5.1 DEFINITION

Work measurement is also called "Time study." Work measurement is absolutely essential for both the planning and control of operations. Without measurement data, we cannot determine the capacity of facilities or it is not possible to quote delivery dates or costs. We are not in a position to determine the rate of production and also labour utilisation and efficiency. It may not be possible to introduce incentive schemes and standard costs for budgetary control.

Time study has been defined by British Standard Institution as **"The application of techniques designed to establish the time for a qualified worker to carry out a specified job at a defined level of performance."**

5.2 OBJECTIVES OF WORK MEASUREMENT

The use of work measurement as a basis for incentives is only a small part of its total application.

The objectives of work measurement are to provide a sound basis for:

1. Comparing alternative methods.
2. Assessing the correct initial manning (manpower requirement planning).
3. Planning and control.
4. Realistic costing.
5. Financial incentive schemes.
6. Delivery date of goods.
7. Cost reduction and cost control.
8. Identifying substandard workers.
9. Training new employees.

5.4 TECHNIQUES OF WORK MEASUREMENT

For the purpose of work measurement, work can be regarded as:

1. **Repetitive Work:** The type of work in which the main operation or group of operations repeat continuously during the time spent at the job. These apply to work cycles of extremely short duration.
2. **Non-repetitive Work:** It includes some type of maintenance and construction work, where the work cycle itself is hardly ever repeated identically.

Various techniques of work measurement are:

1. Time study (stop watch technique)
2. Synthesis
3. Work sampling
4. Analytical estimating
5. Predetermined motion and time study

Time study and work sampling involve direct observation and the remaining are data based and analytical in nature.

Time study: A work measurement technique for recording the times and rates of working for the elements of a specified job carried out under specified conditions and for analysing the data so as to determine the time necessary for carrying out the job at the defined level of performance.

Synthetic data: A work measurement technique for building up the time for a job or parts of the job at a defined level of performance by totalling element times obtained previously from time studies on other jobs containing the elements concerned or from synthetic data.

Work sampling: A technique in which a large number of observations are made over a period of time of one or group of machines, processes or workers. Each observation records what is happening at that instant and the percentage of observations recorded for a particular activity, or delay, is a measure of the percentage of time during which that activities delay occurs.

Predetermined Motion Time Study (PMTS): A work measurement technique whereby times established for basic human motions (classified according to the nature of the motion and conditions under which it is made) are used to build up the time for a job at the defined level of performance. The most commonly used PMTS is known as Methods Time Measurement (MTM).

Analytical Estimating

A work measurement technique, being a development of estimating, whereby the time

required to carry out elements of a job at a defined level of performance is estimated partly from knowledge and practical experience of the elements concerned and partly from synthetic data.

The work measurement techniques and their applications are shown in Table 5.1.

Table 5.1: Work Measurement Techniques and their Application.

S.No.	Techniques	Applications	Unit of Measurement
1.	Time study	Short cycle repetitive jobs. Widely used for direct work	Centi minute (0.01 min)
2.	Working sampling	Long cycle jobs/hetero-geneous operations.	Minutes
3.	Synthetic Data	Short cycle repetitive jobs	Centi minutes
4.	MTM	Manual operations confined to one work centre	TMU (1 TMU = 0.006 min)
5.	Analytical estimating	Short cycle non-repetitive job	Minutes

Steps in Making Time Study

Stop watch time is the basic technique for determining accurate time standards. They are economical for repetitive type of work. Steps in taking the time study are:

1. Select the work to be studied.
2. Obtain and record all the information available about the job, the operator and the working conditions likely to affect the time study work.
3. Breakdown the operation into elements. An element is a distinct part of a specified activity composed of one or more fundamental motions selected for convenience of observation and timing.
4. Measure the time by means of a stop watch, taken by the operator to perform each element of the operation. Either continuous method or snap back method of timing could be used.
5. At the same time, assess the operators effective speed of work relative to the observer's concept of "Normal" speed. This is called performance rating.
6. Adjust the observed time by rating factor to obtain normal time for each element

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

7. Add the suitable allowances to compensate for fatigue, personal needs; contingencies, etc., to give standard time for each element.
8. Compute allowed time for the entire job by adding elemental standard times considering frequency of occurrence of each element.
9. Make a detailed job description describing the method for which the standard time is established.
10. Test and review standards where necessary. The basic steps in time study are represented by a block diagram in Fig. 5.1.

