Chapter 7

WORK MEASUREMENT

CHAPTER OUTLINE

7.1 Work Measurement : Concept and Procedure

7.2 Time Study

7.3 Activity or Work Sampling

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7.1 WORK MEASUREMENT : CONCEPT AND PROCEDURE

Meaning of Work Measurement

Work measurements with assessing the time content of a job performed by an operator to determine the proper time to be allowed and the efforts required for the efficient performance of a job. R.M. Curie has defined work measurement as *application of techniques designed to establish the time for a qualified worker to carryout a specified job at a defined level of performance*. Work measurement involves determination of proper time required for the job and that is why it is popularly known as '*time study*'. Time study or work measurement is a major component of the work study.

Work measurement is a technique to establish the time for a qualified worker to carryout a specified job at a definite level of performance.

Standard time can be expressed in minutes or hours. A realistic formula of calculating the standard time is as under:

$$\text{Standard time} = \frac{\text{Basic time} \times 100}{100 - \text{Allowance in percentage}} \quad (7.1)$$

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$$\text{Basic time} = \frac{\text{Observed time} \times \text{Observed rating of operator}}{\text{Standard rating}}$$

The observed time is the actual time read from a stop watch. Observed time is also called actual time.

Allowed Time : The time allowed for payment purposes to the factory worker where the standard time for some constituent part of it, *viz.*, work content) is increased appropriately by a factor representing a bonus and/or policy allowance.

Standard Minutes : A standard minute (SM) expresses a unit of work in terms of the 100 BS scale. Standard performance is recognised as being 60 SMs an hour. It is different from standard time, in that the latter includes ineffective and unoccupied time.

Objectives of Work Measurement

The main objective of work measurement is to obtain the time standard. The performance of an operator is then measured against it for the following purposes :

(*i*) To ensure correct loading of labour and machinery.

(*ii*) To set standard time for job.

(*iii*) To improve method of doing work.

(*iv*) To reduce or eliminate the ineffective time.

(*v*) To maintain the sound incentive scheme.

(*vi*) To assist method study to develop better and quicker methods.

(*vii*) To assist the future planning of the department.

Advantages of Work Measurement

The advantages of work measurement are as follows:

(*i*) Work measurement determines the normal time for a job and thereby serves as a basis of a sound wage incentive system.

(*ii*) The standard time determined by work measurement helps in labour cost control.

(*iii*) Work measurement provides the relevant data for efficient work planning and control.

(*iv*) Work measurement facilitates effective placement of right kinds of people on plant and equipment.

(*v*) Work measurement technique can be useful in reducing the cost involved in the proposed production orders.

Distinction between Work Measurement and Work Improvement

Work measurement is the study and analysis of time taken in the performance of a specified task. Work improvement denotes the study of methods and techniques of production for increasing efficiency. These two concepts are interlinked with each other because both of these aim at increasing productivity. Efficient work improvement

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...pre-requisite of work measurement involves time study, work sampling and synthetic ...ndards. Work improvement is done to suggest the best method of doing the job, ...ness, work measurement helps in fixing fair day's work, laying down wage incentive ...s, and production planning and control.

7.1 Procedure of Work Measurement.

Work measurement involves the following steps:

(i) Select the work/job to be studied.

(ii) Record all the relevant data pertaining to the circumstances in which the work is being done, the methods and the elements of activities in them, after breaking the job in small elements (elemintisation).

(iii) Measure each element in terms of time over a sufficient number of cycles of activity to ensure that a representative picture has been obtained.

(iv) Examine the recorded data and time element critically to ensue that unproductive or random elements are separated from productive elements; also examine the recorded times of each element and determine a representative time for each.

(v) Compile a time for the operation which provide a realistic standard of performance and will include time allowances to cover suitable rest, personal needs and contingencies, etc.

(vi) Define precisely the series of activities and method of operation for which the time has been allowed and issue the standard time for the activities and methods specified.

The above steps of work measurement are essentially a three stage procedure of **analysis, measurement and synthesis.** The analysis stage occurs when the work to be measured is broken down into its constitutent parts. Measurement records time for an operator to carry out each element. Synthesis takes places when the available information is gathered together into a suitable form use. The three stages are closely connected with each other. Foreign elements like unexpected tool breakage and sudden power failure, etc. should be discarded from study.

Common Terms used in Work Measurement

Observed Time : It is the time directly recorded by stop watch by the Work Study official observing the activity of the operator.

Basic Time or Normal Time : It is the calculated time of activity of the operator taking into account his rate of performance. It is equal to :

$$\text{observed time} \times \frac{\text{Observed rating}}{\text{Standard rating (100\%)}}$$

. For example, if the observed time of the operator is 5 minutes (say) and he is working at a faster rate of 120% rating (according to the concept of Work Study official), then the Basic Time

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$= 5 \times \frac{120}{100} = 6$ minutes. On the other hand, suppose the operator is doing work at a slower rate of 90% (according to the concept of Work Study official) then the Basic Time $= 5 \times \frac{90}{100} = 4.5$ minutes.

Rating Factor : It is a comparison of the actual performance with some standard notion of normal performance. Normal performance is the working rate of the average worker working under capable supervision but without the stimulus of an incentive wage plan. Thus, a rating factor of 1.25 means the operator is working at a faster rate of 125% compared to100% normal performance according to the concept of the Work Study analyst. Similarly a rating factor of 0.90 means an efficiency of 90% compared to the 100% concept of the analyst. As human judgement is involved, the rating is recorded in steps of 5% *i.e.*, 80, 85, 90, 95, 100, 105, 110, 115, 120, etc.

Allowances : It is the time value added to the basic time of the operator to provide him with an opportunity to recover from the physiological and psychological effects of carrying out specified work under specified conditions.

Standard Time : It is the time which is determined to be necessary for a qualified worker working at a pace which is ordinarily used under capable supervision and experiencing fatigue to do a defined amount of work of specified quality, when following the prescribed method.

7.2 TIME STUDY

Time study is a very useful device of work measurement. It is the *art of recording and analysing systematically the time required to perform a motion or a series of motions*. This definition suggests that time study is to be conducted after a motion study has been undertaken. Time study attempts to determine a standard day's work by finding the amount of time needed by workers to perform the various operations. The purposes of time study are to provide production data and to provide incentives. Time study is carried out by studying a worker or a group of workers and carefully measuring with a stop watch how long it takes to perform each operation on the job.

It is a must to do motion study first so that during the time study workers are using only those motions that are necessary and most desirable. If time study is done without motion study and rates of wages are set on the basis of the time study, workers may adopt a method of work which will fetch them higher pay. After time has been measured for the various operations of a job, allowance should be made for fatigue and visits to attend to necessary calls.

The need for time study arises, whenever, a better method of doing a work is introduced in a plant. It is the time study which will help in knowing a fair day's work which an employee should do. The determination of a fair day's work or

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standard task is based on the complete knowledge of the necessary motion needed to do a job. A time study board and a stop watch are used to observe the time required to do each operation.

Benefits of Time Study

The benefits of time study are as follows:

(i) Time study helps in determining the ideal workload of different categories of workers.

(ii) The standards of performance evolved as a result of time studies may be used for evaluating the performance of employees.

(iii) Time study helps in designing a suitable incentive wage plan to motivate the workers to increase their productivity.

(iv) Cost standards are very accurate if they are based on the results of time study.

Limitations of Time Study

Time study suffers from the following limitations :

(i) Generally, there are variations of the standard time determined by different observers. Even one observer sets different standard time each time he is asked to conduct the time study.

(ii) Time study involves an element of subjectivity of the observer. Sufficient judgment has to be used by the observer in the choice of a measure of central tendency, deciding the degree of personal allowance and so on.

(iii) The standard time determined by time study may not be accurate because of incorrect performance rating of the operator under study.

(iv) Time study usually has an adverse effect on the workers. They may not show the normal behaviour pattern when they are being observed. Even the trade unions may resist stop watch time studies.

TABLE 7.1: Motion Study *vs.* Time Study

Basis of Comparison	Motion Study	Time Study
1. Meaning	It relates to watching and recording the movements of workers.	It invovles careful measurement of time required to do the different parts of a job.
2. Nature	Motion study is concerned with minimisation of movement of operators.	Time study is concerned with increasing the productivity to labour.
3. Purpose	The purpose of motion study is to determine the best way of doing a job.	The purpose of time study is to determine fair day's work.
4. Technique	Motion study is conducted with a moving camera.	Time study is conducted with a stop watch.

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7.2.1 Steps in Time Study

The procedure for time study involves the following steps :

(*i*) Selection of work to be studied.

(*ii*) Establishing standardised methods, equipment and working conditions.

(*iii*) Selecting the average worker who is to be studied while performing work. Necessary confidence in the worker should be created so as to obtain his operation.

(*iv*) Division of work into elements suitable for time study.

(*v*) Studying the operator doing the job. For the validity of the time study results, it is necessary that the analyst should take readings not once but a number of times. The number of times for which time study should be repeated (*i.e.*, number of cycles) will depend upon the level of confidence needed.

(*vi*) Recording time with the help of stop watch on the time study board for the required number of work cycles.

(*vii*) After the time values for each element for sufficient number of cycles have been recorded, the mode value is selected. The mode value represents the most frequently appearing time value for an element of job. Mode values of different elements will be added to get the normal time for doing a job. Normal time is the time required by an average worker working under normal conditions to perform a job.

(*viii*) Adding allowances to normal time to get the standard time. Relaxation allowances include personal allowance, fatigue allowance, delay allowance, etc.

In the above-mentioned procedure, we have suggested that an average worker should be chosen for the purpose of time study. If an average worker is not chosen, performance rating factor will have to be assessed to determine the normal time for each category of worker. For instance, workers are divided into three categories (*i*) Poor workers (75 points); (*ii*) Normal or average workers (100 points) ; and (*iii*) Good workers (125 points). If a good worker is studied, the time taken by him to perform the job will be multiplied by 125/100 to get the normal time taken by an average worker.

Time study board and observation sheet are specially prepared for the purpose of time study. The observation sheet is clamped on the board and a stop watch is fixed in a bracket installed on the right hand top corner of the board. The switching on and off of the stop watch is done by the forefinger of the left hand and the time study date is written by the right hand. The stop watch used for time study is a decimal minute stop watch whose main dial is divided into 100 divisions. The watch also contains a small dial with 30 divisions, each division corresponding to one minute. The time may be recorded either by continuous reading of the stop

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watch or by discontinuous or trap back reading. In the former case, once the stop watch is started, it is not stopped till the completion of the entire job. All the readings are taken continuously. The observer has to subtract the two consecutive readings to get the elapsed time for each element. In case of discontinuous observation, the stop watch is stopped after measuring each element and the button is pressed to bring the taller hand to zero. The method is not very popular because it is susceptible to error in observation.

7.2 Time Study Equipment

The equipment used in carrying out time study consists of the following aids :

(*i*) *Stop Watch.* This watch is used to findout the time taken in doing a particular element of the job. It can measure up to 1/100th part of a second. Several types of stop watch, *e.g.*, flyback, non-flyback, split hand, etc., are used.

(*ii*) *Time Study Board.* It is a flat board on which forms used to record time are fixed. It may have a fitting to hold the watch so that the watch can be read easily and the hands of the time study expert are left free. A strong spring clip fitted to the board holds the forms on which the time is recorded.

Time study board is rigid and larger than the largest form likely to be used. The overall size of the board should be such that not too much static strain gets developed in the body support system that is required to keep the board in proper position all throughout the observation phase. A study board which is too long or too short for a study man's arm soon becomes tiresome to use.

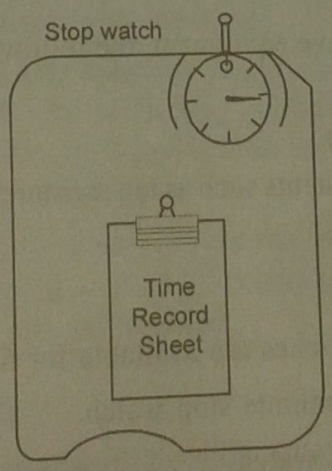

Fig. 7.1. *Time Study Board.*

(*iii*) *Time Study Forms.* Printed forms of a standard size are used to ensure that the time studies are always recorded in a standard manner and no essential details are omitted. Several types of forms are used depending upon the method used in timing. A time study form or *time study sheet* contains several columns for recording data relating to the study, reference, process information, operator identification, working conditions and time study details. A format of typical time study sheet is given below :

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TIME STUDY SHEET

Department : Operation : Machine : Tools & Gauges : Material : Date :	Study No. : Sheet No. : Time off : Time on : Elapsed time : Operator : Studied by : Checked by :

S. No.	Description of Element	R	OT	BT	RA	ST	Remarks
	Time before						
1.							
2.							
3.							
4.							
5.							
	Time after						

R = Rating
OT = Observed Time
BT = Basic Time
RA = Relaxation Allowance
ST = Standard Time

Fig. 7.2. *Time Study Sheet.*

In addition to tbe above equipment, the following items are also required for time study:

(*i*) a small calculator

(*ii*) measuring instruments such as tap measure, steel rule, micrometer, spring balance, etc.

Stop Watch

Two types of stop watches are available for time study:

(1) Flyback decimal minute stop watch.

(2) Non-flyback stop watch.

In practice, flyback decimal minute stop watch is mostly used for time study. In this type of watch, the movement is started and stopped by moving the slide forward and backward respectively. One complete revolution of the large hand represents 1 minute and since the dial is divided into 100 parts, reading to within 0.01 minute can be obtained. Every time the large hand makes one revolution, the small hand will register 1 minute and is able to register up to 30 minutes.

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If the analyst stops the watch at any point by moving the slide backward, he can return both hands to zero by pressing the winding knob B. So long as the slide remains in the backward position, the hands will not rotate. If the side slide is in the forward position, it means that the hands are rotating and pressing the winding knob will return the hands back to zero. However, as soon as the winding knob is released, the hands will begin rotating again. This is because the watch had not been stopped by moving the side slide backward.

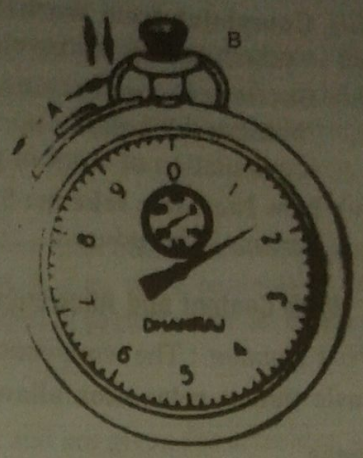

Fig. 7.3. *Decimal stop-watch for time study.*

Non-fly back type stop watch is controlled by pressure on the top of winding knob. The first pressure starts the watch; the second pressure stops it; the third pressure returns the hands to zero. This type of watch is suitable only for cumulative timings.

Motion Picture Camera. It is used for micro-motion study. It is deriven at constant speed of several ranges. Because of constant speed, time taken by each film can be calculated. Thus by knowing the number of films covered by one operational element, the exact time can be found. For example, if camera was set at 1000 films per minute, *i.e.*, each film takes 0.001 minute and if operational element covers 70 films, then time required for this operational element would be 0.07 minute. Thus, this method is very accurate, but it is used for high precision work as it is much expensive than other methods.

Time Study Machine. In this machine, there is a paper tape which totates on two rollers at uniform speed. The paper tape is graduated in such a way that it records timing in fraction of a minute. Readings can be seen and recorded through a slit provided in the casing of equipment.

Its advantage over the stop watch is that the work study staff is free to observe the operation continuously instead of having short elements to be timed. The tape has to be read at the end of the study.

7.2.3 Reasons for Time Study

Time study is most easily conducted for routine jobs where appreciable labour costs are involved and, especially, where a number of workers are performing identical operations. Time study is carried out on the request of some department or to set the time standards. Some possible reasons for time study are:

(*i*) **New job.** The job to be done is a new one; not previously carried out (*e.g.*, new product: component, operation, or set of activities).

(*ii*) **Change in method or material.** A change in method or material has been made and a new time standard is required.

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(*iii*) **Complaint from workers.** A complaint has been received from workers or their representative about the time standards for an operation.

(*iv*) **Bottleneck operations.** A particular operations appears to be a "bottleneck" holding up subsequent operations and possibly (through accumulation of work in process behind it) previous operations.

(*v*) **New Incentive scheme.** Standard times are required before an incentive scheme is introduced.

7.2.4 Work Content and Allowances

Work Content : The work content of a job or operation is defined as:

basic time + relaxation allowance + any allowance for additional work

Allowances

Standard time of a job obtained by adding various allowances to the normal time of the job. These allowances are considered or provided to compensate the worker/operator for the production interruptions that may occur due to his personal legitimate needs or the factors beyond his control. For example, the delay may occur due to operator's personal needs (such as drinking water, taking tea, going to toilet, etc.) unavoidable delays (like waiting for tools, materials or equipment, maintenance of machine and periodic inspection of material/parts). The fundamental purpose of allowances is to add enough time to the normal time of production in order to enable the average worker to meet the standard while performing at normal pace.

Personal Allowance

This time is allowed for physical needs of the worker. A worker does not work continuously like a machine and hence personal allowance is provided to him in order to satisfy his personal requirements (like drinking water, taking tea, visiting toilet and trip to dressing room, etc.). The general working conditions and the nature of work shall influence the time required for personal allowance. Thus working conditions involving heavy work performed at high temperatures and in humid atmosphere like hot forging shop; foundry or in the press room of a rubber moulding department require greater allowance to meet personal needs in comparison with light work performed in comfortable working conditions.

Studies have revealed that a personal allowance of five per cent per shift is necessary under normal conditions. However for tasks performed under adverse environments, operators may be given 50 per cent allowance *i.e.* 240 minutes per shift of 8 hours.

Relaxation or Fatigue Allowance

Rellaxation allowance is an addition to the basic time intended to provide the worker with the opportunity to recover from the physiological and psychological effects of carrying out specified work under specified conditions and to allow attention to personal needs. The amount of allowance will depend on the nature of the job.

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Contingency or Delay Allowance

A contingency allowance is a small allowance of time which may be included in a standard time to meet legitimate and expected items of work or delays, the precise measurement of which is uneconomical because of their infrequent or irregular occurence.

Policy Allowances

A policy allowance is an increment, other than bonus increment, applied to standard time (or to some constituent part of it, *e.g.*, work content) to provide a satisfactory level of earnings for a specified level of performance under exceptional circumstances.

Special Allowance

These may be temporary or permanent and are given for activities which are generally the part of work cycle but are considered essential for completing the work satisfactorily. Special allowances may be provided as:

(*i*) Periodic activity allowances which are (for example setting up a planner, maintenance of a lathe machine) carried out periodically.

(*ii*) Interference allowance *i.e.* when a operator is looking after two or more machines and one or more stop working while he is busy with some machine. The result of machine stoppages or machine interference causes loss of production. Thus for none of his faults, the worker suffers because of low out put. So interference allowance is to be provided.

Allowances in Work Content

Special allowance may be given for any activities, which are not normally part of the operation cycle but which are essential to the satisfactory performance of the work.

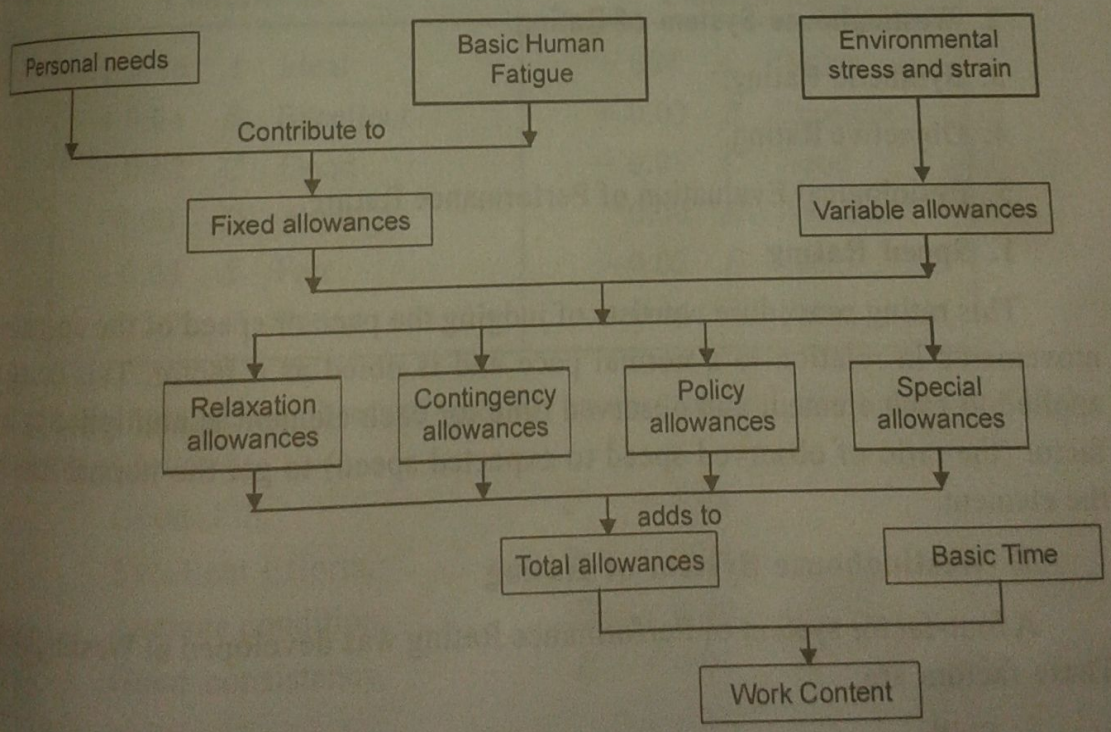

Fig. 7.4. *Different allowances in work content.*

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Performance Rating

In work measurement, it is important to determine the performance rating of the worker, whose job is measured. ILO has defined rating as follows:

Rating is the assessment of the worker's rate of working relative to the observer's concept of the rate corresponding to the standard pace.

The rating of the worker helps the comparison of the rate of working observed with respect to the standard level, which is the average rate of a qualified worker, when he uses correct methods and when he is motivated to apply himself to the work.

In mathematical term,

$$\text{Performance Rating} = \frac{\text{Observed Performance}}{\text{Normal Performance}} \times 100$$

The concept of normal performance must be such that the time standards are set from it, are within the capacity of the majority of workers in the enterprise. It would be of no use in setting standards so high that only the best worker could attain them since programmes or estimates based on them would never be fulfilled. Similarly low standard would result very high earnings for some of the workers and consequently, excessively high labour cost of the product and very large difference in the earnings of the workers:

Methods of Performance Rating

The important methods used for performance rating are :

1. Speed Rating.
2. Westinghouse System of Rating.
3. Synthetic Rating.
4. Objective Rating.
5. Pysiological Evaluation of Performance Rating.

1. Speed Rating

This rating procedure consists of judging the pace or speed of the operator's movements in relation to a normal pace and is noted as a factor. This rating is applied to each element and observed time for each element is multiplied by this factor (the ratio of observed speed to expected speed) to get the normal time for the element.

