PRODUCTIVITY

What is productivity?

In the simplest form, productivity can be defined as the ratio between output and input.

$$\text{Productivity} = \frac{Output}{Input}$$

But productivity definition does not end here. Above ratio is also measurement of efficiency. The output has to be useful also, which means that output should lead to gains. Therefore, we can now refine the definition of productivity as ***Productive Efficiency.***

Let us understand this concept of productive efficiency from a real life example.

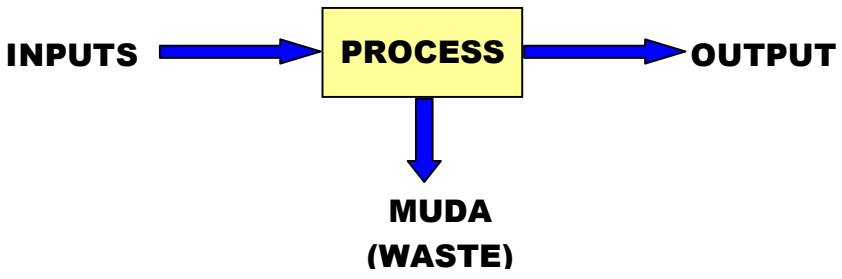
Not very long years ago, there happened a industrial dispute in a shoe factory in the fabled productive country called Japan. Unlike Indian labour, the labour of that factory did not stop the work and instead increased the rate of production. But what they did was that they were manufacturing only left leg shoes. Thus, the production was unmarketable and inventory began to pile up forcing the factory owner to give in to their demands.

In the above story, while workers were working more efficiency than ever before, their productivity was ZERO because their output was unmarketable.

Thus, any performance has to first serve the purpose and then it has to be efficient to qualify as Productivity.

Productivity is meant to capture the efficiency of production process.

How to improve the productivity?



The easiest and simplest way to improve the productivity is to ***identify and cut out wastage*** *(called* ***Muda*** *in Japanese).*

Productivity improvement is a three step process -

(a) Eliminate wasteful activities

(b) Simplify the activities.

(c) Improve the Process. Combine two or more activities *(But mind you, combine only human activities. Don't try to combine machine activities. eg, Teller operation in bank where multiskilled people are employed to deliver a single window deposit and withdrawal facility to customer against earlier practice of check/withdrawal form passing through 4 or 5 tables and consequent costs and delays).*

Historical Background

Man, since time immemorial, probably since the days of Adam and Eve, has endeavoured to make its tasks easier, better and faster. That is what we call productivity. But, a formal and methodical study about productivity is not too very old. It started with Mr Fredrick Taylor who introduced scientific management (later termed as Motion Study) to improve productivity. Later, Gilbreth couple introduced Time Study some 50 years back and the combined form was named "Time and Motion Study" of industrial production. Over the time it has grown far beyond production and time and motion study and encompassed almost every facet of work including services. The new name for such expanded form of Time and Motion Study is Work Study.

Time and Motion Study – Time and motion study involves breaking entire activity into smallest elements of motion (as small as moving the eyes) and timing each motion. Thereafter, movements are subjected to eliminate, reduce/simplify and combine philosophy to achieve better and faster methods of working.

In any Time And Motion study, it is method which is studied first and broken into small elements which are then timed.

Productivity is not about working hard but working smart. Productivity is balance of all factors that will give greatest return for least efforts.

Factors of Production – There are essentially five factors of production represented as 5 M's –

(a) Machine

(b) Material

(c) Method

(d) Man days

(e) Money

If you can reduce usage of any of these factors for per unit of your business, (with nil or less than proportionate increase in other factors), productivity will increase.

Productivity and Performance

Productivity is not same as performance. While performance takes into account only the output, unmindful of resources consumed, Productivity focuses on consumption of

resources in relation of output.

$$\text{Productivity} = \frac{Output}{Input} = \frac{Performance\ Achieved}{Resources\ \ Consumed}$$

Productivity and Production

Same is true about production also. Production is measurement of final output. Production measurement does not take into account inputs. It is often possible to increase production with simultaneous and incommensurate increase in inputs.

Partial Productivity

Any product normally takes more than one resource. Improvement in productivity generally means reduction in sum total of all resources consumed for each unit of output. But when consumption of only one resource is taken to calculate the productivity, it is called partial productivity. Take the case of a farmer deciding to improve per hectare yield of crop by adding more fertilisers. In case of farming, inputs are Land, labour, capital (for seeds, fertilisers, irrigation, etc). Output is crop yield. Now, when output is increased due to fertiliser, productivity of land (yield per hectare of land) has increased. But what about productivity of capital? It is quite possible that money spent in producing each quintal of crop may have increased due to higher expenditure on fertilisers. Thus, productivity of capital has decreased. What about total productivity? It could have increased if increase in yield had more than offset the cost of additional fertilisers or vice versa.

Thus, partial productivity is viewing the productivity with respect to only one variable at a time and therefore it could be some times fallacious. So, if there are 20 different inputs in an activity, there can be 20 different partial productivities.

Measurement of Productivity in terms of Sales Value is generally avoided *(Though it is not always possible and more so in case of partial productivity).* Sales price movement is influenced by too many factors beyond control of the factors of production. It is always preferable to measure productivity in terms of units of production.

Total Factor Productivity

Total factor productivity is calculated by considering total output and total input simultaneously.

$$\text{Total Factor Productivity} = \frac{Total\ \ Output}{Total\ \ Inputs} = \frac{Performance\ Achieved}{Total\ \ Resources\ \ Consumed}$$

Now let us see various productivity terms defined above in terms of numbers.

Example - Problem

For month of Feb 07, following were the factory statistics of Rajesh International –

(a) Total Production – 1,00,000 units

(b) Raw Materials Consumed – 50,000 units

(c) Labour Cost– Rs 25,000

(d) Labour Hrs Consumed – 1000

For the month of Mar 07, following were the statistics –

(e) Total Production – 1,20,000 units

(f) Materials Consumed – Rs 55,000

(g) Labour Cost– Rs 35,000

(h) Labour Hrs Consumed – 1100

Solution

What we see above is that total production has increased from 1,00,000 units in Feb to 1,20,000 in Mar 07. Therefore, ***Production*** of the Rajesh International has improved.

Similarly, performance of labour has also improved since they produced 20% extra in Mar compared to Jun (we have not even looked at what they consumed)

Partial Productivity –

Raw Material Productivity (Feb) - $\frac{Total\ \ Output}{Material\ Inputs} = \frac{100000}{50000} = 2$

Raw Material Productivity (Mar) - $\frac{Total\ \ Output}{Material\ Inputs} = \frac{120000}{55000} = 2.18$

Labour Cost Productivity (Feb) - $\frac{Total\ \ Output}{Labour\ Cost} = \frac{100000}{25000} = 4$

Labour Cost Productivity (Mar) - $\frac{Total\ \ Output}{Labour\ cost} = \frac{120000}{35000} = 3.43$

Labour Hrs Productivity (Feb) - $\frac{Total\ \ Output}{Labour\ Hrs\ Input} = \frac{100000}{10000} = 10$

Labour Hrs Productivity (Mar) - $\frac{Total\ \ Output}{Labour\ Hrs\ Inputs} = \frac{120000}{11000} = 10.91$

Total Factor Productivity

Total Factor Productivity (Feb) - $\frac{Total\ \ Output}{Total\ \ Input} = \frac{100000}{50000+25000} = 1.33$

Total Factor Productivity (Mar)- $\frac{Total\ \ Output}{Total\ \ Inputs} = \frac{120000}{55000+30000} = 1.41$

Now let us analyse the above data.

We see from above calculation that partial productivity of Raw Materials has increased from 2 to 2.18 but partial productivity of labour cost has decreased in the same period from 4 to 3.43. And even though labour cost productivity has gone down, labour hrs productivity has gone up from 10 to 10.91 *(It is indicative of the fact that labour were given financial incentives to improve their productivity. Therefore, cost has gone up due to incentives but actual hrs of labour at work have not increased proportionately)*

Finally, total factor productivity has increased from 1.33 to 1.41. This increase is primarily due to reduction in material consumed (material wastages have been reduced). *(Please also note that we have not considered labour hrs in the total factor productivity. It is because we had already considered labour cost. So, in total factor productivity, we take one factor only once even though in partial productivity different attributes of same factor may have been considered separately)*

Total Productivity Model

Total Productivity Model developed by Sumanth is extension of earlier models. In this model he considers five items as inputs, ie, Human, Material, Energy, Capital and other expenses.

Total Productivity - $\frac{Total\ \ Tangible\ \ Output}{Total\ Tangible Input}$

Total Tangible Output = Value of finished goods produced
+ Partial units produced (WIP)
+ Dividend from securities
+ Interest from bonds
+ Other income

Total Tangible Inputs = Value of Human Inputs (employees)
+ Capital inputs
+ Materials Consumed
+ Energy inputs
+ Other expenses (taxes, transport, office, etc)

American Productivity Centre (APC) Model

Purpose of business is to earn profit. The models that we have so far considered have been advocating disregarding of cost as measure of productivity. But what use is increasing productivity if business is losing money. Thus, American Productivity Centre came up with new measurement of productivity which approaches productivity from profitability angle.

$$\text{Profitability} = \frac{Sales}{Costs} =$$

$$= \frac{Output\ Quantities \times Prices}{Input\ Quantities \times Unit\ Costs}$$

= Productivity x Price Recovery Factor

What is Price Recovery Factor

Price Recovery Factor captures the effect of inflation on profitability. It is ratio of Sales Price and Unit costs of inputs. Thus, the effect of changes in selling price or procurement prices of inputs or both is captured by Price Recovery Factor.

Thus, American Productivity Centre Model gives total productivity and separates out profits from productivity due to usage of inputs from changes in profit due to effect of inflation.

Quality

Another factor which impacts productivity and is therefore intricately meshed with productivity concepts is QUALITY. Quality has been used as a tool to improve productivity.

It is a well entrenched notion in most people's mind that better quality means more time and more money and therefore low productivity. However, empirical results show that productivity improves with quality and it is only at very high levels of quality that the two assume inverse relationship as is common belief. Better quality means less rejection rate and less rework (saving of mandays and material). The savings achieved from lesser rejection and rework more than compensate loss due to investments made in quality. Remember that on an average if one piece is rejected, it eats away profit earned from 5 good pieces. *(Rejection means total loss of cost of one unit which is often 4 to 5 times the profit earned).* Thus, if rejection can be brought down say from 4% to 2%, you have effectively increased profits by approximately 10%.

Besides direct profits, there are plenty of intangible benefits of quality like better reputation of product and company in the market and therefore realisation of better sale price, repeat orders, growth in market share, etc.

But, what is quality? How do you define it?

Again starting with simplest definition given by the founder of TQM concept – "Quality is

fitness for use". If a product is not fit for use, obviously the quality is bad. But then a glass tumbler costing Rs 10 in the market with air bubbles in the glass and 90% clarity is as good for drinking water as the finest Swarovski Crystal Glass costing in tens of thousand.

So, a more appropriate definition is – Quality is what a customer demands and more importantly, ready to pay for.

