CHAPTER

1

# Applied Thinking for Productivity

## Various Definitions

Design thinking is a non-linear, iterative process that teams use to understand users, challenge assumptions, redefine problems and create innovative solutions to prototype and test. Involving five phases—Empathize, Define, Ideate, Prototype and Test—it is most useful to tackle problems that are ill-defined or unknown.[1]

Design thinking originally came about as a way of teaching engineers how to approach problems creatively, as designers do. One of the first people to write about design thinking was John E. Arnold, a professor of mechanical engineering at Stanford University. In 1959, he wrote "Creative Engineering," the text that established the four areas of design thinking. From there, design thinking began to evolve as a "way of thinking" in the fields of science and design engineering—as can be seen in Herbert A. Simon's book "The Sciences of the Artificial" and in Robert McKim's "Experiences in Visual Thinking".[2]

A designer's biggest task is to identify and solve existing problems with a product and leave users happier than they were before. At times this task can seem overwhelming and hard to grasp.

Design thinking is an undeniably powerful tool for companies, but what does it look like in practice? How have organizations applied it and how does it work? Is design thinking training something your company needs? [4]

There are many more scores of such definitions propounded by various organisations or individuals. However, in a nutshell, what it aims at is answering the following questions?

1. What is your need?
2. What do you want to achieve?
3. Can you clearly define, explain and quantify your needs in all terms, be they physical, Chemical, Biological or whatever…
4. A few such examples are in Table 1.1.

1. https://www.interaction-design.org/literature/topics/design-thinking
2. https://www.invisionapp.com/inside-design/what-is-design-thinking/
3. https://careerfoundry.com/en/blog/ux-design/design-thinking-examples/
4. https://voltagecontrol.com/blog/8-great-design-thinking-examples/

**Table 1.1 Examples of Wants/Needs.**

| When you say "I want a ……" | Don't say "I want a ……" | But say "I want ….." | What you need is… |
|---|---|---|---|
| Fan | Fan | Flowing air or Breeze". | Create a differential air pressure for facilitating airflow |
| Refrigerator | Refrigerator | Controlled temperature" | Maintain temperature and humidity |
| Bulb or Tube light | Bulb or Tube light | Light | Visibility or Lux level |
| Car | Car | 300 Kgs. Load to be moved from point "A" to point "B" in "X" minutes. | Conveyance with comfort |
| Toothpaste | Toothpaste | Remove flak and deposits from my teeth | Physical, Chemical or Biological option |
| Woolen Sweater | Woolen Sweater | Keep me warm | Heat Insulation between your body and the ambient atmospheric temperature |
| Shoes | Shoes | Protect my feet (against what?) | Doesn't allow dust, dirt, mud, water or chemicals to get in touch with your feet |
| Transformer oil | Transformer oil | To maintain system temperature and Avoid short-circuiting or earthing | Electrical insulation and temperature control |

## What is a business?
## The simple way to understand:

A business is an entity, owned by an individual (A Proprietary Firm), a small group of individuals (A Partnership Firm) or a large no. of shareholders (A Publicly held company), is involved in either producing products or offering services, and aims at an ever-increasing growth, either by vertical integration or a horizontal expansion.

The growth can be only achieved by creating enough re-allocable surpluses which can be ploughed back into the capital. This is possible only and only through making net profits.

The net profit is the difference between the gross revenues less the gross committed expenses, all paid for.

For any business, the only way to grow is to maximise net profits, which can be pooled or ploughed back into the capital of the business, thus helping it grow.

Increasing the net re-allocable surpluses is possible only through either of the two ways, viz. increasing the prices of the products or services or reducing the expenditure.

Of the two options, the easier one is to try to reduce the expenses.

The expenditure is a function of the amounts of consumed resources in the form of direct raw materials, direct labour, Indirect material and labour, the plant and equipment deployed and the energy consumed.

All these are in the hands of the executives. They need the requisite skills and knowledge and competence to apply all the management tools to either minimise or optimise them.

This is possible in many ways e.g. product redesign or simplification, process redesign or simplification, reduction in specific energy consumption, automation, innovation in products and processes or any combination of them. The conventional methods adopted by the industry for cost reduction are centred on the product/s as they exist, which offers less scope for cost reduction. These include all the conventional Industrial Engineering techniques like Method Study, Work Measurement, Process Planning, Capacity Utilisation, Inventory Control etc. However, the outcome of all the above techniques would be more than offset by just redesigning the product, which might result in either a total elimination of the product itself or at least a few components, or remodelled components, which may not need some of the above techniques.

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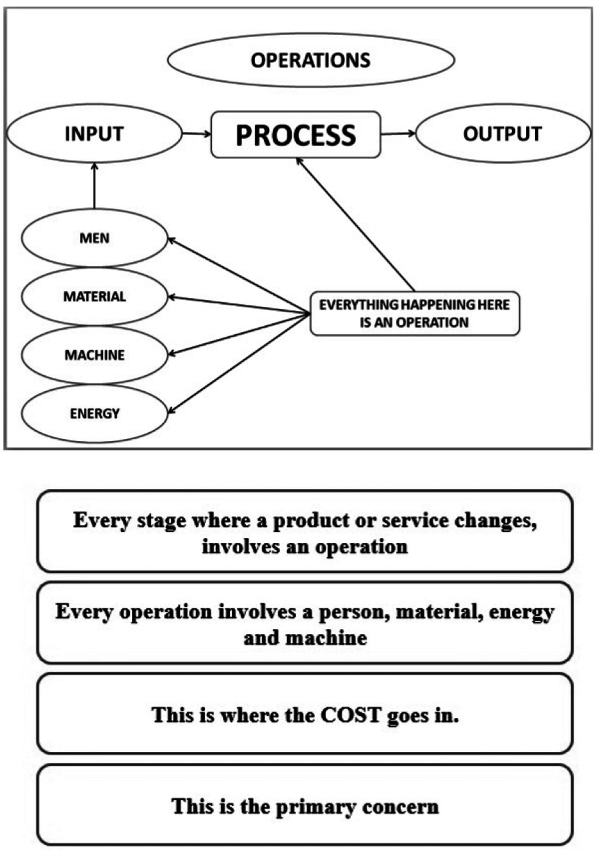


**Figure 1.1 Operations: A system's approach.**

Process Planning, Capacity Utilisation, Inventory Control etc. However, the outcome of all the above techniques would be more than offset by just redesigning the product, which might result in either a total elimination of the product itself or at least a few components, or remodelled components, which may not need some of the above techniques.

Here comes the challenge. While deploying additional resources is the generally trodden path, the smarter of the lots have been concentrating on optimising the existing resources.

All the case studies covered in the book aim at it. Figure 1 depicts the system and use of various resources by any organisation.

## Building the Value Proposition

To ensure sustained growth of an organisation, it is an undisputed fact that the organisation must make "Net" profits, i.e. a positive gap between the Gross Revenues and Gross Expenditure. To be able to plough back the capital in to the organisation, the profit margin should be widened as far as possible without any binding limits.

In any business system,

$$PRn = Cn + Pn$$

where PRn, Cn, and Pn are the Price, Cost, and Profit of the $n^{th}$ manufacturer such that

$$PRn = Cn + Pn$$

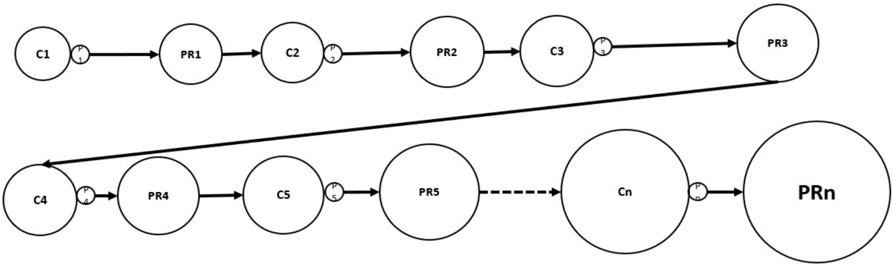


**Figure 1.2 Cost and Price escalation at various stages of supply chain.**

This PRn, in turn becomes the $Cn_{+1}$, or the cost of the next user.

Figure 1.2 explains the Bull Whip effect of Cost, Price and Value at different stages of the supply chain.

If the (n+l)th end user is willing to pay C(n+l), it is in the interest of the manufacturer "n" to reduce Cn so that Pn can be increased for him, provided of course that Performance, Reliability and Quality of the item remain constant, or improved further, if possible. To achieve the above end, there are four possible.

(a) Keeping the Cost of Production Cn constant, increase the selling price PRn. This has got its repercussions on the market demand pattern, and any price enhancement is normally linked up with a fall in demand.

(b) Keeping the Selling Price PRn constant, reduce the cost of production, by using various conventional methods of cost reduction, like Method Study, Materials Management, Preventive Maintenance, and other Productivity Techniques. It has been observed that more often than not, such a cost reduction approach has resulted in a substandard quality product and had been rejected in a competitive market, in favour of a better-performing alternative.

(c) A simultaneous combination of the above two i.e., (a) and (b).

(d) Reduce the Price PRn and reduce the cost of production Cn in a higher proportion.

Considering all the above alternatives and simultaneously taking into account the behaviour of the market, one realises that the user is not interested in a reduced price only, because time and again it has been observed that invariably a user would not mind a higher price, if he is satisfied that the additional performance or benefits which the product offers, will more than compensate the additional price he would pay for that product. Analysing the pattern of criteria based on which the (n+l)th user pays Price PRn for an item or service, it is clear that the buyer pays the price for the following factors.

(a) For the overall life performance and not the immediate performance,

(b) Aesthetic looks and pride to possess
(c) Considering the salvage or resale value at the end of use,
(d) Satisfy his/her sentimental values.

These considerations indicate that we should concentrate on providing the VALUE for the money of an item and not the Price or Cost.

## Understanding the Terms Cost, Price & Value

### The Cost

For this chapter, our system would comprise only two elements viz., the seller at one end and the user at the other end. In this system, the seller offers a certain item by consuming some material, use of machinery and labour, power, and carrying certain overheads as a necessary part of the business set-up, which of course is subject to question. For all these items we give a generic name viz., the Inputs. The inputs are available only against a payment made or promise to pay; it becomes a commitment of the seller, which sooner or later he has to pay. As this amount has got no relevance to whether the product will be sold or not, it is independent of the market, and thus remains a fact. This part would form, and is, the Cost of the product or service.

### The Price

Once the product or service is produced, the seller adds a certain amount of money to the Cost of production which he desires as his profit. In some rare cases, as a strategy to capture the initial market, they may sell or offer the product even at a loss and put the output in the market for sale. This amount which he expects in return for the product is called the Price of the product, or service. The Price is always a matter of policy.

### The Value

Although the term Value is used very commonly as a synonym for Cost or Price, it is an entirely different term. To highlight the difference between the three terms, we must consider the total system. Once the product or service is available in the market, there comes the user or the buyer, purchases it. His decision "To buy" or "Not to buy", depends on the following criteria:

(a) The Need for the Product
(b) Buyer's Paying Capacity
(c) Similar Alternatives/Substitutes available in the Market.

There always is a chance that the buyer might decide not to buy an item. The decision to buy is taken only when he knows that by not having that item, he is sure to lose something. Unless this loss is more than the price he is paying, he would never decide in favour of buying. The larger the difference between the estimated loss and the price, the more would be the saleability of the item.

He knows that by spending a certain amount of money for buying the Price-PRn he is going to save something equivalent to W i.e. the loss, or the Worth and he would decide in favour of buying only when,

$$W > PRn$$

but never, if

$$W < PRn.$$

This notation W would be called as Worth of that item, and the relationship between W & P is the main deciding criteria for the saleability of an item. This relationship is the Value of the item.

The decision to buy an item, product or service would be taken only if,

$$(W/PRn > 1$$

This relation W/PRn or Worth to Price ratio is termed as Value. Although we are using the term PRn (Price) here in the context of the user, it is his cost 'Cn+1 because that is what he is incurring to get the Worth or the functional requirement achieved. Even the manufacturer, while producing the item has the same criteria for his Inputs (the Cost which is the previous Seller's Price).

The Value "V" can be improved if W/Cn+1 is improved and in turn, the profitability of the organisation goes up. Of course "V" can also be increased by improving the "W" for the item or a better combination of both, so that

$$V1 = W1/C1 \ \& \ V2 = W2/C2$$

In actual situations when Value Analysis is to be carried out, if W/C < 1, it is a strong case for the application of VA. Figure 1.3 explains the domains of the three terms viz: Cost, Price and Value.

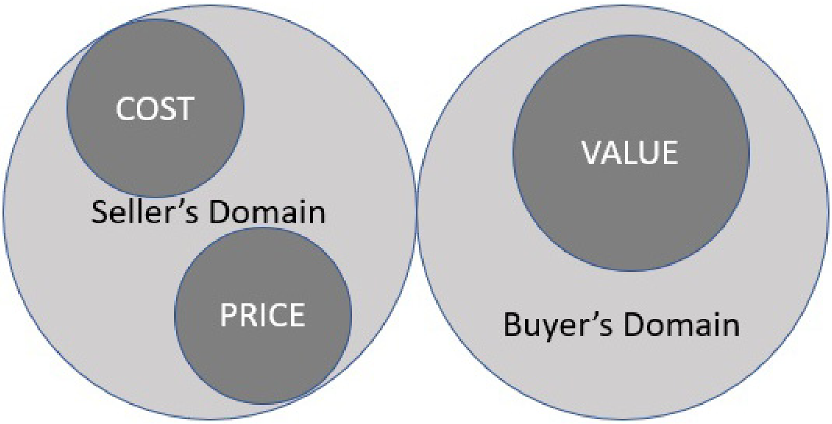


**Figure 1.3 Cost, Price and Value domains.**

In a manufacturer-user system, we see that the whole system comprises many manufacturers producing something to be used by the next man to manufacture something else and so on. The process of valuation starts with the ultimate end user, because, he is spending his money to procure or Buy the final output.

## Resource Efficiency

To be competitive in the market, every organisation needs to understand how the costs of their products or services are built up.

The four main resources viz: the Material, the Machine, Manpower and Energy, are used by the processes depending upon how the process or product is conceived and designed.

Once designed, the process will have to be carried out as per design. Hence, if there is any flaw in the basic design of the product, the same will be carried over to the cost. The same is the case with machine or plant times, the amount of energy consumed and the amount of labour consumed.

It may be observed that the entire amount of consumed resources can be broadly divided into five basic areas, viz:

1. The portion of resource which is the theoretic basic minimum to perform the desired function,
2. The portion of resource which is added due to a bad design of the product or the process,
3. The portion of resource which is added due to the usage of the wrong machine or plant or equipment
4. The portion of resource which is added due to flaws in the management processes and
5. The portion of resource which is added due to operators or workers bad or wrong practices.

In addition, there are contributing causes which sometimes results in the consumption of additional resources. These are the external factors beyond the control of any management, e.g. changed governmental policy, natural disasters, strikes, fire etc.

Figure 1.4 provided a bird's eye view of the utilisation of resources and causes for excess resource consumption.

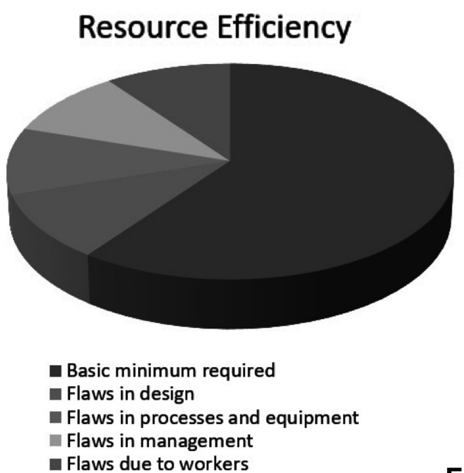


**Figure 1.4 Resource efficiency.**

Once we understand the causes, the appropriate management tools and techniques to avoid them can be thought of.

Table 1.2 provides a bird's eye view of the entire process for the management of resources, and thus the costs of production.

**Table 1.2 Process for management of resources.**

| Factors contributing to use of excessive resources | Avoidable effects there-of | Management tools, techniques & strategies |
|---|---|---|
| Resource content Added by defects in design or specification of the product | Bad Design of Product Prevents use of most economic processes | Optimal design |
| | Lack of Standardisation | Product Development and Value Analysis |
| | Prevents use of proper production processes | Specialization and Standardisation enable high-production processes to be used |
| | Incorrect Quality Standards Cause unnecessary re-source | Market, consumer and product Research ensure correct quality standards |
| | Design demands removal of Excess Material | Product Development and Value Analysis reduce resource content due to excess material |
| Resource Content added by inefficient methods of manufacture or operation | Wrong Machine Used | Process Planning Ensure selection of correct machi-nes, Capacity Utilisation, Production Planning and Control |
| | Process not operated correctly Or in bad condi-tions | Process Planning and Research ensure correct operation of processes |
| | Wrong Tools Used | Process Planning and Method study ensure correct selection of tools |
| | Bad shop floor layout causing wasted movement | Method Study reduces work content due to bad layout |

**Table 1.2** *Contd...*

| Factors contributing to use of excessive resources | Avoidable effects there of | Management tools, techniques & strategies |
|---|---|---|
| | Operative's bad working methods | Method Study and Operator Training reduce resource content due to bad working methods |
| Ineffective resource content due to shortcoming of the management of resources adds idle resource of men and machines | Excessive Product Variety adds idle resource due to short runs | Marketing and speciali-zation reduce idle resource due to product variety |
| | Lack of standardization adds idle resource due to short runs | Standardization reduces idle resource due to short runs |
| | Frequent design Changes add ineffective resource due to stoppages and resource | Product Development reduces ineffective resource due to changes in design |
| | Bad Planning | Production Planning and control based on resource measurement reduces idle resource due to bad planning |
| | Lack of Raw Materials due to bad planning adds idle resource of men and machines | Material Control reduces idle resource due to lack of raw materials , Materials Management, Inventory Control, Stores layout, Materials handling equipment |
| | Plant Breakdowns add idle resource of men and machines | Properly planned Predictive and Preventive Maintenance Management System reduces idle resource of men and machines due to breakdowns |
| | Plant in Bad Condition adds ineffective resource by way of rejects and reworks | Maintenance reduces ineffective resource due to plant in bad condition |

**Table 1.2** *Contd...*

| Factors contributing to use of excessive resources | Avoidable effects there of | Management tools, techniques & strategies |
|---|---|---|
| | Bad working conditions add ineffective resource through forcing workers to rest | Improved working Conditions enable workers to work steadily , |
| | Accidents add ineffective resource through stop-pages and absence | Safety measures reduce ineffective resource due to accidents |
| Ineffective and additional resources within the control of the worker | Absence, Lateness and Idleness add ineffective time | Organization structure design, Sound personnel Policy and incentives consumption reduce ineffective resource due to absence, Duties, Respon-sibilities, Account-ability |
| | Careless workmanship adds ineffective resource due to scrap and reworks | Personnel Policy and operator Training reduce ineffective resource due to carelessness, Manpower Assessment, Incentive scheme design |
| | Accidents add ineffective resource through stoppages and absence | Safety Training reduce ineffective resource due to accidents, Suggestion schemes |

Figure 1.3 provides another way of depicting the details as in Table 1.2.

In addition, many other approaches and systems are deployed e.g., Job Descriptions, Job Evaluation, Procurement procedures, Operations Research (OR) models, use of Energy efficient equipment, Time Measurement and Time standards, Production standards and Norms, Supply Chain Design, Plant Layout, Marketing and Branding, Agile manufacturing system, Advertisement, Business Process Reengineering (BPR) etc.

