Chapter 9
Total Quality Management

Abstract An exclusive total quality management (TQM) details are provided. Charts containing organization, master plan, design standards, and concurrent engineering are the main focus of this chapter.

TQM aids the new product development processes and produces better quality of processes and products and also the shortening of the developmental time cycles. The Deming prize committee checking points are the practice of concurrent engineering with early involvement of suppliers.

In the processes employed in defining "product concept" typically in non-TQM companies, the customers' inputs namely specification are treated as the product concept in totality.

In a TQM organization the customers' inputs, bench marketing practices, and in-house technology capabilities together would redefine the product as appropriate. From the redefined concept would flow the target quality function and the target specification as below

Cross-functional teams
Practice of FMEA (Failure Mode Effect Analysis)
Time to market trends
Number of design changes and their timings.

Organization for Promoting TQM

TQM organization must be designed to suit each company's need. There is no general rule.

The participating companies should meet once a month and exchange ideas on the tools and techniques being used and also share experiences. Training of facilitators would be a vital input.

Master Plan for TQM Implementation

The balanced score card concept

The weightages assigned could be subjective.
Aggregating the scores of QCD could result in distortions.

K.L. Sundarkrishnaa, *Friction Material Composites*,
Springer Series in Materials Science 171, DOI 10.1007/978-3-319-14069-8_9

The processes are as important as results.
There are established measurement techniques to assess effects of TQ.
Following points are in the master plan.
High-visibility events and conventions which would enhance employee involvement.
Contribution to society.
Apex council as the internal auditing authority.
SOPs and manuals be part of master plan.
Inclusion of policy deployment and daily work management with milestones for implementation.

Design Standards

Concurrent engineering
The subcomponents are as follows

Quality = Filed (customer line rejections, warranty returns) Manufacturing (machining and assembly).
Vendor (quality and schedule adherence) customer satisfaction surveys.
Cost productivity, cost reduction of vendor components.
Delivery sales volume of current and new products and profitability, online delivery performance, inventory management, time to market new products.
Safety accidents.

Morale: Employee morale surveys number of Kaizen activities, number of suggestions, and employee turnover.

Kaizen

The system of implementation of Kaizen practices would be thorough.
Task forces—Fulltime working on projects either sequentially or simultaneously.
Cross-functional teams: Part-time working on specific problems with members drawn from various teams.
Quality improvement teams—to solve specific problems with participants drawn from within functions typically supervisors and managers sometime shop floor workers could be invited to serve on this team.
And quality control circles—Teams comprising of shop floor workers only; the main purpose is to solve small problems. The effect on workers morale is significant.
The author wishes to share the experience with the Japanese approach based on the fact control and the five "why" principles even at the worker level. Educating the people on QC story.

Organization for Promoting TQM

Tier I

TQM apex Council at the respective company/corporate office comprising of Chairman/Vice Chairman, CEOs, Presidents, and Group TQM Coordinator.

Tier II

TQM COMMITTEE at company comprising CEO/President, Head of functions, and Company TQM Facilitator.

Tier III

TQM Teams at unit comprising unit head and departmental heads.

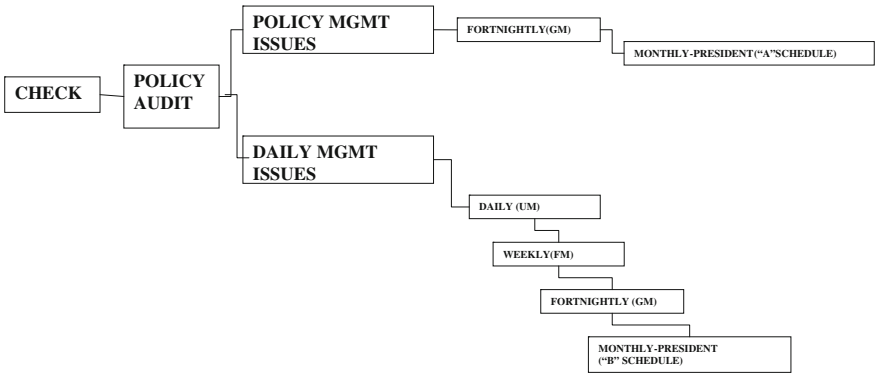
A Typical Master Plan for TQM Implementation Applied to Friction Material Industry