Quality Control Vs Quality Assurance

Quality control is checking the quality before the product is sent to market and rejecting any pieces which do not meet established quality standard.

Quality assurance is what a company claims on the product label. In this case, the company has certain production control system in place which ensures that defects in production are checked at the process stage itself and defective pieces are not produced. Thus, the need to check and reject final product is obviated. Quality assurance is a better strategy than Quality Control.

Another aspect of productivity is concept of Quality Circles. The concept is a misnomer. Quality circles have little to do with quality of product. Quality Circles is again a concept of Japanese origin where in workers form a team voluntarily and meet regularly to identify and attempt to resolve problems being faced in their shops/workplaces.

Next concept in productivity is ***Value Analysis and Value Engineering***. Let us first understand what is Value?

Value is customer's appreciation of the ***worth*** of product. In layman's terms, Value is the maximum price that the customer would be willing to pay for a product. Value is not uniform. It varies from person to person, time to time, market to market depending on availability, competition, etc. A seller takes a mean of these values and sets a selling price.

Defining them together, Value Analysis / Value Engineering (VA/VE) is the systematic analysis of functions, a systematic approach to enhancing value in a process, project, or product by finding better, more efficient ways of delivering the function it performs. Using a variety of recognized tools, we analyze every aspect of the function it performs. This is accomplished in order to invent a means to provide what is functionally necessary and important at the lowest cost.

Value Engineering is complementary to Value Analysis. While Value Analysis aims at enhancing the value of a product already in market, Value Engineering is applied with the same aim to product at design stage. Value Analysis/Value Engineering help in either improving the functionality (adding more features to satisfy customer demand/requirement) at the same cost or finding ways of delivering the existing functions at lesser cost.

Together, they are used to increase the value of products (or services) by considering the benefit of each function and balancing this against the costs incurred in delivering it. The task then becomes to increase the value or decrease the cost or even better, both.

ILO APPROACH TO WORK STUDY

There are numerous methods and approaches to improve productivity but Work Study has the honour of being the first methodical and organised human endeavour to improve the productivity. In this way, is the mother of modern productivity techniques.

Work Study operates on two premises –

1. Refusal to accept without question that things must be done in a certain manner because that is the way they have always been done.

2. Intolerance of waste in any form, whether of material, time, effort or human ability.

Definition – Work Study

> *Work Study is a generic term for those techniques, particularly Method Study and Work Measurement, which are used in the examination of human work in all its contexts, and which lead systematically to the investigation of all the factors which affect the efficiency and economy of the situation being reviewed, in order to effect improvement.*

In simplified form –

> *It is a technique that analyses each element of a specific work to eliminate unnecessary operations and determines better method to achieve same results.*

Work Study is modification of an old technique. In its old Avataar, this technique was called Time and Motion Study. But as the scope of this method expanded from simple production shops to other sectors of business, old title was found to be too narrow and insufficient to bring out the essence of this technique.

A **time and motion study** is defined as a business efficiency technique combining the ***Time Study work*** of Frederick Taylor (father of scientific management) with the ***Motion Study work*** of Frank and Lillian Gilbreth (Husband Wife couple best known through the biographical 1950 film and book *Cheaper by the Dozen*).

A time and motion study would be used to reduce the number of motions in performing a task in order to increase productivity. The best known experiment involved bricklaying operation. Through carefully scrutinising a bricklayer's job, Frank Gilbreth reduced the number of motions in laying a brick from 18 to about 5. Hence, the productivity of bricklayer was increased while simultaneously decreasing his fatigue.

The Gilbreths developed what they called therbligs ("therblig" being "Gilbreth" spelled backwards), a classification scheme comprising 17 basic hand motions.

Components of Modern Work Study

Modern Work Study consists of a two part programme -

1. ***Method Study (Earlier Motion Study)*** – To analyse the elements of a given work to devise a better working method/operating system. This is a macro view of the work process and content.

2. ***Work Measurement (Earlier Time Study)*** – Once the wasteful work has been deleted at the macro level through method study, fine tuning is required at micro level. Each motion is timed and a standard time arrived at for the whole job after allowing due concessions as required for fatigue, rest, etc.

Work Study Vs Other Methods

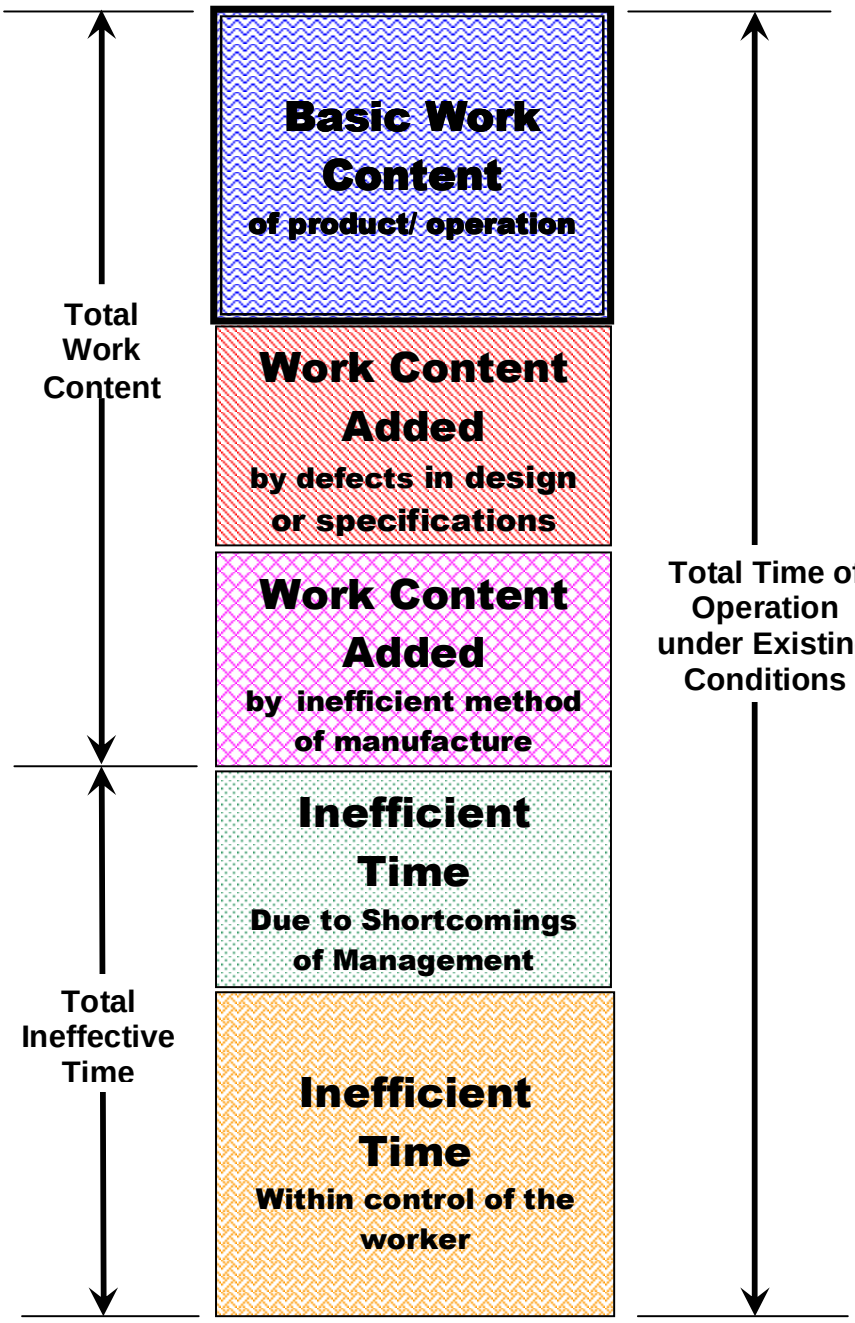
Work Study is a direct means of raising the productivity of existing resources. Most other productivity improvement methods require capital investment. In many cases, there is little real improvement is productivity. In effect, low productivity is shifted to different resource, say, from human resource to capital. Installing a machine may reduce the labour requirement from 10 to 2. But despite reduced labour requirement, and therefore improved labour productivity, company may suffer reduced profitability since the cost of capital, depreciation and maintenance may be higher than the savings in labour. Reduction in capital productivity has overcompensated improvement in labour productivity. In contrast, work study is a definite way of improving profitability through productivity with little or no investment of additional capital.

Limitations of Work Study

However, Work Study suffers from certain limitation. The first limitation is that it is applicable primarily to labour intensive/well defined (repetitive) kind of jobs. Second limitation that it faces is that there is a limit beyond which it can not improve the efficiency. Third limitation is on repeatability, speed and accuracy. Capital investment in technology often brings kind of production efficiency, accuracy and speed which are beyond the realm of work study.

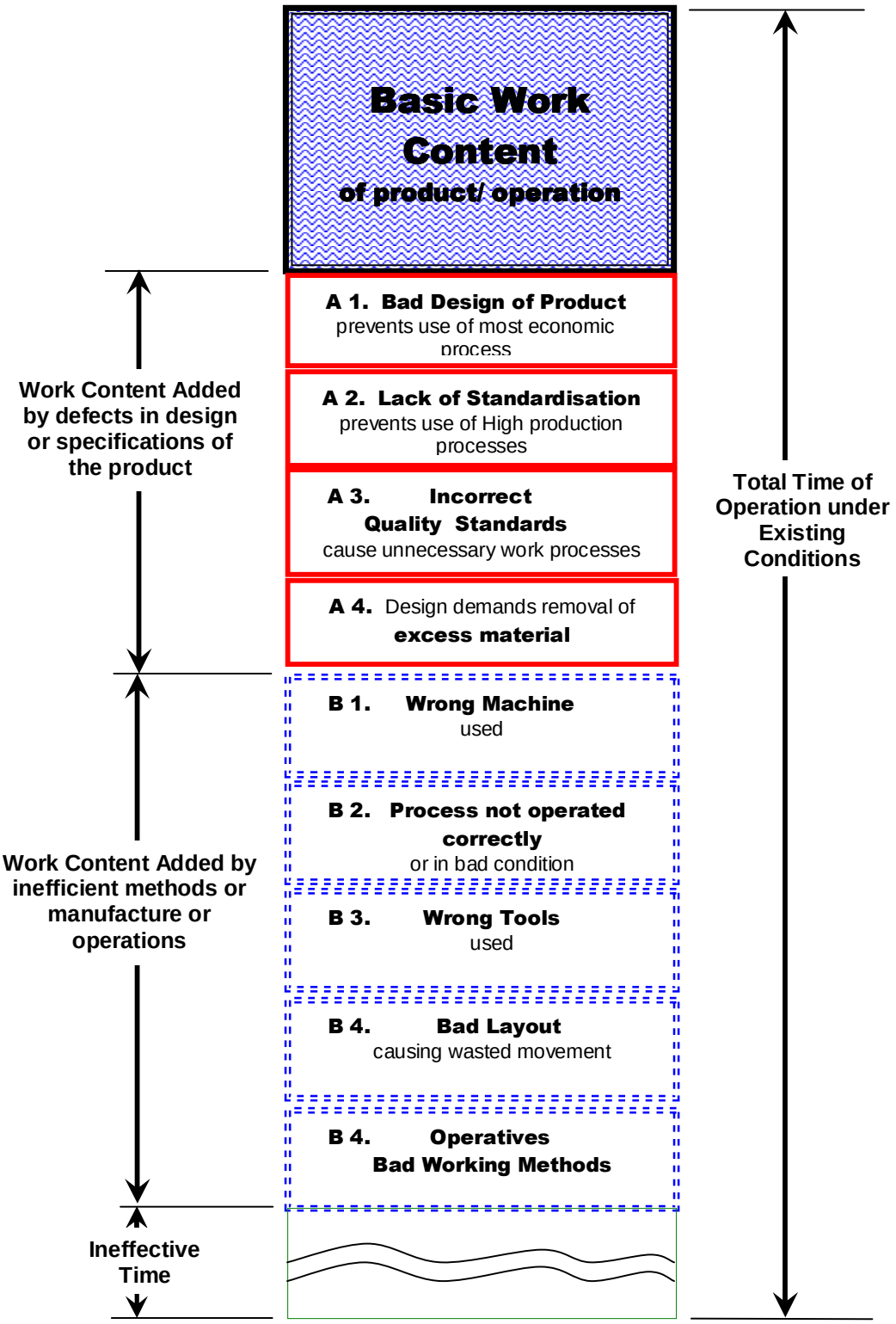
But work study applies even in conjunction with capital investment. Plant layout is a field where there is no substitute for work study. Capital investment will give you fast, accurate and cost efficient machines and production processes but even their productivity can be improved by application of Work Study. How and where to place them in the plant, where and how to store raw materials and finished products, when and how to move the material, etc, are just some of the aspects which make huge impact on overall costs and have to be decided individually for each plant. And to accomplish this job most efficiently, there is no method other than work study.