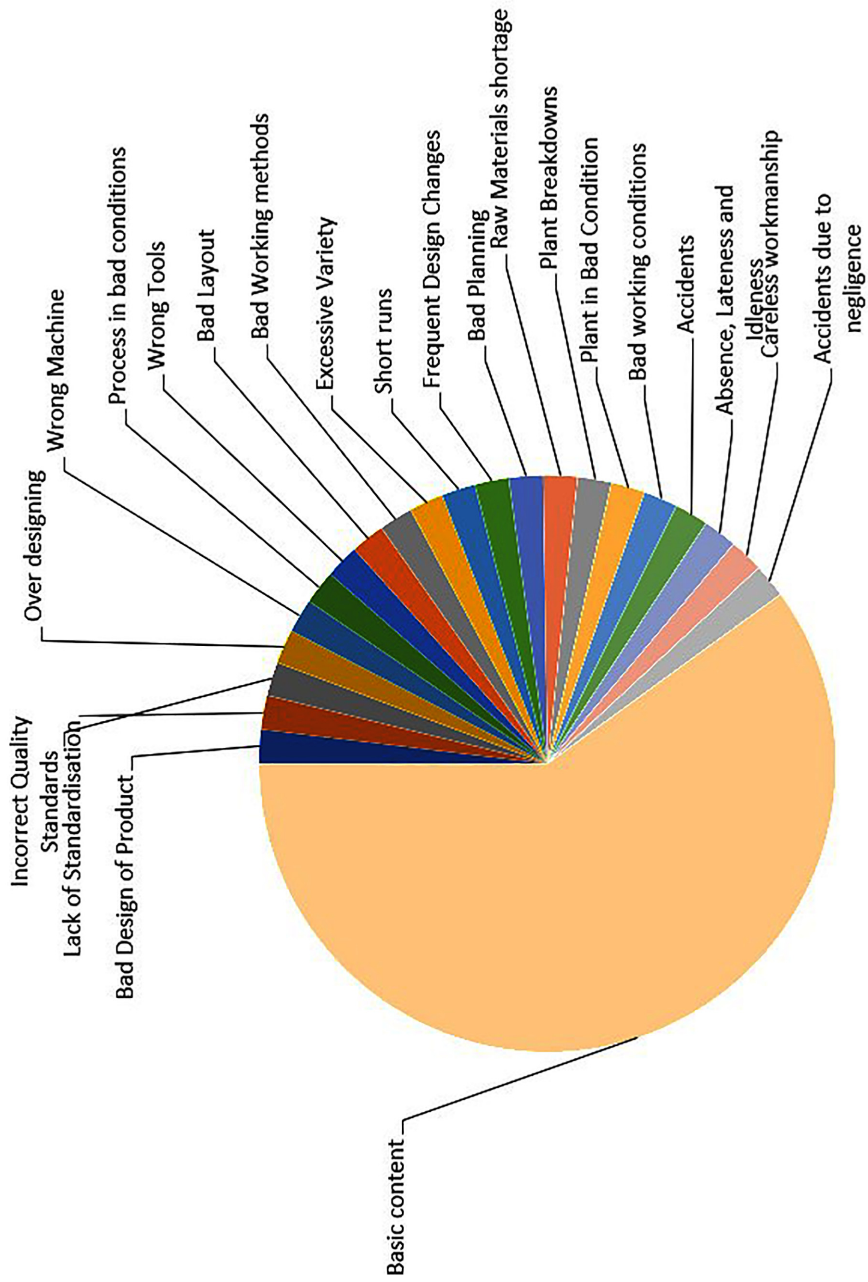


**Figure 1.5 Causes for excess resource content in product process.**

## Critical Analysis

As any operation involves any combination of material, labour, machine and energy, it is necessary to ask a few searching and challenging questions. A sample is given here below in Figure 1.6.

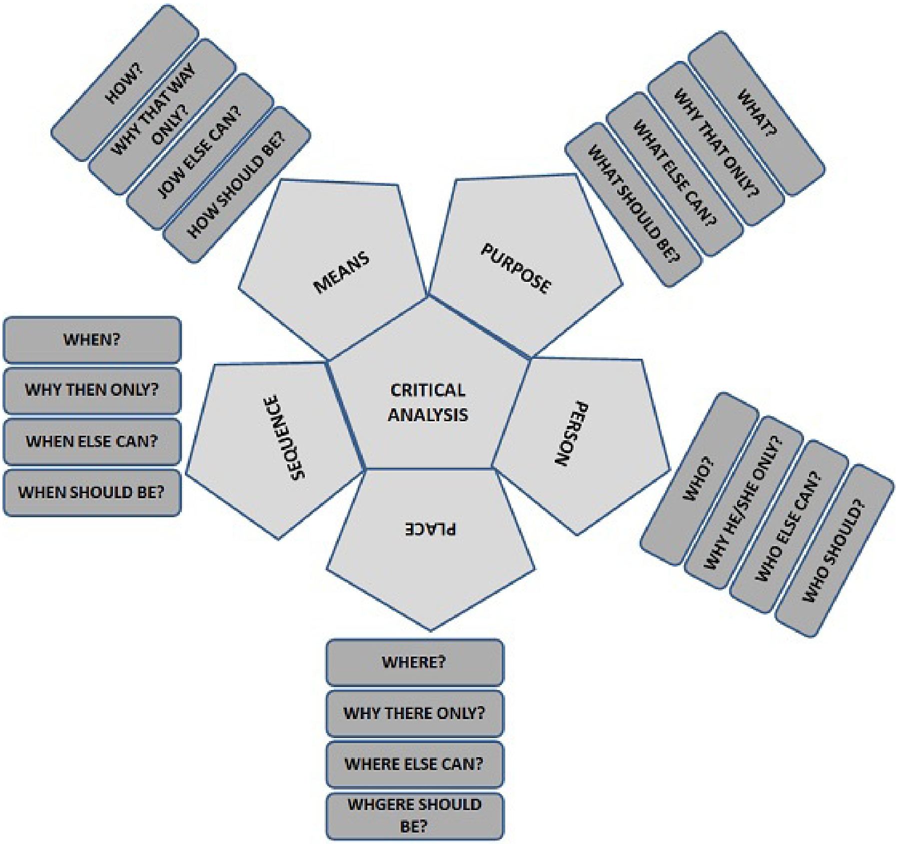


**Figure 1.6 Critical analysis parameters.**

Table 1.3 provides a step-by-step approach for critical analysis

**Table 1.3 Critical Analysis Process.**

| Items to be questioned and challenged | Explanation | Questions | Objective |
| --- | --- | --- | --- |
| Purpose | An operation being carried out is meant to take the product or service to the next stage of completion.<br>The operation has a purpose to achieve. | What is being achieved? | To understand with an open mind and without any biases. |
| | | Why that only is being achieved? | There must be a valid and justifiable answer. |
| | | What else can be achieved | This opens up avenues for development of alternatives |
| | | What should be actually achieved? | Out of the above options, the best is selected. |
| Person | For every operation, a person is assigned to carry out the operation. It is possible that some time either a highly skilled worker, meaning highly paid person may be doing a low skilled and low value job and vice-versa. | Who is doing it? | This will address if right skills are being deployed. The opposite of this is also possible where a lower skilled person might have been deployed on a job needing higher skill. In this eventuality, the person may be spoiling the job needing rework or reduced value, waste, reprocessing etc. |
| | | Why he or she only is doing it? | The managers should be in a position to answer as to why only that person is deployed on the job. |

**Table 1.3** *Contd...*

| Items to be questioned and challenged | Explanation | Questions | Objective |
|---|---|---|---|
| | | Who else can do it? | This is to explore the alternative person/s who can do the job properly and at a lower cost. |
| | | Who should actually do it? | Out of the options above, the best should be chosen. |
| Place | For every operation, a specific place is assigned. The movement of materials depends upon the place of work | Where is it being done? | This question is aimed at appropriate plant and work place layout. It is poss-ible to improve the layout of the work place to reduce movement of persons and material, work in progress or finished goods. |
| | | Why there Only? | The choice of the current place of operation must be fully justified. |
| | | Where else it can be done? | This will help in identifying alternate locations for carrying the operation, which might result in to reduction of movement and handling losses and damages. |
| | | Where should it actually be done? | The place location should be selected for the operation from among the above. |
| Means | Every operation requires a method, machine, equipment. This answers | How is it being done? | This stage questions the methods of carrying the operation. |

**Table 1.3** *Contd...*

| Items to be questioned and challenged | Explanation | Questions | Objective |
|---|---|---|---|
| | whether the right and appropriate means are deployed, neither more than nor less than the process or operation needs. | Why that way only? | This questions and challenges the way it is being done. There should be a valid justification as to why it is being done that way only. |
| | | How else can it be done? | This explores the possibilities of carrying out the operations through an alternative means. e.g. Turning instead of milling, Biometric instead of recording manu-ally, Pressing in-stead of washing etc. |
| | | How it should actually be done. | The best possible way of doing the job from amongst the above alternatives. |
| Sequence | Every operation either succeeds or precedes another operation. This will answer whether there is any backtracking and unnecessary and avoidable handling is involved. | When is it being done? | This questions the sequence and time when the operation is being carried out. |
| | | Why then only? | The sequence of current operation should be justified as to why is it being carried out only at that stage. |
| | | When else can it be done? | This explores the possibilities of the alternate possible sequences. It is possible to explore the possibility of clubbing the operation with either the previous or the next operation. |
| | | When should it actually be done. | From out of the above, the best sequence is selected. |

## The Order of Addressing the Operations:

By critically questioning the currents ways of carrying the operations, our objective should be in order of

**Step 1: Eliminate the operation:** If the managers cannot answer or justify the purpose as to why a certain operation is being carried out, means that the operation is not necessary.

**Step 2: Combine:** If elimination is not possible, then we should aim at combining the operations to reduce the stages for completing a task.

And finally,

**Step 3: Modify:** Only and only when the above two are not possible, we should aim at simplifying the current operation with simple modifications and improvements.

The following flow charts explain the approach.[1] Figure 1.7.

# Causative Factors Affecting Inefficiencies

Once the above is understood well and applied, we will be able to understand the causative factors contributing to the inefficiencies in operation and manufacturing.

The approach and methodology for addressing the issues are very well brought out by the International Labour Organisation (ILO) in its publication “The Work Study” more than 6 decades back. However, experience with the industry has brought out that all the tools and techniques propagated in the publication are equally valid even today, though in different names and jargon.

The causative factors resulting in inefficiencies of all forms are categorised into four categories, viz:

A: Excess resource content added due to defects in the basic design of the product or process.

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[1]Work Study: ILO

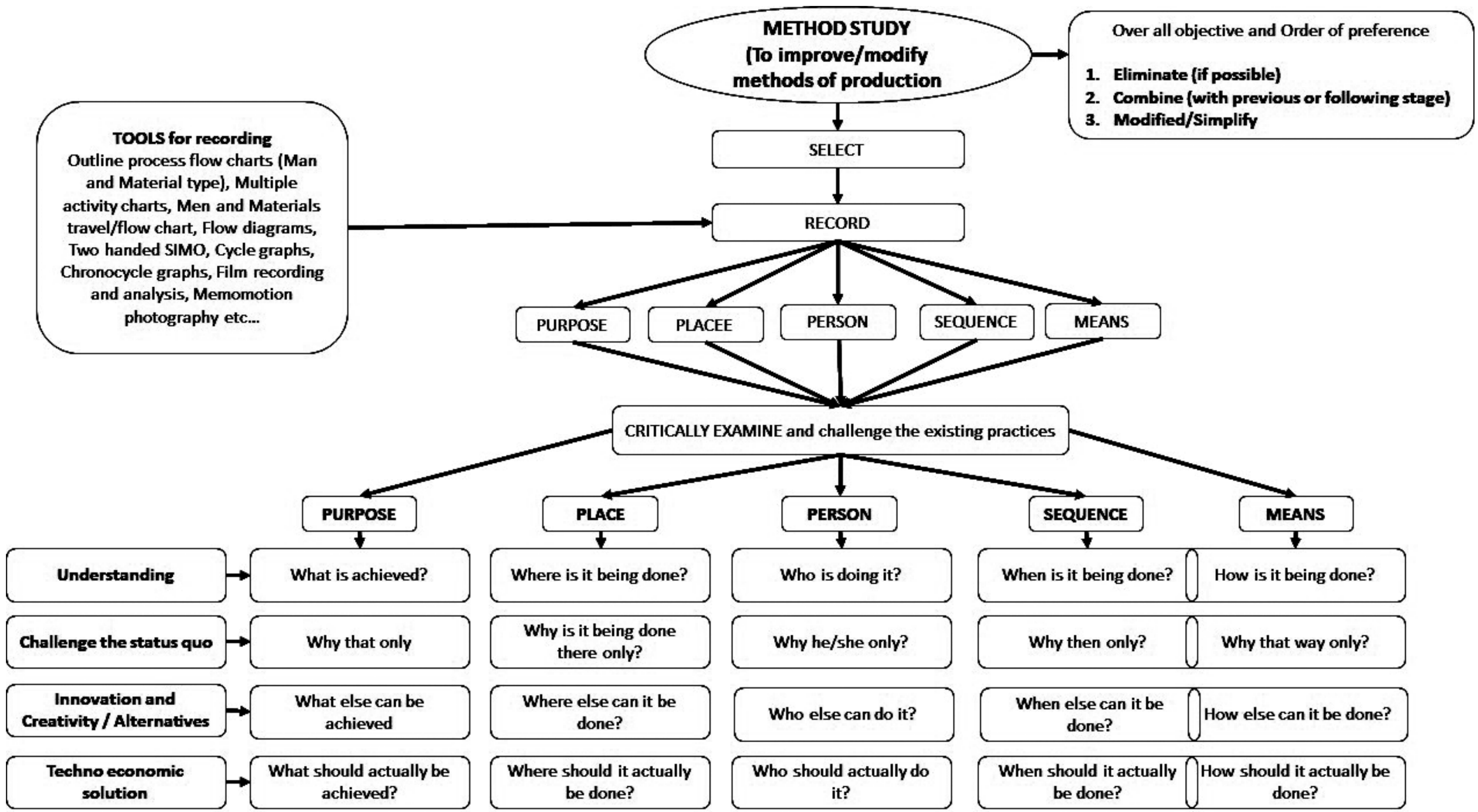



Figure 1.7 Method Study.

B: Excess resource content added due to the ineffective methods (Methods and equipment) of operations.

C: Excess resource content added due to the shortcomings in management, and

D: Excess resource content added due to the factors within the control of the operators.

In “C” above, it may be emphasised that the word “Management” does not mean the people in the higher levels of the organisational hierarchy, but the systems and controls used in the organisation.

The above four categories have been further elaborated in the following figures into different types of causes under the category and the corresponding management tools and techniques available to the management to address the causes and take appropriate measures. Figure 1.8 depicts the total resource consumption, the basic minimum required and four main reasons contributing to the use of excess resources.

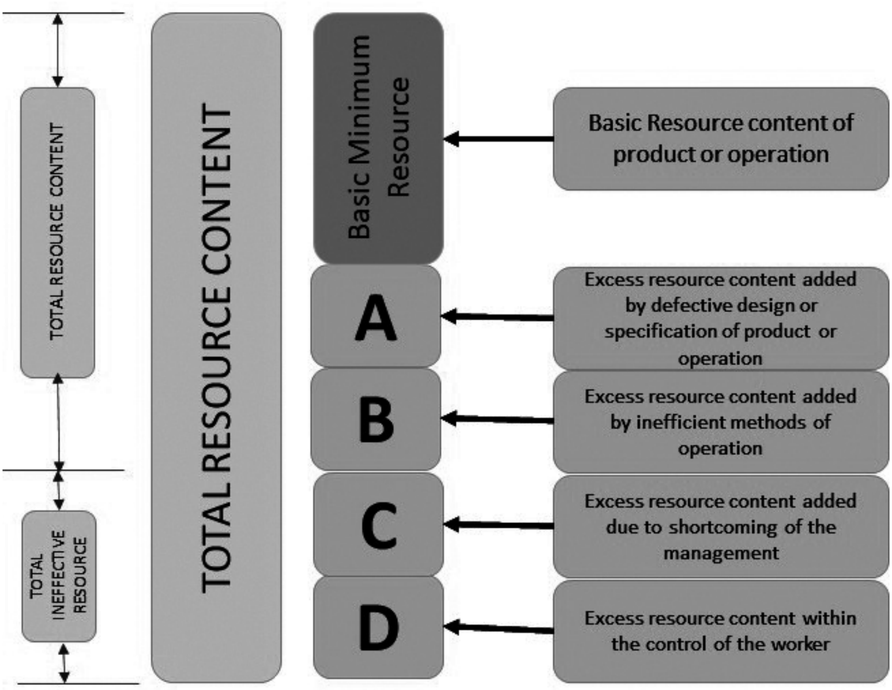



**Figure 1.8 Basic and excess of resources.**

Figure 1.9 provides reasons for excess resource content added by faulty design, specifications and inefficient methods.

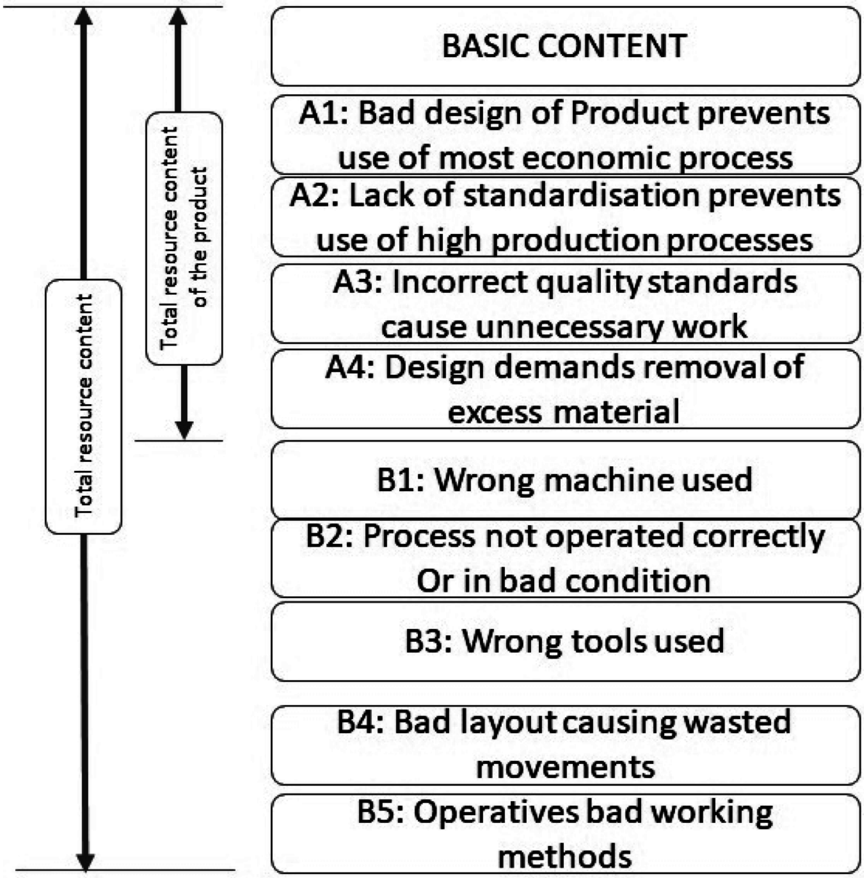



**Figure 1.9 Resource content added by faulty design, specifications and inefficient methods.**

Figure 1.10 provides reasons for excess Resource content added by shortcomings in management and within the control of workers

