CHAPTER 14

Work Study - Method Study and Work Measurement

Industry everywhere has been striving hard to discover new work methods and techniques which could help produce goods of required quality at reasonable costs. The search has resulted in finding techniques such as work simplification, job design, value analysis and the like. All these are collectively called 'methods engineering' or 'industrial engineering'. The other names used are 'work design', 'work study', 'methods analysis' and 'operation analysis'. Methods engineering is closely affiliated with the functions of work measurement (or time study) and method study. This chapter is devoted to a detailed discussion of these approaches.

For the sake of simplicity or for avoiding confusion, we use the term *'work study'*, which comprises two techniques known as 'method study' and 'work measurement', throughout this chapter.

Importance of Work Study

In today's competitive business environment, it is necessary that the employees work harder, be more productive so that, production costs can be kept low to meet global competition. Operations managers have to continuously strive for low production costs, high product quality and improve every facet of manufacturing. In this direction, improving labour productivity and reducing costs by improving work methods and simplifying the work, needs special attention by operations managers. To facilitate this, the work study technique (now known as industrial engineering) has been developed over a period of time.

Definition of Work Study

Work study is defined as that body of knowledge concerned with the analysis of the work methods and the equipment used in performing a job, the design of an optimum work method and the standardisation of proposed work methods. Work study has contributed immeasurably to the search for better methods, and the effective utilisation of this management tool has helped in the accomplishment of higher productivity. Work study is a management tool to achieve higher productivity in any organization, whether manufacturing tangible products or offering services to its customers.

Work study is also understood as a systematic, objective and critical examination of the factors, affecting productivity for the purpose of improvement. It make use of techniques of method study and work measurement to ensure the best possible use of human and material resources in carrying out a specific activity.

To give a clear and better understanding of this chapter, definitions of various terms are listed in Table 14.1.

Table 14.1 : Definitions of Terms often Used

Term	Definition
1. Work Design or Work System Design	Systematic investigation of contemplated and present work systems in order to formulate, through the ideal system concept, the easiest and most effective systems and methods for achieving the necessary functions/goals/purposes.
2. Work Study	The generic term used 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 the facts which affect efficiency and economy of the situation being reviewed, in order to effect improvement.
3. Methods Engineering	That body of knowledge concerned with the analysis of the methods and the equipment used in performing a job, the design of an optimum method and the standardisation of the proposed methods, are frequently referred to as 'Work Study'.
4. Industrial Engineering	Concerned with the design, improvement and installation of integrated systems of men, materials and equipments to improve productivity.
5. Method Study or Methods Analysis or Operations Analysis	The systematic recording and critical examination of existing and proposed ways of doing work as a means of developing and applying easier and more effective methods and reducing costs.
6. Motion Study or Motion Analysis	Detailed study of the manual and/or body motions used in a work-task or at one work area often involving comparative analysis of right hand and left hand motions. (Part of method study)
7. Work Measurement	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.
8. Work Simplification	Involves improvements in work methods or work flow initiated and developed by workers or supervisors on the job as a result of methods training and/or economic incentives. It is an organised use of common sense to find and apply better ways of doing any work at lesser cost.
9. Time Study	A technique of work measurement used for determining as accurately as possible from a limited number of observations, the time necessary to carry out a given activity at a defined standard of performance. A stop watch is used for the purpose of recording the actual time taken by the worker under observation to perform various elements of the work or task.

Objectives of Work Study

1. To analyse the present method of doing a job, systematically in order to develop a new and better method.
2. To measure the work content of a job by measuring the time required to do the job for a qualified worker and hence to establish standard time.

3. To increase the productivity by ensuring the best possible use of human, machine and material resources and to achieve best quality product/service at minimum possible cost.
4. To improve operational efficiency.

Benefits of Work Study

1. Increased productivity and operational efficiency.
2. Reduced manufacturing costs.
3. Improved work place layout.
4. Better manpower planning and capacity planning.
5. Fair wages to employees.
6. Better working conditions to employees.
7. Improved work flow.
8. Reduced material handling costs.
9. Provides a standard of performance to measure labour efficiency.
10. Better industrial relations and employee morale.
11. Basis for sound incentive schemes.
12. Provides better job satisfaction to employees.

The purpose of work study is to determine the best or most effective method of accomplishing a necessary operation or function. The criteria for the best method could be an increase in job satisfaction and individual morale, reduction in physiological fatigue, decrease in number of accidents and personal injuries, minimization of material usage, tool breakage or usage of consumable supplies and increase in productivity by reduction of performance time. Every operation/activity in an organization contains to a certain degree, of mechanical, physiological, psychological and sociological factors. The purpose of work measurement is to quantify these factors.

Relationship of Time and Motion Study to Work Study

Both time study and motion study which resulted from the integration of concepts and practices developed by F.W. Taylor and by Frank B. and Lilian M. Gilbreth, are concerned with the systematic analysis and improvement of manually controlled work situations. However, time study is a quantitative analysis leading to the establishment of a time standard whereas motion study is a qualitative analysis of a work station leading to the design or improvement of an operation/activity. Fig. 14.1 illustrates the relationship between motion and time studies as a part of the total work study procedure.

Work study as a discipline is concerned with:

a. Better ways of performing jobs/tasks, and
b. Exercising control over the output in respect of those jobs/tasks by setting standards for performance (i.e., for output/work) with respect to time.

The former technique is known as method study (also known as method analysis or operation analysis) and the latter technique is known as work measurement (or time study).

Fig. 14.2 illustrates the steps involved in work study, comprising the techniques of method study and work measurement.

Method study and work measurement are closely linked. Method study is concerned with reduction of work content while work measurement is concerned with the inv tion

and reduction of the *ineffective time* and the subsequent establishment of time standards for the task or job or operation on the basis of the work content established by the method study. Usually method study should precede work measurement. However, when time-standards for output are being set, it is often necessary to use an appropriate work-measurement technique such as activity sampling (also known as work sampling) in order to determine the ineffective time or idle time. This will facilitate corrective action to be taken by the management before going for method study. On the other hand, time study may be used to compare the effectiveness of alternative work methods or operations.

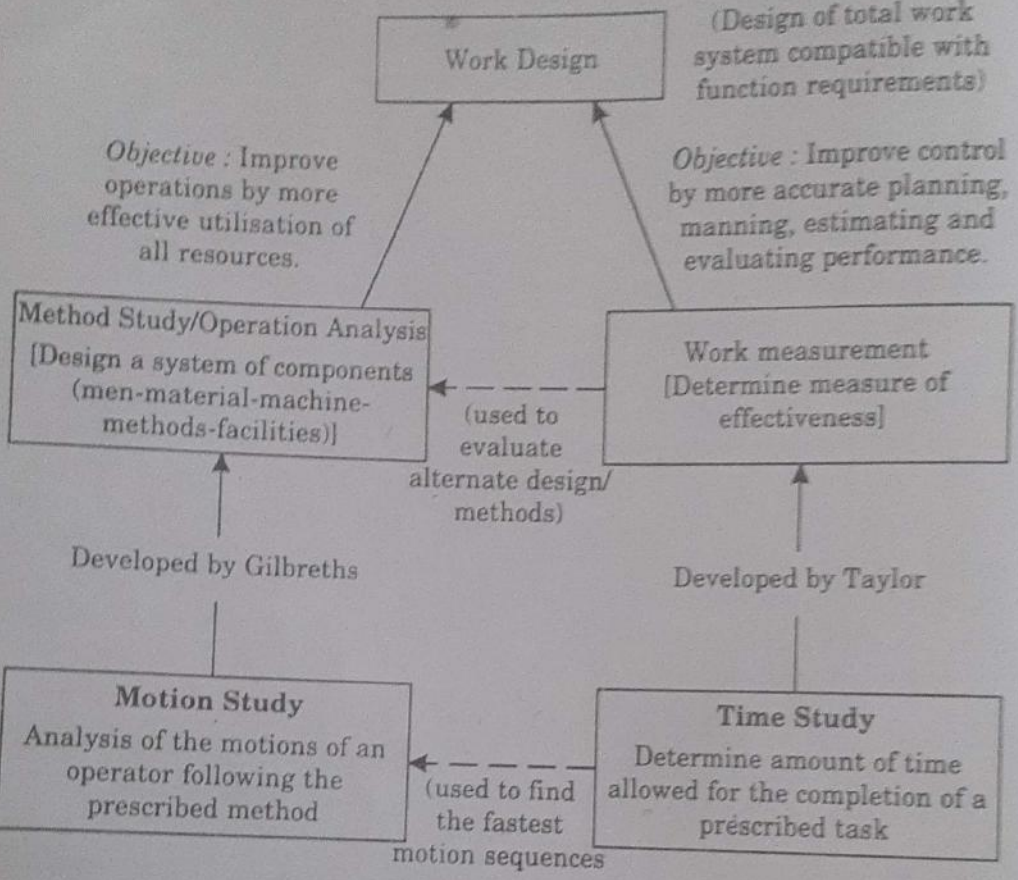


Fig.14.1 Relationship of motion and time study to work design

(*Source :* Carson, Bolz, Young, *Production Hand Book*. 3rd Edn., John Wiley & Sons New York. p.12.4)