2. Westinghouse System of Rating

A four-factor system of Performance Rating was developed at Westinghouse. These factors are:

1. Skill.
2. Effort.
3. Conditions.
4. Consistency.

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A scale of numerical values for each factor was supplied in the tabular form, worker was watched while working and given a value from these tables. The obtained from time study is then levelled by applying the sum of the ratings all the four factors.

Skill			*Effort*		
+0.15	A_1	Super	+0.13	A_1	Excessive
+0.13	A_2		+0.12	A_2	
+0.11	B_1	Excellent	+0.10	B_1	Excellent
+0.08	B_2		+0.08	B_2	
+0.06	C_1	Good	+0.05	C_2	Good
+0.03	C_2		+0.02	C_2	
+0.00	D	Average	+0.00	D	Average
−0.05	E_1	Fair	−0.04	E_1	Fair
−0.10	E_2		−0.08	E_2	
−0.16	F_1	Poor	−0.12	F_1	Poor
−0.22	F_2		−0.17	F_2	

Conditions			*Consistency*		
+0.06	A	Ideal	+004	A	Perfect
+0.04	B	Excellent	+0.03	B	Excelent
+0.02	C	Good	+0.01	C	Good
0.00	D	Average	0.00	D	Average
−0.03	E	Fair	−0.02	E	Fair
−0.07	F	Poor	−0.04	F	Poor

For example, if the observed time for an operator is 1.50 minutes and if the ratings are as follows:

Good skill,	C_1	+ 0.06
Excellent Efforts,	B_2	+ 0.08
Average condition,	D	+ 0.00
Good consistency,	C	+ 0.01
Total		+ 0.15

The normal time for the operation would be 1.50 × 1.15 = 1.72 min.

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3. Synthetic Rating

In this method, performance of the worker is rated from the values already known as PMTS (Predetermined Motion Time System). In this procedure, time study is done in the usual manner and then actual time obtained for certain elements from this study is compared with that of known standards. The ratio of standard time of a particular element to that of observed time to the same element is rating factor for the study. The rating factor for the study is the average of rating factors obtained for different elements of the study. Efforts must be made to determine the rating factors for as many elements as possible. In this method, it is assumed that performance for the whole of the study will be same as that obtained in these elements.

If,

R = Performance rating factor.

P = Predetermined standard for an element.

A = Average of actual time obtained in the time study for that element.

Then $$R = \frac{P}{A}$$

4. Objective Rating

In this method, Rating is done in two stages, in first stage, operator's speed is rated, by observing speed of movement or rate of activity, and no attention is paid for the job difficulties. After the pace rating is made, in the second stage, an allowance of a secondary adjustment is added to the pace rating by considering the job difficulties. Job difficulties are divided into six clauses. A table provided the percentage of adjustments to be made for each of these six factors. These factors are:

(*i*) Amount of body used.

(*ii*) Foot Pedals.

(*iii*) Bimanualness.

(*iv*) Eye-hand co-ordination.

(*v*) Handling requirements.

(*vi*) Weight.

For example, if the selected time for an element is 0.30 minute, the pace rating is 110% and if the sum of all secondary adjustments amounts to 20% then the normal time will be

$$= 0.3 \times 1.10 \times 1.20 = 0.396 \text{ min.}$$

5. Physiological Evaluation of Performance Rating

Many studies have shown that there is relationship between physical work and the amount of oxygen consumed by the operator. More recently, it has also

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found that the change in heart rate is also a reliable measure of muscular ity. This technique is however not being used now but large number of people rious parts of the world are working on this problem.

5 Time Record

A very convenient technique of work measurement is time record or time logs. this approach, every employee maintains a record of the time spent on each ity and the number of activities performed by him.

The steps involved in this method are as follows:

(a) Develop standardised definitions of the work activities and work counts that the employees are to record.

(b) Explain to the employees how time records are to be maintained.

(c) Design the forms to be used in collecting the data.

(d) Maintain logs sufficient to give a representative sample of the activities performed in the work centre.

(e) Summarise the record times and find the time spent per activity.

(f) Develop time standards.

Time record technique is easy to install and administer. Employees will not sent the records once they are explained the purpose and the information obtained properly utilised. However, it is difficult to summarise the vast multitude of logs hat may be produced. Employes may not like to bear the burden of maintaining etailed time records. Moreover, standards set by averaging past performance merely tell what was done rather than what should be done?

7.3 ACTIVITY OR WORK SAMPLING

We have observed above that time study can play a significant role in increasing the productivity and efficiency of any undertaking. But, workers because of lower level of education and cultural factors do not favour being constantly watched by a time study expert. They may feel that the results of a time study will go against them and reduce their wage rates. Therefore, they may show resistance towards the idea of time study. Moreover, time study is a costlier technique of work measurement particularly in case of non-repetitive work. Because of these factors, the technique of activity sampling is gaining popularity.

Work sampling is based on the statistical method first devised by Tippet in 1934 who used this method for determining the causes of loom stoppages while working for the British Cotton Industry Research Institute. *Work sampling is a fact finding tool and a measurement technique for quantitative analysis in terms of time, of the activity of operators, machines or of any observable state or condition of operation.*

This tool is particularly useful when information s urgently needed about men or machines, especially in the analysis of non-repetitive or irregaularly

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occurring activity where no complete method and frequency description is available. Work sampling can be used to study almost any type of work; repetitive or non-repetitive, factory or office, executive or supervisory, clerical or engineering, handlers, salesmen, nurses and what you have?

Activity sampling involves direct personal observation of time taken in the performance of an operation by a worker or a group of workers. The observations are taken on random basis in the normal course of business. Activity sampling is less accurate and less objective as compared to the stop watch time study. The sample observations may not be representative. Nonetheless, work sampling is simpler, more economical as compared to time study. Workers do not show resistance. It helps in determining not only the type and amount of activity of the operators, but also the active and ideal periods of the machines. Thus, work sampling technique helps in bringing improvement and increasing efficiency of the entire unit.

Work sampling provides a way to :

(*i*) obtain information about either certain long cycle work or non-repetitive type of jobs for which it would be clearly impractical to use continuous observation methods,

(*ii*) indicate it certain activities should be studied in details.

(*iii*) help design the work, load distribution in formulating a new work system,

(*iv*) study any operation for possible methods improvement,

(*v*) help establish job content as an aid to job evaluation and employment purposes,

(*vi*) aid supervisors to organise their time,

(*vii*) aid appraisal of shop effectiveness, efficiency, safety performance, etc.,

(*viii*) provide feedback information about compliance to stated management policies,

(*ix*) assest in establishing standards of performance, and

(*x*) establish control on labour, material or machine utilization,

Use of Probability

Based upon the law of probability, it can be said that a sample taken at random from a large group tends to have the same pattern of distribution as the large parent group and if the sample is large enough, the characteristics of the sample will differ very little from the characteristics of the parent group or population. Sampling is the analysis of the characteristics of a population based on the analysis of a small group collected at random from it.

The sampling process should be completely unbiased and each part comprising the population must have an equal chance of being drawn. This can be ensured

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the help of random sampling. It is necessary to decide before hand what level confidence is desired in the final work sampling results. The most commonly confidence level is 95% which means that one is confident that 95% of the the random observations will represent the facts and that 5% of the time they not.

For 95% confidence level, a relationship exists between the number of vations (N), the extent of the phenomenon being observed-expresed as decimal and the accuracy of the sample results (s). This is given below: (If p = 25% s = ± 4%, it means the value of N calculated out would be valid for the range as 25% ± 4% of 25 *i.e.*, 24% to 26% at the said confidence level).

For 95% confidance level :

$$sp = 2\sqrt{\frac{p(1-p)}{N}} \quad \begin{cases} \text{For 70\% confidence level,} & sp = \sqrt{\dfrac{p(1-p)}{N}} \\ \text{For 99\% confidence level,} & sp = 3\sqrt{\dfrac{p(1-p)}{N}} \end{cases}$$

antages of Work Sampling

(*i*) The activites which are costly to measure by time study can be measured readily by work sampling.

(*ii*) A single observer can make work sampling study of several operators or machines.

(*iii*) The cost and time involved in work sampling study is quite less as compared to that required for continuous time study.

(*iv*) A work sampling study may be interrupted at anytime without affecting the results.

(*v*) There is less chance of obtaining misleading results as the operators are not under close observations.

(*vi*) Work sampling studies are less tedious and cause less fatigue to the observer.

(*vii*) Stop watch or other timing devices are not required for work sampling studies.

Limitations of Work Sampling

(*i*) Work sampling does not permit finer breakdown of activities and delays. It can't provide much detailed information.

(*ii*) It is practicable only when a large number of operators are observed, or for studying operators or machines located over wide areas.

(*iii*) In certain kinds of work sampling studies, the record of method used by the operators is not made. Therefore, whenever a method change occurs in any element an entirely new study must be made.

(*iv*) Management and workers may not understand statistical work sampling as readily as they do time.

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Main uses of work sampling are as follows:

(*a*) It measures the working and idle time of people and machines.

(*b*) It determines delay allowances.

(*c*) It estimates the rate of utilisation of machines and equipment.

(*d*) It measures a task for establishing a time standard for it.

(*e*) It estimates the percentage of time devoted to each of the duties involved in the job.

7.4 SYNTHETIC (PRE-DETERMINED) TIME STANDARDS

Synthetic standards are predetermined time standards for performing certain common operations developed by various research institutions. These standards can be used by an undertaking without undergoing the procedure of time study. Synthetic time standards are available only for a limited number of motions common to the most industrial operations. Two important motions systems which give time values for fundamental motions are *Method Time Measurement* (MTM) and *Work Factor* (WF), MTM consists of catalogue of work motions with a table of time values for each. Similarly, work factor also provides a table of time values for various skilled and unskilled operations. It may be noted that these systems are based on the assumption that the time for performing a job is the sum of times taken by the constituent motions, if the time for each fundamental motion is not affected by the nature of the previous or future motion.

Thus, predetermined time standards are standard data systems for a wide variety of basic body motions that are common in most of the industrial operations. These standards have been developed by research and technical institutions after intensive investigations. In all human work, there are common elementary human motions, *e.g.*, move, reach, position, and so forth. Predetermined time standards contain tables of standard time values for such motions. Mannual work in industry consists of different combinations of these basic motions.

Predetermined time standards offer several *advantages:*

(*i*) These standards are readymade. They save time and cost of time study.

(*ii*) Time standards for most of the manual activities can be determined from these standards as the standards are available for a wide variety of elements.

(*iii*) Time standards offer a precise means of recording the subjective judgement or bias of the rater.

(*iv*) This method involves no interference in the normal work routine and faces little resistance from the workers.

(*v*) Any change in the method can be immediately identified due to detailed breakdown.

(*vi*) In order to use these standards, the engineer must analyse the job in detail and this automatically helps him to discover any defective methods existing in the study.

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7.4.1 Predetermined Motion Time and Systems (PMTS)

This is defined as "A work measurement technique whereby times established for basic human motions (classified according to the nature of motion and the conditions under which it is made) are used to build up the time for a job at a defined level of performance.

It is possible to produce standard data which can be of universal use. Such a data are usually collected from the micromotion analysis of films made on large number of jobs. The operations themselves are broken into therbligs to which the standard values are given.

Thus, if an operation is analysed into basic motions and each of these motions is evaluated, it is possible to determine the time values for the whole of the operation. This is the basis for PMTS.

PMTS in other words are techniques for synthesising operation times from the standard time data for basic elementary motions comprising the operation.

The nature of PMTS can be illustrated by the simple example of the work cycle involved in putting a washer on a bolt. The detailed critical analysis shows the following elementary operations carried out: operator reaching the washer, grasping the washer, moving the washer to the bolt, positioning it on the bolt and releasing it.

Some of the commercial PMTS which give time values for fundamental motions and are now used in industry are:

1. Method Time Measurement (MTM).
2. Work Factor (WF).
3. Dimensional Motion Times (DMT).
4. Basic Motion Time (BMT).
5. Motion Time Analysis (MTA).

7.4.2 Method Time Measurement MTM

One of the systems of PMTS is MTM. It is a procedure which analyses any manual operation or method into the basic motions required to perform it and assigns to each motion a predetermined time value by the nature of motion and the conditions under which it is made.

MTM was developed from motion picture studies on industrial operations and the time standards were established in 1948, the time unit is known as TMU. One TMU = 0.0006 minute.

Basically, MTM is a tool of method analysis that provides answer in terms of time without the use of stop watch. There are a number of different motions such as Reach, Move, Turn, Grasp, etc. Each motion is given a number such as case A for Reach, which is to reach for object in a fixed location. A table of distance is given with values which vary according to whether the hand is in motion or not and so on. Such tables are prepared on the basis of research.

For a particular operation when all motions have been identified, classified and recorded, the time values for each are determined from the MTM data. The

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sum of these motion times is the time an operator of average skill would take to perform the task which is the representative time for that operation. By adding proper allowances to the representative time, standards can be set up very accurately.

TABLE : 7.2: Comparison of Work Measurement Techniques

Basis	*Stopwatch Time Study*	*Predetermined Time Standard*	*Work Sampling*
Type of Standard	• Very accurate for the repetitive task	• Extremely accurate for repetitive task	• Fairly accurate for both short and long cycle operations
Produced	• Tight standard	• Very tight standard	• Loose standard.
Advantages	• Accurate • Speedy applications • Generates detailed information	• Accurate • Speedy application • Generates detailed information	• Ease of application • Employees' reaction is favourable • May be used for the long cycle operations.
Limitations	• Chances of employees resistance • Not suited for work requiring long cycle • Not suited for mental work • Chances of subjective levelling.	• Specialised training is needed • Not suited for long cycle • Not suited for mental work.	• Lacks detailed information • Needs long sample period. • Difficult to explain and justify this technique.

MTM can be used for the following purposes:

(*i*) Developing effective methods before starting production.
(*ii*) Improving existing methods.
(*iii*) Establish time standards.
(*iv*) Training of supervisors to become method conscious.
(*v*) Training of operators
(*vi*) Determining incentives, wage rates, etc.
(*vii*) Research in operating methods, training and performance rating.

7.4.3 Work Estimation or Analytical Estimation

Work estimation or analytical estimation is a work measurement technique whereby the time required to carry out elemens of a job at a defined level of performance is estimated from knowledge and practical experience of the elements concerned. This technique is used primarily for longer-cycle jobs and for jobs containing variable elements.

Examples of such jobs are found in office routines, stores duties, engineering and mainenance where the jobs are seldom repeated. For example, a fitter may

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one nut easily in one minute. But the next nut may be rusted and may take minutes to remove. Similarly, a typist will probably never type the same letter Therefore, a standard time for an averge letter or page of typing may be set.

As in other techniques, the job is broken into basic elements, but the elements comparatively of longer duration. Skilled and experienced craftsmen are to estimate the time involved in each element. The trained estimators time for each element based on the standard. Performance times are estimated basis of the estimator's experience. When all the element times are recorded, are added together and basic time for the job or operation is calculated. ation and other allowances are then added to find out the standard time.

Work estimation is a simple and inexpensive technique of work measurement. and costs involved are nominal. But it is a slightly less precise technique greater reliance on human judgment. There are several practical problems application of analytical estimation. The guidance of work study expert is ial. The success of this technique depends on the knowledge, experience, acter and judgment of the estimators. A thorough training of craftsmen in and motion study is, therefore, a prerequisite to work estimation.

5 APPLICATION OF WORK STUDY TO OFFICE

Work study is an important tool in the hands of management for achieving er productivity in the organisation. *It is an analytical study of the use of ers, materials and equipment in order to improve existing methods and work rmance by elimination of every type of waste.* Taylor recommended the nique of time study or work measurement and determination of time standards. reths devised the technique of motion study to carry out the work study. It be mentioned that motion study also includes fatigue study to eliminate cessary fatigue. Thus, work study covers both time study and motion study work measuement and work improvement.

The objectives of work study are listed below:

1. Effective use of manpower.
2. Effective use of methods, machines and equipment.
3. Efficient layout of plant.
4. Elimination of unnecessary human motions.
5. Simplification and standardisation of operations.
6. Measurement of time required to perform an operation and establishment of standard level of performance of each worker.

Work Study involves method study (*i.e*,, work simplification) and work rement (time study). Work measurement has limited application in office because of the following reasons:

(i) It is not possible to rate a clerk engaged in mental activities.

(ii) It is uneconomic to measure non-repetitive types of clerical work.

(iii) A number of clerical activitiees cannot be quantified and so the final output cannot be ascertained.

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(*iv*) It is usually difficult to lay down quality specifications for clerical work.

(*v*) It would be difficult to implement work measurement results in office work because of the fluctuating work load.

Some examples of the types of office work which can be measured include:

(*i*) Signing documents.

(*ii*) Mailroom operation (such as fixing stamps on envelops).

(*iii*) Ledger posting or other simple tabulations.

(*iv*) Word processing.

(*v*) Counting cash.

The techniques applied for measuring office work include:

1. Work sampling.
2. Stopwatch time study.
3. Predetermined motion time standards.
4. Standard Data.

The need for simplifying office work is greater today because of mechanisation and automation of office work. Work simplification leads to efficient and economical operation in the enterprise. It improves work efficiency as well as human comfort and satisfaction. If human facor is not given due consideration, there may be decrease in efficiency despite the improvement of work methods, materials, machines, etc. Therefore, work simplification programme should not overlook the importance of human factor.

A well designed work simplification programme leads to the following advantages :

(*i*) It simplifies office procedures and methods by eliminating unnecessary forms and details. It provides means which give any person a better and clearer insight into what work is and what it is comprised of.

(*ii*) It leads to economy in the use of office machines and equipment needed. There is fuller utilisation of machines and equipment through uninterrupted runs.

(*iii*) It reduces labour costs through increased specialisation and better training.

(*iv*) There is improvement in communication at all levels of management as a result of simplification of office forms and procedures.

Organising the Work Simplification Programme

The task of work simplifcation or systems and procedures analysis is very challenging. It may be asigned to the Office Manager who performs this function alongwith other duties. In some organisations, there is a separate staff department (may be known as Systems and Procedures Analysis Department or Organisation and Methods Department) to carry out the work simplification programme. A big organisation may also employ a firm of management consultants to make detailed surveys of office systems and procedures. The choice of anyone of the three alternatives will depend upon the requirements of each organisation.

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Analysing the Office Systems and Procedures

It may also be called '*work study*' which means an analytical study of the use of workers, materials and equipment in order to improve existing methods and work performance by elimination of every type of waste. Taylor recommended the technique of time study for work measurement and determination of time standards. Gibreths designed the technique of motion study to carryout the work study. Thus, work study covers both time study and motion study for work measurement and work simplification. Work simplification involves analysing the existing methods of doing an operation to simplify office systems and procedures.

Work Measurement

Work measurement establishes time standards for doing various jobs. The time standards so set help in planning and controlling the operations. The basic objective of work measurement is to facilitate planning and controlling of office operations.

In addition, work measurement can be used for the following purposes:

(*i*) To determine standard workload for each worker.

(*ii*) To determine manpower needs or the number of persons required.

(*iii*) To measure efficiency of employees, a department or the organisation as a whole.

(*iv*) To serve as a basis for incentive wages.

(*v*) To help in simplifying office systems and routines.

Importance of Work Measurement

Work measurement is indispensable in carrying out the control function. It is an important management tool to control the size of workforce and improve the efficiency of office staff and thereby control the labour cost. Work measurement can be used as a basis of incentive scheme in order to motivate the workers for better performance. Work measurement provides the relevant data for efficient work planning and control. Without work measurement, the manager cannot control the performance of workers. It is also not possible to lay down sound plans if there is no scheme for work measurement.

Work measurement can be sued for effective allocation of work to workers and for preparing work schedules. Proper manning of various machines is also facilitate by work measurement. Lastly, work measurement can be used in sending quotations as it makes it possible to know the time and cost involved in the proposed piece of work.

7.5.1 Techniques of Work Measurement in Office

Subjective Judgment. This method is also known as rule of thumb method under which standards are set up by guess work or subjective judgment. This method is, generally, neither precise nor accurate because of biasness of the manager and lack of complete information.The standards are based on experience and intuition of the manager. They cannot be verified scientifically.

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Past Performance. This method is based on the records of past performance of various types of office operations. The records of performance may be kept by the supervisor concerned or by the workers themselves. The records are studied to know about the best performance for each type of work. This acts as the basis of setting standards of performance. The logic behind this method is that "we did it before, we should be able to do it again." In other words, this method can be used to determine what performance can be achieved during a particular time period? This method cannot determine the amount of time a job should take. This is the main drawback of this method.

Time Study. Time study is a very useful device of work measurement. It is the art of recording and analysing systematically the time required to perform a motion or a series of motions. This definition suggests that time study is to be conducted after a motion study has been undertaken. Time study attempts to determine a standard day's work by finding the amount of time needed by workers to perform the various operations. The purposes of time study are to provide production data and to provide incentives. Time study is carried out by studying a worker or a group of workers and carefully measuring with a stop watch how long it takes to perform each operation on the job.

It is a must to do motion study first so that during the time study workers are using only those motions that are necessary and most desirable. If time study is done without motion study and rates of wages are set on the basis of he time study, workers may adopt a method of work which will fetch them higher pay. After times have been measured for the various operations of a job, allowance should be made for fatigue and visits to attend to necessary calls.

The need for time study arises whenever a better method of doing a work is to be introduced. It is the time study which will help in knowing a fair day's work which an employee should do. The determination of a fair day's work or standard task is based on the complete knowledge of the necessary motions needed to do a job. A time study board and a stop watch are used to observe the time required to do each operation.

Activity or Work Sampling. Activity sampling involves direct personal observation of time taken in the performance of an operation by a worker or a group of workers. The observations are taken on random basis in the normal course of business. Activity sampling is less accurate and less objective as compared to the stop watch time study. The sample observations may not be representative. Nonetheless, work samplinng is simpler, more economical as compared to time study. Workers do not show resistance. it helps is determining not only the type and amount of activity of the operators, but also the active and ideal periods of the machines. Thus , work sampling technique helps in bringing improvement and increasing efficiency of the entire department.

Synthetic (Pre-determined) Time Standards. Synthetic standards are predetermined time standards for performing certain common operations developed by various research institutions. These standards can be used by an undertaking without undergoing to procedure of time study. Synthetic time standards are available only for a limited number of motions common to the most operations.

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important motion systems which give time values for fundamental motions *Method Time Measurement* (MTM) and *Work Factor* (WF). MTM consists of ique of work motions with a table of time values for each. Similarly, work also provides a table of time values for each. Similarly, work factor also ides a table of time values for various skilled and unskilled operations. It may ted that these systms are based on the assumption that the time for performing is the sum of times of all the constituent motions, if the time for each mental motion is not affected by the nature of the previous or future motion.

3.2 Organisation and Methods (O & M)

O & M refers to the systematic attempt on the part of an organisation to ove organisation, simplify and improve methods and maintain office inistration at a high level of efficiency. It is the scientific checking on the iciency of office work. Organisation and Methods covers everything that ributes to efficiency, but in particualr it deals with office organisation, office em, methods, machines and equipment, office layout and work measurement. is through O & M that office operations and procedures are continuously oved, work simplification is possible and efficiency and economy are achieved.