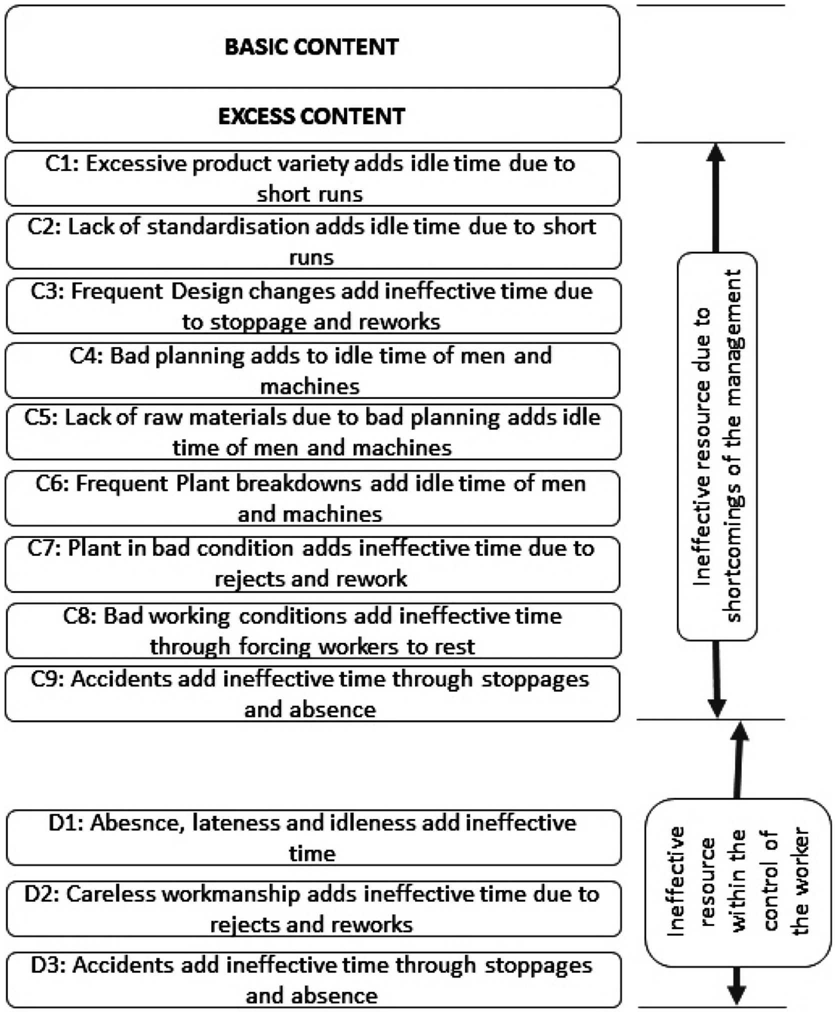



**Figure 1.10 Resource content added by shortcomings in management and within the control of workers.**

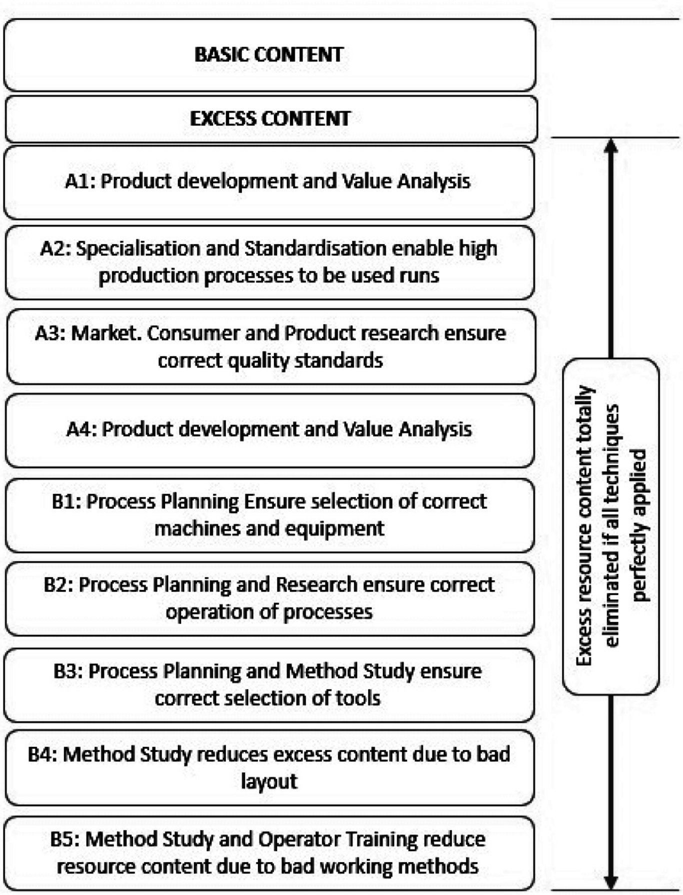



**Figure 1.11 Tools and techniques to eliminate excess resource consumption due to defective design.**

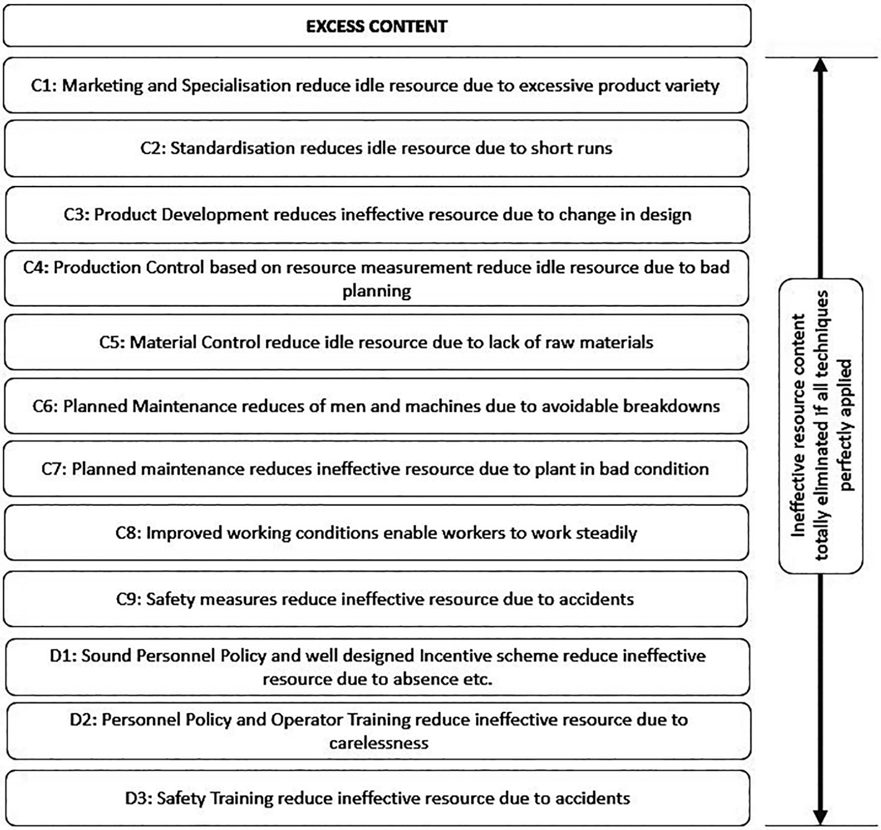



**Figure 1.12 Tools and techniques to eliminate excess resource consumption due to management faults and in control of workers.**

## Value Engineering

The term Value Engineering is also used in place of Functional Analysis, Value analysis or and Value management. Value Engineering is essentially a process which uses function cost analysis to optimise cost. Founded by Lawrence D. Miles in the 1940s, it has a proud 70+ year history of success at reducing cost.

But times and needs have changed.

The more commonly used name "Value Analysis" usually comes into play after the design is finished, but the thoroughness we seek in design can be achieved only when decisions are made early." Value Engineering plays the lead role at this stage. To be effective within the integrated product and process development process (IPPD), Value Engineering should be given a higher priority to become an integral element of the design process.

The definition of value used by Value Engineering in America is different from the definition of value in design for competitive advantage. In Value Engineering practice, the term Value is largely equated with reduced cost in design for competitive advantage.

Value is defined as the measure of customer choice. Value is a function of quality, as well as cost. Value Engineering should be a necessary part of any design stage. However, the strong focus on cost reduction disqualifies Value Engineering as a general method for evaluating quality.

As practised today, Value Engineering largely ignores the fact that customer choice is usually based upon far more than the minimum essential product function. Quality Function Deployment (QFD) extends Value Engineering in that it is not restricted to minimum essential product function. Although not regularly practised, customer-focused Value Engineering is similar to QFD and has been around for some time. A similarity exists in that the derived product functions are those which are felt by the team to relate to why the customer will buy the product, as opposed to the technical functions of the parts. However, it does not complete the customer desire versus function matrix of Comprehensive QFD to assure that they are the functions that the customer demands or which will go further and delight the customer.

It is also interesting that it was published around the same time frame that Dr. Akao added the analogous transformations to QFD.

Evidence is increasing that Value Engineering had strong influences on or parallels with the development of QFD. Evidence also indicates that Value Engineering and QFD have followed similar growth paths, the difference being that QFD has developed far more comprehensively and rapidly. It thus seems that the challenge for Value Engineering today is to become integrated within the IPPD process and improve on the expanded function served by quality function deployment and then move beyond it.

Until then, Value Engineering continues to be a powerful tool for cost reduction.

VE can be integrated within the very important target costing process. Finally, a coupling of Value Engineering with comprehensive QFD to ensure that the customer obtains full value.

**Function Analysis**

Function analysis is the process of analysing the functional, rather than the physical, characteristics of a system. To better understand the purpose of a product or service, one should be clear about the intended function expected from the product which needs to be performed. A function is expressed as a combination of a Verb and a Noun, e.g. the function of an electrical conductor can be expressed as "Conduct (Verb) and Current (Noun), or that of a ceiling fan as "Create (Verb) Differential pressure (Noun)".

The functions of a product can be differentiated as a-Work function and b-Sell function. While the work function helps in achieving the basic intended result, the Sell function adds to the acceptance levels of the product.

Table 1.4 can be used as a guide list of Verbs and Nouns (Work and Sell functions) to define the various Functions in various combinations. This is only an indicative listing, and not exhaustive. Similarly, digesting food, Conduct Current, Provide Insulation, Transport People, Provide Light, Conduct Heat, Insulate Heat, Pulverize Material, Protect Surfaces etc. are some of the typical functions in the life of most of us.

**Table 1.4 Functional expression.**

| Work Functions | | | | Sell Functions | |
|---|---|---|---|---|---|
| Verbs | | Nouns | | Verbs | Nouns |
| Support | Change | Weight | Current | Increase | Beauty |
| Transmit | Interrupt | Light | Insulation | Decrease | Appearance |
| Create | Establish | Heat | Energy | Improve | Convenience |
| Hold | Shield | Radiation | Density | Look | Style |
| Enclose | Modulate | Friction | Circuit | | Prestige |
| Collect | Control | Voltage | Repair | | Features |

**Table 1.4** *Contd...*

| Work Functions | | | | Sell Functions | |
|---|---|---|---|---|---|
| **Verbs** | | **Nouns** | | **Verbs** | **Nouns** |
| Conduct | Transmit | Force | Liquid | | Form |
| Insulate | Emit | Damage | Solid | | Symmetry |
| Protect | Repel | Protection | Gas | | Effect |
| Prevent | Alter | Fluid | | | Exchange |
| Reduce | Filter | Flow | | | |
| Amplify | Impede | Oxidation | | | |
| Rectify | Induce | Cooling | | | |
| Apply | Provide | Oxidation | | | |

All products and services are endowed by their creators with certain purposes. Function analysis reveals the intentions or purposes behind the creation of a product or service and thereby identifies the nature of that product or service. Although products and services exist as physical objects or systems, they are not created out of nothing.

They are preceded by an idea - a concept - which is the basis of their creation. Function analysis identifies the nature of products and services by revealing these concepts.

Having determined the nature of an object, one can then conceptualize many physical realizations which serve the purpose and choose the realization with the best value. In this manner, breakthroughs are designed.

**Types of Functions:**

The Functions of a product or service are of basically two categories or types, viz:

**1: Primary Function**

The basic purpose for which the product is designed: What is desired to be achieved. and

**2: Secondary or Supportive Functions:** The additional features which help achieve the primary function in a better way and make it work better.

Let us look at some of the common and daily consumed items to understand the process of splitting their functions into the Primary and Secondary Functions.

Figure 1.13 a filter cigarette, Figure 1.14 a welding electrode, Figure 1.13 an electric cable and Figure 16 a toothbrush.

**1: A filter cigarette.**

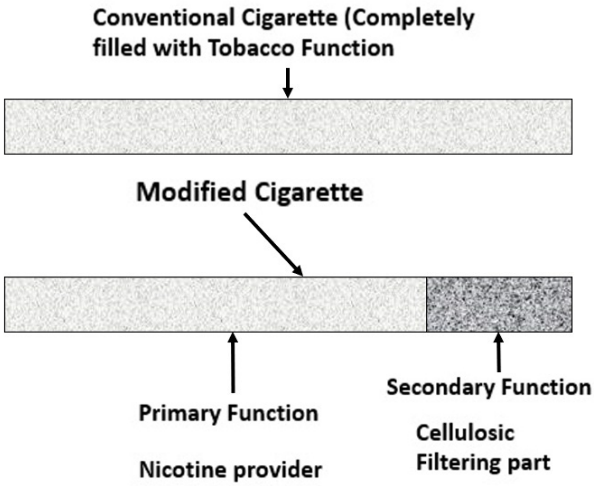



**Figure 1.13 Plain and Filter Cigarette.**

The traditional old cigarettes used to be filled with tobacco till the holding end. Functional analysis revealed that the but portion of the cigarette has a different function to perform than the main body of the cigarette.

**Primary function:** Provide the feeling of consuming nicotine (whatever it means).

And

**Secondary function:** To be able to suck gases. The butt portion of their cigarette is always thrown after use(discarded). As a result, the costlier tobacco in the butt was also wasted. The functions of the butt portion were identified as;

- Facilitate holding between fingers
- Allow gases to pass through
- Withstand high temperature
- Withstand chemical reactions with nicotine and

- Absorb or filter nicotine
- Do not produce any harmful by-products which are injurious to humans.

**Modified design:** Based on the above analysis, it was established that the butt of a cigarette does not have to use tobacco but any material other than the costly tobacco. The part providing Nicotine only is filled with tobacco, The other part which facilitates holding and filtering nicotine is replaced with a non-tobacco and cheaper material. The cellulosic filtering material has thus come into being. Apart from meeting all the functional requirements of the butt, it added value and started getting sold at a higher price than the conventional design of cigarettes.

In this process, the new design saved costly tobacco and also helped in reducing helth hazards, thereby enhancing the Value.

**2: A Welding Electrode:**

A traditional welding electrode has two basic components;

(a) The parent material rod melts and gets bonded with the material being welded. The flux covering facilitates melting and provides a smoke shield during the welding process.

(b) The butt for holding and facilitating the welding process. A torch holder is used to hold the electrode during the welding process.

The Primary and Secondary functions of the electrode can be explained as under.

**Primary Function:** To provide the molten metal for bonding with the material being welded and

**Secondary Function:** To facilitate holding of the electrode, Accelerate the process of melting of the parent metal and protect the joint from chemical reactions with atmospheric gases and Conduct the required amount of current (amperes)

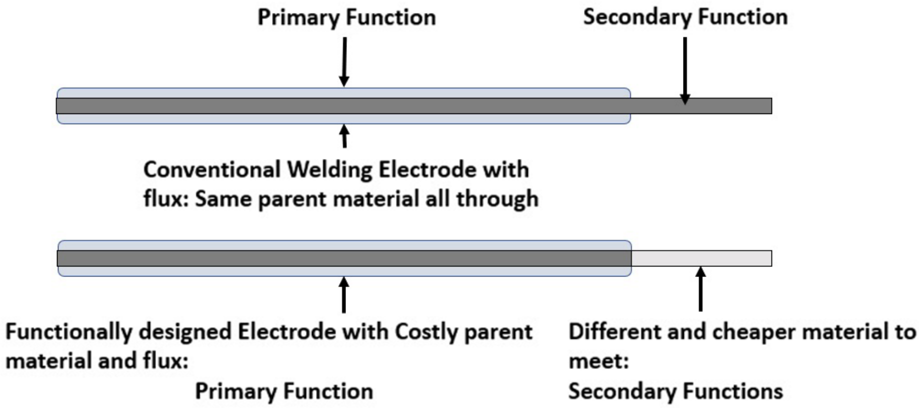



**Figure 1.14 Welding Electrode.**

Along the same lines, we may look at some other well-known items e.g. an electric cable and a tooth brush as in the pictures below.

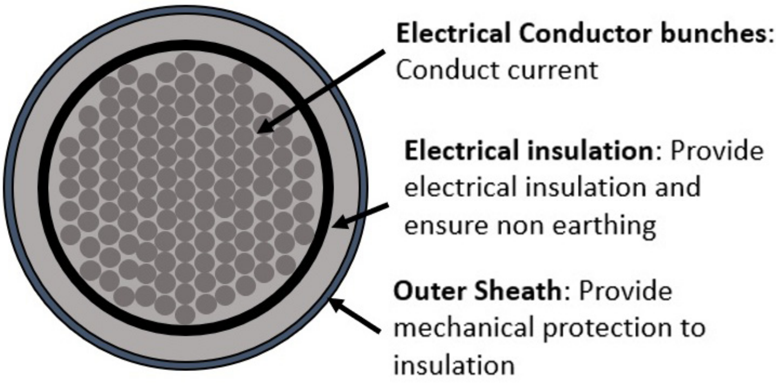



**Figure 1.15 Electric cable section.**

**3: An Electrical Cable or Conductor.**

**4: Tooth brush**

A toothbrush is one of the most commonly used items across the globe. A careful analysis of the total product would reveal that the bristles perform the Primary function of cleaning the teeth, whereas the handle performs the Secondary function of ease of handling the bristles Ref. Figure 1.16 and 1.17.

However, a details analysis would reveal that the handle alone costs about 80% of the entire cost of the toothbrush, which is discarded after the bristles have either deformed or have come to the end of their life.


**Figure 1.16 Tooth brush and main components (Primary and Secondary functions).**

If only the bristles are modified to have a slip-in feature, which can fit onto the finger of the user, it will perform the same function, with the added advantage of flexibility in reaching the remote parts of teeth, while at the same time saving the environment by avoiding plastic waste in the form of the plastic handles thrown or discarded.

**Figure 1.17 Finger mounted bristles.**

**The approach to understand the Products and/or Services.**

FAST (Function Analysis System Technique) is used for understanding complex products and Services.

We know that complex equipment or plant comprises many assemblies, sub-assemblies, individual components in an assembly and the geometric features of a component and the material specifications. Each of these is expected to do something. And that "Doing something" is termed as (Performing a Function) in the Value Engineering parlance.

The basic approach in using the FAST approach is to start questioning "WHY" a particular feature has been provided on a component and "WHY" a particular material is specified for that component. The reverse sequence is to start asking "HOW" a specific Function is being performed in the existing product.

Also, to be understood is the fact that a complex Higher-Level function is performed by a huge set of many Lower-Level functions.

Functional decomposition is the process of asking "how" for each higher-level function to derive lower-level functions. Functional composition is the process of asking "why" for each lower-level function to derive higher-level functions. The result is a tree or systematic diagram of functions which fall under some ultimate top-level function.

## FAST: Functional Analysis System Technique

The functional Analysis System Technique (FAST) is one of the most effective tools to understand the functions of a part, subassembly or entire system. It uses a matrix as shown in Table 1.5(a). It is drawn in such a way that the individual features or components of a system are listed on the rightmost column, The corresponding sub-systems (Lower-level functions) follow in the leftward direction, culminating in the entire system on the leftmost column. The reader or user of this matrix should be in a position to clearly define and explain WHY a particular feature or element has been used (to understand the very function) needed to be performed). If the user or maker of the system cannot answer or explanation as to WHY it is there, it means that the element is perhaps not needed at all. We proceed in the same way of answering the WHY question in the leftward direction stage by stage, thus reaching the Higher levels of functions.

Similarly, we proceed from left to right (Higher to Lower-level functions), answering the HOW of a system.

This set of questions leads us to explain why certain resources have been used to make the complete system.