Basic Work Study Procedure

There are eight basic steps involved in a work study procedure. Some of them are common to both method study and work measurement. These steps are:

1. *Select* the job or the process or the operation to be studied.
2. *Record* all relevant facts about the job or process or operation using suitable charting techniques such as operation process chart, flow process chart, flow diagram, SIMO chart (simultaneous motion chart) and man-machine chart.
3. *Examine* critically all the recorded facts, questioning the purpose, place, sequence, person and the means of doing the job/process/operation.
4. *Develop* the new method for the job/process/operation.
5. *Measure* the work content and establish the standard time using an appropriate work-

measurement technique, viz; time study using stop watch, synthesis method, analytical estimating method, pre-determined motion time system and work sampling.

6. *Define* the new method for the job/process/operation.
7. *Install* the new method as standard practice.
8. *Maintain* the new method for the job/process/operation.

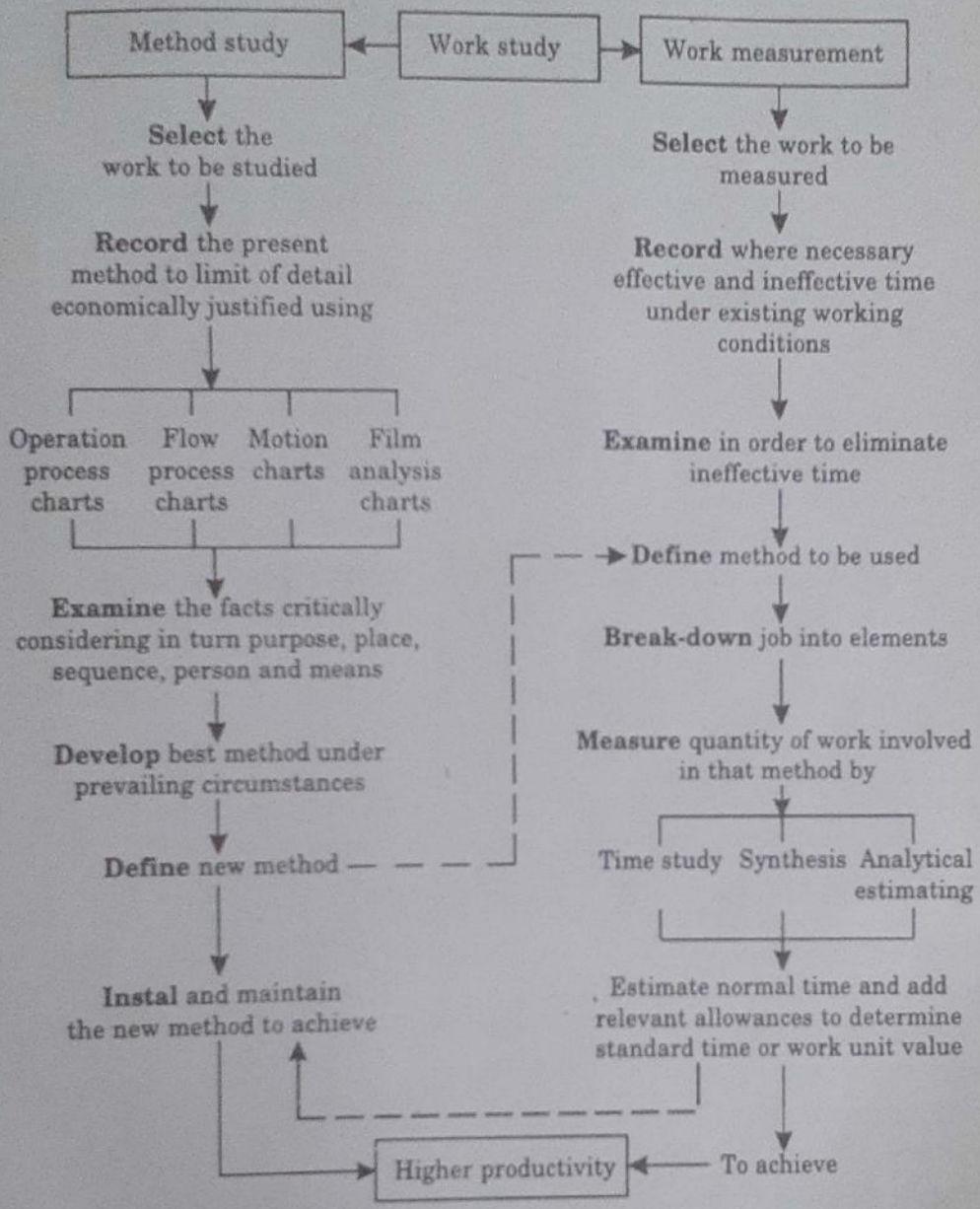


Fig.14.2 Steps involved in work study

Method Study or Methods Analysis

Work methods analysis or method study is a scientific technique of observing, recording and critically examining the present method of performing a task or job or operation with the aim of improving the present method and developing a new and cheaper method. It is also known as methods improvement or work improvement. It encompasses the study of work processes, working conditions and equipments and tools used to carry out the job.

Method study may be understood as the systematic recording and critical examination of existing and proposed ways of doing work, as a means of developing and applying easier and more effective method and reducing costs.

Objectives of Method Study

1. To study the existing/proposed method of doing any job, operation or activity.
2. To develop an improved method to improve productivity and to reduce operating costs.
3. To reduce excessive materials handling or movement and thereby reduce fatigue of workmen.
4. To improve utilization of resources.
5. To eliminate wasteful and inefficient motions.
6. To standardise work methods or processes, working conditions, machinery, equipments and tools.

Advantages of Method Study

1. Work simplification
2. Improved working method (cheaper method)
3. Better product quality
4. Improved workplace layout
5. Improved equipment design
6. Better working conditions/environment
7. Better materials handling and lesser materials handling cost
8. Improved work flow
9. Less fatigue to operator
10. Optimum utilization of all resources
11. Higher safety to workmen
12. Shorter production cycle time
13. Higher job satisfaction for workmen
14. Reduced material consumption and wastages
15. Reduced manufacturing cost and higher productivity

Factors facilitating Method Study

1. High operating cost
2. High wastage and scrap
3. Excessive movement of materials and workmen
4. Excessive production bottlenecks
5. Excessive rejections and rework
6. Complaints about quality
7. Complaints about poor working conditions
8. Increasing number of accidents
9. Excessive use of overtime

Method Study Procedure

The various steps involved in method study are:

1. ***Select*** the work or job to be studied and define the objectives to be achieved by method study. The job selected to have maximum economic advantage, shall offer vast scope for work

improvement through reduction of excessive materials handling and fatigue of workmen, after scope for improving the working conditions and improving the utilisation of resources.

2. ***Record*** all the relevant facts or informations pertaining to the existing method using the recording techniques such as –

(a) *Process charts*
- (i) Outline process chart
- (ii) Operation process chart
- (iii) Flow process chart–material type, man-type and machine type/ equipment type.
- (iv) Man-machine chart
- (v) Two handed process chart
- (vi) Multiple activity chart
- (vii) Simultaneous motion chart (SIMO chart)
- (viii) Motion chart
- (xi) Film analysis chart.