How manufacturing time is made up



What we see above is that basic work content and therefore actual time required on job is only a smart portion of total effort and time invested on the job. Work Study aims at identifying and eliminating all the added work content and inefficient time. Next we will see as to how work content gets added.

Work content due to product and processes



Once all the wastages and their sources are identified whether through extra work added or ineffective time on the job, conscious efforts are made to eliminate/minimise them.

Following are some of the essentials of this programme-

1. In order to take full advantage of work study, it is necessary that the programme be applied to the whole organisation rather than on piece meal basis here and there. Else, while the percentage savings on an individual job may be substantial, its impact on organisation will be miniscule.

2. It is not a part time job which some one can do along with his routine job. Work study requires continuous and keen observation of each job and then mental deliberation on the observations. Therefore, a person undertaking work study needs to be a specialist and has to work full time.

3. Everyone in the organisation needs to be bitten by the work study bug. Most of the suggestions for improvement in methods and procedure often come from the workers themselves even when external consultants are hired. So, their cooperation is must for work study programme to succeed.

4. Work Study is designed to bring to light various inefficiencies in the system and people and that can create lot of bad blood between people involved in the Work Study and the workers and managers. Therefore, situation needs to be handled carefully. Else, cooperation of people will stop leading to complete failure of the programme. May be it's a good idea to initially play down the programme and keep the results confidential.

Basic Procedure of Work Study

Work Study is an eight step procedure –

1. ***Select the job/process to be studied*** – While it is necessary to study almost every job in the organisation, a selective approach is required to begin with.

2. ***Record from Direct Observation*** – Record every activity by breaking down to the lowest level. Select the most suitable technique from various recording techniques that are available. Each technique is suitable for a different kind of job.

3. ***Examine the recorded facts critically and challenge every thing*** with 5 Ws and 1 H – Why, Who, When, Where, Which and How. Start with seeking justification for necessity of that activity - why is that activity is required. Follow the process of eliminate, reduce, modify. Eliminate the activity if possible. If not, reduce the level of activity. If reduction is also not possible, check if it can be modified to do it faster and better.

4. ***Develop the best method*** taking into account all circumstances. Remember, the most economical is not always the best.

5. ***Measure the quantity of work*** involved in the method selected and calculate the standard time for doing it (Work Measurement).

6. ***Define the new method*** and related time for future.

7. ***Install*** the new method as agreed standard practice with the time allowed.

8. ***Maintain*** the new standard practice by proper control procedure.

METHOD STUDY AND WORK MEASUREMENT

Definitions –

Work Study

Method Study is the systematic recording and critical examination of existing and proposed ways to doing work, as a means of developing and applying easier and more effective methods and reducing costs.

Work Measurement

Work Measurement is the application of techniques designed to establish the time for a qualified worker to carry out a specified job at a defined level of performance.

The efforts and time that a job demands often has a lot of wasteful content. Method study is linked with reduction in total efforts (called work content in the ILO parlance) required to accomplish the task. Work measurement attacks the ineffective time on the job and then sets a pragmatic standard sans all wastages which every worker is expected to achieve or excel.

Method Study

Method Study is improvement over old Motion Study. While the motion study covered only body movement, method study covers a much broader scope including procedure and processes. It is, therefore, a much holistic approach than motion study.

Objects of Method Study –

1. Improvement of processes and procedures
2. Improvement of factory, shop and workplace layout and design
3. Economy in human effort and reduction of unnecessary fatigue (original motion study)
4. Improvement in the use of materials, machine and manpower.
5. Development of better physical working environment.

There are a host of method study techniques available for tackling problems ranging from reorganisation of factory layout to movements of a worker on a repetitive job. But irrespective of the techniques fundamentals of work study remain same.

Work Measurement

Work measurement is synonymous with time study of the yore. As a matter of fact, the difference between Work Measurement and Time Study is not as great as in case of Method Study and Motion Study.

Purpose of Work Measurement

Work measurement provides the management with a means of measuring the time taken in the performance of an operation in such a way that ineffective time shows up and can be separated from effective time. Thus, the existence, nature and extent of ineffective time are known where as they were previously hidden within the total time. Once known, remedial measures can be taken.

Second purpose is to set the standards in terms of time for each job. If the standards are set, it is human tendency to at least match those standards if not excel them. It also helps to correct any creeping back to old ways.

Third purpose it serves is to help design incentive schemes.

Techniques of Work Measurement

Following are the principal techniques by which work measurement is carried out –

1. ***Work Sampling*** – A random observation method. Activity is observed and timed at random intervals in an unannounced manner. This method is suitable when the continuous observation data is going to be very large, like, starting stopping data (utilisation data) of 100 machines in a workshop. This method achieves acceptable level of accuracy at reasonable cost and effort.

2. ***Stop Watch Time Study*** – This is a very elaborate and detailed process where time is measured in parts of a second. This is specifically useful for erstwhile Motion Study

3. Predetermined time standards (PTS)

4. Standard Data

Work Measurement Approach

Work measurement has two pronged approach to tackle ineffective time on job. First prong tackles the ineffective time due to management shortcomings and second prong attacks the ineffective time in control of the workers. In both cases, it exposes people in most direct manner. Methods of measurement are also very intrusive. Thus, work measurement has historically attracted maximum opposition from all quarters; direct non-operation from workers and indirect non-cooperation from middle level managers.

In most cases, management uses its clout with Study Group to influence management

shortcomings report and tries to instead highlight the ineffective time in control of workers. This antagonises workers and creates problems. The right approach is to first tackle the ineffective time due to management and then only attempt to address the ineffective time in control of workers.

Work Study and the Human Factor

The biggest challenge in application of work study is to get the cooperation of all concerned. As stated earlier, work study is an extremely intrusive tool of investigation and is designed to bring out lacunae in planning, organisation, control, training and execution. Every one, starting from senior managers to the lowest level worker, is under the threat of getting exposed for his inefficiency and ineptitude. Workers at lower level even feel threatened that higher productivity might lead to reduction in workforce and they may be laid off. Resistance of public sector bank employees towards efforts to computerise functioning in 1990 had the same genesis.

Workers tend to view the work study as a ploy to extract more work out of them without compensating them. Therefore, even if the threat factor is some how removed, workers always want their pound of flesh from any gains that company might earn. Workers Unions use it as a bargaining tool for little extra pay. This trend is pronounced in developing and under developed countries with socialist form of governments. India has all the elements that aggravate this situation.

It is here that change management comes into picture. Getting support of every one around, by which ever way, is a prerequisite for successful application of work study. Guarantee them security of their job and opportunities. It may not be a bad idea to share some of the gains from rise in productivity with the workers to make them a willing participant in the exercise.

It is generally a better idea to ignore labour productivity at the beginning which always draws the maximum resistance. Start by improving management efficiency (cutting inefficient time due to shortcomings of the management like poor material supply, delays in material procurement, etc) and material productivity which are least threatening to the workers. Follow it up with space utilisation and plant utilisation.

Involving workers in the work study, asking for their suggestions, recognising their contributions through awards, rewards and publicity generally wins their cooperation.

Epilogue

The classical ILO approach was Task Based. It breaks manufacturing time into basic work content, added work content and inefficient time. This approach focuses on reducing unproductive work and time in the total work content.

CREATIVITY BASED TECHNIQUES

Most of the productivity techniques that we have discussed so far are attempt to improve and perfect the existing process; make the processes faster, make the people work faster; cut out the steps to increase process speed, eliminate waste (effort as well as material) and so on. But, such methods bring only percentage improvements. They may at the best improve productivity by 100%. Any thing more than that is often far fetched, if not completely impossible.

But then, there could be other method to do the same job which could be many times superior. For example, take the case of dictation taken by the secretary. One option is to keep training secretary to improve her shorthand speed and accuracy. Other option is to equip her with a Dictaphone which takes away all the effort, time and money involved in training her. Even better method is to use Voice Recognition Software which converts speech into typed text. Such path breaking methods emerge out of creativity of people.

There are various methods to coax out the creativity of people –

- Brain Storming
- Nominal Group technique
- Lateral Thinking

BRAIN STORMING

Means of getting large number of ideas from a group of people in a short time by following certain rules.

Even though brain storming gives a large number of ideas, there is no guarantee that the ideas will be practicable. It works on the premise that among the large quantity, there will be at least some good quality ones too by theory of probability. But, there are no methods or thumb rules or any hint as to which idea is best among them. Finding the best and discarding the rest is the job of the management.

Ground Rules for Brain Storming

(a) ***Size*** – The group should be between 6-20 people. Ideal size is 12.

(b) ***Composition*** – The group should be as heterogeneous as possible; age gender, specialisation, profession, experience, etc. Such heterogeneity is important because it brings out different view points from a cross section.

(c) ***Encourage Free Wheeling*** – Let people suggest wild, patently grotesque

appearing ideas. Such out of the box thinking only will yield to new methods. More often than not, new methods will emerge out of most silly, appalling and contrarians ideas.

(d) ***Suspend Judgement*** – Don't pass any judgement either way till the end of session. Just listen and keep listing them. Don't even discuss them for too long. Let the person explain his/her idea and logic followed by small discussion.

(e) ***Cross Fertilisation of Ideas*** – Encourage group members to hitch hike on each other's ideas. Often two or three ideas complement each other and together become an implementable idea.