1. Establish TQM promotion organization company CEO
2. Systemetize the top management processes
3. Policy formulation
4. Goal setting
5. Business planning
6. Introduce formal QA system
7. Revisit the important policies
8. Policy deployment
9. TQM awareness campaign
10. Training employees in
    (a) TPM
    (b) Quality circles
    (c) Kaizen
    (d) Customer in concept
    (e) Usage of statistical tools
11. Standardization
12. Introduction of SOPS
13. Introduction of DRM
14. Introduction of TPM
15. Introduce quality circle activities
16. ISO 14000 certification
17. Introduce the balanced score card systems
18. CEOS audit
19. Application for deming prize

Topic	Indicative minimum hours of input	Top management	Managers (incl. engineers)	Supervisors	Workers
General concept of TQM	3				
QC of tools	6				
SPC (SOP, QCPC, and control charts)	3				
DOE	12				
QFD	4.5				
FMEA	4.5				
Reliability techniques	4.5				
Regression analysis	4.5				
QC story	4.5				

Policy Management (Tool)

Policy establishment (P)	X-type matrix	Objective	Tree diagram
Policy deployment (D)	Annual plan	Communication	V_{cs}
	Quarterly plan	Identify bottleneck	
	Monthly plan		
Policy audit (C)	Review format		
	Control chart, radar diagram, and flag diagram		Identify reason for nonachievement
Action (A)	Improvement plan		
	Repeat cycle		



Brainstorming

What is it?

Brainstorming is a technique that encourages creative thinking and the generation of ideas. Analysis and evaluation are prevented in the early stages of brainstorming ensuring radical and different ideas are aired.

How it's done?

Assemble the brainstorming group.
Assemble a scribe and if appropriate a separate timekeeper.

1. Explain the purpose of the meeting and the ground rules. Agree on a statement of the topic or issues to be brainstormed. Write this up at the top of the chart.
2. Allocate time to brainstorm and time to review the outputs; 5–20 min is usually sufficient for generating ideas, but brainstorms can go for hours.

Ground Rules for Brainstorming

No criticism—Crucial if barriers to creative thinking are to be overcome.
Encourage wild ideas—All ideas are acceptable.
Strive for creativity—Generate as many ideas and volumes as possible.
Hitchhike—Build on, add to, and combine ideas.
List of all ideas—No editing or interpretation by the scribe.
Incubate—Take time to reflect on ideas listed often which stimulates new thoughts.

3. Start the ideas coming—make sure all ideas are visible to everyone in the group. Either allow random contributions or go around the team repeatedly to ensure everyone is involved. Individuals can "pass" if they have nothing to add.
4. Ascribe, do not abbreviate or interpret. It is important to capture ideas exactly as they are expressed.
5. Having generated a number of ideas, you can evaluate their usefulness toward meeting the original objective at this stage.
6. Analytical thought should be used. Before doing this; you may need to seek clarification as not all suggestions maybe clear to everyone. Also check for duplications and combine if appropriate.
7. Establish some initial classification. Group ideas with a common theme for example.
8. Evaluate and select the most appropriate ideas. It is here that the output from the brainstorming session can become the input to other techniques/tools such as cause and effect analysis, paired comparisons, and consensus reaching.

Consensus Reaching

What it is?

Making decisions is an important and possibly the most difficult aspect of any manager's job. Involving those affected by a decision will contribute to making a right decision. Consensus reaching enables a group of people to arrive at a decision in a structured way.

How it is done?

1. Explain the Need for a Decision
   Review the circumstances that require a decision. Ensure that everyone understands the need.
2. Brainstorming Ideas/Alternatives
   Log ideas, solutions, and alternatives, using brainstorming rules.
3. Check Understanding
   Ensure that all contributions are fully understood by everyone.
4. Determine the Number of Votes
   Give a reasonable number of votes to each member of the group (fewer votes than ideas—5 votes, 10 ideas). State the maximum number of votes a member can give to any one idea.
5. Allocate Votes
   Ask each member to allocate votes to their preferred solution(s). Select the solution(s) with the most votes. If necessary, go a second round, allocate votes only to the selected solution(s). Voting tests opinion. It does not, in itself secure consensus.
6. Check for Practicality
   Review the results—check that the solution(s) is (are) feasible and that other solutions are less appropriate.
7. Ask for Consensus
   Ask each member to agree to the selected solution.

