UNIT 7 WORK DESIGN

Objectives

Upon completion of this unit, you would be able to:

- relate the reasons and objectives for studying Work Design
- identify the need for an integrated approach to Work Design
- understand that Work Study is one of the productivity improvement techniques chosen for achieving objectives of World Design
- realise that the approach is essentially a scientific, systematic method of problem solving
- conduct Methods Studies, Time Studies and Work Sampling with a fair degree of confidence
- detect certain factors that have not found a place in this unit, though they are also of prime importance to Work Design
- realise that concepts discussed in the unit are not necessarily restricted only to manufacturing situations

Structure

7.1 INTRODUCTION TO WORK DESIGN

For most of us, work is a major source of economic livelihood and human enrichment. Everyone works. The attitudes towards work held by various individuals and different societies keep changing at various times in human history. In defining the work system, we could set boundaries to what must be effectively and efficiently managed. A work system brings together technical competence in the form of people and equipment to achieve the organisational objective. Work Design is concerned with the study and design of work system in any type of organisation or institution.

Historical Trends in the Management of Work

From the beginning of mankind, individuals or groups of individuals have engaged themselves in a multitude of activities with a progressive degree of sophistication and ingenuity to satisfy their basic needs and wants. Over the years, the effort has been to provide work and time saving devices, some of which have resulted from flashes of genius and long experience rather than from any degree of systematic study of work.

The scientific method of work design produced its greatest achievements in the mass production assembly lines of the post Word War I phase. Man was viewed as an extension of the machine or rather as an element or cog in a complex production system dominated by costly equipment. The primary emphasis was on profit, concern for streamlining operations, eliminating waste, and financially motivating the workers to increase output and productivity. Industrial engineers employed a machine theory of man to study and design work, concentrating primarily on the technological side of work resulting in a highly standardised, economically efficient form of work. On the other hand, the social scientists were equally concerned with work design aspects from the behavioural angle. Technologically, work is seen in terms of the tools, techniques and methods used for production.of finished goods. Economically, work has come to be associated with paid employment

Work Design for Increased Productivity

The continued progress of any enterprise is dependent on its ability to optimally and judiciously allocate and utilise its resources so as to provide desired products and/or services at the right time, place, price, quality and quantity to the community. This requires an integrated approach. Efficiency and effectiveness spring from unity of purpose and the application of the right principles to a given situation. The effort of any enterprise should be to raise productivity and reduce wastivity, so as to ensure a higher standard of living, greater purchasing power and an enhanced human dignity. This `total spiral pattern' of movement would hopefully lead to a better `quality of life. Taylor had illustrated that high levels of productivity result in more quality goods at lower costs which is the basis for lower prices, higher purchasing power and real earnings, improvement in working and living conditions and sometimes even shorter working hours (and hence perhaps more leisure).

All organisations need increased productivity. They must continually seek better and less expensive ways to perform their functions/tasks if they hope to survive in an increasingly competitive and quality conscious economy. It is hoped that increasing the effectiveness of accomplishing work reduces the actual cost of the work, which makes the resulting product and/or service available to more individuals which in turn increases the demand for work and, hopefully leads to generation of work and employment. In fact, productive activities are the primary source of material benefits. These benefits from increased productivity are shared by employees, managers, owners, enterpreneurs, consumers and society at large. There are non-material benefits also which might, after a stage, assume greater importance. We would leave some of these aspects to be discussed in the next unit on `Job Design' and go on to discuss the Work System Design in the belief that work exists and it would have to be done.

The Work System Design

Work problems do not exist without work. Work does not exist without the desire to render a service or manufacture a product which is needed by someone, somewhere, at some time. Certain resources like men, machines, materials, money, methods and management are to be so organised as to produce the desired output effectively and efficiently. Work problems usually originate within the individual work station. However, the man-material-machine combination, which is at the centre of almost every work problem, is only a part of the entire organisation or work system which itself is a part of yet a larger super system. Most work systems or sub-systems are essentially open systems. Therefore, there is a great deal of complexity in the forces of interaction and reaction. The magnitude of these `forces' is determined by the value structure associated with the work system. The quantifiability and even adequate identification of these forces is rather difficult. The systems conceptualisation is ideal but sometimes impregnable. In addition to system is the method' which is also important in Work Design.

In fact Work Design is the systematic investigation of contemplated and present work systems to formulate through the ideal system concept, the easiest and most effective systems and methods for achieving necessary functions/goals/purpose. Nadler proposes the following five Work Design assumptions or philosophies:

1 Increasing productivity and developing manpower effectiveness are the objectives for studying work system.

2 Work systems can be encountered in three states or conditions-design, betterment and improvement.

3 All aspects of the work system, regardless of the system level, are to be considered in Work Design.

4 People, their abilities, and talents are an integral part of Work Design. This results from the recognition that people, at all levels, can really understand many of even the most involved techniques and situations.

Work Design does not advocate the use of any particular set of techniques. Work systems and their components are to be studied continually. Since a system involves a multitude of components, it would appear that each function of the enterprise, through its specific systems, would take a segregated part of the total project or study, and accomplish its function within the framework of its specific objectives, for increased productivity and higher effectiveness. Among the numerous techniques available for enhancing productivity, one is Work Study which is perhaps one of the most popularly used techniques. No doubt, the success of the technique,: lies in its simplicity as well as the method and scope of its application. It cannot possibly exist in a vacuum. It must be part of an overall programme with due support from management and employees, that encourages increased productivity for specific reasons so as to finally provide a higher standard of living, human dignity and quality of life.

7.2 THE WORK-STUDY APPROACH: AN OVERVIEW

Work study is indeed an important tool for achieving higher productive efficiency of an organisation in a scientific manner.

Work study is a generic term for those techniques, particularly method study and work measurement which are used in the examination of human work in all its contexts, and which lead systematically to the investigations of all the facts which affect the efficiency and economy of the situation being reviewed, in order to effect improvement.

Method study: The systematic recording and critical examination of existing and proposed ways of doing work as a means of developing and applying easier and more effective methods, and reducing costs.

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

The main objective of work study is to improve the effectiveness of important parameters of production such as men, machines and methods.

Method study and Work measurement are closely linked. Method study is concerned with reduction of the work-content of the operation, while Work measurement is concerned with the investigation and reduction of the ineffective time and the subsequent establishment of time-standards for the. operation on the basis of the work content as established by Method study. Usually a method study should precede work measurement. However, when time-standards for output are being set, it is often necessary to use one of the work measurement techniques like work-sampling in order to determine where ineffective time is occurring and its extent so that management action can be taken to eliminate it even before going in for method study. Equally, on the other hand, time study may be used to compare the effectiveness of alternative methods.

Basic Work Study Procedure

There are eight basic steps, some of which are common to both method study (MS) and work measurement (WM)

1 Select (MS and WM)
2 Record (MS and WM)
3 Examine (MS and WM)
4 Develop (MS)
5 Measure (WM)
6 Define (WM)
7 Install (MS)
8 Maintain (MS)

However, good relations must be established before conducting a work study. There must be top management support apart from good cooperation from the supervisors/ foremen, who must be sounded about the utility of conducting the study. All instructions and questions should preferably have the supervisors `green signal'. Contrary to the widely held belief, work study, properly applied, tends to improve industrial relations. The workers feel happy that a member of management takes the trouble to come to them to discuss about their job and problems. Do not conduct the study amidst distrust and suspicion. Try to win the confidence of all concerned. There could usually be strong resistance to change in working methods by the set of older skilled workers. Moreover, employees may be concerned with redundancy arising out of the results of work study, Leading either to unemployment or transfer to some other department or work station elsewhere. This is perhaps one of the greatest fears in a developing country such as ours. This argument is very much like the ones criticising the advent of the Industrial Revolution, the age of high mechanisation and now the Hi-Tech process of rapid computerisation. Let us learn from history to welcome these developments for the ultimate good of people in the long run.

A work study person should have at least a good secondary or preferably a graduate education. It is desirable that he has some actual on-the-job work experience. Practical experience will make the work study analyst command respect from the employees/subjects being studied and also the supervisory personnel. A work study person should have sincerity, honesty, enthusiasm, interest in and sympathy for people, tact and self-confidence. Though it is difficult perhaps to find a person with all these qualities, at least the work study person must have the ability to deal with people. It will be seen that the results of work study, however `scientifically' arrived at, require to be applied with `art' just like any other management technique.

Having given a basic overview of work study, we can now go on to discuss method study, primarily concentrating on the steps involved with a view to raising effectiveness and productivity. We shall be skipping over some details of physical environment, therbligs, principles of motion economy, etc. which are to be included in the following unit, while discussing various aspects of Job Design.