The *objectives* of O & M are as fillows:

(i) All unnecessary operations should be eliminated;

(ii) All operations which can, with advantage, be combined should be so combined;

(iii) All operations should be made as simple as possible;

(iv) Most efficient procedures for all types of office work should be established;

(v) The cost of office operations should be minimum possible;

(vi) All operations should be in their right sequence so that their is no back-tracking; and

(vii) The flow of work should not only be fast but also have an even tempo.

3.3 Setting up O & M Department

A separate department may be set up by large concems for carrying out the ctives of O & M. However, O & M work can also be performed by the ervisors, particularly in small organisations, provided their efforts are co-inated by some higher management authority. Setting up a separate O & M rtment in *necessary* because of many reasons. The officer-in-charge of the O M department will have definite responsibility and so the will analyse the work ctively and independently. O & M department will be a specialised department provide efficienty service to all other departments.

O & M department will adopt the following *procedure:*

(1) Determination of *objects* of the assignment and defining them in writing as far as possible.

(2) Drawing up a *plan of work* indicating the general and specific purposes of the tasks involved, the nature of information to be obtained and sources of information to be tapped.

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(3) Making a *detailed examination* of the existing procedures to ascertain:
(*a*) the purpose of each operation and the methods of doing it;
(*b*) skill required for efficient performance;
(*c*) persons engaged in the operation;
(*d*) the place of doing the work;
(*e*) flow of information used in the performance of the operation with special reference to the time of performance;
(*f*) forms used in relation to the procedure and the number of documents handled in normal and peak hours;
(*g*) nature and frequency of occurrence of the transactions;
(*h*) nature and degree of supervision needed;
(*i*) degree of mechanisation; and
(*j*) cost of operations.
(4) Making a detailed *study of the sources of information to* ascertain :
(*a*) the mode of preparation of document, *i.e.*, prepared either manually or with the help of machines;
(*b*) origin of internal and external documents and information;
(*c*) degree of accuracy of information desired and actually obtained ; and
(*d*) promptness with which the information is required and the causes of delay.
(5) Designing a new or modified procedure and preparation of report.

Review Questions

Short Answer Questions

1. Explain he concept of work measurement.
2. What are the steps in time study ?
3. What are the benefits of time study ?
4. In what respects is motion study different from time study ?
5. What are the benefits of time study?
6. What are synthetic time standards?

Long Answer Questions

1. What is work measurement ? Discuss the techniques of work measurement.
2. Discuss the meaning and significance of work measurement in an industrial enterprise. Explain the stop watch method of work measurement.
3. What do you understand by time and motion study? How can their application increase productivity of labour ?
4. Differentiate between time study and motion study. Discuss the benefits and limitations of time study.
5. Explain the steps in time study.
6. Explain the benefits and limitations of time study.
7. Write short notes on the following:
   (*a*) Work measurement (*b*) Time study (*c*) MTMS.

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Chapter 8

QUALITY CONTROL AND CONTROL CHARTS

CHAPTER OUTLINE

8.1 Concept and Determinants of Quality

8.2 Quality Control

8.3 Statistical Quality Control

8.4 Control Charts

8.5 Zero Defect

8.1 CONCEPT AND DETERMINANTS OF QUALITY

According to International Organisation for Standardisation (ISO), "Quality means the totality of features and characteristics of a product or service that bear on its ability to satisfy stated or implied needs". While earlier quality meant product specifications and test reports, today it refers to the entire organisation—its systems, strengths and ability to deliver cost effective and consistency good products or services. In simple words, quality means meeting the customer or client needs everytime.

8.1.1 Factors Influencing Quality (Determinants of Quality)

The factors affecting quality are interrelated and interdependent and it is a difficult task to evaluate the influence of each individual factor on the product quality of industrial units. The impact of certain important factors is briefly examined below :

(*i*) **Technological Advancement.** Technological developments play an important part to influence quality. The technological factors include degree of

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mechanisation, technical knowhow, product design, etc. Improvement in any of the technological factors will contribute towards increasing the quality. In India, introduction of semi-automatic and automatic machines, improvements in the production processes, better integration of production processes and higher degree of specialisation have contributed a lot towards the increase in quality.

(*ii*) **Quality of Human Resources.** The human resources play a significant role in raising standards of quality in most of the industries. If the employees are not adequately qualified and/or not properly motivated, all the steps taken to increase quality will have no result. Three important factors which influence the quality of work are : (*a*) quality of the worker, (*b*) willingness of the worker, and (*c*) the environment under which he has to work.

(*iii*) **Availability of Funds.** The ambitious plans of an industrial unit of increasing quality will remain mere dreams if adequate financial resources are not available to introduce new technical improvements and give appropriate training to the workers. The greater the degree of mechanisation to be introduced, the greater is the need for capital. Capital will also be required for investment in research and development activities, advertisement campaign, better working conditions to the workers, unkeep of plant and machinery, etc.

(*iv*) **Management Commitment.** Professional managers are required to make better use of the new technology to improve quality. Since the modern enterprises are run on a large scale, the managers must possess imagination, judgement and must be willingness to take initiative to create better quality products.

(*v*) **Natural Factors.** The natural factors such as physical, geographical and climatic exert considerable impact on quality. The relative importance of these factors depends upon the nature of the industry, goods and services produced and the extent to which physical conditions controlled.

8.1.2 Steps to Improve Quality

The following measures should be taken to increase quality :

(*i*) **Improved Raw Materials.** Raw materials of right quality should be procured by every industrial unit. This will reduce wastage and increase the productivity of workers and machines.

(*ii*) **Better Technology.** Latest machines and equipment should be procured by the industrial units as they are more efficient and economical. The industrial units using old machines produce low quality and so can't complete with those units using new technology.

(*iii*) **Scientific Selection of Workers.** In order to handle various positions in the organisation, right type of employees should be appointed. They should also be provided adequate training in the use of raw materials, machines, etc.

(*iv*) **Good Working Conditions.** There should be proper arrangements of lighting, ventilation, cleanliness, cooling and heating of workplace. If these arrangements are not proper, quality is likely to be low.

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(*v*) **Harmonious Relations.** There should be industrial peace in the organisation. Cordial relations between the workers and the management are key to higher quality. Higher quality targets can be achieved if there are minimum possible conflicts between the workers and the management.

(*vi*) **Quality and Cost Consciousness.** Both the workers and the management should be conscious about cost and quality. This will reduce unnecessary wastages in the production process.

(*vii*) **Industrial Research.** The government should encourage industrial research by the industrial units and research institutions. New methods and techniques of production will increase the quality of products produced.

8.2 QUALITY CONTROL

The word 'quality' refers to the degree of excellence of a product. In other words, the quality of a product means the degree of excellence of the characteristics it possesses. It is a relative term, like high, low, or inferior grade or in terms of conformity with certain specifications. The word 'control' is used to denote the process of setting standards, measuring the performance and taking corrective action. *"Control of quality deals with the determination of quality standards and measurement and control necessary to see that the established standards are maintained and practised."*

Quality control is the function of ensuring that the product quality conforms to predetermined standards. Quality standards, relate to various aspects of product such as dimensions, weight, colour, appearance, durability, ductility, plasticity, tensility, resistance to rust, viscosity, shrinkage, resistance to abrasion, etc. Deviations from standards occur due to variability in materials, machines, operating conditions, and men.

8.2.1 Areas of Application of Quality Control

Quality Control can be applied to the following areas :

(*i*) **Products.** Quality control of final products is very common. Quality standards are determined well in advance and range of deviations from the standards is also decided. Actual products are compared with the standards to ensure that only goods meeting the standards are sold to customers.

(*ii*) **Processes.** Production processes and equipment are inspected from time to time to ensure their better working. Quality standards are kept in mind while buying any production process or equipment.

(*iii*) **People.** Quality control is also applicable to people or employees who are an important part of any industrial enterprise. If the employees are not properly trained, goods produced by them will not be of the required quality. Thus, quality control needs to applied to the training of employees.

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Quality control is concerned with :

(*i*) determining tolerances, *i.e.*, range within which deviations in actual quality from standards will be acceptable ;

(*ii*) conducting inspections and tests of materials, processes and products,

(*iii*) separating acceptable units from the ones which do not conform to quality standard;

(*iv*) drawing management's attention to conditions which adversely affect quality; and

(*v*) advising management on ways and means of improving the quality.

A good quality control programme involves the following steps :

(*i*) Establishing the standards and specifications of products on the basis of the preferences of the customers and the cost of manufacture.

(*ii*) Design and use of measures for making production conform to the standards.

(*iii*) Selection of the process of manufacture.

(*iv*) Establishing a logical inspection plan and collection and analysis of data. It also includes evaluation of methods and processes of manufacture.

(*v*) Coordination of activities to improve the quality.

8.2.2 Significance of Quality Control

The importance of quality control has been described by Frank M. Steadman in the following words. "Without quality control you, as a producer or purchaser, are in the same position of the man who bets on a horse-race with one exception, the odds are not posted. Statistical quality control will give you the tools and your materials. It will tell you at what level and with what variation you are operating and, more important, it will tell you when your process, tools or materials change from that level and range of variability—possibility most important of all will be the change in outlook on your purchases or production, and the inspection of both".

The following benefits can be derived from the efficient system of quality control :

(*i*) Quality control brings quality consciousness in the enterprise which discourages the manufacture or production of sub-standard products.

(*ii*) Quality control ensures better utilisation of resources.

(*iii*) Quality control helps in providing greater satisfaction to customers. If the customers are satisfied, the sales are increased.

(*iv*) Since there is less waste, the cost of production is reduced.

(*v*) The morale of the employees is increased. They feel that they are working in an enterprise producing goods of higher quality.

(*vi*) Quality control creates a good public image of the enterprise by helping it to provide goods and services of the higher quality to the society.

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8.2.3 Functions and Scope of Quality Control

The major functions of the quality control department are as follows :

(*i*) It helps top management in making the strategic product quality decision.

(*ii*) It coordinates with design engineers who design the product, and specify tolerances for components, parts, and finished products.

(*iii*) It coordinates with industrial engineers who design tools and equipment, and determine standards of performance.

(*iv*) It coordinates with construction engineers who construct plant and equipment.

(*v*) it inspects and tests materials, tools, parts, etc., purchased by the purchasing department.

(*vi*) It inspects and tests components, parts, sub-assemblies and final assembly at various stages in the manufacturing process so as to prevent further processing of defective material and parts.

(*vii*) It identifies and analyses causes of deviations from standards at various stages of production and advises line management on preventive measures.

(*viii*) It inspects the final product before it is dispatched to store or warehouse for stocking, or to customers.

Quality control function is thus not confined to performing inspections and tests of materials, parts and products, and weeding out the sub-standard ones from those which meet standards. It also participates with other engineers and managers in establishing quality standards, and more importantly, in improving quality and reducing scrap losses. It is becoming increasingly concerned with providing customers true product reliability. Quality control, therefore, applies not only when products finally move out of the assembly line but through all stages of production including strategic product quality decision, product design, product engineering, plant engineering, purchasing and manufacturing.

BOX 8.1 : Tools of Quality Control

Quality control department uses the following tools for performing its functions :

1. Standards and specifications relating to various product features and performance.
2. Inspection and testing of raw materials, tools, processing equipment, parts, sub-assemblies and products.
3. Inspection and testing of measuring tools and devices such as sgauges, automatic electronic sorters, electron tubes, radiography equipment, magnetic testing devices, in-process control devices, closed-circuit industrial television (ITV), etc.
4. Statistical techniques based on probability theory and control charts.

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8.3 STATISTICAL QUALITY CONTROL

The technique of statistical quality control (SQC) was first developed by the Bell Telephone Laboratories and Western Electric Company in the 1920's and it started gaining wide acceptance in 1940's. Statistical Quality Control uses sample inspection instead of 100 per cent inspection which is not only costly and time consuming but also impractical in case of destructive tests. The items for inspection are selected on the basis of the techniques of random sampling so that each unit has an equal probability of being drawn and the sample is representative of the universe—it has the same characteristics as the lot from which it is drawn.

Statistical Quality Control (SQC) applies statistical tools to testing or inspection. It is based on the theory of probability. Statistical Quality Control makes sample inspection more reliable. In case of sample inspection, a small part of a certain lot of products is inspected and its quality is assumed to be the quality of the lot. This is called *statistical inference*. The characteristics of the whole lot of population are inferred to be like the sample. Sampling may prove to be risky because of the possibility that a sample may not have exactly the same characteristics as the lot.

Sampling is very useful if it is reliable. It eliminates 100% inspection and is the only possible method for products which must be tested until they fail or break. It is also the only method to test the chemical characteristics of liquids and powdered materials or the thickness gauge of sheet metal, paper and cloth. Sampling saves money as well as time.

Statistical quality control deals with samples and their reliability as the indicators of the characteristics of the lot. The objectives of statistical quality control are to show how reliable the sample is and how to control the risk associated with sampling technique. According to Moore and Hendrick, "Statistics quality control has three general uses : (1) to control the quality of work done on individual operations while the work is being done, (2) to decide whether to accept or reject lots of products already produced (whether purchased or made within the company), and (3) to furnish management with a quality audit of the company's products."

Statistical Quality Control is based on the assumption that quality measurements of the diameter of a sample of radio values, will vary within narrow limits from the standard, and most of the measurements will be close to the arithmetic mean of the size. Suppose this diameter standard is one inch with tolerance of 0.002, expressed as 1 ± 0.002. It means that diameter variations between 1.002 and 0.998 are acceptable. if variations in diameter occur only due to chance variables, and not assignable variables, actual measurements will vary between 1.002 and 0.998, and most of them will be 1,000.

If the frequencies of measurements of diameter, *i.e.*, the number of times each measurement occurs, are plotted on a graph, it will take the shape of a

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symmetrical bell-shaped curve, as shown in Fig. 8.1. It is called **normal distribution curve.** Normal distribution curve has the following properties :

(*i*) it has a single peak or node;

(*ii*) most of the frequencies tend to be around arithmetic mean of frequencies, measured by $\Sigma \frac{x}{n}$;

(*iii*) the curve is symmetrical around the centre; and

(*iv*) the range of deviations below and above the central value, is equal.

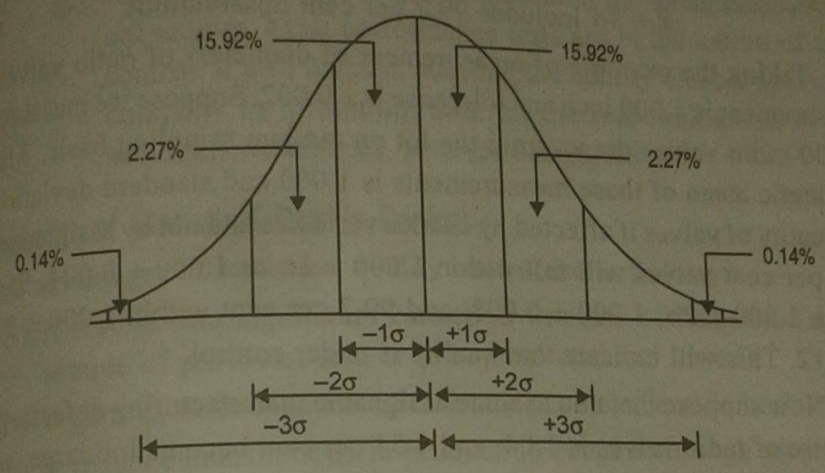

Fig. 8.1 : *Normal Distribution Curve.*

Two measures are needed for the application of probability theory to quality control—arithmetic mean and standard deviation. As indicated earlier, mean is estimated by the following formula.

$$\bar{x} = \frac{\Sigma x}{n}$$

where $\bar{x}$ is arithmetic mean of the frequency distribution of measurements in a simple size of n.

A second measure is needed to show the degree of dispersion of the values (measurements in our illustration) around mean. This measure of dispersion is standard deviation is which is computed by taking squareroot of the mean of squared deviations from the mean. Standard deviations is estimated by the following equation :

$$\sigma = \sqrt{\Sigma\left(\frac{x_i - \bar{x}}{n}\right)}$$

where σ = standard deviation or measure of dispersion

x_i = value of x for ith observations (measurements) in the sample,

$i = 1, 2, ..., n$

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$\bar{x}$ = mean value of x for the sample = $\Sigma \frac{x_i}{n}$

n = number of observations in the sample.

As shown in Fig. 8.1,

$\bar{x} \pm 1\sigma$ covers 68.3 per cent of the area of the normal distribution curve, *i.e.*, 68.3 per cent of observations or measurements will be covered by it.

$\bar{x} \pm 2\sigma$ includes 95.5 per cent observations, and

$\bar{x} \pm 3\sigma$ includes 99.7 per cent observations.

Taking the example of measurement of diameters of radio valves, standard measurement is 1.000 inch and tolerance is ± 0.002. Suppose we measure diameters of 500 radio valves drawn from the lot on random sampling basis. Also suppose arithmetic mean of these measurements is 1.000 and standard deviation 0.004. If the quality of valves if affected by chance variables and not by assignable variables, 68.3 per cent valves will fall within 1.000 ± 1σ or 1.000 ± 0.004, 95.5 per cent within 1.000 ± 2σ, 1.000 ± 0.008, and 99.7 per cent within 1.000 ± 3σ or 1.000 ± 0.012. This will indicate that quality is under control.

Now suppose that due to some assignable manufacturing defects, the average diametre of radio valves is 1.04, and 4.54 per cent become too large, as shown in Fig. 8.2. It will indicate that quality is out of control due to high rate of rejections. This deviation from standards can be controlled by adjusting or changing a worn out machine tool or rectifying other processing defects. This shows that SQC aids in the identification and prevention of deviations from standards. These statistical techniques can also be used for controlling production costs, sales volume, etc.

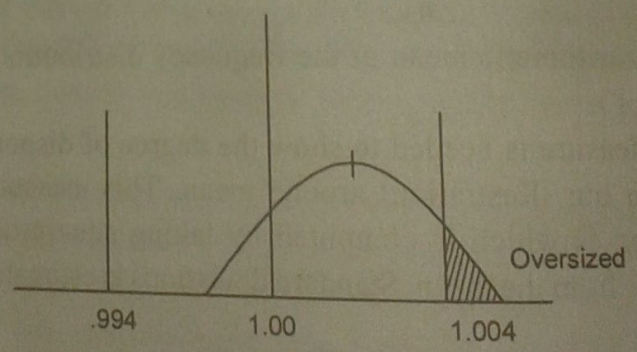

Fig. 8.2. *Variations from Standards : Too Many Oversized.*

Statistical quality control has several uses :

(*i*) It aids in controlling the quality of work in the process of manufacturing. This is called variable control. It deals with average of measurements and range of deviations. Measurements of size, strength of welding points, tensile strength of metals, etc. are variable control measures ;

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(*ii*) It aids in deciding whether to accept or reject lots of materials purchased or products already manufactured. This is called attribute control. It is very important in acceptance sampling, which has been discussed later. It is used :

(*a*) when materials, parts, products are to be separated on the basis of acceptability of quality ;

(*b*) when it is not possible to measure characteristics of the item, and the inspector has to use his judgement, for example, in decision relating to the acceptability of shine on furniture;

(*c*) when a characteristic can be measured but exact measurement is not require. Most performance tests are in the nature of attribute control. It also helps in auditing the quality control system of the company by providing data on the reasonableness of quality standards, tolerances, product design, etc.

8.3.1 Benefits of Statistical Quality Control

The advantages of statistical quality control are as follows :

(*i*) It results into significant reduction in costs of inspection as only a sample of products, etc., is to be inspected and tested ;

(*ii*) It permits determination of toleratnces on a scientific basis ;

(*iii*) It reduces interruptions in production process through more effective process control ;

(*iv*) It also reduces scrap losses through more effective process and attribute control ;

(*v*) It is the only way of performing destructive tests, such as tests of product life, strength of welding points, texile strength, chemical tests of liquids, etc. All these tests destroy the product. In such cases 100 per cent test is impossible ;

(*vi*) It shows the reliability of samples, and helps management in determining the risk it is willing to take ;

(*vii*) It makes operatives and supervisors more quality conscious by placing control charts at the operations, and letting them measure and plot the characteristics of their outputs.

(*viii*) Enhances the goodwill of the enterprise among the customers. It also increases the morale of the workers as they get satisfaction by working in a firm producing higher quality products.

8.3.2 Limitations of Statistical Quality Control

Despite the many advantages which SQC has over 100 per cent inspection method, it has some limitations. These limitations generally occur when the sample

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is not representative of the universe, *i.e.*, when the sample does not have the same characteristics as the lot from which it is taken. In case the lot is of a big size, sample taken from one or a few of its sections may not be representative of the lot. Tests of coal for its heating properties need repeated sampling because all of its sections are not homogeneous. Liquids are also generally characterised by lack of homogeneity. Randomisation is also subject to the honesty of inspectors. They even sometimes connive with line supervisors and take sample from the top of the tote pan while the defective pieces have been hidden in its bottom.

When sample is not representative of the lot, it is possible that a good lot will be rejected and a bad one accepted. If inspectors reject a good lot of purchased materials or parts, it does not hurt their company. On the other hand, the vendor (supplier) sends it again to the same company or another company with a second or third consignment. He keeps on repeating this process until all his good lots are accepted. But the real harm is done by faulty sampling when a poor lot is accepted. It may cause production of sub-standard products.

8.4 CONTROL CHARTS

A control chart is a statistical tool for indicating variations in quality from standards. When measurements are plotted on a graph, they indicate whether variations from standards are within tolerance limits, or getting out of control. Control charts are used for controlling the quality of manufacturing operations as well as finished products. In other words, they are used both for **variable** and **attribute control.** In case of in-process or variable control, control charts indicate the points in the manufacturing process where the quality variations are in excess of high and low tolerance limits so that preventive action may be taken. In case of quality control of finished products, materials, etc. (attribute control), control charts indicate whether the number or percentage of rejections is within or outside the acceptable limits. The commonly used control charts are Mean ($\overline{X}$) Chart, Range (R) Chart, Defective (P) Chart, and Defects per Unit (C) Chart.

8.4.1 Types of Control Charts

The following two types of control charts are usually used :

(1) **Control Charts for Variables :** These charts are used to achieve and maintain an acceptable quality level for a process, whose output product can be subjected to quantitative measurement or dimensional check such as size of a hole *i.e.* diametre or depth, length of a screw/bolt, wall thickness of a pipe, etc.

(2) **Control Charts for Attributes :** These charts are used to achieve and maintain an acceptable quality level for a process whose output products are not subjected to dimensional or quantitative measurement but can be classified as good or bad or acceptable and non-acceptable, for

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example surface finish of a product brightness of an item is acceptable or not acceptable.

A per-requisite for using a control chart is that quality standards and tolerances should be established in advance. In our example of radio valves, the standard diameter is 1.000 inch and tolerances are ± 0.002. It means that diametre should not be more than 1.002 and less than 0.998. Mean of sample measurements is 1.000 inch and standard deviation 0.004. Then 3α limits are 1.012 and 0.988. This sets the upper control limit (UCL) at 1.012 and lower control limit (LCL) at 0.988. Now a few measurements of valve diameters are taken every hour and their average is plotted on the control chart as shown is Fig. 8.3. If any of these averages fall outside the UCL or LCL (points X and Y in Fig. 8.3), it is a signal for preventive action, such as setting the machine, changing the worn out tool, adjusting the speed of operations, etc.