**Higher Level Function** **Lower-Level Functions**
**(PURPOSE)** ← **WHY** ←

← **HOW** → **(MEANS)**

**Table 1.5(a) Functional hierarchy.**

<table>
<tr><td rowspan="17">Product</td><td rowspan="8">Assembly 1</td><td rowspan="2">Subassy 1</td><td rowspan="2">Subsubassy 1</td><td>Components and Features 1</td></tr>
<tr><td>Components and Features 2</td></tr>
<tr><td rowspan="6">Subassy 2</td><td rowspan="2">Subsubassy 2</td><td>Components and Features 3</td></tr>
<tr><td>Components and Features 4</td></tr>
<tr><td rowspan="2">Subsubassy 3</td><td>Components and Features 5</td></tr>
<tr><td>Components and Features 6</td></tr>
<tr><td rowspan="2">Subsubassy 4</td><td>Components and Features 7</td></tr>
<tr><td>Components and Features 8</td></tr>
<tr><td rowspan="6">Assembly 2</td><td rowspan="4">Subassy 3</td><td rowspan="2">Subsubassy 5</td><td>Components and Features 9</td></tr>
<tr><td>Components and Features 10</td></tr>
<tr><td rowspan="2">Subsubassy 6</td><td>Components and Features 11</td></tr>
<tr><td>Components and Features 12</td></tr>
<tr><td rowspan="2">Subassy 4</td><td rowspan="2">Subsubassy 7</td><td>Components and Features 13</td></tr>
<tr><td>Components and Features 14</td></tr>
<tr><td rowspan="3"></td><td>Subassy 5</td><td>Subsubassy 8</td><td>Components and Features 15</td></tr>
<tr><td rowspan="2">Subassy 6</td><td>Subsubassy 9</td><td>Components and Features 16</td></tr>
<tr><td>Subsubassy 10</td><td>Components and Features 17</td></tr>
</table>

**Higher Level Function** **Lower-Level Functions**
**(PURPOSE)** ← **WHY** ←

← **HOW** → **(MEANS)**

The design pf a conventional toothbrush can be displayed in such a Table 1.5(b).

**Table 1.5(b) Functional hierarchy.**

<table>
<tr><td rowspan="3">Removing Flak and deposits from teeth</td><td rowspan="3">Provide flak & deposits cleaning media (Tooth Paste)</td><td>Provide froth to carry suspended deposits on teeth. Subsubassy 2</td><td>Chemical 1</td></tr>
<tr><td>Provide abrasion effect</td><td rowspan="2">Chemical 2</td></tr>
<tr><td>Safety of teeth and mouth</td></tr>
</table>

**Table 1.5(b)** *Contd...*

| | | | |
|---|---|---|---|
| | Teeth cleaning portion | Strands | Bristles |
| | | Synthetic material | |
| | | Holes in the part | Bristles holding part |
| | | Extended part of the brush | |
| | Handle to facilitate use of the bristles | Long plastic rod | Handle |
| | | Esteem features | |

For management, the top-level or Higher-level function of the hierarchy of the organization is the mission (purpose) of the organization. The next lower-level functions are things the organization must do (means) to accomplish the mission. For systems engineering and software engineering, the top-level function of the hierarchy of product functions is the purpose of the system. The lower-level functions are the means to accomplish the purpose. For a multidisciplinary group, the language of what the system must do is independent of the languages of the disciplines but is common to all. Thus, functional language should be the language of choice for multidisciplinary communication.

Function analysis is also a primary tool for quality function deployment, requirements engineering, and value engineering. Function analysis is the basis for the gene persistation recursion.

## Value Analysis

The question “What is VA?” was the subject of many workshops and seminars on the subject. Most of the questions were from engineers with no specific experience in VA.

**Q. What is Value Analysis?**

A: A team problem-solving system, developed at the General Electric Company in the late 1940s. Nearly every one of the NEW WAVE systems, from Quality Circles to Grid Organization Development, Kepner-Tregoe Root Cause Analysis (RCA), Brainstorming, Continuous Systematic Improvement and Total Quality Management call themselves team problem-solving systems.

**Q. What is so special about VA?**

A: Its special power is a technique called Function Analysis which dramatically shifts the viewpoint of the problem-solvers. When Lawrence D. Miles of General Electric conceived VA in the late 1940s, its unique element and the source of its breakthroughs was Function Analysis.

**Q. What is Function Analysis?**

A: The product or process under study is first converted into several word pairs called Functions. The remainder of the study then concentrates on those word pairs rather than on the concrete product or process.

**Q. Are there other key elements to the Value Analysis process?**

A: Yes, there are several other essential components in a valid Value Analysis study.

**Q. In the sixty years since VA was developed, has it changed?**

A: This leading question has an obvious answer. Yes, it has changed mightily. Users have modified the process to fit their requirements. A version of the process is in heavy use in the US Government, where it is called "Value Engineering." The Construction industry has followed their lead. Their version is also called "Value Engineering." Some refer to the process as "Value Management." Your attention is directed to some generally available books which have been written on the process.

The specific form used for these word pairs is now called a Function. Each pair comprises one verb and one noun. Each noun is ideally a parameter or measurable quantity. Each verb is ideally demonstrable on a non-verbal level. If we recall our sentence diagramming in English learning, will realize that one verb and one noun make up one elemental sentence. Therefore, when the VA question, "What does it do?" is asked of a product or process, the answer becomes a series of two-word sentences. The total number of these sentences could run from forty or eighty for even a simple product or process. Examples are Conduct Current, Exert pressure, Reflect light, Hold part, etc. etc.

In sum, these two-word statements are a total description of the functions of the product or process. Value Analysts call this group of statements a Function Analysis. By concentrating all of their problem-solving effort on these two-word Functions, the team accomplishes several objectives:

They greatly minimize what L.D. Miles called it “functional fixedness.” For example, it is possible to be more creative when tackling a problem defined in terms of improving “Remove Pollutants” than one defined in terms of “Make a better Catalytic Converter.” Miles defined this creative focus of Function Analysis in terms of the technique he called “Create-by-Function.”

In the Creative Phase team session, the focus is on Function. This Function-focus maintains the critical perspective of Function; the WHAT IT DOES for the customer, rather than the WHAT IT IS in the mechanical sense. Over the years, few practitioners of Value Analysis have truly understood and fully applied the concept of “Create-by-Function.” A Function should be treated in its semantic sense and resist the tendency of reverting to simply creating solutions to the problems of the product under study.

The following chapters and case studies contain examples of some of the systems/products/Sub-assemblies and components that were taken up by the author.

The costs of a product or a process are commonly presented in a hierarchical structure called the Costed Bill of Materials. A Costed Bill of Functions would be far more conducive to creative problem-solving. To this end, the costs should be allocated to the Functions than to parts or features. A Costed FAST Diagram needs to be prepared, which allocates costs to every lower-level function. This will provide a new viewpoint, that of Function-Cost, to replace its customary viewpoint of Hardware-Cost. Their solutions therefore typically reach far closer to the limits of the envelope of practicality.

It is also possible to add to the FAST Diagram carefully structured but unconstrained data on the attitude, needs and desires of the user/customer. This adds the dimension of Function-Worth to each of the Functions. With Function-Cost and Function-Worth, the team can identify and focus on only those functions where there is a mismatch between the two parameters.

**The Ve Job Plan**

The Team and Ownership

The Function related items have been discussed above. What follows is a brief discussion of each of the other elements:

**Implementation**

In modern VA, Implementation is step one. This is in keeping with Leonardo DaVinci's famous exhortation, "Think of the end before the beginning." The team prepares a list, before even starting the study, of all of the possible areas in which they might anticipate their results to fall. They then list all of the roadblocks which they might expect to strike in implementing those results, and they then list all of the actions which they must consider during the study to circumvent those roadblocks. These lists are updated throughout the study. This commonly results in few surprises during the later effort to implement the results of the study. Implementation rates of a properly conducted VA study are typically very near 100%.

Miles' system followed a rigorous six-step procedure which he called the Value Analysis Job Plan. Others have varied their Job Plan to fit their peculiar constraints. A modern version has the following eight steps:

1. Selection of the projects or problem areas
2. Information collection or gathering
3. Analysis of the functional requirements
4. Creation of alternatives/options; Ideas generation
5. Synthesis
6. Development of the ideas and protypes of the suggested solution
7. Presentation
8. Follow-up for implementation and post-implementation continuity

## The Team

The ideal VA team comprises five experts on the product under study, each from a different discipline. They must all be Decision-Makers whose assignment presently includes responsibilities on the product under study. The following capabilities must be included in the team:

**Design:** Project Engineer, Chief Draftsman, Designer. Ideally, the Design Engineer is responsible for the product.

**Operations:** Factory Supervisor, Industrial Engineer, Manufacturing Engineer, Methods Engineer

**Cost:** Cost Estimator, Industrial Engineer, Accountant

**Outreach:** Marketing, Sales, Field Service, Purchasing

**Catalyst:** A Constructive Troublemaker, possibly an Engineer, Product Manager, or Marketer

## Ownership

During the Synthesis Phase of the Job Plan, as ideas and concepts arise, the team leader asks team members which one of them will Champion the idea or concept. If no one raises a hand, the idea or concept is dropped. One who volunteers to become a Champion is charged with investigating the feasibility and economics of the idea or concept. This Champion Concept results in a series of solutions which are highly likely to be implemented.

It is expected that readers of this summary may develop further curiosity about the Value Analysis process. Most of the answers can be found by contacting the Society of American Value Engineers.

# Function Cost Analysis

Function cost analysis is used by value engineers to determine the cost of each product function. In the USA this is typically determined by a bottom-up analysis of the cost of all items, components, labour, etc., necessary for the product to perform each function. In Japan, cost tables are often used. Yoshikawa, Innes, and Mitchell, 1990.

If a function is not essential, then it may be removed from the product and the associated cost may also be removed. If a function is essential, then alternate methods of performing the function are determined. Cost may be saved by choosing the lowest-cost method of performing the function. In this manner, value engineering attains its goal of providing a product with minimum essential functions at the lowest cost.

Function cost analysis, as defined by value engineering, is an accounting allocation of cost and importance to product function. It does not consider the fact that cost is generated by the work required to Geno persist the product. Thus, function cost analysis, as typically used within value engineering, does not address the even greater opportunities for cost reduction through engineering process improvement. Activity-based costing deals with those costs. Activities are implementations of the functions of the system to bring forth, sustain, and retire a product.

Function cost analysis should be viewed as the general case which contains both Value Engineering costing and activity-based costing as the respective processes which deal with the cost of the functions of the product and the cost of the functions of the system to gene persist the product. Even more generally, a function cost analysis can be defined as the determination and prediction of the cost and importance of the functions of the gene presentation recursion.

## Integrated Product and Process Development

Integrated product and process development (IPPD) is the process of bringing forth a product such that all sub-processes required to bring forth the product are integrated harmoniously. Drucker (1990) indicated that four key elements of the future factory are statistical quality control, new manufacturing accounting systems, modular manufacturing, and the systems approach. To be successful, the development must be guided by systemic quality elements and refined to perfection.

Quality function deployment in the large (QFD) implemented under Total Quality Control is by far the most advanced form of IPPD in existence. IPPD is a subset of the Geno persistence recursion.

## Quality Function Deployment

Most Americans associate quality function deployment (QFD) with the "House of Quality" (Hauser and Clausing, 1988) shown here.

QFD as discussed here contains far more. QFD can be viewed as a system engineering process which transforms the desires of the customer/user into the language required, at all project levels, to implement a product. It also provides the glue necessary, at all project levels, to tie it all together and to manage it. Finally, it is an excellent method for assuring that the customer obtains high value from your product, actually the intended purpose of QFD. QFD is far more than has previously been disclosed. It is the mechanism for deploying quality, reliability, cost, and technology throughout the product, the project to bring forth the product, and the enterprise as a whole.

The concept of QFD was introduced in Japan by Yoji Akao in 1966. According to Akao (1990), QFD "is a method for developing a design quality aimed at satisfying the consumer and then translating the consumer's demand into design targets and major quality assurance points to be used throughout the production phase. [QFD] is a way to assure the design quality while the product is still in the design stage." As a very important side benefit, Akao (1990) points out that, when appropriately applied, QFD has demonstrated the reduction of development time by one-half to one-third.

The main objective of any manufacturing company is to bring new (and carryover) products to market sooner than the competition with lower cost and improved quality. The mechanism to do this is called Quality Function Deployment (QFD) is an overall concept that provides a means of translating customer requirements into the appropriate technical requirements for each stage of product development and production (i.e., marketing strategies, planning, product design and engineering, prototype evaluation, production process development, production, sales). In QFD, all operations are driven by the ‘voice of the customer’; QFD, therefore, represents a change from manufacturing-process quality control to product-development quality control.”

The QFD system has been used by Toyota since 1977, following four years of training and preparation. The results have been impressive.

## Cost Deployment

As practised by the Japanese, cost deployment is a means of allocating target costs to functions, mechanisms, and parts. Akao and Ono (1993) present the latest thinking in Japan. Dean (1995a) reviews the Japanese efforts through 1993. Dean (1995b) reviews parametric cost analysis and proposes that it be used to estimate the cost of functions, mechanisms, and parts, in terms of quality characteristics of the product and the system to bring forth the product.

Cost deployment is one of the four deployments within comprehensive QFD.

## Target and Kaizen Costing

Tanaka (1993) notes that “A manager in Europe or the United States generally expects to use cost information to make decisions about pricing or investments, while a Japanese manager expects to use cost information to control costs.” Tanaka provides a rather insightful look into the cost planning at Toyota which is “an effort to reduce cost at the design stage.”

Target costing, as used at Toyota, is a rigorous engineering process, which uses value engineering, to reduce the cost of their products.

Kaizen costing is a continuing reduction of cost during production through the implementation of kaizen.

Design-to-cost, as used by the U.S. military community, is an attempt at target costing. However, lacking the rigour of Japanese cost planning, it falls far short of the mark.

Cost deployment, as used within, appears to be a means of allocating the cost targets to specific system components.

Target costing and kaizen costing are true forms of design for cost.

**Benefits of using the value methodology**

The value methodology (also called value engineering, value analysis or value management) is a powerful problem-solving tool that can reduce costs while maintaining or improving performance and quality requirements. It is a function-oriented, systematic team approach to providing value in a product or service.

The value methodology helps organizations compete more effectively in local, national and international markets by:

- Decreasing costs
- Increasing profits
- Improving quality
- Expanding market share
- Saving time
- Solving problems
- Using resources more effectively

Value methodology easily produces savings of 30 per cent of the estimated cost of manufacturing a product, constructing a project or providing a service. The return on investment that public and private organizations derive from implementing VM programs averages 10 to 1. That is, for every dollar invested in a VM study - including participants' time and implementation costs - $10 in net savings results.

## VM and Design Thinking Applications

Value methodology can increase customer satisfaction and add value to an organization's investment in any business or economic setting. Value practitioners apply the value methodology to products and services in industries such as corporations and manufacturing, construction, transportation, government, health care and environmental engineering.

**Value methodology vs. other business processes**

Since value methodology's invention in the 1940s, several other management approaches have caught the eye of business leaders: TQM, QFD, Project management, Concurrent engineering, Re-engineering, Benchmarking etc. The value methodology lends itself to use with other approaches, and its combined strengths - customer needs, teamwork, creativity and a rigorous system approach - rise above the strengths of other processes. Table 1.6 shows a comparison of each approach.

**Table 1.6 Evaluation of the Focus of Each Approach[2].**

| | VA, VE, VM | TQM | QFD | PM | CE | R* | B |
|---|---|---|---|---|---|---|---|
| Customers' needs/satisfaction | 8 | 10 | 10 | 4 | 5 | 6 | 6 |
| Multidisciplinary team | 8 | 10 | 8 | 6 | 7 | 9 | 6 |
| Creativity | 8 | - | 6 | 5 | 5 | 10 | 6 |
| Rigorous system approach | 9 | - | 10 | 6 | 7 | 7 | 6 |
| Cultural/structural change | 6 | 10 | 6 | 4 | 6 | 9 | 8 |
| Scope | 6 | 10 | 5 | 4 | 4 | 9 | 7 |

"I am continually amazed by the impressive array of value proposals and recommendations that are developed when value methodology is applied to any programs, processes or projects. There is no limit to the utilization of the valuation methodology and no limit to the

[2]Tahmazian, Berge. Quest for Value. Value World 21(2): 2-7 (June 1998)

benefits that can be achieved." (Source: Kurt Gernerd: U.S. Department of the Interior: SAVE International Vice President)

**How does the value methodology work?**

The value methodology works through a Value Management (VM) study that brings together a multidisciplinary team of people who own the problem and have the expertise to identify and solve it. A VM study team works under the direction of a facilitator who follows an established set of procedures - the VM job plan - to review the project, making sure the team understands customer requirements and develops a cost-effective solution.

The VM job plan includes pre-study and post-study phases, as well as the value study itself, which is composed of six phases:

- Information collection
- Functional analysis
- Creative and alternatives generation
- Evaluation of alternatives
- Recommendation
- Implementation

## Selection of Projects

In any project of this nature, the results depend upon the mental preparedness of the management and the working teams. The points of attack can be either on single components, Sub-assemblies or the system as a whole. The higher the system level at which it is being attacked, the better will be the results. However, conventionally, the projects are aimed at making marginal changes at the component level than at the assembly level or system level.

More so, making marginal changes in the dimensions or alternate materials is generally found to be an easy way, as people don't want to disturb the system. The product can be attacked at any one of the five levels viz: I- Criticise the dimensions or material spec., ii- Simple modifications in the thicknesses etc, iii- Develop the alternate model, iv- New Design of same product and v- An entirely new concept on which the function can be performed.

The following diagram explains the implications of the Efforts required to make changes, the probability of success of implementing the ideas, and the savings potential.

**Information Collection:** This is by far the most important phase, after the identification of the products for VE projects.

The most critical stage is getting the right information on the cost of the materials, components, parts, labour costs, machining costs etc. Most of the time these details are not made available to the team members on the plea that it is confidential. However, without this information. no VE exercise can be fruitfully undertaken.

**Example 6:** A Transformer Tap Changer's Tap position indicator tube assembly containing 23 parts was redesigned to a modified 9 parts design.

With such details available, we can decide where to attack the problem.

Once the items have been identified and selected, the next stage is to get information on the Function of each of the items. Functions not only of the components and material but so also of each of the features on the parts., i.e., Chamfers, Tapers, Bends, Finishes etc. etc., because it does cost money to provide each of them.

In this instance, the team came out with an alternate design, which fulfilled all the functional requirements with only a set of 9 components as against 30 initially. Such an exercise resulted in much higher reliability, in addition to savings in cost.

## Establishing a Design Thinking & Value Engineering activity:

Establishing a Value Engineering activity in any organization needs to consider a few very important issues.

1. VE, unlike any other functional management area, is a specific tool requiring the attention and involvement of the Design and Engineering function. This being the core activity of the organization which has a direct impact on the very existence of an organization, has to have the decision makers involved.
2. As VE is not a formula or a basic subject, it can not be just inducted into the system, but does require careful planning, because, sooner or later, it will need changes in the basic design of the products and services of the organisation.
3. The typical induction of VE in an organization follows the five stages as follows.

   The different stages of implementing the VE activity in any organisation go through the following phases.
4. A typical VE application involves many stages. At each stage, because of the implications, different levels of management strata need to play a direct role. The process stages and involvement of different levels of management are depicted in the table below.

## Three-Tier Training Program

To harvest the advantages of Design Thinking, it is necessary to inculcate the habit into the minds of all organisations. The Design Thinking training in organisations can be three tiers.

**Tier 1: A half-day Appreciation programme**: For the top management

**Tier 2: A two days Orientation programme:** For the senior management group and shop floor managers and executives, covering the theory behind the technique and concrete examples of its application in various industries.

**Tier 3: An application-oriented programme:** The duration of such a programme varies between 5 days to 15 days, where the participants from a single organization are put on selected projects to be able to apply the learnings and demonstrate the results to the management, in their organisation.

**Methodology of Application-oriented training:** This is a three-tier training approach, as detailed below. Under this Module, a set of three training workshops are conducted for all the executives in Tier 1, Tier 2 and Tier 3 in the organization. Figure 1.20 depicts the various tiers of people managing the organisation and Table 1.7 explains figure 1.18 further in detail.