7.3 METHOD STUDY

You will recall from the previous section that the techniques of method study aim essentially to do three things:

- reveal and analyse fully the facts concerning any situation
- examine the facts critically
- develop from the examination of facts, the best possible answer under the circumstances.

The findings of method study should definitely result in better utilisation of manpower and other tangible resources. It would also have identified bottleneck activities and initiated necessary action to minimise, if not totally. eliminate, the bottlenecks. However, while making suggestions for improvements, economy in human effort, the reduction of unnecessary fatigue and the development of a better physical working environment should be taken note of. Some of these aspects have been discussed in the following unit on Job Design

Method study in its generalized field of activity can also be termed as work simplification.

The following section deal with it in a definite and ordered sequence of defferent a definite and ordered sequence of different stages as under:

i) Ideatification
ii) Recording
iii) Examination
iv) Development
v) Installation

Identification

As mentioned above, the first stage is the selection of work to be studied which is primarily based on:

a) Economic considerations
b) Technical considerations
c) Human considerations.

Economic considerations are important. The obvious areas of application of method study are bottlenecks, excessive movement, operations involving repetitive work, excessive work in process and unsafe work conditions.

The most important thing in technical consideration is to ensure availability of relevant technical knowledge with which to make the study. Human considerations and reactions, need to be accounted for too. Method Study, will be more readily accepted if the first subjects/jobs are the unpopular ones such as dirty jobs having many allied unpleasant features. If the study improves these type of jobs by reducing unpleasantness, effort and fatigue, then method study/work study will be welcomed. If however, the study of a particular job appears to be leading to unrest or ill feeling, then leave it alone and wait for an appropriate time or switch over to alternative subjects.

Figure I: Conventional Symbols and Definitions of Activities used in Work Analysis.

Standard symbol	Name of Activity	Definition of activity
○	Operation	An operation occurs whenever something is **produced** or a task is **accomplished.** An object is intentionally changed in any of its physical or chemical characteristics, is assembled or disassembled from another object. An operation also occurs when information is given or received when planning or calculation takes place. Operations could be 'do' type, 'make ready' type or 'put away' type.
➔	Transportation	A transportation occurs when an object is **moved** from one operation to another, from one place to another, except when such movements are a part of the operation or are caused by the operator at the work station during an operation or an inspection.
□	Inspection	An inspection occurs when either a qualitative or quantitative appraisal or verification is made.
D	Delay	A delay occurs to an object when conditions except those which intentionally change the chemical or physical characteristics of the object, do not allow or require immediate performance of the next planned step. It is essentially a temporary storage which describes a state of inactivity and has an **interference** effect.
∇	Storage	A storage occurs when an object is kept and protected against unauthorised removal. The difference between storage and delay is often a fine one, e.g. material is formally committed to storage but is informally delayed.
□ ➔	Combined Activity	A combined activity occurs when two activities occur simultaneously. Various combinations of simultaneous occurrence of two activities could be possible.

After selecting the work to be studied and before actual commencement of the subsequent steps, it is important to decide on the objectives to be attained, in order of priority. With the objectives for the study in mind, it will then be possible to consider the degree of detail that should be gone into. Clearly, no study should be more detailed than is justified economically, and so the selection of a job must be based on an estimate of time and expense needed.

Recording

When a job has been selected and the detail and extent of the investigation decided, the systematic analysis of the work is begun. A record is to be made of all the relevant facts relating to the present method which would have to be subjected to a critical examination. But before that let us discuss the models of sequence or flow of work which are best understood by most persons when presented pictorially.

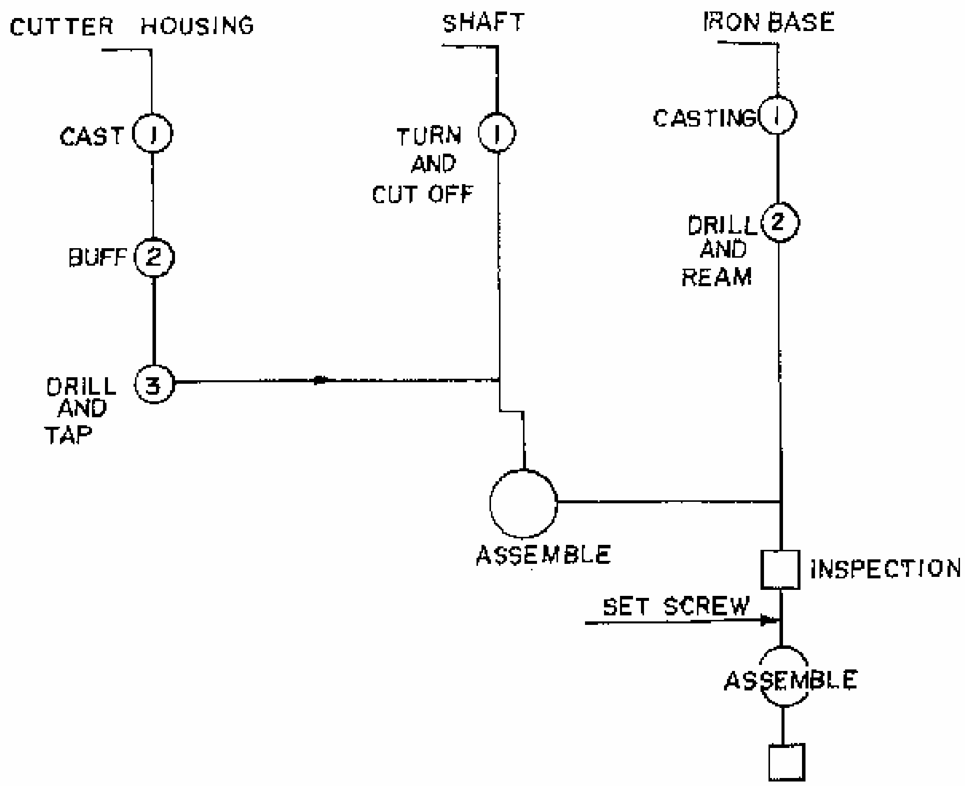
Need for graphical methods/charts

Most people find the graphical or pictorial representation of information invaluable when they are faced with a mass of facts that they must study systematically, because there is less chance of overlooking any detail. Many types of charts and diagrams form a vital part of the `Recording stage' in `work study', especially while conducting method study'. It is preferable to adhere to standard conventions of charting shown in Figure I, so as to enhance its utility in recording, examining and development stages. Let us now discuss some charts which would be particularly relevant for work study.

a) **Chronological sequence analysis:** In this case, break down the process under study into events or activities chronologically. There could be product/material-oriented process charts or person-oriented process charts.

In process charts, a sequence of events is portrayed diagramatically by means of a set of process chart symbols to help a person visualise a process as a means of examining and improving it.

Figure II: Operation Process Chart



An operation/outline process chart: Figure II is the one giving an overall picture by recording in sequence only the main **operations** and **inspections**. Only the major events such as principal operations and inspections are recorded. It provides an overall view, a quick idea of the entire process from beginning to end at a glance.

A more detailed type, highly developed version of process charts is the **flow process chart** which is a graphic representation of the chronological sequence of all **operations**, transportation, inspections, delays and **storages** occurring during a process or procedure, and includes information considered desirable for analysis such as time required, distance moved, etc. There could be the following types of flow process charts:

i) Material or Product type, Figure III which records what happens to material/ product.

ii) Man type which records what the worker/operator does.

iii) Equipment type which records how the equipment is used. The equipment type chart is similar to the product/material type chart.

Figure III: Flow Process Chart (Material)

Sr. No.	ACTIVITY DESCRIPTION	○	□	▽	D	⇨	REMARKS
1.	Casting lying in the foundry store			•			
2.	Moved to cutting-machine					•	Trolley used. Distance moved 20 meters.
3.	Wait, cutting machine being set.				•		
4.	Risers cut	•					
5.	Wait for trolley.				•		
6.	Moved to machine shop					•	Trolley used. Distance moved 15 meters
7.	Inspect before-machining		•				
	SUMMARY						

The flow process charts are usually either of material or man or equipment type. But in some cases it could be possible to develop a combined flow process chart for triple resources involving a person, material and equipment.