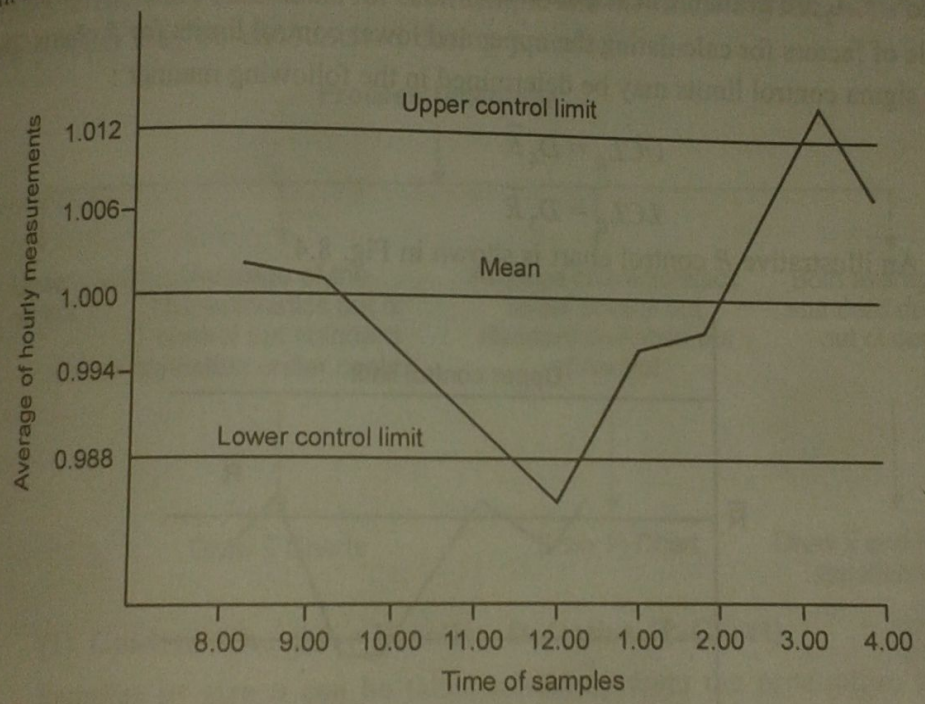

Fig. 8.3: *Mean ($\overline{X}$) control chart for variables.*

Control Charts for Variables

In-process control chart or control chart for variables is generally based on mean ($\overline{X}$) or range (R) of sample measurements. We have discussed above mean control chart for variables. When the quality controller is interested in the range of difference between the largest and when the quality controller is interested in the range or difference between the largest and smallest measurements, he uses the R control chart. This chart is valuable when there is concern about the consistency of the parts—the variations between the extremes. The procedure for constructing the R chart is the same as for $\overline{X}$ chart. Range of variations for each samples is calculated by subtracting the smallest from the largest measurement. Then, mean of range $\overline{R}$ is calculated by using the

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formula, $\frac{\sum R}{n}$, and standard deviation is calculated by the following formula :

$$\sigma R = \sqrt{\sum \frac{(R_i - \bar{R})^2}{n}}$$

where σR = Standard deviation of range

R_i = Value of R for ith observation in the sample, $i = 1, 2, ..., n$

$\bar{R}$ = Mean value of R for the sample

n = Number of observations in the sample.

The upper and lower control limits are determined by $\bar{\bar{X}} \pm 3\bar{R}\ \sqrt{nd^2}$. Values of $3/\sqrt{nd^2} = A_2$ are available in standardized statistical tables. These tables also provided a table of factors for calculating the upper and lower control limits for R charts. These three sigma control limits may be determined in the following manner :

$$UCL_R = D_4 \bar{R}$$

$$LCL_R = D_3 \bar{R}$$

An illustrative R control chart is shown in Fig. 8.4.

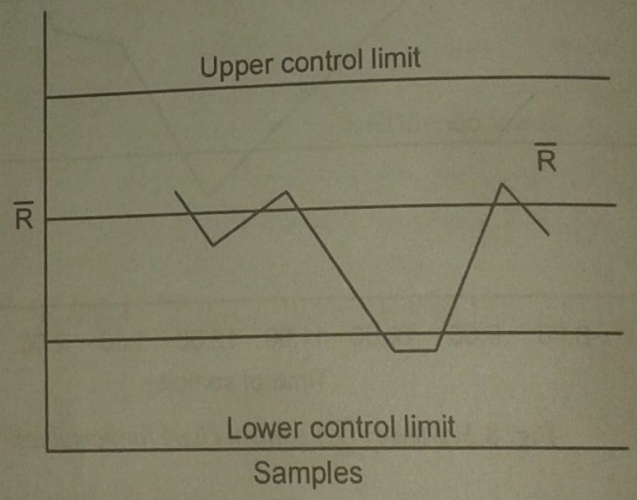

Fig. 8.4 : *Range (R) Control Chart.*

The advantages of control charts of variables are as follows :

(*i*) Control charts warn in time. If required rectification is done well in time, the scrap and percentage rejection will be reduced.

(*ii*) It ensures product quality level.

(*iii*) A control chart indicates whether the process is in control or out of control thus information about the selection of process and tolerance limits are provided.

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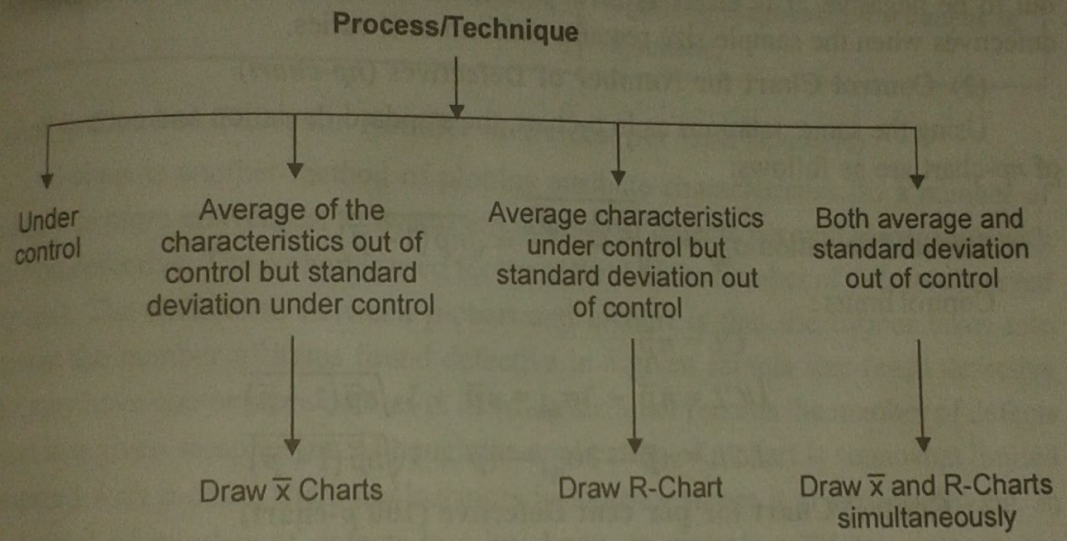
(*iv*) The inspection work is reduced.

(*v*) The control charts separate out the chance and assignable causes of variations in the observation thus substantial quality improvement is possible.

(*vi*) Determines process variability that and detects unusual variations taking place. So reputation of the concern/firm can be built by application of these charts.

Control charts are used for measurable, quality characterstics. Let the quality characteristics of all the products be measured in subgroups. The subgroups are the samples having fixed number of items/products/component taken at random over a period of time. The mean and the standard deviations of the quality characteristics are calculated for each sample and the following situations regarding the process may be encountered during practice.



(1) Control Chart for Fraction Defective (P-Chart)

Samples of size n can be taken randomly from the production process or output at different time intervals. If d is the number of defectives in a sample, then the fraction defective in the sample.

$$p = \frac{d}{n} = \frac{\text{Number of defective unit in a sample}}{\text{Total number of units in a sample}}$$

Or Actual number of defectives

$$d = n \cdot p$$

If $\overline{p}$ is the proportion of defectives produced by the entire processing or the average fraction defective and it is given by the following formula :

$$\overline{p} = \frac{\text{Total number of defective items in all the samples inspected}}{\text{Total number of items in all the samples}}$$

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p-chart is based on binomial distribution. The binomial distribution has the standard deviation σ_p which is given by the relation :

$$\sigma_p = \sqrt{\frac{\bar{p}(1-\bar{p})}{n}}$$

Thus, the control limits for the p-chart are :

Central line $\quad CL = \bar{p}$

Upper control limit $UCL = \bar{p} + 3\sigma_p = \bar{p} + 3\sqrt{\frac{\bar{p}(1-\bar{p})}{n}}$

Lower control limit $LCL = \bar{p} - 3\sigma_p = \bar{p} - 3\sqrt{\frac{\bar{p}(1-\bar{p})}{n}}$

The number of defective units cannot be negative, but if LCL sometimes comes out to be negative, it is taken as zero. p-chart is used to plot and control fraction defectives when the sample size remains uniform or it varies.

(2) Control Chart for Number of Defectives (*np-chart*)

Using the same notations as in p-chart, the standard deviation and control limits of np-chart are as follows:

Standard deviation $\sigma_{np} = n\sqrt{\frac{\bar{p}(1-\bar{p})}{n}} = \sqrt{n\bar{p}(1-\bar{p})}$

Control limits :

$$CL = n\bar{p}$$

$$UCL = n\bar{p} + 3\sigma_{np} = n\bar{p} + 3\sqrt{n\bar{p}(1-\bar{p})}$$

$$LCL = n\bar{p} - 3\sigma_{np} = n\bar{p} - 3\sqrt{n\bar{p}(1-\bar{p})}$$

(3) Control Chart for per cent Defective (100 *p*-chart)

Using the same notation as in p and np charts, the standard deviation and control limits are as follows :

$$\sigma_{100p} = \sqrt{\bar{p} \times 100 \frac{(100 - 100\bar{p})}{n}}$$

Central line $\quad CL = 100\,\bar{p}$

$$UCL = 100 \times \bar{p} + 3\sigma_{100p}$$

$$LCL = 100 \times \bar{p} - 3\sigma_{100p}$$

***P*-Charts are applicable under the following conditions :**

(*i*) np or Number of defective chart is used where group size or sample size, *i.e.*, n, is constant.

(*ii*) p-chart or fraction defective chart and $100p$ or per cent defective chart can be used where sample size is variable or constant.

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TABLE 8.1 : Comparison of $\bar{x}$-*R*-Charts and *P*-Charts

S.No.	$\bar{x}$ -*R*-Charts	*P*-Charts
1.	These are control charts for variables.	These are control charts of attributes.
2.	Cost of data collection is higher due to actual dimensional measurements.	Data collection is comparatively cheaper.
3.	Sample sizes are relatively small.	Larger size samples are to be taken.
4.	The control limits are affected by sample size.	There is less effect of the sample sizer over control limits.
5.	For different measurable quality characteristics, different charts are to be drawn.	Same *p*-chart may be applied to any number of quality characteristics on one item under inspection.
6.	This method is much superior in diagnosing the causes of variability.	This method is comparatively inferior regarding diagnosing the causes of rejections.

(4) Control Chart for Number of Defects per Unit (*C-chart*)

C-chart is another method of plotting attribute characteristics. In a number of cases, it is more convenient to work with number of defects per unit rather than with fraction defective. The *c*-chart is used for the control of the number of defects observed per unit. The difference between *p*-chart and *c*-chart is that the former takes into account the number of items found defective in a given sample size (each defective item may have one or more defects in it) while the latter records the number of defects found in a given sample size. Although the application of *c*-chart is somewhat limited compared with *p*-chart, there are instances in industry where it is very useful *e.g.* in the control of number of defects in a bus body, an aircraft a TV set, a computer, welding defect in a truss, etc.

The construction of the control chart is similar to that of the *p*-chart except that here the control limits are based on the **Poisson distribution** which has often been found fit to describe distribution of defects.

The standard deviation in this case is given by :

$$\sigma_c = \sqrt{\bar{C}}$$

where $\bar{C}$ is the average number of defects

$$\bar{C} = \frac{\text{Total number of defects in all the samples}}{\text{Total number of samples inspected}}$$

The control limits for *c*-chart are :

$$CL = \bar{C}$$

$$UCL = \bar{C} + 3\sigma_c$$

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$$LCL = \bar{C} - 3\sigma_c$$

These control limits are for constant sample size, *i.e.*, for a single unit only. In case the sample consists of a number of units n, the average number of defects per unit :

$$\bar{U} = \frac{\Sigma c}{\Sigma n} \text{ and the control limits will be}$$

$$CL = \bar{U}$$

$$UCL = \bar{U} + 3\sqrt{\frac{u}{n}} = \bar{U} + 3\sqrt{\bar{C}}$$

$$LCL = \bar{U} + 3\sqrt{\frac{u}{n}} = \bar{U} - 3\sqrt{\bar{C}}$$

where $\bar{C} < 3\sqrt{\bar{C}}$ and that LCL is negative, it is to be taken as being O.

(5) Control Charts for Attributes

Control charts for attributes are used for acceptance sampling aimed at accepting or rejecting the lot on the basis of the number or percentage of defective pieces found in the sample. Two methods are used for making control charts for attributes, one is based on the proportion defective, resulting in P chart, and the other is based on number defective in the sample resulting in C chart. The procedure for constructing these charts is the same as for X and R charts. Mean values and standard deviation for proportion or number defective in the sample are computed, and upper and lower control limits are established. Then mean values of P or C are plotted on the graph to indicate rejections above or below the control limits. Deviations from the upper control limit point up the need for preventive action. Deviations below the lower control limit also need to be investigated to find out whether improvement in quality has resulted from more efficient operations. This investigation is necessary because improved quality might have resulted from slower operations, more spoilage of raw materials, excessive costs of maintenance, etc.

The four most commonly used control charts for attributes are :

(1) Control charts from fraction defectives (p-charts)

(2) Control charts for number defectives (np-charts)

(3) Control charts for per cent defectives chart or 100 p-charts.

(4) Control charts for number of defects per unit or c-chart.

8.5 ZERO DEFECT

Zero defect means that even if there is a single defective unit in the sample of manufactured parts or products, the whole lot is rejected. The idea of zero

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defects quality was developed in the sixties but it is used in a limited way. The purpose is to motivate the workers and supervisors to manufacture flawless products in the first instance so that there are no rejections, and the company is able to create an image for high quality products. The objective of defect-free manufacturing is sought to be achieved by preventing the causes of deflection from quality standards. Zero defects production programme is generally associated with a programme of publicity, education, participation, recognition and preventive maintenance. The idea is to create among workers and supervisors pride in workmanship and build quality consciousness.

Zero defect production programmes do not sustain for long as production defects result from many factors including wearing out of tools, lack of perfect homogeneity of materials, human tendency to err, etc. Moreover, zero defects production often results in higher cost of maintenance, and slowing down of operations. Zeal for achieving zero defects production may also tempt engineers to set loose tolerances which may result into production of sub-standard products. However, zero defects production programmes often lead to the search for factors responsible for deviations from quality standards. This may bring enduring gains to the company in terms of improved quality, lower rates of scrap and diminished cost of production.

Review Questions

Short Answer Questions

1. Define quality control.
2. Briefly explain the significance of quality control.
3. What is statistical quality control (SQC) ?
4. How can quality control reduce the cost of production ?
5. What are control charts ?
6. State the functions of quality control.
7. What are the limitations of statistical quality control.
8. Briefly discuss the types of control charts

Long Answer Questions

1. What do you understand by quality? Explain the factors that affect quality.
2. Define the term 'quality' and discuss the factors influencing quality in industry.
3. "Quality Control is a system of inspection, analysis and action applied to a manufacturing process." Discuss this with examples from manufacturing Industry.
4. What is meant by quality control ? Why is it important ?
5. Discuss the importance of quality control in an industry. Why is statistical quality control preferred ? Ex| 'ain.

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6. What is statistical quality control? What are the various techniques of statistical quality control ?
7. State the advantages of quality control. Show clearly how it can reduce the cost of production.
8. Define statistical quality control. Discuss the devices used as tools of statistical control in factories.
9. Explain the benefits and limitations of statistical quality control.
10. Write short notes on the following :
    (*a*) Quality Control.
    (*b*) Control Charts.

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Chapter 9

TOTAL QUALITY MANAGEMENT (TQM)

CHAPTER OUTLINE

9.1 Concept of Total Quality Management (TQM)

9.2 Need and Significance of Total Quality Management

9.3 Steps in Implementation of Total Quality Management

9.4 Philosophical Foundations of Total Quality Management

9.5 Service Quality

9.6 Total Quality Management in Srvices

Quality is a dynamic concept and so is its management. Total Quality Management (TQM) has been accepted throughout the world these days. It calls for continuous improvement of quality with the cooperation of workers through innovation in product and technology so as to meet the changing requirements of the customer. The launching of ISO: 9000 series standards by the International Standards Organisation is an attempt to help the industrial organisations in adopting Total Quality Management to improve their quality and productivity and to serve their customers efficiently.

9.1 CONCEPT OF TOTAL QUALITY MANAGEMENT (TQM)

9.1.1 What is Total Quality?

A process is a series of procedures that transform a set of inputs into an output. In this process, output quality could be only as good as the quality of

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inputs and the quality of business processes that transform the inputs into products or service. It is, therefore, imperative that for ensuring quality of outputs, with consistency and reliability, quality has to be ensured across the whole process and process inputs. *Total Quality relates to the quality management system of the total business process across the organisational functions and processes.* It is not simply the quality of the product or services. The following schematic model illustrates various elements that go into total business process and the need for ensuring quality in each of these elements :

TABLE 9.1: Scope and Coverage of Total Quality

Inputs	*Processes (Total Business Process)*	*Outputs*
Men	Operations/Process Management	
Machines	Order Generation & Fulfillment	PRODUCTS/
Methods	Finance & Accounting	SERVICES
Materials	Supply Chain Management	for Customers.
Money, etc.	Market Development & Sales	
←	TOTAL QUALITY	→

Total Quality is a company wide quality coverage for ensuring quality in everything that is necessary to be done in a company for providing products or services to customers' expectations and delight. In total quality system, quality is the outcome of the collective actions of all members of the organisation, because people are the ones who run the processes. All members include not only the employees, but also the others who are either stakeholders or partners in the business process of the organisation. Stakeholders are customers, employees, shareholders, society, etc. Partners in business processes are vendors and suppliers, contract jobbers, service provider, etc. Management of total quality, therefore, begins with customers by determination of their requirements and ends with the fulfillment of their requirements by achieving customer satisfaction and delight. The suppliers and the organisation fit between these two end points, *i.e.*, requirements and satisfaction of customers. Towards this end, organisations resort to customer-focused internal processes for ensuring customer satisfaction.

Thus, Total Quality Management emerges as an integral part of strategic management of a company for excellence in performance and superior business results. The essential approach to total quality management is to promote a work culture that empowers people in the organisation and make them motivated and committed for customer satisfaction by providing quality at the least cost. In order to bring down cost of quality, **TQM emphasises on doing right thing right, first time and every time.**

9.1.2 What is Total Quality Management (TQM) ?

Total Quality Management (TQM) is a philosophy which believes in a company-wide responsibility towards quality. The main aim of TQM is to actively

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involve the production personnel in the pursuit of quality and to infuse in them the spirit of continuous improvement.

According to Sashkin and Kiser, *Total Quality Management may be defined as creating an organisational culture committed to the continuous improvement of skills, teamwork, processes, product and service quality, and customer satisfiaction.* This definition is anchored to organisational culture because successful TQM is deeply embedded virtually in every aspect of organisational life and calls for the active involvement of all human resources in quality improvement for the delight of customers. Thus, Total Quality Management is a *continuous customer-centred employee driven improvement.*

TQM is an effective system of integrating quality developments, quality maintenance and quality improvement efforts of various groups in an organisation. TQM is the control of all transformation processes of an organisation to satisfy customer's need in the most economical manner. TQM may be defined as creating an organisational culture committed to the continuous improvement of skills, teamwork, process, product and service quality and customer's satisfaction.

Total Quality Management (TQM) refers to meeting the requirements of customers consistently by continuous improvement in the quality of work of all employees. For achieving total quality, three things are essential :

(*i*) Meeting customers' requirement.

(*ii*) Continuous improvement through management process.

(*iii*) Involvement of all employees.

Total Quality Management is a *dynamic concept* as the quality standards do not remain the same forever. They are to be modified or changed to meet the requirements of customers and to make use of new technology. Even the ISO : 9000 series standards have a provision of revision, modification or detection of quality standards after every five years. Total Quality Management also calls for *involvement of employees* in this programme. Without the active involvement of employees, high quality standards can't be achieved. Further, the whole concept of TQM is directed towards meeting the *requirements of customers*.

9.1.3 Objectives of Total Quality Management

Meeting the customer's requirements is the primary objectives and the key to organisational survival and growth. Customers are never regarded as people to whom the company presents its product in a 'take it or leave it' spirit. Relationship with the customers is considered as a supreme act of faith. It is believed that if customers are satisfied, they will continue to patronise the company which, in turn, will make it survive and grow.

The second objective of TQM is the *continuous improvement of quality.* The management should stimulate the employees in becoming increasingly competent

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and creative. They should keep doing better. As long as things are not perfect, there is room for improvement : new products can get to market faster, new adjustments in processes can cut down on time and cost, and the environment for work can be made more satisfying.

Thirdly, TQM aims at developing the relationship of *openness and trust* among the employees at all levels in the organisation.

9.1.4 Components of Total Quality Management

The essential elements of TQM are discussed below :

1. Meeting Customers' Requirements. Under TQM, the term 'customer' means every user of a product or service and not only the end-user. This is a very broad meaning of 'customer'. For example, a product that passes through a number of stages, every next stages is a customer for the preceding stage.

TQM aims at satisfying the requirements of customers which never remain constant, but keep on changing with the change in time, environments, circumstances, needs, fashion, etc. Thus, meeting the changed requirements of customers is a continuous goal of the producer.

2. Do it Right First Time. TQM adopts the policy of zero defect. There is no scope for rework and rejection. The right first time or zero defect is the result of emphasis on prevention, and diligent use of SPC (Statistical Process Control), SQC and, data driven elimination of waste and error. Effort is made for rigorous application of EPDCA approach which means

Evaluate → Plan → Do → Check → Act.

3. Continuous Improvement. The change in customer requirements may be in terms of desire for better quality product/services, bigger size, reduced cost, etc. So a producer has to cope up with new requirements. A new process may have to be developed, or it may require a new design. The production process has thus to be attuned and accelerated to meet these changing requirements. The management has also to take care of competition in the market so that customers do not shift to other producers. For instance, introduction of 300 ml, cold drink bottles by one producer led other producers to shift to bottling of 300 ml. of their brands.