1. Selecting Job for Time Study

The reasons for which time study may be done:

(*i*) The job in question is new one or not previously carried out.

(*ii*) Change in the method of existing time standard.

(iii) Complaint received from workers or unions regarding the time standard.

(iv) A particular operation becomes bottle-neck operation which holds up number of subsequent activities.

(v) Change in the management policy regarding how time standards are used, *i.e.*, General purpose or wage incentive plans.

The general guidelines for selecting the job for time study:

(a) Bottle-neck operations.

(b) Repetitive jobs.

(c) Jobs using a greater deal of manual labour.

(d) Jobs with longer cycle time.

(e) Sections/department frequently working overtime.

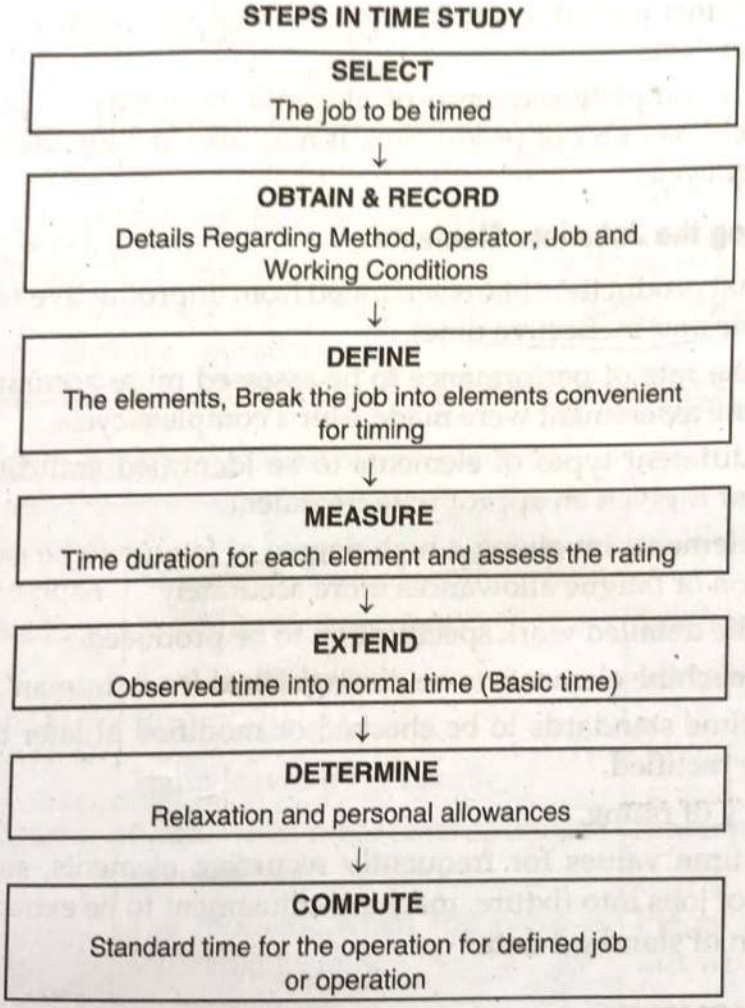

Fig. 5.1: Steps in time study.

2. Obtaining and Recording Information

During this step, all the relevant and necessary information regarding the method, operator and details of working conditions are recorded:

(i) The accuracy of time standards depends upon the correctness of the method employed by the operators. So wrong methods should not be timed. The method is to be standard and the time required to carry out the job as per the standard method is to be timed.