Steps in Brain Storming

Aspects	**Activity**
State problem	State the problem and provide information. Participants must know relevant details
Re-State problem	Allow participants to re-state the problem from their perspective.
Select basic re-statements	List all re-statements. Select one/two most potent ones to lead the brain storming session
Warming up	Define objective of the session and expected outcome. Give time for free wheeling discussions among group members or for quiet meditation for few minutes before beginning the brain storming session.
Idea Generation	People to speak out the idea Leader to note down all the ideas Process continues till ideas dry up
Wildest ideas	Group takes up wildest ideas in another brain storming session

Do's	***Don'ts***
Suspend judgment	Spend too much time on an initial discussion
Allow silly wild ideas	Allow observers
Have warm-up sessions	Tape record proceedings
Encourage noise and laughter	Accept interruptions
Take more than one statement	Drag session if dried up

NOMINAL GROUP TECHNIQUE

The *Nominal Group Technique* is a consensus planning tool that helps prioritize issues.

In the nominal group technique, participants are brought together for a discussion session led by a moderator. After the topic has been presented to session participants and they have

had an opportunity to ask questions or briefly discuss the scope of the topic, they are asked to take a few minutes to think about and write down their responses. The session moderator will then ask each participant to read, and elaborate on, one of their responses. These are noted on a flipchart without the name of the person (no ownership of idea). Once everyone has given a response, participants will be asked for a second and then next response, until all of their answers have been noted on flipcharts sheets posted around the room.

There after the duplications are eliminated and each unique response is assigned a letter or number. Session participants are then asked to choose up to 10 responses that they feel are the most important and rank them according to their relative importance. These rankings are collected from all participants, and aggregated. For example:

Overall Measure

Response	***Participant 1***	***Participant 2***	***Participant 3***	***Final Score and Rank***
A	Ranked 1st	Ranked 2nd	Ranked 2nd	5 = ranked 1st
B	Ranked 3rd	Ranked 1st	Ranked 3rd	7 = ranked 3rd
C	Ranked 2nd	Ranked 3rd	Ranked 1st	6 = ranked 2nd
D	Ranked 4th	Ranked 4th	Ranked 4th	12 = ranked 4th

Sometimes these results are given back to the participants in order to stimulate further discussion, and re-ranking of the responses. This is done only when group consensus regarding the prioritization of issues is important to the overall research or planning project.

Steps

Step 1. Small group gathers, receives instructions, identifies problems

Step 2. Write down ideas

Step 3. Each one presents ideas; Leader notes these ideas on a chart

Step 4. Group discusses, clarifies and evaluates each of the ideas

Step 5. Participants privately rank ideas in their order of preference

Step 6. Group selects highest ranking idea as a group decision

Advantages	***Disadvantages***
Allows formation of an informed opinion	Effective only if personal bias and prejudice is absent
Ranking of ideas by members is the effect of information exchanged by members	Ideas recorded without name of person (Robbed of individual credit)
Fairly rapid process	Secret voting for final choice
Permits exchange of ideas	

LATERAL THINKING

Lateral thinking is a term coined by Edward de Bono, a Maltese psychologist, physician and writer. It first appeared in the title of his book *The Use of Lateral Thinking*, published in 1967. De Bono defines lateral thinking as ***methods of thinking concerned with changing concepts and perception***. Lateral thinking is about reasoning that is not immediately obvious and about ideas that may not be obtainable by using only traditional step-by-step logic.

So, it is an unconventional approach to problem. It is like proposing to make a tired person work more instead of rest to relieve him of his fatigue; Or, proposing to overfeed a fat person to make him lose weight. Most of the time, the ideas appear bizarre in the beginning. It goes in a radically different way.

Conventional Thinking	***Lateral Thinking***
Think to prove / Choose something	Think to generate / explore ideas
In search of answers	In search of questions
Uses information in its meaning	Uses information for effect
Seeks continuity in process	Seeks discontinuity in process
Concentrates on relevant facts & things only	Does not consider anything as irrelevant
Close ended procedure	Open ended process

WHOLE BRAIN THINKING

What is Whole Brain Thinking?

We all have known that human brain has two parts; Left part of the Brain and the right part. Each part has its distinct function. Left part of the brain is responsible for body movements and right side of the brain helps us in thinking process.

We all have preferred ways of thinking, some have very definite preferences, others a little more 'rounded' in the way they see the World. There are no 'right' or 'wrong' thinking preferences – but there are most certainly implications! Implications for our personal success, confidence, and comfort at home, at work and for our future satisfaction.

The research have further divided the brain into four parts. Most of the people have one or two parts of the brain more developed than others. Depending upon which part of the brain is more developed, a person's thinking style varies. However, using only part of the brain puts huge limitations while problem solving. If the whole brain can be used for problem solving, we will get much better solutions. Whole Brain Thinking is about stimulating other parts of the brain for problem solving.

Following are the typical traits associated with each part of the brain –

Upper Left	***Upper Right***
• Likes working with facts • Deals with facts/issues in a precise and exact way • Looks at problems in a logical & rational way • Likes working with numbers • Interested in technical aspects • Performance is important • Prefers to analyse facts	• Seeing the whole picture, not detail • Likes change & trying new things • Enjoys being busy with several things at the same time • Has imagination • Does not readily accept "the only right answer", but looks for alternatives • Enjoys a challenge and a risk • Can have a gut-feeling for new ideas • Can rearrange ideas and put them together into a new whole (synthesising) • Does not always do things in the same way • Likes to find a connection between the present & the future
Lower Left	***Lower Right***
• Prefers traditional thinking (the way I know how) • Likes facts to be organized and orderly • Likes to work with detail • Prefers a stable & reliable work environment • Feels comfortable with procedure • Prefers security & safety to risk risk-taking • Facts must be sequential & chronological • The task at hand is important – will complete it on time • Likes practical aspects	• Facts experienced in an emotional way • Sympathetic & intuitive towards people • Likes interaction • Makes use of figurative language as well as non-verbal communication (body language, facial expressions) • Feels empathy towards others • Problem solving is often an emotional, not a logical process • Shows enthusiasm when he/she likes a new idea

If you are a person with strongly developed upper right brain, you will solve problems in a logical way, you are precise, will consider financial aspects, and not show much emotion. Factual accuracy and the evaluation of facts are important to you.

The person with strong lower left preferences would prefer to organize and keep track of essential information. Projects are implemented on time and this person keeps a firm hand on financial matters. Security is a priority.

The person with strong lower right preferences would have a 'feel' for people and situations, be able to read the body language of others and enjoy social interaction

The person with strong upper right principles would tend to see the big picture rather then the detail, recognize hidden possibilities, not always play according to the rules and act upon a gut-feeling rather than logic for problem solving; this person wants to do his or her 'own thing'.

The interesting part of this is that we are all dominant in one or more of the four thinking styles.

- 60% of the population are dominant in any two styles
- 30% in any three styles
- 7% are single dominant
- 3% are whole brained i.e. equally at home with all four styles.

There is no best profile. There are strengths of any profile just as there are challenges for any profile.

An understanding of one's own thinking style is a first step to becoming a whole brained principal. It's an interesting, challenging and exciting journey.

SYNECTICS

Synectics is a problem solving tool that stimulates thought processes which would normally not occur to the person. This method, developed by William Gordon, has as its central principle:

"Trust things that are alien, and alienate things that are trusted."

What it means simply is that don't take any thing for granted while seeking solution to your problems. Don't limit yourself to your trusted old methods nor should you disregard a old failed method. It is thus possible for new and surprising solutions to emerge. Its main tool is analogy or metaphor.

Synectics is more demanding a process than brainstorming, since it involves many steps

Procedure

1. ***Analyse and Define the Problem*** – Like, Team functioning getting affected due to regular querelling by two workers.

2. ***Start by Looking for Spontaneous Solutions*** – Like, terminate the services of the troublesome worker, or counsel them or warn them.
3. ***Reformulation of the Problem*** - Like, querrel between two groups of members *(please note that in this reformulation, blame has shifted equally between two groups rather than two workers taking entire blame for querrel)*
4. ***Create Direct Analogies*** – Like, Create situations that lead to clashes between two groups.
5. ***Personal Analogies (Identification)*** – Like, Put yourself in the shoes of those two workers and then analyse the situation.
6. ***Symbolic Analogies (Contradictions)*** – Look for contradictory approach. Could it be that those two workers are right and other wrong? Could it be that others are instigating these two workers to fight due to some hidden motive.
7. ***Analyse the Analogies*** – Once you have all possible analogies, analyse them. Leave none as "Beyond Doubt".
8. ***Development of Possible Solutions***.

VALUE ANALYSIS & VALUE ENGINEERING

Before we get down to Value Analysis and Value Engineering, let us once again see what is Value.

Value's most simple definition is – "the perceived worth of the product by the buyer". ***Worth*** in turn can be defined as – "Benefits expected to be derived from the product". Worth depends upon the customer's requirement of that product at that moment. Therefore, different people attach different value to the same product at the same time OR same person attaches different value to the same product at different times based on its utility and availability. A King, lost in desert for days, had offered half his kingdom for half a glass of water. However, in business, the firm takes the ***Value*** that most people will attach most of the time and sets a price that is below that perceived value to make it attractive for the buyers.

Mathematically, it is represented as: $\text{Value} = \frac{Function\ or\ Performance}{Cost}$

Different Types of Values

1. Economic value
2. Aesthetic value
3. Emotional value
4. Esteem Value
5. Social value
6. Religious value

Different values play different roles in different products. For basic utilitarian items, like food items, washing detergent, etc, it is economic value which is most important. For decorative items, like clothes, furniture, glass ware, decorative pieces, etc, it is aesthetic value which commands more price. For life style products, like designer watches, eye wear, premium pens, jewellery, etc, it is esteem value. Emotional Value is personal to every individual. A letter or card or small memorabilia of negligible economic value from a loved one holds far greater emotional value which could be hundreds and thousands time greater than its economic value. Remember, how Lord Krishna valued puffed rice brought by Sudama? Awards and medals carry social value which is rated much higher than their other values. Some items carry religious value, like, Ganges water.

Definitions

Value Analysis

"Value Analysis is an organized effort directed at analyzing the function of

systems, products, specifications, standards, practices, and procedures for the purpose of satisfying the required function at the lowest total cost of effective ownership consistent with the requirements for performance, reliability, quality and maintainability".

Value Engineering

"An organized methodology that identifies and selects the lowest lifecycle cost options in design, materials and processes that achieves the desired level of performance, reliability and customer satisfaction". It seeks to eliminate unnecessary costs in the above areas and is often a joint effort with cross-functional internal teams and relevant suppliers.

Birth of VA/VE Concept

During the 2nd World War, facing acute shortage of metals for war effort, US reserved copper/brass & gun metal for armament industry. General Electric, one of the largest users of these metals was in a fix. To overcome this problem, Lawrence D'Miles, a GE purchase executive, made substitutions for all the metals. Surprisingly, these substitutions brought down the costs while maintaining the quality.