How it helps?

Consensus reaching enables each member in the group to:

1. Contribute actively to the decision.
2. Gain a clear understanding of another's point of view.

The result is:

A select viewpoint has a high degree of acceptance and commitment from everyone.

Force Field Analysis

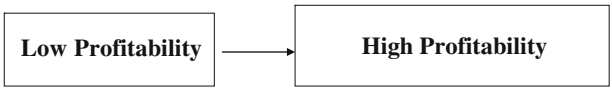
What is it?

Force field analysis is a means of identifying the forces that will help or hinder change. A plan is then developed to harness the positive driving forces and remove, reduce, or avoid the negative or resisting forces. Doing so will increase the likelihood of success.

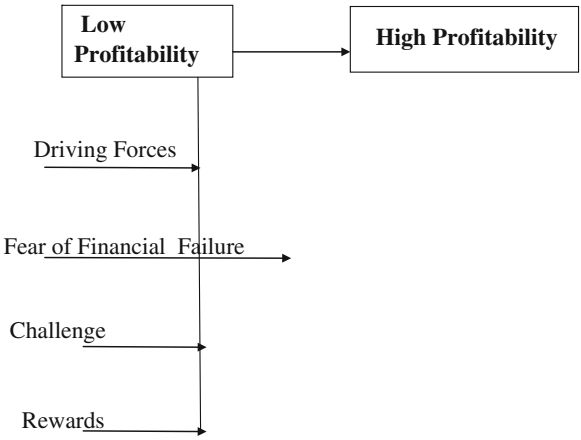
Force field analysis can be used in conjunction with consensus reaching and action plans.

How it is done?

1. Define your current situation. → **Low Profitability**
2. Define your target.



3. Brainstorm the forces which will drive you.



4. Brainstorm the forces which will restrain you from achieving your target solution. It is helpful to cover the driving forces when you brainstorm the restraining forces. This will discourage you from simply listing opposites

Analyze the Forces Decide which will have the greatest impact. It is helpful to focus on reducing the restraining forces as this will allow the existing drivers to take you forward more quickly. Consensus reaching or paired comparisons can be used to hone in on the most significant force or the one which can be tackled most easily.

5. *Develop an Action Plan* To tackle the main forces which you have identified.

How it helps?

Reducing the restraining forces can be more effective than increasing the driving forces. Force field analysis is a simple but quick and structured way of reviewing the forces which will help or hinder your success, in order to identify priorities for action. It can be very powerful at turning a negative situation into a more positive one.

Paired Comparisons

What it is?

In many situations several options or alternatives will be available but there is a need to determine which option or combination of options provides the best result.

Paired comparisons enable a small range of options to be evaluated by choosing between a series of pairs.

How it is done?

1. List the Options
   List the options and alternatives that are to be evaluated on the left-hand column of the grid, example: possible opportunities for improvement or alternative solutions.
2. Decide Evaluation Criteria
   Determine the question to be used to evaluate the pairs of options, e.g., which option provides the biggest benefit? Which option is the most likely to be successful? Which option will deliver the quickest results?
3. Compare Pairs
   Compare option 1 with option 2, determine which is preferred and circle the preferred option on the grid.
   Compare option 1 with option 3, determine which is the preferred option and circle the preferred option on the grid.
   Continue until option 1 has been evaluated against all the other options. Then start to compare option 2 with each of the others in turn. Continue until option 2 has been evaluated against all the other options. This process is continued until all the possible pairs have been evaluated against the evaluation criteria.
4. Count the Preferred Options
   Add up the number of times each option has been chosen and rank in numeral order.

The analysis can be repeated against several different criteria if required and the findings combined.

How it helps?

Paired comparisons enable priorities to be determined in a quick and qualitative way against agreed criteria. It is helpful for deciding priorities when numbers of options are available. It can be used either by an individual or by a team.

Cause and Effect Analysis: Fishbone Diagram

What it is?

Cause and effect analysis is a technique for identifying all the possible causes (inputs) associated with a particular problem/effect (output) before narrowing down to the small number of main root causes which need to be addressed.