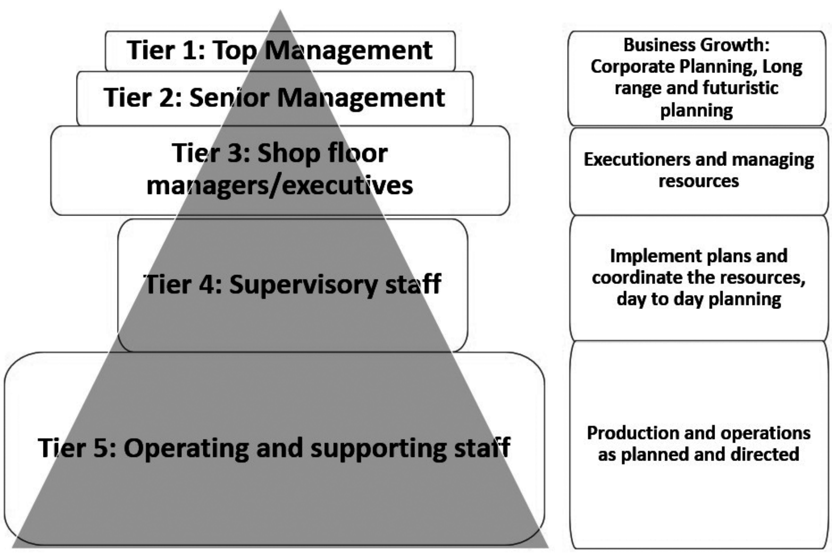



**Figure 1.18 Tiers of management.**

The logic behind this approach is as below:

**Table 1.7 Tiers of management.**

| Tier | Level of participants | Duration (Days) | Objectives and Reasons |
|---|---|---|---|
| I | **Top management executives**<br>CEOs, General Managers and Directors of company | 1/2 | The Module covers only the basics of approach to VE and specific industry cases.<br>These are the executives who have the financial and decision-making power vested in them. However, due to their very senior profiles, they do not have the time to go in to the intricacies of issues. Based upon the recommend-ations of the Tier II level executives, they can sanction trials of alternative suggested by the Tier III executives after they have been vetted by the Tier II executives. |
| II | 2 | Middle and Senior Management Senior Managers, Dy. General Managers and Additional General Managers | The Module covers only the basics of approach to VE and specific industry cases. It would cover the risk taking and need for calculated risk taking and experimenting develop-ment of prototype.<br>These are the employees who have gone through the experiences in the past and have been looking for solutions. However, due to their preoccupation with management issues are not in a position to pursue improvements.<br>They however have the ability to weigh the consequences of any change and can vet the suggestions and compare the |

**Table 1.7** *Contd...*

| Tier | Level of participants | Duration (Days) | Objectives and Reasons |
|---|---|---|---|
| | | | relative advantages and analyse the risks involved in the alternative options.<br>Their experience in looking in to the techno economic effects of implementation of an alternative process or material or technology would help in modifying the suggested alternatives by the Tier III executives.<br>After weighing the pros and cons of various alternatives, they can submit their recommendations to the top management (Tier I) who have the delegated financial power vested in them and can take decisions and calculated risks. |
| III | 5 to 15 | Shop level executives (Engineers, Sr. Engineers, Dy. Managers and Managers | The Module covers the theory, approach and application details. Various examples of contemporary industry experiences through specific implemented VE cases are discussed, together with the decision-making process. The participants are taken through two days of theoretical details. After the theoretical details, the participants are formed in to small teams of 3 to 5 members and specific industry cases. Depending upon the seriousness of the technical issues and projects, this phase would take 3 to 12 days. |

**Table 1.7** *Contd...*

| Tier | Level of participants | Duration (Days) | Objectives and Reasons |
|---|---|---|---|
| | | | The participants are made to work out the basic techno economic modelling of implementation of the suggested alternative designs and in some cases may also be able to test run prototype models.<br>These are the employees who face the problems on the shop floor daily and have the time to explore alternative solutions to problems. They however do not have the decision making powers vested in them and hence most of the good ideas normally die down. Once good ideas are generated and they do not get implemented results in to disappointments and discouragement. |

## Subject wise Analysis of Functions and Information Listing (SWAFIL)

For listing down the functions of a component or a subassembly or a major assembly or even a total system, we use the Verb-Noun combination. To help the reader in arriving at the proper definition and identification of the functions, a representative and indicative list of subjects is provided below. The functions of a system or elements normally would fall under one of the many subjects, viz: Physics, Chemistry, Biology, geography, history etc. Table 8 provides a list of some of such subjects, the principles of which can be used to define the functions.

**Table 1.8 Subject Wise Analysis of Functions and Information Listing (SWAFIL).**

| Subject | Examples of some terms we may use to identify the functions |
|---|---|
| Physics | Magnetism, Sound, Light, Heat, Friction, |
| Chemistry | Reaction, Liquid, Solid, Gas, Neutralise, Accelerate, |
| Biology | Animals, Walk, Seat, Bend, Jump, Grasp, Hold, Grab |
| History | Fight, Life, Longivity, Preserve, Damage, |
| Civics | Drain, Cover, Aethetic, Clean |
| Sociology | Behaviour, Bigger, Smaller, Learn |
| Mechanical | Pressure, Force, Clamp, |
| Electrical | Conduct, Current, Withstand, Voltage, Amperes, Wattage, Heat, Light, Rotate, Crush, Press, Amplitude |
| Metallurgical | Grain, Structure, Strength, Hardness, Anneal |
| Electronics | Impedance, Reactance, Wave, Smoothen, Resist, |
| Biochemistry | Antibody, Antibiotic |
| Statics | Load, Force, Resultant Force, Directional Force |
| Dynamics | Motion, Velocity, Acceleration, Speed, RPM, Centrifugal, Centripetal |
| Statistics | Distribute, Normal, Variance, Mean, Mode, Media, Trend |
| Astronomy | Gravity, Attraction, Repulsion, Force, Light, Radiation, Ultra Violet, Infra Red, Ozone |
| Geography | Height, Depth, Water, Trees, Oxygen, Nitrogen, Gases, Ozone |
| Geology | Extract, Loosen, Hole, Tunnel, Metals, Elements |
| Medical | Scan, Pulse, Pressure, Straighten, Support, Cut, Cover, Seal, React, Scan, Transparent, Transluscent, Opaque, Heal, Coagulate |
| Anatomy | Bones, Blood, Fat, Pump, Bypass, Divert, Flow, Pressure |
| Structural | Support, Stop, Screen, Shut, Transfer, Withstand, Space, Enclose, Extend, Span, Bridge, Gap |
| Physiology | Height, Width |
| Hydraulics | Fluid, Transfer, Pressure, Load, Compress, Expand, Move, Flow |
| Aeronautics | Dip, Drag, Draught, Streamline, Flow, Fly, Lift, Thrust, Drop |

**Table 1.8** *Contd...*

| Subject | Examples of some terms we may use to identify the functions |
|---|---|
| Botany | Chemical, Wood, Leaves, Chlorofil, Smell, Odour, Fragrance, Vitamin, Energy, Calories, |
| Zoology | Jump, Move, Crawl, Speed, Motion, Light, Absorb, Sound, Smell, Sense, Feel, Grab, Digest |
| Seismology | Vibration, Separation, Temperatures, Pressures |
| Meteorology | Temperature, Pressure, Water, Rain, Proof, Flow, Drop, Raise |
| Oceanography | Waves, Pressures, Up, Down, Water, Temperature, Animals, Air, Dissolved, Eject, Swim, Float, Drown |

# Problem Selection Criteria

Any serious exercise in this area does consume resources in the form of time and money for trials. Almost every functional area in management needs continuous improvements. To maximise the results, it is necessary that the selection of such projects should be done systematically and in a prudent way, so that with minimum efforts we achieve maximum results.

Following are some guidelines for the selection of the projects. The areas should be such which have;

- Products or processes with poor profit margins
- Comparison with competitive products
- Modifications (Market demand-oriented)
- High Service Costs
- High Tooling costs
- Import problems
- Availability
- Maintenance and operational complexities
- Obsolescence of technology

**VM Use Improves Environment**

While countries such as the United States pass increasingly stricter environmental laws, industrial and governmental organizations face increasing pressures. They must deliver safe, effective solutions that are cost-effective as well.

The value methodology (also called value engineering, value analysis or value management) can achieve those objectives. U.S. Office of Management and Budget Circular A-131 requires the use of the value methodology for wastewater-treatment projects that cost more than $10 million. VM use produces the following results:

- Quick, creative, effective solutions
- Optimized environmental impact
- Maximized resources
- Optimized construction expenditures
- Lower life-cycle costs
- Alternative technology discoveries
- Sustainable environmental solutions
- Collaboration Produces Results

Environmental stewardship requires a complex partnership between government, industry and the public at large.

Citizens increasingly scrutinize environmental solutions in terms of their health issues, thoroughness and permanence of remediation techniques, and cost of services. Legislators, consumer groups, employers and healthcare providers are divided on the overall effects of environmental crises.

These same groups focus on the future issue of environmental degradation, misuse of resources, potential hazards and the future effects of what is now considered safe to use. And no one wants to spend more than necessary to remediate disturbed environments The requirements of the UN SDGs must be kept in mind, while designing any product or service.

“Value Engineering has great potential in hazardous, toxic, radiological waste remediation. Environmental work is usually high-cost. It offers greater opportunities for VE savings.”

—Merle L. Braden and John D. Sankey Office of Value EngineeringU.S. Army Corps of Engineers

Providers of environmental services must deliver quality to retain certification of compliance while containing costs to ensure viability. The VM process can focus on eliminating waste, enhancing staff creativity and effectiveness, and lowering the costs of investigation, analysis, construction, operations and future maintenance – while maximizing the effectiveness of environmental solutions to meet the needs of the public.

**VM use is mandated in the U.S. government**

The value methodology (also called value engineering, value analysis or value management) originated in the industry community, but its use has rapidly spread to all levels of government — in the United States as well as overseas — due to its potential for yielding a large return on investment.

“Value Engineering is a proven management tool that can be used by agencies to streamline operations, improve quality and reduce contract costs.”

Franklin Rains U.S. Office of Management and Budget

U.S. government agencies are realizing an average of more than $20 for every dollar invested. These savings increase the funds available to achieve mission objectives.

“Over the past about three decades VM has saved the city of New York hundreds of millions of dollars, has identified alternative strategic approaches, has confirmed or modified the direction of dozens of major projects, and has identified flaws in poorly conceived projects early enough to adjust them.” Jill Woller Nw York City Office of Management and Budget

VM use has long been recognized as an effective technique for lowering government costs while maintaining necessary quality levels. The value methodology is helping to reinvent the U.S. government by:

- Identifying cost-saving alternatives
- Using resources more effectively

- The decreasing project, operation and maintenance costs
- Improving safety programs for major government installations
- Reducing paperwork
- Simplifying procedures
- Improving project schedules
- Streamlining an agency's organizational structure
- Cutting down on waste

"Having hands-on experience with value engineering, I agree with citizens' groups that urged Fairfax County, Va., to mandate VE on capital projects."[1]

**Several U.S. laws mandate VM used in the public sector:** The Défense Authorization Act (Public Law 104-106) states that each executive agency must establish and maintain cost-effective VM procedures and processes.

The 1995 National Highway System Designation Act requires states to carry out a VM analysis for all federal-aid highway projects with an estimated total cost of $25 million or more.

The 1986 Water Resources Development Act (Public Law 99-662) requires a new cost-cutting review (the value methodology) on all federally funded water and wastewater-treatment projects with a total cost of over $10 million.

The Office of Management and Budget's Circular A-131 requires federal agencies to use the value methodology as a management tool to reduce program and acquisition costs.

"Many school districts have relied on VM to assist them in demonstrating to the school boards and the taxpayers that they are building the most cost-effective facilities. VM is also an important component in helping the governor's budget office have better credibility with the legislature when submitting budgets for large projects."

[3]Stuart Mendelsohn: County Board of Supervisors, Fairfax County

## Value Methodology Curbs Healthcare Costs

Healthcare spending — especially in countries such as the United States — is escalating at a rapid pace. At the same time, the quality and effectiveness of healthcare services continue to attract attention.

### Benefits to service providers

Healthcare providers such as hospitals, pharmaceutical companies and medical-equipment manufacturers can benefit from VM use. The value methodology (also known as value engineering, value analysis and value management) can help a healthcare organization by:

- Lowering operating and maintenance costs.
- Improving quality management.
- Improving resource efficiency.
- Simplifying procedures.
- Minimizing paperwork.
- Lowering staffing costs.
- Increasing procurement efficiency.
- Optimizing construction expenditures.

"Bristol-Myers Squibb has for several years used VM to maximize value while meeting demanding standards of performance, safety and quality. Central Engineering systematically uses VM from project definition through construction."

Using the valuation methodology can help providers deliver quality while retaining patient volume and containing costs to ensure viability. The VM process can meet the goal of helping the customer by lowering operations and construction costs, improving the quality of care and developing a bond with the client.

Management and staff will benefit from the mutual efforts to effect an increase in efficiency and effectiveness, lowered costs, and improved image to the client and other user groups. Involving healthcare suppliers in the VM process can result in cost savings through a restructuring of supplier processes.

### VM studies in construction save millions

Construction projects face many challenges: budget constraints, safety issues, and environmental impact. By applying the value methodology (also called value engineering, value analysis or value management) to construction projects, highway and transportation departments saved U.S. taxpayers $750 million in 1998. Transportation agencies around the world employ the value methodology to benefit transportation providers, travellers and taxpayers by:

- Reducing project construction costs
- Decreasing operation and maintenance costs
- Reducing paperwork
- Simplifying procedures
- Improving project schedules
- Reducing waste
- Increasing procurement efficiency
- Using resources more effectively
- Developing innovative solutions
- Meeting federal and state laws requiring VM

The value methodology enhances cost-effectiveness and functionality in the following areas:

- Airports and air transport
- Rail and bus facilities and systems
- Ports, waterways and shipping
- Public and private transportation systems
- Highway facilities and traffic control
- Intermodal stations and terminals
- Transportation data and communication
- Environmental impact
- Regional transportation planning

VE *methodology*, *U.S.* highway and transportation departments *saved U.S. Taxpayers $750 million* in 1998[1]

U.S. highway and transportation departments saved taxpayers a record amount in 1998 by implementing the value methodology on federally funded highway projects. State and federal transportation agencies completed 421 VM studies in 1998. The studies produced more than $750 million in cost savings — the largest in the program's history and a 47 per cent increase over the savings in 1997.

"Value Engineering demonstrates President Clinton's commitment to common sense government. Federal programs like this allow [the U.S. Department of Transportation] to work with state and local governments to build safe roads, to stretch the buying power of federal dollars and, in some cases, to complete roadway projects ahead of schedule. Value Engineering is beginning to pay off literally, and states that have developed active programs are finding the results well worth the investment." Rodney E. Slater: S. Secretary of Transportation

"Virginia became the first state to statutorily require the use of the value management process on all transportation projects exceeding $2 million. Since the VE program was expanded in 1990, VDOT has achieved over $100 million in total cost savings." Ron F. Garrett Virginia Department of Transportation

Value methodology savings enables states to get more value from their highway-construction dollars. State transportation departments spent more than $6 million to administer VM programs and realized a return on investment of $121 for every dollar spent.

The U.S. highway industry has employed the methodology for more than 20 years. A 1995 congressional mandate requires a VM study on all federal-aid projects of $25 million or more.

"Aside from the cost savings generated, the Value Engineering process fostered a greater understanding of the project goals and the need for systems integration among the members of the design team. The inclusion of a member of the end-user group on the VE team helped them examine operational concerns for the base design and the potential alternatives, and gave the users a much clearer understanding of what they were getting."[2]

Companies around the world have saved billions of dollars with the value methodology (also called value engineering, value analysis or value management). Value methodology easily produces savings of 30 per cent of the estimated cost of manufacturing a product or providing a service.

"The first documented use of the value methodology in General Motors was in 1960. It is obvious that this technique has stood the test of time, but why not? One cannot argue that providing customer value and saving hundreds of millions of dollars at the same time is extremely worthwhile."[3]

The return on investment that organizations derive from implementing VM programs averages 10 to 1. That is, for every dollar invested in the study - including participants' time and implementation costs - $10 in net savings results.

"DuPont's senior management is committed to VE, and so we've formally used VE on over 300 projects for improving our new and existing chemical processes. VE has saved 10 per cent to 12 per cent of the investment for all these projects combined and has elevated us to best in class for project cost, as measured in industry benchmarking analyses."[4]

A wide spectrum of businesses and industries - from automakers to zipper manufacturers - employ the value methodology to yield a high return on investment while maintaining the quality and performance of products, processes or services.

"The value analysis process has been integrated into our time-to-market process, Xerox's product-delivery process. VA enables Xerox product programs to meet or beat their customer requirements at the lowest total life cycle cost and optimizes organizational and process productivity and effectiveness."[5]

Since its origins in the U.S. industrial community in the 1940s, the value methodology has reduced unnecessary costs while improving performance in the world's largest organizations. In the 1990s, international consulting firms such as Arthur Andersen discovered the value methodology and began recommending its use to clients. The following companies, which appeared on Fortune magazine's "Global 500" list of the largest companies in the world, employ the value methodology:

Boeing, BP Amoco, DuPont Co., Fiat, General Electric, General Motors Corp., Hewlett-Packard, Kmart Corp., Lockheed Martin, Mitsubishi, Motorola, Nissan Motor, Northern Telecom, Royal Dutch/Shell Group, Toyota, TRW, United Technologies Corporation, Volkswagen, Xerox Corp, Pratt & Whitney's and many more.

Why? Because it works!"

"Arthur Andersen sees that the use of VE as part of an overall target-costing process will be critical to suppliers to remain profitable under the pricing pressure and year-to-year cost reduction required by the vehicle manufacturers. If suppliers wait until production to begin cost reduction, they will not be able to achieve the required cost targets."[6]

1. Z. Turk, ýR. Scherer - 2002 - ýTechnology & Engineering
2. Kelly Giblin: Jersey Department of Transportation
3. Jim Rains, General Motors Corp. SAVE International President
4. Michael Cook, DuPont Co. SAVE International Vice President-Education
5. Harry Rosenfeld, Xerox Corp.
6. Eoin Comerford, Arthur Andersen

## Creativity: Stress your Brain: Think

### A Squarecle or a Cirsquare?

This is an exercise for the participants in a creativity session. We ask the group to draw a point, a line, a circle, a square, a rectangle, a pentagon and so on. They just do it. Of course, don't go into the accuracy of the drawings.

Then suddenly we ask the group to draw a Squarecle or a Cirsquare. What? Can you pl. repeat it? So, you repeat "Draw a Squarecle or a Cirsquare. Still have the same doubt. Here is why they would react like that. Because they have never heard about these terms or the name of geometric figures. After a while of prodding, they start to draw weird pictures and shapes. A circle in a square, or a square in a circle, and so on. Some of such drawings are shown in Figure 1.19.

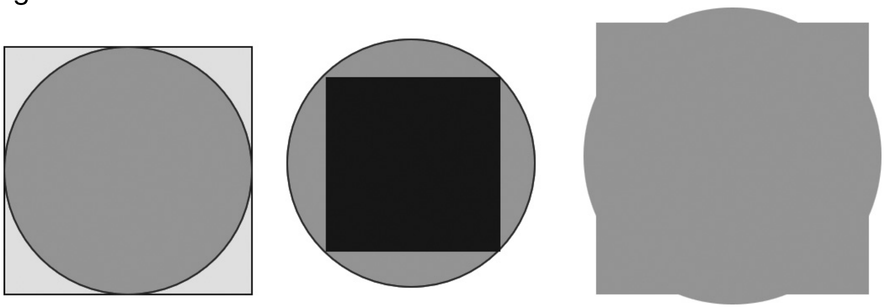


**Figure 1.19 Squarcle or Cirsquare?.**

Then we show them the following pictures as in Figure 1.20 showing a gradual transition from a square to a circle. The first in this set of pictures is a SQUARE and the last is a CIRCLE. The we ask them what would they call the second, the third, the fourth, the fifth and so on…

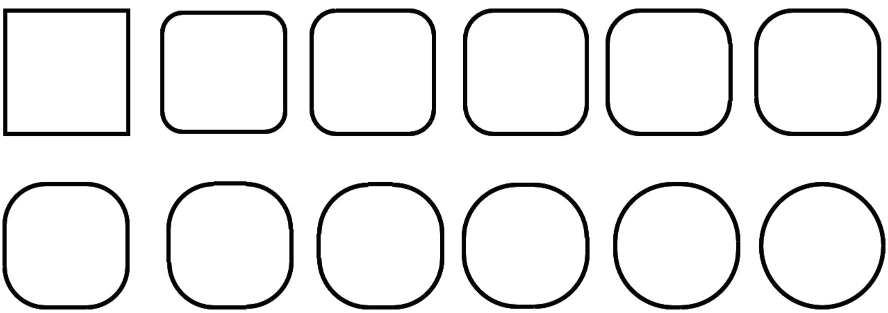


**Figure 1.20 Transition from square to circle.**

The responses would be like this, the second one would be called a "Rounded cornered square"

The Third one: "More rounded cornered Square"

The fourth one: "Very much rounded cornered Square"

The fifth one: "Too much rounded cornered Square"

The sixth one: "Almost fully rounded cornered Square"

And the seventh one: "Fully rounded cornered Square" OR

"A Circle"

The first and the last are a Square and a Circle, What names do you give to the pictures or shapes between the first and the last?