Difference between Value Analysis and Value Engineering

Value Analysis	***Value Engineering***
Applies to an existing product	Applies to the product at design stage
All factors involve in Value Analysis, like, workers, engineers, sales person, etc, with their experience and knowledge	Done by the product design team
It may change the present stage of product or operation	Changes are made before product reaches the production stage.
It is achieved mostly with the help of general knowledge and experience	It requires specific technical knowledge.

Cost: Cost means total landed cost. Again cost is different for different people. For a producer, cost means - labour + material + overheads. For a consumer, cost means – price (producer's cost + profit) + Retailer's margin + taxes + handling charges + transport + …

Strategies for Increasing the Value of a Product

Performance	***Cost***
Same →	Decrease ↓
Enhance ↑	Same →
Enhance ↑	Decrease ↓
Very high enhancement ↑↑	Marginal enhancement ↑

	Method		***Strategy***	***Example***
1	Decrease cost for same performance	V =P→ / C↓	- High tech/speed vol/recording m/c - Lower versions	Cassettes/colour printers/ digital wrist watches/ calculators
2	Enhance performance at same cost	V =P↑ / C→	Enhancing advt/ product promo revenues	- TOI/ECO Times added supplements - CD with Chip Magazine/ Cassette with Filmfare/ Cosmetics with Femina
3	Decrease cost with increase in performance	V =P↑ / C↓	- Better R&D - Conversion cost reduction	- - pentium performance increase price reduces - - high tech CTV - - Auto cameras
4	Increase performance larger than price increase	V =P↑↑ / C↑	- Increase revenue/ MS - reduce conversion/ other costs	- Cold drinks -increased vol at slight increase in price - Parle biscuits - double pack at 1 1/2 price - Toothpaste - 20% extra + brush at marginal extra price - Mineral water - 1 1/2 ltr bottle at slight extra cost

Functions & Their types

Meaning

Function is the characteristic of product which satisfies the need of the customer. Example: to protect/cut/coat/sew/write/etc.

'One product has got several functions. Mobile phone is the archetypical multifunctional product. A joke listed nine functions of a mobile phone and then, as an after thought, added – "It can be used to talk also".

Categories

Functions can be broadly classified into following categories –

1. ***Utility Function & Aesthetic Function*** – The primary purpose or reason for existence of that product. Most clothes have utility function of keeping the body comfortable and safe from elements of weather. Thus, this is the primary function.

However, they also perform the aesthetic function of improving the appearance of the person. Similarly, curtains have high utility value of restricting the view and ambient light into the room. Its secondary function is to improve aesthetics of the room. Basic function must always exist though the method and means to achieve the same may change.

2. ***Primary/Basic Function & Secondary Function*** – A function that supports the basic function and results from the specific design approach to achieve the basic function. As methods or design approaches to achieve the basic function are changed, secondary functions may also change. There are four kinds of secondary functions:

   (a) ***Required*** - A secondary function that is essential to support the performance of the basic function under the current design approach. Eg. Lighting up a match to light up a cigarette. But the flame can also be used as a light source for view. Thus, heat generation is primary function of a match which is supported by flame. But light generation is secondary function which is integral part of heat generation through flame.

   (b) ***Aesthetic*** - A secondary function improving the appearance. Goggles worn to protect eyes from harsh light also improve appearance.

   (c) ***Unwanted*** - A negative function caused by the method used to achieve the basic function such as, the smoke produced from fire lighted up to cook, or, sound of a car engine.

   (d) ***Sell*** - A function that provides primarily esteem value. Like, Mercedes car, besides performing the basic function of comfortable and safe travel mode, is also a status symbol in the society. For marketing studies, it may be the basic function.

   While for shoes, Primary/basic function is to protect the feet and secondary function is to improve appearance, for belt it is just the opposite. Though, the stated primary purpose of belt is to keep the pant in place, it is worn more for appearance sake and less for keeping the pant in place. In any VA/VE exercise, Basic function has to be satisfied. It is secondary function which can be sacrificed, if required.

3. ***Higher Order Function & Lower Order Function*** – The basic function of a product is achieved through a process. A process in turn is a series of actions each performing a small function. Thus, the basic function is a collection of small functions linked in particular order. Take the case of a torch. ***Why*** is a torch carried? To give light. So, basic function of torch is to give light. How does the torch give the light? By lighting up the bulb. How is the bulb lighted? By pressing the on-off switch. How does the switch light up the bulb? By passing the current from battery to the bulb. And so on. ***The question which is answered by the Why is the Highest Order function.*** Each of the function thereafter, which is answered by question ***How***, like pressing the switch, passing the current to the through Basic function of a

torch is a progressively Lower Order function.

Identify the basic function & secondary function of the following products & also explain how the are satisfied or sacrificed.

1. 300 ml Pepsi bottles –

   Basic Function - To act as container to hold the soft drink.

   Secondary Function – To facilitate easy grip while drinking soft drink.

   Sacrifice – When large containers are used, like 2 litre bottles, the secondary function is sacrificed. They are no more easy to grip while drinking.

2. 500 ml Milk Bottles –

   Basic Function – To act as container for dispensation of fixed quantity of milk.

   Secondary Function – Safeguard adulteration

   Sacrifice – When plastic pouches are used, basic function is served but secondary function of safeguarding against adulteration is compromised. Pouches are known to be easy target for adulteration.

Application of VE

Value Engineering is technique that is also applied to existing product in following situation

(a) Saturated stage / decline stage of Product Life Cycle

(b) Stiff competition faced by product on price / utility / aesthetic front

(c) Facilitate brand extension / launch modified / improved product

Principle

(a) Eliminate everything that is not value adding

(b) Applied to product / processes / systems / services

(c) Enrich product per at lower cost

Job Plan for VA/VE

Various steps of Job Plan for VA

1. ***Orientation Phase***

(a) Train the managers / supervisors - Exposure to VA/VE/ABC/Pareto analysis

(b) Select product for analysis/study

(c) Form teams: Heads of design, marketing, finance, production, etc.

2. ***Info Phase –*** Collect/tabulate data about

(a) Functions/process/time requirement, and

(b) Cost of process/material /component/etc

3. ***Function Phase***: Construct a FAST diagram *(comes for short note)*

"***F***unctional ***A***nalysis ***S***ystems ***T***echnique"

(a) List all parts / components of product

(b) List all basic function of each part

(c) Probe every basic function by why & how

(d) Put cost of each part (make FAST cost diag)

4. ***Creative Phase***: Brain storm sessions *(success of project depends on this phase)*

(a) Suggest alternative means to do same function at lesser cost

(b) List all alternatives

(c) Check possibility to eliminate / modify / combine / consolidate component

(d) Repeat brain storming for diverse alternatives

5. ***Evaluation Phase***

(a) Evaluate each alternative in terms of -

(i) Performs all the basic function

(ii) Meets all requirements

(iii) Reduces cost to effect saving

(b) Short list all the alternatives which stands the test.

6. ***Recommendation Phase***

(a) Design change suggested

(b) Reason for the change

(c) Additional expenditure (for dies/advt exp)

(d) Savings (cost of parts/processes etc.)

Recommendations accepted by CEO

7. ***Implementation Phase***

   (a) List – design modifications, fabrication of die, new Ad campaign, Trial production run.

   (b) Work time span / activity schedules

   (c) Prepare PERT chart

   (d) Allocate responsibilities

   (e) Monitor progress / take action

8. ***Audit*** & ***Follow up Phase***:

   (a) Note actual progress

   (b) Compare with plan

   (c) Take corrective action if required

THE "FAST" MODEL

Charles Bytheway extended Mile's Function Analysis concepts and introduced the methodology called ***F***unction ***A***nalysis ***S***ystems ***T***echnique (FAST) in 1965. FAST uses intuitive logic to decompose a high level, or objective function into secondary and lower level functions that are displayed in a logic diagram called a FAST model.

The FAST Methodology

In the Value Engineering methodology, function analysis is performed by an interdisciplinary team in a workshop setting. A Value Engineering workshop follows a structured six step job plan. Function Analysis is central to this methodology. In fact, if Function Analysis is not performed, the workshop can not be called a Value Engineering workshop. In the classical method of Function Analysis developed by Larry Miles, only two words were allowed to describe each function, an active verb and measurable noun. For example, the function of a light bulb would be to "illuminate area", and not, "light room." The importance of using and active verb and measurable noun can not be emphasized enough. Later in the function analysis phase, values are assigned to these functions. These values can be dollars, weight, or any other pertinent value. These values are then used to evaluate the functions in terms of their importance, or value to the overall system. The FAST modelling process starts with the facilitator asking several probing questions designed to identify the scope of the model, its objective function, and basic function, or basic functions. Three main questions that are asked are:

1. What is the problem, or opportunity we are here to discuss?

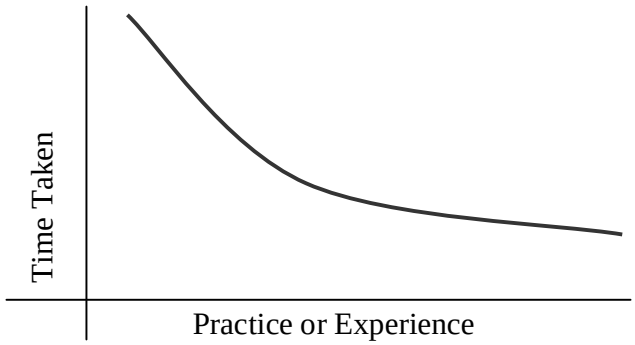
2. Why is this a problem; or opportunity?

3. Why is a solution necessary?

These questions are designed to identify the mission of the system while bounding the scope of the problem, or opportunity. By stating the mission of the system as a problem, or opportunity helps the team specify what the system is to accomplish. The basic structure of a FAST model looks somewhat similar to a process flow chart. However, there are some very significant differences (see figure 2). First, the blocks represent functions, and not process steps. The FAST model is a logic diagram, and not time oriented. There are several methods used to identify and decompose functions to start the model. One common method is to randomly "brainstorm" functions by starting with the objective, or mission of the system and brainstorming how it might be accomplished. Once a function is identified, the process is repeated until all possible ways are exhausted. Then, some of the identified functions become topics for the brainstorming and the process is repeated.

LEARNING CURVE AND ITS APPLICATIONS

When you do a job for the first time, it takes much longer than it takes the second time. After you have done it a few times, the time taken reduces significantly. When you do it for the first time, you are not sure about the procedures, so you are tentative. You make mistakes and therefore have to redo a few things. You may even need to refer the manual or ask some one for the help. Your body movements are not so well synchronised and therefore slow. But as you keep doing the same job repetitively, you know the processes by heart, you have learned the key elements, your limbs have fallen into a practiced movement. And you do the job in a carefree and nonchalant manner. As more and more experience is gained, you become faster and faster. This is called learning process. When this process is plotted on a graph of ***Practice Vs Time***, we get a curve which is called learning curve.



Learning Curve

The other names given to learning curve are experience curve, improvement curve or progress curve.

This learning effect is not infinite. It is highest during the initial phase and tapers off over the time and stabilises as the limits of learning are reached. Studies have indicated that the reduction in time taken to complete the job is at a fixed percentage rate. Each time the experience is doubled, the time required to do a job is reduced by a fixed percentage of average time taken at the previous experience level (please note that it is percentage of time taken at the previous experience level and not the first job. And time for each successive job is reducing. So, while percentage reduction is constant, net reduction in time is tapering off).