(ii) The selection of an operator refers to choosing an operator amongst many operators doing the same job. He should be a representative worker with a normal

pace neither too fast nor too slow. So the details of the operator is essential to be recorded before starting actual time study.

(*iii*) Information to enable the identification details such as. Part number and name, machine no. speed and feed, materials, operator details etc.

(*iv*) Working conditions under which an operator carries out the job like temperature, dust, smoke, vibrations, noise etc.

(*v*) Working position such as standing, sitting, bending, etc., and weights handled, protective clothing etc.

3. Breaking the Jobs into Elements

Once the recording of the basic information regarding the job and, operator are done, the next step is breaking job into elements.

Element is a distinct part of a specified job selected for convenience of observation, measurement and analysis.

Work cycle is a complete sequence of elements necessary to perform a specified activity or job to yield one unit of production. It may also include the elements which do not occur with every cycle.

Reasons for Breaking the Jobs into Elements

1. To ensure that productive time is separated from unproductive activities (separating effective time and ineffective time).
2. To permit the rate of performance to be assessed more accurately than would be possible if the assessment were made over a complete cycle.
3. To enable different types of elements to be identified and distinguished so that each element is given an appropriate treatment.
4. To ensure elements involving a high degree of fatigue to be isolated and to make the allocation of fatigue allowances more accurately.
5. To enable the detailed work specification to be produced.
6. To enable machine elements to be distinguished from 'human' elements.
7. To enable time standards to be checked or modified at later date, omissions and errors to be rectified.
8. For accuracy of rating.
9. To enable time values for frequently recurring elements, such as the loading/unloading of jobs into fixture, machine adjustment to be extracted and used in the compilation of standard data.

5.5 TYPES OF ELEMENTS

1. **A repetitive element** is an element which occurs in every work cycle of the job. *Examples*, Picking up part for assembly, element of locating a work piece in a holding device.
2. **An occasional element** is one that does not occur in every work cycle of the job or which may occur at regular intervals. *Examples*, tool changing after sometime, adjusting tension or machine setting, instruction from supervisor. Occasional element is useful work to be included in standard time.
3. **A constant element** is an element for which the basic time remains constant whenever it is performed. *Examples*, Switch on machine, measure diameter, insert cutting tools.

4. **A variable element** is an element for which the basic time varies in relation to some basic characteristics of the product, equipment or process. *Examples*, Dimensions, weight, quality, etc.
5. **A manual element** is an element performed by a worker.
6. **A machine element** is an element automatically performed by a power driven machine. *Examples*, Press working parts, annealing tubes.
7. **Governing element** is an element occupying a longer time than that of any other element which is being performed concurrently example Gauge dimensions while turning diameter (turning diameter will be a governing element).
8. **A foreign element** is one that is observed during study but do not form part of the given activity of the cycle. *Example*, Dropping work on the floor, operator talking to his colleague.

Guidelines for Breaking Jobs into Elements

1. Elements should be easily identified.
2. Each element should have a definite beginning and end.
3. Manual elements should be separated from variable elements.
4. Occasional elements should be timed separately.
5. Elements should be as short as can be conveniently timed by a trained observer.
6. Elements should be chosen so that they represent naturally unified and recognisably district segments of the operation.

A Qualified Worker as Defined by ILO

A qualified worker is one who is accepted as having the necessary physical attributes, who possesses the required intelligence and education, and who has acquired necessary skill and knowledge to carry out the work in hand to satisfactory standards of safety quantity and quality.

The time study man should not make any attempt to time the operative without his knowledge, from a concealed position or with the watch in the pocket.

5.7 PERFORMANCE RATING

Performance rating is the process of adjusting the actual pace of working of an operator by comparing it with the mental picture of pace of an operator working at normal speed.

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

In other words, rating is a levelling factor to convert observed timings into normal timings.

Factors Affecting Performance Rating

There exists a variation from element to element and even among the elements in the same operation. This is due to the inconsistency in the speed of the working of the operator.