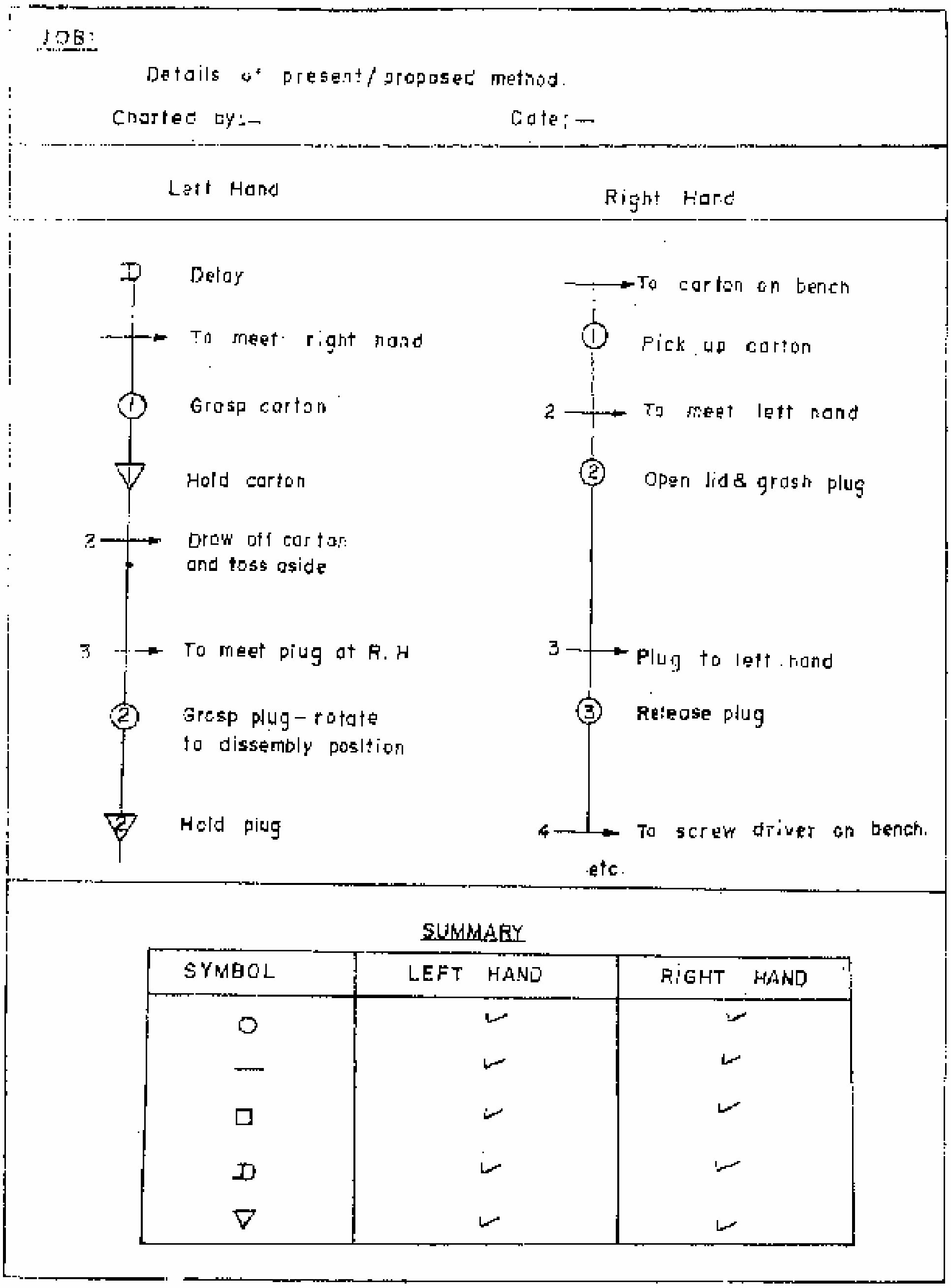
There is yet another type of flow process chart called a **form process** chart which is a graphic symbolic representation of the proces flow of paperwork form. In this case the item of interest is one or more forms. Such a chart may show organisations, operations, movement, temporary and controlled storage, inspection or verification, disposal of all forms charted, and the source and type of information transmitted between forms. Perhaps such form process charts are more useful in Organisation and Methods (O&M) Studies which are applications of work study in offices.

Then there could also be **two-handed** process charts (Figure IV), in which the activities of a Worker's/operator's hands (or limbs) are recorded chronologically to one another. Somewhat similar to the above types of charts are the **multiple activity** charts (Figure V) where the activities of more than one subject (worker, machine or equipment) are recorded on a common time scale to show their inter-relationship.

b) Movement and Flow of Activities: Process charting helps to visualise the sequence of events in a situation but it cannot illustrate the pattern of movement that men, materials and tools have to follow when a job is being done. Here we find that certain types of diagrams are helpful to indicate visually the path of movement.

One such type of diagram is the flow diagram Figure VI. In its simplest form, it should show a rough (or scaled) view of the space, which shows the location of specific activities carried out, the extent of work areas, machines, or desks, with a connecting set of arrows and lines to indicate the routes of travel followed by workers, materials or equipment.

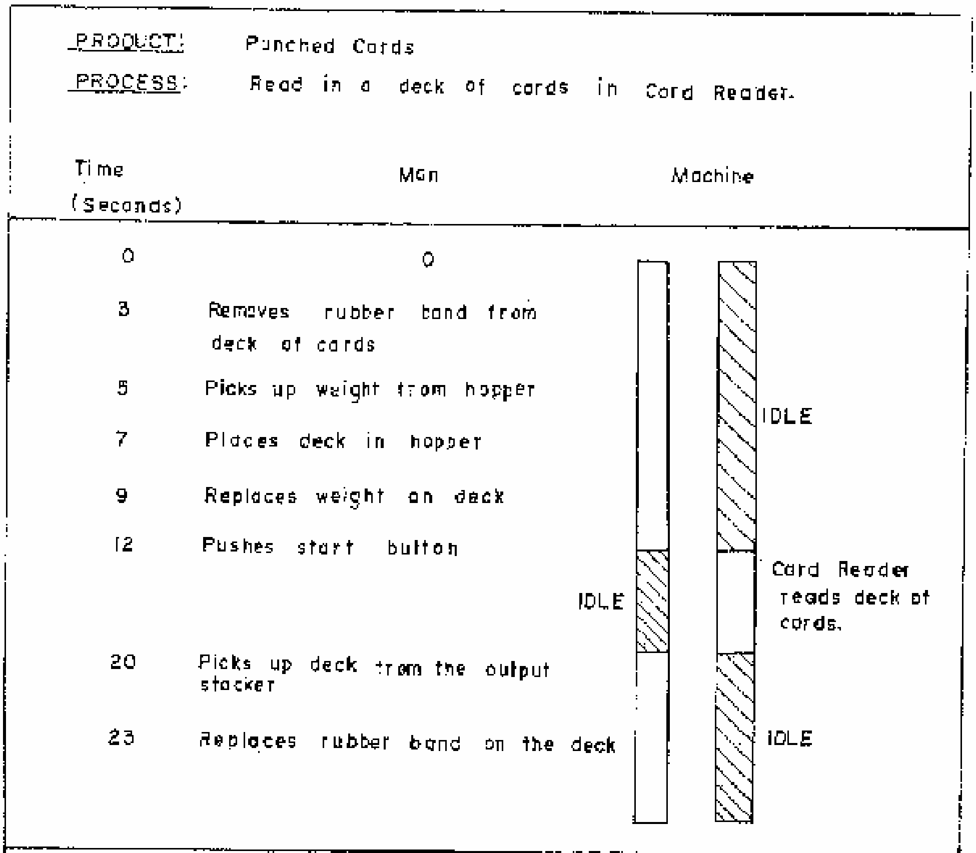
Figure IV: Left Hand Right Hand Process Chart



Yet another type of diagram to depict flow is the **string diagram**, Figure VII (shown on page 14). It is a scale plan or model on which a thread or a string is used to trace and measure the path of workers, materials or equipment during a specified sequence of events. String diagrams can deal with complex movements and range over many classes of work. They have been used to cover movement throughout a whole building, and by contrast to illustrate the movement of an operator's hands at a work bench.

Though not very popularly used in our country because of high costs, we could also use SIMO (Simultaneous Motion) charts or you could also resort to a **cycle graph**, This technique was develpped by Gilbreth to help overcome the difficulties of accurately plotting movements that are too fast for the eye to follow. -A **cycle graph** is a record of the path of movement, usually traced by a continuous source of light on a photograph, preferably stereoscopic. One of the defects is that it does not indicate speed or direction of movement. Hence this resulted in development of **chronocycle** graph. Here the light source is suitably interrupted so that the path appears as a series of pear-shaped spots, the pointer indicating the direction of movement and the spacing between the spots indicating the speed *of* movement.