A SQUARCLE

And what if you started from a circle? See below:

The first in this set of pictures is a SQUARE and the last is a CIRCLE.

Say, the second one would be called a "Little flattened edges Circle"

The Third one: "More flattened edges Circle"

The fourth one: "Very much flattened edges Circle"

The fifth one: "Too much-flattened edges Circle"

The sixth one: "Almost fully flattened edges Circle"

And the seventh one: "Fully flattened edges Circle" OR

"A Square?"

The first and the last are a Circle and a Square, What names do you give to the pictures or shapes between the first and the last?

The skill of a Design thinker lies in the fact as to how accurately he or she defines these functions both in terms of ideal requirements and actuals provided. Then the effort would be to attack the gap between the ACTUAL (As it is) and the IDEAL (Desired). The phenomenon 'Vital few and Trivial many', holds good for the Functions also.

Though definition and understanding of the actual function is the nerve centre of Value Analysis, it has been observed to be the weakest area in designing a product.

**Example: Playing cards**

A very common and universally known example is dealt with here to highlight the relevance of establishing the functional requirement and how normally 'One is misled by the perceptual, cultural and habitual blocks.

This example pertains to playing cards. The author has tried this on about 1000 subjects spread over 50 programmes/assignments and the general pattern of responses is summarised here. To start with, show a set of playing cards specially printed in one single colour, Fig. 1.21 to any person supposed to be an expert in cards, and ask him to recognise the cards as displayed. He will read them as Dice Nine, Spade Ten, Spade Jack, Clubs Queen and Hearts Kings.

Give them a few seconds break and display the cards again. This time, ask them to find out if there is something wrong with the cards. On further careful examination, they will come up with a statement that the cards are wrong. Reason -The Hearts King and Diamond Ten are black. So far so good. Quite an expected answer. This is where the perceptual roadblock works.

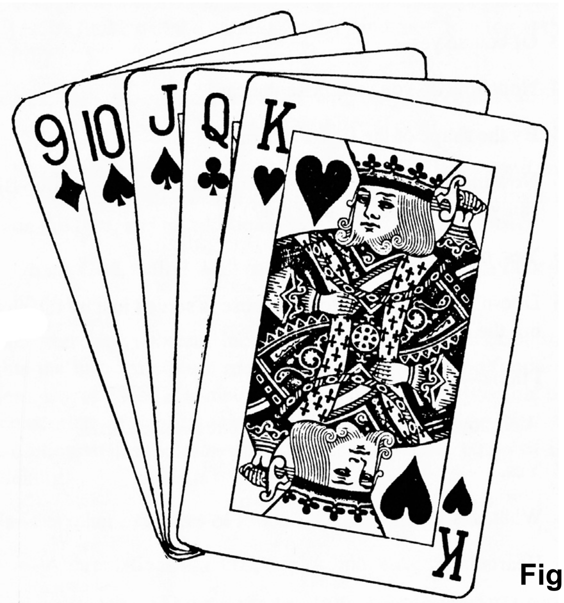



**Figure 1.21 Playing cards.**

Now proceed by showing him another card as per Fig. 1.22 and he would say, Hearts Jack! Right the first time! Sorry! Not right.

With these two examples, proceed with simple questioning shown below, and the answers would naturally follow.

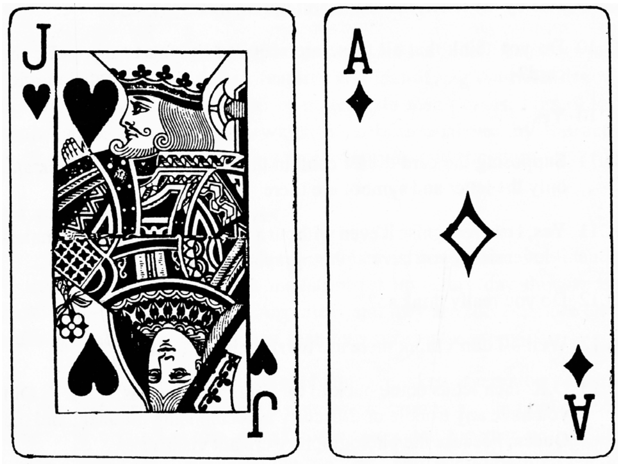


**Figure 1.22 Jack of hearts.**

**Q.1 Why do you say they are wrong?**

A.1 Because Hearts and Diamonds SHOULD be in red.

**Q.2 Why do you think it SHOULD be in red?**

A.2 Because THAT IS THE WAY THEY HAVE BEEN ALWAYS.

**Q.3 No, but can't you recognise the card even if it is black?**

A.3 Of course yes.

**Q.4 Now how do you recognise the card?**

A.4 By the shape of the figure of print.

**Q.5 Now imagine that the cards are printed only in one colour-Black; can you recognise them or not?**

A.5 Yes, of course.

**Q.6 Doesn't it mean that your purpose is served just by the shape and not the colour?**

A.6 I think-yes.

**Q.7 Well now, have you had a look at the second card?**

A.7 Yes.

**Q.8 What was it?**

A.8 Hearts Jack.

**Q.9 How do you know it?**

A.9 Just by the letter, the shape and the figure on the card.

**Q.10 Do you think that all these are required by you to recognise the card?**

A.10 Yes.

**Q.11 Supposing the card didn't contain the photograph of Jack and only the letter and symbol are there**

A.11 Yes, I can recognise it even without a photograph, but then it makes it a lot easier if you have a photograph.

**Q.12 Do you think so?**

A.12 Well, I don't think there are two opinions about it.

**Q.13 O.K. then let us come back to the arranged cards as in fig. 1.19. Did you have any trouble or difficulty in recognising Jack, and the Queen, because the photographs were not visible?**

A.13 I didn't have any difficulty.

**Q.14 Well, then does it mean that most of the time we recognise the cards just by looking at the corners ONLY, and 'not' looking at the card fully?**

A.14 Yes, perhaps we can have cards with only the corners printed so that we can save on the cost of additional printing.

**Q.15 Suggestion: By the way for your information the second card that you saw had J-Hearts in the corners but had King's figures on one half and a Queen's face on the other half.**

A.15 Oh my God, really! Well, can't make out what a Jack or King looks like.

This exercise is a clear indicator of our thinking blocks and also highlights the basic minimum requirements for fulfilling a functional requirement Beyond this if sometimes this solution is not possible because of the constraints of the problem, probably fig. 8(a) can be used as a via media solution with a much lower cost of production in terms of ink and block making.

**Example: Back Tangle?**

Or a set of four RECTANGLES around a SQUARE or an open packing box lower half? Figure 1.23.

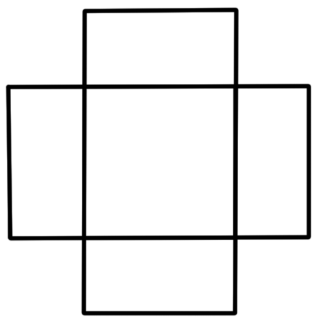


**Figure 1.23 A Backtangle.**

A different way to look at it.

The author, in many of his interactions with the designers and manufacturers of such systems, has been stressing the need to have an analytical look into this subject.

In one such interaction, the following emerged.

**Example: Spare transformer coil**

Major energy utilities compulsorily have to use transformers of very high ratings.

During operation, when a transformer breaks down, the impact of such a breakdown is multi-fold. Most of the breakdowns are attributed to the failure of one of the coils. To avoid long down times, the users have a general practice to keep a spare coil ready.

Conventionally, a spare coil has been supplied by the manufacturers, the construction of which was similar to the main transformer coil, as can be seen in the following drawings.

While this practice has been in vogue for more than 6 decades, there was no attention to trying to establish the difference between the basic functional requirements of the main coil and a spare coil.

In the case of a spare coil, it was realised that the coil is not eletrically charged at all, and hence only immersion in a thin layer of oil is enough, for protecting against drying or cracking, thereby drastically reducing the size of the housing and reduction of oil quantity.

A transformer company was engaged in manufacturing power transformers. The company, while supplying power transformers to the power generation and transmission companies, some time had to supply a spare set of transformer coils. It may be noticed that the same shape and dimensions of the tank were used for the spare coil, as were in the main transformer, with oil filled in the tank.

However, from a critical view of the design, a few questions brought out the scope for adding value to the spare tank.

The spare coil tank (Figure 1.24) primarily comprised three main components viz a- The set of the primary and secondary coil, b- the enclosure of mild steel tank and c- the transformer oil. Table 1.9 provides further information about the functional requirements of a spare coil tank.

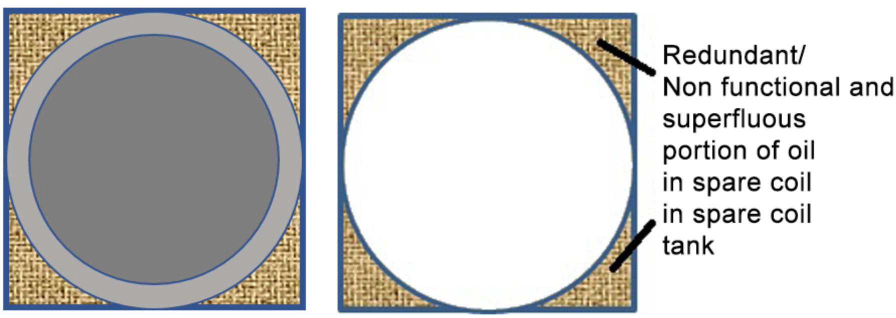



**Figure 1.24 Spare Transformer coil.**

**Table 1.9 Functional requirements of spare coil tank for transformer.**

| Sl.No. | Functional Requirement | Active coil in the transformer | Spare coil |
|---|---|---|---|
| 1. | Di-Electric Strength of the media | Required | NOT Required |
| 2. | Protection against corrosion | Required | Required |

Cost, by its very nature, remains a constant figure under a given set of operating conditions. The Price is changing depending on the demand and supply, whereas Value changes from case to case for the same item depending upon the need and the worth of the item.

Cost & Price are the domain of the manufacturer or producer, whereas Value is the domain of the user or buyer.

To differentiate between the three terms let us take an example under three different operating conditions.

**Example: A polyester shirt**

The total cost of production and distribution

= 60 Rs./piece

Selling price

= 90 Rs,/piece

**Condition 1: Manufactured by a local firm:** Money equivalent of Value which you would be prepared to pay is say 75, which would mean that you would prefer to buy the cloth and get it stitched, for about Rs. 75 than buying a readymade one for Rs. 90.

**Condition 2: Unavoidable circumstances:** The urgency of need, where you don't have time to wait for stitching:

Value 90/- Rs. Equivalent

**Condition 3: Someone close to you presented this to you:** After buying for Rs. 90 and one of your friends is offering you Rs. 90 for it.

Here the question is, whether you would sell it for Rs.. 90, or more, or less, or will not sell it at all. This decision depends on various conditional parameters. Let us look at the following matrix as in Table 1.10.

**Table 1.10 Price and conditions.**

| Case | Sum offered | Your Consideration to sell it to your friend |
|---|---|---|
| 1. | 90 | No. The additional amount does not compensate for the sentimental attachment with the gift |
| 2. | 100 | No |
| 3. | 120 | No |
| 4. | 150 | May be yes. Not decided but weighing the pros and cons. |
| 5. | 175 | Yes. Decided that the amount of Rs. 175 is equivalent or more worthy than the sentiments attached with the shirt or the person who has presented to you. |

But had you bought the shirt for Rs. 90 you might have accepted to resell it for only Rs. 90 or maybe Rs. 95 because you know that you can again replace it for the same sum as it is available readily.

This is only one of the many cases where you or anyone else relates the money equivalent to the worth of the items, all factors considered.

And same is the case with, and behaviour of your customer when he prepares himself to pay a rupee equivalent to the sum or services for your product or service.

### Value Analysis

Value Analysis is a systematic approach to segregate the ‘different parts of the Value, and eliminate by gradual process those parts of unnecessary costs, which, neither,

(a) Increase the function, nor
(b) Provide esteem or ego satisfaction, nor
(c) Enable the resale ability, nor
(d) Provide sentimental attachment or urge to possess.

**Value Engineering**

At this stage, we must examine the definition of Function. The function is defined as the purpose for which a material, a part, a product or a service is required. Once we come down to the purpose for which a part or a product is required, it becomes easier to suggest alternatives for achieving the same purpose.

**Historical Development:** Around 1947, L. D. Miles, in General Electric, USA initiated the Value Analysis (VA) programme for the first time. The programme, since then, has attracted global attention and many organisations worldwide gave successfully applied the technique with attractive results. Initially, though the technique was applied to the analysis of procured or bought-out items, it has been extended to manufactured items as well.

The idea behind Value Analysis is not new, but the approach to the problem essentially differs from that of the other Cost Reduction techniques.

A customer, when buying a product, weighs its functional and other features (appearance, attractiveness and looks) against its price and judges the Value of the product. Manufacturer in turn, to enhance the value of their products, must ensure that he offers all the necessary functional features at the lowest possible price. This functional approach is the basic criteria of Value Analysis. It tries to obtain a Function and Not the Part, at a lower Cost.

This has the fundamental base, as the user is not at all interested as to how the part looks like, or what it is made of, as long as the desired function is performed to his satisfaction along with the required level of Quality and Reliability.

Thus Value analysis is a function-oriented approach and not a product-oriented approach.

## VALUE means different things to different people

To a Designer, Value means Reliability of Performance.

To a Financier, the Value of a product is the financial returns it can bring.

Whereas

To a Customer, Value is a comparative assessment between the performance, other esteem features of a product and its price.

The fundamental principle of VALUE ANALYSIS is thus to analyse the functional and other features and ensure that they are acquired at the lowest possible cost.

Measurement of VALUE is not easy. It has to be evaluated only by comparison. It is the lowest cost combination of Design Materials & Processes, which will reliably give Performance, Esteem, and other required functions expected from the product.

## Value Engineering

This is the stage where the concepts of proportionate functions and their proportionate costs are taken care of at the basic design stage.

DESIGN THINKING & VAVE is a generic name given to this technique of VALUE Analysis and Value Engineering

## Areas for Application of VA VE

Although VA VE can be applied in all spheres of activities of an organisation, the difficulties faced in the application phase have to be realised. In Aristotle's classification of seven types of Values, except ECONOMIC VALUE, all others are highly subjective and individual oriented rather than group or society oriented. The seven classes of Values propounded by Aristotle are:

(a) Economic Value
(b) Political Value
(c) Social Value
(d) Aesthetic Value
(e) Ethical Value

(f) Religious Value

(g) Judicial Value

Table 1.11 shows a comparative analysis and applicability of these different classes.

**Table 1.11 Comparative analysis and applicability of different classes of values.**

| Value Class | Type of Actions (Examples) | Explanations & Analysis | Can Design Thinking & Vave Be Applied? |
|---|---|---|---|
| Economic | A Product or Service bought at a given Price. | Within a given framework and conditions, alter-native products or ser-vices -can be found so as to serve the required function at a much lower cost. | YES |
| Political | People are normally wedded to a particular philosophy thereby have certain political views. | People have been seen to be changing their alliances and phil-osophies in some cases even to a diagonally opp-osite view point, just to gain power. The price one pays in such matters depends on his or her own standing and influ-ences. Under the same circum-stances, two individuals from the same political wing have comp-romised at two different prices. (Need not necessarily be in the cash form). | Subjectivity is involved to a large extent and exact VALUE cannot be ascertained. High subjectivity is involved and the VALUE of not joining the party cannot be evaluated. |

**Table 1.11** *Contd...*

| Value Class | Type of Actions (Examples) | Explanations & Analysis | Can Design Thinking & Vave Be Applied? |
|---|---|---|---|
| Social | Spending a certain amount to attend own brother's marriage (which is a major social function). | If one is close by, he might lake leave from work and join the occasion with family. If the dis-tance is far (but within the country) he decides to join the occasion alone because of travel cost and other expenses. If the person is in a foreign country and the marriage is in India, he might as well decide not TO join the occasion because of the very high cost involved. Also in the same circum-stances one bro-ther might join the group whereas another might decide not to join. | YES |
| Aesthetic | Hobbies and likings of individuals are involved. A Picasso painting is purchased at an astronomical Price by one, whereas a diam-ond studded gold ring is bought by the other. | For the other person the pain-ting may not be worth that amount and he feels that the decision was foolish. In the second case an-other person might feel that instead of spending money on a diamond studded ring he could have bought a deluxe Car and Colour TV Smart. | Value cannot be judged as the functional require-ment cannot be qualified in general. |

**Table 1.11** *Contd...*

| Value Class | Type of Actions (Examples) | Explanations & Analysis | Can Design Thinking & Vave Be Applied? |
|---|---|---|---|
| Ethical | Secret information not to be revealed: An employee of one organisation should not work simultaneously for competitor, etc. | It has been observed that there is a class of patriots who can lay their life for the nation, but at the same time there are others who pass on secret security inform-ation to other countries. | Highly subjective criteria; hence VALUE of ethics cannot be judged. |
| Religeous | Communalism and prevailing values. A person following a particular religion forces others to convert to his own religion but he does not want to change his own' religion. | For gains some people change over to a particular religion (both of cash & kind). It is easy to convert some others. | Purely based on an individual's outlook and his own value system. |
| Judical | Judges lay a certain penalty for a particular crime like Rs. 50,000 or 3 months R.I., whereas, for a similar offence, another person is asked to stand in the court for the rest of the day. | For the same type of case the penalty amount and- the equivalent R.I. period changes. The same person committing the same crime a second time will have a more severe punishment. | The considerations are different from case to case and hence no fixed amount can be assigned. |

A few more can be added to the above list with equally ambiguous situations like:

- Sentimental Value
- Hobby based Value
- Craze or Fashion Value etc.

Value Analysis efforts can be very effectively made when it concerns Economic Value. In other cases, it should be left to the individuals, who are the best judges in their cases. When it concerns an organisation's need, a better approach would be for a team of experts to decide about the Value of these decisions, wherever possible, so that the subjectivity can be reduced, if not eliminated.

### The Economic Value

The economic Value of a product or service can be broadly divided into six basic Values.

### The Use Value

The extent to which the money spent justifies the usefulness of the product or service. This has reference to the specific Functional requirements. For example, the use Value of a Costly Tie Pin can be equated to the cost of a James Clip, for a defined function of holding a tie and shirt together.

### Exchange Value

The extent to which the additional amount paid guarantees the resale or exchange at any point in time. Although in most cases the item is never exchanged, this factor helps by the way of insurance against the crisis. Examples of this are the purchase of a particular brand of the scooter by paying 30% to 50% more than its face Value. Most of the people buying that particular brand never really sell it off. But they are sure that as and if conditions warrant, they can sell it off, easier than other brands. It is perhaps that feeling of safety which forces one to spend the extra amount.

### Esteem Value

The extent to which it meets a particular satisfaction and ego need. Normally this is the most difficult criteria to assess and hence the main aim is to eliminate it, as it does not contribute anything towards the satisfactory performance of the function. The concept of Appearance Engineering is fast picking up now. However, packing a deadly medicine in an attractive package will not enthuse the buyer to go for it unless it has been prescribed by the doctor. In this case, packaging should aim at only preserving the medicine, and nothing more than that. On the other hand, a consumer good can be packed in an appealing package as it would add to the decision-making of the buyer. Government-sponsored and highly subsidised items like Bio-Gas Stoves, Gasifiers etc., need not be made costlier by way of esteem features, as they are supposed to meet the use function more than good looks. (The person who wants to spend his money may even get Gold plating done on his gas stove, provided he spends his own money.)