Each worker by nature has different temperament and attitudes towards the work. Some workers by their nature are fast (above the speed of the average worker) and some are by nature slow. Both these workers will not represent a normal worker.

The variation in actual times for a particular element may be due to the factors both internal and external. The external factors which are not in control of work study man are:

- Variation in the quality or other characteristics of the material used even though it is in prescribed tolerance limit.
- Changes in the operating efficiency of tools and equipment within their useful life.
- Unavoidable changes in methods or conditions of operations.
- Change in working conditions like heat, light, dust etc.

Factors which are within control (Internal Factors) are:

- Acceptable variation in the quality of the product.
- Variation due to operators ability.
- Variation due to his attitude of mind.

The various methods of performance rating are: (1) Speed rating, (2) Westing house system of rating, (3) Synthetic rating, and (4) Objective rating.

Speed Rating: In this technique the speed of the movements of the operator is the only factor considered for performance rating. The speed rating is found by the observer by comparing pace of operators working with his own concept of normal pace. An average worker is rated at 100%, better than average worker is rated at a figure higher than 100 and below average worker will be rated below 100. If a worker is rated at 125% it means that the speed is 25% higher than the observers concept of normal and rating of 80% means the worker is working 20% below the observers concept of a normal worker.

In speed rating, the process of rating is confined to the comparison of speed of movements with a concept of normal speed. On the basis of this assumption, the rating process is made simpler and with training in developing the concept of normal pace, the observer can become quite proficient in his judgement.

Westing House Method of Rating: Westing house system utilises a set of criteria to measure the performance of the operators. The factors are:

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

1. *Skill:* Measures the workers proficiency in adhering to a given method, coordination of proper hand and eye movements, rhythm of the movements. The skill has been classified into six degrees, each degree indicating a specified class of skill within which an operator performs the task.

2. ***Effort:*** Measures the speed with which the skill is applied. The effort is also divided into six degrees.
3. ***Consistency:*** Measures factors which affect the consistency of the operator to perform the work cycle repeatedly within the same time. Elements which affect the consistency variations are in materials, hard spots, presence of foreign elements. Consistency is subdivided into six classes.
4. ***Conditions:*** Measure the extent to which the conditions like temperature, vibrations, light and noise affect the operator's performance.

The Westing house system of classification of skill, effort, consistency and conditions are shown in Table 5.3.

As per this system, the time study observer assign rating for a criteria of particular task. Numerical values are than obtained from Table 5.3 and establishes the performance rating by adding the four values and adding the levelling factor to normalise the observed time.

It is applied to the cycle time in case of a manual time rather than to the individual elemental times.

Table 5.3: Performance Rating Table (Westing house method)

Skill			*Effort*		
+ 0.15	Al	Superskill	+ 0.13	Al	Excessive
+ 0.13	A2		+ 0.12	A2	
+ 0.11	Bl	Excellent	+ 0.10	Bl	Excellent
+ 0.08	B2		+ 0.08	B2	
+ 0.06	Cl	Good	+ 0.05	Cl	Good
+ 0.03	C2		+ 0.02	C2	
0.00	D	Average	0.00	D	Average
– 0.05	El	Fair	– 0.04	El	Fair
– 0.10	E2		– 0.08	E2	
– 0.16	Fl	Poor	– 0.12	Fl	Poor
– 0.22	F2		– 0.17	F2	
Conditions			*Consistency*		
+ 0.06	A	Ideal	+ 0.04	A	Perfect
+ 0.04	B	Excellent	+ 0.03	B	Excellent
+ 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

Illustration of Westing House Method: An observed time for an operation is 0.05 minute and the ratings are as follows:

Skill (Excellent) B2

Effort (Good) C2

Condition (Good) C

Consistency (Good) C

The values for the ratings are assigned from Table 5.3.