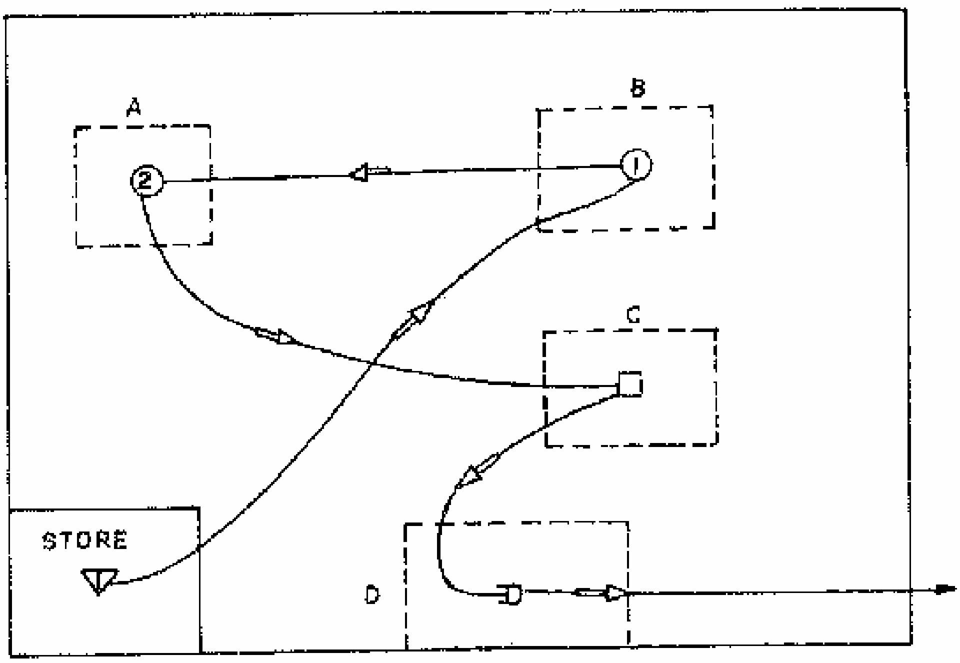
Figure V: Man-Machine Activity Chart

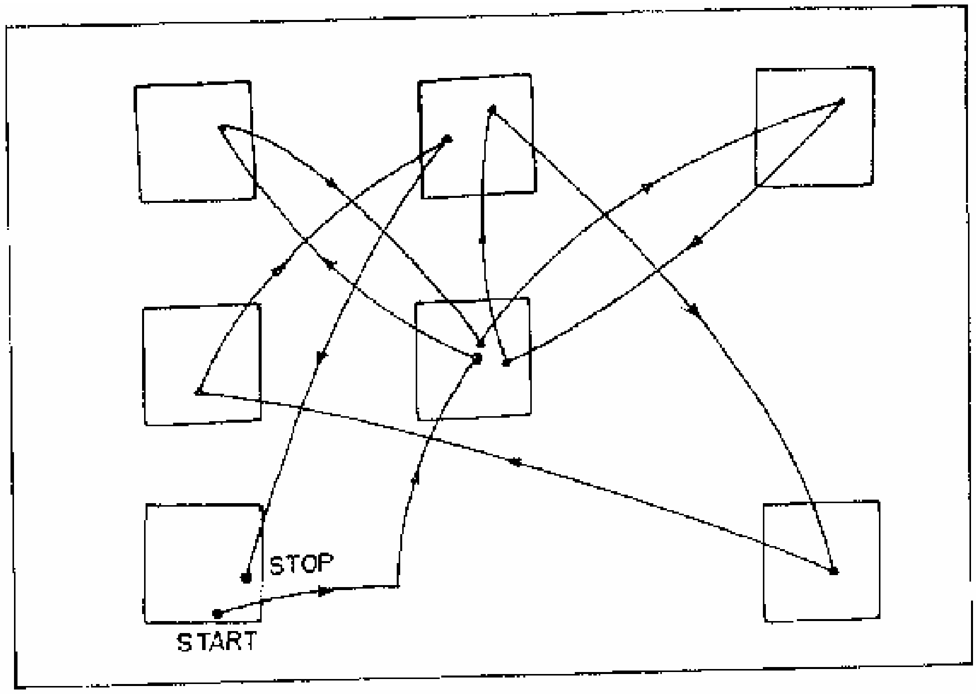


SUMMARY

	MAN Time sec.	MAN %	MACHINE Time sec.	MACHINE %
Work	15	64 app.	8	36 app.
Idle	8	36 app.	15	64 app.

Figure VI: Flow Diagram





Examination

After 'record' comes 'examine' In method study, problems are typically solved by examining critically and systematically the facts that have been collected and recorded in some form of process charts. Close examination of the events/activities in any working situation usually reveals a number of key stages in the progress of the job. Preceding the key activity would be a chain of `Put away activities'. Obviously, therefore, attention ought to, first of all, be-concentrated on these key activities which Gilbreth termed as `Do-operations'. Critical examination may yield the futility of the key activity and, in one stroke, many of the preceding and succeeding activities might just as well be `washed off'. Key activities could preferably be coloured or shown hatched in the process charts after the `record' stage.

Perhaps the best known standard approach to `examine' is the critical examination technique proposed and used by ICI (Imperial Chemical Industries) Ltd. in UK. It is usually a group activity where several persons assist each other in the questioning process in an impartial and objective manner. There are essentially two types of questions-primary questions and secondary questions.

Primary-the first stage of the questioning technique which queries the fundamental need for the performance, place, sequence, person and means of every activity recorded, and seeks a reason for each reply.

Secondary-the second stage of the questioning technique whereby the answers to the primary questions are subjected to further scrutiny to determine whether possible alternatives of place, sequence, persons and/or means are practicable and preferable as a means of improvement over the existing method.

Let us take a common problem that is faced daily at home viz., the job of **washing up after a meal**. If this be the key activity or 'do' operation, there are the set of `make ready' activities like removing used plates from the dining table, carrying them off to the wash basin in the kitchen, filling bowl with lukewarm water etc. The `put away' activities would be drying dishes after washing, moving dishes after washing to draining board, inspection of the dishes after washing etc. It should be fairly obvious to you that the most important key activity of the whole process is the do operation of washing the dishes. Everything else in washing-up is subordinate to this, and so our attention is focused first on this activity.

Key Activity/Do operation: Wash dishes after meal.

Purpose-Primary

What is the purpose? What is achieved?

Food remaining after the meal is removed from the surface of the dishes. Is this necessary? If so, why?

The dishes are used again for meals. Any 'jootha' food left adhering to the plates goes stale. This is unhealthy and also unethical (as per our value system).

Purpose-Secondary

What else could be done? Can the operation be eliminated? Or modified? How? Use disposable plates or 'pattals'. Use the existing plates with disposable napkins. Don't use plates.

The previous set of alternatives might lead you back to answer the question-'Was the meal itself necessary? Could an apple or some fruits serve the purpose? Could the meal have been eaten in a restaurant? (Surely this might be a costly proposition if it is to be done daily).

Perhaps the `buffet' system could have been implemented. This could have cut down drastically on the number of plates used.

In order to bring the **do** operation into greater focus, the **place, sequence, person, and means** aspects are considered next.

Place-Primary

Where is it done? In a bowl in the kitchen sink.

Why there? Hot and cold water is available from nearby taps. Dirty water is easily got rid of down the drain.

Place-Secondary

Where else could it be done? In the sink itself, without the howl or on the kitchen table in the bowl.

Sequence-Primary

When is it done? Immediately after the meal has finished.

Why then? Customary. Food particles are still easily washed off at this stage.

Sequence-Secondary

When else could it be done? Can it be delayed, or brought forward? Can the sequence be changed?

After each course or just before the next meal or once per day.

Person-Primary

Who does it? Normally the housewife.

Why that person? Possibly because of the Indian value system.

Person-Secondary

Who else could do it? Can the grade of labour be changed?

The husband, the children, relatives or perhaps a domestic servant.

The questions-What? Why? When? Where and Who?-have been asked and answered. As regards how, perhaps there is no need to ask in case dishes are not to be washed at all. However, in case dishes are to be washed, then greater details of the washing process, selection and procurement of equipment would have to be recommended on the basis of value analysis studies. All the above material should then lead to the next stage in the investigation, viz. development of the new method.

Development

After developing the alternatives and their consequences, a final selection based on an appropriate criteria is to be done in order to develop the new method. This approved method can be drawn up in a process chart form. This is then compared with the existing method. A summary of the number of operations, delays, inspections, storages and the total distances should be made. You will invariably find that there would be considerable reductions in the `non-productive' areas. The proposals for improvement can now be submitted for approval.