(b) *Diagrams such as*
- (i) Flow diagram
- (ii) String diagram
- (iii) Cycle graph
- (iv) Chronocyclegraph

3. ***Examine*** the recorded facts critically, challenging everything being done and seeking alternatives, questioning the purpose (What is achieved?), the means (How is it achieved?), sequence (When is it achieved?), place (Where is it achieved?), and the person (Who achieves it?).

Table 14.2 illustrates the questioning attitude of methods analysis

Table 14.2 : The Questioning Attitudes of Methods Study

1. What is done ? What is the purpose of the operation ? Why should it be done ? What would happen if it were not done ? Is every part of the operation necessary ?
2. Who does the work ? Why does this person do it ? Who could do it better ? Can changes be made to permit a person with less skill and training to do the work ?
3. Where is the work done ? Why is it done there ? Could it be done somewhere else more economically ?
4. When is the work done ? Why should it be done then ? Would it be better to do it at some other time ?
5. How is the work done ? Why is it done this way ?

(*Source* : Norman Gaither. *Production and Operations Management*, 4th Edn, The Dryden Press, p.641)

4. ***Develop*** the improved method by generating several alternatives and selecting the best method. The factors to be considered while evaluating alternatives and selecting the best method are:

(a) Cost of implementation.
(b) Expected savings in time and cost.
(c) Feasibility.
(d) Producibility.
(e) Acceptance to design, production planning and control, quality control, production and sales departments.

(f) Reaction of employees to the new method.

(g) Short term or long term implication of the alternative.

Establish the new method by providing suitable equipment design, mechanical aids, jigs and fixtures, tools, working conditions, material handling equipments, workplace layout and work planning and control techniques.

5. ***Install*** the improved (new) method in three phases — planning, arranging and implementing phases. In the first two phases, the programme of installation and a schedule (i.e. time table) are planned and necessary requirements such as resources, equipments, tools, operating instructions to workers are provided. The implementation phase involves the introduction of the developed method as standard practice to achieve the desired results.

6. ***Maintain*** the new method by ensuring that the installed method is functioning well. This is done by periodic checks and verifications at regular intervals. Proper control procedures are used to ensure that the new method is practised to achieve the benefits of methods study and also to achieve higher productivity.

Recording Techniques Used in Method Study

Some of the useful recording techniques used in method study are process charts, flow process charts, multiple activity charts, man-machine charts, flow diagram and string diagram.

To facilitate the charting process, some symbols are used such as those illustrated in Fig. 14.3.

Standard Symbol	*Name of Activity*	*Definition of Activity*
○	Operation	Modification of an object at one work place. Object may be changed in any of its physical or chemical characteristics, assembled or disassembled or arranged for another operation, transportation, inspection or storage.
⇨	Transportation or movement	Change in location of an object from one place to another.
□	Inspection	Examination of an object to check on quality or quantity characteristics.
D	Delay/Temporary storage	Retention of an object in a location awaiting next activity.
▽	Storage	Retention of an object in location in storage which is protected against unauthorized removal.
□⇨	Combined activity	A combined activity occurs when two activities occur simultaneously. Various combinations of simultaneous occurrence of two activities could be possible.

Fig.14.3 Symbols used in process charting.

Process Charts used in Method Study

1. ***Outline process chart*** : An outline process chart records an overall picture of the process and records only the main events sequence-wise. It considers only the main operations and inspections.

2. ***Operation process chart*** : The basic process chart, called an *operation process chart*, is understood as a graphic representation of the points at which the materials are introduced into the process and of the sequence of inspections and all operations except those involved in materials handling. It includes information considered desirable for analysis such as time required to carry out the operation and the location.

3. ***Flow process charts*** are graphic representations of the sequence of all operations, transportation, inspections, delays and storages occurring during a process or a procedure and include information considered desirable for analysis such as, time required and distance moved.

The flow process chart could be of three types, viz.,

(i) Flow process chart material or product type.
(ii) Flow process chart--man type.
(iii) Flow process chart machine type or equipment type.

Material or product type flow process chart records what happens to the material or product i.e., the changes the material or product undergoes in location or condition (includes operation and transportation). Man type process chart records the activities of a worker or operator i.e., what a worker or operator does, whereas equipment or machine type flow process chart records the manner in which an equipment or machine is used.

4. ***Two handed process chart*** : In this chart, the activities of a worker's or operator's both hands or limbs are recorded chronographically.

5. ***Multiple activity chart*** : In this chart, the activities of more than one subject (worker, machine or equipment) are recorded on a common time scale to show their inter-relationship.

6. ***The man machine chart or worker-machine chart*** : This is a variation of multiple activity chart and illustrates the operation and delays of the operator and the machine which he operates. An example of man machine chart may be one worker running two machines simultaneously.

7. ***Flow diagram*** : The flow diagram is a drawing or diagram drawn to a scale to show the relative position of a machine or equipment, jigs and fixtures, gangways or aisles and shows the path followed by materials or machines.

8. ***String diagram*** : It is a scale plan or model on which a string or a thread is used to trace and measure the path of workers, materials or equipments during a specified sequence of events.

9. ***SIMO chart*** : The simultaneous motion cycle chart (SIMO) is a type of two handed process chart in which the micromotions (therbligs) of both hands are recorded.

Motion Study

Motion study is the science of eliminating wastefulness, resulting from using unnecessary, ill-directed and inefficient motion. The aim of motion study is to find and perpetuate the scheme of the least waste methods of labour.

Micro motion study provides a valuable technique for making minute analysis of those operations that are short in cycle, contain rapid movements and involve high production over a long period of time. For example, sewing of garments and assembling small parts. Micro-motion study may be used for the following purposes in addition to its primary use for job-analysis work :

(i) To study the inter-relationship among the members of a work group.

(ii) To study the relationship between an operator and the machine which he operates
(iii) To obtain the time for an operation.
(iv) To establish a permanent record of the method of doing a job.

The usual procedure of performing a micro-motion study is to take motion picture of the operations, analyse the film and to prepare a SIMO chart from the results of the film analysis. In analysing the film, very small time values (commonly 1/2000 minute) may be obtained by reading a clock (micro-chronometer) that appears in each of the motion pictures.

The film is analyzed by breaking the job cycle into micromotions or *therbligs* which indicate the basic body motions of the worker.

Therbligs indicate the basic motions consisting of three parts, viz;
(i) When the motion begins.
(ii) The nature of the motion.
(iii) When the motion ends.

The examples of therbligs are

1. *Search (Sr)* : That part of the cycle during which, the eyes or the hands are hunting or groping for the object. Search begins when the eyes or hands begin to hunt for the object and ends when the objects have been found.
2. *Select (St)* : The choice of one object from among several. Select refers to the hunting and locating of one object from among several.
   Example : Locating a particular pencil in a box containing pencils, pens and miscellaneous articles.
3. *Grasp (G)* : Taking hold of an object, closing the fingers around it, preparatory to picking it up, holding it or manipulating it.
   Example : Closing the fingers around a pen on the desk.
4. *Transport Empty (TE)* : Moving the empty hand in reaching for an object.
5. *Transport Loaded (TL)* : Moving an object from one place to another.
6. *Hold (H)* : Retention of an object after it has been grasped, no movement of the object taking place.
7. *Release Load (RL)* : Letting go of the object. Release load begins when the object starts to leave the hand, and ends when the object has been completly separated from the hand or finger.
8. *Position (P)* : Turning or locating an object in such a way that it will be properly oriented to fit into the location for which it is intended.
   Example : Lining up a door key preparatory to inserting it in the key hole.
9. *Pre-position (PP)* : Locating an object in a pre-determined place or locating it in the correct position for some subsequent motion.
10. *Inspect (I)* : Examining an object to determine whether or not it complies with standard size, shape, colour or other qualities previously determined.
11. *Assemble (A)* : Placing one object into or on another object with which it becomes an integral part.
12. *Disassemble (DA)* : Separating one object from another object of which it is an integral part.