**Cost:** To the extent that it is a fact and expenses to produce the item or service have already been incurred.

**Place Value**

To the extent that for a given place the item would have a specific Value whereas in another place It will not have the same Value. A glass of water in a desert is an example.

**Time Value**

To the extent that at a given time only, the Value of an item is important. Once time has passed, the item loses its Value. An example is a blood transfusion to a patient undergoing an operation or a stepney in a car on a long journey.

In V A/VE the normal interaction of a member is with Industry, although VA/VE can be equally applied in other fields. In dealing with a product or service in an industry, very often many criteria are considered, and we find it difficult to allocate part of the total cost to a certain type of functional need. For handling such Situations It is suggested to broadly classify all products or services into four major classes and then allocate weightage to various types of Values to split and analyse the total cost

Table 1.12 provides the Matrix of Sample weightage to various types of Values

**Table 1.12 Sample weightage to various types of Values.**

| Sl.No. | Category of product or service | Use Value | Esteem Value | Place Value | Time Value | Remarks |
|---|---|---|---|---|---|---|
| 1. | Industrial Product | 80 | 5 | 8 | 7 | Because Reliable performance is the main criteria |
| 2. | Consumer Product | 80 | 5 | 5 | 20 | Competitive Monopolistic (competitive market) |
| 3. | Consumer Product (Monopoly market) | 70 | 70 | 20 | - | |
| 4. | Fancy Goods | 10 | 20 | 10 | - | External Components |
| | | 70 | - | 5 | 5 | Hidden or Internal Components |
| 5. | Critical Items | 90 | | | | Where performance is the only criteria |

# Basic Plan & Value Engineering Job Plan

The basic plan for VALUE ANALYSIS is:

Identify the function As far as possible one Verb and one Noun only should be used to define the function. In most cases, it is possible to do this. This is to ensure that we approach nearest to the Basic Function and do not get lost in verbose description.

Prepare a Functional Relationship Chart.

Allocate Proportional Costs to the Functions about their relative importance.

Compare the Actual Functional Costs vis-a-vis the norms thus fixed and establish the Gaps between the Actuals and the Norms.

Identify those Sub-Systems with higher gaps in the Actual vis Ideal and create alternatives to achieve the functions at the ideal costs.

## Value Engineering Job Plan

Several versions of the VE Job Plan can be found in the current VE literature. Some give five, others six and yet many others seven phases. It is the systematic approach which is more important to achieve the desired objectives.

The phases of the Value Engineering Job Plan are as in Table 1.13:

**Table 1.13 Value Engineering Job Plan.**

| | |
|---|---|
| Selection: | Of a problem or project based on well laid selection criteria. |
| Orientation: | Of group members to the problem, so that every member in the team understands the problem in its entirety and on the same underlying conditions and problem boundaries. |
| Information: | Collection of details about the project. |
| Speculation: | Evolving alternatives for a given problem or for achieving the required function. |
| Evaluation: | Of individual evolved alternatives. |
| Planning: | This has to be based on well set and mutually agreed upon criteria by the organisation, with a view to select the optimum option. |
| Implementation: | Of all the above optimum ideas or alternatives. |
| Maintenance: | To avoid chances of people reverting back to old option. This happens due to people's resistance to change. |

### Selection of a Problem

To get a real benefit from the technique, the problem must be rightly understood and selected. Normally, any problem that comes one's way is taken up and a quick study is carried out as per the functional analysis, and, alternatives are suggested. This is followed because of the urge for showing results in terms of high percentage savings, but it might be a very meagre sum as far as the absolute money Value is concerned. What needs to be done is to select those problem areas where a potential for higher net savings is expected, although the percentage scope may be very low, because it is the money saved that matters and not the percentage figures. For ensuring this, the easiest and surest way is to use Pareto's Analysis, more commonly and universally known as ABC analysis used in any problem selection. But ironically the only potential use of this analysis made is in the area of Materials Management. (Here, it is taken for granted that the reader is aware of the methodology of ABC analysis, and hence only a reference is made.

**The Pareto Analysis (ABC):** This analysis is based on the universally common phenomenon of "Vital few and Trivial many". Such an analysis will help in arriving at the "A" class items or areas which contribute to most of the cost and account for very few items/areas in the organisation.

### Selection Criteria

While every operation in an organisation needs an in-depth look, it will require a large resource of skilled personnel to undertake details critical analysis exercises on every operation. It is prudent to optimise such resources by selecting important areas for maximising the effect of such an exercise.

The areas need to be prioritised based on their net impact on the organisation's performance.

A few of the important factors to be considered for the selection of a problem area could be:

(a) Products with a poor profit margin
(b) Comparison with competitive products
(c) Modification (Market demand)
(d) High service cost
(e) High tooling cost
(f) Import problems
(g) Availability
(h) Maintenance and operational complexities
(i) Obsolescence of the technology, etc.

The Pareto analysis can be used for the initial selection of a problem in the organisation. This analysis works on the principle of ' 'Vital few and trivial many". This means that in any given system, there are very few areas which contribute to most of the cost of the system, and a proportionately large portion of items contribute to the least portion of the cost. Selection is made first of areas which give maximum advantages. The amount of information assembled will depend on the decision. For example, the weight and cost of individual components will probably be unnecessary if an alternative to the whole product is thought of.

It is useful to establish the amount of time which should reasonably be expended, taking into account the activities, costs, other work, etc. and to establish a rough target of the savings which is hoped to be achieved.

In the case of DESIGN THINKING & VAVE, because the approach is to reduce the cost while retaining quality and performance, the analysis has to be based on cost distribution among various main and sub-functional levels.

Stated in simple terms, the ABC Analysis as applicable to DESIGN THINKING & VAVE is:

In a given assembly, there would be few components accounting for the majority cost (A class items), and many components accounting for a meagre portion of the total cost. (C Class items). Other items would range somewhere in the middle of these and would be termed B Class items.

The scope and potential of the study can be understood in Figure 1.25.

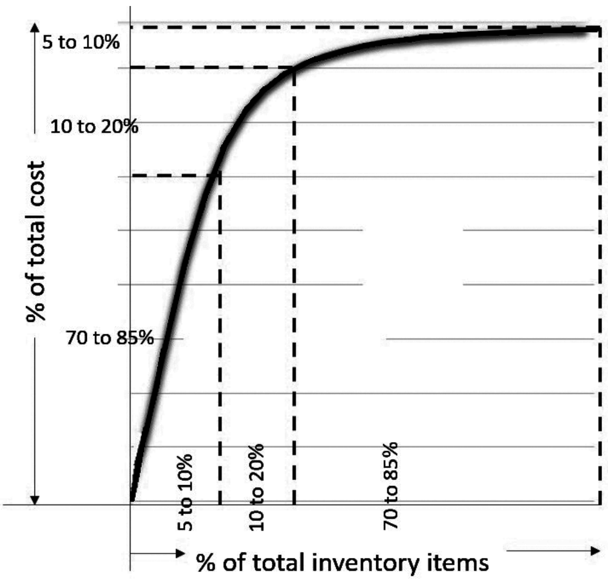



**Figure 1.25 ABC Analysis curve.**

It can be verified from Tables 1.14 through 1.17 in the case of an automobile door handle, an air breather of a transformer, a power loom, and indicator tube assembly of a tap changer of a transformer.

**Table 1.14 Cost analysis of components of an Automobile Door Handle.**

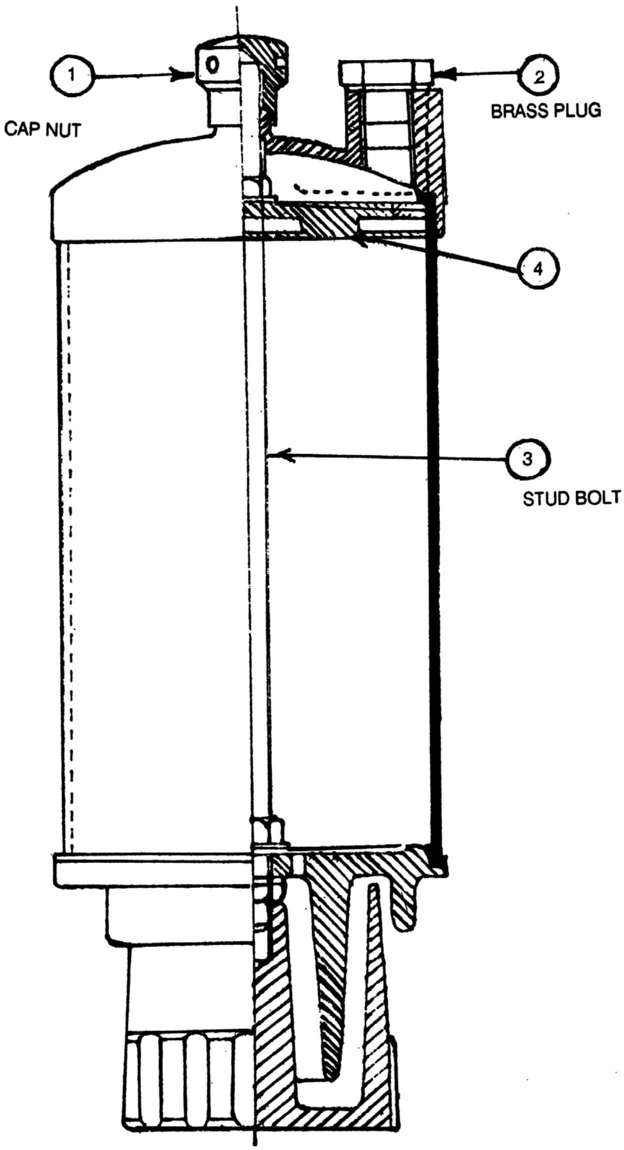
| Sl.No. | Items | Qty | Cost | Cumulative Cost | Class % | |
|---|---|---|---|---|---|---|
| 1. | Handle Body | 1 | 9.60 | 9.60 | 54.60 | A |
| 2. | Lock Body | 1 | 2.90 | 12.50 | 71.00 | |
| 3. | Lock Barrel | 1 | 1.70 | 14.20 | 80.70 | |
| 4. | Intermediate Plate | 1 | 1.40 | 15.60 | 88.7 | B |
| 6. | Return Spring | 1 | 0.40 | 16.60 | 94.40 | |
| 7. | Levers | 8 | 0.40 | 17.00 | 96.60 | |
| 8. | Lock Body Cap | 1 | 0.30 | 17.30 | 98.30 | |
| 9. | Lever Springs | 8 | 0.10 | 17.40 | 98.90 | C |
| 10. | Screw | 1 | 0.10 | 17.50 | 99.50 | |
| 11. | Spring Washer | 1 | 0.05 | 17.55 | 99.80 | |
| 12. | Plate Washer | 1 | 0.04 | 17.59 | 100.00 | |

This analysis of cost shows that only about 33% of the components account for about 89% of the cost and the remaining 67% of components account for only about 11% of the cost. The efforts should be concentrated on the top four items only where the potential effect lies.

Potential Components = 4/12 = 33% (Covering about 90% of the Total Cost.)

## The Transformer Air Breather Assembly

For managing the load conditions in a transformer, an air breather assembly is used. The purpose of using this assembly is to ensure that while breathing in the stage of the transformer, atmospheric air enters the transformer system for balancing the pressure inside the transformer tank. This air contains some moisture, which is detrimental to the functioning of the transformer oil, by adversely affecting its di-electric strength. Ref Figure 1.26.



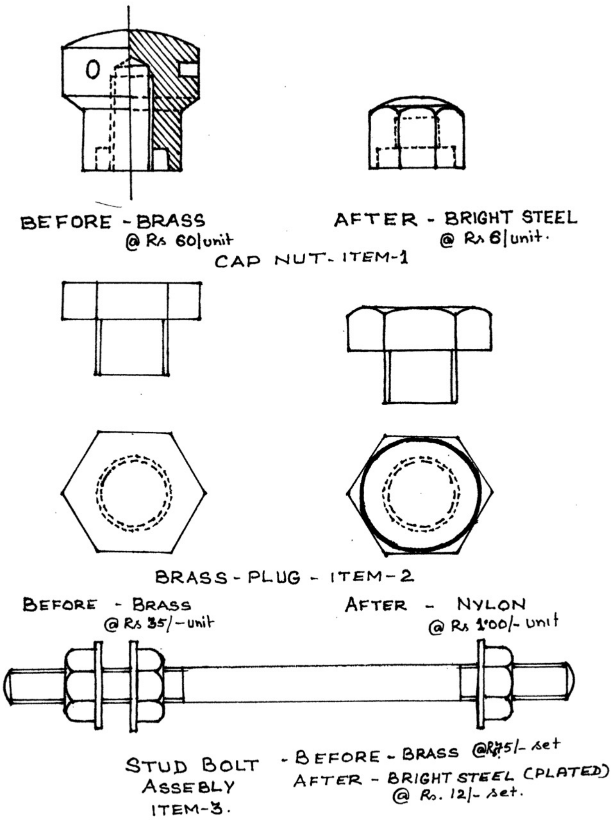



**Figure 1.26 Transformer Air breather assembly and main components.**

**Table 1.15 The Transformer Air Breather Assembly.**

| Sl.No. | Items | Qty | Cost | Cumulative Cost | % of total | |
|---|---|---|---|---|---|---|
| 1. | Cylinder (Perspex) | 1 | 86.67 | 86.67 | 41.90 | A |
| 2. | Brass Plug | 1 | 33.00 | 119.27 | 57.80 | |
| 3. | Top Cover (Die Cast) | 1 | 30.18 | 149.85 | 72.40 | |
| 4. | Intermediate Plate | 1 | 25.14 | 174.99 | 84.50 | |
| 5. | Oil cup (Perspex) | 1 | 22.62 | 197.61 | 95.50 | B |
| 6. | Bolt | 1 | 3.21 | 200.82 | 97.00 | |

**Table 1.15** *Contd...*

| Sl.No. | Items | Qty | Cost | Cumulative Cost | % of total | |
|---|---|---|---|---|---|---|
| 7. | Clamp (Phosphor Bronze) | 1 | 1.95 | 202.77 | 98.00 | |
| 8. | Ring (Rubber) | 2 | 1.02 | 203.79 | 98.50 | |
| 9. | Hexnut M-12-8.4 | 1 | 0.69 | 204.48 | 98.80 | |
| 10. | Round Cap (Plastic) | 1 | 0.69 | 205.17 | 99.10 | |
| 11. | Perforated Plate | 1 | 0.66 | 205.83 | 99.40 | C |
| 12. | Spring Dowell Sleeve (4 x 24) | 1 | 0.54 | 206.37 | 99.70 | |
| 13. | PHD Tapping Screw(N I.4x 1/2") | 1 | 0.24 | 206.61 | 99.80 | |
| 14. | Caution (Transfer Label) | 1 | 0.18 | 206.79 | 99.90 | |
| 15. | Spring Washer B-12 | 1 | 0.15 | 206.94 | 100.00 | |

This analysis shows that only about 33% of the components account for 95% of the cost and the rest 67% account for only 5% cost. The efforts should be concentrated on the top 5 items only. Potential components = 5/15 = 33% (Covering about 90% of the Total cost)

Power loom for Textile Mills

**Table 1.16 Power loom for Textile Mills.**

| Item No. | Name | Qty | Cost | Cumulative | | |
|---|---|---|---|---|---|---|
| | | | | Cost | % | |
| 1. | Side Frame | 2 | 248.00 | 248.00 | 16.90 | A |
| 2. | Crank Shaft | 1 | 204.25 | 452.25 | 30.80 | |
| 3. | Emery Pipe | 1 | 177.01 | 629.26 | 42.80 | |
| 4. | Slay (Wooden) | 1 | 114.40 | 743.66 | 50.60 | |

**Table 1.16** *Contd...*

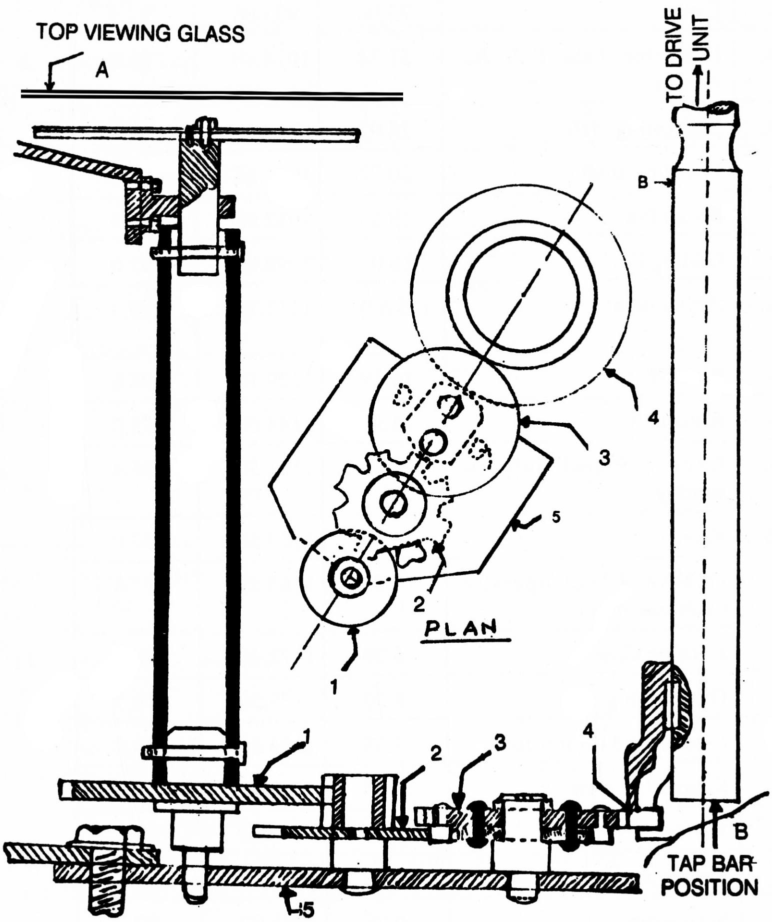
| Item No. | Name | Qty | Cost | Cumulative | | |
|---|---|---|---|---|---|---|
| | | | | Cost | % | |
| 5. | Rail Breast | 1 | 95.77 | 839.43 | 57.10 | A |
| 6. | Bracing Top | 1 | 91.05 | 930.48 | 63.30 | |
| 7. | Tappet Shaft | 1 | 88.40 | 1018.88 | 69.30 | |
| 8. | Spur Wheel (IOT) | 1 | 85.87 | 1104.75 | 75.10 | |
| 9. | Back Rail | 1 | 83.25 | 1188.00 | 80.80 | A |
| 10. | Swing Rail | 1 | 54.79 | 1242.79 | 84.60 | |
| 11. | Front Rail | 1 | 53.00 | 1295.79 | 88.20 | |
| 12. | Whip Roller Bar (Long) | 1 | 50.07 | 1345.86 | 91.66 | |
| 13. | Angle for Central Rail | 1 | 48.87 | 1394.73 | 94.80 | A |
| 14. | Whip Roller Bar (Short) | 1 | 41.15 | 1435.88 | 97.70 | |
| 15. | End for Central rail | 2 | 28.57 | 1464.45 | 99.60 | |
| 16. | Binder bearing brush | 2 | 4.79 | 1469.24 | 100.00 | |

This analysis of cost shows that only 33% of the top components account for 60% of the total cost and the remaining 67% account for the rest 40% of cost only. In this case, most of the components are CI. castings and machined.

Potential Components = 8/16 = 50%
(Covering about 75% of the Total Cost)

**Indicator Tube Assembly for M.R. Tap changer**

A power transformer has a system of Tap Changing. This is used for managing the different loads at different timings and voltages. In a manually controlled system, a tap changer assembly is used. Ref. Figure 1.27.




MAIN TAP CHANGING SHAFT POSITION

INDICATOR TUBE ASSEMBLY: (BEFORE V.E.)