A cause and effect diagram (also known as fishbone or ishikawa diagram) graphically illustrates the results of the analysis and is constructed in steps. Cause and effect analysis is usually carried out by a group who all have experience and knowledge of the problem/effect to be analyzed.

How it is done?

1. Select the Problem
   Select a particular problem or effect.
   Make sure the problem is specific, tightly defined, and relatively small in scope and that everyone participating understands exactly what is being analyzed. Write the problem definition at the top of the flip chart or white board.
2. Brainstorm
   Conduct a brainstorm of all the possible causes of the effect, i.e., the problem. Write each idea on a Post-it to make it easy to transfer them on to the fishbone diagram later. Be careful not to muddle causes and solutions at this stage. It is important to brainstorm before identifying cause categories, otherwise you can constrain the range of ideas.
   However if ideas are slow in coming, use questions such as "What about?" to prompt thoughts.
3. Draw Fishbone Diagram
   Place the effect at the head of the fish (Fig. 9.1).

Review your brainstorm outputs to determine the major cause categories. Frequently used categories are:

1. People

   (1) Equipment
   (2) Materials
   (3) Environment (physical or cultural)
   (4) Method or process

   The following five do not fit every situation and different major categories might well be appropriate but should not exceed six.
   Cause and effect analysis: Fishbone diagram…

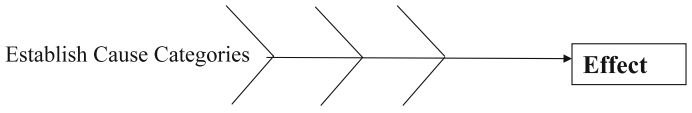


Fig. 9.1 Fishbone diagram

Other commonly used categories are:
(1) Communications
(2) Policies
(3) Measurement
(4) Customers/suppliers
(5) Systems, etc.

2. Allocate Causes
   Transfer the potential causes from the brainstorm to the diagram, placing each cause under the appropriate category. If causes seem to fit more than one category, then it is acceptable to duplicate them. However, if this happens repeatedly, it may be a clue that the categories are wrong and you should go back to step 4.
   Related causes are plotted as "twigs" on the branches.
   Branches and twigs can be further developed by asking questions such as "what", "why", "how", "where". This avoids using broad statements which may in themselves be effects. Beware, however, of digging in and getting into bigger issues that are completely beyond the influence of the team.
3. Analyze for Root Causes
   Consider which are the most likely root causes of the effect. This can be done in several ways.
   (1) Through open discussion among participants, sharing views and experiences. This can be speeded up by using Consensus reaching.
   (2) By looking for repeated causes or number of causes related to a particular category.
   (3) By data gathering using Check Sheets, process maps, or customer surveys to test relative strengths through Pareto analysis.
   (4) Once a relatively small number of main causes have been agreed upon, paired comparisons can be used to narrow down further.
   (5) Some groups find it helpful to consider only those causes they can influence.
4. Test for Reality
   For the most likely causes, e.g., by data gathering and observation, if this has not already been done.
   The diagram can be posted on a wall and added to/modified as further ideas are generated either by team or by others who can review the team's work. Cause and effect analysis can be combined with process.

Mapping

A fishbone maybe developed for each discrete activity within the processes that is generating the output/effect so that causes are linked to particular steps in the process.

How it helps?

Cause and effect analysis is a valuable tool for:

(1) Focusing on causes not symptoms.
(2) Capturing the collective knowledge and experience of a group.
(3) Providing a picture of why an effect is happening.
(4) Establishing a sound basis for further data gathering and action.

Cause and effect analysis can also be used to identify all the areas which need to be tackled to generate a positive effect.

Check Sheet

What it is?

A Check Sheet is a way of collecting and classifying information so that it can be easily presented or analyzed. It is particularly useful at the start of a problem solving process for data gathering but also for monitoring performance once change has been implemented.

No matter how simple or complex the Check Sheet is, the principle is the same.

How it is done?