13. *Use (U)* : Manipulating a tool, device or piece of apparatus for the purpose for which it was intended
14. *Unavoidable Delay (UD)* : A delay beyond the control of the operator.
15. *Avoidable Delay (AD)* : Any delay of the operator for which he is responsible and over which he has control.
16. *Plan (Pn)* : A mental reaction which precedes the physical movement, i.e., deciding how to proceed with job.
17. *Rest for overcoming fatigue (R)* : A fatigue or delay factor or allowance provided to permit the worker to recover from fatigue incurred by his work.
18. *Find (F)* : Mental reaction at the end of search.

Motion Economy and Work Efficiency

Most workers do not enjoy making unnecessary or wasted motions, particularly if they result in unnecessary fatigue. In addition to providing some social and psychological rewards, a job should be reasonably efficient Motion study helps to reduce fatigue and waste motions.

Principles of Motion Economy

The rules of motion economy and efficiency which referred to hand motions of operators were developed by Gilbreths. The principles of motion economy are divided into three groups, viz;

(a) Effective use of the operator
(b) Arrangement of the workplace
(c) Tools and equipment

Table 14.3 lists twenty two principles of motion economy as developed by Barnes.

Table 14.3 : Principles of Motion Economy

a. **Rules concerning use of human body**

1. The two hands should begin as well as complete their motions at the same time.
2. The two hands should not be idle at the same time except during rest periods.
3. Motions of the arms should be made in opposite and symmetrical directions, and should be made simultaneously.
4. Hand and body motions should be confined to the lowest classification with which it is possible to perform the work sstisfactorily.

   The ascending order of motion classification is

   (a) Fingers only. (b) Fingers and wrists. (c) Fingers, wrists and lower arms.
   (d) Fingers, wrists, lower and upper arms. (e) Hands, arms and body.
5. Momentum should be employed to assist the worker wherever possible, and it should be reduced to a minimum if it must be overcome by muscular effort.
6. Smooth, continuous curved motions of the hands are preferable to straight line motions involving sudden and sharp changes in direction.
7. Ballistic movements are faster, easier and more accurate than restricted or controlled movements.
8. Work should be arranged to permit easy and natural rhythm wherever possible.
9. Eye fixation should be as free and as close together as possible.

b. **Rules concerning arrangement of the work place**

There should be a definite and fixed place for all tools and materials.

11. Tools, materials and controls should be located close to the point of use.
12. Gravity feed bins and containers should be used to deliver material close to the point of use.
13. Drop deliveries should be used wherever possible.
14. Materials and tools should be located to permit the best sequence of motions.
15. Provisions should be made for adequate conditions for seeing. Good illumination is the first requirement for satisfactory visual perception.
16. The height of the work place and the chair should preferably be arranged so that alternate sitting and standing at work are easily possible.
17. A chair of the type and height to permit good posture should be provided for every worker.

c. **Rules concerning the design of tools and equipment**

18. The hands should be relieved of all work that can be done more advantageously by a jig, a fixture or a foot-operated device.
19. Two or more tools should be combined wherever possible.
20. Tools and materials should be pre-positioned whenever possible.
21. Where each finger performs some specific movement such as in type-writing, the load should be distributed in accordance with the inherent capacities of the fingers.
22. Levers, cross bars, and hand wheels, which should be located in such positions that, the operator can manipulate them with the least change in body position and with the greatest mechanical advantage.

(*Source* : Carson Bolz, Young, Production Handbook, 3rd Edn., John Wiley and Sons p.13.23)

Through the application of the principles of motion economy, it is possible to greatly increase the output of manual labour with a minimum of fatigue.

Memomotion Study

Memomotion study which originated by M.E. Mundel, is a special form of micro-motion study in which motion pictures are taken at slow speed using a motion picture camera. Sixty frames per minute and one hundred frames per minute are most common.

Memomotion study has been used frequently to study the flow and handling of materials, new activities and multi-man-and machine relationships and activities of department store clerk. In addition to all the advantages of micro-motion study, it can be used at relatively low film cost and permit rapid visual review of long sequences of activities.

This technique is not usable unless the work is restricted to a general area which can be covered by a motion picture camera. If the person under observation moves from place to place, it could be difficult to use this study.

Work Measurement

Method Study and work measurement are two techniques of work study. Whereas method study or methods analysis is a tool for standardising the methods of doing a job, work measurement establishes the *work content* of a job. Work content of a job can accurately be established only after the method of doing a job is standardised. Hence, it is needless to mention that method study should precede work measurement.

Both, method study and work measurement are important elements in achieving higher labour productivity. The overall *productivity* of an organisation is the result of the productivity achieved by all components of the organisation such as capital assets, labour, material, and plant and equipment. Hence, managers must be concerned about the productivity of all resources and at the individual worker level, labour productivity is determined by work measurement.

Definition of Work-measurement

Work measurement is defined as the application of techniques designed to establish the work content of a *specified task* by determining the time required for carrying out the task at a defined standard of performance by a qualified worker.

Qualified Worker

"*A qualified worker is one who is accepted as having the necessary physical attributes, possessing the required intelligence and education and having acquired the necessary skill and knowledge to carry out the work in hand to satisfactory standards of safety, quantity and quality*" definition by International Labour organization (ILO). In short, work measurement may be defined as the techniques applied to determine the amount of time necessary for a qualified worker to perform a particular task. The amount of time that a job is expected to take is expressed as *time standard, work standard, labour standard, production standard* or *standard time*. The *standard time* is the amount of time a qualified worker, working at a normal rate of speed, will require to perform the specified task. It may be expressed as minutes per unit of output or units of output per hour (i.e., standard output).

Work measurement is concerned with measuring the work content of any activity under study with a view to assess the *human effectiveness* or to compare one method with another or to develop *labour standards* that will be used for planning and controlling operations and thereby achieving high labour productivity.

Objectives of work measurement can be to achieve:

1. Improved planning and control of activities or operations;
2. More efficient manning of the plant;
3. Reliable ideas for labour performance;
4. Reliable basis for labour cost control;
5. Basis for sound, incentive schemes.

Benefits of Work-measurement

Work measurement helps

1. To develop a basis for comparing alternate methods developed in method study by establishing the work content in each method of doing the job.
2. To prepare realistic work schedules by accurate assessment of human work
3. To set standards of performances for labour utilization by establishing the labour standards for an element of work, operation or product under ordinary working condition.
4. To compare actual time taken by the worker with the allowed time (standard time) for proper control of labour.
5. To assist in labour cost estimation.
6. To provide information related to estimation of tenders, fixation of selling price and assessment of delivery schedule.

Techniques of Work-measurement

The main techniques used to measure work are:

1. Direct Time Study.
2. Synthesis Method.
3. Analytical Estimating.
4. Pre-determined Motion Time System (PMTS).
5. Work sampling or Activity Sampling or Ratio Delay Method.