The advancement in technology is another important factor in improving the quality. The innovations in a particular field may cause some of the existing technologies to become obsolete and as a result the survival of the producer not adopting technological advancements would become very difficult. For example. Photocopier was a big machine with a manual process wen it was introduced in India for the first time. The process was time consuming and even quality was not up to the mark. Thereafter, new photocopiers (Xerox machines) were introduced and slowly old machines disappeared for the simple reason that customers' need underwent a sea change.

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4. Involvement of Employees. As said above; TQM requires a continuous improvement in quality of products. This calls for the improvement in the quality of work of employees through training and development. The enhancement of skills or employees will not only improve quality, but also bring down the cost of products through efficient use of machines and materials and reduction of wastages. The employees must also be conscious about the need for improvement in the quality of work. Quality circle is an outstanding example in this regard. It is because of employees' involvement in improvement of quality that TQM is referred to as people's process.

TQM should be the concern of all managers and workers in the organisation if it is to serve its purpose fully. No doubt, TQM is planned by the top managers, the people at the middle and lower levels must be taken into confidence before launching the TQM. Thus, each and every employee must be encouraged to become involved in implemented, necessary skills and resources must be invested in the organisation.

TQM is a philosophy that calls for development of a company-wide culture for quality. TQM typically involves an increase of awareness through training and motivation. It requires every member of the organisation to accept quality as his responsibility. TQM signifies an understanding and performance of role by each and every individual in the pursuit of quality improvement. A positive attitude towards customer and constant enhancement of quality must be ingrained in the minds of the employees.

5. Empowerment of Employees. Empowerment occurs when employees are adequately trained, provided with all relevant information and the best possible tools, fully involved in key decisions and are fairly rewarded for best results. Training enables people to think for themselves and to make decisions for themselves. Empowerment may result in few mistakes, but the risks of staff errors are outweighed by increase in creativity, productivity, motivation, commitment and customer service that results from empowerment.

6. Benchmarking. Benchmarking is the practice of identifying, studying and building upon the best practices in the industry or in the world. Dynamic companies are constantly monitoring information from the external environment to compare their process, products and services with the best industry practices. Such companies establish quality targets which enhances their competitive strength.

7. Feedback Mechanisms. The customer feedback and employee feedback are the essential requirements to create customer-oriented quality culture. These feedback mechanisms provide an accurate evaluation of the operations of the company from boh internal and external perspectives. This evaluation indicates how the operations affect internal and external customers and provide a measurement of customer satisfaction. Feedback information can be gathered through questionnaire surveys, interviews, use of focus groups and field complaints, suggestion systems, etc.

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Emergence of TQM

The emergence of the concept of TQM is not just sudden. It developed in four stages beginning from 1910. These stages are as follows :

(*i*) **Detection and Rectification of Defects.** The first stage was initiated because of the need for detection of defectives. The quality control responsibility was identified with quality and inspection function. The emphasis here was on *detection and correction of defects* in the product during the course of its process.

(*ii*) **Prevention of Defects.** During 1930s, the emphasis of quality management in U.S.A. shifted to prevention of defectives. It was realised that detection of defects and correction leaves a lot of scope for wastage. Prevention of defects was sought to be achieved by method of **process control,** by analysing the process and finding out reasons of occurrence of defects and then taking adequate steps so that the reccurrence does not take place.

(*iii*) **Product Design Improvement.** Process control could not be used to remove those defects which were inherent in product design and engineering. That is why, Japanese organisations started concentration on product improvement in the 1960s and later talked of 'total quality management'. Product improvement, product design, and product planning were emphasized to meet the changing requirements of customers. All these can be achieved with the involvement of employees.

(*iv*) **Creativity and Innovation.** The decade 1980 paved the way for creativity and innovation in technology and management practices. Quality circles were inproduced to enlist the active support of workers in quality improvement. Total Quality Management became the catch word not only in Japan, but also in other countries of the world.

Roadmap for TQM

Total Quality Management involves the following phases :

1. Quality planning
2. Quality implementation
3. Quality monitoring and control

1. Quality Planning

The planning phase of quality should deal with the following aspects :

(*i*) To set quality objectives and targets.

(*ii*) To find out whether the company is capable of producing and marketing the products of a certain quality.

(*iii*) To establish the relative importance of the quality characteristics and specifications, and communicate it to the production line people as well as to the vendors supplying materials. Specifications and drawing person can never communicate what that particular specification stands for and why?

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(*iv*) To look after various vender quality control aspects such as examining new vendor facilities, their procedures and systems, setting up of the vendor rating scales and periodic performance evaluation of the vendors.

(*v*) To establish statistical control techniques, charts and sampling plans.

(*vi*) To establish training programmes for various personnel in the company so that quality consciousness gains a firm ground in the organisation.

In short, designing the desired and deliverable quality standards in the job of quality planning.

2. **Quality Implementations**

The implementation part of quality management deals with :

(*i*) Performing laboratory tests and analysis on the raw materials, finished products and the semifinished products for acceptance/rejection or for process control.

(*ii*) Maintaining quality control equipment (Process, Laboratory and Inspection).

(*iii*) Advising and providing assistance for the clarification and solution of quality management problems in manufacture.

3. **Quality Monitoring and Control**

The monitoring and control function deals with :

(*i*) Appraising the quaity plan *vis-a-vis* the problems of production and the problems of vender quality, so that appropriate action is taken to correct the initial planning errors.

(*ii*) Appraising quality planning *vis-a-vis* the actual quality which has reached the customer and what the latter's reaction is regarding the product quality; how such reactions can be set right by modifications to the original quality plan.

(*iii*) In addition to performing quality audits, monitoring the costs of quality and providing such information to the quality-planners so that they take appropriate action for the future.

9.2 NEED AND SIGNIFICANCE OF TQM

Total Quality Management is the need of all modern organisations. This realisation first came in Japan where it was felt that quality cannot be ensured by inspection and test along ; every department and the individual had a role to play in the achievement of quality. Thus, 'Quality Control' which was basically restricted to test and inspection of the end-product gave way to '*Quality Assurance*'. In addition to inspection of the product, quality assurance also involved the inspection of the production process and equipment.

Total Quality Management goes a step further as its aim is to actively involve all the employees in the pursuit of quality and to infuse in them the spirit of continuous improvement of satisfy the ever changing needs of the customers. It intends to achieve desired quality rather than control and prevent defects in the

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goods produced. TQM is the sum total of the quality of various aspects of the business system, namely, product design and development, production, purchase, marketing, financing, etc. It also involves all technical and administrative systems and procedures which can ensure the desired quality on a consistent basis. This is why organisations all over the world have become conscious of the need of total quality management.

The benefits of TQM are that it encourages innovation, makes the organisation adaptable to change, motivates people for better quality, unites the business (arising out of a common purpose) and all these provide the organisation with a valuable and distinctive competitive edge.

9.2.1 Benefits of Total Quality Management

The following benefits can be derived from a sound TQM programme :

(*i*) Total Quality Management brings quality consciousness in the enterprise which encourages the production of quality products.

(*ii*) TQM helps in providing greater satisfaction to customers by meeting their requirements. If the customers are satisfied, the sales are increased.

(*iii*) It creates a good public image of the enterprise by helping it to provide goods and services of higher quality to the society.

(*iv*) There is better utilisation of materials, machines, capital, human resources, etc.

(*v*) Wastages are reduced to the minimum. As a result, cost of production is reduced and profitability is increased. Even the customers could be provided goods at lower prices. The competitive position of the firm in the market is improved.

(*vi*) The employees are committed to higher quality and feel highly motivated. Their morale is also higher because of the public image of the firm and its goods in the market.

(*vii*) There is better customer care and greater satisfaction of customer.

9.3 STEPS IN IMPLEMENTATION OF TQM

W.E. Deming, an internationally renowned quality expert known as father of TQM, has suggested *Plan-Do-Check-Act Cycle* for the implementation of TQM in any organisation. The steps in PDCA cycle as shown in Fig. 9.1 are as follows :

(*i*) Lay down policies and objectives of TQM. Determine what the customer is supposed to receive and what they are actually receiving.

(*ii*) Chalk out the methods to achieve TQM objectives.

(*iii*) Educate and train workers and managers to understand and meet the requirements of TQM.

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(*iv*) Start the operation of TQM by introducing new product, machines, procedures, etc.

(*v*) Check the causes of non-conformance to quality standards.

(*vi*) Determine the consequences of non-conformance and place the report before the top management.

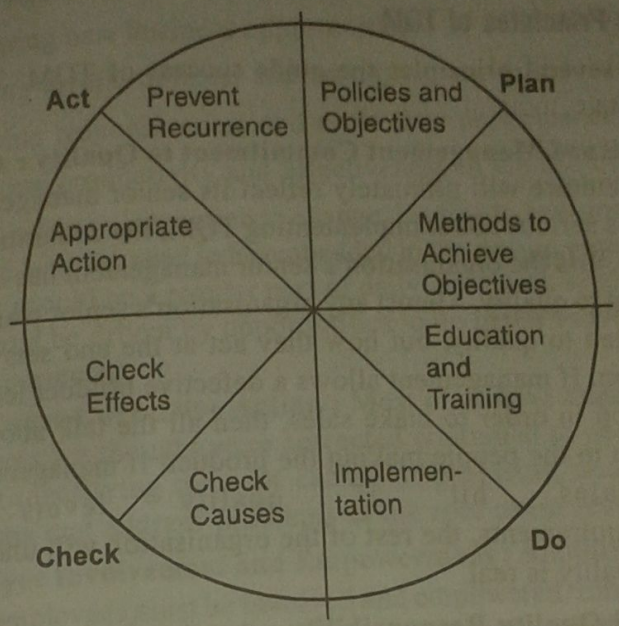

Fig. 9.1. *Steps in TQM Process.*

(*vii*) Meet with suppliers and enlist their help in Quality improvement. Establish personal relationships with employees so they can voice their concerns and ideas.

(*viii*) Work on problem prevention rather than problem correction.

9.3.1 Requirements of a Successful TQM Programme

For the successful implementation of TQM, the following guidelines should be followed :

(*i*) The objectives and policies of the firm must reflect its commitment to quality as a philosophy of customer satisfaction.

(*ii*) The TQM philosophy must be effectively communicated to each and every employee and department so that it is clearly understood throughout the organisation.

(*iii*) The TQM programme should be properly designed to meet the requirements of the customers.

(*iv*) The participation of all the employees should be encouraged so that innovative ideas are put forward by the employees. TQM should not be imposed upon the employees. The management should make TQM an employees' programme through proper education of workers.

(*v*) Workers and managers should be given the necessary training for the effective implementation of TQM.

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(*vi*) TQM must involve product design and improvement, adoption of new technology, systems and procedures.

(*vii*) TQM should be considered a continuous programme as the requirements of customers keep on changing. TQM should also try to integrate the operations of various departments.

9.3.2 Guiding Principles of TQM

There are several principles the guide success of TQM. These are briefly discussed below :

1. **Sustained Management Commitment to Quality :** An organisation's personality and culture will ultimately reflect its senior management's values. If an organisation is serious about implementing TQM, the commitment to do so has to start at the top, and the organisation's senior management has to be unwavering in its commitment to quality. Almost any organisation's senior managers will claim they are committed to quality, but how they act at the end sets the tone for the entire organisation. If management allows a defective product leave the premises of the organisation in order to make sales, then all the talk about quality won't make a difference to the people making the product. If management is willing to take a sales hit if quality levels are not up to customer requirements, the rest of the organisation will understand that the commitment to quality is real.

2. **Universal Quality Responsibility :** Another basic TQM precept is that the responsibility for quality is not restricted to an organisation's quality assurance department, but is instead a guiding philosophy shared by everyone in an organisation. TQM requires that everyone takes responsibility for quality. As quality improves, the quality assurance department gets smaller. In fact, world over, a few companies fully committed to TQM have done' away completely with their quality assurance organisations.

3. **Focusing on the Customer :** According to lee lacocca there are only three rules : Satisfy the customer, satisfy the customer, and satisfy the customer. This sums up the importance of customer focus in the TQM philosophy. Ultimately it the satisfaction of the customers that determines the success of an organisations.

4. **Preventing Defects :** TQM is a management philosophy that seeks to prevent poor quality in products and services, rather than simply to detect and sort out defects. "An ounce of prevention is worth a pound of cure." A little precaution before a crisis occurs is preferable to a lot of fixing up afterward. This also saves cost and time.

5. **Continuous Improvement and Learning :** TQM espouses a philosophy of continuous improvement in all areas of an organisation. This philosophy ties in closely with the quality measurement and universal quality responsibility. Quality measurement is needed in order to focus improvement efforts appropriately. Continuous improvement is a part of the management of all systems and processes. Achieving the highest levels of performance requires a well-defined and well-

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executed approach to continuous improvement and learning. "Continuous improvement" refers to both incremental and "breakthrough" improvement. Improvements may be of several types :

- Enhancing value to the customer through new and improved products and services;
- Developing new business opportunities;
- Reducing errors, defects, and waste;
- Improving responsiveness and cycle time performance; and
- Improving productivity and effectiveness in the use of all resources.

"Learning" refers to adaptation to change, leading to new goals or approaches. Improvement and learning need to be embedded in the way an organisation operates. This means they should be a regular part of daily work seek to eliminate problems at their source, and be driven by opportunities to do better as well as by problems that need to be corrected.

6. **Root Cause Corrective Action :** Most of us have experienced situations in which problems we thought were corrected continued to occur. TQM seeks to prevent this by identifying the root causes of problems, and by implementing corrective actions that address problems at the root cause level.

7. **Employee Involvement and Empowerment :** Another fundamental TQM concept is that employees must be involved and empowered. Employee involvement means every employee is involved in running the business and plays an active role in helping the organisation meet its goals. Employee empowerment means employees and management employees who are provided with the necessary tools and authority to do so.

8. **Training :** Training is basic to the TQM process. The concept is based on of empowering employees by providing the tools necessary for continuous improvement.

9. **Supplier Teaming :** Another principle of the TQM philosophy is to develop long-term relationships with a few high-quality suppliers, rather than simply selecting those suppliers with the lowest initial cost.

10. **Inventory Reduction :** Largely in response to their lack of natural resources (as well as the 1970s worldwide oil shortages), the Japanese pioneered the concept of reducing inventories. This management. The Japanese JIT inventory management concepts caught on in the United States and other nations. Although the concept was originally intended to address material shortages, an interesting side effect immediately emerged : As inventories grew smaller, quality improved.

11. **Value Improvement :** The linkage between continuous improvement and value improvement is simultaneously obvious and subtle. This linkage becomes apparent when one considers the definition of quality, which is the ability to meet or exceed customer requirements and expectations. The essence of value improvement is the ability to meet or exceed customer expectations while removing

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unnecessary cost. But simply cutting costs, however, will not improve value i the focus does not remain on satisfying customer requirements and expectations.

9.3.3 TQM and Traditional Management Practices

TQM is quite different from traditional management practices, requiring changes in organisational processes, beliefs and attitudes, and behaviours. "Traditional management" means the way things are usually done in most organisation in the absence of a TQM focus. Many "traditional" organisations have been applying the following TQM principles all along :

1. **Strategic Planning and Management :** Quality planning and strategic business planning are indistinguishable in TQM. Quality goals are the cornerstone of the business plan. Measures such as customer satisfaction, defect rates, and process cycle times receive as much attention in the strategic plan as financial and marketing objectives.

2. **Changing Relationships with Customers and Suppliers :** In TQM, quality is defined as products and services beyond present needs and expectations of customers. Innovation is required to meet and exceed customers' needs. Traditional management places customers outside of the enterprise and within the domain of marketing and sales. TQM views everyone inside the enterprise as a customer. Marketing concepts and tools can be used to assess internal customer needs and to communicate internal supplier capabilities.

3. **Organisational Structure :** TQM views the enterprise as a system of interdependent processes, linked laterally over time through a network of collaborating (internal and external) suppliers and customers. Each process is connected to the enterprise's mission and purpose through a hierarchy of micro- and macro-processes. Every process contains sub-processes and is also contained within a higher process. This structure of processes is repeated throughout the hierarchy.

4. **Organisational Change :** In TQM the environment in which the enterprise interacts is considered to be changing constantly. Management's job, therefore, is to provide the leadership for continual improvement and innovation in processes and systems, products, and services. External change is inevitable, but a favourable future can be shaped.

5. **Teamwork :** In TQM individuals cooperate in team structures such as quality circles, system optimization through cross-functional teamwork.

6. **Motivation :** TQM managers provide leadership rather than overt intervention in the processes of their subordinates, who are viewed as process managers rather than functional specialists. People are motivated to make meaningful contributions society. The system enables people to feel like winners.

9.4 PHILOSOPHICAL FOUNDATIONS OF TQM

Three eminent thinkers of the US–Dr. W. Edward Deming, Dr. Joseph Juran and Phillip B. Crosby, together with Masaki Imai of Japan led the development of

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quality management tools and philosophies that created a "quality revolution" in the 20th century and laid the foundation for total quality management practice of today. Deming, Turan and Crosby are known as **'quality gurus'.**

Deming is known for his "14 points for management", "5 deadly sins and diseases", "the theory of variance" and "the role of management in TQM". Deming's philosophy is based on improving products and services by reducing uncertainty and variations. Systems thinking, statistical understanding of variation, theory of knowledge and psychology are the foundations of his philosophy. His 14 points advocate radical cultural change in organisations. Deming's *chain reaction* states that quality improvement reduces costs, increases productivity, increases market share and allows the firm to stay in business and provide jobs to people.

Joseph Juran outlined "habit of quality," "quality triology" and "universal breakthrough sequences." His "Quality Control Handbook" in called the Bible of quality. Juran's philosophy seeks to provide change in the management system. Quality is defined as fitness for use. The quality trilogy–planning, control and improvement-provides a direction for quality assurance in organisations.

Philip B. Crosby enumerated absolutes of quality management and 14 steps for quality improvement. He is well known for his concept of "zero defects" and his book titled "Quality is free". Philip Crosby's approach to quality is summarised in his "Absolutes of Quality Management". He emphasised more on behavioural change than use of statistical techniques.

Masaki Imai is known for his concept of **'Kaizan'** which means continuous improvement. Masaki Imai's concept of "Kaizen" has been largely responsible for Japan's economic success. Three guiding priciples of "Kaizen" are : (*i*) Process view of the system, (*ii*) Stress comes from people and (*iii*) Constant sense of urgency.

A.V. Feigenbaum views quality as a strategic business tool and coined the phrase "total quality control". He promoted the importance of shifting quality responsibility to everyone in the organisation and developing cost of quality approach.

Kaoru Ishikawa was instrumental in the Japanese quality movement, particularly in advocating a company wide quality control approach, the use of employee teams and the use of problem solving tools for quality improvement.

Genichi Taguchi advocated that to improve quality one must look upstream at the design stage because that is where quality begins. Taguchi's strong belief in this approach has brought "design of experiments" into wider use by quality experts and designers. He believed that design teams should aim for robust designs. He also originated "quality engineering" which is an approach to combine engineering and statistical methods to reduce costs and improve quality. Taguchi is well known for his "*quality loss function*" called "Taguchi's quality loss function", which estimates the loss to society from the failure of a product to meet its target value for a particular performance characteristic.

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Dr. Walter Shewhart recognised the variability associated with manufactured component (control charts) to monitor the on-going process and to ensure that the process is operating in the "*state of statistical control*". He also did some early work on acceptance sampling technique along with Dodge and Romig.

Shingo proposed his own version of "zero defects" clled "*poka-yoke*". The idea is to handle errors as they occur.

9.4.1 Taguchi Philosophy

Genichi Taguchi proposed that it is not just sufficient to control process, inspect quality of output, identify and remove defects and rely on custumer feedback. He suggested that to improve quality, one must **look upstream at the design stage because that is where quality begins.** Quality must be designed first and inspected later. One fact of obtaining better design is experimentation on variables that contribute to a product's performance. Taguchi's strong belief in this approach has brought *Design of Experiments* (DoE) into wider use by quality experts, designers.

Taguchi also believes that teams should aim for **robust designes**-designs that can withstand the hard-to-eliminate variabilities that occur in transformation processes or later in customer use.

Taguchi *developed quality engineering* an approach that involves combining engineering and statistical methods to reduce costs and improve quality be optimising product design and manufacturing processes. Taguchi methods help product designers estimate the true cost of quality and then cost-effectively improve quality. This is done by improving the design of the product as well as the process by which it is made.

Taguchi's contribution has been widely acclaimed because of the following reasons:

(*i*) Taguchi philosophy identifies quality as a societal issue and not just an organisational issue.

(*ii*) Taguchi's methods full quality right back into the design stage rather than relying on adjustments to the process online or inspection of the final product.

9.4.2 Taguchi Quality Loss Function

Taguchi asserts that the quality of a product is a function of key product characteristics referred to as performance characteristics. The ideal value (or state) of a performance characteristic is its target value. A high-quality product performs near these target values consistently throughout its life span and under all operating conditions. Taguchi's quality loss function estimates the loss to society from the failure of a product to meet its target value for a particular performance characteristic. This loss can be incurred by the consumers (*e.g.*, short product life, increased maintenance and repair costs), by the company (*e.g.*, increased

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scrap, rework and warranty costs, damage to the company's reputation, loss of market share) or by society in general (*e.g.*, pollution).

Taguchi's quality loss function is a statement that any deviation from the target value of a quality characteristic results in extra costs to some segment of the society. Taguchi defines quality in terms of the social loss, loss to producers and consumers from the time a product is conceived. The smaller the value of this social loss, the more desirable is the product.

Taguchi's Quality Loss Function is illustrated in Fig. 9.2.

Quality loss function is expressed as

$$L = C(X - T)^2$$

where L = Total loss

C = a cost constant

X = actual average value of quality characteristic and

T = target value of quality characteristic.

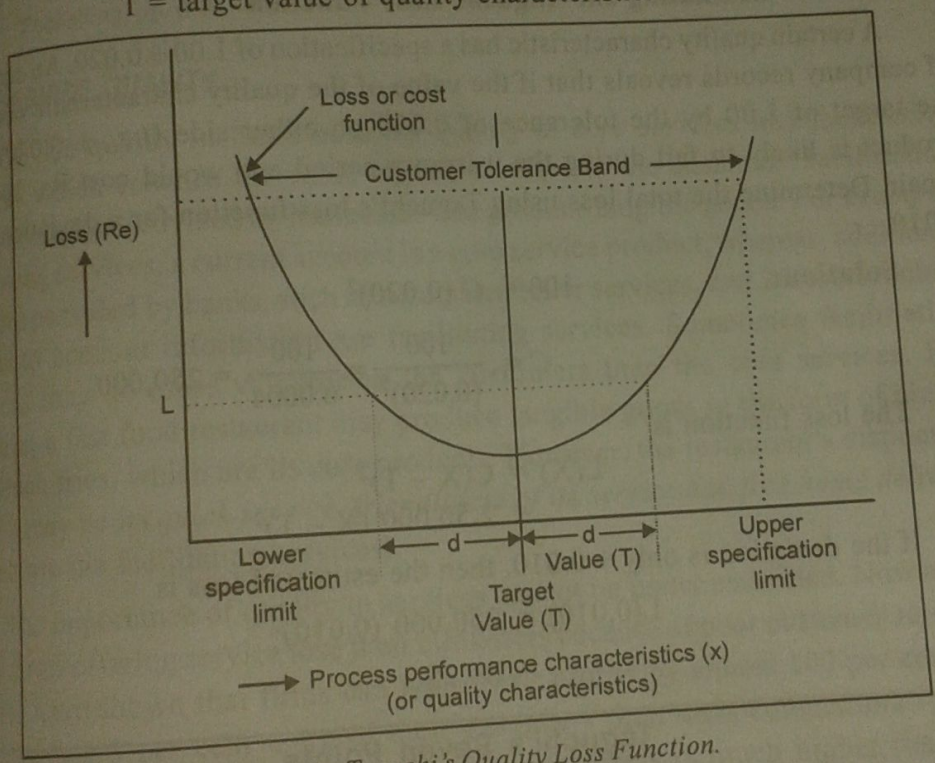

Fig. 9.2. *Taguchi's Quality Loss Function.*

(*Source:* Richard J. Schonberger, p. 82)

Taguchi holds that unwelcome costs are associated with any deviation of process performance (or quality characteristic) from the quality characteristic's target value. The loss from performance variation (L) is directly related to the square of the deviation (d) of the performance characteristic (X) from its target value (T).

i.e.,

$$L = C\,d^2$$
$$= C(X - T)^2$$

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Where L = Total loss

C = a cost constant

X = actual average value of quality characteristic

and T = target value of quality characteristics.