The reduced average time taken in percentage terms when experience is doubled is called learning rate. So, if first piece takes 20 hrs and second piece takes 12 hrs, total time taken for manufacturing two pieces is 32 Hrs. Average time per piece taken for first two pieces is 32/2 = 16 Hrs which is 80% of the time taken for the first piece. So, learning rate is 80%. In other words, at 80% learning rate, if the first car assembly requires 100 direct labour hours, *average time per car* required for assembly of two aircrafts would be 0.8x100 = 80 labour

hours. *Average time per aircraft* for assembly of four aircrafts would be 0.8 x 80 = 64 labour hours, and for 8 it would be 0.8 x 64 = 51.2 labour hours and so on.

Hundred minus the percentage reduction is known as the learning rate. The learning rate in the present example is 100 - 20 = 80% or 0.8.

The learning curve concept has found many useful applications in managerial decisions in the areas of marketing, new product start-up, bidding for tenders and make-or-busy decisions.

The rate at which learning occurs is influenced by many factors including the relative unfamiliarity of workers with the task, the relative novelty and uniqueness of the job, the complexity of the process, the impact of incentive plans, supervision etc.

The factors that result in reduction of time are not all about labour efficiency. A variety of factors are responsible for bringing about a reduction in time of manufacturing:

(a) **Labour Efficiency -** Human beings have the capacity to learn to do a job faster and more accurately by repeatedly doing the same job. Further, with repetitive experience, maintenance and supervisory activities also become more effective.

(b) **New Process and Improved Methods -** In the light of the experience gained progressively, improvements are made in the production processes, methods, or operations by technical and industrial engineering studies. Better tooling methods are developed and used. This will reduce time, labour and material cost.

(c) **Product Redesign -** The design of product is improved to make the production processes faster. Needless and costly design feature are eliminated by value analysis.

(d) **Product Standardization -** Take an example of design of a machine where design engineer has specified 10 different sizes of screws with minor variation is sizes and different kind of heads, Hexagonal, Slotted, Star, Allen Key, etc as per the best engineering practices. A little value analysis revealed that cost of all screws is almost same and there is no weight consideration in the machine. It was decided to use a single type of screw (with highest strength) at all the places. This decision saved lot of efforts for the worker who earlier needed to reach out to 10 different boxes to pick the right screws, wasted time in fiddled with tools to pick right kind of screw driver. Even if it is not possible to use a single size of screw, the heads of all screws can be modified so that a single tool can fix all of them. Over repetitive experience, reduction can be brought about in changeover and set-ups times.

(e) **Scale Effects –** As volumes of activity increase, benefits of scale effects are taken. Production processes are modified, like use of assembly lines or dedicating machines for each job thereby eliminating requirement for changing

tools or setups, which reduces the time drastically.

Learning curve is not just about reducing the production time. It also affects the cost of production. Learning curves reduces the direct labour hrs and therefore increasing production out of same fixed set up. Thus there is reduction in the fixed cost element in products. In addition, learning effect also affects material usages in terms of quantity and even type. Due to better skills, processes, methods, materials, etc, rejections, rework and wastages are also considerably reduced though there is no co-relation between such reduction and the experience, as is the case with time and experience.

Various costs are subject to inflationary pressures. During calculations, use of actual costs may give distorted picture as reduction in direct labour may not get reflected due to hike in wage rate (salaries of workers). Hence, in any study of learning curve effect, direct measurements of some physical unit (such as labour hours, machine-hours) should be used instead of the rupee value costs.

Applications:

Learning curve finds application in labour intensive situations. Higher the labour element, and more complex the job, higher the prospect of saving through learning effect. Automated processes have limited scope for cost reduction through learning effect since machines don't learn.

The conditions conducive to learning are present in the electronics, home appliances, construction, ship building and machine shop areas. On the other hand, the industries which are capital intensive such as petroleum refining would find the learning curve of little value.

Learning curve knowledge can be used for following purposes: -

1. ***Pricing*** **–** Since learning curve permits better cost predictions, it can be used for initial pricing of a product. Without knowledge of this phenomenon, initial cost of product could be too prohibitive to be able to penetrate the market. Knowing that labour and few other cost would stabilise at much lower level than at the beginning, company can decide to take in little losses in the launch period.

   An extension of the use of learning curves for pricing decisions is in buying from a supplier. Sometimes supplier will experience high initial outlays resulting from the fact that the supplier is at the early stages of its learning curve relative to the job. A purchasing firm may agree to pay a higher price initially if the supplier agrees to subsequently lowers the price.

2. ***Work Scheduling*** **–** Learning curves increase a firm's ability to predict their required labour input and make it possible to forecast labour needs. These in turn permit the firm to do a better job of scheduling maintenance and overhead activities like, quality control, material purchasing and product promotion. Better forecasting and scheduling result in lower costs through better cost control and improved

customer relations.

3. ***Capital Budgeting*** **–** One of the most important aspects in capital budgeting decisions is cash flows. The learning effect suggests that unit costs are likely to be high and taper off. This is in contrast to the steady state, constant unit costs usually assumed in capital budgeting analysis. Further more, the learning curve permits improved estimates of production levels and thus has implications for cash flows. These modifications can be particularly important where the project startup period is large relative to the life of the project.

4. ***Motivation*** **–** Costs are often controlled using standards and variances from standards. If these standards are set in comparison with other industry, without regard to the learning phenomenon, highly unfavourable initial variances may occur with resultant motivational impact. An efficient production manager during the initial period may be fired for his inability to meet the standard labour cost and his less competent replacement may earn undeserved recognition and promotion when labour efficiency shoots up due to learning curve phenomenon. Similarly, if incentive schemes are designed based on initial data, labour would be unduly benefited at the cost of the company.

5. ***External Reporting*** **–** Learning influences profits through its effects on cost and output.

Assume a situation where profit margins on a labour intensive product are thin and losses are expected in the beginning due to high labour costs. However, it is known that labour costs will come down in due course due to learning curve effect and thereafter product will have decent profit margin to cover initial losses also. If financial reports are to be an effective aid in decision making, some attempt should be made to separate non recoverable losses from costs that are incurred as part of the learning process and capitalise them. Where there is good reason to believe that learning will take place, it is appropriate to capitalize some or all of a firm's early losses as assets rather than mislead investors into believing that the financial situation is unfavorable.

Limitations of Learning Curve Theory

1. All activities of a firm are not subject to learning effect. Following types of activities are subject to learning effect.

   (a) Those, that have not been performed in this present operational mode.

   (b) Those which are being performed by new workmen, new employees or others not familiar with the particular activity. In contrast, activities being performed by experienced workmen, who are thoroughly familiar with those activities will not be subject to learning effect.

   (c) Those involving utilization of material not used by firm so far.

2. It is correct that learning effect does take place and average time taken is likely to reduce. But in practice it is highly unlikely that there will be a regular consistent rate of decease, as explained earlier. Therefore any cost predictions based on conventional learning curves should be viewed with caution.

3. Considerable difficulty arises in obtaining valid data that will form basis for computation of learning effect.

4. Even slight change in circumstances quickly renders the learning curve obsolete. While the regularity of conventional learning curves can be questioned, it would be wrong to ignore learning effect altogether in predicting future cost for decision purposes.

Learning Curve Model

The cost behaviour under a learning curve effect may be expressed as a mathematical model given under

$$Y = a X^{-b} \qquad \ldots(1)$$

where

Y = Average direct labour hours per unit

a = Direct labour hours for the first unit (or batch)

X = Cumulative number of units produced to date

b = A constant called index of learning rate ($0 < b < 1$)

STATISTICAL QUALITY CONTROL

(Use of Control Charts)

Q. State the use of Control Charts in controlling quality.

Ans. Let us start with defining what is product quality. As stated earlier, according to Juran, the father of TQM concept, it is fitness for use. Going into a little more detail, quality is meeting the customer's needs and expectation. And here is a classical example how the customer view quality.

A company produces screw drivers. Company has designed the product to turn screws. But there are any numbers of customers who use screw drivers for variety of purposes that company never intended the screw drivers to be used for. Eg, chisel, lever, scraper, etc. Now, the extra punishment that the screw driver goes through in the above extra functions might lead to bend in the shaft or damage to handle. The customer will perceive it to be of bad quality even though it would have never got damaged had it not been for such extra uses.

Thus, quality is customer driven. If I know that customer is also going to use my product for purposes other than it is intended for, I might as well design the product to meet those needs of the customer.

Dimensions of Quality –

1. ***Performance*** – Does it do what it is supposed to do? Does the screw driver turn the screw with ease?
2. ***Range and Type of Features*** – What extra features does it carry? What other needs of the customer can it satisfy? Can it be used as lever and chisel?
3. ***Durability and Reliability***– How long and with what surety will it continue to perform satisfactorily?
4. ***Maintainability and Serviceability*** – This frequency, expense and difficulty of actions to keep the product in satisfactory working condition.
5. ***Sensory Characteristics*** – Pertains to appearance and feel. For some products, appearance, feel, smell, taste or sound may determine the quality. For clothes, their feel and look are more important aspects of quality than other characteristics.

Control Charts

Control Charts work through random sampling method. Measurements obtained from some randomly picked samples is plotted on a simple chart where X axis represents the sample number and Y axis the measurement.

These control charts act a advance warning about a process getting out of control before it actually starts producing defective pieces. In lot of cases it also indicates the source of defect.

Processes can be out of control in two different ways. One – The average value of product

is more or less than target; Two – Even though the average value of targets is within limits, individual values are alternating between high and low both of which are beyond acceptable limits. There are three popular control charts to reveal these problems –

- The $\overline{X}$ Charts –
- The R Charts, and
- The σ Charts.

1. ***The $\overline{X}$ Charts*** – Plotted by Sample Mean. It indicates deviation of average/mean value from standard/target value. If you have a group of values as 10, 12, 9 , 8 and 11, mean value or $\overline{X}$ is (10+12+9+8+11)/5 = 10.

   How is it useful in process/quality control - Eg. you are packing food packets for distribution as charity. You have been given 250 Kg of Biryani and asked to make 1000 packets of 250 grams each. Here, even a 25-30 gm variation (from mean value of 250 gms) in quantities in each packet is immaterial. But you should not be running short or left with excess in the end. So, you pick up some packets as samples and weigh them. If their average weight is 250 gms your process is under control.

2. ***The R Charts*** – These are Range charts. These Charts highlight magnitude of process variation. How much is the variation between minimum and maximum value in a group of samples. If you have a group of values as 10, 12, 9 , 8 and 11, minimum value is 8 and maximum value is 12. So, Range is 12 – 8 = 4.

   How is it useful in process/quality control – In the Biryani example given above, if it was not for charity, a variation of ± 25 gms would be unacceptable. Suppose, you were packing them for sale in the shop. You would like your packets to be within 5 gms of mean value. Here $\overline{X}$ chart would be ineffective. So, you plot a R chart. This will show the process accuracy.