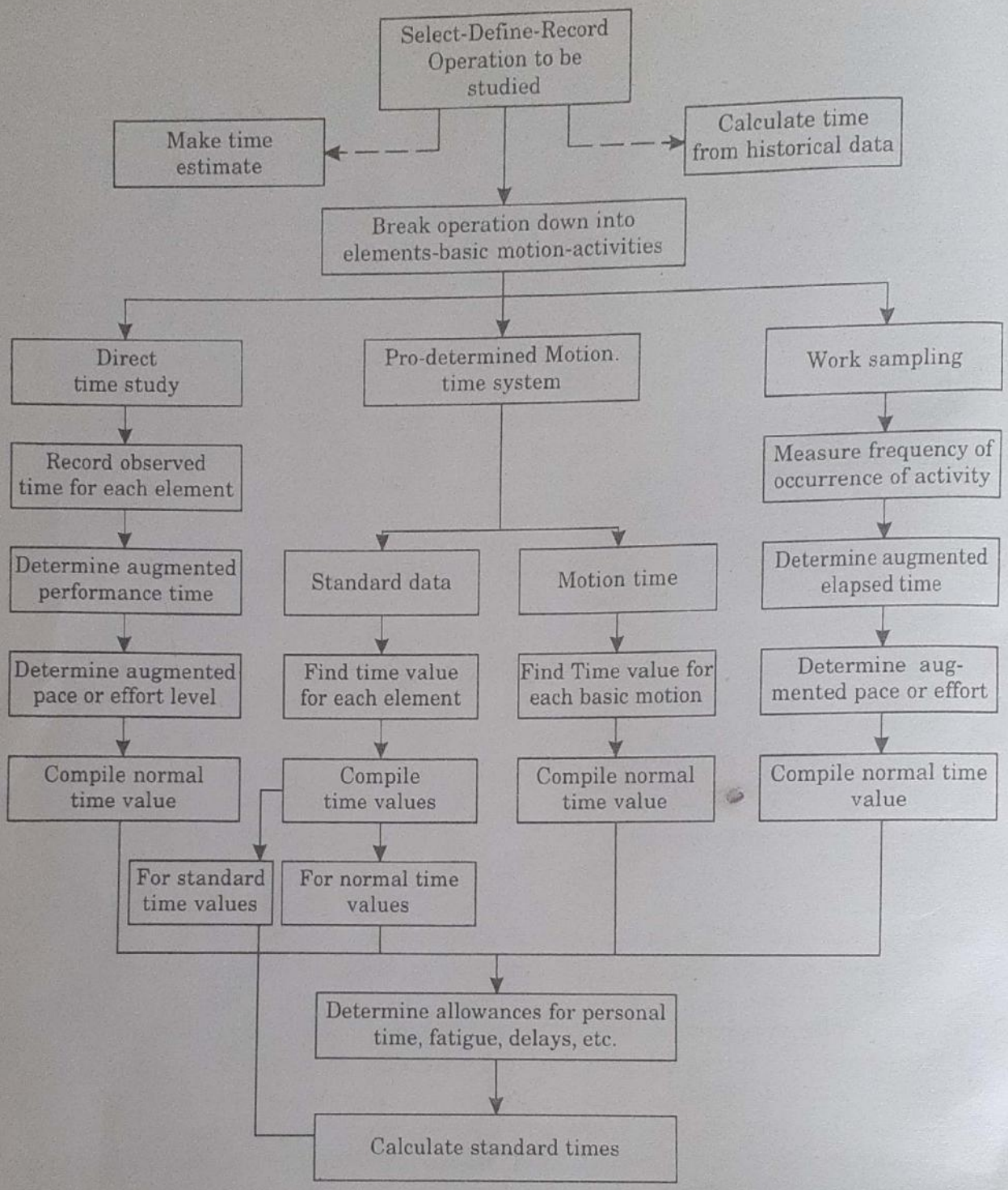


Fig 14.4 Techniques for determining standard time values for an operation

(*Source:* Carson, Bolz, Young, *Production Hand Book*, 3rd Edn., p.12.8)

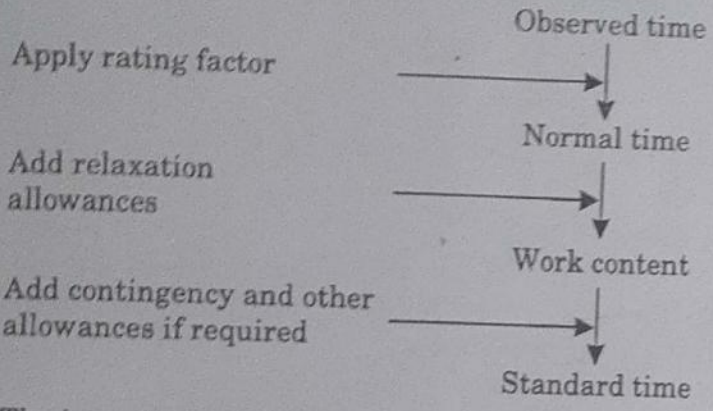
Fig.14.4 summarises the various techniques that may be used to establish standard time values.

Steps in Work-measurement

The various steps are :

1. Break the job into elements.
2. Record the observed time for each element by means of either time study, synthesis or analytical estimating method.
3. Establish elemental time values by extending observed time into normal time for each element by applying a rating factor.
4. Assess relaxation allowance for personal needs and physical and mental fatigue involved in carrying out each element.
5. Add the relaxation allowance time to the normal time for each element to arrive at the work content.
6. Determine the frequency of occurrences of each element in the job, multiply the work content of each element by its frequency (i.e., number of time the element occurs in the job) and add up the times to arrive at the work content for the job.
7. Add contingency allowance, if any, to arrive at the standard time to do the job.

The above procedure may be explained as follows:



The important work measurement techniques are explained below:

1. Time study

Time study is concerned with the determination of the amount of time required to perform a unit of work. It consists of the process of observing and recording the time required to perform each element of an operation so as to determine the reasonable time in which the work should be completed. Time study is defined by ILO as follows: *'Time study is a work measurement technique for recording the times and rates of working for the elements of a specified job carried out under specified conditions and for analysing the data so as to obtain the time necessary for carrying out the job at a defined level of performance'*.

Objectives of time study : The main objective is 'to determine by direct observation, the quantity of human work in a specified task and hence to establish the standard time, within which an average worker working at a normal pace should complete the task using a specified method'.

The other objectives are:

(a) To furnish a basis of comparison for determining operating effectiveness.
(b) To set labour standard for satisfactory performance.
(c) To compare alternative methods in method study in order to select the best method.
(d) To determine standard costs.

(d) Retraining labour time and cost
(e) Training supervisors to be method conscious
(f) Choosing between alternative methods

(iv) **Work Factor**: This technique is based on basic motions which are modified elements of difficulty, all of which tend to make movements slower. These features or work factors are weight or resistance, change of direction, need for care, stopping a motion and manual control. Each of these features is known as a 'work factor' and it modifies the basic time value.

(v) **Basic Motion Times (BMT)**: In this system, the times were derived from laboratory experiments and were carefully checked against a variety of factory operations before being accepted for general use. BMT data are based on basic motions. A basic motion covers everytime a body member which is at rest moves and again comes to rest. For example, the action of knocking on a door requires two basic motions for every knock – one to draw the hand back and another to move the hand forward and knock.

Basic motions are classified as 'finger, hand and arm motions, foot and leg motions and miscellaneous body motions. The motions of finger, hand and arm are further classified as 'class A' motions, 'class B' motions and 'class C' motions, depending on the use of muscular control or stopping the motions 'class A' motions are stopped without muscular control by impact with an object, 'class B' motions are stopped entirely by the use of muscular control and 'class C' motions are stopped by the use of muscular control both to slow down the motion and to end it in grasping or placing action.

5. Work Sampling or Activity Sampling or Ratio-Delay Method

Work sampling is a work measurement technique that randomly samples the work of one or more employees at periodic intervals to determine the proportion of total operations that is accounted for in one particular activity.

These studies are frequently used to estimate the percentage of time spent by the employees in unavoidable delays (commonly called ratio-delay studies), repairing finished products from an operation and supplying material to an operation.

Uses of Work Sampling Technique

1. To estimate the percentage of a protracted time period consumed by various activity states of a resource such as equipment, machines or operators.
2. To determine the allowances for inclusion in standard times.
3. To indicate the nature of the distribution of work activities within a gang operation.
4. To estimate the percentage of utilization of groups of similar machines or equipment.
5. To indicate how materials handling equipments are being used.
6. To provide a basis for indirect labour time standards.
7. To determine the productive and non-productive utilization of clerical operations.
8. To determine the standard time for a repetitive operation as an alternative to the stop watch method.

Work Sampling Procedure

In work sampling study, the works study engineer takes a great number of observations of a worker or machine random times throughout the working shift or day. He records precisely what the worker or the machine is doing (i.e. working or idle) at the time of observation. No stop-watch is used. The objective is to find the frequency of occurrence of every work element.

The technique is based upon the laws of probability. It is based on the statistical premise that, the occurrences in an adequate random sample observations of an activity will follow the same distribution pattern that might be found in a lengthy, continuous study of the same activity.

Algebraically put,

$$p = \frac{x}{N} = \frac{\text{Number of observations of the activity}}{\text{Total number of observations}}$$

Thus, the work sampling method, as stated above, consists of taking a number of intermittent, randomly spaced instantaneous observations of the activity being studied and from this determining the percent of time devoted to each aspect of the operation.

In order to set a standard by the work sampling procedure, it is necessary to level or rate the performance of the worker being studied (as with stop watch time study) and to count the actual number of units produced during the period under study.