Taguchi contends that the loss function remains valid at all times during a product's life. In theory, when process output performance reaches the specification limit (upper or lower specification limit), the customer's *economic* interest in the item is neutral, i.e., is, the losses will exactly offset any gain from having the item.

For Taguchi, social loss must affect quality cost management decisions, i.e., investments in quality improvement should be compared with savings to the society rather than to the firm alone. Ultimately, the society will reward or penalise the firm for its record of societal savings or loss respectively.

Illustration: Estimating the Taguchi Loss Function

A certain quality characteristic has a specification of 1.00 ± 0.020. An analysis of company records reveals that if the value of the quality characteristic exceeds the target of 1.00 by the tolerance of 0.020 on either side (*i.e.*, $\pm$ 0.020), the product is likely to fail during the warranty period and would cost Rs. 100 for repair. Determine the total loss using Taguchi's loss function for a deviation of $\pm$ 0.010.

Solution:

$$100 = C\,(0.020)^2$$

$$C = \frac{100}{(0.020)^2} = \frac{100}{0.0004} = 250{,}000$$

The loss function is

$$L(X) = C(X - T)^2$$
$$= 2{,}50{,}000\,(X - T)^2$$

If the deviation is only $\pm$ 0.010, then the estimated loss is

$$L(0.010) = 250{,}000\,(0.010)^2$$
$$= \text{Rs } 25$$

Taguchi's Seven Points

Conventionally, quality control activities centre around final inspection, sampling or on control charts and process control. This is known as "*on-line quality control*". Taguchi pushed the process upstream to focus on product and process design. This is known as "*off-line quality control*".

Taguchi's *seven points* are :

(*i*) Product quality is measured by the total loss to the society created by that product.

(*ii*) Continuous quality improvement and cost reduction are necessary to survive in world competition.

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(iii) Quality improvement requires continual and repeated reduction of variation in the product/process performance around the standard nominal values.

(iv) Quality loss is frequently proportional to the square of the deviation of the performance from the nominal value.

(v) Product and process design can have an important impact on a product's quality and cost.

(vi) Performance variation can be reduced by suitable adjustment of the product's parameters and/or the process parameters.

(vii) The appropriate parameter settings that reduce variation can be identified with the appropriate statistically designed experiments.

Source : Thomas E. Mortan, *Production Operations Management*, South Western College Publishing, pp. 6-7.

9.5 SERVICE QUALITY

Service quality includes both the quality of *core services and facilitating* services which enhance the value of core services to the customer. Facilitiating services are also provided by businesses that produce tangible goods. *For example,* in banking services, a current account is a core service product, whereas, additional services provided by banks, such as automated teller services, and 24 hours mobile access to account information are facilitating services. Sometimes facilitiating services may be more valuable to the customers than the core services. For instance, a fast food restaurant may produce tangible goods in the form of pizzas and fench fries, which are its core products. However, the restaurant's distinctive feature may be its *quick service*, *friendliness of its service* and *free home delivery* (which are the facilitating services).

The importance of quality in services cannot be under estimated. Nowadays many firms offering service lose their customers because of poor customer service. Studies have shown that firms can boost their profits by almost 100 per cent by retaining just 5 per cent more of their customers than their competitors retain. This is because the cost of acquiring new customers is much higher than the costs associated with retaining existing customers. Firms with loyal, long-time customers can financially outperform competitors with higher customer turnover even when their unit costs are higher and their market share is smaller.

The definitions of quality that apply to manufactured products apply equally to service products. The very nature of service implies that it must respond to the needs of the customer. The service must meet or exceed customer expectations. The production of services differs from manufacturing in many ways and these differences have important implications for quality management in services.

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TABLE 9.2: Difference in the Manufacturing Sector and Services Sector

Manufacturing Sector	*Service Sector*
1. Product is tangible.	1. Service consists of tangible and intangible components.
2. Products can be stored.	2. Services cannot be stored.
3. Producer is the only party involved in the making of the product.	3. Producer and consumer are both involved in the delivery of the service.
4. Product can be resold.	4. Services cannot be resold.
5. Customer usually provides formal specifications of the product.	5. Formal specifications need not be provided by the consumer. In fact, in monopolies involving public utilities such as electricity, gas, telephone, etc., state laws dictate the requirements.
6. Customer acceptance of the product is easily quantifiable.	6. Customer satisfaction is difficult to quantify because a behavioural component associated with the delivery of the service is involved.
7. Ownership of a product changes hands at a specific point in time.	7. Rendering of a service takes place over an interval of time.

The eight dimensions of quality defined by Garvin which are applicable to services as well as manufactureed goods are :

(*i*) *Performance*—a product's (good or service) operating characteristics.

(*ii*) *Features*

(*iii*) *Reliability*

(*iv*) *Conformance* (to preestablished standards)

(*v*) *Durability*

(*vi*) *Serviceability*

(*vii*) *Aesthetics*

(*viii*) *Perceived quality.*

In addition to the above, services have other unique dimensions which are as follows :

(*i*) *Time* : How long must a customer wait for the service and for completion of the service?

(*ii*) *Timeliness* : Will the package be delivered by 10.30 the next morning?

(*iii*) *Completeness* : Are all ordered items delivered?

(*iv*) *Courtesy* : Do front-line employees greet each customer?

(*v*) *Consistency* : Are services delivered in the same fashion each time for each customer?

(*vi*) *Acceptability and Convenience* : Is the service easy to obtain?

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(vii) *Accuracy* : Is the service performed accurately the first time?

(viii) *Responsiveness* : Can service personnel react quickly to unexpected problems?

9.6 TOTAL QUALITY MANAGEMENT IN SRVICES

Quality of services is more difficult to measure than quality of manufactured goods. Generally, a user of services has a few features in mind as a basis for comparision among alternatives. Lack of one feature may eliminate a service firm from consideration.

Extensive in-depth interviews with consumer focus groups in the USA resulted in the following conclusions:

(i) *Consumer's perceptions of service quality result from a comparison of their before service expectations with their actual service experience.* In other words, service qualty is judged on the basis of whether it meets consumer's expectations.

(ii) *Quality perceptions are derived from the service process as well as from the service outcome.* From the consumer's view point, the way the service is performed can be as important as the actual service.

(iii) *Services quality is of two types, normal and exceptional.* This mean (*a*) there is a quality level at which the regular service is delivered; and (*b*) there is a quality level at which 'exceptions" or "problems' are handled.

Components of Service System Quality

The differences between manufacturing and service organisations create distrinct challenges for managing quality. Many service organisations such as airlines, banks and hotels have well developed quality assurance systems but they are more product-oriented than service oriented. Standards for intangible quality characteristics are difficult to establish. Often they must be set judgementally and then tested for satisfactory levels because *employee performance and behaviour* and *service transaction speed* are the strong determinants of perceived service quality. The two key components of service system quality are *employees* and *information technology.*

Employees : Customers evaluate a service primarily by the quality of human contact It has been found by researchers that when service employee's job satisfaction is high, customer satisfiaction is high and that when employee job satisfaction is low, customer satisfaction is also low. Many service companies have the motto "*If we take care of our employees, they will take care of our customers*".

Information Technology : Information technology incorporates computing, communication, data processing and various other means of converting data into useful information. Information technology is essential in modern service

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organisations because of high volumes of information that must be processed and also because customers demand service at ever-increasing speeds. Intelligent use of information technology not only leads to improved quality and productivity, but also to competitive advantage. Every service industry is exploiting information technology to improve customer service.

Customer Expectations in Service

Customer expectations are beliefs about service delivery that function as standards or reference points against which performance is judged. Because customers compare their perceptions of performance with these reference points when evaluating service quality, thorogh knowledge about customer expectations is critical to service marketers. Knowing what the customer expects is the first and possibly most critical step in delivering quality service. Being wrong about what customers want can mean losing a customer's business when another company hits the target exactly.

Review Questions

Short Answer Questions

1. What is Total Quality Management ?
2. What are the objectives of TQM ?
3. Briefly explain the need and significance of TQM.
4. What are the features of TQM?
5. State the benefits of TQM.
6. What are the requirements of a successful TQM Profrance?

Long Answer Questions

1. Define Total Quality Management and describe its elements.
2. What is meant by Total Quality Management ? Explain its components.
3. Explain the steps in the implementation of Total Quality Management.
4. Write an explanatory note on Total Quality Management and HRD.
5. "TQM is the need of modern industrial organisations." Examine this statement.
6. Explain the concept of Total Quality Management (TQM.). How far do you agree with the view that 'quality is the concern of each employee'?
7. Define Total Quality Management. What are the chief requirements for the successful working of total quality management programme in an industrial organisation ?
8. Explain Taguchi's Philosophy of Total Quality Management.
9. Explain the concept of service quality and state the dimensions of service quality.
10. Write an explanatory note on TQM in services.
11. Write short notes on the following:
    (*a*) Emergence of TQM
    (*b*) Deming Philosophy
    (*c*) Roadmap for TQM.

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Chapter 10

SIX SIGMA AND OTHER TOOLS OF TQM

CHAPTER OUTLINE

10.1 Six Sigma
10.2 Quality Assurance
10.3 Standardisation
10.4 Kaizen
10.5 Just-in-Time Production and Kanban Systems
10.6 Empowerment
10.7 Benchmarking
10.8 Quality Circles
10.9 TQM in India

10.1 SIX SIGMA

Six sigma is often related to **Motorola**, the company that invented it. In the eighth decade of the 20th century, Motorola's significantly changed the discussion of quality from one where quality levels were measured in percentages (parts per hundred) to parts per million or even parts per billion. It pointed out that modern technology was so complex that old ideas about acceptable quality levels are no longer acceptable. The success of Motorola effectively changed the focus of quality worldwide. Many giants like **Xerox, Boeing, GE, Kodak** followed Motorola's lead. In India also, **Tatas, WIPRO** and **Bharti** and others are effectively reaping the benefits of six-sigma.

Human quest for better quality is unending. With the help of technology and newer tools organisations enhance quality of their products that are seemingly of

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very good quality. Quality refers to the degree of excellence and standard. Better quality is often correlated with superior processes and products.

Strategically, a product of good quality should be able to meet the specifications of customer and should be able to satisfy him. If battery of a wristwatch lasts for eight months, but is expected to last for a year by the customer, then the product battery is not of desired quality. Good quality should not always be associated with good products.

Another dimension of quality is that it should not be restricted to satisfying the existing desires of customers. It should not put a boundary on quality by limiting it to the current information and perspective of customers. Rather it should be futuristic, *i.e.*, in addition to meeting customer's present expectations, it should be able to improve them.

10.1.1 What is Six Sigma ?

Six Sigma implies maintenance of the desired quality in processes and end-products. It means taking systemic and integrated efforts toward improving quality and reducing cost. Six Sigma is a highly disciplined process that helps in developing and delivering near-perfect products and services. It strives to meet and improve organisational goals on quality, cost, scheduling, manpower, new products and so on. It works continuously towards revising the current standards and establishing higher ones.

Six Sigma has its base in the concept of probability and normal distribution in statistics. Six Sigma strives that 99.99966% of products manufactured are defect free. Six Sigma is a smart way to manage a business or a department. Six Sigma puts the customer first and uses facts and data to drive better solutions.

Six Sigma efforts target three main areas :

(*i*) Improving customer satisfaction

(*ii*) Reducing cycle time

(*iii*) Reducing defects

Improvements in the above areas usually represent dramatic cost savings to businesses, as well as opportunities to retain customers, capture new markets, and build a reputation for top performing products and services.

Although it involves measuring and analysing an organisation's business processes, Six Sigma is not merely a quality initiative; it is a business initiative. Achieving the goal of Six Sigma requires more than small incremental improvements; it requires breakthroughs in every area of an operation. In statistical terms, "reaching Six Sigma" means that the process or product will perform with almost no defects. But the real message of Six Sigma goes beyond statistics. Six Sigma is a total management commitment and philosophy of excellence, customer focus, process improvement, and the rule of measurement rather than gut fell. Six Sigma is about making every area of the organisation better able to meet the changing needs of

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customers, markets, and technologies—with benefits for employees, customers, and shareholders.

The background of Six Sigma stretches back eighty-plus years, from management science concepts developed in the United States to Japanese management breakthroughs to "Total Quality" efforts in the 1970s and 1980s. But its real impact can be seen in the waves of change and positive results sweeping such companies as GE, Motorola, Johnson & Johnson, and American Express.

TABLE 10.1: GE's Key Concepts of Six Sigma

Critical to Quality	Attributes most important to the customer
Defect	Failing to deliver what the customer wants
Process Capability	What your process can deliver
Variation	What the customer sees and feels
Stable Operations	Ensuring consistent, predictable processes to improve that the customer sees and feels
Design for Six Sigma	Designing to meet customer needs and process capability

Source : http://www.ge.com/sixsigma/sixsigstrategy.html

10.1.2 Six Sigma Methodology

For implementing six sigma there are two separate key methodologies for existing and new processes. Conceptually there is some overlapping between the two. The two methodologies as follows :

1. **DMAIC :** DMAIC methodology is an acronym for five different steps used in Six Sigma directed towards improvement of existing product, process or service. The five steps are as follows :
   - *Define :* To begin with six sigma experts define the process improvement goals that are consistent with the strategy of the organisation and customer demands. They discuss different issues with the senior managers so as to define what needs to done.
   - *Measure :* The existing processes are measured to facilitate future comparison. Six sigma experts collect process data by mapping and measuring relevant processes.
   - *Analyze :* Verify cause-and-effect relationship between the factors in the processes. Experts need to identify the relationship between the factors. They have to make an comprehensive analyses to identify hidden or not so obvious factor.
   - *Improve :* On the basis of the analysis experts make a detailed plan to improve.
   - *Control :* Initial trial or pilots are run to establish process capability and transition to production. Afterwards continuously measure the process to ensure that variances are identified and corrected before they result in defects.

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2. **DMADV :** DMADV is again acronym for the steps followed in implementing Six Sigma. It is a strategy for designing new products, processes and services.
   - *Define :* As in case of DMAIC six sigma experts have to formally define goals of the design activity that are consistent with strategy of the organisation and the demands of the customer.
   - *Measure :* Next identify the factors that are critical to quality (CTQs). Measure factors such as product capabilities and production process capability. Also assess the risks involved.
   - *Analyse :* Develop and design alternatives. Create high-level design and evaluate to select the best design.
   - *Design :* Develop details of design and optimise it. Verify designs may require using techniques such as simulations.
   - *Verify :* Verify designs through simulations or pilot runs. Verified and implemented processes are handedover to the process owners.

10.1.3 What is New About Six Sigma?

In the 1980s, Total Quality Management (TQM) gained popularity. It was an improvement-focused programmes, but it ultimately died a slow and silent death in may companies. What makes Six sigma different ? Three key characteristic separate Six Sigma from other quality programmes of the past :

1. *Six Sigma is customer focused.* It's almost an obsession to keep external customer needs in plain sight, driving the improvement effort. (External customers are mostly those who buy business's products and services.)
2. *Six Sigma projects produce major returns on investment.* GE's CEO, jack Welch, wrote in the annual report that in just three years, Six Sigma had saved the company more than $ 2 billion.
3. *Six Sigma changes how management operates.* Six Sigma is much more than improvement projects. Senior executives and leaders throughout a business are learning the tools and concepts of Six Sigma : new approaches to thinking, planning, and executing to achieve results. In a lot of ways, Six Sigma is about putting into practice the notions of working smarter, not harder.

Six Sigma has produced some impressive numbers. But reaching them requires a great deal of organisational teamwork. It means having the systems to provide customers what they want when they want it. It means providing employees with the time and training to tackle work challenges with some basic, and some sophisticated, analytical tools.

When a business violates important customer requirements, it is generating defects, complaints, and cost. The greater the number of defects that occur, the greater the cost of correcting them, as well as the risk of losing the customers.

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Ideally, any company would like to avoid any defects and the resulting cost in money and customer satisfaction. But if a company has lots of customers, some defects are bound to slip through. The problem is that even a seemingly low percentage of defects can mean a lot of unhappy customers. If a company processed 250,000 credit card bills a month and operated at 99.38 per cent accuracy (4 sigma), we would have about 1,550 unhappy customers every month.

The goal of Six Sigma is to help people and processes aim high in aspiring to deliver defect-free products and services. The notion of zero defects is not at work here; Six Sigma recognises that there's always some potentials for defects, even in the best run processes or best-built product. But at 99.9997 per cent performance, Six Sigma sets a performance target where defects in many processes and products are almost nonexistent. There is no denying the fact that defects can lead to lost customers, and turned-off customers tell others about their experiences, making it that much more difficult to recover from defects. As customers get more and more demanding and impatient, the higher levels of defects put a company in serious risk. But keeping customers happy is good and profitable for the business. A 5 per cent increase in customer retention has been shown to increase profits more than 25 per cent. It is estimated that companies lose 15 percent to 20 per cent of revenues each year to ineffective, inefficient processes—although some might suggest that it's even higher. Six Sigma provides a goal that applies to both product and service activities and that sets attainable, short-term goals while striving for long-range business objectives.

10.1.4 Six Sigma as a System of Management

A significant difference between Six Sigma and seemingly similar programmes of past years is the degree to which management plays a key role in regularly monitoring programme results and accomplishments. When Jack Welch introduced the Six Sigma programme at GE, he told senior executives that 40 per cent of their annual bonus would be based on their involvement and success in implementing Six Sigma.

That focused executive attention on turbo-changing Six Sigma in their individual divisions. Training in GE was given a huge boost, and thousands of teams were trained in large sessions. At the same time, executives throughout GE participated in days and sometimes weeks of Six Sigma training. But training alone is not a management system. A management system involves accountability for results and ongoing reviews to ensure results. With both accountability and regular reviews, managers can begin to use Six Sigma as a guide to leading their businesses.

As a management system, though Six Sigma is not owned by senior managers (although their role is critical) or driven by middle management (although their participation is key). The ideas, solutions, process discoveries, and improvements

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that arise from Six Sigma take place at the front lines of the organisation. Six Sigma companies are striving to put more responsibility into the hands of the people who directly with customers.

In short, Six Sigma is a system that combines both strong leadership and grassroots energy and involvement. In addition, the benefits of Six Sigma are not just financial. People at all levels of a Six Sigma company find that better understanding of customers, clearer processes, meaningful measures, and powerful improvement tools make their work more rewarding.

10.2 QUALITY ASSURANCE

Quality assurance engineering deals with the assuring of the desired quality, reliability, service and other aspects in the manufactured product through various scientific techniques. The job of evaluating the company's activities with respect to quality, reporting the results of evaluation to all concerned for information and necessary action and the subsequent action taken is called quality assurance.

There are three stages in consideration of total quality of product.

$$\text{Total Quality Assurance} = \left\{\begin{matrix}\text{Quality of}\\ \text{design}\end{matrix}\right\} + \left\{\begin{matrix}\text{Quality of}\\ \text{manufacturing}\end{matrix}\right\} + \left\{\begin{matrix}\text{Quality of}\\ \text{performance}\end{matrix}\right\}$$

The quality of design combined with the quality of performance is termed as 'reliability', whereas the field covering quality of manufacturing according to design is termed as quality control.

Many quality assurance activities provide protection against quality problems through early warnings of trouble ahead. The assurance comes from evidence—a set of facts. For simple products, the evidence is usually some form of inspection or testing of the product. For complex products, the evidence is not only inspection and test data but also reviews of plans and audits of the execution of plans. A family of assurance techniques is available to cover a wide variety of needs.

In the field of industrial management, the following activities are related with quality assurance :

(*i*) Processing of field complaints.

(*ii*) Quality rating of outgoing product.

(*iii*) Quality audit.

(*iv*) Preparation of reports.

(*v*) Setting up quality level.

(*vi*) Inspection planning.

(*vii*) Measuring and reporting reliability.

The following benefits could be expected from quality assurance :

(*i*) Reduced scrap and defects makes production economical.

(*ii*) Fewer complaints in product and service are reported.

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(iii) Good relations with customers are attained by supplying them quality products.

(iv) Higher efficiency and productivity is obtained.

TABLE 10.2 : Quality Assurance Activities by Various Departments

Department	*Assurance Activity*
Product Development	Design review, Reliability analysis Maintainability analysis Safety analysis Human factors analysis Manufacturing, inspection and transportation analysis Value engineering
Marketing	Product evaluation by a test market. Controlled use of product Product monitoring Captive service activity Competitive evaluation
Supplier Relations	Qualification of supplier design Qualification of supplier process Evaluation of initial samples Evaluation of first shipments
Production	Design review, Process capability analysis Pre-production trials. Failure mode, effect, and criticality analysis for process Review of manufacturing planning Evaluation of proposed process control tools Self-control analysis Audit of production quality
Inspection	Inter-laboratory tests for measuring accuracy
Customer Service	Audit of packaging, transportation, and storage Evaluation of maintenance services.

10.3 STANDARDISATION

Standardisation is an important management tool for improving quality and productivity. Quality and standardisation are the two essential pre-requisites for a company to market its products and services in the competitive business environment. Quality begins with standards. Quality encompares safety, reliability, durability, performance and acceptability of products by consumers. Hence quality standards are to be built in the product during research, design, development and production. The foundation on which quality is built is the standards.

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The steps involved in standardisation are as follows :

(*i*) With the help of market research, and experience, determine what is to be sold in future.

(*ii*) Define a range of products.

(*iii*) From the range of products, select the minimum variety of components matching the range for manufacturing. Introduce new materials, components, etc., if necessary.

Applications of Standardisation

Standardisation can be applied to a major extent in the following fields :

(*i*) Finished products, *e.g.*, cars, air-conditioners, and televisions.

(*ii*) Sub-assemblies and components, *e.g.*, automobile gearboxes and auto-electric bulbs.

(*iii*) Materials, *e.g.*, both direct material (plain carbon and alloy steels, welding electrode, core wire, etc.) and indirect materials such as oils and greases.