Installation

And so now you have reached the final stages of method study.

Installation can be divided into five phases:

1. Gain acceptance of change by departmental supervision.
2. Gain approval of change by works and general management.
3. Gain acceptance of change by workers involved and their representatives.
4. Retain the workers to operate new methods.
5. Continual monitoring of whether or not the new method is being used.

The last phase is in fact a function of the maintenance stage. Casual changes in method may arise for a variety of reasons. They need to be monitored and reviewed by the work study analyst in an impartial manner.

In the sections that will follow, we focus our attention to the other component of work study namely work measurement.

7.4 WORK MEASUREMENT

Work measurement is concerned with the determination of the amount of time required to perform a unit of work. It provides management with a basis for comparison of alternative methods, and also a basis for initial manning. Moreover, it makes available the necessary data for effective planning and scheduling and provides a basis for wage and salary administration especially for devising sound incentive schemes.

Work Measurement Procedure

The basic steps to be followed sequentially for work measurement are:

1. **Select** the work to be studied, after having made a preliminary survey.
2. **Record** all the relevant data pertaining to the circumstances in which the work is being done, the methods and the elements of activity in them.
3. **Measure** each element in terms of **time** over a **sufficient number of cycles** of activity to ensure that a representative picture has been obtained.
4. **Examine** the recorded data and time elements **critically** to ensure 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.
5. **Compile** a time for the operation which will provide a realistic standard of performance and will include time allowances to cover suitable rest, personal needs, contingencies etc.
6. **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 constituent parts. Measurement takes place when the available information is gathered together into a suitable form for use. It is important to appreciate that the three stages are closely connected with each other.

Techniques of Work Measurement

The principal techniques used to measure work are:

a) Time study
b) Work sampling
c) Pre-determined motion-time system (PMTS)
d) Analytical estimating
e) Synthesis from standard data
f) MOST.

The first two techniques would be discussed in detail in this unit, whereas the remaining ones would be explained only very briefly.

Time Study

Let us now discuss one of the primary methods of work measurement, namely, the stop watch technique of time study. Basic time study equipment consists of a stop watch, a study board, pencils, a pocket calculator (optional) and measuring instruments for distance and speed (such as a ruler, tape measure, micrometer and technometer/revolution counter).

The decimal-minute stop watch has been adopted as standard equipment. It may take you some time to get used to this system as most of us are used to the seconds system Regular checks. are necessary for monitoring the accuracy of the watch at regular intervals. In some situations, much more expensive type of equipment like motion-picture camera could be used. But we don't think it to be feasible in our country, as yet. As regards the time study board, an ordinary clip-board used by us when appearing in examinations could suffice. However, do not forget to keep at least two or three sharpened pencils or pens/dot-pens along with you while conducting the study. If one pencil point breaks, then you have the other one ready. You. can't afford to go in for sharpening the pencil because this would lead to erroneous recording of the elements. Perhaps you might not be able to appreciate this trivial point now. But you will realise your helplessness. if you experience such a situation while conducting a time study yourself.

It is needles to emphasise once again that some preliminary points need to be kept in mind. Make sure you have sought the cooperation of all concerned parties. On no 'account should any attempt be made to time the operator without his knowlegde from a concealed position or with the watch in the pocket. In fact, Work Study should have nothing to hide. Moreover, though most operators quickly settle down to their normal working pace, there could be some `nervous workers' who could keep fumbling and making errors. If this happens, stop the study. Perhaps you should start chatting with the operator to put him/her at ease. On the other hand, you must guard against the so-called `clever operators' who try to be `one-up'. You would have to tactfully handle such nuisance.

It would be worthwhile to give a formal definition of time study before we move on to the steps involved in conducting a time study. Time study is a technique for determining as accurately as possible from a limited number of observations, the time necessary to carry out a given activity at a defined standard of performance.

Time Study Procedure

The basic steps in time study procedure are as follows:

1. **Select** the job to be studied (short cycle or long cycle, repetitive or non-repertitive). A job might be selected for a variely of reasons. It could be because of
   a) a new job,
   b) a change in method for which a new standard time is needed,
   c) a complaint received from workers or their representatives about time allowed for a operation,
   d) a bottlenack operation,
   e) a change in management policy such as the introduction or withdrawal of an incentive scheme.

However, first make sure the method of working is right before continuing with the time study. Do survey the job content for the correct Method, operating conditions and quality. Assess nature of constituents to be measured.

2. Record all the information about the job, the operator and the surrounding conditions which are likely to affect carrying out of the work. Plan the programme by which all the constituents can be measured economically and accurately, record a complete description of the method and break down the operation into `elements' which could be conveniently observed, measured, analysed and synthesised.
3. Measure with a stopwatch the time for each element repeated for sufficient number of cycles, so as to provide reliable data covering all expected conditions. Also, while observing, do not forget to assess the effective speed of the working of the operator relative to a predetermined `normal' speed. This process is called `Performance Rating', and if it is not reliable enough it could be a `bone of contention' between the various relevant parties. Due to its importance, we would like to devote some time to understand Performance Rating.

By definition, rating is a comparison of actual performance with some standard notion or normal performance.

Normal performance (or pace) is the working rate of the average worker working under capable supervision but without the stimulus of an incentive wage plan. This pace can easily be maintained day after day without undue physical or mental fatigue and is characterised by the fairly steady exertion of reasonable effort.

Some accepted standards or norms are that an average person walks at a speed of about three miles per hour or deal a pack of cards within 52 seconds. Let us take a pin board where we have a wooden board with 30 holes drilled equidistantly into which will enter 30 wood pins of the suitable size. If the operator holds the board by the left hand, and uses his right hand to fill the pins on the board, he shall take 0.62 minutes. If he uses both the hands, the time taken will be around 0.41 minutes. Film rating exercises are also available so that the time study person can provide reliable indices for. performance rating. There are various systems of rating such as

i) 60-rating (Bedaux work unit equivalent to 1 minute).

ii) 100% rating (popularly used in USA).

iii) Synthetic rating (makes use of levelling factor depending on predetermined motion time values).

iv) Westinghouse method of rating (based on skill, effort ,conditions and consistency)

v) Objective rating (based on concept of speed to which is complemented allowances for job-complexities).

If normal and standard performances coincide, then 60. would be normal for 60-rating whereas a rating of 100 would be given in the 100% rating scheme. We shall be using the 100% rating scheme.

Let us now return to the subsequent steps of the time-study procedure.

Examine and Compile.

Now examine the recorded times and the associated ratings so that we are in a position to compile realistic standards. Using the 100% rating scheme, the normalised time can be obtained as follows:

$$\text{Normalised time= observed time} \times \frac{\text{Rating}}{\text{Normalrating}}$$

It is a usual practice of rounding off ratings to the nearest multiple of five on the scale, viz. if the performance rating is judged to be 123% we would put down 125% (122% would be put as 120%).

To the normalised time, we need to add time because of allowances that need to be given on account of **process, rest special and policy** allowances. The subtotal of the normalised time and all relevant allowances will give us the standard time.

We shall discuss the type of and need for allowances in greater depth in the subsequent unit on Job Design.

Define

Now you should precisely define the activities covered and issue the allowed time for a particular job/operation. Obviously, this allowed time should have had the approval of management and the support of the employees and their representatives so that no conflicts occur when the plan is actually put into practice.

It is important, however, for the time study person to have taken sufficient number of readings. This can be determined by.using the following formula which is based on a normal distribution for 95% level of confidence and a precision need.of predicting the final results within ± 5%

$$N_{\text{expected}} = \frac{40NX^2\text{-}(X)^2}{X}$$

Where N represents observations already taken

X denotes the value of each observation

N_{expected} represents the sufficient number of readings

If $N_{\text{expected}} > N$, then we will have to take a further number of observations, rework the calculations for least N value and check again. If N_{expected}

$A=\pm 2\sqrt{p(100\text{-}p)/n}$ N, then we are confident that the results are in fact based on a confidence level of 95% with preciseness of ± 5%.

Activity A

The time taken for an element in a time study for 30 observations revealed the following information:

x(in seconds)	0.05	0.06	0.07	0.08
f(frequency)	14	14	1	1

Have sufficient observations been taken for a precision of ± 5% and 95% confidence level?

The answer is yes, but can you tell us how many observations need to have been taken?

Figure VIII: Time Study Worksheet
Observed time for the operation = 0.37 minutes.