1. Specify the objective of the Check Sheet.
   Decide why the facts are required. For example, to determine reasons for increasing levels of credit notes.
   (1) Agree on the information to be collected.
   Decide the types of data required and how it will be classified. For example, customer, order number, nature of complaint, date, and driver.
   Ensure data can be broken into subgroups/classes if there are likely to be differences. For example, by root or customer type.
   (2) Identify appropriate timescales.
   Decide over what period the data will be collected-hours, days, weeks, months. At what intervals will the data be taken if it is on a sample basis: Once an hour? Every tenth batch/customer? At random? For example, all credit notes for 4 weeks using daily driver returns.
   (3) Decide who will collect the data.
   Identify the most appropriate individuals to collect the data. Ensure that they have the time and information to do so accurately.
   (4) Design the Check Sheet.
   Prepare an initial design. Ensure it is clear, complete, and easy to use.
   (5) Trial the Check Sheet.
   After an appropriate period, review the classifications and timescales—update as appropriate. Make sure that everyone collecting the facts understands the meaning of the classifications. Go back to step 2 if necessary.

2. Collect the data.
   The people collecting the facts should ideally be those included in the problem —not advisors, consults, or inspectors! Check, however, that everyone is clear about what they are doing and that the exercise is being applied consistently and accurately.
3. Analyze the data.
   Use data display and/or Pareto analysis to highlight main patterns, trends, and issues.
4. Use other tools as appropriate to identify their next steps once completed, these Check Sheets would be analyzed to categorize reasons for credit notes, for example,

Main reasons for credit notes issued	Number issued
Product damage (packaging)	40
Product quality (manufacturing)	2
Missing items	2
Wrong quality	4
Wrong pack size	38
Wrong brand	8

   Once their main category(s) is identified, cause and effect analysis could be used to analyze why this keeps recurring.

How it helps?

Facts are better than opinions. The Check Sheet allows facts about the problem to be established at the source. The facts can then be subjected to Pareto analysis.

A completed example:

Check sheet		Credit Note
Driver: Date:		FRED
Order no.	Customer name	Reason for credit note
134	Jo's Café	Wrong pack size of frozen chips
650	Newton high school	Split 25 lbs. bags of frozen peas
329	Miller Industrial	Missing five dozen eggs
456	Refresh retirement home	Wanted 10 not hundred packs of incontinuence pads
294	Upmarket restaurant	Returned inedible pastry mix

Customer–Supplier Agreement

What it is?

A Customer–Supplier Agreement (CSA) is a written document detailing:

(1) The needs of a customer (either internal or external)
(2) What the supplier can deliver
(3) What is to be done to improve the delivery of the customer requirements

It is sometimes called a "service level agreement."

How it is done?

(1) Decide on the customer—supplier relationship to be addressed
The two main players—the supplier of the output and the customer—should agree in principle that a CSA would improve their part of the quality chain.
(2) Identify Other Interested Parties
Make sure that all interested parties understand what is happening and are willing to "buy in" to the CSA.
(3) Prepare for the Meeting
The two main players should individually review their customer—supplier relationship to generate ideas on, for example, needs and improvement targets. Data can also be gathered to make the discussion more objective.
(4) CSA Discussion
The main players (and other interested parties if appropriate) should meet to discuss and develop an agreement.
Aim to keep the draft as simple as possible. A proforma is shown along with instructions on what to put in each box.
(5) Trial Period
The initial agreement should be for a trial period and amended as required at the end of this time.
(6) Regular Review
The CSA should then be reviewed on a regular basis by the main players in order to update needs and performance measures and identify actions to further improve the relationship.

A CSA Checklist to Help Prepare Is Shown

Agreement checklist
Who are the customer and supplier?
Are there other interested parties?
What are the customer requirements?
How are the outputs measured?
How is the customer response monitored?

What are the respective responsibilities to ensure quality output?
What opportunities for improvement exist now?
What action does each party agree to take?
Other headings, (e.g., what to do in case of disagreement) may be addressed as appropriate.

How it helps?

A CSA can help ensure that the expectations of both customer and supplier are matched and highlight the elements which are key to maintaining or achieving a quality output. It fosters teamwork between different departments and individuals.

CSAs can become extremely complicated—often it is best to start with a simple letter of understanding and add to it as problems are exposed. CSAs can also become overly bureaucratic. It is important that they are focussed on the areas of greatest need and paperwork is kept to a minimum.

Data Display

What it is?