(*iv*) Production equipments, *e.g.*, machine tools, press, welding equipments, etc.

Benefits of Standardisation

The major benefits of standardisation are as follows :

(*i*) Uniformity in documentation and systems.

(*ii*) Streamlining of production and increase in productivity and efficiency.

(*iii*) Setting the recognised level of quality at reasonable price.

(*iv*) Creation of quality and standardisation culture.

(*v*) Facilitation of interchangeability.

(*vi*) Reduction of inventory and optimum utilisation of resources.

(*vii*) Reduction in inventory carrying cost and procurement cost.

BOX 10.1: Requirements of a Good Standard

(*i*) Reasonably stable
(*ii*) Reducible to permanent form
(*iii*) Reproducible
(*iv*) Representative
(*v*) Applicable
(*vi*) Universal within limit of problem
(*vii*) Free from ambiguity

10.4 KAIZEN

Dynamic organisations make continuous improvement a way of life. The Japanese word for continuous improvement is **kaizen,** which means improving

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the overall system by constantly improving the little details. *Koizen practitioners view quality as an endless journey, not a final destination. They are always experimenting, measuring, adjusting, and improving.* Rather than naively assuming that zero defects means perfection, they search for potential and actual trouble spots for improvement of product design and processes.

There are four general avenues for continuous improvement for any organisation. These include:

(*i*) Improved and more consistent product and service *quality*.

(*ii*) Faster *cycle times* (in cycles ranging from product development to order processing to payroll processing).

(*iii*) Greater *flexibility* (for example, faster response to changing customer demands and new technology).

(*iv*) Lower *costs* and less *waste* (for example, eliminating needless steps, scrap, rework, and non-value-adding activities).

International attention is being focussed on the outstanding performance of the Japanese economy and the success of management practices being adopted by Japanese firms. Interest in Japanese management system has rapidly increased in the western and other countries of the world. 'Quality improvement' is central to the Japanese system alongwith life time employment, seniority based promotion, group participation, etc. In Japanese system, *quality is expressed in relation to continuous improvement known as kaizen.*

Though lifetime commitment and seniority systems have proved difficult for Western organisations to absorb, yet quality and flexibility have been taken up as the processes which have demonstrated the greatest transferability from Japan. This is particularly the case where Japanese transplant companies in the West have not only set up their own procedures but have also encouraged or required Western suppliers and subcontractors to follow suit. Perhaps the most significant work organisation innovations that have been adopted in the West are the group of operations which are variously known *as JIT (just-in-time) and Kanban.* Each of these is different, and represents a variation on tighter and more controlled supply and manufacturing systems.

10.5 JUST-IN-TIME PRODUCTION AND KANBAN SYSTEMS

Just-in-time (JIT) production is defined as **"a philosophy that focuses attention on eliminatng waste by purchasing or manufacturing just enough of the right times just in time"**. Some observers have called JIT a hand-to-mouth approach to production. Thus, JIT attacks the problem of bloated inventories that historically have hampered productivity and profitability. However, JIT involves much more. In pursuit of the JIT ideal, managers try for varying combinations of the following:

(*i*) Purchase and produce goods in smaller but higher-quality lots.

(*ii*) Design more efficient workflows by eliminating costly bottlenecks.

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(*iii*) Reduce scrap and rework.

(*iv*) Prevent disruptive machine breakdowns.

(*v*) Enhance employee motivation through genuine participation or empowerment.

The concept of JIT is extended to the whole system of production, *i.e.*, to produce and deliver finished goods just-in-time to be sold, sub-assemblies just-in-time to be assembled into finished goods, fabricated parts just in time to go into sub-assemblies, and purchase materials just in time to be transformed into fabricated parts. Thus, JIT stands for 'producing necessary units in necessary quantities at the necessary time.' The purpose of JIT is to produce product in such a way that there is minimum work-in-process and minimum stock of finished goods in inventories. Therefore, unnecessary inventories which are a 'collection of troubles and bad causes' are eliminated.

In practice, managers employ combinations of several elements which include smoothing of production, providing for process flexibility and versatility, standardisation of jobs, and utilisation of an ordering and delivery system called *kanban*. Fig. 10.1 shows the various elements which lead to the implementation of JIT. Smoothing production can be achieved by reducing set up time and thereby lowering lot size. With reduced set up time and lot size, there will be a significant improvement in quality, scrap, and worker motivation, alongwith reduced need for storage space, material handling equipment, inventory control and support personnel.

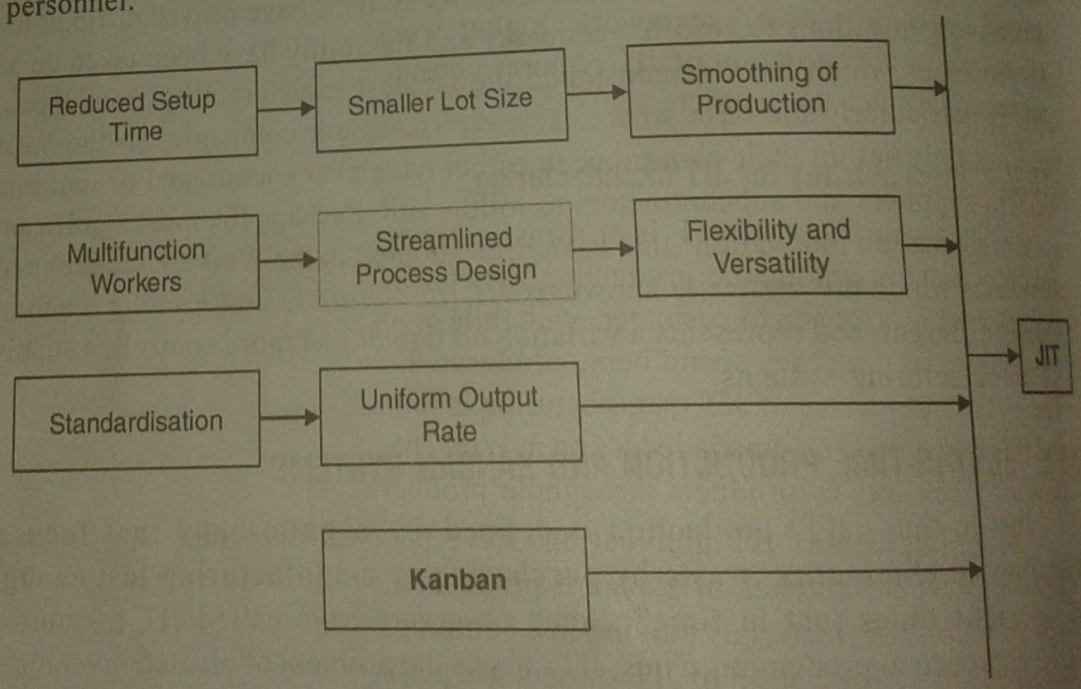

FIG. 10.1. *The JIT System.*

Multiskilled workers are a key factor in designing of streamlined process. The processes are designed in such a way that each worker can handle two or more machines and move from one work centre to another. Multifunction workers

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also perform maintenance, quality inspection and cleanup operations and participate in work improvement projects. Development of multifunction workers not only decreases the number of workers and increases productivity, but also increases team work and morale among the workers. Standardisation of job is also important alongwith process flexibility in a JIT system. This includes standard cycle times, standard routings and standard quantities in containers holding work-in-process. Standardisation of jobs leads to a more uniform output rate.

Kanban is an integral part of a JIT system. *Kanban* is a 'pull' inventory system aimed at part feeder stages of production. It employs manual cards instead of computers for planning and controlling parts movements. There are two types of *kanbans*—withdrawal *kanban* and production-ordering *kanban*. The quantity to be withdrawn by the subsequent process is written on the withdrawal *kanban*, while the quantity that should be produced by the preceding process in shown on the production *kanban*.

Because of JIT, production operations are lean and flexible. Leanness is achieved by keeping work-in-process inventories to a minimum. Flexibility is achieved by reducing machine set up times so that single units or small batches of different products can be produced in rapid succession. Furthermore, JIT places more emphasis on *feed forward* control than is typically found in traditional factories. For instance, preventive maintenance is the personal responsibility of machine operators in factories pursuing the JIT system.

The potential benefits of JIT include quality improvement, higher productivity, lower cost, less work-in-process, less inventory of raw materials, finished goods, saved space, increased teamwork, higher workers' morale and motivation. However, implementation of JIT requires considerable cooperation between the management and the workers.

10.5.1 Prerequisites for JIT Manufacturing

The basic idea of JIT is to drastically reduce work-in-process (WIP) inventories throughout the production system. In this way, products flow from suppliers to production to customers with little or no delays or interruptions beyond the amount of time they spend being produced at work centres in manufacturing. The overall objective of JIT manufacturing is to reduce manufacturing lead time, and this is achieved by drastic reduction in WIP. The result is a smooth, uninterrupted flow of small lots of products throughout production.

Most successful JIT applications have been in repetitive manufacturing operations where batches of standard products are produced at high speed and high volumes with materials moving in a continuous flow. The Toyota automobile factories, where the notion of JIT started, are perhaps the best example of the use of JIT in repetitive manufacturing. In these factories, continuous production makes planning and control rather simple, and JIT works best in these shop-floor situations. Successful use of JIT is rare in large highly complex job shops where production planning and control is extremely complicated. Smaller, less complex job shops have used JIT, but these units have taken many steps to change operations

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so that they behave somewhat like repetitive manufacturing.

JIT requires the following changes to be made in the way the industrial enterprises are managed :

(*i*) Stabilize production schedules.

(*ii*) Make the factories more focused.

(*iii*) Increase production capacities of manufacturing work centres.

(*iv*) Improve products quality.

(*v*) Cross-train workers so that they are multiskilled and competent in several jobs.

(*vi*) Reduce equipment breakdowns through preventive maintenance.

Eliminating Waste

Eliminating waste of all kinds is the basic idealogy behind JIT. Shigeo, a JIT authority at Toyota, identified seven types of waste in production that should be eliminated. (See Box 10.3)

BOX 10.3: Eliminating Waste in Manufacturing

A recognised JIT authority and engineer at the Toyota Motor Company, Shigeo Shingo, has identified seven areas where waste could be eliminated. These include :

1. **Overproduction :** Make only what is needed now.
2. **Waiting :** Coordinate flows between operations and balance load imbalances by flexible workers and equipment.
3. **Transportation :** Design facility layouts that reduce or eliminate materials handling and shipping.
4. **Unneeded production :** Eliminate all unneeded production steps.
5. **Work-in-Process (WIP) Inventories :** Eliminate WIP inventories by reducing set up time, increasing production rates, and better coordination of production rates between work stations.
6. **Motion and Effort :** Improve productivity and quality by eliminating unnecessary human motions, make necessary motions more efficient, mechanise, then automate.
7. **Defective products :** Eliminate defects and, thus, need for inspection. Make perfect products.

Source. *R Hall, Attaining Manufacturing Excellence (Dow Jones-Irwin, Homewood, IL, 1987) p. 26.*

10.5.2 Enforced Problem Solving and Continuous Improvement

In traditional manufacturing, in-process inventories allow production to continue even if production problems occur ; thus, high machine and worker utilisation is achieved. If defective products are discovered, machines malfunction, or material stock outs occur, in-process inventory can be used to feed what would otherwise be idle workers and machines. The in-process inventory covers up

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production problems in traditional manufacturing. Behind JIT is the continuous drive to improve production process and methods. Toward that end, JIT strives to reduce inventories because high inventory levels are thought to cover up production problems. By drastically reducing in-process inventories, production problems are uncovered and production stops until the causes of the production problems are removed. Only when the machine is fixed, the quality control problem is solved, or the cause behind the stock out is found and corrected, only then can production begin again.

In JIT system, ever material is expected to meet quality standards, every part is expected to arrive exactly at the time promised and precisely at the place it is supposed to be, every worker is expected to work productively, and every machine is expected to function as intended without breakdowns. Managers in JIT manufacturing have a choice. They can put a huge effort into finding and solving the causes of production problems, or they can live with an intolerable level of interruption. One of the approaches to implementing a JIT programme is to reduce in-process inventories incrementally in small steps. At each step, different production problems have been removed. But the job of eliminating production problems is not over. Vigilance in continuing to study potential problem areas is needed to ensure continuous improvement.

Japanese manufacturers have long practiced what they called ***kaizen***, the goal of continuous improvement in every phase of manufacturing. Managers may encourage workers to reduce in-process inventories a step further to see if any production problem occur, thus identifying a target for the workers to eliminate. Machine set ups may be studied with workers and managers working to strip away the fat so that set ups are almost instantaneous. Japanese manufacturers have long used the term less than a minute set up, meaning that their goal is to have all set ups take less than a minute.

Benefits of JIT Manufacturing

Some of the benefits of JIT manufacturing system are as follows :

(*i*) Inventory levels are drastically reduced.

(*ii*) The time it takes for products to get through the factory is greatly reduced, thus enabling factories to engage in time based competition, using speed as a weapon to capture market share.

(*iii*) Product quality is improved, and the cost of scrap is reduced. Product quality improves because of workers' involvement in solving the causes of production problem and with smaller lots, defective parts are discovered earlier.

(*iv*) With less in-process inventory, less space is taken up with inventory and materials handling equipment. Workers are closer together so that they can see each other, communicate more easily, work out problems more efficiently, learn each other's jobs, and switch jobs as needed.

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This promotes teamwork among workers and flexibility in work assignment.

(*v*) Because the focus in manufacturing is on finding and correcting the causes of production problems, manufacturing operations are streamlined and problem-free.

10.5.3 JIT Purchasing

In JIT purchasing, suppliers use the replacement principle of Kanban by using small standardized containers and making several shipments daily to each customer. If Kanban is used by a supplier, Kanban cards authorize the movement of containers of parts between the supplier's shop and the customer. In such arrangements, suppliers are ordinarily located near their customers. JIT, therefore, not only reduces in-process inventories by using Kanban, but raw-materials inventories are also reduced by applying the same principles to suppliers.

The essential elements of JIT purchasing are as follows :

(*i*) Supplier development and supplier relations undergo fundamental changes. The nature of the relationships between customers and suppliers shifts from being adversarial to being cooperative. The Japanese call these relationships as **subcontractor networks.**

(*ii*) Purchasing department develops long-term relationships with suppliers. The result is long-term supply contracts with a few suppliers rather than short-term supply contracts with many suppliers. Repeat business is awarded to the same suppliers, and competitive bidding is ordinarily limited to new parts or components.

(*iii*) Although price is important, delivery scheduled, product quality, and mutual trust and cooperation become the primary basis for supplier selection.

(*iv*) Suppliers are encouraged to extend JIT methods to their own suppliers.

(*v*) Suppliers are ordinarily located near the buying firm's factory, or if they are some distance from the factory, they are usually clustered together. This causes lead time to be shorter and more reliable.

(*vi*) Shipments are delivered directly to the customer's production line. Because suppliers are encouraged to produce and supply parts at a steady rate that matches the use rate of the buying firm. Company-owned hauling equipment tends to be preferred.

(*vii*) Delivered material is of near-perfect quality. Because suppliers have a long-term relationship with the buying firm and because parts are delivered in small lot sizes, the quality of purchased materials tends to be higher.

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10.6 KANBAN SYSTEM

Accomplishing the Just-in-Time objective rests on systems for determining production methods, and the information system called Kanban. Both of these concepts contribute to the objective of having the right number of parts or components at the right place at the right time.

The Kanban system is a unique Japanese information system that "harmoniously" controls the production quantities in each process. It is a simple information system used by a Work Centre (WC) to signal its supplier WC to send a container of an item and to authorise the supplier WC to make another container of the particular item. The name comes from the Japanese word Kanban, which means "card" or "sign". Originally a card was used to signal the supplying work centre. A WC can use any of a variety of methods to trigger resupply by its supplier WC. For example, a flashing light, the empty container itself, or a message on a computer terminal can communicate a request for more material. We shall now discuss the two-card Kanban system to provide some detail about how it is links the work centres.

In the two-card kanban system, one type of card, called a production card, or P-card, authorises a WC to make one standard container of a particular part specified on the card. The second type of card, called a move card, or M-card, authorises the movement of one container of the specified part from a particular WC to another WC as specified on the card. These cards are ordinarily recirculated and new cards are issued only when production of an item is to be started or changed significantly. The production card circulates repeatedly between the outbound material location at a WC and the work area where the item is produced. Similar card transactions link the supplier WC and the WCs that supply it. The user WC will also be linked to one or more WCs of the suppliers. A series of these linkages connects the final assembly operation with the WC that performs the first operations in making the product. Often, even the raw material vendor is linked with the starting operation through a kanban signal. Kanbans picked up when one delivery is made authorise the vendor to make specified items and deliver them on the next delivery.

The Kanban system can be a very simple, inexpensive, and effective method of coordinating work centres and vendors. The organisations must be well disciplined so that there is always an authorising kanban with every container, ensuring that only the appropriate items are produced and excessive inventory does not build up. There is also the opposite danger that some WC might run out of material and cause work to stop at all subsequent WCs. If this or any other pull method is to work well with small inventories, there must be no problems to disrupt production because there simply is not enough inventory to keep the plant running while a problem is being addressed.

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10.6.1 Empowerment

Empowerment occurs when employees are adequately trained, provided with all relevant information and the best possible tools, fully involved in key decision and are fairly rewarded for result. Empowerment is a key building block of progressive management by those who view power you give away (to the lower levels), the more you have in terms of productivity and performance. This can be a difficult concept to grasp for traditional authoritarian managers who see empowerment as a threat to their authority. Today, the issue is not empowerment *versus* no empowerment. Rather, the issue is how empowerement should take place.

The famous example of empowerment is Total Quality Management (TQM) which is employee driven for ensuring best possible quality products and services for the satisfaction of customers. TQM empowers employees at all levels in order to tap their full creativity, motivation and commitment. The other practices which encourage teamwork and employer involvement include suggestion system, quality circles, self-managed team, participative leadership, etc.

10.7 BENCHMARKING

Any business house seeking some improvement in business affairs needs to know the standard it will use to set its goals and assess its progress. This explains the need for benchmarking for better results. **Benchmarking is the practice of identifying, studying and building upon the best practices in the industry or in the world.** For instance, in 1992, Ford Motor Company delivered a knock down punch to Honda. Thanks to extensive fleet sales and aggressive discounting (practices Honda avoided), Ford's Taurus pulled ahead of Honda's Accord for the first time in four years to earn the title of best selling passenger car in the United States. The symbolic marketing value of Ford's achievement was immense. To the person on the street, the event signalled the return of America's industrial competitiveness. Much more than bragging rights were involved, though. Ford's achievement was a strong endorsement for benchmarking.

Learning from the experiences and best practices of others is essential to survive and grow in the turbulent market environment. Dynamic companies are constantly monitoring information from the external environment to compare their process, products and services with the best industry practices known as 'benchmarking'. Such comparisons help establish quality targets which lead to a competitive advantage.

The concept of benchmarking was developed and used extensively by **Xerox.** When Xerox was attempting to regain market share that had been lost to Japanese copier manufacturers in the late 1970s and early 1980s, Xerox undertook a study of competitors' products in terms of quality, features, and costs in comparison with Xerox's products. The company was shocked to learn that its unit manufacturing costs were equal to the best Japanese maker's selling price in the

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United States, the number of suppliers used by Xerox was nine times the number used by the competitors, assembly line rejects were ten times higher, product lead times were two times longer, and defects per 100 machines were seven times higher. After second benchmarking study confirmed the results of the first one, the company assembled its top 25 managers to begin planning their human resource system and total quality management efforts that eventually brought about the turnaround.

Ford used benchmarking to make the Taurus a world class automobile in the nineteen eighties. Ford started with the customer; it compiled a list of some 400 features its customers said were the most important, then set about finding the car with the best of each. Then it tried to match or top the best of the competition. The result was the hot-selling Taurus.

BOX 10.2: The Benchmarker's Guide

1. *Don't go on a fishing expedition.* Pick a specific area you want to improve, like accounts payable, and do your homework. Study your own procedures thoroughly and, obviously, choose a company or companies to benchmark that handle the process well.
2. *Send out the people who will have to make the changes.* They need to see for themselves. It won't help if senior executives or consultants do the benchmarking, then come back and tell the "owners" of a process what to do. Keep visits short and teams small.
3. *Be prepared to exchange information.* You should be ready to answer any question you ask another company.
4. *Avoid legal problems.* Discussions that might imply price fixing, market allocations, or other illegal activities will lead to trouble. Don't expect to learn much about new products. Most benchmarking missions focus on existing products, business practices, human resources and customer satisfaction.
5. *Respect the confidentiality of the data you obtain.* Companies that do not mind sharing with you may not want the information going to a competitor.

Source. Jeremy Main, "How to Steal the Best Ideas Around," *Fortune*, October 19, 1992.

10.8 QUALITY CIRCLES

10.8.1 Concept and Nature of Quality Circle

The Concept of Quality Circle emerged from quality control. Quality circles are quite popular in Japan. Looking at their success, many organisations in U.S.A. and India have also attempted to implement quality circles. It should be noted that quality circles provide a future-oriented approach. They seek high quality products in the current production run and in the future.

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A quality circle is a small group of employees doing similar or related work who meet regularly to identify, analyse and solve product-quality problems and to improve general operations.

The quality circles are relatively autonomous units (ideally about 10 workers), usually led by a supervisor or a senior worker and organised as work units. The workers, who have a shared area of responsibility, meet periodically to discuss, analyse, and propose solutions to on going problems.

The key features of a Quality Circle (QC) are as under :

1. A quality circle is a voluntary group.
2. It represents a collective effort of the group members.
3. It intends to improve the quality of output.
4. It coordinates the activities of members towards improving the quality of work in the workshop.
5. It facilitates frequent meetings and discussions of members for improving quality.
6. There is no discrimination against age, sex and position.

Purpose of Quality Circles

Some typical efforts in improving production methods and quality involve reducing defects, scrap, rework, and downtime, which are expected to lead to cost reduction as well as increased productivity. In addition, the circles intend to focus attention on the self-development of workers and the improvement of working conditions. Through this process, there is improvement of workers' morale and motivation, stimulation of teamwork, and recognition to their achievements.

The technique of quality circle has been refined over the years. It is now followed to achieve the following objectives :

1. Overall improvement of quality of products manufactured by the enterprise.
2. Improvement of production methods and productivity of the enterprise.
3. Self-development of the employees who take part in quality circles.
4. Encouragement of innovative ideas among the employees.
5. Building high morale of employees by developing team-work in the organisation.

Benefits of Quality Circles

Quality circles are supposed to bring the following benefits for the organisations:

(*i*) Formation of quality circles in Japan and other countries has helped in bringing out several innovations and changes in work methods and product.

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(*ii*) Quality circles have proved to be a valuable tool for increasing productivity, improving quality and increasing workers' job satisfaction.

(*iii*) Membership in a quality circle means a participative environment that provides identification with the work-group. Participation encourages commitment of the employees in producing quality products. Through quality circles, everyone becomes involved with the operation of the company. Everyone from top to bottom works towards a single goal, *i.e.*, success through quality.

(*iv*) Quality circles help in the development of the participants as they are encouraged to produce innovative ideas and find new ways to improve product quality.