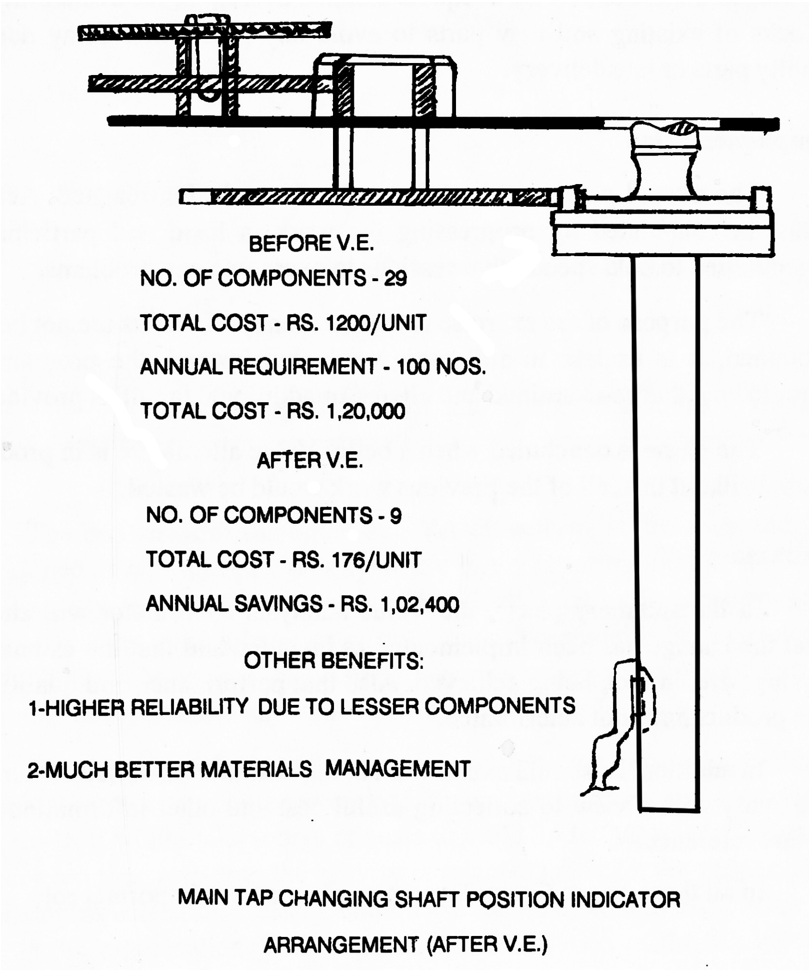



**Figure 1.27 Tap Changer Assembly (Before and After).**

**Table 1.17 Indicator Tube Assembly For M.R. Tap changer.**

| Sl. No. | Part List | Cost | Cumulative | | Class |
|---|---|---|---|---|---|
| | | | Cost | % | |
| 1. | Indicator Tube | 447.61 | 447.61 | 37.5 | A |
| 2. | Gear | 644.28 | 196.67 | 54.0 | |
| 3. | Coupling Dog | 755.06 | 110.78 | 63.3 | |
| 4. | Geneva Wheel Operator | 840.06 | 85.00 | 70.4 | |
| 5. | Gear | 914.06 | 74.00 | 76.6 | |
| 6. | Geneva Wheel | 950.06 | 36.00 | 79.6 | B |
| 7. | Gear | 983.06 | 33.00 | 82.4 | |
| 8. | Indicator Tube Sub Assembly | 1014.80 | 31.74 | 85.0 | |
| 9. | Supporting Plate | 1042.82 | 28.02 | 87.3 | |
| 10. | Coupling shaft | 1063.54 | 20.72 | 89.1 | |
| 11. | Roller Pin | 1082.08 | 18.54 | 90.6 | |
| 12. | Gudgeon Pin | 1098.09 | 16.01 | 92.0 | |
| 12 A. | (Other item) | 1113.71 | 15.62 | 93.3 | |
| 13. | Rivet bolt | 1129.10 | 15.39 | 94.6 | |
| 14. | Rivet bolt | 1144.00 | 14.90 | 95.8 | |
| 15. | Geneva Wheel Sub Assembly | 1151.56 | 7.56 | 96.4 | |
| 16. | Washer | 1158.55 | 6.99 | 97.0 | A |
| 17. | Geneva Wheel operator (assembly) | 1165.51 | 6.96 | 97.6 | |
| 18. | Locking Cam | 1172.30 | 6.79 | 98.2 | |
| 19. | Driving Dog | 1178.50 | 6.20 | 98.7 | |
| 20. | Position indicator plate | 1183.85 | 5.35 | 99.1 | |
| 21. | Supporting plate | 1188.89 | 5.04 | 99.5 | |
| 22. | Washer | 1190.20 | 1.33 | 99.7 | A |
| 23. | Spring pin | 1191.20 | 1.00 | 99.8 | |
| 24. | Spring pin | 1191.97 | 0.75 | 99.9 | |
| 25. | Hex screw steel | 1192.37 | 0.40 | 99.9 | |
| 26. | Spring washers | 1192.67 | 0.30 | 99.9 | |
| 27. | Snap head rivet (steel) | 1192.97 | 0.30 | | |
| 28. | Circlip light | 1193.22 | 0.25 | | |
| 29. | Snap head rivet (steel) | 1193.37 | 0.15 | | |
| | TOTAL | 1193.37 | | | |

Potential Components = 10/29 = 33%
(Covering about 90% of the Total Cost)

Please refer to Figure 1.26 for details of the assembly

A good approach to the overall sales is to determine a total profit factor for each product. This can be derived by multiplying unit profit by sales volume for each product. The product should then be ranked by this total profit factor. A secondary ranking could be made by the two criteria viz., High volume low profit and low volume high profit. This product ranking may be further subjected to the following ground rules:

1. Rule out items with very limited production life or those with spasmodic production requirements.
2. Rule out those low-volume items which might require costly changes such as in engineering or tooling where these changes might more than offset any improvement in profits.

One area which should always be considered is new products. Value improvement in this area not only results in maximum profits but will also increase the potential market penetration through more competitive pricing.

The new products can be ranked with established products by estimating the volume and profits.

In some industries product analysis is not feasible because the output consists of large and complex products. Value Engineering would in such cases be applied to specific operations or components. The approach here should be through preliminary in-process analysis. This analysis would rank operations by their percentage of total operation cost. The selection for Value engineering study could be made on high-cost operations first.

For the selection of a problem for Value Analysis applications, as in any other approach, we must take the cost of production or operation as the starting point with the ABC Classification of cost factors like Materials, Labour and Overheads; Once the prime area is selected" say, Materials, then further analysis of Materials and organisational level can be made for selecting 'A' items for control purpose. The nature of organisations and their operations differ from each other as in Table 1.18.

**Table 1.18 Guidelines for selecting appropriate areas.**

| SL. No | Type of organisation | Areas and suggested approach |
|---|---|---|
| 1. | Engineering Mfg. | Select product groups in • A' class by material contribution. Then within the selected groups, go for an in-depth analysis of a specific component in "A' Category. |
| 2. | Services | |
| 2.1 | Electricity | Generation, Transmission and Distribution. Once the "A" item is selected there, then go for ABC Analysis of the particular item, say for example, if Transmission Cost is the' A' area, then a further classification might show that the Transmission towers and conductors are the main cost components whereas Transmission loss factor, insulation and bushes might be 'C' item. |
| 2.2 | Water Supply | Industrial, Domestic, Public Supply. Say domestic supply happens to be 'A' item then within that the loss due to pressure drops due to closed lines/ scale formation may be the further 'A' item. |
| 3. | Process Plant | Product-wise cost analysis |
| 3.1 | Multi Product | Once a product is selected then the components of cost can be further analysed. |
| 3.2 | Single Product | The components of cost can be analysed for selecting "A" items. |
| 4. | Education | |
| | • Buildings | If it is Buildings: Why not open air like Shantiniketan? |
| | • Furniture | If it is Furniture: Why not Indian Style? |
| | • Salaries | If it is Salaries: Why not self motivated? |
| | • Stationery | If it is Stationery: Which one and why use stationery at all? Only when you cannot eliminate then try to reduce it while meeting the requirements to full extent. |
| | • Examination | |
| | • Maintenance | |
| 5. | Systems | The maximum consumed forms can be selected for examination. |
| 6. | Construction | Foundations, Walls, Plastering or Furnishing? |
| 7. | Transportation | Capital Equipment, Furnishing, Fuel or Ticketing? |
| 8. | Mining | Overburden removal, Spares Consumed, Transportation, Loading/Handling, Energy. |

It is most desirable to select those products and/or operations for the application of Value Engineering" that seem likely to bear the most fruit.

There is no mathematical formula or thumb rule that will directly help in identifying areas for Value engineering study.

Sales analysis provides a good starting point. Emphasis should be placed first on high volume low-profit items since even small improvements here would be magnified by the volume. The next choice would be products with low volume and low profit. Special attention should be given to the overhead costs carried by these items, which in many cases is the cause of low profits.

A significant improvement in this area might lead to increased profits in many products through the reduction of overhead cost burden. Low-volume high-profit products should not be overlooked. Value Engineering studies in this area could give increased total profits by increasing the volume through lower costs and pricing.

## The VE Team Formation

Once the area for the attack has been selected, we need to form a team of members who would be working in the problem-solving sessions. As any problem-solving session calls for multidisciplinary dimensions, it is necessary to form a team with members from each of the functional disciplines.

While every discipline can be represented in the team, it is advisable to have people necessarily from Engineering & Design, Process Planning & Manufacturing Engineering

Materials Management, Costing & Finance

Once the working team has been formed, we proceed on to the Orientation of the team, to the given problem.

**Orientation**

In the preliminary selection phase, the projects to be studied are identified or selected from the range of work carried out by the organisation concerned. The general scope, restrictions and aims of the study may be defined at this stage.

In this phase, it is also necessary to decide on the approach to be used.

The scope of the study should be defined clearly in terms of, whether we want:

- To study the whole product (or system)
- To divide into assemblies or functional areas and study each in turn,
- OR
- To study individual parts.

**The Information Phase**

Most of the exercises carried out during any VA VE training programme or exercise sessions are treated as more of an academic exercise, and most of the time is spent on creativity sessions for ideas generation.

People find it very interesting because of the games, puzzles, quizzes and brain teasers used for opening up the mind and crossing the halo barriers. But things don't proceed beyond this. It is mainly because neither before, nor after the exercise, the full information regarding the problem is collected.

The inadequacy of information is due to two main reasons:

(a) Because of the limited time allowed for such exercises, the participants or team members do not find the right source of the required information. Even if the source is known, there are procedural roadblocks to obtaining the information. The team members, more often than not, either guess the figures or collect from any other source which they think fits.

(b) Cost is the main important information for DESIGN THINKING & VAVE. Most of the financial managers and other departmental heads keep it a confidential item and resist divulging it to the team members, on the plea that it is secret.

Although cost details must be confidential in an organisation, the issues to be considered are:

- What is confidential?

- Confidential for whom? And
- When is it confidential?

Nothing should be concealed from the DESIGN THINKING & VAVE team, otherwise, the results cannot be ensured. After all, the team members are part of the organisation. Without the actual cost details, no DESIGN THINKING & VAVE exercise can be fruitful. It would be better not to attempt DESIGN THINKING & VAVE, than doing it through assumed costs and drawing wrong conclusions.

**Collection of Information**

Although the most important, COST is not the only information to be collected. In addition, there are many more things to be collected, and they can be ensured only through

Consulting everybody who has got anything to do with the item/ service. The suggestions always lie within the organisation; outsiders can only help as catalysts.

The total information regarding a product or service can be classified into seven groups:

1. Design:

1.1 Basic parameters

1.2 Materials Specifications and their Capabilities

1.3 Manufacturing Methods

1.4 Performance, Quality and Reliability

2. R&D

3. Production

4. Services (Operation)

5. Marketing

6. Materials Recovery

7. Finance

One should collect the information relevant to the following three questions:

- What is it?

- What does it do?
- What does it cost?

The cost should be separately available for the following items.

- Materials
- Labour
- Process
- Packaging
- Other Overheads

**What to Collect?**

One should be able to find trees in the woods. Too much information does lead to unnecessary information being collected and thereby more confusion. The team should concentrate on collecting the details about

- Specification
- Drawings/materials/Finishes/tolerances
- Desired Life
- Aesthetics and esteem requirements
- Desired Reliability
- Areas of Operations/Working conditions
- Others using the same Product or Service.
- history of the function fulfilment
- Problems Specified (if any)
- Special requirements of the users, and, above all, the costs thereof

By getting the answers to the above items, one would be in a position to consolidate the information.

**The Functional Requirement Establishment**

The nerve centre of the Value Engineering approach is the understanding of the FUNCTION of an item Product or Service. The following are important:

## The Function

Functions are the natural or characteristic actions performed by an item or can be thought of as the properties of an item which enable it to perform the requirements placed on it in terms of Use, Quality and Reliability.

## Functional Analysis

An item is purchased only because it performs some specific function. A customer's needs to have be fulfilled by the performance of a function that is initially established. This may come from the customer's awareness of a need or the development of a need in the customer by industry. For example, the customer may want some way to heat bread. At this point, we will assume that no product, such as a toaster, is available to fulfil the required function. The customer recognises a function he would like to have fulfilled. Now the industry, which in itself has a function to fulfil (make a profit) searches for and recognises this customer desire. Industry, to fulfil its function of making a profit, develops an item to satisfy the desired customer function of heating bread. During development, the industry may add certain features to the product which do not relate to the function of heating bread but that they feel will contribute to the saleability of the product. They may add (what they hope to be) esteem Value, through an additional process and cost, such as chrome plating.

Normally then, out of the functions that a part performs, some are related to the use of Value and others to esteem Value. The ratio between Functional Values can vary from item to item. For example, a mink coat manufacturer places high weightage on use Value, i.e. to keep the body warm through the thermal insulation characteristics of the mink. However, by using a superior lining and attractive diamond-studded gold buttons and other attachments, the saleability of the mink would increase.

Thus, in every case, a product or operation will include Primary (Basic Function) and Secondary Functions. The two-word description offers two major advantages.

1. The description pinpoints the function. The description is not cluttered with superfluous information. This enables concentration on the exact requirement when alternatives for providing function are developed during the speculative phase of the job plan.
2. Possible alternative solutions for providing the function are not unduly restricted. This is helpful in the creative phase of the job plan when a full range of possible alternatives is desired. The longer the list of ideas for providing the required functions the greater probability that the list will contain the lowest cost method.

**The Functional Hierarchical Tree**

Every product or service used is meant to serve some functional requirement or fulfil an established need. This is termed the Primary Function. While fulfilling this primary functional requirement, it also does something more than that. This “something more” is a Secondary requirement which becomes necessary for meeting the main requirement with a better effect or say to perform the primary function in a better way.

To this extent, the Secondary Function becomes subservient to the Primary function. “In actual practice, we come across regular cases where the product has one additional feature whose function cannot be explained in the given set-up, like the collar in a shirt.

**Relative Evaluation of Functions**

When all the Basic and Secondary Functions of the product or operation have been listed, the next problem is to evaluate each function. The technique of evaluating a function is primarily one of skill, and in VE, as with any skill, practice makes one perfect. The analyst must never operate under the impression that these techniques included hard and fast rules or formulae. Value is a relative term, and therefore, may be different for each analyst. This is why it is so important to evaluate the function rather than the item. This keeps, the study aimed at the need for this item. As the Value Engineer becomes skilled in evaluating functions, he will no doubt develop some of his own.

### Evaluation by Comparison

The value of a function can be judged by using the Value of something readily known. If we consider a lamp, the function can be expressed as 'Provide Light'. This could be evaluated by using the cost of a match or an incandescent lamp. Another example might be a special fastener where we can define the function as 'fasten assembly' or, 'hold parts together'. A quick reference to a hardware catalogue would show the cost of a standard nut and bolt to perform the basic function. The Value of the secondary function might also be required, so, if the fastener also 'transmits force', the cost of a tie rod should be listed.

### Evaluating Functional Areas

Often in analysing a product, it is easier to determine functional areas rather than specific functions. This is done by first dividing the product or assembly into the portion which makes it work (performance) and the portion which makes it sell (features, attractiveness). The performance portion can be broken into Mechanical, Electrical, Chemical, Magnetic etc. Mechanical components may be divided into Transmitting, Rotating, etc., while attractiveness may cover such things as machine finish, surface coatings, shape or form, safety for the user, etc.

These functions would then be evaluated by relative worth (percentages) or by using known or predetermined Values for basic functions. In evaluating the functional areas by relative worth, percentages are assigned to each area listed, depending on relative worth, including both performance and features.

## Functional Hierarchy

The total functional requirements of a product or service are divided into three parts:

A - The Basic or Primary Function

B - The Supporting or Secondary Function, and

C - The Unnecessary or Redundant Functions.

### Basic or Primary Function

A basic function is defined as the specific purpose for which the item was designed. There can be one or more basic functions depending on a particular individual or organisational viewpoint. For example, one person might say that the basic function of a woman's wristwatch costing Rs. 100 is to indicate time. Another person may state that the basic function is to 'Provide status'. Within an organisation, there should be an agreement between the decision and policymakers as to what the functions of the products are.

The primary or basic function of a product or operation can be identified by asking the following questions:

1. What is its purpose?
2. What does it do?
3. Why is it required?
4. What makes it work?
5. What makes it sell? and finally, perhaps,
6. What would happen if it is not there at all?

### Secondary Functions

A secondary function can be defined as anything that makes the product or operation work better or sells better and can be identified by asking the following questions.

1. What makes it work better?
2. What makes it sell better?
3. What else can it do?
4. How does it support the basic function?
5. Can the secondary function eliminate the basic function?\

### Unnecessary or Redundant Function

Unnecessary functions are those characteristics of an item which are not required either as a basic function or as a secondary function. The Value Engineer must be on the lookout for unnecessary functions and eliminate them.

To understand the implications of defining the functions, let us take the example of a common product -Paint.

In the normal sense a paint is expected to protect the surface, however, depending on specific applications, additional functional requirements would become necessary, as shown in Table 1.19.

**Table 1.19 Functional requirements of paint.**

| Application | Functional Requirements |
|---|---|
| On a Water Drum | Protect from corrosion |
| | Add esteem |
| On a Refrigerator | Add esteem |
| | Provide thermal insulation |
| | Protect from corrosion |
| On a Transformer | Protect from atmospheric condition |
| | Ensure resistance against high abrasive winds |
| | Provide thermal conduction |
| On a Gasifier | Protect from atmospheric condition |
| (a) In the oxidation zone | Withstand temperatures up to 1400°C. |
| | Resist oxidising atmosphere |
| | Resist wear from flowing mass |
| (b) In reduction zone | Resist reducing atmosphere |
| | Resist wear from flowing mass |
| | Withstand upto 1000°C. |
| (c) On the Surge tank | Withstand upto 200°C. |

Thus, depending on specific applications, we have to add specific ingredients to the paint to fulfil the different functional requirements.

Various other examples of functional fulfillment are:

- Abbreviations like viz., e.g., Admn, etc.
- Codes like MAS for Madras, BPL for Bhopal, NDLS for New Delhi and DLI for Delhi. Symbols like Red Triangle for Family Planning, Monograms etc. etc.

The approach of defining the primary and secondary functions of the components and their design features and identifying the redundancy of functions resulted in a reduction of material in many cases.

## Evolution of Alternatives

In any situation, whenever a problem is faced, there is a standard approach to solving it. In an industrial set-up, every day thousands of problems are faced by the management and they are solved, more based on experience and hunches, than by a systematic approach.

More often than not, these problems are taken as a matter of routine and are not termed as problems unless it creates a situation of crisis.

Whenever a crisis erupts, a task force is created together with a time-bound action plan, for solving the problem. This is exactly how the concepts of DESIGN THINKING & VAVE also have been treated.

If a problem can be solved in a crisis, why cannot the same be done even when there is no crisis? That means, as a routine and planned activity.

Instead of waiting for a crisis and then attacking the problem, if the same problem is diagnosed voluntarily, the efforts required would be much less. This would mean creating or simulating a problem and then solving it, rather than letting the problem become a crisis and then trying to solve it.