Criteria	*Rating*	*Numerical Value*
Skill	B2	+ 0.08
Effort	C2	+ 0.02
Condition	C	+ 0.02
Consistency	C	+ 0.01
	Total	+ 0.13

(*a*) Performance rating factor = 1 + 0.13 = 1.13 = 113% = 113%

(*b*) Normal time of operation = Observed time × performance rating

= 0.05 × 1.13

= 0.0565 minutes

Synthetic Rating: The performance rating under this method is established by comparing observed time of some of the manual elements with those of known time values of the elements from predetermined motion and time studies (PMTS).

The procedure is to make the time study in a usual manner and then compare the actual time for the elements with predetermined time values for the same elements.

A ratio is computed between predetermined time value for the element and actual time value for the element.

This ratio is the performance index or rating factor for the operator for the particular element. Performance rating factor, (*R*) is given by:

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

P = Predetermined time for elements (minutes)

A = Average actual time value (selected time) for the same element '*P*' (minutes)

Objective Rating: In this method, the operator's speed is rated against a single standard pace which is independent of job difficulty. The observer merely rates speed of movement or activity, paying no attention to job itself. After the pace rating is made, an allowance or a secondary adjustment is added to the pace rating to take care of job difficulty.

Job difficulty is divided into six classes, and percentage is provided for each of these factors.

The job difficulties as per the founder of this system—M.E. Mundel have been categorised into six classes as follows:

1. Amount of body used
2. Foot pedals
3. Bi-manualness
4. Eye-hand coordination
5. Handling requirements
6. Weight

5.8 ALLOWANCES

The normal time for an operation does not contain any allowances for the worker. It is impossible to work throughout the day even though the most practicable, effective method has been developed. Even under the best working method situation, the job will

still demand the expenditure of human effort and some allowance must therefore be made for recovery from fatigue and for relaxation. Allowances must also be made to enable the worker to attend to his personal needs. The allowances are categorised as: (1) Relaxation allowance, (2) Interference allowance, and (3) Contingency allowance.

Relaxation Allowance

Relaxation allowances are calculated so as to allow the worker to recover from fatigue.

Relaxation 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 nature of the job.

Relaxation allowances are of two types—fixed allowances and variable allowances.

Fixed Allowances Constitute

- Personal needs allowance. It is intended to compensate the operator for the time necessary to leave, the workplace to attend to personal needs like drinking water, smoking, washing hands. Women require longer personal allowance than men. A fair personal allowance is 5% for men and 7% for women.
- Allowances for basic fatigue. This allowance is given to compensate for energy expended during working. A common figure considered as allowance is 4% of the basic time.

Variable Allowance

Variable allowance is allowed to an operator who is working under poor environmental conditions that cannot be improved, added stress and strain in performing the job.

The variable fatigue allowance is added to the fixed allowance to an operator who is engaged on medium and heavy work and working under abnormal conditions. The amount of variable fatigue allowance varies from organisation to organisation.

Interference Allowance

It is an allowance of time included into the work content of the job to compensate the operator for the unavoidable loss of production due to simultaneous stoppage of two or more machines being operated by him. This allowance is applicable for machine or process controlled jobs.

Interference allowance varies in proportion to number of machines assigned to the operator.

The interference of the machine increase the work content.

Contingency 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 in frequent or irregular occurrence.

This allowance provides for small unavoidable delays as well as for occasional minor, extra work.

Some of the examples calling for contingency allowance are:

- Tool breakage involving removal of tool from the holder and all other activities to insert new tool into the tool holder.
- Power failures of small duration.
- Obtaining the necessary tools and gauges from central tool store. Contingency allowance should not exceed 5%.