Data display, as the name suggests, are different methods of displaying information in order to use, to highlight patterns, trends, and relationships and make data more interesting for a wider population. The main types of charts are:

(1) Bar charts
(2) Histograms
(3) Pie charts
(4) Run (trends) graphs
(5) Spider diagrams
(6) Scatter diagrams

The patterns, trends, or relationships you wish to show will determine which of the above you choose.

How it is done?

Bar Charts

This display tool enables comparison of several discrete items with each other. For example, average sales at a grocery store (over a 3-month period).

To develop a bar chart:

(1) Identify the items to be measured.
(2) Design a method for collecting the data (including sampling, time frames, and Check Sheets as needed).
(3) Review the data collected and decide on a suitable horizontal scale.
(4) Plot items up the vertical scale.
(5) Draw in bars to show different quantities/performance/values, etc. of each item.

Histogram

A histogram shows the range of data which has been collected on a particular process or characteristic. It shows the frequency distribution in bar form. The data used in histograms is also the starting point for developing control charts as it is linked to variation.

For example,

To develop a histogram:

(1) Identify the variable to be measured (it could be age, size, satisfaction, cost, color, etc.).
(2) Set up a method to collect information (categories, sampling, timeframes, Check Sheets, etc.).
(3) Total the number of times (frequency) that each category of the variable has occurred.
(4) Break the horizontal axis into sections for each category.
(5) Choose a suitable scale for the vertical axis given the frequency distribution.
(6) Plot the bars for each category.

Pie Charts

This display tool shows proportions in relation to the whole item. It has visual impact and also allows easy, visual comparison with other pie charts when percentages are used.

For example, sources of company profit.

To develop a pie chart:

(1) Identify the item to be measured and the appropriate subdivisions.
(2) Collect data on the total performance (number of people, products, money, rejects, satisfaction, ratings, etc.).
(3) Identify how this is broken down across the subdivisions already identified.
(4) Turn the total and subdivisions into percentages.
(5) Break up the pie chart in proportion to these percentages and label clearly.

Data Display

Run (trend) chart

(sometimes called a line graph)

This display tool is used to display trends in one variable over time.

For example, overall sickness rates in a unit.

To develop a run chart:

(1) Identify the variable to be measured.
(2) Develop a method of data collection (timeframes, definitions, who collects, etc.).
(3) Draw the axes on suitable scales given the overall time frame and range of likely performance.
(4) Plot each measure either retrospectively or allow the graph to build over time as the measures become available.

Spider Diagram

A spider diagram is a way of showing performance on a range of dimensions each of which is a component of an overall issue.

For example, leadership performance.

To develop a spider diagram

(1) Identify the issue to be measured and its component parts.
(2) Develop a method of collecting data which will allow the information to be plotted on linear scales.
(3) Collect the data.
(4) Collate the data and summarize the performance of each component on a common scale (e.g., percentages, dimensions, cost, ratings, etc.).
(5) Draw a spider diagram with the appropriate number of "legs" and add the same scale to each.
(6) Plot the performance of each component and label clearly.
(7) If appropriate add previous performances/targets/benchmarks for comparison.

Scatter Diagram

This display tool identifies relationships between two variables by plotting changes in both.

For example, the relationship between advertising and sales volumes.

To develop a scatter diagram:

(1) Identify the two variables to be considered.
(2) Devise a method of collecting performance data on both over time/sites/individuals/products, etc.
(3) Plot suitable scales on each axis. While it is wrong to jump immediately to a cause and effect relationship, plot the more likely cause or driver on the horizontal axis.
(4) Plot each pair of measures on the graph.
(5) The more closely the dots are aligned, the stronger the correlation (positive or negative) between the two. A random pattern of dots means there is no relationship.

How it helps?

Data display helps to demonstrate relationships, patterns, and trends in data. The methods available are visual, interesting, and easier to use than tables of raw data. They help to turn raw data into usable information.

Pareto Analysis

What it is?

This technique is used to record and analyze data relating to a problem in such a way as to highlight the most significant areas, inputs, or issues.

Pareto analysis often reveals that a small number of failures are responsible for the bulk of quality costs, a phenomenon called the "Pareto Principle." This pattern is also called the "80/20 Rule" and shows itself in many ways.