Cycle no.	1		2		3		4		5		6		7		8		9		10		Average
Element Description	R	T	R	T	R	T	R	T	R	T	R	T	R	T	R	T	R	T	R	T	Element time
1 Pick up invoice place next to CRT terminal	08	08	37	07	66	08	01	09	33	08	66	10	97	10	27	08	60	09	91	08	85/10 = 8.5
2 Punch in the data from invoice	22	14	51	14	84	18	16	15	47	14	80	14	12	15	43	16	76	16	05	14	150/10 = 15.0
3 Place the invoice aside	30	08	58	07	93	08	25	09	56	09	87	07	19	07	51	08	83	07	13	08	78/10 = 7.8

R – readings of the stopwatch in hundredths of a minute

T – derived elemental time in hundredths of a minute

Sample illustration: The readings on the stop-watch at the end of 1st and 2nd elements (in cycle no. 1) are 08 and 22 Therefore, the time for the 2nd element is 22−8= 14 as shown above.

Element no.	Avg. Elem. Time	Rating (Normalised)	Normal Time	5% allowances	Standard Time
1	8.5	120% or 1.2	8.5 × 1.2 = 10.2	10.2 × 0.05 = 0.5	10.2 − 0.5 = 10.7
2	15.0	110% or 1.1	15.0 × 1.1 = 16.5	16.5 × 0.05 = 0.8	16.5 + 0.8 = 17.3
3	7.8	110% or 1.1	7.8 × 1.1 = 8.6	8.6 × 0.05 = 0.4	8.6 − 0.4 = 9.0
			Standard allowed time for the operation		= 37.0

Let us consider the key punching operation for invoice which consists of the following elements in sequence.

1 Pick up an invoice, place it next to the CRT (Cathode Ray Tube) terminal.

2 Punch in the data on the terminal keyboard.

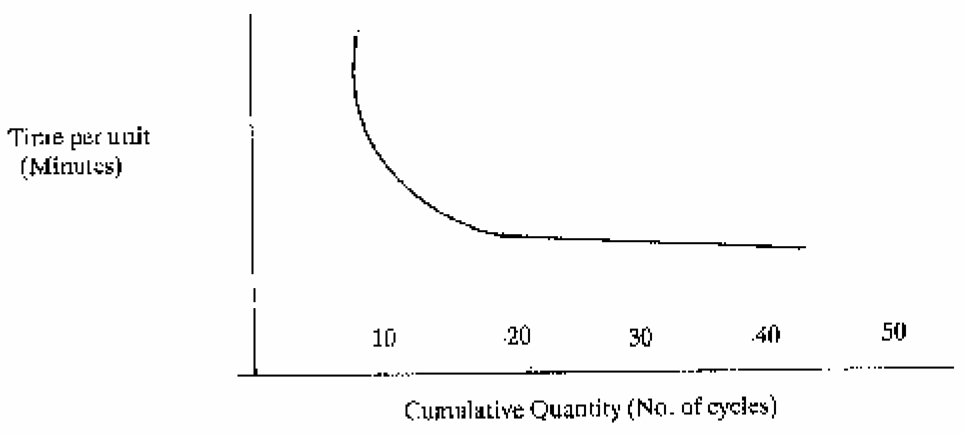
3 3 Place the invoice aside.

A stop-watch time study for 10 cycles was conducted. Stop-watch readings were taken at the start of each element. These are shown in the `R' columns in Figure. V II I illustrating the time study worksheet. Moreover, the observer also assigned a performance rating (PR) of 120%, 110% and 110% to the elements, 1,2 and 3 respectively. These rating factors are multiplied by the average elemental times to obtain the normal times for each of the three elements. Let us assume that the company has decided to give at best an allowance of 5% of the normal time taken by each element. The standard time taken for each element is therefore the normal time plus the allowances allowed therein. The sum-total of these standards times would be the standard time for the total job under study. As can be seen from Figure Viii the standard allowed time for the operation is 0.37 minutes.

Learning Curve

One word of caution in trying to establish standards. It could happen that the operator selected for time study is performing the job for the first time. Sometimes it could also be the case when the operations being performed are complex in nature. In such cases, it is quite possible that initially the operator takes longer time to accomplish these jobs as compared to the subsequent cycles when he would have acquired the necessary skill and feel in `learning' the job. Usually, this learning curve is hyperbolic in nature, as shown in Figure IX.

Figure IX: Learning Curve



Activity B

Well, you could try this experiment. Have you ever played cards? If you haven't, fine, then you could perform the experiment yourself. In case you have been playing cards, find someone in your family or friends circle who has never played cards. The task of the novice (person who has not been playing cards), is to distribute a pack of 52 cards in four equitable heaps, placing not more than one card at a time at each heap.

Note the method and time taken for the first time, second time and so on. Take a graph paper and plot the times taken (Minutes) versus the number of times the novice distributes the cards. What is your experience? Do you get a hyperbolic curve of the type shown in Figure IX? Make your observations on the validity of the learning curve principle on the basis of the above experiment.

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Some of the advantages of a learning curve are:

1 It allows us to predict the cost of a future product or an operation.
2 It determines the point where we can start to apply work measurement for establishing the standard time for an operation.
3 Sometimes it could also provide a basis for transfer and promotion of employees.

The general approach to determining the rate of learning is to identify the relative importance of each factor contributing to learning. Can the causes and influences be measured and predicted? Though the `learning curve' concept is an important one, yet it seems that it has not been given due importance. We feel it would be unfair if learning phase' is not accounted fur while determining standard. Let us now discuss yet another powerful and useful technique of work measurement namely work sampling.

Work Sampling

The origin of this technique is credited to L.H.C. Tippet. He used the method of 'snap reading for determining the causes of loom stoppages in Textile factories in 1935 while working for the British Cotton Industry Research Institute. Since then, the technique has been successfully applied in many different situations under such names as Ratio Delay Study, Random Observation Method, Observation Ratio Study, Activity Sampling and Work Sampling.

Work Sampling is a fact-finding tool. It is 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 is urgently needed about men or machines, especially in the analysis of non-repetitive or irregularly occurring activity where no complete method and frequency description is available. Work sampling can be used to study almost any type of work: repetitive and non-repetitive, factory or office, executive or supervisory, clerical or engineering, handlers, salesmen, nurses and what have you.

Work sampling is a method of randomly observing work, noting state or condition of the object being studied. From the proportions of observations in each category, inferences are drawn concerning the total work activity under study. It can be used for fact-finding, work measurement and methods analysis.

a) Some uses of Work Sampling

Work Sampling provides a way to:

1 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.

2 indicate if certain activities should be studied in detail.

3 help design the work load distribution in formulating a new work system.

4 study any operation for possible methods improvement.

5 help establish job content as an aid to job evaluation and employment purposes.

6 aid supervisors to organise their time.

7 aid appraisal of shop effectiveness, efficiency, safety performance etc.

8 provide feedback information about compliance to stated management policies.

9 assist in establishing standards of performance.

10 establish controls on labour, material or machine utilisation.

The object of the observations maybe personnel, equipment or facilities which can be categorised as follows: typical categories applied to people are (a) Working (b) Being idle (c) Being out of area (d) Walking (e) Handling material (f) Inspecting (g) Changing tools (h) Cleaning up (i) Handling clerical tasks (j) Talking.

Typical categories applied to machines/equipments are:

(a) At work (b) Idle-no operator (c) Idle-no stock (d) Idle-being serviced (e) Idle-interference.

b) Accuracy and Confidence Considerations

The results of a work sampling study are in. percentages which are estimates of true values that indicate how the total time is allocated to the various activity categories in the long run. Accuracy of work sampling is determined by the number of observations, the greater the number of observations, the greater the accuracy and confidence. But nearly all problems have a point beyond which greater accuracy of data is not worthwhile.

The theoretical basis of work sampling is based on the statistical law of probability and is derived from the statistical sampling facility provided by the mean and standard deviation of a binomial distribution that closely approximates to a normal curve under certain set of conditions. In work sampling, each observation can be considered an experiment where an activity of interest is occurring or not occurring. If the individual, observations were independent of one another and if the system under observation was stable. then the process can he described by the binomial probability distribution. The binomial distribution gives the mean and standard deviation of p (the percentage of occurrences in the sample of the activity of interest that would be expected if many samples of size n would be taken).

$$\text{Standard deviation} = p = \sqrt{p'(100-p')/n}$$

where p' is the true population percentage of occurrence of the activity of interest. For large sample sizes of n = 100 or larger, the binomial distribution can be approximated by the normal distribution. Accordingly, you can expect about 95% of the values of p to fall in the interval of p' ±2p. Conversely, for a single sample, one can he 95% confident that p is within 2 p for p'. Since p' is not known, p is used as an estimate of it. so that accuracy A at the 95% of confidence level is given as

$$A = \pm 2\sqrt{p(100-p)/n}$$

In general we can state

$$A = \pm 2\sqrt{p(100-p)/n}$$

Where

K = 1 would indicate 68% confidence
K = 2 would indicate 95% confidence
K = 3 would indicate 99.7% confidence.