Finally it may be stated that the accuracy of the approach depends on the number of observations made. Higher the number of observations, greater is the occurrence.

Steps in Work Sampling

The work sampling study consists of essentially the following steps:

1. Determine the objective of the study, including definitions of the states of activity to be observed.
2. Plan the sampling procedure including:
   (a) An estimate of the percentage of time being devoted to each phase of the activity
   (b) The setting of accuracy limits
   (c) An estimation of the number of observations required
   (d) The selection of the length of the study period and the programming of the number of readings over this period
   (e) The establishment of the mechanics of making the observations, the route to follow and the recording of data
3. Collect the data as planned.
4. Process the data and present the results.

Principles Involved in Work Sampling

Work sampling is based on statistical theory of random sampling and probability of normal distribution and confidence level associated with standard deviation. This is best illustrated by the following example.

Let x = number of observations of the activity in a pilot study

n = Total number of observations of the activity in the pilot study. Then the proportion of activity $p = \frac{x}{n}$

The proportion of 'no activity' = 1 – p = q (say)

The total of the two states which are mutually exclusive is 1, i.e., p + q = 1.

Where p = probability of an occurrence (eg. working)

q = probability of no occurrence (eg. not working or idling)

8.5 TOTAL QUALITY MANAGEMENT (TQM)

8.5.1 Meaning and Definition of TQM

Q31) *What do you mean by total quality management?*

Answer :

TQM involves effective decision making, problem solving and integration of quality planning, quality implementation and quality improvement strategies of all the departments of an organization, committed and involved employees, lower costs, higher revenue and high profits for the organization.

In a total quality management concept, the word quality has a wider meaning, it means quality of output of every department and by every employee, cleanness orderliness, punctuality, customer service, standardization of works and continuous efforts of their improvement are also part of TQM. In this, needs of the customer are constantly monitored to improve the products and processes to meet their requirements.

In total quality management program, voluntary participation of work people is sought for the quality of the task.

TQM has to be defined properly, for implementation to be effective. Survey of literature reveals that TQM has many definitions. Some are,

According to Bill Creech, "A total approach to put quality in every aspect of management."

According to Alan Graham, David Walden, "TQM is an evolving system of practices, tools and training methods for managing companies to provide customer satisfaction in a rapidly changing world."

As per the Helga Drummond, "TQM is basically a business philosophy funded on customer satisfaction. TQM involves two strands, namely, careful design of the product or service and ensuring that the organization's systems can consistently produce the design."

In the words of Ashok Rao, "The foundation on which a successful TQM effort rests includes customer focus, total participation and continual improvement."

8.5.2 Principles of TQM

Q32) *State the basic principles of TQM?*

Answer :

The main principles that underlie TQM are summarized below :

1) **Prevention :** Prevention is better than cure. In the long run, it is cheaper to stop products defects than trying to find them

2) **Zero Defects :** The ultimate aim is no (zero) defects - or exceptionally low defect levels if a product or service is complicated

3. **Getting Things Right First Time** : Better not to produce at all than produce something defective.

4. **Quality Involves Everyone** : Quality is not just the concern of the production or operations department - it involves everyone, including marketing, finance and human resources.

5. **Continuous Improvement** : Businesses should always be looking for ways to improve processes to help quality.

6. **Employee Involvement** : Those involved in production and operations have a vital role to play in spotting improvement opportunities for quality and in identifying quality problems.

4.3.3 Elements of TQM

Q22. *What are the basic elements involved in the total quality management?*

Answer

The following are the elements of total quality management :

1) Customers satisfaction.
2) Employees involvement and empowerment.
3) Morale of employees.
4) Quality control circles and suggestion system.
5) Higher revenue.
6) Lower cost.
7) Quality control.
8) Control of production.
9) Quality planning.
10) Quality improvement.
11) Quality implementation.
12) Quality assurance system.
13) Vendor control and quality in procurement.
14) Customer relationship management.
15) Total organization analysis.
16) Measurement information analysis.
17) Quality education and training.
18) Strategic quality management.
19) Leadership.

8.5.5 Implementation of TQM

Q35) *How the total quality management are implemented?*

Answer :

Implementation of TQM is not an easy task a total change in organization culture, shifting or responsibility to management and continuous participation of all in quality improvement process. W.E. Deming, father of TQM, has suggested Plan-Do-Check-Act cycle for implementation of TQM in any organization. The various steps in PDCA cycle are as shown in Fig. 8.5.3.

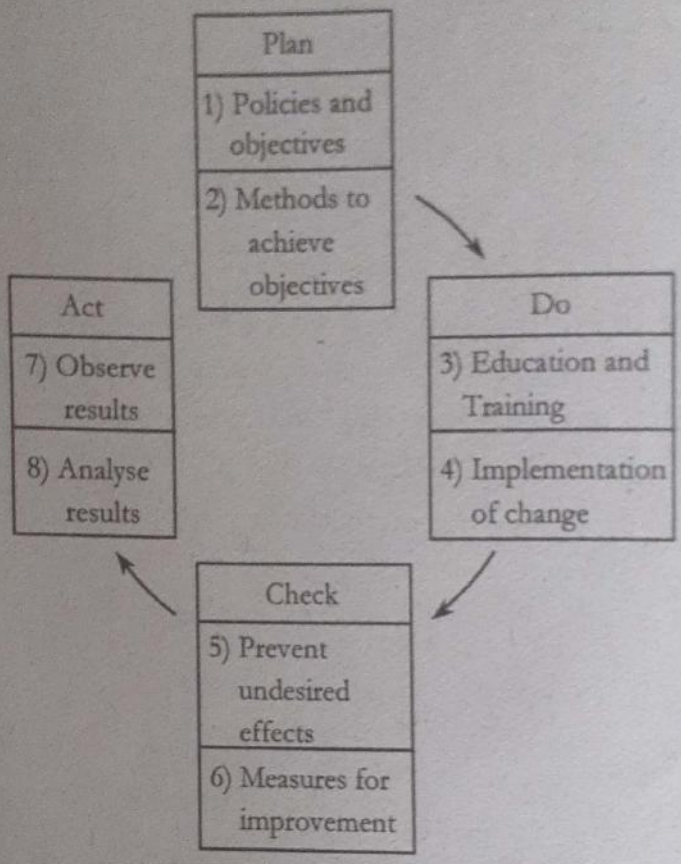


Fig. 8.5.3 Plan do Check Act Cycle for TQM

8.5.6 Factors Affecting Total Quality Management

Q36) *What are the factors that affects the total quality management?*

Answer :

The nine fundamental factors (9 M's), which are affecting the quality of products and services are, markets, money, management, men, motivation, materials, machines and mechanization, modern information methods and mounting product requirements.

1) **Market :** Because of technology advancements, we could see many new products to satisfy customer wants. At the same time, the customer wants are also changing dynamically. So, it is the role of companies to identify needs and then meet it with existing technologies or by developing new technologies.

2) **Money :** The increased global competition necessitates huge outlays for new equipments and process. This should be rewarded by improved productivity. This is possible by minimizing quality costs associated with the maintenance and improvements of quality level.

3) **Management :** Because of the increased complex structure of business organization, the quality related responsibilities lie with persons at different levels in the organization.

4) **Men :** The rapid growth in technical knowledge leads to development of human resource with different specialization. This necessitates some groups like, system engineering group to integrate the ideal of full specialization.

5) **Motivation :** If we fix the responsibility of achieving quality with each individual in the organization with proper motivation techniques, there will not be any problem in producing the designed quality products.

6) **Materials :** Selection of proper materials to meet the desired tolerance limit is also an important consideration. Quality attributes like, surface finishing, strength, diameter etc., can be obtained by proper selection of material.

7) **Machines and Mechanizations :** In order to have quality products which will lead to higher productivity of any organization, we need to use advanced machines and mechanize various operations.

8) **Modern Information Methods :** The modern information methods helps is storing and retrieving needed data for manufacturing, marketing and servicing.

9) **Mounting Product Requirement :** Product diversification to meet customers tastes leads to intricacy in design, manufacturing and quality standards. Hence, companies should plan adequate system to tackle all these requirements.