For example,

(1) 80 % of sales are generated by 20 % of customers.
(2) 80 % of quality costs are caused by 20 % of the problems.
(3) 20 % of stock lines will account for 80 % of the value of the stock.

A Pareto diagram allows data to be displayed as a bar chart and enables the main contributors to a problem to be highlighted

How it is done?

(1) Gather facts about the problem using Check Sheets or brainstorming, depending on the availability of information.
For example, typing rework

Reasons for typing rework	Number of times
Author errors	12
Incorrect entry	2
Poor layout	5
Improved content	15
Information became out of date	3

(2) Rank the contributions to the problem in order of frequency

Error	Frequency
Improved content	15
Author errors	12
Poor layout	5
Information became out of date	3
Incorrect entry	2
Total	37

(3) Draw the value (errors, facts, etc.) as a bar chart.
(4) Review the chart—if a 80/20 combination is not obvious, you may need to redefine your classifications and go back to stage 1 or 2.

How it helps?

Pareto analysis is useful to:

(1) Identify and prioritize major problem areas.
(2) Separate the "vital few" from the "useful many" things to do.
(3) Identify major causes and effects.

The technique is often used in conjunction with brainstorming and cause and effect analysis.

Priorities Grid

What it is?

A priorities grid is a tool to help a team decide which option or solution to adopt using the criteria of payoff and ease of implementation.

How it is done?

(1) Brainstorm the options available.
(2) Assess the payoff available for each option (if it helps, do a full cost-benefit analysis). Rate each option on a scale from high to low.
(3) Assess the ease of implementation of each option in terms of time taken/resources needed/knock-on effects and rate each one on a scale from easy to difficult to do.
(4) Build up a grid to show the relative positions of the options against the two scales. Use Post-it notes to do these so that you can easily move the options around on the grid until you are happy that they are in the correct relative positions.
(5) Clearly, the nearer the top right-hand corner of the grid, the better the option. Use the relative positions of all the options to decide which will give the greatest payoff while being easy to do.

For example, addressing declining market share.

How it helps?

A priorities grid is a quick and simple tool for differentiating between a range of potential solutions or options.

Time/Cost Analysis

What it is?

Time/Cost analysis is a graphical way of illustrating the relationship between the time taken to complete each stage of a process, the amount of cost added/invested in each stage, and the overall cycle time.

How it is done?

(1) Identify the process to be analyzed.
(2) Use process mapping to identify the specific steps that make up the process.
(3) For the item(s) going through the process,

Collect data on:

(1) Amount of time spent working on each step.
(2) The elapsed time of each step.
(3) The cost of each step (labor, materials, equipment, space, etc.)
If there is significant variation in the process, use a histogram to identify the average time or cost per unit/batch.

(4) Plot costs/unit against time/unit for each step of the process on a graph.
(5) Use this graph to question:

    (1) Areas of high investment of time.
    (2) Areas of high added cost.
    (3) The amount of active as opposed to waiting time for each activity as a basis for identifying process improvements.

For example,
Decorating a room (DIY enthusiast version)

	Buy wall paper and paint	Empty and prepare room	Paint
Time spent			
Elapsed time			
Cost of each step			

The goal of the analysis is to:

(1) Reduce overall cycle time
(2) Increase value-added more quickly by cutting out wasted time
(3) Remove non-value adding steps

How it helps?

Time/Cost analysis can be used to identify the areas' greatest opportunity (in terms of time and money) for process improvement.

Dynamometer for Heavy Truck

Inertia dynamometer friction and wear test on a heavy commercial truck brake.

Basic principle and structure of the dynamometer consist of the main machine (which includes low inertia flywheel group that is geometric in progression, medium inertia flywheel group that is arithmetical in progression, high inertia flywheel group, slide test station, and base), speed alter system, control system, PC system, cooling system, pneumatic brake system, etc.

Rotating components of the brake sample (brake drum or brake disk) is installed on the main shaft by the flange. Nonrotating components are installed on the main shaft of the test station. The two parts keep the relative position that is same on vehicle. DC motor, drive the main shaft and flywheel to raise and arrive at the preset speed by the PC programs, then the main shaft is broken on preset programs. The PC system record the information such as pressure, torque, temperature, moderator, braking distance, braking time, frictional force, etc. by sensor and magnifier, that can be read by CRT monitor or output by color printer.