(*v*) Quality circles provide opportunities for better understanding among the members.

(*vi*) Quality circles create awareness of the potential of the workers.

10.8.2 Introducing Quality Circles in an Organisation

Quality circle is a participative concept and its introduction may cause some resistance on the part of the employees. Therefore, before introducing quality circles, all precautions must be taken as in case of any organisational change. The steps in the introduction of quality circle are briefly discussed below :

1. Selling the Idea Quality Circle. The workers must be educated about the need and significance of quality circle from the point of view of the organisation and the workers. The scope of quality circle should also be adequately publicised. The workers should be allowed to clear their doubts about quality circle. Attempts should be made to seek their voluntary cooperation in implementing quality circles in the organisation. The management may also arrange for some kind of training of the employees who want to form quality circles.

2. Constitution of Quality Circles. The employees should be encouraged to form quality circles by drawing members doing the same kind of work. The membership of a quality circle should not exceed ten to twelve members. The information about the constitution of a quality circle should be made available to the top management.

3. Analysis of Quality Problems. The members of a quality circle are supposed to meet periodically, say once a month. They would collect data and analyse the same. Past records, employees suggestions, customers suggestions are very important in this regard. This will lead to identification of the problems that hinder quality.

4. Problem Solving. The members of a quality circle will discuss the problems thoroughly and make a list of possible solutions. The merits and demerits of each alternative will be evaluated. The final decision about the solution to the problem will be taken by the consensus of all members.

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5. Presentation of Suggestions to the Management. The suggestions for improving the quality are put in writing and forwarded to the management. Top management may form a committee to evaluate the suggestions of different quality circles in the organisation. The committee may also meet the members of the quality circles, if it has any doubt. The final report will be prepared by the committee. It will list the suggestions which must be implemented for improving the quality of goods and services.

6. Implementation. Proper publicity should be given to the suggestions of quality circles which are being put into practice. This will motivate the employees as they will feel the importance of having contributed to the well-being of the organisation. The implementation of the suggestions should be properly monitored by the management so that the change over to new methods is smooth.

10.8.3 Problems in Implementation of Quality Circles

There are several pitfalls in quality circles. Despite their merits, they have failed in many companies. The common hurdles in initiating quality circles in India are as under :

1. Negative Attitude. The employees and even managers may have negative attitude towards the quality circle. Naturally, they will resist its implementation. The wrong notions of the people about quality circles should be cleared. They should be properly informed about the concept of quality circle and its utility.

2. Lack of Ability. The workers in India have a low level of education and also lack initiative. To overcome this hurdle, Workers' Education Programme should be initiatied. It must educate the workers about quality circle.

3. Lack of Management Commitment. The top management may not be committed to the concept of quality circle. The employees may not be allowed to hold meetings of quality circles during the working hours. The employees will be least interested in devoting their personal time to the quality circle. Therefore, the management should allow the workers to hold quality circle meetings periodically during the working hours. It should extend the assistance required by the quality circles for their smooth working.

4. Non-implementation of Suggestions. The workers will feel disheartened if their suggestions are turned down by the top management without any reason. The suggestions of each quality circle should be given due weightage. If they are likely to improve quality of products, they must be implemented. This will enthuse the members of the quality circle.

10.8.4 Requirements of Effective Quality Circles

For increasing the effectiveness of quality circles, the following guidelines should be followed:

(*i*) The employees who are concerned with quality should be encouraged to come forward on their own to suggest ways and means to improve upon it.

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(*ii*) The QC members must be given full training in the areas of statistical analysis (graphs and table reading, histograms, scatter diagrams, stratification, etc.) to facilitate information processing.

(*iii*) Since the members of quality circles have to work in groups, an understanding of group dynamics is also necessary. Additionally, they should develop a problem solving approach.

(*iv*) The members should feel independent to choose any problem which they feel is most crucial. In addition, they should be free to implement and monitor the results.

(*v*) Each quality circle should have a number of meetings and discussions. Hence facilities for such meetings should be provided without any hindrance. In other words, quality circles must have the support of top management.

BOX 10.3: Important Concepts

Total Quality Management (TQM)

Total Quality Management is a philosophy which believes in a company-wide responsibility towards quality. The main aim of TQM is to actively involve the production personnel in the pursuit of quality and to infuse in them the spirit of continuous improvement.

Total Quality Management (TQM) refers to meeting the requirements of customers consistently by continuous improvement in the quality of work of all employees. For achieving total quality, three things are essential : (i) Meeting customers' requirement ; (ii) Continuous improvement ; (iii) Involvement of all employees.

Kaizen

It is a Japanese term which means improving the overall system by constantly improving the little details. TQM managers dedicated to Kaizen are never totally happy with things. They view quality as an endless journey, not a final destination. They are always experimenting, measuring, adjusting, and improving.

Just-in-Time (JIT)

Just-in-time production focuses attention on eliminating waste by purchasing or manufacturing just enough of the right items just-in-time. Some observers have called JIT a hand-to-mouth approach to production. JIT attacks the problem of bloated inventories that historically have hampered productivity and profitability.

Benchmarking

Any business house seeking some improvement in business affairs need to know the standard it will use to set its goals and assess its progress. This explains the need for benchmarking for better results. Benchmarking is the practice of identifying, studying and building upon the best practices in the industry or in the world.

Quality Circle

A quality circle is a small group of employees doing similar or related work—who meet regularly to identify, analyse and solve product-quality problems and to improve general operations.

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10.9 TQM IN INDIA

India awakened to the adoption of the concept of TQM, in the late 1980s though 'quality control' has been emphasised since the adoption of the Industrial Policy Resolution, 1956. The quality control efforts did not prove to be adequate to raise the quality of Indian products and to increase their exports. But this scenario changed with the announcement of Industrial Policy, 1991 which talked of integration of Indian economy with the world economy. The introduction of liberalisation measures such as delicensing of industries and entry of foreign capital into the country had the immediate effect of opening up Indian industry to international competition as also increased competition from within. In an extremely competitive environment, only the fittest can survive and for survival, every organisation has to embark upon a workable quality improvement process. This illustrates the significance of continuous quality improvement by the Indian industry.

Many of the organisations in India have started augmenting ways and means of creating quality consciousness and involving employees at all levels in quality improvement process. This will help them to meet competition from the foreign multinationals, increase exports, and also provide greater satisfaction to their customers. Several companies in India have even acquired the ISO-9000 certification, the European Standard of Quality for product and process.

In India, consultancy and guidance in connection with the registration for ISO : 9000 series standards is provided by many institutions such as :

1. Bureau of Indian Standards (BIS)
2. National Productivity Council.
3. National Centre for Quality Management.
4. Chambers of Commerce and Industry such as FICCI, CII, ASSOCHAM and AIMO.

It is sometimes believed that higher quality causes lower production which is a reflection on the production unit. That is why, production people tend to increase productivity without caring for quality. The misconception of reverse relationship between quality and quantity has to be removed. In fact, a well planned TQM programme generally results in increased production due to reduced wastage, rework, breakdown, etc.

The implementation of TQM has to be a specialised job lest it should end up in a chaos. In India, the concept of TQM, is new, the experts on TQM are not many. The external consultants prove very expensive and even their competence in not guaranteed. Therefore, it is essential that a responsible person from within the organisation should be provided adequate training and be made responsible for monitoring and implementation of TQM programme.

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10.9.1 ISO : 9000 Standards

The International Standards Organisation (ISO) was founded in 1946 and has its headquarters at Geneva in Switzerland. It has emerged as an apex institution of 'standard organisations' of 91 countries including India. The major thrust of ISO is on quality systems and well knitted procedures for stringent quality standards to the manufacturer on quality systems and management. The series of specifications are commonly known as ISO-9000. It may be noted that ISO-9000 is a coveted standard not only for the quality of products, but also for the systematised planning and management of an organisation as a whole.

The International Standards Organisation is responsible for promotion and development of international standards and related activities including conformity assessments such as *testing, inspection, laboratory, accredition, certification and quality assessment.* ISO constitutes technical committees and the result of the work of these committees are published as international standards. *ISO covers standardisation in all fields except electrical and electronic engineering standards* which are covered by International Electrotechnical Commission (IEC).

ISO : 9000 Series

The salient features of ISO : 9000 series standards are as follows :

(*i*) ISO : 9000 series standards were prepared in 1987 for providing guidelines for organisations on managing quality and standards.

(*ii*) ISO : 9000 series standards call for integration of all activities which have a direct or indirect effect on the quality of a product or service. They, in fact, lead to the implementation of the concept of Total Quality Management (TQM).

(*iii*) ISO : 9000 standard series tells suppliers and manufacturers what is required of quality oriented working system. It does not set out extra special requirements which only a very few firms can comply with. Instead it is a practical standard for quality systems which can be used by small as well as large organisations.

(*iv*) It defines the basic concepts and specifies the procedures and criteria to ensure that the outgoing product meets the customer's requirements. It requires the user organisation top establish its own procedures.

(*v*) The quality standards are designed to be user-friendly. They are generic in nature, and follow a logical, easily understood format. They are applicable to every product, let it be a tooth brush or a nuclear reactor.

(*vi*) There is no compulsion to get ISO : 9000 certification. However, the customer would be sure of the quality if the company has ISO : 9000 certification.

(*vii*) The total system of quality is thrown open for verification by the

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customer and confidence is built in him that the organisation is capable of delivering the products or services of desired quality.

Areas Covered by ISO Standards

The ISO has outlined 20 areas for quality systems which range from recruiting and training of personnel to handling of stores and finished products. The areas covered for quality systems are : management responsibility, quality system, contract review, design control, document control, purchasing, purchaser's supplied products, product identification and traceability, process control, inspection and testing, inspection, measuring and testing department, inspection and test status, non-conformity control, corrective actions, handling, storage, packing and delivery, quality records, internal quality audits, training, services and statistical techniques.

ISO Standards and India

ISO standards were laid down in *1987 to be renewed every five years* to determine whether they should be *confirmed, revised* or *withdrawn.* Standards organisations of various nations have adopted the ISO standards, though changing their numbers. For example, ISO : 9000 in Britain is known as *BS 5750,* in European Community as *EN 29000,* in Australia *AS 39000,* in Denmark *DS/EN 29000,* etc. In India, Bureau of Indian Standards (BIS) has published *IS : 14000* series as quality system standard equivalent of ISO : 9000.

ISO : 9000 (IS 14000) Quality Management and Quality Assurance Standard

ISO has provided different models for adaptation which relate to the stage of the product or service at which the quality needs assurance. This standard gives guidelines for selection and use of appropriate model.

ISO 9001 : 1987 (IS 14001 : 1988) Model for Quality Assurance in Design/ Development, Production, Installation and Servicing

A product or service has to pass through several stages after it is conceived and before it is supplied to the customer. Even after it is supplied to the user, a necessity may arise to take a follow up action so that the user does not face any problem in suing the product. ISO : 9001 standard gives a model for quality assurance at all stages starting from designing the product and seryicing after the product is delivered to the customer.

ISO–9001: It is a model for quality assurance in design, development, production, installation and servicing. It demonstrates the vendor's capability to design and supply the product or service. This standard is aimed to industries who design, produce, install product and provide services after sales as per the requirements of the customer. It provides guidelines regarding organisational structure of quality system, responsibilities, distribution of authority and

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interrelationship of all employees. It also provides guidance regarding inspection, testing, monitoring of design, production, installation and servicing of the process and product. It gives information about measurement, procedure, design, design control, process monitoring, etc.

ISO : 9001 applies to industries which design, produce, install product and provide after sales service as per the requirements of the customer. Some specific examples are heat exchangers, coolers, filters, extraction columns, etc. for process industries. In these cases, the customer states his requirements and the supplier works out the final design, makes changes if required. A set of specifications is then prepared, after the design requirements are mutually agreed. The supplier has to open his manufacturing stages to the customer so as to enable him to judge the suppliers' capability of manufacturing the product as per his requirements.

BOX 10.5 : ISO Standards and Equivalent Indian Standards

S. No.	International Standard	Title	Equivalent Indian Standard
01.	ISO 8402 : 1986	Quality systems – Vocabulary	IS 13999 : 1988
02.	ISO 9000 : 1987	Quality system – Guidelines for selection and use of standards on quality system	IS 14000 : 1988
03.	ISO 9001 : 1987	Quality systems – Model for quality assurance in design/development production, installation and servicing	IS 14001 : 1988
04.	ISO 9002 : 1987	Quality systems – Model for quality assurance in production and installation	IS 14002 : 1988
05.	ISO 9003 : 1987	Quality system – Model for quality assurance in final inspection and test	IS 14003 : 1988
06.	ISO 9004 : 1987	Quality Management and quality systems elements Guidelines	IS 14004 : 1991
07.	ISO 9004 : 2	Quality management and quality system elements—part 2 Guidelines for servies	IS 14004 : 1991
08.	ISO 10011-1	Guidelines for auditing quality system-part 1 auditing	IS 14011 (Part 1) : 1991
09.	ISO 10011-2	Guidelines for auditing quality system—part 2 Qualifications criteria for auditors	IS 14011 (Part 2) : 1991
10.	ISO 10011-3	Guidelines for auditing quality system—Part-3 Management audit programmes	IS 14011 (Part-3) : 1991
11.	ISO 10012-1	Quality assurance requirements for measuring—Part-1 Management of measuring equipment	IS 14013 (Part 1)

After the product is manufactured and inspected for conformance with specifications, it should be installed by the supplier at the customer's premises and a trial run should be conducted. Even after installation, the supplier has to

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provide necessary services for maintenance of equipment for trouble-free performance.

ISO : 9002 : 1987 (IS : 14002 : 1988) Model for Quality Assurance in Production and Installation

Some products require quality assurance only during production and till they are delivered to the customer/or installed in his premises. ISO : 9002 gives a model quality assurance for such products. In such cases, the manufacturer gives his own design to meet the customer's requirements and has to production process is capable of producing the product/equipment as per the requirements of the customer.

ISO 10011 part-3 deals with establishment of audit function. The management should establish a separate quality audit function outside the quality system implementation.

ISO 9003 : It is a model for quality assurance in final inspection and test. Certain products require quality assurance only after they are manufactured at the time of supply. ISO 9003 standard gives a model of quality assurance in such cases.

ISO 9004 : It gives guidelines for quality management. When there is no contract between supplier and contractor. The ISO 9004 is used for quality management.

The areas of application of ISO : 9000 standard are as shown in Fig. 10.2.

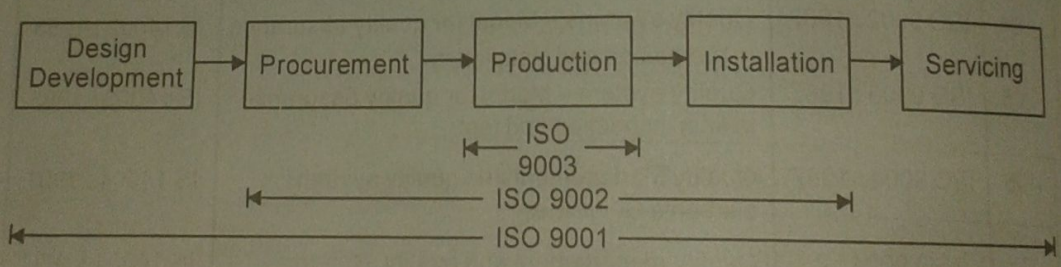

Fig. 10.2. *Scope of ISO Standards*

Benefits of ISO : 9000 Series

If a business concern gets ISO-9000 certification, if will draw the following advantages :

(*i*) It is an internationally accepted series of quality system standards. It provides for competitive edge in the domestic as well as international market.

(*ii*) It helps in achieving consistency, economy and cost effectiveness through standardisation of operations.

(*iii*) It increases customer's confidence in the supplier through quality system transparency.

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(*iv*) It is a versatile marketing tool in today's international scenario. The European countries and some other countries don't accept foreign goods unless they carry the ISO-9000 certification.

(*v*) It paves the way for total quality management (TQM) since it ensures continuous quality improvement to meet the requirements of customers.

(*vi*) It reduces the need for inspection by the buyers. It thus saves time and money which would be spent on multiple inspection of the products for conformance if it does not carry the ISO : 9000 certificate.

(*vii*) In India, some concessions for import have been given as per Export and Import Policy to the companies adopting ISO : 9000 standard.

(*viii*) The ISO : 9000 certification by a company is a source of motivation to its employees. The employees feel proud in achieving excellence.

Limitations of ISO : 9000

There are a few limitations of ISO : 9000 series of standards. These are :

(*i*) The implementation of ISO : 9000 series of standards is very much demanding on resources. The formulating and documenting of the system is time consuming, and may involve considerable cost.

(*ii*) Assessment and registration are quite expensive. Only the big firms can afford ISO : 9000 certification.

(*iii*) Unless carefully interpreted and planned, the system can become burdensome quite often obstructing normal operations.

(*iv*) The system to change attitudes and accept new standards may be resisted by the workers and even by the managers who are not open to new ideas.

BOX 10.6 : ISO : 9000 At A Glance

What is ISO : 9000 ?

- It is a set of written standards which comprise quality system.
- It defines the basic elements of the system through documentation.
- It creates a quality system rooted in customers' requirements.
- It ensures uniform systems that are universally recognised.
- It is based on world-recognised standards.
- The quality standards are designed to be user friendly.

How does ISO : 9000 facilitate TQM ?

- It complements TQM's emphasis on the human element.
- It helps assess the organisation's quality standards.
- It translates quality concepts into achieveable targets.
- It provides an opportunity to create and improve quality systems.
- It helps spread the message of quality across the organisation.

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Whom does ISO : 9000 help ?

- Companies that market their products to the Europeans and other countries.
- Vendors supplying to companies that demand ISO : 9000 certification.
- Companies whose competitors carry IOS : 9000 certification.
- Companies with global operations.
- Companies whose transnational parent companies have ISO : 9000 certification.

Source : Adapted from *BIS-Booklet and Business Today,* Jan. 7 – 21, 1995.

Procedure of ISO : 9000 Registration

ISO is located in Geneva, Switzerland. Each nation has its own National Standard Organisation (NSO) which is affiliated to the ISO. The system and procedures are laid down by NSO's. As for example, in the case of electronic equipment, IEC (International Electro-ISO-9000) registration means the certification of quality systems by third party through the machanism of registration. European countries expect Indian companies to have their quality system registered to ISO9001 or 9002 or 9003. This is normally done by accredited independent third party on-site audit of the company's operation against the requirements of the appropriate standards. The following steps are required to be followed for ISO : 9000 registration :

(*i*) *Management Commitment.* The top management decision to start the implementation of ISO : 9000 standard in the company is the prime requirement. If the top management is not committed to the concept of total quality management (TQM), it will not lend support to the idea of getting ISO : 9000 certification.

(*ii*) *Selection of Model.* The next step would be to select the model which is applicable to the organisation. The selection of the ISO : 9000 model will depend upon the type of product and the stage at which the quality is to be achieved. Each clause of the selected model is to be understood carefully before proceeding further.

(*iii*) *Steering Group and Sub-Groups.* The management must appoint a steering group and a number of sub-groups to identify the activities to be carried out. The groups will study the existing practices of quality assurance system and find out their deficiencies. This will help them identify the activities for quality improvement.

(*iv*) *Preparation of Checklist.* The steering group will prepare a checklist, and categories the elements, (*a*) which are already in practice, (*b*) which are in practice but need change or improvement, and (*c*) which are not in practice. The list of equipments and other facilities required is prepared. The equipment which may need to be modified is also identified.

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(v) *Preparation of Quality Manual.* At this stage, a quality manual is prepared which contains all documents required for ISO registration.

(vi) *Training of Leaders and Workers.* Training courses in the ISO : 9000 standards would be necessary for the co-ordinators and group leaders. It would also be beneficial to ensure the participation of operative employees in training programme. This would secure the acceptance of new standards and methods of doing work.

(vii) *Internal Audit.* It involves the appraisal of the quality assurance system as documented by the organisation. This will determine the extent to which the organisation's own documented quality assurance procedures adequately meet the relevant ISO : 9000 series of standard. Internal quality audit is carried out for two broad purposes :

(*a*) To find out whether all quality related functions comply with the laid down procedure; and

(*b*) To determine whether the implemented systems as such are effective.

The internal audit should be carried out by a person independent of quality control and production activities. Based on internal audit, corrections regarding procedural requirements to meet the standard are made and the procedure is finalised and documented.

(viii) *Trial Audit.* The next step is to apply to Bureau of Indian Standards or any other certifying body for a trail audit and get their recommendations. The management must implement the recommendations, if any, given by certifying body and include them in quality manual and audit checklist.

(ix) *Application for Registration.* Once the trial audit's result is positive, the organisation can apply for registration to BIS or any other internationally recognised body.

(x) *Adequacy Audit.* After the application has been accepted, the documented quality system will be examined by the BIS or any other recognised certifying body for verifying the conformance to the relevant standard. Discrepancies, if any, will have to be corrected by the applicant.

(xi) *Grant of Licence.* The corrective action taken by the applicant on the discrepancies observed during assessment will have to be verified by the BIS. Based on the findings of the assessment team and satisfactory report, licence will be granted to the applicant by BIS/ISO to use the certification mark in letter heads, quality certificates, etc.

Review Questions

Objective Type Questions

Indicate whether the following statements are **true** or **false** :

1. Six Sigma strives that 99.99966% of the products manufactured are defect free.
2. DMAIC and DMADV techniques are used for implementing Six Sigma.

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3. Six Sigma and Total Quality Management con be used interchangably.
4. Kaizen is an American technique which involves continuous improvement.
5. JIT production is intemded to produce necessary products in required quantities at the right time.
6. Kanbant is not related to JIT production system.
7. Quality circles consist of managers concerned with quality control.

Ans.: 1. T, 2. T, 3. F, 4. F, 5. T, 6. F, 7. F.

Short Answer Questions

1. Define the term 'Six Sigma'.
2. What is the need of quality improvement ?
3. Explain the concept of quality assurance.
4. Briefly explain the need and significance of JIT.
5. What are the benefits of standardisation ?
6. What are ISO : 9000 standards ?
7. What are the features of a Quality Circle ?
8. State the benefits of Quality Circles.
9. What is Benchmarking?

Long Answer Questions

1. Explain the role of Six Sigma in improving quality in industrial organisations? Briefly explain the Six Sigma methodology.
2. Explain the concept of Six Sigma? How is it different from other quality techniques?
3. Explain standardisation as a tool of improving quality. What are its benefits?
4. What is just-in-time manufacturing? Also explain the Kanban system in this context.
5. Write explanatory notes as Kaizen and Benchmarking.
6. Explain the concept and process of just-in-time production system.
7. What is meant by quality circle ? State its features and benefits.
8. Illustrate the procedure of introducing quality circles in an industrial organisation. What problems hinder the implementation of quality circles in an organisation ?
9. How can quality circles be introduced in an organisation ? What are the requirements of effective quality circles ?
10. Write an explanatory note on 'Total Quality Management' in India.
11. Write notes on the following :
    (*a*) Benchmarking
    (*b*) Kaizen
    (*c*) Quality circle.

❑❑❑

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