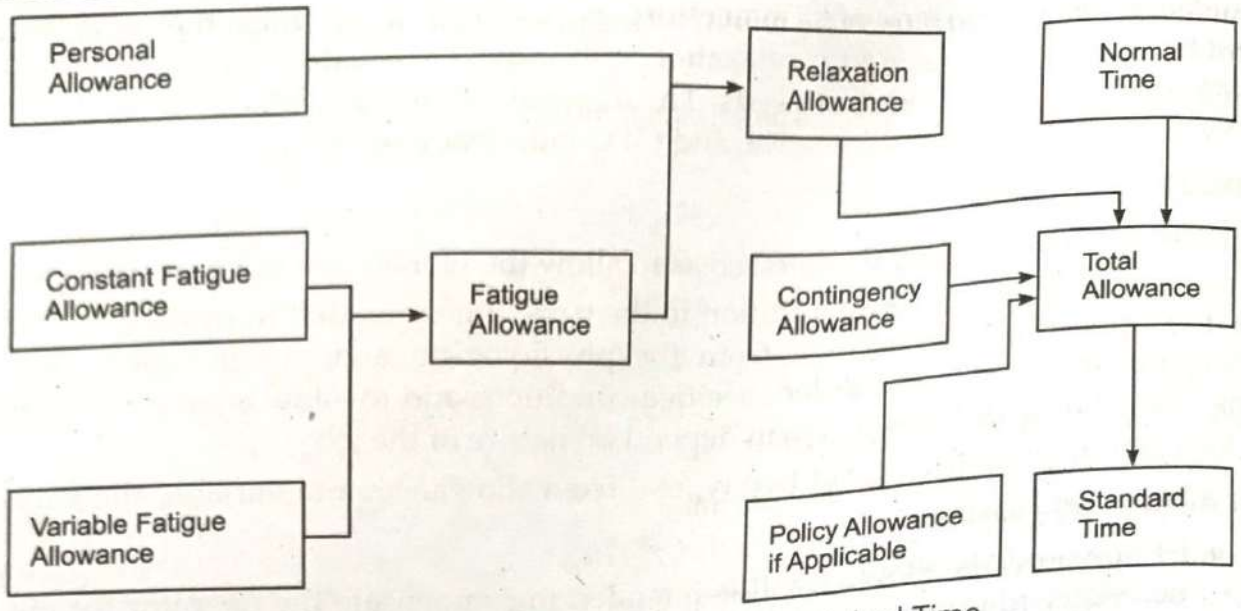

Fig. 5.5: Various Allowances to Build Standard Time

Policy Allowance

Policy allowances are not the genuine part of the time study and should be used with utmost care and only in clearly defined circumstances.

The usual reason for making the policy allowance is to line up standard times with requirements of wage agreement between employers and trade unions.

The policy allowance as defined by ILO:

"A policy allowance is an increment, other than bonus increment, applied to a 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. Policy allowance are sometimes made as imperfect functioning of a division or part of a plant."

Various allowances used to build the standard time is shown in Fig. 5.5.

5.9 COMPUTATION OF STANDARD TIME

Standard time is the time allowed to an operator to carry out the specified task under specified conditions and defined level of performance.

The basic constituents of standard time are as shown in Fig. 5.6.

