the table indicates. Now both the internal failures and external failures are quite low. Efforts should be made in the same direction so that overall COQ reduces further. Thus, TWM is aimed at enabling the lowest cost of quality.

ANALYSIS OF EXTERNAL, FAILURE COST

Similarly an analysis of external failures was made by the organization. The pie chart below indicates the distribution of causes of external failure.



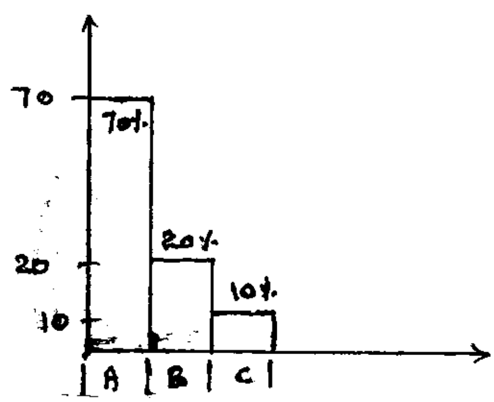
The above pie chart gives the priorities for action to be taken as given below:

1. Improve quality of soldering
2. Eliminate the cause of failure of diode D_1.
3. Estimate the correct rating of fuse and analyze the causes of failure of fuse.

If all the above failures can be eliminated then the failure cost will reduce to about 10 per cent.

ANALYSIS OF INTERNAL FAILURE COSTS

From the data available, the causes for the internal failure costs were analyzed and plotted as a Pareto Diagram.



1. Wrong component placed
2. Soldering failure
3. Other causes.

A major cause of internal failure was insertion of wrong components in the PCB. The process was studied and found that the lighting in assembly line needed improvement and the operators needed training. This analysis and the external failure analysis pointed to problems in the soldering process. A thorough study was required to reduce the defects caused by poor soldering.

Thus, it is very important to analyze the data more closely to derive benefits to the organization.

The COQ analysis gives the following benefits to the organization.

1. Brings out the magnitude of the quality problem in the organization. It further leads to establishing goals for the organization to improve quality.
2. Enables cost reduction owing to steps taken for improvement based on analysis.
3. Enables taking steps to improve customer satisfaction.
4. Displaying the results motivates employees to improve further.