3. ***σ Charts*** – These charts are constructed both for $\overline{X}$ as well as R charts. They indicate the confidence level that a process is within control. What is the probability of defect occurring in the process.

QUALITY CIRCLES (QC)

Evolution

May 1962 – First QC launched by Dr. Ishikawa in Japan

1982 – Launched in India BY Mr D R Udpa (BHEL)

Concept

QC is a small voluntary group of employees (ideally 8 to 10) from the same work area OR doing similar type of work which meets regularly (normally one hour every week) to identify, analyze, solve work related problems, leading to improvement in total performance and enrichment of work life. They don't get any monetary incentives but are applauded in various public forums.

"One who wears the shoe knows best where it pinches". A worker knows his job, problems and even solutions to those problems, better than most consultants. Only, no one asks him or worse still, listens to him. Many consultants have been known to rely on workers for solution of the nagging problems of the company that has hired them at considerable cost. A quality circle tries to bring out workers' knowledge and participation in solving problems that they know best.

In Japanese culture, there is very strong bond between Employer and Employees (Neither do the employers fire the employees nor do the employees quit the jobs. In most cases, it is one life one job concept there). People are workaholics. Productivity is a national passion. Quality Circles give them an avenue to improve productivity of company and profits. It is a way to show their loyalty to their company. This is a concept where investment is minimal and gains to company are huge. But gains to individual, other than sense of achievement, are minimum and intangible. This is one reason that this concept did not succeed in many countries. Getting employees' (workers as well as managers) loyalty for this programme without any tangible benefits has been the main problem. Other reason has been lack of faith of top management in this concept. Yet other reason is management's impatience. Some managements wanted quick fix solutions which this concept does not give.

Quality Circles Vs Quality Improvement

Quality Circles is a misnomer. Fact is that Quality Circles have <u>almost</u> nothing to do with Quality. Hardly ever does a Quality Circle team attempt to improve quality. Quality circles identify various problems being faced in their domain of work and attempt to solve them. They find better methods and processes of doing work. Thus, productivity improves. Some times the problem is of poor quality, and that is the only time when quality issue is purposely addressed.

Purpose

(a) To promote grass root involvement/participation of workers in company's affairs.

(b) Promote creative thinking for improving work process/product quality/ reliability/safety/cost reduction /relationship/work culture in the company.

(c) Enormous value addition/prosperity for the organisation/employees

Basic Framework

(a) Membership - Strictly Voluntary

(b) Composition - Member from same work area but varied disciplines

(c) Size - Min 5 - Max 10

(d) Frequency of meeting - once a week

(e) Venue of Meeting - conducted within working area – Study problem from all angles

Benefits for Organization

As stated earlier, organisation is the main beneficiary of this programme.

Primary Benefits –

(a) Enhancement of productivity & reliability of the products / services

(b) Reduces wastage / material content

Secondary (Intangible Benefits)

(a) High employee motivation at negligible cost

(b) Teamwork culture development

(c) Self developed organization structure – better superior-subordinate relationships

(d) Healthy Industrial relations

Benefits for Individuals

There are no tangible benefits for employees. Intangible benefits are –

(a) Enhancement of 3Cs - Confidence, Creativity and Capability

(b) Opportunity to learn new techniques to identify and solve problems

(c) Job Satisfaction: Problem solving capability

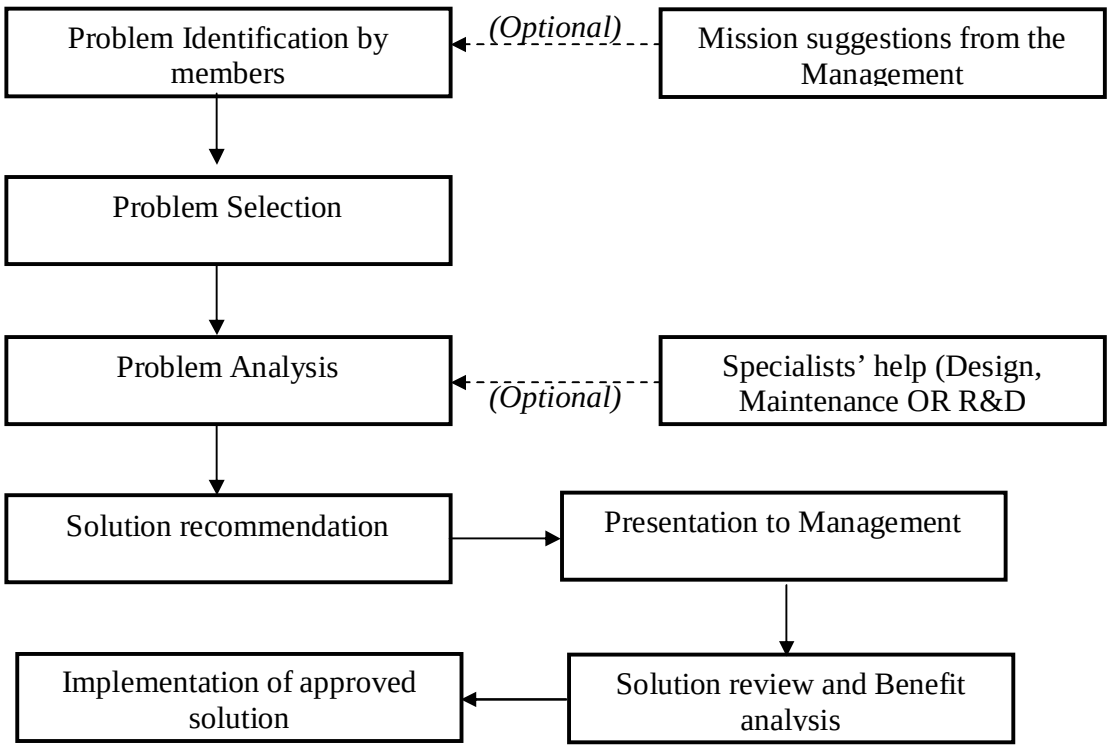
(d) Learn prevention of problems

(e) Safety awareness

(f) Better / improved interpersonal relationships

(g) Develop leadership skills

Working Process and Expected results



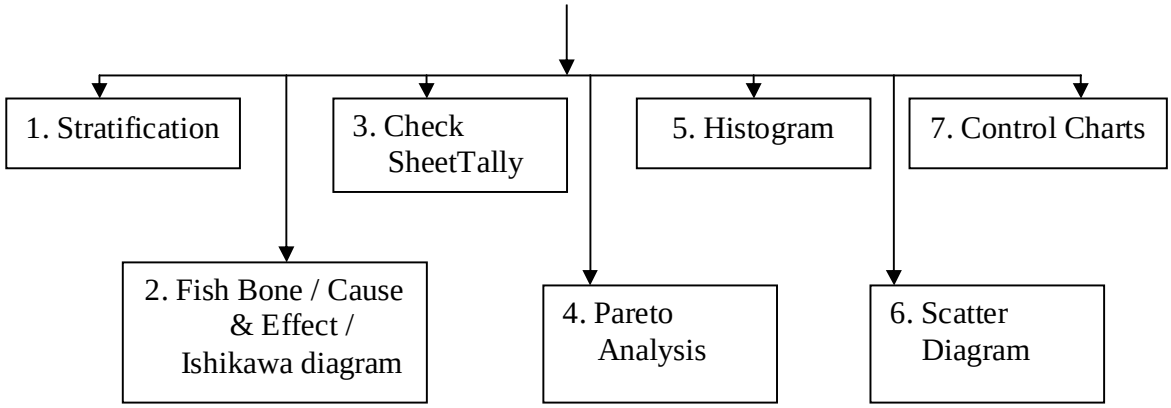
Various Layers and Functions

Elements	***Functions***	***Need to train for***
Non-Members	• Involve / Support implementation	• Co-operation • Team Work
Members *(Basic Structure Element)*	• Participate in problem solving, data gathering / record keeping. • Ensure highest levels of performance	•
Leader *(Chosen by the members or appointed by rotation)*	• Conduct the meetings. • Register problems and solutions. • Set goals and performance standards • Make the action plan	• Leadership • Goal Setting • Group techniques application

	• Maintain team cohesiveness • Encourages non-members to join	• Communication Skills • Conduct meetings
Facilitator Senior official in the department	• Attend/guide meetings/proceedings • Co-ordinates with training officer / steering committee • Obtain support from other areas • Ensures circles' record keeping • Encourages generation of new ideas	• Improving leadership skills • Catalyzing circles' activities • Promote participation • Simple techniques of problem solving • Identifying pitfalls & risks

Elements	***Functions***	***Need to train for***
Co-coordinator Unit / Works chief	• Registers circles in the unit • Nominates coordinators • Attends presentations and steering committee meetings • Publishes newsletter • Provides policy resources	Excellent inter-personal relations
Steering Committee CEO / Divisional heads	• Provide Annual budgets • Encourage healthy competition • Provide guidance	
Top Management CEO / Profit Center Manager	• Include QC as mission / Objective • Attend presentations • Verify implementation • Review progress periodically	

SEVEN TOOLS FOR QUALITY CONTROL



2. ***Stratification*:-**

- What we see as problems are actually the symptom (effect) of the problems. Root cause lies somewhere else. Often, there could be more than one cause having same symptoms and what we experience is the combined effect of all

the causes.

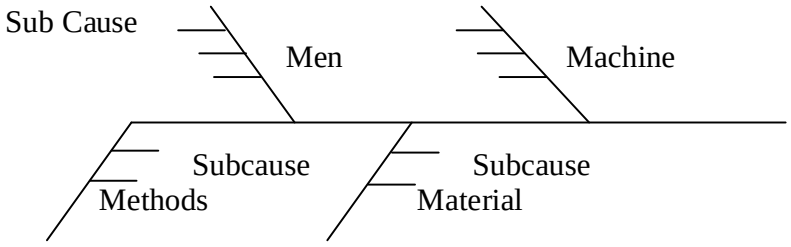
- Thus, there is a need to identify the root causes and their individual effects on performance. This process is called stratification.
- Need skills and expertise to do stratification.

Eg. Problem: Low output on a day

Causes: 1st shift - machine breakdown, 2nd shift powercut, 3rd shift - raw materials shortage. Conclusion: Problem is same but reasons are different

2. ***Cause & Effect diagram (Fishbone or Ishikawa Diagramme)***

It is an investigative tool. Rearrange possible causes of the problem. All the possible causes are identified by brain storming method. Segregate into 4 Ms; Men, Machine, Method & Material.



Advantages

(a) Good starting point for diagnosis

(b) Ensures no cause has been missed out

(c) Must be prepared by experts

3. ***Tally Table/Check list.*** All possible causes of problem (symptom) are listed and each time the problem occurs, tally line is increased against the particular cause by one. Thus, we get the frequency of each cause.

Eg. A machine drawing a very delicate copper wire is experiencing repeated breaking of wire. We draw the tally table as follows -

Cause	**Tally Marks**	**Frequency**	**Remarks**
Broken Pin	~~IIII~~ II	7	(2)
Blink	III	3	(0)
Loose Contacts	~~IIII IIII~~ II	10	(2)
No Power	II	2	
		24	

4. ***Pareto Analysis***

It is an 80/20 analysis and the principle says, 80% of total effect is generated by 20% of the causes. Example: 80% revenue is generated by 20% products. 80% of total stock or inventory value is built up by 20% of items. Pareto diagram is built up to identify vital 20 which are the causes/effects of 80% of total problems.