(c) Work Sampling Procedure:

The following steps are usually required in conducting a work sampling study.

1 Define the problem: There could he many reasons for conducting a work sampling study. it is essential to state the main objective, purpose or goal of the project or problem. This would provide a frame of reference and help place a limit on the costs for the study to secure the desired results. It is better to work on a homogeneous parent population, for instance similar presses being studied for their capacity utilisation. Where unlike objects are grouped to constitute a heterogeneous population, the sample estimates will have only an aggregate meaning. Therefore, it is better to identify, for instance, what group of people and/or machines to study, what sub-groups are to he included and what accuracy is desired from the study and which other agencies might benefit from the results of the work sampling study.

2 Preliminary survey of work activities: It is very vital to obatain the approval of the head/supervisor of the department in which the study is to he conducted as well as necessary cooperation of the employees of the concerned departments. A good deal of public relations effort might be called for at this stage. The person making the study must he familiar with the activities of the subjects being considered. Perhaps a person of the same profession/trade could he more acceptable. Where this is not possible, the observer should review the work to gain a fair deal of familiarity.

3 Activity classification: The purpose of the study as enunciated in step-1 will indicate how the number of work functions or activities is to be broken down. There is no unique rule to specify the levels of breakdown. You must be interested to know whether the subject is idle or otherwise. On the other hand, some of you might want to know the reasons contributing to such idleness or otherwise as well.

4 Design of necessary forms for Recording study data: Decide how the observations are to be recorded on the observation sheet. In most cases a new observartion form will have to be designed for each study. One such possible format is shown in Figure X.

Figure X : Work Sampling Record Sheet

Observer ________ Sheet ________ of ________
Date ________

Tour	Time of tour	Identity of person or subject studied	(Activity Code)
1	8.05		
2	8.20		
3	9.06		

Activity Code:			
	A = Active		
	B = Inactive	Breakdown	Management's fault
	C = Inactive	lack of material	
	D = Inactive	lack of work	
	X = Absent	Worker to blame	
	Y = Idle		

5 Develop properly randomised times of observation: A single observation consists of an **instantaneous** or **snapshot** look at the operation or activity in order to determine the state in which it is as defined in the activity code in step 4. In work sampling, the times of observation for any given sampling must he selected without bias viz., these observations must be completely random with respect to time. One of the most effective ways to ensure this is by making use of a random number table. A scheme or a code must be evolved to convert the random numbers into times while avoiding any method which may be biased towards certain times. Let us take a small illustration.

Assume that 15 observations are required for a given study over a one-day (480 minutes) study period, the starting time being 8.00 a.m. Let us examine increments where possible snapshot observations could be taken. Let us refer to the random number table in Figure Xi. it is a 2-digit random number table and only shown partly.

Figure X1: An extract from a 2-digit random number table

61	46	38	Say we start here.
05	88	69	
88	08	13	
45	82	63	
34	56	65	
28	22	87	
44	49	18	
		04	
		29	
		21	
		09	
		08	
		18	
		84	
		64	
		81	
		98	
		55	

From the random number table pick up arbitrarily any number, say 69 as indicated in the Figure XI. Now follow the. vertically downward sequence and note the random numbers in Figu[r]e XII. In deriving usable random numbers, omit any numbers that numerically exceed the total number of increments (96 in this illustration). Also omit any repeat numbers. Accordingly, numbers 18 and 98 are scored off. The usable random numbers remaining are arranged in an ascending order for which corresponding observation times are then derived. Therefore, the first observation for 04 would be 5 increment (00,01, 02, 03, 04) viz. 20 minutes after the starting time at 8.20 a.m Note that observation 55 would have occurred during the one-hour lunch period (12.00 to 1.00 pm), therefore, actual observation is one clock hour late. This is to be for all subsequent cases after lunch.

Figure XII:

Random numbers read from R.N. Table	Usable Random Numbers (URN)	URN arranged in ascending order	Corresponding observation Time
69	69	04	
13	13	08	
63	63	09	
65	65	13	
87	87	18	
18	18	21	
04	04	29	
29	29	55	
21	21	63	
09	09	64	
08	08	65	
18	84	69	
84	64	81	
64	81	84	
81	55	87	

clock hour later. This is to be for all subsequent cases after lunch.

Now these observations of timing schedules should be known only to the observer, otherwise some biased results might accrue.

6 Select and Train Observers: The observers should be chosen carefully. They must be trained to follow the sampling study rules and specific limitations. Observations should made at the proper times as desired in step-5. They should avoid any bias in making observations. Explicitly they should be asked not to anticipate any particular action but to record exactly what they see at the given instant snapshot observations. All clarifications should be sought and solved out by the observer before actually conducting the final study.

7 Estimate Number of Observations: The basic problem is economic and to find the balance of the minimum number of observations to achieve the confidence and accuracy desirable. The confidence level chosen is usually 95% while the desired accuracy could range from ±1% to 10%. The observer first conducts a pilot study to make a rough estimate, ± (the proportion of time occupied by the particular activity) After making 20 observations, the activity was observed 12 times viz., p is 60%. For a 95% confidence level, and if A (accuracy limit) be 10% then on substituting in the formula

$$A=\pm 2\sqrt{p(100\text{-}p)/n}$$

and on rearranging, we shall get the number of observations n

$$n=4\ p\ (100\text{-}p)\ A^2=4\times 60(100\text{-}60)10^2=96$$

This would indicate that (96-20) =76 more observations would have to be taken. Nov after conducting 76 more observations, a recheck could be carried out. The new vale of p on the basis of all the 96 readings is known. Now recalculate the value of A by using the formula

$$A=\pm 2p\ (100\text{-}p)/n$$

If A conforms to ±10% as planned, then we could stop the study and say with 95% confidence that the actual value of p (of parent population) has been estimated as ^{p} with a 95% confidence level. However, if A does not conform to ± 10%, then for value of A as ±10% and for new value of P (obtained on the basis of 96 readings) again determine n, the number of observations required. This interactive procedure could be continued till the values of p and n give the desired accuracy of A as being within ±10%.

If there are a number of characteristics being studied, there would be a number of p values. Larkin says 'hat it can be verified whether most readings are required to be determined by a size of p that is nearest in value to 50%. Thus, if the activity possessing this characteristic is used to estimate n, then it can be expected that the percentages for all the other activities will also be within the limits adopted for the study.

Let us now discuss briefly some of the remaining techniques of work measurement.

Predetermined Motion Time System (PMTS)

Every element of work is composed of some combination of basic human motions. Apart from mental activity, all work can be broken down into elements that are usually a fundamental movement of the body or body members. After this analysis stage, the basic motions that have been isolated have a time allotted to them on the basis of predetermined motion times. This is the measurement (or rather premeasured) stage. The synthesis stage involves combining the basic motions in specific combinations and frequencies to form basic elements which would go to complete the total work operation. This method is particularly suited to situations where direct observations may not be possible or it may be some entirely new method of working which, however, is composed of work of basic elements which are standard with a new combination or mix. It is suited to both repetitive as well as non-repetitive work.

Analytical Estimating

After the job has been broken down into its constituent elements in certain types of non-repetitive work, we find that analytical estimating serves as best for measuring work. In the analysis stage we find that usually these basic elements are much larger as compared to the elements in PMTS or time study. For the measuring stage, the time, which will be occupied by the element at a specific speed of working, is estimated. Many values may be obtained from the records of previous studies. The synthesis of all such records or data can be clubbed together for meaningful purpose.

Synthesis from Standard Data

Now here we find yet another technique of work measurement to obtain synthetic times (or synthesised time standards) that are synthesised from element times previously obtained from direct time studies. The analysis and measurement stages are thus conducted prior to the actual study. The technique primarily focuses on the synthesis stage. Most organisations that have had work studies conducted for some time usually build up synthetic tables covering the common elements in their own type of work. You could also refer to some standard tables, but be cautious in adapting it to your own organisations by duly keeping the framework in mind for which the standards might be applicable.

MOST Measurement System

The word MOST stands for Maynard Operation Sequence Technique. It is yet another work measurement technique. It was conceptualised around 1967 but was formalised only in 1975. The basic assumption here is that for an overwhelming majority of work, there is a common denominator from which work can be studied: the displacement of objects: In fact, all basic units of work are organised for the purpose of accomplishing some useful result by simply moving objects. MOST is a system to measure work by concentrating on the movement of objects. Consequently, MOST technique is composed of the following basic sequence models:

The General Move Sequence (for the spatial movement of an object freely through the air)

The Controlled Move Sequence (for the movement of an object when it remains in contact with a surface or is attached to another object during the movement

The Tool Use Sequence (for the use of common hand tools).