8.5.7 Advantages of TQM

Q37) ***Briefly mention the implication of total quality management?***

Answer :

1) **Advantages Unique to TQM**

i) It makes company a leader not follower.

ii) TQM creates goal direct connection between customers, management and workers. Every one is motivated to contribute. It thus fosters effective team work.

iii) It makes the company more sensitive to customer needs.

iv) It makes the company adopt more readily to change.

2) **Benefits to Customers**

i) Fewer problems with the product or service.

ii) Better customer care.

iii) Greater satisfaction.

3) **Benefits for the Company**

i) Better product quality.

ii) Staff are more motivated and quality-conscious.

iii) Productivity improvement.

iv) Reduced quality costs.

v) Enhanced problem solving capacity.

vi) Increased market.

vii) Increased competitive position of the firm, improved profitability

viii) Good public image of the enterprise by helping it to provide goods and services of higher quality at lower cost to the society.

ix) Improvement in human relations and work area morale.

4) **Benefits to Staff**

i) Empowerment.

ii) Enhancement of job interest and security.

iii) More training and improvement in skills.

iv) Reduced employee grievances.

8.6 ISO CERTIFICATION

Q38) ***Explain the concept of international organization for standardization?***

Answer :

ISO is the International Organization for Standardization, set up with the objective to promote the development of standards and related activities, for facilitating international exchange of goods and services.

It is mechanism by which customer can have confidence in a company and is most effective when carried out by a national certification body.

The ISO certification is application to quality management system encompassing quality in all functions such as marketing design, purchase, manufacture, assembly, testing, packing, shipping, installations, after sales service and all other activities of an organization.

8.6.1 ISO 9000 Series Standards

Q39) ***Write about the ISO 9000 Certification?***

Answer :

ISO 9000 series of standards developed in 1987, relate to quality systems. It has evolved from the standardization of quality policy assurance system standards of several nations all over the world.

The standards allow a wide flexibility, but at the same time, are rigid too. They permit a supplier to formulate his own quality policy and write the quality manual, procedures and instructions in his own way, within the framework of the system elements, but does not allow rendering of non conforming products or services.

ISO 9000 Series : There are five standards in the ISO 9000 series viz., ISO 9000, ISO 9001, ISO 9002, ISO 9003 and ISO 9004.

ISO 9000, 9001, 9002, 9003 are applicable to contractual situation.

ISO 9004, is for non-contractual cases and is used for internal management purpose.

8.6.2 Characteristics of ISO 9000

Q40) *What are the basic features of ISO 9000?*

Answer :

1) ISO 9000 is the only available internationally accepted standard for quality management system.
2) It does not replace but complements the product standards.
3) ISO 9000 is applicable to all types of industries or organization in manufacturing or service sector.
4) It stands for systematic Standardization and certification rather than product standardization and certification.
5) ISO 9000 is a documentation oriented system which allows complete freedom on selection and use of processes and framing of operating procedures and work instruction.
6) A mistake made in selection of proper product standard can never be compensated by ISO 9000 implementation.
7) ISO 9000 can be implemented in any type and size of organization.
8) It is independent of the product, size and country.
9) It has international acceptance and recognition.
10) It ensures consistent improvement in quality.

8.6.3 Different Areas of ISO Series

Q41) *Briefly mention the different consequents of ISO series?*

Answer :

1) ISO 9000 provides the guidelines for selection and use of the quality standards.
2) ISO 9001 is a quality system model for quality assurance in design/development, production, installation and servicing. This is most exhaustive standard. The engineering organizations, where the manufacturing capabilities are based on in-house designs have to work for ISO 9001 certification manufacturers of,
   i) Household goods like TV, refrigerator etc.
   ii) Perishable consumer goods like toothpaste etc., which have both servicing and design/development have to work towards ISO 9001.

8.7 SIX SIGMA

Q45) *What do you mean by six sigma?*

Answer :

Six sigma has now-a-days over taken almost all the methods for deploying statistical quality assurance and it is a leading methodology in many top ranked industries.

Six sigma is a planned approach implemented with a view of enhancing the given organization's operational performance by taking into consideration the observed data and statistical records and hence, decreasing the short coming observed during production and service related processes to large extent.

Six sigma can be defined in both statistical and business terms. In business terms, six sigma is, "A business improvement strategy used to improve profitability, to drive out waste, to reduce quality costs and improve the effectiveness and efficiency of all operations or processes that meet or even exceed customers needs and expectation". In statistical terms, six sigma is a term that refers to 3.4 defects per million opportunities, where sigma is a term used to represent the variation about the average of any process.

According to Dr. Mikel J.Harry, "Six sigma is a statistical measurement, which helps us to establish our course and gauge our pace in the race for total customer satisfaction".

8.7.1 History of Six Sigma Quality

Q46) *What are the advents of six sigma in quality movement?*

Answer :

Many people associate Six sigma with the quality movement. So, it seems logical at this point, to start from that perspective. How does six sigma differ from the "Quality" programs you may have already experienced? To answer that question, let's briefly recap the history of the quality movement.

No understanding of the quality movement would be complete without mentioning the visionary W. Edwards Deming, best known for helping the Japanese revitalize their industries after world war II. His approach was radically new and had significant impact on the evolution of quality and continuous improvement programs in organizations around the world.

It is fair to say that Deming's management approach, which came to be known as Total Quality Management or TQM (though Deming didn't like that term), has changed the way thousands of companies conduct their operations. By the mid 1980s, the extent to which corporate management was focusing on quality was significant, businesses adopting TQM underwent a major paradigm shift, a transformation of "Unlearning" everything previously believed about business to create better products and services. They began to understand that quality did not require higher costs but more efficient and reliable processes that delivered defect-free outputs and that they had to focus on process improvement and customer satisfaction. TQM is an excellent foundation from which to build toward the next level of quality management, represented by the six sigma approach.

But six sigma is far more than the latest "Quality" trend. The proof Companies that have implemented six sigma have achieved outstanding financial results and developed a disciplined, pragmatic plan for improved financial performance and growth.

Companies such as Motorola, Texas Instruments, IBM, AliedSignal and General Electric have successfully implemented six sigma and reduced costs literally by billions of dollars. More recently Ford, DuPont, Dow Chemical, Microsoft and American Express have started working on instituting the six sigma methodology. But it's about more than money. Jack Welch, the CEO who started six sigma at General Electric, called it "The most important initiative GE has ever undertaken" and said that six sigma is "part of the genetic code of our future leadership."

8.7.2 Phases of Six Sigma

Q47) ***Explain the process of six sigma?***

Answer :

Six sigma is the most widely used statistical quality assurance in industry today. Originally popularized by Motorola in the 1980s, the six sigma strategy "Is a rigorous and disciplined methodology that uses data and statistical analysis to measure and improve a company's operational performance by identifying and eliminating 'Defects' in manufacturing and service related process." The term "Six Sigma" is derived from six standard deviations – 3.4 instances (defects) per million occurrences implying an extremely high quality standard. The six sigma methodology defines three core steps :

Step 1 : Define customer requirements, dreliverables and project goals via well-defined methods of customer communication. Initially gather the data related to customer requirements, their deliverable and finally estimate the required project goal in most sophisticated manner keeping in view all the comfort of the customers.

Step 2 : Measure the existing process and its output to determine current quality performance (collect defect metrics).

Step 3 : Analyze defect metrics and determine the vital few causes.

If an existing software process is in place, but improvement is required, Six Sigma suggests two additional steps.

Step 4 : Improve the process by eliminating the root causes of defects.

Step 5 : Control the process to ensure that future work does not reintroduce the c of defects. So that any change made to it will not rebirth, the causes of errors were be e

These core and additional steps are sometimes referred to as the DMAIC (Def Analyze, Improve and Control) method.

If an organization is developing a software process (rather than imp the core steps is augmented as follows :

7.1 PRODUCTIVITY

7.1.1 Basic Concept of Productivity

Q1) *Basic concept of productivity?*

Answer :

A former produces from one hectare of land 10 more bags of wheat during a seas improved farming techniques and better quality seeds.

The farmer is able to produce more from the same piece of land without bringing additional input. He has only change his farming technique and used a better quality of Thus we may say that without any change in input the output from the land has inc

In engineering we call the ratio, as $\frac{\text{output}}{\text{input}}$ as efficiency.