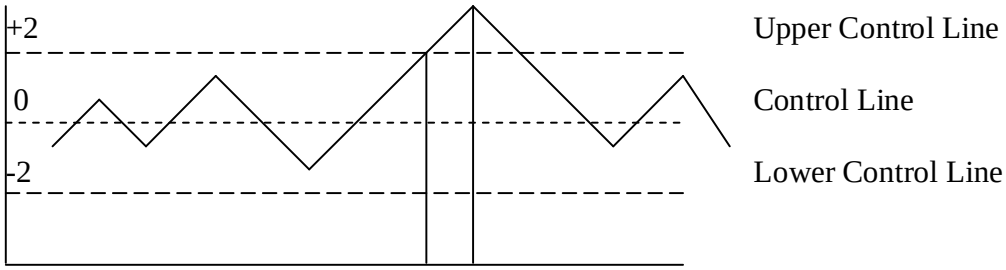
5. ***Histogram***

Method of representation of Pareto Analysis. This is useful to locate the concentration of gravity.

6. ***Scatter Diagram***

It tries to establish relationship between any two parameters or variables. One variable or parameter is plotted on X axis second is on Y axis. lt shows whether the relationship exists between 2 variables which is (a) directly proportional (b) Inversely proportional (c) There is no co-relation between each other/f the relationship between variables is directly or inversely proportional, the block at either end can be selected for corrective action.

7. ***Control Charts***



Control Charts are used to investigate whether the manufacturing process is in stable condition or not and is used to maintain the process within the tolerance (acceptable variance). If the tolerance is crossed (-ve or +ve) control charts try to assign the reason of variance either to (a) Machine and tool (b) Process Capability. This technique helps in taking the right decision for selection of the machine with higher processing capabilities (lower variances)

Steps in Organizing and Planning of a Circle

Setting of Objectives –

Company's vision and mission statement.

- Setting up of objectives/formulation of strategies data analysis.

- Set goals of each department division in line with firms overall direction
- Short time objectives developed logically

Financial Implications

- Determine financial implications of the plan.
- Evaluation of investment
- Choose plan if end results are tuned to cost

Review and Approval

- Review and approval should be ongoing throughout process,
- Plans presented to CEO & Senior Mgmt,
- Management/Quality council informed,
- Provide guidance throughout plan development
- Draft reviewed by other part of the organization

Launching of Quality Circle

Management determination. - Management shall commit itself to company wide quality control or total quality control involving development of management attitudes/practices towards defect free operation.

Steps in Launching QC

(a) Exposure to middle level executives, conducive climate to start QC

(b) Exposure to employees, invite member volunteer

(c) Nominate facilitators for area senior officers

(d) Form steering committee, CEO as a chairman and departmental head as members

(e) Facilitators fixes meeting, Hour a week for QC members

(f) Formal inauguration of QC, Launch in one department

(g) Support with facilities for circle meeting

(h) Extend concept to other departments

TQM

Definition

Total Quality Management is defined as an integrated approach in delighting the customer (both internal and external) by meeting their expectations on a continuous basis, through every one involved with the organisation, working on continuous improvement along with proper problem solving methodology.

Total Quality Management (TQM) is a management strategy aimed at embedding awareness of quality in not only all organizational processes but even up and down the value chain. TQM encompasses even suppliers and stockists, retailers (all except the end user). It has been widely used in manufacturing, education, government, and service industries, as well as NASA space and science programs.

Total Quality provides an umbrella under which everyone in the organization can strive and create customer satisfaction.

TQM was born when American companies came under pressure from Japanese manufacturers who were offering better products at lower prices. Then they studied the Japanese production practices and compiled them under the name TQM. TQ is a people focused management system that aims at continual increase in customer satisfaction at continually lower real costs.

Two Americans are considered to be the father of TQM; Deming and Juran. Deming came out with a 14 point programme for TQM. These are –

1. Create constancy of purpose to improve products and service.
2. Adopt the new philosophy of quality. We can no longer accept delays, mistakes, defective materials and poor workmanship.
3. Cease dependence on mass inspection. Instead require quality that is built in. Prevent defects rather than detect them.
4. Buy components based on quality as well as price. Eliminate suppliers whose quality is not acceptable.
5. Search for problems and continually improve the production system.
6. Institute and improve training; teach workers to do the job right.
7. Institute leadership so that supervisors help workers improve rather than simply ordering and punishing workers.
8. Drive out fear so that every one may work effectively for the company.
9. Breakdown barriers between departments so that people in different departments will work as a team.
10. Eliminate numerical goals, posters and slogans which ask for new levels of

productivity without providing improved methods.

11. Eliminate work standards based on numerical quotas.
12. Remove barriers that stand between workers and their pride of workmanship.
13. Institute a vigorous program of education and retraining.
14. Top management must take action to institute the new program.

Quality Triology

Juran characterised his quality program as a quality triology made up of Quality Planning, Quality Monitoring and Control, and quality improvement.

The Principles of TQM

TQM is based on following principles –

1. Primary responsibility for product quality rests with top management.
2. Quality should be customer focussed and evaluated using customer based standards – A product is not good and service is not prompt and courteous unless customer says they are.
3. The production process and work methods must be designed consciously to achieve quality conformance.
4. Ever employee is responsible for achieving good product quality.
5. Quality can not be inspected into a product. So, make it right the first time and every time
6. Quality must be monitored to identify problems quickly and correct quality problems immediately.
7. The organisation must strive for continuous improvement.
8. Companies must work with and extend TQM programs to their suppliers to ensure quality inputs.

JUST IN TIME

The first fundamental of improvement in productivity is to cut waste from the processes. This waste could be any thing; material waste, labour waste, process waste, and so on. Just in Time focuses on eliminating or reducing the waste imbedded in the process.

Any process is a set of activities. Some activities add value to the product and some are non value adding activities. When we talk of value, we are talking from customer's perspective. Take for instance, the stationery issue procedure in your office. The stationery is purchased centrally, received, accounted, stored, issued and re-accounted by personnel of stores department. The overheads that are involved in the entire process are huge; cost of ordering and processing costs, manpower costs, finance cost, inventory management costs, wastages and so on. Have all these processes added any value to stationery that you get? It is precisely the same stationery that was supplied. There could only be deterioration in quality due to storage. So, entire stationery procedure is a non value adding process. Then why is this process in vogue in almost every company? Stationery inventory and for that matter every inventory is maintained to ensure that item is available whenever it is required. There is no stock out at critical moments.

Just in time hits at the root of these non values adding inventory management procedures. Just in Time is a concept that hits at wastages accrued due to time factor.

What exactly does JIT mean?

Many people mistake JIT for Zero Inventory Concept. It is fallacy. JIT is much more than Zero Inventory. Though it is true that this is a concept that is mostly applied to production scheduling and inventory management where by products are produced only to meet actual demand and raw materials are received or produced for each stage of production "just in time" to fulfil the requirement. JIT is about minimising the cycle time from procurement of raw material to delivery to customer. It is an effort to bring down the cycle time to the level of process time. Many companies have been able to reduce the inventory by up to 90% by use of JIT.

What has been described above is commonly understood philosophy of JIT called ***Little JIT***. In addition, there is ***Big JIT*** which is a much more holistic approach to production system and encompasses many more organisational and operational improvements. It is also called lean production system.

But it is easier said than done. Unfortunately there are too many variables beyond control of managers to implement JIT so easily. What does a manager do about variations in demand? What can the poor guy do about erratic suppliers whose delivery time keeps varying like the direction of a butterfly? What does he do about machine breakdown? What does he do about absenteeism of employees and unscheduled power cuts? What does he do about the huge set up time that requires certain minimum EOQ production? And there is

absolutely nothing that he can do about interruption in supplies due to political parties calling Bandhs because Aamir Khan made a statement. And this is just the tip of iceberg. There are many more challenges to overcome for implementing JIT.

Fortunately, most of these impossible looking situations do have a solution if you really look for them. JIT is about looking for those solutions beyond keeping lot of inventories. For example, erratic/interruption in supply time is solved by treating your suppliers like your partners in business and having them locate their plants close to your plant. Problem of large batch size is solved by employing single Minute Die Exchange (SMED) methods. Absenteeism of employees is solved by sound HR policies. If you act opportunist with them, throwing them out wherever you wish, they will be no less opportunist.

Poka Yoke

Poka in Japanese means inadvertent and Yoke means to Avoid. Thus, Poka Yoke means to avoid inadvertent errors. How it works. Poka Yoke is about designing the part or procedure in such a way that error becomes impossible. Take for instance the briefcases. Opening briefcases upside down is impossible now. Unless the right side is up, briefcase won't open. This is done by a latch which is locked be a ball when in upside down position. A small inexpensive device has saved lot of trouble to lot of people every day. In computers, you just can not fit a plug into the wrong socket even deliberately.

All these conditions look so daunting that the manager would prefer to forget about JIT. But the fact is that, notwithstanding all the above, JIT can still be applied and has been successfully applied by large number of companies around the world. Companies have been able to find solutions to these daunting challenges. And when these problems are cleared, it is realised that there is lot of inefficiency hidden behind these covers.

In order to implement the big JIT, it is necessary that a lot of systems in the company are straightened out. Various methods were used to straighten out the problems.

Kanban

Kanban in Japanese means a Card. It is an order card. Whenever some one requires an item, he posts a Kanban (one Kanban for each piece) stating the time and place the item is required, on the bulletin board of the concerned supplying department. It is posted with just the adequate notice for manufacturing of the item. Thus, Kanban serves the purpose of "supply order". Concerned department starts manufacturing/procurement of the item only on receipt of the Kanban. Once the item is ready, the Kanban card is attached to the item and sent to the demanding department.

Kaizen

Kaizen, Japanese for "change for the better" or "improvement", the English translation is "continuous improvement", or "continual improvement") is an approach to productivity improvement.

Kaizen is about effecting small changes continously. Employees are encouraged to participate and innovate with process and materials. The improvements effected by the employees do not get materially rewarded (In Japanese system, there are no rewards for improvement. It is your thanks giving to the company which provides you your livelihood. The only reward they get is name on the notice board). In Kaizen also, each improvement is reported and placed on the notice board.

A closer definition of the Japanese usage of Kaizen is "to take it apart and put back together in a better way." What is taken apart is usually a process, system, product, or service.

Kaizen is not about radical big bang improvements. It is a daily activity. And the changes are so small that they literally do not cost any money. It is quite possible that an improvement effected today may get altered tomorrow itself with a better method.

Everyone participates in kaizen; people of all levels in an organization, from the CEO down, as well as external stakeholders when applicable. The format for kaizen can be individual, suggestion system, small group, or large group.

Delphi Techniques: This technique solicits estimates from a group of experts, and HRP experts normally act as intermediaries, summarizes various responses and report the findings back to experts.