In contrast to Methods Time Measurement, PMTS etc., the primary work units are no longer basic motions, but fundamental activities (collections of basic motions) dealing with moving objects.

At this stage we would like to stop our discussion of MOST and refer you to Zandine's book on MOST in case you are interested in further details on the topic.

7.5 WORKS STUDY APPLICATIONS

Work study techniques can be applied in a large number of situations. They are not necessarily confined to manufacturing at the shop floor level. Work study could be applied in office situations in which case the technique is more popularly known as O&M (Organisation & Methods). Work study could be applied in the Building Industry. In fact, Frank Gilbreth developed his ideas on time and motion study in a construction situation. Quite often, repetitive work is to be found on one site, e.g. laying precast concrete floor units, etc. Work study, particularly method study has, in such cases, been found to be very beneficial.

Again, we could utilise work study in the context of agriculture, which remains largely non-mechanised in our country. Savings in time and effort of farmers can be used to increase their effectiveness and efficiency. Identification and elimination of fatiguing, and costly or unproductive activities could be undertaken.

Work study could be used in a hospital setting also. Work study groups can achieve great success in the nursing patterns and staffing, ward design and hospital layout improvement in services such as catering, laundry work, domestic cleaning, typing, secretarial work and documentation etc.

In some countries abroad, work study has been used in national and local government services for maintenance of parks, playing fields, housing schemes, street cleaning, rubbish collection and disposal, post office sorting etc. It can also be used in defence services both for repair and logistic functions etc. Work study can also be used in hotel management for housekeeping, linen service, kitchen work, reception, preparation, cooking and serving of foods etc.

Work study personnel could also prove to be beneficial if they are included in design teams which require an inter-disciplinary approach for greater effectiveness. Accordingly, work study people along with value analysts would certainly increase design worthiness.

7.6 SUMMARY

Work is a major source of economic livelihood. A key function in production and operation management is organising work. Work design is concerned with the study and design of any type of management or work system in any type of organisation. We have noted the historical trends in the management of work and the need for adopting a scientific, systematic and integrated approach to work design so as to have increased productivity leading finally to enhanced human dignity and a better quality of life. In this unit we have concentrated on the work study approach to enhance productivity and effectiveness of the work systems design. As you would notice, we have skipped some factors and details pertaining to physical environment, therblings, human engineering/ergonomic aspects which will be discussed in the subsequent unit on the Job Design. A generalised approach of 8 basic steps of work study have been mentioned. Some of these steps are then discussed in detail while discussing method study and work measurement. Various charts have been discussed which would help you in the `record stage' of method study. A critical examination technique checklist has been provided to aid you in examinin$_5$ and developing methods. Work measurement techniques, especially time study and work sampling, have been discussed at length. Before setting standards, you must take note of the `learning curve' phenomena. Work study applications show that the technique can be effectively applied to a large variety of situations; it is not just limited to the manufacturing sector. This chapter on work design needs to be followed up in the subsequent unit on job design to give a total understanding of the realm and utility of work and job design, which, by adopting a socio-technical system approach, would go a long way in increasing effectiveness, productivity and quality of life.

7.7 KEY WORDS

Activity chart: Divides operations into major task segments performed by workers and machines; times them to determine idle and productive times; appropriate for routine, repetitive task with worker-machine interaction.

Allowed time: The levelled time plus allowances for fatigue and delays.

Flow process chart: Analyses interstation activities to capture the flows of products through the overall production process.

Learning curve: Pattern of input resources consumed in creating successive units of a product; generally initial units require higher amounts of inputs (time), and later units require progressively fewer inputs.

Management: The organisation and control of human activity directed towards specific ends in an optimal manner.

Method study: The systematic recording, analysis and critical examination of existing and proposed ways of doing work and the development and application of easier and more effective methods.

Multiple activity process chart: A form of process chart recording the related sequence of work of a number of operators and/or machines.

Open system: A system that is an integral part of a larger system; its viability depends upon successful adjustments to varied inputs from and outputs to its environment.

Process chart: A graphic representation of a sequence of events that occur in the work method, classifying them by-symbols according to the nature 6f the events. It is a device for visualising a procedure for the purpose of improving it.

Productivity: The ratio of output to input.

Rating: The mental comparison, by a work study man, of the performance of an operator under observation with his own idea of a standard performance for a given method.

SIMO chart: A chart used to record against a time-scale the therbligs performed by an operator or operators at work; showing each therbligs by colour, sequence and duration, together with the parts of the body or machine affected by them.

Standard minute: The unit of measurement of output of work. It represents the output of work in one minute of the allowed time for any given operation.

Standard time: The allowed 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 and delays, to do a defined amount of work of specified quality when following the prescribed method.

Time study: A measurement technique for determining as accurately as possible, from a sufficient number of observations, the time necessary to carry out a given activity at a defined standard of performance.

Two-handed process chart: A form of operator process chart recording the work of both the operator's hands.

Work cycle: The complete sequence of the elements necessary to perform a specified activity or task or to yield a unit of production. It may include elements which do not recur in every cycle.

Work measurement: The application of techniques designed to establish the work content of a specified work tasks by determining the time required for carrying it out at a defined standard of performance by a qualified worker.

Work sampling: A work measurement technique that involves defining the condition `working', sampling the activity `overtime', and computing proportion of time the worker is engaged in `work'.

Work study: A term used to embrace the techniques of method study and work measurement which are employed to ensure the best possible of human and material resources in carrying out a specified activity.

7.8 SELF-ASSESSMENT EXERCISES

1 It is usually presumed that `resistance to change is a characteristic attributed to people'. What would be your personal reactions, if some work design analyst came to your work station to conduct a study of your work.

2 Place six piles of foolscap paper before you, then collate sets of six in order and staple them. How would you place the piles? Make a chart of the method you used. If you had to do this by the thousands, what improvements in method can you suggest? Develop an improved method.

3 **Time study problem:** Determine the standard time for the following job. Add 20% for allowances. The times shown are continuous stop-watch readings in hundredths of a minute.

Element	1	Cycle 2	3	4	5	6	7
a) Get two cases	10		5		04		52
b) Put part into case	21	40	64	82	15	33	59
c) Fasten parts into position	28	47	72	96	22	40	81

Performance rating of the elements a, b and c were 105%,115% and 95% respectively.

4 **Man-machine chart problem:** Consider one person operating two semi-automatic machines. The cycle consists of

a) load machine - 45 seconds
b) machine part - 90 seconds
c) unload machine - 30 seconds

The two machines are alike, and each completes the machining operation and stops automatically. Assuming that both machines are empty, at the start, draw a man-machine chart for four such cycles. What do you infer from the chart? Make your recommendations accordingly.

5 **Man-machine chart problem:** Now if there is a large volume item and several semi-automatic machines are in operation, an operator can operate several machines. If the machines do not, however, stop after they have finished their operations, the operator must be there to take out the finished pieces. The time it takes for one of the operations needed to make the item is: unloading machine 0.2 minutes, loading machine 1.7 minutes and machine time is 7.0 minutes. You may assume that the machines are so close together that the time it takes to go from one machine to the other can be neglected.

i) How many machines can a person operate? Draw up a worker machine chart showing how your plan works.
ii) Suppose that in answer (i), you have to concern yourself with costs and suppose that a worker costs Rs. 12.00 a minute and machine's idle time costs Rs. 15.00 a minute. Is the answer still the same? Justify.
iii) If there were a large number of machines, is there any way to eliminate the idle time of both machines and workers?

6 **Work sampling problem**: A working sampling study revealed that out of a total number of readings, 1050 taken thus far, the number of times a machine was idle was 345. If the limit of error required is to be ± 2 per cent for 95 cases in 100, how many more readings are required?

7 **Work sampling tour schedule problem:** Given the following random numbers, can *you* design a tour schedule for taking 25 observations for a work sampling study. Assume an 8-hour observation period.

Column	1	2	3	4	5
Row					
1	03991	10461	93716	16894	98953
2	038555	95554	32886	59780	09958
3	17546	73704	92052	46215	159917
4	32643	52861	95819	06831	19640
5	69572	68777	39510	35905	85244

Hint: Go row-wise choosing two numbers at a time. The first four numbers would therefore be 03, 99, 11, 04 (starting from first row column).

7.9 FURTHER READINGS

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