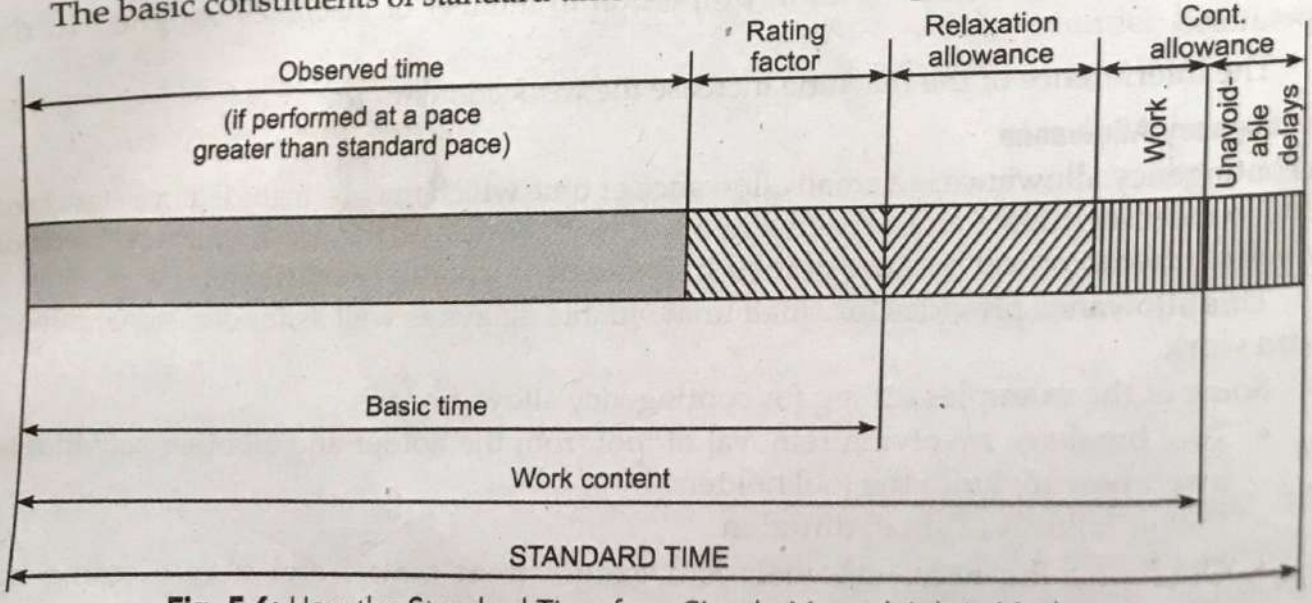

Fig. 5.6: How the Standard Time for a Simple Manual Job is Made up

Problem 1: *The elemental times (in minutes) for 4 cycles of an operation using a stop watch are presented below:*

Elements	*Cycle time in minutes*			
	1	*2*	*3*	*4*
1	*1.5*	*1.5*	*1.3*	*1.4*
2	*2.6*	*2.7*	*2.4*	*2.6*
3	*3.3*	*3.2*	*3.4*	*3.4*
4	*1.2*	*1.2*	*1.1*	*1.2*
5	*0.51*	*0.51*	*0.52*	*0.49*

Calculate standard time for the operation if

(i) Elements 2 and 4 are machine elements

(ii) For other elements, the operator is rated at 110%

(iii) Total allowances are 15% of the normal time.

Solution: The normal times are shown in Table 5.3.

Table 5.4: Computation of Normal Time

Element No.	*Cycle Time (min.)*				*Avg. cycle time (3)*	*Rating (4)*	*Normal time = Avg. time × rating*
	1	2	3	4			
1	1.5	1.5	1.3	1.4	1.425	110%	1.425 × 1.1 = 1.568
2	2.6	2.7	2.4	2.6	2.575	m/c elem.	= 2.575
3	3.3	3.2	3.4	3.4	3.325	110%	3.325 × 1.1 = 3.658
4	1.2	1.2	1.1	1.2	1.175	m/c elem.	= 1.175
5	0.51	0.51	0.52	0.4	0.505	110%	0.505 × 1.1 = 0.555

Normal time for the cycle = 1.568 + 2.575 + 3.658 + 1.175 + 0.555 = 9.531

Standard time = (9.531 + (0.15 × 9.531))

= **10.484 minutes**

Problem 2: *The following data refers to the study conducted for an operation. Table shows actual time for elements in minutes:*

Cycle— Elements	*1*	*2*	*3*	*4*	*5*
1	*2.5*	*2.1*	*2.2*	*5.4*	*2.5*
2	*6.2*	*6.00*	*6.1*	*5.9*	*5.9*
3	*2.3*	*2.0*	*2.1*	*2.1*	*2.2*
4	*2.4*	*2.1*	*2.8*	*3.0*	*23*

(i) Element 2 is a machine element.

(ii) Consider the observations as abnormal and delete the same if they are more than 2 % of average time of that element.

(iii) Take performances rating as 120.

(iv) Take following allowances personal allowance 30 minutes in a shift of 8 hours. Fatigue allowance—15%, contingency allowance—2%. Estimate the standard time of operation and production per 8 hours shift.