In production system we may call this ratio as the production efficiency or produc So, when this ratio increases, there is an increase in productivity.

Therefore, productivity is an efficiency of the production system which is expres the ratio between output and input. When the tailor is able to reduce the length of cloth per shirt by adopting an improved cutting technique, the input (cloth) per shirt reduced the output (shirts) remains constant. Thus, there is an increase in productivity, in the utili of the material (cloth)

Similarly, the productivity of a machine tool increases by using improved cutting tool also by using improved method of working.

7.1.2 Meaning and Definition of Productivity

Q2) *What do you mean by productivity?*

Answer :

Productivity is measure of how much input is required to produce a given output i.e., it is of output to input.

Productivity is the ratio between the amount produced and the amount of resources in the course of production. The resources may be any combination of materials, machi men and space.

European productivity council defines " Productivity is an attitude of mind. It is a menta of progress, of the constant improvement of that which exists; it is the certainty of being to do better than yesterday and continuously. It is constant adaptation of economic and so life to changing conditions. It is continual effort to apply new techniques and methods the faith in human progress."

According to Peter Drucker, "Productivity means balance between all factors of production that will give the maximum output with the smallest effort."

I.L.O generally takes productivity to mean, "The ratio between the volume of output as measured by production indices and the corresponding volume of labour input as measured by employment indices."

$$\text{Productivity} = \frac{\text{Measure of output}}{\text{Measure of input}}$$

In most cases output will be goods and services produced, for which input will be men, money, equipment, power, plant facilities and other items used in the process of production. Total productivity of the firm can be defined as :

$$P_T = \frac{Q_T}{L+C+R+M}$$

L : Labour input

C : Capital input

R : Raw material and purchased parts input

M : Other miscellaneous goods and services input factors

Q_T : Total output

7.1.3 Utilization of Productivity

Q3) ***How the productivity is being utilized?***

Answer :

Productivity refers to efficient utilization of the resources. The resources utilized for production are :

1) **Land and Building :** Land is a convenient location on which the buildings and other facilities necessary for the operation of manufacture are erected.

2) **Materials :** Materials that can be converted into products to be sold. They include fuel, chemicals for use in the process of manufacture, packing and other indirect and materials etc.

3) **Machines :** Plant, equipment and tools necessary to carry out operations of manufacture and the transport of materials, heating, ventilation and power plant, office equipment and furniture.

4) **Manpower :** Men and women to perform the manufacturing operations, to plan and control, to do clerical work, to design and to research to buy and sell.

7.1.4 Techniques of Productivity Improvement

Q4) *Explain briefly the different approaches for productivity?*

Answer :

Productivity Improvement Techniques can be Categorized as,

1) **Technology Based**
   i) Computer aided design (CAD), Computer aided manufactured (CAM) - Computer Requirements Planning (CRP) - Materials Requirements Planning (MRP).
   ii) Robotics.
   iii) Laser Technology.
   iv) Energy Technology.
2) **Employee Based**
   i) Financial and non financial incentives.
   ii) Employee promotions.
   iii) Job design, job enlargement and job enrichment.
   iv) Workers participation in decision making.
   v) Quality Circles (QC).
   vi) Personal development.
3) **Material Based**
   i) Material Planning and Control.
   ii) Purchasing and logistics.
   iii) Material storage and retrieval.
   iv) Source selection and procurement of quality material.
4) **Process Based**
   i) Methods engineering and work simplification.
   ii) Job evaluation.
   iii) Human factors engineering.
5) **Product Based**
   i) Value analysis and value engineering.
   ii) Product diversification.
   iii) Standardization, simplification and specialization.
   iv) Reliability engineering.
   v) Product mix and promotion.
6) **Management Based**
   i) Management style.
   ii) Communication in the organization.
   iii) Work culture.
   iv) Promoting group activity.

7.1.5 Measurement of Productivity

Q5) *How the productivity is determined?*

Answer :

1) **Partial Productivity Measures (PPM) :** Depending upon the individual input, partial productivity measure can be expressed as :

$$\text{Partial Productivity} = \frac{\text{Total output}}{\text{individual input}}$$

i) $$\text{Labour Productivity} = \frac{\text{Total output}}{\text{Labout input}}$$

ii) $$\text{Capital Productivity} = \frac{\text{Total output}}{\text{Material input}}$$

iii) $$\text{Material Productivity} = \frac{\text{Total output}}{\text{Capital input}}$$

iv) $$\text{Energy Productivity} = \frac{\text{Total output}}{\text{Energy input}}$$

2) **Total Productivity Measure (TPM) :** It Is based on all inputs. This model can be applied to any manufacturing organization or service company.

7.1.6 Productivity Index

Q6) *What is meant by productivity index?*

Answer :

Productivity index is used to compare the productivity during the current year with the productivity during the base year. Base year is any year which the company uses for comparative study.

$$\text{Productivity Index} = \frac{\text{Productivity during the current year}}{\text{Productivity during the base period}}$$

7.1.7 Kinds of Productivity Measures

Q7) *Explain the different methods of productivity measures?*

Answer :

Material Productivity : There are many industries in which the cost of raw material represents 60% or more of the cost of finished product. Many industries have to import very large proportion of their basic raw materials and pay for them in scarce foreign currencies. Under either of these conditions the productivity of materials becomes a key factor in economic production or operation.

$$\text{Material Productivity} = \frac{\text{Number of units produced}}{\text{Cost of material}}$$

Raw Material Productivity can be Increased by,

1) Proper choice of design.
2) Proper training and motivation of workers by way of better handling of materials reduction of rejection.
3) Better material planning and control, use of jigs and fixtures.
4) Waste reduction, scrap control.
5) Proper care of materials in storage.
6) Recycling and reuse of materials.
7) Searching alternative cheaper materials etc.

Labour Productivity

$$\text{Labour Productivity} = \frac{\text{Aggregate Output}}{\text{Amount of Labour}}$$

Where output can be measures in total quantity produced and labour can be measured in t man hours required to produce that output. Out put and labour can also be measured in te of their value in money units.

$$\text{Thus, Labour Productivity} = \frac{\text{Total Revenue from Production}}{\text{Expenditure on labour}}$$

The Labour Productivity can be Increased by :

i) Selection of product design and process of manufacture so as to ensure most economi use of labour.
ii) Providing training to use best method of production.
iii) Constantly motivation workers by providing financial and non-financial incentives.
iv) Keeping high morale of employees.
vi) By providing opportunities for self-development.

Capacity Productivity

Capital

$$\text{Capital Productivity} = \frac{\text{Turn over}}{\text{Captial employed}}$$

Capital Productivity can be Improved by,

i) Better utilization of capital resources like land, building, machines.
ii) Careful make or buy decision.
iii) By using modern techniques of production, maintenance, flexible manufacturing system proper plant layout etc.

Machine Productivity

$$\text{Machine Productivity} = \frac{\text{Output}}{\text{Actual machine hours utilized}}$$

Machine Productivity can be Improved by Following :

i) Preventive maintenance.

ii) Use of proper speed, feed, depth of cut etc.

iii) Using method study techniques (Using best method)

iv) Use of skilled properly trained workers.

v) Line balancing etc.

General Measure of Productivity

$$\text{Aggregate Productivity} = \frac{\text{Output}}{\text{Land + Labour + Material + Capital + Other Inputs}}$$

7.1.8 Factors Affecting Productivity

Q8) ***What are the different factors which are responsible for productivity consideration?***

Answer :

(A) Factors Affecting National Productivity

1) Human Resources

i) The general level of eduction is an important factor in national Productivity. The use of computers and other sophisticated equipment and systems requires better educated employees.

Government can help by sponsoring more education, especially in fields that directly affect productivity.

ii) Employees need to be motivated productive. Pay is not enough; they need to have good, safe, working conditions and to be recognized as the most vital part of the enterprise.

iii) Labour unions and management may be adversaries in negotiating pay and benefits but can cooperate in seeking productivity improvements, to the benefit of all.

2) Technology and Capital Investment

i) The major factor in long range continuing productivity improvement is technology, and new technology depends on Research and development.

ii) For industry or services to put new technology into use they [illegible] vest in new machinery and equipment.